CONTENTS

CHAPTER 1

SOME BASIC CONCEPTS OF CHEMISTRY

FACT/DEFINITION TYPE QUESTIONS

1. A mixture of sand and iodine can be separated by
(a) crystallisation
(b) distillation
(c) sublimation
(d) fractionation

2. Difference in density is the basis of
(a) ultrafiltration
(b) molecular sieving
(c) molecular attraction
(d) gravity separation

3. Which of the following is an example of a heterogeneous substance?
(a) Bottled water
(b) Table salt
(c) Pieces of copper
(d) Candle

4. Which of the following substances cannot be separated in to its constituents by physical methods?
(a) Sugar and water solution
(b) Salt and sugar
(c) Solid glucose
(d) Both (a) and (b)

5. Which of the following pair of substances contain element and compound within a pair ?
(A) O_2, CH_4
(B) H_2, O_2
(C) N_2, CO_2
(D) Na, CO
(a) A, C, D
(b) B only
(c) C and D
(d) All of these

6. Which of the following statements about a compound is incorrect?
(a) A molecule of a compound has atoms of different elements.
(b) A compound cannot be separated into its constituent elements by physical methods of separation.
(c) A compound retains the physical properties of its constituent elements.
(d) The ratio of atoms of different elements in a compound is fixed.

7. Choose the correct combination

	Element	Compound	Mixture
(a)	Ammonia	Sodium	Air
(b)	Water	Sugar	Aqueous sugar solution
(c)	Hydrogen	Oxygen	Water
(d)	Silver	Water	Air

8. Choose the correct statement.
(a) The particle s in liquids are more closely held than gases but less free to move than solids.
(b) The particles of solids are arranged in orderly fashion but they can move as freely as liquids.
(c) The particles of gases are far apart as compared to solids and liquids and their movement is easy and fast.
(d) The particles of gases moves faster than liquids only when the gases are heated.

9. A mixture contains two or more substances in ________ which are called its ________.
(a) fixed ratio, compounds
(b) fixed ratio, elements
(c) any ratio, components
(d) any ratio, elements

10. Which one of these is not a pure compound?
(a) O_3
(b) H_2O_2
(c) H_2O
(d) Sucrose solution

11. One fermi is
(a) 10^{-15} cm
(b) 10^{-13} cm
(c) 10^{-10} cm
(d) 10^{-12} cm

12. The prefix 10^{18} is
(a) giga
(b) kilo
(c) exa
(d) nano

13. The prefix zepto stands for (in m)
(a) 10^{9}
(b) 10^{-12}
(c) 10^{-15}
(d) 10^{-21}

14. The unit J Pa^{-1} is equivalent to
(a) m^3
(b) cm^3
(c) dm^3
(d) None of these

15. Which has highest weight ?
(a) 1 m^3 of water
(b) A normal adult man
(c) 10 litre of Hg
(d) All have same weight

16. Which one of the following set of units represents the smallest and largest amount of energy respectively?
(a) J and erg
(b) erg and cal
(c) cal and eV
(d) eV and L-atm

17. A measured temperature on Fahrenheit scale is 200 °F. What will this reading be on Celsius scale ?

(a) 40° C
(b) 94° C
(c) 93.3 °C
(d) 30° C

18. Which of the following is not a SI unit?

(a) metre
(b) candela
(c) mole
(d) litre

19. The prefix 10^{-24} is

(a) yotta
(b) zeta
(c) yocto
(d) zepto

20. Many countries use Fahrenheit scale for expressing temperature of atmosphere. If temperature in any such country is measured 41°F then what is its value in celcius scale and would you expect hot or cold atmosphere in that country?

(a) 15°C, cold
(b) 25°C, normal
(c) 5°C, cold
(d) 41°C, hot

21. A sample was weighted using two different balances. The results were

(i) 3.929 g
(ii) 4.0 g

How would the weight of the sample be reported?

(a) 3.93 g
(b) 3g
(c) 3.9 g
(d) 3.929 g

22. Two students performed the same experiment separately and each one of them recorded two readings of mass which are given below. Correct reading of mass is 3.0 g. On the basis of given data, mark the correct option out of the following statements.

Students	Readings	
	(i)	(ii)
A	3.01	2.99
B	3.05	2.95

(a) Results of both the students are neither accurate nor precise.
(b) Results of student A are both precise and accurate.
(c) Results of student B are neither precise nor accurate.
(d) Results of student B are both precise and accurate.

23. 0.00016 can be written as ...A... in scientific notaiton. Here, A refers to

(a) 1.6×10^{-4}
(b) 24.50×10^{-9}
(c) 2.450×10^{-8}
(d) 24.50×10^{-7}

24. If the true value for an experimental result is 6.23 and the results reported by three students X, Y and Z are :

X: 6.18 and 6.28
Y: 6.20 and 6.023
Z: 6.22 and 6.24

Which of the following option is correct :

(a) X precise, Y accurate, Z precise and accurate.
(b) X precise and accurate, Y not precise, Z precise
(c) Both X & Z precise & accurate, Y not precise.
(d) Both X & Y neither precise nor accurate, Z both precise and accurate.

25. In the final answer of the expression

$$\frac{(29.2-20.2)(1.79\times10^{5})}{1.37}$$

the number of significant figures is :

(a) 1
(b) 2
(c) 3
(d) 4

26. The number of significant figures for the three numbers 161 cm, 0.161 cm, 0.0161 cm are

(a) 3,4 and 5 respectively
(b) 3,4 and 4 respectively
(c) 3,3 and 4 respectively
(d) 3,3 and 3 respectively

27. Given P = 0.0030m, Q = 2.40m, R = 3000m, Significant figures in P, Q and R are respectively

(a) 2, 2, 1
(b) 2, 3, 4
(c) 4, 2, 1
(d) 4, 2, 3

28. If the density of a solution is 3.12 g mL^{-1}, the mass of 1.5 mL solution in significant figures is______.

(a) 4.7 g
(b) 4680×10^{-3} g
(c) 4.680 g
(d) 46.80 g

29. In which of the following number all zeros are significant?

(a) 0.0005
(b) 0.0500
(c) 50.000
(d) 0.0050

30. The correctly reported answer of addition of 29.4406, 3.2 and 2.25 will have significant figures

(a) 3
(b) 4
(c) 2
(d) 5

31. The number of significant figures in 10.3106 g is

(a) 2
(b) 3
(c) 1
(d) 6

32. Choose the correct option that represents the result of the given calculation to the appropriate number of significant figures:

$$\frac{43.0\times0.0243}{0.340\times4}$$

(a) 0.768
(b) 0.77
(c) 0.76
(d) 0.7683

33. Arrange the numbers in increasing no. of significant figures. 0.002600, 2.6000, 2.6, 0.260

(a) $2.6 < 0.260 < 0.002600 < 2.6000$
(b) $2.6000 < 2.6 < 0.002600 < 0.260$
(c) $0.260 < 2.6 < 0.002600 < 2.6000$
(d) $0.002600 < 0.260 < 2.6 < 2.6000$

34. Dimension of pressure are same as that of

(a) Energy
(b) Force
(c) Force per unit volume
(d) Energy per unit volume

35. n g of substance X reacts with m g of substance Y to form p g of substance R and q g of substance S. This reaction can be represented as, X + Y = R + S. The relation which can be established in the amounts of the reactants and the products will be

(a) $n - m = p - q$
(b) $n + m = p + q$
(c) $n = m$
(d) $p = q$

36. 20 g of $CaCO_3$ on heating gave 8.8 g of CO_2 and 11.2 g of CaO. This is in accordance with
(a) The law of conservation of mass.
(b) The law of constant composition.
(c) The law of reciprocal proportion.
(d) None of these

37. Which of the following is the best example of law of conservation of mass?
(a) 12 g of carbon combines with 32 g of oxygen to form 44 g of CO_2
(b) When 12 g of carbon is heated in a vacuum there is no change in mass
(c) A sample of air increases in volume when heated at constant pressure but its mass remains unaltered
(d) The weight of a piece of platinum is the same before and after heating in air

38. Which of the following statements is correct about the reaction given below ?

$$4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(g)$$

(a) Total mass of iron and oxygen in reactants = total mass of iron and oxygen in product therefore, it follows law of conservation of mass.
(b) Total mass of reactants = total mass of product; therefore, law of multiple proportions is followed.
(c) Amount of Fe_2O_3 can be increased by reducing the amount of any one of the reactants (iron or oxygen).
(d) Amount of Fe_2O_3 produced will decrease if the amount of any one of the reactants (iron or oxygen) is taken in excess.

39. In an experiment 4.2 g of $NaHCO_3$ is added to a solution of acetic acid weighing 10.0 g, it is observed that 2.2 g of CO_2 is released into the atmosphere. The residue left behind is found to weigh 12.0 g
The above observations illustrate
(a) law of definite proportions.
(b) law of conservation of mass
(c) law of multiple proportions
(d) None of these

40. In one experiment, 4g of H_2 combine with 32g of O_2 to form 36g of H_2O. In another experiment, when 50g of H_2 combine with 400g of O_2 then 450g of H_2O is formed. Above two experiments follow
(a) The law of conservation of mass
(b) The law of constant composition
(c) Both (a) and (b)
(d) Neither (a) nor (b)

41. Irrespective of the source, pure sample, of water always yields 88.89% mass of oxygen and 11.11% mass of hydrogen. This is explained by the law of
(a) conservation of mass (b) multiple proportions
(c) constant composition (d) constant volume

42. The percentage of copper and oxygen in samples of CuO obtained by different methods were found to be the same. The illustrate the law of
(a) constant proportions (b) conservation of mass
(c) multiple proportions (d) reciprocal proportions

43. The law of definite proportions was given by –
(a) John Dalton (b) Humphry Davy
(c) Proust (d) Michael Faraday

44. Which one of the following pairs of compounds illustrate the law of multiple proportions ?
(a) H_2O and Na_2O (b) MgO and Na_2O
(c) Na_2O and BaO (d) $SnCl_2$ and $SnCl_4$

45. Among the following pairs of compounds, the one that illustrates the law of multiple proportions is
(a) NH_3 and NCl_3 (b) H_2S and SO_2
(c) CS_2 and $FeSO_4$ (d) CuO and Cu_2O

46. Two samples of lead oxide were separately reduced to metallic lead by heating in a current of hydrogen. The weight of lead from one oxide was half the weight of lead obtained from the other oxide. The data illustrates
(a) law of reciprocal proportions
(b) law of constant proportions
(c) law of multiple proportions
(d) law of equivalent proportions

47. In compound A, 1.00g of nitrogen unites with 0.57g of oxygen. In compound B, 2.00g of nitrogen combines with 2.24g of oxygen. In compound C, 3.00g of nitrogen combines with 5.11g of oxygen. These results obey the following law
(a) law of constant proportion
(b) law of multiple proportion
(c) law of reciprocal proportion
(d) Dalton's law of partial pressure

48. Which of the following statements indicates that law of multiple proportion is being followed.
(a) Sample of carbon dioxide taken from any source will always have carbon and oxygen in the ratio 1 : 2.
(b) Carbon forms two oxides namely CO_2 and CO, where masses fo oxygen which combine with fixed mass of carbon are in the simple ration 2 : 1.
(c) When magnesium burns in oxygen, the amount of magnesium taken for the reaction is equal to the amount of magnesium in magnesium oxide formed.
(d) At constant temperature and pressure 200 mL of hydrogen will combine with 100 mL oxygen to produce 200 mL of water vapour.

49. The molecular weight of O_2 and SO_2 are 32 and 64 respectively. At 15°C and 150 mm Hg pressure, one litre of O_2 contains 'N' molecules. The number of molecules in two litres of SO_2 under the same conditions of temperature and pressure will be :
(a) N/2 (b) 1N
(c) 2N (d) 4N

50. 10 dm^3 of N_2 gas and 10 dm^3 of gas X at the same temperature contain the same number of molecules, the gas X is

(a) CO_2 (b) CO
(c) H_2 (d) NO

51. One mole of a gas occupies a volume of 22.4 L. This is derived from

(a) Berzelius' hypothesis (b) Gay-Lussac's law
(c) Avogadro's law (d) Dalton's law

52. One of the following combination which illustrates the law of reciprocal proportions ?

(a) N_2O_3, N_2O_4, N_2O_5 (b) NaCl, NaBr, NaI
(c) CS_2, CO_2, SO_2 (d) PH_3, P_2O_3, P_2O_5

53. Equal volumes of two gases A and B are kept in a container at the same temperature and pressure. Avogadro's law is invalid if

(a) the gases are reactive
(b) the gases are non-reactive
(c) gas A has more number of molecules than gas B.
(d) None of these

54. Molecular mass is defined as the

(a) mass of one atom compared with the mass of one molecule
(b) mass of one atom compared with the mass of one atom of hydrogen
(c) mass of one molecule of any substance compared with the mass of one atom of C-12
(d) None of the above

55. 1 amu is equal to

(a) $\frac{1}{14}$ of O-16 (b) $\frac{1}{12}$ of C-12
(c) 1 g of H_2 (d) 1.66×10^{-23} kg

56. The modern atomic weight scale is based on

(a) O^{16} (b) C^{12}
(c) H^1 (d) C^{13}

57. The percentage weight of Zn in white vitriol $[ZnSO_4.7H_2O]$ is approximately equal to $(Zn = 65, S = 32, O = 16 \text{ and } H = 1)$

(a) 33.65 % (b) 32.56 %
(c) 23.65 % (d) 22.65 %

58. The average atomic mass of neon based on following data is :

Isotope	**Relative abundance**
^{20}Ne	0.9051
^{21}Ne	0.0027
^{22}Ne	0.0922

(a) 0.33 u (b) 20.187 u
(c) 6.729 u (d) 18.058 u

59. What is the average atomic mass of bromine from the following data : (abundance is in %)

Isotope	**Mass**	**Abundance**
^{79}Br	78.9183361	50.69
^{81}Br	80.916289	49.31

(a) 79.9 (b) 76.6
(c) 75.9 (d) 69.9

60. What is the mass of an atom of oxygen (in gm)?

(a) 2.656×10^{-23} (b) 1.567×10^{-22}
(c) 2.0×10^{-22} (d) 3.5×10^{-23}

61. If the mass of the one atom is found to be 2.324784×10^{-23}g, then this atom can be ?

(a) Oxygen (b) Carbon
(c) Fluorine (d) Nitrogen

62. What is the mass of 1 molecule of CO.

(a) 2.325×10^{-23} (b) 4.65×10^{-23}
(c) 3.732×10^{-23} (d) 2.895×10^{-23}

63. Calculate the volume at STP occupied by 240 gm of SO_2.

(a) 64 (b) 84
(c) 59 (d) 73

64. At S.T.P. the density of CCl_4 vapours in g/L will be nearest to:

(a) 6.87 (b) 3.42
(c) 10.26 (d) 4.57

65. The number of gram molecules of oxygen in 6.02×10^{24} CO molecules is

(a) 10 gm molecules (b) 5 gm molecules
(c) 1 gm molecules (d) 0.5 gm molelcules

66. The number of oxygen atoms in 4.4 g of CO_2 is

(a) 1.2×10^{23} (b) 6×10^{22}
(c) 6×10^{23} (d) 12×10^{23}

67. Which has maximum number of molecules?

(a) 7 gm N_2 (b) 2 gm H_2
(c) 16 gm NO_2 (d) 16 gm O_2

68. Number of atoms in 558.5 gram Fe (at. wt. of Fe = 55.85 g mol^{-1}) is

(a) twice that in 60 g carbon
(b) 6.023×10^{22}
(c) half that in 8 g He
(d) $558.5 \times 6.023 \times 10^{23}$

69. The number of molecules in 16 g of methane is

(a) 3.0×10^{23} (b) $\frac{16}{6.02} \times 10^{23}$
(c) 6.023×10^{23} (d) $\frac{16}{3.0} \times 10^{23}$

70. Number of g of oxygen in 32.2 g $Na_2SO_4.10\,H_2O$ is

(a) 20.8 (b) 2.24
(c) 22.4 (d) 2.08

71. The number of moles of oxygen in one litre of air containing 21% oxygen by volume, under standard conditions are

(a) 0.0093 mole (b) 0.21 mole
(c) 2.10 mole (d) 0.186 mole

72. The number of molecules in 8.96 litre of a gas at 0ºC and 1 atm. pressure is approximately

(a) 6.023×10^{23} (b) 12.04×10^{23}
(c) 18.06×10^{23} (d) 24.08×10^{22}

73. The mass of a molecule of water is

(a) 3×10^{-25} kg (b) 3×10^{-26} kg
(c) 1.5×10^{-26} kg (d) 2.5×10^{-26} kg

74. One mole of CO_2 contains :

(a) 3 g atoms of CO_2
(b) 18.1×10^{23} molecules of CO_2
(c) 6.02×10^{23} atoms of O
(d) 6.02×10^{23} atoms of C

75. Volume of a gas at NTP is 1.12×10^{-7} cm^3. The number of molecules in it is :

(a) 3.01×10^{12} (b) 3.01×10^{24}
(c) 3.01×10^{23} (d) 3.01×10^{20}

76. How many atoms are contained in one mole of sucrose ($C_{12}H_{22}O_{11}$)?

(a) $20 \times 6.02 \times 10^{23}$ atoms/mol
(b) $45 \times 6.02 \times 10^{23}$ atoms/mol
(c) $5 \times 6.02 \times 10^{23}$ atoms/mol
(d) None of these

77. One litre oxygen gas at S.T.P will weigh :

(a) 1.43 g (b) 2.24 g
(c) 11.2 g (d) 22.4 g

78. Number of moles of NaOH present in 2 litre of 0.5 M NaOH is :

(a) 1.5 (b) 2.0
(c) 1.0 (d) 2.5

79. O_2, N_2 are present in the ratio of 1 : 4 by weight. The ratio of number of molecules is :

(a) 7 : 32 (b) 1 : 4
(c) 2 : 1 (d) 4 : 1

80. How many moles of $Al_2(SO_4)_3$ would be in 50 g of the substance ?

(a) 0.083 mole (b) 0.952 mole
(c) 0.481 mole (d) 0.140 mole

81. The mass of 1 mole of electrons is

(a) 9.1×10^{-28}g (b) 1.008 mg
(c) 0.55 mg (d) 9.1×10^{-27} g

82. 10 g of hydrogen and 64 g of oxygen were filled in a steel vessel and exploded. Amount of water produced in this reaction will be:

(a) 3 mol (b) 4 mol
(c) 1 mol (d) 2 mol

83. Which has the maximum number of molecules among the following ?

(a) 44 g CO_2 (b) 48 g O_3
(c) 8 g H_2 (d) 64 g SO_2

84. The weight of one molecule of a compound $C_{60}H_{122}$ is

(a) 1.2×10^{-20} gram (b) 1.4×10^{-21} gram
(c) 5.025×10^{23} gram (d) 6.023×10^{23} gram

85 The simplest formula of a compound containing 50% of element X (atomic mass 10) and 50% of element Y (atomic mass 20) is

(a) XY (b) XY_3
(c) X_2Y (d) X_2Y_3

86. Empirical formula of hydrocarbon containing 80% carbon and 20% hydrogen is :

(a) CH_3 (b) CH_4
(c) CH (d) CH_2

87. The empirical formula of a compound is CH_2. One mole of this compound has a mass of 42 grams. Its molecular formula is :

(a) C_3H_6 (b) C_3H_8
(c) CH_2 (d) C_2H_2

88. A compound contains 54.55 % carbon, 9.09% hydrogen , 36.36% oxygen. The empirical formula of this compound is

(a) C_3H_5O (b) $C_4H_8O_2$
(c) $C_2H_4O_2$ (d) C_2H_4O

89. In a hydrocarbon, mass ratio of hydrogen and carbon is 1:3, the empirical formula of hydrocarbon is

(a) CH_4 (b) CH_2
(c) C_2H (d) CH_3

90. An organic compound contains carbon, hydrogen and oxygen. Its elemental analysis gave C, 38.71% and H, 9.67%. The empirical formula of the compound would be :

(a) CH_3O (b) CH_2O
(c) CHO (d) CH_4O

91. A hydrocarbon is composed of 75% carbon. The empirical formula of the compound is

(a) CH_2 (b) CH_3
(c) C_2H_5 (d) CH_4

92. 12 gm of Mg (atomic mass 24) will react completely with hydrochloric acid to give

(a) One mol of H_2
(b) 1/2 mol of H_2
(c) 2/3 mol of O_2
(d) both 1/2 mol of H_2 and 1/2 mol of O_2

93. 20.0 kg of $N_{2(g)}$ and 3.0 kg of $H_{2(g)}$ are mixed to produce $NH_{3(g)}$. The amount of $NH_{3(g)}$ formed is

(a) 17 kg (b) 34 kg
(c) 20 kg (d) 3 kg

94. 20.0 kg of H_2(g) and 32 kg of O_2(g) are reacted to produce H_2O(l). The amount of H_2O (l) formed after completion of reaction is

(a) 62 kg (b) 38 kg
(c) 42 kg (d) 72 kg

95. What is the weight of oxygen required for the complete combustion of 2.8 kg of ethylene ?

(a) 2.8 kg (b) 6.4 kg
(c) 9.6 kg (d) 96 kg

96. In the reaction

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$$

When 1 mole of ammonia and 1 mole of O_2 are made to react to completion,

(a) 1.0 mole of H_2O is produced
(b) 1.0 mole of NO will be produced
(c) all the oxygen will be consumed
(d) all the ammonia will be consumed

97. What is the molarity of 0.2N Na_2CO_3 solution?

(a) 0.1 M (b) 0 M
(c) 0.4 M (d) 0.2 M

98. The molar solution of H_2SO_4 is equal to :

(a) N/2 solution (b) N solution
(c) 2N solution (d) 3N solution

99. Volume of water needed to mix with 10 mL 10N HNO_3 to get 0.1 N HNO_3 is :

(a) 1000 mL (b) 990 mL
(c) 1010 mL (d) 10 mL

100. One kilogram of a sea water sample contains 6 mg of dissolved O_2. The concentration of O_2 in the sample in ppm is

(a) 0.6 (b) 6.0
(c) 60.0 (d) 16.0

101. A 5 molar solution of H_2SO_4 is diluted from 1 litre to a volume of 10 litres, the normality of the solution will be :

(a) 1N (b) 0.1N
(c) 5N (d) 0.5N

102. With increase of temperature, which of these changes?

(a) Molality (b) Weight fraction of solute
(c) Molarity (d) Mole fraction

103. 6.02×10^{20} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is

(a) 0.02 M (b) 0.01 M
(c) 0.001 M (d) 0.1 M

(Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1})

104. Two solutions of a substance (non electrolyte) are mixed in the following manner. 480 ml of 1.5 M first solution + 520 ml of 1.2 M second solution. What is the molarity of the final mixture?

(a) 2.70 M (b) 1.344 M
(c) 1.50 M (d) 1.20 M

STATEMENT TYPE QUESTIONS

105. Which of the following statements are correct ?

(i) Both solids and liquids have definite volume.
(ii) Both liquids and gases do not have definite shape.
(iii) Both solids and gases take the shape of the container.

(a) (i) and (iii) (b) (ii) and (iii)
(c) (i) and (ii) (d) (i), (ii) and (iii)

106. Choose correct option based on following statements. Here T stands for true statement and F for false statement.

(i) Homogeneous mixture has uniform composition throughout.
(ii) All components of a heterogeneous mixture are observable to naked eyes.
(iii) All solutions are homogeneous in nature.
(iv) Air is an example of heterogeneous mixture.

(a) TTFF (b) TFTF
(c) FFTT (d) TFFF

107. Read the following and choose the incorrect statements.

(i) Both weight and mass are same quantities used for measurement of amount of matter present in a substance
(ii) Mass and weight of a substance vary from one place to another due to change in gravity.
(iii) SI unit of mass is kilogram and while SI unit of weight is gram.

(a) (i) and (iii) (b) (ii) and (iii)
(c) (i) and (ii) (d) All of these

108. Moon takes 27.3 days to complete one orbit around the Earth. Now read the following statements and choose the correct code. Here T is for true statement and F is for 'False statement'.

(i) Moon takes 655.2 hours to complete one orbit around the Earth.
(ii) Moon takes 39312 seconds to complete one orbit around the earth.
(iii) Moon takes 1638 minutes to complete one orbit around the Earth.

(a) F T F (b) T T T
(c) T F F (d) T F T

109. Give the correct order of initials T or F for following statements. Use T if statement is true and F if it is false.

(i) Gay-Lussac's law of gaseous volumes is actually the law of definite proportion by volume.

(ii) Law of conservation of mass is true for physical change, but not for chemical change.

(iii) The percentage of oxygen in H_2O_2 is different from that in H_2O. Hence, it violates law of definite proportions.

(iv) Fixed mass of A reacts with two different masses of B (say x and y), then the ratio of x/y can be any positive integer.

(v) At STP, 5 mL of N_2 and H_2 have different no. of molecules.

(a) TTFTF (b) FTTFT
(c) TFFTF (d) TFTTF

110. Consider the following statements.

(i) Atoms of H, O, N and C have identical properties but different mass.

(ii) Matter is divisible into atoms which are further indivisible.

(iii) The ratio of N: H in NH_3 is 1 : 3 and N : O in nitric oxide is 2 : 1.

(iv) Dalton's atomic theory support law of conservation of mass.

Which of the following pairs of statements is true according to Dalton's atomic theory ?

(a) (i) and (ii) (b) (ii) and (iii)
(c) (ii) and (iv) (d) (i) and (iv)

111. Choose the correct option based on following statements. Here 'T' stands for true and 'F' stands for false statement.

(i) Molecular mass of cane sugar ($C_{12}H_{22}O_{11}$) is 182 amu.

(ii) 1 mole of cane sugar contains 6.022×10^{23} molecules of cane sugar.

(iii) 34.20 g of cane sugar contains 6.022×10^{21} molecules of cane sugar.

(a) TTF (b) TFT
(c) FTF (d) FTT

MATCHING TYPE QUESTIONS

112. Match the items of Column I, II and III appropriately and choose the correct option from the codes given below.

Column I (Multiple)	Column II (Prefix)	Column III (Symbol)
(A) 10^{-15}	(p) Kilo	(i) m
(B) 10^{-3}	(q) yotta	(ii) f
(C) 10^{3}	(r) milli	(iii) k
(D) 10^{24}	(s) femto	(iv) Y

(a) A – (s), (ii); B – (r), (i); C – (p), (iii); D – (q), (iv)
(b) A – (p), (ii); B – (q), (iii); C – (r), (i); D – (s), (iv)
(c) A – (q), (iv); B – (p), (ii); C – (p), (i); D – (r), (iii)
(d) A – (r), (iii); B – (p), (ii); C – (s), (i); D – (q), (iv)

113. Match the columns

Column-I (Number)	Column-II (Significant figures)
(A) 29900.	(p) 2
(B) 290	(q) 1
(C) 1.23 × 1.331	(r) 4
(D) 20.00	(s) 3
(E) 2.783 – 1	(t) 5

(a) A – (r), B – (q), C – (t), D – (p), E – (s)
(b) A – (t), B – (p), C – (s), D – (r), E – (q)
(c) A – (p), B – (t), C – (s), D – (r), E – (q)
(d) A – (t), B – (s), C – (r), D – (q), E – (p)

114. Match the columns

Column-I (Laws of chemical combinations)	Column-II (Scientist)
(A) Law of definite proportions	(p) Antoine Lavoisier
(B) Law of multiple proportions	(q) Gay Lussac
(C) Law of conservation of mass	(r) Dalton
(D) Law of gaseous volumes	(s) Joseph Proust

(a) A – (s), B – (r), C – (p), D – (q)
(b) A – (p), B – (r), C – (s), D – (q)
(c) A – (r), B – (p), C – (s), D – (q)
(d) A – (q), B – (s), C – (r), D – (p)

115. Match the columns

Column-I	Column-II
(A) $C_6H_5NH_2$	(p) 84
(B) C_6H_6	(q) 100
(C) C_6H_{12}	(r) 93
(D) $CaCO_3$	(s) 78

(a) A – (p), B – (r), C – (q), D – (s)
(b) A – (r), B – (s), C – (p), D – (q)
(c) A – (r), B – (p), C – (q), D – (s)
(d) A – (r), B – (q), C – (s), D – (p)

116. Match the columns.

Column-I	Column-II
(A) 88 g of CO_2	(p) 0.25 mol
(B) 6.022×10^{23} molecules of H_2O	(q) 2 mol
(C) 5.6 litres of O_2 at STP	(r) 1 mol
(D) 96 g of O_2	(s) 6.022×10^{23} molecules
(E) 1 mol of any gas	(t) 3 mol

(a) A – (q), B – (r), C – (p), D – (t), E – (s)
(b) A – (r), B – (q), C – (p), D – (t), E – (s)
(c) A – (q), B – (p), C – (r), D – (t), E – (s)
(d) A – (q), B – (r), C – (p), D – (s), E – (t)

117. Match the mass of elements given in Column I with the number of moles given in Column II and mark the appropriate choice. Choose the correct codes formt he options given below.

	Column-I		**Column-II**
(A)	28 g of He	(p)	2 moles
(B)	46 g of Na	(q)	7 moles
(C)	60 g of Ca	(r)	1 mole
(D)	27 g of Al	(s)	1.5 mole

(a) A – (s), B – (r), C – (q), D – (p)
(b) A – (p), B – (r), C – (q), D – (s)
(c) A – (r), B – (q), C – (p), D – (s)
(d) A – (q), B – (p), C – (s), D – (r)

118. Match the columns.

	Column-I **(Physical quantity)**		**Column-II** **(Unit)**
(A)	Molarity	(p)	mol
(B)	Mole fraction	(q)	Unitless
(C)	Mole	(r)	mol L^{-1}
(D)	Molality	(s)	mol kg^{-1}

(a) A – (r), B – (q), C – (s), D – (p)
(b) A – (r), B – (p), C – (q), D – (s)
(c) A – (r), B – (q), C – (p), D – (s)
(d) A – (q), B – (r), C – (p), D – (s)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

119. Assertion : Significant figures for 0.200 is 3 whereas for 200 it is 1.

Reason : Zero at the end or right of a number are significant provided they are not on the right side of the decimal point.

120. Assertion : 1.231 has three significant figures.

Reason : All numbers right to the decimal point are significant.

121. Assertion : One atomic mass unit is defined as one twelfth of the mass of one carbon - 12 atom.

Reason : Carbon-12 isotope is the most abundunt isotope of carbon and has been chosen as standard.

122. Assertion : Volume of a gas is inversely proportional to the number of moles of gas.

Reason : The ratio by volume of gaseous reactants and products is in agreement with their mole ratio.

123. Assertion : Equal moles of different substances contain same number of constituent particles.

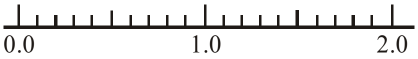
Reason : Equal weights of different substances contain the same number of constituent particles.

124. Assertion : The empirical mass of ethene is half of its molecular mass.

Reason : The empirical formula represents the simplest whole number ratio of various atoms present in a compound.

CRITICAL THINKING TYPE QUESTIONS

125. What are the significant figure(s) in a broken "ruler" show below?



(A) 1 (B) 2
(C) 3 (D) 0
(a) A, B and C (b) A, B, D
(c) A only (d) A and B

126. Which one of the following sets of compounds correctly illustrate the law of reciprocal proportions?
(a) P_2O_3, PH_3, H_2O (b) P_2O_5, PH_3, H_2O
(c) N_2O_5, NH_3, H_2O (d) N_2O, NH_3, H_2O

127. If we consider that 1/6, in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will
(a) decrease twice
(b) increase two fold
(c) remain unchanged
(d) be a function of the molecular mass of the substance

128. The maximum number of molecules are present in
(a) 15 L of H_2 gas at STP (b) 5 L of N_2 gas at STP
(c) 0.5 g of H_2 gas (d) 10 g of O_2 gas

129. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms?
(a) 1.25×10^{-2} (b) 2.5×10^{-2}
(c) 0.02 (d) 3.125×10^{-2}

130. Volume occupied by one molecule of water (density = 1 g cm^{-3}) is : **]**
(a) 9.0×10^{-23} cm^3 (b) 6.023×10^{-23} cm^3
(c) 3.0×10^{-23} cm^3 (d) 5.5×10^{-23} cm^3

131. The number of atoms in 0.1 mol of a triatomic gas is : ($N_A = 6.02 \times 10^{23}$ mol^{-1})
(a) 6.026×10^{22} (b) 1.806×10^{23}
(c) 3.600×10^{23} (d) 1.800×10^{22}

132. 1 c.c. N_2O at NTP contains :

(a) $\frac{1.8}{224} \times 10^{22}$ atoms

(b) $\frac{6.02}{22400} \times 10^{23}$ molecules

(c) $\frac{1.32}{224} \times 10^{23}$ electrons

(d) All of the above

133. How much time (in hours) would it take to distribute one Avogadro number of wheat grains if 10^{20} grains are distributed each second ?

(a) 0.1673 (b) 1.673
(c) 16.73 (d) 167.3

134. Arrange the following in the order of increasing mass (atomic mass: O = 16, Cu = 63, N = 14)

I. one atom of oxygen
II. one atom of nitrogen
III. 1×10^{-10} mole of oxygen
IV. 1×10^{-10} mole of copper

(a) II < I < III < IV (b) I < II < III < IV
(c) III < II < IV < I (d) IV < II < III < I

135. If 1.5 moles of oxygen combines with Al to form Al_2O_3, the mass of Al in g [Atomic mass of Al = 27] used in the reaction is

(a) 2.7 (b) 54
(c) 40.5 (d) 81

136. Which one of the following is the lightest?

(a) 0.2 mole of hydrogen gas
(b) 6.023×10^{22} molecules of nitrogen
(c) 0.1 g of silver
(d) 0.1 mole of oxygen gas

137. In a compound C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular weight of compound is 108. Molecular formula of compound is

(a) $C_2H_6N_2$ (b) C_3H_4N
(c) $C_6H_8N_2$ (d) $C_9H_{12}N_3$.

138. The empirical formula of an acid is CH_2O_2, the probable molecular formula of acid may be :

(a) $C_3H_6O_4$ (b) CH_2O
(c) CH_2O_2 (d) $C_2H_4O_2$

139. A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g. of CO_2. The empirical formula of the hydrocarbon is :

(a) C_2H_4 (b) C_3H_4
(c) C_6H_5 (d) C_7H_8

140. Which of the following is the correct empirical and molecular formulae of a compound, if the molecular mass of a compound is 80 and compound contains 60% of C, 5% of H and 35% of N ?

(a) C_2H_2N ; $C_4H_4N_2$ (b) $C_3H_4N_2$; $C_6H_8N_4$
(c) $C_2H_4N_2$; $C_4H_8N_4$ (d) C_2H_2N ; C_2H_2N

141. Which of the following is the correct empirical and molecular formulae of a compound, if the molecular mass of a compound is 93 and compound containing 77.43% of C, 7.53% of H and 15.05% of N ?

(a) $C_3H_{3.5}N_{1.5}$ and C_6H_7N
(b) C_6H_7N and C_6H_7N
(c) C_3H_3N and C_6H_7N
(d) C_3H_3N and $C_6H_6N_2$

142. Liquid benzene (C_6H_6) burns in oxygen according to the equation $2C_6H_6(l) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(g)$

How many litres of O_2 at STP are needed to complete the combustion of 39 g of liquid benzene?(Mol. wt. of O_2 = 32, C_6H_6 = 78)

(a) 74 L (b) 11.2 L
(c) 22.4 L (d) 84 L

143. Assuming fully decomposed, the volume of CO_2 released at STP on heating 9.85 g of $BaCO_3$ (Atomic mass, Ba = 137) will be

(a) 2.24 L (b) 4.96 L
(c) 1.12 L (d) 0.84 L

144. The mass of $BaCO_3$ produced when excess CO_2 is bubbled through a solution of 0.205 mol $Ba(OH)_2$ is :

(a) 81 g (b) 40.5 g
(c) 20.25 g (d) 162 g

145. For the reaction $Fe_2O_3 + 3CO_2 \rightarrow 2Fe + 3CO_2$, the volume of carbon monoxide required to reduce one mole of ferric oxide is

(a) 67.2 dm^3 (b) 11.2 dm^3
(c) 22.4 dm^3 (d) 44.8 dm^3

146. How many moles of lead (II) chloride will be formed from a reaction between 6.5 g of PbO and 3.2 g of HCl ?

(a) 0.044 (b) 0.333
(c) 0.011 (d) 0.029

147. Fat is an important source of energy and water, this is important for the desert animals like camel which store fat in its hump and provide water and energy. How many grams and moles of H_2O are produced from the combustion of fat $C_{57}H_{110}O_6$ from 450 gram of fat stored in hump of camel ?

$$C_{57}H_{110}O_6 + \frac{163}{2}O_2 \rightarrow 57CO_2 + 55H_2O$$

(a) 500.56 , 27.80 (b) 450, 26.80
(c) 580, 25.0 (d) 400, 26.6

148. Which of the following option represents correct limiting reagents in reactions (i), (ii) and (iii) respectively.

(i) $C + O_2 \rightarrow CO_2$
(26g) (20g)
(ii) $N_2 + 3H_2 \rightarrow 2NH_3$
(60g) (80g)
(iii) $P_4 + 3O_2 \rightarrow P_4O_6$
(100g) (200g)

(a) C, N_2, O_2
(b) C, N_2, P_4
(c) O_2, H_2, P_4
(d) O_2, N_2, P_4

149. 10 mL of 2(M) NaOH solution is added to 200 mL of 0.5 (M) of NaOH solution. What is the final concentration ?

(a) 0.57 (M)
(b) 5.7 (M)
(c) 11.4 (M)
(d) 1.14 (M)

150. If maximum fluoride ion presence was set to be 4 ppm number of moles of fluoride in 10 ml drinking water ?

(a) 2.10×10^{-3}
(b) 2.10×10^{-2}
(c) 3.10×10^{-3}
(d) 3.3×10^{-2}

151. The increasing order of molarity with 25 gm each of NaOH, LiOH, $Al(OH)_3$, KOH, $B(OH)_3$ in same volume of water?

(a) $Al(OH)_3 < B(OH)_3 < KOH < NaOH < LiOH$
(b) $LiOH < NaOH < KOH < B(OH)_3 < Al(OH)_3$
(c) $LiOH < NaOH < B(OH)_3 < KOH < Al(OH)_3$
(d) $NaOH < LiOH < B(OH)_3 < Al(OH)_3 < KOH$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** By sublimation since I_2 sublimes.

2. **(d)** It forms the basis of gravity separation.

3. **(d)** Candle is a heterogeneous mixture of wax and threads. Copper is an element while bottled water and table salt are compounds.

4. **(c)** Glucose is a pure substance hence its constituents cannot be separated by simple physical method.

5. **(a)** In case of B, none of O_2 and H_2 is a compound since compound consist of two or more different atoms.

6. **(c)**

7. **(d)** Silver is an element, water is a compound and air is a mixture.

8. **(c)** Attraction between particles in solid is maximum and hence their movement is minimum amongst the phases.

Attraction between particles in gases is minimum and hence their movements is maximum amongst the three phases.

Attraction between the particles and their movements in liquids is intermediate i.e., between solids and gases.

9. **(c)** A mixture may contain any number of components in any ratio.

e.g. air is a mixture of various gases.

10. **(d)** It is a solution and is a mixture of sucrose and water.

11. **(b)** One fermi is 10^{-13} cm.

12. **(c)** Exa = 10^{18}

13. **(d)** 1 zepto = 10^{-21}

14. **(a)** Joule is the unit of work and Pascal is unit of pressure.

$$\mathrm{JPa^{-1}} = \frac{\mathrm{J}}{\mathrm{Pa}} = \frac{\text{Work}}{\text{Pressure}} = \frac{\mathrm{Nm}}{\mathrm{Nm^{-2}}} = \mathrm{m^3}$$

15. **(a)** 1 m^3 of water 10^6 cm^3 of water

$\therefore$ Mass of 10^6 cm^3 water

$= 10^6\ \mathrm{cm^3} \times 1\ \mathrm{g\ cm^3}$ ($\because$ density of $H_2O = 1\ \mathrm{g\ cm^3}$)

$$= 10^6\ \mathrm{g} = \frac{10^6}{10^3}\ \mathrm{kg} = 10^3\ \mathrm{kg} = 1000\ \mathrm{kg}$$

(b) Weight of normal adult man = 65 kg

$\therefore$ Weight of 1 m^3 of water is highest.

(c) Density of Hg = 13.6 g cm^{-3}

Volume of Hg = 10 L = 10 × 1000 = 10^4 cm^3

$\therefore$ Weight of Hg = 13.6 × 10^4 = 136000 g = 136 kg

16. **(d)** Smallest and largest amount of energy respectively are eV and L-atm.

$$1\ \mathrm{eV} = 1.6 \times 10^{-19}\ \mathrm{J}$$
$$1\mathrm{L\text{-}atm} = 101.325\ \mathrm{J}$$

17. **(c)**

18. **(d)** Litre (L) is not an SI unit. It is used for measurement of volume of liquids.

19. **(c)** yocto = 10^{-24}

20. **(c)** $°\mathrm{C} = \frac{5}{9}(°\mathrm{F} - 32) = \frac{5}{9}(41 - 32) = 5°\mathrm{C}$

It will be cold.

21. **(a)** Out of two 3.929 g is more accurate and will be reported as 3.93 after rounding off.

22. **(b)**

23. **(a)** 0.00016 can be written as 1.6×10^{-4} in scientic notation.

24. **(d)** Both Y and X are neither precise nor accurate as the two values in each of them are not close. With respect to X & Y, the values of Z are close & agree with the true value. Hence, both precise & accurate.

25. **(c)** On calculation we find

$$\frac{(29.2 - 20.2)(1.79 \times 10^5)}{1.37} = 1.17 \times 10^6$$

As the least precise number contains 3 significant figures therefore, answers should also contains 3 significant figures.

26. **(d)** We know that all non-zero digits are significant and the zeros at the beginning of a number are not significant. Therefore number 161 cm, 0.161 cm and 0.0161cm have 3, 3 and 3 significant figures respectively.

27. **(b)** Given P = 0.0030m, Q = 2.40m & R = 3000m. In P(0.0030) initial zeros after the decimal point are not significant. Therefore, significant figures in P(0.0030) are 2. Similarly in Q (2.40) significant figures are 3 as in this case final zero is significant. In R = (3000) all the zeros are significant hence, in R significant figures are 4 because they come from a measurement.

28. **(a)**

29. **(c)** If zero is used to locate the decimal point it is considered as a significant figure. In 50.000 all zero are significant.

30. **(a)** Sum of the figures 29.4406, 3.2 and 2.25 is 34.8906. The sum should be reported to the first place of decimal as 3.2 has only one decimal place. After rounding off the sum is 34.9. Hence number of significant figures is three.

31. **(d)** 10.3106 g has 6 significant figures. Since all non-zero digits are significant and a zero becomes significant if it appears between two non-zero digits.

32. **(b)** $\frac{43.0 \times 0.0243}{0.340 \times 4} = 0.7683088$

The least precise term has two significant figures (leaving the exact number). Hence after rounding off correct answer is 0.77.

33. **(a)** 2.6 has two significant figures.

0.260 has three significant figures.

0.002600 has four significant figures.

2.6000 has five significant figures.

34. **(d)** $\frac{\text{Energy}}{\text{volume}}$ which can be shown

Pressure

$$= \frac{\text{Force}}{\text{area}} = \frac{\text{Work (energy/di stance)}}{\text{Area}} = \frac{\text{Energy}}{\text{Volume}}$$

35. **(b)** $\underset{ng}{X} + \underset{mg}{Y} \rightleftharpoons \underset{pg}{R} + \underset{qg}{S}$

$n + m = p + q$ by law of conservation of mass.

36. **(a)** $\underset{20\text{ g}}{CaCO_3} \rightarrow \underset{8.8\text{ g}}{CaO} + \underset{11.2\text{ g}}{CO_2}$

mass of reactant = mass of products = 20g.

Hence the law of conservation of mass is obeyed.

37. **(a)** **38.** **(a)**

39. **(b)** $\underset{4.2g}{NaHCO_3} + \underset{10.0g}{CH_3COOH} \longrightarrow \underset{12.0g}{\text{Residue}} + \underset{2.2g}{CO_2} \uparrow$

Mass of reactants = 4.2 + 10.0 = 14.2 g

Mass of products = 12.0 + 2.2 = 14.2 g

Hence, given reaction illustrate law of conservation of mass.

40. **(c)** I experiment : $\frac{\text{mass of } H_2 \text{ combined}}{\text{mass of } O_2 \text{ combined}} = \frac{4}{32} = \frac{1}{8}$

II experiment : $\frac{\text{mass of } H_2 \text{ combined}}{\text{mass of } O_2 \text{ combined}} = \frac{50}{400} = \frac{1}{8}$

Hence both law of conservation of mass and constant composition is obeyed.

41. **(c)** The H : O ratio in water is fixed, irrespective of its source. Hence it is law of constant composition.

42. **(a)** Constant proportions according to which a pure chemical compound always contains same elements combined together in the same definite proportion of weight.

43. **(c)**

44. **(d)** $SnCl_2$ $SnCl_4$

$119 : 2 \times 35.5$ $119 : 4 \times 35.5$

Chlorine ratio in both compounds is

$= 2 \times 35.5 : 4 \times 35.5 = 1 : 2$

45. **(d)** In CuO and Cu_2O the O : Cu is 1 : 1 and 1 : 2 respectively. This is law of multiple proportion.

46. **(c)**

47. **(b)** Law of multiple proportion. As the ratio of oxygen which combine with fix weights of 1 g of nitrogen bears a simple whole number ratio

0.57 : 1 : 12 : 1.7031 : 2 : 3

48. **(b)**

49. **(c)** According to Avogadro's law "equal volumes of all gases contain equal number of molecules under similar conditions of temperature and pressure". Thus if 1 L of one gas contains N molecules, 2 L of any other gas under the same conditions of temperature and pressure will contain 2N molecules.

50. **(b)** The number of molecules of N_2 and X are same. Hence they must have the same molecular weights.

∴ X is CO.

51. **(c)**

52. **(c)** In law of reciprocal proportions, the two elements combining with the third element, must combine with each other in the same ratio or multiple of that Ratio of S and O when combine with C is 2 : 1. Ratio of S and O is SO_2 is 1 : 1

53. **(d)** Avogadro's law is independent of the reactive or unreactive nature of the gases.

According to Avogadro's law equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

54. **(c)**

55. **(b)** 1 amu = $\frac{1}{12}$ of the mass of C-12.

56. **(b)** The modern atomic weight scale is based on C^{12}.

57. **(d)** Molecular weight of $ZnSO_4.7H_2O$

$= 65 + 32 + (4 \times 16) + 7(2 \times 1 + 16) = 287.$

∴ percentage mass of zinc (Zn)

$= \frac{65}{287} \times 100 = 22.65\%$

58. **(b)** Average atomic mass of neon

$= 20 \times 0.9051 + 21 \times 0.0027 + 22 \times 0.0922$

$= 20.187$ u

59. **(a)** $(78.9183361) \times (0.5069) + (80.916289) \times (0.4931)$

60. **(a)** Mass of oxygen atom is 15.995 amu, becasue 1 amu = 1.66056×10^{-24} g, hence 15.995 × value of 1 amu give the value equal to option (a).

61. **(d)** $\frac{2.824784 \times 10^{-23}}{1.66056 \times 10^{-24}} = 14$ amu

Where 1.66056×10^{-24} is equal to one atomic mass (amu)

62. **(b)** Gram molecular weight of CO = 12 + 16 = 28 g

6.023×10^{23} molecules of CO weight 28 g

1 molecule of CO weighs $= \frac{28}{6.02 \times 10^{23}} = 4.65 \times 10^{-23}$g

63. **(b)** Molecular weight of $SO_2 = 32 + 2 \times 16 = 64$

64 g of SO_2 occupies 22.4 litre at STP

240 g of SO_2 occupies $= \frac{22.4}{64} \times 240 = 84$ litre at STP

64. **(a)** 1 mol CCl_4 vapour $= 12 + 4 \times 35.5$

$= 154$ g ≡ 22.4 L at STP

∴ Density $= \frac{154}{22.4}\,gL^{-1} = 6.875\,gL^{-1}$

65. **(b)** 6.02×10^{23} molecules of CO = 1mole of CO

6.02×10^{24} CO molecules = 10 moles CO

= 10 g atoms of O = 5 g molecules of O_2

66. **(a)** $4.4\,g\,CO_2 = \frac{4.4}{44} = 0.1\,mol\,CO_2$ (mol. wt. of $CO_2 = 44$)
$= 6 \times 10^{22}$ molecules $= 2 \times 6 \times 10^{22}$ atoms of O.

67. **(b)** 2g of H_2 means one mole of H_2, hence contains 6.023×10^{23} molecules. Others have less than one mole, so have less no. of molecules.

68. **(a)** Fe (no. of moles) $= \frac{558.5}{55.85} = 10$ moles $= 10N_A$ atoms.
No. of moles in 60 g of C = 60/12 = 5 moles = $5N_A$ atoms.

69. **(c)** 16 g CH_4 is 1 mol. Hence number of molecules = Avogadro number = 6.023×10^{23}.

70. **(c)** M. Wt of $Na_2SO_4.10H_2O$ is 322 g which contains 224 g oxygen.
∴ 32.2 g will contain 22.4 g oxygen.

71. **(a)** 21% of 1 litre is 0.21 litre.
22.4 litres = 1 mole at STP

$$\therefore 0.21\ \text{litre} = \frac{0.21}{22.4} = 0.0093\ \text{mol}$$

72. **(d)** At S.T.P. 22.4 litre of gas contains 6.023×10^{23} molecules
∴ molecules in 8.96 litre of gas

$$= \frac{6.023 \times 10^{23} \times 8.96}{22.4} = 24.08 \times 10^{22}$$

73. **(b)** Mass of one molecule of Water

$$= \frac{18}{6.023 \times 10^{23}} = 3 \times 10^{-23}\,g = 3 \times 10^{-26}\,Kg$$

74. **(d)** 1 molecule of CO_2 has one atom of C and two atoms of oxygen.
∴ 1 mole of CO_2 has $= 6.02 \times 10^{23}$ atoms of C
$= 2 \times 6.02 \times 10^{23}$ atoms of O

75. **(a)** Given, $V = 1.12 \times 10^{-7}\,cm^3$
$22400\,cm^3$ at NTP $= 6.02 \times 10^{23}$ molecules

$$\therefore\ 1.12 \times 10^{-7}\,cm^3 \text{ at NTP} = \frac{6.02 \times 10^{23}}{22400} \times 1.12 \times 10^{-7}$$

$= 3.01 \times 10^{12}$ molecules.

76. **(b)** Total atoms in 1 molecule of $C_{12}H_{22}O_{11}$
$= 12 + 22 + 11 = 45$
∴ Total atoms in 1 mole of $C_{12}H_{22}O_{11}$
$= 45 \times 6.02 \times 10^{23}$ atoms/mol.

77. **(a)** 22.4 L of O_2 at STP = 32 g

$$\therefore\ 1\ \text{L of } O_2 \text{ at STP} = \frac{32}{22.4} \times 1 = 1.428\,g = 1.43\,g$$

78. **(c)** Given $V = 2$ L, Molarity = 0.5M, Moles = ?

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{V \text{ of solution in L}} \text{ or } 0.5 = \frac{\text{Moles}}{2}$$

∴ Moles = 2 × 0.5 = 1.0

79. **(a)** Let mass of O_2 = 1 g
∴ Mass of N_2 = 4g

No. of molecules of $O_2 = \frac{1}{32}$

No. of molecules of $N_2 = \frac{4}{28}$

$$\text{Ratio of no. of molecules} = \frac{1}{32} : \frac{4}{28} = \frac{1}{32} : \frac{1}{7} = 7 : 32$$

80. **(d)** $$\text{No. of moles} = \frac{\text{weight}}{\text{mol. wt.}} = \frac{50}{342} = 0.14\ \text{mole}$$

81. **(c)** Mass of 1 electron $= 9.11 \times 10^{-28}$ g
∴ Mass of 1 mole (6.02×10^{23}) electrons
$= 9.11 \times 10^{-28} \times 6.02 \times 10^{23}$g
$= 55 \times 10^{-5}$ g $= 55 \times 10^{-5} \times 10^{3}$ mg = 0.55 mg.

82. **(b)**

$$\underset{\substack{10g \\ \left(\frac{10}{2}=5\text{ mol}\right)}}{H_2} + \underset{\substack{64g \\ \left(\frac{64}{32}=2\text{ mol}\right)}}{\frac{1}{2}O_2} \longrightarrow H_2O$$

In this reaction oxygen is the limiting agent. Hence amount of H_2O produced depends on the amount of O_2 taken
∵ 0.5 mole of O_2 gives H_2O = 1 mol
∴ 2 mole of O_2 gives H_2O = 4 mol

83. **(c)**

	No. of molecules
Moles of $CO_2 = \frac{44}{44} = 1$	N_A
Moles of $O_3 = \frac{48}{48} = 1$	N_A
Moles of $H_2 = \frac{8}{2} = 4$	$4N_A$
Moles of $SO_2 = \frac{64}{64} = 1$	N_A

84. **(b)** Molecular weight of $C_{60}H_{122} = (12 \times 60) + 122 = 842$.
Therefore weight of one molecule

$$= \frac{\text{Molecular weight of } C_{60}H_{122}}{\text{Avagadro's number}}$$

$$= \frac{842}{6.023 \times 10^{23}} = 1.4 \times 10^{-21}\,g$$

85. **(c)** 50% of X (Atomic mass 10), 50% of Y (Atomic mass 20).
Relative number of atoms of X $= \frac{50}{10} = 5$ and than
$Y = \frac{50}{20} = 2.5$
Simple Ratio 2 : 1. Formula X_2Y

86. **(a)**

Element	**%**	**Atomic mass**	**Relative no.of atoms**	**Simple ratio of atoms**
C	80	12	$\frac{80}{12} = 6.66$	$\frac{6.66}{6.66} = 1$
H	20	1	$\frac{20}{1} = 20.0$	$\frac{20.0}{6.66} = 3$

∴ Empirical formula is CH_3

87. **(a)** Empirical formula of compound = CH_2
Molecular mass of the compound = 42
$\therefore n = 42/14 = 3$
$\therefore$ Hence molecular formula = C_3H_6

88. **(d)**

C	54.55	54.55/12 = 4.5	4.5/2.27 = 2
H	9.09	9.09/1 = 9.09	9.09/2.27 = 4
O	36.36	36.36/16 = 2.27	2.27/2.27 = 1

Hence empirical formula of the compound = C_2H_4O

89. **(a)** Mass ratio of H : C = 1 : 12
However, given mass ratio of H : C = 1 : 3
Therefore, for every C atom, there are 4 H atoms, hence empirical formula = CH_4

90. **(a)**

Element	Percentage	Atomic weight	Atomic ratio	Simple ratio
C	38.71	12	$\frac{38.71}{12} = 3.23$	$\frac{3.23}{3.23} = 1$
H	9.67	1	$\frac{9.67}{1} = 9.67$	$\frac{9.67}{3.23} = 3$
O	100 – (38.71 + 9.67) = 51.62	16	$\frac{51.62}{16} = 3.23$	$\frac{3.23}{3.23} = 1$

Thus empirical formula is CH_3O.

91. **(d)**

Element	%	At. Mass	Rel.No. of Atoms	Simple Ratio
C	75	12	75/12 = 6.25	1
H	25	1	25/1 = 25	4

$\therefore$ Empirical formula is CH_4.

92. **(b)**

$$\begin{array}{lll} Mg & +2HCl \rightarrow MgCl_2 & +H_2\uparrow \\ 1\text{ mole} & & 1\text{ mole} \\ \frac{1}{2}\text{ mole} & & \frac{1}{2}\text{mole (12g of Mg} = \frac{1}{2}\text{mol)} \end{array}$$

93. **(a)** We know that

$$\begin{array}{lll} N_2 & + \ 3H_2 \rightarrow & 2NH_3 \\ 28\text{ g} & 6\text{ g} & 34\text{ g} \\ 14\text{ g} & 3\text{ g} & 17\text{ g} \end{array}$$

Here given H_2 is 3 kg and N_2 is 20 kg but 3 kg of H_2 can only react with 14 g of N_2 and thus the obtained NH_3 will be of 17 kg.

94. **(d)**

$$\begin{array}{lll} 2H_2 & + \ O_2 \longrightarrow & 2H_2O \\ 4g & 32g & 36g \\ 4kg & 32\text{ kg} & 36kg \end{array}$$

95. **(c)** $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$
28 g   96 g
$\because$ 28 g of C_2H_4 undergo complete combustion by = 96 g of O_2
$\therefore$ 2.8 kg of C_2H_4 undergo complete combustion by = 9.6 kg of O_2.

96. **(c)** According to stoichiometry they should react as follow

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

4 mole of NH_3 requires 5 mole of O_2.

1 mole of NH_3 requires = $\frac{5}{4}$ = 1.25 mole of O_2.

Hence O_2 is consumed completely.

97. **(a)** $$\text{Molarity} = \text{Normality} \times \frac{\text{Equivalent mass}}{\text{Molecular mass}}$$

$$= 0.2 \times \frac{M}{2 \times M} = 0.1\text{ M}$$

98. **(a)** $$\text{Molarity} = \frac{\text{Normality}}{\text{Replaceable hydrogen atom}}$$

$\because$ H_2SO_4 is dibasic acid.
$\therefore$ Molar solution of H_2SO_4 = N/2 H_2SO_4

99. **(b)** Given $N_1 = 10N$, $V_1 = 10$ ml, $N_2 = 0.1N$, $V_2 = ?$

$$N_1V_1 = N_2V_2$$

or $10 \times 10 = 0.1 \times V_2$

or $V_2 = \frac{10 \times 10}{0.1}$, $V_2 = 1000$ ml

Volume of water to be added

$= V_2 - V_1 = 1000 - 10 = 990$ ml.

100. **(b)** $$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

$$\therefore \text{ppm} = \frac{6 \times 10^{-3}}{1000} \times 10^6 = 6.$$

101. **(a)** 5 M H_2SO_4 = 10 N H_2SO_4,
($\because$ Basicity of $H_2SO_4 = 2$)
$N_1V_1 = N_2V_2$,
$10 \times 1 = N_2 \times 10$ or $N_2 = 1$ N

102. **(c)** Among all the given options molarity is correct because the term molarity involve volume which increases on increasing temperature.

103. **(b)** Moles of urea present in 100 ml of sol. = $\frac{6.02 \times 10^{20}}{6.02 \times 10^{23}}$

$$\therefore M = \frac{6.02 \times 10^{20} \times 1000}{6.02 \times 10^{23} \times 100} = 0.01M$$

[$\because$ M = Moles of solute present in 1L of solution]

104. **(b)** From the molarity equation.
$M_1V_1 + M_2V_2 = MV$
Let M be the molarity of final mixture,

$$M = \frac{M_1V_1 + M_2V_2}{V} \quad \text{where } V = V_1 + V_2$$

$$M = \frac{480 \times 1.5 + 520 \times 1.2}{480 + 520} = 1.344\text{ M}$$

STATEMENT TYPE QUESTIONS

105. **(c)** Both solids and liquids have definite volume, but gases do not.
Solids have their own shape, but liquids and gases takes the shape of the container in which they are put in.

106. (b) For statement (ii), it is not necessary that all components of a heterogeneous mixture are observable to naked eyes for example blood is a heterogeneous mixture whose components are not visible to naked eyes. For statement (iv) air is a homogeneous mixture of various gases.

107. (d) Mass of a substance is the amount of matter present in it while weight is the force exerted by gravity on an object.

Mass is constant while weight may vary from one place to another due to gravity.

SI unit of both mass and weight is kilogram.

108. (c) 27.3 days = 27.3 × 24 hours

= 655.2 hours

27.3 days = 27.3 × 24 × 60 minutes

= 39312 minutes

27.3 days = 27.3 × 24 × 60 × 60 seconds

= 2358720 seconds

109. (c) For statement (i), T = The other name of Gay-Lussac's law is law of definite proportions by volume.

For statement (ii), F = Law of conservation of mass is valid for both physical and chemical change.

For statement (iii), F = Law of definite proportion is valid for each compound individually and not for comparing two different compounds.

For statement (iv), T = x/y must be a simple whole number ratio and must be a positive integer.

For statement (v), F = Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.

110. (c) For statement (i) : H, O, C, N = All have different chemical properties.

For statement (ii) : It is true as per Dalton's postulate.

For statement (iii) : N : O = 1 : 1 (NO)

For statement (iv) : Dalton's postulates says, atoms can neither be created nor destroyed.

111. (c) Molecular mass of cane sugar ($C_{12}H_{22}O_{11}$)

$= 12 \times 12 + 22 \times 1 + 11 \times 16$

= 342 amu

1 mole of cane sugar ($C_{12}H_{22}O_{11}$) = 342 g

(Molecular mass of cane sugar = 342 g)

342 g of cane sugar contain = 6.022×10^{23} molecules

34.20 g of cane sugar contain = $\frac{6.022 \times 10^{23}}{342} \times 34.20$

= 6.022×10^{22} molecules.

MATCHING TYPE QUESTIONS

112. (a)

113. (b) Terminal zeros are not significant if there is no decimal i.e., 290 contains two significant figures whereas in 29900. there are 5 significant figures; 1.23 × 1.331 = 1.63713 but keeping the mind the 1.23 has only few significant figures i.e., only three significant figures, so result should also be reported in three significant figures only. Thus 1.6373 should be rounded off to 1.64. Value 1.783 is rounded off to 2, so has only one significant figure.

114. (a) **115. (b)** **116. (a)**

117. (d) $A : 28 \text{ g of He} = \frac{28}{4} = 7 \text{ mol}$

$B : 46 \text{ g of Na} = \frac{46}{23} = 2 \text{ mol}$

$C : 60 \text{ g of Ca} = \frac{60}{40} = 1.5 \text{ mol}$

$D : 27 \text{ g of Al} = \frac{27}{27} = 1 \text{ mol}$

118. (c)

ASSERTION- REASON TYPE QUESTIONS

119. (c)

120. (d) 1.231 has four significant figures all no. from left to right are counted, starting with the first digit that is not zero for calculating the no. of significant figure.

121. (b)

122. (d) We know that from the reaction $H_2 + Cl_2 \rightarrow 2HCl$ that the ratio of the volume of gaseous reactants and products is in agreement with their molar ratio.The ratio of $H_2 : Cl_2 : HCl$ volume is 1: 1: 2 which is the same as their molar ratio. Thus volume of gas is directly related to the number of moles. Therefore, the assertion is false but reason is true.

123. (c) Equal moles of different substances contain same number of constituent particles but equal weights of different substances do not contain the same number of consituent particles.

124. (a)

CRITICAL THINKING TYPE QUESTIONS

125. (b) For, 0.0 significant figure is zero. For 0.1 to 0.9 significant figure will be 1 whereas from 1.0 to 2.0 significant figures will be 2.

126. (a) In law of reciprocal proportions, the two elements combining with the third element, must combine with each other in the same ratio or multiple of that ratio. P_2O_3, PH_3 and H_2O correctly illustrate the law of reciprocal proportions. Ratio in the number of atoms of hydrogen and oxygen combining with one P is 3 : 1.5 i.e., 2 : 1.

127. (a) Relative atomic mass

$$= \frac{\text{Mass of one atom of the element}}{1/12^{\text{th}} \text{ part of the mass of one atom of Carbon} - 12}$$

$$\text{or } \frac{\text{Mass of one atom of the element}}{\text{mass of one atom of the C} - 12} \times 12$$

Now if we use $^1/_6$ in place of $^1/_{12}$ the formula becomes

$$\text{Relative atomic mass} = \frac{\text{Mass of one atom of element}}{\text{Mass of one atom of carbon}} \times 6$$

$\therefore$ Relative atomic mass decrease twice

128. (a) No. of molecules in different cases

(a) $\because$ 22.4 litre at STP contains

$= 6.023 \times 10^{23}$ molecules of H_2

$\therefore$ 15 litre at STP contains $= \frac{15}{22.4} \times 6.023 \times 10^{23}$

$= 4.03 \times 10^{23}$ molecules of H_2

(b) $\because$ 22.4 litre at STP contains

$= 6.023 \times 10^{23}$ molecules of N_2

$\because$ 5 litre at STP contains $= \frac{5}{22.4} \times 6.023 \times 10^{23}$

$= 1.344 \times 10^{23}$ molecules of N_2

(c) $\because$ 2 gm of $H_2 = 6.023 \times 10^{23}$ molecules of H_2

$\because$ 0.5 gm of $H_2 = \frac{0.5}{2} \times 6.023 \times 10^{23}$

$= 1.505 \times 10^{23}$ molecules of H_2

(d) Similarly 10 g of O_2 gas

$= \frac{10}{32} \times 6.023 \times 10^{23}$ molecules of O_2

$= 1.88 \times 10^{23}$ molecules of O_2

Thus (a) will have maximum number of molecules

129. (d) 1 Mole of $Mg_3(PO_4)_2$ contains 8 mole of oxygen atoms

$\therefore$ 8 mole of oxygen atoms $\equiv$ 1 mole of $Mg_3(PO_4)_2$

0.25 mole of oxygen atom $\equiv \frac{1}{8} \times 0.25$ mole of $Mg_3(PO_4)_2$

$= 3.125 \times 10^{-2}$ mole of $Mg_3(PO_4)_2$

130. (c) $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$

$1 \text{ gram cm}^{-3} = \frac{1 \text{gram}}{\text{cm}^3}$

$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{1 \text{gram}}{1 \text{gram cm}^{-3}} = 1 \text{cm}^3$

$\therefore$ Volume occupied by 1 gram water = 1 cm^3

or Volume occupied by

$\frac{6.023 \times 10^{23}}{18}$ molecules of water = 1 cm^3

[$\therefore$ 1g water $= \frac{1}{18}$ moles of water]

Thus volume occupied by 1 molecule of water

$= \frac{1 \times 18}{6.023 \times 10^{23}} \text{cm}^3 = 3.0 \times 10^{-23} \text{ cm}^3$.

131. (b) The number of atoms in 0.1 mole of a triatomic gas

$= 0.1 \times 3 \times 6.023 \times 10^{23.}$

$= 1.806 \times 10^{23}$

132. (d) At NTP 22400 cc of $N_2O = 6.02 \times 10^{23}$ molecules

$\therefore$ 1 cc $N_2O = \frac{6.02 \times 10^{23}}{22400}$ molecules

$= \frac{3 \times 6.02 \times 10^{23}}{22400}$ atoms $= \frac{1.8}{224} \times 10^{22}$ atoms

No. of electrons in a molecule of $N_2O = 7 + 7 + 8 = 22$

Hence no. of electrons

$= \frac{6.02 \times 10^{23}}{22400} \times 22$ electrons $= \frac{1.32 \times 10^{23}}{224}$

133. (b) If 10^{20} grains are distributed in one sec, 6.023×10^{23} grains will be distributed in

$\frac{6.023 \times 10^{23} \times 1}{10^{20} \times 60 \times 60} = 1.673$ hrs

134. (a) Mass of 6.023×10^{23} atoms of oxygen = 16 g

Mass of one atom of oxygen

$= \frac{16}{6.023 \times 10^{23}} = 2.66 \times 10^{-23}$ g

Mass of 6.023×10^{23} atoms of nitrogen = 14 g

Mass of one atom of nitrogen

$= \frac{14}{6.023 \times 10^{23}} = 2.32 \times 10^{-23}$ g

Mass of 1×10^{-10} mole of oxygen $= 16 \times 10^{-10}$

Mass of 1 mole of copper = 63 g

Mass of 1 mole of oxygen = 16 g

Mass of 1×10^{-10} mole of copper $= 63 \times 1 \times 10^{-10}$

$= 63 \times 10^{-10}$

So, the order of increasing mass is II < I < III < IV.

135. (b) The equation for the formation of Al_2O_3 can be represented as

$$\underset{\text{2 moles}}{2Al} + \underset{\text{1.5 moles}}{3/2O_2} \longrightarrow \underset{\text{1 mole}}{Al_2O_3}$$

Thus, 1 mole of alumina is obtained by the reaction of 1.5 moles of oxygen and 2 moles of aluminium. Thus, the amount of aluminium

$= 2 \times 27$ g = 54 g. [mol. mass of Al = 27]

136. (c) (a) Weight of H_2 = mole × molecular wt.

$= 0.2 \times 2 = 0.4$ g

(b) $6.023 \times 10^{23} = 1$ mole

Thus $6.023 \times 10^{22} = 0.1$ mole

Weight of $N_2 = 0.1 \times 28 = 2.8$ g

(c) Weight of silver = 0.1 g

(d) Weight of oxygen $= 32 \times 0.1 = 3.2$ g

137. (c)

	Percentage	R.N.A	Simplest ratio
C	9	$\frac{9}{12}=\frac{3}{4}$	3
H	1	$\frac{1}{1}=1$	4
N	3.5	$\frac{3.5}{14}=\frac{1}{4}$	1

Empirical formula $= C_3H_4N$

$(C_3H_4N)_n = 108$

$(12\times 3+4\times 1+14)_n = 108$

$(54)_n = 108$

$$n=\frac{108}{54}=2$$

$\therefore$ molecular formula $= C_6\,H_8N_2$

138. (c) The acid with empirical formula CH_2O_2 is formic acid, H—COOH.

139. (d) $\because$ 18 gm, H_2O contains = 2 gm H

$$\therefore\ 0.72\text{ gm }H_2O\text{ contains}=\frac{2}{18}\times 0.72\text{ gm}=0.08\text{ gm H}$$

$\because$ 44 gm CO_2 contains = 12 gm C

$$\therefore\ 3.08\text{ gm }CO_2\text{ contains}=\frac{12}{44}\times 3.08=0.84\text{ gm C}$$

$$\therefore\ C:H=\frac{0.84}{12}:\frac{0.08}{1}=0.07:0.08=7:8$$

$\therefore$ Empirical formula $= C_7H_8$

140. (a) Let 100 g of compound be there.

$$\text{Number of moles of Nitrogen}=\frac{35}{14}=2.5$$

$$\text{Number of moles of Hydrogen}=\frac{5}{1.008}=4.9$$

$$\text{Number of moles of Carbon}=\frac{60}{12.01}=4.9$$

Since 2.5 is the smallest value division by it give ratio

N : H : C

1 : 1.96 : 1.96

= 1 : 2 : 2

Empirical formula $= C_2H_2N$

Empirical formula weight = 2 × 12 + 2 + 14 = 40

Molecular mass = 80

Molecular formulae = $n\ (C_2H_2N)$

$$= 2\ (C_2H_2N)\left(n=\frac{80}{40}\right) = C_4H_4N_2$$

141. (b) Let 100 g of compound be there.

$$\text{Number of moles of C}=\frac{77.43\text{g}}{12.01\text{g / mol}}=6.44$$

$$\text{Number of moles of H}=\frac{7.53\text{g}}{1.008\text{g / mol}}=7.47$$

$$\text{Number of moles of N}=\frac{15.05}{14.00\text{g / mol}}=1.075$$

1.074 is the smallest value, division by it gives a ratio of C : H : N

= 5.9 : 6.9 : 1

= 6 : 7 : 1

Empirical formula $= C_6H_7N$

Empirical formula weight = 6 × 12 + 7 + 14 = 93

$$n=\frac{\text{Molecular mass}}{\text{Empirial formula weight}}=1$$

Molecular formula = 1 × C_6H_7N = C_6H_7N

142. (d)
$$\underset{2(78)}{2C_6H_6}+\underset{15(32)}{15O_2(g)}\rightarrow 12\,CO_2(g)+6\,H_2O(g)$$

$\because$ 156 gm of benzene required oxygen = 15 × 22.4 litre

$$\therefore 1\text{ gm of benzene required oxygen }=\frac{15\times 22.4}{156}\text{litre}$$

$\therefore$ 39 gm of Benzene required oxygen

$$=\frac{15\times 22.4\times 39}{156}=84.0\text{ litre}$$

143. (c)
$$\underset{197\text{ gm}}{BaCO_3}\rightarrow BaO+CO_2$$

$\because$ 197 gm of $BaCO_3$ released carbon dioxide = 22.4 litre at STP

$$\therefore\ 1\text{ gm of }BaCO_3\text{ released carbon dioxide}=\frac{22.4}{197}\text{ litre}$$

$\therefore$ 9.85 gm of $BaCO_3$ released carbon dioxide

$$=\frac{22.4}{197}\times 9.85=1.12\text{ litre}$$

144. (b)
$$\underset{n\text{ mol}}{Ba(OH)_2}+CO_2\longrightarrow\underset{n\text{ mol}}{BaCO_3}+H_2O$$

n mol $Ba(OH)_2 = n$ mol $BaCO_3$

$$\therefore\ 0.205\text{ mol }Ba(OH)_2\equiv 0.205\text{ mol }BaCO_3$$

Wt. of substance = No. of moles × Molecular mass

$= 0.205 \times 197.3 = 40.5$ g

145. (a)
$$\underset{\substack{1\text{ vol.}\\1\text{ mol.}}}{Fe_2O_3}\quad+\quad\underset{\substack{3\text{ vol.}\\3\text{ mol.}}}{3CO}\quad\rightarrow\quad\underset{\substack{2\text{ vol.}\\2\text{ mol.}}}{2Fe}\quad+\quad\underset{\substack{3\text{ vol.}\\3\text{ mol.}}}{3CO_2}$$

($\because$ vol% = mol%)

One gram mol of any gas occupies 22.4 litre at NTP. 1 mol of Fe_2O_3 requires 3 mol of CO for its reduction i.e., 1 mol of Fe_2O_3 requires 3 × 22.4 litre or 67.2 dm^3 CO to get itself reduced.

146. (d) Writing the equation for the reaction, we get

$$\underset{\substack{207\,+\,16\\=\,223\text{ g}}}{PbO}\quad+\quad\underset{\substack{2\,\times\,36.5\\=\,73\text{g}}}{2HCl}\longrightarrow\underset{\substack{207\,+\,71\\=\,278\text{g}}}{PbCl_2}\quad+\quad H_2O$$

$$\text{No. of moles of PbO }=\frac{6.5}{223}=0.029$$

$$\text{No. of moles of HCl }=\frac{3.2}{36.5}=0.0877$$

Thus PbO is the limiting reactant 1 mole of PbO produce 1 mole $PbCl_2$.

0.029 mole PbO produces 0.029 mole $PbCl_2$.

147. (a) $C_{57}H_{110}O_6 + \frac{163}{2}O_2 \rightarrow 57CO_2 + 55H_2O$

890 gram of fat produces 990 gram of H_2O

450 gram fat produces $\left(\frac{990}{890}\times 450\right)$

= 500.56 g of H_2O

Moles of $H_2O = \frac{500.56\text{g}}{18\text{g/mol}} = 27.80$

148. (d) $n_C = \frac{26\text{g}}{12\text{ g/mol}} = 2.16$

$n_{O_2} = \frac{20\text{g}}{32\text{ g/mol}} = 0.625$

O_2 will be a limiting reagent in reaction (i)

$n_{N_2} = \frac{60\text{g}}{28\text{g/mol}} = 2.14$

$n_{H_2} = 40$

According to balanced equation,
1 mol of N_2 requires 3 mole of N_2
2.14 mol of N_2 require 6.42 mol of N_2
N_2 will be a limiting reagent in reaction (ii)

$n_{P_4} = \frac{100\text{g}}{4\times 31} = 0.86 \qquad n_{O_2} = 6.25$

According to balanced equation
1 mol of P_4 require 3 mol of O_2
0.86 mol of P_4 require 2.58 mol of O_2
So P_4 is a limiting reagent in reaction (iii)

149. (a) From molarity equation
$M_1V_1 + M_2V_2 = MV_{(\text{total})}$

$$2\times\frac{10}{1000} + 0.5\times\frac{200}{1000} = M\times\frac{210}{1000}$$

$120 = M\times 210$

$M = \frac{120}{210} = 0.57\text{ M}$

150. (a) 1 ppm = 1 mg / 1 litre (for liquids)
4 ppm = 4 mg / 1 litre
1 litre contains 4 mg of fluoride ions

10 ml contains $\frac{4}{1000}\times 10 = 0.04$ mg

Number of moles of fluoride = $\frac{0.04\text{g}}{19\text{g / mol}}$

$= 2.10 \times 10^{-3}$

151. (a) Molarity (M) $= \frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$

Molarity $\propto n_{\text{solute}}$

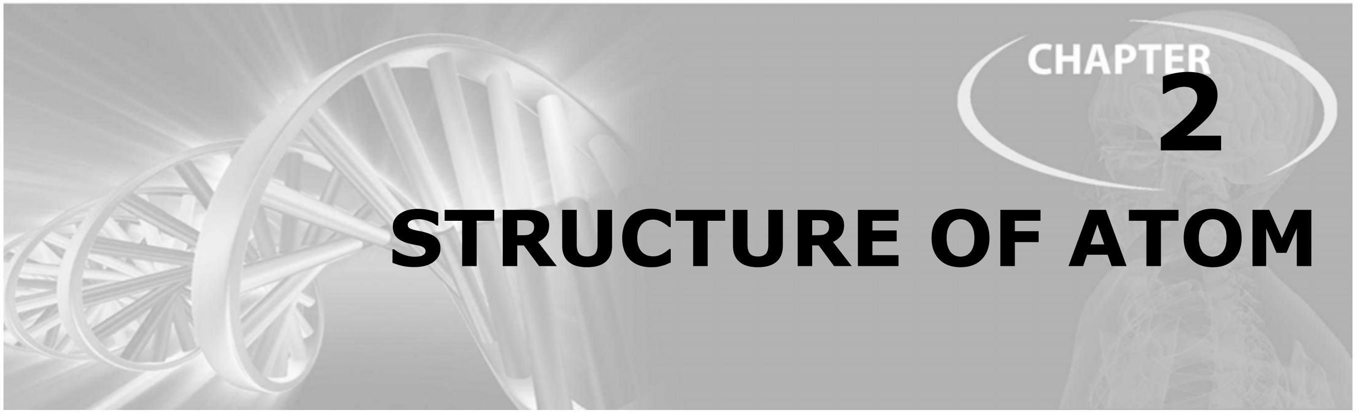
$n_{\text{NaOH}} = \frac{25}{40} = 0.625$

$n_{\text{LiOH}} = \frac{25}{24} = 1.04$

$n_{\text{Al(OH)}_3} = \frac{25}{(17+3\times 17)} = 0.32$

$n_{\text{KOH}} = \frac{25}{(39+17)} = 0.45$

$n_{\text{B(OH)}_3} = \frac{25}{(11+17\times 3)} = 0.403$



CHAPTER 2

STRUCTURE OF ATOM

FACT/DEFINITION TYPE QUESTIONS

1. Which of the scientist were able to prove that atom is no longer non-divisible?

(a) Dalton (b) Michael Faraday
(c) Thomson (d) Chadwick

2. Which of the following is never true for cathode rays ?

(a) They possess kinetic energy.
(b) They are electromagnetic waves.
(c) They produce heat.
(d) They produce mechanical pressure.

3. Cathode rays are deflected by

(a) an electric field only (b) magnetic field only
(c) by both (d) by none

4. Which of the following statement is not correct about the characteristics of cathode rays?

(a) They start from the cathode and move towards the anode.
(b) They travel in straight line in the absence of an external electrical or magnetic field.
(c) Characteristics of cathode rays do not depend upon the material of electrodes in cathode ray tube.
(d) Characteristics of cathode rays depend upon the nature of gas present in the cathode ray tube.

5. Which of the following statements about the electron is incorrect?

(a) It is negatively charged particle
(b) The mass of electron is equal to the mass of neutron.
(c) It is a basic constituent of all atoms.
(d) It is a constituent of cathode rays.

6. While performing cathode ray experiments, it was observed that there was no passage of electric current under normal conditions. Which of the following can account for this observation ?

(a) Dust particles are present in air
(b) Carbon dioxide is present in air
(c) Air is a poor conductor of electricity under normal conditions
(d) None of the above

7. Which is not true with respect to cathode rays?

(a) A stream of electrons
(b) Charged particles
(c) Move with speed same as that of light
(d) Can be deflected by magnetic fields

8. What is the optimum conditions required to study the conduction of electricity through gases.

(a) High pressure and low voltage
(b) High pressure and high voltage
(c) Low pressure and high voltage
(d) Low pressure and low voltage

9. In discharge tube experiment stream of negatively charged particles travel from

(a) anode to cathode (b) cathode to anode
(c) Both (a) and (b) (d) Electrons does not travel

10. Millikan performed an experiment method to determine which of the following ?

(a) Mass of the electron (b) Charge of the electron
(c) e/m ratio of electron (d) Both (a) and (b)

11. The discovery of neutron became very late because :

(a) neutrons are present in nucleus
(b) neutrons are chargeless
(c) neutrons are fundamental particles
(d) all of the above

12. Which is correct statement about proton ?

(a) Proton is nucleus of deuterium
(b) Proton is α-particle
(c) Proton is ionized hydrogen molecule
(d) Proton is ionized hydrogen atom

13. The lightest particle is :

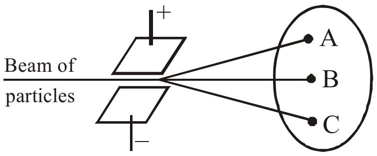
(a) α-particle (b) positron
(c) proton (d) neutron

14. When beryllium is bombarded with alpha particles (Chadwick's experiment) extremely penetrating radiations, which cannot be deflected by electrical or magnetic field are given out. These are :

(a) A beam of protons
(b) Alpha rays
(c) A beam of neutrons
(d) A beam of neutrons and protons

15. Neutron is discovered by
(a) Chadwick (b) Rutherford
(c) Yukawa (d) Dalton

16. Suppose beam containing all three fundamental subatomic particles are allowed to pass through an electric field as shown in figure. The subatomic particles detected at three points A, B and C on the screen respectively are ?



(a) Protons, neutrons, electrons
(b) Electrons, neutrons, protons
(c) Electrons, protons, neutrons
(d) Neutrons, protons, electrons

17. Which of the following properties of atom could be explained correctly by Thomson Model of atom?
(a) Overall neutrality of atom.
(b) Spectra of hydrogen atom.
(c) Position of electrons, protons and neutrons in atom.
(d) Stability of atom.

18. Arrange the following in terms of penetrating power.
α-rays, β-rays, γ-rays
(a) $\alpha > \beta > \gamma$ (b) $\alpha < \beta < \gamma$
(c) $\alpha > \beta < \gamma$ (b) $\alpha > \gamma > \beta$

19. Which of the rays are not deflected by the electric and magnetic field ?
(a) γ-rays (b) X-rays
(c) β-rays (d) Both (a) and (b)

20. Rutherford's experiment on the scattering of α -particles showed for the first time that the atom has :
(a) electrons (b) protons
(c) nucleus (d) neutrons'

21. When atoms are bombarded with alpha particles, only, a few in million suffer deflection, others pass out undeflected. This is because
(a) the force of repulsion on the moving alpha particle is small
(b) the force of attraction between alpha particle and oppositely charged electrons is very small
(c) there is only one nucleus and large number of electrons
(d) the nucleus occupies much smaller volume compared to the volume of the atom

22. Rutherford's α-particle dispersion experiment concludes
(a) all positive ions are deposited at small part
(b) all negative ions are deposited at small part
(c) proton moves around the electron
(d) neutrons are charged particles.

23. Rutherford's experiment which established the nuclear model of the atom used a beam of
(a) β-particles which impinged on a metal foil and got absorbed
(b) γ-rays which impinged on a metal foil and ejected electrons
(c) helium atoms, which impinged on a metal foil and got scattered
(d) helium nuclei, which impinged on a metal foil and got scattered

24. Which of the following scientists explained his model on the basis of centrifugal force ?
(a) Thomson (b) Dalton
(c) Millikan (d) Rutherford

25. The number of neutrons in dipositive zinc ion with mass number 70 is
(a) 34 (b) 36
(c) 38 (d) 40

26. The number of electrons in $\left[{}^{40}_{19}\mathrm{K}\right]^{1-}$ is
(a) 20 (b) 40
(c) 18 (d) 19

27. Which of the following does not contain number of neutrons equal to that of ${}^{40}_{18}\mathrm{Ar}$?
(a) ${}^{41}_{19}\mathrm{K}$ (b) ${}^{43}_{21}\mathrm{Sc}$
(c) ${}^{40}_{21}\mathrm{Sc}$ (d) ${}^{42}_{20}\mathrm{Ca}$

28. Number of protons, neutrons and electrons in the element ${}_{89}\mathrm{X}^{231}$ is
(a) 89, 89, 242 (b) 89, 142, 89
(c) 89, 71, 89 (d) 89, 231, 89

29. An element has atomic number 11 and mass number 24. What does the nucleus contain?
(a) 11 protons, 13 neutrons
(b) 11 protons, 13 neutrons, 13 electrons
(c) 13 protons, 11 neutrons
(d) 13 protons, 11 electrons

30. The number of electrons and neutrons of an element is 18 and 20 respectively. Its mass number is
(a) 2 (b) 17
(c) 37 (d) 38

31. 'A' represents mass no. and Z represents atomic no. then α - decay is characterized by
(a) Z increases by 2, A decreases by 4
(b) Z decreases by 2, A increases by 4
(c) Z decreases by 2, A decreases by 4
(d) Z increases by 2, A increases by 4.

32. Nucleons are
(a) only neutrons
(b) neutrons + protons
(c) neutrons + protons + electrons
(d) neutrons + electrons

33. Atoms with same mass number but different atomic numbers are called
(a) isotopes (b) isobars
(c) isochores (d) None of these

34. Which of the following pairs will have same chemical properties ?

(a) $^{14}_{6}\text{C}$ and $^{15}_{7}\text{N}$ (b) O^{2-} and F^{-}

(c) $^{40}_{18}\text{Ar}$ and $^{40}_{19}\text{K}$ (d) $^{35}_{17}\text{Cl}$ and $^{37}_{17}\text{Cl}$

35. What is the difference between two species if one has atomic mass = 14 and atomic number = 7 whereas the other has atomic mass = 14 and atomic number = 6 ?

(a) Neutrons (b) Protons

(c) Electrons (d) All of these

36. From the data given below A, B, C and D respectively are,

(A) 10 e^-, atomic no. 11 (B) 10 e^-, atomic no. 6

(C) 10 e^-, atomic no. 10 (D) 10 e^-, atomic no. 9

(a) Na^+, C^{4-}, Ne, F^- (b) C^{4-}, Ne, Na^-, F^-

(c) F^-, Na^+, Ne, C^{4-} (d) F^-, Na^+, C^{4-}, Ne

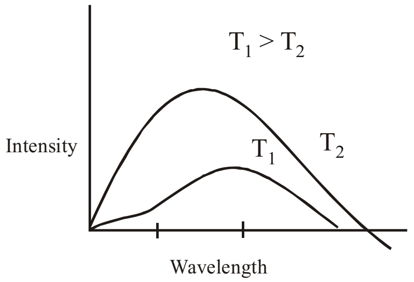
37. If the wavelength of the electromagnetic radiation is increased to thrice the digital value, then what will be the percent change in the value of frequency of the electromagnetic radiation.

(a) Increases by 33% (b) Decreases by 33%

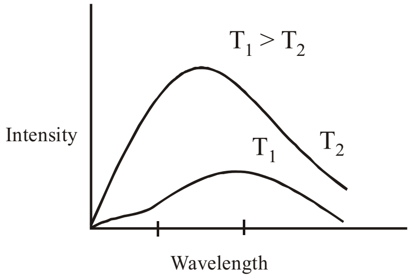
(c) Increases by 66% (d) Decreases by 66%

38. Which is the correct schematic representation of the graph of black body radiation.

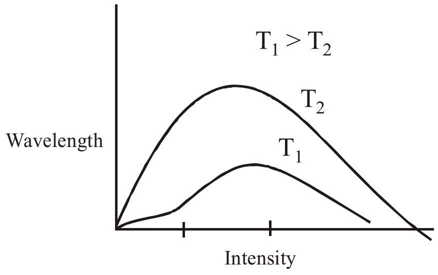
(a)



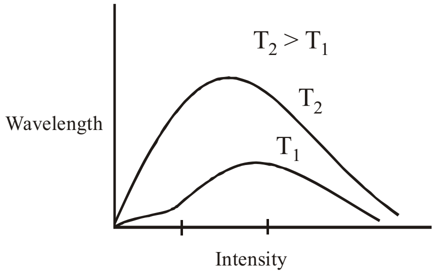
(b)



(c)



(d)



39. The ideal body, which emits and absorbs radiations of all frequencies, is called a black body and the radiation emitted by such a body is called

(a) white body radiation (b) black body radiation

(c) black body emission (d) None of these

40. Which one of the following is not the characteristic of Planck's quantum theory of radiation ?

(a) The energy is not absorbed or emitted in whole number or multiple of quantum

(b) Radiation is associated with energy

(c) Radiation energy is not emitted or absorbed continuously but in the form of small packets called quanta

(d) This magnitude of energy associated with a quantum is proportional to the frequency.

41. Which of the following is related with both wave nature and particle nature ?

(a) Interference (b) $E = mc^2$

(c) Diffraction (d) $E = h\nu$

42. The value of Planck's constant is 6.63×10^{-34} Js. The velocity of light is 3.0×10^8 m s^{-1}. Which value is closest to the wavelength in nanometers of a quantum of light with frequency of 8×10^{15} s^{-1} ?

(a) 3×10^7 (b) 2×10^{-25}

(c) 5×10^{-18} (d) 4×10^1

43. In the photo-electron emission, the energy of the emitted electron is

(a) greater than the incident photon

(b) same as than of the incident photon

(c) smaller than the incident photon

(d) proportional to the intensity of incident photon

44. When a metal surface is exposed to solar radiations

(a) The emitted electrons have energy less than a maximum value of energy depending upon frequency of incident radiations

(b) The emitted electrons have energy less than maximum value of energy depending upon intensity of incident radiation

(c) The emitted electrons have zero energy

(d) The emitted electrons have energy equal to energy of photons of incident light

45. In photoelectric effect, at which frequency electron will be ejected with certain kinetic energy (ν_0 = threshold frequency).

(a) $\nu > \nu_0$ (b) $\nu_0 > \nu$

(c) $\nu_0 \geq \nu$ (d) $\nu \geq \nu_0$

46. In continous spectrum light of (i) wavelength is deviated the ii

(a) (i) = longest, least
(b) (ii) = shortest, least
(c) (i) = shortest, most
(d) (i) = longest, most

47. Which of the following statements do not form a part of Bohr's model of hydrogen atom ?

(a) Energy of the electrons in the orbits are quantized
(b) The electron(s) in the orbit nearest to the nucleus has the lowest energy
(c) Electrons revolve in different orbits around the nucleus
(d) The position and velocity of the electrons in the orbit cannot be determined simultaneously

48. An electron from one Bohr stationary orbit can go to next higher orbit

(a) by emission of electromagnetic radiation
(b) by absorption of any electromagnetic radiation
(c) by absorption of electromagnetic radiation of particular frequency
(d) without emission or absorption of electromagnetic radiation

49. For a Bohr atom angular momentum M of the electron is ($n = 0, 1, 2, ...$) :

(a) $\frac{nh^2}{4\pi}$
(b) $\frac{n^2h^2}{4\pi}$
(c) $\frac{\sqrt{nh^2}}{4\pi}$
(d) $\frac{nh}{2\pi}$

50. According to Bohr's theory, the angular momentum of an electron in 5th orbit is

(a) $10\,h/\pi$
(b) $2.5\,h/\pi$
(c) $25\,h/\pi$
(d) $1.0\,h/\pi$

51. In Bohr's model, atomic radius of the first orbit is y, the radius of the 3rd orbit, is

(a) $y/3$
(b) y
(c) $3y$
(d) $9y$

52. The radius of 1st Bohr's orbit for hydrogen atom is 'r'. The radius of second Bohr's orbit is

(a) 4r
(b) r^3
(c) $4r^2$
(d) $r^{1/3}$

53. The third line of the Balmer series, in the emission spectrum of the hydrogen atom, is due to the transition from the

(a) fourth Bohr orbit to the first Bohr orbit
(b) fifth Bohr orbit to the second Bohr orbit
(c) sixth Bohr orbit to the third Bohr orbit
(d) seventh Bohr orbit to the third Bohr orbit

54. Which one of the following pairs is not correctly matched ?

(a) Rutherford-Proton
(b) J.J. Thomson-Electron
(c) J.H. Chadwick-Neutron
(d) Bohr-Isotopes

55. If r is the radius of the first orbit, the radius of n^{th} orbit of H-atom is given by

(a) rn^2
(b) rn
(c) r/n
(d) $r^2\,n^2$

56. The radius of hydrogen atom in the ground state is 0.53 Å. The radius of Li^{2+} ion (atomic number = 3) in a similar state is

(a) 0.17 Å
(b) 0.265 Å
(c) 0.53 Å
(d) 1.06 Å

57. The energy of an electron in the n^{th} Bohr orbit of hydrogen atom is

(a) $-\frac{13.6}{n^4}$ eV
(b) $-\frac{13.6}{n^3}$ eV
(c) $-\frac{13.6}{n^2}$ eV
(d) $-\frac{13.6}{n}$ eV

58. The energy of second Bohr orbit of the hydrogen atom is -328 kJ mol^{-1}; hence the energy of fourth Bohr orbit would be:

(a) -41 kJ mol^{-1}
(b) -82 kJ mol^{-1}
(c) -164 kJ mol^{-1}
(d) -1312 kJ mol^{-1}

59. In a hydrogen atom, if energy of an electron in ground state is 13.6. eV, then that in the 2nd excited state is

(a) 1.51 eV
(b) 3.4 eV
(c) 6.04 eV
(d) 13.6 eV.

60. The energy of an electron in second Bohr orbit of hydrogen atom is :

(a) -5.44×10^{-19}eV
(b) -5.44×10^{-19}cal
(c) -5.44×10^{-19}kJ
(d) -5.44×10^{-19}J

61. The energy of electron in first energy level is -21.79×10^{-12} erg per atom. The energy of electron in second energy level is :

(a) -54.47×10^{-12} erg atom^{-1}
(b) -5.447×10^{-12} erg atom^{-1}
(c) -0.5447×10^{-12} erg atom^{-1}
(d) -0.05447×10^{-12} erg atom^{-1}

62. The ionisation potential of a hydrogen atom is -13.6 eV. What will be the energy of the atom corresponding to n = 2.

(a) -3.4 eV
(b) -6.8 eV
(c) -1.7 eV
(d) -2.7 eV

63. The line spectrum of He^+ ion will resemble that of

(a) hydrogen atom
(b) Li^+ ion
(c) helium atom
(d) lithium atom

64. What does negative sign in the electronic energy for hydrogen atom convey.

(a) Energy of electron when n = ∞
(b) The energy of electron in the atom is lower than the energy of a free electron in motion
(c) The energy of electron in the atom is lower than the energy of a free electron of rest
(d) The energy of electron decreases as it moves away from nucleus

65. In which of the following Bohr's stationary state, the electron will be at maximum distance from the nucleus ?

(a) IInd
(b) Ist
(c) Vth
(d) IIIrd

66. The wavelength of the radiation emitted, when in a hydrogen atom electron falls from infinity to stationary state 1, would be (Rydberg constant = $1.097\times10^{7}\ \text{m}^{-1}$)

(a) 406 nm (b) 192 nm
(c) 91 nm (d) 9.1×10^{-8} nm

67. The frequency of radiation emitted when the electron falls from $n = 4$ to $n = 1$ in a hydrogen atom will be (Given : ionization energy of H=2.18×10^{-18}J atom^{-1}and $h = 6.625\times10^{-34}$ J s)

(a) $1.54\times10^{15}\ \text{s}^{-1}$ (b) $1.03\times10^{15}\ \text{s}^{-1}$
(c) $3.08\times10^{15}\ \text{s}^{-1}$ (d) $2.00\times10^{15}\ \text{s}^{-1}$

68. Which of the following transitions of electrons in the hydrogen atom will emit maximum energy ?

(a) $n_5 \to n_4$ (b) $n_4 \to n_3$
(c) $n_3 \to n_2$ (d) all will emit same energy

69. The first emission line of hydrogen atomic spectrum in the Balmer series appears is (R = Rydberg constant)

(a) $\frac{5}{36}R\ \text{cm}^{-1}$ (b) $\frac{3}{4}R\ \text{cm}^{-1}$
(c) $\frac{7}{144}R\ \text{cm}^{-1}$ (d) $\frac{9}{400}R\ \text{cm}^{-1}$

70. According to the Bohr theory, which of the following transitions in the hydrogen atom will give rise to the least energetic photon ?

(a) n = 6 to n = 1 (b) n = 5 to n = 4
(c) n = 6 to n = 5 (d) n = 5 to n = 3

71. The wavelength (in cm) of second line in the Lyman series of hydrogen atomic spectrum is (Rydberg constant = R cm^{-1})

(a) $\left(\frac{8R}{9}\right)$ (b) $\left(\frac{9}{8R}\right)$
(c) $\left(\frac{4}{3R}\right)$ (d) $\left(\frac{3R}{4}\right)$

72. The shortest wavelength in hydrogen spectrum of Lyman series when $R_H = 109678\ \text{cm}^{-1}$ is

(a) 1002.7Å (b) 1215.67Å
(c) 1127.30Å (d) 911.7Å

73. What is the expression of frequency (ν) associated with absorption spectra of the photon.

(a) $\nu = \frac{R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) n_i > n_f$

(b) $\nu = \frac{R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) n_f > n_i$

(c) $\nu = -\frac{R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) n_f > n_i$

(d) All the above are correct

74. Bohr model can explain :

(a) the solar spectrum
(b) the spectrum of hydrogen molecule
(c) spectrum of any atom or ion containing one electron only
(d) the spectrum of hydrogen atom only

75. Which of the following statements do not form a part of Bohr's model of hydrogen atom ?

(a) Energy of the electrons in the orbits are quantized
(b) The electron in the orbit nearest the nucleus has the lowest energy
(c) Electrons revolve in different orbits around the nucleus
(d) The position and velocity of the electrons in the orbit cannot be determined simultaneously.

76. Bohr's theory can be applied to which of the following ions.

(a) Na^+ (b) Be^{2+}
(c) Li^+ (d) Li^{2+}

77. Bohr's model is not able to account for which of the following.

(a) Stability of atom.
(b) Spectrum of neutral helium atom.
(c) Energy of free electron at rest.
(d) Calculation of radii of the stationary states.

78. If electron, hydrogen, helium and neon nuclei are all moving with the velocity of light, then the wavelength associated with these particles are in the order

(a) Electron > hydrogen > helium > neon
(b) Electron > helium > hydrogen > neon
(c) Electron < hydrogen < helium < neon
(d) Neon < hydrogen < helium < electron

79. The de Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 metres per second is approximately

(a) 10^{-31} metres (b) 10^{-16} metres
(c) 10^{-25} metres (d) 10^{-33} metres

Planck's constant, $h = 6.63\times10^{-34}$ Js

80. If the energy difference between the ground state of an atom and its excited state is 4.4×10^{-4} J, the wavelength of photon required to produce the transition :

(a) 2.26×10^{-12} m (b) 1.13×10^{-12} m
(c) 4.52×10^{-16} m (d) 4.52×10^{-12} m

81. The mass of a photon with a wavelength equal to 1.54×10^{-8} cm is

(a) 0.8268×10^{-34} kg (b) 1.2876×10^{-33} kg
(c) 1.4285×10^{-32} kg (d) 1.8884×10^{-32} kg

82. If the Planck's constant $h = 6.6\times10^{-34}$ Js, the de Broglie wavelength of a particle having momentum of 3.3×10^{-24} kg ms^{-1} will be

(a) 0.002 Å (b) 0.5Å
(c) 2Å (d) 500Å

83. The values of Planck's constant is 6.63×10^{-34} Js. The velocity of light is 3.0×10^{8} m s^{-1}. Which value is closest to the wavelength in nanometres of a quantum of light with frequency of 8×10^{15} s^{-1}?

(a) 5×10^{-18} (b) 4×10^{1}

(c) 3×10^{7} (d) 2×10^{-25}

84. The de Broglie wavelength of a car of mass 1000 kg and velocity 36 km/hr is :

(a) 6.626×10^{-34} m (b) 6.626×10^{-38} m

(c) 6.626×10^{-31} m (d) 6.626×10^{-30} m

85. Heisenberg uncertainty principle can be explained as

(a) $\Delta x \geq \frac{\Delta P \times h}{4\pi}$ (b) $\Delta x \times \Delta P \geq \frac{h}{4\pi}$

(c) $\Delta x \times \Delta P \geq \frac{h}{\pi}$ (d) $\Delta P \geq \frac{\pi h}{\Delta x}$

86. Heisenberg's uncertainity principle is applicable to

(a) atoms only (b) electron only

(c) nucleus only (d) any moving object

87. The position of both, an electron and a helium atom is known within 1.0 nm. Further the momentum of the electron is known within 5.0×10^{-26} kg ms^{-1}. The minimum uncertainty in the measurement of the momentum of the helium atom is

(a) 50 kg ms^{-1} (b) 80 kg ms^{-1}

(c) 8.0×10^{-26} kg ms^{-1} (d) 5.0×10^{-26} kg ms^{-1}

88. Uncertainty in the position of an electron (mass = 9.1×10^{-31} kg) moving with a velocity 300 ms^{-1}, accurate upto 0.001% will be (h = 6.63×10^{-34} Js)

(a) 1.92×10^{-2} m (b) 3.84×10^{-2} m

(c) 19.2×10^{-2} m (d) 5.76×10^{-2} m

89. The uncertainty in the position of an electron (mass = 9.1×10^{-28} g) moving with a velocity of 3.0×10^{4} cm s^{-1} accurate upto 0.011% will be

(a) 1.92 cm (b) 7.68 cm

(c) 0.175 cm (d) 3.84 cm.

90. The Heisenberg uncertainity principle will be most significant for which of the following object ?

(a) Object A of mass 9.11×10^{-30} kg

(b) Object B of mass 9.11×10^{-28} g

(c) Object C of mass 9.11×10^{-24} mg

(d) Object D of mass 9.11×10^{-28} kg

91. The orientation of an atomic orbital is governed by

(a) Spin quantum number

(b) Magnetic quantum number

(c) Principal quantum number

(d) Azimuthal quantum number

92. For which one of the following sets of four quantum numbers, an electron will have the heighest energy?

	n	l	m	s
(a)	3	2	1	1/2
(b)	4	2	–1	1/2
(c)	4	1	0	–1/2
(d)	5	0	0	–1/2

93. Which of the following sets of quantum numbers is correct for an electron in 4f orbital ?

(a) $n = 4, \ell = 3, m = +1, s = +½$

(b) $n = 4, \ell = 4, m = -4, s = -½$

(c) $n = 4, \ell = 3, m = +4, s = +½$

(d) $n = 3, \ell = 2, m = -2, s = +½$

94. What is the correct orbital designation of an electron with the quantum number, $n = 4$, $\ell = 3, m = -2, s = 1/2$?

(a) 3s (b) 4f

(c) 5p (d) 6s

95. Which of the following represents correct set of the four quantum numbers for an electron in a 4d subshell ?

(a) 4, 2, 1, 0 (b) 4, 2, 1, – 1/2

(c) 4, 3, 2, + 1/2 (d) 4, 3, – 2, – 1/2

96. The total number of electrons that can be accommodated in all orbitals having principal quantum number 2 and azimuthal quantum number 1 is

(a) 2 (b) 4

(c) 6 (d) 8

97. For azimuthal quantum number $\ell = 3$, the maximum number of electrons will be

(a) 2 (b) 6

(c) 0 (d) 14

98. Which of the following is **not** permissible arrangement of electrons in an atom?

(a) $n = 5, l = 3, m = 0, s = +1/2$

(b) $n = 3, l = 2, m = -3, s = -1/2$

(c) $n = 3, l = 2, m = -2, s = -1/2$

(d) $n = 4, l = 0, m = 0, s = -1/2$

99. Which of the following sets of quantum numbers represents the highest energy of an atom?

(a) $n = 3, l = 0, m = 0, s = +1/2$

(b) $n = 3, l = 1, m = 1, s = +1/2$

(c) $n = 3, l = 2, m = 1, s = +1/2$

(d) $n = 4, l = 0, m = 0, s = +1/2$

100. Which set of quantum numbers are not possible?

	n	l	m	s
(a)	3	2	0	+1/2
(b)	2	2	1	+1/2
(c)	1	0	0	–1/2
(d)	3	2	–2	+1/2

101. What will be the sum of all possible values of l and m for $n = 5$?

(a) 12 (b) 13

(c) 4 (d) 9

102. The following quantum numbers are possible for how many orbital(s) $n = 3, l = 2$, m = +2 ?

(a) 1 (b) 3

(c) 2 (d) 4

103. The orbitals are called degenerate when

(a) they have the same wave functions

(b) they have the same wave functions but different energies

(c) they have different wave functions but same energy

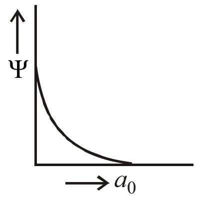
(d) they have the same energy

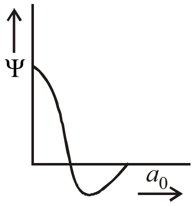
104. The number of spherical nodes in 3p orbitals are

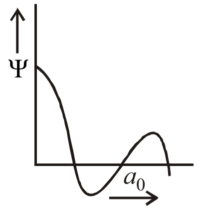
(a) one (b) three

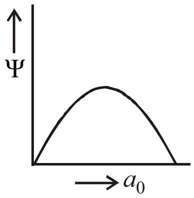
(c) two (d) None of these

105. Which of the following graph correspond to one node

(a)


(b)


(c)


(d)


106. If there are five radial nodes, then what can be the correct representation of the orbital for n = 8.

(a) 8d (b) 8s

(c) 8p (d) 8f

107. What can be the representation of the orbital having 3 angular nodes and $n = 5$.

(a) 5d (b) 5f

(c) 5p (d) 5s

108. The number of orbitals present in the fifth shell will be

(a) 25 (b) 10

(c) 50 (d) 20

109. Arrange the orbital of same shell in the increasing order of shielding strength of the outer shell of electrons.

s, f, d, p

(a) s < p < d < f (b) s > p < d < f

(c) s > p > d < f (d) s > p > d > f

110. Which of the following is not correct for electronic distribution in the ground state ?

(a) Co	[Ar]	↑↓	↑↓	↑↓				
(b) Ni	[Ar]	↑↓	↑↓	↑↓	↑↓			
(c) Cu	[Ar]	↑↓	↑↓	↑↓	↑↓	↑↓		

(d) All of the above

111. The electronic configuration of gadolinium (Atomic number 64) is

(a) [Xe] $4f^8 5d^0 6s^2$ (b) [Xe] $4f^3 5d^5 6s^2$

(c) [Xe] $4f^6 5d^2 6s^2$ (d) [Xe] $4f^7 5d^1 6s^2$

112. The order of filling of electrons in the orbitals of an atom will be

(a) $3d, 4s, 4p, 4d, 5s$ (b) $4s, 3d, 4p, 5s, 4d$

(c) $5s, 4p, 3d, 4d, 5s$ (d) $3d, 4p, 4s, 4d, 5s$

113. The number of d-electrons retained in Fe^{2+} (At. no. of Fe = 26) ion is

(a) 4 (b) 5

(c) 6 (d) 3

114. The electronic configuration of an element is $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^1$. This represents its

(a) excited state (b) ground state

(c) cationic form (d) anionic form

115. Number of unpaired electrons in N^{2+} is

(a) 2 (b) 0

(c) 1 (d) 3

116. An ion has 18 electrons in the outermost shell, it is

(a) Cu^+ (b) Th^{4+}

(c) Cs^+ (d) K^+

117. In a given atom no two electrons can have the same values for all the four quantum numbers. This is called

(a) Hund's Rule (b) Aufbau principle

(c) Uncertainty principle (d) Pauli's exclusion principle

118. The electronic configuration of Cu (atomic number 29) is

(a) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 3d^9$

(b) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^1$

(c) $1s^2, 2s^2 2p^6, 3p^2 3p^6, 4s^2 4p^6, 5s^2 5p^1$

(d) $1s^2, 2s^2 2p^6, 3p^2 3p^6, 4s^2 4p^6 3d^3$

119. The orbital diagram in which the Aufbau principle is violated is :

	2s	**2p**		
(a)	↑↓	↑↓	↑	
(b)	↑	↑↓	↑	↑
(c)	↑↓	↑	↑	↑
(d)	↑↓	↑↓	↑	↑

120. If n = 6, the correct sequence for filling of electrons will be :

(a) ns → (n – 2) f → (n – 1) d → np

(b) ns → (n – 1) d → (n – 2) f → np

(c) ns → (n – 2) f → np → (n – 1) d

(d) ns → np (n – 1) d → (n – 2) f

121. Maximum number of electrons in a subshell of an atom is determined by the following:

(a) $2l + 1$ (b) $4l - 2$

(c) $2n^2$ (d) $4l + 2$

122. The correct order of increasing energy of atomic orbitals is

(a) $5p < 4f < 6s < 5d$ (b) $5p < 6s < 4f < 5d$

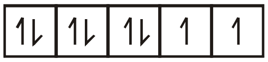
(c) $5p < 5d < 4f < 6s$ (d) None of these

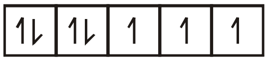
123. For which element, the valence electron will be present in the highest energy orbital.

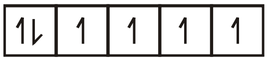
(a) $_3Li$ (b) $_{16}S$

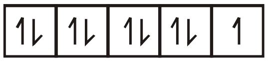
(c) $_{20}Ca$ (d) $_{21}Sc$

124. Which of the following electronic configuration of d-orbital will have highest affinity for gaining an electron?

(a) 

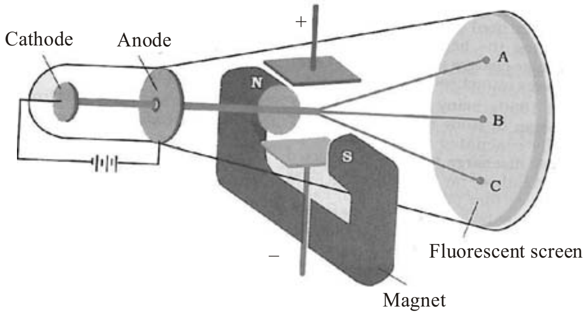
(b) 

(c) 

(d) 

STATEMENT TYPE QUESTIONS

125. On the basis of figure given below which of the following statement(s) is/are correct ?



(i) At point B, when only electric field is applied.

(ii) At point C, when both electric and magnetic field is applied.

(iii) At point B, when both electric and magnetic fields are balanced.

(iv) At point C, when only magnetic field is applied.

Which of the following is/are correct?

(a) (i) and (ii) (b) only (iii)

(c) (iii) and (iv) (d) (i) and (iii)

126. Which of the following statements are not correct about electromagnetic radiation ?

(i) Electromagnetic waves require medium to travel.

(ii) Different electromagnetic radiations travel at same speed in vaccum.

(iii) The oscillating electric and magnetic fields produced by oscillating charged particles are perpendicular to each other, but not to the direction of propagation.

(iv) The oscillating electric field and magnetic field are perpendicular to each other, and also to the direction of propagation.

(a) (i), (ii) and (iii) (b) (ii) and (iii)

(c) (i) and (iii) (d) (i) and (iv)

127. Which of the following statement(s) is/are incorrect regarding photoelectric effect?

(i) The number of electrons ejected is proportional to the intensity of light.

(ii) There is some time lag between the striking of light beam on the metal surface and the ejection of electrons.

(iii) The kinetic energy of ejected electrons depends upon the brightness of light.

(iv) The kinetic energy of the ejected electron is proportional to the frequency of the incident radiation.

(a) (i) and (ii) (b) (ii) and (iii)

(c) (ii) only (d) (ii) and (iv)

128. For Balmer series in the spectrum of atomic hydrogen, the wave number of each line is given by $\bar{v} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R_H is a constant and n_1 and n_2 are integers. Which of the following statement(s) is (are) correct?

(i) As wavelength decreases, the lines in the series converge.

(ii) The integer n_1 is equal to 2.

(iii) The ionization energy of hydrogen can be calculated from the wave number of these lines.

(iv) The line of longest wavelength corresponds to $n_2 = 3$.

(a) (i), (ii) and (iii) (b) (ii), (iii) and (iv)

(c) (i), (i) and (iv) (d) (ii) and (iv)

129. Which of the following statements of quantum mechanics was in agreement with Bohr's model?

(i) The path of an electron in an atom can never be determined accurately.

(ii) The energy of electrons in atom is quantized i.e., can only have specific values.

(iii) An orbital cannot contain more than two electrons.

(a) Only (i) (b) (i) and (ii)

(c) Only (ii) (d) (ii) and (iii)

130. Which of the following statements concerning the quantum numbers are correct ?

(i) Angular quantum number determines the three-dimensional shape of the orbital.

(ii) The principal quantum number determines the orientation and energy of the orbital.

(iii) Magnetic quantum number determines the size of the orbital.

(iv) Spin quantum number of an electron determines the orientation of the spin of electron relative to the chosen axis.

The correct set of option is

(a) (i) and (ii) (b) (i) and (iv)

(c) (iii) and (iv) (d) (ii), (iii) and (iv)

MATCHING TYPE QUESTIONS

131. Match the columns.

Column-I	Column-II
(A) $^{1}_{1}H$, $^{2}_{1}H$ and $^{3}_{1}H$	(p) Isobars
(B) $^{14}_{6}C$ and $^{14}_{7}N$	(q) Isotopes
(C) Na^{+} and Mg^{2+}	(r) Isoelectronic species

(a) A – (p), B – (q), C – (r)
(b) A – (q), B – (p), C – (r)
(c) A – (r), B – (q), C – (p)
(d) A – (p), B – (r), C – (q)

132. Match the columns.

Column-I	Column-II
(A) X-rays	(p) $v = 10^{0} - 10^{4}$ Hz
(B) UV	(q) $v = 10^{10}$ Hz
(C) Long radio waves	(r) $v = 10^{16}$ Hz
(D) Microwave	(s) $v = 10^{18}$ Hz

(a) A – (s), B – (r), C – (p), D – (q)
(b) A – (r), B – (s), C – (p), D – (q)
(c) A – (s), B – (p), C – (r), D – (q)
(d) A – (s), B – (r), C – (q), D – (p)

133. Match the columns.

Column-I	Column-II
(A) $\|\Psi\|^2$	(p) Energy can be emitted or absorbed in packets
(B) de Brolie	(q) Significant only for motion of microscopic objects.
(C) Heisenberg	(r) The probability of finding an electron at a point within an atom
(D) Planck's	(s) Every object in motion has a wave character.

(a) A – (q), B – (s), C – (r), D – (p)
(b) A – (r), B – (p), C – (q), D – (s)
(c) A – (r), B – (s), C – (q), D – (p)
(d) A – (s), B – (p), C – (r), D – (q)

134. Match the columns.

Column-I (Quantum number)	Column-II (Information provided)
(A) Principal quantum number	(p) orientation of the orbital
(B) Azimuthal quantum number	(q) energy and size of orbital
(C) Magnetic quantum number	(r) spin of electron
(D) Spin quantum number	(s) shape of the orbital

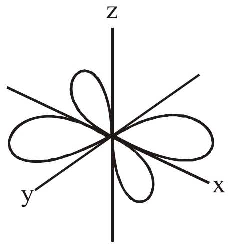
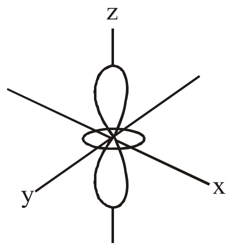
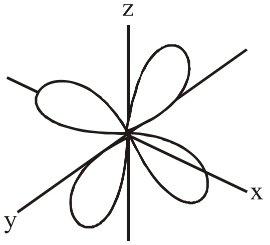
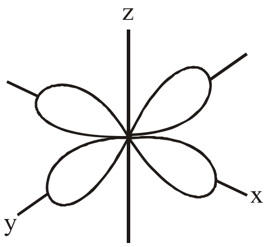
(a) A – (q), B – (s), C – (p), D – (r)
(b) A – (s), B – (q), C – (p), D – (r)
(c) A – (q), B – (p), C – (s), D – (r)
(d) A – (q), B – (s), C – (r), D – (p)

135. Match the columns.

Column-I (Sub shell)	Column-II (Number of orbitals)	Column-III (Angular/Azimuthal Quantum Number)
(A) d	(p) 1	(i) 1
(B) f	(q) 3	(ii) 2
(C) s	(r) 5	(iii) 0
(D) p	(s) 7	(iv) 3

(a) A – (r) – (ii), B – (s) – (iv), C – (p) – (iii), D – (q) – (i)
(b) A – (q) – (i), B – (s) – (iv), C – (p) – (iii), D – (r) –(ii)
(c) A – (p) – (iii), B – (s) – (iv), C – (r) – (ii), D – (q) – (i)
(d) A – (r) – (ii), B – (p) – (iii), C – (s) – (iv), D – (q) – (i)

136. Match the columns.

Column-I	Column-II
(A) $d_{x^2-y^2}$	(p) 
(B) d_{xy}	(q) 
(C) d_{yz}	(r) 
(D) d_{z^2}	(s) 

(a) A – (p), B – (s), C – (r), D – (q)
(b) A – (s), B – (p), C – (r), D – (q)
(c) A – (s), B – (p), C – (q), D – (r)
(d) A – (s), B – (r), C – (p), D – (q)

137. Match the columns

Column-I (Rules)	Column-II (Statements)
(A) Hund's Rule	(p) No two electrons in an atom can have the same set of four quantum numbers.
(B) Aufbau Principle	(q) Half-filled and completely filled orbitals have extra stablity.
(C) Pault Exclusion Principle	(r) Pairing of electrons in the orbitals belonging to the same subshell does not take place until each orbital is singly occupied.
(D) Heisenberg's Uncertainty Principle	(s) It is impossible to determine the exact position and exact momentum of a subatomic particle simultaneously.
	(t) In the ground state of atoms, orbitals are filled in the order of their increasing energies.

(a) A – (r), B – (p), C – (t), D – (s)
(b) A – (r), B – (t), C – (s), D – (p)
(c) A – (r), B – (t), C – (p), D – (s)
(d) A – (t), B – (r), C – (p), D – (s)

138. Match the columns.

Column-I (Atom / Ion)	Column-II (Electronic configuration)
(A) Cu	(p) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$
(B) Cu^{2+}	(q) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$
(C) Zn^{2+}	(r) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$
(D) Cr^{3+}	(s) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$
	(t) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3$

(a) A – (s), B – (r), C – (p), D – (t)
(b) A – (r), B – (s), C – (p), D – (t)
(c) A – (r), B – (s), C – (t), D – (p)
(d) A – (r), B – (s), C – (p), D – (s)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

139. Assertion : The position of an electron can be determined exactly with the help of an electron microscope.

Reason : The product of uncertainty in the measurement of its momentum and the uncertainty in the measurement of the position cannot be less than a finite limit.

140. Assertion : The radius of the first orbit of hydrogen atom is 0.529Å.

Reason : Radius of each circular orbit (r_n) - 0.529Å (n^2/Z), where n = 1, 2, 3 and Z = atomic number.

141. Assertion : All isotopes of a given element show the same type of chemical behaviour.

Reason : The chemical properties of an atom are controlled by the number of electrons in the atom.

142. Assertion : Black body is an ideal body that emits and absorbs radiations of all frequencies.

Reason : The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

143. Assertion : It is impossible to determine the exact position and exact momentum of an electron simultaneously.

Reason : The path of an electron in an atom is clearly defined.

CRITICAL THINKING TYPE QUESTIONS

144. What is the ratio of mass of an electron to the mass of a proton?
(a) 1 : 2
(b) 1 : 1
(c) 1 : 1837
(d) 1 : 3

145. The increasing order for the values of e/m (charge/mass) is
(a) e, p, n, α
(b) n, p, e, α
(c) n, p, α, e
(d) n, α, p, e

146. In which of the following the amount of deviation from their path in the presence of electric and magnetic field will be maximum?
(a) N^{2-}
(b) N^{3-}
(c) N^-
(d) N

147. The deflection of the particles from their path in presence of electric and magnetic field will be maximum in which of the following.
(a) O
(b) N
(c) U
(d) He

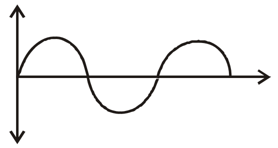
148. Which of the following pairs have identical values of e/m?
(a) A proton and a neutron
(b) A proton and deuterium
(c) Deuterium and an α-particle
(d) An electron and γ-rays

149. If the alpha-particles are projected against the following atoms Fe, Be, Mg, Al then increasing order in which the alpha-particle feel repulsion will be
(a) Be, Mg, Al, Fe
(b) Be, Al, Mg, Fe
(c) Mg, Al, Mg, Fe
(d) Al, Mg, Fe, Be

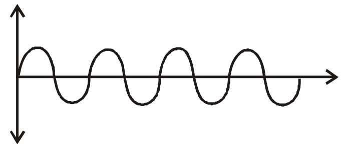
150. Chlorine exists in two isotopic forms, C1-37 and C1-35 but its atomic mass is 35.5. This indicates the ratio of C1-37 and C1-35 is approximately
(a) 1 : 2
(b) 1 : 1
(c) 1 : 3
(d) 3 : 1

151. The number of electrons, neutrons and protons in a species are equal to 10, 8 and 8 respectively. The proper symbol of the species is
(a) $^{16}O_8$
(b) $^{18}O_8$
(c) $^{18}Ne_{10}$
(d) $^{16}O_8^{2-}$

152. What will be the difference between electromagnetic radiation shown in A and B respectively ?



(A)



(B)

(i) Velocity (ii) Wavelength
(iii) Frequency (iv) Energy
(a) (ii) only (b) (ii) and (iv)
(c) (ii), (iii) and (iv) (d) (iv) only

153. Arrange the electromagnetic radiations a, b, c, d and e in increasing order of energy. Frequencies of a, b and c are 10^{15}, 10^{14} and 10^{17} respectively whereas wavelength of (d) and (e) are 350 nm and 100 nm respectively ?

(a) a, b, c, d, e (b) a, b, d, e, c
(c) a, d, b, e, c (d) b, d, a, e, c

154. An electron, e_1 is moving in the fifth stationary state, and another electron e_2 is moving in the fourth stationary state. The radius of orbit of electron, e_1 is five times the radius of orbit of electron, e_2 calculate the ratio of velocity of electron e_1 (v_1) to the velocity of electron e_2 (v_2).

(a) 5 : 1 (b) 4 : 1
(c) 1 : 5 (d) 1 : 4

155. The Li^{2+} ion is moving in the third stationary state, and its linear momentum is 7.3×10^{-34} kg ms^{-1}. Calculate its angular momentum.

(a) 1.158×10^{-45} kg m^{2}s^{-1}
(b) 11.58×10^{-48} kg m^{2}s^{-1}
(c) 11.58×10^{-47} kg m^{2}s^{-1}
(d) 12×10^{-45} kg m^{2}s^{-1}

156. The Bohr orbit radius for the hydrogen atom ($n = 1$) is approximately 0.530 Å. The radius for the first excited state (n = 2) orbit is (in Å)

(a) 0.13 (b) 1.06
(c) 4.77 (d) 2.12

157. According to Bohr's theory the energy required for an electron in the Li^{2+} ion to be emitted from n = 2 state is (given that the ground state ionization energy of hydrogen atom is 13.6 eV)

(a) 61.2 eV (b) 13.6 eV
(c) 30.6 eV (d) 10.2 eV

158. Among species H, Li^{2+}, He^+, Be^{3+} and Al^{3+} Bohr's model was able to explain the spectra of

(a) All of these
(b) None of these
(c) all other species except Be^{3+}
(d) all other species except Al^{3+}

159. Which of the following levels of H and He^+ have same energy respectively ?

(A) 1, 2 (B) 3, 4
(C) 2, 4 (D) 3, 6
(a) A and D (b) A and B
(c) C and D (d) A, C and D

160. Bohr radius of *n*th orbit of an atom is given by the expression:

(a) $r = \dfrac{n^2h^2}{4\pi^2me^2}$ (b) $r = \dfrac{nh}{4\pi^2mZe^2}$

(c) $r = \dfrac{n^2h^2}{4\pi^2mZ}$ (d) $r = \dfrac{n^2h^2}{4\pi^2me^2Z}$

161. The ratio between kinetic energy and the total energy of the electrons of hydrogen atom according to Bohr's model is

(a) 2 : 1 (b) 1 : 1
(c) 1 : – 1 (d) 1 : 2

162. The potential energy of electron present in ground state of Li^{2+} ion is represented by :

(a) $\dfrac{+3e^2}{4\pi\varepsilon_0 r}$ (b) $\dfrac{-3e}{4\pi\varepsilon_0 r}$

(c) $\dfrac{-3e^2}{4\pi\varepsilon_0 r^2}$ (d) $\dfrac{-3e^2}{4\pi\varepsilon_0 r}$

163. In hydrogen atomic spectrum, a series limit is found at 12186.3 cm^{-1}. Then it belong to

(a) Lyman series (b) Balmer series
(c) Paschen series (d) Brackett series

164. Which transition in the hydrogen atomic spectrum will have the same wavelength as the transition, n = 4 to n = 2 of He^+ spectrum?

(a) n = 4 to n = 3 (b) n = 3 to n = 2
(c) n = 4 to n = 2 (d) n = 2 to n = 1

165. Arrange the following elements in the order of ease of detection of wave properties, in the de Broglie experiment. H, Li, Be, B, K

(a) H < Be, B < Li < K. (b) H > Li > K > Be > B
(c) H > Li > Be > B > K (d) H < Li < Be < B < K

166. A 600 W mercury lamp emits monochromatic rediation of wavelength 331.3 nm. How many photons are emitted from the lamp per second ? ($h = 6.626 \times 10^{-34}$ Js; velocity of light $= 3 \times 10^8$ ms^{-1})

(a) 1×10^{19} (b) 1×10^{20}
(c) 1×10^{21} (d) 1×10^{23}

167. Calculate the velocity of ejected electron from the metal surface when light of frequency 2×10^{15} Hz fall on the metal surface and the threshold frequency is 7×10^{14} Hz for metal ?

(a) 1.37×10^6 (b) 1.26×10^6
(c) 1.45×10^7 (d) 1.37×10^7

168. What is the wavelength (in m) of the electron emitted in the above question (Q. no. 167) ?

(a) 5.308×10^{-10} (b) 5.89×10^{-11}
(c) 4.37×10^{-13} (d) 3.98×10^{-10}

169. The velocity of particle A is 0.1 ms^{-1} and that of particle B is 0.05 ms^{-1}. If the mass of particle B is five times that of particle A, then the ratio of de-Broglie wavelengths associated with the particles A and B is

(a) 2 : 5
(b) 3 : 4
(c) 6 : 4
(d) 5 : 2

170. Two fast moving particles X and Y are associated with de Broglie wavelengths 1 nm and 4 nm respectively. If mass of X in nine times the mass of Y, the ratio of kinetic energies of X and Y would be

(a) 3 : 1
(b) 9 : 1
(c) 5 : 12
(d) 16 : 9

171. Uncertainty in position of an electron (mass = 9.1×10^{-28} g) moving with a velocity of 3×10^4 cm/s accurate upto 0.001% will be (use $h/4\pi$) in uncertainty expression where $h = 6.626 \times 10^{-27}$ erg-second).

(a) 1.93 cm
(b) 3.84 cm
(c) 5.76 cm
(d) 7.68 cm

172. The measurement of the electron position is associated with an uncertainty in momentum, which is equal to 1×10^{-18} g cm s^{-1}. The uncertainty in electron velocity is, (mass of an electron is 9×10^{-28} g)

(a) 1×10^9 cm s^{-1}
(b) 1×10^6 cm s^{-1}
(c) 1×10^5 cm s^{-1}
(d) 1×10^{11} cm s^{-1}

173. In an atom, an electron is moving with a speed of 600 m/s with an accuracy of 0.005%. Certainity with which the position of the electron can be located is ($h = 6.6 \times 10^{-34}$ kg m^2s^{-1}, mass of electron, $e_m = 9.1 \times 10^{-31}$ kg)

(a) 5.10×10^{-3} m
(b) 1.92×10^{-3} m
(c) 3.84×10^{-3} m
(d) 1.52×10^{-4} m

174. If uncertainty in position and momentum are equal, then uncertainty in velocity is :

(a) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$
(b) $\sqrt{\frac{h}{2\pi}}$
(c) $\frac{1}{m}\sqrt{\frac{h}{\pi}}$
(d) $\sqrt{\frac{h}{\pi}}$

175. Which of the following sets of quantum numbers is correct?

(a) $n = 5, l = 4, m = 0, s = +½$
(b) $n = 3, l = 3, m = +3, s = +½$
(c) $n = 6, l = 0, m = +1, s = -½$
(d) $n = 4, l = 2, m = +2, s = 0$

176. Which combinations of quantum numbers, n, ℓ, m and s for the electron in an atom does not provide a permissible solution of the wave equation ?

(a) $3, 2, 1, \frac{1}{2}$
(b) $3, 1, 1, -\frac{1}{2}$
(c) $3, 3, 1, -\frac{1}{2}$
(d) $3, 2, -2, \frac{1}{2}$

177. An electron has principal quantum number 3. The number of its (i) subshells and (ii) orbitals would be respectively

(a) 3 and 5
(b) 3 and 7
(c) 3 and 9
(d) 2 and 5

178. The electrons identified by quantum numbers n and ℓ :

(A) $n = 4, \ell = 1$
(B) $n = 4, \ell = 0$
(C) $n = 3, \ell = 2$
(D) $n = 3, \ell = 1$

can be placed in order of increasing energy as :

(a) (C) < (D) < (B) < (A)
(b) (D) < (B) < (C) < (A)
(c) (B) < (D) < (A) < (C)
(d) (A) < (C) < (B) < (D)

179. The five d-orbitals are designated as $d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}$ and d_{z^2}. Choose the correct statement.

(a) The shapes of the first three orbitals are similar but that of the fourth and fifth orbitals are different
(b) The shapes of all five d-orbitals are similar
(c) The shapes of the first four orbitals are similar but that of the fifth orbital is different
(d) Ths shapes of all five d-orbitals are different

180. If the nitrogen atom has electronic configuration $1s^7$, it would have energy lower than that of the normal ground state configuration $1s^2 2s^2 2p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates.

(a) Heisenberg uncertainty principle
(b) Hund's rule
(c) Pauli exclusion principle
(d) Bohr postulate of stationary orbits

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(b)**

2. **(b)** Cathode rays are never electromagnetic waves.

3. **(c)** Cathode rays are made up of negatively charged particles (electrons) which are deflected by both the electric and magnetic fields.

4. **(d)** **5.** **(b)** **6.** **(c)** **7.** **(c)**

8. **(c)** The electrical discharge through the gases could be observed only at low pressure and high voltage.

9. **(b)** The cathode rays (negatively charged particles stream) originates from cathode and move towards anode.

10. **(b)** Millikan determined the value of charge on the electron by using oil drop experiment.

11. **(b)**

12. **(d)** Proton is the nucleus of H-atom (H-atom devoid of its electron)

13. **(b)** Positron (positive electron, $+_1e^0$) is positively charged electron without any mass, so it is the lightest particle among given choices.

14. **(c)** As the neutron is a chargeless particle, hence, the beam of neutrons is not deflected by electrical or magnetic field.

15. **(a)** James Chadwick in 1932 discovered the neutrons.

16. **(b)** Since electrons are negatively charged particles they got deflected toward positively charged electrode whereas proton being positively charged will get deflected toward negative electrode. Since neutrons are neutral, so they went straight.

17. **(a)**

18. **(b)** α-rays have the least penetrating power, followed by β-rays (100 times that of α-rays) and γ-rays (1000 times that of α-rays).

