ESSENTIALS OF CHEMISTRY

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

Class XII

Physical Chemistry

The Solid State

- **Density of unit cell:** $d = \frac{Z \times M}{a^3 \times N_A}$ g cm^{-3}
- **Total no. of atoms per unit cell:**

sc	bcc	fcc
$8 \times \frac{1}{8} = 1$	$8 \times \frac{1}{8} + 1 \times 1 = 2$	$8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$

- **Relation between d, a and r**
  $sc: r = \frac{d}{2} = \frac{a}{2}$; $fcc: r = \frac{d}{2} = \frac{a}{2\sqrt{2}}$; $bcc: r = \frac{d}{2} = \frac{\sqrt{3}a}{4}$
- **Coordination number and packing efficiency**
  sc : CN = 6, PE = 52.4%; bcc : CN = 8, PE = 68%; fcc : CN = 12, PE = 74%
- **Size and no. of voids:**

Type	Size	No. of Voids
Octahedral	$0.414\ R$	N
Tetrahedral	$0.225\ R$	$2N$

Solutions

- **Expression for concentration of a solution:**
  $M = \frac{w_2 \times 1000}{M_2 \times V_{(\text{in mL})}}$; $N = \frac{w_2 \times 1000}{E_2 \times V_{(\text{in mL})}}$
  $x_2 = \frac{n_2}{n_1 + n_2}$, $x_1 = \frac{n_1}{n_1 + n_2}$; ppm $= \frac{w_2}{M_{\text{soln}}} \times 10^6$
- **On mixing solutions:** $N_1V_1 + N_2V_2 = N_3(V_1 + V_2)$; $M_1V_1 + M_2V_2 = M_3(V_1 + V_2)$
- **For liquid solutions:** $p_A = x_A \times p_A^\circ$; $p_B = x_B \times p_B^\circ$;
  $P_{\text{total}} = p_A + p_B$; $y_A = \frac{p_A}{p_A + p_B}$, $y_B = 1 - y_A$
- **Colligative properties:** $\Delta T_b = iK_b \times m$
  $\Delta T_f = iK_f \times m$; $\pi = i\frac{n}{V}RT$; $\frac{p^\circ - p_s}{p^\circ} = x_2$
  $\alpha_{(\text{disso.})} = \frac{i-1}{n-1}$; $\alpha_{(\text{asso.})} = (1-i)\frac{n}{n-1}$
  $i = \frac{M_c}{M_o}$ or $\frac{C_o}{C_c}$ (where M = molar mass, C = colligative property)

Electrochemistry

- $R = \frac{V}{I}$; $G = \frac{1}{R}$; $\rho = R\frac{a}{l}$; $\kappa = G \times \frac{l}{a}$
- $\Lambda_{eq} = \kappa \times V = \kappa \times \frac{1000}{N}$; $\Lambda_m = \kappa \times V = \kappa \times \frac{1000}{M}$
- $\Lambda_m^c = \Lambda_m^\infty - b\sqrt{C}$; $\Lambda_{eq}^\infty = \lambda_c^\infty + \lambda_a^\infty$; $\Lambda_m^\infty = x\lambda_c^\infty + y\lambda_a^\infty$
- $\alpha = \frac{\Lambda_m^c}{\Lambda_m^\infty}$; $\Delta G^\circ = -nFE^\circ_{cell} = -RT \ln K_c$
- $W = ZIt$; $\frac{W_1}{W_2} = \frac{E_1}{E_2}$; $E^\circ_{cell} = E^\circ_{(cathode)} - E^\circ_{(anode)}$
- $E_{cell} = E^\circ_{cell} - \frac{0.0591}{n}\log\frac{1}{[M^{n+}]}$; $E^\circ_{cell} = \frac{0.0591}{n}\log K_c$

Chemical Kinetics

- **Expressions for different orders:**

Rate law	Integrated rate law	Half-life
Rate $= k[A]^0$ [0 order]	$[A]_t = -kt + [A]_0$	$t_{1/2} = [A]_0/2k$
Rate $= k[A]^1$ [1st order]	$\ln[A]_t = -kt + \ln[A]_0$	$t_{1/2} = 0.693/k$
Rate $= k[A]^2$ [2nd order]	$1/[A]_t = kt + 1/[A]_0$	$t_{1/2} = 1/k[A]_0$
Rate $= k[A][B]$ [2nd order]	$kt = \frac{1}{[A]_0 - [B]_0}\ln\frac{[B]_0[A]}{[A]_0[B]}$	$t_{1/2} = 1/k[A]_0$
Rate $= k[A]^n$ [nth order]	$(n-1)kt = \frac{1}{[A]^{n-1}} - \frac{1}{[A]_0^{n-1}}$	$t_{1/2} = \frac{2^{n-1}-1}{k(n-1)[A]_0^{n-1}}$

