

# CLASS 12 - CHEMISTRY

## FORMULA BOOK

### THE SOLID STATE

- ☛ **Calculation of number of particles per unit cell**
- ☐ Contribution of each atom present on the corner =  $\frac{1}{8}$

- ☐ Contribution of each atom present on the face =  $\frac{1}{2}$

- ☐ Contribution of each atom present on the edge centre =  $\frac{1}{4}$

- ☐ Contribution of each atom present at the body centre = 1

- ☛ **Relation between radius ( $r$ ) of a void and the radius ( $R$ ) of the spheres in the close packing**

- ☐ Radius ( $r$ ) of the tetrahedral void =  $0.225R$
- ☐ Radius ( $r$ ) of the octahedral void =  $0.414R$

- ☛ **Radius ratio rules**

Radius ratio ( $r_+/r_-$ )	Coordination Number	Structural arrangement
0.155–0.225	3	Planar triangular
0.225–0.414	4	Tetrahedral
0.414–0.732	6	Octahedral
0.732–1	8	Body-centred cubic

- ☛ **Relation between no. of voids and spheres in the packing**

- ☐ No. of octahedral voids = No. of atoms (ions) present in the close packing.
- ☐ No. of tetrahedral voids =  $2 \times$  No. of atoms (ions) in the close packing  
=  $2 \times$  No. of octahedral voids.

- ☛ **Relation between nearest neighbour distance ( $d$ ) and edge ( $a$ ) of cubic unit cell**

- ☐ Simple  $d = a$
- ☐ Body-centred  $d = \frac{\sqrt{3}}{2} a = 0.866 a$
- ☐ Face-centred  $d = \frac{a}{\sqrt{2}} = 0.707 a$
- ☛ **Relation between atomic radius  $r$  ( $= \frac{d}{2}$  for pure elements) and edge ( $a$ ) of cubic unit cell**

Simple	Body-centred	Face-centred
$r = \frac{a}{2}$	$r = \frac{\sqrt{3}}{4} a$ = $0.433 a$	$r = \frac{a}{2\sqrt{2}}$ = $0.3535 a$

- ☛ **Calculation of density of a cubic crystal from its edge**

$$\rho = \frac{Z \times M}{a^3 \times N_0 \times 10^{-30}} \text{ g/cm}^3$$

- ☐ **For elements:**

$Z$  = no. of atoms/unit cell (1 for simple, 2 for bcc and 4 for fcc)  
 $M$  = atomic mass of the element  
 $a$  = edge of the unit cell in pm  
 $N_0$  = Avogadro's number.

- ☐ **For ionic compounds:**

$Z$  = no. of formula units in one unit cell  
 e.g. 4 for NaCl and ZnS, 1 for CsCl, etc.  
 $M$  = formula mass (molecular mass) of the compound  
 $a$  = edge =  $2 \times$  distance between  $\text{Na}^+$  and  $\text{Cl}^-$  in case of NaCl.

- ☛ **Ionic and covalent radii :**

- ☐ Interionic distance in  $A^+B^- = r_{A^+} + r_{B^-}$
- ☐ Bond length of a covalent molecule  
 $(A-A) = 2 \times r_A$
- ☐ Bond length of a covalent molecule  
 $(A-B) = r_A + r_B$

- ☛ **No. of cation vacancies:** Each ion like  $\text{Sr}^{2+}$  when introduced into  $\text{Na}^+\text{Cl}^-$  creates one cation vacancy because for electrical neutrality, one  $\text{Sr}^{2+}$  replaces two  $\text{Na}^+$  ions.