19. **(d)** X- and γ-rays are not deflected by the electric and magnetic field.

20. **(c)** Rutherford's α-ray scattering experiment first showed the existence of a small positivily charged entity in the centre of atom, called nucleus.

21. **(d)** The nucleus occupies much smaller volume compared to the volume of the atom.

22. **(a)** All positive ions are deposited at small part. (nucleus of atom).

23. **(d)** Rutherford used doubly charged helium particle. (α - particle)

24. **(d)** Electrons are revolving around the nucleus, and centrifugal force is balancing the force of attraction.

25. **(d)** Number of neutrons = Mass number – Atomic number = 70 – 30 = 40.

26. **(a)** $19 + 1e^- = 20$ electrons.

27. **(c)** $_{18}Ar^{40}$ contains 22 neutrons and $_{21}Sc^{40}$ contains 19 neutrons. The number of neutrons = (A – Z)

28. **(b)** Number of p = number of e^- = 89 and neutrons $231 - 89 = 142$.

29. **(a)** Z = 11, A = 24. Hence protons = 11 the neutrons $(24 - 11) = 13$.

30. **(d)** For neutral atom . No. of p = No. of e^- = 18 and A = Z + No. of neutrons = 18 + 20 = 38.

31. **(c)** When an alpha particle is emitted from a nucleus its atomic number decreases by two and its atomic mass decreases by four e.g.

$$_ZX^A \xrightarrow{-\alpha} {}_{Z-2}X^{A-4}$$

32. **(b)** Nucleons are total number of protons and neutrons. Both of these are collectively known as nucleons.

33. **(b)** Atoms with mass number but different atomic numbers are called isobars. Examples; $^{14}_{6}C$, $^{14}_{7}N$ are isobars.

34. **(d)** $_{17}Cl^{35}$ and $_{17}Cl^{37}$ are isotopes, so they will have same chemical properties.

35. **(d)** Atomic number is equal to number of protons or number of electrons. Thus if two species have different atomic number they must contain different number of protons and electrons. Number of neutrons = Atomic mass – Atomic number. Therefore due to difference of atomic numbers two species also have different number of neutrons.

36. **(a)**

37. **(d)** $\nu_1 = \frac{c}{\lambda_1}$

$$\nu_2 = \frac{c}{\lambda_2} = \frac{c}{3\lambda_1}$$

$$\text{\% change in frequency} = \frac{\nu_2 - \nu_1}{\nu_1} \times 100$$

$$= \frac{\frac{c}{3\lambda_1} - \frac{c}{\lambda_1}}{\frac{c}{\lambda_1}} \times 100 = \frac{-\frac{2c}{3\lambda_1} \times 100}{\frac{c}{\lambda_1}}$$

$= -66\%$

38. **(b)**

39. **(b)** The ideal body, which emits and absorbs radiations of all frequencies, is called a black-body and the radiation emitted by such a body is called black-body radiation.

40. **(a)** Energy is always absorbed or emitted in whole number or multiples of quantum.

41. **(d)** (i) Interference and diffraction support the wave nature of electron.

(ii) $E = mc^2$ supports the particle nature of electron.

(iii) $E = h\nu = \frac{hc}{\lambda}$ is de-Broglie equation and it supports both wave nature and particle nature of electron.

42. **(d)** $E = h\nu = \frac{hc}{\lambda}$ or $\lambda = \frac{c}{\nu}$

$$\Rightarrow \lambda = \frac{3 \times 10^8}{8 \times 10^{15}} = 3.75 \times 10^{-8}\,\text{m}$$

In nanometer $\lambda = 3.75 \times 10$

which is closest to 4×10^1

43. **(c)** K.E. of emitted electron

$= h\nu - h\nu_0$ (i.e. smaller than $h\nu$).

44. **(a)**

45. **(a)** At a frequency $\nu > \nu_0$, the ejected electrons come out with certain kinetic energy.

46. **(a)**

47. **(d)** This statement is known as uncertainty principle which was given by Heisenberg it is not a Bohr's postulate.

48. **(c)** Since the energy difference between two consecutive Bohr orbits is quantized and the energy of higher orbit is more than that of lower orbit, so an electron from one Bohr stationary orbit can go to next higher orbit by absorption of electromagnetic radiation of particular wavelength or frequency.

49. **(d)** For a Bohr atom, angular momentum M of the electron

$= \frac{nh}{2\pi}$.

50. **(b)** Angular momentum of an electron in nth orbit is given by

$$mvr = \frac{nh}{2\pi}$$

For $n = 5$, we have

Angular momentum of electron $= \frac{5h}{2\pi} = \frac{2.5h}{\pi}$

51. **(d)** $y \propto n^2$

For 1st orbit $y = 1$

For IIIst orbit $= y \propto 3^2 = 9$

So it will $9y$.

52. **(a)** $r_n = r_1 \times n^2$ (for hydrogen atom)

$r_n = r \times n^2$

as $r_1 = r$ (given)

$r_2 = r \times 2^2$ ($n = 2$, for second Bohr's orbit)

$= 4r$

53. **(b)** **54.** **(d)**

55. **(a)** Radius of n^{th} orbit $= r_1 n^2$. (for H-atom)

56. **(a)** For hydrogen atom $(n) = 1$ (due to ground state)

Radius of hydrogen atom (r) = 0.53 Å.

Atomic number of Li (Z) = 3.

Radius of Li^{2+} ion $= r_1 \times \frac{n^2}{Z} = 0.53 \times \frac{(1)^2}{3} = 0.17$

57. **(c)** Energy of an electron in Bohr's orbit is given by the relationship. $E_n = -\frac{13.6}{n^2}\text{eV}$.

58. **(b)** We know that $E_n = \frac{-1312}{n^2}$ kJ mol^{-1}

$n = 4$ (Fourth Bohr orbit)

Given $E_4 = \frac{-1312}{4^2} = -82$ kJ mol^{-1}

59. **(a)** 2nd excited state will be the 3rd energy level.

$$E_n = \frac{13.6}{n^2}\text{eV} \text{ or } E = \frac{13.6}{9}\text{eV} = 1.51 \text{ eV}.$$

60. **(d)** For H atom, $E_n = -\frac{13.6Z^2}{n^2}\text{eV}$

For second orbit, $n = 2$

Z = At. no. = 1 (for hydrogen)

$$\therefore\ E_2 = -\frac{13.6 \times (1)^2}{(2)^2} = \frac{-13.6}{4}\text{eV}$$

$$= \frac{-13.6 \times 1.6 \times 10^{-19}}{4}\text{J} = -5.44 \times 10^{-19}\,\text{J}$$

61. **(b)** If we assume the atom to be hydrogen like, energy of nth energy level

$E_n = \frac{E_1}{n^2}$ where E_1 is energy of first energy level

$$E_2 = -\frac{E_1}{2^2} = -\frac{E_1}{4} = \frac{-21.79 \times 10^{-12}}{4}$$

$= -5.447 \times 10^{-12}$ erg per atom.

62. **(a)** Energy of an electron $E = \frac{-E_0}{n^2}$

For energy level ($n = 2$)

$$E = -\frac{13.6}{(2)^2} = \frac{-13.6}{4} = -3.4 \text{ eV}.$$

63. **(a)** H,He^+ and Li^{2+} are single electron species thus show similar line spectra.

64. **(c)**

65. **(c)** Vth stationary state, as radii of stationary state is given as $r_n = n^2 \times a_0 \Rightarrow n = 5$

66. **(c)** $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$\frac{1}{\lambda} = 1.097 \times 10^7\left(\frac{1}{1} - \frac{1}{\infty}\right) = 1.097 \times 10^7\,\text{m}^{-1}$$

$$\lambda = 91.15 \times 10^{-9}\,\text{m} \approx 91\text{nm}$$

67. **(c)** $\nu = \frac{1}{h}\times \text{IE}\times\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$

$$= \frac{2.18\times10^{-18}}{6.625\times10^{-34}}\times\left[\frac{1}{1}-\frac{1}{16}\right] = 3.08\times10^{15}\,\text{s}^{-1}$$

68. **(c)** ΔE for two energy levels $= 21.79\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ J/atom

69. **(a)** $\Delta E = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$;

First line in Balmer series results in the transition : $n_2 = 3$ to $n_1 = 2$.

70. **(c)** Energy of photon obtained from the transition n = 6 to n = 5 will have least energy.

$$\Delta E = 13.6Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

71. **(a)** $\bar{\upsilon} = \frac{1}{\lambda} = \text{R}\left[\frac{1}{\text{n}_1^2}-\frac{1}{\text{n}_2^2}\right]$

For second line in lyman series

$\text{n}_2 = 3$

$$\therefore \frac{1}{\lambda} = \text{R}\left[\frac{1}{1^2}-\frac{1}{3^2}\right] = \text{R}\left[\frac{1}{1}-\frac{1}{9}\right] = \frac{8\text{R}}{9}$$

72. **(d)** The shortest wavelength in hydrogen spectrum of Lyman series is given by formula :

$$\frac{1}{\lambda} = \frac{\text{R}_\text{H}}{\text{n}^2} = \frac{\text{R}_\text{H}}{1^2} = \frac{109678}{1}$$

$\Rightarrow \lambda = 9.117\times10^{-6}$ cm

$= 911.7\times10^{-10}$ m $= 911.7$ Å.

73. **(b)**

74. **(c)** Bohr model can explain spectrum of any atom or ion containing one electron only (that is H-like species)

75. **(d)** Uncertainty principle which was given by Hiesenberg and not Bohr's postulate.

76. **(d)** Bohr's model can be applied to one electron system only.

77. **(b)** Bohr model can only explain one electron system

78. **(a)** $\lambda = h/m\text{v}$; for the same velocity, λ varies inversely with the mass of the particle.

79. **(d)** $\lambda = \frac{\text{h}}{\text{mv}} = \frac{6.6\times10^{-34}}{60\times10^{-3}\times10} = 10^{-33}\,\text{m}$

80. **(d)** Given $\Delta E = 4.4\times10^{-4}$ j, $\lambda = ?$

$$\lambda = \frac{hc}{\Delta E} = \frac{6.6\times10^{-34}\times3\times10^{8}}{4.4\times10^{-4}} = 4.5\times10^{-22}\,m$$

81. **(c)** We know that $\lambda = \frac{h}{m\text{v}}$; $\therefore m = \frac{h}{\text{v}\lambda}$

The velocity of photon (v) = 3×10^8 m sec^{-1}

$\lambda = 1.54\times10^{-8}\,\text{cm} = 1.54\times10^{-10}$ meter

$$\therefore m = \frac{6.626\times10^{-34}\ \text{Js}}{1.54\times10^{-10}\,\text{m}\times3\times10^{8}\,\text{m sec}^{-1}}$$

$$= 1.4285\times10^{-32}\ \text{kg}$$

82. **(c)** $\lambda = \frac{h}{p} = \frac{6.6\times10^{-34}}{3.3\times10^{-24}} = 2\times10^{-10}\,m = 2\text{Å}$

83. **(b)** $\text{E} = \text{h}\upsilon = \frac{\text{ch}}{\lambda}$; and $\upsilon = \frac{\text{c}}{\lambda}$

$$8\times10^{15} = \frac{3.0\times10^{8}}{\lambda}$$

$$\therefore \lambda = \frac{3.0\times10^{8}}{8\times10^{15}} = 0.37\times10^{-7} = 37.5\times10^{-9}\ \text{m} = 4\times10^{1}\ \text{nm}$$

84. **(b)** $\lambda = \frac{h}{mv}$

$h = 6.6\times10^{-34}$ J/s

$m = 1000$ kg

$v = 36\ \text{km/hr} = \frac{36\times10^3}{60\times60}\ \text{m/sec} = 10\ \text{m/sec}$

$$\therefore \lambda = \frac{6.6\times10^{-34}}{10^3\times10} = 6.6\times10^{-38}\ \text{m}$$

85. **(b)** Heisenberg uncertainity principle can be explained by the relation

$$\Delta\text{x}.\ \Delta\text{P} \Rightarrow \frac{\text{h}}{4\pi}$$

where Δx = uncertainity in position

ΔP = uncertainity in momentum

86. **(d)** Heisenberg's uncertainty Principle is applicable to any moving object.

87. **(d)** By Heisenberg uncertainty Principle $\Delta x\times\Delta p = \frac{h}{4\pi}$ (which is constant)

As Δx for electron and helium atom is same thus momentum of electron and helium will also be same therefore the momentum of helium atom is equal to 5×10^{-26} kg. m.s^{-1}.

88. **(a)** Given m = 9.1×10^{-31}kg

$h = 6.6\times10^{-34}$Js

$$\Delta v = \frac{300\times.001}{100} = 0.003\text{ms}^{-1}$$

From Heisenberg's uncertainity principle

$$\Delta x = \frac{6.62\times10^{-34}}{4\times3.14\times0.003\times9.1\times10^{-31}} = 1.92\times10^{-2}\,\text{m}$$

89. (c) $\Delta x \,.\, \Delta p = \frac{h}{4\pi}$ or $\Delta x \,.\, m\Delta v = \frac{h}{4\pi}$;

$$\Delta v = \frac{0.011}{100} \times 3 \times 10^4 = 3.3 \text{ cms}^{-1}$$

$$\Delta x = \frac{6.6 \times 10^{-27}}{4 \times 3.14 \times 9.1 \times 10^{-28} \times 3.3} = 0.175 \text{ cm}$$

90. (b) $\Delta x.\Delta v$ value will be large for object of smallest mass and is therefore the most significant for calculating uncertainity.

91. (b) Magnetic quantum no. represents the orientation of atomic orbitals in an atom. For example p_x, p_y & p_z have orientation along X-axis, Y-axis & Z-axis

92. (b) The sub-shell are 3*d*, 4*d*, 4*p* and 4*s*, 4*d* has highest energy as $n + \ell$ value is maximum for this.

93. (a) The possible quantum numbers for 4*f* electron are

$n = 4$, $\ell = 3$, $m = -3, -2 -1, 0, 1, 2, 3$ and $s = \pm\frac{1}{2}$

Of various possiblities only option (a) is possible.

94. (b) $n = 4$ represents 4th orbit

$\ell = 3$ represents *f* subshell

$m = -2$ represents orientation of *f*-orbital

$s = 1/2$ represents direction of spin of electron.

$\therefore$ The orbital is 4*f*.

95. (b) For 4*d* orbitals, $n = 4$, $l = 2$

$$\begin{bmatrix} \text{For } s \text{ orbital } l = 0 \\ \text{For } p \text{ orbital } l = 1 \\ \text{For } d \text{ orbital } l = 2 \end{bmatrix}$$

$m = -2, -1, 0, +1$ or $+2$

$s = +\frac{1}{2}$ and $-\frac{1}{2}$

Thus choice *b* having $n = 4$, $l = 2$, $d = 1$ and $s = \frac{1}{2}$ is correct.

96. (c) $n = 2$, $l = 1$ means 2*p*–orbital. Electrons that can be accommodated = 6 as *p* sub-shell has 3 orbital and each orbital contains 2 electrons.

97. (d) $\ell = 3$ means *f*-subshell. Maximum no. of electrons $= 4\ell + 2 = 4 \times 3 + 2 = 14$

98. (b) $m = -l$ to $+l$, through zero thus for $l = 2$, values of *m* will be $-2, -1, 0, +1, +2$.

Therefore for $l = 2$, m cannot have the value -3.

99. (c) (a) $n = 3$, $\ell = 0$ means 3*s*-orbital and $n + \ell = 3$

(b) $n = 3$, $\ell = 1$ means 3*p*-orbital $n + \ell = 4$

(c) $n = 3$, $\ell = 2$ means 3*d*-orbital $n + \ell = 5$

(d) $n = 4$, $\ell = 0$ means 4*s*-orbital $n + \ell = 4$

Increasing order of energy among these orbitals is

$3s < 3p < 4s < 3d$

$\therefore$ 3d has highest energy.

100. (b) Value of $l = 0$ ....$(n - 1)$

l cannot be equal to n.

101. (b) For $n = 5$, $l = n - 1 = 5 - 1 = 4$

$m = 2l + 1 = 2(4) + 1 = 9$

Sum of values of *l* and $m = 9 + 4 = 13$

102. (a) Quantum number $n = 3$, $l = 2$, $m = +2$ represent an orbital with

$s = \pm\frac{1}{2}$ $\left(3d_{xy} \text{ or } 3d_{x^2-y^2}\right)$

which is possible only for one electron.

103. (d) The orbitals which have same energy are called degenerate orbitals eg. p_x, p_y and p_z.

104. (a) No. of radial nodes in 3*p*-orbital $= (n - \ell - 1)$

[for *p* ortbital $\ell = 1$]

$= 3 - 1 - 1 = 1$

105. (b)

106. (a) As $n - l - 1 = 5$ or $8 - l - 1 = 5 \Rightarrow l = 2$.

107. (b) According to given information $n = 5$ and $l = 3$.

108. (a) The number of allowed orbitals are given by n^2.

Thus when n = 5

$(5)^2 = 25$

109. (d) Spherical shaped *s*-orbital shields the outer shell electrons move effectively than *p*-orbital, which in turn shields more effectively than *d*-orbital and so on.

110. (d) According to Hund's rule electron pairing in p, d and f orbitals cannot occur until each orbital of a given subshell contains one electron each or is singly occupied.

111. (d) We know that atomic number of gadolinium is 64. Therefore the electronic configuration of gadolinium is [Xe] $4f^7\, 5d^1\, 6s^2$. Because the half filled and fully filled orbitals are more stable.

112. (b) The sub-shell with lowest value of $(n + \ell)$ is filled up first. When two or more sub-shells have same $(n + \ell)$ value the subshell with lowest value of '*n*' is filled up first therefore the correct order is

orbital	4*s*	3*d*	4*p*	5*s*	4*d*
$n + \ell$	$4+0$	$3+2$	$4+1$	$5+0$	$4+2$
value	$=4$	$=5$	$=5$	$=5$	$=6$

113. (c) Fe^{++} $(26 - 2 = 24) = 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s^0\, 3d^6$ hence no. of *d* electrons retained is 6. [Two 4*s* electron are removed]

114. (b) This configuration represents ground state electronic configuration of Cr.

$1s^2\, 2s^2\, 2p^6\, 3s^2 3p^6 3d^5\, 4s^1$

115. (c) $N(7) = 1s^2\, 2s^2\, 2p^3$

$N^{2+} = 1s^2, 2s^2\, 2p_x^1$

Unpaired electrons = 1.

116. (a) $Cu^+ = 29 - 1 = 28\ e^-$

thus the electronic confingration of Cu^+ is

$$Cu^+ (28) = 1s^2\ 2s^2\ 2p^6\ \underbrace{3s^2\ 3p^6\ 3d^{10}}_{18e^-}$$

117. (d) This is as per the definition of Pauli's exclusion principle.

118. (b) Electronic configuration of Cu (29) is $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^1$ and not $1s^2, 2s^2\,2p^6\,3s^2\,3p^6\,3d^9 4s^2$ due to extra stability of fully filled orbitals.

119. (b) According to Aufbau principle, the orbital of lower energy (2*s*) should be fully filled before the filling of orbital of higher energy starts.

120. (a) $ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np \quad [n = 6]$

121. (d) The number of sub shell is $(2\,l + 1)$. The maximum number of electrons in the sub shell is $2\,(2\,l + 1) = (4\,l + 2)$.

122. (b)

	5*p*	4*f*	6*s*	5*d*
(n + *l*)	5 + 1	4 + 3	6 + 0	5 + 2
	6	7	6	7

Hence the order is 5p < 6s < 4f < 5d

123. (d)

124. (d) The *d*-orbital represented by option (d) will become completely filled after gaining an electron. Therefore option (d) is correct.

STATEMENT TYPE QUESTIONS

125. (c) When both electric and magnetic field is applied, electron strikes at point B, and at point C when only magnetic field is applied.

126. (c)

127. (b) For statement (ii) there is no time lag between striking of light beam and the ejection of electrons. For statement (iii) refer statement (iv).

128. (c) (i) Beyond a certain wavelength the line spectrum becomes band spectrum.

(ii) For Balmer series $n_1 = 2$

(iii) For calculation of longest wavelength use nearest value of n_2. Hence for longest wavelength in Balmer series of hydrogen spectrum,

$n_1 = 2$ & $n_2 = 3$.

129. (c) Statement (i) is related to Heisenberg's uncertainity principle. Statement (iii) belongs to Pauli's exclusion principle.

130. (b) Angular quantum number determines the 3d shape of the orbital.

Spin quantum number of an electron determines the orientation of the spin of electron relative to the chosen axis.

MATCHING TYPE QUESTIONS

131. (b) Isotopes have same atomic number. Isobars have same mass number, whereas isoelectronic species have same number of electrons although the (A) has same number of electrons but the protons they carry are same while in case of isolelectronic species number of protons they carry are different.

132. (a) **133. (c)** **134. (a)**

135. (a) For *d*-subshell ⇒ Number of orbitals = 5, $l = 2$

f-subshell ⇒ Number of orbitals = 7, $l = 3$

s-subshell ⇒ Number of orbitals = 1, $l = 0$

p-subshell ⇒ Number of orbitals = 3, $l = 1$

136. (b) **137. (c)** **138. (b)**

ASSERTION-REASON TYPE QUESTIONS

139. (d) The statement-1 is false but the statement-2 is true exact position and exact momentum of an electron can never be determined according to Heisenberg's uncertainty principle. Even not with the help of electron microscope because when electron beam of electron microscope strikes the target electron of atom, the impact causes the change in velocity and position of electron .

140. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

Radius, $r_n = \dfrac{n^2h^2}{4\pi e^2 mZ} = \dfrac{n^2}{Z} \times 0.529\,\text{Å}.r_n$

For first orbit of H-atom

$n = 1$

$$r_1 = \frac{(1)^2}{1} \times 0.529\,\text{Å} = 0.529\,\text{Å}$$

141. (a) **142. (b)** **143. (c)**

CRITICAL THINKING TYPE QUESTIONS

144. (c)

145. (d) $\dfrac{e}{m}$ for (i) neutron $= \dfrac{0}{1} = 0$

(ii) α-particle $= \dfrac{2}{4} = 0.5$

(iii) proton $= \dfrac{1}{1} = 1$

(iv) electron $= \dfrac{1}{1/1837} = 1837$

146. (b) N^{3-} The amount of deviation depends upon the magnitude of negative charge on the particle.

147. (d) The lesser is the mass of particle, greater is the deflection.

148. (c) Deuterium and an α-particle have identical values of *e*/*m*.

149. (a) Considering the core of an atom, higher the positive charge concentrated in the nucleus, greater the repulsion for an alpha-particle.

Coulombic force of repulsion $= \dfrac{kq_1(z_e)}{r^2}$

q_1 = charge on α-particle

(z_e) = charge on nucleus of atom

150. (c)

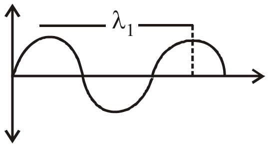
151. (d) Atomic number = No. of protons = 8

Mass number = No. of protons + No. of neutrons

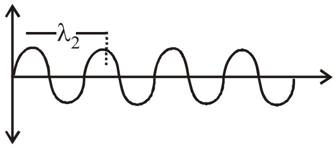
$= 8 + 8 = 16$

Since the no. of electrons are two more than the no. of protons, hence, it is a binegative species. Thus, the species is ${}^{16}O_8^{2-}$.

152. (c) e/m waves shown in figure A has higher wavelength in comparison to e/m waves shown in figure B. Thus these waves also differ in frequency and energy. $\nu = \frac{c}{\lambda}$



$(A) \Rightarrow E_1 = \frac{hc}{\lambda_1}$



$(B) \Rightarrow E_2 = \frac{hc}{\lambda_2}$

$\lambda_1 > \lambda_2 \Rightarrow E_1 < E_2$

153. (d) $E = h\nu$

and $\nu = \left(\frac{c}{\lambda}\right)$

$\nu_a = 10^{15}$, $\nu_b = 10^{14}$,
$\nu_c = 10^{17}$, $\nu_d = 0.85 \times 10^{15}$
and $\nu_e = 10 \times 10^{15}$,

154. (d) From the expression of Bohr's theory, we know that

$$m_e v_1 r_1 = n_1 \frac{h}{2\pi}$$

$$\& \ m_e v_2 r_2 = n_2 \frac{h}{2\pi}$$

$$\frac{m_e v_1 r_1}{m_e v_2 r_2} = \frac{n_1}{n_2} \frac{h}{2\pi} \times \frac{2\pi}{h}$$

Given, $r_1 = 5 r_2, n_1 = 5, n_2 = 4$

$$\frac{m_e \times v_1 \times 5 r_2}{m_e \times v_2 \times r_2} = \frac{5}{4}$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{5}{4 \times 5} = \frac{1}{4} = 1:4$$

155. (b) Z = 3 for Li^{2+} ions

So $r_n = \frac{52.9 \times n^2}{Z}$

$n = 3, Z = 3$

$$r_n = \frac{52.9 \times (3)^2}{3} \text{pm}$$

$= 158.7$ pm

Also, linear momentum (mv) = 7.3×10^{-34} kg ms^{-1}

Then angular momentum will be

$\omega = (mv) \times r$

$= (7.3 \times 10^{-34} \text{ kg ms}^{-1})(158.7 \text{ pm})$

$= 7.3 \times 10^{-34} \text{ kg ms}^{-1} \times (158.7 \times 10^{-12} \text{ m})$

$= 11.58 \times 10^{-48} \text{ kg m}^2 \text{ s}^{-1}$

$= 11.58 \times 10^{-45} \text{ g m}^2 \text{s}^{-1}$

156. (d) Given : Radius of hydrogen atom = 0.530 Å, Number of excited state (n) = 2 and atomic number of hydrogen atom (Z) = 1. We know that the Bohr radius.

$$(r) = \frac{n^2}{Z} \times \text{Radius of atom} = \frac{(2)^2}{1} \times 0.530$$

$$= 4 \times 0.530 = 2.12 \text{ Å}$$

157. (c) Energy of electron in 2nd orbit of Li^{+2} $= -13.6 \frac{z^2}{n^2}$

$$= \frac{-13.6 \times (3)^2}{(2)^2} = -30.6 \text{ eV}$$

Energy required = 0 – (–30.6) = 30.6 eV

158. (d) Except Al^{3+} all contain one electron and Bohr's model could explain the spectra for one electron system, Bohr's model was not able to explain the spectra of multielectron system.

159. (d) $E_n^H = -2.18 \times 10^{-18} \left(\frac{Z^2}{n_H^2}\right) J = \frac{-2.18 \times 10^{-18}}{n_H^2} J$

$$E_n^{He^+} = -2.18 \times 10^{-18} \left(\frac{Z^2}{n_{He^+}^2}\right) J = \frac{-2.18 \times 10^{-18} \times 4}{n_{He^+}^2} J$$

$$E_n^H = E_n^{He^+} \Rightarrow \frac{1}{n_H^2} = \frac{4}{n_{He^+}^2} \Rightarrow n_{He^+} = 2 \times n_H$$

If $n_H = 1$ Then $n_{He^+} = 2$
If $n_H = 2$ Then $n_{He^+} = 4$
If $n_H = 3$ Then $n_{He^+} = 6$

160. (d) Radius of n^{th} orbit $= \frac{n^2 h^2}{4\pi^2 m e^2 Z}$

where n = no. of orbit
h = Plank's constant
e = charge on one electron
m = mass of one electron
Z = atomic number

161. (c)

162. (d) In S.I. units the $P.E. = \frac{-Ze^2}{4\pi\varepsilon_0 r}$.

For Li^{2+}, Z = 3.

$$\therefore P.E. = \frac{-3e^2}{4\pi\varepsilon_0 r}.$$

163. (c) Series limit is the last line of the series, i.e. $n_2 = \infty$.

$$\therefore \bar{\upsilon} = \frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R\left[\frac{1}{n_1^2} - \frac{1}{\infty^2}\right] = \frac{R}{n_1^2}$$

$$\because \bar{\upsilon} = 12186.3 = \frac{109677.76}{n_1^2}$$

$$\Rightarrow n_1^2 = \frac{109677.76}{12186.3} = 9 \Rightarrow n_1 = 3$$

$\therefore$ The line belongs to Paschen series.

164. (d) For He^+ ion, $\frac{1}{\lambda} = Z^2 R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$(2)^2 R\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = \frac{3R}{4}$$

For hydrogen atom, $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$\frac{3R}{4} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \text{ or } \frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{3}{4}$$

$n_1 = 1$ and $n_2 = 2$.

165. (c) The wavelengths of elements decreases with increase in their mass. $\left(\because \lambda = \frac{h}{mv}\right)$

166. (c) Energy of a photon, $E = \frac{hc}{\lambda}$

$$= \frac{6.626 \times 10^{-34} (Js) \times 3 \times 10^8 (ms^{-1})}{331.3 \times 10^{-9} (m)} = 6 \times 10^{-19}\ J$$

No. of photons emitted per second

$$= \frac{600\ (J)}{6 \times 10^{-9} (J)} = 10^{21}$$

167. (a) $\frac{1}{2} mv^2 = h\nu - h\nu_0$

$$\Rightarrow \frac{1}{2} mv^2 = h(\nu - \nu_0)$$

$$\Rightarrow v = \sqrt{\frac{2h}{m}(\nu - \nu_0)}$$

168. (a) According to de-Broglie,

$$\lambda = \frac{h}{mv}$$

where m = mass of electron, v = velocity

169. (d) Given, $v_A = 0.1\ ms^{-1}$ and $v_B = 0.05\ ms^{-1}$ also, $m_B = 5m_A$

de-Broglie wavelength, $\lambda = \frac{h}{mv}$

$$\therefore \frac{\lambda_A}{\lambda_B} = \frac{h/m_A v_A}{h/m_B v_B} = \frac{m_B v_B}{m_A v_A}$$

$$= \frac{5m_A \times 0.05}{m_A \times 0.1} = 5 \times 0.5 = 2.5 = 5/2$$

$$\therefore \lambda_A : \lambda_B = 5:2$$

170. (d) de Broglie wavelength $\lambda = \frac{h}{mv}$

$$\frac{\lambda_1}{\lambda_2} = \frac{m_2 v_2}{m_1 v_1};\ \frac{1}{4} = \frac{1}{9} \times \frac{v_2}{v_1}$$

$$\frac{v_2}{v_1} = \frac{9}{4}$$

$$\frac{v_1}{v_2} = \frac{4}{9}$$

$$KE = \frac{1}{2} mv^2$$

$$\frac{KE_1}{KE_2} = \frac{m_1}{m_2} \times \frac{v_1^2}{v_2^2} = \frac{9}{1} \times \left(\frac{4}{9}\right)^2 = \frac{16}{9}$$

171. (a) Given mass of an electron(v) $= 9.1 \times 10^{-28}$ g;

Velocity of electron $(v) = 3 \times 10^4$ cm/s;

Accuracy in velocity $= 0.001\% = \frac{0.001}{100}$;

Actual velocity of the electron

$$(\Delta v) = 3 \times 10^4 \times \frac{0.001}{100} = 0.3\ \text{cm/s}.$$

Planck's constant $(h) = 6.626 \times 10^{-27}$ erg-sec.

$\therefore$ Uncertainty in the position of the electron

$$(\Delta x) = \frac{h}{4\pi m \Delta v} = \frac{6.626 \times 10^{-27} \times 7}{4 \times 22 \times (9.1 \times 10^{-28}) \times 0.3}$$

$= 1.93$ cm

172. (a) $\Delta p = m\Delta v$

Substituting the given values of Δx and m, we get $1 \times 10^{-18}\ g\ cm\ s^{-1} = 9 \times 10^{-28}\ g \times \Delta v$

$$\text{or } \Delta v = \frac{1 \times 10^{-18}}{9 \times 10^{-28}}$$

$= 1.1 \times 10^9\ cm\ s^{-1} \simeq 1 \times 10^9\ cm\ s^{-1}$

i.e. option (a) is correct.

173. (b) According to Heisenberg uncertainty principle.

$$\Delta x . m\Delta v = \frac{h}{4\pi} \qquad \Delta x = \frac{h}{4\pi m \Delta v}$$

Here $\Delta v = \frac{600 \times 0.005}{100} = 0.03$

So, $\Delta x = \dfrac{6.6\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times0.03}$

$= 1.92 \times 10^{-3}$ meter

174. (a) We know $\Delta p.\Delta x \geq \dfrac{h}{4\pi}$

since $\Delta p = \Delta x$ (given)

$\therefore\ \Delta p.\Delta p = \dfrac{h}{4\pi}$

or $m\Delta v\ m\Delta v. = \dfrac{h}{4\pi}$ $[\therefore\ \Delta p = m\Delta v]$

or $(\Delta v)^2 = \dfrac{h}{4\pi m^2}$

or $\Delta v = \sqrt{\dfrac{h}{4\pi m^2}} = \dfrac{1}{2m}\sqrt{\dfrac{h}{\pi}}$

Thus option (a) is the correct option.

175. (a) For $n = 5$, l may be 0, 1, 2, 3 or 4

For $l = 4$, $m = 2l + 1 = 2 \times 4 + 1 = 9$

$= -4, -3, -2, -1, 0, +1, +2, +3, +4$

For $m = 0$, $s = +\dfrac{1}{2}$

Hence, (a) is correct option.

(b) For any value of n, the value of l cannot be equal or greater than value of n, hence it is incorrect.

(c) For $l = 0$, $m = 0$ hence it is incorrect.

(d) The value of s can never be zero. Thus this option is also incorrect.

176. (c) Possible values of ℓ and m depend upon the value of n

$\ell = 0$ to $(n - 1)$

$m = -\ell$ to $+\ \ell$ through zero

$s = +\dfrac{1}{2}$ and $-\dfrac{1}{2}$

Thus for $n = 3$,

ℓ may be 0, 1 or 2; but not 3

m may be $-2, -1, 0, +1$ or $+2$

s may be $+\dfrac{1}{2}$ or $-\dfrac{1}{2}$

177. (c)

178. (b) (A) $4p$ (B) $4s$

(C) $3d$ (D) $3p$

According to Bohr Bury's $(n + \ell)$ rule, increasing order of energy will be (D) < (B) < (C) < (A).

Note : If the two orbitals have same value of $(n + \ell)$ then the orbital with lower value of n will be filled first.

179. (c) First four orbitals contain four lobes, while fifth orbital consists of only two lobes. The lobes of d_{xy} orbital lie between x and y axis. Similarly in the case of d_{yz} and d_{zx}. their lobes lie between yz and zx axis respectively. Four lobes of $d_{x^2-y^2}$ orbital are lying along x and y axis while two lobes of d_{z^2} orbital are lying along z-axis.

180. (c) As per Pauli exclusion principle "no two electrons in the same atom can have all the four quantum numbers equal or an orbital cannot contain more than two electrons and it can accommodate two electrons only when their directions of spin are opposite".

CHAPTER 3

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

FACT/DEFINITION TYPE QUESTIONS

1. Periodic classification of elements is used to examine the
(a) periodic trends in physical properties of elements
(b) periodic trends in chemical properties of elements
(c) Both (a) and (b)
(d) None of the above

2. Cl, Br, I, if this is Dobereiner's triad and the atomic masses of Cl and I are 35.5 and 127 respectively the atomic mass of Br is
(a) 162.5 (b) 91.5
(c) 81.25 (d) 45.625

3. If the two members of a Dobereiner triad are phosphorus and antimony, the third member of this triad is
(a) arsenic (b) sulphur
(c) iodine (d) calcium

4. The law of triads is applicable to a group of
(a) Cl, Br, I (b) C, N, O
(c) Na, K, Rb (d) H, O, N

5. In 1800, only ....X.... elements were known. Here, X refers to
(a) 63 (b) 31
(c) 114 (d) 92

6. Johann Doberiner gave the idea of trends among physical and ...X... of several groups of three elements. Here, X refers to
(a) atomic number (b) atomic mass
(c) chemical properties (d) None of these

7. Which of the following is the correct set of elements to Dobereiner's triads ?
(a) $\underset{7}{\text{Li}}\ \underset{23}{\text{Na}}\ \underset{39}{\text{K}}$ (b) $\underset{80}{\text{Br}}\ \underset{35.5}{\text{Cl}}\ \underset{127}{\text{I}}$
(c) $\underset{55.85}{\text{Fe}}\ \underset{58.71}{\text{Ni}}\ \underset{58.93}{\text{Co}}$ (d) Data insufficient

8. On which of the following Dobereiner's Triad law is not applicable?
(a) Cl, Br, I (b) Ca, Sr, B
(c) F, Cl, Br (d) Li, Na, K

9. Newlands could classify elements only upto –
(a) copper (b) chlorine
(c) calcium (d) chromium

10. According to Newlands theory, when elements are arranged in the order of increasing atomic weight which number element had similar properties to the first element.
(a) third (b) seventh
(c) eighth (d) sixth

11. Lothar Meyer plotted the physical properties such as atomic volume, melting point and ...X... against atomic weight. Here, X refers to
(a) mass (b) boiling point
(c) surface tension (d) None of these

12. The most significant contribution towards the development of periodic table was made by
(a) Mendeleev (b) Avogadro
(c) Dalton (d) Cavendish

13. Noble gases were included in Mendeleev's periodic table in the
(a) 1st group (b) 7th group
(c) 8th group (d) None of these

14. Mendeleev classified elements in
(a) increasing order of atomic groups
(b) eight periods and eight groups
(c) seven periods and nine groups
(d) eight periods and seven groups

15. Select the correct chronological order for the discoveries of the following scientists.
Dobereiner, Newlands, Chancourtois, Mendeleev
(a) Chancourtois, Dobereiner, Newlands, Mendeleev
(b) Dobereiner, Chancourtois, Newlands, Mendeleev
(c) Dobereiner, Newlands, Chancourtois, Mendeleev
(d) Chancourtois, Newlands, Dobereiner, Mendeleev

16. The molecular formula of chloride of Eka-Aluminium and Eka-Silicon respectively are
(a) $GaCl_3$ and SiO_4 (b) $GaCl_3$ and $AlCl_3$
(c) $AlCl_3$ and $SiCl_4$ (d) $GaCl_3$ and $GeCl_4$

17. Who developed long form of the periodic table?
(a) Lothar Meyer (b) Neils Bohr
(c) Mendeleev (d) Moseley

18. At present, how many elements are known
(a) 110 (b) 112
(c) 113 (d) 118

19. Which of the scientists given below discovered that periodic table should be based on the atomic number ?
(a) Mendeleev (b) Newlands
(c) Moseley (d) Lothar Meyer

20. How many elements are there in 6th period of periodic table?
(a) 18 (b) 8
(c) 30 (d) 32

21. Modern periodic table is based on the atomic number of the elements. The experiment which proved the significance of the atomic number was
(a) Mulliken's oil drop experiment
(b) Mosley's work on X-ray spectra
(c) Bragg's work on X-ray diffraction
(d) Discovery of X-rays by Rontgen

22. The period number in the periodic table corresponds to the ...A... principal quantum number (n) of the elements. Here, A refers to
(a) lowest (b) highest
(c) middle (d) None of these

23. The symbol and IUPAC name for the element with atomic number 120, respectively are
(a) Ubn and unbinilium (b) Ubn and unbiunium
(c) Ubn and unnibium (d) Ubn and unnilium

24. Element with which of the following atomic number was named by American Society as Rutherfordium, while by Soviet Society it was named as Kurchatovium?
(a) 108 (b) 104
(c) 114 (d) 110

25. What is the IUPAC name of the element with atomic number 114 ?
(a) Ununnnium (b) Unnilquadium
(c) Ununquadium (d) Unnilennium.

26. Element with electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^3$ belongs to the following group of the periodic table
(a) 2nd (b) 5th
(c) 3rd (d) 7th

27. The long form of periodic table consists of
(a) seven periods and eight groups
(b) seven periods and eighteen groups
(c) eight periods and eighteen groups
(d) eighteen periods and eight groups

28. All the members in a group in long form of periodic table have the same
(a) valence
(b) number of valence electrons
(c) chemical properties
(d) All of the above

29. Elements of which group form anions most readily?
(a) Oxygen family (b) Nitrogen family
(c) Halogens (d) Alkali metals

30. Element having atomic no. of 56 belongs to which of the following block of periodic table?
(a) *p*- block (b) *d*-block
(c) *f*- block (d) *s*-block

31. In the modern periodic table one of the following does not have appropriate position –
(a) transition elements
(b) inert gases
(c) inner transition elements
(d) halogens

32. If the atomic number of an element is 33, it will be placed in the periodic table in the
(a) First group (b) Third group
(c) Fifth group (d) Seventh group.

33. An atom has electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$, you will place it in which group?
(a) Fifth (b) Fifteenth
(c) Second (d) Third

34. Which of the following is not an actinoid ?
(a) Curium ($Z = 96$) (b) Californium ($Z = 98$)
(c) Uranium ($Z = 92$) (d) Terbium ($Z = 65$)

35. The period number in the long form of the periodic table is equal to
(a) magnetic quantum number of any element of the period.
(b) atomic number of any element of the period.
(c) maximum Principal quantum number of any element of the period.
(d) maximum Azimuthal quantum number of any element of the period.

36. The electronic configuration of four elements are given below. Which elements does not belong to the same family as others?
(a) $[Xe]4f^{14}5d^{10}1s^2$ (b) $[Kr]4d^{10}5s^2$
(c) $[Ne]3s^2 3p^5$ (d) $[Ar]\ 3d^{10}\ 4s^2$

37. The elements with atomic numbers 9, 17, 35, 53 and 85 belong to
(a) alkali metals (b) alkaline earth metals
(c) halogens (d) noble gases

38. Which of the following pairs has both members from the same period of the periodic table.
(a) Na – Ca (b) Na – Cl
(c) Ca – Cl (d) Cl – Br

39. The elements which are characterized by the outer electronic configuration ns^1 to $ns^2\ np^6$ are collectively called
(a) Transition elements
(b) Representative elements
(c) Lanthanides
(d) Inner transition elements

40. f-block elements are called inner transition elements because
(a) they have properties similar to those of transition elements
(b) they exist in between transition elements
(c) the last electron enters into the f-orbital of the penultimate shell
(d) the last electron enters into any orbital of penultimate shell

41. An element, which belongs to third period and group 16 in the periodic table has electronic configuration.

(a) $1s^2, 2s^2 2p^6, 3s^2 3p^3$ (b) $1s^2, 2s^2 2p^6, 3s^2 3p^4$
(c) $1s^2, 2s^2 2p^6, 3s^2 3p^5$ (d) $1s^2, 2s^2 2p^4$

42. Which of the following is non-metallic ?

(a) B (b) Be
(c) Mg (d) Al

43. Which group of the periodic table contains coinage metal ?

(a) IIA (b) IB
(c) IA (d) None of these

44. The only non-metal which is liquid at ordinary temperature is

(a) Hg (b) Br_2
(c) NH_3 (d) None of these

45. Which is a metalloid?

(a) Pb (b) Sb
(c) Bi (d) Zn

46. In the long form of the periodic table all the non-metals are placed in

(a) *s*-block (b) *p*-block
(c) *f*-block (d) *d*-block

47. Arrange the following elements in the order of their increasing non-metallic character

Li, O, C, Be, F

(a) F < O < C < Be < Li (b) Li < Be < C < O< F
(c) F < O < C < Be < Li (d) F < O < Be < C < Li

48. Which is the correct order of ionic sizes (At. No. : Ce = 58, Sn = 50, Yb = 70 and Lu = 71) ?

(a) Ce > Sn > Yb > Lu (b) Sn > Ce > Yb > Lu
(c) Lu > Yb > Sn > Ce (d) Sn > Yb > Ce > Lu

49. The order of increasing sizes of atomic radii among the elements O, S, Se and As is :

(a) As < S < O < Se (b) Se < S < As < O
(c) O < S < As < Se (d) O < S < Se < As

50. In the ions P^{3-}, S^{2-} and Cl^-, the increasing order of size is

(a) Cl^-, S^{2-}, P^{3-} (b) P^{3-}, S^{2-}, Cl^-
(c) S^{2-}, Cl^-, P^{3-} (d) S^{2-}, P^{3-}, Cl^-

51. Which of the following is correct ?

(a) Isoelectronic ions have same nuclear charge
(b) Isoelectronic ions have same neutrons
(c) Isoelectronic ions have same number of electrons
(d) All are correct

52. On going down a main sub-group in the periodic table (example *Li* to *Cs* in IA or *Be* to *Ra* in IIA), the expected trend of changes in atomic radius is a

(a) continuous increase
(b) continuous decrease
(c) periodic one, an increase followed by a decrease
(d) decrease followed by increase

53. Why the size of an anion is larger than the parent atom?

(a) Due to increased repulsion among the electrons.
(b) Due to decrease in effective nuclear charge.
(c) Due to increased in effective nuclear charge.
(d) Both (a) and (b)

54. Which ionisation potential (IP) in the following equations involves the greatest amount of energy ?

(a) $Na \rightarrow Na^+ + e^-$ (b) $K^+ \rightarrow K^{2+} + e^-$
(c) $C^{2+} \rightarrow C^{3+} + e^-$ (d) $Ca^+ \rightarrow Ca^{2+} + e^-$

55. Arrange S, P, As in order of increasing ionisation energy

(a) S < P < As (b) P < S < As
(c) As < S < P (d) As < P < S

56. The statement that is not correct for periodic classification of elements is :

(a) The properties of elements are periodic function of their atomic numbers.
(b) Non-metallic elements are less in number than metallic elements.
(c) For transition elements, the 3*d*-orbitals are filled with electrons after 3*p*-orbitals and before 4*s*-orbitals.
(d) The first ionisation enthalpies of elements generally increase with increase in atomic number as we go along a period.

57. Consider the following changes

$A \rightarrow A^+ + e^- : E_1$ and $A^+ \rightarrow A^{2+} + e^- : E_2$

The energy required to pull out the two electrons are E_1 and E_2 respectively. The correct relationship between two energies would be

(a) $E_1 < E_2$ (b) $E_1 = E_2$
(c) $E_1 > E_2$ (d) $E_1 \geq E_2$

58. Of the given electronic configurations for the elements, which electronic configuration indicates that there will be abnormally high difference in the second and third ionization energy for the element?

(a) $1s^2 2s^2 2p^6 3s^2$ (b) $1s^2 2s^2 2p^6 3s^1$
(c) $1s^2 2s^2 2p^6 3s^2 3p^1$ (d) $1s^2 2s^2 2p^6 3s^2 3p^2$

59. Alkali metals are powerful reducing agents because

(a) these are metals
(b) their ionic radii are large
(c) these are monovalent
(d) their ionisation potential is low

60. Which of the following metals requires the radiation of highest frequency to cause the emission of electrons ?

(a) Na (b) Mg
(c) K (d) Ca

61. Halogens and chalcogens family have highly ...P.. electron gain enthalpy. Here, P refers to

(a) negative (b) positive
(c) zero (d) infinity

62. Which of the following represents the correct order of increasing electron gain enthalpy with negative sign for the elements O, S, F and Cl ?

(a) Cl < F < O < S (b) O < S < F < Cl
(c) F < S < O < Cl (d) S < O < Cl < F

63. The electron affinity for the inert gases is –

(a) zero (b) high
(c) negative (d) positive

64. The element with positive electron gain enthalpy is

(a) hydrogen (b) sodium
(c) oxygen (d) neon

65. Which of the following will have the least negative electron gain enthalpy?

(a) P (b) S
(c) Cl (d) F

66. Which is the correct order of electronegativity ?

(a) $F > N < O > C$ (b) $F > N > O > C$
(c) $F > N > O < C$ (d) $F < N < O = C$

67. The correct order of decreasing electronegativity values among the elements I-beryllium, II-oxygen, III-nitrogen and IV-magnesium is

(a) II > III > I > IV (b) III > IV > II > I
(c) I > II > III > IV (d) I > II > IV > III

68. An element having electronic configuration

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ forms

(a) Acidic oxide (b) Basic oxide
(c) Amphoteric oxide (d) Neutral oxide

69. Diagonal relationship is shown by

(a) All elements with their diagonally downward elements towards right
(b) Most of the elements of second period
(c) All 3d series elements
(d) None of the above

70. In any period the valency of an element with respect to oxygen

(a) Increases one by one from IA to VIIA
(b) Decreases one by one form IA to VIIA
(c) Increases one by one from IA to IVA and then decreases from VA to VIIA one by one
(d) Decreases one by one from IA to IVA and then increases from VA to VIIA one by one

71. What will be the formula of the compound formed by the silicon and bromine ?

(a) $SiBr_2$ (b) $SiBr_4$
(c) $SiBr_3$ (d) $SiBr$

72. Which of the following sequence correctly represents the decreasing acidic nature of oxides ?

(a) $Li_2O > BeO > B_2O_3 > CO_2 > N_2O_3$
(b) $N_2O_3 > CO_2 > B_2O_3 > BeO > Li_2O$
(c) $CO_2 > N_2O_3 > B_2O_3 > BeO > Li_2O$
(d) $B_2O_3 > CO_2 > N_2O_3 > Li_2O > BeO$

STATEMENT TYPE QUESTIONS

73. Choose the correct coding for following statements. Here T stands for True and F stands for False statement.

(i) Mendeleev left several gaps in his periodic table for the undiscovered elements.
(ii) The gap under aluminium and a gap under silicon was left and these elements were called Eka aluminium and Eka silicon.
(iii) Germanium was placed in place of Eka-aluminium and gallium was placed in place of Eka silicon.

(a) TTT (b) TFF
(c) TTF (d) TFT

74. Which of the following statement(s) about the modern periodic table is/are incorrect ?

(i) The elements in the modern periodic table are arranged on the basis of their decreasing atomic number
(ii) The elements in the modern periodic table are arranged on the basis of their increasing atomic masses
(iii) Isotopes are placed in adjoining group(s) in the periodic table
(iv) The elements in the modern periodic table are arranged on the basis of their increasing atomic number

(a) (i) only (b) (i), (ii) and (iii)
(c) (i), (ii) and (iv) (d) (iv) only

75. Consider the following statements:

(i) The discovery of inert gases later on did not disturb Mendeleev's arrangement.
(ii) In the present periodic table, periodicity in the properties of elements is related to the periodicity in their electronic configurations.

Which of these statement(s) is/are correct ?

(a) (i) only (b) (ii) only
(c) Both (i) and (ii) (d) Neither (i) nor (ii)

76. Which of the following statements are correct?

(i) The second period ($n = 2$) starts with lithium and third electron enters the $2s$ orbital. The next element, beryllium has four electrons and has the electronic configuration $1s^2 2s^2$. From the next element boron, the $2p$ orbitals are filled with electrons when the L shell is completed at neon ($2s^2 2p^6$). Thus there are 8 elements in the second period.
(ii) Successive filling of $3s$ and $3p$ orbitals gives rise to the third period of 8 elements from sodium to argon.
(iii) The fourth period ($n = 4$) starts at potassium and the added electron fill up the first $4s$ and $4p$ orbitals than $3d$ orbital is filled.
(iv) Fifth period begins with rubidium with the filling of $5s$ orbital and ends at xenon with the filling up of the $5p$ orbital.

(a) (i) and (ii) (b) (i), (ii) and (iii)
(c) (iii) and (iv) (d) (i), (ii) and (iv)

77. With reference to the chemical element with atomic number 17, consider the following statements:

(i) It belongs to second period in the periodic table of chemical elements.
(ii) It forms anion with unit negative charge.

Which of the statement(s) given above is/are correct ?

(a) (i) only (b) (ii) only
(c) Both (i) and (ii) (d) Neither (i) nor (ii)

78. Choose the correct codes for the following statements related to *s*-block elements. Here 'T' stands for true and F stands for false statement.

(i) They are all reactive metals with low ionization enthalpies.
(ii) Their metallic character and reactivity increase as we go down the group.
(iii) They are found in pure form in nature.
(iv) All the compounds of *s*-block elements are ionic in nature.

(a) TTFF (b) TTFT
(c) TTTF (d) TFFF

79. Consider the following statements:

(i) The elements silicon, germanium and arsenic are called metalloids.

(ii) Metalloids have properties quite different from those of metals and non-metals.

Which of these statement(s) is/are correct ?

(a) (i) only (b) (ii) only

(c) Both (i) and (ii) (d) Neither (i) nor (ii)

80. Consider the following statements:

(i) Metals will be found on the right side of the periodic table.

(ii) The element P, S and O belong to the same period.

Which of these statement(s) is/are correct ?

(a) (i) only (b) (ii) only

(c) Both (i) and (ii) (d) Neither (i) nor (ii)

81. Consider the following statements:

(i) Atomic radii decreases across a row of the periodic table when we move from left to right.

(ii) Atomic radii increases down the column as we move from top to bottom.

(iii) Although the order of elements is based on atomic numbers, vertical families share similar chemical properties.

Which of the statement(s) given above is/are correct?

(a) (i) and (ii) (b) (i) and (iii)

(c) (ii) and (iii) (d) (i), (ii) and (iii)

82. Consider the following statements:

(i) Fluorine has the highest electron affinity in the periodic table.

(ii) Noble gases are placed extremely left in periodic table.

(iii) Magnesium is more metallic in nature than sodium.

Which of these statement(s) is/are correct ?

(a) (i) and (ii) (b) (i) and (iii)

(c) Only (i) (d) Only (ii)

83. Which of the following statement(s) is/are incorrect?

(i) Ionization enthalpy is expressed in units of $kJmol^{-1}$.

(ii) Ionization enthalpy is always positive.

(iii) Second ionization enthalpy will be higher than the third ionization enthalpy.

(a) Only (ii) (b) Only (iii)

(c) (ii) and (iii) (d) None of these

84. Consider the following statements:

(i) There are 16 groups and 7 periods in the modern periodic table.

(ii) Electro-positive character decreases on moving down a group.

(iii) Electro-negativity in a period increases right from the alkali metal to the inert gas element.

Which of these statement(s) is/are correct ?

(a) (i) and (ii) (b) (i) and (iii)

(c) All are correct (d) All are incorrect

85. Read the following three statements and choose the correct option. Here T stands for true and F stands for false statement.

(i) Boron has a smaller first ionization enthalpy than beryllium.

(ii) Nitrogen has smaller first ionization enthalpy than oxygen.

(iii) The first ionization enthalpy increases across a period.

(a) FTT (b) TFT

(c) TFF (d) FFT

86. Consider the following statements

(i) The radius of an anion is larger than that of the parent atom.

(ii) The ionization energy generally increases with increasing atomic number in a period.

(iii) The electronegativity of elements increases on moving down across a group.

Which of the above statements is/are correct?

(a) (i) alone (b) (ii) alone

(c) (i) and (ii) (d) (ii) and (iii)

MATCHING TYPE QUESTIONS

87. Match the Column-I and Column-II and select correct answer by given codes.

Column-I (Year)	**Column-II (The number of elements discovered)**
(A) 1800	(p) 118
(B) 1865	(q) 63
(C) At present	(r) 31

(a) A – (q), B – (p), C – (r)

(b) A – (r), B – (p), C – (q)

(c) A – (q), B – (r), C – (p)

(d) A – (r), B – (q), C – (p)

88. Match the columns.

Column-I	**Column-II**
(A) Newland law of octaves	(p) Atomic mass vs Atomic volume
(B) Mendeleev	(q) Li, Na, K
(C) Electronic configuration	(r) One to seven groups sub-divided into group A and B
(D) Lother Meyer	(s) Periodic repetition of properties of elements
(E) Dobereiner's triad	(t) Only 56 elements known

(a) A–(t); B–(s); C–(r); D–(p); E–(q)

(b) A–(t); B–(r); C–(s); D–(p); E – (q)

(c) A–(t); B–(r); C–(s); D–(q); E – (p)

(d) A–(r); B–(t); C–(s); D–(p); E – (q)

89. Match the columns :

	Column-I		**Column-II**
(A)	On arraging in order of atomic weights, physical and chemical properties are repeated at regular intervals.	(p)	Mendeleev
(B)	Elements are arranged in the order of increasing atomic weights.	(q)	Lothar Meyer
(C)	Elements were arranged on the basis of similar properties ignoring order of atomic weights	(r)	Moseley
(D)	Atomic number is a more fundamental property of an element than its atomic mass	(s)	Chancourtois

(a) A – (p), B – (q), C – (s), D – (r)
(b) A – (r), B – (s), C – (r), D – (p)
(c) A – (q), B – (p), C – (s), D – (r)
(d) A – (q), B – (s), C – (p), D – (r)

90. Match Column-I (IUPAC nomenclature of element) with Column-II (IUPAC official name).

	Column-I		**Column-II**
(A)	Unnilhexium	(p)	Lawrencium
(B)	Unniltrium	(q)	Dubnium
(C)	Unnilunium	(r)	Seaborgium
(D)	Unnilpentium	(s)	Mendelevium

(a) A – (s), B – (p), C – (r), D – (q)
(b) A – (r), B – (p), C – (s), D – (q)
(c) A – (r), B – (s), C – (p), D – (q)
(d) A – (q), B – (r), C – (p), D – (s)

91. Match the columns.

	Column-I **(Name of element)**		**Column-II** **(Group of element)**
(A)	Nitrogen	(p)	15
(B)	Aluminium	(q)	16
(C)	Chlorine	(r)	17
(D)	Oxygen	(s)	13
(E)	Copper	(t)	11

(a) A – (p), B – (s), C – (r), D – (q), E – (t)
(b) A – (s), B – (p). C – (r), D – (q), E – (t)
(c) A – (p), B–(s), C – (q), D – (r), E – (t)
(d) A – (p), B – (s), C – (r), D – (t), E – (q)

92. Match the columns.

	Column-I **(Name of element)**		**Column-II** **(Period of element)**
(A)	Hydrogen	(p)	3
(B)	Sodium	(q)	4
(C)	Calcium	(r)	6
(D)	Barium	(s)	1
(E)	Iodine	(t)	5

(a) A – (p), B – (s), C – (q), D – (r), E – (t)
(b) A – (s), B – (p), C – (q), D – (r), E – (t)
(c) A – (s), B – (q), C – (p), D – (r), E – (t)
(d) A – (s), B – (p), C – (q), D – (t), E – (r)

93. Match the columns.

	Column-I		**Column-II**
(A)	‘s’ block elements	(p)	Cr
(B)	‘p’ block elements	(q)	Na
(C)	‘d’ block elements	(r)	Ce
(D)	‘f’ block elements	(s)	Si

(a) A – (s), B – (q), C – (p), D – (r)
(b) A – (q), B – (s), C – (r), D – (p)
(c) A – (q), B – (p), C – (s), D – (r)
(d) A – (q), B – (s), C – (p), D – (r)

94. Match the columns.

	Column-I		**Column-II**
(A)	Element with largest size in second period	(p)	Boron
(B)	Element with smallest size in group 13	(q)	Fluorine
(C)	Element with maximum non-metallic character	(r)	Bromine
(D)	Element with smallest size in fourth period	(s)	Lithium
(E)	Element with most metallic character in group 14	(t)	Lead

(a) A – (s), B – (p), C – (q), D – (t), E – (r)
(b) A – (p), B – (s), C – (q), D – (r), E – (t)
(c) A – (s), B – (q), C – (p), D – (r), E – (t)
(d) A – (s), B – (p), C – (q), D – (r), E – (t)

95. Match the columns.

	Column-I		**Column-II**
(A)	Electronegativity	(p)	Isotopes
(B)	Lanthanides	(q)	increases along a period
(C)	Transition elements	(r)	*f*-group of elements
(D)	Ionisation energy	(s)	*d*-group of elements
(E)	Elements of same atomic number but different mass number	(t)	decreases along a group

(a) A – (q), B – (r), C – (s), D – (p), E – (t)
(b) A – (r), B – (q), C – (s), D – (t), E – (p)
(c) A – (q), B – (r), C – (s), D – (t), E – (p)
(d) A – (q), B – (s), C – (r), D – (t), E – (q)

96. Match Column-I with Column-II and select the correct answer by the given codes.

	Columnn-I **(Atoms)**		**Column-II** **(Properties)**
(A)	He	(p)	High electronegative
(B)	F	(q)	Most electropositive
(C)	Rb	(r)	Strongest reducing agent
(D)	Li	(s)	Highest ionisation energy

(a) A – (s), B – (q), C – (r), D – (p)
(b) A – (p), B – (s), C – (q), D – (r)
(c) A – (s), B – (p), C – (r), D – (q)
(d) A – (s), B – (p), C – (q), D – (r)

97. Match the Column-I and Column-II and select the correct answer by given codes.

	Column-I		**Column-II**
	(Elements)		**(Properties)**
(A)	$Li^+ < Al^{3+} < Mg^{2+} < K^+$	(p)	DEA (Electron affinity)
(B)	$Li^+ > Al^{3+} > Mg^{2+} > K^+$	(q)	Ionic radii
(C)	$Cl > F > Br > I$	(r)	EN (Electronegativity)
(D)	$F > Cl > Br > I$	(s)	Effective nuclear charge

(a) A – (q), B – (s), C – (r), D – (p)
(b) A – (q), B – (s), C – (p), D – (r)
(c) A – (s), B – (q), C – (r), D – (p)
(d) A – (s), B – (q), C – (p), D – (r)

98. Match the columns on the basis of diagonal relationship between elements.

	Column-I		**Column II**
(A)	Li	(p)	Na
(B)	Be	(q)	Al
(C)	B	(r)	Si
		(s)	Mg

(a) (A) – (s), B – (r), C – (p)
(b) (A) – (s), B – (q), C – (r)
(c) (A) – (s), B – (q), C – (p)
(d) (A) – (q), B – (s), C – (p)

99. Match the columns

	Column-I		**Column-II**
(A)	$[BF_4]^-$	(p)	7, +7
(B)	$[A1F_6]^{3-}$	(q)	4, +4
(C)	OF_2	(r)	6, +3
(D)	SiF_4	(s)	2, +2
(E)	IF_7	(t)	4, +3

(a) A – (s), B – (q), C – (t), D – (r), E – (p)
(b) A – (t), B – (r), C – (s), D – (q), E – (p)
(c) A – (q), B – (r), C– (t), D – (s), E – (p)
(d) A – (r), B – (q), C – (s), D – (p), E – (t)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

100. Assertion : In a triad, the three elements present have same gaps of atomic masses.
Reason : Elements in a triad have similar properties.

101. Assertion : According to Mendeleev, periodic properties of elements is a function of their atomic number.
Reason : Atomic number is equal to the number of protons.

102. Assertion : Atomic number of the element ununbium is 112.
Reason : Name for digits 1 and 2 is un- and bi-respectively in latin words.

103. Assertion : Second period consists of 8 elements.
Reason : Number of elements in each period is four times the number of atomic orbitals available in the energy level that is being filled.

104. Assertion : Helium is placed in group 18 along with p-block elements.
Reason : It shows properties similar to p-block elements.

105. Assertion : Hydrogen can be placed in group 1.
Reason : Hydrogen can gain an electron to achieve a noble gas arrangement.

106. Assertion : Atomic size increases along a period.
Reason : Effective nuclear charge increases as the atomic number increases resulting in the increased attraction of electrons to the nucleus.

107. Assertion : Second ionization enthalpy will be higher the first ionization enthalpy.
Reason : Ionization enthalpy is a quantitative measure of the tendency of an element to lose electron.

108. Assertion : Alkali metals have least value of ionization energy within a period.
Reason : They precede alkaline earth metals in periodic table.

109. Assertion : Electron gain enthalpy can be exothermic or endothermic.
Reason : Electron gain enthalpy provides a measure of the ease with which an atom adds an electron to form anion.

110. Assertion : Smaller the size of an atom greater is the electronegativity.
Reason : Electronegativity refers to the tendency of atom so share electrons with other atom.

CRITICAL THINKING TYPE QUESTIONS

111. Which fact is not valid for Dobereiner's triads?
(a) The atomic weight of middle element is roughly average of the other two elements
(b) The properties of middle element is roughly average of the other two elements
(c) The elements of triads belong to the same group of modern periodic table
(d) The elements of triads have same valency electrons.

112. In the Mendeleev periodic table, which of the following element instead of having lower atomic weight was placed after the element of higher atomic weight thereby ignoring the order of increasing atomic weights.
(a) Iodine (b) Antimony
(c) Bromine (d) Molybdenum

113. Which of the following is correct about Eka-Aluminium and Eka-Silicon ?
(a) Oxides of Eka-Aluminium is Al_2O_3 and Eka-Silicon is Si_2O_3
(b) Oxides of Eka-Aluminium is Ga_2O_3 and Eka-Silicon is GeO_2
(c) Melting point of Eka-Aluminium is lower than the melting point of Eka-Silicon
(d) Both (a) and (c)

114. Which of the following elements are found in pitch blende?
(a) Actinium and protoactinium
(b) Neptunium and plutonium
(c) Actinium only
(d) Both (a) and (b)

115. Which of the following period contain most of the man-made radioactive elements?
(a) Seventh (b) Fifth
(c) Sixth (d) Both (a) and (c)

116. The electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^3$. What is the atomic number of the element, which is just below the above element in the periodic table?
(a) 33 (b) 34
(c) 36 (d) 49

117. Which of the following elements show the given properties?
(i) All elements are metals.
(ii) Most of the elements form coloured ions, exhibit variable valence and paramagnetism.
(iii) Oftently used as catalysts.
(a) Chalcogens
(b) Transition elements
(c) Inner transition elements
(d) Representative elements

118. Which of the given elements A, B, C, D and E with atomic number 2, 3, 7, 10 and 30 respectively belong to the same period?
(a) A, B, C (b) B, C, D
(c) A, D, E (d) B, D, E

119. According to Mendeleev's periodic classification, the electronic configuration of hydrogen atom resembles that of alkali metals, which are given below as :

$H = 1s^1$, $Li = 2s^1$, $Na = 3s^1$, $K = 4s^1$

On the other hand like halogens, hydrogen also exist as diatomic molecules, such as : H_2, Cl_2, Br_2, I_2, etc.

On the basis of above information hydrogen can be placed with :
(a) Alkali metals (b) Halogens
(c) Both (a) and (b) (d) None of these

120. Which of the following statements is **incorrect** from the point of view of modern periodic table ?
(a) Elements are arranged in the order of increasing atomic number
(b) There are eighteen vertical columns called groups
(c) Transition elements fit in the middle of long periods
(d) Noble gases are arbitrarily placed in eighteenth group

121. Element X forms a chloride with the formula XCl_2, which is a solid with a high melting point. X would most likely be in the same group of the periodic table as –
(a) Na (b) Mg
(c) Al (d) Si

122. An element X belongs to fourth period and fifteenth group of the periodic table. Which one of the following is true regarding the outer electronic configuration of X ? It has
(a) Partially filled *d*-orbitals and completely filled *s*-orbitals
(b) Completely filled *s*-orbital and completely filled *p*-orbitals
(c) Completely filled *s*-orbital and half-filled *p*-orbitals
(d) Half-filled *d*-robitals and completely filled *s*-orbitals

123. An element has electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^4$.
(a) Period = 3rd, block = p, group = 16
(b) Period = 5th, block = s, group = 1
(c) Period = 3rd, block = p, group = 10
(d) Period = 4th, block = d, group = 12

124. The periodic table of elements does not
(a) include the inert gases
(b) tell us about the arrangement of atoms in a molecule
(c) allow us to make accurate guess of the properties of undiscovered elements
(d) reveal regularities in the occurance of elements with similar properties

125. The lightest liquid metal is
(a) Hg (b) Ga
(c) Cs (d) Fr

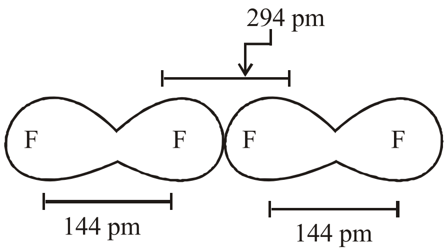
126. The correct sequence which shows decreasing order of the ionic radii of the elements is
(a) $Al^{3+} > Mg^{2+} > Na^+ > F^- > O^{2-}$
(b) $Na^+ > Mg^{2+} > Al^{3+} > O^{2-} > F^-$
(c) $Na^+ > F^- > Mg^{2+} > O^{2-} > Al^{3+}$
(d) $O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$

127. The ionic radii (Å) of C^{4-} and O^{2-} respectively are 2.60 and 1.40. The ionic radius of the isoelectronic ion N^{3-} would be
(a) 2.6 (b) 1.71
(c) 1.4 (d) 0.95

128. Which of the following species will have the smallest and the largest size?
$Cl, Na, Cl^-, Al^{3+}, Mg^{2+}, Na^+$
(a) Smallest = Na^+, Largest = Cl^-
(b) Smallest = Al^{3+}, Largest = Cl^-
(c) Smallest = Al^{3+}, Largest = Cl
(d) Smallest = Na, Largest = Cl

129. Covalent radii of atoms varies in range of 72 pm to 133 pm from F to I while that of noble gases He to Xe varies from 120pm to 220pm. This is because in case of noble gases
(a) covalent radius is very large
(b) van der Waal radius is considered
(c) metallic radii is considered
(d) None of these

130. The van der Waal and covalent radii of fluorine atom respectively from the following figure are.



(a) 219pm, 72pm (b) 75pm, 72pm
(c) 147pm, 72pm (d) 147pm, 144pm

131. Arrange the following in increasing order of ionic radii? $C^{4-}, N^{3-}, F^{-}, O^{2-}$

(a) $C^{4-} < N^{3-} < O^{2-} < F^{-}$
(b) $N^{3-} < C^{4-} < O^{2-} < F^{-}$
(c) $F^{-} < O^{2-} < N^{3-} < C^{4-}$
(d) $O^{2-} < F^{-} < N^{3-} < C^{4-}$

132. The first ($\Delta_i H_1$) and second ($\Delta_i H_2$) ionization enthalpies (in kJ mol^{-1}) and the electron gain enthalpy ($\Delta_{eg}H$) (in kJ mol^{-1}) of the elements I, II, III, IV and V are given below

Element	$\Delta_i H_1$	$\Delta_i H_2$	$\Delta_{eg}H$
I	520	7300	– 60
II	419	3051	– 48
III	1681	3374	– 328
IV	1008	1846	– 295
V	2372	5251	+ 48

The most reactive metal and the least reactive non-metal of these are respectively

(a) I and V (b) V and II
(c) II and V (d) IV and V

133. Among the following transition elements, pick out the element/elements with highest second ionization energy.

(A) V (At. no = 23) (B) Cr (At. no = 24)
(C) Mn (At. no = 25) (D) Cu (At. no = 29)
(E) Zn (At. no = 30)
(a) (A) and (C) (b) (B) and (D)
(c) (B) and (E) (d) Only (D)

134. As we move across the second period from C to F ionisation enthalpy increases but the trend from C to F for ionisation enthalpy is C < O < N < F why it is not C < N < O < F. This is because

(a) atomic radii of O > atomic radii of N
(b) electronic configuration of N is more stable than electronic configuration of O
(c) atomic radii of N > atomic radii of O
(d) None of these

135. If ionisation enthalpy of oxygen is lesser than nitrogen because of two of the four 2p– electrons occupy same 2p-orbital than why such case is not possible with fluorine which contain greater no of paired electrons because.

(a) greater size of atomic orbitals
(b) smaller size of orbitals
(c) nuclear charge overpower electronic repulsions.
(d) None of these

136. Which of the following statements is wrong ?

(a) van der Waal's radius of iodine is more than its covalent radius
(b) All isoelectronic ions belong to same period of the periodic table
(c) $I.E._1$ of N is higher than that of O while $I.E._2$ of O is higher than that of N
(d) The electron gain enthalpy of N is almost zero while that of P is 74.3 kJ mol^{-1}

137. Which one of the following statements is incorrect ?

(a) Greater the nuclear charge, greater is the electron affinity
(b) Nitrogen has zero electron affinity
(c) Electron affinity decreases from fluorine to iodine in 17th group
(d) Chlorine has highest electron affinity

138. The elements with zero electron affinity are

(a) Boron and Carbon
(b) Beryllium and Helium
(c) Lithium and Sodium
(d) Fluorine and Chlorine

139. Which of the following property of element is directly related to electronegativity?

(a) Atomic radius (b) Ionization enthalpy
(c) Non-metallic character (d) None of these

140. Which is not the correct order for the stated property.

(a) Ba > Sr > Mg ; atomic radius
(b) F > O > N ; first ionization enthalpy
(c) Cl > F > I ; electron affinity
(d) O > Se > Te ; electronegativity

141. In which of the following arrangements, the order is NOT according to the property indicated against it?

(a) Li < Na < K < Rb :
Increasing metallic radius
(b) I < Br < F < Cl :
Increasing electron gain enthalpy
(with negative sign)
(c) B < C < N < O
Increasing first ionization enthalpy
(d) $Al^{3+} < Mg^{2+} < Na^{+} < F^{-}$
Increasing ionic size

142. The compounds of the s-block elements, with the exception of lithium and ...X... are predominantly ionic. Here, X refers to

(a) hydrogen (b) helium
(c) magnesium (d) beryllium

143. Among Al_2O_3, SiO_2, P_2O_3 and SO_2 the correct order of acid strength is

(a) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$
(b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
(c) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$
(d) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$

144. Observe the following periodic table :

H 1								He 2
Li 2, 1	Be 2, 2		B 2, 3	C 2, 4	Y 2, 5	O 2, 6	F 2, 7	Ne 2, 8
Na 2, 8, 1	Ag 2, 8, 2		Al 2, 8, 3	Z 2, 8, 4	P 2, 8, 5	S 2, 8, 6	Cl 2, 8, 7	Ar 2, 8, 8
K 2, 8, 8, 1	X 2, 8, 8, 2							

Arrange the following elements X, Y, Z in increasing order of their valencies :

(a) X > Z > Y
(b) Y > Z > X
(c) Z > Y > X
(d) X > Y > Z

145. Which of the following is the reason for the different chemical behaviour of the first member of a group of elements in the *s*- and *p*-blocks compared to that of the subsequent members in the same group?

(i) Small size
(ii) Large charge / radius ratio
(iii) Low electronegativity of the element

(a) (i) and (iii)
(b) (i), (ii) and (iii)
(c) (i) and (ii)
(d) (ii) and (iii)

146. Which of the following statement(s) is/are correct ?

(i) Aluminium react with HCl to form Al^{3+} and H_2 is liberated
(ii) Aluminium dissolve in NaOH to form $NaAl(OH)_4$ and H_2

(a) (i) and (ii)
(b) Only (ii)
(c) Only (i)
(d) Neither (i) nor (ii)

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** Periodic classification of elements follow a logical consequence of electronic configuration of atoms which is used to examine the physical and chemical properties of the elements.

2. **(c)** According to Dobereneir's triad the atomic mass of Br will be average of the atomic masses of Cl & I

$$=\frac{35.5+127}{2}=81.25$$

3. **(a)**

4. **(a)** According to the law of triads the atomic wt of the middle element is arithmatic mean of I and III.

$$\text{At wt of Br}=\frac{\text{At.wt of Cl}+\text{At wt of I}}{2}$$

5. **(b)** In 1800, only 31 elements were known by 1865 the number of identified elements had more than doubled to 63. At present 116 elements are known. Of them the recently discovered elements are man-made.

6. **(c)** Johann Dobereiner in early 1800's was the first to consider the idea of trends among properties of elements. By 1829 he noted a similarity among the physical and chemical properties of several groups of three elements (triads).

7. **(a)** According to law of triad,

$$\begin{array}{ccc} \text{Li} & \text{Na} & \text{K} \\ \downarrow & \downarrow & \downarrow \end{array}$$

$$\frac{39+7}{2}=\frac{46}{2}=23$$

8. **(c)** Arithmetic mean of atomic mass of F and Br

$$=\frac{19+80}{2}=49.5.$$

Atomic mass of Cl = 35.5

$\therefore$ Arithmetic mean of atomic masses of F and Br $\neq$ Atomic mass of Cl.

9. **(c)**

10. **(c)** Every eighth element had the similar properties to the first element.

11. **(b)** Lothar Meyer plotted the physical properties such as atomic volume, melting point and boiling point against atomic weight and obtained a periodically repeated pattern.

12. **(a)** **13.** **(d)** **14.** **(c)**

15. **(b)** Correct order is Dobereiner, Chancourtois, Newlands, Mendeleev.

16. **(d)** Chloride formulas

(i) Eka-Aluminium = $GaCl_3(ECl_3)$

(ii) Eka-Silicon = $GeCl_4(ECl_4)$

Mendeleef arranged elements in horizontal rows and vertical columns of a table in order to their increasing atomic weights.

17. **(b)**

18. **(d)** 118 elements are known at present. The recently discovered elements are man-made.

19. **(c)** Moseley discovered that atomic number is more fundamental property than atomic mass.

20. **(d)** 6th period consists of 32 elements.

21. **(b)**

22. **(b)** The period number corresponds to the highest principal quantum number (n) of the element.

23. **(a)** Atomic number (Z) = 120

IUPAC name = Unbinilium

Symbol = Ubn

24. **(b)** Element with atomic number 104 was named by American society as Rutherfordium and Kurchatovium by soviet society.

25. **(c)**

Digit	**Name**
1	un
4	quad

Using above notation IUPAC name of element 114 is Ununquadium.

26. **(b)** Its valence shell has 5 electrons (ns^2, np^3). It belongs to 5th group of the periodic table.

27. **(b)**

28. **(d)** Because of the presence of same number of valence electrons the elements of same group have similar chemical properties.

29. **(c)** Halogens are most electronegative elements i.e., they are likely to form anions most readily.

30. **(d)** Barium has atomic number 56. It is an alkaline earth metal i.e., found in *s*-block.

31. **(c)**

32. **(c)** Element with Z = 33

($1s^2 2s^2 p^6 3s^2 p^6 d^{10} 4s^2 p^3$) lies in fifth (or 15th) group.

33. **(a)** The electronic configuration clearly suggest that it is a d-block element (having configuration $(n-1)\,d^{1-10}\,ns^{0-2}$) which starts from III B and goes till II B. Hence with d^3 configuration it would be classified in the group.

34. **(d)** **35.** **(c)**

36. (c) Elements (a), (b) and (d) belong to the same group since each one of them has two electrons in the s sub shell. In contrast, element (c) has seven electrons in the valence shell and hence does not lie in the same group in which elements (a), (b) and (d) lie.

37. (c)

38. (b) Na and Cl both belongs to III period.

39. (b) **40. (b)**

41. (b) $1s^2, 2s^2 2p^6, \underbrace{3s^2 3p^4}_{\downarrow}$

Number of shell = 3
(Principal quantum number)
Number of period = 3
Valence electrons = 6 i.e., 2 + 4
Number of group = 16

42. (a) Metallic character decreases down group and increases along a period.

43. (b) Cu, Ag and Au are coinage metals. They belong to group IB (*d*-block) of periodic table.

44. (b) **45. (b)**

46. (b) Non-metals are mainly placed in p-block elements.

47. (b) Non-metallic character increases on moving from left to right in a period.

48. (b) Correct order of ionic size is Sn > Ce > Yb > Lu.

49. (c) On moving down in a group atomic radii increases due to successive addition of extra shell hence
O < S < Se
Further As is in group 15 having one less electron in its *p* orbital hence have higher atomic radii than group 16 elements.
i.e., O < S < Se < As

50. (a)

51. (c) Isoelectronic ions have same number of electrons.

52. (a) Continuous increase as no. of shells increases down the group.

53. (d) The size of an anion will be larger than that of the parent atom because the addition of one or more electron(s) would result in increased repulsion among the electrons and a decrease in effective nuclear charge.

54. (b) $K^+ \rightarrow K^{2+} + e^-$. Since e^- is to be removed from stable configuration.

55. (c) **56. (c)**

57. (a) IE_1 is always less than IE_2.

58. (a) $Mg = 1s^2 2s^2 2p^6 3s^2$
After removing of 2 electron, the magnesium acquired noble gas configuration hence removing of 3rd electron will require large amount of energy.

59. (d) ns^1 configuration and lesser IE.

60. (b) As I.E. of Mg is more

61. (a) The halogen (group-17) and the chalcogens (group-16) are two groups of elements having highly negative electron gain enthalpies.

62. (b) O < S < F < Cl
Electron gain enthalpy – 141, –200, –333, – 349 kJ mol^{-1}

63. (a)

64. (d) Noble gases have positive values of electron gain enthalpy because the anion is higher in energy than the isolated atom and electron.

65. (a) Within a group, electron gain enthalpy becomes less negative down a group. However, adding an electron to the 2*p*-orbital leads to greater repulsion than adding an electron to the larger 3*p*-orbital. Hence, phosphorus has the least negative electron gain enthalpy.

66. (a)

67. (a) Electronegativity values of given elements are as follows:
Be – 1.5 (I) Mg – 1.2 (IV)
O – 3.5 (II) N – 3.0 (III)
i.e. II > III > I > IV

68. (b) It is electronic configuration of alkali metal. Hence it will form basic oxide.

69. (d) **70. (c)**

71. (b) Silicon has valence of 4 and bromine has valence of 1. Hence formula of compound will be $SiBr_4$.

72. (b) On passing from left to right in a period acidic character of the normal oxides of the elements increases with increase in electronegativity.

STATEMENT TYPE QUESTIONS

73. (c) Gallium was placed in place of Eka aluminium and germanium was placed in place of Eka silicon.

74. (b) **75. (c)**

76. (d) In fourth period filling up of 3*d* orbital becomes energetically favourable before the 4*p* orbital is filled.

77. (b) The chemical element with atomic number 17 is chlorine. It belongs to third period in the periodic table and forms anion with unit negative charge (Cl^-).

78. (a) For statement (iii) the *s*-block elements because of their high reactivity are never found pure in nature. For statement (iv) the compounds of the *s*-block elements with the exception of lithium and beryllium are predominantly ionic.

79. (c) **80. (d)** **81. (d)**

82. (c) Noble gases are placed extremely right in periodic table. Sodium is more metallic than magnesium as it is more electropositive and has low ionisation energy.

83. (b) Second ionization enthalpy will be higher than the first ionization enthalpy but lower than the third ionization enthalpy.

84. (d)

85. (b) Oxygen has smaller first ionization enthalpy than nitrogen.

86. (c)

MATCHING TYPE QUESTIONS

87. (d) A. 1800 → 31 elements were known
B. 1865 → 63 elements
C. At present → 118

88. (b) **89. (d)** **90. (b)** **91. (a)** **92. (b)**

93. (d) **94. (d)** **95. (c)**

96. (d) Helium (He) $1s^2$ → Highest ionisation energy due to noble gas in nature.
Fluorine (F) $1s^2, 2s^2 2p^3$ → High electronegativity in nature due to small size and –1 oxidation state.
Rubidium (Rb) → Most electronegative element due to large atomic size.
Lithium (Li) → Strongest reducing agent due to small size and positive oxidation state (+1)

97. (b) A. $Li^+ < Al^{2+} < Mg^{2+} < K^+$

The cation with the greater positive charge will have a smaller radius because of the greater attraction of the electrons to the nucleus. Anion with the greater negative charge will have the larger radius.

$$\text{Positive charge} \propto \frac{1}{\text{ionic radius}}$$

Negative charge $\propto$ ionic radius

B. Greater positive charge, increases effective nuclear charge in case of isoelectronic species. While for same group elements effective nuclear charge decreases down the groups.

C. $Cl > F > Br > I$
electron affinity of Cl is highest in halogen family.

D. $F > Cl > Br > I$
electronegativity of fluorine (F) is higher than Cl, Br and I.

98. (b) **99. (b)**

ASSERTION-REASON TYPE QUESTIONS

100. (d) In a triad, the atomic mass of the middle element is the mean of the atomic masses of the first and third elements.

101. (d) According to Mendeleev, periodic properties of elements is a function of their atomic masses.

102. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

103. (c) Number of elements in each period is twice the number of atomic orbitals available in the energy level that is being filled.

104. (c) He ($1s^2$) should be placed along with s-block elements because of its electronic configuration but it has a completely filled valence shell and as a result it exhibits properties of noble gases, thus it is placed along with noble gases (ns^2, np^6).

105. (b) Both the statements are correct but assertion is not correct explanation for reason.

106. (c) Atomic size generally decreases along a period.

107. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.
It is difficult to remove an electron from a positively charged ion than a neutral atom.

108. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.
Alkali metals belong to first group and have largest size in a period and hence low I.E.

109. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.
Depending on the element, the process of adding an electron to the atom can be either endothermic or exothermic.

110. (c) Assertion is true but reason is false.
Electronegativity refers to the tendency of atom to attract bonding electrons.

CRITICAL THINKING TYPE QUESTIONS

111. (b)

112. (a) Iodine with lower atomic weight than that of tellurium (Group VI) was placed in Group VII along with fluorine, chlorine, bromine because of similarities in properties.

113. (d) Oxides of Eka-Aluminium = Ga_2O_3
Oxides of Eka-Silicon = SiO_2
Melting point of Eka-Aluminium = Low (302 K)
Melting point of Eka-Silicon = High (1231 K)

114. (d) Neptunium and plutonium like actinium and protoactinium are also found in pitch.

115. (a) Seventh period includes most of the man-made radioactive elements.

116. (a) Atomic number of the given element is 15 and it belongs to 5th group. Therefore atomic number of the element below the above element
$= 15 + 18 = 33$.

117. (b) These are characteristic properties of *d*-block elements.

118. (b) **119. (c)** **120. (d)** **121. (b)** **122. (c)**

123. (a) By observing principal quantum number (n). Orbital (s, p, d, f) and equating no. of e^-'s we are able to find the period, block and group of element in periodic table.

124. (b) Periodic table deals with elements and not molecules.

125. (c) Cs is a metal. It is liquid at room temperature. It is lighter than Hg (also a liquid metal).

126. (d) All the given species contains 10 e^- each i.e. isoelectronic.
For isoelectronic species anion having high negative charge is largest in size and the cation having high positive charge is smallest.

127. (b) The ionic radii of isoelectronic ions decrease with the increase in the magnitude of the nuclear charge.
So, decreasing order of ionic radii is $C^{4-} > N^{3-} > O^{2-}$.

128. (b) Anions will be larger and cations will be smaller than the parent atoms. Among isoelectronic species (Na^+, Mg^{2+} and Al^{3+}), the one with the larger positive nuclear charge will have a smaller radius.

$\therefore$ Largest = Cl^- and smallest = Al^{3+}

129. (b) In case of halogens covalent radius is considered this bond is formed by overlapping of electron clouds; while noble gases remain monoatomic, in this case only way to obtain radius is through van der Waal radii.

130. (c) Covalent radius is radius of an atom in its bound state i.e., in fluorine it is half of distance between two covalently bonded fluorine atoms; van der Waal radii is one-half of the distance between the nuclei of two identical non-bonded isolated atoms. These atoms are attracted toward each other through weak van der Waal's force hence van der Waal radii are very large.

131. (c) All the given species are isoelectronic. In case of isoelectronic species ionic radii increases with increase in negative charge on anions.

132. (c) I represents Li, II represents K

III represents Br, IV represents I

V represents He

So, amongst these, II represents most reactive metal and V represents least reactive non-metal.

133. (b) **134. (b)** **135. (c)**

136. (b) In the isoelectronic species, all isoelectronic anions belong to the same period and cations to the next period.

137. (c) Electron affinity of ^9F is less than that of ^{17}Cl

138. (b) Fully filled electronic configuration.

139. (c) The increase in the electronegativities across a period is accompanied by an increase in non-metallic properties (or decrease in metallic properties) of elements.

140. (b) On moving along the period, ionization enthalpy increases.

In second period, the order of ionization enthalpy should be as follows :

$F > O > N.$

But N has half-filled structure, therefore, it is more stable than O. That is why its ionization enthalpy is higher than O. Thus, the correct order of IE is

$F > N > O.$

141. (c) In a period the value of ionisation potential increases from left to right with breaks where the atoms have some what stable configuration. In this case N has half filled stable orbitals. Hence has highest ionisation energy. Thus the correct order is

$$B < C < O < N$$

and not as given in option (c)

142. (d) With the exception of lithium and beryllium compounds of s-block elements are predominantly ionic.

143. (d) As the size increases the basic nature of oxides changes to acidic nature i.e., acidic nature increases.

$$\underset{\text{Acidic}}{SO_2 > P_2O_3} > \underset{\text{Weak acidic}}{SiO_2} > \underset{\text{Amphoteric}}{Al_2O_3}$$

SO_2 and P_2O_3 are acidic as their corresponding acids H_2SO_3 and H_3PO_3 are strong acids.

144. (c)

145. (c) The anomalous behaviour of first member of a group of element in the *s*- and *p*-block element is due to their small size, large charge/radius ratio and high electronegativity.

146. (a) Because Al is amphotoric in nature so it dissolve in both acid and base.

CHAPTER

4

CHEMICAL BONDING AND MOLECULAR STRUCTURE

FACT/DEFINITION TYPE QUESTIONS

1. The attractive force which holds various constituents (atoms, ions etc.) together in different chemical species is called a

(a) chemical bond (b) chemical compound

(c) ionic bond (d) covalent bond

2. The evolution of various theories of valence and the interpretation of the nature of chemical bonds have closely been related to the developments in the understanding of

(a) structure of atom

(b) electronic configuration of elements

(c) periodic table

(d) All of the above

3. Who provide explanation of valence based on intertness of noble gases ?

(a) Lewis (b) Kössel-Lewis

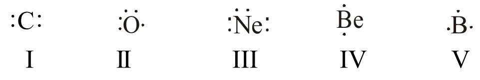
(c) Langmuir (d) Sidgwick & Powell

4. In the formation of a molecule which of the following take part in chemical combination?

(a) cation (b) anion

(c) valence electron (d) inner shell electron

5. Which of the following do(es) not represent correct Lewis symbols?



(a) I, IV & V (b) II, III & IV

(c) II only (d) II & III

6. The bond formed as a result of the electrostatic attraction between the positive and negative ions is termed as ...

(a) Chemical bond (b) Electrovalent bond

(c) Co-ordinate bond (d) Covalent bond

7. Cation and anion combines in a crystal to form following type of compound

(a) ionic (b) metallic

(c) covalent (d) dipole-dipole

8. Electrovalence of calcium and chlorine respectively is

(a) + 2, – 1 (b) + 1, – 1

(c) + 1, – 2 (d) + 2, – 2

9. When a metal atom combines with non-metal atom, the non-metal atom will

(a) lose electrons and decrease in size

(b) lose electrons and increase in size

(c) gain electrons and decrease in size

(d) gain electrons and increase in size

10. Who introduced the term covalent bond ?

(a) Lewis (b) Langmuir

(c) Nyholm and Gillespie (d) Heitler and London

11. Which of the following is/are not the condition(s) for Lewis dot structure?

(i) Each bond is formed as a result of sharing of an electron pair between the atoms.

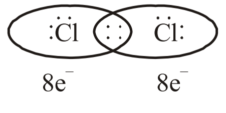
(ii) From the two combining atoms only one atom contribute electron(s) to the shared pair.

(iii) The combining atoms attain the outer shell noble gas configurations as a result of the sharing of electrons.

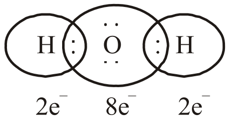
(a) (i) and (iii) (b) (ii) and (iii)

(c) (ii) only (d) (iii) only

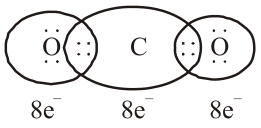
12. Which of the following does not represent the correct Lewis dot structure?



(A)



(B)

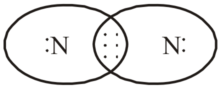


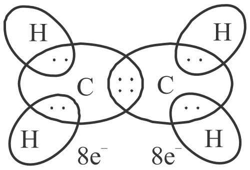
(C)

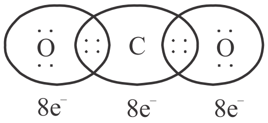
(a) A (b) B

(c) C (d) A and C

13. Which of the following statements are correct based on given Lewis dot structure ?

(i)


(ii)


(iii)


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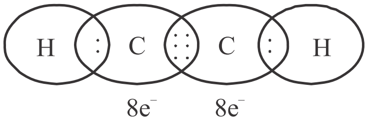
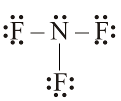
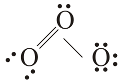
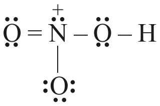


(a) (i) and (iv) represents formation of triple bond
(b) Only (iii) represents formation of double bond
(c) Only (ii) represents formation of single bond
(d) (ii) and (iii) both represents formation of single bond.

14. Which of the following Lewis representation of the molecules NF_3, O_3 and HNO_3 is correct ?


I


II


III

Choose the correct option(s).

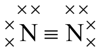
(a) Only I	(b) Only II
(c) Only III	(d) I, II and III

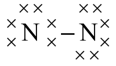
15. In N_2 molecule, the number of electrons shared by each nitrogen atom is

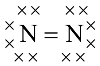
(a) 1	(b) 2
(c) 3	(d) 5

16. Which of the following represents the Lewis structure of N_2 molecule?

(a) ${}^{\times}_{\times}N \equiv N^{\times}_{\times}$

(b)

$${}^{\times}_{\times}\overset{\times\times}{N} \equiv \overset{\times\times}{N}{}^{\times}_{\times}$$

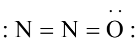
(c)

$${}^{\times}_{\times}\overset{\times\times}{N}{}^{\times}_{\times} - \underset{\times\times}{\overset{\times\times}{N}}{}^{\times}_{\times}$$

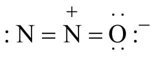
(d)

$${}^{\times}_{\times}\underset{\times\times}{\overset{\times\times}{N}} = \underset{\times\times}{\overset{\times\times}{N}}{}^{\times}_{\times}$$

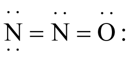
17. Which of the following shows the Lewis dot formula for CO_2 ?

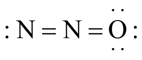
(a) $:\ddot{O}::C::\ddot{O}:$	(b) $:\underset{\cdot\cdot}{\ddot{O}}:\ddot{C}::\ddot{O}:$
(c) $:\ddot{O}::C:\underset{\cdot\cdot}{\ddot{O}}:$	(d) $:\underset{\cdot\cdot}{\ddot{O}}:C:\underset{\cdot\cdot}{\ddot{O}}:$

18. Which of the following is the correct electron dot structure of N_2O molecule?

(a)

$$:N = N = \overset{\cdot\cdot}{O}:$$

(b)

$$:N = \overset{+}{N} = \underset{\cdot\cdot}{\overset{\cdot\cdot}{O}}:^{-}$$

(c)

$$\underset{\cdot\cdot}{\overset{\cdot\cdot}{N}} = \overset{\cdot\cdot}{N} = \overset{\cdot\cdot}{O}:$$

(d)

$$:N = N = \underset{\cdot\cdot}{\overset{\cdot\cdot}{O}}:$$

19. What is X, Y and Z in the following expression of formal charge.

Formal charge (F.C) on an atom in a Lewis structure

$$= X - Y - \frac{1}{2}(Z)$$

(a) X = Total number of non bonding electrons
Y = Total number of bonding electrons
Z = Total number of valence electrons in the free atom

(b) X = Total number of valence electrons in the free atom
Y = Total number of bonding electrons
Z = Total number of non bonding electrons

(c) X = Total number of valence electrons in the free atom
Y = Total number of non bonding electrons
Z = Total number of bonding electrons

(d) X = Total number of electrons in the free atom
Y = Total number of non bonding electrons
Z = Total number of valence electrons

20. The lowest energy structure is the one with the .... formal charges on the atoms.

(a) smallest	(b) highest
(c) zero	(d) negative

21. In PO_4^{3-} ion, the formal charge on each oxygen atom and P—O bond order respectively are

(a) –0.75, 0.6	(b) –0.75, 1.0
(c) –0.75, 1.25	(d) –3, 1.25

22. In the cyanide ion, the formal negative charge is on
(a) C
(b) N
(c) Both C and N
(d) Resonate between C and N

23. What are the exceptions of the octet rule ?
(a) The incomplete octet of central atom
(b) An odd number of electrons on central atom.
(c) Expanded octet of the central atom
(d) All of these

24. In which of the following molecules octet rule is not followed?

(a) NH_3	(b) CH_4
(c) CO_2	(d) NO

25. In which of the following compounds octet is complete and incomplete for all atoms :

	Al_2Cl_6	$Al_2(CH_3)_6$	AlF_3	Dimer of $BeCl_2$	Dimer of BeH_2
(a)	IC	IC	IC	C	C
(b)	C	IC	IC	C	IC
(c)	C	IC	C	IC	IC
(d)	IC	C	IC	IC	IC

(**Note :** C for complete octet and IC for incomplete octet.)

26. Which of the following molecule(s) obey the octet rule?
(i) $[BF_4]^-$, (ii) $[AlCl_4]^-$, (iii) SO_2, (iv) CCl_4

(a) (i), (ii), (iii), (iv)	(b) (ii), (iii), (iv)
(c) (i), (iii), (iv)	(d) (i), (ii), (iii)

27. Among the following the electron deficient compound is

(a) BCl_3 (b) CCl_4

(c) PCl_5 (d) $BeCl_2$

28. Which of the following is the electron deficient molecule?

(a) C_2H_6 (b) B_2H_6

(c) SiH_4 (d) PH_3

29. Which of the following compounds does not follow the octet rule for electron distribution?

(a) PCl_5 (b) PCl_3

(c) H_2O (d) PH_3

30. A pair of compound which have odd electrons in the group NO, CO, ClO_2, N_2O_5, SO_2 and O_3 are

(a) NO and ClO_2 (b) CO and SO_2

(c) ClO_2 and CO (d) SO_2 and O_3

31. Which of the following statements is incorrect ?

(a) The formation of ionic compounds depend upon the ease of formation of the positive and negative ions from the respective neutral atoms.

(b) Formation of ionic compounds depend upon arrangement of the positive and negative ions in the solid.

(c) Formation of positive ion involves addition of electron(s) while that of negative ion involves removal of electron(s).

(d) None of these

32. Complete the following statement by choosing the appropriate option.

Ionic bonds will be formed more easily between elements with comparatively ___A___ and elements with comparatively high negative value of ___B___.

(a) A = low electronegativity
B = ionization enthalpy

(b) A = low ionization enthalpy
B = electron gain enthalpy

(c) A = high ionization enthalpy
B = electron gain enthalpy

(d) A = high electronegativity
B = ionization enthalpy

33. In ionic solids how crystal structure get stabilized

(a) By the energy released in the formation of crystal lattice.

(b) By achieving octet of electrons around the ionic species in gaseous state.

(c) By electron gain enthalpy and the ionization enthalpy.

(d) None of these

34. Energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions is called ....

(a) Ionisation enthalpy

(b) Electron gain enthalpy

(c) Bond dissociation enthalpy

(d) Lattice enthalpy

35. The effect of more electronegative atom on the strength of ionic bond

(a) increases (b) decreases

(c) remains the same (d) decreases slowly

36. Which of the following combination will form an electrovalent bond ?

(a) P and Cl (b) NH_3 and BF_3

(c) H and Ca (d) H and S

37. Among the following which compound will show the highest lattice energy ?

(a) KF (b) NaF

(c) CsF (d) RbF

38. Which of the following bond will have highest ionic character?

(a) H–I (b) H–F

(c) H–Cl (d) H–Br

39. Which of the following pairs will form the most stable ionic bond ?

(a) Na and Cl (b) Mg and F

(c) Li and F (d) Na and F

40. Which of the following methods is used for measuring bond length ?

(a) X-ray diffraction

(b) Electron-diffraction

(c) Spectroscopic techniques

(d) All of these

41. .... is measured as the radius of an atom's core which is in contact with the core of an adjacent atom in a bonded situation.

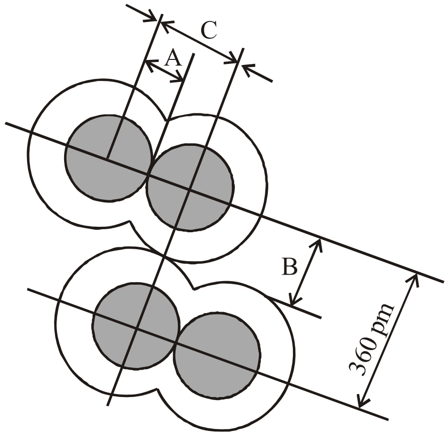
(a) van der Waal's radius

(b) Bond length

(c) Covalent radius

(d) Ionic radius

42. Following figure represent a chlorine molecule. Identify A B and C in the given figure.



(a) A = Bond length, B = van der Waal's radius
C = Covalent radius

(b) A = Covalent radius, B = Bond length
C = Ionic radius

(c) A = Ionic radius, B = van der Waal's radius
C = Covalent radius

(d) A = Covalent radius, B = van der Waal's radius
C = Bond length

43. Which of the following statement is correct?
(a) Amount of energy required to break one mole of bonds of a particular type between two atoms in a gaseous state is called bond enthalpy.
(b) The unit of bond enthalpy is kJ mol^{-1}
(c) Larger the bond dissociation enthalpy, stronger will be the bond in the molecule
(d) All of these

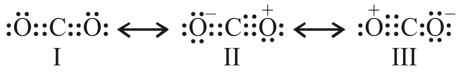
44. Complete the following statements.
With ___**A**___ in bond order, ___**B**___ increases and ___**C**___ decreases.
(a) A = increase, B = bond length, C = bond enthalpy
(b) A = decrease, B = bond enthalpy, C = bond length
(c) A = increase, B = bond enthalpy, C = bond length
(d) A = increase, B = bond angle, C = bond enthalpy

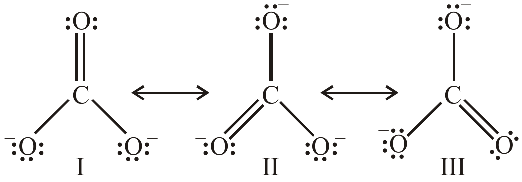
45. Which of the following molecules have same bond order ?

$$\underset{\text{I}}{H_2}, \underset{\text{II}}{Cl_2}, \underset{\text{III}}{CO}, \underset{\text{IV}}{Br_2}, \underset{\text{V}}{N_2}$$

Choose the correct option.
(a) I, II and IV have same bond order
(b) III and V have same bond order
(c) Both (a) and (b) are correct
(d) None of the above

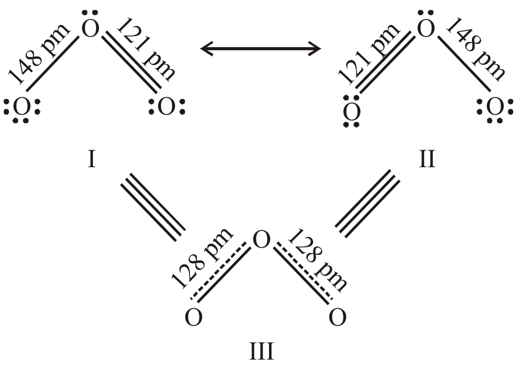
46. Which one of the following is not correct representation of resonance ?

A.


B.


Choose the correct option.
(a) Only A (b) Only B
(c) Both A and B (d) None of the above

47. Which of the following structure represents structure of O_3 more accurately?



(a) I (b) II
(c) III (d) I and II

48. Which of the following is/are misconception(s) associated with resonance ?
(i) The molecule exist for a certain fraction of time in one cannonical form and for other fractions of time in other cannonical forms.
(ii) The cannonical forms have no real existence.
(iii) There is no such equilibrium between the cannonical forms.
(a) (i) only (b) (ii) and (iii)
(c) (i) and (iii) (d) (iii) only.

49. The number of possible resonance structures for CO_3^{2-} is
(a) 2 (b) 3
(c) 6 (d) 9

50. Which one of the following is not the resonance structure of CO_2?
(a) $O=C=O$ (b) $^{-}O-C\equiv O^{+}$
(c) $^{+}O\equiv C-O^{-}$ (d) $O\equiv C=O$

51. All the bond lengths of sulphur – oxygen in sulphate ion, are equal because of:
(a) symmetry
(b) resonance
(c) high electronegativity of oxygen
(d) None of these

52. Resonance is due to
(a) delocalization of sigma electrons
(b) delocalization of pi electrons
(c) migration of protons
(d) Both (a) and (b)

53. Which one of the following pairs of molecules will have permanent dipole moments for both members ?
(a) NO_2 and CO_2 (b) NO_2 and O_3
(c) SiF_4 and CO_2 (d) SiF_4 and NO_2

54. The molecule which has zero dipole moment is
(a) CH_3Cl (b) NF_3
(c) BF_3 (d) ClO_2

55. Which of the following has dipole moment?
(a) CO_2 (b) *p*-dichlorobenzene
(c) NH_3 (d) CH_4

56. Identify the non polar molecule in the following compounds
(a) H_2 (b) HCl
(c) HF and HBr (d) HBr

57. A neutral molecule XF_3 has a zero dipole moment. The element X is most likely
(a) chlorine (b) boron
(c) nitrogen (d) carbon

58. Among the following, the molecule of high dipole moment is
(a) CCl_4 (b) NH_3
(c) H_2O (d) $CHCl_3$

59. Which one of the following molecules is expected to have zero dipole moment?
(a) H_2O (b) CO_2
(c) SO_2 (d) CaF_2

60. The correct order of dipole moments of HF, H_2S and H_2O is

(a) $HF < H_2S < H_2O$ (b) $HF < H_2S > H_2O$

(c) $HF > H_2S > H_2O$ (d) $HF > H_2O < H_2S$

61. The most polar bond is

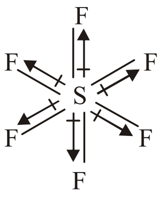
(a) C – F (b) C – O

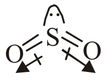
(c) C – Br (d) C – S

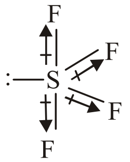
62. Which of the following possess dipole moment SF_6(a), SO_2(b), H_2S(c), SF_4(d) ?

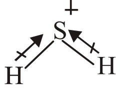
(a) b and c (b) a and c

(c) b, c and d (d) a and b









63. According to Fajan's rule, covalent bond is favoured by

(a) Large cation and small anion

(b) Large cation and large anion

(c) Small cation and large anion

(d) Small cation and small anion

64. Arrange the following in increasing order of covalent character (i) NaCl, (ii) RbCl, (iii) $MgCl_2$, (iv) $AlCl_3$?

(a) (i), (ii), (iii), (iv) (b) (iv), (ii), (i), (iii)

(c) (ii), (i), (iii), (iv) (d) (iii), (i), (ii), (iv)

65. The correct sequence of increasing covalent character is represented by

(a) $LiCl < NaCl < BeCl_2$ (b) $BeCl_2 < LiCl < NaCl$

(c) $NaCl < LiCl < BeCl_2$ (d) $BeCl_2 < NaCl < LiCl$

66. Which of the following salt shows maximum covalent character?

(a) $AlCl_3$ (b) $MgCl_2$

(c) CsCl (d) $LaCl_3$

67. Polarisibility of halide ions increases in the order

(a) F^-, I^-, Br^-, Cl^- (b) Cl^-, Br^-, I^-, F^-

(c) I^-, Br^-, Cl^-, F^- (d) F^-, Cl^-, Br^-, I^-

68. The covalent bond length is the shortest in which one of the following bonds?

(a) C — O (b) C — C

(c) $C \equiv N$ (d) O — H

69. Hydrogen chloride molecule contains

(a) polar covalent bond (b) double bond

(c) co-ordinate bond (d) electrovalent bond

70. Sodium chloride is an ionic compound whereas hydrogen chloride is mainly covalent because

(a) sodium is less reactive

(b) hydrogen is non-metal

(c) hydrogen chloride is a gas

(d) electronegativity difference in the case of hydrogen and chlorine is less than 2.1.

71. According to VSEPR theory the geometry of a covalent molecules depends upon

(a) the number of bond pairs of electrons

(b) the number of lone pairs of electrons

(c) the number of electron pairs present in the outer shell of the central atom

(d) All the above

72. The geometry of ClO_3^- ion according to Valence Shell Electron Pair Repulsion (VSEPR) theory will be

(a) planar triangular (b) pyramidal

(c) tetrahedral (d) square planar

73. In BrF_3 molecule, the lone pairs occupy equatorial positions to minimize

(a) lone pair - bond pair repulsion only

(b) bond pair - bond pair repulsion only

(c) lone pair - lone pair repulsion and lone pair - bond pair repulsion

(d) lone pair - lone pair repulsion only

74. Which of the correct increasing order of lone pair of electrons on the central atom?

(a) $IF_7 < IF_5 < ClF_3 < XeF_2$

(b) $IF_7 < XeF_2 < ClF_2 < IF_5$

(c) $IF_7 < ClF_3 < XeF_2 < IF_5$

(d) $IF_7 < XeF_2 < IF_5 < ClF_3$

75. The number of lone pair and bond pair of electrons on the sulphur atom in sulphur dioxide molecule are respectively

(a) 1 and 3 (b) 4 and 1

(c) 3 and 1 (d) 1 and 4

76. A molecule has two lone pairs and two bond pairs around the central atom. The molecule shape is expected to be

(a) V-shaped (b) triangular

(c) linear (d) tetrahedral

77. Using VSEPR theory, predict the species which has square pyramidal shape

(a) $SnCl_2$ (b) CCl_4

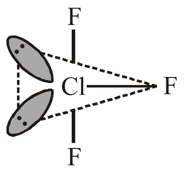
(c) SO_3 (d) BrF_5

78. Among the following molecules : SO_2, SF_4, ClF_3, BrF_5 and XeF_4, which of the following shapes does not describe any of the molecules mentioned?

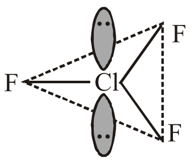
(a) Bent (b) Trigonal bipyramidal

(c) See-saw (d) T-shape

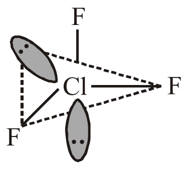
79. Which of the following structure is most stable ?



I



II



III

Choose the correct option.

(a) Only I

(b) Only II

(c) Only III

(d) All three have same stability

80. A σ-bonded molecule MX_3 is T-shaped. The number of non-bonding pairs of electron is

(a) 0
(b) 2
(c) 1
(d) can be predicted only if atomic number of M is known.

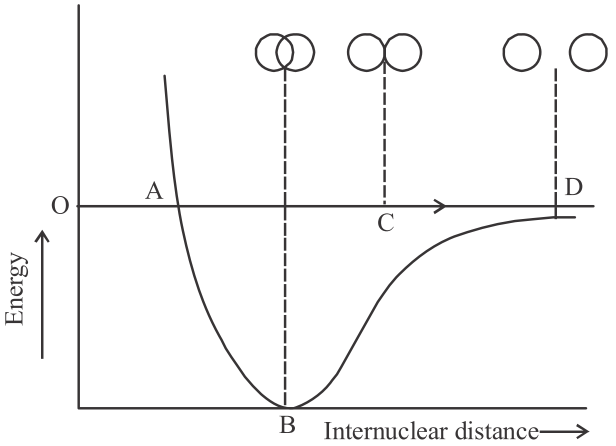
81. Shape of methane molecule is

(a) tetrahedral (b) pyramidal
(c) octahedral (d) square planar

82. The shape of stannous chloride molecule is

(a) see-saw (b) square planar
(c) trigonal pyramidal (d) bent

83. Look at the following potential energy curve which of the following correctly represents the most stable state of hydrogen molecule.



(a) A (b) B
(c) C (d) D

84. Which of the following statements is false ?

(a) H_2 molecule has one sigma bond
(b) HCl molecule has one sigma bond
(c) Water molecule has two sigma bonds and two lone pairs
(d) Acetylene molecule has three pi bonds and three sigma bonds

85. The number of sigma (σ) and pi (π) bonds present in 1,3,5,7 octatetraene respectively are

(a) 14 and 3 (b) 17 and 4
(c) 16 and 5 (d) 15 and 4

86. Allyl cyanide molecule contains

(a) 9 sigma bonds, 4 pi bonds and no lone pair
(b) 9 sigma bonds, 3 pi bonds and one lone pair
(c) 8 sigma bonds, 5 pi bonds and one lone pair
(d) 8 sigma bonds, 3 pi bonds and two lone pairs

87. The molecule not having π-bond is

(a) Cl_2 (b) O_2
(c) N_2 (d) CO_2

88. In hexa-1, 3-diene-5-yne the number of C — C δ, C — C π and C — H σ bonds, respectively are

(a) 5, 4 and 6 (b) 6, 3 and 5
(c) 5, 3 and 6 (d) 6, 4 and 5

89. The angle between the overlapping of one s-orbital and one p-orbital is

(a) 180° (b) 120°
(c) 109°28' (d) 120° 60'

90. The enolic form of a acetone contains

(a) 9 sigma bonds, 1 pi bond and 2 lone pairs
(b) 8 sigma bonds, 2 pi bonds and 2 lone pairs
(c) 10 sigma bonds, 1 pi bond and 1 lone pair
(d) 9 sigma bonds, 2 pi bonds and 1 lone pair

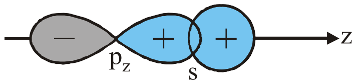
91. Linear combination of two hybridized orbitals belonging to two atoms and each having one electron leads to a

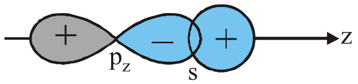
(a) sigma bond
(b) double bond
(c) co-ordinate covalent bond
(d) pi bond.

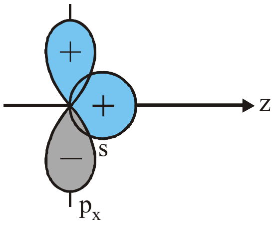
92. Which of the following statements is not correct ?

(a) Double bond is shorter than a single bond
(b) Sigma bond is weaker than a π (pi) bond
(c) Double bond is stronger than a single bond
(d) Covalent bond is stronger than hydrogen bond

93. Which of the following represents zero overlap of atomic orbitals.

(a)


(b)


(c)


(d) All of these

94. As the s-character of hybridised orbital increases, the bond angle

(a) increase (b) decrease
(c) becomes zero (d) does not change

95. Which of the following is/are not essential condition(s) for hybridisation?

(i) The orbitals present in the valence shell of the atom are hybridised.
(ii) The orbitals undergoing hybridisation should have almost equal energy.
(iii) Promotion of electron is essential prior to hybridisation
(iv) Only half filled orbitals participate in hybridisation.

(a) (i) only (b) (iii) only
(c) (iv) only (d) (iii) and (iv)

96. The nature of hybridisation in the ammonia molecule is
(a) sp^2 (b) dp^2
(c) sp (d) sp^3

97. The shape of sulphate ion is
(a) square planar (b) triagonal
(c) trigonal planar (d) tetrahedral

98. The strength of bonds formed by s–s and p–p, s–p overlap in the order of
(a) s–p > s–s > p–p (b) p–p > s–s > s–p
(c) s–s > p–p > s–p (d) s–s > s–p > p–p

99. Which of the following will have sp^3d^3 hybridisation?
(a) BrF_5 (b) PCl_5
(c) XeF_6 (d) SF_6

100. The shape of CO_2 molecule is
(a) linear (b) tetrahedral
(b) planar (d) pyramidal

101. The hybridisation state of carbon in fullerene is
(a) *sp* (b) sp^2
(c) sp^3 (d) sp^3d

102. Which of the following statements is true for an ion having sp^3 hybridisation?
(a) all bonds are ionic
(b) H-bonds are situated at the corners of a square
(c) all bonds are co-ordinate covalent
(d) H-atoms are situated at the corners of tetrahedron

103. Which of the following molecule does not have a linear arrangement of atoms ?
(a) H_2S (b) C_2H_2
(c) BeH_2 (d) CO_2

104. In which one of the following molecules the central atom said to adopt sp^2 hybridization?
(a) BeF_2 (b) BF_3
(c) C_2H_2 (d) NH_3

105. Considering the state of hybridization of carbon atoms, find out the molecule among the following which is linear ?
(a) $CH_3-CH=CH-CH_3$
(b) $CH_3-C\equiv C-CH_3$
(c) $CH_2=CH-CH_2-C\equiv CH$
(d) $CH_3-CH_2-CH_2-CH_3$

106. Equilateral shape has
(a) *sp* hybridisation (b) sp^2 hybridisation
(c) sp^3 hybridisation (d) None of these

107. In an octahedral structure, the pair of *d* orbitals involved in d^2sp^3 hybridization is
(a) $d_{x^2-y^2}, d_{z^2}$ (b) $d_{xz}, d_{x^2-y^2}$
(c) d_{z^2}, d_{xz} (d) d_{xy}, d_{yz}

108. The trigonal bipyramidal geometry is obtained from the hybridisation
(a) dsp^3 or sp^3d (b) dsp^2 or sp^2d
(c) d^2sp^3 or sp^3d^2 (d) None of these

109. In which of the following species is the underlined carbon having sp^3 - hybridisation ?
(a) $CH_3-\underline{C}OOH$ (b) $CH_3\underline{C}H_2OH$
(c) $CH_3\underline{C}OCH_3$ (d) $CH_2=\underline{C}H-CH_3$

110. A sp^3-hybrid orbital contains
(a) 25% s-character (b) 75% s-character
(c) 50% s-character (d) 25% p-character

111. The types of hybridisation of the five carbon atoms from left to right in the molecule $CH_3-CH=C=CH-CH_3$ are
(a) $sp^3, sp^2, sp^2, sp^2, sp^3$ (b) $sp^3, sp, sp^2, sp^2, sp^3$
(c) $sp^3, sp^2, sp, sp^2, sp^3$ (d) $sp^3, sp^2, sp^2, sp, sp^3$

112. Pick out the incorrect statement from the following
(a) sp hybrid orbitals are equivalent and are at an angle of 180° with each other
(b) sp^2 hybrid orbitals are equivalent and bond angle between any two of them is 120°
(c) sp^3d^2 hybrid orbitals are equivalent and are oriented towards corners of a regular octahedron
(d) sp^3d^3 hybrid orbitals are not equivalent

113. All carbon atoms are sp^2 hybridised in
(a) 1, 3-butadiene (b) $CH_2=C=CH_2$
(c) cyclohexane (d) 2-butene

114. Which one of the following is not correct in respect of hybridization of orbitals?
(a) The orbitals present in the valence shell only are hybridized
(b) The orbitals undergoing hybridization have almost equal energy
(c) Promotion of electron is not essential condition for hybridization
(d) Pure atomic orbitals are more effective in forming stable bonds than hybrid orbitals

115. Molecular orbital theory was given by
(a) Kossel (b) Mosley
(c) Mulliken (d) Werner

116. Atomic orbital is monocentric while a molecular orbital is polycentric. What is the meaning of above statements?
(a) Electron density in atomic orbital is given by the electron distribution around a nucleus in an atom. While in molecular orbital it is given by the electron distribution around group of nuclei in a molecule.
(b) While an electron in an atomic orbital is influenced by one nucleus, in a molecular orbital it is influenced by two or more nuclei depending upon the number of atoms in the molecule.
(c) The electron in an atomic orbital is present in one nucleus while in molecular orbital electrons are present on more than one nuclei depending upon the number of atoms in the molecule.
(d) All of these

117. With increasing bond order, stability of bond
(a) Remain unaltered (b) Decreases
(c) Increases (d) None of these

118. The given increasing order of energies of various molecular orbitals is not true for which of the following molecule?
$\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$
(a) B_2 (b) C_2
(c) N_2 (d) O_2

119. Which of the following corresponds unstable molecule? Here N_b is number of bonding electrons and N_a is number of antibonding electrons.
(a) $N_b > N_a$ (b) $N_b < N_a$
(c) $N_a = N_b$ (d) Both (b) and (c)

120. If N_x is the number of bonding orbitals of an atom and N_y is the number of antibonding orbitals, then the molecule/atom will be stable if
(a) $N_x > N_y$ (b) $N_x = N_y$
(c) $N_x < N_y$ (d) $N_x \le N_y$

121. In the molecular orbital diagram for O_2^+ ion, the highest occupied orbital is
(a) σ MO orbital (b) π MO orbital
(c) π^* MO orbital (d) σ^* MO orbital

122. The theory capable of explaining paramagnetic behaviour of oxygen is
(a) resonance theory
(b) V.S.E.P.R. theory
(c) molecular orbital theory
(d) valence bond energy

123. In an anti-bonding molecular orbital, electron density is minimum
(a) around one atom of the molecule
(b) between the two nuclei of the molecule
(c) at the region away from the nuclei of the molecule
(d) at no place

124. When two atomic orbitals combine, they form
(a) one molecular orbital (b) two molecular orbital
(c) three molecular orbital (d) four molecular orbital

125. Paramagnetism is exhibited by molecules
(a) not attracted into a magnetic field
(b) containing only paired electrons
(c) carrying a positive charge
(d) containing unpaired electrons

126. The difference in energy between the molecular orbital formed and the combining atomic orbitals is called
(a) bond energy (b) activation energy
(c) stabilization energy (d) destabilization energy

127. The bond order in N_2^+ is
(a) 1.5 (b) 3.0
(c) 2.5 (d) 2.0

128. Which molecule has the highest bond order?
(a) N_2 (b) Li_2
(c) He_2 (d) O_2

129. Which one of the following molecules is expected to exhibit diamagnetic behaviour ?
(a) C_2 (b) N_2
(c) O_2 (d) S_2

130. The correct statement with regard to H_2^+ and H_2^- is
(a) both H_2^+ and H_2^- are equally stable
(b) both H_2^+ and H_2^- do not exist
(c) H_2^- is more stable than H_2^+
(d) H_2^+ is more stable than H_2^-

131. Mark the incorrect statement in the following
(a) the bond order in the species O_2, O_2^+ and O_2^- decreases as $O_2^+ > O_2 > O_2^-$
(b) the bond energy in a diatomic molecule always increases when an electron is lost
(c) electrons in antibonding M.O. contribute to repulsion between two atoms.
(d) with increase in bond order, bond length decreases and bond strength increases.

132. According to molecular orbital theory which of the following statement about the magnetic character and bond order is correct regarding O_2^+
(a) Paramagnetic and Bond order < O_2
(b) Paramagnetic and Bond order > O_2
(c) Diamagnetic and Bond order < O_2
(d) Diamagnetic and Bond order > O_2

133. Bond order is a concept in the molecular orbital theory. It depends on the number of electrons in the bonding and antibonding orbitals. Which of the following statements is true about it ? The bond order
(a) can have a negative quantity
(b) has always an integral value
(c) can assume any positive or integral or fractional value including zero
(d) is a non-zero quantity

134. Which of the following does not exist on the basis of molecular orbital theory ?
(a) H_2^+ (b) He_2^+
(c) He_2 (d) Li_2

135. The paramagnetic property of the oxygen molecule is due to the presence of unpaired electrons present in
(a) $(\sigma 2p_x)^1$ and $(\sigma^* 2p_x)^1$
(b) $(\sigma 2p_x)^1$ and $(\pi 2p_y)^1$
(c) $(\pi^* 2p_y)^1$ and $(\pi^* 2p_z)^1$
(d) $(\pi^* 2p_x)^1$ and $(\pi^* 2p_z)^1$

136. In which of the following state of compound the magnitude of H-bonding will be maximum and in which case it will be minimum ?
(a) Maximum = Solid, Minimum = Liquid
(b) Maximum = Liquid, Minimum = Gas
(c) Maximum = Solid, Minimum = Gas
(d) Maximum = Gas, Minimum = Solid

137. Which of the following are correctly classified ?

	Intermolecular H-bonding	**Intramolecular H-bonding**
(a)	HF	H_2O
(b)	CH_3OH	HF
(c)	H_2O	*o*-nitrophenol
(d)	HF	*p*-nitrophenol

138. Intramolecular hydrogen bond exists in
(a) *ortho* nitrophenol
(b) ethyl alcohol
(c) water
(d) diethyl ether

139. The boiling point of *p*-nitrophenol is higher than that of *o*-nitrophenol because
(a) NO_2 group at *p*-position behave in a different way from that at *o*-position.
(b) intramolecular hydrogen bonding exists in *p*-nitrophenol
(c) there is intermolecular hydrogen bonding in *p*-nitrophenol
(d) *p*-nitrophenol has a higher molecular weight than *o*-nitrophenol.

140. Which one of the following is the correct order of interactions ?
(a) Covalent < hydrogen bonding < vander Waals < dipole-dipole
(b) vander Waals < hydrogen bonding < dipole < covalent
(c) vander Waals < dipole-dipole < hydrogen bonding < covalent
(d) Dipole-dipole < vander Waals < hydrogen bonding < covalent.

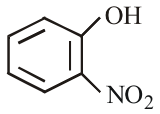
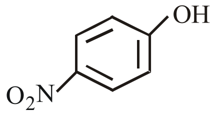
141. Strongest hydrogen bond is shown by
(a) water
(b) ammonia
(c) hydrogen fluoride
(d) hydrogen sulphide

142. The low density of ice compared to water is due to
(a) induced dipole-induced dipole interactions
(b) dipole-induced dipole interactions
(c) hydrogen bonding interactions
(d) dipole-dipole interactions

143. Methanol and ethanol are miscible in water due to
(a) covalent character
(b) hydrogen bonding character
(c) oxygen bonding character
(d) None of these

144. The hydrogen bond is shortest in
(a) $S-H\cdots S$
(b) $N-H\cdots O$
(c) $S-H\cdots O$
(d) $F-H\cdots F$

145. Hydrogen bonding is maximum in
(a) C_2H_5OH
(b) CH_3OCH_3
(c) $(CH_3)_2C=O$
(d) CH_3CHO

146. The vapour pressure of  is higher than  due to
(a) dipole moment
(b) dipole-dipole interaction
(c) H-bonding
(d) lattice structure

147. The reason for exceptionally high boiling point of water is
(a) its high specific heat
(b) its high dielectric constant
(c) low ionization of water molecule
(d) hydrogen bonding in the molecules of water

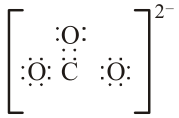
148. Acetic acid exists as dimer in benzene due to
(a) condensation reaction
(b) hydrogen bonding
(c) presence of carboxyl group
(d) presence of hydrogen atom at α-carbon

149. Hydrogen bonding is formed in compounds containing hydrogen and
(a) highly electronegative atoms
(b) highly electropositive atoms
(c) metal atoms with *d*-orbitals occupied
(d) metalloids

STATEMENT TYPE QUESTIONS

150. Read the following statements and choose the correct sequence of T and F from the given codes. Here T represents true and F represents false statement.
(i) The number of dots in Lewis symbol represents the number of valence electrons.
(ii) Number of valence electrons helps to calculate group valence of element.
(iii) Group valence is given as 8 minus the number of inner shell electrons.
(a) T T T
(b) T F F
(c) T T F
(d) F F F

151. Based on the following Lewis dot structure which of the given statement(s) is/are correct?



(i) There is formation of a double bond and two single bonds.
(ii) There are two additional electrons than those provided by the neutral atoms.
(iii) The least electropositive atom occupies the central position in the molecule/ion.
(a) (i) and (iii)
(b) (i), (ii) and (iii)
(c) (iii) only
(d) (i) and (ii)

152. Choose the correct sequence of T and F for following statements. Here T stands for true statement and F stands for false statement.

(i) Formal charge in the Lewis structure helps in keeping track of the valence electrons in the molecule.
(ii) Formal charge indicates the actual charge separation within the molecule.
(iii) Formal charges help in the selection of the lowest energy structure from a number of possible Lewis structures.

(a) T T F (b) T F T
(c) T T T (d) F T T

153. Read the following statements and choose the correct option. Here T stands for True and F stands for False statement.

(i) The smaller the size of the cation and the larger the size of the anion, the greater the covalent character of an ionic bond.
(ii) The smaller the charge on the cation, the greater the covalent character of the ionic bond.
(iii) For cations of the same size and charge, the one, with electronic configuration $(n-1)d^n ns^0$, typical of transition metals, is more polarising than the one with a noble gas configuration, $ns^2\ np^6$, typical of alkali and alkaline earth metal cations.

(a) T T T (b) T T F
(c) T F T (d) F T T

154. Choose the correct sequence of T and F for following statements. Here T stands for True and F for False statement.

(i) Sigma bond is formed by head on overlap of bonding orbitals along the internuclear axis.
(ii) Pi bond is formed when atomic orbitals overlap in such a way that their axes remain parallel to each other and perpendicular to the internuclear axis.
(iii) Half-filled *s*-orbital of one atom and half filled *p*-orbitals of another atom forms. π bond on overlapping.
(iv) Overlapping in case of pi-bond takes place to a larger extent as compared to sigma bond.

(a) T T T T (b) T F T F
(c) T T F F (d) T T F T

155. Give the correct order of initials *T* or *F* for following statements. Use *T* if statement is true and *F* if it is false :

(i) The order of repulsion between different pair of electrons is $l_p - l_p > l_p - b_p > b_p - b_p$
(ii) In general, as the number of lone pair of electrons on central atom increases, value of bond angle from normal bond angle also increases
(iii) The number of lone pair on O in H_2O is 2 while on N in NH_3 is 1
(iv) The structures of xenon fluorides and xenon oxyfluorides could not be explained on the basis of VSEPR theory

(a) TTTF (b) TFTF
(c) TFTT (d) TFFF

156. Which of the following statements is/are not correct for combination of atomic orbitals?

(i) The combining atomic orbitals must have the same or nearly the same energy.
(ii) Greater the extent of overlap, the greater will be the electron density between the nuclei of a moleculer orbital.
(iii) $2p_z$ orbital of one atom can combine with either of $2p_x$, $2p_y$ or $2p_z$ orbital of other atom as these orbitals have same energy.

(a) (i) and (ii) (b) (iii) only
(c) (i) only (d) (ii) and (iii)

MATCHING TYPE QUESTIONS

157. Match the columns

	Column-I		Column-II
(A)	BeH_2	(p)	Odd electron molecules
(B)	SF_6	(q)	Expanded octet
(C)	NO_2	(r)	Incomplete octet of central atom

(a) A – (p), B – (q), C – (r)
(b) A – (q), B – (r), C – (p)
(c) A – (r), B – (q), C – (p)
(d) A – (r), B – (p), C – (q)

158. Match the columns

	Column-I		Column-II
(A)	HCl	(p)	Covalent compound with directional bond
(B)	CO_2	(q)	Ionic compound with non-directional bonds
(C)	NaCl	(r)	Polar molecule
(D)	CCl_4	(s)	Non-polar molecule

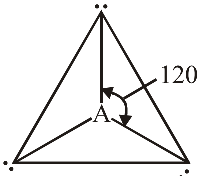
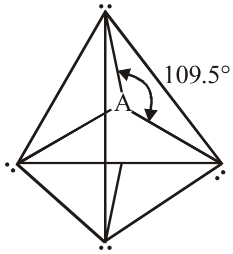
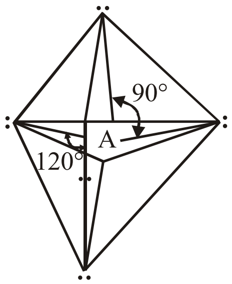
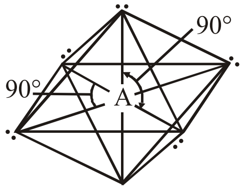
(a) A – (p, q, r), B – (q, r), C – (p, q), D – (r)
(b) A – (q), B – (r), C – (p), D – (s)
(c) A – (p, r), B – (p, s), C – (q), D – (p, s)
(d) A – (q), B – (r), C – (p, q), D – (s)

159. Match Column-I with Column-II and Column-III and choose the correct option from the given codes.

	Column-I Molecule		Column-II (No. of lone pairs and bond pairs)		Column-III (Shape of molecule)
(A)	NH_3	(i)	1, 2	(p)	Bent
(B)	SO_2	(ii)	1, 4	(q)	Trigonal pyramidal
(C)	SF_4	(iii)	2, 3	(r)	T-shape
(D)	ClF_3	(iv)	1, 3	(s)	See-Saw

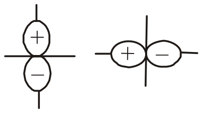
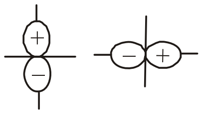
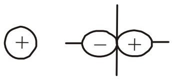
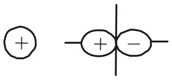
(a) A – (iv, q); B – (ii, p); C – (i, r); D – (iii, s)
(b) A – (iv, q); B – (i, p); C – (ii, s); D – (iii, r)
(c) A – (i, p); B – (iii, s); C – (iv, r); D – (ii, q)
(d) A – (iv, p); B – (i, r); C – (iii, q); D – (ii, s)

160. Match the columns

Column-I	**Column-II**
(A) Trigonal planar  	(p) PCl_5
(B) Tetrahedral  	(q) NH_4^+
(C) Trigonal bipyramidal  	(r) SF_6
(D) Octahedral  	(s) BF_3

(a) A – (p), B – (q), C – (r), D – (s)
(b) A – (s), B – (r), C – (q), D – (p)
(c) A – (s), B – (q), C – (p), D – (r)
(d) A – (r), B – (p), C – (q), D – (s)

161. Match the columns

Column-I	**Column-II**
(A) 	(p) negative overlap
(B) 	(q) zero overlap
(C) 	(r) positive overlap
(D) 	

(a) A – (p), B – (q), C – (p), D – (r)
(b) A – (p), B – (r), C – (q), D – (p)
(c) A – (q), B – (q), C – (p), D – (r)
(d) A – (r), B – (p), C – (q), D – (p)

162. Match Column-I (molecule) with Column-II (type of hybridisation) and choose the correct option from the codes given below.

