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 : $\frac{\text{Average mass of an atom}}{\frac{1}{12}\times \text{Mass of an atom of C-12}}$
- Number of gram atoms = $\frac{\text{Mass of an element}}{\text{Gram atomic mass}}$
- 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 = $\frac{\text{Mass of element in compound}}{\text{Molecular mass}}\times 100$

Structure of Atom

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

Chemical Bonding

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

States of Matter

- $P_1V_1 = P_2V_2$; $\frac{V_1}{T_1} = \frac{V_2}{T_2}$; $\frac{P_1}{T_1} = \frac{P_2}{T_2}$; $\frac{V_1}{n_1} = \frac{V_2}{n_2}$; $PV = nRT$
- $d = \frac{PM}{RT}$; $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{d_2}{d_1}}$; $K.E._{av} = \frac{3}{2}kT$
- $c_{rms} = \sqrt{3RT/M}$; $c_{mp} = \sqrt{2RT/M}$; $c_{av} = \sqrt{8RT/\pi M}$
- $T_b = a/Rb$; $T_c = 8a/27Rb$; $P_c = a/27b^2$; $V_c = 3b$
- $Z = \frac{PV_m}{nRT}$; $P_cV_c = \frac{3}{8}RT_c$; $\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$

Thermodynamics

- $w_{irr} = -P\Delta V$
- $w_{rev} = -2.303nRT\log\frac{V_2}{V_1} = -2.303nRT\log\frac{P_1}{P_2}$
- $\Delta H = \Delta E + \Delta n_gRT$; $C_v = \left(\frac{\partial E}{\partial T}\right)_V$; $C_p = \left(\frac{\partial H}{\partial T}\right)_P$
- $\log\frac{P_2}{P_1} = \frac{\Delta H_{vap}}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$
- $\Delta S = 2.303nR\log\left(\frac{V_2}{V_1}\right)$; $\Delta G = \Delta H - T\Delta S$
- $\Delta G^\circ = -2.303RT\log K$

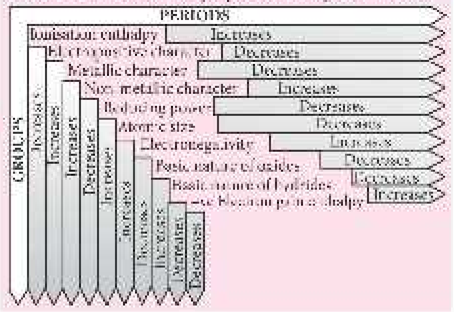
Equilibrium

- $\frac{k_f}{k_b} = K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$, $K_p = \frac{p_C^c p_D^d}{p_A^a p_B^b}$; $K_p = K_c(RT)^{\Delta n}$
- $\log\frac{K_2}{K_1} = \frac{\Delta H}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$; $K = \frac{C\alpha^2}{1-\alpha} \approx C\alpha^2$
- $K_w = K_a\times K_b$; $K_{sp} = [A^{y+}]^x[B^{x-}]^y$
- $pH = pK_a + \log\frac{[\text{Salt}]}{[\text{Acid}]}$; $pOH = pK_b + \log\frac{[\text{Salt}]}{[\text{Base}]}$
- $pH = \frac{1}{2}[pK_w - pK_b - \log C]$ (for salt of strong acid and weak base)
- $pH = \frac{1}{2}[pK_w + pK_a - pK_b]$ (for salt of weak acid and weak base)
- $pH = \frac{1}{2}[pK_w + pK_a + \log C]$ (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 :** $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$
  $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$ ($SrSO_4$, $BaSO_4$: Almost insoluble)
  $BeC_2O_4 > CaC_2O_4 < SrC_2O_4 < BaC_2O_4$ (CaC_2O_4, SrC_2O_4, BaC_2O_4: 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 :**
  $CO_2 > SiO_2 > GeO_2 > SnO_2 > PbO_2$ (CO_2, SiO_2: Acidic; GeO_2: Less acidic; SnO_2, PbO_2: 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 = $\frac{12}{44}\times\frac{\text{Mass of } CO_2 \text{ formed}}{\text{Mass of compound taken}}\times 100$
  % of H = $\frac{2}{18}\times\frac{\text{Mass of } H_2O \text{ formed}}{\text{Mass of compound taken}}\times 100$
- **Dumas method :**
  % of N = $\frac{28}{22400}\times\frac{\text{Vol. of } N_2 \text{ at STP}}{\text{Wt. of compound}}\times 100$
- **Kjeldahl's method :**
  % of N = $\frac{1.4\times M_{acid}\times V_{acid}\times \text{Basicity of acid}}{\text{Wt. of compound}}$
- **Carius method :**
  % of X = $\frac{\text{At. wt. of } X}{108 + \text{At. wt. of } X}\times\frac{\text{Wt. of AgX formed}}{\text{Wt. of compound}}\times 100$
  % of S = $\frac{32}{233}\times\frac{\text{Wt. of } BaSO_4 \text{ formed}}{\text{Wt. of compound}}\times 100$
- **Ignition method :**
  % of P = $\frac{62}{222}\times\frac{\text{Wt. of } Mg_2P_2O_7 \text{ formed}}{\text{Wt. of compound}}\times 100$
- **Iodine method :**
  % of O = $\frac{32}{88}\times\frac{\text{Wt. of } CO_2 \text{ formed}}{\text{Wt. of compound}}\times 100$

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.