

CBSE XII

Series 1

CHAPTERWISE PRACTICE PAPER : THE SOLID STATE | SOLUTIONS

Time Allowed : 3 hours

Maximum Marks : 70

GENERAL INSTRUCTIONS

- (i) All questions are compulsory.
- (ii) Q. no. 1 to 5 are very short answer questions and carry 1 mark each.
- (iii) Q. no. 6 to 10 are short answer questions and carry 2 marks each.
- (iv) Q. no. 11 to 22 are also short answer questions and carry 3 marks each.
- (v) Q. no. 23 is a value based question and carries 4 marks.
- (vi) Q. no. 24 to 26 are long answer questions and carry 5 marks each.
- (vii) Use log tables if necessary, use of calculators is not allowed.

1. What are pseudo solids?
2. What is a de-icing agent? How does it function?
3. Give the significance of a 'lattice point'.
4. Why is Fe_3O_4 ferrimagnetic at room temperature but becomes paramagnetic at 850 K?
5. Solid A is a very hard electrical insulator in solid as well as in molten state and melts at extremely high temperature. What type of solid is it?
6. In spite of long range order in the arrangement of particles, why are the crystals usually not perfect?
7. Explain with suitable examples in each case why the molar masses of some substances determined with the help of colligative properties are
 - (i) higher
 - (ii) lower than the actual values.
8. An element crystallises in a *fcc* lattice having edge length 400 pm. Calculate the maximum diameter of atom which can be placed in interstitial site without distorting the structure.
 - (i) What type of semiconductor is obtained when silicon is doped with boron?
 - (ii) What type of magnetism is shown in the following alignment of magnetic moments?
 $\uparrow \uparrow \uparrow \uparrow \uparrow \uparrow$
9. H_2S , a toxic gas with rotten egg like smell, is used for qualitative analysis. If the solubility of H_2S in water at STP is 0.195 m, calculate Henry's law constant.
10. Schottky defects generate an equal number of cation and anion vacancies while doping produces only cation vacancies and not anion vacancies. Why?
11. (i) Niobium crystallises in body-centred cubic structure. If density is 8.55 g cm^{-3} , calculate atomic radius of niobium using its atomic mass 93 u.
(ii) Name the parameters that characterise a unit cell.
12. Henry's law constant for CO_2 in water is $1.67 \times 10^8 \text{ Pa}$ at 298 K. Calculate the quantity of CO_2 in 500 mL of soda water when packed under 2.5 atm CO_2 pressure at 298 K.

OR



13. (i) Zinc oxide is white but it turns yellow on heating. Explain.
(ii) A sample of drinking water was found to be severely contaminated with chloroform, CHCl_3 which is supposed to be a carcinogen. The level of contamination was 15 ppm (by mass).
(a) Express this in percent by mass.
(b) Determine the molality of chloroform in the water sample.
14. At 25°C , the vapour pressures of benzene (C_6H_6) and toluene (C_7H_8) are 93.4 torr and 26.9 torr, respectively. A solution is made by mixing 35.0 g of benzene and 65.0 g of toluene. At what applied pressure, in torr, will this solution boil at 25°C ?
15. (i) Why glasspanes fixed to windows and doors of old buildings are found to be slightly thicker at the bottom part?
(ii) Why the defects of crystalline solids are called thermodynamic defects?
(iii) What structural changes are observed when sodium chloride crystals are subjected to high pressure?
- OR**
- Metallic gold crystallises in a face-centred cubic lattice. The length of the cubic unit cell is $a = 4.070 \text{ \AA}$. (atomic mass of gold = 197 u)
- (i) What is the closest distance between gold atoms?
(ii) How many "nearest neighbours" does each gold atom have?
(iii) What is the density of gold?
16. (i) Osmotic pressure of a solution containing 7 g of dissolved protein per 100 cm^3 of solution is 25 mm Hg at body temperature (310 K). Calculate the molecular mass of protein ($R = 0.08205 \text{ L atm mol}^{-1} \text{ deg}^{-1}$).
(ii) Calculate the boiling point of a solution containing 0.456 g of camphor (molar mass = 152 g mol^{-1}) dissolved in 31.4 g of acetone (b.p. = 56.30°C), if the molal elevation constant of acetone is $1.72^\circ\text{C kg mol}^{-1}$.
17. Calculate the molarity of a solution of CaCl_2 , if it is found that 200 cm^3 of CaCl_2 solution contains 3.01×10^{22} chloride ions. Assume that CaCl_2 is completely ionised in solution.
18. (i) Graphite is a conductor of electricity. Give reasons.
(ii) How will you differentiate between *hcp* and *ccp* lattice?
19. What will be the osmotic pressure of a 0.1 M monobasic acid, if its pH is 2.0 at 25°C ?
20. How many mL of 0.1 M HCl are required to react completely with 1 g mixture of Na_2CO_3 and NaHCO_3 containing equimolar amounts of the two?
21. Aluminium crystallises in a cubic close packed structure. Radius of the atom in the metal is 125 pm.
(i) What is the length of the unit cell?
(ii) How many unit cells are there in 1 cm^3 of aluminium?
22. (i) Based on solute-solvent interactions arrange the following in order of increasing solubility in *n*-octane and explain.
Cyclohexane, KCl, CH_3OH , CH_3CN
(ii) Two elements *A* and *B* form compounds having molecular formula AB_2 and AB_4 . When dissolved in 20 g of benzene (C_6H_6), 1 g of AB_2 lowers the freezing point by 2.3 K whereas 1 g of AB_4 lowers it by 1.3 K. The molal depression constant for benzene is $5.1 \text{ K kg mol}^{-1}$. Calculate atomic masses of *A* and *B*.
23. Aamir, a science student dismantled an old electronic gadget to know about its components. He found that the gadget is composed of various chips, wires and other small components fitted on a circuit plate. To further explore, he searched about these chips and other components on internet and found that majority of these components are made up of a specific class of solids.
(i) What are the values shown by Aamir?
(ii) What is this class of solids called?
(iii) Explain why this class of solids is used to prepare components of electric devices?
(iv) What is the conductivity range of this class of solids?
24. (i) Heating crystals of KCl in potassium vapours makes crystals violet, why?
(ii) The density of KBr is 2.75 g cm^{-3} . The length of edge of the unit cell is 654 pm. Predict the type of cubic lattice to which unit cell of KBr belongs. ($N_A = 6.023 \times 10^{23} \text{ mol}^{-1}$,
Atomic mass : K = 39, Br = 80)

