CONCEPT MAP

ESSENTIALS OF CHEMISTRY

Some important formulae, trends and terms for a 'quick recap'. **Class XI**

Physical Chemistry

Some Basic Concepts of Chemistry

- Atomic mass ; $\dfrac{\text{Average mass of an atom}}{\frac{1}{12}\times\text{Mass of an atom of C-12}}$
- Number of gram atoms = $\dfrac{\text{Mass of an element}}{\text{Gram atomic mass}}$
- Atomic mass = 6.4/Specific heat (cal/g)
- Gram molar volume = 22.4 L
- Molecular mass = 2 × Vapour density
- Molarity = No. of moles/Volume (L)
- Normality = No. of gram equivalents/Volume (L)
- % of an element = $\dfrac{\text{O cuu"qh"vj g"gngo gpv}}{\text{Molecular mass}}\times 100$

Structure of Atom

- $E = h\upsilon = \dfrac{hc}{\lambda} = \dfrac{1}{\lambda} = \bar{\upsilon} = R\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)\ \text{cm}^{+1}$; mvr ; $\dfrac{nh}{2\pi}$
- r_n ; $\dfrac{n^2}{Z}\times 0.529\,\text{Å}$; $E_n = \dfrac{+Z^2}{n^2}\times 13.6$ eV per atom
- v_n ; $\dfrac{Z}{n}\times 2.188\times 10^8$ cm/s; $P.E. = \dfrac{+kZe^2}{r}$
- $K.E.$; $\dfrac{1}{2}\dfrac{kZe^2}{r}$; $Bx\cdot\Delta p \geq \dfrac{h}{4\pi}$

Chemical Bonding

- Ionic potential ; $\dfrac{\text{Charge on cation}}{\text{Size of cation}}$
- % of ionic character = $16(\chi_A - \chi_B) + 3.5(\chi_A - \chi_B)^2$
- Dipole moment, $\mu = q \times d$
- % of ionic character = $\dfrac{\kappa_{\text{observed}}}{\mu_{\text{theoretical}}}\times 100$

States of Matter

- $P_1V_1 = P_2V_2$; $\dfrac{V_3}{T_1} = \dfrac{V_2}{T_2}$; $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$; $\dfrac{V_1}{n_1}$; $\dfrac{V_2}{n_2}$; $PV = nRT$
- $d = \dfrac{PM}{RT} = \dfrac{r_3}{r_2} = \sqrt{\dfrac{M_2}{M_1}} = \sqrt{\dfrac{d_2}{d_1}}$; $K.E.$; $\dfrac{3}{2}kT$
- $c_{rms} = \sqrt{5RT/M}$; $c_{mp} = \sqrt{2RT/M}$; $c_{av} = \sqrt{8RT/\pi M}$
- $T_b = a/Rb$; $T_c = 8a/27Rb$; $P_c = a/27b^2$; $V_c = 3b$
- Z ; $\dfrac{PV_m}{nRT}$; $P_cV_c = \dfrac{5}{8}RT_c$; $\left(P + \dfrac{n^2a}{V^2}\right)(V - nb) = nRT$

Thermodynamics

- $w_{irr} = -P\Delta V$
- w_{rev} ; $-2.303nRT\log\dfrac{V_2}{V_1} = -2.303nRT\log\dfrac{P_1}{P_2}$
- $\Delta H = \Delta E + \Delta n_g RT$; $C_v = \left(\dfrac{"E}{\partial T}\right)_V$; $C_p = \left(\dfrac{\partial H}{\partial T}\right)_p$
- $\log\dfrac{P_2}{P_1} = \dfrac{\text{B}H_{vap}}{2.303R}\left(\dfrac{T_2 - T_1}{T_1T_2}\right)$
- $\Delta S = 2.303nR\log\left(\dfrac{V_4}{V_1}\right)$; $\Delta G = \Delta H - T\Delta S$
- $\Delta G° = -2.303\,RT\log K$