Column-I (Molecule)	**Column-II (Type of hybridisation)**
(A) SF_6	(p) sp^3d
(B) PF_5	(q) sp^3
(C) BCl_3	(r) sp^3d^2
(D) C_2H_6	(s) sp^2

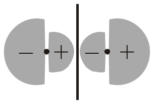
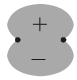
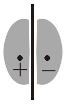
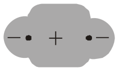
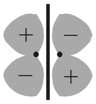
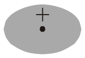
(a) A – (r), B – (p), C – (s), D – (q)
(b) A – (r), B – (p), C – (q), D – (s)
(c) A – (p), B – (r), C – (q), D – (s)
(d) A – (p), B – (r), C – (s), D – (q)

163. Match the columns

Column-I	**Column-II**
(A) Valence bond theory	(p) Nyholm and Gillespie
(B) Octet rule	(q) F. Hund & R. S Mulliken
(C) Molecular orbital theory	(r) Heitler and London
(D) The valence shell electron pair repulsion theory	(s) Kössel and Lewis

(a) A – (p), B – (q),C – (r), D – (s)
(b) A – (q), B – (r),C – (s), D – (p)
(c) A – (p), B – (s),C – (q), D – (r)
(d) A – (s), B – (r), C – (q), D – (p)

164. Match the columns

Column-I	**Column-II**	**Column-III**
(A) 1s	(p) 	(i) 
(B) $2p_z$	(q) 	(ii) 
(C) $2p_x$	(r) 	(iii) 

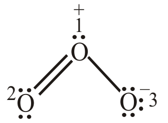
(a) A – (q, iii), B – (r, i), C – (p, ii)
(b) A – (q, iii), B – (p, ii), C – (r, i)
(c) A – (p, iii), B – (q, ii), C – (r, i)
(d) A – (p, ii), B – (q, iii), C – (r, i)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

165. **Assertion :** The correct Lewis structure of O_3 may be drawn as



Reason : The formal charges on atom 1, 2 and 3 are +1, 0 and –1 respectively.

166. **Assertion :** Atoms can combine either by transfer of valence of electrons from one atom to another or by sharing of valence electrons.
Reason : Sharing and transfer of valence electrons is done by atoms to have an octet in their valence shell.

167. **Assertion :** The lesser the lattice enthalpy more stable is the ionic compound.
Reason : The lattice enthalpy is greater, for ions of highest charge and smaller radii.

168. **Assertion :** Sulphur compounds like SF_6 and H_2SO_4 have 12 valence electrons around S atom.
Reason : All sulphur compounds do not follow octet rule.

169. **Assertion :** BF_3 molecule has zero dipole moment.
Reason : F is electronegative and B–F bonds are polar in nature.

170. **Assertion :** CH_2Cl_2 is non-polar and CCl_4 is polar molecule.
Reason : Molecule with zero dipole moment is non-polar in nature.

171. **Assertion :** Lone pair-lone pair repulsive interactions are greater than lone pair-bond pair and bond pair-bond pair interactions.
Reason : The space occupied by lone pair electrons is more as compared to bond pair electrons.

172. **Assertion :** In NH_3, N is sp^3 hybridised, but angle is found to be 107°.
Reason : The decrease in bond angle is due to repulsion between the lone pair.

173. **Assertion :** Shape of NH_3 molecule is tetrahedral.
Reason : In NH_3 nitrogen is sp^3 hybridized.

174. **Assertion :** pi bonds are weaker than σ bonds.
Reason : pi bonds are formed by the overlapping of p-p orbitals along their axes.

175. **Assertion :** The bond order of helium is always zero.
Reason : The number of electrons in bonding molecular orbital and antibonding molecular orbital is equal.

176. **Assertion :** Bonding molecular orbital has greater stability than corresponding antibonding molecular orbital.
Reason : The electron density in a bonding molecular orbital is located away from the space between the nuclei while in antibonding molecular orbital it is located between the nuclei of the bonded atoms.

177. **Assertion :** Water is one of the best solvent.
Reason : H-bonding is present in water molecules.

CRITICAL THINKING TYPE QUESTIONS

178. What is the correct mode of hybridisation of the central atom in the following compounds?

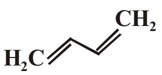
	NO^-_2	SF_4	PF_6^-
(a)	sp	sp^2	sp^3
(b)	sp^2	sp^3d	sp^3d^2
(c)	sp^2	sp^3	d^2sp^3
(d)	sp^3	sp^3	sp^3d^2

179. Which of the following molecules has trigonal planar geometry?
(a) BF_3 (b) NH_3
(c) PCl_3 (d) IF_3

180. Which of the following molecules is planar?
(a) SF_4 (b) XeF_4
(c) NF_3 (d) SiF_4

181. Hybridization present in ClF_3 is
(a) sp^2 (b) sp^3
(c) dsp^2 (d) sp^3d

182. Which of the following represents the given mode of hybridisation sp^2 –sp^2 – sp - sp from left to right ?
(a) $H_2C=CH-C\equiv N$ (b) $HC\equiv C-C\equiv CH$
(c) $H_2C=C=C=CH_2$ (d)



183. Hybridisation states of C in CH_3^+ and CH_4 are
(a) sp^2 & sp^3 (b) sp^3 & sp^2
(c) sp^2 & sp^2 (d) sp^3 & sp^3

184. The type of hybridization in xenon atom and the number of lone pairs present on xenon atom in xenon hexafluoride molecule are respectively
(a) sp^3d^3 , one (b) sp^3d^3 , two
(c) sp^3d^3 , two (d) sp^3d^2 , zero

185. In which of the following species, all the three types of hybrid carbons are present?
(a) $CH_2=C=CH_2$ (b) $CH_3-CH=CH-CH_2^+$
(c) $CH_3-C\equiv C-CH_2^+$ (d) $CH_3-CH=CH-CH_2^-$

186. If an organic compound contain 92.3% C and 7.7% H, than number of sp^3,sp^2 and sp hybridized carbon atoms in all possible structures of compound respectively are (molecular mass = 52g/mol)
(a) 1, 2, 5 (b) 0, 4, 4
(c) 0, 8, 4 (d) None of these

187. Arrange the following in increasing order of bond length

(i) N_2 (ii) N_2^+

(iii) N_2^{2+}

(a) (ii), (i) and (iii) (b) (ii), (iii) and (i)

(c) (iii), (ii) and (i) (d) (i), (ii) and (iii)

188. Which of the following molecule exist ?

(a) He_2 (b) Be_2

(c) Li_2 (d) Both (a) and (b)

189. Hybridization and structure of I^{3-} are

(a) sp^2 and trigonal planar

(b) sp^3d^2 and linear

(c) sp^3d and linear

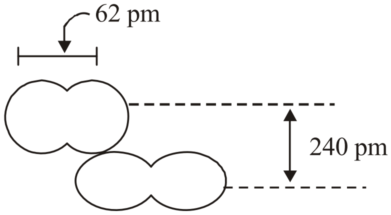
(d) sp^3 and T-shape

190. What is the change in hybridization when $AlCl_3$ changes to $[Al_2Cl_6]^{-3}$?

(a) sp^3d to sp^3d^2 (b) sp^3 to sp^3d

(c) sp^2 to sp^3d^2 (d) None of these

191. From the given figure the van der Waal radius and covalent radius of the hydrogen atom respectively are



(a) 151, 31 (b) 120, 31

(c) 31, 100 (d) 30, 120

192. Which of the following substances has the greatest ionic character ?

(a) Cl_2O (b) NCl_3

(c) $PbCl_2$ (d) $BaCl_2$

193. Among the following species, identify the pair having same bond order CN^-, O_2^-, NO^+, CN^+

(a) CN^- and O_2^- (b) O_2^- and NO^+

(c) CN^- and NO^+ (d) CN^- and CN^+

194. Which of the following is not correct with respect to bond length of the species ?

(a) $C_2 > C_2^{2-}$ (b) $B_2^+ > B_2$

(c) $Li_2^+ > Li_2$ (d) $O_2 > O_2^-$

195. The molecule which has the highest bond order is

(a) C_2 (b) N_2

(c) B_2 (d) O_2

196. The compound which cannot be formed is

(a) He (b) He^+

(c) He_2 (d) He^{+2}

197. The ground state electronic configuration of valence shell electrons in nitrogen molecule (N_2) is written as KK $\sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^2, \pi 2p_y^2 \sigma 2p_z^2$ Bond order in nitrogen molecule is

(a) 0 (b) 1

(c) 2 (d) 3

198. Bond order in benzene is

(a) 1 (b) 2

(c) 1.5 (d) None of these

199. In O_2^- , O_2 and O_2^{-2} molecular species, the total number of antibonding electrons respectively are

(a) 7, 6, 8 (b) 1, 0, 2

(c) 6, 6, 6 (d) 8, 6, 8

200. N_2 and O_2 are converted to monopositive cations N_2^+ and O_2^+ respectively. Which is incorrect ?

(a) In N_2^+ the N–N bond is weakened

(b) In O_2^+ the bond order increases

(c) In O_2^+ the paramagnetism decreases

(d) N_2^+ becomes diamagnetic

201. Bond order normally gives idea of stability of a molecular species. All the molecules viz. H_2, Li_2 and B_2 have the same bond order yet they are not equally stable. Their stability order is

(a) $H_2 > B_2 > Li_2$ (b) $Li_2 > H_2 > B_2$

(c) $Li_2 > B_2 > H_2$ (d) $B_2 > H_2 > Li_2$

202. According to MO theory which of the following lists ranks the nitrogen species in terms of increasing bond order?

(a) $N_2^{2-} < N_2^- < N_2$ (b) $N_2 < N_2^{2-} < N_2^-$

(c) $N_2^- < N_2^{2-} < N_2$ (d) $N_2^- < N_2 < N_2^{2-}$

203. Hydrogen bonding would not affect the boiling point of

(a) HI (b) H_2O

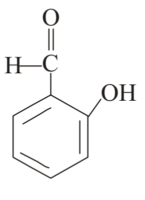
(c) NH_3 (d) CH_3OH

204. Which one of the following molecules will form a linear polymeric structure due to hydrogen bonding?

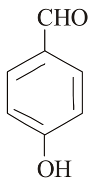
(a) NH_3 (b) H_2O

(c) HCl (d) HF

205. Which among the following can form intermolecular H – bonding ?



(A)



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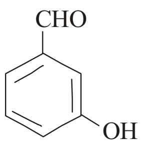
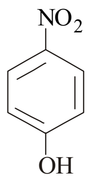


(C)



(D)

(a) A (b) B and D

(c) B, C and D (d) A and C

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** Chemical bond is an attractive force, which holds various constituents (atoms, ions etc.) together in different chemical species.

2. **(d)** The evolution of various theories of valence and the interpretation of the nature of chemical bonds have closely been related to the developments in the understanding of structure of atom, electronic configuration of elements and Periodic Table.

3. **(b)** Kossel and Lewis provide some logical explanation of valence which was based on the intertness of noble gases.

4. **(c)** In the formation of a molecule, only the outer shell electrons take part in chemical combination and they are known as **valence electrons.**

5. **(d)** Valence electrons in O = 6

∴ Correct Lewis symbol = $:\ddot{O}:$

Similarly, Ne is a noble gas having valence electrons = 8

∴ Correct Lewis symbol for Ne = $:\ddot{\underset{..}{Ne}}:$

6. **(b)** Electrovalent bond is formed as a result of electrostatic attraction between the positive and negative ions.

7. **(a)** The electrostatic force that binds the oppositely charged ions which are formed by transfer of electron(s) from one atom to another is called ionic bond. Cation and anion are oppositely charged particles therefore they form ionic bond in crystal.

8. **(a)** Calcium is assigned a positive electrovalence of two, while chlorine has a negative electrovalence of one.

9. **(d)** When a metal for example Na combines with a non metal e.g., Cl_2. Following reaction occurs

$$2Na + Cl_2 \longrightarrow 2NaCl$$

In this process Na loses one electron to form Na^+ and Cl accepts one electron to form Cl^-

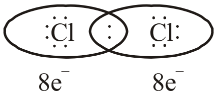
$$Na \longrightarrow Na^+ + e^-$$
$$Cl + e^- \longrightarrow Cl^-$$

Therefore, in this process Cl gain electrons and hence its size increases.

10. **(b)** **Langmuir** (1919) refined the Lewis postulations by abandoning the idea of the stationary cubical arrangement of the octet, and by introducing the term **covalent bond.**

11. **(c)** Each combining atom contributes at least one electron to the shared pair.

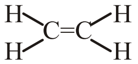
12. **(a)** In formation of Cl_2 molecule a pair of electrons is shared between the two chlorine atoms. Each chlorine atom contribute one electron to the shared pair.



13. **(a)** (i) represents $:N \equiv N:$

(iv) represents $H - C \equiv C - H$

(ii) and (iii) represents respectively :



and $\ddot{\underset{..}{O}}=C=\ddot{\underset{..}{O}}$

14. **(a)** All Lewis representation of the molecules NH_3, O_3 and HNO_3 given in question are correct.

15. **(c)** N_2 ; $N \equiv N$

3 electrons are shared by each nitrogen atom

16. **(a)** Lewis structure of N_2 is $\overset{\times\times}{N} \equiv \overset{\times\times}{N}$

17. **(a)** Step I : Skeleton OCO

Step II : A = 1 × 4 for C + 2 × 6 for O = 4 + 12 = 16 electrons

Step III : Total no. of electrons needed to achieve noble gas configuration (N)

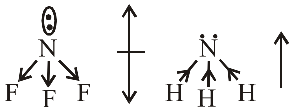
$N = 1 \times 8 + 2 \times 8 = 24$

Step IV : Shared electrons, S = N – A = 24 – 16 = 8 electrons

Step V : O::C::O

Step VI : $:\ddot{O}::C::\ddot{O}: \Rightarrow :\ddot{O} = C = \ddot{O}:$

18. **(b)**



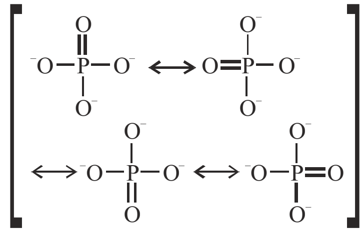
$:N\equiv\overset{+}{N}-\ddot{\underset{..}{O}}:^{-}$ octet of each atom is complete.

19. **(c)** Formal charge (F.C.) on an atom in a Lewis structure = [total number of valence electrons in the free atom] – [total number of non bonding (lone pair) electrons] – (1/2) [total number of bonding (shared) electrons]

20. **(a)** The lowest energy structure is the one with the smallest formal charges on the atoms.

21. **(c)** Bond order between P – O

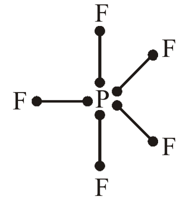
$$= \frac{\text{no. of bonds in all possible direction}}{\text{total no. of resonating structures}} = \frac{5}{4} = 1.25$$



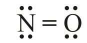
Formal charge on oxygen = $-\frac{3}{4} = -0.75$

22. (b) In CN^- ion formal negative charge is on nitrogen atom due to lone pair of electrons.

23. (d) According to octet role, the central atom must have 8 electrons but in some compounds the number of electrons is more than 8, or less than 8 or an odd number of electrons is left on the central atom e.g., PCl_5, BF_5, NO.

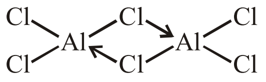

10 electrons around P


6 electrons around B

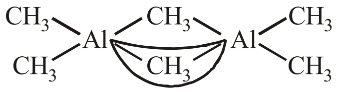

Odd electrons around N

24. (d)

25. (c) (i)

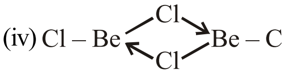

(Complete octet)

(ii)


(3c – 2e) bond (incomplete octet)

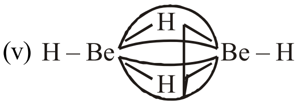
(iii) $\underset{\text{(ionic compound)}}{AlF_3} \longrightarrow \underset{\text{(octet complete)}}{\underset{2s^2 2p^6}{Al^{3+}}} + \underset{\text{(octet complete)}}{\underset{2s^2 2p^6}{3F^-}}$

(iv)


(Incomplete octet)

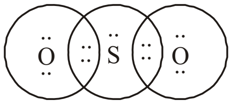
(inomplete octet)

(v)


(Incomplete octet)

(3c – 2e⁻) bond

26. (d)



Total no. of valence electron around sulphur in SO_2 is 10 while in case of other molecules total no. of 8 electrons are present in each.

27. (a) Boron in BCl_3 has 6 electrons in outermost shell. Hence BCl_3 is a electron deficient compound.

28. (b) The compounds in which octet of central atom is incomplete are known as electron deficient compounds. Hence B_2H_6 is a electron deficient compound.

29. (a) PCl_5 does not follow octet rule, it has 10 electrons in its valence shell.

30. (a)

31. (c) Formation of positive ion involves removal of electron(s) from neutral atom and that of the negative ion involves addition of electron(s) to the neutral atom.

32. (b) Ionic bonds will be formed more easily between elements with comparatively low ionization enthalpies and elements with comparatively high negative value of electron gain enthalpy.

33. (a) In ionic solids, the sum of the electron gain enthalpy and the ionization enthalpy may be positive but still the crystal structure gets stabilized due to the energy released in the formation of the crystal lattice.

34. (d) Lattice enthalpy is required to completely separate one mole of a solid ionic compound into gaseous constituent ions.

35. (a) An ionic bond tightly held the two ions of opposite charges together, so it is a dipole. More is the electronegativity of anion higher will be the electron density and higher will be its charge which consequently increses the strength of ionic bond.

36. (c) Higher the difference in electronegativity between the two atoms, more will be electrovalent character of the bond. Among given choices, calcium and hydrogen have maximum difference in their electronegativities.

37. (b) For compounds containing cations of same charge, lattice energy increases as the size of the cation decrease. Thus, NaF has highest lattice energy. The size of cations is in the order $Na^+ < K^+ < Rb^+ < Cs^+$

38. (b) Ionic character of a bond is directly proportional to the difference of electro negativities of bonded atoms. So, H – F in which electronegativity difference is highest, will have highest ionic character.

39. (b) The stability of the ionic bond depends upon the lattice energy which is expected to be more between Mg and F due to +2 charge on Mg atom.

40. (d) Bond lengths are measured by spectroscopic, X-ray diffraction and electron diffraction techniques.

41. (c) The covalent radius is measured approximately as the radius of an atom's core which is in contact with the core of an adjacent atom in a bonded situation.

42. (d) A = Covalent radius
B = van der Waal's radius
C = Bond length

43. (d) All of the given statements are correct.

44. (c) Bond order $\propto$ bond enthalpy $\propto \dfrac{1}{\text{bond length}}$

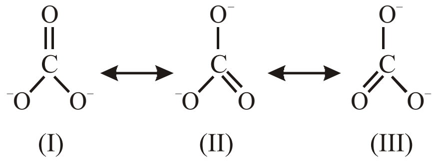
45. (c) In CO (three shared election pairs between C and O) the bond order is 3. For N_2 bond order is 3 and its $\Delta_g H^{\ominus}$ is 946 kJ mol^{-1}, being one of the highest for a diatomic molecule, isoelectronic moleculaes and ions have identical bond order for example F_2 and O_2^{2-} have bond ordeer 1, N_2, CO and NO^+ have bond order 3.

46. **(c)** Both representation of resonating structures in molecules of CO_2 and CO_3^{2-} are correct.

47. **(c)** I and II structure shown above constitute the cannonical structure. III structure represents the structure of O_3 more accurately. This is also called resonance hybrid.

48. **(a)** The molecule does not exist for a certain fraction of time in one cannonical form and for other fractions of time in other cannonical forms.

49. **(b)** There are three resonance structures of CO_3^{2-} ion.

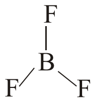


50. **(d)** Choices (a), (b) and (c) are the resonance structures of CO_2.

51. **(b)** **52.** **(b)**

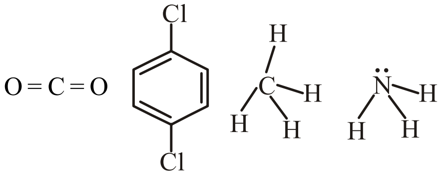
53. **(b)** Both NO_2 and O_3 have angular shape and hence will have net dipole moment.

54. **(c)** The dipole moment of symmetrical molecules is zero.



Triangular planar (symmetrical molecule)

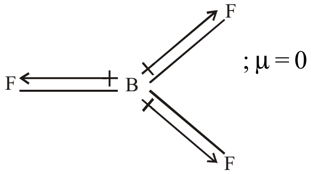
55. **(c)** Dipole moment is a vector quantity, hence the dipole moment of symmetrical molecules is zero. As CO_2, *p*-dichlorobenzene and CH_4 have regular symmetrical shape. Hence $\mu = 0$



However, NH_3 has distorted structure due to presence of lone pair of electrons on N atom and thus has definite dipole moment.

56. **(a)** In H_2, both atoms are identical, so the molecule is non polar.

57. **(b)** BF_3 has planar and symmetrical structure thus as a result the resultant of two bond moments, being equal and opposite to the third, cancels out and hence molecule possess zero dipole moment.



58. **(c)** CCl_4 and BF_3 being symmetrical have zero dipole moment. H_2O, $CHCl_3$ and NH_3 have dipole moments of 1.84 D, 1.01 D and 1.46 D respectively. Thus among the given molecules H_2O has highest dipole moment.

59. **(b)** $O=C=O$

60. **(a)** The correct order of dipole moments of HF, H_2S and H_2O us

$HF < H_2S < H_2O$

61. **(a)** $\overset{\delta+}{C} - \overset{\delta-}{F}$

Because difference between electronegativity of carbon and flourine is highest.

62. **(c)** In case of SF_6 resultant dipole moment is zero while all other possess dipole moment.

63. **(c)**

64. **(c)** According to Fajan's rule, smaller size and greater charge on cation favour the formation of partial covalent character in ionic bonds.

65. **(c)** As difference of electronegativity increases % ionic character increases and covalent character decreases i.e., electronegativity difference decreases covalent character increases.

Further greater the charge on the cation and smaller the size more will be its polarising power. Hence covalent character increases.

66. **(a)** According to Fajan's rule, as the charge on the cation increases, and size decreases, its tendency to polarise the anion increases. This brings more and more covalent nature to electrovalent compounds. Hence $AlCl_3$ shows maximum covalent character.

67. **(d)** In case of anions having same charge as the size of anion increases, polarisibility of anion also increases.

68. **(d)** The electronegativity difference is maximum in O—H bond hence O—H bond length is the smallest among the given set.

69. **(a)** A gaseous HCl molecule has hydrogen and chlorine linked by a covalent bond. Here electronegativity of chlorine is greater than that of hydrogen. Due to this the shared pair of electron is more attracted towards chlorine. Thus, chlorine end of molecule has higher electron density and becomes slightly negative and the hydrogen and slightly positive. Hence the covalent bond in HCl has a polar character as shown below

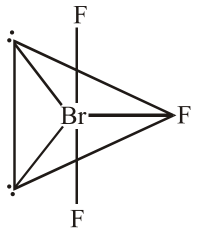
$$\overset{\delta^+}{H} \longrightarrow \overset{\delta^-}{Cl}$$

70. **(b)** Hydrogen is non metal and non metal atoms form covalent bond.

71. **(d)**

72. **(b)** Hybridisation is sp^3 and shape pyramidal.

73. **(c)**



In BrF_3, both bond pairs as well as lone pairs of electrons are present. Due to the presence of lone pairs of electrons (lp) in the valence shell, the bond angle is contracted and the molecule takes the T-shape. This is due to greater repulsion between two lone pairs or between a lone pair and a bond pair than between the two bond pairs.

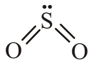
74. **(a)** The number of lone pairs of electrons on central atom in various given species are

Species	Number of lone pairs on central atom
IF_7	nil
IF_5	1
ClF_3	2
XeF_2	3

Thus the correct increasing order is

$IF_7 < IF_5 < ClF_3 < XeF_2$

0 1 2 3

75. **(d)** 

lp = 1

bp = 4

76. **(a)** V-shaped H_2O like structure.

77. **(d)** BrF_5 has square pyramidal geometry.

78. **(b)** SO_2 – bent

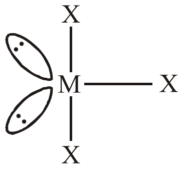
SF_4 – see-saw

ClF_3 – T-shape

BrF_5 – square pyramidal

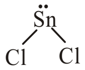
XeF_4 – square planar.

79. **(a)** I is the most stable geometry because both the lone pairs are present at equitorial position. Due to which repulsion is minimum in molecule as compared to the repulsion in other molecules where lone pair is in axial position.

80. **(b)** 

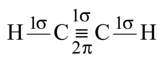
Number of lone pair = 2

81. **(a)** In methane molecule C is sp^3 hybridised so its shape will be tetrahedral.

82. **(d)**  Bent

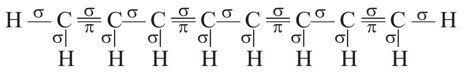
83. **(b)** The minimum in the energy curve corresponds to the most stable state of H_2.

84. **(d)** Structure of acetylene molecule



$$H \overset{1\sigma}{—} C \underset{2\pi}{\overset{1\sigma}{\equiv}} C \overset{1\sigma}{—} H$$

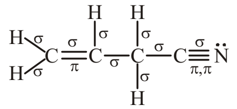
Thus acetylene molecule has 3σ bonds and 2π bonds.

85. **(b)** 

1, 3,5, 7 - octatetraene

17 σ and 4π

86. **(b)** Allyl cyanide is :



∴ It contains 9 sigma bonds, 3 pi bonds and 1 lone pair of electrons.

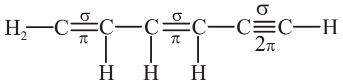
87. **(a)** Cl_2 : Cl – Cl (1σ , No π)

O_2 : O = O (1σ , 1π)

N_2 : N ≡ N (1σ, 2π)

CO_2 : O = C = O (2σ, 2π)

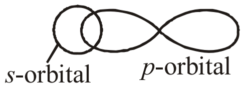
88. **(a)** The given molecule is



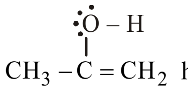
The number of C—C 'σ' bonds = 5

The number of C—C 'π' bonds = 4

The number of C—C 'σ' bonds = 6

89. **(a)** 

The overlap between s- and p-orbitals occurs along internuclear axis and hence the angle is 180°.

90. **(a)** 

$$CH_3 - \overset{\ddot{O}-H}{\overset{|}{C}} = CH_2$$ has $9\sigma, 1\pi$ and 2 lone pairs.

91. **(a)** Linear combination of two hybridized orbitals leads to the formation of sigma bond.

92. **(b)** Sigma bond is stronger than π-bond. The electrons in the π bond are loosely held. The bond is easily broken and is more reactive than σ -bond. Energy released during sigma bond formation is always more than π bond because of greater extent of overlapping

93. **(c)** Option (c) represents zero overlapping.

94. **(a)** Bond angle increases with increase in s-character of hybridised orbital. The table given below shows the hybridised orbitals, their % s-chatracter and bond angles.

Hybridised orbitals	% s-character	Bond angle
sp^3	25	109.5°
sp^2	33	120°
sp	50	180°

95. **(d)** Promotion of electron is not an essential condition prior to hybridisation. It is not necessary that only half filled orbitals participate in hybridisation. In some cases, even filled orbitals of valence shell take part in hybridisation.

96. **(d)** The hybridisation in a molecule is given by

$$H = \frac{1}{2}[V + M - C + A] \qquad ....(1)$$

where V = no. of valency e^- in central atom
M = no. of monovalent atoms around central atom
C = charge on cation, A = charge on anion
For NH_3; V = 5, M = 3, C = 0, A = 0
Putting these values in (1), we get

$$H = \frac{1}{2}[5 + 3 - 0 + 0] = 4$$

For H = 4, the hybridisation in molecule is sp^3.

97. **(d)** Hybridisaiton of SO_4^{2-} ion is given by

$$H = \frac{1}{2}[V + M + A - C]$$

Where V = valency of central metal atom
M = no. of monovalent atoms surrounding central metal atom.
A = charge on anion, C = charge on cation

For SO_4^{2-}; V = 6, M = 0, A = 2, C = 0

$$\therefore \ H = \frac{1}{2}[6 + 0 + 2 - 0] = 4$$

i.e., sp^3 hybridisation and tetrahedral shape.

98. **(d)** The strength of a bond depends upon the extent of overlapping. s-s and s-p overlapping results in the formation of σ bond but extent of overlapping along internuclear axis is more in case of s-s overlapping than in s-p. p-p overlapping may result in σ bond if overlapping takes place along internuclear axis or may result in π–bond if sideways overlapping takes place. In any case the extent of overlapping is lesser in p - p than that of the other two, s-s and s-p. Hence the correct order is

$$s - s > s - p > p - p.$$

99. **(c)** In case of Xenon compounds

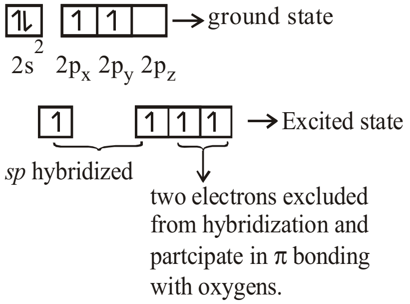
$$\text{Hybridization} = \frac{1}{2}[\text{No. of valence electrons of Xe + number of monovalent atoms surrounding Xe – charge on cation + charge or an ion}]$$

In $XeF_6 = \frac{1}{2}[8 + 6 - 0 + 0] = 7$ i.e. sp^3d^3 hybridizaiton.
In case of SF_6, Sulphur is $\mathbf{sp^3d^2}$ hybridized.
In case of BrF_5.Bromine atom has seven valence electrons and 5 are contributed by the fluorine atoms.
∴ Total number of electron pairs in valence shell of central

$$\text{atom} = \frac{7 + 5}{2} = 6$$

Number of shared pairs = 5
Number of one pairs = 1
The molecule is **square pyramidal.**
In PCl_5 P is $\mathbf{sp^3d}$ hybridised. i.e. the correct answer is XeF_6 or option (c)

100. **(a)** O = C = O
$C(6) = 1s^2\,2s^2\,2p^2$



101. **(b)** In fullerene, carbons are sp^2-hybridised like graphite. Fullerenes are also the allotropes of carbon other than diamond and graphite but have been produced synthetically, e.g.; C_{60}.

102. **(d)** Ions having sp^3 hybridisation contain hydrogen atoms at the corners of tetrahedron.

103. **(a)** For linear arrangement of atoms the hybridisation should be sp(linear shape, 180° angle). Only H_2S has sp^3-hybridization and hence has angular shape while C_2H_2, BeH_2 and CO_2 all involve sp - hybridization and hence have linear arrangement of atoms.

104. **(b)** BF_3 involves sp^2-hybridization.

105. **(b)** $\overset{sp^3}{H_3C} — \overset{sp}{C} \equiv \overset{sp}{C} — \overset{sp^3}{CH_3}$
linear

106. **(b)** Equilateral or triangular planar shape involves sp^2 hybridization.

107. **(a)** Only those *d* orbitals whose lobes are directed along X, Y and Z directions hybridise with *s* and *p* orbitals. In other three *d* orbitals namely d_{xy}, d_{yz} and d_{xz}, the lobes are at an angle of 45° from both axis, hence the extent of their overlap with *s* and *p* orbitals is much lesser than $d_{x^2-y^2}$ and d_{z^2} orbitals.

108. **(a)** According to VSEPR theory, trigonal bipyramidal geometry results from sp^3d or dsp^3 hybridisation. dsp^2 hybridisation results in square planar geometry, while d^2sp^3 leads to octahedral shape.

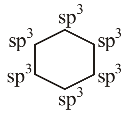
109. **(b)** In $CH_3\,CH_2OH$ underlined C is forming 4 σ bonds, hence sp^3 hybridisation. In others it is sp^2 hybridised (due to 3 σ bonds).

110. **(a)** Each sp^3-hybrid orbital has 25% s-character and 75% p-character.

111. **(c)** $\underset{sp^3}{H_3C}-\underset{sp^2}{CH} = \underset{sp}{C} = \underset{sp^2}{CH}-\underset{sp^3}{CH_3}$

112. **(d)**

113. **(a)** $\overset{sp^2}{CH_2} = \overset{sp}{C} = \overset{sp^2}{CH_2}$



$$\overset{sp^3}{CH_3}-\overset{sp^2}{CH}=\overset{sp^2}{CH}-\overset{sp^3}{CH_3}$$

$$H\overset{sp}{C}\equiv \overset{sp}{C}-\overset{sp}{C}\equiv \overset{sp}{C}H$$

$$\underset{\text{1, 3-butadiene}}{\overset{sp^2}{CH_2}=\overset{sp^2}{CH}-\overset{sp^2}{CH}=\overset{sp^2}{CH_2}}$$

114. (d) Statement (d) is incorrect.

115. (c) Molecular orbital theory was given by Mulliken.

116. (b) Atomic orbital is monocentric because an electron in it is influenced by one nucleus. While molecular orbital is polycentric as it is influenced by two or more nuclei depending upon the number of atoms in the molecule.

117. (c)

118. (d) For oxygen correct increasing order is
$\sigma 1s < \sigma{*}1s < \sigma 2s < \sigma{*}2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi{*}2p_x = \pi{*}2p_y) < \sigma{*}2p_z$

119. (d) $N_b < N_a$ or $N_a = N_b$
i.e., a negative or zero bond order corresponds to an unstable molecule.

120. (a) **121. (c)**

122. (c) Paramagnetism of O_2 is best explained by molecular orbital theory.

123. (b)

124. (b) One bonding M.O. and one anti-bonding M.O.

125. (d) Molecules having unpaired electrons show paramagnetism.

126. (c)

127. (c) $N_2^+ = 7 + 7 - 1 = 13$ electrons
Configuration is
$\sigma 1s^2,\ \sigma{*}1s^2,\ \sigma 2s^2,\ \sigma{*}2s^2,\ \pi 2p_x^2$
$= \pi 2p_y^2,\ \sigma 2p_z^1$
Bond order =

$$\frac{1}{2}\left(\begin{matrix}\text{No. of } e^-s \text{ in bonding} \\ \text{molecular orbital}\end{matrix} - \begin{matrix}\text{No. of } e^-s \text{ in antibonding} \\ \text{molecular orbital}\end{matrix}\right)$$

$$= \frac{1}{2}(9-4) = \frac{1}{2}\times 5 = 2.5$$

128. (a)

129. (a, b) The molecular orbital structures of C_2 and N_2 are

$N_2 = \sigma 1s^2\,\sigma{*}1s^2\,\sigma 2s^2\,\sigma{*}2s^2\,\sigma 2p_x^2\pi 2p_y^2\pi 2p_z^2$

$C_2 = \sigma 1s^2\,\sigma{*}1s^2\,\sigma 2s^2\,\sigma{*}2s^2\pi 2py^2\pi 2P_z^2$

Both N_2 and C_2 have paired electrons, hence they are diamagnetic.

130. (d) $H_2^+ : (\sigma\ 1s^1)$

$$\text{Bond order} = \frac{1}{2}(1-0) = \frac{1}{2}$$

$H_2^- : (\sigma 1s^2)\,(\sigma^* 1s^1)$

$$\text{Bond order} = \frac{1}{2}(2-1) = \frac{1}{2}$$

The bond order of H_2^+ and H_2^- are same but H_2^+ is more stable than H_2^-. In H_2^- the antibonding orbital is filled with 1 electron so this causes instability.

131. (b) The removal of an electron from a diatomic molecule may increase the bond order as in the conversion $O_2\,(2) \longrightarrow O_2^+(2.5)$ or decrease the bond order as in the conversion, $N_2(3.0) \longrightarrow N_2^+(2.5)$, As a result, the bond energy may increase or decrease. Thus, statement (b) is incorrect.

132. (b) $O_2 : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2,$

$$\begin{cases}\pi 2p_x^2 \\ \pi 2p_y^2\end{cases}, \begin{cases}\pi^* 2p_x^1 \\ \pi^* 2p_y^1\end{cases}$$

$$\text{Bond order} = \frac{10-6}{2} = 2$$

(two unpaired electrons in antibonding molecular orbital)

$$O_2^+ : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \begin{cases}\pi 2p_x^2, \\ \pi 2p_y^2,\end{cases} \begin{cases}\pi^* 2p_x^1 \\ \pi^* 2p_y^0\end{cases}$$

$$\text{Bond order} = \frac{10-5}{2} = 2.5$$

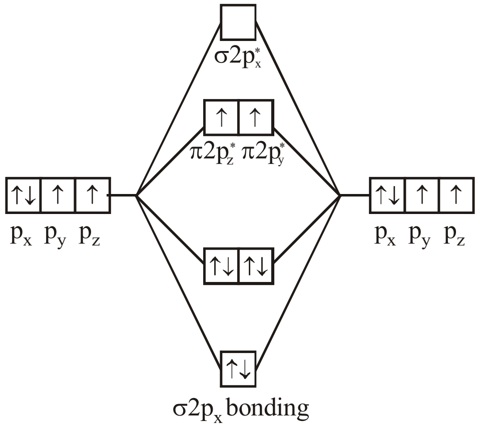
(One unpaired electron in antibonding molecular orbital)

Hence O_2 as well as O_2^+ both are paramagnetic, and bond order of O_2^+ is greater than that of O_2.

133. (c)

134. (c) Helium molecule does not exist as bond order of $He_2 = 0$.

135. (c) The paramagnetic property in oxygen came through unpaired electron which can be explained by molecular orbital theory.

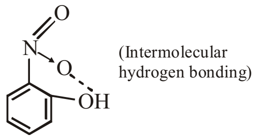


So 2 unpaired of electron present in $\pi 2p_y^*$ and $\pi 2p_z^*$

136. (c) H-bonding is maximum in the solid state and minimum in gaseous state.

137. (c) H_2O shows intermolecular hydrogen bonding while o-nitrophenol shows intramolecular H-bonding.

138. (a)



o-nitrophenol

139. (c) The b.p. of p-nitrophenol is higher than that of o-nitrophenol because in p-nitrophenol there is intermolecular H-bonding but in o-nitrophenol it is intramolecular H-bonding.

140. (b) The strength of the interactions follows the order vander Waal's < hydrogen – bonding < dipole-dipole < covalent.

141. (c) H–F shows strongest H-bonds due to high electronegativity of F atom.

142. (c) Ice has many hydrogen bonds which give rise to cage like structure of water molecules. This, structure possess larger volume and thus makes the density of ice low.

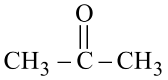
143. (b) Methanol and ethanol are soluble because of the hydrogen bonding.

144. (d) F—H----F bond is shortest, because with the increase of electronegativity and decrease in size of the atom to which hydrogen is linked, the strength of the hydrogen bond increases.

145. (a) Hydrogen bonding is possible only in compounds having hydrogen attached with F, O or N.

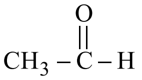
C_2H_5-OH (H-bonding possible)

CH_3-O-CH_3 (H-bonding not possible)



$$CH_3-\overset{\overset{\displaystyle O}{||}}{C}-CH_3$$

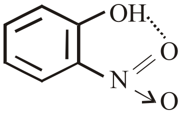
(H-bonding not possible)



$$CH_3-\overset{\overset{\displaystyle O}{||}}{C}-H$$

(H-bonding not possible)

146. (c) *ortho*-Nitrophenol has intramolecular H-bonding



and *para*-nitrophenol has intermolecular H-bonding.

147. (d) Hydrogen bonding increases the boiling point of compound.

148. (b)

149. (a) Hydrogen bond is formed when hydrogen is attached with the atom which is highly electronegative and having small radius.

STATEMENT TYPE QUESTIONS

150. (c) The group valence of the elements is generally either equal to the number of dots in Lewis symbols or 8 minus the number of dots or valence electrons.

151. (d) The least electronegative atom occupies the central position in the molecule/ion.

152. (b) Formal charges do not indicate real charge separation within the molecule. Indicating the charges on the atoms in the Lewis structure only helps in keeping track of the valence electrons in the molecule.

153. (c) The greater the charge on the cation, the greater the covalent character of the ionic bond.

154. (d) Statement (c) and (d) are incorrect.

155. (b) (ii) (*F*) In general as the number of lone pair of electrons on central atom increases, value of bond angle from normal bond angle decreases due to lp – lp > lp – bp.
(iv)(*F*) Structures of xenon fluorides and xenon oxyfluoride are explained on the basis of VSEPR theory.
In $SOBr_2$, S – O bond has minimum bond length in comparison to S – O bond lengths in SOF_2 and $SOCl_2$, because in $SOBr_2$, S – O bond has been formed by hybrid orbital containing less *s*-character.

156. (b) Atomic orbitals having same or nearly same energy will not combine if they do not have the same symmetry. $2p_z$ orbital of one atom cannot combine with $2p_x$ or $2p_y$ orbital of other atom because of their different symmetries.

MATCHING TYPE QUESTIONS

157. (c) BeH_2 : Incomplete octet of central atom.
Be has 2 valence electrons
SF_6 : Expanded octet
There are 12 electrons around the S atom in SF_6
NO_2 : Odd electron molecules.
In molecules with an odd number of electrons like NO_2, the octet rule is not satisfied.

158. (c)

159. (b) $NH_3 \rightarrow$ 1lp, 3bp $\rightarrow$ Trigonal pyramidal
$SO_2 \rightarrow$ 1lp, 2bp $\rightarrow$ Bent
$SF_4 \rightarrow$ 1lp, 4bp $\rightarrow$ See-saw
$ClF_3 \rightarrow$ 2lp, 3bp $\rightarrow$ T-shape

160. (c) Trigonal planar = BF_3
Tetrahedral = NH_4^+
Trigonal bipyramidal = PCl_5
Octahedral = SF_6

161. (c)

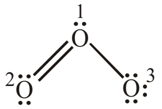
162. (a) $SF_6 \Rightarrow sp^3d^2$
$PF_5 \Rightarrow sp^3d$
$BCl_3 \Rightarrow sp^2$
$C_2H_6 \Rightarrow sp^3$

163. (c) Valence bond theory = Heitler and London
Octet rule = Kössel and Lewis
Molecular orbital theory = F. Hund and R.S. Mulliken
VSEPR theory = Nyholm and Gillespie

164. (b)

ASSERTION-REASON TYPE QUESTIONS

165. (a)

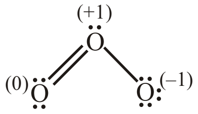


Formal charge on $O_1 = 6-2-\frac{1}{2}(6) = +1$

Formal charge on $O_2 = 6-4-\frac{1}{2}(4) = 0$

Formal charge on $O_3 = 6-6-\frac{1}{2}\times 3 = -1$

Hence, correct representation of O_3 is



166. (a) Atoms combine either by transfer of valence electrons from one atom to another or by sharing of valence electrons to have an octet in their valence shell.

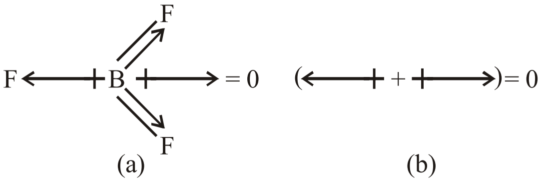
167. (d) Assertion is false but reason is true.

The greater the lattice enthalpy, more stable is the ionic compound.

168. (c) Sulphur forms many compounds in which the octet rule is obeyed. For example SCl_2 has an octet of electrons around it.

169. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

BF_3 is sp^2 hybridized. Dipole moment is a vector quantity. The three bond moments give a net sum of zero, as the resultant of any two is equal and opposite to the third.



(a) (b)

170. (d) Assertion is false but reason is true.

CH_2Cl_2 is polar while CCl_4 is non-polar because in CCl_4 net dipole moment cancels.

171. (a) While the lone pairs are localised on the central atom, each bonded pair is shared between two atoms. As a result, the lone pair electrons in a molecule occupy more space as compared to the bonding pairs of electrons. This results in greater repulsion between lone pairs of electrons as compared to the lone pair -bond pair and bond pair - bond pair repulsions.

172. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

lone pair – lone pair repulsion > lone pair – bond pair repulsion > bond pair – bond pair repulsion. In the ammonia molecule, NH_3 there are three bond pairs and one lone pair. The three N – H bond pairs are pushed closer because of the lone pair – bond pair repulsion, and HNH bond angle gets reduced from 109°23' (the tetrahedral angle) to 107°.

173. (d) Assertion is false but reason is true.

NH_3 molecule is pyramidal is shape, because out of four electron pairs, three are bonding pairs and one is lone pair.

174. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

pi bonds are formed by the overlapping of p-p orbitals perpendicular to their axis i.e., sidewise overlap.

175. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

Helium molecule is formed by linking two helium atoms. Both have 1s orbitals. These will combine to form two molecular orbitals σ (1s) and σ^* (1s). Four available electrons are accommodated as $\sigma(1s)^2$ and $\sigma^*(1s)^2$.

176. (c) The electron density in a bonding molecular orbital is located between the nuclei of the bonded atoms because of which the repulsion between the nuclei is very less while in case of an antibonding molecular orbital, most of the electron density is located away from the space between the nuclei. Electrons placed in a bonding molecular orbital tend to hold the nuclei together and stabilise a molecule.

177. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

Water is excellent solvent because it has high value of dielectric constant. Due to high value of dielectric constant, the electrostatic force of attraction between the ions decrease and these ions get separated and ultimately get solvated by the solvent molecules.

CRITICAL THINKING TYPE QUESTIONS

178. (b) Hybridisation of the central atom in compound is given by

$$H = \frac{1}{2}[V + M - C + A]$$

where V = No. of valency electrons in central metal atom,

M = No. of monovalent atoms surrounding the central atom,

C = charge on cation and A = charge on anion

- For NO_2^-, $H = \frac{1}{2}[5+0-0+1] = 3$

  sp^2 hybridisation

- For SF_4, $H=\frac{1}{2}[6+4-0+0]=5$

  sp^3d hybridisation

- For PF_6^-, $H=\frac{1}{2}[5+6-0+1]=6$

  sp^3d^2 hybridisation.

So, option (a) is correct choice.

179. (a) BF_3 is sp^2 hybridised. So, it is trigonal planner. NH_3, PCl_3 has sp^3 hybridisation hence has trigonal bipyramidal shape, IF_3, has sp^3d hydridization and has linear shape.

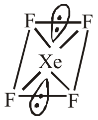
180. (b) XeF_4 hybridisation is $=\frac{1}{2}(V+X-C+A)$

hence V = 8 (no. of valence e^-)

$X = 4$ (no. of monovalent atom)

$$\frac{1}{2}(8+4+0-0)=6 \quad sp^3d^2$$

C = 0 charge on cation

A = 0 (charge on anion). The shape is  square planar shape.

181. (d) Hybridisation present in a molecule can be find out by the following formula.

$$H=\frac{1}{2}(V+M-C+A)$$

Where V = No. of electrons in valence shell of central atom

M = No. of singly charged atoms

C = charge on cation

A = charge on anion

So, Hybridisation (in ClF_3) $=\frac{1}{2}[7+3-0+0]=5$

$\Rightarrow$ sp^3d Hybridisation

182. (a) $\underset{1}{CH_2}=\underset{2}{C}H-\underset{3}{C}\equiv\underset{4}{N}$

3 σ bonds (sp^2 hybridisation); 2 σ bonds (sp - hybridisation)

$C_1 = 3$ σ bonds, $C_2 = 3$ σ bonds,

$C_3 = 2$ σ bonds

183. (a) Hybridisation of carbon in CH_3^+ is sp^2 and in CH_4 its hybridisation is sp^3

184. (a) XeF_4 having one lone pair of electron show distorted pentagonal bipyramidal shape and sp^3d^3 hybridisation.

185. (c) (a) $\underset{sp^2}{CH_2}=\underset{sp}{C}=\underset{sp^2}{CH_2}$

(b) $\underset{sp^3}{CH_3}-\underset{sp^2}{CH}=\underset{sp^2}{CH}-\underset{sp^2}{CH_2^+}$

(c) $\underset{sp^3}{CH_3}-\underset{sp}{C}\equiv\underset{sp}{C}-\underset{sp^2}{CH_2^+}$

(d) $\underset{sp^3}{CH_3}-\underset{sp^2}{CH}=\underset{sp^2}{CH}-\underset{sp^3}{CH_2^-}$

Note : Carbocations and carboanions are sp^2 and sp^3 hybridised respectively.

186. (c) Let amount of compound = 100 g

No. of moles of C $=\frac{92.3}{12}=7.69=7.7$

No. of moles of H $=\frac{7.7}{1}=7.7$

Empirical formula = CH

Empirical formula mass = 12 + 1 = 13 g/mol

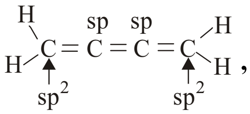
Molecular mass = 52 g/mol

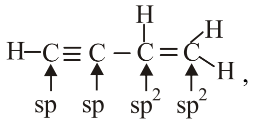
$$n=\frac{52}{13}=4$$

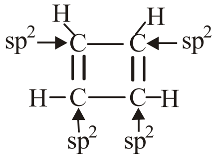
$\therefore$ Molecular foumula = Empirical formula × 4

$= C_4H_4$

Possible structures







187. (d) As the bond order decreases, bond length increases

Bond order

$$=\frac{\text{No. of bonding } e^-\text{s} - \text{No. of antibonding } e^-\text{s}}{2}$$

For N_2, electronic configuration is

$$\sigma1s^2<\sigma^*1s^2<\sigma2s^2<\sigma^*2s^2<(\pi2p_x^2=\pi2p_y^2)<2p_z^2$$

(i) Bond order of $N_2=\frac{10-4}{2}=3$

(ii) Bond order of $N_2^+=\frac{9-4}{2}=2.5$

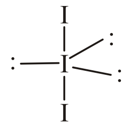
(iii) Bond order of $N_2^{2+}=\frac{8-4}{2}=2$

Hence, order of Bond length will be,

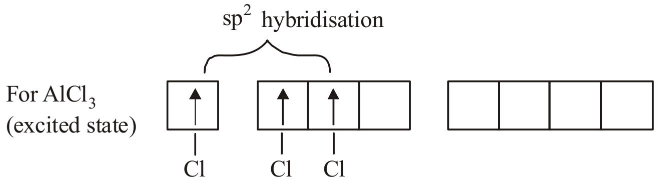
$$N_2<N_2^+<N_2^+$$

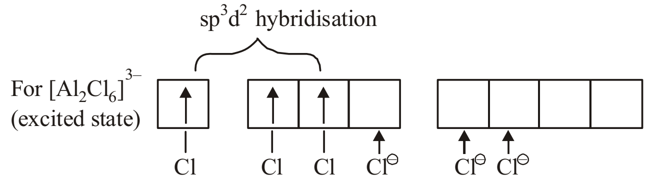
188. (c) According to molecular orbital theory, bond order of Li_2 is 1 , while in all other cases bond order is 0, so they do not exist. Li_2 molecules are known to exist in the vapour phase.

189. (c) I_3^- has sp^3d hybridisation and has linear structure



190. (c)





191. (b) Covalent radius is half of the distance between atoms in bonding state, while van der Waal radius is half of the distance between atoms in its non bonding state.

192. (d) According to Fajan's rule :

$$\text{Covalent character } \propto \frac{1}{\text{size of cation}}$$

$$\propto \text{size of anion}$$

Among the given species order of size of cations
$N^{3+} < O^{2+} < Pb^{2+} < Ba^{2+}$
order of size of anions $O^{2-} > Cl^-$.
Hence the order of covalent character is

$NCl_3 > Cl_2O > PbCl_2 > BaCl_2$

$BaCl_2$ is most ionic in nature.

193. (c) M.O. electronic configuration of CN^- is $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2 \pi 2p_x^2\ \pi 2p_y^2\ \sigma 2p_z^2$

$$\therefore \text{ B.O.} = \frac{10-4}{2} = 3$$

M.O. electronic configuration of O_2^- is
$\sigma 1s^2\ \sigma^*1s^2 \sigma 2s^2 \sigma^*2s^2 \sigma 2p_z^2 \pi 2p_x^2$
$\pi 2p_y^2\ \pi^*2p_x^2 \pi^*2p_y^1$

$$\therefore \text{ B.O.} = \frac{10-7}{2} = 1.5$$

M.O. electronic configuration of CN^+
$\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2 \pi 2p_x^2\ \pi 2p_y^2\ \sigma 2p_z^1$

$$\therefore \text{ B.O.} = \frac{9-4}{2} = 2.5$$

M.O. electronic configuration of NO^+ is
$\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2 \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2$

$$\therefore \text{ B.O.} = \frac{10-4}{2} = 2$$

$\therefore$ CN^- and NO^+ have bond order equal to 3

194. (d) On calculating bond order of species given in question

$C_2 = 2 \quad C_2^{2-} = 3$

$B_2^+ = 0.5 \qquad B_2 = 1$

$Li_2^+ = 0.5 \qquad Li_2 = 1$

$N_2^+ = 2.5 \qquad N_2 = 3$

$O_2 = 2.0 \qquad O_2^- = 1.5$

$$\text{Bond length} \propto \frac{1}{\text{Bond order}}$$

$\therefore\ O_2^- > O_2$

195. (b) For C_2 (12) :
$(\sigma 1s)^2 (\sigma{*}1s)^2 (\sigma 2s)^2 (\sigma{*}2s)^2 (\pi 2p_x)^2 (\pi\, 2p_y)^2$

$$\text{B.O.} = \frac{8-4}{2} = 2$$

For N_2(14) :

$(\sigma 1s)^2 (\sigma{*}1s)^2 (\sigma 2s)^2 (\sigma{*}2s)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\sigma 2p_z)^2$

$$\therefore \text{B.O.} = \frac{10-4}{2} = 3$$

For B_2 (10)

$= (\sigma 1s)^2\ (\sigma{*}1s)^2 (\sigma 2s)^2 (\sigma{*}2s)^2 (\pi 2p_x)^1 (\pi 2p_y)^1$

$$\therefore \text{B.O.} = \frac{6-4}{2} = 1$$

For O_2 (16)

$= (\sigma 1s)^2\ (\sigma{*}1s)^2 (\sigma 2s)^2 (\sigma{*}2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2$
$(\pi 2p_y)^2 (\pi{*}2p_x)^1 (\pi{*}2p_y)^1$

$$\therefore \text{ B.O.} = \frac{10-6}{2} = 2$$

F_2 is (18)

$= (\sigma 1s)^2\ (\sigma{*}1s)^2 (\sigma 2s)^2 (\sigma{*}2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2$
$(\pi 2p_y)^2 (\pi{*}2p_x)^2 (\pi{*}2p_y)^2$

$$\therefore \text{ B.O.} = \frac{10-8}{2} = 1$$

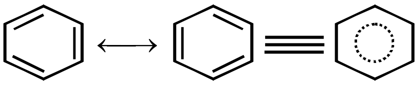
$\therefore$ N_2 has the highest bond order = 3.

196. (c) $\text{B.O.} = \frac{1}{2}[N_b - N_a] = 0$; cannot exist

197. (d) In this configuration, there are four completely filled bonding molecular orbitals and one completely filled antibonding molecular orbital. So that $N_b = 8$ and $N_a = 2$.

$$\therefore \text{ Bond order} = \frac{1}{2}(N_b - N_a) = \frac{1}{2}(8-2) = 3.$$

198. (c) Benzene has the following resonance structures–



Hence, its bond order is

$$\frac{\text{no of possible resonating structures}}{2} = 1.5.$$

199. (a) Molecular orbital electronic configuration of these species are :

$$\mathrm{O_2^-}(17e^-) = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2,$$
$$\pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x^2 = \pi 2^* p_y^1$$

$$O_2(16e^-) = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2,$$
$$\pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x^1 = \pi^* 2p_y^1$$

$$O_2^{2-}(18e^-) = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2,$$
$$\pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x^2 = \pi^* 2p_y^2$$

Hence number of antibonding electrons are 7, 6 and 8 respectively.

200. (d) $\sigma_b^2\, \sigma^{*2}_a\, \sigma_b^2\, \sigma_a^{*2} (\pi_b^2 = \pi_b^2) \sigma_b^1 (\mathrm{N_2^+} = 13\,\text{electrons})$

it contains one unpaired electron hence paramagnetic.

201. (N) None of the given option is correct.

The molecular orbital configuration of the given molecules is

$\mathrm{H_2} = \sigma 1s^2$ (no electron anti-bonding)

$\mathrm{Li_2} = \sigma 1s^2\, \sigma^* 1s^2\, \sigma 2s^2$(two anti-bonding electrons)

$\mathrm{B_2} = \sigma 1s^2\, \sigma^* 1s^2\, \sigma 2s^2\, \sigma^* 2s^2 \left\{\pi 2p_y^1 = \pi 2p_z^1\right\}$

(4 anti-bonding electrons)

Though the bond order of all the species are same (B.O = 1) but stability is different. This is due to difference in the presence of no. of anti-bonding electron.

Higher the no. of anti-bonding electron lower is the stability hence the correct order is $\mathrm{H_2 > Li_2 > B_2}$

202. (a) Molecular orbital configuration of

$$\mathrm{N_2^{2-}} = \sigma 1s^2\, \sigma^* 1s^2 \sigma 2s^2\, \sigma^* 2s^2 \text{ - } \left\{\begin{matrix}\pi 2p_x^2 \\ \pi 2p_y^2\end{matrix}\right. \sigma 2p_z^2 \left\{\begin{matrix}\pi^* 2p_x^1 \\ \pi^* 2p_y^1\end{matrix}\right.$$

$$\text{Bond order} = \frac{10-6}{2} = 2$$

$$\mathrm{N_2^-} = \sigma 1s^2\, \sigma^* 1s^2\, \sigma 2s^2 \sigma^* 2s^2 \left\{\begin{matrix}\pi 2p_x^2 \\ \pi 2p_y^2\end{matrix}\right. \sigma 2p_z^2 \left\{\begin{matrix}\pi^* 2p_x^1 \\ \pi^* 2p_y^0\end{matrix}\right.$$

$$\text{Bond order} = \frac{10-5}{2} = 2.5$$

$$\mathrm{N_2} = \sigma 1s^2\, \sigma^* 1s^2\, \sigma 2s^2 \sigma^* 2s^2 \left\{\begin{matrix}\pi 2p_x^2 \\ \pi 2p_y^2\end{matrix}\right., \sigma 2p_z^2$$

$$\text{Bond order} = \frac{10-4}{2} = 3$$

$\therefore$ The correct order is $= \mathrm{N_2^{2-} < N_2^- < N_2}$

203. (a) Hydrogen bonding is not possible in HI due to low electronegativity of iodine. So, hydrogen bonding would not affect boiling point of HI.

204. (d) HF form linear polymeric structure due to hydrogen bonding.

205. (c) B, C and D form intermolecular hydrogen bonding while A form intramolecular hydrogen bonding due to proximity of oxygen and hydrogen.

CHAPTER 5

STATES OF MATTER

FACT/DEFINITION TYPE QUESTIONS

1. Which of the following is not a type of van der Waal's forces?
(a) Dipole - dipole forces
(b) Dipole - induced dipole forces
(c) Ion - dipole forces
(d) London forces

2. Who proposed the concept of dispersion force ?
(a) Heitler and London (b) van der Waal
(c) Gay Lussac (d) Fritz London

3. Which of the following option correctly represents the relation between interaction energy and distance between two interacting particles (r) for London forces ?
(a) $\frac{1}{\sqrt{r}}$ (b) $\frac{1}{r^6}$
(c) $\frac{1}{r^{12}}$ (d) $\frac{1}{r^3}$

4. The interaction energy of London force is inversely proportional to sixth power of the distance between two interacting particles but their magnitude depends upon
(a) charge of interacting particles
(b) mass of interacting particles
(c) polarisability of interacting particles
(d) strength of permanent dipoles in the particles.

5. London forces are always ...I... and interaction energy is inversely proportional to the ...II... power of the distance between two interacting particles.
Here, I and II refer to
(a) I → repulsive, II → sixth
(b) I → attractive, II → fourth
(c) I → attractive, II → sixth
(d) I → repulsive, II → fourth

6. Dipole-dipole forces act between the molecules possessing permanent dipole. Ends of dipoles possess ‘partial charges’. The partial charge is
(a) more than unit electronic charge
(b) equal to unit electronic charge
(c) less than unit electronic charge
(d) double the unit electronic charge

7. Dipole-dipole interaction is stronger than the London forces but is weaker than ion-ion interaction because
(a) only partial charges are involved
(b) only total charges are involved
(c) both (a) and (b)
(d) sometimes (a) and sometimes (b)

8. Induced dipole moment depend upon the
I. dipole moment present in the permanent dipole.
II polarisability of the electrically neutral molecules.
Identify the correct option.
(a) I is correct but II is wrong
(b) I is wrong and II is correct
(c) Both I and II are wrong
(d) Both I and II are correct

9. Dipole-induced dipole interactions are present in which of the following pairs :
(a) Cl_2 and CCl_4 (b) HCl and He atoms
(c) SiF_4 and He atoms (d) H_2O and alcohol

10. Which of the following exhibits the weakest intermolecular forces ?
(a) NH_3 (b) HCl
(c) He (d) H_2O

11. Strength of the hydrogen bond is determined by interaction between the
I. lone pair of the electronegative atom and the hydrogen atom of other atom.
II. bond pair of the electronegative atom and the hydrogen atom of other atom.
Identify the correct option.
(a) Only I is correct
(b) Only II is correct
(c) Both I and II are correct
(d) Neither I nor II are correct

12. Which of the following statements regarding thermal energy is correct?

(a) Thermal energy is the measure of average kinetic energy of the particles of the matter and is thus responsible for movement of particles.

(b) Intermolecular forces tend to keep the molecules together but thermal energy of the molecules tends to keep them apart.

(c) Three states of matter are the result of balance between intermolecular forces and the thermal energy of the molecules.

(d) All of the above

13. Which of the following is the correct order of thermal energy in three states of matter ?

(a) Solid < Liquid < Gas (b) Liquid < Gas < Solid

(c) Liquid < Solid < Gas (d) Gas < Solid < Liquid

14. Which of the following are arrangement in the correct order?

I. Gas > Liquid > Solid (Thermal energy)

II. Solid > Liquid > Gas (Intermolecular force)

Select the correct option.

(a) I only (b) II only

(c) Both I and II (d) None of these

15. Which one of the following statements is not correct about the three states of matter i.e., solid, liquid and gaseous ?

(a) Molecules of a solid possess least energy whereas those of a gas possess highest energy.

(b) The density of solid is highest whereas that of gases is lowest

(c) Gases like liquids possess definite volumes

(d) Molecules of a solid possess vibratory motion

16. Which of the following is true about gaseous state ?

(a) Thermal energy = Molecular attraction

(b) Thermal energy >> Molecular attraction

(c) Thermal energy << Molecular attraction

(d) Molecular force >> Those in liquids

17. The first reliable measurement on properties of gases was made by _____________

(a) Gay Lussac (b) Jacques charles

(c) Robert Boyle (d) Avogadro

18. At constant temperature, for a given mass of an ideal gas

(a) the ratio of pressure and volume always remains constant.

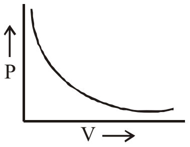
(b) volume always remains constant.

(c) pressure always remains constant.

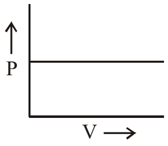
(d) the product of pressure and volume always remains constant.

19. Which of following graph(s) represents Boyle's law

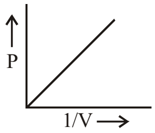
I.



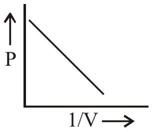
II.



III.



IV.



(a) Only I (b) II and IV

(c) I and III (d) Only III

20. Which of the following represents Boyle's law in terms of density ?

(a) $d \cdot p = k'$ (b) $\frac{d}{p} = k'$

(c) $\frac{dp}{2} = k'$ (d) $d = k'\sqrt{p}$

(Here d = density, p = pressure, k' = constant)

21. Boyle's law states that the

(a) pressure of a gas is directly proportional to the temperature at constant volume

(b) pressure of a gas is inversely proportional the volume at constant temperature

(c) volume is directly proportional to the temperature at constant pressure

(d) None of the above

22. 600 c.c. of a gas at a pressure of 750 mm of Hg is compressed to 500 c.c. Taking the temperature to remain constant, the increase in pressure, is

(a) 150 mm of Hg (b) 250 mm of Hg

(c) 350 mm of Hg (d) 450 mm of Hg

23. The lowest hypothetical or imaginary temperature at which gases are supposed to occupy zero volume is called _________

(a) Kelvin temperature (b) absolute zero

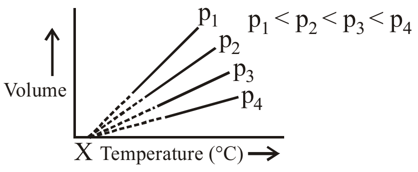
(c) Charle's temperature (d) constant temperature

24. 500 ml of nitrogen at 27°C is cooled to –5°C at the same pressure. The new volume becomes

(a) 326.32 ml (b) 446.66 ml

(c) 546.32 ml (d) 771.56 ml

25. What is the value of X in °C for given volume vs temperature curve ?



(a) 0° C (b) 273.15° C

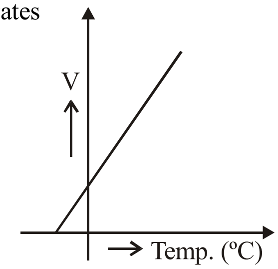
(c) −273.15° C (d) 300° C

26. Which of the following expression at constant pressure represents Charle's law?

(a) $V \propto \frac{1}{T}$ (b) $V \propto \frac{1}{T^2}$

(c) $V \propto T$ (d) $V \propto d$

27. The following graph illustrates



(a) Dalton's law

(b) Charle's law

(c) Boyle's law

(d) Gay-Lussac's law

28. Air at sea level is dense. This is a practical application of

(a) Boyle's law (b) Charle's law

(c) Kelvin's law (d) Brown's law

29. Use of hot air balloons in sports and meteorological observations is an application of

(a) Boyle's law (b) Charle's law

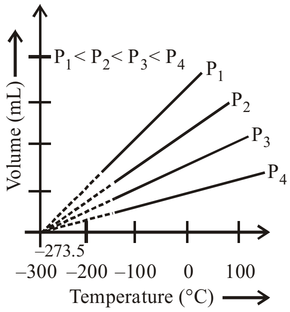
(c) Kelvin's law (d) Gay-Lussac's law

30. An ideal gas will have maximum density when

(a) P = 0.5 atm, T = 600 K (b) P = 2 atm, T = 150 K

(c) P = 1 atm, T = 300 K (d) P = 1 atm, T = 500 K

31.



Arrange the pressures P_1, P_2, P_3 and P_4 in the increasing order which are shown in the graphs.

(a) $P_1 < P_2 < P_3 < P_4$ (b) $P_4 < P_3 < P_2 < P_1$

(c) $P_1 = P_2 = P_3 = P_4$ (d) $P_4 = P_3 < P_2 = P_1$

32. On a ship sailing in pacific ocean where temperature is 23.4°C, a balloon is filled with 2 L air. What will be the volume of the balloon when the ship reaches Indian ocean, where temperature is 26.1°C ?

(a) 2.018 L (b) 2.8 L

(c) 3.5 L (d) 1.5 L

33. Which of the following represents Gay Lussac's law ?

I. $\frac{P}{T}$ = constant II. $P_1T_2 = P_2T_1$

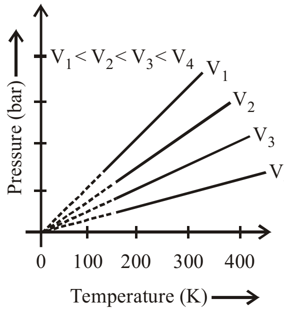
III. $P_1V_1 = P_2V_2$

Choose the correct option.

(a) I, II and III (b) II and III

(c) I and III (d) I and II

34.



The relationship which is shown in the figure is derived from

I. Boyle's law.

II. Avogadro law.

III. Charles' law.

Which of the following is the correct option ?

(a) I and II (b) II and III

(c) I and III (d) Only I

35. Which of the following represents Avogadro law ?

(a) V = kn (b) $V = k\frac{m}{M}$

(c) M = kd (d) All of these

36. At STP molar volume of an ideal gas or a combination of ideal gases is ___________

(a) 22.71098 L mol^{-1} (b) 20.71098 L mol^{-1}

(c) 22.4139 L mol^{-1} (d) 24.78 L mol^{-1}

37. 4.4 g of a gas at STP occupies a volume of 2.24 L, the gas can be

(a) O_2 (b) CO

(c) NO_2 (d) CO_2

38. An ideal gas is one which obeys the gas laws under

(a) a few selected experimental conditions

(b) all experimental conditions

(c) low pressure alone

(d) high temperature alone

39. For an ideal gas, number of moles per litre in terms of its pressure P, gas constant R and temperature T is

(a) PT/R (b) PRT

(c) P/RT (d) RT/P

40. Select one correct statement. In the gas equation, $PV = nRT$

(a) n is the number of molecules of a gas

(b) V denotes volume of one mole of the gas

(c) n moles of the gas have a volume V

(d) P is the pressure of the gas when only one mole of gas is present.

41. Correct gas equation is

(a) $\frac{V_1T_2}{P_1} = \frac{V_2T_1}{P_2}$ (b) $\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$

(c) $\frac{P_1T_2}{V_1} = \frac{P_2V_2}{T_2}$ (d) $\frac{V_1V_2}{T_1T_2} = P_1P_2$

42. The correct value of the gas constant '*R*' is close to :
(a) 0.082 litre-atmosphere K
(b) 0.082 litre-atmosphere K^{-1} mol^{-1}
(c) 0.082 litre – $atmosphere^{-1}$ K mol^{-1}
(d) 0.082 $litre^{-1}$ $atmosphere^{-1}$ K mol

43. If *P*, *V*, *M*, *T* and *R* are pressure, volume, molar mass, temperature and gas constant respectively, then for an ideal gas, the density is given by
(a) $\frac{RT}{PM}$
(b) $\frac{P}{RT}$
(c) $\frac{M}{V}$
(d) $\frac{PM}{RT}$

44. Pure hydrogen sulphide is stored in a tank of 100 litre capacity at 20° C and 2 atm pressure. The mass of the gas will be
(a) 34 g
(b) 340 g
(c) 282.68 g
(d) 28.24 g

45. At N.T.P the volume of a gas is found to be 273 ml. What will be the volume of this gas at 600 mm of Hg and 273°C?
(a) 391.8 ml
(b) 380 ml
(c) 691.6 ml
(d) 750 ml

46. Pressure of a mixture of 4 g of O_2 and 2 g of H_2 confined in a bulb of 1 litre at 0°C is
(a) 25.215 atm
(b) 31.205 atm
(c) 45.215 atm
(d) 15.210 atm

47. Gas equation $PV = nRT$ is obeyed by
(a) Only isothermal process
(b) Only adiabatic process
(c) Both (a) and (b)
(d) None of these

48. The total pressure of a mixture of two gases is :
(a) the sum of the partial pressures
(b) the difference between the partial pressures
(c) the product of the partial pressures
(d) the ratio of the partial pressures

49. If three unreactive gases having partial pressures P_A, P_B and P_C and their moles are 1, 2 and 3 respectively then their total pressure will be
(a) $P = P_A + P_B + P_C$
(b) $P = \frac{P_A + P_B + P_C}{6}$
(c) $P = \frac{\sqrt{P_A + P_B + P_C}}{3}$
(d) None of these

50. Dalton's law of partial pressure will not apply to which of the following mixture of gases
(a) H_2 and SO_2
(b) H_2 and Cl_2
(c) H_2 and CO_2
(d) CO_2 and Cl_2

51. Pressure exerted by saturated water vapour is called ____________
(a) Aqueous tension
(b) Partial pressure
(c) Total pressure
(d) Both (a) and (b)

52. The pressure exerted by 6.0g of methane gas in a 0.03 m^3 vessel at 129°C is (Atomic masses : C = 12.01, H = 1.01 and R = 8.314 JK^{-1} mol^{-1})
(a) 31684 Pa
(b) 215216 Pa
(c) 13409 Pa
(d) 41648 Pa

53. A gaseous mixture was prepared by taking equal mole of CO and N_2. If the total pressure of the mixture was found 1 atmosphere, the partial pressure of the nitrogen (N_2) in the mixture is
(a) 0.5 atm
(b) 0.8 atm
(c) 0.9 atm
(d) 1 atm

54. A bubble of air is underwater at temperature 15°C and the pressure 1.5 bar. If the bubble rises to the surface where the temperature is 25°C and the pressure is 1.0 bar, what will happen to the volume of the bubble ?
(a) Volume will become greater by a factor of 1.6.
(b) Volume will become greater by a factor of 1.1.
(c) Volume will become smaller by a factor of 0.70.
(d) Volume will become greater by a factor of 2.5.

55. A mixture contains 64 g of dioxygen and 60 g of neon at a total pressure of 10 bar. The partial pressures in bar of dioxygen and neon are respectively (atomic masses O = 16, Ne = 20)
(a) 4 and 6
(b) 6 and 4
(c) 5 and 5
(d) 8 and 2

56. 500 mL of air at 760 mm pressure were compressed to 200 mL. If the temperature remains constant, what will be the pressure after compression?
(a) 1800 mm
(b) 1900 mm
(c) 2000 mm
(d) 1500 mm

57. Value of universal gas constant (R) depends upon
(a) Number of moles of gas
(b) Volume of gas
(c) Temperature of gas
(d) None of these

58. Two vessels of volumes 16.4 L and 5 L contain two ideal gases of molecular existence at the respective temperature of 27°C and 227°C and exert 1.5 and 4.1 atmospheres respectively. The ratio of the number of molecules of the former to that of the later is
(a) 2
(b) 1
(c) $\frac{1}{2}$
(d) $\frac{1}{3}$

59. 56 g of nitrogen and 96 g of oxygen are mixed isothermally and at a total pressure of 10 atm. The partial pressures of oxygen and nitrogen (in atm) are respectively
(a) 4, 6
(b) 5, 5
(c) 2, 8
(d) 6, 4

60. If 10^{-4} dm^3 of water is introduced into a 1.0 dm^3 flask at 300 K, how many moles of water are in the vapour phase when equilibrium is established ?
(Given : Vapour pressure of H_2O at 300 K is 3170 Pa; $R = 8.314\ J\,K^{-1}\,mol^{-1}$)
(a) 5.56×10^{-3} mol
(b) 1.53×10^{-2} mol
(c) 4.46×10^{-2} mol
(d) 1.27×10^{-3} mol

61. The total pressure of a mixture of two gases is
(a) the sum of the partial pressures
(b) the difference between the partial pressures
(c) the product of the partial pressures
(d) the ratio of the partial pressures

62. Ideal gas equation is the combination of
I. Boyle's law
II. Charles's law
III. Avogadro law
IV. Dalton's law of partial pressure
Choose the correct option.
(a) Only I and II (b) I, II and III
(c) II and III (d) I, III aor IV

63. According to the kinetic theory of gases, in an ideal gas, between two successive collisions a gas molecule travels
(a) in a wavy path
(b) in a straight line path
(c) with an accelerated velocity
(d) in a circular path

64. Gases consist of large number of identical particles (atoms or molecules) that are so small and so far apart on the average that the actual volume of the molecules is negligible in comparison to the empty space between them.
Above given statement explain which property of gases ?
(a) Gases occupy all the space available to them.
(b) Gases has fixed shape.
(c) Compressibility of gases.
(d) None of these.

65. If there were loss of kinetic energy, the motion of gas molecules will ____A____ and gas will ____B____.
(a) A = increase, B = collide
(b) A = stop, B = settle down
(c) A = increase,
B = exert more pressure on walls of container
(d) A = decrease, B = get liquified

66. Which of the following assumption of kinetic molecular theory states that gases do not have fixed shape ?
(a) Particles of a gas move in all possible directions in straight line.
(b) Particles of a gas are always in constant and random motion.
(c) Total energy of molecules before and after the collision remains same.
(d) None of these

67. Which of the following assumption of kinetic theory if hold good than the pressure vs volume graph of experimental data (real gas) and that of theoretically calculated from Boyle's law (ideal gas) should coincide ?
(i) There is no force of attraction between the molecules of a gas.
(ii) Volume of the molecules of a gas is negligibly small in comparison to the space occupied by the gas.
(a) (i) only (b) (ii) only
(c) Both (i) and (ii) (d) None of these

68. Kinetic theory of gases proves
(a) only Boyle's law (b) only Charles' law
(c) only Avogadro's law (d) All of these

69. Which one of the following is the wrong assumption of kinetic theory of gases ?
(a) Momentum and energy always remain conserved.
(b) Pressure is the result of elastic collision of molecules with the container's wall.
(c) Molecules are separated by great distances compared to their sizes.
(d) All the molecules move in straight line between collision and with same velocity.

70. When is deviation more in the behaviour of a gas from the ideal gas equation $PV = nRT$?
(a) At high temperature and low pressure
(b) At low temperature and high pressure
(c) At high temperature and high pressure
(d) At low temperature and low pressure

71. In van der Waal's equation of state of the gas law, theconstant 'b' is a measure of
(a) volume occupied by the molecules
(b) intermolecular attraction
(c) intermolecular repulsions
(d) intermolecular collisions per unit volume

72. In van der Waal's equation of state for a non-ideal gas, the term that accounts for intermolecular forces is
(a) $(V-b)$ (b) RT
(c) $\left(P+\frac{a}{V^2}\right)$ (d) $(RT)^{-1}$

73. The values of van der Waal's constant 'a' for the gases O_2, N_2, NH_3 and CH_4 are 1.360, 1.390, 4.170 and 2.253 L^2 atm mol^{-2} respectively. The gas which can most easily be liquified is
(a) O_2 (b) N_2
(c) NH_3 (d) CH_4

74. A gas described by van der Waal's equation
(i) behaves similar to an ideal gas in the limit of large molar volume
(ii) behaves similar to an ideal gas in the limit of large pressure
(iii) is characterised by van der Waal's coefficients that are dependent on the identity of the gas but are independent of the temperature
(iv) has the pressure that is lower than the pressure exerted by the same gas behaving ideally
(a) (i) and (ii) (b) (i) and (iii)
(c) (i), (ii) and (iii) (d) (ii) and (iv)

75. The units of constant a in van der Waal's equation is
(a) dm^6 atm mol^{-2} (b) dm^3 atm mol^{-1}
(c) dm atm mol^{-1} (d) atm mol^{-1}

76. The van der Waal's constant 'a' for four gases P, Q, R and S are 4.17, 3.59, 6.71 and 3.8 atm L^2 mol^{-2} respectively. Therefore, the ascending order of their liquefaction is
(a) $R < P < S < Q$ (b) $Q < S < R < P$
(c) $Q < S < P < R$ (d) $R < P < Q < S$

77. At low pressure the van der Waal's equation is reduced to

(a) $Z = \frac{pV_m}{RT} = 1 - \frac{ap}{RT}$ (b) $Z = \frac{pV_m}{RT} = 1 + \frac{b}{RT}p$

(c) $pV_m = RT$ (d) $Z = \frac{pV_m}{RT} = 1 - \frac{a}{RT}$

78. The compressibility factor for a real gas at high pressure is :

(a) $1 + \frac{RT}{pb}$ (b) 1

(c) $1 + \frac{pb}{RT}$ (d) $1 - \frac{pb}{RT}$

79. The gas with the highest critical temperature is

(a) H_2 (b) He

(c) N_2 (d) CO_2

80. A gas is said to behave like an ideal gas when the relation PV/T = constant. When do you expect a real gas to behave like an ideal gas ?

(a) When the temperature is low
(b) When both the temperature and pressure are low
(c) When both the temperature and pressure are high
(d) When the temperature is high and pressure is low

81. An ideal gas can't be liquefied because

(a) its critical temperature is always above 0°C
(b) Its molecules are relatively smaller in size
(c) it solidifies before becoming a liquid
(d) forces between its molecules are negligible

82. Gases possess characteristic critical temperature which depends upon the magnitude of intermolecular forces between the particles. Following are the critical temperature of some gases.

Gases	H_2	He	O_2	N_2
Critical temperature in Kelvin	33.2	5.3	154.3	126

From the above data what would be the order of liquefaction of these gases ?

Start writing the order from the gas liquefying first

(a) H_2, He, O_2, N_2 (b) He, O_2, H_2, N_2

(c) N_2, O_2, He, H_2 (d) O_2, N_2, H_2, He

83. Above Boyle point, real gases show ____X____ from ideality and Z values are ____Y____ than one.

(a) X = Negative deviation, Y = Less
(b) X = Negative deviation, Y = Greater
(c) X = Positive deviation, Y = Less
(d) X = Positive deviation, Y = Greater

84. Select the one that when used would be considered as best condition for liquification of a gas.

(a) Increasing the temperature.
(b) Decreasing the pressure.
(c) Increasing the pressure and decreasing the temperature.
(d) Decreasing the pressure and increasing the temperature.

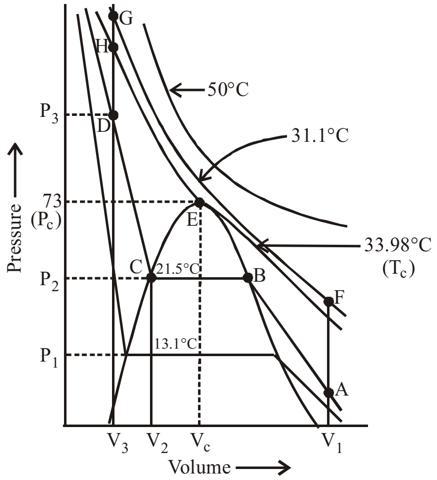
85. Following table represents critical temperature of some gases. Arrange these gases in their increasing order of liquifaction.

Gas	T_c / K
H_2	33.2
He	5.3
N_2	126
O_2	154.3

(a) He < N_2 < H_2 < O_2 (b) H_2 < He < N_2 < O_2

(c) He < H_2 < N_2 < O_2 (d) O_2 < N_2 < H_2 < He

86. Choose the correct statement based on the following isotherms of carbon dioxide at various temperature.



(i) We can move from point A to F vertically by increasing the temperature.
(ii) We can reach the point G by compressing the gas at constant temperature.
(iii) We can move down from G towards D by increasing the temperature.
(iv) As soon as we cross the point D on the critical isotherm we get liquid.

(a) (i) and (ii) (b) (i), (ii) and (iii)

(c) (i), (ii) and (iv) (d) (i), (ii), (iii) and (iv)

87. At 1 atm pressure boiling temperature is called ____X____. If pressure is 1 bar then the boiling point is called ____Y____ of the liquid.

(a) X = Standard boiling point, Y = Normal boiling point
(b) X = Normal boiling point, Y = Standard boiling point
(c) X = Critical boiling point, Y = Normal boiling point
(d) X = Critical boiling point, Y = Standard boiling point

88. Which of the following statement is incorrect ?

(a) Standard boiling point of liquid is slightly lower than the normal boiling point.
(b) 1 atm pressure is slightly less than 1 bar pressure
(c) The normal boiling point of water is 100°C and its standard boiling point is 99.6°C
(d) None of the above

89. A liquid can exist only
(a) between triple point and critical temperature
(b) at any temperature above the melting point
(c) between melting point and critical temperature
(d) between boiling and melting temperature

90. The kinetic energy of molecules in gaseous state is
(a) more than those in the liquid state
(b) less than those in the liquid state
(c) equal to those in the liquid state
(d) less than those in solid state

91. A pin or a needle floats on the surface of water, the reason for this is
(a) surface tension (b) less weight
(c) upthrust of liquid (d) None of the above

92. The spherical shape of rain-drop is due to
(a) density of the liquid (b) surface tension
(c) atmospheric pressure (d) gravity

93. Which of the following phenomena is caused by surface tension ?
(a) Particles at the bottom of river remain separated but they stick together when taken out.
(b) A liquid rise in a thin capillary.
(c) Small drops of mercury from spherical bead instead of spreading on the surface.
(d) All of the above

94. A drop of oil is placed on the surface of water. Which of the following statement is correct ?
(a) It will remain on it as a sphere
(b) It will spread as a thin layer
(c) It will be partly as spherical droplets and partly as thin film
(d) It will float as a distorted drop on the water surface

95. When the temperature increases, the viscosity of
(a) gases decreases and viscosity of liquids increases
(b) gases increases and viscosity of liquids decreases
(c) gases and liquids increases
(d) gases and liquids decreases

96. The surface tension of which of the following liquid is maximum?
(a) C_2H_5OH (b) CH_3OH
(c) H_2O (d) C_6H_6

97. In which phenomena water changes into water vapour below its B.P. ?
(a) Evaporation (b) Condensation
(c) Boiling (d) No such phenomena exist

98. The liquid which has the highest rate of evaporation is
(a) petrol (b) nail-polish remover
(c) water (d) alcohol

99. The correct order of viscosity of the following liquids will be
(a) Water < methyl alcohol < dimethyl ether < glycerol
(b) methyl alcohol < glycerol < water < dimethyl ether
(c) dimethyl ether < methyl alcohol < water < glycerol
(d) glycerol < dimethyl ether < water < methyl alcohol

STATEMENT TYPE QUESTIONS

100. Which of the following statement(s) is/are true for London force ?
(i) These forces are always attractive.
(ii) These forces are important for long distance too.
(iii) Their magnitude depends on the polarisability of the particle.
(a) (i) and (ii) (b) (i) only
(c) (iii) only (d) (i) and (iii)

101. Choose the correct sequence of T and F for following statements. Here T stands for true and F stands for false statement.
(i) Dipole - dipole forces act between the molecules possessing permanent dipole.
(ii) Partial charge possessed by these dipoles is always equal to unit electronic charge.
(iii) Dipole - dipole interaction is weaker than London forces and ion - ion interaction.
(a) TTF (b) TFF
(c) TTT (d) TFT

102. Which of the following statements are correct ?
(i) Hydrogen bonding is a special case of dipole - dipole interaction.
(ii) Energy of hydrogen bond varies between 10 to 100 kJ mol^{-1}.
(iii) Hydrogen bonds are powerful force in determining the structure and properties of compounds like proteins, nucleic acids etc.
(iv) Strength of the hydrogen bond is determined by the coulombic interaction between the lone-pair electrons of the electronegative atom of one molecule and the hydrogen atom of other molecule.
(a) (i) and (ii) (b) (i), (ii) and (iii)
(c) (ii), (iii) and (iv) (d) All of these

103. Which of the following statements are correct regarding the characteristic of gases ?
(i) Gases are highly compressible.
(ii) Gases exert pressure equally in all directions.
(iii) Gases have much higher density than the solids and liquids.
(iv) Gases mix evenly and completely in all proportion without any mechanical aid.
Choose the correct option.
(a) (i), (ii) and (iii) (b) (ii), (iii) and (iv)
(c) (i), (ii) and (iv) (d) (i), (ii), (iii) and (iv)

104. Read the following statements and choose the correct option. Here T stands for true and F stands for false statement.

(i) Equation : $V = \frac{nRT}{P}$ will be applicable to any gas, under those conditions when behaviour of the gas approaches ideal behaviour.

(ii) Value of universal gas constant at 0° C and 1 atm pressure is 8.20578×10^{-2} L atm K^{-1} mol^{-1}

(iii) Ideal gas equation describes the state of any gas, therefore it is also called equation of state.

(iv) Value of R in units of Pa m^3 K^{-1} mol^{-1} is 8.314×10^{-2}

(a) T T T T (b) T T T F

(c) T F T F (d) T F F T

105. Choose the correct sequence of T and F for following statements. Here T stands for true and F stands for false.

(i) There may be exchange of energy between colliding molecules, their individual energies may change, but the sum of their energies remains constant.

(ii) At any particular time, different particles in the gas have different speeds and hence different kinetic energies.

(iii) Particles of a gas move in all possible directions in straight lines. During their random motion, they collide with each other and with the walls of the container.

(iv) In kinetic theory it is assumed that average kinetic energy of the gas molecules is directly proportional to the absolute temperature.

(a) TTTT (b) TTTF

(c) TFTT (d) TFFT

106. Which of the following statements are correct ?

(i) Real gases show deviations from ideal gas law because molecules interact with each other.

(ii) Due to interaction of molecules the pressure exerted by the gas is given as :

$$p_{real} = p_{ideal} + \frac{an^2}{V^2}$$

(iii) Value of 'a' is measure of magnitude of intermolecular attractive forces within the gas and depends on temperature and pressure of gas.

(iv) At high pressure volume occupied by the molecules also becomes significant because instead of moving in volume *V*, these are now restricted to volume (*V*-*nb*)

(a) (i) and (iv) (b) (i), (ii) and (iii)

(c) (i), (iii) and (iv) (d) (i) and (iii)

107. Choose the correct sequence of true and false for following statements. Here T represents true and F represents false statement.

(i) Greater the viscosity, the more slowly the liquid flows.

(ii) Glass is an extremely viscous liquid.

(iii) Viscosity of liquid increases as the temperature rise.

(a) TFF (b) FFT

(c) TFT (d) TTF

MATCHING TYPE QUESTIONS

108. Match the columns

	Column-I		Column-II
(A)	Attractive force that operates between the polar molecules having permanent dipole and the molecule lacking permanent dipole	(p)	Dipole-dipole force
(B)	Interaction in which interaction energy between stationary polar molecules is proportional to $\frac{1}{r^3}$	(q)	London force
(C)	Force that are important only at short distances (~ 500 pm)	(r)	Dipole-induced dipole force

(a) A – (r), B – (p), C – (q)

(b) A – (p), B – (r), C – (q)

(c) A – (r), B – (q), C – (p)

(d) A – (q), B – (r), C – (p)

109. Match the columns

	Column-I		Column-II
(A)	Volume of a fixed mass of a gas at constant pressure is directly proportional to its absolute temperature	(p)	Boyle's Law
(B)	At constant volume, pressure of a fixed amount of a gas varies directly with the temperature.	(q)	Avogadro's Law
(C)	Equal volumes of all gases under the same conditions of temperature and pressure contain equal number of molecules.	(r)	Charle's Law
(D)	At constant temperature, the pressure of a fixed amount (i. e., number of moles *n*) of gas varies inversely with its volume.	(s)	Gay Lussac's Law

(a) A – (s), B – (r), C – (q), D – (p)

(b) A – (r), B – (s), C – (q.), D – (p)

(c) A – (r), B – (q), C – (p), D – (s)

(d) A – (q), B – (p), C – (s), D – (r)

110. Match the columns

	Column-I		Column-II
(A)	Boyle's law	(p)	V ∝ n at constant T and P
(B)	Charle's law	(q)	$p_{\text{total}} = p_1 + p_2 + p_3 + ...$ at constant T, V
(C)	Dalton's law	(r)	$\frac{pV}{T} = \text{Constant}$
(D)	Avogadro law	(s)	$V \propto T$ at constant n and p
		(t)	$p \propto \frac{1}{V}$ at constant n and T

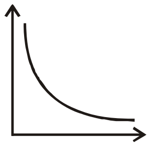
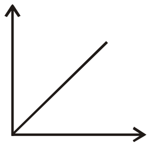
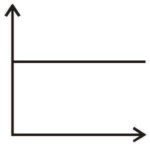
(a) A – (t), B – (s), C – (q), D – (p)
(b) A – (s), B – (q), C – (p), D – (t)
(c) A – (r), B – (t), C – (q), D – (p)
(d) A – (t), B – (q), C – (s), D – (r)

111. Match the graphs between the following variables (Column-I) with their names (Column-II) :

	Column-I (Graphs)		Column-II (Names)
(A)	Pressure vs temperature graph at constant molar volume.	(p)	Isotherms
(B)	Pressure vs volume graph at constant temperature	(q)	Constant temperature curve
(C)	Volume vs temperature graph at constant pressure	(r)	Isochores
		(s)	Isobars

(a) A – (p), B – (r), C – (s)
(b) A – (r), B – (p), C – (s)
(c) A – (r), B – (q), C – (p)
(d) A – (s), B – (q), C – (r)

112. Match the following graphs of ideal gas (Column-I) with their co-ordinates (Column-II) :

	Column-I (Graphical representation)		Column-II (x and y co-ordinates)
(A)		(p)	pV vs. V
(B)		(q)	p vs. V
(C)		(r)	p vs. $\frac{1}{V}$

(a) A – (r), B – (p), C – (q)
(b) A – (r), B – (q), C – (p)
(c) A – (q), B – (r), C – (p)
(d) A – (p), B – (r), C – (q)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

113. **Assertion :** Three states of matter are the result of balance between intermolecular forces and thermal energy of the molecules.

Reason : Intermolecular forces tend to keep the molecules together but thermal energy of molecules tends to keep them apart.

114. **Assertion :** Gases expand and occupy all the space available to them

Reason : There is no force of attraction between the particles of a gas at ordinary temperature and pressure.

115. **Assertion :** Gases do not liquefy above their critical temperature, even on applying high pressure.

Reason : Above critical temperature, the molecular speed is high and intermolecular attractions cannot hold the molecules together because they escape because of high speed.

116. **Assertion :** At critical temperature liquid passes into gaseous state imperceptibly and continuously.

Reason : The density of liquid and gaseous phase is equal to critical temperature.

117. **Assertion :** The temperature at which vapour pressure of a liquid is equal to the external pressure is called boiling temperature.

Reason : At high altitude atmospheric pressure is high.

118. **Assertion :** Liquids tend to have maximum number of molecules at their surface.

Reason : Small liquid drops have spherical shape.

CRITICAL THINKING TYPE QUESTIONS

119. Arrange the following in increasing order their intermolecular interaction

(A) HCl (B) SF_6 and (C) NaCl

(a) A, B, C (b) A, C, B
(c) B, A, C (d) B, C, A

120. When a sample of gas is compressed at constant temperature from 15 atm to 60 atm, its volume changes from 76 cm^3 to 20.5 cm^3. Which of the following statements are possible explanations of this behaviour?

(1) The gas behaves non-ideally

(2) The gas dimerises

(3) The gas is adsorbed into the vessel walls

(a) 1, 2 and 3 (b) 1 and 2 only

(c) 2 and 3 only (d) 1 only

121. Three different gases X, Y and Z of molecular masses 2, 16 and 64 were enclosed in a vessel at constant temperature till equilibrium is reached. Which of the following statement is correct?

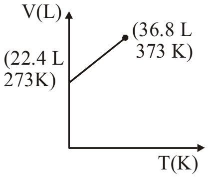
(a) Gas Z will be at the top of the vessel

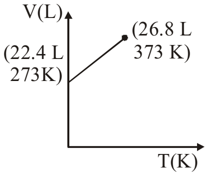
(b) Gas Y will be at the top of the vessel

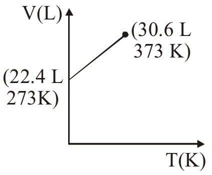
(c) Gas Z will be at the bottom and X will be at the top

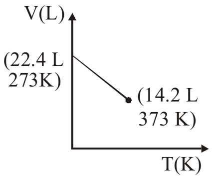
(d) Gases will form homogenous mixture

122. Which of the following volume (V) - temperature (T) plots represents the behaviour of one mole of an ideal gas at one atmospheric pressure ?

(a) 

(b) 

(c) 

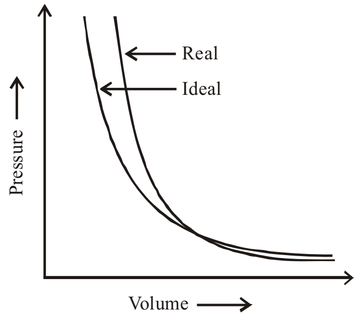
(d) 

123. Consider the case of hot air balloon, density of air at 20° C is 1.2Kg/m^3, if the air was heated to 99°C, density of air becomes 0.94kg/m^3. What would be the volume (in m^3) at 20°C if the volume at 99°C is 2800 m^3 and how much air (in kg) has been escaped at 99°C , if the air in inflated balloon was heated to 99°C (if the inflated volume of balloon was found to be 2800m^3) respectively are

(a) 2243, 728 (b) 3495.3, 596

(c) 2687, 593 (d) 2956, 771

124. From the given figure what can be said about the gases does not deviate much from ideal gases at



(a) Higher pressure and low volume.

(b) Low pressure and low volume.

(c) High pressure and high volume.

(d) Low pressure and high volume.

125. 16 g of oxygen and 3 g of hydrogen are mixed and kept at 760 mm of Hg pressure and 0° C. The total volume occupied by the mixture will be nearly

(a) 22.4 litres (b) 33.6 litres

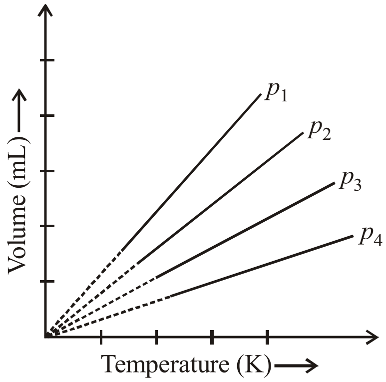
(c) 448 litres (d) 44800 ml

126. The density of neon will be highest at

(a) S.T.P. (b) 0ºC, 2 atm

(c) 273ºC, 1 atm. (d) 273ºC, 2 atm.

127. A plot of volume (V) versus temperature (T) for a gas at constant pressure is a straight line passing through the origin. The plots at different values of pressure are shown in figure. Which of the following order pressure is correct for this gas ?



(a) $p_1 > p_2 > p_3 > p_4$ (b) $p_1 = p_2 = p_3 = p_4$

(c) $p_1 < p_2 < p_3 < p_4$ (d) $p_1 < p_2 = p_3 < p_4$

128. At constant temperature, for a given mass of an ideal gas

(a) The ratio of pressure and volume always remains constant.

(b) Volume always remains constant.

(c) Pressure always remains constant.

(d) The product of pressure and volume always remains constant.

129. If 500 ml of gas A at 400 torr and 666.6 ml of B at 600 torr are placed in a 3 litre flask, the pressure of the system will be

(a) 200 torr (b) 100 torr
(c) 550 torr (d) 366 torr

130. What is the partial pressure (mmHg) of nitrogen if total atmospheric pressure is 760mmHg ?

(a) 159 (b) 300
(c) 592.8 (d) 230

131. Cyclopropane and oxygen at partial pressures 170 torr and 570 torr respectively are mixed in a gas cylinder. What is the ratio of the number of moles of cyclopropane to the number of moles of oxygen (nC_3H_6/nO_2)?

(a) $\frac{170\times 42}{570\times 32}=0.39$ (b) $\frac{170}{42}\Big/\left(\frac{170}{42}+\frac{570}{32}\right)\approx 0.19$

(c) $\frac{170}{740}=0.23$ (d) $\frac{170}{570}=0.30$

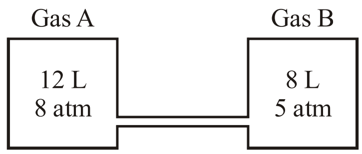
132. An evacuated glass vessel weights 50 g when empty, 144.0 g when filled with a liquid of density 0.47 g ml^{-1} and 50.5 g when filled with an ideal gas at 760 mm Hg at 300 K. The molar mass of the ideal gas is
(Given R = 0.0821 L atm K^{-1} mol^{-1})

(a) 61.575 (b) 130.98
(c) 123.75 (d) 47.87

133. The pressure of a 1:4 mixture of dihydrogen and dioxygen enclosed in a vessel is one atmosphere. What would be the partial pressure of dioxygen ?

(a) 0.8×10^5 atm (b) 0.008 Nm^{-2}
(c) 8×10^4 Nm^{-1} (d) 0.25 atm

134. Two vessels containing gases A and B are interconected as shown in the figure. The stopper is opened, the gases are allowed to mix homogeneously. The partial pressures of A and B in the mixture will be, respectively



(a) 8 and 5 atom (b) 9.6 and 4 atm
(c) 4.8 and 2 atm (d) 6.4 and 4 atm

135. A neon-dioxygen mixture contains 70.6 g O_2 and 167.5 g neon. If pressure of the mixture of gases in the cylinder is 25 bar. What is the partial pressure of O_2 and Ne in the mixture respectively ?

(a) 5.25 bar, 10 bar (b) 19.75 bar, 5.25 bar
(c) 19.75 bar, 10 bar (d) 5.75 bar, 19.75 bar

136. 0.5 mole of each H_2, SO_2 and CH_4 are kept in a container. A hole was made in the container. After 3 h, the order of partial pressures in the container will be

(a) $p_{SO_2} > p_{CH_4} > p_{H_2}$ (b) $p_{H_2} > p_{SO_2} > p_{CH_4}$

(c) $p_{H_2} > p_{CH_4} > p_{SO_2}$ (d) $p_{SO_2} > p_{H_2} > p_{CH_4}$

137. For a person travelling to the peak of the mountain which of the following statement(s) is/are correct ?

(i) Oxygen level goes on decreasing.
(ii) Gas law can be applied to this situation.
(a) Both (i) and (ii)
(b) Only (i)
(c) Only (ii)
(d) Neither (i) nor (ii)

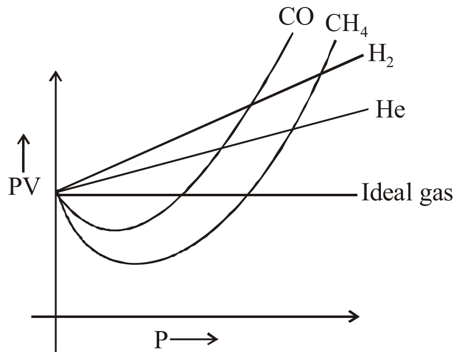
138. Pressure in well inflated tyres of automobiles is almost constant, but on a hot summer day this increases considerably and tyre may burst if pressure is not adjusted properly. During winters, on a cold morning one may find the pressure in the tyres of a vehicle decreased considerably. Which of the following law explain the above observations?

(a) Charle's Law (b) Avogadro Law
(c) Boyle's Law (d) Gay Lussac's Law

139. What is the ratio of pressure of the 2gm of hydrogen to that of 4 gm of helium at temperature of 298K, 20ml volume? (consider the ideal behaviour)

(a) 1 : 2 (b) 2 : 1
(c) 1 : 1 (d) 2 : 2

140. In case of CO and CH_4 curve goes to minima then increases with increase in pressure but in case of H_2 and He the curve is linear because:



(a) Intermolecular interactions for H_2 and He are very low.
(b) Molecular size or atomic size for H_2 and He is small.
(c) Both (a) and (b)
(d) Neither (a) nor (b)

141. Which among the following has lowest surface tension ?

(a) Hexane (b) Water

(c) CH_3OH (d) CH_3CH_2OH

142. Water droplets was not able to maintain its spherical shape in the presence of gravity but mercury does, why ?

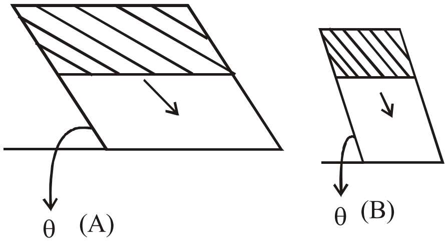
(a) Force of attraction between atoms of mercury is very high than that of molecules in case of water.

(b) Surface tension of mercury is very high.

(c) Both (a) and (b)

(d) Neither (a) nor (b)

143. Consider the case of honey flowing over a slope for this situation which of the following statement(s) is/are correct ?



(i) Velocity with which honey is flowing is slower in A than B (θ being same in both cases)

(ii) Velocity increases with increase in temperature.

(a) (i) and (ii) (b) Only (i)

(c) Only (ii) (d) Neither (i) nor (ii)

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** Attractive forces between an ion and a dipole are known as ion - dipole forces and these are not van der Waals forces.

2. **(d)** Fritz London explained the concept of dispersion force.

3. **(b)** Interaction energy $\propto \frac{1}{r^6}$

4. **(c)**

5. **(c)** London forces are always attractive and interaction energy is inversely proportional to the sixth power of the distance between two interacting particles.

6. **(c)**

7. **(a)** Dipole-dipole interaction is stronger than the London forces but is weaker than ion-ion interaction because only partial charges are involved e.g., HCl molecules. The attractive force decreases with the increase of distance between the dipoles.

8. **(d)** Induced dipole moment depends upon the dipole moment present in the permanent dipole and the polarisability of the electrically neutral molecule. Molecules of large size can be easily polarized. High polarisability increases the strength of attractive interactions.

9. **(b)** This type of attractive force operates between the polar molecules having permanent dipole and the molecules lacking permanent dipole.

HCl is polar ($\mu \neq 0$) and He is non polar ($\mu = 0$), thus gives dipole-induced dipole interaction.

10. **(c)** Nobel gases has no intermolecular forces due to inertness.

11. **(a)** Strength of the hydrogen bond is determined by coulombic interaction between lone pair electrons of the electronegative atom of one molecule and the hydrogen atom of the other molecule.

12. **(d)** **13.** **(a)**

14. **(c)** Gaseous state of substance has the maximum thermal energy.

15. **(c)** Gases do not have definite shape and volume. Their volume is equal to the volume of the container.

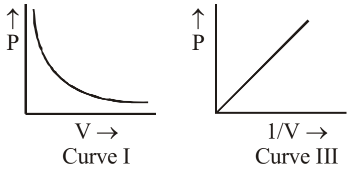
16. **(b)** It is characteristic of gases i.e., Thermal energy >> molecular attraction.

17. **(c)** Robert Boyle made first reliable measurement on properties of gases.

18. **(d)** According to Boyle's law at constant temperature,

$V \propto \frac{1}{P}$ or PV = constant

19. **(c)**



Both these graphs represents Boyle's law.

20. **(b)** According to Boyle's Law

$pv = k$

$$p\frac{m}{d} = k$$

$$\frac{p}{d} = \frac{k}{m} = k'$$

21. **(b)** Boyle's law

$$P \propto \frac{1}{V}$$

$$P = \frac{K}{V}$$

$$PV = K$$

22. **(a)** Given initial volume (V_1) = 600 c.c.; Initial pressure (P_1) = 750 mm of Hg and final volume (V_2) = 500 c.c. according to Boyle's law,

$P_1V_1 = P_2V_2$

or $750 \times 600 = P_2 \times 500$

or $P_2 = \frac{750 \times 600}{500} = 900$ mm of Hg

Therefore increase of pressure = (900 – 750) = 150 mm of Hg

23. **(b)** The lowest hypothetical or imaginary temperature at which gases are supposed to occupy zero volume is called **absolute zero**.

24. **(b)** Given initial volume (V_1) = 500 ml ; Initial temperature (T_1) = 27ºC = 300 K and final temperature (T_2) = –5ºC = 268 K.

From Charle's law :

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } \frac{500}{300} = \frac{V_2}{268}$$

Where V_2 = New volume of gas

$$V_2 = \frac{500}{300} \times 268 = 446.66 \text{ml.}$$

25. **(c)** At any given pressure, graph of volume vs temperature (in °C) is a straight line and on extending to zero volume each line intercepts the temperature axis at – 273.15° C.

26. **(c)** According to Charle's law $V \propto T$ or $\frac{V}{T} = k$

27. **(b)** Charle's law $V \propto T$ at constant P.

28. **(a)** $d \propto p$, Boyle's law, $\left(d = \frac{MP}{RT}\right)$. At sea level pressure is more, hence density of air is more.

29. **(b)** Hot air is lighter due to less density (Charle's law) $\left(d = \frac{MP}{RT}\right)$

30. **(b)** Higher P, lower T, greater the density. $\left(d = \frac{MP}{RT}\right)$

31. **(a)** Order of pressure, $p_1 < p_2 < p_3 < p_4$.

32. **(a)** $V_1 = 2\,L,\ T_2 = (26.1 + 273)\,K = 299.1\,K, V_2 = ?$

$T_1 = (23.4 + 273)\,K = 296.4\,K$

From Charle's law, $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow V_2 = \frac{V_1T_2}{T_1}$

$\Rightarrow V_2 = \frac{2L \times 299.1K}{296.4K} = 2L \times 1.009$

$= 2.018\,L$

33. **(d)** $\frac{P}{T} =$ constant (Gay Lussac's law)

$\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_1T_2 = P_2T_1$

PV = constant

$P_1V_1 = P_2V_2$ [Boyle's law]

34. **(c)** This relationship is derived from Boyle's and Charles' law.

35. **(d)** All of the given relations are true for Avogadro's law.

36. **(a)** At STP molar volume of an ideal gas or a combination of ideal gases is $22.71098\ L\,mol^{-1}$.

37. **(d)** 44g at STP occupies volume 22.4 litre which is molecular mass of CO_2. Molecular mass occupies 22.4 litre at STP.

38. **(b)** An ideal gas obeys the gas laws under all experimental conditions.

39. **(c)** $PV = nRT$

$\therefore n/V = P/RT$.

40. **(c)** In the equation $PV = nRT$, n moles of the gas have volume V.

41. **(b)** $\frac{PV}{T} =$ constant or $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\Rightarrow \frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$

42. **(b)** $R = 0.0082$ litre atm K^{-1} mole^{-1}.

43. **(d)** $PV = nRT = \frac{m}{M}RT$

or $PM = \frac{m}{V}RT = dRT \Rightarrow d = \frac{PM}{RT}$

44. **(c)** $n = \frac{PV}{RT} = \frac{m}{M}$

$$m = \frac{MPV}{RT} = \frac{34 \times 2 \times 100}{0.082 \times 293} = 282.68\text{gm}$$

45. **(c)** $V_2 = \frac{P_1V_1}{T_1}\frac{T_1}{P_2} = \frac{760}{600} \times \frac{546}{273} \times 273 = 691.6\,\text{ml}$

46. **(a)** Total moles

$= \frac{4}{32} + \frac{2}{2} = 1.125;\ PV = nRT$

$\Rightarrow P = 1.125 \times .0821 \times 273$

$P = 25.215$ atm

47. **(c)** PV = nRT is for an ideal gas which follows both isothermal and adiabatic processes.

48. **(a)** By Dalton's law of partial pressures, the total pressure of a mixture of two gases is the sum of the partial pressures of components of the mixture.

49. **(a)**

50. **(b)** Because H_2 & Cl_2 gases may react with each other to produce HCl gas hence Dalton's law is not applicable.

51. **(a)** Pressure exerted by saturated water vapour is called aqueous tension.

52. **(d)** $P = \frac{nRT}{V} = \frac{6}{16.02}\frac{\times 8.314 \times 402}{0.03} \simeq 41648\,\text{Pa}$

53. **(a)** Given $n_{CO} = n_{N_2}$

$P_{CO} + P_{N_2} = 1$ atm

Partial pressure of a gas = mole fraction of gas × total pressure

$$\therefore P_{N_2} = \frac{n_{N_2}}{n_{CO} + n_{N_2}} \times 1 = \frac{n_{N_2}}{2n_{N_2}} \times 1 = \frac{1}{2} = 0.5 \text{ atm.}$$

54. **(a)** Given

$P_1 = 1.5$ bar $T_1 = 273 + 15 = 288\,K\ V_1 = V$

$P_2 = 1.0$ bar $T_1 = 273 + 25 = 298K\ V_2 = ?$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{1.5 \times V}{288} = \frac{1 \times V_2}{298}$

$V_2 = 1.55\,V$ i.e., volume of bubble will be almost 1.6 time to initial volume of bubble.

55. **(a)** Partial pressure = total pressure × mole fraction

Moles of oxygen $= \frac{64}{32} = 2$

Moles of neon $= \frac{60}{20} = 3$

Mole fraction of oxygen $= \frac{2}{2+3} = \frac{2}{5}$

$P_{O_2} = \frac{2}{5} \times 10 = 4$ bar

Mole fraction of neon = $\frac{3}{2+3} = \frac{3}{5}$

$$P_{Ne} = \frac{3}{5} \times 10 = 6 \text{ bar}$$

56. **(b)** $P_1V_1 = P_2V_2$
$760 \times 500 = P_2 \times 200.$

$$P_2 = \frac{760 \times 500}{200} = 1900 \text{mm Hg}$$

57. **(d)** Value of gas constant depends only upon units of measurement.

58. **(a)** Given conditions
$V_1 = 16.4 \text{ L}, V_2 = 5 \text{ L}$
$P_1 = 1.5 \text{ atm}, P_2 = 4.1 \text{ atm}$
$T_1 = 273 + 27 = 300 \text{ K},$
$T_2 = 273 + 227 = 500 \text{ K}$

Applying gas equation, $\frac{P_1V_1}{P_2V_2} = \frac{n_1T_1}{n_2T_2}$

$$\frac{n_1}{n_2} = \frac{P_1V_1T_1}{P_2V_2T_2}$$

$$\therefore \frac{1.5 \times 16.4 \times 500}{4.1 \times 5 \times 300} = \frac{2}{1}$$

59. **(d)** On applying Dalton's law,
Partial pressure of a component
= Mole fraction × Total pressure
Given, mass of N_2 = 56 g, mass of O_2 = 96 g
Total pressure = 10 atm

$$^{n}N_2 = \frac{56}{28} = 2, \quad ^{n}O_2 = \frac{96}{32} = 3$$

$$^{x}N_2 = \frac{^{n}N_2}{^{n}N_2 + {}^{n}O_2} = \frac{2}{2+3} = 0.4,$$

$$^{x}O_2 = \frac{^{n}O_2}{^{n}N_2 + {}^{n}O_2} = \frac{3}{2+3} = 0.6$$

$\therefore {}^{P}N_2 = 0.4 \times 10 = 4 \text{ atm}, {}^{P}O_2 = 0.6 \times 10 = 6 \text{ atm}$

60. **(d)** From the ideal gas equation :

$PV = nRT$

or $n = \frac{PV}{RT} = \frac{3170 \times 10^{-3}}{8.314 \times 300} = 1.27 \times 10^{-3}$

61. **(a)** By Dalton's law of partial pressures, the total pressure of a mixture of two gases is the sum of the partial pressures.

62. **(b)** An ideal gas equation is the combination of Boyle's law, Charles' law and Avogadro law.

63. **(b)** According to kinetic theory the gas molecules are in a state of constant rapid motion in all possible directions colloiding in a random manner with one another and with the walls of the container and between two successive collisions molecules travel in a straight line path but show haphazard motion due to collisions.

64. **(c)** Given statement explain the great compressibility of gases.

65. **(b)** If there were loss of kinetic energy, the motion of molecule will stop and gases will settle down.

66. **(b)** Particles of a gas are always in constant and random motion. If the particles were at rest and occupy fixed positions, then a gas would have a fixed shape which is not observed.

67. **(b)** If assumption (ii) is correct, the pressure vs volume graph of experimental data (real gas) and that of theoretically calculated for Boyle's law (ideal gas) should coincide.

68. **(d)** Kinetic theory of gases proves all the given gas laws.

69. **(d)** Molecules move very fast in all directions in a straight line by colliding with each other but with different velocity.

70. **(b)** At low temperature and high pressure.

71. **(a)** In van der waals equation '*b*' is for volume correction

72. **(c)** $\left(P + \frac{a}{V^2}\right)(V - b) = RT$; Here $\left(P + \frac{a}{V^2}\right)$ represents the intermolecular forces.

73. **(c)** '*a*' is directly related to forces of attraction. Hence greater the value of '*a*', more easily the gas gets liquified.

74. **(b)**

(i) At very large molar volume

$$P + \frac{a}{V_m^2} \approx P \text{ and } V_m - b = V_m$$

(iii) According to van der Waals equation '*a*' and '*b*' are independent of temperature.

75. **(a)** $P = \frac{n^2 a}{V^2}; \; a = \frac{PV^2}{n^2} = \text{atm dm}^6 \text{ mol}^{-2}$

76. **(c)** Easily liquefiable gases have greater intermolecular forces which is represented by high value of '*a*'. The greater the value of '*a*' more will be liquefiability.
So, the order is Q < S < P < R.

77. **(a)** When pressure is low '*b*' can be neglected, thus

$$\left(P + \frac{a}{V^2}\right)V = RT$$

$$PV + \frac{a}{V} = RT$$

$$PV = RT - \frac{a}{V}$$

$$\frac{PV}{RT} = \frac{RT}{RT} - \frac{a}{VRT}$$

$$Z = \frac{PV}{RT} = 1 - \frac{a}{VRT}$$

78. **(c)** $\left(P+\frac{a}{V^2}\right)(V-b)=RT$ at high pressure $\frac{a}{V^2}$ can be neglected

$PV-Pb=RT$ and $PV=RT+Pb$

$$\frac{PV}{RT}=1+\frac{Pb}{RT}$$

$Z=1+\frac{Pb}{RT}$; $Z>1$ at high pressure

79. **(d)** CO_2 has highest critical temperature of 304.2 K

80. **(d)** *At low pressure and high temperature:* At low pressure volume correction for 1 mole of a gas in negligible, i.e b = 0

thus the gas equation becomes

$$\left(P+\frac{a}{V^2}\right)V=RT$$

$$\text{or } Z=\frac{PV_m}{RT}=1-\frac{a}{V_mRT}$$

At higher pressure, the pressure correction for 1 mole of gas in negligible i.e $\frac{a}{V^2}=0$

or $(P+0)(V-b)=RT$

or $P(V_m-b)=RT$

or $PV_m=RT+Pb$

$$\text{or } Z=\frac{PV_m}{RT}=1+\frac{Pb}{RT}$$

81. **(d)** In the ideal gas, the intermolecular forces of attraction are negligible and hence it cannot be liquefied.

82. **(d)**

83. **(d)** Above Boyle point, real gases show positive deviation from ideality and Z values are greater than one.

84. **(c)**

85. **(c)** More will be critical temperature easier is the liquifaction of the gas. Hence correct order will be $He < H_2 < N_2 < O_2$

86. **(a)** For statement (iii), we can move down from G towards D by lowering the temperature.

For statement (iv), we get liquid as soon as we cross point H.

87. **(b)** At 1 atm pressure boiling temperature is called normal boiling point. If pressure is 1 bar than the boiling point is called standard boiling point of the liquid.

88. **(b)** 1 bar pressure is slightly less than 1atm pressure.

89. **(d)** A substance exists as a liquid above its m. pt. and below its b. pt.

90. **(a)** The kinetic energy of molecules in gaseous state is more than those in the liquid state as the molecules in gaseous state can move freely (with higher speed) as compared in liquid state.

91. **(a)** **92.** **(b)**

93. **(d)** All these phenomena are caused by surface tension.

94. **(b)** **95.** **(b)**

96. **(c)** Due to intermolecular H-bonding the surface tension of H_2O is more than other liquid. One H_2O molecule is joined with 4 another H_2O molecule through H–bond. Hydrogen bonding is in order $H_2O > C_2H_5OH > CH_3OH$.

97. **(a)** Boiling point of water is 100°C whereas evaporation of water into water vapours occurs at room temperature.

98. **(a)** As intermolecular forces are least in case of petrol. Thus, it has highest rate of evaporation.

99. **(c)** The correct order of viscosity of the given liquids is dimethyl ether < methyl alcohol < water < glycerol.

STATEMENT TYPE QUESTIONS

100. **(d)** These forces are important only at short distances (~ 500 pm)

101. **(b)** For statement (ii), partial charge possessed by these dipoles is always less than the unit electronic charge. For statement (iii), dipole - dipole interaction is stronger than London forces but weaker than ion - ion interaction.

102. **(d)** All of the given statements are correct for hydrogen bond.

103. **(c)** Gases have much lower density than the solids and liquids.

104. **(b)** Value of $R = 8.314\ Pa\ m^3\ K^{-1}\ mol^{-1}$

105. **(a)** All the given statements are true.

106. **(a)** For statement (ii), $p_{real}=p_{ideal}-\frac{an^2}{V^2}$

For statement (iii), value of 'a' is independent of temperature and pressure.

107. **(d)** Viscosity of liquid decreases as temperature rise.

MATCHING TYPE QUESTIONS

108. **(a)** **109.** **(b)** **110.** **(a)** **111.** **(b)** **112.** **(c)**

ASSERTION-REASON TYPE QUESTIONS

113. **(a)**

114. **(a)** Gases expand and occupy all the space available to them because there is no force of attraction between the particles of a gas at ordinary temperature and pressure.

115. **(a)** **116.** **(a)**

117. **(c)** At high altitude atmospheric pressure is low.

118. **(d)**

CRITICAL THINKING TYPE QUESTIONS

119. (c) In case of HCl molecules their is dipole-dipole interaction which is stronger than London forces as in case of SF_6. Now between HCl and NaCl the ion-ion interaction present in NaCl is far more stronger than dipole-dipole interaction of HCl.

120. (d) Given, $P_1 = 15$ atm, $P_2 = 60$ atm

$V_1 = 76\ cm^3$, $V_2 = 20.5\ cm^3$.

If the gas is an ideal gas, then according to Boyle's law, it must follow the equation,

$$P_1V_1 = P_2V_2$$

$$P_1 \times V_1 = 15 \times 76 = 1140$$

$$P_2 \times V_2 = 60 \times 20.5 = 1230$$

$$\therefore P_1V_1 \neq P_2V_2$$

∴ The gas behaves non-ideally.

The given information is not sufficient to comment on other statements.

121. (d) All the gases occupy the available volume and will form homogeneous mixture.

122. (c) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ at const. pressure

$$\Rightarrow \frac{22.4}{273} = \frac{V_2}{373},\ V_2 = 30.6 \text{ litre}$$

123. (a) Since atmospheric pressure remain constant

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V_1}{298K} = \frac{2800m^3}{372K}$$

$V_1 = 2243\ m^3$

$2800\ m^3$ volume of inflated balloon.

Mass of air in inflated ballon = $2800\ m^3 \times 0.94\ kg\ m^{-3}$ = 2632 kg

Keeping the volume same = $2800\ m^3$

The mass of air, which occupies it with density ($1.2\ kg/m^3$) is 2800 × 1.2 = 3360 kg

Amount of air which had been escaped = 3360 – 2632 = 728 kg

124. (d)

125. (d) n of $O_2 = \frac{16}{32} = \frac{1}{2}$

n of $H_2 = \frac{3}{2}$

Total no. of moles $= \frac{3}{2} + \frac{1}{2} = 2$

$$V = \frac{nRT}{P} = \frac{2 \times .082 \times 273}{1} = 44.8 lit = 44800 \text{ ml}$$

126. (b) $d = \frac{PM}{RT}$

It means density of gas is directly proportional to pressure and inversely proportional to temperature. Density of neon will be maximum at highest pressure and lowest temperature.

127. (c)

128. (d) According to Boyle's law at constant temperature,

$$V \propto \frac{1}{P} \text{ or } PV = \text{constant}$$

129. (a) Applying Boyle's law $P_1V_1 = P_2V_2$ for both gases

$$\frac{500}{1000} \times 400 = P \times 3 \Rightarrow P = \frac{200}{3}$$

$$600 \times \frac{666.6}{1000} = P' \times 3 \Rightarrow P' = \frac{400}{3}$$

$$\Rightarrow P_T = P + P' = \frac{200}{3} + \frac{400}{3} = \frac{600}{3} = 200 \text{ tor}$$

130. (c) Percentage of nitrogen in atmosphere is 78% .Partial pressure of N_2 = 0. 78 × 760

131. (d) By Ideal gas equation

$$P_1V = n_1RT$$

$$n_1 \propto P_1 \text{ and } n_2 \propto P_2$$

$$\frac{n_1}{n_2} = \frac{P_1}{P_2} \Rightarrow \frac{n_1}{n_2} = \frac{170}{570} = 0.30$$

132. (a) Given weight of empty glass vessel = 50 g

Weight of vessel filled with liquid = 144 g

∴ Weight of liquid = 144 – 50 = 94 g.

Volume of liquid = Mass/density = 94/0.47

= 200 ml = 200×10^{-3} L.

Given, pressure of ideal gas = 760 mm Hg = 1 atm

Temperature = 300 K

$R = 0.0821\ L\ atm\ K^{-1}\ mol^{-1}$

Mass of ideal gas = 50.5 – 50 = 0.5 g

According to ideal gas equation,

$$PV = nRT = \frac{w}{M}RT$$

$$1 \times 200 \times 10^{-3} = \frac{0.5}{M} \times 0.0821 \times 300$$

$$M = \frac{0.5 \times 0.0821 \times 300}{200 \times 10^{-3}} = 61.575$$

133. (d) $p_1 = 1.5$ atm, $T_1 = 15°C = (15 + 273)K = 288\ K$

$p_2 = 1$ atm, $T_2 = 25°C = (25 + 273)K = 298\ K$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$\frac{p_1T_2}{T_1p_2} = \frac{V_2}{V_1} \Rightarrow \frac{V_2}{V_1} = \frac{1.5 \times 298}{288 \times 1} = 1.55$$

134. (c) Moles of A, $(n_A) = \frac{p_A v_A}{RT} = \frac{8\times12}{RT} = \frac{96}{RT}$

Moles of B, $(n_B) = \frac{p_B v_B}{RT} = \frac{8\times5}{RT} = \frac{40}{RT}$

Total pressure × total volume $= (n_A + n_B)\times RT$

$$p\times(12+8) = \frac{1}{RT}(96+40)RT$$

$$p = 6.8$$

Partial pressure of A = p × mole fraction of A

$$= 6.8\left(\frac{96}{RT}\Big/\frac{96+40}{RT}\right)$$

$$= 4.8 \text{ atm}$$

Partial pressure of B $= 6.8 - 4.8 = 2$ atm.

135. (d) Number of moles of $O_2 = \frac{70.6\text{g}}{32\text{g mol}^{-1}} = 2.21$ mol

Number of moles of Ne $= \frac{167.5\text{g}}{20\text{g mol}^{-1}} = 8.375$ mol

Mole fraction of $O_2 = \frac{2.21}{2.21+8.375} = 0.21$

Mole fraction of Ne $= 1 - 0.21 = 0.79$

Partial pressure of a gas = Mole fraction × total pressure

Partial pressure of $O_2 = 0.21 \times 25 = 5.25$ bar

Partial pressure of Ne $= 0.79 \times 25 = 19.75$ bar

136. (a) Extent of diffusion $H_2 > CH_4 > SO_2$ because rate of diffusion $\propto \frac{1}{\text{molar mass}}$

Order of partial pressure after diffusion is

$$p_{SO_2} > p_{CH_4} > p_{H_2}$$

137. (a) As the height increases, atmospheric pressure decreases, so now the volume of the gas increases and gas tends to become less denser, hence the concentration of oxygen decreases.

138. (d) The mathematical relationship between pressure and temperature was given by Gay Lussac's law.

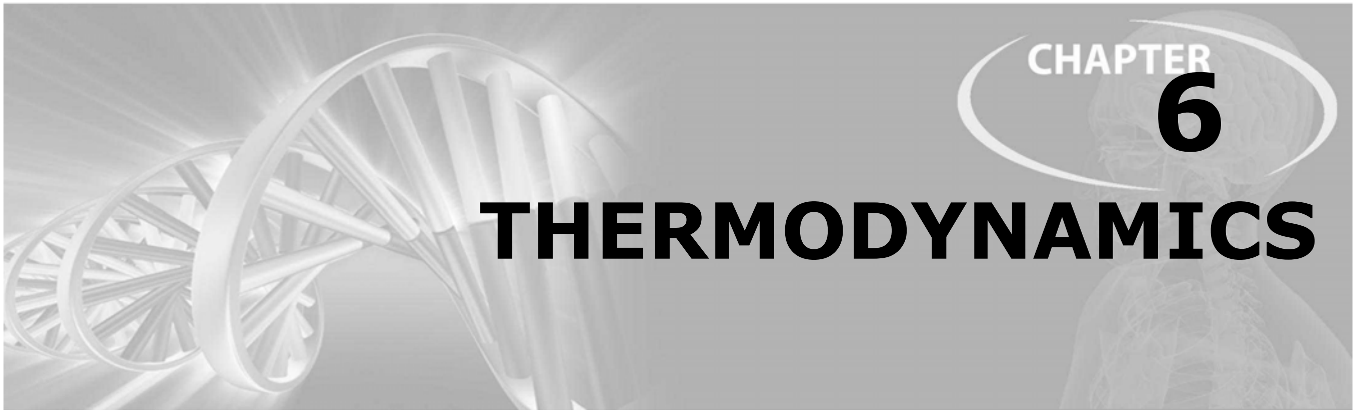
139. (c) Number of moles, temperature and volume are same.

140. (c) Due to small size of these species (H_2 and He) intermolecular interactions (van der Waal forces) are very low, therefore it is difficult to compress these .

141. (a) Since surface tension depends on the attractive forces between the molecules, and hydrogen bonding a special type of dipole-dipole interactions in (b), (c) and (d) which is stronger than London forces of attraction in hexane.

142. (c)

143. (a) Force is required to maintain the flow of layer which is inversely proportional to the area of contact of layer therefore flow in B is greater than that in A as the area of contact is greater in A. Also viscosity of the fluid decreases with increase in temperature therefore liquid flow increases.



CHAPTER 6

THERMODYNAMICS

FACT/DEFINITION TYPE QUESTIONS

1. Thermodynamics is not concerned about____.
(a) energy changes involved in a chemical reaction.
(b) the extent to which a chemical reaction proceeds.
(c) the rate at which a reaction proceeds
(d) the feasibility of a chemical reaction.

2. Which of the following statements is not true regarding the laws of thermodynamics ?
(a) It deal with energy changes of macroscopic systems.
(b) It deal with energy changes of microscopic systems.
(c) It does not depends on the rate at which these energy transformations are carried out.
(d) It depends on initial and final states of a system undergoing the change.

3. A…………….. in thermodynamics refers to that part of universe in which observations are made and remaining universe constitutes the……………...
(a) surroundings, system (b) system, surroundings
(c) system, surroundings (d) system, boundary

4. The universe refers to
(a) only system
(b) only surroundings
(c) both system and surroundings
(d) None of these

5. Which of the following statements is correct?
(a) The presence of reacting species in a covered beaker is an example of open system.
(b) There is an exchange of energy as well as matter between the system and the surroundings in a closed system.
(c) The presence of reactants in a closed vessel made up of copper is an example of a closed system.
(d) The presence of reactants in a thermos flask or any other closed insulated vessel is an example of a closed system.