- (iii) Sodium has a *bcc* structure with nearest neighbour distance 365.9 pm. Calculate its density (Atomic mass of sodium = 23).

OR

- (i) Refractive index of a solid is observed to have the same value along all directions. Comment on the nature of this solid. Would it show cleavage property?
- (ii) (a) Sodium chloride is insulator in solid state but conductor in aqueous solution. Explain why?
(b) What kind of magnetic properties are exhibited by ions of NaCl?
(c) What type of defects are generally observed in sodium chloride?
25. (i) Why is camphor preferred as a solvent in determination of depression in freezing point (ΔT_f)?
(ii) Aquatic species are more comfortable in cold water rather than in warm water. Why?
(iii) The vapour pressures of pure liquids *A* and *B* are 450 and 700 mm Hg at 350 K respectively. Find out the composition of the liquid mixture, if total vapour pressure is 600 mm Hg. Also, find the composition of the vapour phase.

OR

- (i) When kept in water, raisins swell in size. Name and explain the phenomenon involved with the help of a diagram. Give three applications of the phenomenon.
- (ii) Explain why on addition of 1 mol of NaCl to 1 litre of water, the boiling point of water increases, while addition of 1 mol of methyl alcohol to one litre of water decreases its boiling point.
26. (i) Frenkel defects are not found in alkali metals. Explain.
(ii) Br^- ions form close packed structure. If the radius of Br^- ion is 195 pm, calculate the radius of the cation that just fits in the tetrahedral hole. Can a cation A^+ having a radius of 82 pm be slipped into the octahedral hole of the crystal A^+B^- .
(iii) (a) Name the non-stoichiometric point defect responsible for colour in alkali metal halides.
(b) What is Piezoelectric effect? Explain with suitable example.

OR

- (i) In terms of band theory, what is the difference
(a) between a conductor and an insulator
(b) between a conductor and a semiconductor?
- (ii) Non-stoichiometric cuprous oxide, Cu_2O can be prepared in the laboratory. In this oxide, copper to oxygen ratio is slightly less than 2:1. Can you account for the fact that this substance is a *p*-type semiconductor?