### SOLUTIONS

- % by wt. =  $\frac{\text{wt. of the solute in g}}{\text{wt. of the solution in g}} \times 100$
- % by wt./vol. =  $\frac{\text{wt. of solute in g}}{\text{Vol. of solution in cc}} \times 100$
- % by volume =  $\frac{\text{Vol. of solute in cc}}{\text{Vol. of solution in cc}} \times 100$
- Strength of a solution =  $\frac{\text{wt. of the solution in g}}{\text{Vol. of solution in litres}}$
- Molarity =  $\frac{\text{Moles of the solute}}{\text{Vol. of solution in cc}} \times 1000$   
where moles =  $\frac{\text{Mass of the solute in g}}{\text{Molecular mass of the solute}}$
- Normality =  $\frac{\text{g. Eq. of the solute}}{\text{Vol. of solution in cc}} \times 1000$   
where g eq. =  $\frac{\text{Mass of the solute in g}}{\text{Eq. mass of the solute}}$
- Normality of a solution = Molarity  $\times \frac{\text{Mol. mass}}{\text{Eq. mass}}$
- Normality of an acid = Molarity  $\times$  Basicity
- Normality of a base = Molarity  $\times$  Acidity
- Molality =  $\frac{\text{Moles of solute}}{\text{Mass of the solvent in g}} \times 1000$
- Mole fraction of solute in solution  
$$(x_2) = \frac{n_2}{n_1 + n_2} = \frac{w_2/M_2}{w_1/M_1 + w_2/M_2}$$
- Mole fraction of solvent in solution  
$$(x_1) = \frac{n_1}{n_1 + n_2} = \frac{w_1/M_1}{w_1/M_1 + w_2/M_2}$$
  
where  $w_1, M_1$  are mass and molecular mass of solvent and  $w_2, M_2$  for the solute.  $x_1 + x_2 = 1$ .
- In general, for a solution containing many components (A, B, C.....), mole fraction of A.  
$$(x_A) = \frac{n_A}{n_A + n_B + n_C + \dots}$$
 and so on.  
$$x_A + x_B + \dots = 1$$
- Mass fraction of component A ( $x_A$ ) =  $\frac{w_A}{w_A + w_B}$

- Mass fraction of component B ( $x_B$ ) =  $\frac{w_B}{w_A + w_B}$   
$$x_A + x_B = 1$$
- Parts per million (ppm) of substance A  
$$= \frac{\text{Mass of A}}{\text{Mass of solution}} \times 10^6 \text{ or } \frac{\text{Vol. of A}}{\text{vol. of solution}} \times 10^6$$
- Normality equation (for dilution of a solution or for a complete reaction between two solutions)  
$$N_1 V_1 = N_2 V_2$$
- Molarity equation (for dilution of a solution)  
$$M_1 V_1 = M_2 V_2$$
- If two non-reacting solutions of different normalities are mixed, the normality of the final solution can be calculated using relations :  
$$N_1 V_1 + N_2 V_2 = N_3 V_3$$
- According to Henry's law :  $p_A = k_H x_A$   
where  $k_H$  = Henry's constant
- According to **Raoult's law**, for a solution containing volatile components A and B,  
$$p_A = x_A p_A^\circ \text{ and } p_B = x_B p_B^\circ$$
  
$$P_{\text{Total}} = p_A + p_B = x_A p_A^\circ + x_B p_B^\circ$$
  
$$= (1 - x_B) p_A^\circ + x_B p_B^\circ = (p_B^\circ - p_A^\circ) x_B + p_A^\circ$$
  
Mole fraction of A in the vapour phase  
$$= \frac{p_A}{p_A + p_B}$$
- Raoult's law for non-volatile solutes :  
$$\frac{p^\circ - p_s}{p^\circ} = \frac{n_2}{n_1 + n_2} \approx \frac{n_2}{n_1}$$
  
(if solution is dilute i.e. < 5%)  
$$= \frac{w_2/M_2}{w_1/M_1 + w_2/M_2} \approx \frac{w_2/M_2}{w_1/M_1}$$
  
(if solution is dilute)
- Osmotic pressure,  $\pi = \frac{n}{V} RT$  where  $n = \frac{w}{M}$
- For isotonic solutions,  $\pi_1 = \pi_2$  which means at the same temp.  $C_1 = C_2$ .
- Elevation in boiling point,  $\Delta T_b = K_b m$  where  $K_b$  = molal elevation constant and  $m$  = molality of the solution.
- Units of  $K_b = \Delta T_b / m = \text{deg./molality} = \frac{\text{K}}{\text{mol kg}^{-1}}$   
$$= \text{K kg mol}^{-1}$$