- **Arrhenius equation:**
  $k = Ae^{-E_a/RT}$; $\log\frac{k_2}{k_1} = \frac{E_a}{2.303\,R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$

Surface Chemistry

- **–vely charged sols:** Metals, sulphides, acidic dyes, starch, clay, silk.
- **+vely charged sols:** Metal hydroxides, oxides, basic dyes, haemoglobin.
- **Hardy–Schulze rule:** Coagulation power for –vely charged sols: $Al^{3+} > Ba^{2+} > Na^+$
  +vely charged sols: $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$

Inorganic Chemistry

General Principles and Processes of Isolation of Elements

Main steps involved in extraction of metals:

- **Concentration of the ore:** *Hydraulic separation*: for oxide ores; *Froth floatation*: for sulphide ores; *Electromagnetic separation*: for magnetic impurities/ores; *Leaching*: chemical method
- **Conversion of ore to oxide:** *Calcination*: for carbonates and hydrated oxides; *Roasting*: for sulphide ores.
- **Reduction of oxide into free metal:** *Smelting*: Reduction with carbon; *Alumino thermite process*: Reduction with Al; *Auto-reduction*: for less electropositive metals; *Electrometallurgy*: Electrolysis of fused oxide
- **Refining of crude metal:** *Liquation*: for metals having low b.pts.; *Distillation*: for volatile metals; *Poling*: for metals having own oxides as impurities; *Electrorefining*: for Cu, Ag, Au, Ni, Cr, Al; *Zone refining*: for Si, Ge, Ga; *van Arkel method*: for Ti, Zr; *Chromatography*: for elements available in minute quantities.

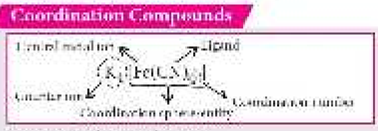
The p-Block Elements

- **Group 15 (Nitrogen family):**
  - *Bond angle, Thermal stability and Basic strength*: $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$
  - *B.Pt.*: $PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$
    M.Pt.: $PH_3 < AsH_3 < SbH_3 < NH_3$
  - *Reducing nature*: $NH_3 < PH_3 < AsH_3 < SbH_3 < BiH_3$
  - *Bond angle*: $PF_3 < PCl_3 < PBr_3 < PI_3$
  - *Lewis acid strength*: $PCl_3 > AsCl_3 > SbCl_3$; $PF_3 > PCl_3 > PBr_3 > PI_3$
- **Group 16 (Oxygen family):** *Bond angle and Thermal stability*: $H_2O > H_2S > H_2Se > H_2Te$
  - *Volatility*: $H_2S > H_2Se > H_2Te > H_2O$
  - *Acidic strength and Reducing nature*: $H_2O < H_2S < H_2Se < H_2Te$
  - *Stability*: $SF_6 > SeF_6 > TeF_6$
- **Group 17 (Halogen family):**
  - *Oxidising power*: $F_2 > Cl_2 > Br_2 > I_2$
  - *B.Pt. and M.Pt.*: $HF > HCl < HBr < HI$
  - *Dipole moment and Thermal stability*: $HF > HCl > HBr > HI$
  - *Bond length, Acidic strength and Reducing nature*: $HF < HCl < HBr < HI$
  - *Acidic strength*: $HClO < HClO_2 < HClO_3 < HClO_4$; $HOCl > HOBr > HOI$; $HClO_4 > HBrO_4 > HIO_4$
  - *Oxidising power*: $HClO > HClO_2 > HClO_3 > HClO_4$
- **Group 18 (Noble gases):** *M.Pt., B.Pt., Ease of liquefaction, Solubility, Adsorption and Polarizability*: He < Ne < Ar < Kr < Xe
  - *Thermal conductivity*: He > Ne > Ar > Kr > Xe

d- and f-Block Elements

- **d-block elements:** $(n-1)d^{1-10}ns^{0-2}$
  - *3d series*: $_{21}Sc - _{30}Zn$
  - *4d series*: $_{39}Y - _{48}Cd$; *5d series*: $_{57}La, _{72}Hf - _{80}Hg$
  - *6d series*: $_{89}Ac, _{104}Rf - _{112}Cn$
  - *Acidic character*: $MnO < Mn_3O_4 < Mn_2O_3 < MnO_2 < Mn_2O_7$; *Ionic character*: $MnO > Mn_3O_4 > Mn_2O_3 > MnO_2 > Mn_2O_7$
- **f-block elements:** $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$
  - $La(OH)_3$ to $Lu(OH)_3$: Basicity decreases; La^{3+} to Lu^{3+} : Tendency to form complexes increases