- Amorphous solids which have tendency to flow slowly and resemble liquids in many respects are called pseudo solids or super cooled liquids. *e.g.*, glass.
- De-icing agent is a substance which prevents the formation of ice by lowering the freezing point of water to such an extent that it does not freeze to form ice.
- Each lattice point represents one constituent particle of the solid which may be an atom, an ion, or a molecule.
- Fe_3O_4 is ferrimagnetic at room temperature because in its crystals magnetic domains of Fe (II) and Fe (III) ions are unequal in magnitude and aligned in parallel and antiparallel directions but when heated at 850 K, the arrangement is randomised and substance becomes paramagnetic.
- Covalent or network solid.
- An ideal crystal is one which has the same unit cell containing the same lattice points across the whole crystal. But when crystallisation of solids takes place specially at fast or moderate rate some deviations from ideal arrangement may be introduced which are called defects. Thus, crystals are usually imperfect.
- When a solute undergoes association in the solution then the number of solute particles decreases. Hence, the colligative property will be lower and the molar mass will be higher *e.g.*, $2\text{CH}_3\text{COOH} \longrightarrow (\text{CH}_3\text{COOH})_2$.
 - When a solute undergoes dissociation in solution then the number of solute particles increases. Hence, colligative property will be higher and the molar mass will be lower *e.g.*, $\text{NaCl} \longrightarrow \text{Na}^+ + \text{Cl}^-$.
- In a cubic crystal system, there are two types of voids known as octahedral and tetrahedral voids. If r is the radius of void and R is the radius of atom creating these voids then

$$\left(\frac{r}{R}\right)_{\text{octa}} = 0.414 \quad \text{and} \quad \left(\frac{r}{R}\right)_{\text{tetra}} = 0.225$$

The above radius ratio values indicate that octahedral void has larger radius hence, for maximum diameter of atom to be present in interstitial space.

$$r = 0.414 R$$

Also, in *fcc*, $4R = \sqrt{2}a$

Diameter required ($2r$) = $(2R) \times 0.414$

$$= \frac{a}{\sqrt{2}} \times 0.414 = \frac{400 \times 0.414}{\sqrt{2}} = 117 \text{ pm}$$

OR

- When silicon is doped with boron which contains only three valence electrons, a hole is created at the place where the fourth valence electron is missing. This hole increases the conductivity and this type of semiconductors are called *p*-type semiconductors.
 - As all the magnetic moments are aligned in one direction hence, the substance will show ferromagnetism.
9. Solubility of H_2S = 0.195 m = 0.195 mol in 1000 g of the solvent (water)

$$n_{\text{H}_2\text{O}} = \frac{1000 \text{ g}}{18 \text{ g mol}^{-1}} = 55.55 \text{ moles}$$

$$\therefore x_{\text{H}_2\text{S}} = \frac{n_{\text{H}_2\text{S}}}{n_{\text{H}_2\text{S}} + n_{\text{H}_2\text{O}}} = \frac{0.195}{0.195 + 55.55} = \frac{0.195}{55.745} = 0.0035$$

Pressure at STP = 0.987 bar

Applying Henry's law, $p_{\text{H}_2\text{S}} = K_{\text{H}} \times x_{\text{H}_2\text{S}}$

$$\text{or } K_{\text{H}} = \frac{p_{\text{H}_2\text{S}}}{x_{\text{H}_2\text{S}}} = \frac{0.987 \text{ bar}}{0.0035} = 282 \text{ bar.}$$

10. Schottky defects exist in pairs to maintain electrical neutrality. So, equal number of cation and anion vacancies are generated. Ionic solids are doped with metal ions of higher valency and some cations of lower valency are displaced to maintain electrical neutrality. Hence, only cation vacancies are produced not anion vacancies.

11. (i) Given $d = 8.55 \text{ g cm}^{-3}$, $M = 93 \text{ g mol}^{-1}$, $Z = 2$ (for *bcc*), $N_{\text{A}} = 6.022 \times 10^{23}$, $r = ?$

Using formula,

$$a^3 = \frac{M \times Z}{d \times N_{\text{A}}} = \frac{93 \times 2}{8.55 \times 6.022 \times 10^{23}}$$

or, $a^3 = 3.61 \times 10^{-23} = 36.1 \times 10^{-24} \text{ cm}^3$
 $\therefore a = 3.304 \times 10^{-8} \text{ cm} = 330.4 \times 10^{-12} \text{ m}$
 $= 330.4 \text{ pm}$

For body-centred cubic,

$$r = \frac{\sqrt{3}}{4}a = 0.433a = 0.433 \times 330.4 \text{ pm}$$

$$= 143.1 \text{ pm}$$

- (ii) The size and shape of a unit cell is determined by the lengths of the edges of the unit cell (a , b and c) which may or may not be mutually perpendicular and by the angles α , β and γ between the edges b and c , c and a and a and b respectively.