- $M_2 = \frac{1000 K_b w_2}{w_1 \Delta T_b}$  if  $K_b$  is molal elevation constant per 1000 g of the solvent.  
However if  $K_b$  is per 100 g of the solvent,

$$M_2 = \frac{100 K_b w_2}{w_1 \Delta T_b}$$

- Depression in freezing point,  $\Delta T_f = K_f m$  where  $K_f$  = molal depression constant and  $m$  = molality of the solution.
- Units of  $K_f$  = same as those of  $K_b$ .
- $M_2 = \frac{1000 K_f w_2}{w_1 \Delta T_f}$  if  $K_f$  is per 1000 g of the solvent or  $M_2 = \frac{100 K_f w_2}{w_1 \Delta T_f}$  if  $K_f$  is per 100 g of the solvent.

- $K_b = \frac{RT_0^2}{1000 l_v} = \frac{M_1 RT_0^2}{1000 \Delta H_v}$   
where  $T_0$  = boiling point of the liquid (pure solvent)  $l_v$  = latent heat of vaporisation per g of the solvent  $\Delta H_v$  = latent heat of vaporisation per mole of the solvent.  
 $M_1$  = molecular mass of the solvent.  
 $R$  = gas const. =  $8.314 \text{ JK}^{-1} \text{ mol}^{-1}$  if  $l_v$  or  $\Delta H_v$  is in calories.

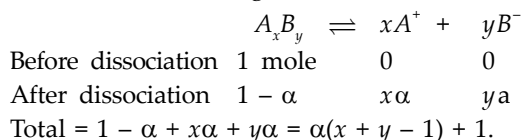
- $K_f = \frac{RT_0^2}{1000 l_f} = \frac{M_1 RT_0^2}{1000 \Delta H_f}$   
where  $T_0$  = freezing point of the liquid (pure solvent)  $l_f$  = latent heat of fusion per g of the solvent  
 $\Delta H_f$  = latent heat of fusion per mole of the solvent  
 $M_1$  = molecular mass of the solvent  
 $R$  = gas const.  $8.314 \text{ JK}^{-1} \text{ mol}^{-1}$ .

- Van't Hoff factor ( $i$ ) =  $\frac{\text{Observed value of Colligative property}}{\text{Calculated value of Colligative property}}$   
 $= \frac{\text{Calculated mol. mass}}{\text{Observed mol. mass}} = \frac{M_c}{M_o}$   
 $\left( \because \text{Mol mass} \propto \frac{1}{\text{Colligative property}} \right)$

- For solutes undergoing dissociation/association

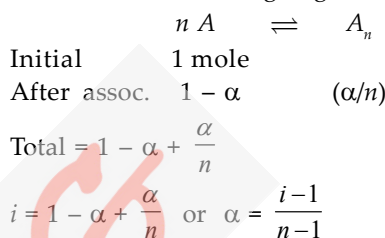
$$\Delta T_b = i K_b m, \Delta T_f = i K_f m, \pi = i \frac{n}{V} RT$$

- For an electrolyte  $A_x B_y$  undergoing dissociation with degree of dissociation  $\alpha$ .