Coordination Compounds



- **Spectrochemical series:**
  $I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edta^{4-} < NH_3 < en < NO_2^- < CN^- < CO$
- $\mu = \sqrt{n(n+2)}$ B.M.; $\Delta_t = \frac{4}{9}\Delta_o$
- CFSE $= (-0.4x + 0.6y)\Delta_o$ where, x = no. of e^-s in t_{2g} orbitals, y = no. of e^-s in e_g orbitals

Organic Chemistry

Haloalkanes and Haloarenes

- **Reactivity order:** RI > RBr > RCl; 3° > 2° > 1°; S_N1 reaction: 3° > 2° > 1°; S_N2 reaction: 1° > 2° > 3°
- **Dipole moments:**
  - $CH_3Cl > CH_3F > CH_3Br > CH_3I$
  - $CH_3Cl > CH_2Cl_2 > CHCl_3 > CCl_4$ (zero)
  - o-Dichlorobenzene > m-dichlorobenzene ≥ chlorobenzene > p-dichlorobenzene (zero)

Alcohols, Phenols and Ethers

- **Acidity:** Phenols > water > 1° alcohol > 2° alcohol > 3° alcohol
- **Distinction test of alcohols:**

Alcohol	Dichromate (Oxidation) test	Victor Meyer's test	Lucas test
1°	Acid (Orange solution becomes green)	Blood red colour	No turbidity
2°	Ketone (Orange solution becomes green)	Blue colour	Turbidity in 5 minutes
3°	No reaction	Colourless	Turbidity immediately

- **Distinction test of phenol:**

Test	Observation
$FeCl_3$ test	Violet colour
Br_2-H_2O test	White ppt.
Liebermann's nitroso test ($NaNO_2$ + conc. H_2SO_4)	Deep green/blue colour which changes into red on dilution.
Azo dye test	Orange colour

Aldehydes, Ketones and Carboxylic Acids

- **Reactivity order towards S_N reactions:** HCHO > RCHO > PhCHO > RCOR > RCOPh > PhCOPh
- **Distinction test of aldehydes & ketones:**

Test	Aldehydes	Ketones
Schiff's reagent	Pink colour	No colour
Fehling's solution	Red ppt.	No ppt.
Tollens' reagent	Silver mirror	No ppt.

- **Acidity:** Carboxylic acids > Phenols > Alcohols
- **Distinction test of carboxylic acids:**

Test	Carboxylic acids	Phenols
$NaHCO_3$	Brisk effervescence of CO_2 gas	No reaction
$FeCl_3$	Buff coloured ppt.	Violet colour

Amines

- **Basic nature:** Aliphatic amine > NH_3 > aromatic amine; 3° > 2° > 1° > NH_3 [in gas phase in non aq. solvent]; 2° > 1° > 3° > NH_3 [in aq. phase only $-CH_3$ substituted amines]; 2° > 3° > 1° > NH_3 [in aq. phase only $-C_2H_5$ substituted amines]
- **Distinction test (Hinsberg's test):**
  $C_6H_5SO_2Cl$ + 1°, 2° or 3° amines
  → Clear solution $\xrightarrow{KOH}$ Soluble salt [1° amine]
  → ppt. $\xrightarrow{KOH}$ No reaction [2° amine]
  → No reaction [3° amine]
  - $ArN_2^+X^-$ are more stable than $RN_2^+X^-$.
  - EDGs stabilise while EWGs destabilise the diazonium salts.

Biomolecules

- **Reducing sugars:** All monosaccharides
- **Non reducing sugars:** All polysaccharides and disaccharides like sucrose.
- **Fat soluble vitamins:** A, D, E and K.
- **Water soluble vitamins:** B_1, B_2, B_6, B_{12} and C

Polymers

- **Addition homopolymers:** Polythene, polystyrene
- **Condensation homopolymers:** Nylon-6, PHB
- **Addition copolymers:** Buna-S, Buna-N
- **Condensation copolymers:** Nylon-6,6
- **Biodegradable copolymers:** PHBV, Nylon-2-nylon-6