12. Since, $1 \text{ atm} = 1.01325 \times 10^5 \text{ pascal}$
Hence, $2.5 \text{ atm} = 2.5 \times 1.01325 \times 10^5 \text{ pascal}$
 $= 2.533125 \times 10^5 \text{ pascal}$

By Henry's law $p_{\text{CO}_2} = K_H x_{\text{CO}_2}$

$$x_{\text{CO}_2} = \frac{p_{\text{CO}_2}}{K_H} = \frac{2.533125 \times 10^5 \text{ Pa}}{1.67 \times 10^8 \text{ Pa}}$$

$$= 1.52 \times 10^{-3}$$

Also, 500 mL soda water (water containing CO_2)
 $= 500 \text{ g}$ (assuming density of water $= 1 \text{ g mL}^{-1}$)

$$n_{\text{H}_2\text{O}} = \frac{500}{18} = 27.77 \text{ mol}$$

Let $n_{\text{CO}_2} = n \text{ mol}$

$$\therefore \text{Total moles} = 27.77 + n$$

$$\therefore x_{\text{CO}_2} = \frac{n}{27.77 + n} = 1.52 \times 10^{-3}$$

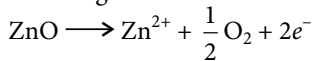
$$\therefore \frac{n}{27.77} = 1.52 \times 10^{-3} \quad (\because n \ll 27.77)$$

$$\therefore n_{\text{CO}_2} = 1.52 \times 10^{-3} \times 27.77 \text{ mol}$$

$$= 0.0422 \text{ mol} = 0.0422 \text{ mol} \times 44 \text{ g mol}^{-1}$$

$$= 1.8568 \text{ g}$$

13. (i) On heating ZnO loses oxygen according to the following reaction :



Zn^{2+} ions are entrapped in the interstitial voids and electrons are entrapped in the neighbouring interstitial voids to maintain electrical neutrality. These electrons absorb visible light and radiate yellow colour.

- (ii) (a) 15 ppm means 15 parts per million, i.e., 15 parts of CHCl_3 in 10^6 parts by mass of the solution.

$$\therefore \% \text{ by mass} = \frac{15}{10^6} \times 100 = 15 \times 10^{-4} \%$$

- (b) Taking 15 g chloroform in 10^6 g of the solution so, mass of solvent $= 10^6 \text{ g}$

$$\text{Molar mass of } \text{CHCl}_3 = 12 + 1 + 3 \times 35.5$$

$$= 119.5 \text{ g mol}^{-1}$$

$$\therefore n_{\text{CHCl}_3} = \frac{15}{119.5}$$

$$\therefore \text{Molality} = \frac{n_{\text{CHCl}_3}}{w_{\text{H}_2\text{O}} (\text{in g})} \times 1000$$

$$= \frac{15/119.5}{10^6} \times 1000 = 1.25 \times 10^{-4} \text{ m}$$

14. This solution of benzene and toluene will boil at 25°C when the pressure above the solution is equal to the sum of the vapour pressures of benzene and toluene in the solution.

$$p_{\text{C}_6\text{H}_6}^\circ = 93.4 \text{ torr}, p_{\text{C}_6\text{H}_5\text{CH}_3}^\circ = 26.9 \text{ torr}$$

$$w_{\text{C}_6\text{H}_6} = 35 \text{ g}, w_{\text{C}_6\text{H}_5\text{CH}_3} = 65 \text{ g}$$

$$\text{Molar mass of } \text{C}_6\text{H}_6 = 12 \times 6 + 1 \times 6$$

$$= 72 + 6 = 78 \text{ g mol}^{-1}$$

$$\text{Therefore, } n_{\text{C}_6\text{H}_6} = \frac{35}{78} = 0.449$$

$$\text{Molar mass of } \text{C}_6\text{H}_5\text{CH}_3 = 12 \times 7 + 8 \times 1 = 92 \text{ g mol}^{-1}$$

$$\text{Therefore, } n_{\text{C}_6\text{H}_5\text{CH}_3} = \frac{65}{92} = 0.707$$

Now, the mole fractions of C_6H_6 and $\text{C}_6\text{H}_5\text{CH}_3$ are

$$x_{\text{C}_6\text{H}_6} = \frac{n_{\text{C}_6\text{H}_6}}{n_{\text{C}_6\text{H}_6} + n_{\text{C}_6\text{H}_5\text{CH}_3}}$$

$$= \frac{0.449}{0.449 + 0.707} = \frac{0.449}{1.156} = 0.388$$

$$x_{\text{C}_6\text{H}_5\text{CH}_3} = \frac{n_{\text{C}_6\text{H}_5\text{CH}_3}}{n_{\text{C}_6\text{H}_5\text{CH}_3} + n_{\text{C}_6\text{H}_6}}$$