6. Which of the following is closed system ?
(a) Jet engine
(b) Tea placed in a steel kettle
(c) Pressure cooker
(d) Rocket engine during propulsion

7. An isolated system is that system in which
(a) There is no exchange of energy with the surroundings
(b) There is exchange of mass and energy with the surroundings
(c) There is no exchange of mass or energy with the surroundings
(d) There is exchange of mass with the surroundings

8. The state of a thermodynamic system is described by its measurable or macroscopic (bulk) properties. These are
(a) Pressure and volume
(b) Pressure, volume, temperature and amount
(c) Volume, temperature and amount
(d) Pressure and temperature

9. Which of the following are *not* state functions ?
(I) $q + w$ (II) q
(III) w (IV) $H - TS$
(a) (I) and (IV) (b) (II), (III) and (IV)
(c) (I), (II) and (III) (d) (II) and (III)

10. Among the following the state function(s) is (are)
(i) Internal energy
(ii) Irreversible expansion work
(iii) Reversible expansion work
(iv) Molar enthalpy
(a) (ii) and (iii) (b) (i), (ii) and (iii)
(c) (i) and (iv) (d) (i) only

11. Enthalpy change (ΔH) of a system depends upon its
(a) Initial state
(b) Final state
(c) Both on initial and final state
(d) None of these

12. ………………. is a quantity which represents the total energy of the system
(a) Internal energy (b) Chemical energy
(c) Electrical energy (d) Mechanical energy

13. Which of the following factors affect the internal energy of the system ?
(a) Heat passes into or out of the system.
(b) Work is done on or by the system.
(c) Matter enters or leaves the system.
(d) All of the above

14. The system that would not allow exchange of heat between the system and surroundings through its boundary is considered as

(a) isothermal (b) adiabatic

(c) isobaric (d) isochoric

15. The enthalpy change of a reaction does not depend on

(a) The state of reactants and products

(b) Nature of reactants and products

(c) Different intermediate reactions

(d) Initial and final enthalpy change of a reaction.

16. The q is ……………. when heat is transferred from the surroundings to the system and q is……………………….. When heat is transferred from system to the surroundings.

(a) positive , negative (b) negative , positive

(c) high, low (d) low, high

17. Adiabatic expansions of an ideal gas is accompanied by

(a) decrease in ΔE

(b) increase in temperature

(c) decrease in ΔS

(d) no change in any one of the above properties

18. Which of the following statements is incorrect?

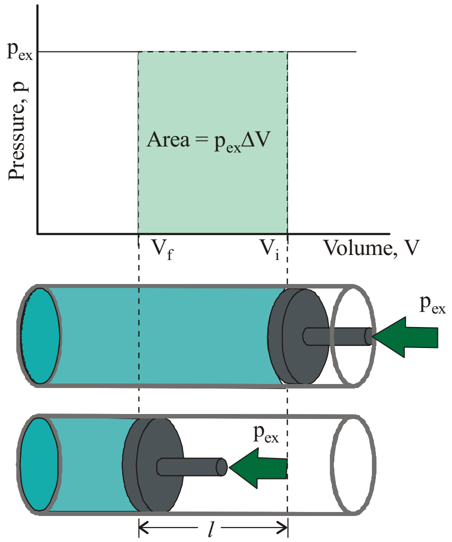
(a) q is a path dependent function.

(b) H is a state function.

(c) Both H and q are state functions.

(d) Both (a) and (b)

19. Figure below is showing that one mole of an ideal gas is fitted with a frictionless piston. Total volume of the gas is V_i and pressure of the gas inside is p. If external pressure is p_{ex} which is greater than p is applied, piston is moved inward till the pressure inside becomes equal to p_{ex}.



What does the shaded area represents in the figure ?

(a) Work done (b) Pressure change

(c) Volume change (d) Temperature change

20. When 1 mol of a gas is heated at constant volume, temperature is raised from 298 to 308 K. If heat supplied to the gas is 500 J, then which statement is correct ?

(a) $q = w = 500\ J, \Delta U = 0$ (b) $q = \Delta U = 500\ J, w = 0$

(c) $q = -w = 500\ J, \Delta U = 0$ (d) $\Delta U = 0, q = w = -500\ J$

21. The work done during the expansion of a gas from a volume of 4 dm^3 to 6 dm^3 against a constant external pressure of 3 atm is (1 L atm = 101.32 J)

(a) – 6 J (b) – 608 J

(c) + 304 J (d) – 304 J

22. Which of the following statements/relationships is **not** correct in thermodynamic changes ?

(a) $\Delta U = 0$ (isothermal reversible expansion of a gas)

(b) $w = -nRT \ln \frac{V_2}{V_1}$ (isothermal reversible expansion of an ideal gas)

(c) $w = nRT \ln \frac{V_2}{V_1}$ (isothermal reversible expansion of an ideal gas)

(d) For a system of constant volume heat involved directly changes to internal energy.

23. An ideal gas expands in volume from 1×10^{-3} to $1 \times 10^{-2}\ m^3$ at 300 K against a constant pressure of $1 \times 10^5\ Nm^{-2}$. The work done is

(a) 270 kJ (b) – 900 kJ

(c) – 900 J (d) 900 kJ

24. The difference between ΔH and ΔU is usually significant for systems consisting of

(a) only solids (b) only liquids

(c) both solids and liquids (d) only gases

25. If a reaction involves only solids and liquids which of the following is true ?

(a) $\Delta H < \Delta E$ (b) $\Delta H = \Delta E$

(c) $\Delta H > \Delta E$ (d) $\Delta H = \Delta E + RT\Delta n$

26. During isothermal expansion of an ideal gas, its

(a) internal energy increases

(b) enthalpy decreases

(c) enthalpy remains unaffected

(d) enthalpy reduces to zero.

27. Assume each reaction is carried out in an open container. For which reaction will $\Delta H = \Delta E$?

(a) $C(s) + 2H_2O\,(g) \rightarrow 2H_2\,(g) + CO_2\,(g)$

(b) $PCl_5\,(g) \rightarrow PCl_3\,(g) + Cl_2\,(g)$

(c) $2CO\,(g) + O_2\,(g) \rightarrow 2CO_2\,(g)$

(d) $H_2\,(g) + Br_2\,(g) \rightarrow 2\,HBr\,(g)$

28. For the reaction $CO\,(g) + \frac{1}{2}O_2\,(g) \rightarrow CO_2\,(g)$

Which one of the statement is correct at constant T and P ?

(a) $\Delta H = \Delta E$

(b) $\Delta H < \Delta E$

(c) $\Delta H > \Delta E$

(d) ΔH is independent of physical state of the reactants

29. For a reaction in which all reactants and products are liquids, which one of the following equations is most applicable ?

(a) $\Delta H < \Delta E$ (b) $\Delta H = \Delta S$
(c) $\Delta H = \Delta E$ (d) $\Delta H = \Delta G$

30. The relationship between enthalpy change and internal energy change is

(a) $\Delta H = \Delta E + P\Delta V$ (b) $\Delta H = (\Delta E + V\Delta P)$
(c) $\Delta H = \Delta E - P\Delta V$ (d) $\Delta H = P\Delta V - \Delta E$

31. For the reaction

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O_{(l)}$$

at constant temperature, $\Delta H - \Delta E$ is

(a) $-RT$ (b) $+RT$
(c) $-3\,RT$ (d) $+3\,RT$

32. Consider the reaction : $N_2 + 3H_2 \rightarrow 2NH_3$ carried out at constant temperature and pressure. If ΔH and ΔU are the enthalpy and internal energy changes for the reaction, which of the following expressions is true ?

(a) $\Delta H > \Delta U$ (b) $\Delta H < \Delta U$
(c) $\Delta H = \Delta U$ (d) $\Delta H = 0$

33. Among the following, the intensive properties are

(i) molar conductivity (ii) electromotive force
(iii) resistance (iv) heat capacity
(a) (ii) and (iii) (b) (i), (ii) and (iii)
(c) (i) and (iv) (d) (i) only

34. Which is an extensive property of the system ?

(a) Volume (b) Viscosity
(c) Temperature (d) Refractive index

35. Which of the following is an example of extensive property?

(a) Temperature (b) Density
(c) Mass (d) Pressure

36. Which of the following factors do not affect heat capacity?

(a) Size of system (b) Composition of system
(c) Nature of system (d) Temperature of the system

37. The heat required to raise the temperature of body by 1 C° is called

(a) specific heat (b) thermal capacity
(c) water equivalent (d) None of these.

38. Equal volumes of two monoatomic gases, A and B, at same temperature and pressure are mixed. The ratio of specific heats (C_p/C_v) of the mixture will be :

(a) 0.83 (b) 1.50
(c) 3.3 (d) 1.67

39. The molar heat capacity of water at constant pressure is 75 $JK^{-1}\ mol^{-1}$. When 1kJ of heat is supplied to 100 g of water, which is free to expand, the increase in temperature of water is

(a) 6.6 K (b) 1.2 K
(c) 2.4 K (d) 4.8 K

40. Calorie is equivalent to :

(a) 0.4184 Joule (b) 4.184 Joule
(c) 41.84 Joule (d) 418.4 Joule

41. Which of the following is not true regarding thermo-chemical equations?

(a) The coefficients in a balanced thermo-chemical equation refer to the number of moles of reactants and products involved in the reaction
(b) The coefficients in a balanced thermo-chemical equation refer to the number of molecules of reactants and products involved in the reaction
(c) The numerical value of $\Delta_r H$ refers to the number of moles of substances specified by an equation.
(d) Standard enthalpy change $\Delta_r H^{\ominus}$ will have units as $kJ\ mol^{-1}$.

42. The enthalpies of elements in their standard states are taken as zero. The enthalpy of formation of a compound

(a) is always negative
(b) is always positive
(c) may be positive or negative
(d) is never negative

43. If enthalpies of formation of $C_2H_4(g)$, $CO_2(g)$ and $H_2O_{(l)}$ at 25°C and 1atm pressure are 52, – 394 and – 286 kJ/mol respectively, the change in ethalpy is equal to

(a) – 141.2 kJ/mol (b) – 1412 kJ/mol
(c) + 14.2 kJ/mol (d) + 1412 kJ/mol

44. The enthalpy change for a reaction does **not** depend upon

(a) use of different reactants for the same product
(b) the nature of intermediate reaction steps
(c) the differences in initial or final temperatures of involved substances
(d) the physical states of reactants and products

45. On the basis of thermochemical equations (i), (ii) and (iii), find out which of the algebric relationships given in options (a) to (d) is correct.

(i) $C\ (graphite) + O_2(g) \rightarrow CO_2(g);\ \Delta_r H = x\ kJ\ mol^{-1}$
(ii) $C(graphite) + \frac{1}{2}O_2(g) \rightarrow CO\ (g);\ \Delta_r H = y\ kJ\ mol^{-1}$
(iii) $CO\ (g) + \frac{1}{2}O_2\ (g) \rightarrow CO_2\ (g);\ \Delta_r H = z\ kJ\ mol^{-1}$

(a) $z = x + y$ (b) $x = y - z$
(c) $x = y + z$ (d) $y = 2z - x$

46. Given that bond energies of H – H and Cl – Cl are 430 $kJ\ mol^{-1}$ and 240 $kJ\ mol^{-1}$ respectively and ΔH_f for HCl is – 90 $kJ\ mol^{-1}$, bond enthalpy of HCl is

(a) 380 $kJ\ mol^{-1}$ (b) 425 $kJ\ mol^{-1}$
(c) 245 $kJ\ mol^{-1}$ (d) 290 $kJ\ mol^{-1}$

47. Bond dissociation enthalpy of H_2, Cl_2 and HCl are 434 , 242 and 431 $kJ\ mol^{-1}$ respectively. Enthalpy of formation of HCl is:

(a) 93 $kJ\ mol^{-1}$ (b) – 245 $kJmol^{-1}$
(c) – 93 $kJmol^{-1}$ (d) 245 $kJmol^{-1}$

48. From the following bond energies:

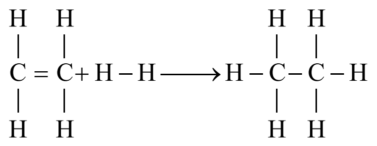
H – H bond energy: 431.37 kJ mol^{-1}

C = C bond energy: 606.10 kJ mol^{-1}

C – C bond energy: 336.49 kJ mol^{-1}

C – H bond energy: 410.50 kJ mol^{-1}

Enthalpy for the reaction,



$$H_2C{=}CH_2 + H{-}H \longrightarrow H_3C{-}CH_3$$

will be:

(a) – 243.6 kJ mol^{-1} (b) –120.0 kJ mol^{-1}

(c) 553.0 kJ mol^{-1} (d) 1523.6 kJ mol^{-1}

49. The following two reactions are known :

$Fe_2O_{3(s)} + 3CO_{(g)} \longrightarrow 2Fe_{(s)} + 3CO_{2(g)}$; $\Delta H = -26.8$ kJ

$FeO_{(s)} + CO_{(g)} \longrightarrow Fe_{(s)} + CO_{2(g)}$; $\Delta H = -16.5$ kJ

The value of ΔH for the following reaction

$Fe_2O_{3(s)} + CO_{(g)} \longrightarrow 2FeO_{(s)} + CO_{2(g)}$ is;

(a) + 6.2 kJ (b) + 10.3 kJ

(c) – 43.3 kJ (d) – 10.3 kJ

50. Consider the following processes :

	ΔH (kJ/mol)
$1/2\,A \to B$	+150
$3B \to 2C + D$	–125
$E + A \to 2D$	+350

For $B + D \to E + 2C$, ΔH will be :

(a) 525 kJ/mol (b) – 175 kJ/mol

(c) – 325 kJ/mol (d) 325 kJ/mol

51. The $\Delta_f H^\circ$ for $CO_2(g)$ $CO(g)$ and $H_2O(g)$ are –393.5, –110.5 and –241.8 kJ/mol respectively, the standard enthalpy change (in kJ) for the reaction

$CO_2(g) + H_2(g) \to CO(g) + H_2O(g)$ is :

(a) 524.1 (b) 41.2

(c) –262.5 (d) – 41.2

52. If enthalpies of formation of $C_2H_4(g)$, $CO_2(g)$ and $H_2O(l)$ at 25°C and 1atm pressure are 52, – 394 and – 286 kJ/mol respectively, the change in enthalpy is equal to

(a) – 141.2 kJ/mol (b) – 1412 kJ/mol

(c) + 14.2 kJ/mol (d) + 1412 kJ/mol

53. Hess's law is used to calculate :

(a) enthalpy of reaction. (b) entropy of reaction

(c) work done in reaction (d) All of the above

54. Which thermochemical process is shown by the following figure ?

$$\begin{tikzcd}
\boxed{X} \arrow[r, "\Delta_r H"] \arrow[d, "\Delta_r H_1"] & \boxed{Y} \\
\boxed{P} \arrow[r, "\Delta_r H_2"] & \boxed{Q} \arrow[u, "\Delta_r H_3"]
\end{tikzcd}$$

(a) Standard enthalpy of a reaction

(b) Born – Haber cycle of lattice enthalpy

(c) Hess's law of constant heat summation

(d) Standard enthalpy of a solution

55. The enthalpy change on breaking one mole of bonds completely to obtain atoms in the gas phase is known as

(a) enthalpy of atomization.

(b) enthalpy of formation

(c) enthalpy of sublimation

(d) enthalpy of vaporization

56. Which of the following statements is true for the given reaction?

$$Na(s) \to Na(g);\ \Delta H^{\ominus} = 108.4 \text{ kJ mol}^{-1}$$

(a) The enthalpy of atomization is same as the enthalpy of vaporisation

(b) The enthalpy of atomization is same as the enthalpy of sublimation.

(c) The enthalpy of atomization is same as the bond enthalpy

(d) The enthalpy of atomization is same as the enthalpy of solution

57. The heat of combustion of a substance is :

(a) Always positive

(b) Always negative

(c) Numerically equal to the heat of formation

(d) Unpredictable

58. During complete combustion of one mole of butane, 2658 kJ of heat is released. The thermochemical reaction for above change is

(a) $2C_4H_{10}(g) + 13O_2(g) \to 8CO_2(g) + 10H_2O(l)$ $\Delta_c H = -2658.0$ kJ mol^{-1}

(b) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \to 4CO_2(g) + 5H_2O\,(g)$ $\Delta_c H = -1329.0$ kJ mol^{-1}

(c) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \to 4CO_2(g) + 5H_2O\,(l)$ $\Delta_c H = -2658.0$ kJ mol^{-1}

(d) $C_4H_{10}(g) + \frac{13}{2}O_2\,(g) \to 4CO_2(g) + 5H_2O\,(l)$ $\Delta_c H = +2658.0$ kJ mol^{-1}

59. Given that heat of neutralisation of strong acid and strong base is – 57.1 kJ. The heat produced when 0.25 mole of HCl is neutralised with 0.25 mole of NaOH in aqueous solution is :

(a) 14.275 kJ (b) 57.1 kJ

(c) 22.5 kJ (d) 28.6 kJ

60. For most of the ionic compounds, ΔH_{sol} is ....and the dissociation process is...............

(a) positive ,exothermic (b) negative, exothermic

(c) positive, endothermic (d) negative,endothermic

61. Pick out the wrong statement
(a) The standard free energy of formation of all elements is zero
(b) A process accompanied by decrease in entropy is spontaneous under certain conditions
(c) The entropy of a perfectly crystalline substance at absolute zero is zero
(d) A process that leads to increase in free energy will be spontaneous

62. Identify the correct statement for change of Gibbs energy for a system (ΔG_{system}) at constant temperature and pressure
(a) If $\Delta G_{system} = 0$, the system has attained equilibrium
(b) If $\Delta G_{system} = 0$, the system is still moving in a particular direction
(c) If $\Delta G_{system} < 0$, the process is not spontaneous
(d) If $\Delta G_{system} > 0$, the process is not spontaneous

63. Identify the correct statement regarding a spontaneous process:
(a) Lowering of energy in the process is the only criterion for spontaneity.
(b) For a spontaneous process in an isolated system, the change in entropy is positive.
(c) Endothermic processes are never spontaneous.
(d) Exothermic processes are always spontaneous.

64. A chemical reaction will be spontaneous if it is accompanied by a decrease of
(a) entropy of the system.
(b) enthalpy of the system.
(c) internal energy of the system.
(d) free energy of the system.

65. In which of the following entropy decreases?
(a) Crystallization of sucrose solution
(b) Rusting of iron
(c) Melting of ice
(d) Vaporization of camphor

66. A spontaneous reaction is impossible if
(a) both ΔH and ΔS are negative
(b) both ΔH and ΔS are positive
(c) ΔH is negative and ΔS is positive
(d) ΔH is positive and ΔS is negative

67. For the gas phase reaction,

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

which of the following conditions are correct ?
(a) $\Delta H = 0$ and $\Delta S < 0$ (b) $\Delta H > 0$ and $\Delta S > 0$
(c) $\Delta H < 0$ and $\Delta S < 0$ (d) $\Delta H > 0$ and $\Delta S < 0$

68. The factor of ΔG values is important in metallurgy. The ΔG values for the following reactions at 800ºC are given as :

$$S_2(s) + 2O_2(g) \longrightarrow 2SO_2(g)\ ;\ \Delta G = -544\ kJ$$

$$2Zn(s) + S_2(s) \longrightarrow 2ZnS(s)\ ;\ \Delta G = -293\ kJ$$

$$2Zn(s) + O_2(g) \longrightarrow 2ZnO(s)\ ;\ \Delta G = -480\ kJ$$

Then ΔG for the reaction :

$$2ZnS(s) + 3O_2(g) \longrightarrow 2ZnO(s) + 2SO_2(g)$$

will be :
(a) –357 kJ (b) –731 kJ
(c) –773 kJ (d) –229 kJ

69. Identify the correct statement regarding entropy.
(a) At absolute zero temperature, entropy of a perfectly crystalline substance is taken to be zero.
(b) At absolute zero temperature, the entropy of a perfectly crystalline substance is positive.
(c) Absolute entropy of a substance cannot be determined.
(d) At 0°C, the entropy of a perfectly crystalline substance is taken to be zero

70. Unit of entropy is
(a) $JK^{-1}\ mol^{-1}$ (b) $J\ mol^{-1}$
(c) $J^{-1}\ K^{-1}\ mol^{-1}$ (d) $JK\ mol^{-1}$

71. Considering entropy (S) as a thermodynamic parameter, the criterion for the spontaneity of any process is
(a) $\Delta S_{system} + \Delta S_{surroundings} > 0$
(b) $\Delta S_{system} - \Delta S_{surroundings} > 0$
(c) $\Delta S_{system} > 0$ only
(d) $\Delta S_{surroundings} > 0$ only

72. In an exothermic reaction (reversible) which of the following has positive value?
(a) Enthalpy (b) Entropy
(c) Gibb's free energy (d) None of these

73. A reaction cannot take place spontaneously at any temperature when
(a) both ΔH and ΔS are positive
(b) both ΔH and ΔS are negative
(c) ΔH is negative and ΔS is positive
(d) ΔH is positive and ΔS is negative

74. A reaction is spontaneous at low temperature but non-spontaneous at high temperature. Which of the following is true for the reaction?
(a) $\Delta H > 0, \Delta S > 0$ (b) $\Delta H < 0, \Delta S > 0$
(c) $\Delta H > 0, \Delta S = 0$ (d) $\Delta H < 0, \Delta S < 0$

75. At the sublimation temperature, for the process $CO_{2(s)} \rightleftharpoons CO_{2(g)}$
(a) ΔH, ΔS and ΔG are all positive
(b) $\Delta H > 0, \Delta S > 0$ and $\Delta G < 0$
(c) $\Delta H < 0, \Delta S > 0$ and $\Delta G < 0$
(d) $\Delta H > 0, \Delta S > 0$ and $\Delta G = 0$

76. Choose the reaction with negative ΔS value.
(a) $2NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$
(b) $Cl_{2(g)} \rightarrow 2Cl_{(g)}$
(c) $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$
(d) $2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$

77. A chemical reaction is spontaneous at 298 K but non-spontaneous at 350 K. Which one of the following is true for the reaction?

	ΔG	ΔH	ΔS
(a)	–	–	+
(b)	+	+	+
(c)	–	+	–
(d)	–	–	–

78. For a particular reversible reaction at temperature T, ΔH and ΔS were found to be both +ve. If T_e is the temperature at equilibrium, the reaction would be spontaneous when

(a) $T_e > T$ (b) $T > T_e$

(c) T_e is 5 times T (d) $T = T_e$

79. Which of the following pairs of a chemical reaction is certain to result in a spontaneous reaction?

(a) Exothermic and increasing disorder

(b) Exothermic and decreasing disorder

(c) Endothermic and increasing disorder

(d) Endothermic and decreasing disorder

80. In which of the following reactions, standard entropy change ($\Delta S°$) is positive and standard Gibb's energy change ($\Delta G°$) decreases sharply with increasing temperature ?

(a) $\text{C graphite} + \frac{1}{2}O_2(g) \rightarrow CO(g)$

(b) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

(c) $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s)$

(d) $\frac{1}{2}\text{C graphite} + \frac{1}{2}O_2(g) \rightarrow \frac{1}{2}CO_2(g)$

81. Consider the following reaction occurring in an automobile

$$2C_8H_{18}(g) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(g)$$

the sign of ΔH, ΔS and ΔG would be

(a) +, –, + (b) –, +, –

(c) –, +, + (d) +, +, –

82. A reaction occurs spontaneously if

(a) $T\Delta S < \Delta H$ and both ΔH and ΔS are + ve

(b) $T\Delta S > \Delta H$ and ΔH is + ve and ΔS is – ve

(c) $T\Delta S > \Delta H$ and both ΔH and ΔS are + ve

(d) $T\Delta S = \Delta H$ and both ΔH and ΔS are + ve

83. The enthalpy of fusion of water is 1.435 kCal/mol. The molar entropy change for the melting of ice at 0°C is :

(a) 10.52 cal / (mol K) (b) 21.04 cal / (mol K)

(c) 5.260 cal / (mol K) (d) 0.526 cal / (mol K)

STATEMENT TYPE QUESTIONS

84. Read the following statements carefully and choose the correct option

(i) The state of the system is specified by state functions or state variables.

(ii) Variables like P, V and T are called state variables or state functions

(iii) Their values depend only on the state of the system and not on how it is reached.

(a) (i) and (ii) are correct

(b) (ii) and (iii) are correct

(c) (i) , (ii) and (iii) are correct

(d) Only (iii) is correct

85. Read the following statements carefully and choose the correct option

(i) Internal energy, U, of the system is a state function.

(ii) –w shows, that work is done on the system.

(iii) +w shows, that work is done by the system

(a) (i) and (ii) are correct (b) (ii) and (iii) are correct

(c) (i) and (iii) are correct (d) Only (i) is correct

86. Read the following statements carefully and choose the correct answer

(i) Expansion of a gas in vacuum ($p_{ex} = 0$) is called free expansion.

(ii) Work is done during free expansion of an ideal gas whether the process is reversible or irreversible

(iii) No work is done during free expansion of an ideal gas whether the process is reversible or irreversible

(iv) No work is done during free expansion of an ideal gas when the process is reversible

(a) Only statement (iii) is correct

(b) Statements (i) and (iii) are correct

(c) Statements (ii) and (iv) are correct

(d) Statements (i) and (iv) are correct

87. Which of the following statement(s) is/are correct ?

(i) In case of expansion maximum amount of work can be obtained under isothermal conditions by reversibly carrying out the process rather than through irreversible route.

(ii) In case of compression, minimum amount of work can be done on system by carrying out the process irreversibly than reversibly.

(a) (i) and (ii) (b) Only (i)

(c) Only (ii) (d) Neither (i) nor (ii)

88. Read the following statements carefully and choose the correct option

(i) In case of diatomic molecules the enthalpy of atomization is also the bond dissociation enthalpy.

(ii) In case polyatomic molecules, bond dissociation enthalpy is different for different bonds within the same molecule.

(a) Both (i) and (ii) are correct

(b) (i) is correct but (ii) is incorrect

(c) (ii) is correct but (i) is incorrect

(d) Both (i) and (ii) are incorrect

89. Read the following statements regarding spontaneity of a process and mark the appropriate choice.

(i) When enthalpy factor is absent than randomness factor decides spontaneity of a process.

(ii) When randomness factor is absent then enthalpy factor decides spontaneity of a process.

(iii) When both the factors take place simultaneously, the magnitude of both the factors decide spontaneity of a process.

(a) Statements (i) and (ii) are correct and (iii) is incorrect.
(b) Statement (iii) is correct, (i) and (ii) are incorrect.
(c) Statements (i), (ii) and (iii) are correct.
(d) Statements (i), (ii) and (iii) are incorrect.

90. Which of the following statement is incorrect ?

(a) The standard enthalpy of reaction is the enthalpy change for a reaction when all the participating substances are in their standard states.

(b) The standard state of a substance at a specified temperature is its pure form at 1 bar.

(c) The standard state of solid iron at 298 K is pure iron at 1 bar

(d) Standard conditions are denoted by adding the superscript $\ominus$ to the symbol ΔH e.g., $-\Delta H^{\ominus}$

MATCHING TYPE QUESTIONS

91. Match the columns

Column-I	Column-II
(A) C_m	(p) $C_v \Delta T$
(B) q	(q) C/n
(C) $\Delta \cup$	(r) $C_p \Delta T$
(D) ΔH	(s) $C \Delta T$

(a) A – (q), B – (s), C – (r), D – (p)
(b) A – (q), B – (s), C – (p), D – (r)
(c) A – (s), B – (q), C – (p), D – (r)
(d) A – (q), B – (p), C – (r), D – (s)

92. Match the columns

Column-I	Column-II
(A) Free expansion at $\Delta V = 0$	(p) $q = -w = nRT\,\ell n \dfrac{V_f}{V_i}$
(B) Isothermal irreversible change	(q) $\Delta U = w_{ad}$
(C) Isothermal reversible change	(r) $\Delta U = q_v$
(D) For adiabatic change	(s) $q = -w = P_{ex}(V_f - V_i)$

(a) A – (s), B – (p), C – (r), D – (q)
(b) A – (r), B – (q), C – (p), D – (s)
(c) A – (r), B – (s), C – (p), D – (q)
(d) A – (q), B – (r), C – (s), D – (p)

93. Match the columns

Column-I	Column-II
(A) $p_{ext} = 0$	(p) Free expansion of an ideal gas
(B) $q = p_{ext}(V_f - V_i)$	(q) Adiabatic change
(C) $q = 2.303\, nRT \log (V_f / V_i)$	(r) Isothermal reversible change
(D) $\Delta U = W_{ad}$	(s) Isothermal irreversible change

(a) A – (p), B – (s), C – (r), D – (q)
(b) A – (p), B – (q), C – (r), D – (s)
(c) A – (p), B – (r), C – (s), D – (q)
(d) A – (p), B – (r), C – (q), D – (s)

94. Match the columns

Column-I	Column-II
(A) $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$	(p) $\Delta H = \Delta U - 2RT$
(B) $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$	(q) $\Delta H = \Delta U + 3RT$
(C) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	(r) $\Delta H = \Delta U$
(D) $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$	(s) $\Delta H = \Delta U + RT$

(a) A – (r), B – (p), C – (q), D – (s)
(b) A – (r), B – (s), C – (p), D – (q)
(c) A – (q), B – (p), C – (s), D – (r)
(d) A – (s), B – (q), C – (p), D – (r)

95. Match the columns

Column-I	Column-II
(A) $C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O; \Delta H = -w$	(p) Enthalpy of atomisation
(B) $CH_4 \rightarrow C + 4H; \Delta H = x$	(q) Enthalpy of formation
(C) $H_2 + Br_2 \rightarrow 2HBr; \Delta H = y$	(r) Enthalpy of combustion
(D) $Na^-(s) \rightarrow Na(g); \Delta H = z$	(s) Enthalpy of sublimation

(a) A – (s), B – (p), C – (q), D – (r)
(b) A – (q), B – (r), C – (p), D – (s)
(c) A – (r), B – (p), C – (q), D – (s)
(d) A – (p), B – (q), C – (s), D – (r)

96. Match the columns

Column-I	Column-II
(A) Exothermic	(p) $\Delta H = 0, \Delta E = 0$
(B) Spontaneous	(q) $\Delta G = 0$
(C) Cyclic process	(r) ΔH is negative
(D) Equilibrium	(s) ΔG is negative

(a) A – (q), B – (r), C – (p), D – (s)
(b) A – (s), B – (p), C – (r), D – (q)
(c) A – (p), B – (q), C – (s), D – (r)
(d) A – (r), B – (s), C – (p), D – (q)

97. Match the columns

	Column-I		Column-II
(A)	$\Delta H = -ve$; $\Delta S = -ve$ $\Delta G = -ve$	(p)	Reaction will be non-spontaneous at high temperature
(B)	$\Delta H = -ve$; $\Delta S = -ve$ $\Delta G = +ve$	(q)	Reaction will be non-spontaneous at low temperature
(C)	$\Delta H = +ve$; $\Delta S = +ve$ $\Delta G = +ve$	(r)	Reaction will be spontaneous at low temperature
(D)	$\Delta H = +ve$; $\Delta S = +ve$ $\Delta G = -ve$	(s)	Reaction will be spontaneous at high temperature

(a) A – (q), B – (r), C – (p), D – (s)
(b) A – (r), B – (p), C – (q), D – (s)
(c) A – (r), B – (q), C – (s), D – (p)
(d) A – (q), B – (s), C – (p), D – (r)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

98. Assertion : T, P and V are state variables or state functions.
Reason : Their values depend on the state of the system and how it is reached.

99. Assertion : At constant temperature and pressure whatever heat absorbed by the system is used in doing work.
Reason : Internal energy change is zero.

100. Assertion : For an isothermal reversible process Q = –W i.e. work done by the system equals the heat absorbed by the system.
Reason : Enthalpy change (ΔH) is zero for isothermal process.

101. Assertion : Absolute value of internal energy of a substance cannot be determined.
Reason : It is impossible to determine exact values of constitutent energies of the substances.

102. Assertion : A process is called adiabatic if the system does not exchange heat with the surroundings.
Reason : It does not involve increase or decrease in temperature of the system.

103. Assertion : There is exchange in internal energy in a cyclic process.
Reason : Cyclic proces is the one in which the sytem returns to its initial state after a number of reactions.

104. Assertion : Internal energy is an extensive property.
Reason : Internal energy depends upon the amount of the system.

105. Assertion : The mass and volume of a substance are the extensive properties and are proportional to each other.
Reason : The ratio of mass of a sample to its volume is an intensive property.

106. Assertion : First law of thermodynamics is applicable to an electric fan or a heater.
Reason : In an electric fan, the electrical energy is converted into mechanical work that moves the blades. In a heater, electrical energy is converted into heat energy.

107. Assertion : The value of enthalpy of neutralization of weak acid and strong base is numerically less than 57.1 kJ.
Reason : All the OH^- ions furnished by 1 g equivalent of strong base are not completely neutralized.

108. Assertion : When a solid melts, decrease in enthalpy is observed.
Reason : Melting of a solid is endothermic.

109. Assertion : Many endothermic reactions that are not spontaneous at room temperature become spontaneous at high temperature.
Reason : Entropy of the system increases with increase in temperature.

110. Assertion : An exothermic process which is non-spontaneous at high temperature may become spontaneous at a low temperature.
Reason : There occurs a decrease in entropy factor as the temperature is decreased.

CRITICAL THINKING TYPE QUESTIONS

111. In an adiabatic process, no transfer of heat takes place between system and surroundings. Choose the correct option for free expansion of an ideal gas under adiabatic condition from the following.
(a) $q = 0, \Delta T \neq 0, w = 0$
(b) $q \neq 0, \Delta T = 0, w = 0$
(c) $q = 0, \Delta T = 0, w = 0$
(d) $q = 0, \Delta T < 0, w \neq 0$

112. According to the first law of thermodynamics which of the following quantities represents change in a state function ?
(a) q_{rev}
(b) $q_{rev} - W_{rev}$
(c) q_{rev}/W_{rev}
(d) $q_{rev} + W_{rev}$

113. If ΔH is the change in enthalpy and ΔE, the change in internal energy accompanying a gaseous reaction, then
(a) ΔH is always greater than ΔE
(b) $\Delta H < \Delta E$ only if the number of moles of the products is greater than the number of moles of the reactants
(c) ΔH is always less than ΔE
(d) $\Delta H < \Delta E$ only if the number of moles of products is less than the number of moles of the reactants

114. For an isothermal reversible expansion process, the value of q can be calculated by the expression
(a) $q = 2.303 nRT \log \frac{V_2}{V_1}$
(b) $q = -2.303 nRT \log \frac{V_2}{V_1}$
(c) $q = -P_{exp} nRT \log \frac{V_1}{V_2}$
(d) None of these

115. A piston filled with 0.04 mol of an ideal gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0ºC. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be:
(R = 8.314 J/mol K) (ln 7.5 = 2.01)

(a) q = + 208 J, w = – 208 J
(b) q = – 208 J, w = – 208 J
(c) q = – 208 J, w = + 208 J
(d) q = + 208 J, w = + 208 J

116. According to the first law of thermodynamics, $\Delta U = q + W$. In special cases the statement can be expressed in different ways. Which of the following is not a correct expression ?

(a) At constant temperature q = –W
(b) When no work is done $\Delta U = q$
(c) In gaseous system $\Delta U = q + P\Delta V$
(d) When work is done by the system : $\Delta U = q + W$

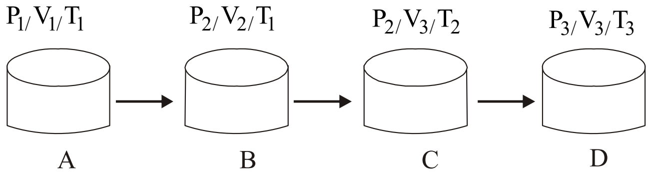
117. The internal energy change when a system goes from state A to B is 40 kJ/mole. If the system goes from A to B by a reversible path and returns to state A by an irreversible path what would be the net change in internal energy ?

(a) > 40 kJ (b) < 40 kJ
(c) Zero (d) 40 kJ

118. Under isothermal condition for one mole of ideal gas what is the ratio of work done under reversible to irreversible process, initially held at 20 atm undergoes expansion from 1L to 2L, at 298K, under external pressure of 10 atm?

(a) 1.7 (b) 2.0
(c) 1.4 (d) 1.0

119. Processes A to B, B to C and C to D shown in the figure below respectively are ?



(a) Isothermal, isobaric and isochoric
(b) Isobaric, isothermal and isochoric
(c) Isothermal, isothermal and isobaric
(d) Isobaric, isobaric and isothermal

120. What is the internal energy (kJ) change occurs when 36g of $H_2O(l)$ converted to $H_2O(g)$? $\Delta H°$(vapourisation) = 40.79kJ/mol

(a) 75.38 (b) 80.98
(c) 70.98 (d) 45.89

121. Consider the reaction :

$$4NO_2(g) + O_2(g) \rightarrow 2N_2O_5(g),$$

$\Delta_r H = -111$ kJ.
If $N_2O_5(s)$ is formed instead of $N_2O_5(g)$ in the above reaction, the $\Delta_r H$ value will be :
(given, ΔH of sublimation for N_2O_5 is –54 kJ mol^{-1})

(a) + 54 kJ (b) + 219 kJ
(c) – 219 J (d) – 165 kJ

122. An ideal gas is allowed to expand both reversibly and irreversibly in an isolated system. If T_i is the initial temperature and T_f is the final temperature, which of the following statements is correct?

(a) $(T_f)_{rev} = (T_f)_{irrev}$
(b) $T_f = T_i$ for both reversible and irreversible processes
(c) $(T_f)_{irrev} > (T_f)_{rev}$
(d) $T_f > T_i$ for reversible process but $T_f = T_i$ for irreversible process

123. Given

Reaction	**Energy Change (in kJ)**
$Li(s) \rightarrow Li(g)$	161
$Li(g) \rightarrow Li^+(g)$	520
$\frac{1}{2}F_2(g) \rightarrow F(g)$	77
$F(g) + e^- \rightarrow F^-(g)$	(Electron gain enthalpy)
$Li^+(g) + F^-(g) \rightarrow LiF(s)$	– 1047
$Li(s) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$	– 617

Based on data provided, the value of electron gain enthalpy of fluorine would be :

(a) – 300 kJ mol^{-1} (b) – 350 kJ mol^{-1}
(c) – 328 kJ mol^{-1} (d) – 228 kJ mol^{-1}

124. The standard enthalpy of formation ($\Delta_f H°_{298}$) for methane, CH_4 is – 74.9 kJ mol^{-1}. In order to calculate the average energy given out in the formation of a C – H bond from this it is necessary to know which one of the following?

(a) The dissociation energy of the hydrogen molecule, H_2.
(b) The first four ionisation energies of carbon.
(c) The dissociation energy of H_2 and enthalpy and sublimation of carbon (graphite).
(d) The first four ionisation energies of carbon and electron affinity of hydrogen.

125. For complete combustion of ethanol,

$$C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l),$$

the amount of heat produced as measured in bomb calorimeter, is 1364.47 kJ mol^{-1} at 25ºC. Assuming ideality the enthalpy of combustion, $\Delta_c H$, for the reaction will be:
(R = 8.314 kJ mol^{-1})

(a) –1366.95 kJ mol^{-1} (b) –1361.95 kJ mol^{-1}
(c) –1460.95 kJ mol^{-1} (d) –1350.50 kJ mol^{-1}

126. Standard enthalpy of vapourisation $\Delta_{vap} H°$ for water at 100°C is 40.66 kJ mol^{-1}. The internal energy of vaporisation of water at 100°C (in kJ mol^{-1}) is :

(a) +37.56 (b) –43.76
(c) +43.76 (d) +40.66

(Assume water vapour to behave like an ideal gas).

127. Consider the following reactions:

(i) $H^+_{(aq)} + OH^-_{(aq)} = H_2O_{(l)}$, $\Delta H = -X_1$ kJ mol^{-1}

(ii) $H_{2(g)} + \frac{1}{2}O_{2(g)} = H_2O(l)$, $\Delta H = -X_2$ kJ mol^{-1}

(iii) $CO_{2(g)} + H_{2(g)} = CO_{(g)} + H_2O$, $\Delta H = -X_3$ kJ mol^{-1}

(iv) $C_2H_{2(g)} + \frac{5}{2}O_{2(g)} = 2CO_2(g) + H_2O(l)$’ $\Delta H = +\ 4X_4$ kJ mol^{-1}

Enthalpy of formation of $H_2O_{\ (l)}$ is

(a) $+X_3$ kJ mol^{-1}
(b) $-X_4$ kJ mol^{-1}
(c) $+X_1$ kJ mol^{-1}
(d) $-X_2$ kJ mol^{-1}

128. Diborane is a potential rocket fuel which undergoes combustion according to the equation

$$B_2H_6(g) + 3O_2(s) \longrightarrow B_2O_3(s) + 3H_2O(g)$$

Calculate the enthalpy change for the combustion of diborane. Given

(i) $2B(s) + \frac{3}{2}O_2(g) \longrightarrow B_2O_3(s)$; $\Delta H = -1273$ kJ per mol

(ii) $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$; $\Delta H = -286$ kJ per mol

(iii) $H_2O(l) \longrightarrow H_2O(g)$; $\Delta H = 44$ kJ per mol

(iv) $2B\ (s) + 3H_2\ (g) \longrightarrow B_2H_6\ (g)$; $\Delta H = 36$ kJ per mol

(a) +2035 kJ per mol
(b) –2035 kJ per mol
(c) +2167 kJ per mol
(d) –2167 kJ per mol

129. How many molecules of ATP, undergo hydrolysis to raise the temperature of 180 kg of water which was originally at room temperature by 1°C ? C{P,m} water = 75.32J/mol/K, ΔH{P} for ATP hydrolysis= 7 kcal/mol

(a) 1.5×10^{25}
(b) 2.00×10^{23}
(c) 3.4×10^{25}
(d) 4.0×10^{24}

130. What is the amount of heat (in Joules) absorbed by 18 g of water initially at room temperature heated to 100°C ? If 10g of Cu is added to this water , than decrease in temperature (in Kelvin) of water was found to be? C (p,m) for water 75.32J/mol K ; C (p,m) for Cu = 24.47J/mol K.

(a) 5649, 369
(b) 5544, 324
(c) 5278, 342
(d) 3425, 425

131. The enthalpy changes for the following processes are listed below :

$Cl_2(g) \to 2Cl(g)$,	242.3 kJ mol^{-1}
$I_2(g) \to 2I(g)$,	151.0 kJ mol^{-1}
$ICl(g) \to I(g) + Cl(g)$,	211.3 kJ mol^{-1}
$I_2(s) \to I_2(g)$,	62.76 kJ mol^{-1}

Given that the standard states for iodine and chlorine are $I_2(s)$ and $Cl_2(g)$, the standard enthalpy of formation for $ICl(g)$ is :

(a) +16.8 kJ mol^{-1}
(b) +244.8 kJ mol^{-1}
(c) –14.6 kJ mol^{-1}
(d) –16.8 kJ mol^{-1}

132. What is the equilibrium constant if ATP hydrolysis by water produce standard free energy of –50 kJ/mole under normal body conditions ?

(a) 2.66×10^8
(b) 5.81×10^8
(c) 1.18×10^7
(d) 1.98×10^8

133. A reaction with ΔH = 0, is found to be spontaneous. This is due to

(a) ΔS is negative
(b) ΔS is positive
(c) TΔS is positive
(d) Both (b) and (c)

134. In an irreversible process taking place at constant T and P and in which only pressure-volume work is being done, the change in Gibbs free energy (dG) and change in entropy (dS), satisfy the criteria

(a) $(dS)_{V,\ E} > 0,\ (dG)_{T,\ P} < 0$
(b) $(dS)_{V,\ E} = 0,\ (dG)_{T,\ P} = 0$
(c) $(dS)_{V,\ E} = 0,\ (dG)_{T,\ P} > 0$
(d) $(dS)_{V,\ E} < 0,\ (dG)_{T,\ P} < 0$

135. In conversion of lime-stone to lime,

$CaCO_{3(s)} \to CaO_{(s)} + CO_{2(g)}$ the values of ΔH° and ΔS° are + 179.1 kJ mol^{-1} and 160.2 J/K respectively at 298 K and 1 bar. Assuming that ΔH° and ΔS° do not change with temperature, temperature above which conversion of limestone to lime will be spontaneous is

(a) 1118 K
(b) 1008 K
(c) 1200 K
(d) 845 K.

136. For vaporization of water at 1 atmospheric pressure, the values of ΔH and ΔS are 40.63 kJmol^{-1} and 108.8 JK^{-1} mol^{-1}, respectively. The temperature when Gibbs energy change (ΔG) for this transformation will be zero, is:

(a) 293.4 K
(b) 273.4 K
(c) 393.4 K
(d) 373.4 K.

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)**

2. **(b)** The laws of thermodynamics deal with energy changes of macroscopic systems involving a large number of molecules rather than microscopic systems containing a few molecules.

3. **(b)**

4. **(c)** The universe = The system + The surroundings

5. **(c)**

6. **(c)** Closed system can exchange energy and not matter with surroundings. Pressure cooker provides closed system.

7. **(c)** Isolated system can not exchange mass or energy.

8. **(b)** We can describe the state of a gas by quoting its pressure (P), volume (V), temperature (T), amount (n) etc.

9. **(d)** We know that q (heat) and work (w) are not state functions but (q + w) is a state function. H – TS (i.e. G) is also a state functions. Thus II and III are not state functions so the correct answer is option (d).

10. **(c)** Internal energy and molar enthalpy are state functions. Work (reversible or irreversible) is a path function.

11. **(c)**

12. **(a)** Internal energy is a quantity which represents the total energy of the system. It may be chemical, electrical, and mechanical or any other type of energy you may think of, the sum of all these is the internal energy of the system.

13. **(d)** **14.** **(b)**

15. **(c)** In accordance with Hess's law.

16. **(a)**

17. **(a)** $\Delta E = \Delta Q - W$

For adiabatic expansion, $\Delta Q = 0$

$\Rightarrow \Delta E = -W$

The negative sign shows decrease in Internal energy, which is equal to the work done on the system by the surroundings.

18. **(d)** q is a path dependent function, H is a state function because it depends on U, p and V, all of which are state functions.

19. **(a)** The shaded area shows work done on an ideal gas in a cylinder when it is compressed by a constant external pressure

20. **(b)** As volume is constant hence work done in this proces is zero hence heat supplied is equal to change in internal energy.

21. **(b)** $W = -\ p\Delta V$

$= -3(6-4) = -6$ litre atmosphere

$= -6 \times 101.32 = -608\,J$

22. **(c)** For isothermal reversible expansion.

$$w = -nRT\ln\frac{V_2}{V}$$

23. **(c)** $W = -P\Delta V = -10^5(1\times10^{-2} - 1\times10^{-3}) = -900J$

24. **(d)** The difference between ΔH and ΔU is not usually significant for systems consisting of only solids or liquids. Solids and liquids do not suffer any significant volume changes upon heating. The difference, however, becomes significant when gases are involved.

25. **(b)** $\Delta H = \Delta E + P\Delta V$, for solid and liquid,

$\Delta V =$ or $\Delta H = \Delta E + \Delta n\,RT$, for solids and liquids $\Delta n = 0$.

26. **(c)** During isothermal expansion of an ideal gas,

$\Delta T = 0$. Now $H = E + PV$

$\because\ \Delta H = \Delta E + \Delta(PV)$

$\therefore\ \Delta H = \Delta E + \Delta(nRT)$;

Thus if $\Delta T = 0.$, $\Delta H = \Delta E$

i.e., remain unaffected

27. **(d)** We know that

$\Delta H = \Delta E + P\Delta V$

In the reactions, $H_2 + Br_2 \rightarrow 2HBr$ there is no change in volume or $\Delta V = 0$

So, $\Delta H = \Delta E$ for this reaction

28. **(b)** $\Delta n = -\frac{1}{2}$; $\Delta H = \Delta E - \frac{1}{2}RT$; $\Rightarrow \Delta E > \Delta H$

29. **(c)** As all reactant and product are liquid $\Delta n_{(g)} = 0$

$\Delta H = \Delta E - \Delta nRT$

$\Delta H = \Delta E \qquad (\because \Delta n = 0)$

30. **(a)** $\Delta H = \Delta E + P\Delta V$

31. **(c)** $\Delta H = \Delta E + \Delta nRT$

$\Delta n = 3 - (1+5)$

$= 3 - 6 = -3$

$\Delta H - \Delta E = (-3RT)$

32. **(b)** $\Delta H = \Delta U + \Delta nRT$ for $N_2 + 3H_2 \longrightarrow 2NH_3$

$\Delta n_g = 2 - 4 = -2$

$\therefore \Delta H = \Delta U - 2RT$ or $\Delta U = \Delta H + 2RT$ $\therefore \Delta U > \Delta H$

33. **(a)** Mass independent properties (molar conductivity and electromotive force) are intensive properties. Resistance and heat capacity are mass dependent, hence extensive properties.

34. **(a)** Volume depends upon mass. Hence it is extensive property.

35. **(c)** An extensive property is a property whose value depends on the quantity or size of matter present in the system. For example, mass, volume, internal energy, enthalpy, heat capacity, etc. are extensive properties

36. **(d)** The magnitude of the heat capacity depends on the size, composition and nature of the system.

37. **(b)** The heat required to raise the temperature of body by 1C° is called thermal capacity or heat capacity.

38. **(d)** $\frac{C_P}{C_V} = \frac{\frac{5}{2}R}{\frac{3}{2}R} = \frac{5}{3} = 1.67$

39. **(c)** Given $C_p = 75\ JK^{-1}\ mol^{-1}$

$n = \frac{100}{18}$ mole , $Q = 1000\ J \quad \Delta T = ?$

$Q = nC_p\Delta T \Rightarrow \Delta T = \frac{1000 \times 18}{100 \times 75} = 2.4\ K$

40. **(b)** 1 calorie = 4.184 joule

41. **(b)** The coefficients in a balanced thermo-chemical equation refer to the number of moles (not to molecules) of reactants and products involved in the reaction.

42. **(c)**

43. **(b)** Enthalpy of formation of C_2H_4, CO_2 and H_2O are 52, – 394 and – 286 kJ/ mol respectively. (Given)

The reaction is

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O.$

change in enthalpy,

$(\Delta H) = \Delta H_{products} - \Delta H_{reactants}$

$= 2 \times (-394) + 2 \times (-286) - (52 + 0)$

$= -\ 1412\ kJ/\ mol.$

44. **(b)** **45.** **(c)**

46. **(b)** $\frac{1}{2}H_2 + \frac{1}{2}Cl_2 \longrightarrow HCl$

$\Delta H_{HCl} = \sum B.E.\ of\ reactant$

$\qquad - \sum B.E.\ of\ products$

$-90 = \frac{1}{2} \times 430 + \frac{1}{2} + \frac{1}{2} \times 240 - B.E.\ of\ HCl$

$\therefore$ B.E. of HCl = 215 + 120 + 90

$= 425\ kJ\ mol^{-1}$

47. **(c)** The reaction for formation of HCl can be written as

$H_2 + Cl_2 \rightarrow 2HCI$

$H-H + Cl-Cl \rightarrow 2\,(H-Cl)$

Substituting the given values, we get enthalpy of formation of

2HCl = – (862 – 676) = –186 kJ.

$\therefore$ Enthalpy of formation of

$HCl = \frac{-186}{2} kJ = -93\ kJ.$

48. **(b)** Enthalpy of reaction

$= B.E_{(Reactant)} - B.E_{(Product)}$

$= \left[B.E_{(C=C)} + 4\,B.E._{(C-H)} + B.E._{(H-H)}\right]$

$\qquad - \left[B.E._{(C-C)} + 6\,B.E._{(C-H)}\right]$

$= [606.1 + (4 \times 410.5) + 431.37)] - [336.49 + (6 \times 410.5)]$

$= -120.0\ kJ\ mol^{-1}$

49. **(a)** $Fe_2O_{3(s)} + CO_{(g)} \longrightarrow 2FeO_{(s)} + CO_{2(g)}$

$\Delta H = -26.8 + 33.0 = +6.2\ kJ$

50. **(b)** Given $\quad \Delta H$

$\frac{1}{2}A \longrightarrow B \qquad +150 \qquad ...(1)$

$3B \longrightarrow 2C + D \qquad -125 \qquad ...(2)$

$E + A \longrightarrow 2D \qquad +350 \qquad ...(3)$

To calculate ΔH operate

2 × eq. (1) + eq. (2) – eq. (3)

ΔH = 300 – 125 – 350 = – 175

51. **(b)** $\Delta H = \Sigma\left[\Delta H_f^\circ\ products\right] - \Sigma\left[\Delta H_f^\circ\ reactants\right]$

$\Delta H^\circ = [\Delta H_f^\circ(CO)(g) + \Delta H_f^\circ(H_2O)(g)] -$

$[\Delta H_f^\circ(CO_2)(g) + \Delta H_f^\circ(H_2)(g)]$

$= [-\ 110.5 + (-\ 241.8)] - [-\ 393.5 + 0] = 41.2$

52. **(b)** $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O.$

Change in enthalpy,

$\Delta H = \Delta H_{products} - \Delta H_{reactants}$

$= 2 \times (-394) + 2 \times (-286) - (52 + 0)$

$= -1412\ kJ/\ mol.$

53. **(a)** Hess's law is used for calculating enthalpy of reaction.

54. **(c)** $X \xrightarrow{\Delta H} Y$

$X \xrightarrow{\Delta H_1} P \xrightarrow{\Delta H_2} Q \xrightarrow{\Delta H_3} Y$

$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$

55. **(a)** **56.** **(b)**

57. **(b)** Heat of combustion of a substance is always negative as it is the amount of heat evolved (i.e. decrease in enthalpy) when one mole of the substance is completely burnt in air or oxygen.

58. **(c)**

59. **(a)** Conc. of HCl = 0.25 mole

Conc. of NaOH = 0.25 mole

Heat of neutralization of strong acid by strong base = – 57.1 kJ

$HCl + NaOH \longrightarrow NaCl + H_2O - 57.1kJ$

1 mole of HCl neutralise 1 mole of NaOH, heat evolved = 57.1 kJ

$\therefore$ 0.25 mole of HCl neutralise 0.25 mole of NaOH

$\therefore$ Heat evolved = 57.1 × 0.25 = 14.275 kJ

60. **(c)**

61. **(d)** A process is spontaneous only when there is decrease in the value of free energy, i.e., ΔG is –ve.

62. **(a)** If $\Delta G_{system} = 0$ the system has attained equilibrium is right choice.

In it alternative (d) is most confusing as when $\Delta G > 0$, the process may be spontaneous when it is coupled with a reaction which has $\Delta G < 0$ and total ΔG is negative, so right answer is (a).

63. **(b)** Spontaneity of reaction depends on tendency to acquire minimum energy state and maximum randomness. For a spontaneous process in an isolated system the change in entropy is positive.

64. **(d)** ΔG is negative for a spontaneous process.

65. **(a)** Crystallization of sucrose solution. Entropy is a measure of randomness during the crystallisation of sucrose solution liquid state is changing into solid state hence entropy decreases.

66. **(d)** $\Delta G = \Delta H - T\Delta S$; ΔG is positive for a reaction to be non-spontaneous when ΔH is positive and ΔS is negative.

67. **(b)** For the reaction

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

The reaction given is an example of decomposition reaction and we know that decomposition reactions are endothermic in nature, i.e, $\Delta H > 0$.

Further

$\Delta n = (1 + 1) - 1 = +1$

Hence more number of molecules are present in products which shows more randomness i.e. $\Delta S > 0$ (ΔS is positive)

68. **(b)** For the reaction

$2ZnS \rightarrow 2Zn + S_2$; $\Delta G_1^o = 293$ kJ ....(1)

$2Zn + O_2 \rightarrow 2ZnO$; $\Delta G_2^o = -480$ kJ ....(2)

$S_2 + 2O_2 \rightarrow 2SO_2$; $\Delta G_3^o = -544$ kJ ....(3)

ΔG^o for the reaction

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

can be obtained by adding eqn. (1), (2) and (3)

$\Rightarrow \Delta G^o = 293 - 480 - 544 = -731$ kJ

69. **(a)** Third law of Thermodynamics.

70. **(a)** $\Delta S = \dfrac{q}{T}$

$q \longrightarrow$ required heat per mole

$T \longrightarrow$ constant absolute temperature

Unit of entropy is $JK^{-1}\ mol^{-1}$

71. **(a)** For a spontaneous process, ΔS_{total} is always positive.

72. **(d)** For an exothermic reaction all three enthalpy, entropy and Gibb's free energy change have negative values.

73. **(d)** Gibb's-Helmholtz equation is

$\Delta G = \Delta H - T\Delta S$

For a reaction to be non-spontaneous at all temperatures, ΔH should be +ve and ΔS should be –ve

$\therefore \Delta G = +ve - T \times (-ve)$; the value of ΔG is always positive for such a reaction and hence it will be non-spontaneous at all temperatures.

74. **(d)** We know that $\Delta G = \Delta H - T\Delta S$

When $\Delta H < 0$ and $\Delta S < 0$ then ΔG will be negative at low temperatures (positive at high temperature) and the reaction will be spontaneous.

75. **(d)** Since the process is at equilibrium $\Delta G = 0$ for $\Delta G = 0$, they should be $\Delta H > 0$, $\Delta S > 0$.

76. **(c)** ΔS has negative value if number of gaseous moles decreases during a reaction, $\Delta n_g = -ve$

For the reaction

$2SO_2 + O_2 \rightarrow 2SO_3$

$\Delta n_g = 2 - 3 = -1$

77. **(d)** $\Delta G = \Delta H - T\Delta S$

For a reaction to be spontaneous,

$\Delta H = -ve$, $\Delta S = +ve$

at all temperatures.

but at high temperature, $\Delta G = \underbrace{\Delta H}_{-ve} - \underbrace{T\Delta S}_{+ve}$

Thus the second term will have high positive value and reaction will be non-spontaneous.

78. **(b)** At equilibrium $\Delta G = 0$

Hence, $\Delta G = \Delta H - T_e\Delta S = 0$

$\therefore \Delta H = T_e\Delta S$ or $T_e = \dfrac{\Delta H}{\Delta S}$

For a spontaneous reaction

ΔG must be negative which is possible only if

$\Delta H - T\Delta S < 0$

$\therefore \Delta H < T\Delta S$ or $T > \dfrac{\Delta H}{\Delta S}$; $T_e < T$

79. **(a)** Measure of disorder of a system is nothing but Entropy. For a spontaneous reaction, $\Delta G < 0$. As per Gibbs Helmholtz equation,

$\Delta G = \Delta H - T\Delta S$

Thus ΔG is –ve only

When $\Delta H = -ve$ (exothermic)

and $\Delta S = +ve$ (increasing disorder)

80. **(a)** Since, in the first reaction gaseous products are forming from solid carbon hence entropy will increase i.e. $\Delta S = +ve$.

$$C\,(gr.) + \frac{1}{2}\,O_2(g) \rightarrow CO(g);\ \Delta S^\circ = +\ ve$$

Since, $\Delta G^\circ = \Delta H^\circ - T\Delta S$ hence the value of ΔG decrease on increasing temperature.

81. **(b)** This is combustion reaction, which is always exothermic hence

$\Delta H = -ve$

As the no. of gaseous molecules are increasing hence entropy increases

now $\Delta G = \Delta H - T\Delta S$

For a spontaneous reaction

$\Delta G = -\text{ve}$

Which is possible in this case as $\Delta H = -\text{ve}$ and $\Delta S = +\text{ve}$.

82. (c) For a spontaneous reaction $\Delta G(-\text{ve})$, which is possible if $\Delta S = +\text{ve}$, $\Delta H = +\text{ve}$ and $T\Delta S > \Delta H$ [As $\Delta G = \Delta H - T\Delta S$]

83. (c) $\Delta S = \dfrac{\Delta H}{T} = \dfrac{1.435 \times 10^3}{273}$

$= 5.260\ \text{cal} / (\text{mol K})$

STATEMENT TYPE QUESTIONS

84. (c) Variables like P, V and T which describes the state of system are called state variables or state functions because their values depend only on the state of the system and not on how it is reached.

85. (d) The positive sign expresses when work is done on the system. Similarly, negative sign expresses when work is done by the system

86. (b) **87. (a)** **88. (a)**

89. (c) All the statements regarding spontaneity of a reaction are correct.

90. (c) The standard enthalpy of reaction is the enthalpy change for a reaction when all the participating substances are in their standard states. The standard state of a substance at a specified temperature is its pure form at 1 bar. For example, the standard state of liquid ethanol at 298 K is pure liquid ethanol at 1 bar. Standard state of solid ion at 500 K is pure iron at 1 bar. The standard conditions are denoted by adding the superscript $\ominus$ to the symbol ΔH e.g., $-\Delta H^{\ominus}$.

MATCHING TYPE QUESTIONS

91. (b) **92. (c)**

93. (a) A – (p), B – (s), C – (r), D – (q)

Expansion of a gas in vacuum ($p_{ext} = 0$) is called free expansion.

For isothermal irreversible change

$q = -W = p_{ext}(V_f - V_i)$

for isothermal reversible change

$q = -W = nRT \ln (V_f/V_i)$

$= 2.303\ nRT \log V_f/V_i$

For adiabatic change, $q = 0$, $\Delta U = W_{ad}$

94. (b) (A) $\Delta n_g = 2 - 2 = 0$ hence $\Delta H = \Delta U$

(B) $\Delta n_g = 2 - 1 = 1$ hence $\Delta H = \Delta U + RT$

(C) $\Delta n_g = 2 - 4 = -2$ hence $\Delta H = \Delta U - 2RT$

(D) $\Delta n_g = 5 - 2 = 3$ hence $\Delta H = \Delta U + 3RT$

95. (c) **96. (d)** **97. (b)**

ASSERTION-REASON TYPE QUESTIONS

98. (c) Values of state functions depend only on the state of the system and not on how it is reached.

99. (a) $Q = -W$ if $\Delta E = 0$

100. (b) In an isothermal process change in internal energy (ΔE) is zero (as it is a function of temperature).

$\therefore$ According to first law of thermodynamics

$\because\ Q + W = \Delta E$. Hence $Q = -W$ (if $\Delta E = 0$)

If a system undergoes a change in which internal energy of the system remains constant (i.e. $\Delta E = 0$) then $-W = Q$. This means that work done by the system equals the heat absorbed by the system.

101. (a) It is fact that absolute values of internal energy of substances cannot be determined. It is also true that it is not possible to determine exact values of constitutent energies of a substance.

102. (c) It may involve increase or decrease in temperature of the system. Systems in which such processes occur, are thermally insulated from the surroundings.

103. (a) As internal energy is a state function so its value depends on intial and final states of the system. In case of cyclic system initial and final states are same. So $\Delta E = 0$, and similarly $\Delta H = 0$.

104. (a) The properties whose magnitude depends upon the quantity of matter present in the system are called extensive properties eg, internal energy.

105. (b) The mass and volume depend upon the quantity of matter so these are extensive properties while ratio of mass to its volume does not depend upon the quantity of matter so this ratio is an extensive property.

106. (a) In case of electric fan electrical energy is converted into mechanical energy and in case of heater, electrical energy is converted into heat energy. Therefore, these follow the first law of thermodynamics.

107. (c) The value of enthalpy of neutralisation of weak acid by strong base is less than 57.1 kJ. This is due to the reason that the part of energy liberated during combination of H^+ and OH^+ ions is utilised in the ionisation of weak acid.

108. (d) When a solid melts, increase in enthalpy is observed.

109. (b) The factor $T\Delta S$ increases with increase in temperature.

110. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

For a process to be spontaneous ΔG must be negative.

$\Delta G = \Delta H - T\Delta S$

Exothermic process (ΔH is negative) is non-spontaneous if ΔS is negative and temperature is high because in such condition $T\Delta S > \Delta H$. ($\Delta G = \Delta H - T\Delta S = +$ tive). When temperature is decreased, $T\Delta S < \Delta H$ ($\Delta G = \Delta H - T\Delta S = -$tive) and so the reaction becomes spontaneous.

CRITICAL THINKING TYPE QUESTIONS

111. (c) Justification : free expansion $w = 0$

adiabatic process $q = 0$

$\Delta U = q + w = 0$, this means that internal energy remains constant. Therefore,

$\Delta T = 0$.

112. (d) Mathematical expression of first law of thermodynamics

$\Delta E = q + w$, ΔE is a state function.

113. (d) As $\Delta H = \Delta E + \Delta n_g RT$

if $n_p < n_r$; $\Delta n_g = n_p - n_r = -\text{ve}$.

Hence $\Delta H < \Delta E$.

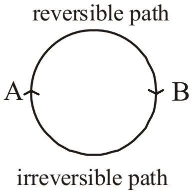
114. (a) $q = -W = 2.303 nRT \log \frac{V_2}{V_1}$

115. (a) Process is isothermal reversible expansion, hence $\Delta U = 0$, therefore $q = -W$.

Since $q = +208$ J, $W = -208$ J

116. (d) When work is done by the system, $\Delta U = q - W$

117. (c) For a cyclic process the net change in the internal energy is zero because the change in internal energy does not depend on the path.



118. (a) $-W_{\text{irreversible}} = P_{\text{ext}}(V_2 - V_1)$

$= 10 \text{ atm } (2L - 1L)$

$= 10 \text{ atm} - L$

$$-W_{\text{reversible}} = \int_{V_1}^{V_2} P_{ex} dv$$

$$= 2.303 \text{ nRT} \log \frac{V_2}{V_1}$$

$$= 1 \times 2.303 \times 0.0821 \text{ atm–L/K/mol} \times \log \frac{2}{1}$$

$$= 16.96 \text{ atm–L}$$

$$\frac{W_{\text{reversible}}}{W_{\text{irreversible}}} = \frac{16.96}{10.00} = 1.69 \approx 1.7$$

119. (a)

120. (a) $H_2O(l) \rightarrow H_2O(g)$

$\Delta H_{vap} = 40.79$ kJ/mol

$\Delta H = \Delta U + \Delta n_g RT$

$\Rightarrow 40.79 \text{ kJ/mol} = \Delta U + (1)(8.314 \text{ JK}^{-1} \text{ mol}^{-1})(373 \text{ K})$

$$\Rightarrow \Delta U^o = \left(40.79 \text{ kJ/mol} - \frac{8.314 \times 373}{1000} \text{kJ/mol}\right)$$

$$= (40.79 - 3.10) \text{ kJ/mol}$$

$$= 37.69 \frac{\text{kJ}}{\text{mol}}$$

Internal energy change for 36 g of water

$$= 37.69 \frac{\text{kJ}}{\text{mol}} \times \frac{36\text{g}}{18\text{g/mol}}$$

$\Delta U = 75.98$ kJ

121. (d)

$$\begin{tikzcd} 4NO_2(g) + O_2(g) \arrow[r] \arrow[dr, "\Delta H'"'] & 2N_2O_5(g),\ \Delta_r H = -111 \text{ kJ} \arrow[d, "-54 \text{ kJ}"] \\ & 2N_2O_5(s) \end{tikzcd}$$

$-111 - 54 = \Delta H'$

$\Delta H' = -165$ kJ

122. (c) In a reversible process the work done is greater than in irreversible process. Hence the heat absorbed in reversible process would be greater than in the latter case. So

$$T_f(\text{rev.}) < T_f(\text{irr.})$$

123. (c) Applying Hess's Law

$$\Delta_f H^\circ = \Delta_{\text{sub}} H + \frac{1}{2}\Delta_{\text{diss}} H + \text{I.E.} + \text{E.A} + \Delta_{\text{lattice}} H$$

$$-617 = 161 + 520 + 77 + \text{E.A.} + (-1047)$$

$\text{E.A.} = -617 + 289 = -328 \text{ kJ mol}^{-1}$

$\therefore$ electron affinity of fluorine

$= -328 \text{ kJ mol}^{-1}$

124. (a) To calculate average enthalpy of C – H bond in methane following informations are needed

(i) dissociation energy of H_2 i.e.

$$\frac{1}{2}H_2(g) \longrightarrow H(g);\ \Delta H = x(\text{suppose})$$

(ii) Sublimation energy of C(*graphite*) to C(*g*)

$$C(graphite) \longrightarrow C(g);\ \Delta H = y(\text{Suppose})$$

Given

$$C(graphite) + 2H_2(g) \longrightarrow CH_4(g);\ \Delta H = 75 \text{ kJ mol}^{-1}$$

125. (a) $C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$

Bomb calorimeter gives ΔU of the reaction

Given, $\Delta U = -1364.47 \text{ kJ mol}^{-1}$

$\Delta n_g = -1$

$$\Delta H = \Delta U + \Delta n_g RT = -1364.47 - \frac{1 \times 8.314 \times 298}{1000}$$

$$= -1366.93 \text{ kJ mol}^{-1}$$

126. (a) $H_2O(\ell) \rightleftharpoons H_2O(g) + Q$

$\Delta E = 37558$ J/mol

$\Delta E = 37.56 \text{ kJ mol}^{-1}$

127. (d) This reaction shows the formation of H_2O, and the X_2 represents the enthalpy of formation of H_2O because as the definition suggests that the enthalpy of formation is the heat evolved or absorbed when one mole of substance is formed from its constituent atoms.

128. (b) For the equation

$$B_2H_6(g) + 3O_2(g) \longrightarrow B_2O_3(g) + 3H_2O(g)$$

Eqs. (i) + 3 (ii) + 3 (iii) – (iv)

$$\Delta H = -1273 + 3(-286) + 3(44) - 36$$
$$= -1273 - 858 + 132 - 36$$
$$= -2035 \text{ kJ/mol}$$

129. (a) $q_p = \Delta H = C_p dT$

$$\Rightarrow q_p = 75.32 \frac{J}{K\,mol} \times (299 - 298) K$$

$$\Rightarrow q_p = 75.32 \frac{J}{K\,mol}$$

For 180 kg of water, no. of moles of water

$$= \frac{180 \times 10^3 g}{18 g/mol} = 10^4 g \text{ moles}$$

$$q_p = 75.32 \frac{J}{mol} \times 10^4 \text{ moles}$$

$$= 753.2 \times 10^3 J = 753.2 \text{ kJ}$$

ΔH for ATP = 7 kcal / mol

$$= 7 \times 4.184 \text{ kJ/mol}$$
$$= 29.2 \text{ kJ/mol}$$

6.022×10^{23} molecules of ATP produce = 29.2 kJ

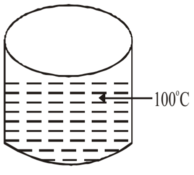
29.2 kJ produced from 6.022×10^{23} molecules

753.2 kJ produced from $6.022 \times 10^{23} \times \frac{75.8}{29.2}$

$$= 1.5 \times 10^{25} \text{ molecules}$$

130. (a) 18gm of water at 100°C

10gm of Cu at 25°C is added.



$q_p = C_{p,m} dT$

$$= 75.32 \times \frac{J}{K\,mol} \times \frac{18g}{18g/mol} (373 - 298) K$$

$$= 75.32 \frac{J}{K} \times 75 K$$

$$= 5.649 \times 10^3 J$$

If now 10g of copper is added $C_{p,m} = 24.47$ J/ mol K

Amount of heat gained by Cu

$$= 24.47 \frac{J}{K\,mol} \times \frac{10g}{63g/mol} (373 - 298) K$$

$$= 291.3 J$$

Heat lost by water = 291.30 J

$$-291.30 J = 75.32 \frac{J}{K} \times (T_2 - 373 K)$$

$$\Rightarrow -3.947 K = T_2 - 373 K$$

$$\Rightarrow T_2 = 369.05 K$$

131. (a) $I_2(s) + Cl_2(g) \longrightarrow 2ICl(g)$

$\Delta_r H = [\Delta H(I_2(s) \to I_2(g)) + \Delta H_{I-I} + \Delta H_{Cl-Cl}] - [\Delta H_{I-Cl}]$

$$= 151.0 + 242.3 + 62.76 - 2 \times 211.3 = 33.46$$

$$\Delta_f H°(ICl) = \frac{33.46}{2} = 16.73 \text{ kJ/mol}$$

132. (a) $\Delta G = -RT \ln K_{eq}$: Normal body temperature = 37°C

$$\Rightarrow -50 \frac{kJ}{mol} = 8.314 \frac{J}{K\,mol} \times 310 \ \ln K_{eq}$$

$$\Rightarrow 19.39 = \ln K_{eq}$$

$$\Rightarrow K_{eq} = 2.6 \times 10^8$$

133. (b) $\Delta G = \Delta H - T\Delta S$

$\Delta G = -T\Delta S$ (when $\Delta H = 0$ and $\Delta S = +ve$)

$\Delta G = -ve$

134. (a) For spontaneous reaction, $dS > 0$ and dG should be negative i.e. < 0.

135. (a) $\Delta G° = \Delta H° - T\Delta S°$

For a spontaneous reaction $\Delta G° < 0$

or $\Delta H° - T\Delta S° < 0 \Rightarrow T > \frac{\Delta H°}{\Delta S°}$

$$\Rightarrow T > \frac{179.3 \times 10^3}{160.2} > 1117.9 K \approx 1118 K$$

136. (d) $H_2O_{(\ell)} \xrightleftharpoons{1atm} H_2O_{(g)}$

$\Delta H = 40630 \text{ J mol}^{-1}$

$\Delta S = 108.8 \text{ JK}^{-1} \text{ mol}^{-1}$

$\Delta G = \Delta H - T\Delta S$ When $\Delta G = 0$,

$\Delta H - T\Delta S = 0$

$$T = \frac{\Delta H}{\Delta S} = \frac{40630 \text{ J mol}^{-1}}{108.8 \text{ J mol}^{-1}} = 373.4 K.$$

CHAPTER 7

EQUILIBRIUM

FACT/DEFINITION TYPE QUESTIONS

1. Which of the following is not a general characteristic of equilibria involving physical processes ?

(a) Equilibrium is possible only in a closed system at a given temperature.

(b) All measurable properties of the system remain constant.

(c) All the physical processes stop at equilibrium.

(d) The opposing processes occur at the same rate and there is dynamic but stable condition.

2. The liquid which has a ………..vapour pressure is more volatile and has a ………….boiling point.

(a)	Higher , higher	(b)	Lower, lower
(c)	Higher, lower	(d)	Lower, higher

3. Boiling point of the liquid depends on the atmospheric pressure. It depends on the altitude of the place; at high altitude the boiling point…………..

(a) increases

(b) decreases

(c) either decreases or increases

(d) remains same

4. In an experiment three watch glasses containing separately 1mL each of acetone, ethyl alcohol, and water are exposed to atmosphere and the experiment with different volumes of the liquids in a warmer room is repeated, it is observed that in all such cases the liquid eventually disappears and the time taken for complete evaporation in each case was different. The possible reason is/are

(a) the nature of the liquids is different

(b) the amount of the liquids is different

(c) the temperature is different

(d) All of the above

5. A small amount of acetone is taken in a watch glass and it is kept open in atmosphere. Which statement is correct for the given experiment?

(a) The rate of condensation from vapour to liquid state is higher than the rate of evaporation.

(b) The rate of condensation from vapour to liquid state is equal to the rate of evaporation.

(c) The rate of condensation from vapour to liquid state is much less than the rate of evaporation.

(d) The rate of condensation from vapour to liquid state is equal or less than the rate of evaporation.

6. When pressure is applied to the equilibrium system

Ice $\rightleftharpoons$ Water

Which of the following phenomenon will happen?

(a) More ice will be formed

(b) Water will evaporate

(c) More water will be formed

(d) Equilibrium will not be formed

7. A reaction is said to be in equilibrium when

(a) the rate of transformation of reactant to products is equal to the rate of transformation of products to the reactants.

(b) 50% of the reactants are converted to products.

(c) the reaction is near completion and all the reactants are converted to products.

(d) the volume of reactants is just equal to the volume of the products.

8. Which of the following is not true about a reversible reaction?

(a) The reaction does not proceed to completion

(b) It cannot be influenced by a catalyst

(c) Number of moles of reactants and products is always equal

(d) It can be attained only in a closed container

9. If the synthesis of ammonia from Haber's process is carried out with exactly the same starting conditions (of partial pressure and temperature) but using D_2 (deuterium) in place of H_2. Then

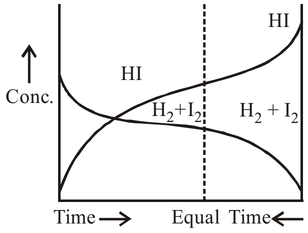
(a) the equilibrium will be disturbed

(b) the composition of reaction mixture will remain same at equilibrium.

(c) Use of isotope in reaction will not produce ammonia.

(d) At equilibrium rate of forward reaction will be greater than the rate of reverse reaction

10. Consider the following graph and mark the correct statement.



(a) Chemical equilibrium in the reaction, $H_2 + I_2 \rightleftharpoons 2HI$ can be attained from other directions.

(b) Equilibrium can be detained when H_2 and I_2 are mixed in an open vessel.

(c) The concentrations of H_2 and I_2 keep decreasing while concentration of HI keeps increasing with time.

(d) We can find out equilibrium concentration of H_2 and I_2 from the given graph.

11. What are the product formed when Deuterium is added equilibrium reaction of H_2 and I_2 ?

(i) HD (ii) DI

(iii) D_2 (iv) HI

(a) (i), (ii) and (iv) (b) (i) and (ii)

(c) (ii) and (iv) (d) All of these

12. If a system is at equilibrium, the rate of forward to the reverse reaction is :

(a) less (b) equal

(c) high (d) at equilibrium

13. K_1 and K_2 are equilibrium constant for reactions (1) and (2)

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ ....(1)

$NO(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$ ......(2)

Then,

(a) $K_1 = \left(\frac{1}{K_2}\right)^2$ (b) $K_1 = K_2^2$

(c) $K_1 = \frac{1}{K_2}$ (d) $K_1 = (K_2)^0$

14. The equilibrium constant for the reversible reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is K and for reaction $\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightleftharpoons NH_3$, the equilibrium constant is K'

The K and K' will be related as:

(a) $K \times K' = 1$ (b) $K = K'$

(c) $K' = \sqrt{K}$ (d) $K = \sqrt{K'}$

15. In the following equilibrium reaction

$2A \rightleftharpoons B + C$,

the equilibrium concentrations of A, B and C are 1×10^{-3} M, 2×10^{-3} M and 3×10^{-3} M respectively at 300 K. The value of K_c for this equilibrium at the same temperature is

(a) $\frac{1}{6}$ (b) 6

(c) $\frac{1}{36}$ (d) 36

16. Given the reaction between 2 gases represented by A_2 and B_2 to give the compound AB(g).

$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$.

At equilibrium, the concentration

of $A_2 = 3.0 \times 10^{-3}$ M

of $B_2 = 4.2 \times 10^{-3}$ M

of $AB = 2.8 \times 10^{-3}$ M

If the reaction takes place in a sealed vessel at 527°C, then the value of K_C will be :

(a) 2.0 (b) 1.9

(c) 0.62 (d) 4.5

17. A reaction is $A + B \rightleftharpoons C + D$. Initially we start with equal concentrations of A and B. At equilibrium we find that the moles of C is two times of A. What is the equilibrium constant of the reaction?

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) 4 (d) 2

18. In $A + B \rightleftharpoons C$. The unit of equilibrium constant is :

(a) Litre $mole^{-1}$ (b) Mole litre

(c) Mole $litre^{-1}$ (d) No unit

19. For the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$, the partial pressures of CO_2 and CO are 2.0 and 4.0 atm respectively at equilibrium. The K_p for the reaction is.

(a) 0.5 (b) 4.0

(c) 8.0 (d) 32.0

20. In which of the following equilibrium K_c and K_p are not equal?

(a) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$

(b) $SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$

(c) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(d) $2C(s) + O_2(g) \rightleftharpoons 2CO_2(g)$

21. For the following reaction in gaseous phase

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$, K_p / K_c is

(a) $(RT)^{1/2}$ (b) $(RT)^{-1/2}$

(c) (RT) (d) $(RT)^{-1}$

22. The K_P/K_C ratio will be highest in case of

(a) $CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$

(b) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(c) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

(d) $7H_2(g) + 2NO_2(g) \rightleftharpoons 2NH_3(g) + 4H_2O(g)$

23. For a chemical reaction ;

$$A(g) + B(\ell) \rightleftharpoons D(g) + E(g)$$

Hypothetically at what temperature, $K_p = K_c$

(when, $R = 0.08$ ℓ-atm/mole-K)

(a) $T = 0\,K$ (b) $T = 1K$

(c) $T = 12.5\,K$ (d) $T = 273\,K$

24. Steam reacts with iron at high temperature to give hydrogen gas and Fe_3O_4 (s). The correct expression for the equilibrium constant is

(a) $\dfrac{P_{H_2}^2}{P_{H_2O}^2}$ (b) $\dfrac{(P_{H_2})^4}{(P_{H_2O})^4}$

(c) $\dfrac{(P_{H_2})^4[Fe_3O_4]}{(P_{H_2O})^4[Fe]}$ (d) $\dfrac{[Fe_3O_4]}{[Fe]}$

25. For the reaction $C_{(s)} + CO_{2(g)} \rightarrow 2CO_{(g)}$, $K_p = 63$ atm at 1000 K. If at equilibrium : $P_{co} = 10\,P_{co_2}$, then the total pressure of the gases at equilibrium is

(a) 6.3 atm (b) 6.93 atm

(c) 0.63 atm (d) 0.693 atm

26. The rate constant for forward and backward reaction of hydrolysis of ester are 1.1×10^{-2} and 1.5×10^{-3} per minute respectively. Equilibrium constant for the reaction

$CH_3COOC_2H_5 + H^+ \rightleftharpoons CH_3COOH + C_2H_5OH$ is

(a) 4.33 (b) 5.33

(c) 6.33 (d) 7.33

27. Value of K_P in the reaction

$MgCO_{3(s)} \rightarrow MgO_{(s)} + CO_{2(g)}$ is

(a) $K_P = P_{CO_2}$

(b) $K_P = P_{CO_2} \times \dfrac{P_{CO_2} \times P_{MgO}}{P_{MgCO_3}}$

(c) $K_P = \dfrac{P_{CO_2} \times P_{MgO}}{P_{MgCO_3}}$

(d) $K_P = \dfrac{P_{MgCO_3}}{P_{CO_2} \times P_{MgO}}$

28. Which of the following is an example of homogeneous equilibrium ?

(a) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(b) $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$

(c) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

(d) $NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$

29. Unit of equilibrium constant for the given reaction is

$Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$

(a) $(mol/l)^{-3}$ (b) $(mol/l)^3$

(c) $(mol/l)^{-4}$ (d) $(mol/l)^4$

30. The thermal dissociation of calcium carbonate showing heterogeneous equilibrium is

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

For this reactions which of the following is/are true

(i) $K'_c = [CO_2(g)]$

(ii) $Kp = pCO_2$

(iii) $[CaCO_3(s)]$ and $[CaO(s)]$ are both constant

(iv) $[CO_2(g)]$ is constant

(a) (i), (ii) and (iv) (b) (i), (ii) and (iii)

(c) (ii) and (iv) (d) (i), (iii) and (iv)

31. In a reversible chemical reaction having two reactants in equilibrium, if the concentration of the reactants are doubled then the equilibrium constant will

(a) Also be doubled (b) Be halved

(c) Become one-fourth (d) Remain the same

32. On doubling P and V with constant temperature the equilibrium constant will

(a) remain constant (b) become double

(c) become one-fourth (d) None of these

33. If for the reaction

$N_2 + 3H_2 \rightleftharpoons 2NH_3$, $\Delta H = -92.38$KJ/mole than what happens if the temperature is increased?

(a) Reaction proceed forward

(b) Reaction proceed backward

(c) No effect on the formation of product

(d) None of these

34. If K_c is in the range of .... appreciable concentrations of both reactants and products are present.

(a) 10^{-4} to 10^4 (b) 10^{-3} to 10^3

(c) 10^{+3} to 10^{-3} (d) 10^{-5} to 10^3

35. The reaction quotient (Q) for the reaction

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

is given by $Q = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$. The reaction will proceed from right to left if

(a) $Q = 0$ (b) $Q = K_c$

(c) $Q < K_c$ (d) $Q > K_c$

where K_c is the equilibrium constant

36. The reaction quotient Q is used to

(a) predict the extent of a reaction on the basis of its magnitude

(b) predict the direction of the reaction

(c) calculate equilibrium concentrations

(d) calculate equilibrium constant

37. The correct relationship between free energy change in a reaction and the corresponding equilibrium constant, K_c is

(a) $\Delta G = RT \ln K_c$ (b) $-\Delta G = RT \ln K_c$

(c) $\Delta G° = RT \ln K_c$ (d) $-\Delta G° = RT \ln K_c$

38. Using the equation ($K = e^{-\Delta G^{\ominus}/RT}$), the reaction spontaneity can be interpreted in terms of the value of $\Delta G°$ is/are

(a) If $\Delta G^{\ominus} > 0$, then $-\Delta G^{\ominus}/RT$ is positive, and $e^{-\Delta G^{\ominus}/RT} > 1$ making $K > 1$, which implies a spontaneous reaction or the reaction which proceeds in the forward direction to such an extent that the products are present predominantly.

(b) If $\Delta G^{\ominus} > 0$, then $-\Delta G^{\ominus}/RT$ is negative, and $e^{-\Delta G^{\ominus}/RT}$ < 1 making $K < 1$, which implies a non-spontaneous reaction or a reaction which proceeds in the forward direction to such a small degree that only a very minute quantity of product is formed.

(c) Both (a) and (b)

(d) None of the above

39. Which of the following relation represents correct relation between standard electrode potential and equilibrium constant?

I. $\log K = \dfrac{nFE°}{2.303\ RT}$

II. $K = e^{\frac{nFE°}{RT}}$

III. $\log K = \dfrac{-nFE°}{2.303\ RT}$

IV. $\log K = 0.4342 \dfrac{-nFE°}{RT}$

Choose the correct statement(s).

(a) I, II and III are correct

(b) II and III are correct

(c) I, II and IV are correct

(d) I and IV are correct

40. According to Le-chatelier's principle, adding heat to a solid $\rightleftharpoons$ liquid equilibrium will cause the

(a) temperature to increase

(b) temperature to decrease

(c) amount of liquid to decrease

(d) amount of solid to decrease

41. Which one of the following information can be obtained on the basis of Le Chatelier principle?

(a) Dissociation constant of a weak acid

(b) Entropy change in a reaction

(c) Equilibrium constant of a chemical reaction

(d) Shift in equilibrium position on changing value of a constraint

42. For the manufacture of ammonia by the reaction

$N_2 + 3H_2 \rightleftharpoons 2NH_3 + 2\,\text{kcal}$

the favourable conditions are

(a) Low temperature, low pressure and catalyst

(b) Low temperature, high pressure and catalyst

(c) High temperature, low pressure and catalyst

(d) High temperature, high pressure and catalyst

43. Which of the following reaction will be favoured at low pressure ?

(a) $H_2 + I_2 \rightleftharpoons 2HI$

(b) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

(c) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

(d) $N_2 + O_2 \rightleftharpoons 2NO$

44. The equilibrium which remains unaffected by pressure change is

(a) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

(b) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(c) $2O_3(g) \rightleftharpoons 3O_2(g)$

(d) $2NO_2(g) \rightleftharpoons N_2O_4(g)$

45. Suitable conditions for melting of ice :

(a) high temperature and high pressure

(b) high temperature and low pressure

(c) low temperature and low pressure

(d) low temperature and high pressure

46. In which of the following reactions, the equilibrium remains unaffected on addition of small amount of argon at constant volume?

(a) $H_2\,(g) + I_2\,(g) \rightleftharpoons 2HI\,(g)$

(b) $PCl_5\,(g) \rightleftharpoons PCl_3\,(g) + Cl_2\,(g)$

(c) $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$

(d) The equilibrium will remain unaffected in all the three cases.

47. Le-Chatelier principle is not applicable to

(a) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(b) $Fe(s) + S(s) \rightleftharpoons FeS(s)$

(c) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(d) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

48. In an equilibrium reaction if temperature increases

(a) equilibrium constant increases

(b) equilibrium constant decreases

(c) any of the above

(d) no effect

49. In a two-step exothermic reaction

$$A_2(g) + B_2(g) \underset{\text{Step 1}}{\rightleftharpoons} 3C(g) \underset{\text{Step 2}}{\rightleftharpoons} D(g)$$

Steps 1 and 2 are favoured respectively by

(a) high pressure, high temperature and low pressure, low temperature

(b) high pressure, low temperature and low pressure, high temperature

(c) low pressure, high temperature and high pressure, high temperature

(d) low pressure, low temperature and high pressure, low temperature

50. What happens when an inert gas is added to an equilibrium keeping volume unchanged?
(a) More product will form
(b) Less product will form
(c) More reactant will form
(d) Equilibrium will remain unchanged

51. In a vessel N_2, H_2 and NH_3 are at equilibrium. Some helium gas is introduced into the vessel so that total pressure increases while temperature and volume remain constant. According to Le Chatelier's principle, the dissociation of NH_3
(a) increases (b) decreases
(c) remains unchanged (d) equilibrium is disturbed

52. Effect of a catalyst on a equilibrium reaction.
(i) A catalyst increases the rate of the chemical reaction by making available a new low energy pathway for the conversion of reactants to products.
(ii) It increases the rate of forward and reverse reactions that pass through the same transition state and does not affect equilibrium.
(iii) It lowers the activation energy for the forward and reverse reactions by exactly the same amount.
Which of the above statement(s) is/are correct ?
(a) Only (i) (b) (i) and (ii)
(c) (i), (ii) and (iii) (d) (ii) and (iii)

53. Which of the following is/are electrolytes?
(i) Sugar solution (ii) Sodium chloride
(iii) Acetic acid (iv) Starch solution
(a) (i) and (iv) (b) (ii) and (iv)
(c) (ii) and (iii) (d) (i) and (iii)

54. The geometry of hydronium ion is
(a) tetrahedral (b) linear
(c) trigonal pyramidal (d) trigonal planer

55. Which of the following statements are correct regarding Arrhenius theory of acid and base?
(a) This theory was applicable to only aqueous solutions
(b) This theory was applicable to all solutions
(c) This theory could not explain the basicity of substances like ammonia which do not possess a hydroxyl group
(d) Both (a) and (c)

56. Would gaseous HCl be considered as an Arrhenius acid ?
(a) Yes
(b) No
(c) Not known
(d) Gaseous HCl does not exist

57. A base, as defined by Bronsted theory, is a substance which can
(a) lose a pair of electrons
(b) donate protons
(c) gain a pair of electrons
(d) accept protons

58. BF_3 is an acid according to
(a) Arrhenius concept (b) Bronsted-Lowry concept
(c) Lewis Concept (d) Both (b) and (c)

59. Which of the following can act as both Bronsted acid and Bronsted base?
(a) Na_2CO_3 (b) OH^-
(c) HCO_3^- (d) NH_3

60. Conjugate acid of NH_2^- is :
(a) NH_4^+ (b) NH_3
(c) NH_2 (d) NH

61. Among boron trifluoride, stannic chloride and stannous chloride, Lewis acid is represented by
(a) only stannic chloride
(b) boron trifluoride and stannic chloride
(c) boron trifluoride and stannous chloride
(d) only boron trifluoride

62. Which of the following molecules acts as a Lewis acid ?
(a) $(CH_3)_2O$ (b) $(CH_3)_3P$
(c) $(CH_3)_3N$ (d) $(CH_3)_3B$

63. Which one of the following molecular hydrides acts as a Lewis acid?
(a) NH_3 (b) H_2O
(c) B_2H_6 (d) CH_4

64. Which of these is least likely to act as Lewis base?
(a) F^- (b) BF_3
(c) PF_3 (d) CO

65. Which one of the following is the correct statement ?
(a) HCO_3^- is the conjugate base of CO_3^{2-}.
(b) NH_2^- is the conjugate acid of NH_3.
(c) H_2SO_4 is the conjugate acid of HSO_4^-.
(d) NH_3 is the conjugate base of NH_2^-.

66. Water is well known amphoprotic solvent. In which chemical reaction water is behaving as a base?
(a) $H_2SO_4 + H_2O \longrightarrow H_3O^+ + HSO_4^-$
(b) $H_2O + H_2O \longrightarrow H_3O^+ + OH^-$
(c) $H_2O + NH_2^- \longrightarrow NH_3 + OH^-$
(d) $H_2O + NH_3 \longrightarrow NH_4^+ + OH^-$

67. An acid/ base dissociation equilibrium is dynamic involving a transfer of proton in forward and reverse directions. Now, with passage of time in which direction equilibrium is favoured ?
(a) in the direction of stronger base and stronger acid
(b) in the direction of formation of stronger base and weaker acid
(c) in the direction of formation of weaker base and weaker acid
(d) in the direction of formation of weaker base and stronger acid

68. Three reactions involving $H_2PO_4^-$ are given below:
(i) $H_3PO_4 + H_2O \rightarrow H_3O^+ + H_2PO_4^-$
(ii) $H_2PO_4^- + H_2O \rightarrow HPO_4^{2-} + H_3O^+$
(iii) $H_2PO_4^- + OH^- \rightarrow H_3PO_4 + O^{2-}$
In which of the above does $H_2PO_4^-$ act as an acid ?
(a) (ii) only (b) (i) and (ii)
(c) (iii) only (d) (i) only

69. The value of the ionic product of water
(a) depends on volume of water
(b) depends on temperature
(c) changes by adding acid or alkali
(d) always remains constant

70. A base when dissolved in water yields a solution with a hydroxyl ion concentration of 0.05 mol litre^{-1}. The solution is
(a) basic (b) acidic
(c) neutral (d) either (b) or (c)

71. pH scale was introduced by :
(a) Arrhenius (b) Sorensen
(c) Lewis (d) Lowry

72. pH of solution is defined by expression
(a) $\log[H^+]$ (b) $\log\left[\frac{1}{H^+}\right]$
(c) $\frac{1}{\log[H^+]}$ (d) $\frac{1}{-\log[H^+]}$

73. The pH of a 10^{-3} M HCl solution at 25°C if it is diluted 1000 times, will be –
(a) 3 (b) zero
(c) 5.98 (d) 6.02

74. How many litres of water must be added to 1 litre an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2 ?
(a) 0.1 L (b) 0.9 L
(c) 2.0 L (d) 9.0 L

75. What is the approximate pH of a 1×10^{-3} M NaOH solution?
(a) 3 (b) 11
(c) 7 (d) 1×10^{-11}

76. Calculate the pOH of a solution at 25°C that contains 1×10^{-10} M of hydronium ions, i.e. H_3O^+.
(a) 4.000 (b) 9.0000
(c) 1.000 (d) 7.000

77. The pH value of a 10 M solution of HCl is
(a) less than 0 (b) equal to 0
(c) equal to 1 (d) equal to 2

78. What is the H^+ ion concentration of a solution prepared by dissolving 4 g of NaOH (Atomic weight of Na = 23 amu) in 1000 ml?
(a) 10^{-10} M (b) 10^{-4} M
(c) 10^{-1} M (d) 10^{-13} M

79. Calculate the pOH of a solution at 25°C that contains 1×10^{-10} M of hydronium ions, i.e. H_3O^+.
(a) 4.000 (b) 9.0000
(c) 1.000 (d) 7.000

80. The pH of 0.005 molar solution of H_2SO_4 is approximately:
(a) 0.010 (b) 1
(c) 2 (d) 0.005

81. Which solution has pH equal to 10 ?
(a) 10^{-4} M KOH (b) 10^{-10} M KOH
(c) 10^{-10} M HCl (d) 10^{-4} M HCl

82. Which of the following has highest pH ?
(a) $\frac{M}{4}$KOH (b) $\frac{M}{4}$NaOH
(c) $\frac{M}{4}NH_4OH$ (d) $\frac{M}{4}Ca(OH)_2$

83. A weak acid, HA, has a K_a of 1.00×10^{-5}. If 0.100 mole of this acid dissolved in one litre of water, the percentage of acid dissociated at equilbrium is closest to
(a) 1.00% (b) 99.9%
(c) 0.100% (d) 99.0%

84. A monobasic weak acid solution has a molarity of 0.005 and pH of 5. What is the percentage ionization in this solution?
(a) 2.0 (b) 0.2
(c) 0.5 (d) 0.25

85. Calculate the pH of a solution obtained by diluting 1 mL of 0.10 M weak monoacidic base to 100 mL at constant temperature if K_b of the base is 1×10^{-5} ?
(a) 8 (b) 9
(c) 10 (d) 11

86. The ionisation constant of an acid, K_a, is the measure of strength of an acid. The K_a values of acetic acid, hypochlorous acid and formic acid are 1.74×10^{-5}, 3.0×10^{-8} and 1.8×10^{-4} respectively. Which of the following orders of pH of 0.1 mol dm^{-3} solutions of these acids is correct?
(a) acetic acid > hypochlorous acid > formic acid
(b) hypochlorous acid > acetic acid > formic acid
(c) formic acid > hypochlorous acid > acetic acid
(d) formic acid > acetic acid > hypochlorous acid

87. The first and second dissociation constants of an acid H_2A are 1.0×10^{-5} and 5.0×10^{-10} respectively. The overall dissociation constant of the acid will be
(a) 0.2×10^5 (b) 5.0×10^{-5}
(c) 5.0×10^{15} (d) 5.0×10^{-15}.

88. Equimolar solutions of HF, HCOOH and HCN at 298 K have the values of K_a as 6.8×10^{-4} and 4.8×10^{-9} respectively. What is the observed trend of dissociation constants in successive stages ?
(a) HF > HCN > HCOOH (b) HF > HCOOH > HCN
(c) HCN > HF > HCOOH (d) HCOOH > HCN > HF

89. At 25°C, the dissociation constant of a base, BOH, is 1.0×10^{-12}. The concentration of hydroxyl ions in 0.01 M aqueous solution of the base would be
(a) 1.0×10^{-5} mol L^{-1} (b) 1.0×10^{-6} mol L^{-1}
(c) 2.0×10^{-6} mol L^{-1} (d) 1.0×10^{-7} mol L^{-1}

90. Which of the following pK_a value represents the strongest acid ?
(a) 10^{-4} (b) 10^{-8}
(c) 10^{-5} (d) 10^{-2}

91. The dissociation constant of two acids HA_1 and HA_2 are 3.14×10^{-4} and 1.96×10^{-5} respectively. The relative strength of the acids will be approximately
(a) 1 : 4 (b) 4 : 1
(c) 1 : 16 (d) 16 : 1

92. Given

$$HF + H_2O \xrightarrow{K_a} H_3O^+ + F^-$$

$$F^- + H_2O \xrightarrow{K_b} HF + OH^-$$

Which of the following reaction is correct

(a) $K_b = K_w$ (b) $K_b = \frac{1}{K_w}$

(c) $K_a \times K_b = K_w$ (d) $\frac{K_a}{K_b} = K_w$

93. At 298*K* a 0.1 M CH_3COOH solution is 1.34% ionized. The ionization constant K_a for acetic acid will be

(a) 1.82×10^{-5} (b) 18.2×10^{-5}

(c) 0.182×10^{-5} (d) None of these

94. For dibasic acid correct order is

(a) $K_{a_1} < K_{a_2}$ (b) $K_{a_1} > K_{a_2}$

(c) $K_{a_1} = K_{a_2}$ (d) not certain

95. For a polybasic acid, the dissociation constants have a different values for each step, e.g.,

$$H_3A \rightleftharpoons H^+ + H_2A^- \; ; \; K = K_{a_1}$$

$$H_2A^- \rightleftharpoons H^+ + HA^{2-} \; ; \; K = K_{a_2}$$

$$HA^{2-} \rightleftharpoons H^+ + A^{3-} \; ; \; K = K_{a_3}$$

What is the observed trend of dissociation constants in successive stages ?

(a) $K_{a_1} > K_{a_2} > K_{a_3}$ (b) $K_{a_1} = K_{a_2} = K_{a_3}$

(c) $K_{a_1} < K_{a_2} < K_{a_3}$ (d) $K_{a_1} = K_{a_2} + K_{a_3}$

96. K_{a_1}, K_{a_2} and K_{a_3} are the respective ionisation constants for the following reactions.

$$H_2S \rightleftharpoons H^+ + HS^-$$

$$HS^- \rightleftharpoons H^+ + S^{2-}$$

$$H_2S \rightleftharpoons 2H^+ + S^{2-}$$

The correct relationship between K_{a_1}, K_{a_2} and K_{a_3} is

(a) $K_{a_3} = K_{a_1} \times K_{a_2}$ (b) $K_{a_3} = K_{a_1} + K_{a_2}$

(c) $K_{a_3} = K_{a_1} - K_{a_2}$ (d) $K_{a_3} = K_{a_1} / K_{a_2}$

97. Cationic hydrolysis gives the following solution:

(a) acidic (b) basic

(c) neutral (d) amphoteric

98. In qualitative analysis, in III group NH_4Cl is added before NH_4OH because

(a) to increase the concentration of NH_4^+ ions

(b) to increase concentration of Cl^- ions

(c) to reduce the concentration of OH^- ions

(d) to increase concentration of OH^- ions

99. The solubility of AgI in NaI solution is less than that in pure water because :

(a) the temperature of the solution decreases

(b) solubility product to AgI is less than that of NaI

(c) of common ion effect

(d) AgI forms complex with NaI

100. When sodium acetate is added to an aqueous solution of acetic acid :

(a) The pH of the solution decreases

(b) The pH of the solution increases

(c) The pH of the solution remains unchanged

(d) An acid salt is produced

101. Which of the following statements about pH and H^+ ion concentration is incorrect?

(a) Addition of one drop of concentrated HCl in NH_4OH solution decreases pH of the solution.

(b) A solution of the mixture of one equivalent of each of CH_3COOH and NaOH has a pH of 7

(c) pH of pure neutral water is not zero

(d) A cold and concentrated H_2SO_4 has lower H^+ ion concentration than a dilute solution of H_2SO_4

102. H_2S gas when passed through a solution of cations containing HCl precipitates the cations of second group of qualitative analysis but not those belonging to the fourth group. It is because

(a) presence of HCl decreases the sulphide ion concentration.

(b) solubility product of group II sulphides is more than that of group IV sulphides.

(c) presence of HCl increases the sulphide ion concentration.

(d) sulphides of group IV cations are unstable in HCl.

103. A salt 'X' is dissolved in water of pH = 7. The salt is made resulting solution becomes alkaline in nature. The salt is made

(a) A strong acid and strong base

(b) A strong acid and weak base

(c) A weak acid and weak base

(d) A weak acid and strong base

104. Aqueous solution of ferric chloride is acidic due to

(a) ionization (b) polarization

(c) dissociation (d) hydrolysis

105. The pK_a of a weak acid, HA, is 4.80. The pK_b of a weak base, BOH, is 4.78. The pH of an aqueous solution of the correspondng salt, BA, will be

(a) 9.58 (b) 4.79

(c) 7.01 (d) 9.22

106. The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffer solution of HA in which 50% of the acid is ionized is

(a) 7.0 (b) 4.5

(c) 2.5 (d) 9.5

107. A buffer solution is prepared in which the concentration of NH_3 is 0.30M and the concentration of NH_4^+ is 0.20 M. If the equilibrium constant, K_b for NH_3 equals 1.8×10^{-5}, what is the pH of this solution ? (log 2.7 = 0.433).

(a) 9.08 (b) 9.43

(c) 11.72 (d) 8.73

108. What is $[H^+]$ in mol/L of a solution that is 0.20 M in CH_3COONa and 0.10 M in CH_3COOH ? K_a for CH_3COOH $= 1.8 \times 10^{-5}$.

(a) 3.5×10^{-4} (b) 1.1×10^{-5}
(c) 1.8×10^{-5} (d) 9.0×10^{-6}

109. Which of the following pairs constitutes a buffer?
(a) NaOH and NaCl (b) HNO_3 and NH_4NO_3
(c) HCl and KCl (d) HNO_2 and $NaNO_2$

110. Buffer solutions have constant acidity and alkalinity because
(a) these give unionised acid or base on reaction with added acid or alkali.
(b) acids and alkalies in these solutions are shielded from attack by other ions.
(c) they have large excess of H^+ or OH^- ions
(d) they have fixed value of pH

111. The buffering action of an acidic buffer is maximum when its pH is equal
(a) 5 (b) 7
(c) 1 (d) pK_a

112. When a buffer solution, sodium acetate and acetic acid is diluted with water :
(a) Acetate ion concentration increases
(b) H^+ ion concentration increases
(c) OH^- ion conc. increases
(d) H^+ ion concentration remains unaltered

113. The product of ionic concentration in a saturated solution of an electrolyte at a given temperature is constant and is known as
(a) Ionic product of the electrolyte
(b) Solubility product
(c) Ionization constant
(d) Dissociation constant

114. The K_{sp} for $Cr(OH)_3$ is 1.6×10^{-30}. The solubility of this compound in water is :
(a) $\sqrt[4]{1.6\times10^{-30}}$ (b) $\sqrt[4]{1.6\times10^{-30}/27}$
(c) $1.6\times10^{-30/27}$ (d) $\sqrt{1.6\times10^{-30}}$

115. At 25°C, the solubility product of $Mg(OH)_2$ is 1.0×10^{-11}. At which pH, will Mg^{2+} ions start precipitating in the form of $Mg(OH)_2$ from a solution of 0.001 M Mg^{2+} ions?
(a) 9 (b) 10
(c) 11 (d) 8

116. pH of a saturated solution of $Ba(OH)_2$ is 12. The value of solubility product (K_{sp}) of $Ba(OH)_2$ is :
(a) 3.3×10^{-7} (b) 5.0×10^{-7}
(c) 4.0×10^{-6} (d) 5.0×10^{-6}

117. If s and S are respectively solubility and solubility product of a sparingly soluble binary electrolyte then :
(a) $s = S$ (b) $s = S^2$
(c) $s = S^{1/2}$ (d) $s = \frac{1}{2}S$

118. Why only As^{+3} gets precipitated as As_2S_3 and not Zn^{+2} as ZnS when H_2S is passed through an acidic solution containing As^{+3} and Zn^{+2}?
(a) Solubility product of As_2S_3 is less than that of ZnS
(b) Enough As^{+3} are present in acidic medium
(c) Zinc salt does not ionise in acidic medium
(d) Solubility product changes in presence of an acid

119. Solid $Ba(NO_3)_2$ is gradually dissolved in a 1.0×10^{-4} M Na_2CO_3 solution. At which concentration of Ba^{2+}, precipitate of $BaCO_3$ begins to form ? (K_{sp} for $BaCO_3$ $= 5.1 \times 10^{-9}$)
(a) 5.1×10^{-5} M (b) 7.1×10^{-8} M
(c) 4.1×10^{-5} M (d) 8.1×1^{-7} M

120. Solubility product of silver bromide is 5.0×10^{-13}. The quantity of potassium bromide (molar mass taken as 120 g mol^{-1}) to be added to 1 litre of 0.05 M solution of silver nitrate to start the precipitation of AgBr is
(a) 1.2×10^{-10} g (b) 1.2×10^{-9} g
(c) 6.2×10^{-5} g (d) 5.0×10^{-8} g

121. At 25°C, the solubility product of $Mg(OH)_2$ is 1.0×10^{-11}. At which pH, will Mg^{2+} ions start precipitating in the form of $Mg(OH)_2$ from a solution of 0.001 M Mg^{2+} ions?
(a) 9 (b) 10
(c) 11 (d) 8

STATEMENT TYPE QUESTIONS

122. Read the following statements carefully and choose the correct answer
(i) Water and water vapour remain in equilibrium position at atmospheric pressure (1.013 bar) and at 100°C in a closed vessel.
(ii) The boiling point of water is 100°C at 1.013 bar pressure
(iii) Boiling point of the liquid depends on the atmospheric pressure.
(iv) Boiling point depends on the altitude of the place; at high altitude the boiling point increases.
(a) (i), (ii) and (iv) are correct
(b) (i), (iii) and (iv)
(c) (i), (ii) and (iii) are correct
(d) only (iii) is correct

123. You must have seen that when a soda water bottle is opened, some of the carbon dioxide gas dissolved in it fizzes out rapidly. There is equilibrium between the molecules in the gaseous state and the molecules dissolved in the liquid under pressure i.e.,

$$CO_2(gas) \rightleftharpoons CO_2(\text{in solution})$$

Which of the following statements is/are correct regarding this?
(i) The phenomenon arises due to difference in solubility of carbon dioxide at different pressures.
(ii) This equilibrium is governed by Henry's law.
(iii) The amount of CO_2 gas dissolved in liquid increases with decrease of temperature.
(iv) The amount of CO_2 gas dissolved in liquid decreases with increase of temperature.
(a) (i), (ii) and (iv) are correct
(b) (i) , (iii) and (iv)
(c) (i), (ii) and (iii) are correct
(d) only (iii) is correct

124. Identify the CORRECT statements below regarding chemical equilibrium:

(i) All chemical reactions which are in equilibrium are irreversible.

(ii) Equilibrium is achieved when the forward reaction rate equals the reverse reaction rate.

(iii) Equilibrium is achieved when the concentrations of reactants and product remain constant.

(iv) Equilibrium is dynamic in nature

(a) (i), (ii) and (iv) are correct

(b) (i), (ii), (iii) and (iv) are correct

(c) (i), (ii) and (iii) are correct

(d) only (ii) is correct

125. Nobel gas is added to a reaction at equilibrium involving gaseous reactant and gaseous product.

Which of the following statement is true for above reaction?

Statement 1 : Reaction will proceed forward, as total pressure has increased due to addition of Nobel gas.

Statement 2 : Reaction will proceed backward, if Nobel gas react with reactant.

(a) Statement 1 and 2 are both correct.

(b) Statement 1 is correct but statement 2 is incorrect.

(c) Statement 1 is incorrect but statement 2 is correct.

(d) Statement 1 and 2 both are incorrect.

126 Read the following statements and choose the correct option.

(i) The value of equilibrium constant is independent of initial concentrations of the reactants and products.

(ii) Equilibrium constant is temperature dependent

(iii) The equilibrium constant for the reverse reaction is equal to the inverse of the equilibrium constant for the forward reaction.

(iv) The equilibrium constant for the reverse reaction is equal to the equilibrium constant for the forward reaction.

(a) (i), (ii) and (iv) are correct

(b) (i), (iii) and (iv)

(c) (i), (ii) and (iii) are correct

(d) only (iii) is correct

127. Read the following statements and choose the correct option

(i) The numerical value of the equilibrium constant for a reaction indicates the extent of the reaction.

(ii) An equilibrium constant give information about the rate at which the equilibrium is reached.

(iii) If $K_c > 10^3$, products predominate over reactants, i.e., if K_c is very large, the reaction proceeds nearly to completion.

(iv) If $K_c < 10^{-3}$, reactants predominate over products, i.e., if K_c is very small, the reaction proceeds rarely.

(a) (i), (ii) and (iv) are correct

(b) (i) , (iii) and (iv)

(c) (i), (ii) and (iii) are correct

(d) only (iii) is correct

128. Which of the following statement(s) is/are correct ?

(i) ΔG is negative, then the reaction is spontaneous and proceeds in the forward direction.

(ii) ΔG is positive, then reaction is non-spontaneous

(iii) ΔG is 0, then reaction is at equilibrium

(a) (i), (ii) and (iii) are correct

(b) (i) and (ii)

(c) (ii) and (iii) are correct

(d) only (iii) is correct

129. Read the following statements and choose the correct option

(i) Most of the acids taste sour

(ii) Acids turns blue litmus paper into red

(iii) Bases turns red litmus paper blue

(iv) Bases taste bitter and feel soapy

(a) (i), (ii) and (iv) are correct

(b) (i), (iii) and (iv)

(c) (i), (ii) and (iii) are correct

(d) All statements are correct

130. Which of the following statements are correct ?

(i) Strong acids have very weak conjugate bases

(ii) Weak acids have very strong conjugate bases

(iii) Strong bases have strong conjugate acids

(iv) Weak bases have weak conjugate acids

(a) (i) and (ii) (b) (i) and (iii)

(c) (ii) and (iv) (d) (iii) and (iv)

131. Which of the following statement(s) is/are correct ?

(i) Water has ability to act both as an acid and a base

(ii) In pure water one H_2O molecule donate proton and acts an acid and another water molecule accepts a proton and acts as a base.

(a) Both (i) and (ii) (b) Neither (i) nor (ii)

(c) Only (i) (d) Only (ii)

132. Which of the following statements are correct ?

(i) Ionic product of water $(K_w) = [H^+][OH^-] = 10^{-14} M^2$

(ii) At 298K $[H^+] = [OH^-] = 10^{-7}$

(iii) K_w does not depends upon temperature

(iv) Molarity of pure water = 55.55M

(a) (i), (ii) and (iii) (b) (i), (ii) and (iv)

(c) (i) and (iv) (d) (ii) and (iii)

133. Read the following statements and choose the correct option

(i) K_a (ionization constant) is a measure of the strength of the acids

(ii) Smaller the value of K_a, the stronger is the acid

(iii) K_a is a dimensionless quantity

(a) Statements (i) and (ii) are correct

(b) Statements (ii) and (iii) are correct

(c) Statements (i), (ii) and (iii) are correct

(d) Statements (i) and (iii) are correct

134. Which of the following statement(s) is/are correct ?

(i) In a tribasic acid 2nd and 3rd (K_{a_2}, K_{a_3}) ionization constants are smaller than the first ionisation (K_{a_1})

(ii) It is difficult to remove a positively charged proton from a negative ion due to electrostatic force.

(a) Both (i) and (ii) (b) Neither (i) nor (ii)

(c) Only (i) (d) Only (ii)

135. Which of the following statements are correct ?

(i) The extent of dissociation of an acid depends on the strength and polarity of the H — A bond (where A is an electronegative element.)

(ii) As the strength of H–A bond increases, the energy required to break the bond decreases.

(iii) As the electronegativity difference between the atoms H and A increases, acidity increases

(a) (i) and (ii)
(b) (ii) and (iii)
(c) (i) and (iii)
(d) (i), (ii) and (iii)

MATCHING TYPE QUESTIONS

136. Match the columns

Column-I	**Column-II**
(A) H_2O (l) $\rightleftharpoons$ H_2O (vap)	(p) rate of melting = rate of freezing
(B) I_2 (solid) $\rightleftharpoons$ I_2 (vapour)	(q) rate of evaporation = rate of condensation
(C) Ice $\rightleftharpoons$ water	(r) rate of sublimation= rate of condensation

(a) A – (p), B – (q), C – (r)
(b) A – (r), B – (q), C – (p)
(c) A – (p), B – (r), C – (q)
(d) A – (q), B – (r), C – (p)

137. Match the Column-I with Column-II and mark the appropriate choice.

Column-I	**Column-II**
(A) Liquid $\rightleftharpoons$ Vapour	(p) Saturated solution
(B) Solid $\rightleftharpoons$ Liquid	(q) Boiling point
(C) Solid $\rightleftharpoons$ Vapour	(r) Sublimation point
(D) Solute (s) $\rightleftharpoons$ Solute (solution)	(s) Melting point

(a) A – (p) ; B – (r) ; C – (q) ; D – (s)
(b) A – (q) ; B – (s) ; C – (r) ; D – (p)
(c) A – (s) ; B – (q) ; C – (p) ; D – (r)
(d) A – (r) ; B – (s) ; C – (q) ; D – (p)

138. Match the columns.

Column-I (Reactions)	**Column-II (Effect of increase in pressure)**
(A) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	(p) Reaction proceed backward.
(B) $CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$	(q) No effect on reaction.
(C) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$	(r) Reaction proceed forward

(a) A – (q), B – (r), C – (p)
(b) A – (r), B – (q), C – (p)
(c) A – (p), B – (r), C – (q)
(d) A – (q), B – (p), C – (r)

139. Match the columns :

Column-I	**Column-II**
(A) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)\ (t = 300^\circ C)$	(p) $\Delta n > 0$
(B) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)\ (t = 50^\circ C)$	(q) $K_P < K_C$
(C) $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$	(r) K_P not defined
(D) $CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$	(s) $\Delta n = 1$

(a) A – (q), B – (p), C – (s), D – (r)
(b) A – (p), B – (q), C – (r), D – (s)
(c) A – (r), B – (p), C – (s), D – (q)
(d) A – (s), B – (q), C – (p), D – (r)

140. Match the columns :

Column-I	**Column-II**
(A) For the equilibrium $NH_4I(s) \rightleftharpoons NH_3(g) + HI(g)$, if pressure is increased at equilibrium	(p) Forward shift
(B) For the equilibrium $N_2 + 3H_2 \rightleftharpoons 2NH_3$ If volume is increased at equilibrium	(q) No change
(C) For the equilibrium $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2\ (g)$ inert gas is added at constant pressure at equilibrium	(r) Backward shift
(D) For the equilibrium $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ what happens if more PCl_5 is added	(s) More N_2 and H_2 is formed.

(a) A – (p), B – (q), C – (r), D – (s)
(b) A – (r), B – (s), C – (q), D – (p)
(c) A – (s), B – (p), C – (q), D – (r)
(d) A – (q), B – (s), C – (r), D – (p)

141. Match the columns

Column-I	**Column-II**
(A) $Q_c < K_c$,	(p) Net reaction goes from right to left.
(B) $Q_c > K_c$,	(q) Net reaction goes from left to right.
(C) $Q_c = K_c$,	(r) No net reaction occurs.

(a) A – (p), B – (q), C – (r)
(b) A – (r), B – (q), C – (p)
(c) A – (p), B – (r), C – (q)
(d) A – (q), B – (p), C – (r)

142. Match the columns

	Column-I		Column-II
(A)	Hydrochloric acid	(p)	Lemon and orange
(B)	Acetic acid	(q)	Tamarind paste.
(C)	Citric and ascorbic acids	(r)	Digestive juice
(D)	Tartaric acid	(s)	Constituent of vinegar

(a) A – (q), B – (r), C – (p), D – (s)
(b) A – (r), B – (s), C – (p), D – (q)
(c) A – (s), B – (p), C – (q), D – (r)
(d) A – (r), B – (p), C – (s), D – (q)

143. Match the columns

	Column-I		Column-II
(A)	$HClO_4$	(p)	Strong base
(B)	HNO_2	(q)	Strong acid
(C)	NH_2^-	(r)	Weak base
(D)	HSO_4^-	(s)	Weak acid

(a) A – (s), B – (q), C – (p), D – (r)
(b) A – (q), B – (s), C – (p), D – (r)
(c) A – (r), B – (p), C – (q), D – (s)
(d) A – (s), B – (q), C – (p), D – (r)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

144. Assertion : K_p can be less than, greater than or equal to K_c.
Reason : Relation between K_p and K_c depends on the change in number of moles of gaseous reactants and products (Δn).

145. Assertion : If a volume is kept constant and an inert gas such as argon is added which does not take part in the reaction, the equilibrium remains undisturbed.
Reason : It is because the addition of an inert gas at constant volume does not change the partial pressure or the molar concentrations of the substance involved in the reaction.

146. Assertion : Buffer system of carbonic acid and sodium bicarbonate is used for the precipitation of hydroxides of third group elements.
Reason : It maintains the pH to a constant value, about 7.4.

147. Assertion : Addition of silver ions to a mixture of aqueous sodium chloride and sodium bromide solution will first precipitate AgBr rather than AgCl.
Reason : K_{sp} of AgCl > K_{sp} of AgBr.

CRITICAL THINKING TYPE QUESTIONS

148. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g), K_1$ (1)
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g), K_2$ (2)
$H_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O(g), K_3$ (3)

The equation for the equilibrium constant of the reaction
$2NH_3(g) + \frac{5}{2}O_2(g) \rightleftharpoons 2NO(g) + 3H_2O(g), (K_4)$ in terms of K_1, K_2 and K_3 is :

(a) $\frac{K_1.K_2}{K_3}$ (b) $\frac{K_1.K_3^2}{K_2}$
(c) $K_1 K_2 K_3$ (d) $\frac{K_2.K_3^3}{K_1}$

149. Two equilibria, $AB \rightleftharpoons A^+ + B^-$ and $AB + B^- \rightleftharpoons AB_2^-$ are simultaneously maintained in a solution with equilibrium constants, K_1 and K_2 respectively. The ratio of $[A^+]$ to $[AB_2^-]$ in the solution is
(a) directly proportional to $[B^-]$
(b) inversely proportional to $[B^-]$
(c) directly proportional to the square of $[B^-]$
(d) inversely proportional to the square of $[B^-]$

150. Equilibrium constant (K) for the reaction
$Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$ can be written in terms of
(1) $Ni(s) + 2CO_2(g) + 2C(s) \rightleftharpoons Ni(CO)_4(g)$; equilibrium constant = K_1.
(2) $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$; equilibrium constant = K_2.
What is the relation between K, K_2 and K_2 ?
(a) $K = (K_1)/(K_2)^2$ (b) $K = (K_1 . K_2)$
(c) $K = (K_1)(K_2)^2$ (d) $K = K_1/K_2$

151. K_1, K_2 and K_3 are the equilibrium constants of the following reactions (I), (II) and (III) respectively:
(I) $N_2 + 2O_2 \rightleftharpoons 2NO_2$
(II) $2NO_2 \rightleftharpoons N_2 + 2O_2$
(III) $NO_2 \rightleftharpoons \frac{1}{2}N_2 + O_2$

The correct relation from the following is

(a) $K_1 = \frac{1}{K_2} = \frac{1}{K_3}$ (b) $K_1 = \frac{1}{K_2} = \frac{1}{(K_3)^2}$
(c) $K_1 = \sqrt{K_2} = K_3$ (d) $K_1 = \frac{1}{K_2} = K_3$

152. For the following three reactions a, b and c, equilibrium constants are given:

(i) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g); K_1$

(ii) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g); K_2$

(iii) $CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g); K_3$

(a) $K_1\sqrt{K_2} = K_3$
(b) $K_2K_3 = K_1$
(c) $K_3 = K_1 K_2$
(d) $K_3.K_2^3 = K_1^2$

153. The value of equilibrium constant of the reaction

$HI(g) \rightleftharpoons \frac{1}{2}H_2(g) + \frac{1}{2}I_2$ is 8.0

The equilibrium constant of the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ will be:

(a) $\frac{1}{16}$
(b) $\frac{1}{64}$
(c) 16
(d) $\frac{1}{8}$

154. For the reversible reaction,

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at 500°C, the value of K_p is 1.44×10^{-5} when partial pressure is measured in atmospheres. The corresponding value of K_C, with concentration in mole litre^{-1}, is

(a) $\frac{1.44 \times 10^{-5}}{(0.082 \times 500)^{-2}}$
(b) $\frac{1.44 \times 10^{-5}}{(8.314 \times 773)^{-2}}$
(c) $\frac{1.44 \times 10^{-5}}{(0.082 \times 773)^{2}}$
(d) $\frac{1.44 \times 10^{-5}}{(0.082 \times 773)^{-2}}$

155. Two moles of PCl_5 were heated in a closed vessel of 2L. At equilibrium 40% of PCl_5 is dissociated into PCl_3 and Cl_2. The value of equilibrium constant is

(a) 0.53
(b) 0.267
(c) 2.63
(d) 5.3

156. PCl_5 is dissociating 50% at 250°C at a total pressure of P atm. If equilibrium constant is K_p, then which of the following relation is numerically correct ?

(a) $K_p = 3P$
(b) $P = 3K_p$
(c) $P = \frac{2K_P}{3}$
(d) $K_p = \frac{2P}{3}$

157. For the decomposition of the compound, represented as

$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$

the $K_p = 2.9 \times 10^{-5}$ atm^3.

If the reaction is started with 1 mol of the compound, the total pressure at equilibrium would be :

(a) 1.94×10^{-2} atm
(b) 5.82×10^{-2} atm
(c) 7.66×10^{-2} atm
(d) 38.8×10^{-2} atm

158. The values of Kp_1 and Kp_2 for the reactions

$X \rightleftharpoons Y + Z$ ...(1)

and $A \rightleftharpoons 2B$ ...(2)

are in the ratio of 9 : 1. If degree of dissociation of X and A be equal, then total pressure at equilibrium (1) and (2) are in the ratio :

(a) 3 : 1
(b) 1 : 9
(c) 36 : 1
(d) 1 : 1

159. The dissociation equilibrium of a gas AB_2 can be represented as :

$2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$

The degree of dissociation is 'x' and is small compared to 1. The expression relating the degree of dissociation (x) with equilibrium constant K_p and total pressure P is :

(a) $(2K_p/P)$
(b) $(2K_p/P)^{1/3}$
(c) $(2K_p/P)^{1/2}$
(d) (K_p/P)

160. On increasing the pressure, the gas phase reaction proceed forward to re-establish equilibrium, as predicted by applying the Le Chatelier's principle. Consider the reaction.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Which of the following is correct, if the total pressure at which the equilibrium is established, is increased without changing the temperature?

(a) K will remain same
(b) K will decrease
(c) K will increase
(d) K will increase initially and decrease when pressure is very high

161. The exothermic formation of ClF_3 is represented by the equation :

$Cl_2(g) + 3F_2(g) \rightleftharpoons 2ClF_3(g)$;

$\Delta H = -329$ kJ

Which of the following will increase the quantity of ClF_3 in an equilibrium mixture of Cl_2, F_2 and ClF_3 ?

(a) Adding F_2
(b) Increasing the volume of the container
(c) Removing Cl_2
(d) Increasing the temperature

162. When hydrochloric acid is added to cobalt nitrate solution at room temperature, the following reaction takes place out the reaction mixture becomes blue. On cooling the mixture it becomes pink. On the basis of this information mark the correct answer.

$$\underset{\text{(pink)}}{\left[CO(H_2O)_6\right]^{3+}}(aq) + 4Cl^-(aq) \rightleftharpoons \underset{\text{(blue)}}{\left[COCl_4\right]^{2-}}(aq) + 6H_2O(l)$$

(a) $\Delta H > 0$ for the reaction
(b) $\Delta H < 0$ for the reaction
(c) $\Delta H = 0$ for the reaction
(d) The sign of ΔH cannot be predicted on the basis of this information.

163. In HS^-, I^-, RNH_2 and NH_3, order of proton accepting tendency will be

(a) $I^- > NH_3 > RNH_2 > HS^-$

(b) $HS^- > RNH_2 > NH_3 > I^-$

(c) $RNH_2 > NH_3 > HS^- > I^-$

(d) $NH_3 > RNH_2 > HS^- > I^-$

164. Which equilibrium can be described as an acid-base reaction using the Lewis acid-base definition but not using the Bronsted-Lowry definition?

(a) $2NH_3 + H_2SO_4 \rightleftharpoons 2NH_4^+ + SO_4^{2-}$

(b) $NH_3 + CH_3COOH \rightleftharpoons NH_4^+ + CH_3COO^-$

(c) $H_2O + CH_3COOH \rightleftharpoons H_3O^+ + CH_3COO^-$

(d) $[Cu(H_2O)_4]^{2-} + 4\,NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+} + 4H_2O$

165. Equal volumes of three acid solutions of pH 3, 4 and 5 are mixed in a vessel. What will be the H^+ ion concentration in the mixture ?

(a) 1.11×10^{-4} M

(b) 3.7×10^{-4} M

(c) 3.7×10^{-3} M

(d) 1.11×10^{-3} M

166. The pH of 10^{-10} M NaOH solution is nearest to:

(a) 6

(b) – 10

(c) 4

(d) 7

167. 100 mL of 0.04 N HCl aqueous solution is mixed with 100 mL of 0.02 N NaOH solution. The pH of the resulting solution is:

(a) 1.0

(b) 1.7

(c) 2.0

(d) 2.3

168. Equal volumes of three acid solutions of pH 3, 4 and 5 are mixed in a vessel. What will be the H^+ ion concentration in the mixture ?

(a) 1.11×10^{-4} M

(b) 3.7×10^{-4} M

(c) 3.7×10^{-3} M

(d) 1.11×10^{-3} M

169. At 100°C the K_w of water is 55 times its value at 25°C. What will be the pH of neutral solution? (log 55 = 1.74)

(a) 6.13

(b) 7.00

(c) 7.87

(d) 5.13

170. Ionisation constant of CH_3COOH is 1.7×10^{-5} if concentration of H^+ ions is 3.4×10^{-4}M, then find out initial concentration of CH_3COOH molecules

(a) 3.4×10^{-4}M

(b) 3.4×10^{-3}M

(c) 6.8×10^{-3}M

(d) 6.8×10^{-4}M

171. Values of dissociation constant, K_a are given as follows :

Acid	K_a
HCN	6.2×10^{-10}
HF	7.2×10^{-4}
HNO_2	4.0×10^{-4}

Correct order of increasing base strength of the base CN^-, F^- and NO_2^- will be :

(a) $F^- < CN^- < NO_2^-$

(b) $NO_2^- < CN^- < F^-$

(c) $F^- < NO_2^- < CN^-$

(d) $NO_2^- < F^- < CN^-$

172. The dissociation constants for acetic acid and HCN at 25°C are 1.5×10^{-5} and 4.5×10^{-10} respectively. The equilibrium constant for the equilibrium

$CN^- + CH_3COOH \rightleftharpoons HCN + CH_3COO^-$ would be:

(a) 3.0×10^{-5}

(b) 3.0×10^{-4}

(c) 3.0×10^{4}

(d) 3.0×10^{5}

173. If degree of dissociation of pure water at 100°C is 1.8×10^{-8}, then the dissociation constant of water will be (density of H_2O = 1 gm/cc)

(a) 1×10^{-12}

(b) 1×10^{-14}

(c) 1.8×10^{-12}

(d) 1.8×10^{-14}

174. Ionisation of weak acid can be calculated by the formula

(a) $100\sqrt{\frac{K_a}{c}}$

(b) $\frac{100}{1+10^{(pK_a - pH)}}$

(c) Both (a) and (b)

(d) None of these

175. Equimolar solutions of the following were prepared in water separately. Which one of the solutions will record the highest pH ?

(a) $SrCl_2$

(b) $BaCl_2$

(c) $MgCl_2$

(d) $CaCl_2$

176. Solubility product constant (K_{sp}) of salts of types MX, MX_2 and M_3X at temperature T are 4.0×10^{-8}, 3.2×10^{-14} and 2.7×10^{-15}, respectively. Solubilities (mol dm^{-3}) of the salts at temperature 'T' are in the order –

(a) $MX > MX_2 > M_3X$

(b) $M_3X > MX_2 > MX$

(c) $MX_2 > M_3X > MX$

(d) $MX > M_3X > MX_2$

177. In qualitative analysis, the metals of Group I can be separated from other ions by precipitating them as chloride salts. A solution initially contains Ag^+ and Pb^{2+} at a concentration of 0.10 M. Aqueous HCl is added to this solution until the Cl^- concentration is 0.10 M. What will the concentrations of Ag^+ and Pb^{2+} be at equilibrium?

(K_{sp} for AgCl = 1.8×10^{-10}, K_{sp} for $PbCl_2 = 1.7 \times 10^{-5}$)

(a) $[Ag^+] = 1.8 \times 10^{-7}$ M ; $[Pb^{2+}] = 1.7 \times 10^{-6}$ M

(b) $[Ag^+] = 1.8 \times 10^{-11}$ M ; $[Pb^{2+}] = 8.5 \times 10^{-5}$ M

(c) $[Ag^+] = 1.8 \times 10^{-9}$ M ; $[Pb^{2+}] = 1.7 \times 10^{-3}$ M

(d) $[Ag^+] = 1.8 \times 10^{-11}$ M ; $[Pb^{2+}] = 8.5 \times 10^{-4}$ M

178. The solubility product (K_{sp}) of the following compounds are given at 25°C.

Compound	K_{sp}
AgCl	1.1×10^{-10}
AgI	1.0×10^{-16}
$PbCrO_4$	4.0×10^{-14}
Ag_2CO_3	8.0×10^{-12}

The most soluble and least soluble compounds are respectively.

(a) AgCl and $PbCrO_4$

(b) AgI and Ag_2CO_3

(c) AgCl and Ag_2CO_3

(d) Ag_2CO_3 and AgI

179. What is the molar solubility of $Fe(OH)_3$ if $K_{sp} = 1.0 \times 10^{-38}$?

(a) 3.16×10^{-10}

(b) 1.386×10^{-10}

(c) 1.45×10^{-9}

(d) 1.12×10^{-11}

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** **2.** **(c)** **3.** **(b)**

4. **(d)** The time taken for complete evaporation depends on (i) the nature of the liquid, (ii) the amount of the liquid and (iii) the temperature.