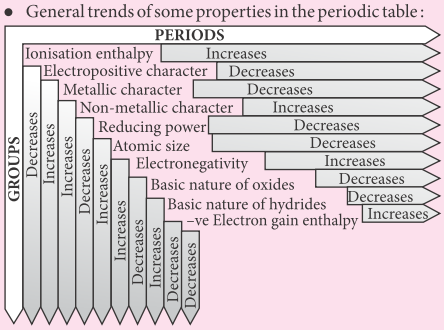
Equilibrium

- $\dfrac{k_f}{k_b}$; $K_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$; $K_p = \dfrac{p_C^c p_D^d}{p_A^a p_B^b}$; $K_p = K_c(RT)^{\Delta n}$
- $\log\dfrac{K_4}{K_1} = \dfrac{\Delta H}{2.303R}\left(\dfrac{T_2 - T_1}{T_1T_2}\right)$; $K = \dfrac{C\alpha^4}{1-\alpha} = C\alpha^2$
- $K_w = K_a \times K_b$; $K_{sp} = [A^{y+}]^x \cdot [B^{x-}]^y$
- pH = $\text{p}K_a + \log\dfrac{]\text{Uc}\nu}{[\text{Acid}]}$; pOH ; $\text{p}K_b + \log\dfrac{[\text{Salt}]}{[\text{Base}]}$
- pH ; $\dfrac{1}{2}[\text{p}K_w - \text{p}K_b - \log C]$ (for salt of strong acid and weak base)
- pH = $\dfrac{3}{2}[\text{p}K_w + \text{p}K_a - \text{p}K_b]$ (for salt of weak acid and weak base)
- pH ; $\dfrac{1}{2}[\text{p}K_w + \text{p}K_a + \log C]$ (for salt of weak acid and strong base)

Inorganic Chemistry

Classification of Elements and Periodicity in Properties

- General trends of some properties in the periodic table :



Redox Reactions

- **Oxidation :** Addition of O or electronegative element; Removal of H or electropositive element; Loss of e's; increase in O. No.
- **Reduction :** Addition of H or electropositive element; Removal of O or electronegative element; Gain of e's; decrease in O. No.
- **Redox reactions :** Oxidation and reduction occur simultaneously.
- **Oxidising agent :** Oxidises others and itself gets reduced.
- **Reducing agent :** Reduces others and itself gets oxidised.

Hydrogen

- Strength of 10 vol. of H_2O_2 solution = 30.35 g/L
- Volume strength = 5.6 × Normality
- Volume strength = 11.2 × Molarity
- **Ortho hydrogen :** Parallel nuclear spins; total nuclear spin = + 1/2 + 1/2 = 1
- **Para hydrogen :** Antiparallel nuclear spins; total nuclear spin = + 1/2 – 1/2 = 0

The *s*- and *p*-Block Elements

- **Basic strength :** LiOH < NaOH < KOH < RbOH < CsOH
  - $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$
  - $B(OH)_3 < Al(OH)_3 < Ga(OH)_3 < In(OH)_3 < Tl(OH)_3$
- **Stability :** $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
  - $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$
  - $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$
- **Solubility :** $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$
  - $BeSO_4 > MgSO_4 > CaSO_4 > \underbrace{SrSO_4 > BaSO_4}_{\text{Almost insoluble}}$
  - $BeC_2O_4 > \underbrace{CaC_2O_4 < SrC_2O_4 < BaC_2O_4}_{\text{Sparingly soluble in water}}$
- **Stability of oxidation states :**
  - $B^{3+} > Al^{3+} > Ga^{3+} > In^{3+} > Tl^{3+}$
  - $B^{+} < Al^{+} < Ga^{+} < In^{+} < Tl^{+}$
  - $Ge^{4+} > Sn^{4+} > Pb^{4+}$
  - $Ge^{2+} < Sn^{2+} < Pb^{2+}$
- **Lewis acid character :**
  - $BX_3 > AlX_3 > GaX_3 > InX_3$
  - $BF_3 < BCl_3 < BBr_3 < BI_3$
- **Catenation tendency :** C >> Si > Ge ≈ Sn >> Pb
- **Acidic strength :**

$\underbrace{CO_2}_{\text{Acidic}} > \underbrace{SiO_2}_{\text{Less acidic}} > \underbrace{GeO_2 > SnO_2 > PbO_2}_{\text{Amphoteric}}$

Acids and Bases

- **Lewis acid :** An electron pair acceptor
- **Lewis base :** An electron pair donor.
- **Arrhenius acid :** Gives H^+ ion in aq. solution.
- **Arrhenius base :** Gives OH^- ion in aq.solution.
- **Bronsted acid :** Proton donor
- **Bronsted base :** Proton acceptor

Environmental Chemistry

- **Classical smog:** Reducing smog, occurs in cool and humid climate, mixture of smoke, fog and sulphur dioxide.
- **Photochemical smog:** Oxidising smog, occurs in warm, dry and sunny climate, mixture of nitrogen oxides and volatile organic compounds.
- **International standard for drinking water :**
  F^- – 1 ppm; SO_4^{2-} – < 500 ppm
  Pb – 50 ppb; NO_3^- – 50 ppm; pH – 5.5 - 9.5