$$= \frac{0.707}{0.707 + 0.449} = \frac{0.707}{1.156} = 0.612$$

Therefore, vapour pressures of C_6H_6 and $\text{C}_6\text{H}_5\text{CH}_3$ are

$$p_{\text{C}_6\text{H}_6} = p_{\text{C}_6\text{H}_6}^\circ \times x_{\text{C}_6\text{H}_6} = 93.4 \times 0.388 = 36.24 \text{ torr}$$

$$p_{\text{C}_6\text{H}_5\text{CH}_3} = p_{\text{C}_6\text{H}_5\text{CH}_3}^\circ \times x_{\text{C}_6\text{H}_5\text{CH}_3}$$

$$= 26.9 \times 0.612 = 16.46 \text{ torr}$$

\therefore Total vapour pressure of the solution,

$$P_{\text{total}} = p_{\text{C}_6\text{H}_6} + p_{\text{C}_6\text{H}_5\text{CH}_3} = 36.24 + 16.46 = 52.7 \text{ torr}$$

15. (i) This is because glass is a supercooled liquid (amorphous solid) and it flows down very slowly making the bottom portion slightly thicker.

- (ii) There is perfect arrangement of the constituent particles only at absolute zero (0 K). This arrangement corresponds to lowest energy. As temperature increases, deviation from perfectly ordered arrangement starts and number of defects increases with temperature. Hence, the defects are called thermodynamic defects.



- (iii) On applying high pressure, NaCl acquires the CsCl structure *i.e.*, the coordination number changes from 6 : 6 to 8 : 8.

OR

- (i) Given, edge length = $a = 4.070 \text{ \AA}$
Closest distance between two gold atoms in *fcc* lattice

$$(d) = 2r = \frac{2 \times a}{2\sqrt{2}}$$

$$\Rightarrow d = \frac{a}{\sqrt{2}} = \frac{4.070}{\sqrt{2}} = 2.878 \text{ \AA}$$

- (ii) Coordination number of each ion in *fcc* lattice is 12 hence, the number of nearest neighbours = 12

$$(iii) d = \frac{ZM}{N_A a^3} = \frac{4 \times 197}{6.02 \times 10^{23} \times (4.07 \times 10^{-8})^3} = 19.4 \text{ g/cm}^3$$

16. (i) We know that

$$\pi V = n_2 RT$$

$$\pi V = \frac{w_2}{M_2} RT \text{ or } M_2 = \frac{w_2 RT}{\pi V}$$

$$\text{Here, } w_2 = 7 \text{ g, } \pi = 25 \text{ mm Hg} = \frac{25}{760} \text{ atm}$$

$$R = 0.08205 \text{ L atm mol}^{-1} \text{ deg}^{-1} \text{ and}$$

$$V = \frac{100}{1000} = 0.1 \text{ litre}$$

$$T = 310 \text{ K}$$

$$\therefore M_2 = \frac{7 \times 0.08205 \times 310 \times 760}{25 \times 0.1} = 54126.7 \text{ g mol}^{-1}$$

- (ii) We know that,

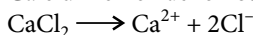
$$\Delta T_b = \frac{1000 K_b w_2}{M_2 w_1 (\text{in g})} = \frac{1000 \times 1.72 \times 0.456}{152 \times 31.4} = 0.16$$

$$\therefore \Delta T_b = \text{Boiling point of solution} - \text{boiling point of solvent}$$

$$\therefore 0.16 = \text{Boiling point of solution} - 56.30$$

$$\Rightarrow \text{Boiling point of solution} = 0.16 + 56.30 = 56.46^\circ\text{C}$$

17. Calcium chloride ionises as follows :



\Rightarrow 1 mole of CaCl_2 gives 2 moles of Cl^- ions.

i.e., $2 \times 6.02 \times 10^{23}$ Cl^- ions are obtained from 1 mole of CaCl_2 .

$\therefore 3.01 \times 10^{22}$ Cl^- ions will be obtained from

$$= \frac{3.01 \times 10^{22}}{2 \times 6.02 \times 10^{23}} = \frac{1}{40} \text{ mole of } \text{CaCl}_2$$

Thus, 200 mL solution contains $\frac{1}{40}$ mole of CaCl_2 .

\therefore 1000 mL solution will contain

$$= \frac{1}{40} \times \frac{1000}{200} = 0.125 \text{ mol of } \text{CaCl}_2$$

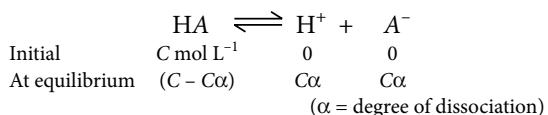
Therefore, molarity of solution is 0.125 M.