5. **(c)** When the watch glass is open to the atmosphere, the rate of evaporation remains constant but the molecules are dispersed into large volume of the room. As a consequence the rate of condensation from vapour to liquid state is much less than the rate of evaporation.

6. **(c)** Ice melts with a reduction in volume. So Increase in pressure shifts equilibrium to water side, result in melting of ice according to Lechatelier's principle.

7. **(a)** A reaction is said to be in equilibrium when rate of forward reaction is equal to the rate of backward reaction.

8. **(c)**

9. **(b)** The reaction mixtures starting either with H_2 or D_2 reach equilibrium with the same composition, except that D_2 and ND_3 are present instead of H_2 and NH_3.

10. **(a)** Equilibrium can be attained by either side of the reactions of equilibrium.

11. **(d)** According to the idea of dynamic equilibrium there is possibility of formation of all product.

12. **(b)** At equilibrium, the rate of forward and backward reactions is equal.

13. **(a)** For reation (1)

$$K_1 = \frac{[NO]^2}{[N_2][O_2]}$$

and for reaction (2)

$$K_2 = \frac{[N_2]^{1/2}[O_2]^{1/2}}{[NO]} \text{ therefore } K_1 = \frac{1}{K_2^2}$$

14. **(c)** $N_2 + 3H_2 \rightleftharpoons 2NH_3$

$\therefore\ K = [NH_3]^2 / [N_2]\,[H_2]^3$ .... (i)

$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightleftharpoons NH_3$

$\therefore\ K' = [NH_3]/[N_2]^{1/2}[H_2]^{3/2}$ .... (ii)

Dividing equation (i) by equation (ii), we get $K' = \sqrt{K}$

15. **(b)** Given reaction, $2A \rightleftharpoons B + C$

$$K_c = \frac{[B][C]}{[A]^2}$$

$$K_c = \frac{2\times10^{-3}\times3\times10^{-3}}{(10^{-3})^2} = 6$$

16. **(c)** $A_2 + B_2 \rightleftharpoons 2AB \quad K_c = \frac{[AB]^2}{[A_2][B_2]}$

$$K_c = \frac{(2.8\times10^{-3})^2}{3\times10^{-3}\times4.2\times10^{-3}} = \frac{(2.8)^2}{3\times4.2} = 0.62$$

17. **(c)** $A + B \rightleftharpoons C + D$

At eqb. x x 2x 2x

$$K_c = \frac{2x.2x}{x.x} = 4$$

18. **(a)** For $A + B \rightleftharpoons C,\ \Delta n = 1 - 2 = -1$

$$\text{Unit of } K_c = \left[\frac{mol}{litre}\right]^{\Delta n} = \left[\frac{mol}{litre}\right]^{-1}$$

$$= \text{Litre mole}^{-1}$$

19. **(c)** $K_p = \frac{P^2CO}{PCO_2}; K_p = \frac{4\times4}{2} = 8;\ C(s) = 1;$

The concentration of solids and liquids are taken as unity.

20. **(d)** $2C(s) + O_2(g) \rightleftharpoons 2CO_2(g)$

$\Delta n = 2 - 1 = +1$

$\therefore$ K_c and K_p are not equal.

21. **(b)** For a gaseous phase reaction K_p and K_c are related as

$$K_p = K_c(RT)^{\Delta n_g}$$

For the given reaction,

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$

$$\Delta n_g = 1 - (1 + 0.5) = -0.5 \text{ or } -\frac{1}{2}$$

$$\therefore\ K_p = K_c(RT)^{-\frac{1}{2}}$$

$$\text{or } \frac{K_p}{K_c} = (RT)^{-\frac{1}{2}}$$

22. **(c)** Using the relation $K_P = K_C.\,(RT)^{\Delta n}$, we get

$$\frac{K_P}{K_C} = (RT)^{\Delta n}$$

Thus $\frac{K_P}{K_C}$ will be highest for the reaction having highest value of Δn.

The Δn values for various reactions are

(a) $\Delta n = 1 - \left(1 + \frac{1}{2}\right) = -\frac{1}{2}$

(b) $\Delta n = 2 - (1+1) = 0$

(c) $\Delta n = (1+1) - 1 = 1$

(d) $\Delta n = (2+4) - (7+2) = -3$

Thus maximum value of $\Delta n = 1$

23. (c) As $K_p = K_c\ RT^{\Delta n_g}$

Here $\Delta n_g = 1$

So, $K_p = K_c$ when RT = 1

Thus T = 12.5 K

24. (b) $3Fe(s) + 4H_2O\,(steam) \rightleftharpoons Fe_3O_4\,(s) + 4\,H_2\,(g)$

$K_p = \frac{(p_{H_2})^4}{(p_{H_2O})^4}$ only gaseous products and reactants.

25. (b) $C(s) + CO_2(g) \longrightarrow 2CO(g)$

Apply law of mass action,

$$K_P = \frac{(P_{CO})^2}{P_{CO_2}} \text{ or } 63 = \frac{(10P_{CO_2})^2}{P_{CO_2}}$$

(Given $K_P = 65$) and $P_{CO} = 10P_{CO_2}$

$$\text{or } 63 = \frac{100(P_{CO_2})^2}{P_{CO_2}} \text{ or } 63 = 100\ P_{CO_2}$$

$$P_{CO_2} = \frac{63}{100} = 0.63 \text{ atm}$$

$$P_{CO} = 10P_{CO_2} = 10 \times 0.63 = 6.3 \text{ atm}$$

$$P_{total} = P_{CO_2} + P_{CO} = 0.63 + 6.3 = 6.93 \text{ atm.}$$

26. (d) Rate constant of forward reaction (K_f) = 1.1×10^{-2} and rate constant of backward reaction (K_b) = 1.5×10^{-3} per minute.

Equilibrium constant $(K_c) = \frac{K_f}{K_b} = \frac{1.1 \times 10^{-2}}{1.5 \times 10^{-3}} = 7.33$

27. (a) $MgCO_3\,(s) \rightarrow MgO(s) + CO_2\,(g)$

MgO & $MgCO_3$ are solid and they donot exert any pressure and hence only pressure exerted is by CO_2.

Therefore $K_P = P_{CO_2}$

28. (a) All the reactants and products are in same physical state.

29. (a) $K = \frac{[Ni(CO)_4]}{[CO]^4} = \frac{mol\,l^{-1}}{(mol\,l^{-1})^4} = (mol\,l^{-1})^{-3}$

30. (b) For the reaction

$CaCO_3\,(s) \rightleftharpoons CaO\,(s) + CO_2\,(g)$

On the basis of the stoichiometric equation, we can write,

$K_c = [CaO(s)]\,[CO_2(g)/[CaCO_3(s)]$

Since $[CaCO_3(s)]$ and $[CaO(s)]$ are both constant, therefore modified equilibrium constant for the thermal decomposition of calcium carbonate will be

$K'_c = [CO_2(g)]$

$K\,p = [p\,CO_2(g)]$

31. (d) Equilibrium constant (K) is independent of concentrations of reactions and products.

32. (a) Equilibrium constant is not effected by change in conditions like P and V. These changes can change only the time required to attain equilibrium.

33. (b) Reaction proceed forward according to Le-chatelier's principle.

34. (b)

35. (d) For reaction to proceed from right to left

$Q > K_c$ i.e the reaction will be fast in backward direction i.e $r_b > r_f$.

36. (b) The equilibrium constant helps in predicting the direction in which a given reaction will proceed at any stage. For this purpose, we calculate the reaction quotient Q. The reaction quotient Q (Q_c with molar concentration and Q_p with partial pressures) is defined in the same way as the equilibrium constant K_c except that the concentrations in Q_c are not necessary equilibrium values.

37. (d)

38. (c) Both (a) and (b) are correct for the equation,

$K = e^{-\Delta G^{\ominus}/RT}$

39. (c) $\Delta G = -2.303\ RT \log K$

$-nFE° = -2.303\ RT \log K$

$$\log K = \frac{nFE°(I)}{2.303\ RT}$$

$$= 0.4342\frac{nFE°}{RT} \qquad \text{........ (i)}$$

$$\ln K = \frac{nFE°}{RT}$$

$$K = e^{\frac{-nFE°}{RT}} \qquad \text{....... (ii)}$$

40. (d) Solid $\rightleftharpoons$ Liquid

It is an endothermic process. So when temperature is raised, more liquid is formed. Hence adding heat will shift the equlibrium in the forward direction.

41. (d) According to Le-chatelier's principle" whenever a constraint is applied to a system in equilibrium, the system tends to readjust so as to nullify the effect of the constraint.

42. (b) The most favourable conditions are :

(i) High pressure ($\Delta n < 0$)

(ii) Low temperature (Exothermic reaction)

(iii) Catalyst Fe is presence of Mo.

43. (c) As in this no. of moles are increasing hence low pressure will favour the forward direction.

$\Delta n = (1+1) - 1 = 1$

44. (a) For $\Delta n = 0$, no effect of pressure.

45. **(a)** Melting of ice involve absorption of heat i.e Endothermic hence high temperature favour the process.
Further for a given mass volume of water is less than ice thus high pressure favour the process. High pressure and high temperature convert ice into liquid.

46. **(d)**

47. **(b)** Le chatelier principle is not applicable to solid-solid equilibrium.

48. **(c)** Effect of increase of temperature on equilibrium constant depends on the fact that whether the reaction is exothermic, or endothermic. If the reaction is exothermic, it is favoured by low temperature and if the reaction is endothermic, it is favoured by high temperature.

49. **(d)** $$A_2(g)+B_2(g)\underset{\text{step-1}}{\rightleftharpoons}3C(g)\underset{\text{step-2}}{\rightleftharpoons}D(g)$$
since the steps 1 and 2 are exothermic hence low temprature will favour both the reactions. In step - 1 moles are increasing hence low pressure will favour it. In step 2 moles are decreasing, hence high pressure will favour it.

50. **(a)** On adding inert gas at constant volume the total pressure of the system is increased, but the partial pressure of each reactant and product remains the same. Hence no effect on the state of equilibrium.

51. **(c)** The backward reaction is not favoured at high pressure.

52. **(c)** A catalyst increases the rate of the chemical reaction by making available a new low energy pathway for the conversion of reactants to products. It increases the rate of forward and reverse reaction that pass through the same transition state and does not affect equilibrium.
Catalyst lowers the activation energy for the forward and reverse reactions by exactly the same amount.

53. **(c)** An aqueous solution of sodium chloride is comprised entirely of sodium ions and chloride ions, while that of acetic acid mainly contains unionized acetic acid molecules and only some acetate ions and hydronium ions. This is because there is almost 100% ionization in case of sodium chloride which is a strong electrolyte as compared to less than 5% ionization of acetic acid which is a weak electrolyte.

54. **(c)** The hydronium ion has a trigonal pyramidal geometry and is composed of three hydrogen atoms and one oxygen atom. There is a lone pair of electrons on the oxygen giving it this shape. The bond angle between the atoms is 113°.

55. **(d)**

56. **(b)** According to Arrhenius, acids are those substances which give proton in aqueous solution, hence gaseous HCl is not an Arrhenius acid.

57. **(d)** Base accepts protons and acid donates protons.

58. **(c)** Lewis concept.

59. **(c)** $$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^{-\cdot}$$
HCO_3^- can donate and accept H^+.

60. **(b)** Because NH_3 after losing a proton (H^+) gives NH_2^-
$$NH_3 + H_2O \rightleftharpoons NH_2^- + H_3O^+$$
(Conjugate acid-base pair differ only by a proton)

61. **(c)** Lewis acid is that compound which have electron deficiency. eg. BF_3, $SnCl_2$.

62. **(d)** $(CH_3)_3$ B - is an electron deficient, thus behave as a lewis acid.

63. **(c)** Boron in B_2H_6 is electron deficient

64. **(b)** BF_3 is Lewis acid (e^- pair acceptor)

65. **(c)** HSO_4^- accepts a proton to form H_2SO_4.
Thus H_2SO_4 is the conjugate acid of HSO_4^-.
$$\underset{\text{base}}{HSO_4^-} \xrightarrow{+H^+} \underset{\substack{\text{conjugate acid}\\ \text{of } HSO_4^-}}{H_2SO_4}$$

66. **(a)** Bronsted base is a substance which accepts proton. In option (a), H_2O is accepting proton, i.e., acting as a base.

67. **(c)**

68 **(a)** (i) $\underset{\text{acid}_1}{H_3PO_4}+\underset{\text{base}_2}{H_2O}\longrightarrow\underset{\text{acid}_2}{H_3O^+}+\underset{\text{base}_1}{H_2PO_4^-}$

(ii) $\underset{\text{acid}_1}{H_2PO_4^-}+\underset{\text{base}_2}{H_2O}\longrightarrow\underset{\text{base}_1}{HPO_4^{--}}+\underset{\text{acid}_2}{H_3O^+}$

(iii) $\underset{\text{base}_1}{H_2PO_4^-}+\underset{\text{acid}_2}{OH^-}\longrightarrow\underset{\text{acid}_1}{H_3PO_4}+\underset{\text{base}_2}{O^{--}}$

Hence only in (ii) reaction $H_2PO_4^-$ is acting as an acid.

69. **(b)** The value of ionic product of water changes with the temperature.

70. **(a)** **Given :** Hydroxyl ion concentration $[OH^-] = 0.05$ mol L^{-1}. We know that
$$[H^+][OH^-] = 1\times10^{-14}$$
or $[H^+] = \dfrac{1\times10^{-14}}{0.05} = 2\times10^{-13}$ mol L^{-1}
We also know that
$$pH = -\log[H^+] = -\log[2\times10^{-13}]$$
$$= -\log 2 - \log 10^{-13} = -\log 2 - (-13)\log 10$$
$$= -0.3010 + 13.0000 = 12.6990.$$
Since the value of pH > 7, therefore the solution is basic.

71. **(b)**

72. **(b)** $pH = -\log[H^+] = \log\left[\dfrac{1}{H^+}\right]$

73. **(c)** On dilution $[H^+] = 10^{-6}$ M $= 10^{-6}$ mol
Now dissociation of water cannot be neglected,
Total $[H^+] = 10^{-6} + 10^{-7} = 11 \times 10^{-7}$
$pH = -\log[H^+]$
$= -\log(11\times 10^{-7}) = 5.98$

74. **(d)** $\because$ $pH = 1$; $H^+ = 10^{-1} = 0.1$ M
$pH = 2$; $H^+ = 10^{-2} = 0.01$ M
$\therefore M_1 = 0.1 \quad V_1 = 1$
$M_2 = 0.01 \quad V_2 = ?$

From
$M_1V_1 = M_2V_2$
$0.1 \times 1 = 0.01 \times V_2$
$V_2 = 10$ litres
∴ Volume of water added = 10 – 1 = 9 litres

75. (b) Given $[OH^-] = 10^{-3}$
∴ pOH = 3
∵ pH + pOH = 14
∴ pH = 14 – 3 = 11

76. (a) Given $[H_3O^+] = 1 \times 10^{-10}$ M
at 25° $[H_3O^+][OH^-] = 10^{-14}$

$$\therefore [OH^-] = \frac{10^{-14}}{10^{-10}} = 10^{-4}$$

$$\text{Now, } [OH^-] = 10^{-p^{OH}} = 10^{-4} = 10^{-p^{OH}}$$

$\therefore p^{OH} = 4$

77. (a) Molarity (M) = 10M. HCl is a strong acid and it is completely dissociated in aqueous solutions as : HCl (10) $\rightleftharpoons$ $H^+(10) + Cl^-$.
So, for every moles of HCl, there is one H^+. Therefore $[H^+] = [HCl]$ or $[H^+] = 10$.
$pH = -\log[H^+] = -\log[10] = -1$.

78. (d) No. of moles of NaOH = $\frac{4}{40} = 0.1$
[Molecular weight of NaOH = 40]
No. of moles of $OH^- = 0.1$

$$\text{Concentration of } OH^- = \frac{0.1}{1 \text{ litre}} = 0.1 \text{Mole/L}$$

As we know that, $[H^+][OH^-] = 10^{-14}$

$$\therefore [H^+] = 10^{-13} \qquad (\because OH^- = 10^{-1})$$

79. (a) Given $[H_3O^+] = 1 \times 10^{-10}$ M
at 25° $[H_3O^+][OH^-] = 10^{-14}$

$$\therefore [OH^-] = \frac{10^{-14}}{10^{-10}} = 10^{-4}$$

$$\text{Now, } [OH^-] = 10^{-p^{OH}} = 10^{-4} = 10^{-p^{OH}}$$

$\therefore p^{OH} = 4$

80. (c) $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$
Given concentration of $H_2SO_4 = 0.005$ M
∴ $[H^+] = 0.005 \times 2 = 0.01 = 10^{-2}$
$pH = -\log[H^+] = -\log 10^{-2} = 2$

81. (a) $pOH = -\log[OH^-]$
pH + pOH = 14
For 10^{-4} KOH, $[OH^-] = 10^{-4}$
$pOH = -\log[OH^-] = -\log 10^{-4} = 4$
pH = 14 – pOH = 10

82. (d) Among M/4 KOH, M/4 NaOH, M/4 NH_4OH and M/4 $Ca(OH)_2$, $Ca(OH)_2$ furnishes highest number of OH^- ions ($\because Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$).
So pH of M/4 $Ca(OH)_2$ is highest.

83. (a) Given $K_a = 1.00 \times 10^{-5}$, C = 0.100 mol
for a weak electrolyte,
degree of dissociation

$$(\alpha) = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{1 \times 10^{-5}}{0.100}} = 10^{-2} = 1\%$$

84. (b) $HA \longrightarrow H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]}, \quad \because [H^+] = 10^{-pH}$$

∴ $[H^+] = 10^{-5}$; and at equilibrium $[H^+] = [A^-]$

$$\therefore K_a = \frac{10^{-5} \times 10^{-5}}{0.0015} = 2 \times 10^{-8}$$

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{2 \times 10^{-8}}{.005}} = \sqrt{4 \times 10^{-6}} = 2 \times 10^{-3}$$

Percentage ionization = 0.2

85. (c) $M_1V_1 = M_2V_2$
$1 \times 0.10 = M_2 \times 100$
$M_2 = 0.001 = 10^{-3}$

$$\begin{array}{lcc} BOH & \rightleftharpoons B^+ & + OH^- \\ C & 0 & 0 \\ C(1-\alpha) & C\alpha & C\alpha \end{array}$$

$$K_b = \frac{C\alpha \times C\alpha}{C(1-\alpha)}$$

$$K_b = C\alpha^2 \qquad (\because 1 - \alpha \approx 1)$$

$$\alpha = \sqrt{K_b / C}$$

$$[OH^-] = C\alpha = \sqrt{\frac{K_b}{C}} \times C = \sqrt{K_b C}$$

$$= \sqrt{10^{-5} \times 10^{-3}} = 10^{-4}$$

∴ pH + pOH = 14
∴ pH = 14 – 4 = 10

86. (d)

87. (d) $H_2A \rightleftharpoons H^+ + HA^-$

$$\therefore K_1 = 1.0 \times 10^{-5} = \frac{[H^+][HA^-]}{[H_2A]} \text{(Given)}$$

$$HA^- \longrightarrow H^+ + A^{--}$$

$$\therefore K_2 = 5.0 \times 10^{-10} = \frac{[H^+][A^{--}]}{[HA^-]} \text{(Given)}$$

$$K = \frac{[H^+]^2[A^{2-}]}{[H_2A]} = K_1 \times K_2$$

$$= (1.0 \times 10^{-5}) \times (5 \times 10^{-10}) = 5 \times 10^{-15}$$

88. (b) Acidic strength $\propto \sqrt{K_a}$

89. (d) Given $K_b = 1.0 \times 10^{-12}$
$[BOH] = 0.01\ M \qquad [OH] = ?$

$$\begin{array}{llll} & BOH & \rightleftharpoons B^+ & + OH^- \\ t=o & c & 0 & 0 \\ t_{eq} & c(1-x) & cx & cx \end{array}$$

$$K_b = \frac{c^2x^2}{c(1-x)} = \frac{cx^2}{(1-x)} \Rightarrow 1.0 \times 10^{-12} = \frac{0.01x^2}{(1-x)}$$

On calculation, we get, $x = 1.0 \times 10^{-5}$
Now, $[OH^-] = cx = 0.01 \times 10^{-5} = 1 \times 10^{-7} mol\ L^{-1}$

90. (b) $pK_a = -\log K_a$
Smaller the value of pK_a, stronger will be acid
$\therefore$ Acid having pK_a value of 10^{-8} is strongest acid.

91. (b) $$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{a_1}}{K_{a_2}}} = \sqrt{\frac{3.14 \times 10^{-4}}{1.96 \times 10^{-5}}} = 4:1$$

92. (c) $$K_a = \frac{[H_3O^+][F^-]}{[HF]} \qquad ...(i)$$

$$K_b = \frac{[HF][OH^-]}{[F^-]} \qquad ...(ii)$$

From (i) and (ii), $K_aK_b = [H_3O^+][OH^-] = K_w$
(ionic product of water)

93. (a) $$K = c\alpha^2 = 0.1 \times \left(\frac{1.34}{100}\right)^2 = 1.8 \times 10^{-5}$$

94. (b) In polyprotic acids the loss of second proton occurs much less readily than the first. Usually the K_a values for successive loss of protons from these acids differ by at least a factor of 10^{-3} i.e., $K_{a_1} > K_{a_2}$

$$H_2X \rightleftharpoons H^+ + HX^- \left(K_{a_1}\right)$$
$$HX^- \rightleftharpoons H^+ + X^{2-} \left(K_{a_2}\right)$$

95. (a) The values of dissociation constants for successive stages decrease.

96. (a)

97. (a) $NH_4Cl + H_2O \rightarrow NH_4OH + HCl$
or
$Cl^- + H_2O \rightleftharpoons HCl + H^+$ i.e., acidic

98. (c) Due to common ion effect addition of NH_4Cl in group (III) suppresses the ionisation of NH_4OH with the result concentration of OH^- decreases.

99. (c) Solubility of weak electrolyte decreases in solvent having common ion. So solubility of AgI in NaI solution is less than in pure water because of common ion effect.

100. (b) Dissociation of CH_3COOH is suppressed by the addition of sodium acetate (CH_3COONa) due to common ion (CH_3COO^-) effect. The $[H^+]$ decreases raising the pH of the acid solution.
Note : After the addition of CH_3COONa to CH_3COOH, a buffer solution is formed which has reserved pH value.

101. (b) CH_3COOH is weak acid while NaOH is strong base, so one equivalent of NaOH can not be neutralized with one equivalent of CH_3COOH. Hence the solution of one equivalent of each does not have pH value as 7. Its pH will be towards basic side as NaOH is a strong base hence conc. of OH^- will be more than the conc. of H^+.

102. (a) IVth group needs higher S^{2-} ion concentration. In presence of HCl, the dissociation of H_2S decreases hence produces less amount of sulphide ions due to common ion effect, thus HCl decreases the solubility of H_2S which is sufficient to precipitate IInd group radicals.

103. (d) A salt of strong base with weak acid undergoes anionic hydrolysis to give basic solution.

104. (d) Ferric chloride is the salt of a strong acid and a weak base, hence on hydrolysis it yields a mixture of weak base and strong acid

$$FeCl_3 + 3H_2O \rightarrow \underset{\text{weak base}}{Fe(OH)_3} + \underset{\text{strong acid}}{3HCl}$$

Due to this, there is predominance of H^+ ions in solution, hence the solution is acidic.

105. (c) In aqueous solution BA(salt) hydrolyses to give

$$BA + H_2O \rightleftharpoons \underset{\text{Base}}{BOH} + \underset{\text{acid}}{HA}$$

Now pH is given by

$$pH = \frac{1}{2}pK_w + \frac{1}{2}pKa - \frac{1}{2}pK_b$$

substituting given values, we get

$$pH = \frac{1}{2}(14 + 4.80 - 4.78) = 7.01$$

106. (d) For acidic buffer $pH = pK_a + \log\left[\frac{salt}{acid}\right]$

or $$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

Given $pK_a = 4.5$ and acid is 50% ionised.
$[HA] = [A^-]$ (when acid is 50% ionised)
$\therefore\ pH = pK_a + \log 1$
$\therefore\ pH = pK_a = 4.5$
$pOH = 14 - pH = 14 - 4.5 = 9.5$

107. (b) Given $[NH_3] = 0.3\ M$, $[NH_4^+] = 0.2\ M$, $K_b = 1.8 \times 10^{-5}$.

$$pOH = pK_b + \log\frac{[salt]}{[base]} \qquad [pK_b = -\log K_b;$$
$$pK_b = -\log 1.8 \times 10^{-5}]$$

$\therefore\ pK_b = 4.74$

$$= 4.74 + \log\frac{0.2}{0.3} = 4.74 + 0.3010 - 0.4771 = 4.56$$

$pH = 14 - 4.56 = 9.436$

108. (d) $$pH = pK_a + \log\left[\frac{Salt}{Acid}\right]$$

$$\log\left[H^+\right] = \log K_a - \log\left[\frac{Salt}{Acid}\right]$$

$$\log\left[H^+\right] = \log K_a + \log\left[\frac{\text{Acid}}{\text{Salt}}\right]$$

$$\left[H^+\right] = K_a\left[\frac{\text{Acid}}{\text{Salt}}\right]$$

$$= 1.8 \times 10^{-5} \times \frac{0.1}{0.2} = 9 \times 10^{-6}\ \text{M}$$

109. (d) HNO_2 is a weak acid and $NaNO_2$ is salt of that weak acid and strong base (NaOH).

110. (a) Lets take an example of an acidic buffer CH_3COOH and CH_3COONa.

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$;

$CH_3COONa \rightleftharpoons CH_3COO^- + Na^+$

when few drops of HCl are added to this buffer, the H^+ of HCl immediatly combine with CH_3COO^- ions to form undissociated acetic acid molecules. Thus there will be no appreciable change in its pH value. Like wise if few drops of NaOH are added, the OH^- ions will combine with H^+ ions to form unionised water molecule. Thus pH of solution will remain constant.

111. (d) Buffering action is maximum when

[Salt] = [Acid]

i.e., $pH = pK_a$

112. (d) pH or $[H^+]$ of a buffer does not change with dilution.

113. (b) Solubility product is the product of ionic concentration in a saturated solution of an electrolyte at a given temperature.

114. (b) $\underset{}{Cr(OH)_3(s)} \rightleftharpoons \underset{s}{Cr^{3+}(aq.)} + \underset{3s}{3OH^-(aq.)}$

$(s)\ (3s)^3 = K_{sp}$

$27S^4 = K_{sp}$

$$s = \left(\frac{K_{sp}}{27}\right)^{1/4} = \left(\frac{1.6\times10^{-30}}{27}\right)^{1/4}$$

115. (b) $Mg(OH)_2 \rightleftharpoons Mg^{++} + 2OH^-$

$K_{sp} = [Mg^{++}][OH^-]^2$

$1.0 \times 10^{-11} = 10^{-3} \times [OH^-]^2$

$$[OH^-] = \sqrt{\frac{10^{-11}}{10^{-3}}} = 10^{-4}$$

$\therefore\ pOH = 4$

$\therefore\ pH + pOH = 14$

$\therefore\ pH = 10$

116. (b) Given $pH = 12$

or $[H^+] = 10^{-12}$

Since, $[H^+][OH^-] = 10^{-14}$

$$\therefore\ [OH^-] = \frac{10^{-14}}{10^{-12}} = 10^{-2}$$

$$Ba(OH)_2 \rightleftharpoons \underset{s}{Ba^{2+}} + \underset{2s}{2OH^-}$$

$[OH^-] = 10^{-2}$

$2s = 10^{-2}$

$$s = \frac{10^{-2}}{2}$$

$K_{sp} = 4s^3$

$$= 4\times\left(\frac{10^{-2}}{2}\right)^3$$

$= 5 \times 10^{-7}$

117. (c) Let binary electrolyte be AB

$$\underset{s}{AB} \rightleftharpoons \underset{s}{A^+} + \underset{s}{B^-}$$

Hence, solubility product of AB

$K_{sp} = [A^+][B^-]$

$S = [s.][s] \Rightarrow s = S^{1/2}$

118. (a) K_{sp} of As_2S_3 is less than ZnS. In acid medium ionisation of H_2S is suppresed (common ion effect) and K_{sp} of ZnS does not exceed.

119. (a) Given $Na_2CO_3 = 1.0 \times 10^{-4}$ M

$\therefore\ [CO_3^{--}] = 1.0 \times 10^{-4}$ M

i.e. $S = 1.0 \times 10^{-4}$ M

At equilibrium

$[Ba^{++}][CO_3^{--}] = K_{sp}$ of $BaCO_3$

$$[Ba^{++}] = \frac{K_{sp}}{[CO_3^{--}]} = \frac{5.1\times10^{-9}}{1.0\times10^{-4}} = 5.1 \times 10^{-5}\ \text{M}$$

120. (b) $AgBr \rightleftharpoons Ag^+ + Br^-$

$K_{sp} = [Ag^+][Br^-]$

For precipitation to occur

Ionic product > Solubility product

$$[Br^-] = \frac{K_{sp}}{[Ag^+]} = \frac{5\times10^{-13}}{0.05} = 10^{-11}$$

i.e., precipitation just starts when 10^{-11} moles of KBr is added to 1ℓ $AgNO_3$ solution

$\therefore$ Number of moles of Br^- needed from

KBr = 10^{-11}

$\therefore$ Mass of KBr = $10^{-11} \times 120 = 1.2 \times 10^{-9}$ g

121. (b) $Mg(OH)_2 \rightleftharpoons Mg^{++} + 2OH^-$

$K_{sp} = [Mg^{++}][OH^-]^2$

$1.0 \times 10^{-11} = 10^{-3} \times [OH^-]^2$

$$[OH^-] = \sqrt{\frac{10^{-11}}{10^{-3}}} = 10^{-4}$$

$\therefore\ pOH = 4$

$\therefore\ pH + pOH = 14\ \ \therefore\ \ pH = 10$

STATEMENT TYPE QUESTIONS

122. (c) Boiling point depends on the altitude of the place; at high altitude the boiling point decreases.

123. (a)

124. (b) Chemical reactions which are in equilibrium are reversible

125. (c) Since equilibrium constant is related to the partial pressure of reactant and product therefore if nobel gas is added, no change is observed, Statement 1 is incorrect.

If Nobel gas react with reactant, concentraction of reactant will decrease and therefore reaction will proceed backword according to Le– chatelier's principle.

126. (c) Equilibrium constant is temperature dependent having one unique value for a particular reaction represented by a balanced equation at a given temperature.

127. (b) An equilibrium constant does not give any information about the rate at which the equilibrium is reached.

128. (a) **129. (d)**

130. (a) As strong acid dissociate completely in water hence resulting base formed would be very weak. On the other hand a weak acid is only partially dissociated in aqueous solution, hence resulting base formed would be strong.

131. (a) $\underset{\text{acid}}{H_2O(l)} + \underset{\text{base}}{H_2O(l)} \rightleftharpoons \underset{\text{conjugate acid}}{H_3O^+(aq)} + \underset{\text{conjugate base}}{OH^-(aq)}$

132. (c) K_w depends upon temperature as it is an equilibrium constant.

133. (d) Larger the value of K_a, the stronger is the acid.

134. (a)

135. (c) Bond energy being directly related to bond strength increases with increase in bond strength

MATCHING TYPE QUESTIONS

136. (d)

137. (b) (A) Liquid $\rightleftharpoons$ Vapour equilibrium exists at the boiling point.

(B) Solid $\rightleftharpoons$ Liquid equilibrium exists at the melting point.

(C) Solid $\rightleftharpoons$ Vapour equilibrium exists at the sublimation point.

(D) Solute $\rightleftharpoons$ Solute (solution) equilibrium exists in a saturated solution.

138. (a) In case of A no. of moles of product and reactant are same, in case of B no. of moles of reactant are greater so reaction go forward, in case of C the no. of moles of product are greater than no. of moles of reactant.

139. (a)

(A) $K_P = K_C\,(RT)^{\Delta n}$

$$\frac{K_P}{K_C} = (RT)^{\Delta n} \text{ as } \Delta n = -ve \Rightarrow K_P < K_C$$

(B) $\Delta n > 0$

(C) $\Delta n = 2 - 1 = 1$

(D) As the reaction is not containing any gaseous component therefore K_P is not defined for this.

140. (b)

(A) As $\Delta n > 0$ therefore if P $\uparrow$, reaction will go in the backward direction.

(B) As $\Delta n < 0$ therefore if V $\uparrow$, P $\downarrow$ reaction will go in the direction in which more number of gaseous moles are formed i.e. backward direction.

(C) As $\Delta n = 0$ hence no effect.

(D) If concentration of reactant is increased reaction will go in the forward direction.

141. (d) **142. (b)**

143. (b) $HClO_4$ is a strong acid

HNO_2 is a weak acid.

NH_2^- is a very good proton acceptor and thus, it is a base.

H_2SO_4 is a strong acid hence its conjugate base (HSO_4^-) will be a weak base.

ASSERTION-REASON TYPE QUESTIONS

144. (a) $K_p = K_c(RT)^{\Delta n}$

145. (a) If the volume is kept constant and an inert gas such as argon is added which does not take part in the reaction, the equilibrium remains undisturbed. It is because the addition of an inert gas at constant volume does not change the partial pressure or the molar concentration of the substance involved in the reaction. The reaction quotient changes only if the added gas is reactant or product involved in the reaction.

146. (d) In biological systems buffer system of carbonic acid and sodium bicarbonate is found in our blood. It maintains the pH of blood to a constant value of about 7.4.

147. (a) Ionic product of AgBr is greater than that of AgCl in comparison with there solubility product AgBr will precipitate first rather than that of AgCl.

CRITICAL THINKING TYPE QUESTIONS

148. (d) To calculate the value of K_4 in the given equation we should apply :

eqn. (2) + eqn.(3) × 3 – eqn. (1)

hence $K_4 = \dfrac{K_2K_3^3}{K_1}$

149. (d) Given,

$$AB \overset{K_1}{\rightleftharpoons} A^+ + B^{-1}$$

$$K_1 = \frac{[A^+][B^-]}{[AB]}$$

$$AB + B^- \overset{K_2}{\rightleftharpoons} AB_2^-$$

$$K_2 = \frac{[AB_2^-]}{[AB][B^-]}$$

Dividing K_1 and K_2, we get

$$K = \frac{K_1}{K_2} = \frac{[A^+][B^-]^2}{[AB_2^-]}$$

$$\therefore \frac{[A^+]}{[AB_2^-]} = \frac{K}{[B^-]^2}$$

150. (a) $K_1 = \frac{Ni(CO)_4}{[CO_2]^2}$; $K_2 = \frac{[CO]^2}{[CO_2]}$

$$K = \frac{[Ni(CO)_4]}{[CO]^4}$$

$$K = \frac{[Ni(CO)_4]}{[CO_2]^2} \times \left(\frac{[CO_2]}{[CO]^2}\right)^2$$

$$K = \frac{K_1}{K_2^2}$$

151. (b) (I) $N_2 + 2O_2 \xrightleftharpoons{K_1} 2NO_2$

$$K_1 = \frac{[NO_2]^2}{[N_2][O_2]^2} \qquad \text{...(i)}$$

(II) $2NO_2 \xrightleftharpoons{K_2} N_2 + 2O_2$

$$K_2 = \frac{[N_2][O_2]^2}{[NO_2]^2} \qquad \text{...(ii)}$$

(III) $NO_2 \xrightleftharpoons{K_3} \frac{1}{2}N_2 + O_2$

$$K_3 = \frac{[N_2]^{1/2}[O_2]}{[NO_2]}$$

$$\therefore \ (K_3)^2 = \frac{[N_2][O_2]^2}{[NO_2]^2} \qquad \text{...(iii)}$$

$\therefore$ from equations (i), (ii) and (iii)

$$K_1 = \frac{1}{K_2} = \frac{1}{(K_3)^2}$$

152. (c) Reaction (c) can be obtained by adding reactions (a) and (b) therefore $K_3 = K_1 . K_2$
Hence (c) is the correct answer.

153. (b) **Given:** Equilibrium constant (K_1) for the reaction

$$HI(g) \xrightleftharpoons{K_1} \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g); \ K_1 = 8; \qquad \text{.........(i)}$$

To find equilibrium constant for the following reaction

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g); \ K_2 = ? \qquad \text{.....(ii)}$$

For this multiply (i) by 2, we get

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g); \ K_1 = 8^2 = 64 \qquad \text{.....(iii)}$$

[**Note:** When the equation for an equilibrium is multiplied by a factor, the equilibrium constant must be raised to the power equal to the factor]
Now reverse equation (iii), we get

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g); K = \frac{1}{64} \qquad \text{.....(iv)}$$

[**Note:** For a reversible reaction, the equilibrium constant of the backward reaction is inverse of the equilibrium constant for the forward reaction.]
Equation (iv) is the same as the required equation (ii), thus K_2 for equation (ii) is $\frac{1}{64}$ i.e. option (b) is correct.

154. (d) $K_c = \frac{K_p}{(RT)^{\Delta n}}$

$$= \frac{1.44 \times 10^{-5}}{(0.082 \times 773)^{-2}} \ (\text{R in L. atm. K}^{-1} \text{mole}^{-1}).$$

155. (b) $\underset{a(1-x)}{PCl_5} \rightleftharpoons \underset{ax}{PCl_3} + \underset{ax}{Cl_2}$

$a = 2, x = 0.4, V = 2$ L

$$\therefore \ [PCl_5] = \frac{2(1-0.4)}{2} = 0.6 \text{ mol L}^{-1}$$

$$[PCl_3] = [Cl_2] = \frac{2 \times 0.4}{2} = 0.4 \text{ mol L}^{-1}$$

$$\therefore \ K_c = \frac{0.4 \times 0.4}{0.6} = 0.267$$

156. (b) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

Moles at equilibrium $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$

Mole fraction at equilibrium $\frac{1}{3}$ $\frac{1}{3}$ $\frac{1}{3}$

Partial pressure at equilibrium $\frac{P}{3}$ $\frac{P}{3}$ $\frac{P}{3}$

$$K_p = \frac{\frac{P}{3} \times \frac{P}{3}}{P/3} = \frac{P}{3}$$

157. (b) $NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$

$$K_P = \frac{(P_{NH_3})^2 \times (P_{CO_2})}{P_{NH_2COONH_4}(s)} = (P_{NH_3})^2 \times (P_{CO_2})$$

As evident by the reaction, NH_3 and CO_2 are formed in molar ratio of 2 : 1. Thus if P is the total pressure of the system at equilibrium, then

$$P_{NH_3} = \frac{2 \times P}{3} \quad P_{CO_2} = \frac{1 \times P}{3}$$

$$K_P = \left(\frac{2P}{3}\right)^2 \times \frac{P}{3} = \frac{4P^3}{27}$$

Given $K_P = 2.9 \times 10^{-5}$

$$\therefore \ 2.9 \times 10^{-5} = \frac{4P^3}{27}$$

$$P^3 = \frac{2.9 \times 10^{-5} \times 27}{4}$$

$$P = \left(\frac{2.9 \times 10^{-5} \times 27}{4}\right)^{1/3} = 5.82 \times 10^{-2} \text{ atm}$$

158. (c) Given reaction are

$X \rightleftharpoons Y + Z$ ..... (i)

and $A \rightleftharpoons 2B$ ......(ii)

Let the total pressure for reaction (i) and (ii) be P_1 and P_2 respectively, then

$$\frac{K_{P_1}}{KP_2} = \frac{9}{1} \quad \text{(given)}$$

After dissociation,

$$X \rightleftharpoons Y + Z$$

At equilibrium $(1-\alpha) \quad \alpha \quad \alpha$

[Let 1 mole of X dissociate with α as degree of dissociation]

Total number of moles $= 1-\alpha+\alpha+\alpha$
$= (1+\alpha)$

$$\text{Thus } P_X = \left(\frac{1-\alpha}{1+\alpha}\right).P_1\ ;\ P_Y = \left(\frac{\alpha}{1+\alpha}\right)P_1;$$

$$P_Z = \left(\frac{\alpha}{1+\alpha}\right).P_1$$

$$\therefore\ K_{P_1} = \left(\frac{\alpha}{1+\alpha}\right).P_1 \times \frac{\alpha}{(1+\alpha)}.$$

$$P_1 / \left(\frac{1-\alpha}{1+\alpha}\right).P_1 \quad \text{... (i)}$$

Similarly for $A \rightleftharpoons 2B$

At equilibrium $(1-\alpha) \quad 2\alpha$

We have,

$$K_{P_2} = \left(\frac{2\alpha P_2}{1+\alpha}\right)^2 / \left(\frac{1-\alpha}{1+\alpha}\right)P_2 \quad \text{...(ii)}$$

Dividing (i) by (ii), we get

$$\frac{K_{P1}}{K_{P_2}} = \frac{\alpha^2.P_1}{4\alpha^2.P_2} \text{ or } \frac{K_{P1}}{K_{P_2}} = \frac{1}{4}.\frac{P_1}{P_2}$$

$$\text{or } 9 = \frac{1}{4}.\frac{P_1}{P_2} \quad \left[\therefore \frac{K_{P_1}}{K_{P_2}} = \frac{9}{1}\right]$$

$$\text{or } \frac{P_1}{P_2} = \frac{36}{1} \text{ or } P_1 : P_2 = 36 : 1$$

159. (b) For the reaction

$$\underset{\text{at equi}}{}\ \underset{2(1-x)}{2AB_2(g)} \rightleftharpoons \underset{2x}{2AB(g)} + \underset{x}{B_2(g)}$$

$$K_c = \frac{[AB]^2[B_2]}{[AB_2]^2} \text{ or } K_c = \frac{(2x)^2 \times x}{\{2(1-x)\}^2}$$

$= x^3$ [(1–x) can be neglected in denominator $(1-x) \simeq 1$]

The partial pressure at equilibrium are calculated on the basis of total number of moles at equilibrium.

Total number of moles

$= 2(1-x) + 2x + x = (2 + x)$

$\therefore\ P_{AB_2} = \frac{2(1-x)}{(2+x)} \times P$ where P is the total pressure.

$$P_{AB} = \frac{2x}{(2+x)} \times P\ ,\ P_{B_2} = \frac{x}{(2+x)} \times P$$

Since x is very small so can be neglected in denominator Thus, we get

$P_{AB_2} = (1-x) \times P \qquad P_{AB} = x \times P$

$$P_{B_2} = \frac{x}{2} \times P$$

$$\text{Now, } K_P = \frac{(P_{AB})^2(P_{B_2})}{(P_{AB_2})^2}$$

$$= \frac{(x)^2 \times P^2.P \times \frac{x}{2}}{(1-x)^2 \times P^2}$$

$$= \frac{x^3.P^3}{2 \times 1 \times P^2} \quad [\therefore 1-x \simeq 1]$$

$$= \frac{x^3.P}{2} \text{ or } x^3 = \frac{2.K_p}{P} \text{ or } x = \left(\frac{2K_p}{P}\right)^{\frac{1}{3}}$$

160. (a) Justification : According to Le-Chatelier's principle, at constant temperature, the equilibrium composition will change but K will remain same.

161. (a) The reaction given is an exothermic reaction thus according to Lechatalier's principle lowering of temperature, addition of F_2 and / or Cl_2 favour the for ward direction and hence the production of ClF_3 .

162. (a)

163. (c) Strong base has higher tendency to accept the proton. Increasing order of base and hence the order of accepting tendency of proton is

$$I^- < HS^- < NH_3 < RNH_2$$

164. (d) $[Cu(H_2O)_4]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+} + 4H_2O$ involves lose and gain of electrons. H_2O is coordinated to Cu by donating electrons (LHS). It is then removed by withdrawing electrons.

165. (b) $[H_3O]^+$ for a solution having pH = 3 is given by

$[H_3O]^+ = 1 \times 10^{-3}$ moles/litre

$[\therefore\ [H_3O]^+ = 10^{-pH}]$

Similarly for solution having pH = 4,

$[H_3O]^+ = 1 \times 10^{-4}$ moles/ litre and for pH = 5

$[H_3O^+] = 1 \times 10^{-5}$ moles/ litre

Let the volume of each solution in mixture be IL, then total volume of mixture solution $L = (1 + 1 + 1)\,L = 3L$

Total $[H_3O]^+$ ion present in mixture solution $= (10^{-3} + 10^{-4} + 10^{-5})$ moles

Then $[H_3O]^+$ ion concentration of mixture solution

$$= \frac{10^{-3} + 10^{-4} + 10^{-5}}{3} M = \frac{0.00111}{3} M$$

$= 0.00037\,M = 3.7 \times 10^{-4}\,M.$

166. (d) Given concentration of NaOH = 10^{-10} M

$NaOH \longrightarrow Na^+ + OH^-$

10^{-10} M $\qquad 10^{-10}$

∴ $[OH^-]$ from NaOH = 10^{-10}

We have to consider dissociation of H_2O

$[OH^-]$ from $H_2O = 10^{-7}$

Total $[OH^-] = 10^{-7} + 10^{-10}$

$$= 10^{-7}(0.001+1) = 10^{-7}\left(\frac{1001}{1000}\right) = 10^{-10} \times 1001$$

∴ $pOH = -\log[OH^-]$

$= -(\log 1001 \times 10^{-10}) = -3.004 + 10 = 6.9996$

$pH = 14 - pOH = 14 - 6.996 = 7.004$

∴ pH of 10^{-10} M NaOH solution is nearest to 7.

167. (c) Number of meq. of the acid = 0.04 × 100 = 4

Number of meq. of the base = 0.02 × 100 = 2

∴ Number of meq. of the acid left on mixing = 4 – 2 = 2

Total volume of the solution = 200 mL

∴ No. of meq of the acid present in 1000 mL of the solution = 10

or No. of eq. of the acid in 1000 mL of the solution

$$= \frac{10}{1000} = 0.01$$

Since the acid is monobasic and completely ionises in solution

0.01 N HCl = 0.01 M HCl

Thus $[H^+] = 0.01$

∴ $pH = -\log(0.01) = -(-2) = 2$

168. (b) $[H_3O]^+$ for a solution having pH = 3 is given by

$[H_3O]^+ = 1\times10^{-3}$ moles/litre

$[\therefore [H_3O]^+ = 10^{-pH}]$

Similarly for solution having pH = 4,

$[H_3O]^+ = 1 \times 10^{-4}$ moles/ litre and for pH=5

$[H_3O^+] = 1\times10^{-5}$ moles/ litre

Let the volume of each solution in mixture be IL, then total volume of mixture solution L = (1 + 1 + 1) L=3L

Total $[H_3O]^+$ ion present in mixture solution

$= (10^{-3} + 10^{-4} + 10^{-5})$ moles

Then $[H_3O]^+$ ion concentration of mixture solution

$$= \frac{10^{-3}+10^{-4}+10^{-5}}{3}\text{M} = \frac{0.00111}{3}\text{M}$$

$= 0.00037\text{ M} = 3.7 \times 10^{-4}$ M.

169. (a) K_w at 25°C = 1×10^{-14}

At 25ºC

$K_w = [H^+][OH^-] = 10^{-14}$

At 100°C (given)

$K_w = [H^+][OH^-] = 55 \times 10^{-14}$

∵ for a neutral solution

$[H^+] \qquad = [OH^-]$

∴ $[H^+]^2 = 55 \times 10^{-14}$

or $[H^+] = (55 \times 10^{-14})^{1/2}$

∵ $pH = -\log[H^+]$

On taking log on both side

$-\log[H^+] = -\log(55 \times 10^{-14})^{1/2}$

$$pH = -\frac{1}{2}\log 55 + 7\log 10$$

$pH = -0.87 + 7$

$= 6.13$

170. (c) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

Given that,

$[CH_3COO^-] = [H^+] = 3.4\times10^{-4}$ M

K_a for $CH_3COOH = 1.7 \times 10^{-5}$

CH_3COOH is weak acid, so in it $[CH_3COOH]$ is equal to initial concentration. Hence

$$1.7\times10^{-5} = \frac{(3.4\times10^{-4})(3.4\times10^{-4})}{[CH_3COOH]}$$

$$[CH_3COOH] = \frac{3.4\times10^{-4}\times3.4\times10^{-4}}{1.7\times10^{-5}}$$

$= 6.8 \times 10^{-3}$M

171. (c) Higher the value of K_a lower will be the value of pK_a i.e. higher will be the acidic nature. Further since CN^-, F^- and NO_2^- are conjugate base of the acids HCN, HF and HNO_2 respectively hence the correct order of base strength will be

$F^- < NO_2^- < CN^-$

(∵ stronger the acid weaker will be its conjugate base)

172. (c) Given, $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$;

$K_{a_1}, = 1.5 \times 10^{-5}$ ....(i)

$HCN \rightleftharpoons H^+ + CN^-$; $K_{a_2} = 4.5 \times 10^{-10}$

or $H^+ + CN^- \rightleftharpoons HCN$;

$$K'_{a_2} = \frac{1}{K_{a_2}} = \frac{1}{4.5\times10^{-10}} \quad \text{...(ii)}$$

∴ From (i) and (ii), we find that the equilibrium constant (K_a) for the reaction,

$CN^- + CH_3COOH \rightleftharpoons CH_3COO^- + HCN$, is

$K_a = K_{a_1} \times K'_{a_2}$

$$= \frac{1.5\times10^{-5}}{4.5\times10^{-10}} = \frac{1}{3}\times10^5 = 3.33\times10^4$$

173. (d) As, molarity, $= \dfrac{\text{wt. of solute per litre of solution}}{\text{Mol. wt. of solute}}$

Molarity of $H_2O = \dfrac{1000}{18}$ mole/litre

$$\begin{array}{lccc} H_2O & \rightleftharpoons H^+ & + & OH^- \\ c(1-\alpha) & c\alpha & & c\alpha \end{array}$$

Thus, $K_a = \dfrac{c\alpha^2}{1-\alpha} = c\alpha^2 = 1.8 \times 10^{-14}$

174. (c) For weak acid dissociation equilibria, degree of dissociation α is given as :

$$\alpha=\sqrt{\frac{K_a}{c}} \quad \therefore \ \%\alpha=100\sqrt{\frac{K_a}{c}}$$

$$\text{Also, } K_a=\frac{[H^+][A^-]}{[HA]}=\frac{[H^+]c\alpha}{c(1-\alpha)}=\frac{[H^+]\alpha}{(1-\alpha)}$$

$$\log K_a=\log H^+ +\log\frac{\alpha}{1-\alpha}$$

$$\text{or } pK_a=pH+\log\frac{1-\alpha}{\alpha}$$

$$pK_a-pH=\log\frac{1-\alpha}{\alpha}$$

$$\frac{1-\alpha}{\alpha}=10^{pK_a-pH}$$

$$\text{or, } \frac{1}{\alpha}=10^{pK_a-pH}+1$$

$$\therefore \quad \alpha=\frac{1}{[1+10^{pK_a-pH}]}$$

175. (b) The highest pH will be recorded by the most basic solution. The basic nature of hydroxides of alkaline earth metals increase as we move from Mg to Ba and thus the solution of $BaCl_2$ in water will be most basic and so it will have highest pH.

176. (d) $MX \rightleftharpoons \underset{s}{M^+}+\underset{s}{X^-}$ (Where s is the solubility)

Then $K_{sp}=s^2$ or $s=\sqrt{K_{sp}}$

Similarly for $MX_2 \longrightarrow \underset{s}{M^{2+}}+\underset{2s}{2X^-}$

$$K_{sp}=s\times(2s)^2=4s^3 \quad \text{or} \quad s=\left[\frac{K_{sp}}{4}\right]^{\frac{1}{3}}$$

and for $M_3X \rightleftharpoons \underset{3s}{3M^+}+\underset{s}{X^{-3}}$

$$K_{sp}=(3s)^3\times s=27s^4 \quad \text{or} \quad s=\left[\frac{K_{sp}}{27}\right]^{\frac{1}{4}}$$

From the given values of K_{sp} for MX, MX_2 and M_3 X, we can find the solubilities of those salts at temperature, T.

Solubility of $MX=\sqrt{4\times10^{-8}}=2\times10^{-4}$

$$\text{Solubility of } MX_2=\left[\frac{3.2\times10^{-14}}{4}\right]^{\frac{1}{3}} \text{ or } \left[\frac{32}{4}\times10^{-15}\right]^{\frac{1}{3}}$$

$$=\left[8\times10^{-15}\right]^{\frac{1}{3}} \text{ or } 2\times10^{-5}$$

$$\text{Solubility of } M_3X=\left[\frac{2.7\times10^{-15}}{27}\right]^{\frac{1}{4}}$$

$$=\left[10^{-16}\right]^{\frac{1}{4}} \text{ or } 10^{-4}$$

Thus the solubilities are in the order MX > M_3 X> MX_2 i.e the correct answer is (d).

177. (c) $K_{sp}=[Ag^+][Cl^-]$
$1.8\times10^{-10}=[Ag^+][0.1]$
$[Ag^+]=1.8\times10^{-9}$ M
$K_{sp}=[Pb^{+2}][Cl^-]^2$
$1.7\times10^{-5}=[Pb^{+2}][0.1]^2$
$[Pb^{+2}]=1.7\times10^{-3}$ M

178. (d) The solubility equilibrium for AgI is

$AgI\,(aq) \rightleftharpoons Ag^+(aq)+I^-(aq)$;

$K_{sp}=[Ag^+][I^-]$
Let solubility of AgI be S moles per litre,
$[Ag^+]=S$, $[I^-]=S$
$K_{sp}=[Ag^+][I^-]$
$1\times10^{-16}=(S)\times(S)=S^2$

$$S=\left(1\times10^{-16}\right)^{\frac{1}{2}}=1\times10^{-8}$$

On calculating solubility of all given compounds

Compound	Solubility
AgCl	1×10^{-5}
AgI	1×10^{-8}
$PbCrO_4$	2×10^{-7}
Ag_2CO_3	1.26×10^{-4}

$\therefore$ Ag_2CO_3 is most soluble and AgI is least soluble.

179. (b) $K_{sp}=[Fe^{3+}].[3OH^-]$
So molar solubility of Fe^{3+} = S and $[3OH^-]$ = 3S

$$Fe(OH)_3 \rightleftharpoons \underset{[S]}{Fe^{3\oplus}}+\underset{[3S]}{3OH^-}$$

$1.0\times10^{-38}=[S]\,[3S]^3$
$1.0\times10^{-38}=S^4\times27$

$$S^4=\frac{1.0\times10^{-38}}{27}$$

$S^4=3.703\times10^{-40}$

$$S=\left(3.703\times10^{-40}\right)^{1/4}=1.386\times10^{-10}$$

CHAPTER 8

REDOX REACTIONS

FACT/DEFINITION TYPE QUESTIONS

1. Which of the following process takes place in oxidation process?

(a) Addition of oxygen (b) Addition of hydrogen
(c) Removal of oxygen (d) Addition of chlorine

2. Given reaction,

$$2K_4[Fe(CN)_6]\ (aq) + H_2O_2\ (aq) \rightarrow 2K_3[Fe(CN)_6](aq) + 2KOH(aq)$$

The above given reaction is oxidation reaction due to

(a) removal of a hydrogen from H_2O_2
(b) addition of electropositive potassium to H_2O_2
(c) removal of electropositive element potassium from potassium ferrocyanide ($K_4[Fe(CN)_6]$)
(d) All of the above are the correct reasons.

3. In the reaction given below, identify the species undergoing redox reaction

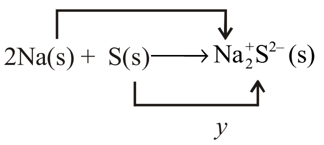
$$2Na(s) + H_2(g) \longrightarrow 2NaH(s)$$

(a) Na is reduced and hydrogen is oxidised
(b) Na is oxidised and hydrogen is reduced
(c) Na undergoes oxidation and hydrogen undergoes reduction
(d) Both (b) and (c)

4. The loss of electron is termed as

(a) oxidation (b) reduction
(c) combustion (d) neutralization

5. Which of the following is correct code for x and y in the following reaction.



(i) x = oxidation reaction, y = reduction reaction
(ii) x = gain of two electrons, y = loss of two electrons,
(iii) x = reduction reaction, y = oxidation reaction
(iv) x = loss of two electrons, y = gain of two electrons

(a) (i) and (ii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (iii) and (iv)

6. Which of the following involves transfer of five electrons ?

(a) $MnO_4^- \rightarrow Mn^{2+}$ (b) $CrO_4^{2-} \rightarrow Cr^{3+}$
(c) $MnO_4^{2-} \rightarrow MnO_2$ (d) $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

7. Which reaction involves neither oxidation nor reduction?

(a) $CrO_4^{2-} \longrightarrow Cr_2O_7^{2-}$ (b) $Cr \longrightarrow CrCl_3$
(c) $Na \longrightarrow Na^+$ (d) $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

8. In the following reaction

$$4P + 3KOH + 3H_2O \longrightarrow 3KH_2PO_2 + PH_3$$

(a) phosphorus is both oxidised and reduced.
(b) only phosphorus is reduced.
(c) phosphorus is not oxidised
(d) None of these

9. Which one of the following reaction involves oxidation-reduction ?

(a) $H_2 + Br_2 \rightarrow 2HBr$
(b) $NaBr + HCl \rightarrow NaCl + HBr$
(c) $HBr + AgNO_3 \rightarrow AgBr + HNO_3$
(d) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

10. In reaction, $4Na + O_2 \longrightarrow 2Na_2O$, sodium behaves as

(a) oxidising agent (b) reducing agent
(c) Both (a) and (b) (d) None of these

11. $Zn^{2+}(aq.) + 2e^- \longrightarrow Zn(s)$. This is

(a) oxidation (b) reduction
(c) redox reaction (d) None of the above

12. $Co(s) + Cu^{2+}(aq) \longrightarrow Co^{2+}(aq) + Cu(s)$

The above reaction is

(a) oxidation reaction (b) reduction reaction
(c) redox reaction (d) None of these

13. One mole of N_2H_4 loses 10 moles of electrons to form a new compound, y. Assuming that all nitrogen appear in the new compound, what is the oxidation state of nitrogen in y (There is no change in the oxidation state of hydrogen)

(a) –1 (b) –3
(c) +3 (d) +5

14. When a strip of metallic zinc is placed in an aqueous solution of copper nitrate the blue colour of the solution disappear due to formation of

(a) Cu^{2+} (b) Zn^{2+}
(c) ZnS (d) Cus

15. The correct order of electron releasing tendency of the metals Cu, Zn and Ag is in the order:

(a) Cu > Zn > Ag (b) Zn > Ag > Cu
(c) Ag > Zn > Cu (d) Zn > Cu > Ag

16. What is the oxidation number of elements in the free or in the uncombined state ?

(a) +1 (b) 0
(c) +2 (d) –1

17. In which of the following compounds oxygen has highest oxidation state and in which it has lowest oxidation state? OF_2, H_2O_2, KO_2, O_2F_2

(a) Highest = KO_2, lowest = H_2O_2
(b) Highest = OF_2, lowest = K_2O_2
(c) Highest = OF_2, lowest = KO_2
(d) Highest = KO_2, lowest = H_2O_2

18. 'Oxidation number of H in NaH, CaH_2 and LiH, respectively is

(a) +1, +1, –1 (b) –1, +1, + 1
(c) +1, + 1, + 1 (d) –1,–1, –1

19. Which of the following is the correct representative of stock notation for auric chloride?

(a) $Au(III)Cl_3$ (b) $Au(II)Cl_2$
(c) $Au(I)Cl_2$ (d) None of these

20. Oxidation number of N in HNO_3 is

(a) – 3.5 (b) + 3.5
(c) –5 (d) + 5

21. In which of the following reactions, there is no change in valency ?

(a) $4\,KClO_3 \longrightarrow 3KClO_4 + KCl$
(b) $SO_2 + 2H_2S \longrightarrow 2H_2O + 3S$
(c) $BaO_2 + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2$
(d) $3\,BaO + O_2 \longrightarrow 2\,BaO_2$.

22. The oxidation number of chromium in potassium dichromate is

(a) + 6 (b) – 5
(c) – 2 (d) + 2

23. The oxidation number of sulphur in S_8, S_2F_2, H_2S respectively, are

(a) 0, +1 and –2 (b) +2, +1 and –2
(c) 0, +1 and +2 (d) –2, +1 and –2

24. Oxidation number of cobalt in $K[Co(CO)_4]$ is

(a) +1 (b) +3
(c) –1 (d) –3

25. Oxidation number of nitrogen in $(NH_4)_2SO_4$ is

(a) –1/3 (b) –1
(c) +1 (d) –3

26. Oxidation number of carbon in CH_2Cl_2 is

(a) –4 (b) +4
(c) 0 (d) –2

27. In which of the following compounds, iron has lowest oxidation state?

(a) $K_3[Fe(CN)_6]$
(b) $K_4[Fe(CN)_6]$
(c) $FeSO_4.(NH_4)_2SO_4.6H_2O$
(d) $Fe(CO)_5$

28. The oxidation state of osmium (Os) in OsO_4 is

(a) +7 (b) +6
(c) +4 (d) +8

29. Which of the following transition metal has zero oxidation state ?

(a) $[Fe(CO)_5]$ (b) $NH_2.NH_2$
(c) $NOClO_4$ (d) CrO_5

30. In which of the compounds does 'manganese' exhibit highest oxidation number ?

(a) MnO_2 (b) Mn_3O_4
(c) K_2MnO_4 (d) $MnSO_4$

31. Among the following, identify the species with an atom in +6 oxidation state

(a) MnO_4^- (b) $Cr(CN)_6^{3-}$
(c) NiF_6^{2-} (d) CrO_2Cl_2

32. In which of the following compounds the oxidation number of carbon is not zero?

(a) HCHO (b) CH_3COOH
(c) $C_{12}H_{22}O_{11}$ (d) CH_3CHO

33. In which of the following compounds, the oxidation number of iodine is fractional ?

(a) IF_7 (b) I_3^-
(c) IF_5 (d) IF_3

34. A metal ion M^{3+} loses 3 electrons, its oxidation number will be

(a) +3 (b) +6
(c) 0 (d) –3

35. The correct name for NO_2 using stock notation is

(a) nitrogen dioxide (b) nitrogen (iv) oxide
(c) nitrogen per oxide (d) All of these

36. The oxide, which cannot act as a reducing agent, is

(a) NO_2 (b) SO_2
(c) CO_2 (d) ClO_2

37. The oxidation state of Fe in Fe_3O_4 is

(a) + 3 (b) 8/3
(c) + 6 (d) + 2

38. In oxygen difluoride, the oxidation number of oxygen is

(a) – 2 (b) – 1
(c) + 2 (d) +1, – 2

39. Oxygen has an oxidation state of +2 in the compound

(a) H_2O_2 (b) CO_2
(c) H_2O (d) F_2O

40. The number of electrons involved in the reduction of one nitrate ion to hydrazine is

(a) 8
(b) 5
(c) 3
(d) 7

41. The average oxidation state of sulphur in $Na_2S_4O_6$ is

(a) +2.5
(b) +2
(c) +3.0
(d) +3.5

42. Which of the following species can function both as oxidizing as well as reducing agent ?

(a) Cl^-
(b) $ClO_4{}^-$
(c) ClO^-
(d) $MnO_4{}^-$

43. The oxidation number of an element in a compound is evaluated on the basis of certian rules. Which of the following rules is not correct in this respect?

(a) The oxidation number of hydrogen is always + 1.
(b) The algebraic sum of all the oxidation numbers in a compound is zero.
(c) An element in the free or the uncombined state bears oxidation number zero.
(d) In all its compounds, the oxidation number of fluorine is – 1.

44. Nitric oxide acts as a reducing agent in the reaction

(a) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
(b) $2NO + 3I_2 + 4H_2O \rightarrow 2NO_3^- + 6l^- + 8H^+$
(c) $2NO + H_2SO_3 \rightarrow N_2O + H_2SO_4$
(d) $2NO + H_2S \rightarrow N_2O + S + H_2O$

45. In the compounds $KMnO_4$and $K_2Cr_2O_7$ the highest oxidation state is of the element

(a) potassium
(b) manganese
(c) chromium
(d) oxygen

46. Atomic number of an element is 22. The highest O.S. exhibited by it in its compounds is

(a) 1
(b) 2
(c) 3
(d) 4

47. Why the displacement reactions of chlorine, bromine and iodine using fluorine are not generally carried out in aqueous solution?

(a) chlorine, bromine and iodine reacts with water and displace oxygen of water
(b) Fluorine being very reactive attacks water and displaces oxygen of water
(c) Fluorine does not react with chlorine, bromine and iodine in aqueous media
(d) None of these

48. Which of the following statement is not true ?

(a) Displacement reaction of chlorine with Br^- and I^- form the basis of identifying Br^- and I^- in laboratory using layer test
(b) F_2, Cl_2, Br_2 and I_2 can be recovered by halogen displacement reactions by using their respective halides
(c) F_2 can be recovered from F^- by oxidising it electrolytically.
(d) None of these.

49. Which of the following do not show disproportionation reaction?

ClO_4^-, F_2, Cl_2, ClO_2^-, P_4, S_8, and ClO^-

(a) ClO_2^-, ClO_4^-, and ClO^-
(b) F_2 only
(c) F_2 and ClO_4^-
(d) ClO_4^- only

50. Which one of the following reactions involves disproportionation?

(a) $2H_2SO_4 + Cu \rightarrow CuSO_4 + 2H_2O + SO_2$
(b) $As_2O_3 + 3H_2S \rightarrow As_2S_3 + 3H_2O$
(c) $2KOH + Cl_2 \rightarrow KCl + KOCl + H_2O$
(d) $Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$

51. The following species will not exhibit disproportionation reaction

(a) ClO^-
(b) ClO_2^-
(c) ClO_3^-
(d) ClO_4^-

52. In the reaction

$$3Br_2 + 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + BrO_3^- + 6HCO_3^-$$

(a) Bromine is oxidised and carbonate is reduced.
(b) Bromine is reduced and water is oxidised
(c) Bromine is neither reduced nor oxidised
(d) Bromine is both reduced and oxidised

53. Which of the following elements does not show disproportionation tendency?

(a) Cl
(b) Br
(c) F
(d) I

54. Phosphorus, sulphur and chlorine undergo disproportion in the ...A... medium.

Here, A refers to

(a) acidic
(b) alkaline
(c) neutral
(d) Both (a) and (b)

55. The reaction, $2\overset{+1}{H_2}\overset{-2}{O}(l) \xrightarrow{\Delta} 2\overset{0}{H_2}(g) + \overset{0}{O_2}(g)$ is an example of

(a) addition reaction
(b) decomposition reaction
(c) displacement reaction
(d) None of these

56. How will you balance the total ionic charge of reactant and products if reaction is carried out in acidic solution?

(a) By using H^+ ions
(b) By using OH^- ions
(c) Adding H_2O molecules to the reactant or product
(d) Multiplying by suitable coefficients.

57. Consider the following reaction occuring in basic medium

$$2MnO_4^-(aq) + Br^-(aq) \longrightarrow 2MnO_2(s) + BrO_3^-(aq)$$

How the above reaction can be balanced further?

(a) By adding 2 OH^- ions on right side
(b) By adding one H_2O molecule to left side
(c) By adding $2H^+$ ions on right side
(d) Both (a) and (b)

58. For the reaction : $NH_3 + OCl^- \longrightarrow N_2H_4 + Cl^-$ in basic medium, the coefficients of NH_3, OCl^- and N_2H_4 for the balanced equation are respectively

(a) 2, 2, 2
(b) 2, 2, 1
(c) 2, 1, 1
(d) 4, 4, 2

59. $C_2H_6(g) + nO_2(g) \rightarrow CO_2(g) + H_2O(l)$

In this equation, the ratio of the coefficients of CO_2 and H_2O is

(a) 1 : 1
(b) 2 : 3
(c) 3 : 2
(d) 1 : 3

60. $2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2\,Z + 5O_2 + 8H_2O$. In this reaction Z is

(a) Mn^{+2}
(b) Mn^{+4}
(c) MnO_2
(d) Mn

61. In the redox reaction,

$x KMnO_4 + NH_3 \longrightarrow y KNO_3 + MnO_2 + KOH + H_2O$

(a) $x = 4, y = 6$
(b) $x = 3, y = 8$
(c) $x = 8, y = 6$
(d) $x = 8, y = 3$

62. What is 'A' in the following reaction

$2Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{2+}(aq) + A$

(a) $Sn^{3+}(aq)$
(b) $Sn^{4+}(aq)$
(c) $Sn^{2+}(aq)$
(d) Sn

63. Given :

$X\,Na_2HAsO_3 + Y\,NaBrO_3 + Z\,HCl \rightarrow NaBr + H_3AsO_4 + NaCl$

The values of X, Y and Z in the above redox reaction are respectively

(a) 2, 1, 2
(b) 2, 1, 3
(c) 3, 1, 6
(d) 3, 1, 4

64. The values of x and y in the following redox reaction

$x\,Cl_2 + 6OH^- \longrightarrow ClO_3^- + y\,Cl^- + 3H_2O$ are

(a) x = 5, y = 3
(b) x = 2, y = 4
(c) x = 3, y = 5
(d) x = 4, y = 2

65. A negative E° means that redox couple is a ___A___ than the H^+/H_2 couple

A positive E° means that the redox couple is a ____B___ than H^+/H_2 couple

(a) A = stronger reducing agent
B = weaker reducing agent
(b) A = stronger oxidising agent
B = weaker oxidising agent
(c) A = weaker oxidising agent
B = stronger oxidising agent
(d) Both (a) and (c)

66. Given $E^\ominus$

(i) $Mg^{2+}/Mg(s)$, $E^\ominus = -2.36$

(ii) $Ag^+/Ag(s)$, $E^\ominus = 0.80$

(iii) $Al^{3+}/Al(s)$, $E^\ominus = -1.66$

(iv) $Cu^{2+}/Cu(s)$, $E^\ominus = 0.52$

Out of the above given elements which is the strongest oxidising agent and which is the weakest oxidising agent ?

(a) (iv) is the strong whereas (ii) is the weakest oxidising agent
(b) (ii) is the strongest whereas (i) is the weakest oxidising agent
(c) (i) is the strongest whereas (ii) is the weakest oxidising agent
(d) (ii) is the strongest whereas (iii) is the weakest oxidising agent

67. Stronger is oxidising agent, more is

(a) standard reduction potential of that species
(b) the tendency to get it self oxidised
(c) the tendency to lose electrons by that species
(d) standard oxidation potential of that species

68. Standard reduction potentials of the half reactions are given below :

$F_2(g) + 2e^- \rightarrow 2F^-(aq);\ E^\circ = +2.85\,V$
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq);\ E^\circ = +1.36\,V$
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq);\ E^\circ = +1.06\,V$
$I_2(s) + 2e^- \rightarrow 2I^-(aq);\ E^\circ = +0.53\,V$

The strongest oxidising and reducing agents respectively are :

(a) F_2 and I^-
(b) Br_2 and Cl^-
(c) Cl_2 and Br^-
(d) Cl_2 and I_2

69. Standard electrode potentials of redox couples A^{2+}/A, B^{2+}/B, C/C^{2+} and D^{2+}/D are 0.3V, – 0.5V, – 0.75V and 0.9V respectively. Which of these is best oxidising agent and reducing agent respectively –

(a) D^{2+}/D and B^{2+}/B
(b) B^{2+}/B and D^{2+}/D
(c) D^{2+}/D and C^{2+}/C
(d) C^{2+}/C and D^{2+}/D

70. The standard reduction potentials at 298K for the following half reactions are given against each

$Zn^{2+}(aq) + 2e \rightleftharpoons Zn(s);\ -0.762\,V$
$Cr^{3+}(aq) + 3e \rightleftharpoons Cr(s);\ -0.740\,V$
$2H^+(aq) + 2e \rightleftharpoons H_2(g);\ 0.00\,V$
$Fe^{3+}(aq) + e \rightleftharpoons Fe^{2+}(aq);\ 0.770\,V$

Which is the strongest reducing agent?

(a) Zn (s)
(b) Cr (s)
(c) $H_2(g)$
(d) Fe^{3+} (aq)

71. Electrode potential data are given below :

$Fe^{+3}_{(aq)} + e^- \longrightarrow Fe^{+2}_{(aq)};\quad E^\circ = +0.77\,V$
$Al^{3+}_{(aq)} + 3e^- \longrightarrow Al_{(s)};\quad E^\circ = -1.66\,V$
$Br_{2\,(aq)} + 2e^- \longrightarrow 2Br^-_{(aq)};\quad E^\circ = +1.08\,V$

Based on the data, the reducing power of Fe^{2+}, Al and Br^- will increase in the order

(a) $Br^- < Fe^{2+} < Al$
(b) $Fe^{2+} < Al < Br^-$
(c) $Al < Br^- < Fe^{2+}$
(d) $Al < Fe^{2+} < Br^-$

72. The standard reduction potentials for Cu^{2+}/Cu; Zn^{2+}/Zn; Li^+/Li; Ag^+/Ag and H^+/H_2 are + 0.34 V, – 0.762 V, – 3.05 V, + 0.80 V and 0.00 V respectively. Choose the strongest reducing agent among the following

(a) Zn
(b) H_2
(c) Ag
(d) Li

73. Given :

$$E^{o}_{\frac{1}{2}Cl_2/Cl^-} = 1.36\,V,\ E^{o}_{Cr^{3+}/Cr} = -0.74\,V,$$

$$E^{o}_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33\,V,\ E^{o}_{MnO_4^-/Mn^{2+}} = 1.51\,V$$

The correct order of reducing power of the species (Cr, Cr^{3+}, Mn^{2+} and Cl^-) will be

(a) $Mn^{2+} < Cl^- < Cr^{3+} < Cr$

(b) $Mn^{2+} < Cl^{3+} < Cl^- < Cr$

(c) $Cr^{3+} < Cl^- < Mn^{2+} < Cr$

(d) $Cr^{3+} < Cl^- < Cr < Mn^{2+}$

74. $E^{\ominus}$ Values of some redox couples are given below. On the basis of these values choose the correct option.

$E^{\ominus}$ values : $Br_2/Br^- = +1.90$; $Ag^+/Ag(s) = +0.80$
$Cu^{2+}/Cu(s) = +0.34$; $I_2(s)/I^- = 0.54$

(a) Cu will reduce Br^- (b) Cu will reduce Ag

(c) Cu will reduce I^- (d) Cu will reduce Br_2

75. Arrange the following in the order of their decreasing electrode potentials : Mg, K, Ba and Ca

(a) K, Ca, Ba, Mg (b) Ba, Ca, K, Mg

(c) Ca, Mg, K, Ba (d) Mg, Ca, Ba, K

76. The standard electrode potentials of four elements A, B, C and D are –3.05, –1.66, –0.40 and +0.80. The highest chemical reactivity will be exhibited by

(a) A (b) B

(c) C (d) D

STATEMENT TYPE QUESTIONS

77. Which of the following statement(s) is/are correct for the given reaction?

$2HgCl_2\,(aq) + SnCl_2(aq) \rightarrow Hg_2Cl_2(s) + SnCl_4(aq)$

(i) Mercuric chloride is reduced to Hg_2Cl_2

(ii) Stannous chloride is oxidised to stannic chloride

(iii) $HgCl_2$ is oxidised to Hg_2Cl_2

(iv) It is an example of redox reaction

(a) (i), (ii) and (iv) (b) (i) and (ii)

(c) (iii) and (iv) (d) (iii) only

78. Which of the following sequences of T and F is correct for given statements. Here T stands for true and F stands for false statements

(i) Reducing agents lower the oxidation number of an element in a given substance. These reagents are also called as reductants

(ii) Reducing agents are acceptor of electrons

(iii) Loss of electron(s) by any species is called oxidation reaction

(iv) Oxidation and reduction always occur simultaneously.

(a) TTTT (b) TFTT

(c) TFFT (d) FTTT

79. If aqueous solution of H_2O_2 is made acidic. For this which of the following statement(s) is/are correct ?

(i) This aqueous solution oxidizes I^-

(ii) This aqueous solution oxidizes F^-

(a) Both statements (i) and (ii) are correct.

(b) Statement (i) is correct and (ii) is incorrect.

(c) Statement (ii) is correct and (i) is incorrect.

(d) Both statements (i) and (ii) are incorrect.

80. Which of the following statement(s) is/are correct ?

(i) All alkali metals and some alkaline earth metals (Ca, Sr and Ba) displace hydrogen from cold water.

(ii) Magnesium and iron react with steam as well as acids to produce hydrogen gas.

(iii) Cadmium and tin do not react with steam but displace hydrogen from acids.

(a) (i) and (ii) (b) (ii) only

(c) (i) and (iii) (d) (i), (ii) and (iii)

81. Which of the following statements are correct concerning redox properties?

(i) A metal M for which E° for the half life reaction $M^{n+} + ne^- \rightleftharpoons M$ is very negative will be a good reducing agent.

(ii) The oxidizing power of the halogens decreases from chlorine to iodine.

(iii) The reducing power of hydrogen halides increases from hydrogen chloride to hydrogen iodide

(a) (i), (ii) and (iii) (b) (i) and (ii)

(c) (i) only (d) (ii) and (iii)

82 Which of the following statement(s) is/are correct ?

(i) A negative value of E^- means that the redox couple is a weaker reducing agent than the H^+/H_2 couple.

(ii) A positive E^- means that the redox couple is weaker reducing agent than the H^+/H_2.

Which of the following code is incorrect regarding above statements?

(a) Only (i) (b) only (ii)

(c) Both (i) and (ii) (d) Neither (i) nor (ii)

83. Which of the following statement(s) is/are correct ?

(i) Oxidation state of carbon in C_3H_4 is –(4/3).

(ii) Electrons are never shared in fraction.

(a) (i) and (ii) (b) Only (i)

(c) Only (ii) (d) Neither (i) nor (ii)

MATCHING TYPE QUESTIONS

84. Match the columns

Column-I	Column-II
(A) Addition of electronegative element	(p) Oxidation reaction
(B) Removal of hydrogen	(q) Reduction reaction
(C) Addition of electropositive element	
(D) Removal of oxygen	

(a) (A) – (p), (B) – (q), (C) – (q), (D) – (p)

(b) (A) – (p), (B) – (p), (C) – (q), (D) – (q)

(c) (A) – (p), (B) – (q), (C) – (p), (D) – (q)

(d) (A) – (q), (B) – (q), (C) – (p), (D) – (p)

85. Match the columns

	Column-I		**Column-II**
(A)	$2Mg + O_2 \longrightarrow 2MgO$	(p)	Removal of hydrogen
(B)	$Mg + Cl_2 \longrightarrow MgCl_2$	(q)	Removal of electropositive element
(C)	$2H_2S + O_2 \longrightarrow 2S + 2H_2O$	(r)	Addition of oxygen
(D)	$2KI + H_2O + O_3 \longrightarrow 2KOH + I_2 + O_2$	(s)	Addition of electronegative element, chlorine

(a) A – (s), B – (q), C – (p), D – (r)
(b) A – (r), B – (s), C – (p), D – (q)
(c) A – (s), B – (r), C – (q), D – (p)
(d) A – (r), B – (p), C – (s), D – (q)

86. Match Column-I (compound) with Column-II (oxidation state of underlined element) and choose the correct option.

	Column - I		**Column - II**
(A)	$\underline{Cu}O$	(p)	4
(B)	$\underline{Mn}O_2$	(q)	3
(C)	$H\underline{Au}Cl_4$	(r)	2
(D)	$\underline{Tl}_2O$	(s)	1

(a) A – (r), B – (p), C – (q), D – (s)
(b) A – (s), B – (r), C – (p), D – (q)
(c) A – (r), B – (s), C – (p), D – (q)
(d) A – (s), B – (q), C – (p), D – (r)

87. Match the columns

	Column-I		**Column-II**
(A)	$V_2O_5(s) + 5\,Ca(s) \rightarrow 2V(s) + 5\,CaO(s)$	(p)	Disproportionation reaction
(B)	$CH_4(g) + 2O_2(g) \xrightarrow{\Delta} CO_2(g) + 2\,H_2O(l)$	(q)	Decomposition reaction
(C)	$P_4(s) + 3OH^-(aq) + 3H_2O(l) \rightarrow PH_3(g) + 3H_2PO_2^-(aq)$	(r)	Combination reaction
(D)	$2\,KClO_3(s) \xrightarrow{\Delta} 2KCl(s) + 3O_2(g)$	(s)	Displacement reaction

(a) A – (s), B – (q), C – (r), D – (p)
(b) A – (s), B – (r), C – (p), D – (q)
(c) A – (r), B – (s), C – (q), D – (p)
(d) A – (r), B – (s), C – (p), D – (q)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

88. **Assertion :** In the reaction $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ sodium is oxidised.
Reason : Sodium acts as an oxidising agent in given reaction.

89. **Assertion :** $HClO_4$ is a stronger acid than $HClO_3$.
Reason : Oxidation state of Cl in $HClO_4$ is +VII and in $HClO_3$ +V.

90. **Assertion :** The reaction :
$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$ is an example of decomposition reaction
Reason : Above reaction is not a redox reaction.

91. **Assertion :** In a reaction
$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$
Zn is a reductant but itself get oxidized.
Reason : In a redox reaction, oxidant is reduced by accepting electrons and reductant is oxidized by losing electrons.

CRITICAL THINKING TYPE QUESTIONS

92. Among NH_3, HNO_3, NaN_3 and Mg_3N_2 the number of molecules having nitrogen in negative oxidation state is
(a) 1 (b) 2
(c) 3 (d) 4

93. Fill up the table from the given choice.

Element	**Oxidation number**
Oxygen	–2 in most compounds ___(i)___ in H_2O_2 and ___(ii)___ in OF_2
Halogen	–1 for ___(iii)___ in all its compounds
Hydrogen	___(iv)___ in most of its compounds ___(v)___ in binary metallic hydrides
Sulphur	___(vi)___ in all sulphides

	(i)	**(ii)**	**(iii)**	**(iv)**	**(v)**	**(vi)**
(a)	+1	+1	Cl	+1	–1	+2
(b)	–1	+2	F	+1	–1	–2
(c)	–1	+1	F	+1	+2	+2
(d)	+1	+2	Cl	+1	+1	+6

94. The correct decreasing order of oxidation number of oxygen in compounds BaF_2, O_3, KO_2 and OF_2 is
(a) $BaO_2 > KO_2 > O_3 > OF_2$
(b) $OF_2 > O_3 > KO_2 > BaO_2$
(c) $KO_2 > OF_2 > O_3 > BaO_2$
(d) $BaO_2 > O_3 > OF_2 > KO_2$

95. Oxidation numbers of P in PO_4^{3-}, of S in SO_4^{2-} and that of Cr in $Cr_2O_7^{2-}$ are respectively
(a) + 3, + 6 and + 5 (b) + 5, + 3 and + 6
(c) – 3, + 6 and + 6 (d) + 5, + 6 and + 6

96. When Cl_2 gas reacts with hot and concentrated sodium hydroxide solution, the oxidation number of chlorine changes from
(a) zero to +1 and zero to –5
(b) zero to –1 and zero to +5
(c) zero to –1 and zero to +3
(d) zero to +1 and zero to –3

97. Which of the following arrangements represent increasing oxidation number of the central atom?

(a) $CrO_2^-, ClO_3^-, CrO_4^{2-}, MnO_4^-$

(b) $ClO_3^-, CrO_4^{2-}, MnO_4^-, CrO_2^-$

(c) $CrO_2^-, ClO_3^-, MnO_4^-, CrO_4^{2-}$

(d) $CrO_4^{2-}, MnO_4^-, CrO_2^-, ClO_3^-$

98. Which of the following act as reducing agents ?

(i) PO_4^{3-} (ii) SO_3

(iii) PO_3^{2-} (iv) NH_3

(a) (i), (ii) and (iii) (b) Only (iii)
(c) (i), (iii) and (iv) (d) (iii) and (iv)

99. In the reaction shown below, oxidation state of the carbon in reactant and product are (*i*) and (*ii*) respectively? Is the given reaction a redox reaction?

$Na_2CO_3(aq) + HCl\,(aq)$

$$\longrightarrow Na^{\oplus}(aq) + Cl^-(aq) + H_2O(\ell) + CO_2(g)$$

(a) (i) 6, (ii) 4, yes (b) (i) 6, (ii) 6, No
(c) (i) 4, (ii) 4, No (d) (i) 4, (ii) 4, yes

100. What products are expected from the disproportionation reaction of hypochlorous acid?

(a) HCl and Cl_2O (b) HCl and $HClO_3$
(c) $HClO_3$ and Cl_2O (d) $HClO_2$ and $HClO_4$

101. In the disproportionation reaction

$3\,HClO_3 \rightarrow HClO_4 + Cl_2 + 2O_2 + H_2O$, the equivalent mass of the oxidizing agent is (molar mass of $HClO_3 = 84.45$)

(a) 16.89 (b) 32.22
(c) 84.45 (d) 28.15

102. Consider the following reaction :

$$xMNO_4^- + yC_2O_4^{2-} + zH^+ \rightarrow xMn^{2+} + 2yCO_2 + \frac{z}{2}H_2O$$

The value's of x, y and z in the reaction are, respectively :

(a) 5, 2 and 16 (b) 2, 5 and 8
(c) 2, 5 and 16 (d) 5, 2 and 8

103. In the balanced chemical reaction

$IO_3^- + aI^- + bH^+ \longrightarrow cH_2O + dI_2$

a, b, c and d respectively corresponds to

(a) 5, 6, 3, 3 (b) 5, 3, 6, 3
(c) 3, 5, 3, 6 (d) 5, 6, 5, 5

104. If equal volume of reactants are used, than no. moles of $KMnO_4$ (moles per liter) used in acidic medium required to completely oxidises the 0.5 M $FeSO_3$?

(a) 0.3 (b) 0.1
(c) 0.2 (d) 0.4

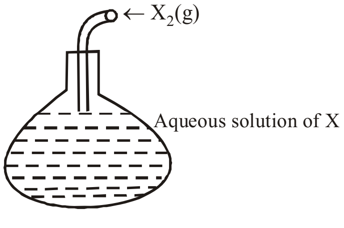
105. Acidic medium used in $KMnO_4$ can be made from which of the following acids?

(a) HCl (b) H_2SO_4
(c) HI (d) HBr

106. If rod of a metal (x) is put in a metal ion solution which is blue in colour , solution turn colorless. The metal rod and solution respectively are?

(a) Zinc and Cu(II) (b) Zinc and Ni(II)
(c) Aluminium and Cu(II) (d) Both (a) and (c)

107. What could be the X^- in the system, Where X signifies halogen ; formation of shown below X_2 takes place, when F_2 is purge into aqueous solution of X^-?



(a) Br^- (b) Cl^-
(c) I^- (d) All of these

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** Addition of oxygen takes place in oxidation.

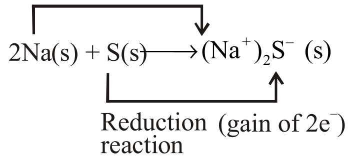
2. **(c)** Given reaction is oxidation reaction due to removal of electropositive element potassium from potassium ferrocyanide.

3. **(d)** $2Na(s) + H_2(g) \xrightarrow{\Delta} 2NaH(s)$

With the careful application of the concept of electronegativity only S we can find that sodium is oxidised and hydrogen is reduced.

4. **(a)** Losing of electron is called oxidation.

5. **(b)** Oxidation reaction (loss of $2e^-$)



$2Na(s) + S(s) \longrightarrow (Na^+)_2S^-\ (s)$

6. **(a)** O.N. of Mn in MnO_4^- is +7 and in Mn^{2+} it is +2. The difference is of 5 electrons.

7. **(a)** Ox. no. of Cr on both side is + 6.

8. **(a)** $4P + 3KOH + 3H_2O \rightarrow KH_2PO_2 + PH_3$

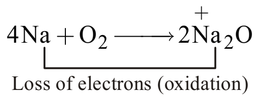
O.N of P = 0, In KH_2PO_2 it is + 1, In PH_3 it is –3.
Hence P is oxidised and reduced.

9. **(a)** In a redox reaction, one molecule is oxidised and other molecule is reduced i.e. oxidation number of reactants are changed.

$\overset{0}{H_2} + \overset{0}{Br_2} \longrightarrow 2\,\overset{+1\,-1}{HBr}$

Here H_2 is oxidised and Br_2 is reduced, thus it is oxidation-reduction reaction.

10. **(b)**



$4Na + O_2 \longrightarrow 2\overset{+}{Na}_2O$

In this reaction, Na converts into ion (Na^+) and Na donates electrons to oxygen atoms, So, Na behaves as reducing agent.

11. **(b)** $Zn^{2+} + 2e^- \rightarrow Zn(s)$

Here electrons are reducing from Zn^{2+} to Zn.

12. **(c)** $Co(s) + Cu^{2+}(aq) \longrightarrow Co^{2+}(aq) + Cu(s)$

This reaction is a redox reaction as Co undergoes oxidation whereas Cu^{+2} undergoes reduction.

13. **(c)** $N_2^{-4}H_4^{+4} \xrightarrow[N]{\text{loss of } 10e^-} N_2^{+6}Y;$

O.N.of N changes from – 2 to +3

14. **(b)** Blue colour of the solution disappear due to formation of Zn^{2+}.

15. **(d)** Correct order is Zn > Cu > Ag.

16. **(b)** For elements, in the free or the uncombined state, each atom bears an oxidation number of zero.

17. **(c)** Oxidation number of oxygen in OF_2 = + 2.

In $KO_2 = \frac{-1}{2}$

18. **(d)** Oxidation number of hydrogen when it is bonded to metals in binary compounds is –1

19. **(a)** Auric Chloride = $Au(III)Cl_3$

20. **(d)** Let the oxidation no. of N in $HNO_3 = x$

$\therefore\ 1 + x + (3 \times -2) = 0$

$\therefore\ x = +5$

21. **(c)** $\overset{+2}{Ba}\overset{-1}{O_2} + \overset{+1}{H_2}\ \overset{+6}{S}\ \overset{-2}{O_4} \longrightarrow \overset{+2}{Ba}\ \overset{+6}{S}\ \overset{-2}{O_4} + \overset{+1}{H_2}\overset{-1}{O_2}$

In this reaction, none of the elements undergoes a change in oxidation number or valency.

22. **(a)** Let x = oxidation no. of Cr in $K_2Cr_2O_7$.

$\therefore (2 \times 1) + (2 \times x) + 7(-2) = 0$

or $2 + 2x - 14 = 0$ or $x = + 6$.

23. **(a)** (i) Oxidation state of element in its free state is zero.

(ii) Sum of oxidation states of all atoms in compound is zero.

O.N. of S in $S_8 = 0$; O.N. of S in $S_2F_2 = + 1$;

O.N. of S in $H_2S = -2$;

24. **(c)** $K[Co(CO)_4]$

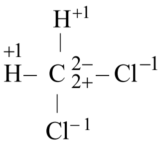
Let O.N. of Co be x then

$\underset{\text{for K}}{1 \times (+1)} + \underset{\text{for Co}}{x} + \underset{\text{for CO}}{4 \times (0)} = 0$

$\therefore$ O.N. of Co is = –1

25. **(d)** $(NH_4)_2\,SO_4$ is split into ions. NH_4^+. Let O.N. of N be x then, $1 \times (x) + 4 \times (+1) = 1$ $\quad\therefore x = -3$

26. **(c)**



$\overset{+1}{H}-\overset{\overset{H^{+1}}{|}}{\underset{\underset{Cl^{-1}}{|}}{C}}\,{}^{2-}_{2+}-Cl^{-1}$ O.N. of C is zero

27. **(d)** O.N. of Fe in (a), (b), (c) and (d) respectively are : +3, +2, +2 and 0.

28. **(d)** OsO_4

Let O.N. of Os be x then $1 \times (x) + 4(-2) = 0$

$\therefore\ x = 8$

29. **(a)** $Fe(CO)_5$ is metal carbonyl, hence O.N. of Fe is zero.

30. **(c)** O.N. of Mn in K_2MnO_4 is +6

31. **(d)** MnO_4^- (O.S. of Mn +7); $Cr(CN)_6^{3-}$ (O.S. of Cr +3), NiF_6^{2-} (O.S. of Ni +4) and CrO_2Cl_2 (O.S. of Cr +6)

32. **(d)** O.N. of carbon in CH_3CHO is –1; in other cases it is zero.

33. **(b)** O.N. of iodine in I_3^- is –1/3

34. **(b)** M^{3+} on losing 3 elections will become M^{+6} and O.N. = + 6.

35. **(b)** The method of representing oxidation number by a Roman numeral within the paranthesis represents Stock notation.

36. **(c)** Carbon has the maximum oxidation state of + 4, therefore carbon dioxide (CO_2) cannot act as a reducing agent.

37. **(b)** Let the oxidation no. of Fe in $Fe_3O_4 = x$

$\therefore\ 3x + (-2 \times 4) = 0$ or $3x = 8$

$\therefore\ x = \frac{8}{3}$

38. **(c)** Let oxidation state of oxygen in $OF_2 = x$

$\therefore\ x + (-1 \times 2) = 0$

$\therefore\ x = +2$

39. **(d)** In $H_2O_2 : \Rightarrow 2 \times (+1) + 2 \times x = 0 \Rightarrow x = -1$

In $CO_2 : \Rightarrow 4 + 2x = 0 \Rightarrow x = -2$

In $H_2O : \Rightarrow 2 \times (+1) + x = 0 \Rightarrow x = -2$

In $F_2O : \Rightarrow 2 \times (-1) + x = 0 \Rightarrow x = +2$

40. **(d)** $\underset{+5}{NO_3^-} \xrightarrow{\quad} \underset{-2}{N_2H_4}$ So, for reduction of 1 mole of NO_3^- number of electrons required is 7.

41. **(a)** Let the oxidation state of S be x.

$S_4O_6^{2-} \Rightarrow 4x - 12 = -2 \Rightarrow 4x = 10 \Rightarrow x = 10/4 = 2.5$

42. **(c)**

Species	**O.N.**
Cl^-	– 1
$\underline{Cl}O_4^-$	+7
$\underline{Cl}O^-$	+1
$\underline{Mn}O_4^-$	+7

In ClO^- chlorine is in +1 oxidation state which can be increased or decreased thus it acts as an oxidising or reducing agent.

In other given species the underlined elements are either in their minimum or maximum oxidation state.

43. **(a)**

44. **(b)** O.N. of N changes from + 2 to + 5 hence NO is reducing.

45. **(b)** In $KMnO_4$: Let O.N. of Mn be x

$\Rightarrow +1 + x + 4(-2) = 0 \Rightarrow x = +7$

In $K_2Cr_2O_7$: Let O.N. of Cr be x

$\Rightarrow 2(1) + 2x + 7(-2) = 0 \Rightarrow x = +6$

46. **(d)** The element is Ti (At. no. 22). Electronic configuration is $1s^2, 2s^2p^6, 3s^2p^6d^2, 4s^2$. the energy level of 3d and 4s is very close. It can have Ti^{4+} O.S.

47. **(b)** Fluorine is so reactive that it attacks water and displaces the oxygen of water :

$$2\overset{+1-2}{H_2O}(l) + 2\overset{0}{F_2}(g) \rightarrow 4\overset{+1-1}{HF}(aq) + \overset{0}{O_2}(g)$$

48. **(b)** As fluorine is the strongest oxidising agent; there is no way to convert F^- ions to F_2 by chemical means. The only way to achieve F_2 from F^- is to oxidise it electrolytically.

49. **(c)** F_2 being most electronegative element cannot exhibit any positive oxidation state.

In ClO_4^- chlorine is present in its highest oxidation state i.e + 7. Therefore it does not show disproportionation reaction.

50. **(c)** A reaction, in which a substance undergoes simultaneous oxidation and reduction, is called disproportionation reaction. In these reactions, the same substance simultaneously acts as an oxidising agent and as a reducing agent. Here Cl undergoes simultaneous oxidation and reduction.

$$2KOH + \underset{0}{Cl_2} \rightarrow \underset{-1}{KCl} + \underset{+1}{KOCl} + H_2O.$$

51. **(d)** In disproportionation reaction, one element of a compound will simultaneously get reduced and oxidised. In ClO_4^-, oxidation number of Cl is + 7 and it can not increase it further. So, ClO_4^- will not get oxidised and so will not undergo disporportionation reaction.

52. **(d)** $3Br_2 + 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + BrO_3^- + 6HCO_3^-$

O.N. of Br_2 changes from 0 to –1 and +5 hence it is reduced as well as oxidised.

53. **(c)**

54. **(b)** Phosphorus, sulphur and chlorine disproportionate in the alkaline medium.

55. **(b)** $2H_2O \xrightarrow{\Delta} 2H_2 + O_2$

There is decomposition of H_2O molecule into H_2 and O_2.

56. **(a)** H^+ ions are added to the expression on the appropriate side so that the total ionic charges of reactants and products become equal.

57. **(d)** Since reaction is occuring in basic medium therefore $2OH^-$ are added on right side.

$$2MnO_4^-(aq) + Br^-(aq) \longrightarrow 2MnO_2(s) + BrO_3^-(aq) + 2OH^-(aq)$$

Now, hydrogen atoms balanced by adding one H_2O molecule to the left side

$$2MnO_4^-(aq) + Br^-(aq) + H_2O(\ell) \longrightarrow 2MnO_2(s) + BrO_3^-(aq) + 2OH^-(aq)$$

58. **(c)** The balanced equation :

$$2NH_3 + OCl^- \longrightarrow N_2H_4 + Cl^- + H_2O$$

59. **(b)** The balanced equation is

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O.$$

Ratio of the coefficients of CO_2 and H_2O is 4 : 6 or 2 : 3.

60. **(a)** $2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O.$

61. **(d)** $8KMnO_4 + 3NH_3 \longrightarrow 8MnO_2 + 3KNO_3 + 5KOH + 2H_2O$

62. **(b)**

Reduction

$$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$$

Oxidation

63. **(c)** On balancing the given reaction, we find

$$3Na_2HAsO_3 + NaBrO_3 + 6HCl \longrightarrow 6NaCl + 3H_3AsO_4 + NaBr$$

64. **(c)**

$$x\overset{0}{Cl_2} + 6OH^- \longrightarrow \overset{+5}{ClO_3} + y\overset{-1}{Cl^-} + 3H_2O$$

change in oxidation number = – 1

on balancing the eq we get

$$3Cl_2 + 6OH^- \longrightarrow ClO_3^- + 5Cl^- + 3H_2O$$

65. **(d)** Negative $E^\Theta \Rightarrow$ Stronger reducing agent or weaker oxidising agent

Positive $E^\Theta \Rightarrow$ Weaker reducing agent or stronger oxidising agent.

66. **(b)** Strongest oxidising agent = $Ag^+/Ag(s)$

Weakest oxidising agent = $Mg^{2+}/Mg(s)$

67. **(a)** More is E°_{RP}, more is the tendency to get itself reduced or more is oxidising power.

68. **(a)** Higher the value of reduction potential higher will be the oxidising power whereas the lower the value of reduction potential higher will be the reducing power.

69. **(c)** The redox couple with maximum reduction potential will be best oxidising agent and with minimum reduction potential will be best reducing agent.

70. **(a)** Since oxidation potential of Zn is highest hence strongest reducing agent.

71. **(a)**

Fe	Al	Br	
0.77	–1.66	1.08	E°_{Red}
–0.77	1.66	–1.08	E°_{Oxi}

Hence, reducing power $Al > Fe^{2+} > Br^-$

72. **(d)** More the negative reduction potential, more is the tendency to lose electron. The reducing power increases as the standard reduction potential becomes more and more negative.

Thus, Li is the strongest reducing agent as the standard reduction potential of Li^+/Li is most negative, –3.05 V.

73. **(a)** Lower the value of reduction potential higher will be reducing power hence the correct order will be $Mn^{2+} < Cl^- < Cr^{3+} < Cr$

74. **(d)**

75. **(d)** Order of decreasing electrode potentials of Mg, K, Ba and Ca is

$Mg > Ca > Ba > K$

It can be explained by their standard reduction potentials.

$$E^\circ_{K^+|K} = -2.925$$

$$E^\circ_{Ba^{2+}|Ba} = -2.90$$

$$E^\circ_{Ca^{2+}|Ca} = -2.87$$

$$E^\circ_{Mg^{2+}|Mg} = -2.37$$

Highly negative value of E°_{red} shows the least value of electrode potential.

76. **(a)** Standard electrode potential i.e. reduction potential of A is minimum (–3.05V) i.e. its oxidation potential is maximum which implies 'A' is most reactive chemically.

STATEMENT TYPE QUESTIONS

77. **(a)** For statement (iii), $HgCl_2$ is reduced to Hg_2Cl_2

78. **(b)** For statement (ii) reducing agents are donor of electrons.

79. **(b)** H_2O_2 is strong oxidizing than I_2, reduction potential of H_2O_2 is greater than that of I_2.

80. **(d)** All the given statements are correct.

81. **(a)** (i) $M^{n+} + ne^- \rightleftharpoons M$, for this reaction, high negative value of E° indicates lower reduction potential, that means M will be a good reducing agent.

$$\left[\begin{array}{c} \text{Stronger reducing agent} \Rightarrow \text{Easy to oxidise} \\ \Downarrow \\ \text{Lower reduction potential} \Leftarrow \text{higher oxidation potential} \end{array}\right]$$

(ii)

Element	F	Cl	Br	I
Reduction potential (E° volt)	+2.87	+1.36	+1.06	+0.54

As reduction potential decreases from fluorine to iodine, oxidising nature also decreases from fluorine to iodine.

(iii) The size of halide ions increases from F^- to I^-. The bigger ion can loose electron easily. Hence the reducing nature increases from HF to HI.

82. **(a)**

83. (a) –(4/3) is the average oxidation state of C in C_3H_4.

MATCHING TYPE QUESTIONS

84. **(b)** Oxidation is addition of electronegative or removal of electroposition element to a substance or removal of hydrogen from a substance.

Reduction is addition of electropositive or removal of electropositive element or removal of oxygen from a substance.

85. **(b)**

86. **(a)** $\underline{Cu}O \Rightarrow +2$

$\underline{Mn}O_2 \Rightarrow +4$

$H\underline{Au}Cl_4 \Rightarrow +3$

$\underline{Tl}_2O \Rightarrow +1$

87. **(b)**

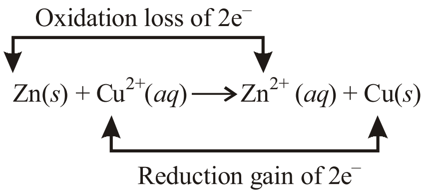
ASSERTION-REASON TYPE QUESTIONS

88. **(c)** In reaction $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ sodium is oxidised by loss of electrons and acts as a reducing agent (donor of electrons).

89. **(b)** Both Assertion and Reason are true but reason is not the correct explanation of assertion. Greater the number of negative atoms present in the oxy-acid make the acid stronger. In general, the strengths of acids that have general formula $(HO)_m ZO_n$ can be related to the value of n. As the value of n increases, acidic character also increases. The negative atoms draw electrons away from the Z-atom and make it more positive. The Z-atom, therefore, becomes more effective in withdrawing electron density away from the oxygen atom that bonded to hydrogen. In turn, the electrons of H – O bond are drawn more strongly away from the H-atom. The net effect makes it easier from the proton release and increases the acid a strength.

90. **(b)** Decomposition of calcium carbonate is not a redox reaction.

91. **(a)**



$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$$

CRITICAL THINKING TYPE QUESTIONS

92. **(c)** Calculating the oxidation state of nitrogen in given molecules;

Oxidation state of N in NH_3 is

$x + 3 \times (+1) = 0$ or $x = -3$

Oxidation state on N in $NaNO_3$ is

$1 + x + 3 \times (-2) = 0$ or $x = +5$

Oxidation state of N in NaN_3 is

$+1 + 3x = 0$ or $x = -\frac{1}{3}$

Oxidation state of N in Mg_3N_2 is

$3 \times 2 + 2x = 0$ or $x = -3$

Thus 3 molecules (i.e. NH_3, NaN_3 and Mg_3N_2 have nitrogen in negative oxidation state.

93. **(b)**

94. **(b)** Oxidation no. of O are + 2, 0, – 1/2 and – 1 respectively

95. **(d)** $PO_4^{3-} = x + 4(-2) = -3;\ x - 8 = -3;\ x = +5$

$SO_4^{2-} = x + 4(-2) = -2;\ x - 8 = -2;\ x = +6$

$Cr_2O_7^{2-} = 2x + 7(-2) = -2;\ 2x - 14 = -2;$

$2x = 12;\ x = +6$

96. **(b)** On reaction with hot and concentrated alkali a mixture of chloride and chlorate is formed

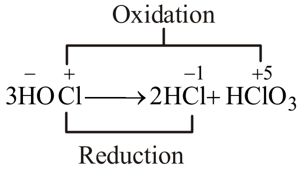
$$3Cl_2 + 3\,NaOH_{(excess)} \xrightarrow{Hot}$$
$$5Na\overset{-1}{Cl} + Na\overset{+5}{Cl}O_3 + 3H_2O$$

97. **(a)**

98. **(d)** In (i) and (ii) both P and S are in highest oxidation state. In (iii) and (iv) ; P has oxidation state of +4 which can be oxidized to +5 state, while in case of NH_3 nitrogen has oxidation state of –3 which can be oxidised.

99. **(c)** The redox reaction involve loss or gain of electron(s) i.e. change in oxidation state. Given reaction is not a redox reaction as this reaction involves no change in oxidation state of reactant or product.

100. **(b)** During disproportionation same compound undergo simultaneous oxidation reduction.



$$3\overset{-}{HO}\overset{+}{Cl} \longrightarrow 2H\overset{-1}{Cl} + H\overset{+5}{Cl}O_3$$

101. **(a)** $ClO_3^- \longrightarrow Cl_2^0$

$x - 6 = -1 \quad x = 0$

$x = +5 \quad x = 0\ (x = \text{oxidation number})$

$$\text{Equivalent mass} = \frac{\text{Molecular mass}}{\text{Oxidation number}} = \frac{84.45}{5} = 16.89$$

102. **(c)** On balancing the given equations, we get

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{++} + 10CO_2 + 8H_2O$$

So, $x = 2, y = 5\ \&\ z = 16$

103. (a) Given reaction is

$IO_3^- + aI^- + bH^+ \longrightarrow cH_2O + dI_2$

Ist half reaction

$I^- \longrightarrow I_2$ ...(i)

$-1 \quad 0$ (oxidation)

IInd half reaction

$IO_3^- \longrightarrow I_2$ ...(ii)

$+5 \quad 0$ (reduction)

On balancing equation (ii) we have

$10e^- + 2IO_3^- + 12H^+ \longrightarrow I_2 + 6H_2O$ ...(iii)

Now, balance equation (i)

$2I^- \longrightarrow I_2 + 2e^-$ ....(iv)

Multiply eqn (iv) by 5 and add it to eqn (iii), we get

$2IO_3^- + 10I^- + 12H^+ \longrightarrow 6I_2 + 6H_2O$

or, $IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$

Hence a = 5, b = 6, c = 3, d = 3

104. (a) Both Fe(ii) and S(iv) in SO_3^{2-} can be oxidised to Fe(iii) and $(SO_4)^{2-}$ respectively hence (3/5)×0.5 =0.3 moles / litre.

$$\left[MnO_4^- + 5e^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O\right] \times \frac{3}{5}$$

$$Fe^{2+} \longrightarrow Fe^{3+} + 1e^-$$

$$SO_3^{2-} \longrightarrow SO_4^{2-} + 2e^-$$

$$\frac{8}{5}MnO_4^- + \frac{24}{5}H^+ + Fe^{2+} + SO_3^{2-} \longrightarrow 3Mn^{2+} + 4H_2O + Fe^{3+} + SO_4^{2-}$$

105. (b) If one uses HCl, HBr or HI, to make acidic medium for $KMnO_4$ than all the halide ion can be oxidized as the reduction potential of $KMnO_4$ is very high in acidic medium, while in case of H_2SO_4, sulphur is already in its highest oxidation state cannot be further oxidized.

106. (d) Reduction potential of Cu(II) is greater than that of Zn(II) and Al(III) thus can be easily replaced by these ions. Moreover solution of copper is blue in color.

107. (d) F_2 is strongest oxididing agent among halogens thus X^- can be possibly Br^-, Cl^- or I^-.

CHAPTER 9

HYDROGEN

FACT/DEFINITION TYPE QUESTIONS

1. Following are some properties of hydrogen which of the following properties resemble with alkali metals and which with halogens

(i) Hydrogen lose one electron to form unipositive ions
(ii) Hydrogen gain one electron to form uninegative ions
(iii) Hydrogen forms oxides, halides and sulphides
(iv) Hydrogen has a very high ionization enthalpy
(v) Hydrogen forms a diatomic molecule, combines with elements to form hydrides and covalent compounds.

(a) Alkali metals resemble (i), (iii) and (iv)
Halogens resemble (ii) and (v)
(b) Alkali metals resemble (i) and (iii)
Halogens resemble (ii), (iii) and (v)
(c) Alkali metals resemble (i) and (iii)
Halogens resemble (ii), (iv) and (v)
(d) Alkali metals resemble (i) only
Halogens resemble (iv) and (v)

2. Hydrogen molecules differs from chlorine molecule in the following respect

(a) Hydrogen molecule is non-polar but chlorine molecule is polar
(b) Hydrogen molecule is polar while chlorine molecule is non-polar
(c) Hydrogen molecule can form intermolecular hydrogen bonds but chlorine molecule does not
(d) Hydrogen molecule cannot participate in coordination bond formation but chlorine molecule can

3. Hydrogen can behave as a metal

(a) at very high temperature
(b) at very low temperature
(c) at very high pressure
(d) at very low pressure

4. The property of hydrogen which distinguishes it from alkali metals is

(a) its electropositive character
(b) its affinity for non metal
(c) its reducing character
(d) its non-metallic character

5. Hydrogen accepts an electron to form inert gas configuration. In this it resembles

(a) halogen (b) alkali metals
(c) chalcogens (d) alkaline earth metals

6. Which of the following statements is correct ?

(a) Hydrogen has same IP as alkali metals
(b) Hydrogen has same electronegativity as halogens
(c) It has oxidation number of –1 and +1
(d) It will not be liberated at anode

7. Why does H^+ ion always get associated with other atoms or molecules?

(a) Ionisation enthalpy of hydrogen resembles that of alkali metals.
(b) Its reactivity is similar to halogens.
(c) It resembles both alkali metals and halogens.
(d) Loss of an electron from hydrogen atom results in a nucleus of very small size as compared to other atoms or ions. Due to small size it cannot exist free.

8. Which one of the following is not an isotope of hydrogen ?

(a) Deuterium (b) Tritium
(c) Ortho hydrogen (d) None of these

9. Number of neutrons in three isotopes of hydrogen, protium, deuterium and tritium respectively is

(a) 0, 1, 2 (b) 1, 1,1
(c) 2, 1, 0 (d) 2, 0, 1

10. Which isotope(s) of hydrogen is/are radioactive and emits low energy β^- particles?

(i) Protium (ii) Tritium
(iii) Deuterium

(a) (i) and (ii) (b) (iii) only
(c) (ii) only (d) (ii) and (iii)

11. Hydrogen bond energy is equal to :

(a) 3-7 cals (b) 30-70 cals
(c) 3-10 kcals (d) 30-70 kcals

12. Which of the following reaction(s) represents commercial method for production of dihydrogen?

(i) $CO(g) + H_2O(g) \xrightarrow[catalyst]{673\,K} CO_2(g) + H_2(g)$
(ii) $2H_2O(l) \xrightarrow[\text{traces of acid/base}]{\text{electrolysis}} 2H_2(g) + O_2(g)$
(iii) $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$
(iv) $CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270K} CO(g) + 3H_2(g)$

(a) (i), (ii) and (iii) (b) (iii) only
(c) (i), (ii) and (iv) (d) (ii), (iii) and (iv)

13. Which of the following is formed when zinc reacts with sodium hydroxide?
(a) Hydrogen gas (b) Sodium zincate
(c) Zinc oxide (d) Both (a) and (b)

14. Identify *x* and *y* in following reaction. What is the mixture of *x* and *y* called?

$CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270K} x + y$

(a) $x = CO_2$, $y = H_2O$, water gas
(b) $x = CO$, $y = H_2O$, syn gas
(c) $x = CO$, $y = H_2$, water gas
(d) $x = CO_2$, $y = H_2$, syn gas

15. Why is water gas (mixture of CO and H_2) also called 'syn gas'?
(a) Because it is synthesised from sewage, saw – dust, scrap wood etc.
(b) Because it is synthesised from methane gas
(c) Because it is used in the synthesis of methanol and a number of hydrocarbons.
(d) None of these

16. Which of the following statements is correct?
(a) Production of syngas from coal is called coal gasification.
(b) $CO(g) + H_2O(g) \xrightarrow[catalyst]{673K} CO_2(g) + H_2(g)$ represents water gas shift reaction.
(c) CO_2 formed in water gas shift reaction is removed by scrubbing with sodium zincate solution.
(d) Both (a) and (b)

17. Which one of the following pairs of substances on reaction will not evolve H_2 gas?
(a) Iron and H_2SO_4 (aqueous)
(b) Iron and steam
(c) Copper and HCl (aqueous)
(d) Sodium and ethyl alcohol

18. Which of the following metal evolves hydrogen on reacting with cold dilute HNO_3 ?
(a) Mg (b) Al
(c) Fe (d) Cu

19. Hydrogen is evolved by the action of cold dil. HNO_3 on
(a) Fe (b) Mn
(c) Cu (d) Al

20. In Bosch's process which gas is utilised for the production of hydrogen gas ?
(a) Producer gas (b) Water gas
(c) Coal gas (d) None of these

21. Hydrogen is not obtained when zinc reacts with
(a) Cold water (b) dil. HCl
(c) dil. H_2SO_4 (d) Hot NaOH (20%)

22. Which one of the following pairs of substances will not produce hydrogen when reacted together?
(a) Copper and conc. nitric acid
(b) Ethanol and metallic sodium
(c) Magnesium and steam
(d) Phenol and metallic sodium

23. Very pure hydrogen (99.9) can be made by which of the following processes ?
(a) Reaction of methane with steam
(b) Mixing natural hydrocarbons of high molecular weight
(c) Electrolysis of water
(d) Reaction of salts like hydrides with water

24. Which of the following is formed on reaction of carbon monoxide gas with dihydrogen in presence of cobalt as a catalyst?
(a) Methanal (b) Methanol
(c) Methane (d) Formic acid

25. Which of the following is not a use of dihydrogen ?
(a) It used in fuel cells for generating electrical energy.
(b) Atomic hydrogen and oxy-hydrogen torches are used for cutting and welding purposes.
(c) It used in the synthesis of hydroquinone and tartaric acid.
(d) Both (b) and (c)

26. Elements of which of the following group do not form hydrides?
(a) Alkali metals (b) Halogens
(c) Alkaline earth metals (d) Noble gases

27. Which of the following statements is incorrect?
(a) Ionic hydrides are stoichiometric compounds of dihydrogen formed with most of *s*-block elements
(b) Ionic hydrides are crystalline, non-volatile and non-conducting in solid state.
(c) Melts of ionic hydrides conduct electricity and liberate dihydrogen gas at cathode.
(d) Both (a) and (c)

28. Saline hydrides react explosively with water, such fires can be extinguished by
(a) water (b) carbon dioxide
(c) sand (d) None of these

29. Choose the correct option for following hydrides.
B_2H_6, CH_4, NH_3 and HF
(a) Electron deficient hydride = B_2H_6 and HF
Electron precise hydride = CH_4
Electron rich hydride = NH_3
(b) Electron deficient hydride = B_2H_6
Electron precise hydride = CH_4
Electron rich hydride = NH_3 and HF
(c) Electron deficient hydride = CH_4
Electron precise hydride = B_2H_6
Electron rich hydride = NH_3 and HF
(d) Electron deficient hydride = CH_4 and HF
Electron precise = B_2H_6
Electron rich hydride = NH_3,

30. Elements of which of the following group(s) of periodic table do not form hydrides.
(a) Groups 7, 8, 9 (b) Group 13
(c) Groups 15, 16, 17 (d) Group 14

31. Which hydride is an ionic hydride ?
(a) H_2S (b) $TiH_{1.73}$
(c) NH_3 (d) NaH

32. Metal hydride on treatment with water gives
(a) H_2O_2 (b) H_2O
(c) Acid (d) Hydrogen

33. The polymeric hydride is
(a) CaH_2 (b) NaH
(c) BaH_2 (d) MgH_2

34. Ionic hydrides reacts with water to give
(a) acidic solutions (b) hydride ions
(c) basic solutions (d) electrons

35. Which of the following in incorrect statement?
(a) s-block elements, except Be and Mg, form ionic hydride
(b) BeH_4, MgH_2, CuH_2, ZnH_2, CaH_2 and HgH_2 are intermediate hydride
(c) p-block elements form covalent hydride
(d) d-and f-block elements form ionic hydride

36. Metal hydrides are ionic, covalent or molecular in nature. Among LiH, NaH, KH, RbH, CsH, the correct order of increasing ionic character is
(a) LiH > NaH > CsH > KH > RbH
(b) LiH < NaH < KH < RbH < CsH
(c) RbH > CsH > NaH > KH > LiH
(d) NaH > CsH > RbH > LiH > KH

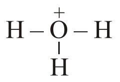
37. $LiAlH_4$ is used as :
(a) An oxidizing agent (b) A reducing agent
(c) A mordant (d) A water softener

38. Water is :
(a) more polar than H_2S
(b) more or less identical in polarity with H_2S
(c) less polar than H_2S
(d) None of these

39. In gas phase water is __A__ molecule with a bond angle of __B__ and O–H bond length of __C__
(a) A = Bent, B = 100.5°, C = 95.7 pm
(b) A = Bent, B = 104.5°, C = 95.7 pm
(c) A = Bent, B = 109.5°,C = 99.7 pm
(d) A = Bent, B = 104.5°, C = 99.7 pm

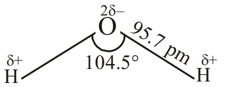
40. The H–O–H angle in water molecule is about
(a) 90º (b) 180º
(c) 102.5° (d) 104.5º

41. Identify the structuer of water in the gaseous phase.
(a) $H-\ddot{\underset{\cdot\cdot}{O}}-H$ (b)



$H-\overset{+}{\underset{|\atop H}{O}}-H$

(c)



(d) None of these

42. The unusual properties of water in the condensed phase (liquid and solid states) are due to the
(a) presence of hydrogen and covalent bonding between the water molecules
(b) presence of covalent bonding between the water molecules
(c) presence of extensive hydrogen bonding between water molecules
(d) presence of ionic bonding

43. The boiling point of water is exceptionally high because
(a) there is covalent bond between H and O
(b) water molecule is linear
(c) water molecules associate due to hydrogen bonding
(d) water molecule is not linear

44. Water possesses a high dielectric constant, therefore :
(a) it always contains ions
(b) it is a universal solvent
(c) can dissolve covalent compounds
(d) can conduct electricity

45. At its melting point ice is lighter than water because
(a) H_2O molecules are more closely packed in solid state
(b) ice crystals have hollow hexagonal arrangement of H_2O molecules.
(c) on melting of ice the H_2O molecule shrinks in size
(d) ice froms mostly heavy water on first melting.

46. The low density of ice compared to water is due to
(a) hydrogen-bonding interactions
(b) dipole-dipole interactions
(c) dipole-induced dipole interactions
(d) induced dipole-induced dipole interactions

47. When two ice cubes are pressed over each other, they unite to form one cube. Which of the following forces is responsible to hold them together ?
(a) Hydrogen bond formation
(b) Van der Waals forces
(c) Covalent attraction
(d) Ionic interaction

48. Which of the following reactions is an example of use of water gas in the synthesis of other compounds?
(a) $CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270K} CO(g) + H_2(g)$
(b) $CO(g) + H_2O(g) \xrightarrow[Catalyst]{673K} CO_2(g) + H_2(g)$
(c) $C_nH_{2n+2} + nH_2O\,(g) \xrightarrow[Ni]{1270K} nCO + (2n+1)H_2$
(d) $CO(g) + 2H_2(g) \xrightarrow[Catalyst]{Cobalt} CH_3OH(l)$

49. Which of the following metals reacts with H_2O at room temp?
(a) Ag (b) Fe
(c) Al (d) Na

50. Which of the following statements do not define the characteristic property of water "Water is a universal solvent"
(a) It can dissolve maximum number of compounds
(b) It has very low dielectric constant
(c) It has high liquid range
(d) None of these

51. Which of the following groups of ions makes the water hard?
(a) Sodium and bicarbonate
(b) Magnesium and chloride
(c) Potassium and sulphate
(d) Ammonium and chloride.

52. The process used for the removal of hardness of water is
(a) Calgon (b) Baeyer
(c) Serpeck (d) Hoope

53. When zeolite (hydrated sodium aluminium silicate) is treated with hard water the sodium ions are exchanged with
(a) H^+ ions (b) Ca^{2+} ions
(c) SO_4^{2-} ions (d) OH^- ions

54. Calgon used as a water softener is
(a) $Na_2[Na_4(PO_3)_6]$ (b) $Na_4[Na_2(PO_3)_6]$
(c) $Na_4[Na_4(PO_4)_5]$ (d) $Na_4[Na_2(PO_4)_6]$

55. Polyphosphates are used as water softening agents because they
(a) form soluble complexes with anionic specise
(b) precipitate anionic species
(c) forms soluble complexes with cationic species
(d) precipitate cationic species

56. Permanent hardness of water can be removed by adding Calgon $(NaPO_3)_n$. This is an example of
(a) Adsorption (b) Exchange of ion
(c) Precipitation (d) None

57. Which one the following removes temporary hardness of water ?
(a) Slaked lime (b) Plaster of Paris
(c) Epsom (d) Hydrolith

58. Permanent hardness of water is due to the presence of
(a) bicarbonates of sodium and potassium
(b) chlorides and sulphates of sodium and potassium
(c) chlorides and sulphates of calcium and magnesium
(d) bicarbonates of calcium and magnesium

59. In lab H_2O_2 is prepared by
(a) Cold $H_2SO_4 + BaO_2$ (b) $HCl + BaO_2$
(c) Conc. $H_2SO_4 + Na_2O_2$ (d) $H_2 + O_2$

60. HCl is added to following oxides. Which one would give H_2O_2
(a) MnO_2 (b) PbO_2
(c) BaO (d) None

61. The oxide that gives H_2O_2 on treatment with dilute H_2SO_4 is–
(a) PbO_2 (b) BaO_2
(c) MnO_2 (d) TiO_2

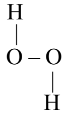
62. 30 volume hydrogen peroxide means
(a) 30% of H_2O_2 solution
(b) 30 cm^3 solution contains 1g of H_2O_2
(c) 1 cm^3 of solution liberates 30 cm^3 of O_2 at STP
(d) 30 cm^3 of solution contains 1 mole of H_2O_2

63. The volume strength of 1.5 N H_2O_2 solution is :
(a) 8.4 (b) 8.0
(c) 4.8 (d) 3.0

64. Commercial 10 volume H_2O_2 is a solution with a strength of approximately
(a) 15% (b) 3%
(c) 1% (d) 10%

65. The structure of H_2O_2 is
(a) planar (b) non planar
(c) spherical (d) linear

66. The O – O – H bond angle in H_2O_2 is
(a) 106° (b) 109°28'
(c) 120° (d) 94.8°

67. Which of the following is the true structure of H_2O_2 ?
(a) H– O – O – H (b)


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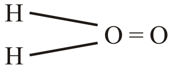
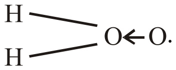


(d)


68. In the hydrogen peroxide molecule :
(a) O – H bonds are polar but molecule is non-polar.
(b) The four atoms are arranged in a non-linear and non-planar manner.
(c) All the four atoms are in same plane.
(d) Two hydrogen atoms are connected to one of the oxygen.

69. H_2O_2 is a
(a) Weak acid (b) Weak base
(c) Neutral (d) None of these

70. When H_2O_2 is oxidised the product is
(a) OH^- (b) O_2
(c) O^{2-} (d) HO_2^-

71. Which of the following is false about H_2O_2
(a) Act as both oxidising and reducing agent
(b) Two OH bonds lies in the same plane
(c) Pale blue liquid
(d) Can be oxidised by ozone

72. In which of the following reactions, H_2O_2 acts as a reducing agent
(a) $PbO_2(s) + H_2O_2(aq) \rightarrow PbO(s) + H_2O(\ell) + O_2(g)$
(b) $Na_2SO_3(aq) + H_2O_2(aq) \rightarrow Na_2SO_4(aq) + H_2O(\ell)$
(c) $2KI(aq) + H_2O_2(aq) \rightarrow 2KOH(aq) + I_2(s)$
(d) $KNO_2(aq) + H_2O_2(aq) \rightarrow KNO_3(aq) + H_2O(\ell)$

73. $H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$; E° = –0.68 V. This equation represents which of the following behaviour of H_2O_2.
(a) Reducing (b) Oxidising
(c) Acidic (d) Catalytic

74. The reaction
$H_2S + H_2O_2 \longrightarrow S + 2H_2O$ manifests
(a) Acidic nature of H_2O_2
(b) Alkaline nature of H_2O_2
(c) Oxidising action of H_2O_2
(d) Reducing action of H_2O_2.

75. Which of the following statements is incorrect ?
(a) H_2O_2 can act as an oxidising agent
(b) H_2O_2 can act as a reducing agent
(c) H_2O_2 has acidic properties
(d) H_2O_2 has basic properties

76. Consider the reactions

(A) $H_2O_2 + 2HI \rightarrow I_2 + 2H_2O$

(B) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$

Which of the following statements is correct about H_2O_2 with reference to these reactions? Hydrogen peroxide is ______ .

(a) an oxidising agent in both (A) and (B)
(b) an oxidising agent in (A) and reducing agent in (B)
(c) a reducing agent in (A) and oxidising agent in (B)
(d) a reducing agent in both (A) and (B)

77. Which of the following equations depict the oxidising nature of H_2O_2?

(a) $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$
(b) $2Fe^{3+} + 2H^+ + H_2O_2 \rightarrow 2Fe^{2+} + 2H_2O + O_2$
(c) $2I^- + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$
(d) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$

78. Which one of the following undergoes reduction with hydrogen peroxide in an alkaline medium ?

(a) Mn^{2+} (b) HOCl
(c) PbS (d) I_2

79. Which of the following does not represent reducing action of H_2O_2?

(a) $PbS(s) + 4H_2O_2(aq) \rightarrow PbSO_4(s) + 4H_2O(l)$
(b) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$
(c) $2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$
(d) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

80. Which of the following is not true for hydrogen peroxide?

(a) H_2O_2 decomposes slowly on exposure to light.
(b) It is kept away from dust because dust can induce explosive decomposition of the compound.
(c) H_2O_2 is used as bleaching agent for textiles, paper pulp etc.
(d) It is used as a moderator in nuclear reactor.

81. The decomposition of H_2O_2 is accelerated by –

(a) glycerine (b) alcohol
(c) phosphoric acid (d) Pt powder

82. H_2O_2 is always stored in black bottles because

(a) It is highly unstable
(b) Its enthalpy of decomposition is high
(c) It undergo auto-oxidation on prolonged standing
(d) None of these

83. H_2O_2 is

(a) Poor polar solvent than water
(b) Better polar solvent than H_2O
(c) Both have equal polarity
(d) Better polar solvent but its strong auto-oxidising ability limits its use as such

84. Which of the following is wrong about H_2O_2? It is used

(a) As aerating agent in production of spong rubber
(b) As an antichlor
(c) For restoring white colour of blackened lead painting
(d) None of these

85.. Heavy water is represented as

(a) $H_2\,^{18}O$ (b) D_2O
(c) $D_2\,^{18}O$ (d) H_2O at 4°C

86. What is formed when calcium carbide reacts with heavy water?

(a) C_2D_2 (b) CaD_2
(c) Ca_2D_2O (d) CD_2

87. D_2O is used in

(a) motor vehicles (b) nuclear reactor
(c) medicine (d) insecticide

88. Complete the following reaction.

$Al_4C_3 + D_2O \rightarrow x + y$

(a) $x = C_2D_2$ and $y = Al(OD)_3$
(b) $x = CD_4$ and $y = Al(OD)_3$
(c) $x = CO_2$ and $y = Al_2D_3$
(d) $x = CD_4$ and $y = Al_2D_3$

89. Which of the following is correct about heavy water ?

(a) Water at 4°C having maximum density is known as heavy water
(b) It is heavier than water (H_2O)
(c) It is formed by the combination of heavier isotope of hydrogen with oxygen
(d) None of these

90. D_2O is preferred to H_2O, as a moderator, in nuclear reactors because

(a) D_2O slows down fast neutrons better
(b) D_2O has high specific heat
(c) D_2O is cheaper
(d) None of these

91. The numbers of protons, electrons and neutrons in a molecule of heavy water are respectively :

(a) 8, 10, 11 (b) 10, 10, 10
(c) 10, 11, 10 (d) 11, 10, 10

92. Choose the incorrect statement

(a) Dihydrogen can release more energy than petrol.
(b) The only pollutant in combustion of dihydrogen is carbon dioxide.
(c) Hydrogen economy is based on the principle of transportation and storage of energy in the form of liquid or gaseous dihydrogen
(d) Hydrogen economy has advantage that energy is transmitted in the form of dihydrogen and not as electric power.

93. Which of the following fuel is used for runnning the automobiles first time in the history of India during October 2005?

(a) D_2O (b) H_2O_2
(c) D_2 (d) H_2

STATEMENT TYPE QUESTIONS

94. The storage tanks used for H_2 are made up of which metal alloy(s)

(i) $NaNi_5$ (ii) B_2H_6
(iii) $Ti–TiH_2$ (iv) $Mg–MgH_2$

(a) (iii) and (iv) (b) (i) and (ii)
(c) (i), (iii) and (iv) (d) (ii), (iii) and (iv)

95. Which of the following sequence of T and F is correct for given statements? Here T stands for true and F stands for false statement

(i) The H–H bond dissociation enthalpy is highest for a single bond between two atoms of any element

(ii) H_2 is relatively inert at room temperature.

(iii) Hydrogen combines with almost all the elements due to its incomplete orbital

(iv) The atomic hydrogen is produced at high temperature in an electric arc or under UV radiations.

(a) TTTT (b) FTFT

(c) FTTT (d) FTTF

96. Which of the following statement(s) is/are incorrect?

(i) Dihydrogen reduces copper (II) oxide to copper

(ii) Reaction of dihydrogen with sodium gives sodium hydride.

(iii) Hydroformylation of olefins yields aldehydes which further undergo reduction to give alcohols.

(iv) Hydrogenation of vegetable oils using iron as catalyst gives edible fats.

(a) (i), (ii) and (iii) (b) (i) and (iv)

(c) (iv) only (d) (iii) and (iv)

97. Choose the correct sequence of T and F for following statements. Here T stands for true and F stands for false statement.

(i) At atmospheric pressure ice crystallises in the hexagonal form, but at very low temperatures it condenses to cubic form.

(ii) Density of ice is less than that of water. Therefore, an ice cube floats on water.

(iii) In winter season ice formed on the surface of a lake makes survival of the aquatic life difficult.

(iv) Hydrogen bonding gives ice a open type structure with wide holes.

(a) TTFT (b) FTFT

(c) FTTT (d) TFTT

98. Which of the following statements are correct ?

(i) Hydrogen peroxide is industrially prepared by the auto-oxidation of 2-alkylanthraquinols

(ii) One millilitre of 30% H_2O_2 means that solution will give 100 V of oxygen at STP

(iii) Dihedral angle of H_2O_2 in gas phase is 90.2° and in solid phase dihedral angle is 111.5°

(a) (i), (ii) and (iii) (b) (i) and (iii)

(c) (ii) and (iii) (d) (i) and (ii)

99. Some statements about heavy water are given below:

(i) Heavy water is used as a moderator in nuclear reactors.

(ii) Heavy water is more associated than ordinary water.

(iii) Heavy water is more effective solvent than ordinary water.