Organic Chemistry

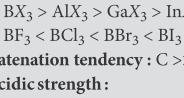
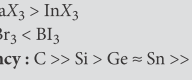
Some Basic Principles and Techniques

- **Preference order of functional groups :** Carboxylic acids > sulphonic acids > anhydrides > esters > acid chlorides > acid amides > nitriles > isocyanides > aldehydes > ketones > alcohols > phenols > thiols > amines > alkenes > alkynes
- **Stability order :**
  Carbocations : $3° > 2° > 1° > \overset{+}{C}H_3$
  Carbanions : $\bar{C}H_3 > 1° > 2° > 3°$
  Free radicals : $3° > 2° > 1° > \dot{C}H_3$
- **–*I* effect :** $-NO_2 > -CN > -COOH > -F > -Cl > -Br > -I > -H$
- **+*I* effect :** $(CH_3)_3C- > (CH_3)_2CH- > CH_3CH_2- > CH_3- > D- > H-$
- **+*R* effect :** $-OH$, $-OR$, $-SH$, $-SR$, $-NH_2$, $-NHR$, $-NR_2$, $-Cl$, $-Br$, $-I$
- **–*R* effect :** $>C=O$, $-CHO$, $-COOR$, $-CN$, $-NO_2$

Quantitative Estimation

- **Liebig's combustion method :**
  % of C ; $\dfrac{12}{44}\times\dfrac{\text{Mass of } CO_2 \text{ formed}}{\text{Mass of compound taken}}\times 100$
  % of H ; $\dfrac{2}{18}\times\dfrac{\text{Mass of } H_2O \text{ formed}}{\text{Mass of compound taken}}\times 100$
- **Dumas method :**
  % of N = $\dfrac{28}{22400}\times\dfrac{\text{Vol. of } N_4 \text{ at STP}}{\text{Wt. of compound}}\times 100$
- **Kjeldahl's method :**
  % of N = $\dfrac{1.4\times M_{ccid}\times V_{acid}\times\text{Basicity of acid}}{\text{Wt. of compound}}$
- **Carius method :**
  ' "qh'X
  = $\dfrac{\text{At. wt. of } X}{108 + \text{At. wt. of } X}\times\dfrac{\text{Wt. of AgX formed}}{\text{Wt. of compound}}\times 100$
  % of S = $\dfrac{32}{233}\times\dfrac{\text{Wt. of } BaSO_6 \text{ formed}}{\text{Wt. of compound}}\times 100$
- **Ignition method :**
  % of P = $\dfrac{62}{222}\times\dfrac{\text{Wt. of } Mg_4P_4O_9 \text{ formed}}{\text{Wt. of compound}}\times 100$
- **Iodine method :**
  % of O = $\dfrac{32}{88}\times\dfrac{\text{Wt. of } CO_4 \text{ formed}}{\text{Wt. of compound}}\times 100$

Hydrocarbons

- **Conformations of ethane :**
  Staggered > Skew or Gauche > Eclipsed
- **Conformations of cyclohexane :**
  Chair > Twist-boat > Boat > Half-chair
- **Stability order of different alkenes :**
  $R_2C=CR_2 > R_2C=CHR > R_2C=CH_2 >$  $>$  $> RCH=CH_2 > CH_2=CH_2$
- ***o*-,*p*-directing groups :**
  $-R$, $-OH$, $-SH$, $-NH_2$, $-O^-$, $-OR$, $-NHR$, $-NR_2$, $-NHCOR$, $-Cl$, $-Br$, $-I$, $-CH_2Cl$, $-CH_2OH$, $-CH_2NH_2$, $-CH_2CN$, $-CH_2COOH$, $-CH=CH_2$, $-CH=CHCOOH$, $-C_6H_5$, $-N=N$, $-NC$, etc.
- ***m*-directing groups :**
  $-SO_3H$, $-NO_2$, $-CHO$, $-COOH$, $-CN$, $-NH_3Cl$, $-SO_2Cl$, $-COCl$, $-COOR$, $-COR$, $-CONH_2$, $-CCl_3$, $-CF_3$, $-\overset{+}{N}H_3$, $-\overset{+}{N}H_2R$, $-\overset{+}{N}HR_2$, $-\overset{+}{N}R_3$, etc.
- **Aromatic compounds :** Cyclic, completely conjugated system of *p*-orbitals in ring, planar, $(4n+2)\pi$-e's.
- **Anti-aromatic compounds :** Cyclic, completely conjugated system of *p*-orbitals in ring, planar, $4n\,\pi$-e's.
- **Non-aromatic compounds :** Does not satisfy any one or more of the above conditions.