18. (i) In graphite, three electrons of each carbon atom are covalently bonded to three other C-atoms of its own layer. The fourth valence electron of each atom forms a delocalised layer of mobile electrons. This is why graphite is a conductor of electricity.

- (ii) In *hcp* lattice, each third layer is parallel to first layer *i.e.*, *ABAB*..... type arrangement.

In *ccp* lattice, each fourth layer is parallel to the first layer *i.e.*, *ABCABC*..... type arrangement.

- 19.



$$\Rightarrow [\text{H}^+] = C\alpha$$

$$\text{But } [\text{H}^+] = 10^{-2} \text{ M} \quad [\because \text{pH} = 2]$$

$$\therefore C\alpha = 10^{-2}$$

$$\text{or } \alpha = \frac{10^{-2}}{C} = \frac{10^{-2}}{0.1} = 0.1$$

Total number of particles after dissociation

$$= C - C\alpha + C\alpha + C\alpha = C(1 + \alpha)$$

$$\therefore \text{van't Hoff factor, } (i) = \frac{C(1 + \alpha)}{C}$$

$$= 1 + \alpha = 1 + 0.1 = 1.1$$

$$\therefore \text{Osmotic pressure } (\pi) \text{ of the monobasic acid} \\ = iCRT = 1.1 \times 0.1 \times 0.0821 \times 298 = 2.69 \text{ atm}$$

20. Let 1 g mixture contains x g of Na_2CO_3 .

$$\therefore \text{Number of moles of } \text{Na}_2\text{CO}_3 = \frac{x}{106} \text{ mol}$$

$$[\because \text{molar mass of } \text{Na}_2\text{CO}_3 = 106 \text{ g mol}^{-1}]$$

$$\text{and number of moles of } \text{NaHCO}_3 = \frac{1-x}{84}$$

$$[\because \text{molar mass of } \text{NaHCO}_3 = 84 \text{ g mol}^{-1}]$$

As the mixture contains equimolar amounts of the two therefore,

$$\frac{x}{106} = \frac{1-x}{84} \Rightarrow x = 0.558 \text{ g}$$

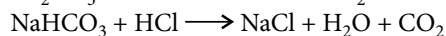
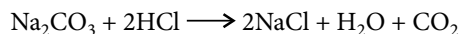
$$\therefore \text{No. of moles of } \text{Na}_2\text{CO}_3 = \frac{0.558}{106} = 0.00526$$

$$\text{and no. of moles of } \text{NaHCO}_3 = \frac{1-0.558}{84}$$

$$= 0.00526 \text{ mol}$$



Reactions of HCl with Na_2CO_3 and NaHCO_3 take place as follows :



From the reaction, 1 mol of Na_2CO_3 requires
2 moles of HCl
 \therefore 0.00526 mol of Na_2CO_3 will require 2×0.00526
= 0.01052 mole of HCl

Similarly, 1 mol of NaHCO_3 requires 1 mole of HCl
 \therefore 0.00526 mol of NaHCO_3 will require 0.00526×1
= 0.00526 mole of HCl

\therefore Total moles of HCl required = 0.01052 + 0.00526
= 0.01578 mol

0.1 M solution of HCl means that

0.1 mol of HCl is present in 1000 mL of solution

\therefore 0.01578 mol of HCl will be present in
= $\frac{1000 \times 0.01578}{0.1}$ = 157.8 mL of HCl solution.

21. (i) For cubic closed packed structure,

$$\text{edge length, } a = \frac{4r}{\sqrt{2}} = 2\sqrt{2}r$$

$$= 2\sqrt{2} \times 125 \text{ pm} = 250\sqrt{2} \text{ pm} = 353.55 \text{ pm}$$

$$= 353.55 \times 10^{-12} \text{ m} = 353.55 \times 10^{-10} \text{ cm}$$

(ii) Volume of 1 unit cell = $(353.55 \times 10^{-10})^3 \text{ cm}^3$
= $4.4193 \times 10^{-23} \text{ cm}^3$

$$4.4193 \times 10^{-23} \text{ cm}^3 = 1 \text{ unit cell}$$

$$\therefore 1 \text{ cm}^3 = \frac{1 \text{ unit cell}}{4.4193 \times 10^{-23}}$$

$$= 2.263 \times 10^{22} \text{ unit cells}$$

22. (i) Solubility in *n*-octane :

$\text{KCl} < \text{CH}_3\text{CN} < \text{CH}_3\text{OH} < \text{Cyclohexane}$.