Which of the above statements are correct?

(a) (i) and (iii) (b) (i) and (ii)

(c) (i), (ii) and (iii) (d) (ii) and (iii)

MATCHING TYPE QUESTIONS

100. Match the columns

	Column-I		Column-II
(A)	Ionic hydrides	(p)	$NiH_{0.6\text{-}0.7}$
(B)	Molecular hydrides	(q)	LiH
(C)	Metallic hydrides	(r)	HF

(a) A – (q), B – (r), C – (p)

(b) A – (r), B – (q), C – (p)

(c) A – (q), B – (p), C – (r)

(d) A – (r), B – (p), C – (q)

101. Match the columns

	Column - I (Chemical property of water)		Column - II (Chemical equation)
(A)	Basic nature	(p)	$2H_2O(l) + 2Na(s) \longrightarrow 2NaOH(aq) + H_2(g)$
(B)	Auto-protolysis	(q)	$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$
(C)	Oxidising nature	(r)	$2F_2(g) + 2H_2O(l) \longrightarrow 4H^+(aq) + 4F^-(aq) + O_2(g)$
(D)	Reducing nature	(s)	$H_2O(l) + H_2S(aq) \rightleftharpoons H_3O^+(aq) + HS^-(aq)$

(a) A – (s), B – (q), C – (r), D – (p)

(b) A – (s), B – (q), C – (p), D – (r)

(c) A – (r), B – (q), C – (s), D – (p)

(d) A – (p), B – (q), C – (s), D – (r)

102. Match the columns

	Column-I		Column-II
(A)	Clark's method	(p)	$Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + Mg(OH)_2\downarrow + 2H_2O$
(B)	Calgon's method	(q)	$2NaZ(s) + M^{2+}(aq) \rightarrow MZ_2(s) + 2Na^+(aq)$
(C)	Boiling	(r)	$Ca(HCO_3)_2 \rightarrow CaCO_3\downarrow + H_2O + CO_2\uparrow$
(D)	Ion exchange method	(s)	$M^{2+} + Na_4P_6O_{18}^{2-} \rightarrow [Na_2MP_6O_{18}]^{2-} + 2Na^+$

(a) A – (s), B – (q), C – (r), D – (p)

(b) A – (q), B – (p), C – (r), D – (s)

(c) A – (p), B – (s), C – (r), D – (q)

(d) A – (r), B – (q), C – (p), D – (s)

103. Match the columns

	Column-I		Column-II
(A)	Coordinated water	(p)	$[Cu(H_2O)_4]^{4+}SO_4^{2-}.H_2O$
(B)	Interstitial water	(q)	$C_{17}H_{35}COONa$
(C)	Hydrogen-bonded water	(r)	$BaCl_2.2H_2O$
		(s)	$[Cr(H_2O)_6]^{3+}3Cl^-$

(a) A – (r), B – (s), C – (q)

(b) A – (q), B – (r), C – (s)

(c) A – (r), B – (q), C – (p)

(d) A – (s), B – (r), C – (p)

104. Match the columns

	Column-I		**Column-II**
(A)	Heavy water	(p)	Bicarbonates of Mg and Ca in water
(B)	Temporary hard water	(q)	No foreign ions in water
(C)	Soft water	(r)	D_2O
(D)	Permanent hard water	(s)	Sulphates & chlorides of Mg & Ca in water

(a) A – (r), B – (s), C – (q), D – (p)
(b) A – (q), B – (r), C – (s), D – (s)
(c) A – (q), B – (s), C – (r), D – (p)
(d) A – (r), B – (p), C – (q), D – (s)

105. Match the Column-I with Column-II and mark the appropriate choice.

	Column-I		**Column-II**
(A)	Syngas	(p)	$Na_6P_6O_{18}$
(B)	Calgon	(q)	$NaAlSiO_4$
(C)	Permutit	(r)	$CO + H_2$
(D)	Producer gas	(s)	$CO + N_2$

(a) (A) – (p), (B) – (q), (C) – (r), (D) – (s)
(b) (A) – (r), (B) – (p), (C) – (q), (D) – (s)
(c) (A) – (r), (B) – (q), (C) – (s), (D) – (p)
(d) (A) – (r), (B) – (q), (C) – (p), (D) – (s)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

106. Assertion : H^+ does not exist freely and is always associated with other atoms or molecules.
Reason : Loss of the electron from hydrogen atom results in nucleus (H^+) of ~ 1.5×10^{-3} pm size. This is extremely small as compared to normal atomic and ionic sizes of 50 to 200 pm.

107. Assertion : Hydrogen combines with other elements by losing, gaining or sharing of electrons.
Reason : Hydrogen forms electrovalent and covalent bonds with other elements.

108. Assertion : Temporary hardness can be removed by boiling.
Reason : On boiling the soluble bicarbonates change to carbonates which being insoluble, get precipitated.

109. Assertion : Calgon is used for removing permanent hardness of water.
Reason : Calgon forms precipitates with Ca^{2+} and Mg^{2+}.

110. Assertion : Hard water is not suitable for laundary.
Reason : Soap containing sodium stearate reacts with hard water to precipitate out as calcium or magnesium stearate.

111. Assertion : Decomposition of H_2O_2 is a disproportionation reaction.
Reason : H_2O_2 molecule simultaneously undergoes oxidation and reduction.

112. Assertion : H_2O_2 is not stored in glass bottles.
Reason : Alkali oxides present in glass catalyse the decomposition of H_2O_2

CRITICAL THINKING TYPE QUESTIONS

113. Hydrogen will not reduce
(a) heated cupric oxide
(d) heated ferric oxide
(c) heated stannic oxide
(d) heated aluminium oxide

114. Which of the following terms is not correct for hydrogen ?
(a) Its molecule is diatomic
(b) It exists both as H^+ and $H^–$ in different chemical compounds
(c) It is the only species which has no neutrons in the nucleus
(d) Heavy water is unstable because hydrogen is substituted by its isotope deuterium

115. The sum of the number of neutrons and protons in all the three isotopes of hydrogen is
(a) 6
(b) 5
(c) 4
(d) 3

116. The hydride ion, $H^–$, is a stronger base than the hydroxide ion, $OH^–$. Which one of the following reactions will occur if sodium hydride (NaH) is dissolved in water?
(a) $H^-(aq) + H_2O(l) \rightarrow H_3O^-(aq)$
(b) $H^-(aq) + H_2O(l) \rightarrow OH^-(aq) + H_2(g)$
(c) $H^-(aq) + H_2O(l) \rightarrow OH^-(aq) + 2H^+(aq) + 2e$
(d) $H^-(aq) + H_2O(l) \rightarrow \text{No reaction}$

117. The reaction of $H_2S + H_2O_2 \rightarrow S + 2H_2O$ manifests
(a) Acidic nature of H_2O_2
(b) Alkaline nature of H_2O_2
(c) Oxidising nature of H_2O_2
(d) Reducing action of H_2O_2

118. Which of the following is not true?
(a) D_2O freezes at lower temperature than H_2O
(b) Reaction between H_2 and Cl_2 is much faster than D_2 and Cl_2
(c) Ordinary water gets electrolysed more rapidly than D_2O
(d) Bond dissociation energy of D_2 is greater than H_2

119. Heavy water reacts respectively with CO_2, SO_3, P_2O_5 and N_2O_5 to give the compounds :
(a) $D_2CO_3, D_2SO_4, D_3PO_2, DNO_2$
(b) $D_2CO_3, D_2SO_4, D_3PO_4, DNO_2$
(c) $D_2CO_3, D_2SO_3, D_3PO_4, DNO_2$
(d) $D_2CO_3, D_2SO_4, D_3PO_4, DNO_3$

120. Identify x and y in following reaction:

$$2HSO_4^-(aq) \xrightarrow{\text{electrolysis}} x \xrightarrow{\text{hydrolysis}} y + 2H^+(aq) + H_2O_2(aq)$$

(a) $x = H_2SO_4\ (aq),\ y = 2HSO_4^-(aq)$
(b) $x = HO_3SOOSO_3H(aq),\ y = 2HSO_4^-(aq)$
(c) $x = HO_3SOOSO_3H\ (aq),\ y = H_2SO_4(aq)$
(d) $x = H_2SO_4(aq)\ ,\ y = HO_3SOOSO_3H(aq)$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** (i) and (iii) are properties of hydrogen which shows its resemblance with alkali metals whereas (ii) , (iv) and (v) shows resemblance with halogens.

2. **(d)** Chlorine has lone pair which it can donate to form coordinate bond while hydrogen cannot.

3. **(c)** Hydrogen behaves as a metal at very high pressure.

4. **(d)** Hydrogen is a non-metal while all other members of group 1 (alkali metals) are metals.

5. **(a)** $\mathbf{H + e^-}\ (1s^1) \rightarrow \mathbf{H^-}\ (1s^2 \text{ or } [\mathrm{He}])$

$\mathbf{F + e^-}([\mathrm{He}]2s^2 2p^5) \rightarrow \mathbf{F^-}\ (\ [\mathrm{He}]\ 2s^2\ 2p^6 \text{ or } [\mathrm{Ne}])$

6. **(c)** In metal hydrides the O.S. of hydrogen –1 otherwise it is +1.

7. **(d)**

8. **(c)** (i) Protium, deuterium and tritium are isotopes of hydrogen.

(ii) Ortho and para hydrogens are allotropes of hydrogen. In ortho hydrogen, protons are spinning in same direction (parallel spin), while in para hydrogen, protons spin in opposite direction (antiparallel).

9. **(a)** Number of neutrons in protium, deuterium and tritium respectively is = 0, 1 and 2

10. **(c)** Tritium is radioactive and emits low energy β^- particles.

11. **(c)** Hydrogen bond is weak force of attraction existing between molecules. Its energy is equal to 3-10 k cal

12. **(c)** Except method given in statement (iii) all other are commercial methods for production of dihydrogen.

13. **(d)** $\mathrm{Zn + 2NaOH \longrightarrow \underset{(Sodium\ zincate)}{Na_2ZnO_2} + H_2}$

14. **(c)** $\mathrm{CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270\,K} CO + 3H_2}$

Mixture of CO and H_2 is called water gas.

15. **(c)** Mixture of CO and H_2 is used in synthesis of methanol and a number of hydrocarbons due to this reason it is also called syn gas.

16. **(d)** Carbon dioxide formed in water gas shift reaction is removed by scrubbing with sodium arsenite solution.

17. **(c)** $\mathrm{Fe + dil.\,H_2SO_4 \rightarrow FeSO_4 + H_2\uparrow}$

$\mathrm{3Fe + \underset{Steam}{4H_2O} \rightarrow Fe_3O_4 + 4H_2\uparrow}$

$\mathrm{Cu + dil.\ HCl \rightarrow}$ No reaction

Copper does not evolve H_2 from acid as it is below hydrogen in electrochemical series.

$\mathrm{2Na + 2C_2H_5OH \rightarrow 2C_2H_5ONa + H_2\uparrow}$

18. **(a)** $\mathrm{Mg + dil.\ HNO_3 \rightarrow Mg(NO_3)_2 + H_2}$ (Mg and Mn give H_2 with dil HNO_3)

19. **(b)** $\mathrm{Mn + 2HNO_3\,(dil.) \rightarrow Mn(NO_3)_2 + H_2}$

20. **(b)** $\mathrm{\underbrace{CO + H_2}_{water\ gas} + H_2O \xrightarrow{catalyst} CO_2 + 2H_2}$

21. **(a)** Zinc has no action on cold water.

22. **(a)** $\mathrm{Cu + 4HNO_3(conc.) \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O}$

$\mathrm{C_2H_5OH + Na \longrightarrow C_2H_5O^-Na^+ + 1/2H_2\uparrow}$

$\mathrm{Mg + 2H_2O(steam) \longrightarrow Mg(OH)_2 + H_2\uparrow}$

$\mathrm{C_6H_5OH + Na \longrightarrow C_6H_5O^-Na^+ + 1/2H_2\uparrow}$

$\mathrm{NaH + H_2O \longrightarrow NaOH + H_2\uparrow}$

23. **(d)** Very pure hydrogen can be prepared by the action of water on sodium hydride.

$\mathrm{NaH + H_2O \longrightarrow NaOH + \underset{(very\ pure\ Hydrogen)}{H_2}}$

24. **(b)** $\mathrm{CO(g) + 2H_2(\mathit{g}) \xrightarrow[catalyst]{cobalt} CH_3OH(\mathit{l})}$

25. **(c)** Hydrogen is not used in the synthesis of hydroquinone and tartaric acid.

26. **(d)** Almost all elements except noble gases, forms hydrides.

27. **(c)** Melts of ionic hydrides conduct electricity and liberate dihydrogen gas at anode.

28. **(c)** Fire due to action of water on saline hydrides cannot be extinguished with water or CO_2. These hydrides can reduce CO_2 at high temperature to produce O_2.

29. **(b)** Electron deficient hydride = B_2H_6

Electron precise = CH_4

Electron rich = NH_3 and HF

30. **(a)**

31. **(d)** All metal hydrides are ionic in nature.

32. **(d)** Metal hydride + $H_2O \rightarrow$ Metal hydroxide + H_2

33. **(d)** Due to its covalent nature MgH_2 is Polymeric in nature.

34. **(c)** Ionic hydrides give the basic solution when it reacts with water, e.g.,

$\mathrm{LiH + H_2O \longrightarrow LiOH + H_2}$

35. **(d)** d- and f-block elements form metallic hydride. While p-block elements form covalent hydrides, s-block elements except Be and Mg form ionic hydrides. Hydrides of Be, Mg, Cu, Zn, Ca and Hg are intermediate hydride.

36. **(b)**

37. **(b)** $\mathrm{LiH + AlCl_3 \longrightarrow (AlH_3)_n \xrightarrow[LiH]{excess} Li[AlH_4]}$

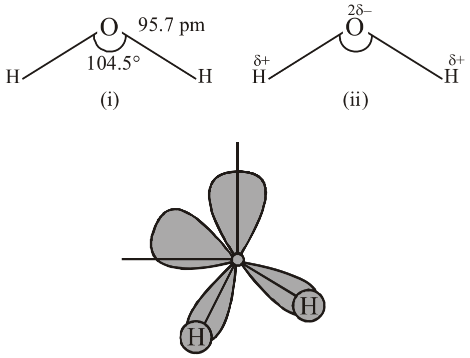
Lithuim aluminium hydride is a most useful organic reducing agent. It reduces functional groups but does not attack double bonds.

38. **(a)** Polarity of bond depends on difference in electronegativity of the two concerned atoms. H_2O is more polar than H_2S because oxygen (in O–H) is more electronegative than sulphur (in S–H).

39. **(b)** In gas phase water is a bent molecule with a bond angle of 104.5° and O–H bond length of 95.7 pm.

40. **(d)** The hybridisation in water is sp^3 and bond angle 104.5º

41. **(c)**



(iii)

42. **(c)** The unusual properties of water in the condensed phase (liquid an solid states) are due to the presence of extensive hydrogen bonding between the water molecules.

43. **(c)** The high boiling point of water is due to H-bonding.

44. **(b)** Due to high dielectric constant, water acts as a good solvent therefore it is also called a universal solvent.

45. **(b)** In the structure of ice each molecule of H_2O is surrounded by three H_2O molecules in hexagonal honey comb manner which results an open cage like structure. As a result there are a number of 'hole' or open spaces. In such a structure lesser number of molecules are packed per ml. When ice melts a large no. of hydrogen bonds are broken. The molecules therefore move into the holes or open spaces and come closer to each other than they were in solid state. This result sharp increase in the density. Therefore ice has lower density than water.

46. **(a)** We know that due to polar nature, water molecules are held together by intermolecular hydrogen bonds. The structure of ice is open with large number of vacant spaces, therfore the density of ice is less than water.

47. **(a)** Two ice cubes stick to each other due to H-bonding.

48. **(d)**

49. **(d)** Sodium is most electropositive element among those given.

$$2Na + 2H_2O \xrightarrow[\text{Room temp.}]{} 2NaOH + H_2$$

50. **(b)** Water has high dielectric constant i.e., 78.39 C^2/Nm^2, high liquid range and can dissolve maximum number of compounds. That is why it is used as universal solvent.

51. **(b)** Temporary hardness is due to presence of bicarbonates of calcium and magnesium and permanent hardness is due to the sulphates and chlorides of both of calcium and magnesium.

52. **(a)** Calgon process is used to remove permanent hardness of water

53. **(b)** $\text{Na zeolite} + CaCl_2 \rightarrow \text{Ca zeolite} + 2NaCl$

54. **(a)** The complex salt of metaphosphoric acid sodium hexametaphosphate $(NaPO_3)_6$, is known as calgon. It is represented as $Na_2[Na_4(PO_3)_6]$

55. **(c)** Polyphosphates (sodium hexametaphosphates, sodium tripolyphosphate or STPP) form soluble complexes with Ca^{+2}, Mg^{+2} present in hard water.

56. **(b)**

57. **(a)** This method is known as Clark's process. In this method temporary hardness is removed by adding lime water or milk of lime.

$$Ca(OH)_2 + Ca(HCO_3)_2 \longrightarrow \underset{\text{ppt.}}{2CaCO_3 \downarrow} + 2H_2O$$

58. **(c)** Permanent hardness of water is due to chlorides and sulphates of calcium and magnesium.

59. **(a)** $H_2SO_4 + BaO_2 \rightarrow BaSO_4 + H_2O_2$

60. **(d)** MnO_2, PbO_2 and BaO will not give H_2O_2 with HCl. MnO_2 and PbO_2 will give Cl_2 and BaO will react with HCl to give $BaCl_2$ and water.

61. **(b)**

62. **(c)** 30 vol of H_2O_2 means one volume of H_2O_2 on decomposition will give 30 volume of oxygen.

63. **(a)** $\text{Normality of } H_2O_2 = \dfrac{\text{vol. strength}}{5.6}$

Volume of normal (1N) H_2O_2 solution = 5.6 volumes.

$\therefore$ Volume of strength of 1.5 N H_2O_2

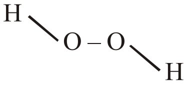
$= 1.5 \times 5.6 = 8.4$ volumes.

64. **(b)** $\text{Strength of 10V } H_2O_2 = \dfrac{68 \times 10}{22400} \times 100 = 3.035\%$

65. **(b)** Structure of H_2O_2 is nonplanar

66. **(d)** O – O – H bond angle in H_2O_2 is 94.8°.

67. **(b)**



is the true structure of H_2O_2.

68. **(b)**

69. **(a)** $\underset{\text{weak acid}}{H_2O_2} \rightarrow H_2O + [O]$

70. **(b)** $H_2O_2 + [O] \xrightarrow{\text{Oxidation}} H_2O + O_2 \uparrow$

71. **(b)** The value of dipole moment of H_2O_2 is 2.1 D, which suggest the structure of H_2O_2 cannot be planar.

An open-book structure is suggested for H_2O_2 in which O – H bonds lie in different plane.

72. **(a)** In the following reaction H_2O_2 acts as a reducing agent.

$PbO_2(s) + H_2O_2\,(aq) \rightarrow PbO(s) + H_2O(\ell) + O_2\,(g)$

73. **(a)** As H_2O_2 is loosing electrons so it is acting as reducing agent.

74. **(c)** H_2S is oxidised to S by H_2O_2.

75. **(d)** H_2O_2 does not have basic properties.

76. **(b)** **77.** **(c)**

78. (b,d) $HOCl(aq) + H_2O_2(aq) \longrightarrow H_3O^+(aq) + Cl^-(aq) + O_2(g)$

$I_2(s) + H_2O_2(aq) + 2OH^-(aq) \longrightarrow 2I^-(aq) + 2H_2O(l) + O_2(g)$

79. (a) Option (a) represents oxidising action of H_2O_2 in acidic medium.

80. (d) H_2O_2 is not used as a moderator in nuclear reactors

81. (d) Decomposition of H_2O_2 can be accelerated by finely divided metals such as Ag, Au, Pt, Co, Fe etc.

82. (c) H_2O_2 is unstable liquid and decomposes into water and oxygen either on standing or on heating.

83. (d) Although H_2O_2 is a better polar solvent than H_2O. However it cannot be used as such because of the strong auto-oxidation ability.

84. (d) H_2O_2 show all these properties.

85. (b) The formula of heavy water (deuterium oxide) is D_2O.

86. (a) $CaC_2 + 2D_2O \rightarrow C_2D_2 + Ca(OD)_2$

87. (b) D_2O is used in nuclear reactors as moderator.

88. (b) $Al_4C_3 + D_2O \rightarrow 3CD_4 + 4Al(OD)_3$

89. (c) Heavy water is formed by the combination of heavier isotope (${}_1H^2$ or D) with oxygen.

$$2D_2 + O_2 \rightarrow \underset{\text{Heavy water}}{2D_2O}$$

90. (d) H_2O absorbs neutrons more than D_2O and this decreases the number of neutrons for the fission process.

91. (b) Heavy water is D_2O hence
number of electrons = 2 + 8 = 10
number of protons = 10
Atomic mass of D_2O = 4 + 16 = 20
hence number of neutron
= Atomic mass – number of protons
= 20 – 10 = 10

92. (b) The only pollutant in combustion of dihydrogen is oxides of dinitrogen (due to the presence of dinitrogen as impurity with dihydrogen).

93. (d) It is for the first time in the history of India that a pilot project using dihydrogen as fuel was launched in October 2005 for running automobiles. Initially 5% H_2 has been mixed in CNG for use in four wheeler vehicles.

STATEMENT TYPE QUESTIONS

94. (c) Tanks of metal alloy like $NaNi_5$, $Ti-TiH_2$, $Mg-MgH_2$ etc are used for storage of dihydrogen in small quantities.

95. (a)

96. (c) Hydrogenation occurs in presence of nickel as a catalyst.

97. (a) In winter seasons ice formed on the surface of a lake provides thermal insulation which ensures the survival of the aquatic life.

98. (d) Dihedral angle of H_2O_2 in gas phase is 111.5° and in solid phase it is 90.2°

99. (b)

MATCHING TYPE QUESTIONS

100. (a) **101. (b)** **102. (c)**

103. (d) Many salts can be crystallised as hydrated salts from an aqueous solutions such an association of water is of different types viz.,

(i) Coordinated water e.g., $[Cr(H_2O)_6]^{3+} 3Cl^-$
(ii) Interstitial water e.g., $BaCl_2 . 2H_2O$
(iii) Hydrogen-bonded water
e.g., $[Cu(H_2O)_4]^{4+} SO_4^{2-}. H_2O$ in $CuSO_4.5H_2O$

104. (d) Heavy water is D_2O (1 – C); Temporary hard water contains the bi-carbonates of Mg and Ca (2 – A); Soft water contains no foreign ions (3 – B); Permanent hard water contains the sulphates and chlorides of Mg and Ca (4 – D) therefore the answer is D.

105. (b)

ASSERTION-REASON TYPE QUESTIONS

106. (a) Due to extremely small size of H^+ as compared to normal atomic and ionic size H^+ does not exist freely.

107. (a) **108. (a)**

109. (c) Both assertion is correct reason is not true.
Correct reason : Calgon forms soluble complexes with Ca^{2+} and Mg^{2+} in which properties of these ions are masked.

110. (a) $2C_{17}H_{35}COONa(aq) + M^{2+}(aq) \longrightarrow (C_{17}H_{35}COO)_2M\downarrow$ (M = Ca or Mg) + $2Na^+(aq)$

111. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

112. (a)

CRITICAL THINKING TYPE QUESTIONS

113. (d) H_2 will not reduce heated Al_2O_3. As Al is more electro-positive than hydrogen. therefore, its oxide will not be reduced by hydrogen.

114. (d) Heavy water is stable.

115. (a) ${}_1H^1$ ${}_1D^2$ ${}_1T^3$
no. of neutrons respectively are 0 , 1 , 2
no. of protons respectively are 1 , 1 , 1
Hence the sum of protons + neutrons = 1 + 2 + 3 = 6

116. (b)

$$\underset{\text{base 1}}{H^-(aq)} + \underset{\text{acid 1}}{H_2O(l)} \longrightarrow \underset{\text{base 2}}{OH^-(aq)} + \underset{\text{acid 2}}{H_2(g)}$$

In this reaction H^- acts as bronsted base as it accepts one proton (H^+) from H_2O and for H_2.

117. (c) $H_2\overset{-2}{S} + H_2O_2 \rightarrow \overset{0}{S} + 2H_2O$

In this reaction H_2O_2 shows oxidising nature.

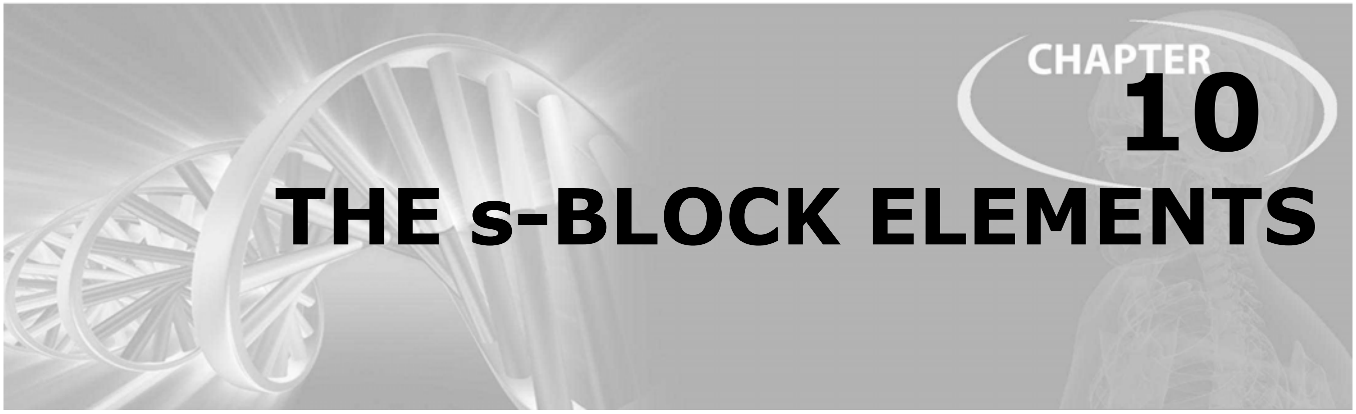
118. (a) D_2O actually has higher freezing point (3.8°C) than water H_2O (0°C)

119. (d)

120. (b)

$$2HSO_4^-(aq) \xrightarrow{\text{electrolysis}} HO_3SOOSO_3H(aq)$$

$$\xrightarrow{\text{Hydrolysis}} 2HSO_4^-(aq) + 2H^+(aq) + H_2O_2(aq)$$



CHAPTER

10

THE s-BLOCK ELEMENTS

FACT/DEFINITION TYPE QUESTIONS

1. Group 2 elements are called alkaline earth metals why? Choose the correct reason(s).

(i) Hydroxides formed by group 2 elements are alkaline in nature.
(ii) Their metal oxides are found in the earth's crust.
(iii) Their oxides are alkaline in nature
(iv) Group 2 elements react with alkalies.

(a) (i) and (ii) (b) (ii) and (iv)
(c) (i), (ii) and (iii) (d) (ii) and (iii)

2. Which of the following alkali metal is highly radioactive?

(a) Rubidium (b) Caesium
(c) Francium (d) Both (a) and (c)

3. Which of the following are found in biological fluids Na^+, Mg^{2+}, Ca^{2+}, K^+, Sr^{2+}, Li^+ and Ba^{2+}

(a) Mg^{2+}, Ca^{2+}, and Sr^{2+}
(b) $Na^{2+}$and K^+
(c) Na^+, K^+, $Mg^{2+}$and Ca^{2+}
(d) Sr^+, Li and Ba^{2+}

4. Which of the following statements is not correct for alkali metals?

(a) Alkali metals are the most electropositive metals.
(b) Alkali metals exist in free state in nature.
(c) These metals have the largest size in a particular period of the periodic table.
(d) Both (b) and (c)

5. Which of the following has largest size ?

(a) Na (b) Na^+
(c) Na^- (d) Can't be predicted

6. Ionization potential of Na would be numerically the same as

(a) electron affinity of Na^+
(b) electronegativity of Na^+
(c) electron affinity of He
(d) ionization potential of Mg

7. Which one of the following properties of alkali metals increases in magnitude as the atomic number rises ?

(a) Ionic radius (b) Melting point
(c) Electronegativity (d) First ionization energy.

8. Which of the following has density greater than water?

(a) Li (b) Na
(c) K (d) Rb

9. The elements of group 1 provide a colour to the flame of Bunsen burner due to

(a) low ionization potential
(b) low melting point
(c) softness
(d) presence of one electron in the outermost orbit

10. The metal that produces red-violet colour in the non-luminous flame is

(a) Ba (b) Ag
(c) Rb (d) Pb

11. The alkali metals have low melting point. Which of the following alkali metal is expected to melt if the room temperature rises to 30°C?

(a) Na (b) K
(c) Rb (d) Cs

12. In the case of the alkali metals

(a) the cation is less stable than the atom
(b) the cation is smaller than the atom
(c) the cation and the atom have about the same size
(d) the cation is larger than the atom

13. Which of the following is not correct ?

(a) $2Li_2O \xrightarrow[673K]{heat} Li_2O_2 + 2Li$

(b) $2K_2O \xrightarrow[673K]{heat} K_2O_2 + 2K$

(c) $2Na_2O \xrightarrow[673K]{heat} Na_2O_2 + 2Na$

(d) $2Rb_2O \xrightarrow[673K]{heat} Rb_2O_2 + 2Rb$

14. The element which on burning in air gives peroxide is

(a) lithium (b) sodium
(c) rubidium (d) caesium

15. Which one of the alkali metals, forms only, the normal oxide, M_2O on heating in air ?
(a) Rb
(b) K
(c) Li
(d) Na

16. Which of the following is used as a source of oxygen in space capsules, submarines and breathing masks ?
(a) Li_2O
(b) Na_2O_2
(c) KO_2
(d) K_2O_2

17. The ionic mobility of alkali metal ions in aqueous solution is maximum for
(a) Li^+
(b) Na^+
(c) K^+
(d) Rb^+

18. For an aqueous solution under an electric field which of the following have lowest mobility ?
(a) Li^+
(b) Na^+
(c) K^+
(d) Rb^+

19. Which of the following pairs of substances would give same gaseous product on reaction with water?
(a) Na and Na_2O_2
(b) Ca and CaH_2
(c) Ca and CaO
(d) Ba and BaO_2

20. Which is the most basic of the following?
(a) Na_2O
(b) BaO
(c) As_2O_3
(d) Al_2O_3

21. Which hydride is most stable
(a) NaH
(b) KH
(c) CsH
(d) LiH

22. The most stable compound is
(a) LiF
(b) LiCl
(c) LiBr
(d) LiI

23. Which of the following represents a correct sequence of reducing power of the following elements?
(a) $Li > Cs > Rb$
(b) $Rb > Cs > Li$
(c) $Cs > Li > Rb$
(d) $Li > Rb > Cs$

24. What is the colour of solution of alkali metals in liquid ammonia?
(a) Bronze
(b) Blue
(c) Green
(d) Violet

25. The alkali metals dissolve in liquid ammonia giving deep blue solution. The solution is $\underline{\quad x \quad}$. In concentrated solution, the blue colour changes to $\underline{\quad y \quad}$ and becomes $\underline{\quad z \quad}$
(a) x = paramagnetic y = colourless z = diamagnetic
(b) x = diamagnetic y = colourless z = paramagnetic
(c) x = paramagnetic y = bronze z = diamagnetic
(d) x = paramagnetic y = black z = diamagnetic

26. Na metal is stored in
(a) C_6H_6
(b) kerosene
(c) alcohol
(d) toluene

27. Which of the following metal is used along with lithium to make the alloy named 'white metal' ?
(a) Nickel
(b) Aluminium
(c) Silver
(d) Lead

28. Which of the following metal is used as a coolant in breeder nuclear reactors?
(a) Potassium
(b) Sodium
(c) Caesium
(d) Rubidium

29. Which is most basic in character ?
(a) CsOH
(b) KOH
(c) NaOH
(d) LiOH

30. Which compound will show the highest lattice energy ?
(a) RbF
(b) CsF
(c) NaF
(d) KF

31. In crystals which one of the following ionic compounds would you expect maximum distance between centres of cations and anions?
(a) LiF
(b) CsF
(c) CsI
(d) LiI

32. Among LiI, NaI, KI, the one which is more ionic and more soluble in water is
(a) KI
(b) NaI
(c) LiI
(d) None of these

33. The products obtained on heating $LiNO_2$ will be
(a) $Li_2O + NO_2 + O_2$
(b) $Li_3N + O_2$
(c) $Li_2O + NO + O_2$
(d) $LiNO_3 + O_2$

34. On heating anhydrous Na_2CO_3,.......is evolved
(a) CO_2
(b) water vapour
(c) CO
(d) no gas

35. Complete the following two reactions.
(i) $4LiNO_3 \rightarrow x + O_2$
(ii) $2NaNO_3 \rightarrow y + O_2$
(a) $x = LiNO_2, y = NaNO_2$
(b) $x = Li_2O + NO_2, y = Na_2O + NO_2$
(c) $x = Li_2O + NO_2, y = NaNO_2$
(d) $x = LiNO_2, y = Na_2O + NO_2$

36. Which of the following does not illustrate the anomalous properties of lithium?
(a) The melting point and boiling point of Li are comparatively high
(b) Li is much softer than the other group I metals
(c) Li forms a nitride Li_3N unlike group I metals
(d) The ion of Li and its compounds are more heavily hydrated than those of the rest of the group

37. Why lithium react less vigorously with water than other alkali metals?

(a) Lithium has most negative $E^{\ominus}$ value
(b) Lithium has small size and very high hydration energy.
(c) Lithium has least negative $E^{\ominus}$ value
(d) Both (a) and (b)

38. Identify the correct statement

(a) Elemental sodium can be prepared and isolated by electrolysing an aqueous solution of sodium chloride
(b) Elemental sodium is a strong oxidising agent
(c) Elemental sodium is insoluble in ammonia
(d) Elemental sodium is easily oxidised

39. Washing soda has formula

(a) $Na_2CO_3.7H_2O$ (b) $Na_2CO_3.10H_2O$
(c) $Na_2CO_3.3H_2O$ (d) Na_2CO_3

40. The process associated with sodium carbonate manufacture is known as

(a) Chamber (b) Haber
(c) LeBlanc (d) Castner

41. In Solvay ammonia process, sodium bicarbonate is precipitate due to

(a) presence of NH_3
(b) reaction with CO_2
(c) reaction with brine solution
(d) reaction with NaOH

42. Sodium carbonate is manufactured by Solvay process. The products which can be recycled are

(a) CO_2 and NH_3 (b) CO_2 and NH_4Cl
(c) NaCl and CaO (d) $CaCl_2$ and CaO.

43. How NH_3 is recovered in Solvay process?

(a) By reaction of NH_4Cl and $Ca(OH)_2$
(b) By reaction of NH_4HCO_3 and NaCl
(c) By reaction of $(NH_4)_2CO_3$ with H_2O
(d) By any of the above

44. Why Solvay process cannot be extended to the manufacture of potassium carbonate?

(a) Ammonium hydrogen carbonate does not react with potassium chloride.
(b) Potassium hydrogen carbonate is too soluble to be precipitated by the addition of ammonium hydrogencarbonate to a saturated solution of potassium chloride.
(c) Ammonium carbonate is precipitated out instead of potassium hydrogen carbonate on reaction of ammonium hydrogen carbonate with potassium chloride
(d) None of the above

45. Which of the following is/are present as impurity in crude sodium chloride, obtained by crystallisation of brine solution?

(i) Sodium sulphate (ii) Calcium chloride
(iii) Magnesium chloride (iv) Potassium chloride
(a) (i), (ii) and (iv) (b) (ii) and (iii)
(c) (iii) and (iv) (d) (i), (ii) and (iii)

46. Which is manufactured by electrolysis of fused NaCl ?

(a) NaOH (b) Na
(c) NaClO (d) $NaClO_3$.

47. Baking soda is

(a) $NaHCO_3$ (b) K_2CO_3
(c) Na_2CO_3 (d) NaOH

48. Baking powder contains :

(a) $NaHCO_3$, $Ca(H_2PO_2)_2$ and starch
(b) $NaHCO_3$, $Ca(H_2PO_2)_2$
(c) $NaHCO_3$, starch
(d) $NaHCO_3$

49. Which of the following is the most abundant ion within cell fluids?

(a) Sodium ions (b) Potassium ions
(c) Calcium ions (d) None of these

50. Which of the following is non-metallic?

(a) B (b) Be
(c) Mg (d) Al

51. Electronic configuration of calcium atom may be written as

(a) [Ne], $4p^2$ (b) [Ar], $4s^2$
(c) [Ne], $4s^2$ (d) [Ar], $4p^2$

52. The outer electronic configuration of alkaline earth metal is

(a) ns^2 (b) ns^1
(c) np^6 (d) nd^{10}

53. Which of the following atoms will have the smallest size ?

(a) Mg (b) Na
(c) Be (d) Li

54. The first ionization energy of magnesium is lower than the first ionization energy of

(a) Lithium (b) Sodium
(c) Calcium (d) Beryllium

55. Which of the following relations is correct with respect to first (I) and second (II) ionization potentials of sodium and magnesium?

(a) $I_{Mg} = II_{Na}$ (b) $I_{Mg} < II_{Na}$
(c) $I_{Na} > I_{Mg}$ (d) $II_{Na} > II_{Mg}$

56. The first ionization energies of alkaline earth metals are higher than those of alkali metals. This is because

(a) there is no change in the nuclear charge
(b) there is decrease in the nuclear charge of alkaline earth metals
(c) there is increase in the nuclear charge of alkaline earth metals
(d) none of these

57. Which of the following has maximum ionization energy

(a) $Ba \longrightarrow Ba^{+} + e^{-}$ (b) $Be \longrightarrow Be^{+} + e^{-}$

(c) $Ca \longrightarrow Ca^{2+} + 2e^{-}$ (d) $Mg \longrightarrow Mg^{2+} + 2e^{-}$

58. The most electropositive amongst the alkaline earth metals is

(a) beryllium (b) magnesium

(c) calcium (d) barium

59. Alkaline earth metals are not found free in nature because of

(a) their thermal instability

(b) their low melting points

(c) their high boiling points

(d) their greater chemical reactivity

60. A firework gives out crimson coloured light. It contains a salt of

(a) Ca (b) Na

(c) Sr (d) Ba

61. Following are colours shown by some alkaline earth metals in flame test. Which of the following are not correctly matched?

	Metal	**Colour**
(i)	Calcium	Apple green
(ii)	Strontium	Crimson
(iii)	Barium	Brick red

(a) (i) and (iii) (b) (i) only

(c) (ii) only (d) (ii) and (iii)

62. Which one of the following properties of alkali metals increases in magnitude as the atomic number rises ?

(a) Ionic radius (b) Melting point

(c) Electronegativity (d) First ionization energy

63. Out of the following elements which one do you expect to be most reactive, chemically ?

(a) Mg (b) Ca

(c) Sr (d) Ba

64. In the reaction $Mg + \underset{\text{(steam)}}{H_2O} \rightarrow X + H_2$; X is

(a) MgO (b) $Mg(OH)_2$

(c) MgH_2 (d) None of these

65. The metals A and B form oxide but B also forms nitride when both burn in air. The A and B are

(a) Cs, K (b) Mg, Ca

(c) Li, Na (d) K, Mg

66. Which of the following is the best method for preparation of BeF_2?

(a) Reaction of Be with F_2

(b) Thermal decomposition of $(NH_4)_2BeF_4$

(c) Reaction of Be with HF

(d) All of the above are equally effective

67. Arrange the following compounds in order of increasing solubility

(i) MgF_2 (ii) CaF_2,

(iii) BaF_2

(a) (i) < (ii) < (iii) (b) (ii) < (i) < (iii)

(c) (ii) < (iii) < (ii) (d) (iii) < (ii) < (i)

68. Alkaline earth metals are

(a) reducing agent (b) amphoteric

(c) dehydrating agent (d) oxidizing agent

69. The oxidation state shown by alkaline earth metals is

(a) +2 (b) +1, +2

(c) –2 (d) –1, –2

70. Which one of the following is the most soluble in water?

(a) $Mg(OH)_2$ (b) $Sr(OH)_2$

(c) $Ca(OH)_2$ (d) $Ba(OH)_2$

71. Which of the following alkaline earth metal hydroxides is amphoteric in character

(a) $Be(OH)_2$ (b) $Ca(OH)_2$

(c) $Sr(OH)_2$ (d) $Ba(OH)_2$

72. Of the metals Be, Mg, Ca and Sr of group 2 A. In the periodic table the least ionic chloride would be formed by

(a) Be (b) Mg

(c) Ca (d) Sr

73. The order of solubility of sulphates of alkaline earth metals in water is

(a) Be > Mg > Ca > Sr > Ba

(b) Mg > Be >> Ba > Ca > Sr

(c) Be > Ca > Mg > Ba >> Sr

(d) Mg > Ca > Ba >> Be > Sr

74. The solubilities of carbonates decrease down the magnesium group due to a decrease in

(a) hydration energies of cations

(b) inter-ionic attraction

(c) entropy of solution formation

(d) lattice energies of solids

75. The correct order of increasing thermal stability of K_2CO_3, $MgCO_3$, $CaCO_3$ and $BeCO_3$ is

(a) $BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$

(b) $MgCO_3 < BeCO_3 < CaCO_3 < K_2CO_3$

(c) $K_2CO_3 < MgCO_3 < CaCO_3 < BeCO_3$

(d) $BeCO_3 < MgCO_3 < K_2CO_3 < CaCO_3$

76. In which of the following the hydration energy is higher than the lattice energy?

(a) $MgSO_4$ (b) $RaSO_4$

(c) $SrSO_4$ (d) $BaSO_4$

77. Which of the following alkaline earth metal sulphates has hydration enthalpy higher than the lattice enthalpy?

(a) $CaSO_4$ (b) $BeSO_4$

(c) $BaSO_4$ (d) $SrSO_4$

78. Beryllium shows diagonal relationship with aluminium. Which of the following similarity is incorrect ?

(a) Be forms beryllates and Al forms aluminates
(b) $Be(OH)_2$ like $Al(OH)_3$ is basic.
(c) Be like Al is rendered passive by HNO_3 .
(d) Be_2C like Al_4C_3 yields methane on hydrolysis.

79. The substance **not** likely to contain $CaCO_3$ is

(a) gypsum
(b) sea shells
(c) dolomite
(d) a marble statue

80. Plaster of Paris is

(a) $CaSO_4.2H_2O$
(b) $CaSO_4.H_2O$
(c) $CaSO_4.\frac{1}{2}H_2O$
(d) $CaSO_4.4H_2O$

81. Gypsum on heating at 120 – 130°C gives

(a) anhydrous salt
(b) hemihydrate
(c) monohydrate
(d) dihydrate

82. Plaster of Paris on making paste with little water sets to hard mass due to formation of

(a) $CaSO_4$
(b) $CaSO_4.1/2H_2O$
(c) $CaSO_4.H_2O$
(d) $CaSO_4.2H_2O$

83. The chemical which is used for plastering the broken bones is

(a) $(CaSO_4)_2H_2O$
(b) $MgSO_4.7H_2O$
(c) $FeSO_4.\ 7H_2O$
(d) $CuSO_4.\ 5H_2O$

84. Dead burn plaster is

(a) $CaSO_4.2H_2O$
(b) $MgSO_4.\ 7H_2O$
(c) $CaSO_4.½\ H_2O$
(d) $CaSO_4$

85. The formula for calcium chlorite is

(a) $Ca(ClO_4)_2$
(b) $Ca(ClO_3)_2$
(c) $CaClO_2$
(d) $Ca(ClO_2)_2$

86. Bone ash contains

(a) CaO
(b) $CaSO_4$
(c) $Ca_3\ (PO_4)_2$
(d) $Ca(H_2PO_4)_2$

87. Mortar is a mixture of

(a) $CaCO_3$, sand and water
(b) slaked lime and water
(c) slaked lime, sand and water
(d) $CaCO_3$ and CaO

88. Which gas is released when $CaCO_3$ reacts with dilute HCl?

(a) H_2
(b) CO_2
(c) O_2
(d) Cl_2

89. Setting of cement is an

(a) exothermic reaction
(b) endothermic reaction
(c) neither endothermic nor exothermic
(d) example of neutralisation reaction

90. For a good quality cement what should be the ratio of following :

I. Silica to alumina
II. CaO to the total of oxides of SiO_2, Al_2O_3 and Fe_2O_3

(a) I = 2.5 to 4
II = Greater than 2
(b) I = Nearly 4
II = Less than 2
(c) I = 2.5
II = Closer to 2
(d) I = 2.5 to 4
II = Closer to 2

91. Calcitonin and parathyroid hormone regulate concentration of which of the following element in plasma?

(a) Calcium
(b) Magnesium
(c) Sodium
(d) Potassium

92. Which of the following metal is found in green colouring pigment chlorophyll of plants?

(a) Fe
(b) Mg
(c) Na
(d) Al

STATEMENT TYPE QUESTIONS

93. Select the correct statements

(i) Cs^+ is more highly hydrated that the other alkali metal ions
(ii) Among the alkali metals Li, Na, K and Rb, lithium has the highest melting point
(iii) Among the alkali metals only lithium forms a stable nitride by direct combination with nitrogen

(a) (i), (ii) and (iii)
(b) (i) and (ii)
(c) (i) and (iii)
(d) (ii) and (iii)

94. Which of the following sequence of T and F is correct for alkali metals ? Here T represents True and F represents False statement.

(i) Alkali metal hydrides are ionic solids with high melting point.
(ii) All alkali halides are ionic in nature.
(iii) Li is the least powerful reducing agent and Na is the most powerful reducing agent.

(a) TTT
(b) TFT
(c) FTF
(d) TFF

95. Which of the following statement(s) is/are correct regarding Li_2CO_3 and Na_2CO_3 ?

(i) Sodium salt evolve CO_2 at higher temperature.
(ii) Polarization of Na^+ is lesser than that of Li^+.

(a) Both statements (i) and (ii) are correct
(b) Both statements (i) and (ii) are incorrect
(c) Statement (ii) is correct explanation for statement (i)
(d) Statement (i) is correct explanation for statement (ii)

96. Which of the following sequence of T and F is correct for given statements?

(i) The alkali metal hydroxides are the strongest of all bases.

(ii) All alkali metal halides have high negative enthalpies of formation.

(iii) The stability of the carbonates and hydrogen carbonates of alkali metals decrease with increase in electropositive character down the group.

(iv) Only $LiHCO_3$ exist as solid.

(a) TTFF (b) TTTT

(c) FTFT (d) TFFT

97. Which of the following statement(s) is/are correct?

(i) The atomic and ionic radii of alkaline earth metals are smaller than those of the corresponding alkali metals in the same periods.

(ii) Second ionisation enthalpies of the alkaline earth metals are smaller than those of the corresponding alkali metals.

(iii) Compounds of alkaline earth metals are more extensively hydrated than those of alkali metals

(a) (i) and (ii) (b) (ii) and (iii)

(c) (i) and (iii) (d) (i), (ii) and (iii)

98. Which of the following statements are correct ?

(i) Copper - beryllium alloys are used in the preparation of high strength springs

(ii) Metallic beryllium is used for making window X-ray tubes.

(iii) Magnesium powder is used in incendiary bombs and singnals.

(iv) Barium is used in treatment of cancer.

(a) (i), (ii) and (iv) (b) (i) and (iii)

(c) (i), (ii) and (iii) (d) (i), (ii), (iii) and (iv)

99. Which of the following is/are not characteristic property(ies) of alkaline earth metals ?

(i) All alkaline earth metal oxides are basic in nature and forms sparingly soluble hydroxides with water.

(ii) The hydrated chlorides, bromides and iodies of Ca, Sr and Ba on heating undergoes hydrolysis while corresponding hydrated halides of Be and Mg on heating undergo dehydration.

(iii) Nitrates of alkaline earth metals decompose on heating as below

$$2M(NO_3)_2 \rightarrow 2MO + 4NO_2 + O_2$$

(a) (i) only (b) (ii) only

(c) (i) and (iii) (d) (i) and (ii)

100. Which of the following statement(s) is/are correct regarding Al and Be ?

(i) Both of these react with alkali.

(ii) There is diagonal relationship among these elements.

(a) Both (i) and (ii) (b) Only (i)

(c) Only (ii) (d) Neither (i) nor (ii)

MATCHING TYPE QUESTIONS

101. Match the columns

Column-I **(Alkali metal)**	**Column-II** **(Colour imparted to an oxidizing flame)**
(A) Cs	(p) Yellow
(B) Rb	(q) Blue
(C) K	(r) Violet
(D) Na	(s) Red violet
(E) Li	(t) Crimson red

(a) A – (q), B – (s), C – (r), D – (p), E – (t)

(b) A – (s), B – (q), C – (r), D – (p), E – (t)

(c) A – (t), B – (r), C – (s), D – (p), E – (q)

(d) A – (q), B – (p), C – (r), D – (p), E – (t)

102. Match the columns

Column-I **(Metal)**	**Column-II** **(Oxide formed on burning)**
(A) Caesium	(p) Superoxide
(B) Lithium	(q) Peroxide
(C) Sodium	(r) Monoxide

(a) A – (q), B – (p), C – (r)

(b) A – (r), B – (q), C – (p)

(c) A – (p), B – (r), C – (q)

(d) A – (q), B – (r), C – (p)

103. Match the columns. Here Column-I shows the names of the metals used with lithium to make useful alloys and Column-II shows the uses of these alloys

Column-I	**Column-II**
(A) Aluminium	(p) Armour plates
(B) Magnesium	(q) Aircraft parts
(C) Lead	(r) Bearings for motor engines.

(a) A – (q), B – (p), C – (r)

(b) A – (q), B – (r), C – (p)

(c) A – (p), B – (q), C – (r)

(d) A – (p), B – (r), C – (q)

104. Match the columns.

Column-I **(Sodium compound)**	**Column-II** **(Uses)**
(A) Sodium carbonate	(p) In fire extinguisher
(B) Sodium chloride	(q) In manufacture of glass, soap, borax and caustic soda.
(C) Sodium hydroxide	(r) In preparation of Na_2O_2, NaOH and Na_2CO_3
(D) Sodium hydrogen carbonate	(s) In petroleum refining

(a) A – (q), B – (r), C – (s), D – (p)

(b) A – (s), B – (q), C – (r), D – (p)

(c) A – (p), B – (s), C – (r), D – (q)

(d) A – (s), B – (r), C – (p), D – (q)

105. Match the columns

	Column-I		**Column-II**
(A)	Quick lime	(p)	$Ca(OH)_2$
(B)	Slaked lime	(q)	CaO
(C)	Bleaching powder	(r)	$Ca(OCl)_2$
(D)	Plaster of Paris	(s)	$CaSO_4 . H_2O$

(a) A – (p), B – (q), C – (r), D – (s)
(b) A – (s), B – (r), C – (q), D – (p)
(c) A – (q), B – (p), C – (r), D – (s)
(d) A – (q), B – (p), C – (s), D – (r)

106. Match the columns

(A)	Quick lime	(p)	Setting fractured bones
(B)	Plaster of Paris	(q)	A constituent of chewing gum
(C)	Slaked lime	(r)	Manufacture of bleaching powder
(D)	Limestone	(s)	Manufacture of dyestuffs

(a) A – (p), B – (s), C – (q), D – (r)
(b) A – (s), B – (p), C – (r), D – (q)
(c) A – (q), B – (r), C – (p), D – (s)
(d) A – (r), B – (q), C – (s), D – (p)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

107. Assertion: Lithium salts are mostly hydrated.
Reason : The hydration enthalpy of alkali metal ions decreases with increase in ionic sizes.

108. Assertion : Lithium carbonate is not so stable to heat.
Reason : Lithium being very small in size polarizes large CO_3^{2-} ion leading to the formation of more stable Li_2O and CO_2

109. Assertion : Compounds of beryllium is largely covalent and get hydrolysed easily.
Reason : This is due to high value of ionisation potential and small size of Be.

110. Assertion : Radium is most abundant *s*-block element.
Reason : *s*-block elements are non-radioactive in nature.

CRITICAL THINKING TYPE QUESTIONS

111. The melting point of lithium (181°C) is just double the melting point of sodium (98°C) because
(a) down the group, the hydration energy decreases
(b) down the group, the ionization energy decreases
(c) down the group the cohesive energy decreases
(d) None of these

112. Li has the maximum value of ionisation potential among alkali metals i.e. lithium has the minimum tendency to ionise to give LI^+ ion. Thus, in aq. solution lithium is
(a) strongest reducing agent
(b) poorest reducing agent
(c) strongest oxidising agent
(d) poorest oxidising agent

113. Lithium is strongest reducing agent among alkali metals due to which of the following factor?
(a) Ionization energy (b) Electron affinity
(c) Hydration energy (d) Lattice energy

114. Which of the following statements is incorrect?
(a) Alkali metal hydroxide are hygroscopic
(b) Dissolution of alkali metal hydroxide is endothermic
(c) Aqueous solution of alkali metal hydroxides are strongly basic
(d) Alkali metal hydroxides form ionic crystals

115. Which of the following on thermal decomposition yields a basic as well as acidic oxide ?
(a) $NaNO_3$ (b) $KClO_3$
(c) $CaCO_3$ (d) NH_4NO_3

116. Which one of the following on hydrolysis, gives the corresponding metallic hydroxide, H_2O_2 and O_2?
(a) Li_2O (b) Na_2O_2
(c) NaO_2 (d) Na_2O

117. Which of the following oxides of potassium is not known ?
(a) K_2O (b) K_2O_4
(c) KO_3 (d) K_2O_3

118. Suppose an element is kept in air chamber, than air content was evaluated after sometime , oxygen and nitrogen content was found to be low comparitively. The given element will be
(a) Li (b) Rb
(c) Na (d) K

119. Suppose metal react with the oxygen to form oxide, than aqueous solution of this oxide when added to a solution of HI, solution turn yellowish brown in colour. This compound is
(a) Na_2O (b) Li_2O
(c) NaOH (d) Na_2O_2

120. Which of the following salt of lithium is most soluble in organic solvent ?
(a) LiF (b) LiCl
(c) LiBr (d) LiI

121. Arrange the following in increasing order of their melting point ?

(A) LiCl, (B) NaCl, (C) KCl

(a) $A < B < C$ (b) $B < A < C$

(c) $C < A < B$ (d) $A < B \simeq C$

122. The raw materials in Solvay Process are

(a) $Na_2CO_3, CaCO_3$ and NH_3

(b) $Na_2SO_4, CaCO_3$ and NH_3

(c) NaCl, NH_3 and $CaCO_3$.

(d) NaOH, CaO and NH_3.

123. Compared with the alkaline earth metals, the alkali metals exhibit

(a) smaller ionic radii (b) highest boiling points

(c) greater hardness (d) lower ionization energies.

124. Property of the alkaline earth metals that increases with their atomic number is

(a) solubility of their hydroxides in water

(b) solubility of their sulphates in water

(c) ionization energy

(d) electronegativity

125. Which one of the following does not react with water even under red hot condition?

(a) Na (b) Be

(c) Ca (d) K

126. Magnesium burns in CO_2 to form

(a) $MgO + C$ (b) $MgO + CO$

(c) $MgCO_3$ (d) MgO.

127. Arrange the following in increasing order of their solubility?
$MgCO_3$(A), $CaCO_3$(B), $SrCO_3$(C), Na_2CO_3(D)

(a) $A < B < C < D$ (b) $A < C < B < D$

(c) $C < A < B < D$ (d) $C < B < A < D$

128. Which of the following will precipitate first when aqueous solution containing sulphate ions are added?

(a) Mg^{2+} (b) Ca^{2+}

(c) Sr^{2+} (d) Ba^{2+}

129. If the fluoride salts of group 2 metals are dissolved in water,than which of the following will show high solubility?

(a) BaF_2 (b) RbF_2

(c) CaF_2 (d) BeF_2

130. Aqueous solution of group 2 is precipitated by adding Na_2CO_3, then this precipitate is tested on flame, no light in visible region is observed , this element can be

(a) Ba (b) Mg

(c) Ca (d) Sr

131. Which of the following statement is false ?

(a) Strontium decomposes water readily than beryllium

(b) Barium carbonate melts at a higher temperature than calcium carbonate

(c) Barium hydroxide is more soluble in water than magnesium hydroxide

(d) Beryllium hydroxide is more basic than barium hydroxide.

132. Bleaching powder is obtained by the interaction of chlorine with

(a) dil. solution of $Ca(OH)_2$

(b) dry CaO

(c) conc. solution of $Ca(OH)_2$

(d) dry slaked lime

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** Group 2 elements are called alkaline earth metals as their oxides and hydroxides are alkaline in nature and these metal oxides are found in the earth's crust.
2. **(c)** Francium is highly radioactive.
3. **(c)** Monovalent sodium and potassium ions and divalent magnesium and calcium ions are found in large proportions in biological fluids.
4. **(b)** Alkali metals readily lose electron to give monovalent M^+ ion. Hence they are never found in free state in nature.
5. **(c)** A cation is always much smaller than the corresponding atom, whereas an anion is always larger than the corresponding atom.

   Hence, correct order of the size is

   $Na^- > Na > Na^+$
6. **(a)** $Na \rightarrow Na^+ + e^-$; IE of Na = + ve

   $Na^+ + e^- \rightarrow Na$; E.A. of Na^+ = – ve

   Both are equal but opposite in nature
7. **(a)** Within a group, ionic radius increases with increase in atomic number. The melting points decrease down the group due to weakening of metallic bond. The electronegativity and the 1st ionization energy also decreases down the group.
8. **(d)** Li, Na, K are lighter than water but Rb is heavier than water.
9. **(a)**
10. **(c)** Alkali metals have large size. When they are heated in the flame of Bunsen burner, the electrons present in the valence shell move from lower energy level to higher energy level by absorption of heat from the flame. When they come back to the ground state, they emit the extra energy in the form of visible light to provide colour to the flame.
11. **(d)**
12. **(b)** Gp 1 metals form cations M^+ by loss of electron from outermost shell. Electronic configuration of Gp 1 metals is ns^1. When the outer electron is removed to give a positive ion, the size decreases because the outermost shell is completely removed. After removal of an electron, the positive charge of the nucleus is greater on the remaining electrons so that each of the remaining electrons are attracted more strongly towards the nucleus. This further reduces the size.
13. **(a)** Lithium does not form peroxide.
14. **(b)** Sodium metal on burning in air gives sodium peroxide.
15. **(c)** All the alkali metals when heated with oxygen form different types of oxides for example lithium forms lithium oxide (Li_2O), sodium forms sodium peroxide (Na_2O_2), while K, Rb and Cs form their respective superoxides.

   $$2Li + \frac{1}{2}O_2 \rightarrow Li_2O$$
16. **(c)** Because KO_2 not only provides O_2 but also removes $1CO_2$ as follows

   $$4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$$
   $$4KO_2 + 4CO_2 + 2H_2O \rightarrow KHCO_3 + 3O_2$$
17. **(d)** Smaller the size of cation higher is its hydration energy and lesser is its ionic mobility hence the correct order is $Li^+ < Na^+ < K^+ < Rb^+$
18. **(a)** In aqueous solution because of high charge density of Li^+ it is heavily hydrated, therefore due to its extensive hydration which increases its size to highest the mobility of Li^+ ion will be lowest.
19. **(b)** Both Ca and CaH_2 produce H_2 gas with water.

   $$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$$
   $$CaH_2 + 2H_2O \longrightarrow Ca(OH)_2 + 2H_2\uparrow$$
20. **(a)**
21. **(d)** The basic character and stability of hydrides decrease down the group.
22. **(a)** For a given metal, order of stability of halides is $MF > MCl > MBr > MI$
23. **(a)** A reducing agent is a substance which can loose electron and hence a reducing agent should have low ionisation energy. Now since ionisation energy decreases from Li to Cs, the reducing property should increase from Li to Cs. The only exception to this is lithium. This is because the net process of converting an atom to an ion takes place in 3 steps.

   (i) $M(s) \rightarrow M(g)$ ΔH = Sublimation energy
   (ii) $M(g) \rightarrow M^+(g) + e^-$ ΔH = Ionisation energy
   (iii) $M^+(g) + H_2O \rightarrow M^+(aq)$ ΔH = Hydration energy

   The large amount of energy liberated in hydration of Li (because of its small size) makes the overall ΔH negative. This accounts for the higher oxidation potential of lithium i.e., its high reducing power.
24. **(b)** The alkali metals dissolve in liquid ammonia giving deep blue solution.
25. **(c)** x = paramagnetic y = bronze

   z = diamagnetic
26. **(b)** Na reacts violently and may catch fire on exposure to moisture (air + water). So it is always stored in kerosene. Na reacts with alcohol to produce H_2.

27. **(d)** Lithium with lead is used to make white metal.

28. **(b)** Liquid sodium is used as a coolant in fast breeder nuclear reactors.

29. **(a)** Since the ionization energies of alkali metals decrease down the group, the ionic character and consequently basic property of their hydroxides increases in the same order, i.e. from LiOH to CsOH.

30. **(c)** With the same anion, smaller the size of the cation, higher is the lattice energy. The correct order of size of cations is –

$Na^+ < K^+ < Rb^+ < Cs^+$

Hence, the lattice energy of NaF will be maximum. i.e., NaF.

31. **(c)** As Cs^+ ion has larger size than Li^+ and I^- has larger size than F^-, therefore maximum distance between centres of cations and anions is in CsI.

32. **(a)** Larger cation (K^+) develops less polarisation in anion and thus KI has more ionic nature and more soluble in water.

33. **(a)** $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

34. **(d)** Anhydrous form of Na_2CO_3 does not decompose on heating even to redness. It is a amorphous powder called soda ash.

35. **(c)** $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

$2\,NaNO_3 \rightarrow 2NaNO_2 + O_2$

36. **(b)** Li is much softer than the other group I metals. Actually Li is harder then other alkali metals.

37. **(b)** Lithium although has most negative $E^{\ominus}$ value reacts less vigorously with water than other alkali metals due to its small size and very high hydration energy.

38. **(d)** Elemental sodium is easily oxidised (has low I.P.) and acts as reductant.

39. **(b)** Washing soda is $Na_2CO_3.10\,H_2O$.

40. **(c)**

41. **(c)** $\underset{\text{Brine}}{NH_4HCO_3 + NaCl} \longrightarrow \underset{\text{Sod. bicarbonate ppt.}}{NaHCO_3 \downarrow} + NH_4Cl$

42. **(a)** CO_2 and NH_3 formed are reused (See Solvay process)

43. **(a)** NH_3 is recovered when the solution containing NH_4Cl is treated with $Ca(OH)_2$

$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + H_2O$

44. **(b)**

45. **(d)** Sodium sulphate, calcium chloride and magnesium chloride are present as impurities in crude sodium chloride.

46. **(b)** Na metal is manufactured by electrolysis of fused NaCl by two methods.

(i) Castner's process

(ii) Down's process

In both the above processes electrolysis of fused sodium chloride produces Na at cathode.

$$2NaOH \rightleftharpoons 2Na^+ + OH^-$$

at cathode $2Na^+ + 2e^- \longrightarrow 2Na$

at anode $4OH^- \longrightarrow 2H_2O + O_2 + 4e$

47. **(a)** $NaHCO_3$ (baking soda) is one of the major constituents of baking powder.

48. **(a)** Baking powder has starch, $NaHCO_3$ and $Ca(H_2PO_2)_2$.

49. **(b)** Potassium ions are the most abundant cations within cell fluids.

50. **(a)** Metallic character decreases, as we go to the right side in a period and increases when we move downwards in a group.

51. **(b)** Ca (20) = $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2$ = [Ar], $4s^2$.

52. **(a)**

53. **(c)** Within a period, the size decreases from left to right, i.e., Na > Mg > Li > Be. Atomic size increases down the group.

54. **(d)**

55. **(d)** The IInd ionisation potential of Na is higher than Mg because it requires more energy to remove an electron from a saturated shell or stable (fully filled) orbital.

$${}_{11}Na \longrightarrow 1s^2,\ 2s^2\,2p^6,\ 3s^1 \xrightarrow{I}$$

$$1s^2,\ 2s^2\,2p^6,\ 3s^0 \xrightarrow{II}$$

$$1s^2,\ 2s^2\,2p^5,\ 3s^0$$

$${}_{12}Mg \longrightarrow 1s^2,\ 2s^2\,2p^6,\ 3s^2 \xrightarrow{I}$$

$$1s^2,\ 2s^2\,2p^6,\ 3s^1 \xrightarrow{II} 1s^2,\ 2s^2\,2p^6,\ 3s^0$$

Here Na-I < Mg-I and Na-II > Mg-II.

56. **(c)** As we go from grp I element to grp II element in a period, an extra electron is added in same shell which results in increase in nuclear charge due to which force of attraction by the nucleus increases and hence ionic radii decreases and consequently I.E. increases.

57. **(d)** **58. (d)** **59. (d)** **60. (c)**

61. **(a)** Calcium gives brick red colour and barium gives apple green colour in flame test.

62. **(a)** Within a group, ionic radius increases with increase in atomic number. The melting points decrease down the group due to weakning of metallic bond. The electronegativity and the 1st ionization energy also decreases down the group.

63. **(d)** Barium is most electropostive element among those given. Hence it is most reactive.

64. **(a)** $Mg(OH)_2$ is not formed because of poor solubility of MgO in H_2O.

65. **(d)** K and Mg, both form oxides

$$K + O_2 \rightarrow KO_2; 2Mg + O_2 \rightarrow 2MgO$$

Mg form nitride also $3Mg + N_2 \rightarrow Mg_3N_2$

K does not form nitride.

66. **(b)** Thermal decomposition of $(NH_4)_2BeF_4$ is the best method for preparation of BeF_2.

67. **(b)** $BaF_2 > MgF_2 > CaF_2$

68. **(a)** Alkaline earth metals have a fairly strong tendency to lose their outermost electrons due to which they act as reducing agent.

69. (a)

70. (d) For a compoud to be soluble, the hydration energy must exceed lattice energy. For Gp.II hydroxides ($Mg(OH)_2$, $Sr(OH)_2$, $Ca(OH)_2$, $Ba(OH)_2$, lattice energy decrease more rapidly than the hydration energy & so their solubility increases down the group. $Ba(OH)_2 > Sr(OH)_2 > Ca(OH)_2 > Mg(OH)_2$

71. (a) $Be(OH)_2$ is amphoteric while $Ca(OH)_2$, $Sr(OH)_2$ and $Ba(OH)_2$ are all basic.

72. (a) Because of small atomic size and high I.E. Be forms covalent chloride.

73. (a)

74. (a) As we move down the group, the lattice energies of carbonates remain approximately the same. However the hydration energies of the metal cation decreases from Be^{++} to Ba^{++}, hence the solubilities of carbonates of the alkaline earth metal decrease down the group mainly due to decreasing hydration energies of the cations from Be^{++} to Ba^{++}.

75. (a) As the basicity of metal hydroxides increases down the group from Be to Ba, the thermal stability of their carbonates also increases in the same order. Further group 1 compounds are more thermally stable than group 2 because their hydroxide are much basic than group 2 hydroxides therefore, the order of thermal stability is

$BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$.

76. (a) In alkaline earth metals ionic size increases down the group. The lattice energy remains constant because sulphate ion is so large, so that small change in cationic sizes do not make any difference. On moving down the group the degree of hydration of metal ions decreases very much leading to decrease in solubility

$$\therefore\ BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$$

77. (b) Be^{2+} is very small, hence its hydration enthalpy is greater than its lattice enthalpy

78. (b) The $Be(OH)_2$ and $Al(OH)_3$ are amphoteric in nature.

79. (a) Gypsum is $CaSO_4.2H_2O$

80. (c) Chemically plaster of Paris is $CaSO_4.1/2H_2O$.

81. (b) $$CaSO_4 \cdot 2H_2O \xrightarrow{120°C} CaSO_4 \cdot \frac{1}{2}H_2O$$

Plaster of Paris is hemihydrate.

82. (d) Plaster of Paris ($CaSO_4 . \frac{1}{2} H_2O$) on making paste with little water sets to a hard mass due to formation of gypsum ($CaSO_4.2H_2O$).

$$\underset{\text{Plaster of Paris}}{CaSO_4 . \frac{1}{2}H_2O} + \frac{3}{2}H_2O \to \underset{\text{Gypsum}}{CaSO_4.2H_2O} + \text{Heat}$$

83. (a) $(CaSO_4)_2.H_2O$ – Plaster of paris is used for plastering the broken bones.

84. (d) **85. (d)** **86. (c)** **87. (c)**

88. (b) $CaCO_3 + 2HCl \longrightarrow 2CaCl_2 + H_2O + CO_2$

89. (a) During setting of cement, silicates and aluminates of calcium are hydrated. Hydration is an exothermic process. Therefore setting of cement is exothermic process.

90. (d) For a good quality cement, the ratio of silica (SiO_2) to alumina (Al_2O_3) should be between 2.5 and 4 and the ratio of lime (CaO) to the total of the oxides of silicon (SiO_2), aluminium (Al_2O_3) and iron (Fe_2O_3) should be as close as possible to 2.

91. (a) The calcium concentration in plasma is regulated at about 100 mgL^{-1}. It is maintained by two hormones : calcitonin and parathyroid hormone.

92. (b)

STATEMENT TYPE QUESTIONS

93. (d) Amongst alkali metal Li ions are highly hydrated.

94. (d) Lithium halides are some what covalent in nature. Li is the most powerful reducing agent and Na is the least powerful reducing agent.

95. (c)

96. (a) For statement (iii), stability of the carbonates and hydrogen carbonates of alkali metals increases with increase in electropositive character down the group. Hydrogen carbonate of lithium does not exist as a solid.

97. (d) All the given statements are correct.

98. (c) Radium is used in treatment of cancer.

99. (d) All alkaline earth metal oxides except BeO are basic in nature. BeO is amphoteric in nature.

Hydrated halides of Ca, Sr and Ba on heating undergo dehydration while corresponding hydrated halides of Be and Mg on heating suffer hydrolysis.

100. (a)

MATCHING TYPE QUESTIONS

101. (a)

102. (c) $Cs + O_2 \to CsO_2$ (Superoxide)

$4Li + O_2 \to 2Li_2O$ (Oxide)

$2Na + O_2 \to Na_2O_2$ (Peroxide)

103. (a) Lithium metal is used to make useful alloys, for example with lead to make 'white metal' bearings for motor engines, with aluminium to make aircraft parts, and with magnesium to make armour plates.

104. (a) **105. (c)**

106. (b) Quick lime is used for the manufacture of dyestuffs.

Plaster of Paris is used for setting of fractured bones.

Slaked lime is used for the manufacture of bleaching powder.

Limestone is a constituent of chewing gum.

ASSERTION-REASON TYPE QUESTIONS

107. (a) Li^+ has maximum degree of hydration among other alkali metals.

108. (a) Lithium carbonate is unstable to heat; lithium being very small in size polarises a large CO_3^{2-} ion leading to the formation of more stable Li_2O and CO_2.

109. (a) Because of high value of ionisation enthalpy and small size it forms compound which are highly covalent in nature, hence, it get hydrolysed easily.

110. (d) Both assertion and reason are false.
Radium is the rarest of all s-block elements comprising only 10^{-10} percent of igneous rocks. Francium (s-block member) is radioactive; its long lived isotope ^{223}Fr ahs a half life of only 21 minutes.

CRITICAL THINKING TYPE QUESTIONS

111. (c) The atom becomes larger on descending the group, so the bonds becomes weaker (metallic bond), the cohesive force/energy decreases and accordingly melting point also decreases.

112. (a) The ionisation potential value of lithium is maximum among alkali metals i.e., its tendency to ionise to give Li^+ ions should be the minimum i.e. Li should be the poorest reducing agent. But, lithium is the strongest reducing agent in aq. solution. This is due to the largest value of hydration energy of Li^+ ions.

113. (c) Li due to highest hydration energy among the alkali metals is the strongest reducing agent.

114. (b) During the dissolution of alkali metal hydrides energy is released in large amount, i.e., it is exothermic in nature.

115. (c) Calcium carbonate on thermal decomposition gives CaO (Basic oxide) and CO_2 (Acidic oxide)

$$CaCO_3 \xrightarrow{\Delta} \underset{\text{Basic oxide}}{CaO} + \underset{\text{Acidic oxide}}{CO_2\uparrow}$$

116. (c) $2NaO_2 + 2H_2O \rightarrow 2NaOH + H_2O_2 + O$

117. (b) O_4^{2-} ion is not possible and K_2O_4 is unknown .

118. (a) All the given elements react with oxygen to form oxides but only Li also react with nitrogen to form Li_3N.

119. (d) (a) and (b) forms corresponding hydroxides (NaOH and LiOH) in aqueous solution

$$M_2O + H_2O \longrightarrow 2M^+ + 2OH^- \ (M = Na \text{ or } Li)$$

Therefore reaction of HI with (a), (b) and (c) is simply a neutralization reaction, while aqueous solution of (d) form H_2O_2 which act as oxidizing agent, hence convert Iodide to Iodine(I_2).

$$Na_2O_2 + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2O_2$$

120. (d) LiI is more soluble as the degree of covalent character is high due to larger size of anion i.e., iodide ion by greater polarization of lithium cation.

121. (a)

122. (c) NaCl (brine), NH_3 and CO_2 are raw materials. $CaCO_3$ is source of CO_2.

123. (d) Because of larger size and smaller nuclear charge, alkali metals have low ionization potential relative to alkaline earth metals.

124. (a) Lattice energy decreases more rapidly than hydration energy for alkaline earth metal hydroxides. On moving down a group $\therefore$ solubility of their hydroxides increases.

125. (b) $2Na + 2H_2O \longrightarrow 2NaOH + H_2\uparrow$

$2K + 2H_2O \longrightarrow 2KOH + H_2\uparrow$

All alkali metals decompose water with the evolution of hydrogen.

$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$

$Sr + 2H_2O \longrightarrow Sr(OH)_2 + H_2\uparrow$

$Be + 2H_2O \longrightarrow$ No reaction

Ca, Sr, Ba and Ra decompose cold water readily with evolution of hydrogen. Mg decomposes boiling water but Be is not attacked by water even at high temperatures as its oxidation potential is lower than the other members.

126. (a) Mg burns in CO_2 to give MgO and C.

127. (d) Group1 carbonates are more soluble than group 2 which are sparingly soluble, and also in case of group 2, down the group the solubility of carbonates decreases.

128. (d) Down the group solubility of sulphate decreases. Thus Ba^{2+} ions will precipitate out most easily.

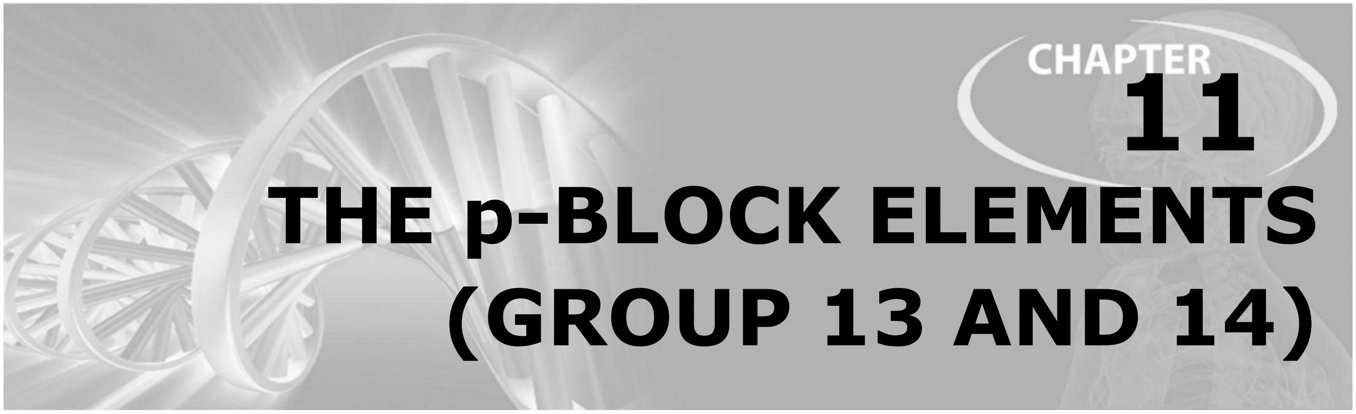
129. (a) BeF_2 is highly soluble in water due to the high hydration enthalpy of the small Be^{2+} ion.

130. (b) Electrons in Mg due to its small size are tightly bound so they cannot be excited by the flame.

131. (d) $Be(OH)_2$ is amphoteric, but the hydroxides of other alkaline earth metals are basic. The basic strength increases gradually.

132. (d) When cold calcium hydroxide reacts with chlorine, then bleaching powder is obtained.

$$\underset{\text{slaked lime}}{3Ca(OH)_2} + 2Cl_2 \longrightarrow \underset{\text{Bleaching powder}}{Ca(OCl)_2.Ca(OH)_2.CaCl_2.2H_2O}$$



CHAPTER 11

THE p-BLOCK ELEMENTS (GROUP 13 AND 14)

FACT/DEFINITION TYPE QUESTIONS

1. The non-metal oxides are ___x___ whereas metal oxides are ___y___ in nature.
(a) x = acidic or neutral, y = basic
(b) x = acidic, y = neutral
(c) x = basic, y = acidic
(d) x = neutral, y = basic

2. Which of the following is most abundant in the earth crust ?
(a) Boron (b) Aluminium
(c) Gallium (d) Thallium

3. Ionisation enthalpy (Δ_iH_1 kJ mol^{-1}) for the elements of Group 13 follows the order.
(a) $B > Al > Ga > In > Tl$ (b) $B < Al < Ga < In < Tl$
(c) $B < Al > Ga < In > Tl$ (d) $B > Al < Ga > In < Tl$

4. The relationship between first, second and third ionisation enthalpies of each group-13 element is
(a) $\Delta_iH_1 > \Delta_iH_2 > \Delta_iH_3$ (b) $\Delta_iH_1 < \Delta_iH_2 < \Delta_iH_3$
(c) $\Delta_iH_1 = \Delta_iH_2 > \Delta_iH_3$ (d) $\Delta_iH_3 > \Delta_iH_1 > \Delta_iH_2$

5. Which of the following properties of aluminium makes it useful for food packaging ?
(a) Good electrical conductivity
(b) Good thermal conductivity
(c) Low density
(d) Non toxicity

6. Which of the following is/are true regarding gallium?
(i) It has unusually low melting point (303 K).
(ii) It exist in liquid state during summer.
(iii) It has a high boiling point (2676 K).
The correct option is
(a) (i) and (ii) (b) (i) and (iii)
(c) (i), (ii) and (iii) (d) (ii) and (iii)

7. The element which shows least metallic character is
(a) Indium (b) Boron
(c) Aluminium (d) Gallium

8. Which one of the following has the lowest m.p.?
(a) B (b) Al
(c) Ga (d) Tl

9. Which of the following does not form M^{3+} ion?
(a) Boron (b) Aluminium
(c) Indium (d) Gallium

10. The group 13 element that is liquid during summer and used for measuring high temperature is
(a) Boron (b) Aluminium
(c) Gallium (d) Indium

11. Thallium shows different oxidation states because
(a) it is transition element
(b) of inert pair effect
(c) of its amphoteric character
(d) of its higher reactivity

12. The exhibition of highest co-ordination number depends on the availability of vacant orbitals in the central atom. Which of the following elements is not likely to act as central atom in MF_6^{3-} ?
(a) B (b) Al
(c) Ga (d) In

13. Which out of the following compounds does not exist?
(a) BF_3 (b) $TlCl_3$
(c) $TlCl_5$ (d) Both (b) and (c)

14. Aluminium chloride is a/an
(a) Bronsted - Lowery acid (b) Arhenius acid
(c) Lewis acid (d) Lewis base

15. The strongest Lewis acid is
(a) BF_3 (b) BCl_3
(c) BBr_3 (d) BI_3

16. $AlCl_3$ on hydrolysis gives
(a) $Al_2O_3 . H_2O$ (b) $Al(OH)_3$
(c) Al_2O_3 (d) $AlCl_3.6H_2O$

17. Which metal is protected by a layer of its own oxide?
(a) Al (b) Ag
(c) Au (d) Fe

18. Aluminium vessels should not be washed with materials containing washing soda because
(a) washing soda is expensive
(b) washing soda is easily decomposed
(c) washing soda reacts with aluminium to form soluble aluminate
(d) washing soda reacts with aluminium to form insoluble aluminium oxide

19. When Al is added to KOH solution

(a) no action takes place (b) oxygen is evolved

(c) water is produced (d) hydrogen is evolved

20. Which of the following does not react with aqueous NaOH ?

(a) B (b) Al

(c) Ga (d) Tl

21. Amphoteric oxide among the following is

(a) B_2O_3 (b) Ga_2O_3

(c) In_2O_3 (d) Tl_2O_3

22. Boron forms covalent compound due to

(a) higher ionization energy

(b) lower ionization energy

(c) small size

(d) Both (a) and (c)

23. NH_3 and BF_3 form an adduct readily because they form

(a) a coordinate bond (b) a hydrogen bond

(c) an ionic bond (d) a covalent bond

24. The factor responsible for weak acidic nature of B–F bonds in BF_3 is

(a) large electronegativity of fluorine

(b) three centred two electron bonds in BF_3

(c) $p\pi$ - $d\pi$ back bonding

(d) $p\pi$ - $p\pi$ back bonding

25. In borax bead test which compound is formed?

(a) Ortho-borate (b) Meta-borate

(c) Double oxide (d) Tetra-borate

26. The formula of mineral borax is

(a) $Na_2B_4O_7$ (b) $Na_2B_4O_7.4H_2O$

(c) $Na_2B_4O_7.5H_2O$ (d) $Na_2B_4O_7.10H_2O$

27. Which of the following hydroxide is acidic ?

(a) $Al(OH)_3$ (b) $Ca(OH)_3$

(c) $Tl(OH)_3$ (d) $B(OH)_3$

28. Orthoboric acid

(a) donate proton to form $H_2BO_3^-$

(b) accept proton of form $H_4BO_3^+$

(c) donate OH^- to form $H_2BO_2^+$

(d) accept OH^- to form $[B(OH)_4]^-$

29. H_3BO_3 on heating up to 373 K yields:

(a) boric anhydride (b) orthoboric acid

(c) metaboric acid (d) tetraboric acid

30. Boric acid is polymeric due to

(a) its acidic nature

(b) the presence of hydrogen bonds

(c) its monobasic nature

(d) its geometry

31. $B(OH)_3$ is

(a) monobasic acid (b) dibasic acid

(c) tribasic acid (d) triacidic base

32. Orthoboric acid when heated to red hot gives

(a) metaboric acid (b) pyroboric acid

(c) boron and water (d) boric anhydride

33. Which is false in case of boric acid H_3BO_3?

(a) It acts as a tribasic acid.

(b) It has a planar structure.

(c) It acts as a monobasic acid.

(d) It is soluble in hot water.

34. BCl_3 does not exist as dimer but BH_3 exists as dimer (B_2H_6) because

(a) chlorine is more electronegative than hydrogen

(b) there is $p\pi$-$p\pi$ back bonding in BCl_3 but BH_3 does not contain such multiple bonding

(c) large sized chlorine atoms do not fit in between the small boron atoms where as small sized hydrogen atoms get fitted in between boron atoms

(d) None of the above

35. In reaction

$BF_3 + 3LiBH_4 \rightarrow 3LiF + X$; X is

(a) B_4H_{10} (b) B_2H_6

(c) BH_3 (d) B_3H_8

36. Inorganic benzene is

(a) $B_3H_3N_3$ (b) BH_3NH_3

(c) $B_3H_6N_3$ (d) $H_3B_3N_6$

37. The structure of diborane (B_2H_6) contains

(a) four 2c-2e bonds and four 3c-2e bonds

(b) two 2c-2e bonds and two 3c-3e bonds

(c) two 2c-2e bonds and four 3c-2e bonds

(d) four 2c-2e bonds and two 3c-2e bonds

38. In diborane

(a) 4–bridged hydrogens and two terminal hydrogens are present

(b) 2– bridged hydrogens and four terminal hydrogens are present

(c) 3–bridged and three terminal hydrogens are present

(d) None of these

39. Diborane upon hydrolysis gives

(a) boric anhydride (b) metaboric acid

(c) orthoboric acid (d) boron oxide

40. Borazole is known as

(a) organic benzene (b) organic xylene

(c) inorganic benzene (d) inorganic xylene

41. The compounds of boron and hydrogen are collectively called

(a) diboranes (b) borazoles

(c) boracits (d) boranes

42. The bonds present in borazole or inorganic benzene are

(a) $9\sigma, 6\pi$ (b) $12\sigma, 3\pi$

(c) $6\sigma, 9\pi$ (d) 15σ only

43. The two type of bonds present in B_2H_6 are covalent and

(a) ionic (b) co-ordinate

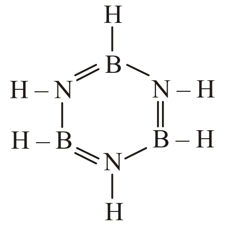
(c) hydrogen bridge bond (d) None of these

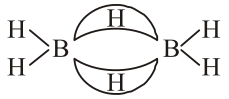
44. Reaction of diborane with ammonia gives initially

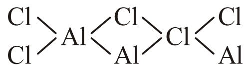
(a) $B_2H_6 \cdot NH_3$ (b) Borazole

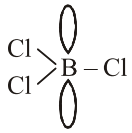
(c) $B_2H_6 \cdot 3NH_3$ (d) $[BH_2(NH_3)_2]^+[BH_4]^-$

45. Which of the following compounds is not matched correctly with its structure?

(a)  – Borazine

(b)  – Diborane

(c)  – Aluminium chloride

(d)  – Boron trichloride

46. The electronic configuration of four different elements is given below. Identify the group 14 element among these

(a) [He] $2s^1$

(b) [Ne] $3s^2$

(c) [Ne] $3s^2 3p^2$

(d) [Ne] $3s^2 3p^5$

47. Which of the following is most electronegative?

(a) Pb

(b) Si

(c) C

(d) Sn

48. Which of the following isotope of carbon is radioactive?

(a) ^{12}C

(b) ^{13}C

(c) ^{14}C

(d) All of these

49. Carbon and silicon belong to group 14. The maximum coordination number of carbon in commonly occurring compounds is 4, whereas that of silicon is 6. This is due to

(a) large size of silicon

(b) more electropositive nature of silicon

(c) availability of *d*-orbitals in silicon

(d) Both (a) and (b)

50. The inert pair effect is most prominent in

(a) C

(b) Pb

(c) Ge

(d) Si

51. The most stable +2 oxidation state is exhibited by

(a) Fe

(b) Sn

(c) Pb

(d) Si

52. Which of the following lead oxides is present in 'Sindhur'?

(a) PbO

(b) PbO_2

(c) Pb_2O_3

(d) Pb_3O_4

53. Mark the oxide which is amphoteric in character

(a) CO_2

(b) SiO_2

(c) SnO_2

(d) CaO

54. Red lead is

(a) Pb_3O_4

(b) Pb_2O_3

(c) Pb_2O

(d) PbO

55. The oxide of lead used in lead accumulators is

(a) PbO

(b) Pb_2O_3

(c) Pb_3O_4

(d) PbO_2

56. Which of the following is/are not correctly matched ?

(i) GeO_2 – Acidic

(ii) PbO_2– Amphoteric

(iii) CO – Neutral

(iv) SiO_2 – Amphoteric

(a) (i) and (iv)

(b) (iv) only

(c) (ii) only

(d) (iii) only

57. Least thermally stable is

(a) CCl_4

(b) $SiCl_4$

(c) $GeCl_4$

(d) $GeBr_4$

58. Unlike the other elements of its group carbon and silicon does not form MX_2 type molecules because

(a) energetically this is not possible

(b) carbon undergoes catenation

(c) it is non-metallic

(d) carbon does not contain d-orbital

59. Which of the following halides is the most stable?

(a) CF_4

(b) CI_4

(c) CBr_4

(d) CCl_4

60. The stability of dihalides of Si, Ge, Sn and Pb increases steadily in the sequence

(a) $PbX_2 << SnX_2 << GeX_2 << SiX_2$

(b) $GeX_2 << SiX_2 << SnX_2 << PbX_2$

(c) $SiX_2 << GeX_2 << PbX_2 << SnX_2$

(d) $SiX_2 << GeX_2 << SnX_2 << PbX_2$.

61. Which of the following is not correct?

(a) $Ge(OH)_2$ is amphoteric

(b) $GeCl_2$ is more stable than $GeCl_4$

(c) GeO_2 is weakly acidic

(d) $GeCl_4$ in HCl forms $[GeCl_2]^{2-}$ ion

62. The main reason that $SiCl_4$ is easily hydrolysed as compared to CCl_4 is that

(a) Si-Si bond is weaker

(b) $SiCl_4$ can form hydrogen bonds

(c) $SiCl_4$ is covalent

(d) Si can extend its coordination number beyond four

63. Which halide is least stable and has doubtful existence

(a) CI_4

(b) GeI_4

(c) SnI_4

(d) PbI_4

64. PbF_4, $PbCl_4$ exist but $PbBr_4$ and PbI_4 do not exist because of

(a) large size of Br^- and I^-

(b) strong oxidising character of Pb^{4+}

(c) strong reducing character of Pb^{4+}

(d) low electronegativity of Br^- and I^-.

65. Catenation i.e., linking of similar atoms depends on size and electronic configuration of atoms. The tendency of catenation in Group 14 elements follows the order :
(a) $C > Si > Ge > Sn$ (b) $C >> Si > Ge \approx Sn$
(c) $Si > C > Sn > Ge$ (d) $Ge > Sn > Si > C$

66. The catenation tendency of C,Si and Ge is in the order $Ge < Si < C$.The bond energies (in kJ mol^{-1}) of C-C,Si-Si and Ge-Ge bonds, respectively are
(a) 167, 180, 348 (b) 180, 167, 348
(c) 348, 167, 180 (d) 348, 180, 167

67. Lead pipes are readily corroded by
(a) H_2SO_4 (b) HCl
(c) CH_3COOH (d) pure water

68. Lead pipes are not suitable for drinking water because
(a) lead forms basic lead carbonate
(b) lead reacts with water containing air to form $Pb(OH)_2$
(c) a layer of lead dioxide is deposited over pipes
(d) lead reacts with air to form litharge

69. The reducing power of divalent species decreases in the order
(a) $Ge > Sn > Pb$ (b) $Sn > Ge > Pb$
(c) $Pb > Sn > Ge$ (d) None of these

70. The element that does not show catenation among the following p-block elements is
(a) carbon (b) silicon
(c) germanium (d) lead

71. How many six membered and five membered rings are present in fullerene?
(a) Six membered = 20, five membered = 10
(b) Six membered = 20, five membered = 12
(c) Six membered = 25, five membered = 10
(d) Six membered = 12, five membered = 25

72. Which of the following is the pure form of carbon ?
(a) Diamond
(b) Fullerene
(c) Graphite
(d) All three forms are equally pure

73. Which one of the following is not an allotrope of carbon ?
(a) Carborundum (b) Diamond
(c) Soot (d) Graphite

74. Which of the following types of forces bind together the carbon atoms in diamond ?
(a) Ionic (b) Covalent
(c) Dipolar (d) van der Waal's

75. Carborundum is
(a) SiC (b) CaC_2
(c) Mg_2C_3 (d) None of these

76. Buckminster fullerene is
(a) pure graphite (b) C-60
(c) diamond (d) C-90

77. The hybridisation state of carbon in fullerene is
(a) sp (b) sp^2
(c) sp^3 (d) sp^3d

78. The number of carbon atoms in Buckminsterfullerene is
(a) 50 (b) 350
(c) 60 (d) 70

79. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behaviour is that graphite
(a) is an allotropic form of diamond
(b) has molecules of variable molecular masses like polymers
(c) has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak inter plate bonds
(d) is a non-crystalline substance

80. In graphite, electrons are
(a) localised on every third C-atom
(b) present in anti-bonding orbital
(c) localised on each C-atom
(d) spread out between the structure

81. The elements commonly used for making transistors are
(a) C and Si (b) Ga and In
(c) P and As (d) Si and Ge

82. The element which is exclusively applied as semi-conductor
(a) Au (b) Ge
(c) Pt (d) Si

83. Glass is a
(a) liquid
(b) solid
(c) supercooled liquid
(d) transparent organic polymer

84. Glass reacts with HF to produce
(a) SiF_4 (b) H_2SiF_6
(c) H_2SiO_3 (d) Na_3AlF_6

85. Producer gas is the mixture of
(a) $CO + N_2$ (b) $CO + H_2$
(c) CO + water vapours (d) $N_2 + CH_4$

86. Coal gas is a mixture of
(a) H_2O and CO (b) H_2, CO, N_2 and CH_4
(c) H_2 and CO (d) CH_4 and CO

87. Crystalline form of silica is called
(a) crystalline silicon (b) quartz
(c) rock (d) talc

88. Dry ice is
(a) solid SO_2 (b) solid NH_3
(c) solid O_2 (d) solid CO_2

89. In silica (SiO_2), each silicon atom is bonded to
(a) two oxygen atoms
(b) four oxygen atoms
(c) one silicon and two oxygen atoms
(d) one silicon and three oxygen atoms

90. R_3SiCl on hydrolysis forms

(a) R_3SiOH (b) $R_3Si-O-SiR_3$

(c) $R_2Si=O$ (d) None of these

91. Which of the following statements is false?

(a) Water gas is a mixture of hydrogen and carbon monoxide

(b) Producer gas is a mixture of CO and nitrogen

(c) Water gas is a mixture of water vapour and hydrogen

(d) Natural gas consists of methane, ethane and gaseous hydrocarbons.

92. Which gas is essential constituent of almost all fuel gases ?

(a) CO_2 (b) N_2

(c) CO (d) H_2O

93. CO_2 is used for extinguishing fire because

(a) it has a relatively high critical temperature

(b) in solid state, it is called dry ice

(c) it is neither combustible nor a supporter of combustion

(d) it is a colourless gas

94. The correct statement with respect to CO is

(a) it combines with H_2O to give carbonic acid

(b) it reacts with haemoglobin in RBC

(c) it is powerful oxidising agent

(d) it is used to prepare aerated drinks

95. Producer gas, a fuel and also a source of nitrogen is obtained by

(a) passing a mixture of steam and air over incandescent coke.

(b) spraying oil into hot retorts.

(c) restricted supply of air through a bed of incandescent coke.

(d) passing steam over incandescent coke.

96. Which of the following shows bond in silicone :

(a) Si – Si – Si – Si (b) – Si – O – Si – O – Si

(c) Si – C – Si – C – Si (d) Si – C – Si – O – Si

97. Which of the following is formed on dehydration of formic acid with concentrated H_2SO_4 ?

(a) CO (b) CO_2

(c) CH_4 (d) H_2

98. _____ helps to maintain pH of blood between 7.26 to 7.42

(a) CO_2 (b) H_2CO_3

(c) CO_3^{2-} (d) H_2CO_3/HCO_3^-

99. Which of the following is not the crystalline form of silica?

(a) Quartz

(b) Cristobalite

(c) Tridymite

(d) All are crystalline form of silica.

100. Which of the following is used in surgical and cosmetic plants?

(a) Silicones (b) Silicates

(c) Silica (d) None of these

101. Which of the following is not a man-made silicate ?

(a) Glass (b) Cement

(c) Zeolites (d) All are man-made silicates

102. Which type of zeolite is used to convert alcohols directly into gasoline ?

(a) ZSM – 3 (b) ZSM – 5

(c) ZSM – 2 (d) All of these

STATEMENT TYPE QUESTIONS

103. Which of the following statement(s) is/are not correct ?

(i) Valence shell electronic configuration of p-block elements is $ns^2\ np^{1-6}$

(ii) Non metals and metalloids exist only in the p-block of the periodic table.

(iii) In boron, carbon and nitrogen families the group oxidation state is the most stable state for the lighter elements in the group.

(iv) For heavier elements in each group oxidation state two unit less than the group oxidation state becomes more stable due to inert pair effect

(a) (ii) only

(b) (ii), (iii) and (iv)

(c) (iii) and (iv)

(d) All given statements are correct

104. Which of the following sequence of T and F is correct for given statements. Here T represents 'True' and F represents 'False' statement.

(i) Aluminium forms $[AlF_6]^{3-}$ ion while boron forms only $[BF_4]^-$ ion due to presence of *d*-orbitals in aluminium.

(ii) The first member of a group differs from the heavier members in its ability to form pπ-pπ multiple bonds to itself and to other second row elements. While heavier member forms dπ-pπ bonds.

(iii) *d*-orbitals contribute more to the overall stability of molecules than pπ-pπ bonding of second row elements.

(a) TTT (b) FTF

(c) TTF (d) FTT

105. Which of the following statement(s) is/are incorrect ?

(i) Trichlorides on hydrolysis in water form tetrahedral $[M(OH)_4]^-$ species.

(ii) Hybridisation state of metal in tetrahedral species is sp^3.

(iii) Aluminium chloride in acidified aqueous solution forms $[Al(OH)_4]^-$ ion.

(a) (i) and (ii) (b) (ii) only

(c) (iii) only (d) (i) and (iii)

106. Which of the following statement(s) regarding BCl_3 and $AlCl_3$ is/are correct ?

(i) BCl_3 possess lower melting point than $AlCl_3$.

(ii) BCl_3 is more covalent in character than $AlCl_3$.

(a) Statement (i) is correct explanation for statement (ii).

(b) Statement (i) and (ii) both are incorrect

(c) Statement (i) and (ii) both are correct

(d) Statement (ii) is correct explanation for statement (i)

107. Which of the following statement(s) is/are incorrect ?
- (i) Higher boranes are not flammable.
- (ii) Boranes are hydrolysed by water to give orthoboric acid.
- (iii) Boranes undergoes cleavage reactions with Lewis bases to give borane adducts.

(a) (i) only (b) (ii) and (iii)
(c) (iii) only (d) (i) and (ii)

108. Select the correct statements for diborane :
- (i) Boron is approximately sp^3 hybridized
- (ii) B – H – B angle is 180°
- (iii) There are two terminal B – H bonds for each boron atom
- (iv) There are only 12 bonding electrons

(a) (i), (ii) and (iv) (b) (i), (ii) and (iii)
(c) (ii), (iii) and (iv) (d) (i), (iii) and (iv)

109. Which of the following sequence of T and F is correct for given statements. Here T stands for the true and F stands for false statement.
- (i) The tendency to show +2 oxidation state increase in the sequence Ge < Sn < Pb.
- (ii) Tin in +2 state is a reducing agent.
- (iii) Lead compounds in +2 state are strong oxidising agents.
- (iv) In tetravalent state molecules of group 13 elements act as electrons donor species.

(a) TTTT (b) TTFF
(c) TTFT (d) TFFT

110. Which of the following statement(s) is / are incorrect for CO_2?
- (i) In laboratory CO_2 is prepared by the action of dilute HCl on calcium carbonate
- (ii) Carbon dioxide is a poisonous gas
- (iii) Increase in carbon dioxide content in atmosphere lead to increase in green house effect.
- (iv) CO_2 as dry ice is used as a refrigerant for ice cream and frozen food.

(a) (i) and (ii) (b) Only (ii)
(c) (i), (ii) and (iii) (d) (ii) and (iii)

111. Which of the following sequence of T and F is correct for given statements. Here T stands for true and F stands for false statement.
- (i) Quartz is extensively used as a piezoelectric material.
- (ii) Kieselghur is an amorphous form of silica which is used in filteration plants.
- (iii) Silica does not react with halogens, dihydrogen and most of the acids and metals even at elevated temperature.

(a) TTT (b) TFF
(b) TFT (d) FFT

MATCHING TYPE QUESTIONS

112. Match the columns

	Column-I		Column-II
(A)	Borax-bead	(p)	Alum
(B)	Inorganic benzene	(q)	Diborane
(C)	Antiseptic	(r)	Metaborate
(D)	Bridged hydrogens	(s)	Borazole

(a) A – (p), B – (r), C – (q), D – (s)
(b) A – (r), B – (s), C – (p), D – (q)
(c) A – (s), B – (r), C – (p), D – (q)
(d) A – (q), B – (r), C – (s), D – (p)

113. Identify (i) to (v) in reactions (1) and (2) on the basis of your identification choose the correct code for matching Column-I with Column-II.

1. $Na_2B_4O_7.10H_2O \xrightarrow{\Delta} (i) \xrightarrow{\Delta} (ii) + (iii)$
2. $Na_2B_4O_7.7H_2O \longrightarrow (iv) + (v)$

	Column-I		Column-II
(A)	(i)	(p)	H_3BO_3
(B)	(ii)	(q)	B_2O_3
(C)	(iii)	(r)	$NaBO_2$
(D)	(iv)	(s)	NaOH
(E)	(v)	(t)	$Na_2B_4O_7$

(a) A – (t), B – (s), C – (p), D – (q), E – (r)
(b) A – (r), B – (q), C – (s), D – (p), E – (t)
(c) A – (t), B – (r), C – (q), D – (p), E – (s)
(d) A – (t), B – (r), C – (s), D – (q), E – (p)

114. Match Column-I (Compound of boron) with Column-II (Use) and choose the correct option.

	Column-I		Column-II
(A)	Metal borides	(p)	Flux for soldering metals
(B)	Boron fibres	(q)	Bullet-proof vest
(C)	Borax	(r)	As a mild antiseptic
(D)	Boric acid	(s)	As control rods in nuclear industry

(a) A – (q), B – (s), C – (r), D – (p)
(b) A – (q), B – (s), C – (p), D – (r)
(c) A – (s), B – (q), C – (r), D – (p)
(d) A – (s), B – (q), C – (p), D – (r)

115. Match the columns

	Column-I		Column-II
(A)	Carbon	(p)	Metal
(B)	Silicon	(q)	Non-metal
(C)	Germanium	(r)	Metalloid
(D)	Tin		
(E)	Lead		

(a) A – (q), B – (q), C – (r), D – (p), E – (p)
(b) A – (q), B – (r), C – (r), D – (p), E – (p)
(c) A – (q), B – (r), C – (r), D – (p), E – (q)
(d) A – (q), B – (q), C – (q), D – (r), E – (p)

116. Match columns

	Column-I		Column-II
(A)	Graphite fibres	(p)	Abrasive for sharpening hard tools
(B)	Carbon black	(q)	Formation of light weight composites.
(C)	Charcoal	(r)	Used in water filters to remove organic contaminators
(D)	Diamond	(s)	As filler in automobile tyres

(a) A – (s), B – (q), C – (r), D – (p)
(b) A – (q), B – (s), C – (r), D – (p)
(c) A – (q), B – (r), C – (s), D – (p)
(d) A – (p), B – (r), C – (s), D – (q)

117. Match the columns

	Column-I		Column-II
(A)	Borazole	(p)	$CaSO_4 \cdot \frac{1}{2} H_2O$
(B)	Plaster of Paris	(q)	C_{60}
(C)	Boric acid	(r)	SiO_2
(D)	Quartz	(s)	$B_3N_3H_6$
(E)	Buckminsterfullerene	(t)	H_3BO_3

(a) A – (r); B – (p); C – (q); D – (t); E – (s)
(b) A – (p); B – (t); C – (r); D – (s); E – (q)
(c) A – (t); B – (q); C – (p); D – (r); E – (s)
(d) A – (s); B – (p); C – (t); D – (r); E – (q)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

118. Assertion : Atomic radius of gallium is higher than that of aluminium
Reason : The presence of additional *d*-electron offer poor screening effect for the outer electrons from increased nuclear charge.

119. Assertion : Boron is metalloid.
Reason : Boron shows metallic nature.

120. Assertion : The use of aluminium and its compounds for domestic purposes is now reduced considerably.
Reason : The highly toxic nature of aluminium is the responsible factor.

121. Assertion : Pb^{4+} compounds are stronger oxidizing agents than Sn^{4+} compounds.
Reason : The higher oxidation states for the group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'.

122. Assertion : PbI_4 of lead does not exist.
Reason : Pb–I bond initially formed during the reaction does not release enough energy to unpair $6s^2$ electrons.

123. Assertion : Graphite is thermodynamically most stable allotrope of carbon.
Reason : $\Delta_f H^{\ominus}$ of graphite is taken as zero.

CRITICAL THINKING TYPE QUESTIONS

124. The liquefied metal which expands on solidification is :
(a) Ga (b) Al
(c) Zn (d) In

125. What is *x* in the following reaction?
$Al(s) + NaOH\,(aq) + H_2O\,(l) \rightarrow x + H_2(g)$
(a) $Na_2[Al(OH)_4]^-$ (b) $Na^+[Al(OH)_4]^-$
(c) $Na_2[Al(OH)_6]^-$ (d) $Na^+[Al(OH)_6]^-$

126. Which among the following oxides react with alkali?
B_2O_3, Al_2O_3 and Tl_2O
(a) B_2O_3 and Al_2O_3 (b) Al_2O_3 and Tl_2O
(c) Only B_2O_3 (d) B_2O_3 and Tl_2O

127. White fumes appeared around the bottle of anhydrous aluminium chloride is due to _____
(a) Cl_2 gas
(b) moist HCl
(c) condensation of aluminium chloride vapours
(d) None of these

128. What is the oxidation state and hybridisation of boron in compound formed when BCl_3 undergoes reaction with the water?
(a) 3, sp^2d (b) 3, sp^3
(c) 4, sp^3 (d) 3, sp^2d

129. Which is not correct?
(a) Al acts as a reducing agent
(b) Al does not react with steam even at higher temperature
(c) Al forms a number of alloys with other metals
(d) Al is ionic in all its compounds

130. Which one of the following is the correct statement?
(a) Boric acid is a protonic acid
(b) Beryllium exhibits coordination number of six
(c) Chlorides of both beryllium and aluminium have bridged structures in solid phase
(d) $B_2H_6.2NH_3$ is known as 'inorganic benzene'

131. BF_3 is used as a catalyst in several industrial processes due to its
(a) strong reducing nature
(b) weak reducing action
(c) strong Lewis acid nature
(d) weak Lewis acid character

132. What is the colour obtained when borax is heated in a Bunsen burner flame with CoO?
(a) Blue (b) Black
(c) Green (d) Violet

133. Which of the following statements about H_3BO_3 is not correct?

(a) It is a strong tribasic acid

(b) It is prepared by acidifying an aqueous solution of borax

(c) It has a layer structure in which planar BO_3 units are joined by hydrogen bonds

(d) It does not act as proton donor but acts as a Lewis acid by accepting a lone pair of electrons

134. The hybridisation of boron atom in orthoboric acid is

(a) sp (b) sp^2

(c) sp^3 (d) sp^3d

135. Which is not the use of orthoboric acid?

(a) As an antiseptic and eye wash.

(b) In glass industry.

(c) In glazes for pottery.

(d) In borax - bead test.

136. Which of the following reaction shows production of diborane on industrial scale ?

(a) $4BF_3 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3LiF + 3AlF_3$

(b) $2NaBH_4 + I_2 \longrightarrow B_2H_6 + 2NaI + H_2$

(c) $2BF_3 + 6NaH \xrightarrow{450K} B_2H_6 + 6NaF$

(d) Both (b) and (c)

137. Identify the statement that is not correct as far as structure of diborane is concerned

(a) There are two bridging hydrogen atoms and four terminal hydrogen atoms in diborane

(b) Each boron atom forms four bonds in diborane

(c) The hydrogen atoms are not in the same plane in diborane

(d) All, B – H bonds in diborane are similar

138. Which of the following structure is similar to graphite?

(a) B (b) B_4C

(c) B_2H_6 (d) BN

139. A compound X, of boron reacts with NH_3 on heating to give another compound Y which is called inorganic benzene. The compound X can be prepared by treating BF_3 with lithium aluminium hydride. The compounds X and Y are represented by the formulas.

(a) $B_2H_6, B_3N_3H_6$ (b) $B_2O_3, B_3N_3H_6$

(c) $BF_3, B_3N_3H_6$ (d) $B_3N_3H_6, B_2H_6$

140. The product/s formed when diborane is hydrolysed is/are

(a) B_2O_3 and H_3BO_3 (b) B_2O_3 only

(c) H_3BO_3 and H_2 (d) H_3BO_3 only

141. Which of the following species exists (A) $[SiF_6]^{2-}$, (B) $[GeCl_6]^{2-}$ and (C) $[CCl_6]^{2-}$?

(a) (A) and (B) (b) (B) and (C)

(c) Only (C) (d) (A) and (C)

142. Ge(II)compounds are powerful reducing agents whereas Pb(IV)compounds are strong oxidants .It is because

(a) Pb is more electropositive than Ge

(b) ionization potential of lead is less than that of Ge

(c) ionic radii of Pb^{2+} and Pb^{4+} are larger than those of Ge^{2+} and Ge^{4+}

(d) of more pronounced inert pair effect in lead than in Ge

143. Which of the following statements is not correct ?

(a) Fullerene is formed by condensation of vapourised C^n small molecules consists of mainly C_{60}.

(b) In fullerene a six membered ring can only fuse with five membered ring and a five membered ring can only fuse with six membered rings.

(c) All carbon atoms are sp^2 hybridised in fullerene

(d) All the above are correct.

144. The element that does not form a monoxide is

(a) lead (b) tin

(c) germanium (d) silicon

145. A group 14 element is oxidised to form corresponding oxide which is gaseous in nature, when dissolved in water pH of the water decreases further addition of group 2 hydroxides leads to precipitation. This oxide can be

(a) GeO_2 (b) CO

(c) CO_2 (d) SnO_2

146. Which among the following can act as reducing agent (A)$SnCl_2$, (B)CO and (C)$PbCl_2$?

(a) (A) and (B) (b) (B) and (C)

(c) (C) and (A) (d) Only (B)

147. Lead is not affected by dil. HCl in cold because

(a) Pb is less electronegative than H

(b) PbO film is formed which resists chemical attack by acid

(c) $PbCl_2$ protective coating gets formed on Pb surface

(d) PbO_2 film is always present on Pb surface, which resist chemical attack

148. The percentage of s-character of the hybrid orbitals of carbon in graphite and diamond are respectively

(a) 33, 25 (b) 50, 50

(c) 67, 25 (d) 33, 67

149. What is the hybridisations of carbon atoms present in diamond, graphite and fullerene respectively ?

(a) sp^3,sp^2 and sp^2 (b) sp^2,sp^3 and sp^2

(c) sp^2,sp^2 and sp^3 (d) sp^3,sp^3 and sp^2

150. Which one of the following allotropic forms of carbon is isomorphous with crystalline silicon?

(a) Graphite (b) Coal

(c) Coke (d) Diamond

151. Which one of the following statements about the zeolites is false ?

(a) They are used as cation exchangers

(b) They have open structure which enables them to take up small molecules

(c) Zeolites are aluminosilicates having three dimensional network

(d) None of the above

152. Which of the following attacks glass

(a) HCl (b) HF

(c) HI (d) HBr

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** The non – metal oxides are acidic or neutral whereas metal oxides are basic in nature.

2. **(b)** Aluminium does not occur in the free state in nature but is most abundant metal in the earth's crust.

3. **(d)**

4. **(b)** The order of ionisation enthalpies, as expected, is $\Delta_i H_1 < \Delta_i H_2 < \Delta_i H_3$.

5. **(c)** Due to the low density of aluminium it is useful for food packaging.

6. **(c)** **7.** **(b)**

8. **(c)** The m.p decreases from B to Ga , hence gallium (Ga) has least m.p. (303 K) among group of 13 element.

9. **(a)** Due to its small size and high ionization energy boron does not form B^{3+} ion.

10. **(c)** Gallium is remarkable for its unusually low M.P. (29.7°C).

11. **(b)** Thallium shows different (+1 and +3) oxidation states because of inert pair effect.

12. **(a)**

13. **(c)** Because Tl^{+5} does not exist

14. **(c)**

15. **(d)** The order of strength of Lewis acid character for boron halides is, $BF_3 < BCl_3 < BBr_3 < BI_3$ (due to back bonding)

16. **(b)** **17.** **(a)** **18.** **(c)**

19. **(d)** $2KOH + 2Al + 2H_2O \rightarrow 2KAlO_2 + 3H_2$

20. **(a)**

21. **(b)** Down the group basic character of oxides increases.

B_2O_3 - Acidc
Al_2O_3 - Amphoteric
Ga_2O_3 - Amphoteric
In_2O_3 - Basic
Tl_2O_3 - Basic

22. **(d)** **23.** **(a)**

24. **(d)** It is $p\pi - p\pi$ back bonding involving B and F. The smaller atoms show more back bonding.

25. **(b)** $Na_2B_4O_7 . 10\,H_2O \xrightarrow[-10H_2O]{\Delta} Na_2B_4O_7$

$$\underset{\text{anhydrous}}{Na_2B_4O_7} \xrightarrow{\Delta} \underset{\text{sod. metaborate}}{2\,NaBO_2} + \underset{\text{Boric anhydride}}{B_2O_3}$$

$$CuO + B_2O_3 \longrightarrow \underset{\text{cupric meta borate (Blue beed)}}{Cu(BO_2)_2}$$

26. **(d)**

27. **(d)** $B(OH)_3$ is acid because it can take OH^- ions.

H_3BO_3 or $B(OH)_3 + OH^- \rightarrow B(OH)_4^-$

28. **(d)** H_3BO_3 acts as a Lewis acid and accepts OH^- ions to form $[B(OH)_4]^-$

29. **(c)** H_3BO_3 on heating at 373K yields metaboric acid (HBO_2)

$$H_3BO_3 \xrightarrow[\Delta]{373K} \underset{\substack{\text{metaboric acid}\\ \text{(orthorombic form)}}}{HBO_2} + H_2O$$

30. **(b)** In Boric acid each B atom is sp^2 hybridized and contains BO_3^{3-} units which are held together by hydrogen bonds.

31. **(a)**

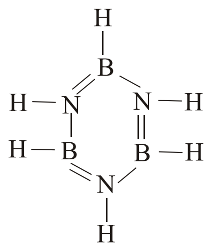
32. **(b)** $H_3BO_3 \xrightarrow{100°C} HBO_2 \xrightarrow{160°C}$

$$H_2B_4O_7 + H_2O \longrightarrow 2B_2O_3 + H_2O$$

33. **(a)** H_3BO_3 is monobasic acid.

34. **(c)** **35.** **(b)**

36. **(c)**

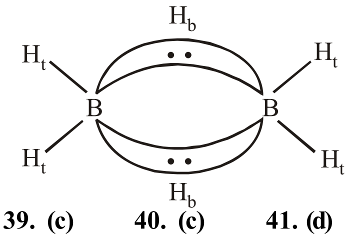


Inorganic benzene, $B_3N_3H_6$

It is isoelectronic with benzene.

37. **(d)** In diborane (B_2H_6) structure there are four 2c-2e bonds and two 3c–2e bonds (see structure of diborane).

Structure of B_2H_6 :

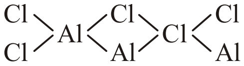


38. **(b)** **39.** **(c)** **40.** **(c)** **41.** **(d)** **42.** **(b)**

43. **(c)** B_2H_6 contains hydrogen bridge bonds. These are one electron bonds also known as banana bonds.

44. **(d)** $B_2H_6 + NH_3 \xrightarrow[\text{low temperature}]{\text{excess } NH_3} B_2H_6.2NH_3$

Diborane with ammonia gives $B_2H_6.2NH_3$ that is formulated as $[BH_2(NH_3)]^+[BH_4]^-$ which when heated to 473K decomposes to give borazole.

45. **(c)** 
$AlCl_3$ (dimer)

46. **(c)** Valence shell electronic configuration of group 14 elements is ns^2p^2.

47. **(c)** Electronegativity decreases down the group.

48. **(c)** ^{14}C is a radioactive isotope with half life of 5770 years and used for radiocarbon dating.

49. **(c)** Due to non-availability of vacant *d*-orbitals, it cannot exceed its coordination number more than four. Thus carbon never forms complexes e.g., $[CCl_6]^{2-}$ deos not exist but $[SiCl_6]^{2-}$ exists.

50. **(b)** The inert pair effect is most prominent in the heavier members of the group. Inert pair effect increases as we move the group down the group.

51. **(c)** Inert pair effect increases down the group. Hence for Pb^{2+}, O.S. is most stable.

52. **(d)** Pb_3O_4 is also known as Sindhur.

53. **(c)** CO_2, SiO_2 are acidic, CaO is basic and SnO_2 is amphoteric.

54. **(a)** Red lead is Pb_3O_4. It is a mixed oxide of Pb (II) and Pb (IV). It acts as a powerful oxidising agent.

55. **(d)** PbO_2 is a strong oxidising agent and is produced in situ in lead storage batteries. The anode is oxidized to PbO_2 and cathode is reduced to spongy Pb.

56. **(b)** SiO_2 is acidic oxide.

57. **(d)** The thermal stability of tetrahalides decreases in order $CX_4 > SiX_4 > GeX_4 > SnX_4$ and in terms of same metal with different halides is in order of

$MF_4 > MCl_4 > MBr_4 > MI_4$.

58. **(a)** The stability of dihalides (MX_2) increases down the group. Except C and Si, the other members form dihalides.

59. **(a)** Since bond energy of C-F > C-Cl > C-Br > C-I

Hence CF_4 is most stable.

60. **(d)** Reluctance of valence shell electrons to participate in bonding is called inert pair effect. The stability of lower oxidation state (+2 for group 14 element) increases on going down the group. So the correct order is

$SiX_2 < GeX_2 < SnX_2 < PbX_2$

61. **(b)** Ge^{4+} is more stable than Ge^{2+}. Hence $GeCl_4$ is more stable than $GeCl_2$

62. **(d)** Carbon halides are not hydrolysed due to absence of *d*-orbitals. On the other hand $SiCl_4$ is easily hydrolysed due to the availability of *d*-orbitals in Si.

$SiX_4 + 2H_2O \rightarrow SiO_2 + 4HX$

63. **(d)** In nature Pb^{4+} is strong oxidant and I^- is strong reductant. Hence PbI_4 cannot exist.

64. **(b)** F and Cl are more oxidising in nature and can achieve Pb in (IV) O.S. but Br_2 and I_2 can not achieve Pb in (IV) O.S. secondly Pb^{4+} is strong in oxidising nature and in its presence, Br^- and I^- can not exist.

65. **(b)**

66. **(d)** The more the bond energy, the more is the catenation.

67. **(c)** Lead pipes are readily corroded by water containing organic acids.

68. **(b)** $2Pb + 2H_2O + O_2 \rightarrow 2Pb(OH)_2$

69. **(a)** The stability of +2 O.S. follows the order

$Pb^{2+} > Sn^{2+} > Ge^{2+}$

Hence reducing power $Ge > Sn > Pb$

70. **(d)** The order of tendency of catenation for elements of C family is

$C >> Si > Ge \approx Sn > Pb$

71. **(b)** Fullerene contains twenty six membered rings and twelve five membered rings.

72. **(b)** Fullerenes are the only pure form of carbon because they have smooth structure without having dangling bonds.

73. **(a)** Carborundum is chemically SiC. It is not an allotrope of carbon.

74. **(b)** In diamond each carbon atom is sp^3 hybridized and thus forms covalent bonds with four other carbon atoms lying at the corners of a regular tetrahedron.

75. **(a)**

76. **(b)** Buckminster fullerene is C_{60}. The molecule has shape of soccer ball.

77. **(b)** In fullerene each carbon atom is bonded to three other carbon atoms and is sp^2 hybridised.

78. **(c)** Buckminster fullerene has the formula C_{60} and is made from interlocking hexagonal and pentagonal rings of C-atoms.

79. **(c)**

80. **(d)** In graphite, each carbon is sp^2 -hybridized and the single occupied unhybridized p-orbitals of C-atoms overlap side wise to give π-electron cloud which is delocalized and thus the electrons are spread out between the structure.

81. **(d)** Si and Ge are semiconductors and are used in making transistors.

82. **(b)** Both Ge and Si are extensively used as semiconductors. Semiconductors are solids where there is only a small difference in energy, called band gap, between the filled valency band of electrons and a conduction band since the band gap of Ge is less than Si, it is a better element to be used as semiconductor.

83. **(c)** Glass is a super cooled liquid.

84. **(b)** $6HF + SiO_2 \rightarrow H_2SiF_6 + 2H_2O$

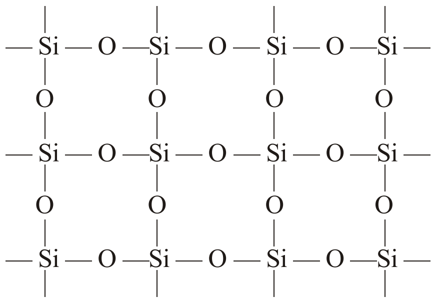
85. (a) Producer gas is a fuel gas and is mixture of CO and N_2.

86. (b) Coal gas is a mixture of $H_2 + CO + N_2 + CH_4$

87. (b) Quartz is crystalline form of silica.

88. (d)

89. (b) In silica (SiO_2); each Si atom is surrounded by four oxygen atom.



Structure of SiO_2

Only Si – O bonds exist and no Si = O.

90. (b) $R_3SiCl + HOH \rightarrow R_3SiOH + HCl$

$$R_3SiOH + HOSiR_3 \rightarrow R_3Si-O-SiR_3 + H_2O$$

91. (a) Water gas is $CO + H_2$

92. (c) CO is essential constituent of almost all fuel gases.

93. (c) CO_2 is incombustible and non supporter of combustion.

94. (b) CO react with haemoglobin, forms carboxy haemoglobin and stopes the supply of O_2

95. (c) Producer gas is mixture of CO + N_2. It is prepared by incomplete combustion of coal in limited supply of air.

96. (b) Silicone has $Si-O-Si-O-Si$ linkage.

97. (a) $HCOOH \xrightarrow[\text{conc. } H_2SO_4]{373K} H_2O + CO$

98. (d) H_2CO_3/HCO_3^- buffer system help to maintain pH of blood between 7.26 to 7.42.

99. (d) Quartz, Cristobalite and Tridymite are crystalline form of silica.

100. (a) Being biocompatible silicones are used in surgical and cosmetic plants.

101. (c) Zeolite is not a man-made silicate.

102. (b) ZSM – 5 type of zeolite is used to convert alcohols directly into gasoline.

STATEMENT TYPE QUESTIONS

103. (d) All the given statements are correct.

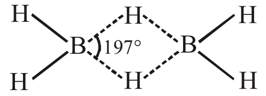
104. (c) *d*-orbitals are of higher energy than the p-orbitals, they contribute less to the overall stability of molecules than pπ-pπ bonding of the second row elements.

105. (c) Aluminium chloride in acidified aqueous solution forms octahedral $[Al(H_2O)_6]^{3+}$ ion.

106. (d) BCl_3 is a covalent compound hence lower melting point.

107. (a) Higher boranes are also spontaneously flammable in air.

108. (d)



B is sp^3 hybridized

Only 12 bonding electrons available

BHB angle is 97° not 180°.

109. (b) Lead compounds in +4 state are strong oxidising agents. In tetravalent state the number of electrons around the central atom in a molecule is eight. Being electron precise molecules, they are normally not expected to act as electron acceptor or electron donor species.

110. (b) Carbon dioxide is not a poisonous gas.

111. (a) All the given statements are true.

MATCHING TYPE QUESTIONS

112. (b)

113. (c) $$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} \underset{(i)}{Na_2B_4O_7} \xrightarrow{\Delta} \underset{(ii)}{2NaBO_2} + \underset{(iii)}{B_2O_3}$$

$$Na_2B_4O_7 + 7H_2O \longrightarrow \underset{(iv)}{4H_3BO_3} + \underset{(v)}{2NaOH}$$

114. (d)

115. (a) Carbon and silicon are non-metals. Germanium is a metalloid. Tin and lead are metals.

116. (b) **117. (d)**

ASSERTION-REASON TYPE QUESTIONS

118. (c) Atomic radius of gallium is less than that of aluminium.

119. (c) Boron is metalloid. Thus assertion is correct. Metalloids possess, metallic as well as non-metallic nature. Hence, reason is false.

120. (a) The use of aluminium and its compounds for domestic purposes is now reduced considerably because of their toxic nature.

121. (c) Assertion is true because lower oxidation state becomes more & more stable for heavier elements in *p*-block due to inert pair effect. Hence Reason is false.

122. (a) PbI_4 does not exist because Pb–I bond initially formed during the reaction does not release enough energy to unpair $6s^2$ electrons and excite one of them to higher orbital to have four unpaired electrons around lead atom.

123. (a)

CRITICAL THINKING TYPE QUESTIONS

124. (a) Gallium (Ga) is soft , silvery metal. Its melting point is 30ºC. This metal expands by 3.1% when it solidifies and hence, it should not be stored in glass or metal containers.

125. (b) $2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow$
$2Na^+[Al(OH)_4]^-(aq) + 3H_2\,(g)$

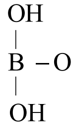
126. (a) B_2O_3 is acidic and Al_2O_3 is amphoteric.

127. (b) Anhydrous aluminium chloride gets partially hydrolysed with atmospheric moisture to liberate HCl gas. Moist HCl appears white in colour.

128. (b) BCl_3 forms $[B(OH)_4]^-$ in which B is sp^3 hybridized and have +3 oxidation state.

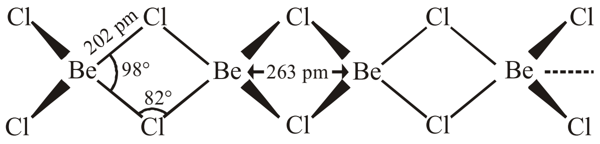
129. (d) Al in its compounds forms covalent bonds.

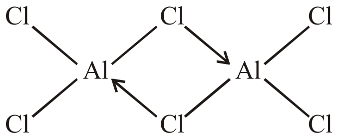
130. (c) The correct formula of inorganic benzene is $B_3N_3H_6$ so (d) is incorrect statement

Boric acid (H_3BO_3 or  $\begin{array}{c}OH\\|\\B-OH\\|\\OH\end{array}$) is a lewis acid so (a) is incorrect statement.

The coordination number exhibited by beryllium is 4 and not 6 so statement (b) is incorrect.

Both $BeCl_2$ and $AlCl_3$ exhibit bridged structures in solid state so (c) is correct statement.





131. (d)

132. (a) When borax is heated in a Bunsen burner flame with CoO on a loop of platinum wire a blue coloured $Co(BO_2)_2$ bead is formed.

133. (a) H_3BO_3 is a weak monobasic acid.

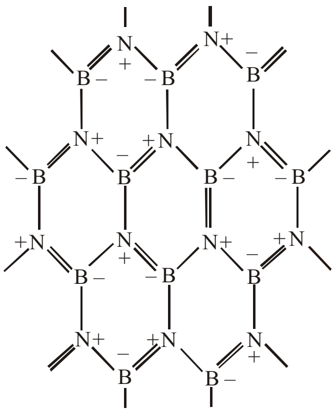
134. (b) The hybridizations of B in H_3BO_3 is sp^2

135. (d) Borax on heating gives B_2O_3 and $NaBO_2$ which is glassy mass and used for borax-bead test.

136. (c) Diborane is produced on industrial scale by the reaction of BF_3 with sodium hydride.

137. (d)

138. (d) Boron nitride (BN) is known as inorganic graphite. The most stable form is hexagonal one. It has layered structure similar to graphite.



139. (a)

140. (c) When diborane is hydrolysed one can get both orthoboric acid and H_2.
$B_2H_6 + 6H_2O \rightarrow 2H_3BO_3 + 6H_2$

141. (a) Carbon does not contain *d*-orbital hence it cannot expand its octet.

142. (d) Ge(II) tends to acquire Ge (IV) state by loss of electrons. Hence it is reducing in nature. Pb (IV) tends to acquire Pb (II) O.S. by gain of electrons. Hence it is oxidising in nature. This is due to inert pair effect.

143. (b) In fullerene a six membered ring can fuse with five as well as with six membered ring while a five membered ring can only fuse with a six membered ring.

144. (d) Silicon does not form mono oxide.

145. (c) CO_2 forms carbonic acid H_2CO_3, when dissolved in water, CO is neutral, whereas other two GeO_2 and SnO_2 are solids.

146. (a) Lead in +2 oxidation is stable while Sn and C are both stable in +4 oxidation.

147. (c) Pb with dil HCl forms protective coating of $PbCl_2$

148. (a) Graphite sp^3, $\therefore$ % s character = 33%
Diamond sp^3, $\therefore$ % s character = 25%

149. (a)

150. (d) Diamond and crystalline silicon are isomorphous.

151. (d)

152. (b) Glass being a mixture of sodium and calcium silicates reacts with hydrofluoric acid forming sodium and calcium fluorosilicates respectively.

$$Na_2SiO_3 + 6HF \rightarrow Na_2SiF_6 + 3H_2O$$

$$CaSiO_3 + 6HF \rightarrow CaSiF_6 + 3H_2O$$

The etching of glass is based on these reactions.

CHAPTER

12

ORGANIC CHEMISTRY–SOME BASIC PRINCIPLES & TECHNIQUES

FACT/DEFINITION TYPE QUESTIONS

1. Which of the following scientist proposed that a 'vital force' was responsible for the formation of organic compounds ?

(a) Berzilius (b) Wohler
(c) Berthelot (d) Kolbe

2. First organic compound to be synthesised was

(a) methane (b) cane sugar
(c) acetic acid (d) urea

3. Which of the following organic compound was synthesised by F. Wohler from an inorganic compound?

(a) Methane (b) Urea
(c) Acetic acid (d) Chloroform

4. The discovery that shook the belief in the vital force theory was

(a) Stereoisomerism
(b) Synthesis of indigo
(c) Wholer's synthesis of urea from ammonium cyanate
(d) Fermentation of sugars

5. In laboratory, first organic compound was synthesised by

(a) Kekule (b) Hennel
(c) Wohler (d) Liebig

6. Who is known as the "Father of Chemistry"?

(a) Faraday (b) Priestley
(c) Rutherford (d) Lavoisier

7. The hybridisation of carbon atom in C — C single bond of $H_2C = CH — CH = CH_2$ is

(a) $sp^3 — sp$ (b) $sp^2 — sp$
(c) $sp^2 — sp^2$ (b) $sp^3 — sp^3$

8. In the hydrocarbon

$$\begin{array}{cccccc} CH_3 - & CH = & CH - & CH_2 - & C \equiv & CH \\ 6 & 5 & 4 & 3 & 2 & 1 \end{array}$$

The state of hybrization of carbons 1, 3 and 5 are in the following sequence

(a) sp^2, sp, sp^3 (b) sp, sp^3, sp^2
(c) sp, sp^2, sp^3 (d) sp^3, sp^2, sp

9. The percentage of s- character of the hybrid orbitals in ethane, ethene and ethyne are respectively.

(a) 50, 75, 100 (b) 10, 20, 40
(c) 25, 33, 50 (d) 25, 50, 75

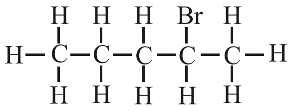
10. Select the molecule which has only one π-bond

(a) $CH \equiv CH$ (b) $CH_2 = CHCHO$
(c) $CH_3CH = CH_2$ (d) $CH_3CH{=}CHCOOH$

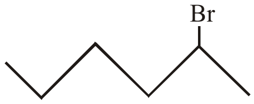
11. 2- Pentene contains

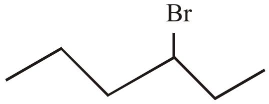
(a) 15 σ- and one π- bond (b) 14 σ-and one π- bond
(c) 15 σ- and two π- bonds (d) 14 σ- and two π- bonds

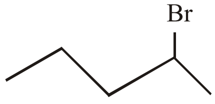
12. Which of the following does not represent the 2 – bromo pentane ?