The order can be explained on the basis of 'like dissolves like'. *n*-Octane is a non polar solvent hence, non polar compounds will be highly soluble in *n*-octane. KCl is an ionic compound, CH_3CN is more polar than CH_3OH and cyclohexane is non polar.

Therefore, solubility increases with decreasing polarity.

(ii) Applying the formula,

$$M_2 = \frac{1000 \times K_f \times w_2}{w_1 \times \Delta T_f}$$

$$M_{AB_2} = \frac{1000 \times 5.1 \times 1}{20 \times 2.3} = 110.87 \text{ g mol}^{-1}$$

$$M_{AB_4} = \frac{1000 \times 5.1 \times 1}{20 \times 1.3} = 196.15 \text{ g mol}^{-1}$$

Suppose atomic masses of A and B are 'a' and 'b' respectively. Then

Molar mass of $AB_2 = a + 2b = 110.87 \text{ g mol}^{-1}$

Molar mass of $AB_4 = a + 4b = 196.15 \text{ g mol}^{-1}$

Eqn. (ii) - Eqn. (i) gives $2b = 85.28$ or $b = 42.64$

Substituting in eqn. (i) we get,

$$a + 2 \times 42.64 = 110.87 \quad \text{or} \quad a = 25.59$$

Thus, atomic mass of A = 25.59 u

atomic mass of B = 42.64 u

23. (i) Curiosity to learn or discover new things and appropriate usage of resources are the values shown by Aamir.

(ii) Semiconductors is the class of solids used in the components of electric devices.

(iii) In electronic devices, there is need to control the current flow in the circuit which is possible only in semiconductors by appropriate doping. However, if conductors are used then such control is not possible and they conduct the whole amount of current from the power source.

(iv) Conductivity range of semiconductors is 10^{-6} to $10^4 \text{ ohm}^{-1} \text{ m}^{-1}$.

24. (i) KCl becomes violet coloured when heated in potassium vapours as there are excess of K^+ ions which attract Cl^- ions and electrons are trapped at the site of anion forming F-centres. These electrons absorb energy from visible light and radiate complimentary violet colour.

(ii) For cubic crystals,

$$d = \frac{Z \times M}{a^3 \times N_A} \quad \text{or,} \quad Z = \frac{d \times a^3 \times N_A}{M}$$

$$\therefore Z = \frac{(2.75 \text{ g cm}^{-3})(654 \times 10^{-10} \text{ cm})^3 \times (6.023 \times 10^{23})}{(39 + 80) \text{ g mol}^{-1}}$$

$$= 3.89 = 4$$

So, there are four formula units of KBr present per unit cell. Hence, it has face-centred cubic lattice.

(iii) For the *bcc* structure, nearest neighbour distance (*d*) is related to the edge length (*a*) as

$$d = \frac{\sqrt{3}}{2} a$$

$$\text{or, } a = \frac{2}{\sqrt{3}} d = \frac{2}{1.732} \times 365.9 = 422.5 \text{ pm}$$

For *bcc* structure, $Z = 2$

For sodium, $M = 23$

$$\text{Density, } \rho = \frac{Z \times M}{a^3 \times N_A}$$



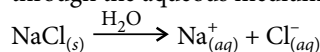
$$\rho = \frac{2 \times 23 \text{ g mol}^{-1}}{(422.5 \times 10^{-10} \text{ cm})^3 \times (6.02 \times 10^{23} \text{ mol}^{-1})} = 1.013 \text{ g/cm}^3$$

OR

(i) As the solid has same value of refractive index along all directions, it is isotropic in nature. It is because there is no long range order and the arrangement is irregular along all the directions and hence, amorphous. Being an amorphous solid, it would not show a clean cleavage when cut with a knife. Instead, it would break into pieces with irregular surfaces.

(ii) (a) In solid state of sodium chloride (NaCl), cations (Na^+) and anions (Cl^-) are held together by strong electrostatic (Coulombic) forces hence, it does not carry electrical charges.

But in the presence of water, sodium chloride gets hydrolysed and splits in cations (Na^+) and anions (Cl^-) which are free to move and carry electrical charges through the aqueous medium.



Hence, sodium chloride which is insulator in solid state, carries charges in aqueous solution and becomes a good conductor.

(b) The electronic configuration of Na^+ is $1s^2 2s^2 2p^6$ and that of Cl^- is $1s^2 2s^2 2p^6 3s^2 3p^6$. As no unpaired electron is present in both the ions hence, both will exhibit diamagnetic properties.

(c) Schottky defect and metal excess defect are generally observed in sodium chloride.

25. (i) Camphor has very high molal depression constant ($K_f = 39.70 \text{ K kg mol}^{-1}$) therefore, depression in freezing point will be large even when small quantity of a solute is added. This would be easily measurable even by an ordinary thermometer.