(i) 

$$\begin{array}{ccccccccccc} & & H & & H & & H & & Br & & H \\ & & | & & | & & | & & | & & | \\ H & - & C & - & C & - & C & - & C & - & C & - H \\ & & | & & | & & | & & | & & | \\ & & H & & H & & H & & H & & H \end{array}$$

(ii) 

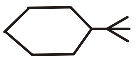
(iii) 

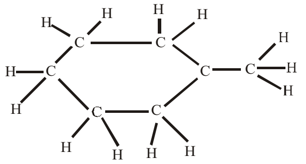
(iv) 

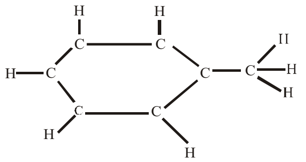
(v) $CH_3CH_2\,CH_2CHBrCH_3$

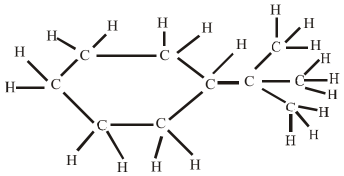
(a) (ii), (iii) and (v) (b) Only (ii)
(c) (ii) and (iii) (d) (iii) and (v)

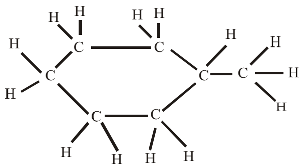
13. Which of the following correctly represents the expanded form of following organic compound ?



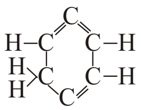
(a) 

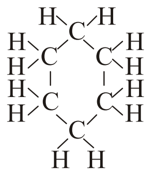
(b) 

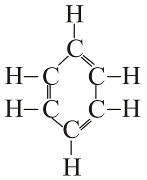
(c) 

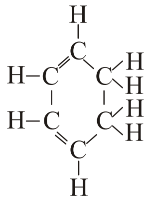
(d) 

14. Structural formula of benzene is

(a) 

(b) 

(c) 

(d) 

15. The successive members in a homologues series differ from each other by ________

(a) $-CH_2CH_2^-$ unit (b) $-CH_2$ unit

(c) $-OCH_3$ unit (d) $-CH_3$ unit

16. Which of the following have incorrect molecular formula?

A. Icosane – $C_{10}H_{22}$

B. Triacontane – $C_{30}H_{62}$

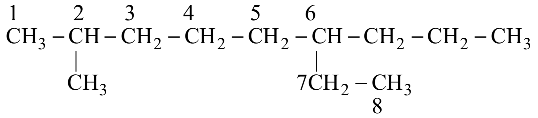
C. Nonane – C_9H_{20}

D. Heptane – C_7H_{14}

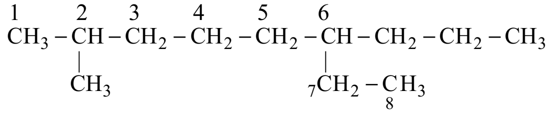
(a) (A) and (D) (b) Only (D)

(c) (B) and (D) (d) Only (B)

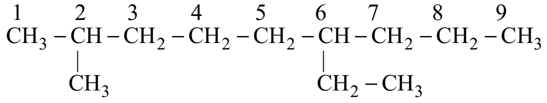
17. Which of the following are incorrect methods of selecting parent chain ?

(i) 

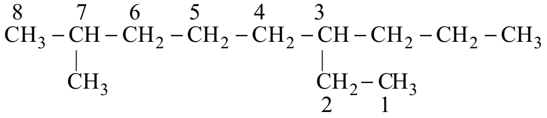
$\overset{1}{CH_3}-\underset{CH_3}{\overset{2}{CH}}-\overset{3}{CH_2}-\overset{4}{CH_2}-\overset{5}{CH_2}-\underset{7CH_2-\underset{8}{CH_3}}{\overset{6}{CH}}-CH_2-CH_2-CH_3$

(ii) 

$\overset{1}{CH_3}-\underset{CH_3}{\overset{2}{CH}}-\overset{3}{CH_2}-\overset{4}{CH_2}-\overset{5}{CH_2}-\underset{_7CH_2-\underset{8}{CH_3}}{\overset{6}{CH}}-CH_2-CH_2-CH_3$

(iii) 

$\overset{1}{CH_3}-\underset{CH_3}{\overset{2}{CH}}-\overset{3}{CH_2}-\overset{4}{CH_2}-\overset{5}{CH_2}-\underset{CH_2-CH_3}{\overset{6}{CH}}-\overset{7}{CH_2}-\overset{8}{CH_2}-\overset{9}{CH_3}$

(iv) 

$\overset{8}{CH_3}-\underset{CH_3}{\overset{7}{CH}}-\overset{6}{CH_2}-\overset{5}{CH_2}-\overset{4}{CH_2}-\underset{\underset{2}{CH_2}-\underset{1}{CH_3}}{\overset{3}{CH}}-CH_2-CH_2-CH_3$

(a) (i) and (ii) (b) (iv) only

(c) (i), (ii) and (iv) (d) (ii) only

18. The correct decreasing order of priority of functional groups is

(a) $-SO_3H$, $-OH$, $-COCl$, $>C=C<$

(b) $-COOH$, $-SO_3H$, $-COOR$, $-OH$

(c) $-C\equiv C$, $-NH_2$, $-OH$, $>C=O$

(d) $-CN$, $-CONH_2$, $>C=O$, $-OH$

19. Which of the following is incorrectly matched –

(a) vinegar → carboxylic acid

(b) C_2H_6 → alkane

(c) ethanol → alcohol

(d) methanol → ketone

20. The functional group present in organic, acid is –

(a) $-OH$ (b) $-CHO$

(c) $-COOH$ (d) $>C=O$

21. Which of these contains the carbonyl group?

(a) ketones (b) aldehydes

(c) esters (d) all of these

22. Butanone is a four-carbon compound with the functional group –

(a) carboxylic acid (b) aldehyde.

(c) ketone (d) alcohol.

23. The functional group present in $CH_3COOC_2H_5$ is –

(a) ketonic (b) aldehydic

(c) ester (d) carboxylic

24. Which of the following compounds contains 1°, 2°, 3° as well as 4° carbon atoms ?

(a) Neopentane (b) 2-methyl pentane

(c) 2,3-dimethyl butane (d) 2,2,3-trimethyl pentane

25. The number of secondary hydrogens in 2, 2-dimethylbutane is

(a) 8 (b) 6

(c) 4 (d) 2

26. The compound which has one isopropyl group is

(a) 2, 2, 3, 3 - Tetramethylpentane

(b) 2, 2 - Dimethylpentane

(c) 2, 2, 3- Trimethylpentane

(d) 2- Methypentane

27. Which of the following statements is false for isopentane ?

(a) It has three CH_3 groups

(b) It has one CH_2 group

(c) It has one CH group

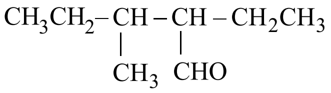
(d) It has a carbon which is not bonded to hydrogen

28. The number of primary, secondary and tertiary carbons in 3, 4-dimethylheptane are respectively
(a) 4, 3 and 2 (b) 2, 3 and 4
(c) 4, 2 and 3 (d) 3, 4 and 2

29. The number of primary, secondary, tertiary and quaternary carbons in neopentane are respectively
(a) 4, 3, 2 and 1 (b) 5, 0, 0 and 1
(c) 4, 0, 0 and 1 (d) 4, 0, 1 and 1

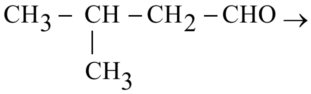
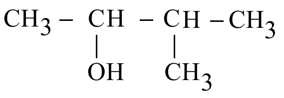
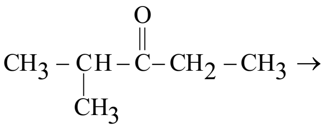
30. What is the IUPAC name of t-butyl alcohol.
(a) Butanol–2 (b) 2–Methyl–propan–2-ol
(c) Butanol–1 (d) Propanol–2

31. The IUPAC name of $CH_3COCH(CH_3)_2$ is -
(a) isopropyl methyl ketone
(b) 2-methyl-3-butanone
(c) 4-methylisopropyl ketone
(d) 3-methyl-2-butanone

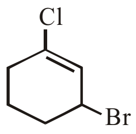
32. 
$CH_3CH_2-\underset{CH_3}{\underset{|}{CH}}-\underset{CHO}{\underset{|}{CH}}-CH_2CH_3$ has the IUPAC name –
(a) 2–sec butylbutanal
(b) 2, 3–diethylbutanal
(c) 2–ethyl–3–methylpentanal
(d) 3–methyl–2–ethylpentanal

33. Which of the following statements is false for isopentane–
(a) It has three CH_3 groups
(b) It has one CH_2 group
(c) It has one CH group
(d) It has a carbon which is not bonded to hydrogen

34. The IUPAC name of the compound
$CH_3OCH_2CH_2CH_2OCH_2CH_3$ is
(a) 3-ethoxy-1-methoxypropane
(b) 1-ethoxy-3-methoxypropane
(c) 2, 5-dioxyhexane
(d) ethoxypropane oxymethane

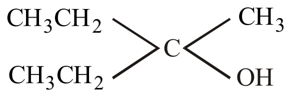
35. Which of the following compounds has wrong IUPAC name?
(a) $CH_3–CH_2–CH_2–COO–CH_2CH_3 \longrightarrow$ ethyl butanoate
(b) 
$CH_3-\underset{CH_3}{\underset{|}{CH}}-CH_2-CHO \rightarrow$ 3-methyl-butanal
(c) 
$CH_3-\underset{OH}{\underset{|}{CH}}-\underset{CH_3}{\underset{|}{CH}}-CH_3 \rightarrow$ 2-methyl-3-butanol
(d) 
$CH_3-\underset{CH_3}{\underset{|}{CH}}-\overset{O}{\overset{||}{C}}-CH_2-CH_3 \rightarrow$ 2-methyl-3-pentanone

36. The IUPAC name of the compound shown below is



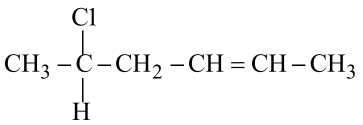
(a) 3-bromo-1-chlorocyclohexene
(b) 1-bromo-3-chlorocyclohexene
(c) 2-bromo-6-chlorocyclohex-1-ene
(d) 6-bromo-2-chlorocyclohexene

37. Name of the following compound is



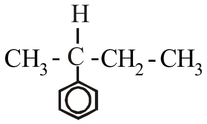
(a) 2-ethylbutan-2-ol
(b) 1-ethyl-1-methylpropan-1-ol
(c) 3-methyl pentan-3-ol
(d) diethylethanol

38. The IUPAC name for


$CH_3-\underset{H}{\underset{|}{\overset{Cl}{\overset{|}{C}}}}-CH_2-CH=CH-CH_3$ is

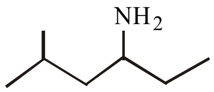
(a) 5–chlorohex–2–ene
(b) 2–chlorohex–5–ene
(c) 1–chloro–1–methylpent–3–ene
(d) 5–chloro–5–methylpent–2–ene

39. IUPAC name of following compound is :



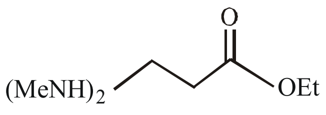
(a) 2 - cyclohexylbutane (b) 2 - phenylbutane
(c) 3 - cyclohexylbutane (d) 3 - phenylbutane

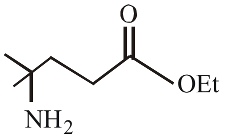
40. What is the IUPAC name of the following compound ?

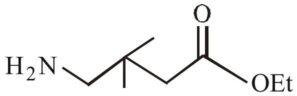


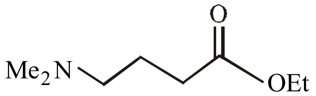
(a) 2-methyl-4-hexanamine
(b) 5-methyl-3-hexanamine
(c) 2-methyl-4-amino hexane
(d) 5-methyl-3-amino hexane

41. Which one of the following is ethyl-4-(dimethyl amino) butanoate ?

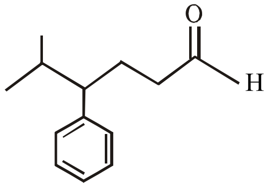
(a) 

(b) 

(c) 

(d) 

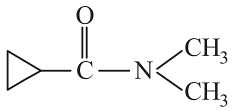
42. Identify the correct IUPAC name of the compound given below



(a) 4 – benzyl – 5 – methyl hexanal
(b) 2 – methyl – 3 – phenyl hexanal
(c) 5 – isopropyl – 5 – phenyl butanal
(d) 5 – methyl – 4 – phenyl hexanal

43. IUPAC name of $(CH_3)_3$ CCl is
(a) 1-butyl chloride
(b) 3-chloro butane
(c) 2-chloro-2-methylpropane
(d) 2-butyl chloride

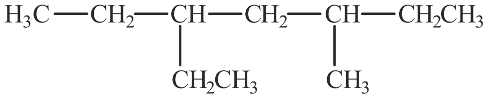
44. IUPAC name of the following compound



(a) N, N-dimethylcyclopropane carboxamide
(b) N-methylcyclopropanamide'
(c) cyclopropionamide
(d) None of these

45. Which of the following is a 3-methylbutyl group?
(a) $CH_3CH_2CH_2CH_2CH_2–$
(b) $(CH_3CH_2)_2CH–$
(c) $(CH_3)_3CCH_2–$
(d) $(CH_3)_2CHCH_2CH_2–$

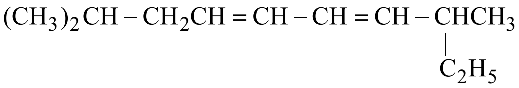
46. The IUPAC name of the following compound



$$H_3C-CH_2-\underset{CH_2CH_3}{\underset{|}{CH}}-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_2CH_3$$

is
(a) 3-ethyl-5-methylheptane
(b) 5-ethyl-3-methylheptane
(c) 3,5-diethylhexane
(d) 1,1-diethyl-3-methylpentane

47. The IUPAC name of the following compound is



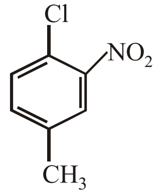
$$(CH_3)_2CH-CH_2CH=CH-CH=CH-\underset{C_2H_5}{\underset{|}{CH}}CH_3$$

(a) 1,1,7,7-tetramethyl-2,5-octadiene
(b) 2,8-dimethyl-3,6-decadiene
(c) 1,5-di-iso-propyl-1,4-hexadiene
(d) 2,8-dimethyl-4,6-decadiene

48. The IUPAC name of the compound $CH_3 — CH(CH_3) — CO – CH_3$, is
(a) 3-methyl 2-butanone
(b) 2-methyl 3-butanone
(c) isopropyl methyl ketone
(d) methyl isopropyl ketone

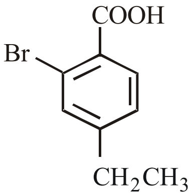
49. The IUPAC name of neopentane is
(a) 2, 2-dimethylpropane (b) 2-methylpropane
(c) 2, 2-dimethylbutane (d) 2-methylbutane

50. The IUPAC name for



(a) 1-Chloro-2-nitro-4-methyl benzene
(b) 1-Chloro-4-methyl-2-nitrobenzene
(c) 2-Chloro-1-nitro-5-methyl benzene
(d) *m*-Nitro-*p*-chlorotoluene

51. What is the IUPAC name of the following compound ?



(a) 6 – bromo – 4 – ethylbenzene carboxylic acid
(b) 2 – bromo – 4 – ethylbenzene carboxylic acid
(c) Ortho – bromo – paraethyl benzoic acid
(d) 4 – bromo – 3 – ethyl benzoic acid

52. Total number of structural isomers possible for C_3H_6 are :
(a) 2 (b) 1
(c) 4 (d) 3

53. An aromatic compound of formula C_7H_7Cl has in all ..... isomers :
(a) 5 (d) 2
(c) 4 (d) 3

54. CH_3CH_2OH and CH_3OCH_3 are the examples of
(a) chain isomerism (b) functional isomerism
(c) position isomerism (d) metamerism

55. Which organic structure among the following is not an isomer of the compound $CH_3–CO–CH_2CH_2CH_2CH_3$?
(a) $CH_3CH_2OCH=CHCH_2CH_3$
(b) $CH_3CH=CHCH_2CH_2CHO$
(c) $(CH_3)_2CH–CO–CH_2CH_3$
(d) $CH_3CH_2COCH_2CH_2CH_3$

56. The least number of carbon atoms in alkane showing isomerism is
(a) 3 (b) 1
(c) 2 (d) 4

57. The number of possible alkynes with molecular formula C_5H_8 is
(a) 2 (b) 3
(c) 4 (d) 5

58. The total number of isomers for C_4H_8 is
(a) 5 (b) 6
(c) 7 (d) 8

59. Which of the following compounds is isomeric with 2, 2, 4, 4- tetramethylhexane?
(a) 3-ethyl -2, 2- dimethylpentane
(b) 4-isopropylheptane
(c) 4-ethyl-3-methyl-4-n propyloctane
(d) 4, 4-diethyl-3-methylheptane

60. Which are isomers ?
(a) ethyl alcohol and dimethyl ether
(b) acetone and acetaldehyde
(c) propionic acid and propanone
(d) methyl alcohol and dimethyl ether

61. Methoxyethane and propanol are the examples of isomerism of the type
(a) structural (b) position
(c) functional (d) tautomerism

62. Isomers of propionic acid are
(a) $HCOOC_2H_5$ and CH_3COOCH_3
(b) $HCOOC_2H_5$ and C_3H_7COOH
(c) CH_3COOCH_3 and C_3H_7OH
(d) C_3H_7OH and CH_3COCH_3

63. $C_6H_5C \equiv N$ and $C_6H_5N \stackrel{\rightarrow}{=} C$ are which type of isomers?
(a) Position (b) Functional
(c) Tautomerism (d) Linkage

64. A functional isomer of 1-butyne is
(a) 2-butyne (b) 1-butene
(c) 2-butene (d) 1, 3-butadiene

65. In which of the following, functional group isomerism is not possible?
(a) Alcohols (b) Aldehydes
(c) Alkyl halides (d) Cyanides

66. The compounds $CH_3CH{=}CHCH_3$ and $CH_3CH_2CH{=}CH_2$
(a) are tautomers
(b) are position isomers
(c) contain same number of $sp^3 - sp^3$, $sp^3 - sp^2$ and $sp^2 - sp^2$ carbon-carbon bonds
(d) exist together in dynamic equilibrium

67. Heterolytic fission of a covalent bond in organic molecules gives
(a) free radicals (b) cations and anions
(c) only cations (d) only anions

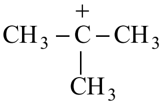
68. Which of the following statements is not correct ?
(a) Carbocation posses sextet of electrons.
(b) The order of carbocation stability is :

$$\overset{+}{C}H_3 > (CH_3)_2\overset{+}{C}H > (CH_3)_3\overset{+}{C}$$

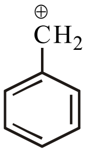
(c) Carbocations have trigonal planar shape
(d) Carbocations are formed by heterolytic cleavage

69. Heterolytic fission of C – Br bond results in the formation of
(a) free radical (b) carbanion
(c) carbocation (d) Both (b) and (c)

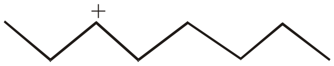
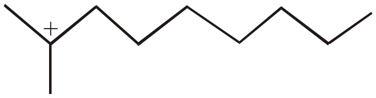
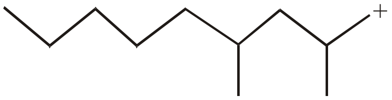
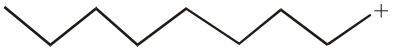
70. Which of the following carbocations is least stable?
(a) *tert*-Alkyl (b) *sec*-Alkyl
(c) *pri*-Alkyl (d) Methyl

71. Which of the following ions is most stable ?
(a) 
$CH_3-\overset{+}{C}(CH_3)-CH_3$
(b) $CH_3CH_2\overset{+}{C}H_2$
(c) $CH_3\overset{+}{C}HCH_2CH_3$ (d) None of these

72. The order of stability of the following carbocations :

$CH_2=CH-\overset{\oplus}{C}H_2$; $CH_3-CH_2-\overset{\oplus}{C}H_2$;  is :
I II III

(a) III > II > I (b) II > III > I
(c) I > II > III (d) III > I > II

73. Select the most stable carbocation amongst the following
(a) 
(b) 
(c) 
(d) 

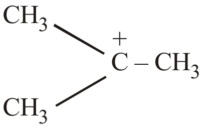
74. What is the correct order of decreasing stability of the following cations.

I. $CH_3-\overset{\oplus}{C}H-CH_3$
II. $CH_3-\overset{\oplus}{C}H-OCH_3$
III. $CH_3-\overset{\oplus}{C}H-CH_2-OCH_3$

(a) II > I > III (b) II > III > I
(c) III > I > II (d) I > II > III

75. The most stable carbonium ion among the following is
(a) $C_6H_5\overset{+}{C}HC_6H_5$ (b) $C_6H_5\overset{+}{C}H_2$
(c) $CH_3\overset{+}{C}H_2$ (d) $C_6H_5CH_2\overset{+}{C}H_2$

76. The organic reaction which proceed through heterolytic bond cleavage are called ________
(a) ionic (b) polar
(c) nonpolar (d) Both (a) and (b)

77. Among the following, the true property about

is

(a) it is non-planar
(b) its C^+ is sp^2-hybridized
(c) an electrophile can attack on its C^+
(d) it does not undergo hydrolysis

78. The shape of methyl carbanion is similar to that of –
(a) BF_3 (b) NH_3
(c) methyl free radical (d) methyl carbocation

79. Arrange the carbanions,

$(CH_3)_3\overline{C}, \overline{C}Cl_3, (CH_3)_2\overline{C}H, C_6H_5\overline{C}H_2$

in order of their decreasing stability :
(a) $(CH_3)_2\overline{C}H > \overline{C}Cl_3 > C_6H_5\overline{C}H_2 > (CH_3)_3\overline{C}$
(b) $\overline{C}Cl_3 > C_6H_5\overline{C}H_2 > (CH_3)_2\overline{C}H > (CH_3)_3\overline{C}$
(c) $(CH_3)_3\overline{C} > (CH_3)_2\overline{C}H > C_6H_5\overline{C}H_2 > \overline{C}Cl_3$
(d) $C_6H_5\overline{C}H_2 > \overline{C}Cl_3 > (CH_3)_3\overline{C} > (CH_3)_2\overline{C}H$

80. The homolytic fission of a covalent bond liberates
(a) Carbonium ions (b) Carbanions
(c) Free radicals (d) Carbenes

81. Homolytic fission of C–C bond in ethane gives an intermediate in which carbon is
(a) sp^3-hybridised (b) sp^2-hybridised
(c) sp-hybridised (d) sp^2d-hybridised

82. Geometry of methyl free-radical is
(a) pyramidal (b) planar
(c) tetrahedral (d) linear

83. In which of the following homolytic bond fission takes place ?
(a) Alkaline hydrolysis of ethyl chloride
(b) Addition of HBr to double bond
(c) Photochlorination of methane
(d) Nitration of benzene

84. On exciting, Cl_2 molecules by UV light, we get
(a) $Cl^{\bullet}$ (b) Cl^+
(c) Cl^- (d) all of these

85. The increasing order of stability of the following free radicals is
(a) $(C_6H_5)_2\dot{C}H < (C_6H_5)_3\dot{C} < (CH_3)_3\dot{C} < (CH_3)_2\dot{C}H$
(b) $(CH_3)_2\dot{C}H < (CH_3)_3\dot{C} < (C_6H_5)_2\dot{C}H < (C_6H_5)_3\dot{C}$
(c) $(CH_3)_2\dot{C}H < (CH_3)_3\dot{C} < (C_6H_5)_2\dot{C}H < (C_6H_5)_3\dot{C}$
(d) $(C_6H_5)_3\dot{C} < (C_6H_5)_2\dot{C}H < (CH_3)_3\dot{C} < (CH_3)_2\dot{C}H$

86. Which of the following orders regarding relative stability of free radicals is correct?
(a) $3° < 2° < 1°$ (b) $3° > 2° > 1°$
(c) $1° < 2° > 3°$ (d) $3° > 2° < 1°$

87. The most stable free radical among the following is
(a) $C_6H_5CH_2\dot{C}H_2$ (b) $C_6H_5\dot{C}HCH_3$
(c) $CH_3\dot{C}H_2$ (d) $CH_3\dot{C}HCH_3$

88. For the reaction of phenol with $CHCl_3$ in presence of KOH, the electrophile is
(a) $^+CHCl_2$ (b) $:CCl_2$
(c) $\dot{C}HCl_2$ (d) CCl_4

89. The least stable free radical is
(a) $CH_3\dot{C}H_2$ (b) $CH_3CH_2\dot{C}H_2$
(c) $(CH_3)_2\dot{C}H$ (d) $\dot{C}H_3$

90. Which of the following is strongest nucleophile
(a) Br^- (b) $:OH^-$
(c) $:CN^-$ (d) $C_2H_5\overline{O}:$

91. Which of the following represents a set of nucleophiles?
(a) BF_3, H_2O, NH_2^- (b) $AlCl_3, BF_3, NH_3$
(c) CN^-, RCH_2^-, ROH (d) All of these

92. Which of the following species does not acts as a nucleophile?
(a) ROH (b) ROR
(c) PCl_3 (d) BF_3

93. Which of the following is an electrophile ?
(a) Lewis acid
(b) Lewis base
(c) Negatively charged species
(d) None of the above

94. Which of the following pairs represent electrophiles?
(a) $AlCl_3, H_2O$ (b) SO_3, NO_2^+
(c) BF_3, H_2O (d) NH_3, SO_3

95. Which out of A, B, C and D is/are not correctly categorised.

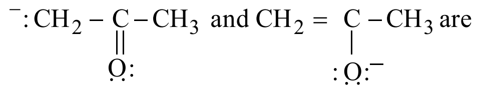
	Nucleophile	Electrophile
A.	HS^-	Cl^+
B.	BF_3	$(CH_3)_3N$
C.	H_2N^-	$-\overset{+}{C}=O$
D.	R_3C-X $(X = Halogen)$	$C_2H_5O^-$

(a) B, C and D (b) C and D
(c) C only (d) B and D

96. Arrangement of $(CH_3)_3-C-$, $(CH_3)_2-CH-$, CH_3-CH_2- when attached to benzyl or an unsaturated group in increasing order of inductive effect is
(a) $(CH_3)_3-C- < (CH_3)_2-CH- < CH_3-CH_2^-$
(b) $CH_3-CH_2- < (CH_3)_2-CH- < (CH_3)_3-C-$
(c) $(CH_3)_2-CH- < (CH_3)_3-C- < CH_3—CH_2-$
(d) $(CH_3)_3-C- < CH_3-CH_2- < (CH_3)_2-CH-$

97. Polarization of electrons in acrolein may be written as
(a) $\overset{\delta-}{CH_2}=CH-\overset{\delta+}{CH}=O$ (b) $\overset{\delta-}{CH_2}=CH-CH=\overset{\delta+}{O}$
(c) $\overset{\delta-}{CH_2}=\overset{\delta-}{CH}-CH=O$ (d) $\overset{\delta+}{CH_2}=CH-CH=\overset{\delta-}{O}$

98. Point out the incorrect statement about resonance?
(a) Resonance structures should have equal energy
(b) In resonating structures, the constituent atoms must be in the same position
(c) In resonating structures, there should not be same number of electron pairs
(d) Resonating structures should differ only in the location of electrons around the constituent atoms

99. 
$^{-}:CH_2-\underset{\underset{\underset{\cdot\cdot}{O}:}{\|}}{C}-CH_3$ and $CH_2=\underset{\underset{:\underset{\cdot\cdot}{O}:^{-}}{|}}{C}-CH_3$ are
(a) resonating structures (b) tautomers
(c) geometrical isomers (d) optical isomers

100. In which of the following, resonance will be possible?

(a) $CH_3-CH_2-CH_2-CHO$

(b) $CH_2=CH-CH=O$

(c) CH_3COCH_3

(d) $CH_2=CH-CH_2-CH=CH_2$

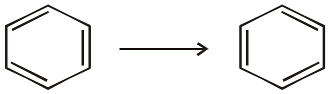
101. Which of the following statements regarding the resonance energy of benzene is *correct*?

(a) Resonance energy is the energy required to break the C–H bond in benzene

(b) Resonance energy is the energy required to break the C–C bond in benzene

(c) Resonance energy is a measure of stability of benzene

(d) Resonance energy is the energy required to convert



102. Which of the following is not correctly matched ?

	Group showing + R effect	Group showing – R effect
(a)	$-NHCOR$	$-COOH$
(b)	$\rangle C=O$	$-OH$
(c)	$-OR$	$-CHO$
(d)	$-OCOR$	$-NO_2$

103. The polarity is produced in the molecule by the interaction of two π – bonds or between a π – bond and lone pair of electrons present on an adjacent atom.

The above statement is true for which of the following ?

(a) Inductive effect (b) Electromeric effect

(c) Resonance effect (d) Hyperconjugation

104. Electromeric effect is a

(a) permanent effect (b) temporary effect

(c) resonance effect (d) inductive effect

105. The kind of delocalization involving sigma bond orbitals is called

(a) inductive effect (b) hyperconjugation effect

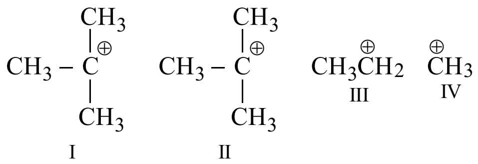
(c) electromeric effect (d) mesomeric effect

106. Hyperconjugation involves overlap of the following orbitals

(a) σ-σ (b) σ - π

(c) p- p (d) π-π

107. Choose the correct order of stability of carbocation using concept of hyperconjugation.



(a) I < II < III < IV (b) IV < III < II < I

(c) III < IV < II < I (d) None of these

108. Hyperconjugation is most useful for stabilizing which of the following carbocations ?

(a) neo-Pentyl (b) tert-Butyl

(c) iso-Propyl (d) Ethyl

109. Which of the following is an example of elimination reaction?

(a) Chlorination of methane

(b) Dehydration of ethanol

(c) Nitration of benzene

(d) Hydroxylation of ethylene

110. $CH_3-Br+NH_3 \rightarrow CH_3-NH_2+HBr$

The above reaction is classified as

(a) substitution (b) addition

(c) elimination (d) rearrangement

111. Which of the following method is not used for determining purity of a compound ?

(a) Chromatographic techniques

(b) Spectroscopic techniques

(c) Melting point

(d) All of the above parameters are used for determining the purity of a compound.

112. Which of the following is not the criteria of purity of a substance?

(a) solubility (b) melting point

(c) boiling point (d) density

113. In crystallisation process impurities which impart colour to the solution are removed by which of the following ?

(a) Repeated crystallisation

(b) Activated charcoal

(c) Bleaching agent

(d) Both (a) and (b)

114. Aniline is purified by

(a) steam distillation (b) simple distillation

(c) vacuum distillation (d) extraction with a solvent

115. Which is purified by steam distillation

(a) Aniline (b) Benzoic acid

(c) Petroleum (d) Naphthalene

116. The best method for the separation of naphthalene and benzoic acid from their mixture is:

(a) distillation (b) sublimation

(c) chromatography (d) crystallisation

117. In steam distillation the vapour pressure of volatile organic compound is

(a) equal to atmospheric pressure

(b) double the atmospheric pressure

(c) less than atmospheric pressure

(d) more than atmospheric pressure

118. Fractional distillation is used when

(a) there is a large difference in the boiling point of liquids

(b) there is a small difference in the boiling points of liquids

(c) boiling points of liquids are same

(d) liquids form a constant boiling mixture

119. Purification of petroleum is carried out by

(a) fractional distillation (b) steam distillation

(c) vacuum distillation (d) simple distillation

120. A liquid decomposes at its boiling point. It can be purified by

(a) steam distillation (b) fractional distillation

(c) vacuum distillation (d) sublimation

121. Distillation under reduced pressure is employed for
(a) C_6H_6
(b) petrol
(c) $CH_2OHCHOHCH_2OH$
(d) organic compounds used in medicine

122. Impure glycerine is purified by
(a) steam distillation (b) simple distillation
(c) vacuum distillation (d) None of these

123. Glycerol can be separated from spent lye in soap industry by which of the following method ?
(a) Steam distillation
(b) Fractional distillation
(c) Distillation under reduced pressure
(d) Differential extraction

124. The latest technique for the purification of organic compounds is
(a) chromatography (b) fractional distillation
(c) crystallization (d) vacuum distillation

125. Which of the following is used as an adsorbent in adsorption chromatography ?
(a) Silica gel (b) Alumina
(c) Zeolite (d) Both (a) and (b)

126. Which of the following acts as the stationary phase in paper chromatography ?
(a) Water (b) Alumina
(c) Silica gel (d) None of these

127. The most satisfactory method to separate mixture of sugars is
(a) fractional crystallisation (b) sublimation
(c) chromatography (d) benedict reagent

128. Chromatography is a valuable method for the separation, isolation, purification and identification of the constituents of a mixture and it is based on general principle of
(a) phase rule (b) phase distribution
(c) interphase separation (d) phase operation

129. In paper chromatography
(a) moving phase is liquid and stationary phase in solid
(b) moving phase is liquid and stationary phase is liquid
(c) moving phase is solid and stationary phase is solid
(d) moving phase is solid and stationary phase is liquid

130. Which of the following is used for detection of carbon and hydrogen ?
(a) $Ca(OH)_2$ (b) CuO
(c) $CaCl_2$ (d) KOH

131. In sodium fusion test of organic compounds, the nitrogen of the organic compound is converted into
(a) sodamide (b) sodium cyanide
(c) sodium nitrite (d) sodium nitrate

132. Which of the following compounds does not show Lassaigne's test for nitrogen ?
(a) Urea (b) Hydrazine
(c) Phenylhydrazine (d) Azobenzene

133. The compound formed in the positive test for nitrogen with the Lassaigne solution of an organic compound is
(a) $Fe_4[Fe(CN)_6]_3$ (b) $Na_3[Fe(CN)_6]$
(c) $Fe(CN)_3$ (d) $Na_4[Fe(CN)_5NOS]$

134. In quantitative analysis of carbon and hydrogen, the mass of water produced is determined by passing the mixture through a weighed U – tube containing ___X___ and carbon dioxide is absorbed in concentrated solution of ___Y___
(a) $X = CaCl_2$, $Y = NaOH$
(b) $X = Ca(OH)_2$, $Y = CuSO_4$
(c) $X = CuSO_4$, $Y = Ca(OH)_2$
(d) $X = CaCl_2$, $Y = KOH$

135. Kjeldahl method is not applicable to which of the following ?
(a) Nitro compounds (b) Azo compounds
(c) Pyridine (d) All of these.

136. Nitrogen in an organic compound can be estimated by
(a) Kjeldahl's method only(b) Duma's method only
(c) Both (a) and (b) (d) Neither (a) nor (b)

137. Duma's method involves the determination of nitrogen content in the organic compound in form of
(a) NH_3 (b) N_2
(c) NaCN (d) $(NH_4)_2SO_4$

138. In Kjeldahl's method nitrogen present is estimated as
(a) N_2 (b) NH_3
(c) NO_2 (d) None of these

139. In kjeldahl's method of estimation of nitrogen, K_2SO_4 acts as
(a) oxidising agent (b) catalytic agent
(c) hydrolysing agent (d) boiling point elevator

140. 0.5g of an organic compound containing nitrogen on Kjeldahlising required 29 mL of N/5 H_2SO_4 for complete neutralization of ammonia. The percentage of nitrogen in the compound is
(a) 34.3 (b) 16.2
(c) 21.6 (d) 14.8

141. The percentage of sulphur in an organic compound whose 0.32 g produces 0.233 g of $BaSO_4$ [At. wt. Ba = 137, S = 32] is
(a) 1.0 (b) 10.0
(c) 23.5 (d) 32.1

142. An organic compound contains C = 40%, H = 13.33% and N = 46.67%. Its empirical formula would be
(a) CHN (b) C_2H_2N
(c) CH_4N (d) C_3H_7N

143. 2.79 g of an organic compound when heated in Carius tube with conc. HNO_3 and H_3PO_4 formed converted into $MgNH_4.PO_4$ ppt. The ppt. on heating gave 1.332 g of $Mg_2P_2O_7$. The percentage of P in the compound is
(a) 23.33% (b) 13.33%
(c) 33.33% (d) 26.66%

144. A compound contains 38.8% C, 16% H and 45.2% N. The formula of compound would be :
(a) CH_3NH_2 (b) CH_3CN
(c) C_2H_5CN (d) $CH_2(NH_2)_2$

145. In estimation of percentage of oxygen. The mixture of gaseous products containing oxygen is passed over red hot coke. All oxygen is converted to ___A___. This mixture is passed through ___B___ when ___A___ is converted to ___C___ .

What is A, B and C in above statement.

(a) $A = CO_2$, $B = KOH$, $C =$ pure O_2

(b) $A = CO$, $B = I_2O_5$, $C = CO_2$

(c) $A = CO$, $B = I_2$, $C = CO_2$

(d) $A = CO_2$, $B = Ca(OH)_2$, $C = CaCO_3$

STATEMENT TYPE QUESTIONS

146. Which of the following statement(s) is/are correct ?

(i) A carbon atom having an *sp* hybrid orbital is less electronegative than carbon atoms possessing sp^2 or sp^3 hybridised orbitals.

(ii) π-bonds provide the most reactive centres in the molecules containing multiple bonds

(iii) The number of σ and π bonds in compound $CH_2{=}C{=}CHCH_3$ are 7 and 2 respectively.

(a) (i) and (iii) (b) (ii) and (iii)

(c) (ii) only (d) (i) only

147. Which of the following sequence of T and F is correct. Here T stands for true statement and F stands for false statement

(i) In heterolytic cleavage the bond breaks in such a fashion that the shared pair of electrons remain with one of the fragment.

(ii) In homolytic cleavage, one of the electrons of the shared pair in a covalent bond goes with each of the bonded atoms.

(iii) $R - X \xrightarrow[\text{light}]{\text{heat or}} \dot{R} + \dot{X}$

This equation represents heterolytic cleavage

(a) TTF (b) FFT

(c) FFF (d) TTT

148. Which of the following is/are correct for inductive effect ?

(i) In inductive effect polarisation of sigma bond is caused by the adjacent σ bond.

(ii) Halogens, $–NO_2$, –CN, and $–CH_3$ are electron withdrawing groups.

(iii) $–CH_2CH_3$ and $–OC_6H_5$ are electron donating groups.

(a) (i) only (b) (ii) only

(c) (i) and (iii) (d) (i), (ii) and (iii)

149. Which of the following sequence of T and F is correct for given statements. Here T stands for correct and F stands for false statement

(i) The more the number of contributing structures, the more is the resonance energy.

(ii) The resonance structures have different positions of nuclei but same number of unpaired electrons

(iii) The energy of actual structure of the molecule (the resonance hybrid) is lower than that of any of the canonical structures.

(a) TTT (b) TFT

(c) FFF (d) TFF

150. Which of the following statements are correct for fractional distillation ?

(i) Fractional distillation method is used if the two liquids have sufficiently large difference in their boiling points.

(ii) A fractionating column provides many surfaces for heat exchange between the ascending vapours and the descending condensed liquid.

(iii) Each successive condensation and vaporisation unit in the fractionating column is called a theoretical plate.

(iv) Fractional distillation method is used to separate different fractions of crude oil in petroleum industry.

(a) (i), (ii) and (iv) (b) (ii), (iii) and (iv)

(c) (i), (ii) and (iii) (d) (i), (ii), (iii) and (iv)

151. Which of the following sequence of T and F is currect for given statements. Here 'T' stands for True and 'F' stands for False statement.

(i) The relative adsorption of each component of mixture is expressed in terms of its retardation factor (R_F)

(ii) Retardation factor is given as :

$$R_F = \frac{\text{Distance moved by the solvent from base line}}{\text{Distance moved by the substance from base line}}$$

(iii) In TLC the spots of colourless compounds can be detected by ultraviolet light.

(iv) Spots of amino acids may be detected by iodine.

(a) TTTF (b) TFFF

(c) TTTT (d) TFTF

152. In Kjeldahl's method for the estimation of N_2 , potassium sulphate and copper sulphate are used. On the basis of their functions which of the following statement(s) is/are correct?

(i) Potassium sulphate raises the bpt. and ensures complete reaction.

(ii) Copper sulphate acts as catalyst.

(iii) Potassium sulphate acts as catalyst and copper sulphate raises the bpt.

(a) Only (iii) is correct (b) (i) and (ii) are correct

(c) Only (ii) is correct (d) None is correct

153. In the estimation of carbon and hydrogen by combustion method which of the following is/are correct ?

(i) A spiral of copper is introduced at the right extreme of combustion tube if the organic compound contains nitrogen.

(ii) A spiral of silver is introduced if the organic compound contains halogens.

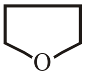
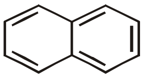
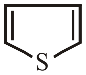
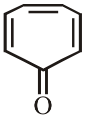
(iii) The copper oxide in the combustion tube is replaced by lead chromate if the organic compound contains sulphur.

(a) (i) and (ii) are correct (b) (i) and (iii) are correct

(c) (ii) and (iii) are correct (d) All are correct

MATCHING TYPE QUESTIONS

154. Match the columns

Column-I	**Column-II**
(A) Non – benzenoid compound	(p) 
(B) Alicyclic compound	(q) 
(C) Benzenoid compound	(r) 
(D) Heterocyclic aromatic compound	(s) 

(a) A – (r), B – (p), C – (s), D – (q)
(b) A – (s), B – (p), C – (q), D – (r)
(c) A – (p), B – (r), C – (s), D – (q)
(d) A – (r), B – (p), C – (q), D – (s)

155. Match Column-I (organic compound) with Column-II (common name of the compound) and choose the correct option.

Column-I	**Column-II**
(Organic compound)	**(Common name of compound)**
(A) $C_6H_5OCH_3$	(p) Neopentane
(B) $H_3CCH_2CH_2OH$	(q) Anisole
(C) $(H_3C)_4C$	(r) Acetophenone
(D) $C_6H_5COCH_3$	(s) n – propyl alcohol.

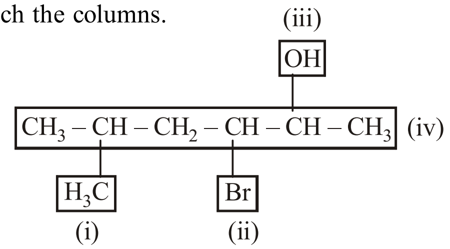
(a) A – (r), B – (s), C – (p), D – (q)
(b) A – (r), B – (p), C – (s), D – (q)
(c) A – (q), B – (s), C – (p), D – (r)
(d) A – (q), B – (s), C – (r), D – (p)

156. Match the columns

Column-I	**Column-II**
(A) Aldehyde	(p) Chloro
(B) Ketone	(q) ol
(C) Alcohol	(r) one
(D) Halogen	(s) al

(a) A – (s), B – (r), C – (q), D – (p)
(b) A – (s), B – (q), C – (p), D – (r)
(c) A – (p), B – (q), C – (r), D – (s)
(d) A – (r), B – (s), C – (q), D – (p)

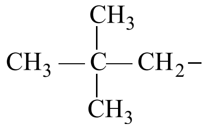
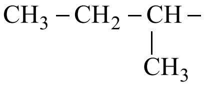
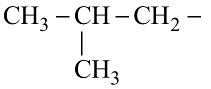
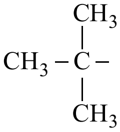
157. Identify (i), (ii), (iii) and (iv) in the structure of given organic compound. On the basis of your identification match the columns.



Column-I	**Column-II**
A (i)	(p) Functional group
B (ii)	(q) Branch chain
C (iii)	(r) Parent chain
D (iv)	(s) Homologues unit

(a) A – (q), B – (p), C – (s), D – (r)
(b) A – (p), B – (s), C – (q), D – (r)
(c) A – (q), B – (p), C – (p), D – (r)
(d) A – (q), B – (p), C – (q), D – (r)

158. Match the columns.

Column-I	**Column–II**
(A)  $CH_3-\overset{CH_3}{\underset{CH_3}{C}}-CH_2-$	(p) Isobutyl
(B)  $CH_3-CH_2-\underset{CH_3}{CH}-$	(q) sec – Butyl
(C)  $CH_3-\underset{CH_3}{CH}-CH_2-$	(r) Neopentyl
(D)  $CH_3-\overset{CH_3}{\underset{CH_3}{C}}-$	(s) tert – Butyl

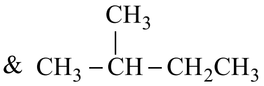
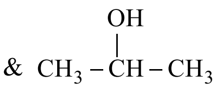
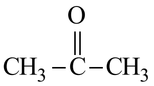
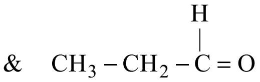
(a) A – (r), B – (q), C – (p), D –(s)
(b) A – (s), B – (p), C – (r), D –(q)
(c) A – (s), B – (p), C – (q), D –(r)
(d) A – (s), B – (q), C – (p), D –(r)

159. Column-II give formula for compounds given in Column-I, match them correctly.

Column-I	**Column-II**
(A) Propane	(p) C_2H_5OH
(B) ethyl alcohol	(q) C_3H_8
(C) carboxylic acid	(r) CH_3COOH
(D) ethyl ethanoate	(s) $CH_3COOC_2H_5$

(a) A – (q), B – (p), C – (r), D – (s)
(b) A – (p), B – (q), C – (s), D – (r)
(c) A – (q), B – (s), C – (p), D – (r)
(d) A – (q), B – (p), C – (s), D – (r)

160. Match the columns

Column-I	**Column-II**
(Organic compounds)	**(Type of isomerism)**
(A) $CH_3CH_2CH_2CH_2CH_3$ &  $CH_3-\overset{CH_3}{CH}-CH_2CH_3$	(p) Functional group isomerism
(B) $CH_3CH_2CH_2OH$ &  $CH_3-\overset{OH}{CH}-CH_3$	(q) Chain isomerism
(C)  $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ &  $CH_3-CH_2-\overset{H}{C}=O$	(r) Metamerism
(D) $CH_3OC_3H_7$ & $C_2H_5OC_2H_5$	(s) Position isomerism

(a) A – (s), B – (q), C – (r), D – (p)
(b) A – (s), B – (q), C – (p), D – (r)
(c) A – (q), B – (s), C – (r), D – (p)
(d) A – (q), B – (s), C – (p), D – (r)

161. Match the columns

	Column-I		**Column-II**
(A)	CH_3COOH & $HCOOCH_3$	(p)	Functional isomers
(B)	1 butene & 2-butene	(q)	Metamers
(C)	diethyl ether & methyl propyl ether	(r)	Position isomers
(D)	dimethyl ether and ethanol	(s)	Chain isomers and ethanol

(a) A – (p), B – (r), C – (q), D – (s)
(b) A – (q), B – (r), C – (s), D – (p)
(c) A – (q), B – (s), C – (p), D – (r)
(d) A – (q), B – (p), C – (s), D – (r)

162. Match the columns

	Column-I		**Column-II**
(A)	Free radical	(p)	Trigonal planar
(B)	Carbocation	(q	Pyramidal
(C)	Carbanion	(r)	Linear

(a) A – (p), B – (q), C – (r)
(b) A – (p), B – (p), C – (q)
(c) A – (r), B – (p), C – (q)
(d) A – (p), B – (p), C – (r)

163. Match the columns

	Column - I		**Column - II**
(A)	Separation of sublimable compounds from non sublimable	(p)	Steam distillation
(B)	Method based on the difference in the solubilities of the compound and the impurities in a suitable solvent	(q)	Sublimation
(C)	Separation of liquids having sufficient difference in their boiling points.	(r)	Distillation
(D)	Separation of substances which are steam volatile and are immiscible with water.	(s)	Crystallisation

(a) A – (q), B – (s), C – (r), D – (p)
(b) A – (q), B – (r), C – (p), D – (s)
(c) A – (s), B – (q), C – (r), D – (p)
(d) A – (q), B – (s), C – (p), D – (r)

164. Match the columns

Column - I (Elements)		**Column - II (Colour of precipitate formed in Lassaigne's test)**	
(A)	Nitrogen	(p)	Yellow
(B)	Sulphur	(q)	Prussian blue
(C)	Chlorine	(r)	Violet
(D)	Phosphorus	(s)	White

(a) A – (q), B – (r), C – (p), D – (s)
(b) A – (r), B – (q), C – (p), D – (s)
(c) A – (q), B – (r), C – (s), D – (p)
(d) A – (r), B – (q), C – (s), D – (p)

165. Match the columns

	Column - I		**Column - II**
(A)	Duma's method	(p)	$\frac{80\times m_1\times 100}{188\times m}$
(B)	Kjeldahl's method	(q)	$\frac{31\times m_1\times 100}{1877\times m}\%$
(C)	Carius method for bromine	(r)	$\frac{1.4\times M\times 2\left(v-\frac{v_1}{2}\right)}{m}\%$
(D)	Percentage of phosphorus	(s)	$\frac{28\times V\times 100}{22400\times m}\%$

(a) A – (s), B – (r), C – (p), D – (q)
(b) A – (r), B – (s), C – (q), D – (p)
(c) A – (s), B – (p), C – (q), D – (r)
(d) A – (p), B – (r), C – (q), D – (s)

ASSERTION-REASON TYPE QUESTIONS

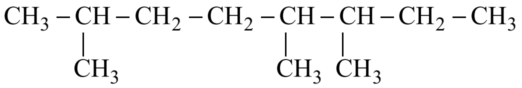
Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

166. **Assertion :** A primary suffix indicates the type of linkage in the carbon atom.
Reason : CN is a Primary suffix

167. **Assertion :** The general formula for a dihydric alcohol is $C_nH_{2n}(OH)_2$
Reason : Ethylene glycol is a dihydric alcohol.

168. **Assertion :** IUPAC name of the following organic compound is 3, 4, 7 – trimethyloctane



$$\underset{\displaystyle CH_3}{CH_3-\underset{|}{CH}}-CH_2-CH_2-\underset{\underset{\displaystyle CH_3}{|}}{CH}-\underset{\underset{\displaystyle CH_3}{|}}{CH}-CH_2-CH_3$$

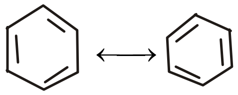
Reason : The numbering is done in such a way that the branched carbon atoms get the lowest possible numbers.

169. **Assertion :** Chain isomerism is observed in compounds containining four or more than four carbon atoms
Reason : Only alkanes show chain isomerism

170. **Assertion :** But-1-ene and 2-methylprop-1-ene are position isomers.
Reason : Position isomers have same molecular formula but differ in position of functional group or C = C.

171. Assertion : Benzene exhibit two different bond lengths, due to C – C single and C = C double bonds.

Reason : Actual structure of benzene is a hybrid of following two structures.



172. Assertion : Aniline is better nucleophile than anilium ion.

Reason : Anilium ion have +ve charge.

173. Assertion : Different number of electron pairs are present in resonance structures.

Reason : Resonance structures differ in the location of electrons around the constituent atoms.

174. Assertion : Energy of resonance hybrid is equal to the average of energies of all canonical forms.

Reason : Resonance hybrid cannot be presented by a single structure.

175. Assertion : Simple distillation can help in separating a mixture of propan-1-ol (boiling point 97°C) and propanone (boiling point 56°C).

Reason : Liquids with a difference of more thatn 20°C in their boiling points can be separated by simple distillation.

176. Assertion : Components of a mixture of red and blue inks can be separated by distributing the components between stationary and mobile phases in paper chromatography.

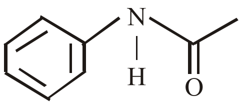
Reason : The coloured components of inks migrate at different rates because paper selectively retains different components according to the difference in their partition between the two phases.

177. Assertion : Sulphur present in an organic compound can be estimated quantitatively by Carius method.

Reason : Sulphur is separated easily from other atoms in the molecule and gets precipitated as light yellow solid.

CRITICAL THINKING TYPE QUESTIONS

178. The IUPAC name of the following compounds is



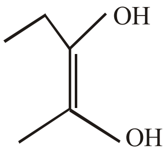
(a) N – phenyl ethanamide

(b) N – phenyl ethanone

(c) N – phenyl methanamide

(d) None of these

179 IUPAC name of



is :

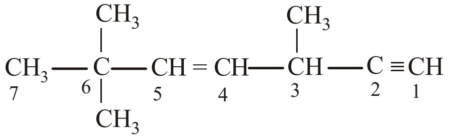
(a) But – 2 ene – 2, 3– diol

(b) Pent – 2 –ene – 2, 3 – diol

(c) 2 – methylbut – 2 – ene – 2, 3 – diol

(d) Hex – 2 – ene – 2, 3 – diol

180. The state of hybridization of C_2, C_3, C_5 and C_6 of the hydrocarbon,



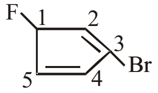
$$\underset{7}{CH_3}-\overset{CH_3}{\underset{CH_3}{\underset{6}{C}}}-\underset{5}{CH}=\underset{4}{CH}-\overset{CH_3}{\underset{3}{CH}}-\underset{2}{C}\equiv\underset{1}{CH}$$

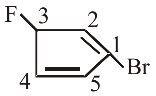
is in the following sequence

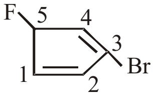
(a) sp^3, sp^2, sp^2 and sp (b) sp, sp^2, sp^2 and sp^3

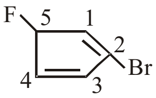
(c) sp, sp^2, sp^3 and sp^2 (d) sp, sp^3, sp^2 and sp^3

181. Which of the following numberings is correct ?

A.


B.


C.


D.


(a) A (b) B (c) C (d) D

182. The ratio of π- to σ- bonds in benzene is

(a) 1 : 4 (b) 1 : 2

(c) 3 : 1 (d) 1 : 6

183. In which of the compounds given below there is more than one kind of hybridization (sp, sp^2, sp^3) for carbon ?

(i) $CH_3CH_2CH_2CH_3$ (ii) $CH_3CH=CHCH_3$

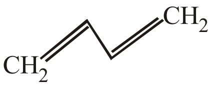
(iii) CH_2=CH–CH=CH_2 (iv) $H-C\equiv C-H$

(a) (ii) (b) (iii) and (iv)

(c) (i) and (iv) (d) (ii) and (iii)

184. Which of the following represents the given mode of hybridisation sp^2–sp^2 – sp – sp from left to right?

(a) $H_2C=CH-C\equiv N$ (b) $CH\equiv C-C\equiv CH$

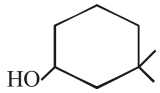
(c) $H_2C=C=C=CH_2$ (d)


185. The compound in which $\overset{x}{C}$ uses its sp^3 - hybrid orbitals for bond formation is

(a) $H\overset{x}{C}OOH$ (b) $(H_2N)_2\overset{x}{C}O$

(c) $(CH_3)_3\overset{x}{C}OH$ (d) $CH_3\overset{x}{C}HO$

186. The IUPAC name of the compound is

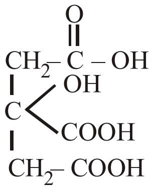


(a) 3, 3-dimethyl - 1- cyclohexanol

(b) 1, 1-dimethyl-3-hydroxy cyclohexane

(c) 3, 3-dimethyl-1-hydroxy cyclohexane

(d) 1, 1-dimethyl-3-cyclohexanol

187. The IUPAC name of compound  is:

(a) 1, 2, 3 - tricarboxy - 2, 1 - propane

(b) 3 - carboxy - 3 hydroxy - 1 , 5 - pentanedioic acid

(c) 3 - hydroxy - 3 - carboxy - 1, 5 - pentanedioic acid

(d) 2 - hydroxy propane -1, 2, 3 - tricarboxylic acid.

188. The number of possible open chain (acyclic) isomeric compounds for molecular formula C_5H_{10} would be

(a) 8 (b) 7

(c) 6 (d) 5

189. Which of the following compounds will show metamerism?

(a) $CH_3–CO–C_2H_5$ (b) $C_2H_5–S–C_2H_5$

(c) $CH_3–O–CH_3$ (d) $CH_3–O–C_2H_5$

190. The compound $C_4H_{10}O$ can show

(a) metamerism (b) functional isomerism

(c) position isomerism (d) All of these

191. Which pair of isomerism is not possible together?

(a) Ring-chain and functional

(b) Geometrical and optical

(c) Metamerism and functional

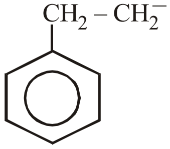
(d) Metamerism and chain

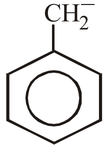
192. Which of the following represents the correct order of stability of the given carbocations ?

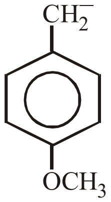
(a) $\overset{+}{F_3C} > F_3C-\underset{|}{\overset{|}{C}}{}^{+} > \overset{+}{CH_3}$ (b) $\overset{+}{H_3C} > F_3C-\underset{|}{\overset{|}{C}}{}^{+} > \overset{+}{F_3C}$

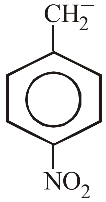
(c) $F_3C-\underset{|}{\overset{|}{C}}{}^{+} > \overset{+}{F_3C} > \overset{+}{H_3C}$ (d) $F_3C-\underset{|}{\overset{|}{C}}{}^{+} > \overset{+}{H_3C} > \overset{+}{F_3C}$

193. The most stable carbanion among the following is

(a) 

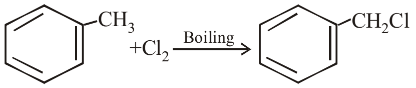
(b) 

(c) 

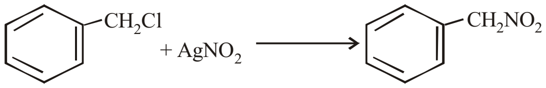
(d) 

194. Which one of the following is a free-radical substitution reaction?

(a) $CH_3CHO + HCN \longrightarrow CH_3CH(OH)CN$

(b) 

(c) 

(d) 

195. Rate of the reaction

$$R-\underset{Z}{C}{=}O + Nu^- \longrightarrow R-\underset{Nu}{C}{=}O + \overset{-}{Z}$$ is fastest when Z is

(a) OC_2H_5 (b) NH_2

(c) Cl (d) $OCOCH_3$

196. For (i) I^-, (ii) Cl^-, (iii) Br^-, the increasing order of nucleophilicity would be

(a) $Cl^- < Br^- < I^-$ (b) $I^- < Cl^- < Br^-$

(c) $Br^- < Cl^- < I^-$ (d) $I^- < Br^- < Cl^-$

197. Which of the following is least reactive in a nucleophilic substitution reaction.

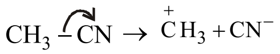
(a) $(CH_3)_3C-Cl$

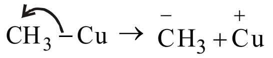
(b) $CH_2=CHCl$

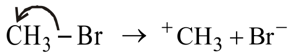
(c) CH_3CH_2Cl

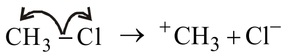
(d) $CH_2=CHCH_2Cl$

198. Which of the following does not represent formation of reactive intermediate correctly ?

(i) 
$CH_3-CN \rightarrow \overset{+}{C}H_3 + CN^-$

(ii) 
$CH_3-Cu \rightarrow \overset{-}{C}H_3 + \overset{+}{C}u$

(iii) 
$CH_3-Br \rightarrow {}^+CH_3 + Br^-$

(iv) 
$CH_3-Cl \rightarrow {}^+CH_3 + Cl^-$

(a) (ii) only (b) (ii) and (iii)
(c) (ii) and (iv) (d) (iii) and (iv)

199. In Lassaigne's test, the organic compound is fused with a piece of sodium metal in order to

(a) increase the ionisation of the compound
(b) decrease the melting point of the compound
(c) increase the reactivity of the compound
(d) convert the covalent compound into a mixture of ionic compounds

200. The most suitable method for separtion of a 1 : 1 mixture of ortho and para nitrophenols is

(a) Sublimation (b) Chromatography
(c) Crystallization (d) Steam distillation

201. The Lassaigne's extract is boiled with dil. HNO_3 before testing for halogens because

(a) silver halides are soluble in HNO_3
(b) Na_2S and NaCN are decomposed by HNO_3
(c) Ag_2S is soluble in HNO_3
(d) AgCN is soluble is HNO_3

202. The molecular mass of an organic compound which contains only one nitrogen atom can be

(a) 152 (b) 146
(c) 76 (d) 73

203. 0.25 g of an organic compound on Kjeldahl's analysis gave enough ammonia to just neutralize $10 cm^3$ of 0.5 M H_2SO_4. The percentage of nitrogen in the compound is

(a) 28 (b) 56
(c) 14 (d) 112

204. During hearing of a court case, the judge suspected that some changes in the documents had been carried out. He asked the forensic department to check the ink used at two different places. According to you which technique can give the best results?

(a) Column chromatography
(b) Solvent extraction
(c) Distillation
(d) Thin layer chromatography

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** Berzilius, a Swedish chemist proposed the concept of 'vital force'.
2. **(d)** Urea was first discovered in human urine by H.M. Rouelle in 1773. It was synthesised in 1828 by Friedrich Wohler and was the first organic compound to be synthesised from inorganic starting materials. It was found when Wohler attempted to synthesize ammonium cyanate, to continue a study of cyanates which he had be carrying out for several years. On treating silver cyanate with ammonium chloride solution he obtained a white crystalline material which proved identical to urea obtained from urine.
3. **(b)** F. Wohler synthesised urea from an inorganic compound ammonium cyanate

$$\underset{\text{Ammonium cyanate}}{NH_4CNO} \xrightarrow{\text{Heat}} \underset{\text{Urea}}{NH_2CONH_2}$$

4. **(c)** According to vital force theory, organic compounds could only be produced by living matter by a vital force. It was in 1828, Friedrich Wholer heated NH_4CNO (derived from inorganic substance) and obtained urea (an organic compound).
5. **(c)** Wholer synthesized urea from ammonium cyanate in 1828. Kekule proposed catenation and structure of benzene. Liebig is a history maker in sports science (energy metabolism).
6. **(d)** Antoine-Laurent de Lavoisier (August 26, 1743 – May 8, 1794) is known as the "*father of modern chemistry*." He was a French nobleman prominent in the histories of chemistry, finance, biology, and economics. He stated the first version of the Law of conservation of mass, co-discovered, recognized and named oxygen (1778) as well as hydrogen, disproved the phlogiston theory, introduced the *Metric system*, invented the first periodic table including 33 elements, and helped to reform chemical nomenclature.
7. **(c)** Hybridisation on the particular carbon can be established by number of σ and π bonds attached to it.

σ Bond	π Bond	Hybridisation
4	–	sp^3
3	1	sp^2
2	2	sp

$$\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H=\overset{4}{C}H_2$$

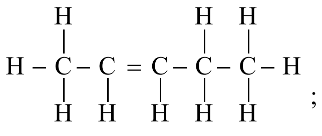
3σ 3σ 3σ 3σ

1π 1π 1π 1π

$\therefore$ sp^2 sp^2 sp^2 sp^2

$\therefore$ Both carbon atoms forming C—C single bond (C_2 and C_3) are sp^2 hybridised

8. **(b)** C – 1 is sp hybridized $(C\equiv C)$
C – 3 is sp^3 hybridized (C– C)
C – 5 is sp^2 hybridized (C = C)
Thus the correct sequence is sp, sp^3, sp^2.
9. **(c)** **10. (c)**
11. **(b)**

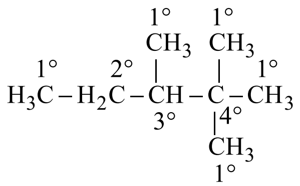


$$\mathrm{H-\underset{H}{\overset{H}{C}}-\underset{H}{C}=\underset{H}{C}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H}\ ;$$

2 – Pentene

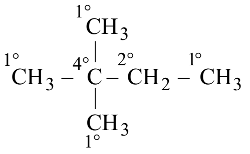
No. of σ bonds = 14, No. of π bonds = 1

12. **(c)** (ii) and (iii) do not represent 2-bromopentane
13. **(c)** Correct expanded form of given structure is shown in option (c).
14. **(c)**
15. **(b)** The successive members of a homologous series differ by a $-CH_2$ unit.
16. **(a)** Correct molecular formula of icosane is $C_{20}H_{42}$
Correct molecular formula of heptane is C_7H_{16}
17. **(c)** (iii) is the only correct method of selecting parent chain.
18. **(b)** Correct order of decreasing priority is
$-COOH, -SO_3H, -COOR, -OH$.
19. **(d)** **20. (c)** **21. (d)** **22. (c)** **23. (c)**
24. **(d)** 2, 2,3-trimethyl pentane



$$\overset{1^\circ}{H_3C}-\overset{2^\circ}{H_2C}-\underset{3^\circ}{\overset{\overset{1^\circ}{CH_3}}{CH}}-\underset{\underset{1^\circ}{CH_3}}{\overset{\overset{1^\circ}{CH_3}}{\overset{}{C}}}{}^{4^\circ}-\overset{1^\circ}{CH_3}$$

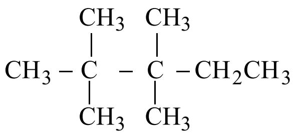
25. **(d)**



$$\overset{1^\circ}{CH_3}-\overset{4^\circ}{\underset{\underset{1^\circ}{CH_3}}{\overset{\overset{1^\circ}{CH_3}}{C}}}-\overset{2^\circ}{CH_2}-\overset{1^\circ}{CH_3}$$

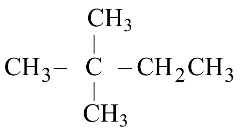
Thus number of secondary hydrogens is two.

26. **(d)**



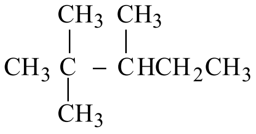
$$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-\underset{CH_3}{\overset{CH_3}{C}}-CH_2CH_3$$

(a)



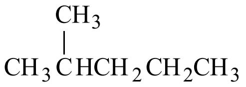
$$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-CH_2CH_3$$

(b)



$$CH_3\underset{CH_3}{\overset{CH_3}{C}}-\overset{CH_3}{C}HCH_2CH_3$$

(c)

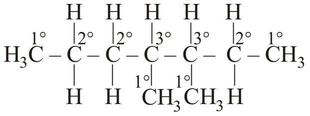


$$CH_3\overset{CH_3}{C}HCH_2CH_2CH_3$$

(d)

27. **(d)** In isopentane, $(CH_3)_2CH\ CH_2\ CH_3$, every carbon is having hydrogen atom(s).

28. **(a)**

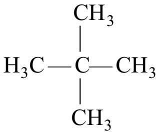


$$\overset{1^\circ}{H_3C}-\underset{H}{\overset{H}{\overset{2^\circ}{C}}}-\underset{H}{\overset{H}{\overset{2^\circ}{C}}}-\underset{\overset{1^\circ}{CH_3}}{\overset{H}{\overset{3^\circ}{C}}}-\underset{\overset{1^\circ}{CH_3}}{\overset{H}{\overset{3^\circ}{C}}}-\underset{H}{\overset{H}{\overset{2^\circ}{C}}}-\overset{1^\circ}{CH_3}$$

3, 4-dimethylheptane

There are four 1° C-atoms, three 2° C-atoms and two 3° C-atoms

29. **(c)** The structure of neopentane is



$$H_3C-\underset{CH_3}{\overset{CH_3}{C}}-CH_3$$

It has 1 quaternary and 4 primary carbons.

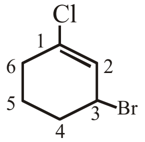
30. **(b)** **31. (d)** **32. (c)** **33. (d)**

34. **(a)** $CH_3-O-\overset{1}{CH_2}-\overset{2}{CH_2}-\overset{3}{CH_2}-O-CH_2CH_3$

3-ethoxy-1-methoxypropane

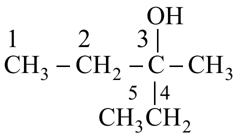
35. **(c)** The correct name is 3 - methylbutan - 2 - ol

36. **(a)**



3-bromo-1chlorocyclohexene

37. **(c)**



$$\overset{1}{CH_3}-\overset{2}{CH_2}-\underset{\overset{5}{CH_3}\overset{4}{CH_2}}{\overset{OH}{\overset{3}{C}}}-CH_3$$

3 – Methyl pentan – 3 – ol

38. **(a)** The IUPAC name of the given compound is 5-chlorohex-2-ene.

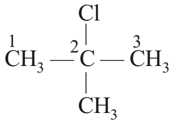
39. **(b)** The compound is a derivative of butane.

40. **(b)** The compound contains longest chain of 6C atoms and amino group. Hence it is an alkanamine.

41. **(d)** The compound is an ester. Its IUPAC name is derived from alkyl alkanoate.

42. **(d)** The compound is an aldehyde containing longest chain of 6 C-atoms and side chains.

43. **(c)**



$$\overset{1}{CH_3}-\underset{CH_3}{\overset{Cl}{\overset{2}{C}}}-\overset{3}{CH_3}$$

2-chloro-2-methyl propane

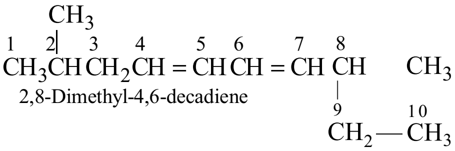
44. **(a)**

45. **(d)** $(CH_3)_2CHCH_2CH_2-$

3-methylbutyl group

46. **(a)**

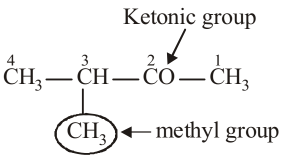
47. **(d)**



$$\overset{1}{CH_3}\overset{CH_3}{\overset{2}{C}}H\overset{3}{C}H_2\overset{4}{C}H=\overset{5}{C}H\overset{6}{C}H=\overset{7}{C}H\underset{\overset{9}{CH_2}-\overset{10}{CH_3}}{\overset{8}{C}H}\quad CH_3$$

2,8-Dimethyl-4,6-decadiene

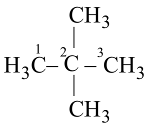
48. **(a)**



$$\overset{4}{CH_3}-\underset{CH_3}{\overset{3}{CH}}-\overset{2}{CO}-\overset{1}{CH_3}$$

3-methyl-2-butanone

49. **(a)**



$$H_3\overset{1}{C}-\underset{CH_3}{\overset{CH_3}{\overset{2}{C}}}-\overset{3}{CH_3}$$

Neopentane
or 2,2- Dimethylpropane

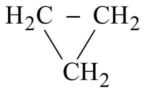
50. **(b)**

51. **(b)** The compound is a derivative of benzoic acid. The positions of substituents attached to benzene nucleus are represented by number of C-atoms and not by ortho, meta and para.

52. **(a)** C_3H_6 has 2 structural isomers.

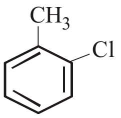
$CH_3-CH=CH_2$ and

propene

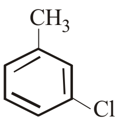


cyclopropane

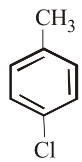
53. **(c)** C_7H_7Cl has 4 isomers



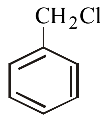
o-Chlorotoluene



m-Chlorotoluene



p-Chlorotoluene



benzyl chloride

54. **(b)** Alcohols and ethers are functional isomers.

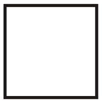
55. **(b)** Structures (*a*), (*c*) and (*d*) have the same molecular formula ($C_6H_{12}O$) while (*b*) has $C_6H_{10}O$ as molecular formula

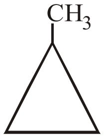
56. **(d)**

57. (b) $\underset{\text{I}}{CH_3CH_2CH_2C{\equiv}CH}$, $\underset{\text{II}}{(CH_3)_2CHC{\equiv}CH}$, $\underset{\text{III}}{CH_3CH_2C{\equiv}CCH_3}$

58. (b) $CH_3CH_2CH{=}CH_2$ $CH_3CH{=}CHCH_3$ $(CH_3)_2C{=}CH_2$

1-butene (*i*) 2- butene (*ii*), (*iii*) (*cis,- trans*) 2-methylpropene (*iv*)


cyclobutane (*v*)



methylcyclopropane (*vi*)

59. (b) 2, 2, 4, 4 - Tetramethylhexane has 10 carbon atoms, only 4-isopropylheptane has also 10 carbon atoms so these two are isomers.

60. (a) **61. (c)** **62. (a)** **63. (b)** **64. (d)**

65. (c)

66. (b) The two isomers differ in the position of the double bond so they are called position isomers.

67. (b)

68. (b) The order of stability of carbocations is :

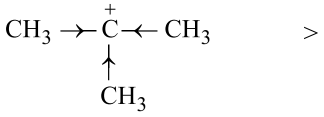
$$(CH_3)_3\overset{+}{C} > (CH_3)_2\overset{+}{C}H > \overset{+}{C}H_3$$

69. (c)

70. (d) Greater the number of alkyl groups attached to a positively charged C atom, greater is the hyperconjugation (no bond resonance) and stable is the cation.

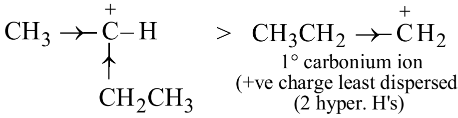
Thus order of decreasing stability of carbocation is, tert – Alkyl > Sec-Alky > Pri-Alkyl > Methyl.

71. (a) Carbonium ions are electron deficient species. More the number of alkyl groups attached to it, more will be stability due to + I effect.



$$CH_3 \rightarrow \underset{\substack{\uparrow\\ CH_3}}{\overset{+}{C}} \leftarrow CH_3 \quad >$$

3°carbonium ion
(+ve charge dispersed to maximum extent)
(9 hyperconjugative H's)



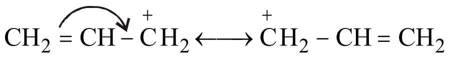
$$CH_3 \rightarrow \underset{\substack{\uparrow\\ CH_2CH_3}}{\overset{+}{C}}-H \quad > \quad CH_3CH_2 \rightarrow \overset{+}{C}H_2$$

2° carbonium ion
(5 hyper. H's)

1° carbonium ion
(+ve charge least dispersed)
(2 hyper. H's)

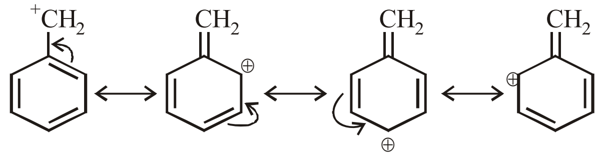
Alternatively, above order of stability order can be explained in terms of hyperconjugation.

72. (d) Higher stability of allyl and aryl substituted methyl carbocation is due to dispersal of positive charge due to resonance



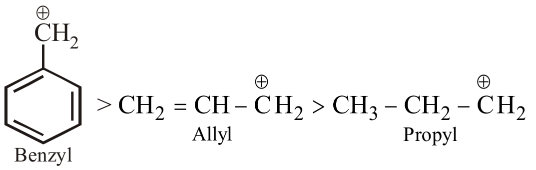
$$CH_2 = CH - \overset{+}{C}H_2 \longleftrightarrow \overset{+}{C}H_2 - CH = CH_2$$

Resonating structures of allyl carbocation



Resonating structures of benzyl carbocation

whereas in alkyl carbocations dispersal of positive charge on different hydrogen atoms is due to hyper conjugation hence the correct order of stability will be



$$> CH_2 = CH - \overset{\oplus}{C}H_2 > CH_3 - CH_2 - \overset{\oplus}{C}H_2$$

73. (b) Structure (*b*) is a 3° carbocation, while (*a*) is 2° and (*c*) and (*d*) are 1° carbocations; thus (*b*) is the most stable.

74. (a)

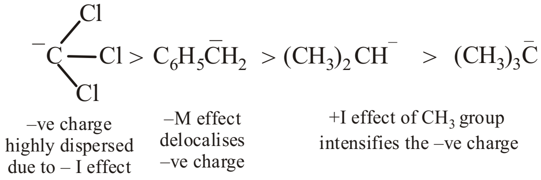
75. (a) Higher the possibility of delocalisation, greater is its stability; in $C_6H_5\overset{+}{C}HC_6H_5$, +ve charge can delocalise over two benzene rings.

76. (d) The organic reaction which proceed through heterolytic bond cleavage are called ionic or heteropolar or just polar reactions.

77. (b) In carbocations, carbon bearing positive charge is always sp^2-hybridised

78. (b) Methyl carbanion is sp^3 hybridised, with three bond pairs and one lone pair same is the case with NH_3.

79. (b)



$$^{-}C(Cl)_3 > C_6H_5\bar{C}H_2 > (CH_3)_2CH^{-} > (CH_3)_3\bar{C}$$

–ve charge highly dispersed due to – I effect

–M effect delocalises –ve charge

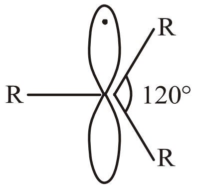
+I effect of CH_3 group intensifies the –ve charge

80. (c) In homolytic fission each of the atoms acquires one of the bonding electrons producing free radicals (species having one unpaired electron).

$$A \overset{\bullet\bullet}{-} B \longrightarrow A\bullet + \bullet B$$

81. (b) Homolytic fission of the C – C bond gives free radicals in which carbon is sp^2- hybridised.

82. (b) The carbon atom of alkyl free radicals which is bonded to only three atoms or groups of atoms is sp^2-hybridized. Thus free radicals have a planar structure with odd electrons situated in the unused *p*-orbital at right angles to the plane of hybrid orbitals.



83. (c)

84. (a) On exposure to UV light, Cl_2 molecule undergoes homolytic fission, to form chlorine free radicals.

$$Cl-Cl \xrightarrow{U.V.} \underset{\text{(Chlorine free radicals)}}{2Cl^{\cdot}}$$

85. (b) The order of stability of free radicals

$$(C_6H_5)_3\dot{C} > (C_6H_5)_2\dot{C}H > (CH_3)_3\dot{C} > (CH_3)_2\dot{C}H$$

The stabilisation of first two is due to resonance and last two is due to inductive effect.

86. (d) Free radicals are stabilized by hyperconjugation, thus 3° free radicals having maximum number of hyperconjugative structures are the most stable, and primary free radical the least.

87. (b) $C_6H_5\dot{C}HCH_3$ is a 2° benzylic free radical, hence stabilized most due to resonance.

88. (b) Dichlorocarbene, $:CCl_2$ (a carbene) is the electrophile formed as an intermediate in Reimer-Tiemann reaction.

89. (d) Order of stability of free radicals is

$3° > 2° > 1° > \dot{C}H_3$

90. (c) The strength of nucleophile depends upon the nature of alkyl group R on which nucleophile has to attack and also on the nature of solvent. The order of strength of nucleophiles follows the order :

$CN^- > I^- > C_6H_5O^- > OH^- > Br^- > Cl^-$

91. (c) **92. (d)**

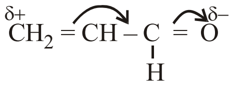
93. (a) Electrophile is positivly charged or electron deficient species. Lewis acids are electron acceptors that is electron deficient species.

94. (b) Electrophiles are electron deficient or positively charged species.

95. (d) BF_3 and R_3C-X are electrophile while $(CH_3)_3N$ and $C_2H_5O^-$ are nucleophile

96. (b) $-CH_3$ group has +I effect, as number of $-CH_3$ group increases, the inductive effect increases.

97. (d) Due to – I effect of the – CHO group, oxygen acquires- δ - charge and the terminal carbon acquires δ + charge.



$$\overset{\delta+}{C}H_2 = CH - \underset{H}{C} = \overset{\delta-}{O}$$

98. (c) All resonating structures should have same number of electron pairs.

99. (a) The two structures involve only movement of electrons and not of atoms or groups, hence these are resonating structures.

100. (b) Only structure (*b*) has a conjugated system, which is necessary for resonance.

101. (c)

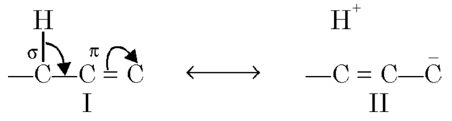
102. (b) – OH shows + R effect while $>C=O$ shows – R effect.

103. (c) Resonance effect is the polarity produced in the molecule by the interactions of two π – bonds or between a π – bond and a lone pair of electrons present on an adjacent atom.

104. (b) Electromeric effect is purely a temporary effect and is brought into play only at the requirement of attacking reagent, it vanishes out as soon as the attacking reagent is removed from reaction mixture.

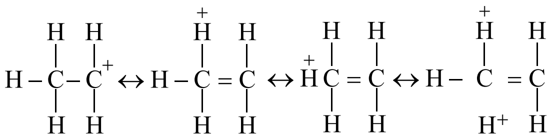
105. (b)

106. (b) Alkyl groups with at least one hydrogen atom on the α-carbon atom, attached to an unsaturated carbon atom, are able to release electrons in the following way.

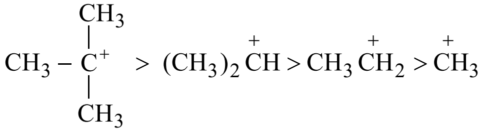


Note that the delocalisation involves σ and π bond orbitals (or *p* orbitals in case of free radicals) ; thus it is also known as σ – π **conjugation.** This type of *electron release due to the presence of the system* H—C—C = C is known as **hyperconjugation**

107. (b) The stability of carbocation on the basis of hyper-conjugation can be explained as hyperconjugation stabilises the carbocation because electron density from the adjacent π-bond helps in dispersing the positive charge.



In general greater the number of alkyl groups attached to a positively charged carbon atom, the greater is the hyperconjugation interaction and stabilisation of the cation. Thus, we have the following relative stability of carbocation.



$$CH_3-\underset{CH_3}{\overset{CH_3}{C^+}} > (CH_3)_2\overset{+}{C}H > CH_3\overset{+}{C}H_2 > \overset{+}{C}H_3$$

Hence, stability of carbocation is directly proportional to number of alkyl group directly attached to carbocations.

108. (b) Stability order of different alkyl carbocations on the basis of hyperconjugation is :

3° > 2° > 1° > methyl

In t-butyl cation, the C-atom bearing the positive charge is attached to three methyl groups therefore it possess nine α-hydrogens. It will give maximum nine hyperconjugative structures leading to maximum stability.

109. (b) In elimination reactions one or two molecules are lost from the substrate to form a multiple bond. Dehydration of ethanol is an example of elimination reaction.

$$C_2H_5OH \xrightarrow[H_2SO_4]{Conc} CH_2 = CH_2 + H_2O.$$

110. (a) **111. (d)** **112. (a)**

113. (b) Coloured impurities are removed by adsorbing over activated charcoal.

114. (a) This method is applied for the purification of substances which (i) are insoluble in water, (ii) are volatile in steam, (iii) are associated with non steam volatile impurities, (iv) have high molecular weights and (v) possess a fairly high vapour pressure at about the boiling point of water e.g. Aniline.

115. (a) Aniline is purified by steam distillation. A mixture of water and aniline boils at 371 K and 760 mm pressure which is less than boiling point of water.

116. (b) Among the given compounds naphthelene is volatile but benzoic acid is non-volatile (it forms a dimer). So, the best method for their separation is sublimation, which is applicable to compounds which can be converted directly into the vapour phase from its solid state on heating and back to the solid state on cooling. Hence it is the most appropriate method.

117. (d)

118. (b) If there is a small difference (10 or less) in the boiling points of liquids fractional distillation is used e.g. acetone b.p. 333 K and methanol b.p. 338 K.

119. (a) Fractional distillation is used for the distillation of petroleum. This method is used for separating a mixture of two or more miscible, volatile liquids having close (less than 40 degrees) boiling points. (For example, a mixture of acetone, b.p., 56°C and methanol, b.p. 65°C)

120. (c) If any liquid decomposes at its boiling point, it can be purified by vacuum distillation.

121. (c) Glycerol decomposes at its boiling point, hence it should be purified by distillation under reduced pressure.

122. (c) Vaccum distillation means distillation under reduced pressure.

123. (c)

124. (a) The latest technique for the purification of organic compounds is chromatography. These are of various types like column, paper and gas-chromatography.

125. (d) Both silica gel and alumina are used as adsorbents in adsorption chromatography.

126. (a) Chromatography paper contains water trapped in it, which acts as the stationary phase.

127. (c) The mixture of sugars is a homogenous one. Homogeneous mixtures of a solvent and one or more solutes (dissolved substances) are often separated by chromatography. Chromatography works to separate a mixture because the components of a mixture distribute themselves differently when they are in contact with a "two phase system". One phase is stationary and the other is moving or mobile. The stationary phase may be a solid packed in a tube or a piece of paper. The mobile phase may be liquid of gaseous.

128. (b) **129. (b)**

130. (b) Carbon and hydrogen are detected by heating the compound with copper (II) oxide. Carbon present in the compound is oxidised to CO_2 and hydrogen to H_2O.

131. (b)

132. (b) Hydrazine (NH_2NH_2) does not contain carbon and hence on fusion with Na metal, it cannot form NaCN; consequently hydrazine does not show Lassaigne's test for nitrogen.

133. (a) Prussian blue $Fe_4[Fe(CN)_6]_3$ is formed in lassaigne test for nitrogen.

$$3Na_4[Fe(CN)_6 + Fe^{3+} \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_4]_3} + 12Na^+$$

134. (d)

135. (d) Kjeldahl method is not applicable to any of the given compounds. As nitrogen of these compounds does not change to ammonium sulphate on heating with conc. H_2SO_4.

136. (c) **137. (b)**

138. (b) In Kjeldahl's method nitrogen is converted into $(NH_4)_2SO_4$, then to NH_3

139. (d) To increase the bpt of H_2SO_4, K_2SO_4 is added

140. (b) $N\% = \dfrac{1.4 \times N \times V}{\text{wt. of organic compound}}$

$$= \frac{1.4 \times 29 \times 1/5}{0.5} = 16.24\%$$

141. (b) $\%\text{ of } S = \dfrac{32}{233} \times \dfrac{0.233}{0.32} \times 100 = 10\%$

142. (c) As in above question,

$$C = \frac{40}{12} = 3.33;\ H = \frac{13.33}{1} = 13.33;\ N = \frac{46.67}{14} = 3.34$$

Relative No. of atoms,

$$C = \frac{3.33}{3.33} = 1;\ H = \frac{13.33}{3.33} = 4;\ N = \frac{3.34}{3.33} = 1$$

$\therefore$ Empirical formula $= CH_4N$

143. (b) Percentage of $P = \dfrac{62}{222} \times \dfrac{\text{wt. of } Mg_2P_2O_7}{\text{wt. of compound}} \times 100$

$$= \frac{62}{222} \times \frac{1.332}{2.79} \times 100 = 13.33\%$$

144. (a)

	% of element	Relative no. of atoms	Simple ratio
C	38.8	$\frac{38.8}{12}=3.2$	1
H	16.0	$\frac{16}{1}=16.0$	5
N	45.28	$\frac{45.28}{14}=3.2$	1

145. (b) Compound $\xrightarrow{\text{heat}}$ O_2 + Other gaseous products

$$2C+O_2 \xrightarrow{1373K} \underset{(A)}{2CO}$$

$$\underset{(B)}{I_2O_5}+\underset{(A)}{5CO} \rightarrow I_2+\underset{(C)}{5CO_2}$$

STATEMENT TYPE QUESTIONS

146. (c) A carbon having an *sp* hybrid orbital with 50% *s*-character is more electronegative than carbon atoms having sp^2 and sp^3 hybrid orbitals with 33% and 25% *s*-character respectively.
In $CH_2 = C = CHCH_3$
Number of σ bonds :
$\sigma_{C-C} = 3$, $\sigma_{C-H} = 6$, total = 6 + 3 = 9
Number of π bonds = 2

147. (a) $$\overset{\frown}{R}-\overset{\frown}{X} \xrightarrow[\text{light}]{\text{heat or}} \dot{R}+\dot{X}$$

Above equation is an example of homolytic cleavge

148. (c) $-CH_3$ is an electron donating group.

149. (b) The resonance structures have same positions of nuclei and same number of unpaired electrons.

150. (b) Fractional distillation method is used if the difference in boiling points of two liquids is not much.

151. (d) For statement (ii),

$$R_F = \frac{\text{Distance moved by the substance from base line}}{\text{Distance moved by the solvent from base line}}$$

For statement (iv), amino acids sports may be detected by spraying the TLC plate with ninhydrin solution.

152. (b) K_2SO_4 raises bpt. and $CuSO_4$ acts as catalyst.

153. (d) When organic compound contains nitrogen, upon combustion it will produce oxides of nitrogen soluble in KOH solution. The copper will convert them into N_2

$$2NO+2Cu \longrightarrow 2CuO+N_2$$

$$2NO_2+4Cu \longrightarrow 4CuO+N_2 \text{ etc.}$$

Halogens will be removed as AgX. In case of sulphur SO_2 formed will be removed as $PbSO_4$.

MATCHING TYPE QUESTIONS

154. (b) **155. (c)** **156. (a)** **157. (c)** **158. (a)**
159. (a) **160. (d)** **161. (a)** **162. (b)** **163. (d)**
164. (c) **165. (a)**

ASSERTION-REASON TYPE QUESTIONS

166. (c) – CN is a secondary suffix.

167. (b)

168. (d) The correct name of the given compound is 2, 5, 6 -trimethyloctane

169. (c) **170. (d)**

171. (c) Benzene has a uniform C – C bond distance of 139 pm, a value intermediate between the C – C single. (154 pm) and C = C double (134 pm) bonds.

172. (a) It is fact that aniline is better nucleophile than anilium ion. Anilium ion contain +ve charge, which reduces the tendency to donate lone pair of electron $\underset{\text{Anilium ion}}{C_6H_5NH_3^+}$.

173. (d) Resonance structures contain the same number of unpaired electrons. However, they differ in the way of distribution of electrons.

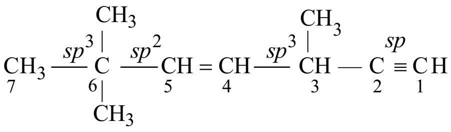
174. (d) **175. (a)** **176. (a)** **177. (c)**

CRITICAL THINKING TYPE QUESTIONS

178. (a) It is derivative of ethanamide having N-phenyl group.

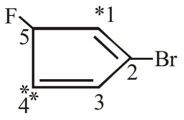
179. (b) The compound contains longest chain of 5C - atoms and e of ene is retained as the suffix name starts with constant

180. (d)

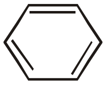


$$\underset{7}{CH_3}\overset{sp^3}{—}\underset{6}{\overset{CH_3}{\underset{CH_3}{C}}}\overset{sp^2}{—}\underset{5}{CH}=\underset{4}{CH}\overset{sp^3}{—}\underset{3}{\overset{CH_3}{CH}}—\underset{2}{\overset{sp}{C}}\equiv\underset{1}{CH}$$

181. (d)



The numbering of C-atom starts from $\overset{*}{C}$ or $\overset{**}{C}$. But numbering from $\overset{*}{C}$ give minimum locant (2) to Br which is correct.

182. (a) 

No. of σ bonds = 12 ; No. of π bonds = 3

$\therefore$ Ratio of $\pi : \sigma$ bonds = 3 : 12 = 1 : 4

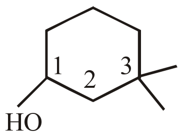
183. (a) In compounds (i), (iii) and (iv), all carbon atoms are sp^3, sp^2 and sp hybridised, respectivley. However, compound (ii) has sp^2 and sp^3 hybridised carbon atoms;

$$\overset{sp^3}{CH_3}-\overset{sp^2}{CH}=\overset{sp^2}{CH}-\overset{sp^3}{CH_3}$$

184. (a)

185. (c) See the number of σ bonds formed by $\overset{x}{C}$ in each case.

In $H\overset{x}{C}OOH$, $(H_2N)_2\overset{x}{C}O$ and $CH_3\overset{x}{C}HO, \overset{x}{C}$ forms 3σ bonds and 1 π bond, hybridisation is sp^2. In $(CH_3)_3\overset{x}{C}OH$, $\overset{x}{C}$ forms 4σ bonds, hence hybridisation is sp^3

186. (a) 

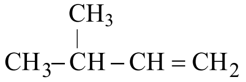
IUPAC name – 3, 3-Dimethyl -1 cyclohexanol

187. (d) The compound contains longest chain of 3 C - atoms and three -COOH groups and one -OH group attached to it (latest convention).

188. (c) C_5H_{10} has 1° degree of unsaturation since the isomers are acyclic, all of these are alkenes. For writing the isomers, first introduce the double bond at different possible positions, and then consider the possibility of branching in the alkyl group.

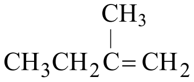
$CH_3CH_2CH_2CH{=}CH_2$ — 1-pentene (*i*)

$CH_3CH_2CH{=}CHCH_3$ — 2- pentene, (*cis,- trans*) (*ii*), (*iii*)



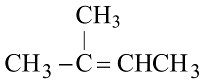
$$CH_3-\overset{\overset{\displaystyle CH_3}{|}}{CH}-CH=CH_2$$

3-methyl-1-butene, (*iv*)



$$CH_3CH_2\overset{\overset{\displaystyle CH_3}{|}}{C}=CH_2$$

2-methyl-1-butene, (*v*)



$$CH_3-\overset{\overset{\displaystyle CH_3}{|}}{C}=CHCH_3$$

2-methyl-2-butene, (*vi*)

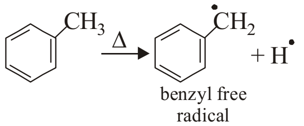
189. (b) **190. (d)**

191. (c) Metamerism shown among compounds of the same functional group.

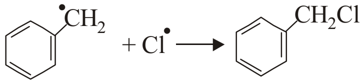
192. (b) – I group destablises carbocation and since inductive effect decreases with increasing length of carbon chain. Therefore (b) is the correct option.

193. (d) $-NO_2$ group, being strong electron-withdrawing, disperses the –ve charge, hence stabilizes the concerned carbanion.

194. (b) In the presence of UV rays or energy, by boiling chlorine, free radical is generated which attack the methyl carbon atom of the toluene.



$$Cl_2 \xrightarrow{hv} 2Cl^{\bullet}$$



195. (c) Cl^- is the best leaving group among the given option.

196. (a) Nucleophilicity increases down the periodic table.

$I^- > Br^- > Cl^- > F^-$

197. (b) $H_2C = CHCl$ is capable of showing resonance which develops a partial double bond character on C–Cl bond, thereby making it less reactive toward nucleophilic substitution.

$$H_2C=CH-\ddot{\underset{\cdot\cdot}{Cl}}: \longleftrightarrow H_2\bar{C}-CH=Cl^+$$

198. (d) $CH_3\overset{\curvearrowright}{-Br} \rightarrow {}^{+}CH_3 + Br^-$

$$\overset{\curvearrowleft\curvearrowright}{CH_3-Cl} \rightarrow \dot{C}H_3 + \dot{C}l$$

199. (d) To convert covalent compounds into ionic compounds such as NaCN, Na_2S, NaX, etc.

200. (d) The boiling point of o-nitrophenol is less than para-nitrophenol due to presence of intramolecular hydrogen bonding. Since p-nitrophenol is less volatile in than o-nitrophenol due to presence of inter molecular hydrogen bonding hence they can be separated by steam distillation.

201. (b) Na_2S and NaCN, formed during fusion with metallic sodium, must be removed before adding $AgNO_3$, otherwise black ppt. due to Na_2S or white precipitate due to AgCN will be formed and thus white precipitate of AgCl will not be identified easily.

$$Na_2S + 2AgNO_3 \longrightarrow 2NaNO_3 + \underset{\text{Black}}{Ag_2S \downarrow}$$

$$NaCN + AgNO_3 \longrightarrow NaNO_3 + \underset{\text{White}}{AgCN \downarrow}$$

$$NaCl + AgNO_3 \longrightarrow NaNO_3 + \underset{\text{white}}{AgCl \downarrow}$$

$$Na_2S + 2HNO_3 \xrightarrow{\text{boil}} 2NaNO_3 + H_2S \uparrow$$

$$NaCN + HNO_3 \xrightarrow{\text{boil}} NaNO_3 + HCN \uparrow$$

202. (d) The compounds with odd number of N-atoms have odd masses and with even number of N-atoms have even masses. This is "nitrogen rule".

203. (b) Percentage of N in a compound

$$= \frac{1.4 \times \text{Normality of acid} \times \text{Volume of acid used}}{\text{Mass of the substance taken}}$$

Given, 0.5 M H_2SO_4 is used.

Normality = Molarity × n

where $n = \frac{\text{Mol.mass}}{\text{Eq.mass}} = \frac{98}{49} = 2$

$\therefore$ Normality = 0.5 × 2 = 1 N H_2SO_4

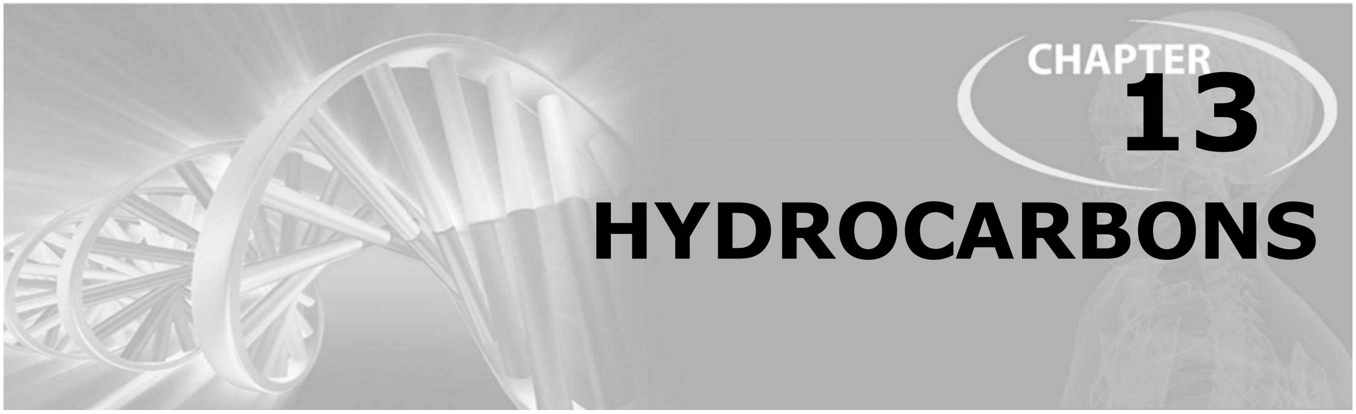
Volume of acid used to neutralise

NH_3 = 10 cm^3

Mass of organic compound taken = 0.25 g

$\therefore \quad \%N = \frac{1.4 \times 1 \times 10}{0.25} = 56.$

204. (d)



CHAPTER 13

HYDROCARBONS

FACT/DEFINITION TYPE QUESTIONS

1. Which of the following fuel cause the least pollution ?
(a) Petrol (b) CNG
(c) Kerosene (d) LPG

2. LPG mainly contains :
(a) ethyne (b) butane
(c) methane (d) ethane

3. Natural gas is a mixture of :
(a) $CH_4 + C_2H_6 + C_3H_8$ (b) $CO + H_2 + CH_4$
(c) $CO + H_2$ (d) $H_2O + CO_2$

4. Which of the following gas is find in coal mines and marshy places?
(a) Methane (b) Ethane
(c) Benzene (d) Propane

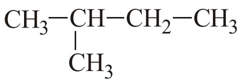
5. Which of the following represents the correct general formula of alkanes ?
(a) C_nH_{2n} (b) C_nH_{2n+2}
(c) C_nH_{2n-2} (d) C_nH_n

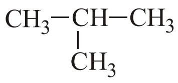
6. Two adjacent members of a homologous series have
(a) a difference of CH_2 in their structure
(b) a different of 14 amu in molecular mass
(c) same general method of preparation
(d) All the above

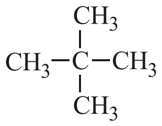
7. Methane, ethane and propane are said to form a homologous series because all are
(a) hydrocarbons
(b) saturated compounds
(c) aliphatic compounds
(d) differ from each other by a CH_2 group

8. Which of the following does not belong to the same homologous series?
(a) CH_4 (b) C_2H_6
(c) C_3H_8 (d) C_4H_8

9. In which of the following compounds only primary carbon atoms are present?

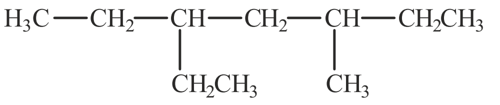
(a) 
$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_2-CH_3$

(b) 
$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_3$

(c) 
$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3$

(d) CH_3-CH_3

10. The IUPAC name of the following compound

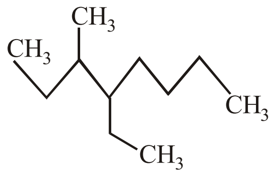

$H_3C-CH_2-\underset{\underset{CH_2CH_3}{|}}{CH}-CH_2-\underset{\underset{CH_3}{|}}{CH}-CH_2CH_3$

is
(a) 3-ethyl-5-methylheptane
(b) 5-ethyl-3-methylheptane
(c) 3,5-diethylhexane
(d) 1,1-diethyl-3-methylpentane

11. The number of chain isomers possible for the hydrocarbon C_5H_{12} is
(a) 1 (b) 2
(c) 3 (d) 4

12. The number of primary, secondary and tertiary carbons in 3, 4-dimethylheptane are respectively
(a) 4, 3 and 2 (b) 2, 3 and 4
(c) 4, 2 and 3 (d) 3, 4 and 2

13. Name of the given compound -



(a) 2, 3-diethyl heptane (b) 5-ethyl-6-methyl octane
(c) 4-ethyl-3-methyl octane (d) 3-methyl-4-ethyl octane

14. Which of the following statements is false for isopentane–
(a) It has three CH_3 groups
(b) It has one CH_2 group
(c) It has one CH group
(d) It has a carbon which is not bonded to hydrogen

15. Molecular formula of which of the following alkane can exist in more than one structure ?
(a) CH_4 (b) C_2H_6
(c) C_3H_8 (d) C_4H_{10}

16. How many isomers are possible for the C_5H_{12} ?
(a) 2 (b) 3
(c) 4 (d) 5

17. The number of 4° carbon atoms in 2,2,4,4-tetramethyl pentane is –
(a) 1 (b) 2
(c) 3 (d) 4

18. Which one of the following cannot be prepared by Wurtz reaction ?
(a) CH_4 (b) C_2H_6
(c) C_3H_8 (d) C_4H_{10}

19. The reaction,
$CH_3-Br+2Na+Br-CH_3 \rightarrow$ the product, is called
(a) Wurtz reaction (b) Perkin's reaction
(c) Aldol condensation (d) Levit reaction

20. Pure methane can be produced by
(a) Wurtz reaction
(b) Kolbe's electrolytic method
(c) Soda-lime decarboxylation
(d) Reduction with H_2

21. Sodium salts of carboxylic acids on heating with soda lime give alkanes containing _______ than the carboxylic acid.
(a) one carbon more (b) one carbon less
(c) two carbon less (d) Either (a) or (b)

22. Which one of the following has the least boiling point?
(a) 2, 2– dimethylpropane (b) n-butane
(c) 2-methylpropane (d) n-pentane

23. Which one of the following has highest boiling point?
(a) n-Octane (b) 2,2 dimethyl pentane
(c) Iso-octan (d) All have equal values

24. Which of the following reactions of methane is incomplete combustion ?
(a) $2CH_4+O_2 \xrightarrow{Cu/523K/100atm} 2CH_3OH$
(b) $CH_4+O_2 \xrightarrow{Mo_2O_3} HCHO+H_2O$
(c) $CH_4+O_2 \rightarrow C(s)+2H_2O(l)$
(d) $CH_4+2O_2 \rightarrow CO_2(g)+2H_2O(l)$

25. In the free radical chlorination of methane, the chain initiating step involves the formation of
(a) chlorine free radical
(b) hydrogen chloride
(c) methyl radical
(d) chloromethyl radical.

26. Which one of the following gives only one monochloro derivative?
(a) n-hexane (b) 2-methylpentane
(c) 2, 3-dimethylpentane (d) neo-pentane

27. Photochemical halogenation of alkane is an example of
(a) electrophilic substitution
(b) electrophilic addition
(c) nucleophilic substitution
(d) free radical substitution

28. 2-Methylbutane on reacting with bromine in the presence of sunlight gives mainly
(a) 1-bromo-3-methylbutane
(b) 2-bromo-3-methylbutane
(c) 2-bromo-2-methylbutane
(d) 1-bromo-2-methylbutane

29. Complete combustion of CH_4 gives :
(a) CO_2+H_2O (b) CO_2+H_2
(c) $COCl_2$ (d) $CO+CO_2+H_2O$

30. Aromatisation of *n*-hexane gives :
(a) cyclohexane (b) benzene
(c) cycloheptane (d) toluene

31. Liquid hydrocarbons can be converted to a mixture of gaseous hydrocarbons by :
(a) oxidation
(b) cracking
(c) distillation under reduced pressure
(d) hydrolysis

32. n-Hexane isomerises in presence of anhydrous aluminium chloride and hydrogen chloride gas to give
(a) 2-Methyl pentane (b) 3-Methyl pentane
(c) Both (a) and (b) (d) Neither (a) nor (b)

33. Which of the following represents the correct reaction ?
(a) $CH_4+2H_2O \xrightarrow{Ni} CO_2+4H_2$
(b) $CH_4+H_2O \xrightarrow{Ni} CO+3H_2$
(c) $CH_4+H_2O \xrightarrow{Ni} CH_3OH+H_2$
(d) $CH_4+H_2O \xrightarrow{Ni} HCHO+2H_2$

34. How many conformations are possible for ethane ?
(a) 2 (b) 3
(c) infinite (d) one

35. Spatial arrangements of atoms which can be converted into one another by rotation around a C–C single bond are called
(a) Stereoisomers (b) Tautomers
(c) Optical isomers (d) Conformers

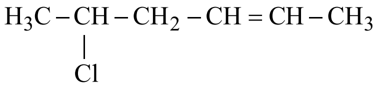
36. General formula of alkenes and alkyl radicals are respectively:
(a) C_nH_{2n} and C_nH_{2n+1} (b) C_nH_{2n} and C_nH_{2n+2}
(c) C_nH_{2n-1} and C_nH_{2n} (d) C_nH_{2n+1} and C_nH_{2n+2}

37. The restricted rotation about carbon-carbon double bond in 2- butene is due to
(a) overlap of one s- and one sp^2-hybridized orbitals
(b) overlap of two sp^2-hybridized orbitals
(c) overlap of one p-and one sp^2-hybridized orbitals
(d) sideways overlap of two p-orbitals

38. Bond angle in alkenes is equal to
(a) 120° (b) 109°28'
(c) 180° (d) 60°

39. The molecular formula of a compound in which double bond is present between C & C :
(a) C_nH_{2n+2} (b) C_nH_n
(c) C_nH_{2n} (d) C_nH_{2n-2}

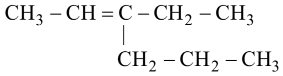
40. IUPAC name of the following compound is



$$H_3C-\underset{\displaystyle Cl}{\underset{|}{CH}}-CH_2-CH=CH-CH_3$$

(a) 5-chloroheptene (b) 4-chloropent-1-ene
(c) 5-chloropent-3-ene (d) 5-chlorohex-2-ene

41. IUPAC name of the following compound will be

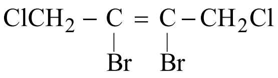


$CH_3-CH=\underset{\underset{CH_2-CH_2-CH_3}{|}}{C}-CH_2-CH_3$

(a) 3–Ethyl–2–hexene (b) 3–Propyl–2–hexene
(c) 3–Propyl–3–hexene (d) 4–Ethyl–4–hexene

42. Which of the following represents the correct IUPAC name of the compound
$CH_2=CH-CH_2Cl$?
(a) Allyl chloride (b) 1- chloro -3- propene
(c) 3- chloro-1- propene (d) Vinyl chloride

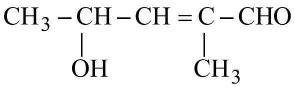
43. The name of



$ClCH_2-\underset{Br}{\underset{|}{C}}=\underset{Br}{\underset{|}{C}}-CH_2Cl$

according to IUPAC nomenclature system is
(a) 2, 3- dibromo -1, 4- dichlorobutene-2
(b) 1, 4- dichloro-2, 3- dibromobutene-2
(c) Dichlorodibromobutene
(d) Dichlorodibromobutane

44. The IUPAC name of



$CH_3-\underset{OH}{\underset{|}{CH}}-CH=\underset{CH_3}{\underset{|}{C}}-CHO$

(a) 4-Hydroxy-1-methylpentanal
(b) 4-Hydroxy-2-methylpent-2-en-1-al
(c) 2-Hydroxy-4-methylpent-3-en-5-al
(d) 2-Hydroxy-3-methylpent-2-en-5-al

45. The alkene that exhibits geometrical isomerism is
(a) 2- methyl propene (b) 2-butene
(c) 2- methyl -2- butene (d) propene

46. Which one of the following exhibits geometrical isomerism?
(a) 1, 2-dibromopropene (b) 2, 3-dimethylbut-2-ene
(c) 2, 3-dibromobut-2-ene (d) Both (a) and (c)

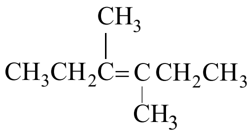
47. The compounds $CH_3CH=CHCH_3$ and $CH_3CH_2CH=CH_2$
(a) are tautomers
(b) are position isomers
(c) contain same number of sp^3-sp^3, sp^3-sp^2 and sp^2-sp^2 carbon-carbon bonds
(d) exist together in dynamic equilibrium

48. The total number of isomers for C_4H_8 is
(a) 5 (b) 6
(c) 7 (d) 8

49. Consider the following statements : A hydrocarbon of molecular formula C_5H_{10} is a
I. monosubstituted alkene
II. disubstituted alkene
III. trisubstituted alkene
Which of the following statement(s) is(are) correct?
(a) I, II and III (b) I and II
(c) II and III (d) I and III

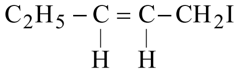
50. Geometrical isomerism is not shown by

(a)



$CH_3CH_2\overset{CH_3}{\overset{|}{C}}=\underset{CH_3}{\underset{|}{C}}CH_2CH_3$

(b)



$C_2H_5-\underset{H}{\underset{|}{C}}=\underset{H}{\underset{|}{C}}-CH_2I$

(c) $CH_2=C(Cl)CH_3$

(d) $CH_3-CH=CH-CH=CH_2$

51. Hex-2-ene and 2-methylpent-2-ene exhibit
(a) chain isomerism (b) position isomerism
(c) geometrical isomerism (d) optical isomerism

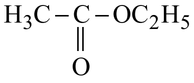
52. Ethyl bromide gives ethylene when reacted with –
(a) ethyl alcohol (b) dilute H_2SO_4
(c) aqueous KOH (d) alcoholic KOH

53. By which reaction ethene is obtained from ethyne -
(a) oxidation (b) polymerisation
(c) hydrogenation (d) dehydrogenation

54. The major product formed when 2-bromobutane is treated with alcoholic KOH is
(a) 2-Butanol (b) 1-Butene
(c) 1-Butanol (d) Trans-2-butene

55. Ethyl alcohol is heated with conc. H_2SO_4. The product formed is :

(a)



$H_3C-\underset{O}{\underset{||}{C}}-OC_2H_5$

(b) C_2H_6

(c) C_2H_4 (d) C_2H_2

56. Alcoholic solution of KOH is used for
(a) Dehydrogenation (b) Dehalogenation
(c) Dehydration (d) Dehydrohalogenation

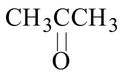
57. Paraffins are soluble in
(a) Distilled water (b) Benzene
(c) Methanol (d) Sea water

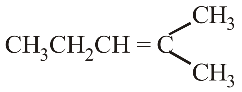
58. When hydrochloric acid gas is treated with propene in presence of benzoyl peroxide, it gives
(a) 2-Chloropropane (b) Allyl chloride
(c) No reaction (d) n-Propyl chloride.

59. "The addition of unsymmetrical reagents to unsymmetrical alkenes occurs in such a way that the negative part of the addendum goes to that carbon atom of the double bond which carries lesser number of hydrogen atoms" is called by :
(a) Saytzeff rule (b) Markownikoff's rule
(c) Kharasch effect (d) Anti-Saytzeff rule

60. When one mole of an alkene on ozonolysis produces 2 moles of propanone, the alkene is
(a) 3-methyl-1-butene
(b) 2, 3-dimethyl-1-butene
(c) 2, 3-dimethyl-2-pentene
(d) 2, 3-dimethyl-2-butene

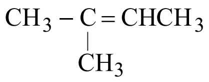
61. Which alkene on ozonolysis gives CH_3CH_2CHO and


$CH_3\underset{\underset{O}{||}}{C}CH_3$

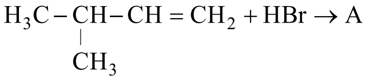
(a) 
$CH_3CH_2CH=C(CH_3)_2$

(b) $CH_3CH_2CH=CHCH_2CH_3$

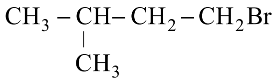
(c) $CH_3\,CH_2\,CH=CH\,CH_3$

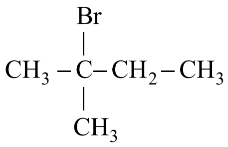
(d) 
$CH_3-\underset{\underset{CH_3}{|}}{C}=CHCH_3$

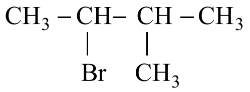
62. Reaction of HBr with propene in the presence of peroxide gives
(a) isopropyl bromide (b) 3-bromo propane
(c) allyl bromide (d) n-propyl bromide

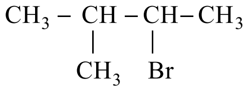
63. 
$H_3C-\underset{\underset{CH_3}{|}}{CH}-CH=CH_2+HBr\rightarrow A$

A(predominantly) is :

(a) 
$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_2-CH_2Br$

(b) 
$CH_3-\overset{\overset{Br}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_2-CH_3$

(c) 
$CH_3-\underset{\underset{Br}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-CH_3$

(d) 
$CH_3-\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{Br}{|}}{CH}-CH_3$

64. Butene-1 may be converted to butane by reaction with
(a) $Sn-HCl$ (b) $Zn-Hg$
(c) Pd/H_2 (d) $Zn-HCl$

65. Alkenes usually show which type of reaction –
(a) addition (b) substitution
(c) elimination (d) superposition

66. A reagent used to test unsaturation in alkene is -
(a) ammonical Cu_2Cl_2 (b) ammonical $AgNO_3$
(c) solution of Br_2 in CCl_4 (d) conc. H_2SO_4

67. In the given reaction

$$CH_3CH_2CH=CHCH_3\xrightarrow{X}CH_3CH_2COOH+CH_3COOH$$

The X is
(a) C_2H_5ONa (b) Conc. HCl + Anhy. $ZnCl_2$
(c) Anh. $AlCl_3$ (d) $KMnO_4/OH^-$

68. Polythene is a resin obtained by polymerisation of
(a) Butadiene (b) Ethylene
(c) Methane (d) Ethyne

69. Ethyl hydrogen sulphate is obtained by reaction of H_2SO_4 on
(a) Ethylene (b) Ethane
(c) Ethyl chloride (d) Ethanol

70. The negative part of an addendum adds on to the carbon atom joined to the least number of hydrogen atoms. This statement is called
(a) Thiele's theory (b) Peroxide effect
(c) Markownikoff's rule (d) Baeyer's strain theory

71. Which of the following compounds does not follow Markownikoff's law ?
(a) $CH_3CH=CH_2$ (b) CH_2CHCl
(c) $CH_3CH=CHCH_3$ (d) None of these

72. In the following sequence of reactions, the alkene affords the compound 'B'

$$CH_3-CH=CH-CH_3\xrightarrow{O_3}A\xrightarrow[Zn]{H_2O}B.$$

The compound B is
(a) CH_3CH_2CHO (b) CH_3COCH_3
(c) $CH_3CH_2COCH_3$ (d) CH_3CHO

73. One mole of a symmetrical alkene on ozonolysis gives two moles of an aldehyde having a molecular mass of 44 u. The alkene is
(a) propene (b) 1-butene
(c) 2-butene (d) ethene

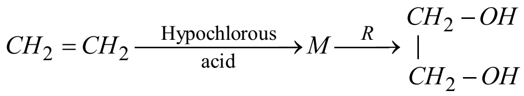
74. The alkene that will give the same product with HBr in the absence as well as in the presence of peroxide is
(a) 2-butene (b) 1-butene
(c) propene (d) 1-hexene

75. Ethylene reacts with alkaline $KMnO_4$ to form
(a) Oxalic acid (b) HCHO
(c) Ethyl alcohol (d) Glycol

76. The reaction of HI with $CH_3-CH=CH_2$ at 400°C yields :
(a) $CH_2I-CH=CH_2$ (b) $CH_3-CHI-CH_3$
(c) $CH_3-CH_2-CH_2I$ (d) $CH_2I-CH_2-CH_2I$

77. Ethene when treated with Br_2 in the presence of CCl_4 which compound is formed
(a) 1, 2-dibromoethane (b) 1-bromo-2-chloroethane
(c) Both (a) and (b) (d) 1, 1, 1-tribromoethane

78. In a reaction

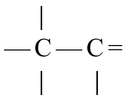

$$CH_2=CH_2\xrightarrow[\text{acid}]{\text{Hypochlorous}}M\xrightarrow{R}\begin{matrix}CH_2-OH\\|\\CH_2-OH\end{matrix}$$

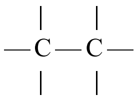
Where M = molecule; R = reagent; M and R are
(a) CH_3CH_2Cl and NaOH
(b) CH_3Cl-CH_2OH and aq. $NaHCO_3$
(c) CH_3CH_2OH and HCl
(d) $CH_2=CH_2$ and heat

79. The test for unsaturation is confirmed by the decolourisation of which of the following
(a) Iodine water (b) $CuSO_4$ solution
(c) Bromine water (d) All of these

80. Isopropyl alcohol is obtained by reacting which of the following alkenes with conc. H_2SO_4 and H_2O
(a) Ethylene (b) Propylene
(c) 2-methyl propene (d) Isoprene

81. Which one of the following is the strongest bond?
(a) $>C=C<$ (b) $—C\equiv C—$

(c)

$$\begin{array}{ccccc} & | & & & \\ — & C & — & C & = \\ & | & & | & \end{array}$$

(d)

$$\begin{array}{ccccccc} & | & & | & \\ — & C & — & C & — \\ & | & & | & \end{array}$$

82. An alkyne has general formula :
(a) C_nH_{2n} (b) C_nH_{2n+1}
(c) C_nH_{2n+2} (d) C_nH_{2n-2}

83. The IUPAC name of the compound $CH_3CH=CHC\equiv CH$ is
(a) Pent-l-yn-3-ene (b) Pent-4-yn-2-ene
(c) Pent-3-en-1-yne (d) Pent-2-en-4-yne

84. Number of alkynes for formula C_5H_8 is –
(a) 2 (b) 3
(c) 4 (d) 5

85. The IUPAC name of the compound having the formula $CH\equiv C-CH=CH_2$ is :
(a) 1-butyn-3-ene (b) but-1-yne-3-ene
(c) 1-butene-3-yne (d) 3-butene-1-yne

86. The homologue of ethyne is
(a) C_2H_4 (b) C_2H_6
(c) C_3H_8 (d) C_3H_6

87. The C - H bond length is minimum in the bond formed by
(a) *sp* - *s* overlapping (as in alkynes)
(b) sp^2-s overlapping (as in alkenes)
(c) sp^3-s overlapping (as in alkanes)
(d) None of these

88. Triple bond of ethyne is made of
(a) Three σ – bonds
(b) Three π – bonds
(c) Two σ and one π – bond
(d) Two π and one σ – bond

89. Maximum carbon-carbon bond distance is found in –
(a) ethyne (b) ethene
(c) ethane (d) benzene

90. The acetylene molecule contains :
(a) 5 sigma bonds (b) 4 sigma and 1 pi bonds
(c) 3 sigma and 2 pi bonds (d) 2 sigma and 3 pi bonds

91. Butyne-2 contains :
(a) *sp* hybridised carbon atoms only
(b) sp^3 hybridised carbon atoms only
(c) both *sp* and sp^2 hybridised carbon atoms
(d) both *sp* and sp^3 hybridised carbon atoms

92. The correct order towards bond length is
(a) $C-C<C=C<C\equiv C$ (b) $C\equiv C<C=C<C-C$
(c) $C=C<C\equiv C<C-C$ (d) $C=C<C-C<C\equiv C$

93. Which C-atom is the most electronegative in this structure?

$$\overset{III}{CH_3}-\overset{II}{CH_2}-C\equiv\overset{I}{CH}$$

(a) I
(b) II
(c) III
(d) all are equal electronegative

94. $R-CH_2-CCl_2-R\xrightarrow{\text{Reagent}}R-C\equiv C-R$
The reagent is
(a) Na (b) HCl in H_2O
(c) KOH in C_2H_5OH (d) Zn in alcohol.

95. Calcium carbide when treated with water gives :
(a) ethylene (b) methane
(c) acetylene (d) ethane

96. Which one of the following has the minimum boiling point ?
(a) 1-Butene (b) 1-Butyne
(c) *n*- Butane (d) Isobutane

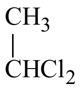
97. Ammonical silver nitrate forms a white precipitate easily with
(a) $CH_3C\equiv CH$ (b) $CH_3C\equiv CCH_3$
(c) $CH_3CH=CH_2$ (d) $CH_2=CH_2$

98. When acetylene is passed through dil. H_2SO_4 in presence of $HgSO_4$, the compound formed is
(a) ether (b) acetaldehyde
(c) acetic acid (d) ketone

99. Which of the following will be the final product when C_2H_2 reacts with HCl

(a)

$$\begin{array}{l} CH \\ \| \\ CHCl \end{array}$$

(b)

$$\begin{array}{l} CH_3 \\ | \\ CHCl_2 \end{array}$$

(c)

$$\begin{array}{l} CHCl \\ \| \\ CHCl \end{array}$$

(d) None of these

100. The hydrocarbon which can react with sodium in liquid ammonia is
(a) $CH_3CH_2CH_2C\equiv CCH_2CH_2CH_3$
(b) $CH_3CH_2C\equiv CH$
(c) $CH_3CH=CHCH_3$
(d) $CH_3CH_2C\equiv CCH_2CH_3$

101. Which of these will not react with acetylene?
(a) NaOH (b) Ammonical $AgNO_3$
(c) Na (d) HCl.

102. When acetylene is passed over heated iron tube, the product obtained is –
(a) C_2H_2 (b) C_4H_4
(c) C_6H_6 (d) C_8H_8

103. But–2–yne on chlorination gives
(a) 1 –chlorobutane
(b) 1, 2 –dichlorobutane
(c) 1, 1, 2, 2 –tetrachlorobutane
(d) 2, 2, 3, 3 –tetrachlorobutane

104. When propyne reacts with aqueous H_2SO_4 in the presence of $HgSO_4$, the major product is
(a) Propanal
(b) Propyl hydrogen sulphate
(c) Acetone
(d) Propanol

105. Propyne on polymerisation gives
(a) Mesitylene (b) Benzene
(c) Ethyl benzene (d) Propyl benzene

106. What happens when a mixture of acetylene and hydrogen is passed over heated Lindlar's catalyst ?
(a) Ethane and water are formed
(b) Ethylene is formed
(c) Acetylene and ethane are formed
(d) None of these

107. Which of the following reaction is shown by alkynes ?
(a) Addition (b) Substitution
(c) Polymerization (d) All of these

108. Which of the following reactions will yield 2, 2-dibromopropane ?
(a) $HC \equiv CH + 2HBr \rightarrow$
(b) $CH_3C \equiv CH + 2HBr \rightarrow$
(c) $CH_3CH = CH_2 + HBr \rightarrow$
(d) $CH_3CH = CHBr + HBr \rightarrow$

109. In the given reactions

$$CH_3C \equiv CH \xrightarrow{A} CH_3CBr_2CHBr_2$$

$$CH_3C \equiv CH \xrightarrow{B} CH_3CBr_2CH_3$$

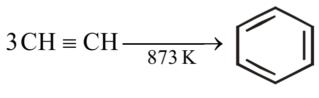
$$CH_3C \equiv CH \xrightarrow[333\,K]{Hg^{2+}/H^+} C$$

$$HC \equiv CH \xrightarrow[333\,K]{Hg^{2+}/H^+} D$$

A, B, C and D are respectively
(a) $HBr, Br_2, CH_3COCH_3, CH_3CHO$
(b) $Br_2, HBr, CH_3COCH_3, CH_3CHO$
(c) $HBr, HBr, CH_3COCH_3, CH_3CHO$
(d) $Br_2, HBr, CH_3CH_2CHO, CH_3CHO$

110. Which of the following polymer can be used as electrodes in batteries ?
(a) Polypropene (b) Polyacetylene
(c) Polyethene (d) Polyisoprene

111. Which of the following catalyst is used for the following conversion ?



(a) Platinized Asbestos (b) Red hot iron tube
(c) Platinized Nickel (d) Iron-molybdenum

112. Which one of the following is a non-benzenoid aromatic compound?
(a) Aniline (b) Benzoic acid
(c) Naphthalene (d) Tropolone

113. Benzene was discovered by
(a) Ramsay (b) Dalton
(c) Faraday (d) Priestley

114. The ring structure of benzene was proposed by
(a) Faraday (b) Davy
(c) Kekule (d) Wohler

115. Six carbon atoms f benzene are of
(a) one type (b) two types
(c) three types (d) six types

116. Select the true statement about benzene amongst the following
(a) Because of unsaturation benzene easily undergoes addition
(b) There are two types of C – C bonds in benzene molecule
(c) There is cyclic delocalisation of pi-electrons in benzene
(d) Monosubstitution of benzene gives three isomeric products.

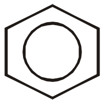
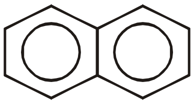
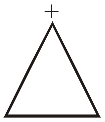
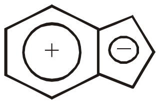
117. The benzene molecule contains
(a) 6 sp^2 hybrid carbons (b) 3 sp^2 hybrid carbons
(c) 6 sp^3 hybrid carbons (d) 3 sp^3 hybrid carbons

118. Aromatic compounds burn with sooty flame because
(a) they have a ring structure of carbon atoms
(b) they have a relatively high percentage of hydrogen
(c) they have a relatively high percentage of carbon
(d) they resist reaction with oxygen of air

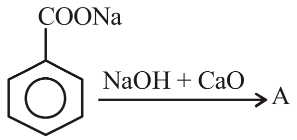
119. Carbon atom in benzene molecule is inclined at an angle of
(a) 120° (b) 180°
(c) 109° 28' (d) 60°

120. The conditions for aromaticity is :
(a) molecule must have cyclic clouds of delocalised π electrons
(b) molecule must contain $(4n + 2)\,\pi$ electrons
(c) Both (a) and (b)
(d) None of the above

121. The chemical system that is non-aromatic is

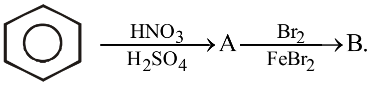
(a) 
(b) 
(c) 
(d) 

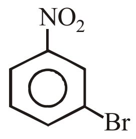
122. Benzene can be directly obtained from
(a) Acetylene (b) Phenol
(c) Chlorobenzene (d) All the above

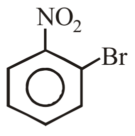
123. 

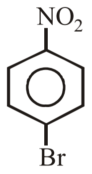
The product A is
(a) Benzene (b) Benzaldehyde
(c) Toluene (d) Benzoic acid

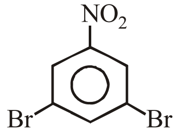
124. In a reaction of C_6H_5Y, the major product (> 60%) is m-isomer, so the group Y is
(a) –COOH (b) $-NH_2$
(c) –OH (d) –Cl

125. 
The compound B is

(a) 

(b) 

(c) 

(d) 

126. Chlorobenzene is *o*, *p*-directing in electrophilic substitution reaction. The directing influence is explained by
(a) +M of Ph (b) +I of Cl
(c) +M of Cl (d) +I of Ph

127. Catalytic hydrogenation of benzene gives
(a) xylene (b) cyclohexane
(c) benzoic acid (d) toluene

128. The strongest ortho - para and strongest meta - directing groups respectively are
(a) $-NO_2$ and $-NH_2$ (b) $-CONH_2$ and $-NH_2$
(c) $-NH_2$ and $-CONH_2$ (d) $-NH_2$ and $-NO_2$

129. For the formation of toluene by Friedal Craft reaction, reactants used in presence of anhydrous $AlCl_3$ are
(a) C_2H_2 and CCl_4 (b) CH_4 and $CaCN_2$
(c) C_6H_6 and CH_3Cl (d) C_2H_5 OH and Zn

130. Benzene can be obtained in the reaction
(a) Ethene + 1, 3-butadiene
(b) Trimerisation of ethyne
(c) Reduction of PhCHO
(d) All of these

131. Nitration of benzene by nitric acid and sulphuric acid is
(a) Electrophilic substitution
(b) Electrophilic addition
(c) Nucleophilic substitution
(d) Free radical substitution

132. $C_6H_6 + CH_3Cl \xrightarrow[AlCl_3]{\text{BHC, anhydrous}} C_6H_5CH_3 + HCl$

is an example of
(a) Friedel - Craft's reaction
(b) Kolbe's synthesis
(c) Wurtz reaction
(d) Grignard reaction

133. Benzene reacts with $CH_3COCl + AlCl_3$ to give
(a) chlorobenzene (b) toluene
(c) benzyl chloride (d) acetophenone

134. Benzene on reaction with ozone forms __________.
(a) 2 molecules of aldehyde and 1 molecule of ketone
(b) 2 molecules of ketone and 1 molecule of aldehyde
(c) triozonide
(d) hexaozonide

135. $AlCl_3$ acts as ________ in Friedel-Crafts reaction
(a) nucleophile (b) electrophile
(c) free radical (d) intermediate

STATEMENT TYPE QUESTIONS

136. The electrophilic substitutions reactions of benzene takes place via
(i) generation of electrophile
(ii) generation of nucleophile
(iii) formation of carbocation intermediate
(iv) removal of proton from the carbocation intermediate
(a) (i), (iii) and (iv) (b) (ii), (iii) and (iv)
(c) (i) and (iv) (d) (ii) and (iv)

137. During the nitration of benzene. In the process of generation of nitronium ion sulphuric acid behaves as a/an ______ and nitric acid behave as a/an _________.
(a) base, acid (b) acid, base
(c) strong acid, weak acid (d) weak acid, strong acid

138. Benzene is highly unsaturated but it does not undergo addition reaction because
(a) π-electrons of benzene are delocalised.
(b) cyclic structures do not show addition reaction
(c) benzene is a non-reactive compound
(d) All of the above

139. Which of the following statements are correct ?
(i) LNG is obtained by liquefaction of natural gas.
(ii) Petrol is obtained by fractional distillation of petroleum.
(iii) Coal gas is obtained by destructive distillation of coal.
(iv) CNG is found in upper strata during drilling of oil wells.
(a) (i), (ii) and (iv) (b) (i), (ii) and (iii)
(c) (i) and (iii) (d) (ii) and (iv)

140. Which of the following statements are correct ?
(i) Saturated hydrocarbons contain only carbon-carbon single bonds.
(ii) Saturated hydrocarbons contain both carbon-carbon and carbon-hydrogen single bond.
(iii) Unsaturated hydrocarbons contain carbon-carbon double bonds.
(iv) Unsaturated hydrocarbons contain carbon-carbon double and triple bonds both.
(a) (i) and (iii) (b) (ii) and (iv)
(c) (i) and (ii) (d) (i) and (iv)

141. Which of the following statements are correct regarding structure of methane ?
(i) Methane has tetrahedral structure.
(ii) The bond angle between all H – C – H bonds is 109.5°.
(iii) The carbon atom is sp^2 hybridized.
(iv) C – C and C – H bond lengths are 154 pm and 112 pm respectively.
(a) (i), (ii) and (iii) (b) (i), (iii) and (iv)
(c) (i), (ii) and (iv) (d) (i), (ii), (iii) and (iv)

142. In the preparation of alkanes from hydrogenation of alkenes and alkynes. Finely divided catalysts are used which of the following statement(s) is/are correct regarding these catalysts
(i) Platinum and palladium catalyse the reaction at room temperature.
(ii) Nickel catalyse the reaction at relatively higher temperature and pressure.
(iii) Platinum and palladium catalyse the reaction at higher temperature.
(a) (i) and (iii) (b) (i) and (ii)
(c) (ii) and (iii) (d) (i) only

143. Which of the following statements are correct ?
(i) The rate of reactivity of alkanes with halogens is $F_2 > Cl_2 > Br_2 > I_2$.
(ii) Rate of replacement of hydrogens of alkanes is $3° > 2° > 1°$
(iii) Fluorination of alkanes is a very slow process.
(iv) Iodination of alkanes is too violent to be controlled.
(a) (i), (ii) and (iii) (b) (i) and (ii)
(c) (ii) and (iii) (d) (i) and (iv)

144. Which of the following statements are correct ?
(i) Decomposition reaction of higher alkanes into smaller fragments by the application of heat is called pyrolysis.
(ii) Pyrolysis and cracking are different processes.
(iii) Dodecane on pyrolysis gives a mixture of heptane and pentene.
(iv) Pyrolysis follow free radical mechanism.
(a) (i), (ii) and (iii) (b) (i), (ii) and (iv)
(c) (i), (iii) and (iv) (d) (ii) and (iv)

145. Which of the following statement(s) is/are correct ?
(i) Alkanes can have infinite number of conformations by rotation around a C – C single bonds.
(ii) Rotation around C – C single bond is completely free.
(iii) Rotation is hindered by a small energy barrier of 1-20 kJ mol^{-1} due to torsional strain.
(a) (i) and (ii) (b) (i) and (iii)
(c) (ii) and (iii) (d) Only (iii)

146. Which of the following statements are correct ?
(i) Stability of conformation is affected due to torsional strain.
(ii) Magnitude of torsional strain depends upon the angle of rotation about C – C bond.
(iii) Eclipsed form has least torsional strain.
(iv) Staggered form has maximum torsional strain.
(a) (i) and (iii) (b) (i) and (ii)
(c) (iii) and (iv) (d) (i) and (iv)

147. Which of the following statements are correct ?
(i) The general formula of alkenes is C_nH_{2n}.
(ii) Alkenes are also known as paraffins.
(iii) Bond length of C–C double bond in alkene is shorter than C–C single bond in alkane.
(iv) Carbon–Carbon double bond in alkene consists of two sigma bonds.
(v) Alkenes are easily attacked by electrophilic reagent.
(a) (i) and (iv) (b) (i), (iii) and (v)
(c) (i) and (iii) (d) (i), (ii), (iv) and (v)

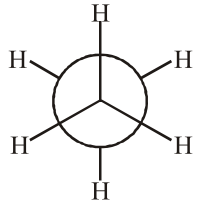
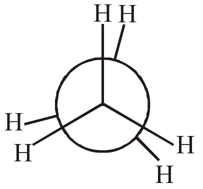
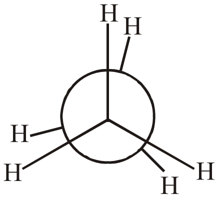
148. Which of the following statements are correct ?
(i) Cis form of alkene is polar whereas trans form is non-polar
(ii) Cis form of alkene is non-polar whereas trans form is polar.
(iii) In case of solid alkenes the trans isomer has higher melting point than the cis isomer.
(iv) Cis and trans both form have same properties.
(a) (i) and (iii) (b) (ii) and (iii)
(c) (i), (iii) and (iv) (d) (i) and (iv)

149. Which of the following statements are correct ?
(i) Alkynes on reduction with palladised charcoal form cis alkenes.
(ii) Alkynes on reduction with palladised charcoal form trans alkenes.
(iii) Alkynes on reduction with sodium in liquid ammonia form trans alkenes.
(iv) Propyne on reduction with palladised charcoal form a mixture of cis and trans propene.
(a) (i) and (iv) (b) (i) and (iii)
(c) (ii) and (iv) (d) (i), (iii) and (iv)

150. Which of the following statements are correct ?
(i) Polynuclear hydrocarbons contain two or more benzene rings fused together.
(ii) Polynuclear hydrocarbons have carcinogenic property.
(iii) Polynuclear hydrocarbons are formed on incomplete combustion of organic materials like tobacco, coal and petroleum.
(iv) They are also produced in human body due to various biochemical reactions.
(a) (i), (ii) and (iv) (b) (i), (iii) and (iv)
(c) (ii), (iii) and (iv) (d) (i), (ii) and (iii)

MATCHING TYPE QUESTIONS

151. Match the columns

Column-I	**Column-II**
(A) Eclipsed	(p) 
(B) Staggered	(q) 
(C) Skew	(r) 

(a) A – (r), B – (p), C – (q) (b) A – (r), B – (q), C – (p)
(c) A – (p), B – (q), C – (r) (d) A – (q), B – (p), C – (r)

152. Match the columns

Column-I	Column-II
(A) $CH_2=CH_2 \rightarrow CH_3-CH_3$	(p) H_2, Zn, H^+
(B) $CH_3Cl \rightarrow CH_4$	(q) NaOH, CaO
(C) $CH_3Br \rightarrow CH_3CH_3$	(r) H_2, Pt/Pd
(D) $CH_3COONa \rightarrow CH_4$	(s) Na, dry ether

(a) A – (r), B – (p), C – (s), D – (q)
(b) A – (p), B – (s), C – (r), D – (q)
(c) A – (s), B – (q), C – (p), D – (r)
(d) A – (q), B – (p), C – (s), D – (r)

153. Match the columns

Column-I	Column-II
(A) $CH_4 + O_2 \xrightarrow{Cu/523K/100\ atm}$	(p) HCHO
(B) $CH_4 + O_2 \xrightarrow[\Delta]{Mo_2O_3}$	(q) $(CH_3)_3COH$
(C) $C_2H_6 + O_2 \xrightarrow[\Delta]{(CH_3COO)_2Mn}$	(r) CH_3OH
(D) $(CH_3)_3CH \xrightarrow[oxidation]{KMnO_4}$	(s) CH_3COOH

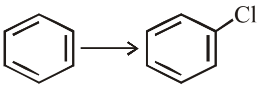
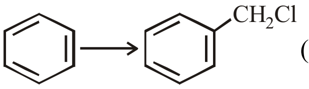
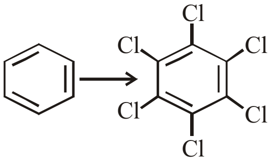
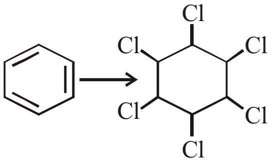
(a) A – (s), B – (p), C – (r), D – (s)
(b) A – (q), B – (p), C – (s), D – (r)
(c) A – (r), B – (p), C – (s), D – (q)
(d) A – (p), B – (q), C – (r), D – (s)

154. Match the columns

Column-I	Column-II
(A) $CH \equiv CH + H_2 \longrightarrow CH_2 = CH_2$	(p) Zn
(B) $CH_3CH_2Br \longrightarrow CH_2=CH_2$	(q) Conc. H_2SO_4
(C) $CH_2BrCH_2Br \longrightarrow CH_2=CH_2$	(r) Pd/C
(D) $CH_3CH_2OH \longrightarrow CH_2 = CH_2$	(s) Alc. KOH

(a) A – (r), B – (s), C – (p), D – (q)
(b) A – (s), B – (r), C – (q), D – (p)
(c) A – (q), B – (p), C – (s), D – (r)
(d) A – (r), B – (s), C – (q), D – (p)

155. Match the columns

Column-I	Column-II
(A) 	(p) Cl_2, uv, 500 K
(B) 	(q) anhy. $AlCl_3$
(C) 	(r) CH_2Cl_2, anhy. $AlCl_3$
(D) 	(s) Cl_2, anhy. $AlCl_3$,

(a) A – (s), B – (r), C – (q), D – (p)
(b) A – (q), B – (r), C – (s), D – (p)
(c) A – (r), B – (p), C – (q), D – (s)
(d) A – (q), B – (p), C – (s), D – (r)

156. Match the following reactants in Column I with the corresponding reaction products in Column II and choose the correct option from the codes given below.

Column - I	Column - II
(A) Benzene + $Cl_2 \xrightarrow{AlCl_3}$	(p) Benzoic acid
(B) Benzene + $CH_3Cl \xrightarrow{AlCl_3}$	(q) Methyl phenyl ketone
(C) Benzene + $CH_3COCl \xrightarrow{AlCl_3}$	(r) Toluene
(D) Toluene $\xrightarrow{KMnO_4/NaOH}$	(s) Chlorobenzene

(a) A – (s), B – (r), C – (q), D – (p)
(b) A – (s), B – (r), C – (p), D – (q)
(c) A – (r), B – (s), C – (p), D – (q)
(d) A – (r), B – (s), C – (q), D – (p)

157. Match the columns

Column - I	Column - II
(A) Alkyl + Acid halide in presence of dry ether	(p) Sulphonation
(B) Arene + Acid halide in presence of $AlCl_3$	(q) Wurtz reaction
(C) Arene + Fuming sulphuric in presence of $AlCl_3$	(r) Catalytic hydrogenation
(D) Arene + Hydrogen in presence of Ni	(s) Friedel-Crafts reaction

(a) A - (p), B - (r), C - (q); D - (s)
(b) A - (s), B - (q), C - (r); D - (p)
(c) A - (r), B - (p), C - (s); D - (q)
(d) A - (q), B - (s), C - (p); D - (r)

158. Match the columns

Column - I	Column - II
(A) Aromatic	(p) Planar
(B) Antiaromatic	(q) Non-planar
(C) Huckel rule	(r) $4n\pi$ localised electrons
(D) Cyclo-octatetraene	(s) $(4n+2)\pi$ delocalised electrons

(a) A - (p, s), B - (p, r), C - (s), D - (q, r)
(b) A - (p, r), B - (p, s), C - (s), D - (q, r)
(c) A - (p, s), B - (s), C - (p, r), D - (q, r)
(d) A - (q, r), B - (p, r), C - (s), D - (p, s)

159. Match the columns

Column - I (Reactants)		Column - II (No. of chlorinated products)
(A) Benzene $\xrightarrow{Cl_2,\, light}$	p.	Three compounds
(B) Toluene $\xrightarrow{Cl_2,\, light}$	q.	Four compounds
(C) Methane $\xrightarrow{Cl_2,\, light}$	r.	Single monochloro derivative
(D) Benzene $\xrightarrow{Cl_2,\, AlCl_3}$	s.	Six isomeric compounds

(a) A – (r), B – (p, r), C – (q, r), D – (s)
(b) A – (s), B – (p, r), C – (q, r), D – (r)
(c) A – (p, r), B – (s), C – (q, r), D – (r)
(d) A – (s), B – (p, r), C – (r), D – (q, r)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

160. Statement-1 : 1-Butene on reaction with HBr in the presence of a peroxide produces 1-bromobutane.

Statement-2 : It involves the free radical mechanism.

161. Statement-1 : CH_4 does not react with Cl_2 in dark.

Statement-2 : Chlorination of CH_4 takes place in sunlight.

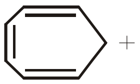
162. Statement-1 : Iodination of alkanes is reversible.

Statement-2 : Iodination is carried out in presence of iodic acid.

163. Statement-1 : All the hydrogen atoms in $CH_2 = C = CH_2$ lie in one plane.

Statement-2 : Carbon atoms are sp^2 and sp hybridized.

164. Statement-1 : Tropylium cation is aromatic in nature



Statement-2 : The only property that determines its aromatic behaviour is its planar structure.

CRITICAL THINKING TYPE QUESTIONS

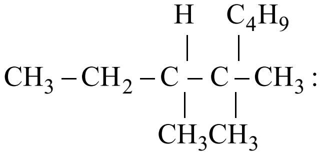
165. In cyclopropane, cyclobutane and cyclohexane, the common group is

(a) $-\overset{|}{\underset{|}{C}}-$ (b) $-\overset{|}{\underset{|}{C}}H$

(c) $-CH_3$ (d) $\overset{|}{\underset{|}{C}}H_2$

166. The number of primary, secondary, tertiary and quaternary carbons in neopentane are respectively

(a) 4, 3, 2 and 1 (b) 5, 0, 0 and 1
(c) 4, 0, 0 and 1 (d) 4, 0, 1 and 1

167. The IUPAC name of  $CH_3-CH_2-\overset{H}{\overset{|}{\underset{\underset{CH_3}{|}}{C}}}-\overset{C_4H_9}{\overset{|}{\underset{\underset{CH_3}{|}}{C}}}-CH_3$: –

(a) 3, 4, 4–Trimethyl octane
(b) 3, 4, 4–Trimethyl heptane
(c) 2–Ethyl, 3,3–dimethyl heptane
(d) 2–Butyl, 2 methyl,3–ethyl butane

168. Which one of the following has the lowest boiling point?

(a) 2-methylbutane (b) 2-methyl propane
(c) 2, 2-dimethyl propane (d) n-pentane

169. Arrange the following in decreasing order of their boiling points.

(A) n–butane (B) 2-methylbutane
(C) n-pentane (D) 2, 2–dimethylpropane
(a) A > B > C > D (b) B > C > D > A
(c) D > C > B > A (d) C > B > D > A

170. When neo-pentyl bromide is subjected to Wurtz reaction, the product formed is

(a) 2,2,4,4-tetramethylhexane
(b) 2,2,4,4-tetramethylpentane
(c) 2,2,5,5-tetramethylhexane
(d) 2,2,3,3-tetramethylhexane

171. Which one of the following reactions is expected to readily give a hydrocarbon product in good yields ?

(a) $RCOOK \xrightarrow[\text{oxidation}]{\text{Electrolytic}}$

(b) $RCOO^-Ag^+ \xrightarrow{Br_2}$

(c) $CH_3CH_3 \xrightarrow[h\upsilon]{Cl_2}$

(d) $(CH_3)_3CCl \xrightarrow{C_2H_5OH}$

172. A hydrocarbon A on chlorination gives B which on heating with alcoholic potassium hydroxide changes into another hydrocarbon C. The latter decolourises Baeyer's reagent and on ozonolysis forms formaldehyde only. A is

(a) Ethane (b) Butane
(c) Methane (d) Ethene

173. Which of the following compounds can yield only one monochlorinated product upon free radical chlorination?

(a) Propane (b) 2, 2-Dimethylpropane
(c) 2-Methylpropane (d) n-Butane

174. In the eclipsed conformation of ethane, the dihedral angle between the hydrogen atoms of adjacent methyl groups is

(a) 60° (b) 120°
(c) 0° (d) 180°

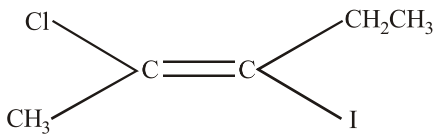
175. The nodal plane in the π-bond of ethene is located in

(a) the molecular plane
(b) a plane parallel to the molecular plane
(c) a plane perpendicular to the molecular plane which bisects the carbon - carbon σ -bond at right angle
(d) a plane perpendicular to the molecular plane which contains the carbon - carbon σ -bond.

176. The IUPAC name of the compound having the formula $(CH_3)_3CCH=CH_2$ is –

(a) 3, 3, 3-trimethyl-1-propane
(b) 1, 1, 1-trimethyl-1-butene
(c) 3, 3-dimethyl-1-butene
(d) 1, 1-dimethyl-1, 3-butene

177. The IUPAC name of the following compound is



(a) trans-2-chloro-3-iodo-2-pentene
(b) cis-3-iodo-4-chloro-3-pentene
(c) trans-3-iodo-4-chloro-3-pentene
(d) cis-2-chloro-3-iodo-2-pentene

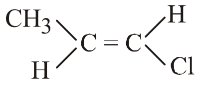
178. The number of possible open chain (acyclic) isomeric compounds for molecular formula C_5H_{10} would be

(a) 8 (b) 7
(c) 6 (d) 5

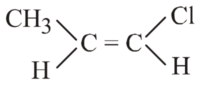
179. Correct order of stability is :

(a) cis -2- butene > 1-butene > trans -2-butene
(b) trans-2-butene > cis-2-butene > 1-butene
(c) 1-butene > cis-2-butene > trans-2- butene
(d) cis-2-butene > trans-2-butene > 1-butene

180. Which of the following is correct set of physical properties of the geometrical isomers –



I



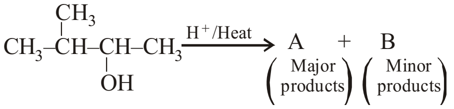
II

	Dipole moment	B.P.	M.P.	Stability
(a)	I > II	I > II	II > I	I > II
(b)	II > I	II > I	II > I	II > I
(c)	I > II	I > II	I > II	I > II
(d)	II > I	II > I	I > II	I > II

181. But-2-ene exhibits cis-trans-isomerism due to

(a) rotation around $C_3 - C_4$ sigma bond
(b) restricted rotation around $C = C$ bond
(c) rotation around $C_1 - C_2$ bond
(d) rotation around $C_2 - C_3$ double bond

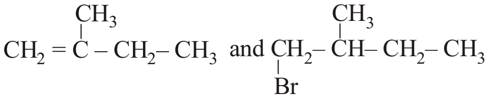
182. In the following reactions,

(i) 

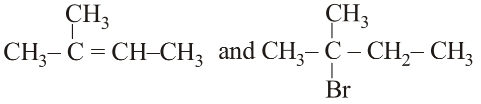
$$CH_3-\overset{CH_3}{\overset{|}{CH}}-\underset{OH}{\underset{|}{CH}}-CH_3 \xrightarrow{H^+/Heat} \underset{\left(\text{Major products}\right)}{A} + \underset{\left(\text{Minor products}\right)}{B}$$

(ii) $$A \xrightarrow[\text{in absence of peroxide}]{\text{HBr, dark}} \underset{\left(\text{Major product}\right)}{C} + \underset{\left(\text{Minor product}\right)}{D}$$

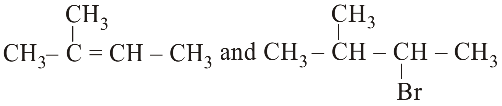
the major products (A) and (C) are respectively :

(a) 

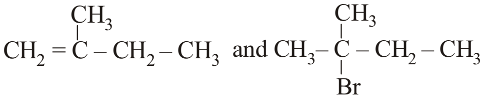
$CH_2=\overset{CH_3}{\overset{|}{C}}-CH_2-CH_3$ and $\underset{Br}{\underset{|}{CH_2}}-\overset{CH_3}{\overset{|}{CH}}-CH_2-CH_3$

(b) 

$CH_3-\overset{CH_3}{\overset{|}{C}}=CH-CH_3$ and $CH_3-\underset{Br}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_2-CH_3$

(c) 

$CH_3-\overset{CH_3}{\overset{|}{C}}=CH-CH_3$ and $CH_3-\overset{CH_3}{\overset{|}{CH}}-\underset{Br}{\underset{|}{CH}}-CH_3$

(d) 

$CH_2=\overset{CH_3}{\overset{|}{C}}-CH_2-CH_3$ and $CH_3-\underset{Br}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_2-CH_3$

183. When 3, 3-dimethyl 2-butanol is heated with H_2SO_4, the major product obtained is

(a) 2,3-dimethyl 2-butene
(b) 3, 3-dimethyl 1- butene
(c) 2, 3-dimethyl 1- butene
(d) *cis* & *trans* isomers of 2, 3-dimethyl 2-butene

184. An alkene having molecular formula C_7H_{14} was subjected to ozonolysis in the presence of zinc dust. An equimolar amount of the following two compounds was obtained

The IUPAC name of the alkene is

(a) 3, 4-dimethyl-3-pentene (b) 3, 4-dimethyl-2-pentene
(c) 2, 3-dimethyl-3-pentene (d) 2, 3-dimethyl-2-pentene

185. Reaction of hydrogen bromide with propene in the absence of peroxide is a/an

(a) free radical addition
(b) nucleophilic addition
(c) electrophilic substitution
(d) electrophilic addition

186. Which of the following types of reaction occur when a reactant has got a double bond ?

(i) Addition
(ii) Photolysis
(iii) Nucleophilic substitution
(iv) Polymerization

(a) (i) and (iv) (b) (i), (ii) and (iii)
(c) (iii) and (iv) (d) (ii) and (iii)

187. The disappearance of the characteristic purple colour of $KMnO_4$ in its reaction with an alkene is the test for unsaturation. It is known as

(a) Markownikoff test (b) Baeyer test
(c) Wurtz test (d) Grignard test

188. $CH_2 = CHCl$ reacts with HCl to form

(a) $CH_2Cl - CH_2Cl$ (b) $CH_3 - CHCl_2$
(c) $CH_2 = CHCl.HCl$ (d) None of these

189. The only alcohol that can be prepared by the indirect hydration of alkene is

(a) Ethyl alcohol (b) Propyl alcohol
(c) Isobutyl alcohol (d) Methyl alcohol

190. Which reactions are most common in alkenes

(a) Electrophilic substitution reactions
(b) Nucleophillic substitution reactions
(c) Electrophilic addition reactions
(d) Nucleophilic addition reactions

191. In the presence of peroxide, hydrogen chloride and hydrogen iodide do not give anti-Markownikov's addition to alkenes because

(a) Both are highly ionic
(b) One is oxidising and the other is reducing
(c) One of the steps is endothermic in both the cases
(d) All the steps are exothermic in both the cases

192. Which of the following statements is incorrect regarding dehydrohalogenation of alkenes ?

(a) During the reaction hydrogen atom is eliminated from the β - carbon atom.
(b) Rate of reaction for same alkyl group;
Iodine > Bromine > Chlorine
(c) Rate of reaction; $(CH_3)_3C - > (CH_3)_2CH - > CH_3CH_2 -$
(d) Only nature of halogen atom determine rate of the reaction.

193. How many structural isomers are possible for the alkyne C_6H_{10} ?

(a) 7 (b) 6
(c) 8 (d) 5

194. Which of the following will have least hindered rotation around carbon - carbon bond ?

(a) Ethane (b) Ethylene
(c) Acetylene (d) Hexachloroethane

195. Acetylenic hydrogens are acidic because

(a) Sigma electron density of C – H bond in acetylene is nearer to carbon, which has 50% *s*-character
(b) Acetylene has only open hydrogen in each carbon
(c) Acetylene contains least number of hydrogens among the possible hydrocarbons having two carbons
(d) Acetylene belongs to the class of alkynes with molecular formula, C_nH_{2n-2}.

196. Propyne can be prepared by dehydrohalogenation of

(a) 1–chloropropane
(b) 1, 2–dichloropropane
(c) 1, 2–dichloroethane
(d) 1, 1, 2, 2–tetrachloroethane

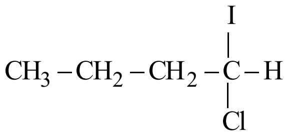
197. Which is the most suitable reagent among the following to distinguish compound (3) from rest of the compounds ?

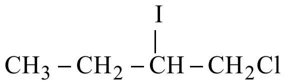
1. $CH_3 - C \equiv C - CH_3$
2. $CH_3 - CH_2 - CH_2 - CH_3$
3. $CH_3 - CH_2C \equiv CH$
4. $CH_3 - CH = CH_2.$

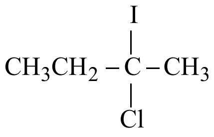
(a) Bromine in carbon tetrachloride
(b) Bromine in acetic acid
(c) Alk $KMnO_4$
(d) Ammonical silver nitrate.

198. Predict the product C obtained in the following reaction of butyne-1.

$$CH_3CH_2 - C \equiv CH + HCl \longrightarrow B \xrightarrow{HI} C$$

(a)

$CH_3 - CH_2 - CH_2 - \underset{Cl}{\overset{I}{C}} - H$

(b)

$CH_3 - CH_2 - \overset{I}{C}H - CH_2Cl$

(c)

$CH_3CH_2 - \underset{Cl}{\overset{I}{C}} - CH_3$

(d)

$CH_3 - \underset{Cl}{C}H - CH_2CH_2I$

199. The correct increasing order of acidity of the following alkynes

(1) $CH_3 - C \equiv C - CH_3$
(2) $CH_3 - C \equiv CH$
(3) $CH \equiv CH$

(a) $1 < 2 < 3$ (b) $2 < 3 < 1$
(c) $3 < 2 < 1$ (d) $1 < 3 < 2$

200. Identify the alkyne in the following sequence of reactions.

$$\text{Alkyne} \xrightarrow[\text{Lindlar's catalyst}]{H_2} A \xrightarrow{\text{Ozonolysis}} \underset{\text{only}}{B} \xleftarrow[\text{Process}]{\text{Wacker}} CH_2=CH_2$$

(a) $H_3C-C\equiv C-CH_3$

(b) $H_3C-CH_2-C\equiv CH$

(c) $H_2C=CH-C\equiv CH$

(d) $HC\equiv C-CH_2-C\equiv CH$

201. Which of the following represent the correct order of acidic strength ?

(i) $HC\equiv CH > H_2C=CH_2 > CH_3-CH_3$

(ii) $HC\equiv CH > CH_3-CH_3 > H_2C=CH_2$

(iii) $CH_3C\equiv CH > HC\equiv CH > CH_3-C\equiv C-CH_3$

(iv) $HC\equiv CH > CH_3-C\equiv CH > CH_3-C\equiv C-CH_3$

(a) (i) and (iii) (b) (ii) and (iv)

(c) (i) and (iv) (d) (i) and (iv)

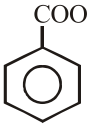
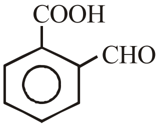
202. Which one of these is not compatible with arenes?

(a) Greater stability

(b) Delocalisation of π-electrons

(c) Electrophilic additions

(d) Resonance

203.  and  are

(a) Position isomer (b) Chain isomer

(c) Functional isomer (d) Stereoisomer

204. The carbon-carbon bond length in benzene is

(a) Same as in C_2H_4

(b) In between C_2H_6 and C_2H_2

(c) In between C_2H_4 and C_2H_2

(d) In between C_2H_6 and C_2H_4

205. Point out the wrong statement in relation to the structure of benzene

(a) It forms only one monosubstitution product

(b) The C - C bond distance in benzene is uniformly 1.397Å

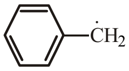
(c) It is a resonance hybrid of a number of canonical forms

(d) It has three delocalised π-molecular orbitals

206. The ratio of σ to π bonds in benzene is :

(a) 2 (b) 3

(c) 4 (d) 8

207. The radical,  is aromatic because it has :

(a) 7 p-orbitals and 6 unpaired electrons

(b) 7 p-orbitals and 7 unpaired electrons

(c) 6 p-orbitals and 7 unpaired electrons

(d) 6 p-orbitals and 6 unpaired electrons

208. (i) Chlorobenzene and (ii) benzene hexachloride are obtained from benzene by the reaction of chlorine, in the pesence of

(a) (i) Direct sunlight and (ii) anhydrous $AlCl_3$

(b) (i) Sodium hydroxide and (ii) sulphuric acid

(c) (i) Ultraviolet light and (ii) anhydrous $FeCl_3$

(d) (i) Anhydrous $AlCl_3$ and (ii) direct sunlight

209. A group which deactivates the benzene ring towards electrophilic substitution but which directs the incoming group principally to the o- and p-positions is

(a) $-NH_2$ (b) $-Cl$

(c) $-NO_2$ (d) $-C_2H_5$

210. Benzene can be obtained by heating either benzoic acid with X or phenol with Y. X and Y are respectively.

(a) Zinc dust and soda lime

(b) Soda lime and zinc dust

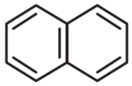
(c) Zinc dust and sodium hydroxide

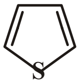
(d) Soda lime and copper

211. Which of the following chemical system is non aromatic?

(a) 

(b) 

(c) 

(d) 

HINTS AND SOLUTIONS

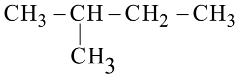
FACT/DEFINITION TYPE QUESTIONS

1. **(d)** LPG is used as a domestic fuel with the least pollution.
2. **(b)** LPG mainly contains butane.
3. **(a)** Natural gas is a mixture of CH_4, C_2H_6 and C_3H_8.
4. **(a)** 5. **(b)** 6. **(d)** 7. **(d)** 8. **(d)**
9. **(d)** $\overset{1°}{CH_3}-\overset{1°}{CH_3}$

   Both carbon atoms in ethane are primary.
10. **(a)**
11. **(c)** Pentane (C_5H_{12}) exists as three chain isomers

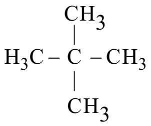
$CH_3CH_2CH_2CH_2CH_3$

n-pentane



$CH_3-\underset{CH_3}{\underset{|}{CH}}-CH_2-CH_3$

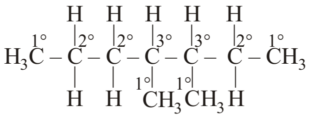
2–methylbutane (iso pentane)



$H_3C-\overset{CH_3}{\overset{|}{\underset{CH_3}{\underset{|}{C}}}}-CH_3$

2,3-dimethylpropane (neo pentane)

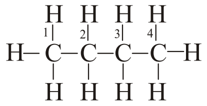
12. **(a)**



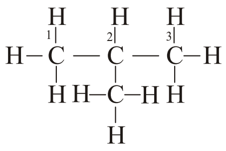
3, 4-dimethylheptane

There are four 1° C-atoms, three 2° C-atoms and two 3° C-atoms

13. **(c)** 14. **(d)**
15. **(d)** CH_4, C_2H_6 and C_3H_8 can have only one structure but C_4H_{10} can have more than one structure. Possible structures of C_4H_{10} are following



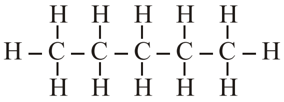
Butane (*n*- butane), (b.p. 273 K)

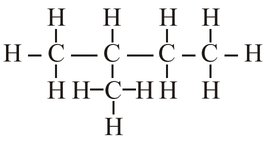


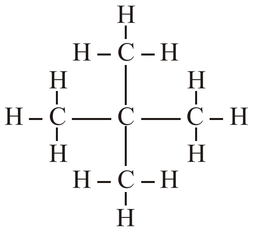
2-Methylpropane (isobutane)

(b.p.261 K)

16. **(b)** Possible isomers of C_5H_{12} are







17. **(b)**
18. **(a)** CH_4 has only one carbon atom, hence it can't be prepared by Wurtz reaction, which involves two molecules of alkyl halide.
19. **(a)** When alkyl halide is treated with sodium metal in presence of ether, alkane is obtained, this reaction is called as Wurtz reaction.

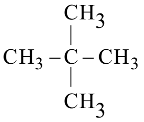
$$R-\mathbf{X}+\mathbf{2Na}+\mathbf{X}-R' \xrightarrow{\text{dry ether}} R-R'+2NaBr$$

$$CH_3–Br+2Na+Br–CH_3 \xrightarrow{\text{dry ether}} CH_3-CH_3+2NaBr$$

20. **(c)** Other three methods can be used for the preparation of alkane having at least two carbon atoms.
21. **(b)** Sodium salts of carboxylic acids on heating with soda lime (mixture of sodium hydroxide and calcium oxide) give alkanes containing one carbon atom less than the carboxylic acid. This process of elimination of carbon dioxide from a carboxylic acid is known as decarboxylation

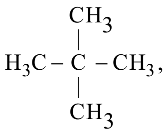
$$\underset{\text{Sodium ethanoate}}{CH_3COO^-Na^+}+NaOH \xrightarrow[\Delta]{CaO} \underset{\text{Methane}}{CH_4}+Na_2CO_3$$

22. **(a)** Higher is the branching lesser will be the boiling point further increase in molecular weight increases boiling point in alkane. Hence 2, 2– dimethyl propane will have least boiling point.



$CH_3-\overset{CH_3}{\overset{|}{\underset{CH_3}{\underset{|}{C}}}}-CH_3$

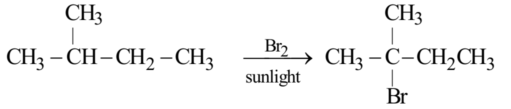
23. **(a)** n-octane has highest boiling point due to unbranched chain and maximum carbon atoms. It has max. Van der Waal forces.
24. **(c)**
25. **(a)** $Cl_2 \xrightarrow[\text{Chain initiation}]{hv} 2Cl^{\bullet}$
26. **(d)** Neo-pentane,



$H_3C-\overset{CH_3}{\overset{|}{\underset{CH_3}{\underset{|}{C}}}}-CH_3$, has only 1° hydrogen and hence gives only one monochloro derivative.

27. **(d)**

28. **(c)**



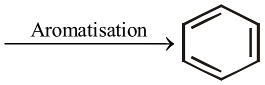
$$CH_3-\underset{}{\overset{CH_3}{\overset{|}{C}H}}-CH_2-CH_3 \xrightarrow[\text{sunlight}]{Br_2} CH_3-\underset{\underset{Br}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_2CH_3$$

2–bromo–2–methyl butane

Ease of replacement of H-atom 3° > 2° > 1°.

29. **(a)** Complete combustion of all organic compounds leads to formation of $CO_2 + H_2O$.

30. **(b)** $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$



Benzene

Aromatisation is a process in which aromatic compounds are formed from open chain compounds.

31. **(b)** During cracking higher hydrocarbons (liquid) are converted to lower gaseous hydrocarbons.

32. **(c)** n-Alkanes on heating with anhydrous aluminium chloride and hydrogen chloride gas isomerise to branched chain alkanes.

33. **(b)** Methane reacts with steam at 1273 K in the presence of nickel catalyst to form carbon monoxide and dihydrogen. This method is used for industrial preparation of dihydrogen gas.

34. **(c)** A conformation is defined as the relative arrangement of atoms or groups around a central atom, obtained by the free rotation of one part of the molecule with respect to rest of the molecule. For a complete rotation of 360°, one part may rotate through any degree say 0.1°, 0.5°, 1° etc. giving rise to infinite number of relative arrangements of group (atom) around a central atom, keeping other part fixed.

35. **(d)** Spatial arrangements of atoms which can be converted around a C – C single bond are called conformations or conformers or rotamers.

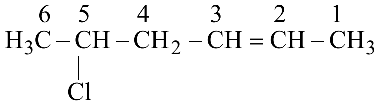
36. **(a)**

37. **(d)**

38. **(a)** As predicted by the VSEPR model of electron pair repulsion, the molecular geometry of alkenes includes bond angles about each carbon in a double bond of about 120°.

39. **(c)** Double bond in between carbon-carbon is present in alkenes whose general formula is C_nH_{2n}.

40. **(d)**



$$\overset{6}{H_3C}-\underset{\underset{Cl}{|}}{\overset{5}{C}H}-\overset{4}{C}H_2-\overset{3}{C}H=\overset{2}{C}H-\overset{1}{C}H_3$$

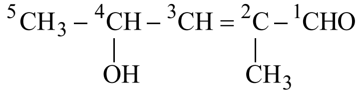
IUPAC name : 5- chlorohex-2-ene

41. **(a)**

42. **(c)** $\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H_2Cl$

43. **(a)** Since **b** (from bromo) comes earlier in alphabetical order than **c** (from chloro), the correct name should be 2, 3-dibromo-1, 4-dichlorobutene-2 and not 1,4-dichloro-2, 3-dibromobutene-2.

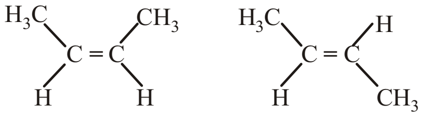
44. **(b)**



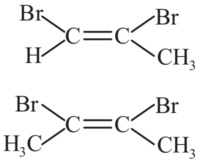
$$^{5}CH_3-\underset{\underset{OH}{|}}{^{4}CH}-{}^{3}CH={}^{2}\underset{\underset{CH_3}{|}}{C}-{}^{1}CHO$$

4-Hydroxy-2-methylpent-2-en-1-al

45. **(b)**



46. **(d)** Alkenes having double bonds with two different groups on each end of the double bond show geometrical isomerism. $A_2b_2c_2$, A_2b_2cd, A_2bcde.



1,2-dibromopropene

2,3-dibromobut-2-ene

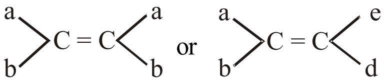
47. **(b)** The two isomers differ in the position of the double bond so they are called position isomers.

48. **(b)** $CH_3CH_2CH{=}CH_2$ 1-butene (*i*) $CH_3CH{=}CHCH_3$ 2- butene (*ii*), (*iii*) (*cis*,- *trans*) $(CH_3)_2C{=}CH_2$ 2-methylpropene (*iv*)

cyclobutane (*v*) methylcyclopropane (*vi*)

49. **(a)** As sketched in the above question , C_5H_{10} may be monosubstituted (i) and (iv), disubstituted as in (ii), (iii) and (v) and trisubstituted as in (vi)

50. **(c)** The condition for geometrical isomerism is

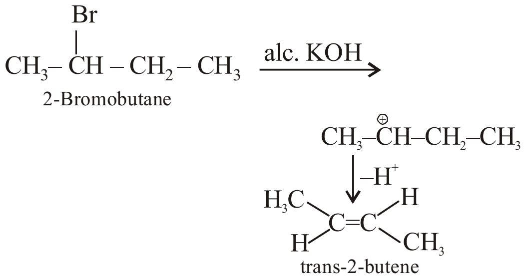


51. **(a)**

52. **(d)** $CH_3-CH_2-Br+\underset{(alc)}{KOH}\longrightarrow CH_2=CH_2+KBr+H_2O$

53. **(c)**

54. **(d)**



55. **(c)** $C_2H_5OH \xrightarrow[KMnO_4]{\text{conc. } H_2SO_4} C_2H_4 + H_2O$

Note : If ethyl alcohol is taken in excess and the reaction is carried out at a temperature of 433-443 K diethyl ether is formed.

$$\underset{(excess)}{2C_2H_5OH} \xrightarrow[433-443\text{ K}]{\text{conc. } H_2SO_4} C_2H_5OC_2H_5 + H_2O$$

56. **(d)** Alcoholic KOH is used for dehydrohalogenation e.g.

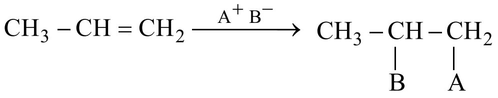
$$CH_3-CH_2-CH_2-CH_2Cl\xrightarrow[KOH]{alc.}CH_3-CH_2-CH=CH_2$$

57. **(b)** Paraffins or alkanes are non-polar compounds. Hence soluble in benzene.

58. **(a)** Peroxide effect is observed only in case of HBr. Therefore, addition of HCl to propene even in the presence of benzyoyl peroxide occurs according to Markovnikov's rule :

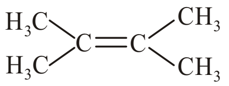
$$CH_3-CH=CH_2\xrightarrow[(C_6H_5CO)_2O_2]{HCl}CH_3-CHCl-CH_3$$

59. **(b)** Markonikov's way of addition :

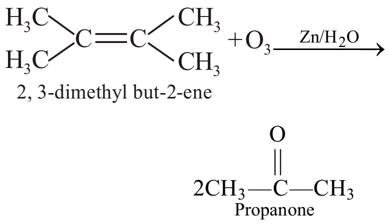


$$CH_3-CH=CH_2\xrightarrow{A^+B^-}CH_3-\underset{B}{\underset{|}{CH}}-\underset{A}{\underset{|}{CH_2}}$$

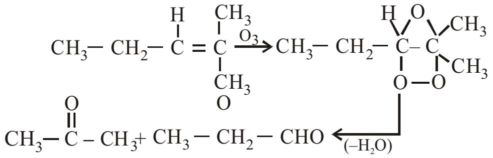
60. **(d)** Since given alkene on ozonolysis gives 2 moles of propanone hence alkene should have a double bond between two equivalent C atoms i.e. the formula should be



i.e.



61. **(a)**

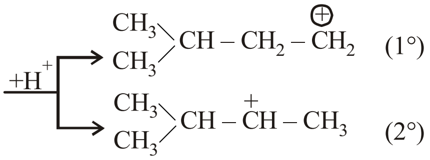


62. **(d)** In presence of peroxide, HBr adds on alkenes in anti–markovnikov's way, thus

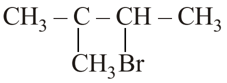
$$\underset{\text{Propene}}{H_3CCH=CH_2}+HBr\xrightarrow{\text{Peroxide}}\underset{n\text{–propyl bromide}}{H_3CCH_2CH_2Br}$$

Kharasch observed that the addition of HBr to unsymmetrical alkene in the presence of organic peroxides follows an opposite course to that suggested by Markownikoff. This is termed anti-Markownikoff or peroxide effect.

63. **(b)** We know that in case of an unsymmetrical alkene there is the possibility of forming two products. In such cases the formation of major product is decided on the basis of *Markownikoffs rule* which is rationalized in terms of *stability of the intermediate* carbocation. Also remember that 3° carbocation is more stable than 2° carbocation and 2° carbocation is more stable than 1° carbocation.



of the two possibilities 2° carbocation is more stable so the product of the reaction expected was predominantly one formed by 2° carbocation i.e.

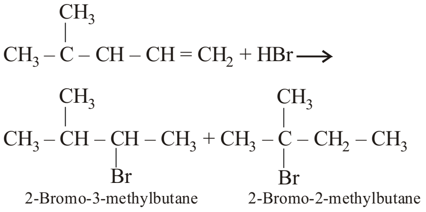


$$CH_3-\underset{CH_3}{\underset{|}{C}}-\underset{Br}{\underset{|}{CH}}-CH_3$$

i.e. 2– Bromo-3-Methylbutane

However *some electrophilic addition reaction form products that are clearly not the result of the addition of electrophile to the sp² carbon bonded to the most hydrogens and the addition of a nucleophile to the other sp² carbon.*

In the above cases the addition of HBr to 3-methyl-1-butene the two products formed are shown below.



$$CH_3-\overset{CH_3}{\overset{|}{C}}-CH-CH=CH_2+HBr\longrightarrow$$

$$\underset{\text{2-Bromo-3-methylbutane}}{CH_3-\overset{CH_3}{\overset{|}{CH}}-\underset{Br}{\underset{|}{CH}}-CH_3}+\underset{\text{2-Bromo-2-methylbutane}}{CH_3-\overset{CH_3}{\overset{|}{\underset{Br}{\underset{|}{C}}}}-CH_2-CH_3}$$

In this case the major product formed is 2- Bromo-2-methylbutane i.e. option (b) is correct answer.

(**Note**: The unexpected product results from a rearrangement of carbocation intermediate. Please note that all carbocation do not rearrange.

64. **(c)** Alkenes combine with hydrogen under pressure and in presence of a catalyst (Ni, Pt or Pd) and form alkanes.

$$\text{Butene - 1}\xrightarrow{H_2/Pd}\text{Butane}$$

65. **(a)** Alkenes are unsaturated hydrocarbon having double bond so generally gives addition reaction.

66. **(c)**

67. **(d)** A doubly bonded carbon atom having an alkyl group is oxidised to aldehyde which is further oxidised to carboxylic acid.

$$CH_3CH_2CH=CHCH_3\xrightarrow[(ii)H^+]{(i)KMnO_4,OH^-}$$

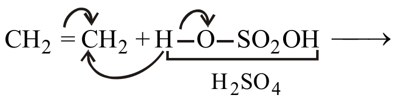
$$\begin{array}{ccc} CH_3CHO & + & CH_3CH_2CHO \\ \downarrow & & \downarrow \\ CH_3COOH & & CH_3CH_2COOH \end{array}$$

68. **(b)** Polythene is manufactured by heating ethylene to 473K under a pressure of 1500 atmosphere and in the presence of a trace of oxygen.

$$n(CH_2=CH_2)\xrightarrow[\text{Trace of oxygen}]{473K, 1500atm}(-CH_2-CH_2-)_n$$

The polythene manufactured in this way is called low density of polythene.

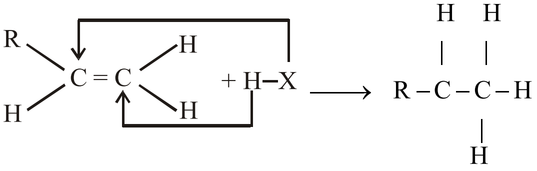
69. (a)



$$CH_3\overset{\oplus}{C}H_2+OSO_2OH\longrightarrow\underset{\text{Ethyl hydrogen sulphate}}{CH_3CH_2OSO_2OH}$$

Addition of sulphuric acid takes place according to Markownikoff's rule. Alkanes do not absorb cold conc. H_2SO_4.

70. (c) According to Markownikoff's rule, "in case of addition of an unsymmetrical reagent (H– X), the positive part get attached to the C which is least substituted or which bears larger number of hydrogen atoms."

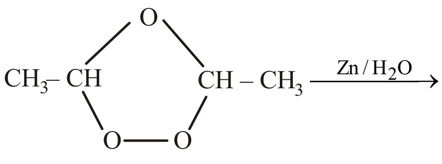


Markownikoff's rule is based on the stability of carbocations (3° > 2° > 1° > methyl).

71. (c) As per Markovnikoff's law, the positive part (e.g. H of HX) or the less negative part of the reagent adds to that carbon atom of alkene which has more number of hydrogen atoms (the rich gets richer). So (c) is the correct option as the two carbons containing the double bond have one H atom each i.e. symmetric.

72. (d) Completing the sequence of given reactions,

$$CH_3-CH=CH-CH_3\xrightarrow{O_3}$$



'A'
(ozonide)

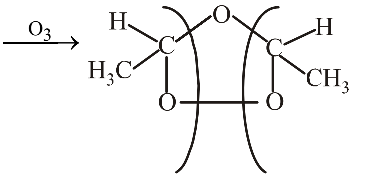
$$\underset{\text{'B'}}{2CH_3CHO}+H_2O+ZnO$$

Thus 'B' is CH_3CHO

Hence (d) is correct answer.

73. (c) The given molecular formula suggests that the aldehyde formed will be acetaldehyde hence the alkene will be

$$\underset{\text{2−butene}}{CH_3CH=CHCH_3}$$

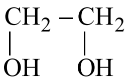


$$\xrightarrow{Zn/H_2O}2CH_3CHO$$

74. (a) The addition of HBr takes place according to anti-Markovnikoff's rule in presence of peroxide for unsymmetrical alkenes.

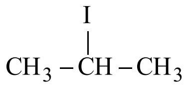
The addition of HBr to symmetrical alkenes is not affected by the presence or absence of peroxide.

75. (d) $CH_2=CH_2+KMnO_4\xrightarrow{OH^{\ominus}}$



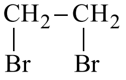
$$\underset{\text{Glycol}}{\underset{OH\quad OH}{CH_2-CH_2}}+MnO_2+KOH$$

76. (b) When unsymmetrical unsaturated hydrocarbon reacts with unsymmetrical reagent, then negative part of reagents attacks that carbon which has less H-atom. [Markownikoff's rule]



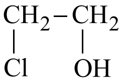
$$\underset{\text{Propene-2}}{CH_3-CH=CH_2+HI}\xrightarrow{400°C}\underset{\text{2-Iodopropane}}{CH_3-\overset{I}{C}H-CH_3}$$

77. (a)

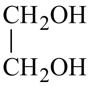


$$CH_2=CH_2+Br_2\xrightarrow{CCl_4}\underset{\text{1, 2-dibromo ethane}}{\underset{Br\quad Br}{CH_2-CH_2}}$$

78. (b)



$$CH_2=CH_2\xrightarrow{HOCl}\underset{Cl\quad OH}{CH_2-CH_2}\xrightarrow{aq.\ NaHCO_3}$$

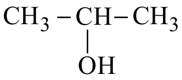


$$\begin{matrix}CH_2OH\\|\\CH_2OH\end{matrix}$$

Glycol

79. (c) By adding bromine water to a solution, if the colour of bromine water decolourise then the compound is unsaturated. This is a confirmatory test for unsaturation.

80. (b) $CH_3-CH=CH_2+H_2O\xrightarrow[\text{Markonikoff's rule}]{\text{Conc. }H_2SO_4}$



$$CH_3-\underset{OH}{CH}-CH_3$$

Isopropyl alcohol

81. **(b)** Greater the *s*-character of C, higher is its electronegativity, shorter and stronger will be the bond formed by it. Thus $-C\equiv C-$ is the strongest bond.

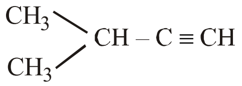
82. **(b)** General formula for alkynes is C_nH_{2n-2}

83. **(c)** When both double and triple bonds are present, then triple bond is considered as the principal group.

$$\underset{5}{CH_3}-\underset{4}{CH}=\underset{3}{CH}-\underset{2}{C}\equiv\underset{1}{CH}$$

84. **(b)** Three alkynes are possible for the formula C_5H_8.

$CH_3CH_2CH_2C\equiv CH$



$CH_3CH_2C\equiv CCH_3$

85. **(c)** If both the double and triple bonds are present, the compound is regarded as derivative of alkyne. Further if double and triple bonds are at equidistance from either side, the preference is given to double bond.

86. **(d)** C_2H_2 and C_3H_4 are homologue because they differ by $-CH_2$ group. Both have triple bond in their molecule.

87. **(a)**

88. **(d)** In $CH\equiv CH$ triple bond consists of one σ and two π bonds.

89. **(c)** In C_2H_6, C – C bond length is 1.54 Å.

90. **(c)** Acetylene molecule can be represented as,

$$H\underset{\sigma}{-}C\overset{\pi}{\underset{\pi}{\equiv_{\sigma}}}C\underset{\sigma}{-}H$$

So, it contains 3 σ and 2 π bonds.

91. **(d)** We know that carbon having

(i) 4 σ bonds correspond to sp^3

(ii) 3 σ and 1 π bond correspond to sp^2

(iii) 2 σ and 2 π bonds correspond to sp

$$\overset{(1)}{H_3C}-\overset{(2)}{C}\equiv\overset{(3)}{C}-\overset{(4)}{CH_3}$$

	(1)	(2)	(3)	(4)
No. of bonds :	4σ	2σ	2σ	4σ
	–	2π	2π	–
Hybridisation :	sp^3	sp	sp	sp^3

Thus, butyne-2 has *sp* and sp^3 hybridised carbon atoms.

92. **(b)** $\underset{1.20A°}{C\equiv C}<\underset{1.34A°}{C=C}<\underset{1.54A°}{C-C}$

93. **(a)** As the number of bonds between carbon atoms increases, electronegativity of that carbon also increases due to increasing active power of electrons. Also *sp* hybrid is more electronegative than sp^2 which is more electronegative than sp^3($\because$ *s* character decreases) Hence, option (a) is correct.

94. **(c)** On heating ethylene chloride (1, 1 dichloro ethane) with alcoholic potash followed by sodamide alkyne is obtained

$$R-CH_2-CCl_2-R\xrightarrow{alc.KOH}R-CH=CCl-R\xrightarrow{NaNH_2}R-C\equiv C-R$$

95. **(c)** $\underset{\text{Calcium carbide}}{CaC_2}+2H_2O\longrightarrow\underset{\text{Acetylene}}{HC\equiv CH}+Ca(OH)_2$

96. **(d)** Among isomeric alkanes, the straight chain isomer has higher boiling point than the branched chain isomer. The greater the branching of the chain, the lower is the boiling point. Further due to the presence of π electrons, these molecules are slightly polar and hence have higher boiling points than the corrosponding alkanes.

97. **(a)** Terminal alkyenes give a white precipitate easily on reaction with ammonical silver nitrate solution.

98. **(b)** $$CH\equiv CH+H_2O\xrightarrow[HgSO_4.60°C]{dil\,H_2SO_4}\underset{\text{unstable}}{[CH_2=CHOH]}\longrightarrow CH_3CHO$$

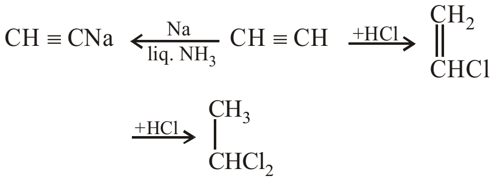
99. **(b)** $CH\equiv CH+HCl\rightarrow CH_2=CH-Cl\xrightarrow{HCl}$

1, 1-dichloroethane

100. **(b)** Alkynes having terminal –C ≡ H react with Na in liquid ammonia to yield H_2 gas. $CH_3CH_2C\equiv CH$ can react with Na in liquid NH_3 so the correct answer is (b).

$$CH_3CH_2C\equiv CH\xrightarrow[\text{liquid }NH_3]{\text{Na in}}CH_3CH_2C\equiv C^-Na^+ +\frac{1}{2}H_2(g)$$

101. **(a)** Acetylene reacts with the other three as:

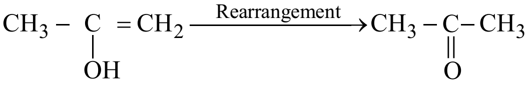


$$CH\equiv CNa\xleftarrow[\text{liq. }NH_3]{Na}CH\equiv CH\xrightarrow{+HCl}\begin{matrix}CH_2\\ \|\\ CHCl\end{matrix}\xrightarrow{+HCl}\begin{matrix}CH_3\\ |\\ CHCl_2\end{matrix}$$

$$CH\equiv CH\xrightarrow{[AgNO_3+NH_4OH]}\underset{\text{white ppt.}}{AgC\equiv CAg}+NH_4NO_3$$

102. **(c)** **103.** **(d)**

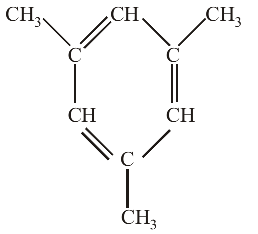
104. **(c)** $CH_3-C\equiv CH+H_2O\xrightarrow[1\%\ HgSO_4]{40\%\ H_2SO_4}$



$$CH_3-\underset{OH}{\underset{|}{C}}=CH_2\xrightarrow{\text{Rearrangement}}CH_3-\underset{O}{\underset{\|}{C}}-CH_3$$

Acetone

105. **(a)** $3CH_3-C\equiv CH\longrightarrow$



Mesitylene or 1, 3, 5-trimethyl benzene

106. (b) $\underset{\text{Acetyle}}{CH \equiv CH} + H_2 \xrightarrow[\text{Pd. BaSO}_4]{\text{Lindlar's Catalyst}} \underset{\text{Ethylene}}{CH_2 = CH_2}$

107. (d) Addition – $CH \equiv CH + 3H_2 \xrightarrow{Ni} CH_3 - CH_3$

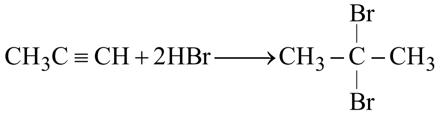
Substitution –

$$CH \equiv CH + Na \longrightarrow CH \equiv C^{-}Na^{+} + \frac{1}{2}H_2$$

Polymerization –

$$3CH \equiv CH \xrightarrow[\text{Polymerization}]{\text{hot Cu tube}} \underset{\text{Benzene}}{C_6H_6}$$

108. (b)



$CH_3C \equiv CH + 2HBr \longrightarrow CH_3 - \underset{Br}{\overset{Br}{\underset{|}{\overset{|}{C}}}} - CH_3$

109. (b)

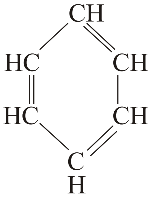
110. (b) Thin film of polyacetylene can be used as electrodes in batteries. These films are good conductors, lighter and cheaper than the metal conductors.

111. (b)

112. (d) Amongst all tropolone is a non-benzenoid aromatic compound.

113. (c)

114. (c) Kekule in 1865 suggested a ring structure of benzene in which the ring was composed of six carbon atoms, each of which carries one atom of hydrogen. To satisfy the fourth valency of the carbon atom, he suggested three alternate double bonds.



115. (a)

116. (c) Benzene do not show addition reactions like other unsaturated hydrocarbons. However it show substitution reactions. Due to resonance all the C – C bonds have the same nature, which is possible because of the cyclic delocalisation of π-electrons in benzene. Monosubstitution will give only a single product.

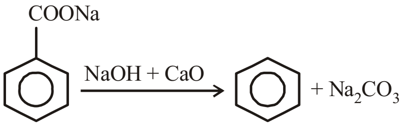
117. (a) In the benzene molecule all the six carbons are sp^2 hybridised as each C has one double bond.

118. (c) They have a relatively high percentage of carbon.

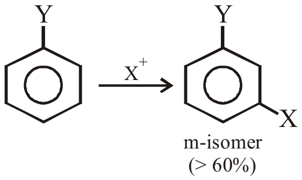
119. (a) **120. (c)** **121. (c)**

122. (d) Benzene can be obtained by all the compounds given.

123. (a) This is an example of decarboxylation reaction.



124. (a)

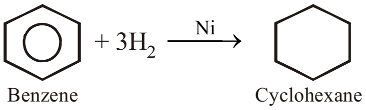


Y = –COOH because it is meta directing group while $-NH_2$, –OH and –Cl are *o* and *p* directing groups.

125. (a) $-NO_2$ is a meta-directing group. As it is also a deactivating group so no chance of introduction of second –Br atom.

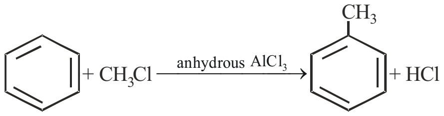
126. (c) Cl exhibits –I effect and +M effect.

127. (b)

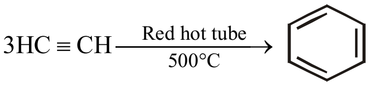


128. (d)

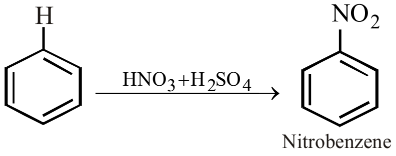
129. (c)



130. (b) Benzene can be obtained by polymerisation of acetylene.



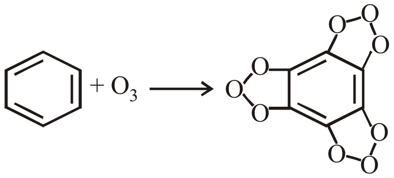
131. (a) In electrophilic substitution reaction an electrophile (in this case NO_2^+) replaces another atom (in this case H) from the substrate (benzene).



132. (a) This is an example of Friedel - Craft alkylation.

133. (d)

134. (c)



Benzene triozonide

135. (b) Friedel- Craft reaction occurs in presence of an attacking reagent which is an electrophile ($AlCl_3$).

STATEMENT TYPE QUESTIONS

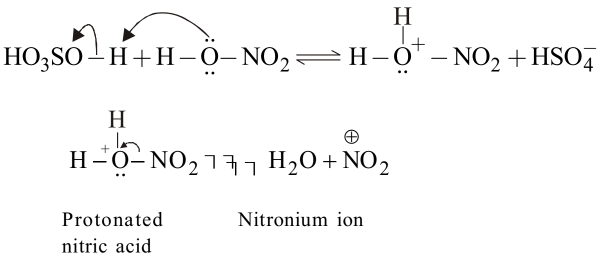
136. (a) According to experimental evidences, electrophilic substitution reactions are supposed to proceed via the following three steps:

(1) Generation of the electrophile

(2) Formation of carbocation intermediate

(3) Removal of proton from the carbocation intermediate

137. (b)



$$HO_3SO-H + H-\ddot{\underset{\cdot\cdot}{O}}-NO_2 \rightleftharpoons H-\overset{H}{\underset{\cdot\cdot}{O^+}}-NO_2 + HSO_4^-$$

$$\underset{\text{Protonated nitric acid}}{H-\overset{H}{\overset{+}{\underset{\cdot\cdot}{O}}}-NO_2} \rightleftharpoons \underset{\text{Nitronium ion}}{H_2O + \overset{\oplus}{NO_2}}$$

In the process of generation of nitronium ion, sulphuric acid serves as an acid and nitric acid as a base.

138. (a) π-electrons of benzene rings are delocalised throughout the molecule. This makes the molecule very stable. The stability resists breaking of double bonds for addition.

139. (b) Natural gas is found in upper strata during drilling of oil wells. The gas after compression is known as Compressed Natural Gas (CNG).

140. (b)

141. (c) In methane carbon atom is sp^3 hybridized.

142. (b) Dihydrogen gas adds to alkenes and alkynes in the presence of finely divided catalysts like platinum, palladium or nickel to form alkanes. These metals adsorb dihydrogen gas on their surfaces and activate the hydrogen-hydrogen bond. Platinum and palladium catalyse the reaction at room temperature but relatively higher temperature and pressure are required with nickel catalyst.

143. (b) For statement (iii), Fluorination is too violent to be controlled. For statement (iv), Iodination is very slow and a irreversible reaction. It can be carried out in the presence of oxidizing agents like HIO_3 or HNO_3

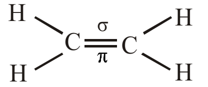
$$CH_4 + I_2 \Rightarrow CH_3I + HI$$
$$5HI + HIO_3 \rightarrow 3I_2 + 3H_2O$$

144. (c) Pyrolysis and cracking are same process.

145. (b) Rotation around a C-C single bond is not completely free. It is hindered by a small energy barrier of 1-20 kJ mol^{-1} due to weak repulsive interaction between the adjacent bonds. Such a type of repulsive interaction is called **torsional strain**.

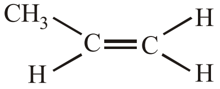
146. (b) Eclipsed form has maximum torsional strain while staggered form has the least.

147. (b) For statement (ii), Alkenes are also known as olefins. For statement (iv), Carbon–Carbon double bond in alkene consists of one sigma and one pi bond.



148. (a) For statement (i), cis form of alkenes have significant dipole moment whereas dipole moment of trans form is almost zero. For statement (iv), due to different arrangements of atoms or groups in space cis and trans isomers differ in their properties like melting point, boiling point, dipole moment, solubility etc.

149. (b) For statement (ii), alkynes on reduction with Pd/C form cis-alkenes. For statement (iv), Propyne on reduction with Pd/C form propene. Propene does not show geometrical isomerism. Only those compounds show geometrical isomerism which have two different atoms or groups attached to each carbon atom.



Propene

150. (d) Polynuclear hydrocarbons are not produced in human body by any biochemical reaction as when they enter into human body they undergo various biochemical reactions which finally damage DNA and cause cancer.

MATCHING TYPE QUESTIONS

151. (a) Among the infinite number of conformations in the staggered conformation hydrogen atoms are as far as apart as possible. While in eclipse conformation hydrogen atoms are perfectly eclipsed.

In skew conformation, hydrogen atoms are closer than in staggered but away than in eclipsed conformation.

152. (a) $\underset{\text{Ethene}}{CH_2 = CH_2} + H_2 \xrightarrow{Pt/Pd/Ni} \underset{\text{Ethane}}{CH_3 - CH_3}$

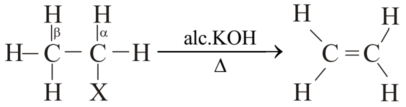
$$\underset{\text{Chloromethane}}{CH_3 - Cl} + H_2 \xrightarrow{Zn, H^+} \underset{\text{Methane}}{CH_4} + HCl$$

$$\underset{\text{Bromomethane}}{CH_3Br} + 2Na + BrCH_3 \xrightarrow{\text{dry ether}} \underset{\text{Ethane}}{CH_3 - CH_3} + 2NaBr$$

$$CH_3COO^-Na^+ + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

153. (c)

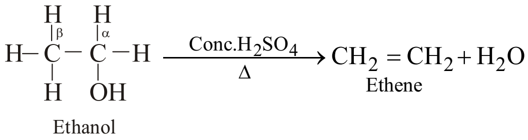
154. (a) $\underset{\text{Ethyne}}{CH \equiv CH} + H_2 \xrightarrow{Pd/C} \underset{\text{Ethene}}{CH_2 = CH_2}$



$$H-\underset{H}{\overset{H}{\underset{|}{\overset{|\beta}{C}}}}-\underset{X}{\overset{H}{\underset{|}{\overset{|\alpha}{C}}}}-H \xrightarrow[\Delta]{\text{alc.KOH}} \begin{matrix} H & & H \\ & C=C & \\ H & & H \end{matrix}$$

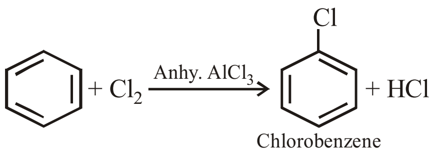
$(X = Cl, Br, I)$

$$CH_2Br - CH_2Br + Zn \longrightarrow CH_2{=}CH_2 + ZnBr_2$$

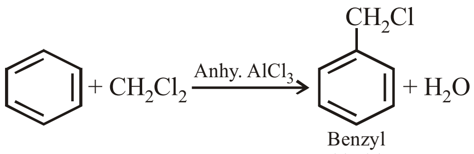


$$\underset{\text{Ethanol}}{H-\underset{H}{\overset{H}{\underset{|}{\overset{|\beta}{C}}}}-\underset{OH}{\overset{H}{\underset{|}{\overset{|\alpha}{C}}}}-H} \xrightarrow[\Delta]{\text{Conc.}H_2SO_4} \underset{\text{Ethene}}{CH_2 = CH_2} + H_2O$$

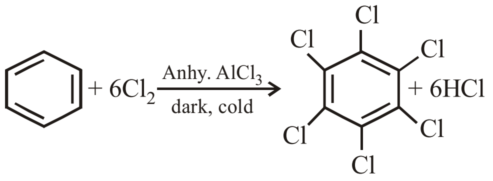
155. (b)



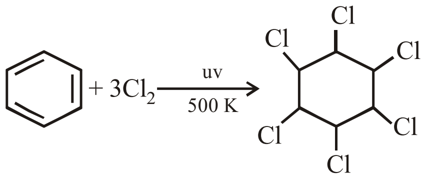
Chlorobenzene



Benzyl chloride



Hexachlorobenzene (C_6Cl_6)



Benzene hexachloride. (BHC)

156. (a) (A) $\underset{\text{(Benzene)}}{C_6H_6} + Cl_2 \xrightarrow{AlCl_3} \underset{\text{(Chlorobenzene)}}{C_6H_5Cl}$

(B) $C_6H_6 + CH_3Cl \xrightarrow{AlCl_3} \underset{\text{(Toluene)}}{C_6H_5CH_3} + HCl$

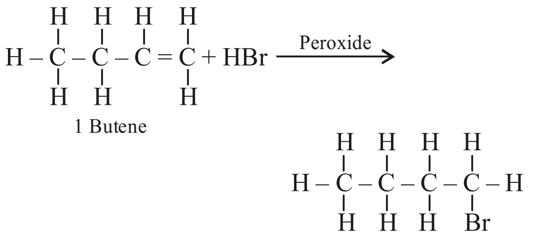
(C) $C_6H_6 + CH_3COCl \longrightarrow \underset{\text{methyl phenyl ketone}}{C_6H_5COCH_3} + HCl$

(D) $\underset{\text{(Toulene)}}{C_6H_5 - CH_3} \xrightarrow[NaOH]{KMnO_4} C_6H_5COOH$

157. (d) **158. (a)** **159. (b)**

ASSERTION-REASON TYPE QUESTIONS

160. (a) This reaction is followed by anti Markownikoff rule



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{C}=\overset{H}{\underset{H}{C}}+HBr \xrightarrow{Peroxide} H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{Br}{C}}-H$$

1 Butene

1-Bromobutane

In this reaction anti Markownikoff's addition is explained on the basis of the fact that in the presence peroxides, addition takes place via free radical mechanism rather than the ionic mechanism.

161. (b) The assertion that chlorination of CH_4 does not take place in dark is correct because it is a free radical reaction and free radicals are obtained in presence of sun light.

162. (b) Iodination is reversible since formed HI is a strong reducing agent and reduces the alkyl iodide back to alkane. $CH_4 + I_2 \rightleftharpoons CH_3I + HI$

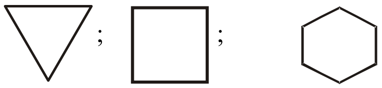
Iodination can be done only in presence of strong oxidising agents like iodic acid which destroys the hydriodic acid.

163. (d) The two hydrogen atoms on first carbon and the two H-atoms on the third carbon atom lie in perpendicular planes. The central carbon atom is *sp*-hybridized while terminal carbon atoms are sp^2-hybridized

164. (c) $(4n + 2)\pi$ electrons and planar structure are the essential conditions for aromaticity.

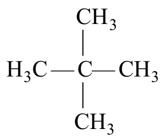
CRITICAL THINKING TYPE QUESTIONS

165. (d)



In all these we find $\overset{|}{\underset{|}{CH_2}}$ group i.e. correct answer is (d).

166. (c) The structure of neopentane is

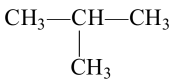


$$H_3C-\overset{CH_3}{\underset{CH_3}{C}}-CH_3$$

It has 1 quaternary and 4 primary carbons.

167. (a)

168. (b) For the compounds with same molecular mass, boiling point decreases with increase in branching. The boiling point also increases steadily with increase in molecular mass. Hence 2-methyl propane will have lowest boiling point

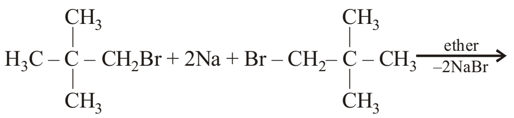


$$CH_3-\underset{CH_3}{CH}-CH_3$$

2-methyl propane

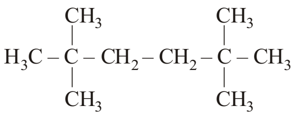
169. (d)

170. (c)



$$H_3C-\overset{CH_3}{\underset{CH_3}{C}}-CH_2Br+2Na+Br-CH_2-\overset{CH_3}{\underset{CH_3}{C}}-CH_3 \xrightarrow[-2NaBr]{ether}$$

neo-pentyl bromide



$$H_3C-\overset{CH_3}{\underset{CH_3}{C}}-CH_2-CH_2-\overset{CH_3}{\underset{CH_3}{C}}-CH_3$$

2,2,5,5-tetramethylhexane

171. (a) Electrolysis of a concentrated aqueous solution of either sodium or potassium salts of saturated mon-carboxylic acids yields higher alkane at anode.

$$2RCOOK \xrightarrow[\text{Oxidation}]{\text{Electrolytic}} \underset{\text{Anode}}{2RCOO^-} + \underset{\text{Cathode}}{2K^+}$$

At anode $2RCOO^- \rightarrow 2RCOO + 2e^- \longrightarrow$

$$R-R + 2CO_2$$

At Cathode $2K^+ + 2e^- \rightarrow 2K$

$$2K + H_2O \rightarrow 2KOH + H_2\uparrow$$

(Kolbe's Method)

172. (a) Given

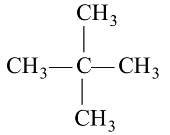
$$A \xrightarrow{Cl_2} B \xrightarrow{alc./KOH} \underset{\text{Hydrocarbon}}{C} \xrightarrow{O_3/H_2O} CH_2O$$

Since hydrocarbon C give only CH_2O, on ozonolysis, C should be $CH_2 = CH_2$ hence going backward A should be ethane. Thus the reactions are

$$\underset{(A)}{CH_3CH_3} \xrightarrow{Cl_2/hv} \underset{(B)}{CH_3CH_2Cl} \xrightarrow[KOH]{alc.} ...$$

$$\underset{(C)}{CH_2{=}CH_2} \xrightarrow[\Delta]{O_3/H_2O} \underset{(D)}{HCHO}$$

173. (b)

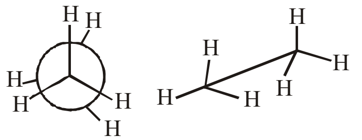


$$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3$$

2,2-dimethyl Propane

All hydrogen atoms are equivalent in 2, 2-dimethylpropane. So it forms only one monochlorinated product.

174. (c) In the eclipsed conformation of ethane, the dihedral angle between hydrogen atoms of adjacent methyl groups is 0°.

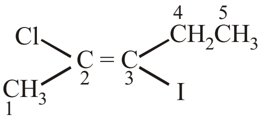


175. (a) The π bond is formed by the sideways overlapping of two *p*-orbitals of the two carbon atoms.

The molecular plane does not have any π electron density as the *p*-orbitals are perpendicular to the plane containing the ethene molecule. The nodal plane in the π-bond of ethene is located in the molecular plane.

176. (c)

177. (a)

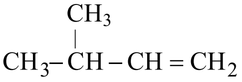


Correct IUPAC name of above compound is trans-2-chloro-3-iodo-2-pentene

178. (c) C_5H_{10} has 1° degree of unsaturation since the isomers are acyclic, all of these are alkenes. For writing the isomers, first introduce the double bond at different possible positions, and then consider the possibility of branching in the alkyl group.

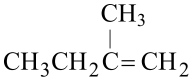
$CH_3CH_2CH_2CH{=}CH_2$
1-pentene (*i*)

$CH_3CH_2CH{=}CHCH_3$
2- pentene, (*cis,- trans*) (*ii*), (*iii*)



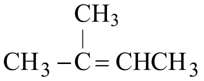
$$CH_3-\overset{\overset{CH_3}{|}}{CH}-CH=CH_2$$

3-methyl-1-butene, (*iv*)



$$CH_3CH_2\overset{\overset{CH_3}{|}}{C}=CH_2$$

2-methyl-1-butene, (*v*)



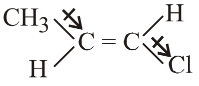
$$CH_3-\overset{\overset{CH_3}{|}}{C}=CHCH_3$$

2-methyl-2-butene, (*vi*)

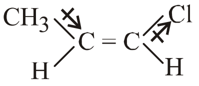
179. (b) Stability of an alkene depends upon the heat of hydrogenation of an alkene. The heat of hydration is the standard enthalpy change in hydrogenation of on alkene. The lower the heat of hydrogenation of an alkene higher will be stability.

Order of stability	Heat of hydrogenation (kJ/mol)
trans-2-butene	– 115.5
cis-2-butene	– 119.6 and
1-butene	– 126.8 respectively.

180. (c) In compounds



I



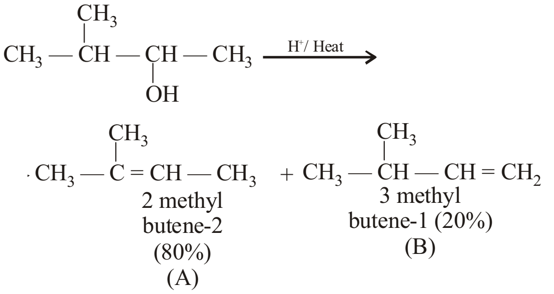
II

first has more dipole moment than second.

Therefore its boiling point will be higher. Melting point depends on symmetry therefore I has higher melting point than II. Steric crowding in I is more than II therefore I is more stable than II.

181. (b)

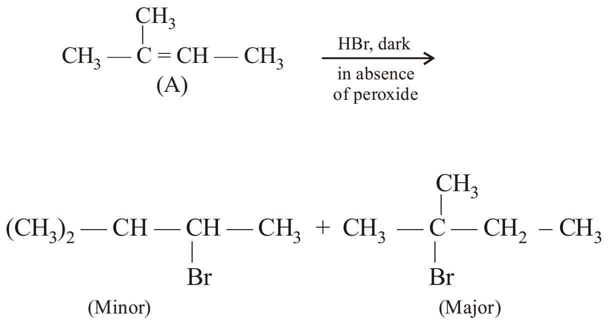
182. (b)



$$CH_3-\overset{\overset{CH_3}{|}}{CH}-\underset{\underset{OH}{|}}{CH}-CH_3 \xrightarrow{H^+/\text{Heat}}$$

$$\underset{\substack{\text{2 methyl}\\ \text{butene-2}\\ (80\%)\\ (A)}}{CH_3-\overset{\overset{CH_3}{|}}{C}=CH-CH_3} + \underset{\substack{\text{3 methyl}\\ \text{butene-1 (20\%)}\\ (B)}}{CH_3-\overset{\overset{CH_3}{|}}{CH}-CH=CH_2}$$

In this case dehydration is governed by Saytzeff's rule according to which hydrogen is preferentially eliminated from the carbon atom with fewer number of hydrogen atoms i.e., poor becomes poorer. Thus, 2-methyl butene-2 is the major product.

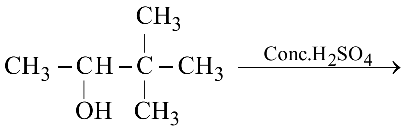


$$\underset{(A)}{CH_3-\overset{\overset{CH_3}{|}}{C}=CH-CH_3} \xrightarrow[\text{in absence of peroxide}]{\text{HBr, dark}}$$

$$\underset{\text{(Minor)}}{(CH_3)_2-CH-\underset{\underset{Br}{|}}{CH}-CH_3} + \underset{\text{(Major)}}{CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{Br}{|}}{C}}-CH_2-CH_3}$$

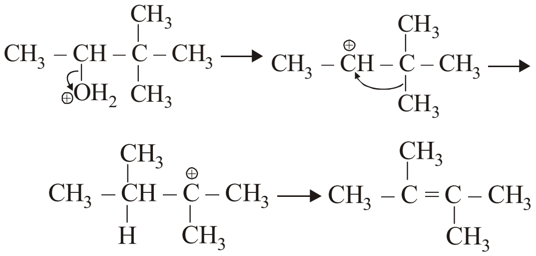
This reaction is governed by Markownikoff's rule according to which when an unsymmetrical reagent e.g. HBr adds to an unsymmetrical alkene, then the negative part of the reagent is added to that carbon atom of the double bond which bears the least number of hydrogen atom. Thus, in above case. 2-methyl 2-bromo butane will be the major product.

183. (a) When 3, 3 dimethyl 2-butanol is heated with H_2SO_4 the major product obtained is 2, 3 dimethyl 2-butene.



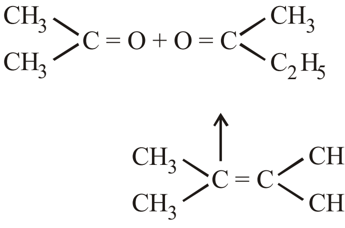
$$CH_3-\underset{\underset{OH}{|}}{CH}-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3 \xrightarrow{Conc.H_2SO_4}$$

3,3–dimethyl 2-butanol



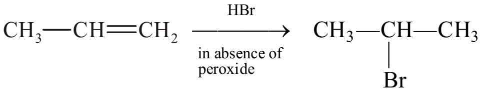
2, 3 dimethyl -2-butene

184. (d)



2,3-Dimethyl-2-pentene

185. (d) Addition of hydrogen halide to alkene is an example of electrophilic addition involving carbocations as intermediates.



$$CH_3-CH=CH_2 \xrightarrow[\text{in absence of peroxide}]{HBr} CH_3-\underset{\underset{Br}{|}}{CH}-CH_3$$

(Markownikoff addition)

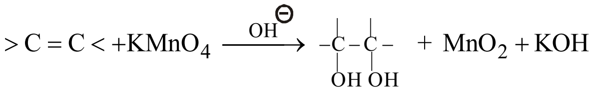
186. (a) Addition reaction occurs on a double bond.

The compound containing double bonds are also undergo polymerisation. So, the correct option are both (a) and (d) e.g.

$$CH_2=CH_2+HOCl \longrightarrow \underset{\text{(addition reaction)}}{CH_2OH-CH_2Cl}$$

$$nCH_2=CH_2 \xrightarrow{\text{Polymerisation}} \underset{\text{Polyethene}}{\left[CH_2-CH_2\right]_n}$$

187. (b) Alkenes react with cold alkaline $KMnO_4$ solution to form glycols. During this reaction $KMnO_4$ (violet) gets converted to MnO_2 (brown ppt.) and therefore the colour of $KMnO_4$ is disappeared.



$$>C=C<+KMnO_4 \xrightarrow{OH^{\ominus}} -\underset{\underset{OH}{|}}{\overset{|}{C}}-\underset{\underset{OH}{|}}{\overset{|}{C}}- + MnO_2+KOH$$

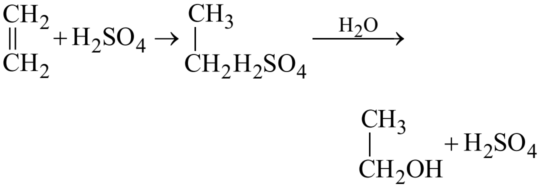
1,2–diols

This test is known as Baeyer test.

188. (b) $CH_2=CH_2-Cl+HCl \longrightarrow CH_3CHCl_2$

Addition of HCl takes place according to Markownikoff's rule. (H goes to C which is least substituted)

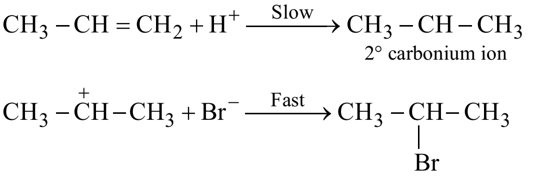
189. (a)



$$\underset{CH_2}{\overset{CH_2}{\|}} + H_2SO_4 \rightarrow \underset{CH_2H_2SO_4}{\overset{CH_3}{|}} \xrightarrow{H_2O} \underset{CH_2OH}{\overset{CH_3}{|}} + H_2SO_4$$

Except ethyl alcohol, no other primary alcohol can be prepared by this method as the addition of H_2SO_4 follows Markownikoff's rule. Generally secondary and tertiary alcohols are obtained.

190. (c) Electrophilic addition reactions are shown by alkenes or alkynes, in these reactions attacking species is electrophile



$$CH_3-CH=CH_2+H^+ \xrightarrow{Slow} \underset{\text{2° carbonium ion}}{CH_3-\overset{+}{C}H-CH_3}$$

$$CH_3-\overset{+}{C}H-CH_3+Br^- \xrightarrow{Fast} CH_3-\underset{\underset{Br}{|}}{CH}-CH_3$$

2-Bromopropane

191. (c)

192. (d) Nature of halogen atom and the alkyl group both determine rate of reaction.

193. (a) (i) $HC\equiv C-CH_2-CH_2-CH_2-CH_3$

Hex–1–yne

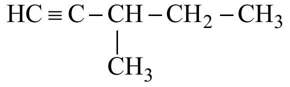
(ii) $CH_3-C\equiv C-CH_2-CH_2-CH_3$

Hex–2–yne

(iii) $CH_3-CH_2-C\equiv C-CH_2-CH_3$

Hex–3–yne

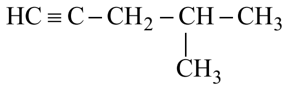
(iv)



$$HC\equiv C-\underset{\underset{CH_3}{|}}{CH}-CH_2-CH_3$$

3- Methylpent -1-yne

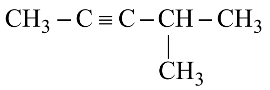
(v)



$$HC\equiv C-CH_2-\underset{\underset{CH_3}{|}}{CH}-CH_3$$

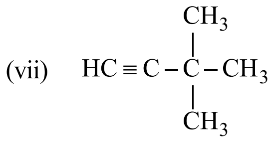
4- Methylpent -1-yne

(vi)



$$CH_3-C\equiv C-\underset{\underset{CH_3}{|}}{CH}-CH_3$$

4- Methylpent -2-yne



(vii) $HC \equiv C - \underset{CH_3}{\overset{CH_3}{\overset{|}{\underset{|}{C}}}} - CH_3$

3,3- Dimethylbut-1-yne

194. (a) Ethylene has restricted rotation, acetylene has no rotation, hexachloroethane has more rotation than ethylene but less than ethane because of greater size of the substituent (chlorine) in hexachloroethane than in ethane (substituent is hydrogen).

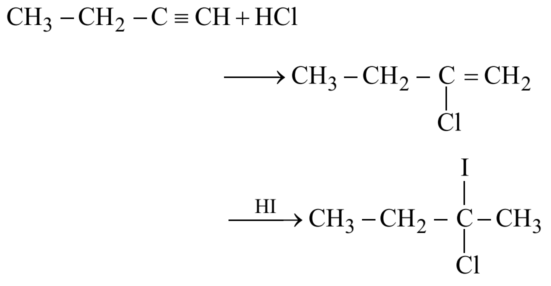
195. (a) The acidity of acetylene or 1–alkyne can be explained on the basis of molecular orbital concept according to which formation of C—H bond in acetylene involves *sp*-hybridised carbon atom. Now since s electrons are closer to the nucleus than *p* electrons, the electrons present in a bond having more *s* character will be correspondingly more closer to the nucleus.

Thus owing to high *s* character of the C—H bond in alkynes (*s* = 50%), the electrons constituting this bond are more strongly held by the carbon nucleus i.e., the acetylenic carbon atom or the *sp* orbital acts as more electronegative species than the sp^2 and sp^3 with the result the hydrogen present on such a carbon atom (≡C—H) can be easily removed as a proton.

196. (b)

197. (d) Br_2 in CCl_4 (a), Br_2 in CH_3 COOH (b) and alk. $KMnO_4$ (c) will react with all unsaturated compounds, i.e., 1, 3 and 4 while ammonical $AgNO_3$ (d) reacts only with terminal alkynes, i.e., 3 and hence 3 can be distinguished from 1, 2 and 4 by. ammonical $AgNO_3$ (d).

198. (c) This reaction occurs according to Markownikoff's rule which states that when an unsymmetrical alkene undergo hydrohalogenation, the negative part goes to that C-atom which contain lesser no. of H-atom.



$$CH_3 - CH_2 - C \equiv CH + HCl$$

$$\longrightarrow CH_3 - CH_2 - \underset{Cl}{\underset{|}{C}} = CH_2$$

$$\xrightarrow{HI} CH_3 - CH_2 - \underset{Cl}{\underset{|}{\overset{I}{\overset{|}{C}}}} - CH_3$$

199. (a) Only terminal alkynes show acidic nature. Ethyne is more acidic than propyne. But-2-yne is not acidic as it does not contain any hydrogen attached to sp hybridised carbon.

200. (a)

201. (c) Due to the maximum percentage of *s* character (50%), the *sp* hybridised orbitals of carbon atoms in ethyne molecules have highest electronegativity; hence, these attract the shared electron pair of the C-H bond of ethyne to a greater extent than that of the sp^2 hybridised orbitals of carbon in ethene and the sp^3 hybridised orbital of carbon in ethane. Thus in ethyne, hydrogen atoms can be liberated as protons more easily as compared to ethene and ethane.

202. (c) In arenes, π electrons are delocalised, hence arenes do not undergo addition reactions easily. Aromatic compounds (Arenes) are highly stable and show resonance. eg. Benzene is the simplest example.

203. (c) Compounds having same molecular formula but different functional groups in their molecules are called functional isomers.

204. (d) In benzene due to delocalisation of π - electrons, all the C – C bond lengths are equal as each C – C bond has some double bond character and thus the bond length is between single and double bond, i.e., between C_2H_6 and C_2H_4.

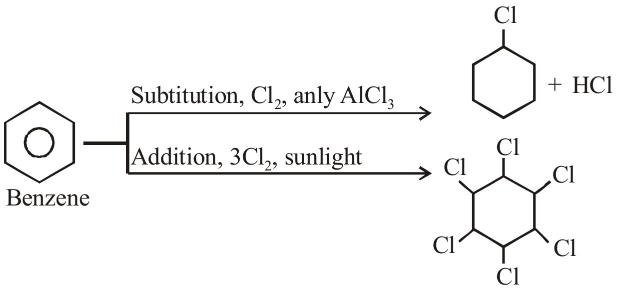
205. (a)

206. (c) Benzene has 12 σ and 3 π bonds.

∴ Ratio of σ bonds to π bonds = 12/3 = 4

207. (d) Presence of 6*p* orbitals, each containing one unpaired electron, in a six membered cyclic structure is in accordance with Huckel rule of aromaticity.

208. (a)



209. (b) –Cl group is o-, p-directing due to +R effect ; however it is deactivating due to strong –I effect of Cl (difference from other o-, p-directing groups which are activating). The net result is that chlorobenzene undergoes o, p-substitution, but with difficulty

210. (b) $C_6H_5COOH + \underset{(X)}{NaOH} \rightarrow C_6H_5COONa + H_2O$

$C_6H_5OH + \underset{(Y)}{Zn} \xrightarrow{\text{distill}} C_6H_6 + ZnO$

211. (a) Huckel rule is not obeyed. It has only four electrons. Further it does not have continous conjugation.

CHAPTER 14

ENVIRONMENTAL CHEMISTRY

FACT/DEFINITION TYPE QUESTIONS

1. The type of pollution caused by spraying of DDT is
(a) air and soil (b) air and water
(c) air (d) air, water and soil

2. What is DDT among the following ?
(a) Greenhouse gas
(b) A fertilizer
(c) Biodegradable pollutant
(d) Non-biodegradable pollutant

3. The uppermost region of the atmosphere is called
(a) Ionosphere (b) Stratosphere
(c) Troposphere (d) Exosphere

4. Which of the following is the coldest region of atmosphere ?
(a) Thermosphere (b) Mesosphere
(c) Troposphere (d) Stratosphere

5. The region which is greatly affected by air pollution is
(a) Thermosphere (b) Stratosphere
(c) Troposphere (d) Mesosphere

6. The region containing water vapour is
(a) thermosphere (b) stratosphere
(c) troposphere (d) mesosphere

7. High concentration of which of the following in atmosphere leads to stiffness of flower buds which eventually fall off from plants?
(a) NO_2 (b) SO_2
(c) CFC (d) Smog

8. The irritant red haze in the traffic and congested places is due to presence of which of the following ?
(i) Oxides of sulphur
(ii) Oxides of nitrogen
(iii) Carbon dioxide
(iv) Mists, smoke and dust
(v) Smog
(a) (i), (iv) and (v) (b) (iii) only
(c) (ii) only (d) (ii) and (v)

9. The quantity of CO_2 in atmosphere is
(a) 3.34% (d) 6.5%
(c) 0.034% (d) 0.34%

10. The substance which is not regarded as a pollutant?
(a) NO_2 (b) CO_2
(c) O_3 (d) Hydrocarbons

11. Which of the following is/are the hazardous pollutant(s) present in automobile exhaust gases?
(i) N_2 (ii) CO
(iii) CH_4 (iv) Oxides of nitrogen
(a) (ii) and (iii) (b) (i) and (ii)
(c) (ii) and (iv) (d) (i) and (iii)

12. The gas emitted by supersonic jet planes that slowly depletes the concentration of ozone layer is
(a) CO (b) NO
(c) SO_2 (d) O_2

13. Carbon monoxide (CO) is harmful to man because
(a) it forms carbolic acid
(b) it generates excess CO_2
(c) it is carcinogenic
(d) it competes with O_2 for haemoglobin

14. Increase in global temperature increases the incidence of which of the following infectious disease(s)
(i) Sleeping sickness (ii) Yellow fever
(iii) Malaria (iv) Dengue
(a) (ii) only (b) (i) and (ii)
(c) (iii) and (iv) (d) (i), (ii), (iii) and (iv)

15. The green house effect is caused by
(a) CO_2 (b) NO_2
(c) NO (d) CO

16. Which is related to 'Green House Effect'?
(a) Farming of Green plants
(b) Farming of Vegetables in Houses
(c) Global Warming
(d) Biodegradable pollutant

17. Green house gases

(a) allow shorter wavelength to enter earth's atmosphere while doesn't allow longer wavelength to leave the earth's atmosphere.

(b) allow longer wavelength to enter earth atmosphere while doesn't allow shorter wavelength to leave the surface

(c) don't have wavelength specific character.

(d) show wavelength specific behaviour near the earth while far from earth these have wavelength independent behaviour.

18. Today the concentration of green house gases is very high because of

(a) use of refrigerator

(b) increased combustion of oils and coal

(c) deforestation

(d) All of the above

19. The greenhouse effect is because of the

(a) presence of gases, which in general are strong infrared absorbers, in the atmosphere

(b) presence of CO_2 only in the atmosphere

(c) pressure of O_3 and CH_4 in the atmosphere

(d) N_2O and chlorofluorohydrocarbons in the atmosphere

20. The greenhouse gas is

(a) CO_2 (b) SO_2

(c) N_2 (d) H_2S

21. Which of the following gases is not a green house gas?

(a) CO (b) O_3

(c) CH_4 (d) H_2O vapour

22. Which of the following strategy is not a correct approach to reduce global warming ?

(a) Reducing the green house gas emission by limiting the use of fossil fuels

(b) Increase the vegetation cover particularly the forest for photosynthetic utilization of CO_2

(c) Minimizing the use of nitrogen fertilizers in agriculture for reducing N_2O emission

(d) Increasing the use of air conditioners, refrigeration unit and production of plastic foams and propellants in aerosal spray cans

23. The substance having the largest concentration in acid rain

(a) H_2CO_3 (b) HNO_3

(c) HCl (d) H_2SO_4

24. When rain is accompanied by a thunderstorm, the collected rain water will have a pH value

(a) slightly lower than that of rain water without thunderstorm

(b) slightly higher than that when the thunderstorm is not there

(c) uninfluenced by occurrence of thunderstorm

(d) which depends upon the amount of dust in air

25. Acid rain is due to

(a) CH_3 (b) N_2O_5

(c) SO_2 and NO_2 (d) C_2H_5OH

26. The pH of normal rain water is

(a) 6.5 (b) 7.5

(c) 5.6 (d) 3.5

27. Which of the following statements is incorrect ?

(a) Smoke particulates consist of solid or mixture of solid and liquid particles formed during combustion of organic matter.

(b) Herbicides and insecticides that miss their target and travel through air form mists.

(c) Organic solvents, metals and metallic oxides form fume particles

(d) None of these

28. Which of the following green house gas is released in paddy field ?

I. CFCs II. CH_4

III. SO_2

(a) Only I (b) Only II

(c) Only III (d) I and II

29. Photochemical smog is due to the presence of

(a) oxides of sulphur (b) oxides of nitrogen

(c) oxides of carbon (d) lead

30. The secondary precursors of photochemical smog are

(a) SO_2 and NO_2

(b) SO_2 and hydrocarbons

(c) NO_2 and hydrocarbons

(d) O_3 and PAN

31. The main element of smog is

(a) O_3 and PAN (b) O_3

(c) PAN (d) PPN and PBN

32. Classical smog occurs in places of

(a) excess SO_2 (b) low temperature

(c) high temperature (d) excess NH_3

33. The smog is essentially caused by the presence of

(a) Oxides of sulphur and nitrogen

(b) O_2 and N_2

(c) O_2 and O_3

(d) O_3 and N_2

34. Air pollution causing photochemical oxidants production include

(a) Carbon monoxide, sulphur dioxide

(b) Nitrous oxide, nitric acid fumes, nitric oxide

(c) Ozone, peroxyacetyl nitrate, aldehydes

(d) Oxygen, chlorine, fuming nitric acid

35. Photochemical smog formed in congested metropolitan cities mainly consists of

(a) ozone, peroxyacetyl nitrate and NO_x

(b) smoke, peroxyacetyl nitrate and SO_2

(c) hydrocarbons, SO_2 and CO_2

(d) hydrocarbons, ozone and SO_x

36. In almost all Indian metropolitan cities like Delhi, the major atmospheric pollutant(s) is/are
(a) suspended particulate matter (SPM)
(b) oxides of sulphur
(c) carbon dioxide and carbon monoxide
(d) oxides of nitrogen

37. The non-viable particulate among the following is
(a) Dust (b) Bacteria
(c) Moulds (d) Fungi

38. Photochemical smog occurs in warm, dry and sunny climate. One of the following is not amongst the components of photochemical smog, identify it.
(a) NO_2
(b) O_3
(c) SO_2
(d) Unsaturated hydrocarbon

39. The pollutants which came directly in the air from sources are called primary pollutants. Primary pollutants are sometimes converted into secondary pollutants. Which of the following belongs to secondary air pollutants?
(a) CO (b) Hydrocarbon
(c) Peroxyacetyl nitrate (d) NO

40. The main element of smog is
(a) O_3 and PAN (b) O_3
(c) PAN (d) Both (a) and (b)

41. Which of the following statements is not true about classical smog?
(a) Its main components are produced by the action of sunlight on emissions of automobiles and factories.
(b) Produced in cold and humid climate.
(c) It contains compounds of reducing nature.
(d) It contains smoke fog and sulphur dioxide

42. Which of the following statements about photochemical smog is wrong?
(a) It has high concentration of oxidising agents
(b) It has low concentration of oxidising agent
(c) It can be controlled by controlling the release of NO_2, hydrocarbons ozone, etc.
(d) Plantation of some plants like pinus helps in controlling photochemical smog.

43. Select the process that does not add particulate materials to air.
(a) Use of air conditioner
(b) Burning of fosssil fuels
(c) Paper industry
(d) Incomplete combustion of coal

44. The biggest particulate matter is
(a) HNO_3 droplets (b) Soot
(c) H_2SO_4 droplets (d) Fly ash

45. The viable particulate among the following is
(a) Fumes (b) Algae
(c) Smoke (d) Mist

46. The aromatic compounds present as particulates are
(a) Polycyclic aromatic hydrocarbons
(b) Benzene
(c) Toluene
(d) Nitrobenzene

47. Which of the following can control the photochemical smog ?
(A) Use of catalytic converters in automobiles.
(B) Plantation of trees like pinus, pyrus vitis etc.
(C) Using less sulphur containing fossil fuels.
(a) A and C (b) B
(c) A and B (d) A, B and C

48. The gas responsible for ozone depletion :
(a) NO and freons (b) SO_2
(c) CO_2 (d) CO

49. Identify the incorrect statement from the following :
(a) Ozone absorbs the intense ultraviolet radiation of the sun.
(b) Depletion of ozone layer is because of its chemical reactions with chlorofluoro alkanes.
(c) Ozone absorbs infrared radiation.
(d) Oxides of nitrogen in the atmosphere can cause the depletion of ozone layer.

50. Identify the wrong statement in the following:
(a) Chlorofluorocarbons are responsible for ozone layer depletion.
(b) Greenhouse effect is responsible for global warming.
(c) Acid rain is mostly because of oxides of nitrogen and sulphur.
(d) Ozone layer does not permit infrared radiation from the sun to reach the earth.

51. Which of the following chemical, harmful to ozone, is released by chlorofluoro carbon?
(a) Sulphur dioxide (b) Fluorine
(c) Chlorine (d) Nitrogen dioxide

52. In Antarctica ozone depletion is due to the formation of following compound
(a) acrolein (b) peroxyacetyl nitrate
(c) SO_2 and SO_3 (d) chlorine nitrate

53. Depletion of ozone layer causes
(a) breast cancer (b) blood cancer
(c) lung cancer (d) skin cancer

54. Select the one that has an adverse effect on ozone layer.
(a) Carbon dioxide (b) Chlorofluorocarbons
(c) Soil (d) Dust particles

55. Ozone hole refers to
(a) Increase in concentration of ozone
(b) Hole in ozone layer
(c) Reduction in thickness of ozone layer in troposphere
(d) Reduction in thickness of ozone layer in stratsophere

56. Which of the following statements is wrong?
(a) Ozone is not responsible for green house effect.
(b) Ozone can oxidise sulphur dioxide present in the atmosphere to sulphur trioxide.
(c) Ozone hole is thinning of ozone layer present in stratosphere.
(d) Ozone is produced in upper stratosphere by the action of UV rays on oxygen.

57. Which of the following statements is correct?
(a) Ozone hole is a hole formed in stratosphere from which ozone oozes out.
(b) Ozone hole is a hole formed in the troposphere from which ozone oozes out.
(c) Ozone hole is thinning of ozone layer of stratosphere at some places.
(d) Ozone hole means vanishing of ozone layer around the earth completely.

58. Ozone is an important constituent of stratosphere because it
(a) Destroys bacteria which are harmful to human life
(b) Prevents the formation of smog over large cities
(c) Removes poisonous gases of the atmosphere by reacting with them
(d) Absorbs ultraviolet radiation which is harmful to human life

59. The gas(es) not responsible for ozone depletion :
(a) NO and freons (b) SO_2
(c) CO_2 (d) Both (b) and (c)

60. What is the concentration of dissolved oxygen in cold water ?
(a) 5 ppm (b) 10 ppm
(c) 200, 000 ppm (d) 100 ppm

61. Water pollution is caused by
(a) pesticides (b) SO_2
(c) O_2 (d) CO_2

62. Minamata disease of Japan is due to pollution of
(a) Aresenic (b) Lead
(c) Cynide (d) Mercury

63. The high amount of E. coli in water is the indicator of
(a) hardness of water
(b) industrial pollution
(c) sewage pollution
(d) presence of chlorine in water

64. A lake with an inflow of domestic sewage rich in organic waste may result in
(a) drying of the lake very soon due to algal bloom
(b) an increase production of fish due to lot of nutrients
(c) death of fish due to lack of oxygen
(d) increased population of aquatic food web organisms

65. Which of the following does not occur when the sewage is discharged into water ?
(a) Increase in O_2
(b) Cyanophycean blooms occur
(c) Depletion of O_2 layers
(d) Eutrophication

66. Which of the following metal is a water pollutant and causes sterility in human being
(a) As (b) Mn
(c) Mg (d) Hg

67. Sewage mostly constitutes
(a) Non-biodegradable pollutants
(b) Biodegradable pollutants
(c) Effluents
(d) Air pollutants

68. Sewage containing organic waste should not be disposed in water bodies because it causes major water pollution. Fishes in such a polluted water die because of
(a) large number of mosquitoes
(b) increase in the amount of dissolved oxygen
(c) decrease in the amount of dissolved oxygen in water
(d) clogging of gills by mud

69. Sewage water is purified by
(a) aquatic plants (b) microoganisms
(c) light (d) fishes

70. Water is often treated with chlorine to
(a) remove hardness
(b) increase oxygen content
(c) kill germs
(d) remove suspended particles

71. Which causes death of fish in water bodies polluted by sewage?
(a) Foul smell (b) Pathogens
(c) Herbicides (d) Decrease in D.O.

72. B.O.D. test or biochemical oxygen demand test is made for measuring
(a) air pollution (b) water pollution
(c) noise pollution (d) soil pollution

73. Brewery and sugar factory waste alters the quality of a water body by increasing
(a) temperature (b) turbidity
(c) pH (d) COD and BOD

74. Which one of the following statement is **not** true ?
(a) pH of drinking water should be between 5.5 – 9.5.
(b) Concentration of DO below 6 ppm is good for the growth of fish.
(c) Clean water would have a BOD value of less than 5 ppm.
(d) Oxides of sulphur, nitrogen and carbon are the most widespread air pollutant.

75. Limit of BOD prescribed by Central pollution Control Board for the discharge of industrial and municipal waste waters into natural surface waters, is
(a) < 100 ppm (b) < 30 ppm
(c) < 3.0 ppm (d) < 10 ppm

76. Biochemical Oxygen Demand, (BOD) is a measure of organic material present in water. BOD value less than 5 ppm indicates a water sample to be __________.
(a) rich in dissolved oxygen
(b) poor in dissolved oxygen
(c) highly polluted
(d) not suitable for aquatic life

77. Phosphate fertilizers when added to water leads to
(a) Increased growth of decomposers
(b) Reduced algal growth
(c) Increased algal growth
(d) Nutrient enrichment (eutrophication)

78. BOD of pond is connected with
(a) Microbes & organic matter
(b) Organic matter
(c) Microbes
(d) None of these

79. The maximum prescribed concentration of cadmium in drinking water in ppm is
(a) 0.05 (b) 3
(c) 2 (d) 0.005

80. Excess nitrate in drinking water can cause
(a) methemoglobinemia (b) kidney damage
(c) liver damage (d) laxative effect

81. Eutrophication causes reduction in
(a) dissolved oxygen (b) nutrients
(c) dissolved salts (d) All of the above

82. Water pollution is caused by
(a) pesticides (b) fly ash
(c) auto exhausts (d) aeroplanes

83. Which causes death of fishes in water bodies polluted by sewage?
(a) Foul smell (b) Pathogens
(c) Clogging of gills by silt (d) Decrease in D.O.

84. Chief source of soil and water pollution is
(a) mining (b) agro industry
(c) thermal power plant (d) All of the above

85. What is DDT among the following ?
(a) Greenhouse gas
(b) A fertilizer
(c) Biodegradable pollutant
(d) Non-biodegradable pollutant

86. The quantity of DDT in food chain
(a) decreases (b) remains same
(c) increases (d) changes

87. The effect of polluted water on soil is, that
(a) it decreases fertility
(b) it contaminates ground water
(c) it renders soil acidic or basic
(d) all of the above

88. Soil is polluted by
I. pesticides
II. synthetic fertilizers
III. green manure
Choose the correct option.
(a) I and III (b) I and II
(c) II and III (d) I, II and III

89. Which of the following trophic level has least concentration of toxins deposition ?
(a) Aquatic plant (b) Small fish
(c) Human being (d) Largest fish

90. Green chemistry means such reactions which :
(a) produce colour during reactions
(b) reduce the use and production of hazardous chemicals
(c) are related to the depletion of ozone layer
(d) study the reactions in plants

91. Which of the following practices will not come under green chemistry?
(a) If possible, making use of soap made of vegetable oils instead of using synthetic detergents.
(b) Using H_2O_2 for bleaching purpose instead of using chlorine based bleaching agents.
(c) Using bicycle for travelling small distances instead of using petrol/ diesel based vehicles.
(d) Using plastic cans for neatly storing substances.

92. "Reducing potentially hazardous waste through smarter production".
This represents a great step forward for
(a) green revolution (b) green chemistry
(c) industrial revolution (d) green biotechnology

93. Use of which of the following solvent in dry cleaning will result in less harm to ground water ?
(a) $Cl_2C = CCl_2$ (b) Liquid CO_2
(c) H_2O_2 (d) None of these

94. Synthesis of ethanal commercially from which of the following reagent is the part of green chemistry ?
(a) CH_3CH_2OH (b) $CH_2 = CH_2$
(c) $HC \equiv CH$ (d) All of these

STATEMENT TYPE QUESTIONS

95. Which of the following sequence of T and F is correct for given statements. Here T stands for True statement and F stands for False statement.

(i) Troposphere is the lowest region of atmosphere in which the human beings along with other organisms live.

(ii) Troposphere extends up to the height of 10 km from sea level.

(iii) Stratosphere lies above troposphere, between 10 and 20 km above sea level.

(iv) Troposphere contains much little water vapour, dinitrogen, dioxygen and ozone

(v) Stratosphere contains ozone, and cloud formation also takes place in this region.

(a) TTTTT (b) TFTFF
(c) TTFFF (d) TFTFT

96. Which of the following statement(s) is / are correct ?

(i) Sulphuric acid, nitric acid as well as ammonium salts are components of acid rain.

(ii) Formation of acid rain can be reduced by using less sulphur content fossil fuels for power plants and industries.

(iii) Catalytic converters must be used in cars to reduce the harmful effect of exhaust.

(iv) Main component of catalytic converter is ceramic honey comb coated with metals like – Au, Ag, Pt etc.

(a) (i), (ii) and (iii) (b) (ii) and (iii)
(c) (ii), (iii) and (iv) (d) (i), (ii), (iii) and (iv)

97. Which of the following statement(s) is/are correct ?

(i) Classical smog is a mixture of smoke, fog and sulphur dioxide.

(ii) Classical smog is also called oxidising smog

(iii) Hydrocarbons, NO_2 and PAN are components of photochemical smog.

(a) (i) and (iii) (b) (i) and (ii)
(c) (iii) only (d) (i), (ii) and (iii)

98. Which of the following statements are not correct?

(i) F^- ion concentration above 2ppm causes brown mottling in teeth.

(ii) Excessive F^- (over 10 ppm) causes harmful effect to bones and teeth.

(iii) Excessive lead in drinking water causes disease methemoglobinemia

(iv) Deficiency of sulphate in drinking water causes laxative effect.

(a) (ii) and (iv) (b) (ii) and (iii)
(c) (ii), (iii) and (iv) (d) (iii) and (iv)

99. Which of the following statement(s) is/are true about waste recycling ?

(i) Clothes can be made from recycled plastic waste.

(ii) Fuel that has high octane rating and contains no lead can be obtained from plastic waste.

(iii) Technology has now been developed to produce electricity from the garbage.

(a) (ii) only (b) (ii) and (iii)
(c) (iii) only (d) All of these

MATCHING TYPE QUESTIONS

100. Match the columns

	Column - I		Column - II
(A)	Concentration of dissolved oxygen in cold water	(p)	6 ppm
(B)	Concentration of dissolved oxygen below which growth of fish gets inhibited	(q)	17 ppm
(C)	BOD value of clean water	(r)	5 ppm
(D)	BOD value of polluted water.	(s)	10 ppm

(a) A – (s), B – (s), C – (q), D – (p)
(b) A – (p), B – (q), C – (r), D – (s)
(c) A – (s), B – (p), C – (r), D – (q)
(d) A – (p), B – (s), C – (q), D – (r)

101. Match the columns

	Column I		Column II
(A)	Acid rain	(p)	$CHCl_2 – CHF_2$
(B)	Photochemical smog	(q)	CO
(C)	Combination with haemoglobin	(r)	CO_2
(D)	Depletion of ozone layer	(s)	SO_2
		(t)	Unsaturated hydrocarbons

(a) A – (r, s), B – (t, s), C – (q), D – (p)
(b) A – (r), B – (s), C – (q), D – (p)
(c) A – (t,s), B – (s), C – (q), D – (r)
(d) A – (r), B – (t), C – (q), D – (p)

102. Match the columns

	Column-I		Column-II
(A)	Oxides of sulphur	(p)	Global warming
(B)	Nitrogen dioxide	(q)	Damage to kidney
(C)	Carbon dioxide	(r)	'Blue baby' syndrome
(D)	Nitrate in drinking water	(s)	Respiratory diseases
(E)	Lead	(t)	Red haze in traffic and congested areas

(a) A – (t), B – (p), C – (r), D – (s), E – (q)
(b) A – (s), B – (t), C – (p), D – (r), E – (q)
(c) A – (s), B – (q), C – (p), D – (t), E – (r)
(d) A – (q), B – (s), C – (t), D – (r), E – (p)

103. Match the columns

	Column-I		**Column-II**
(A)	Nitrous oxide from car exhausts	(p)	Secondary pollutant
(B)	Chlorofluorocarbon (CFCs)	(q)	Combustion of fossil fuels, wood, etc
(C)	Methane	(r)	Denitrification
(D)	Ozone (O_3)	(s)	Refrigerators, aerosol, sprays
(E)	Carbon dioxide	(t)	Cattle, rice fields, toilets.

(a) A – (r), B – (s), C – (t), D – (p), E – (q)
(b) A – (t), B – (p), C – (r), D – (s), E – (q)
(c) A – (s), B – (t), C – (p), D – (q), E – (r)
(d) A – (p), B – (r), C – (s), D – (t), E – (q)

104. Match the columns

	Column-I		**Column-II**
(A)	Releasing gases to the atmosphere after burning waste material containing sulphur	(p)	Water pollution
(B)	Using carbamates as pesticides	(q)	Photochemical smog, damage to plant life, corrosion to building material, induce breathing problems, water pollution
(C)	Using synthetic detergents for washing clothes	(r)	Damaging ozone layer
(D)	Releasing gases produced by automobiles and factories in the atmosphere.	(s)	May cause nerve diseases in human
(E)	Using chlorofluorocarbon compounds for cleaning computer parts	(t)	Classical smog, acid rain, water pollution, induce breathing problems, damage to buildings, corrosion of metals.

(a) A – (t), B – (s), C – (p), D – q, E – (r)
(b) A – (s), B – (t), C – (q), D – (p), E – (r)
(c) A – (q), B – (t), C – (r), D – (p), E – (s)
(d) A – (r), B – (s), C – (p), D – (q), E – (t)

105. Match the columns

	Column I		**Column II**
(A)	Phosphate fertilisers in water	(p)	BOD level of water increases
(B)	Methane in air	(q)	Acid rain
(C)	Synthetic detergents in water	(r)	Global warming
(D)	Nitrogen oxides in air	(s)	Eutrophication

(a) A – (p,s), B – (r), C – (p), D – (q)
(b) A – (p), B – (s), C – (r), D – (q)
(c) A – (s), B – (r), C – (q), D – (p)
(d) A – (p), B – (q), C – (s), D – (r)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

106. Assertion : Uncatalysed oxidation of sulphur dioxide is a slow process.

Reason : Particulate matter in polluted air catalyses the oxidation of sulphur dioxide.

107. Assertion : Dinitrogen and dioxygen do not react with each other at a normal temperature.

Reason : At high altitudes dinitrogen combines with dioxygen to form oxides of nitrogen

108. Assertion : CO_2 causes green house effect.

Reason : Other gases do not show such effect.

109. Assertion : Green house effect was observed in houses used to grow plants and these are made of green glass.

Reason : Green house name has been given because glass houses are made of green glass.

110. Assertion : The pH of acid rain is less than 5.6.

Reason : Carbon dioxide present in the atmosphere dissolves in rain water and forms carbonic acid.

111. Assertion : Photochemical smog is oxidising in nature.

Reason : Photochemical smog contains NO_2 and O_3, which are formed during the sequence of reactions.

112. Assertion : Suspended particulate matter (SPM) is an important pollutant released by diesel vehicles.

Reason : Catalytic converters greatly reduce pollution caused by automobiles.

113. Assertion : Carbon dioxide is one of the important greenhouse gases.

Reason : It is largely produced by respiratory function of animals and plants.

114. Assertion : Ozone is destroyed by solar radiation in upper stratosphere.

Reason : Thinning of the ozone layer allows excessive UV radiations to reach the surface of earth.

115. Assertion : Excessive use of chlorinated synthetic pesticides causes soil and water pollution.

Reason : Such pesticides are non-biodegradables.

116. Assertion : If BOD level of water in a reservoir is less than 5 ppm it is highly polluted.

Reason : High biological oxygen demand means low activity of bacteria in water.

117. Assertion : Eutrophication shows increase in productivity in water.

Reason : With increasing eutrophication, the diversity of the phytoplankton increases.

118. Assertion : The F^- ions make the enamel on teeth much harder.

Reason : F^- ions converts hydroxyapatite $[3(Ca(PO_4)_2 Ca(OH)_2]$ into fluorapatite $[3(Ca_3(PO_4)_2 . CaF_2]$.

CRITICAL THINKING TYPE QUESTIONS

119. In which of the following regions hydrogen and helium are found ?

(a) Stratosphere (b) Mesosphere
(c) Exosphere (d) Troposphere

120. Which one of the following pairs is mismatched ?

(a) Fossil fuel burning - release of CO_2
(b) Nuclear power - radioactive wastes
(c) Solar energy - Greenhouse effect
(d) Biomass burning - release of CO_2

121. Which of the following acts as a sink for CO?

(a) Plants
(b) Haemoglobin
(c) Microorganisms present in the soil
(d) Oceans

122. How many time oxyhaemoglobin is less stable than carboxyhaemoglobin?

(a) 50 (b) 200
(c) 500 (d) 300

123. Dinitrogen and dioxygen are main constituents of air but these do not react with each other to form oxides of nitrogen because __________.

(a) the reaction is endothermic and requires very high temperature.
(b) the reaction can be initiated only in presence of a catalyst.
(c) oxides of nitrogen are unstable.
(d) N_2 and O_2 are unreactive

124. SO_2 is one of the air pollutants. SO_2

(a) is a lung irritant
(b) dissolves in water to form acid rain
(c) both (a) and (b)
(d) none of the above

125 The greatest affinity for haemoglobin is shown by which of the following :

(a) NO (b) CO
(c) O_2 (d) CO_2

126. Which pollutant is harmful for 'Taj Mahal'?

(a) Hydrogen (b) O_2
(c) SO_2 (d) Chlorine

127. The beauty of Taj Mahal is endangered due to

(a) degradation of marble due to high temperature
(b) discharge of industrial waste in Yamuna river
(c) air pollutants released from oil refinery
(d) riparian erosion

128. Acid rain is caused by or recent reports of acid rain in some industrial cities are due to the effect of atmospheric pollution by

(a) excessive release of CO_2 by burning of fuels like wood and charcoal, cutting of forests and increased animal population
(b) excessive release of NO_2 and SO_2 in atmosphere by burning of fossil fuel
(c) excessive release of NH_3 by industrial plants and coal gas
(d) excessive release of CO in atmosphere by incomplete combustion of coke, charcoal and other carbonaceous fuel in paucity of oxygen.

129. Which of the following is the major cause of global warming?

(a) re-radiation of U.V. rays by CO_2 and H_2O
(b) re-radiation of I.R. rays by CO_2 and H_2O
(c) re-radiation of I.R. rays by O_2 and N_2
(d) re-radiation of U.V. rays by O_2 and N_2

130. Formation of London smog takes place in

(a) winter during day time
(b) summer during day time
(c) summer during morning time
(d) winter during morning time

131. The false statement among the followings :

(a) The average residence time of NO is one month
(b) Limestone acts as a sink for SO_x
(c) SO_x can be removed from flue gases by passing through a solution of citrate ions
(d) Ammonia acts as a sink for NO_x

132. Which of the following statements about polar stratosphere clouds (PSCs) is not correct?

(a) PSCs do not react with chlorine nitrate and HCl
(b) Type I clouds are formed at about –77ºC and contain solid $HNO_3 . 3H_2O$
(c) Type II clouds are formed at about –85ºC and contain some ice
(d) A tight whirlpool of wind called Polar Vortex is formed which surrounds Antarctica

133. Which of the following is/are formed when ozone reacts with the unburnt hydrocarbons in polluted air ?

(i) Formaldehyde (ii) Acrolein
(iii) Peroxyacetyl nitrate (iv) Formic acid

(a) (i) and (iv) (b) (ii) only
(c) (iii) only (d) (i), (ii) and (iii)

134. Thermal pollution affects mainly

(a) vegetation (b) aquatic creature

(c) rocks (d) air

135. A dental disease characterised by mottling of teeth is due to presence of a certain chemical element in drinking water. Which is that element?

(a) Boron (b) Chlorine

(c) Fluorine (d) Mercury

136. Frequent occurrence of water blooms in a lake indicates

(a) nutrient deficiency

(b) oxygen deficiency

(c) excessive nutrient availability

(d) absence of herbivores in the lake

137. Which one of the following statements is correct ?

(a) Extensive use of chemical fertilizers may lead to eutrophication of nearby water bodies

(b) Both Azotobacter and Rhizobium fix atmospheric nitrogen in root nodules of plants

(c) Cyanobacteria such as Anabaena and Nostoc are important mobilizers of phosphates and potassium for plant nutrition in soil

(d) At present it is not possible to grow maize without chemical fertilizers

138. Lichens do not like to grow in cities

(a) because of absence of the right type of algae and fungi

(b) because of lack of moisture

(c) because of SO_2 pollution

(d) because natural habitat is missing

139. BOD of pond is connected with

(a) microbes & organic matter

(b) organic matter

(c) microbes

(d) None of these

140. Which is known as 'Third poison of environment' and also creates 'Blue baby syndrome'

(a) Nitrate present in water

(b) Phosphate and detergents found in water

(c) Cynide

(d) Pesticides

141. Negative soil pollution is

(a) reduction in soil productivity due to erosion and over use

(b) reduction in soil productivity due to addition of pesticides and industrial wastes

(c) converting fertile land into barren land by dumping ash, sludge and garbage

(d) None of the above

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(d)** DDT causes air, water and soil pollution.
2. **(d)** DDT is a non-biodegradable pollutant.
3. **(d)** The uppermost region of atmosphere is exosphere.
4. **(b)** The coldest region is mesosphere (temp. –27ºC to – 92ºC)
5. **(c)** Air pollution greatly affect the troposphere.
6. **(c)** Troposphere contains water vapour.
7. **(b)** High concentration of SO_2 leads to stiffness of flower buds.
8. **(c)** The irritant red haze in the traffic and congested places is due to presence of oxides of nitrogen.
9. **(c)**
10. **(b)** CO_2 is generally not regarded as pollutant.
11. **(c)** CO and oxides of Nitrogen are poisnous gases present in automobile exhaust gases.
12. **(b)** Nitric oxide (NO) which may be produced at the ground level due to human activity or natural sources or is produced in large amounts in the exhaust gases by the engine of supersonic transport planes and introduced directly into the strateosphere.

$$NO + O_3 \longrightarrow NO_2 + O_2$$

13. **(d)** CO is highly toxic and impairs respiration. CO combine with haemoglobin of blood and reduces its O_2 carry capacity.
14. **(d)**
15. **(a)** CO_2 causes green house effect.
16. **(c)**
17. **(a)** Radiation coming from sun or outerspace have high energy or short wavelength, which are allowed to enter by green house gases. However, radiation emitted by earth is in infrared region, having long wavelength, are reflected back by the envelope of green house gases.
18. **(d)**
19. **(a)** Green house gases such as CO_2, ozone, methane, the chlorofluorocarbon compounds and water vapour form a thick cover around the earth which prevents the IR rays emitted by the earth to escape. It gradually leads to increase in temperature of atmosphere.
20. **(a)** CO_2 is a green house gas.
21. **(a)** **22. (d)**
23. **(d)** Acid rain contains $H_2SO_4 > HNO_3 > HCl$.
24. **(a)** Normal rain water has pH 5.6. Thunderstorm results in the formation of NO and HNO_3 which lowers the pH.
25. **(c)** Acid rain is rain or any other form of precipitation that is unusually acidic. It has harmful effects on plants, aquatic animals, and infastructure. Acid rain is mostly caused by human emissions of sulfur and nitrogen compounds which react in the atmosphere to produce acids. In recent years, many governments have introduced laws to reduce these emissions.
26. **(c)** pH of normal rain water is 5.6 as CO_2 present in atmosphere combines with moisture to form H_2CO_3.
27. **(d)**
28. **(b)** Large amounts of CH_4 are released in paddy fields, coal mines and by fossil fuels.
29. **(b)** The oxidised hydrocarbons and ozone in presence of humidity cause photochemical smog.
   Hydrocarbons $+ O_2, NO_2, NO, O, O_3 \rightarrow$ Peroxides
30. **(d)** **31. (a)** **32. (b)**
33. **(a)** Smog is caused by oxides of sulphur and nitrogen.
34. **(c)** **35. (a)** **36. (a)** **37. (a)** **38. (c)**
39. **(c)** **40. (a)** **41. (a)** **42. (b)** **43. (a)**
44. **(d)** **45. (b)**
46. **(a)** PAH (Poly Aromatic Hydrocarbon)
47. **(c)** Usually catalytic converters are used in the automobiles, which prevent the release of nitrogen oxide and hydrocarbons to the atmosphere. Certain plants e.g., Pinus, Juniparus. Quercus, Pyrus and Vitis can metabolise nitrogen oxide and therefore, their plantation could help in this matter.
48. **(a)** NO and freons are responsible for ozone depletion.
49. **(c)** The ozone layer, existing between 20 to 35 km above the earth's surface, shield the earth from the harmful U. V. radiations from the sun.
   Depletion of ozone is caused by oxides of nitrogen

$$N_2O + h\upsilon \longrightarrow \underset{\text{reactive nitric oxide}}{NO + N}$$

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$O_3 + h\upsilon \longrightarrow O_2 + O$$

$$NO_2 + O \longrightarrow NO + O_2$$

$$2\,O_3 + h\upsilon \longrightarrow 3\,O_2 \text{ (Net reaction)}$$

   The presence of oxides of nitrogen increase the decomposition of O_3.

50. **(d)** Ozone layer acts as a shield and does not allow ultraviolet radiation from sun to reach earth. It does not prevent infra-red radiation from sun to reach earth, thus option (d) is wrong statement and so it is the correct answer.
51. **(c)** $CF_2Cl_2 \xrightarrow{h\nu} CF_2Cl + \dot{Cl}$

$$\dot{Cl} + O_3 \longrightarrow Cl\dot{O} + O_2$$

52. (a) In antarctica ozone depletion is due to formation of acrolein.
53. (d) Depletion of ozone layer causes skin cancer.
54. (b) They create holes in ozone layer.
55. (d) Ozone hole is reduction in ozone layer in stratosphere.
56. (a) **57. (c)**
58. (d) Ozone absorbs U.V. radiations harmful to human life.
59. (d)
60. (b) In cold water, dissolved oxygen can reach a concentration upto 10 ppm, whereas oxygen in air is about 200, 000 ppm.
61. (a) Pesticides cause water pollution.
62. (d) Minamata is caused by Hg poisoning.
63. (c) **64. (c)** **65. (a)** **66. (b)**
67. (b) Domestic sewage constitute biodegradable pollutants.
68. (c)
69. (b) Sewage water is purified by micro-organisms.
70. (c) Water is often treated with Cl_2 to kill germs.
71. (d) Decrease in D.O causes death of fish.
72. (b) Strength of sewage or degree of water pollution is measured in terms of BOD (Biochemical oxygen demand) value.
73. (d)
74. (b) The ideal value of D.O for growth of fishes is 8 mg/ℓ. 7mg /ℓ is desirable range, below this value fishes get susceptible to disease. A value of 2 mg/ ℓ or below is lethal for fishes.
75. (b) Water pollution is mainly caused by industrial wastes, sewage, insecticide, herbicides, etc.
76. (a)
77. (d) Addition of phosphate fertilizers to water leads to nutrient enrichment (eutrophication).
78. (a) BOD of pond is connected with microbes and organic matter.
79. (d)
80. (a) Excessive concentration of nitrate in drinking water is harmful and can cause methemoglobinemia (blue baby syndrome).
81. (a) Eutrophication causes reduction in D.O
82. (a) Pesticides cause water pollution.
83. (d) Decrease in D.O causes death of fish
84. (d)
85. (d) DDT is a non-biodegradable pollutant.
86. (c) **87. (d)**
88. (b) Pesticides and synthetic fertilizers pollute the soil.
89. (a) Lower trophic level has lower toxins deposition than higher trophic level.
90. (b) Green chemistry may be defined as the programme of developing new chemical products and chemical processes or making improvements in the already existing compounds and processes so as to make less harmful to human health and environment. This means the same as to reduce the use and production of hazardous chemicals.
91. (d)
92. (b) This represents a great step forward for green chemistry.
93. (b) Replacement of earlier used tetra-chloroethene as solvent for dry cleaning by liquid CO_2 results in less harm to ground water.
94. (b) Ethanal is commerically prepared by one step oxidation of ethene in the presence of ionic catalyst in aqueous medium with an yield of 90%.

$$CH_2 = CH_2 + O_2 \xrightarrow[\text{Pb(II)|Cu(II)}\\ \text{(in water)}]{\text{Catalyst}} CH_3CHO$$

STATEMENT TYPE QUESTIONS

95. (c) For statement (iii), Stratosphere lies above troposphere between 10 and 50 km above sea level cloud formation takes place in troposphere.
For statement (iv), Troposphere is a turbulent, dusty zone containing air, much water vapour and clouds.
For statement (v), Stratosphere contains dinitrogen, dioxygen, ozone and little water vapour.
96. (d)
97. (a) Classical smog is also called reducing smog.
98. (d) For statement (iii), Methemoglobinemia (blue baby syndrome) is caused due to excess of nitrate in drinking water.
For statement (iv), Excessive sulphate (> 500 ppm) in drinking water causes laxative effect, otherwise at moderate levels it is harmless.
99. (d) All the given statements are true for about waste recycling.

MATCHING TYPE QUESTIONS

100. (c) **101. (a)** **102. (b)**
103. (a) **104. (a)** **105. (a)**

ASSERTION-REASON TYPE QUESTIONS

106. (a) The presence of particulate matter in polluted air catalyses the oxidation of SO_2 to SO_3
107. (b) At high altitudes when lightening strikes dinitrogen and dioxygen combine to form oxides of nitrogen.
108. (c) Other gases like CFCs, ozone, water vapour and nitrous oxide also show green house effect.
109. (c) **110. (b)** **111. (a)**
112. (b) SPM (Suspended Particulate Matter) is defined as particles floating in the air with a diameter below 10 μm. Studies have shown that high SPM concentrations in the air can have a detrimental impact on respiratory organs. SPM is generated from natural sources (e.g., volcanoes or dust storms) and human activities (vehicles, incinerators and industrial plants).

SPM	Other aerosols
Less than 10 μm	Less than 100 μm
Tend to float longer in air due to small size	Tend to settle fairly quickly due to comparative heaviness

Catalytic converters is a device designed to reduce the amount of emissions from automobiles. The current (so-called three-way) systems use a heated metal catalyst to reduce the emissions of carbon monoxide (CO), hydrocarbons, and nitric oxide (NO), all of which contribute to the formation of photochemical smog. In an automobile's exhaust system, a catalytic converter provides an environment for a chemical reaction where unburned hydrocarbons completely combust.

113. (b) **114. (d)** **115. (a)** **116. (c)**

117. (b) Eutrophication is a natural process which literally means well nourished or enriched. It is a natural state in many lakes and ponds which have a rich supply of nutrients. Eutrophication become excessive, however when abnormally high amount of nutrient from sewage, fertilizers, animal wastage and detergent, enter streams and lakes causes excessive growth or blooms of microorganisms. With increasing eutrophication, the diversity of the phytoplankton community of a lake increases and the lake finally becomes dominated by blue - green algae.

118. (a) The F^- ions make the enamel on teeth much harder by converting hydroxyapatite, $[3(Ca_3(PO_4)]_2.Ca(OH)_2]$. the enamel on the surface of the teeth, into much harder fluorapatite, $[3(Ca_3(PO_4)_2.CaF_2]$.

CRITICAL THINKING TYPE QUESTIONS

119. (c) H_2, He and ionic oxygen are present in exosphere.

120. (c) Solar energy is not responsible for green house effect instead it is a source of energy for the plants and animals.

121. (c) CO is converted into CO_2 by microorganism present in soil.

122. (d) Carboxyhaemoglobin is 300 times more stable than oxyhaemoglobin.

123. (a) **124. (c)**

125. (a) Haemoglobin has great affinity for NO.

126. (c)

127. (c) The beauty of Taj Mahal is endangered due to air pollutants like SO_2 released from oil refinery.

128. (b) When SO_2 pollution in air is much higher. Sometimes, SO_2 mixes in the air with small particles of metals near the factories and gets oxidised into sulphur trioxide SO_3. These gases are harmful and they react with water to form sulphuric acid (H_2SO_4) or sulphurous acid (H_2SO_3) and come down to earth with rain water, it is called acid rain or acid precipitation.

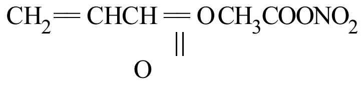
129. (b)

130. (d) London smog is formed in morning during winter.

131. (a) The average residence time of NO is 4 days.

132. (a) PSCs react with chlorine nitrate and HCl to give HOCl and Cl_2.

133. (d) $3CH_4 + 2O_3 \rightarrow \underset{\text{Formaldehyde}}{3CH_2{=}O} + 3H_2O$



$$CH_2{=}CHCH{=}O \quad \underset{\overset{\|}{O}}{C}H_3COONO_2$$

Acrolein Peroxyacetyl nitrate (PAN)

134. (b) Thermal pollution is caused by power plants. Power plant requires a larger quantity of water for cooling. The water after cooling is left in the water body. The temperature of left water is generally very high and affects aquatic life.

135. (c) The excess of fluorine in water causes fluorosis. The symptoms of fluorosis are mottling of teeth (yellowish streaks) and abnormal bones liable to fracture etc. It is an example of endemic disease.

136. (b) **137. (a)**

138. (c) Because they are very sensitive to sulphur dioxide and in cities the amount of SO_2 is high so lichen do not grow in cities.

139. (a) BOD of pond is connected with microbes and organic matter.

140. (b) **141. (a)**