(ii) Aquatic species need dissolved oxygen for breathing. As the solubility of gas, e.g., O_2 decreases with rise in temperature, less oxygen is available in warm water. Hence, they feel more comfortable in cold water when rather more dissolved oxygen is available.

(iii) Given, $p_A^\circ = 450 \text{ mm}$, $p_B^\circ = 700 \text{ mm}$,

$$P_{\text{total}} = 600 \text{ mm}$$

According to Raoult's law, $p_A = x_A \times p_A^\circ$

$$p_B = x_B \times p_B^\circ = (1 - x_A) p_B^\circ$$

$$P_{\text{total}} = p_A + p_B = x_A p_A^\circ + (1 - x_A) p_B^\circ$$

$$= p_B^\circ + (p_A^\circ - p_B^\circ) x_A$$

On substituting the values, we get

$$600 = 700 + (450 - 700) x_A$$

$$\text{or } 250 x_A = 100$$

$$\text{or } x_A = \frac{100}{250} = 0.40$$

Thus, composition of the liquid mixture will be

mole fraction of A (x_A) = 0.40,

mole fraction of B (x_B) = $1 - 0.40 = 0.60$

$$\therefore p_A = x_A \times p_A^\circ = 0.40 \times 450 \text{ mm} = 180 \text{ mm}$$

$$p_B = x_B \times p_B^\circ = 0.60 \times 700 \text{ mm} = 420 \text{ mm}$$

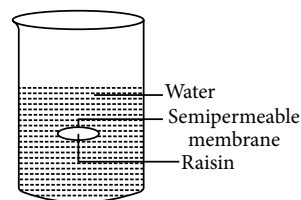
Thus, mole fraction of A in vapour phase

$$= \frac{p_A}{p_A + p_B} = \frac{180}{180 + 420} = 0.30$$

$$\text{Mole fraction of B in vapour phase} = 1 - 0.30 = 0.70$$

OR

(i) This phenomenon is called endosmosis, i.e., movement of water inside the raisin which can be shown with the help of diagram as :



The process of osmosis is of immense biological as well as industrial importance. It is evident from the following examples :

(a) Movement of water from soil into plant roots and subsequently into upper portion of the plant is partly due to osmosis.

(b) Preservation of meat against bacterial action by addition of salt.

(c) Preservation of fruits against bacterial action by adding sugar. Bacteria in canned fruits lose water through the process of osmosis and become inactive.

(ii) NaCl is a non-volatile solute hence, it lowers the vapour pressure of water and boiling point of water increases. Methyl alcohol is a volatile



solute hence, it increases the vapour pressure and results in decrease in boiling point of water.

26. (i) Alkali metal ions have large size and cannot fit into interstitial sites. Hence, Frenkel defect is not found in alkali metals.

(ii) Radius of cation that just fits in the tetrahedral hole,

$$r = 0.225 R$$

or, $r = 0.225 \times 195 = 43.875 \text{ pm}$

For octahedral void, $\frac{r}{R} = 0.414 \text{ to } 0.732$

Radius ratio of given ions, $\frac{r_+}{r_-} = \frac{82}{195} = 0.4205$

As the ratio lies in the range of radius of octahedral void hence, cation A^+ can be slipped into the octahedral void of A^+B^- crystal.

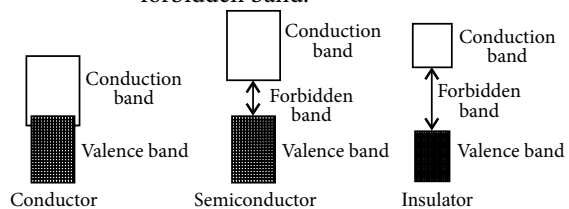
(iii) (a) Metal excess defects due to anionic vacancies result in the formation of F -centres. These F -centres produce colour in alkali metal halides.

(b) When the electricity is produced by applying mechanical stress on some polar crystals, it is known as piezoelectric effect. Quartz shows this property.

OR

(i) (a) According to band theory the energy gap between valence band and conduction band (Forbidden band) in insulator is very large whereas in a conductor valence band and conduction band overlap with each other, it has no forbidden band.

(b) Conductors have no forbidden band whereas semiconductors have small forbidden band.



(ii) Copper to oxygen ratio in Cu_2O is less than 2:1. Thus, the solid has Cu^+ ions less than required. This solid has cation vacancies which are produced when some of Cu^+ ions are replaced by Cu^{2+} ions and holes are produced. Thus, this substance is a p -type semiconductor.