$$i = \alpha(x + y - 1) + 1 \text{ or } \alpha = \frac{i - 1}{x + y - 1}$$

- For a solute  $A$  undergoing association



### ELECTROCHEMISTRY

- According to Ohm's law (Resistance),  
 $R = \frac{V}{I} = \frac{\text{volt}}{\text{amperes}} = \Omega \text{ (ohm)}$
- Conductance ( $C$ ) =  $\frac{1}{R} = \text{Ohm}^{-1}$  or Mho or Siemens (S)
- $R = \rho \times \frac{l}{a}$   
where  $l$  = distance between electrodes in cm,  
 $a$  = area of cross-section of electrodes in  $\text{cm}^2$   
 $\rho$  = specific resistance, where  $\frac{l}{a} = \frac{R}{\rho}$  cell constant ( $\text{cm}^{-1}$ )
- Specific conductance,  $\kappa = \frac{1}{\rho}$  or  
 $\kappa = \frac{1}{R} \cdot \frac{l}{a} = C \times \text{cell constant}$   
 $= \text{ohm}^{-1} \text{ cm}^{-1}$  or  $\text{S cm}^{-1}$
- Equivalent conductance,  
 $\Lambda_{eq} = \kappa \times V = \frac{\kappa \times 1000}{C_{eq}} = \frac{\kappa \times 1000}{\text{normality}}$   
Unit =  $\text{ohm}^{-1} \text{ cm}^2 \text{ g equiv}^{-1}$  or  $\text{S cm}^2 \text{ g equiv}^{-1}$
- Molar conductance,  
 $\Lambda_m = \kappa \times V = \frac{\kappa \times 1000}{C_m} = \frac{\kappa \times 1000}{\text{molarity}}$   
Unit =  $\text{ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$  or  $\text{S cm}^2 \text{ mol}^{-1}$

- For a sparingly soluble salt *e.g.* AgCl, BaSO<sub>4</sub>, etc.

$$\text{Solubility (mol l}^{-1}\text{)} = \frac{\kappa \times 1000}{\Lambda_m^\circ}$$

- Debye Huckel-Onsager equation is  $\Lambda_m = \Lambda_m^\circ - b\sqrt{C}$  [ $\Lambda_m$  = molar conductivity at *C* concentration,  $\Lambda_m^\circ$  is molar conductivity at infinite dilution, *b* = constant.]

- According to Kohlrausch's law molar conductance  $\Lambda_m^\circ = x\lambda_c^\circ + y\lambda_a^\circ$  where  $\lambda_c^\circ$  and  $\lambda_a^\circ$  are molar conductivities of cation and anion respectively. Equivalent conductance at infinite dilution

$$\Lambda_{eq}^\infty = \lambda_c^\circ + \lambda_a^\circ$$

- Degree of dissociation  $\alpha = \frac{\Lambda_m^c}{\Lambda_m^\circ}$   
=  $\frac{\text{Molar conductance at a given concentration}}{\text{Molar conductance at infinite dilution}}$

- Molar conductivity at infinite dilution for weak electrolytes

$$e.g. \Lambda^\circ_{\text{CH}_3\text{COOH}} = \Lambda^\circ_{\text{CH}_3\text{COONa}} + \Lambda^\circ_{\text{HCl}} - \Lambda^\circ_{\text{NaCl}}$$

- Faraday's first law: Weight of the substance liberated at anode

$$w = ZIt = ZQ, Z = \text{electrochemical equivalent, } I = \text{current passed for time } t \text{ seconds}$$

- Faraday's second law :

$$\frac{\text{wt. of metal } A}{\text{wt. of metal } B} = \frac{\text{Eq. wt. of } A}{\text{Eq. wt. of } B}$$

- 1 F = 96500 C

- Electrochemical equivalent of a substance

$$= \frac{\text{atomic weight}}{n \times 96500} = \frac{\text{Eq. wt. of the substance}}{96500}$$

- $E_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$

- $E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{n} \log \frac{[\text{Reduced state}]}{[\text{Oxidised state}]}$

- ☞ For the cell :  $aA + bB \rightarrow xX + yY$  ;

- $E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{n} \log \frac{[X]^x [Y]^y}{[A]^a [B]^b}$  at 25°C

- $\Delta G^\circ = -nFE^\circ$  (in standard state)

- $\Delta G^\circ = -RT \ln K = -2.303 RT \log K$

$$E^\circ_{\text{cell}} = \frac{RT}{nF} \ln K = \frac{2.303RT}{nF} \log K$$

$$= \frac{0.0591}{n} \log K \text{ at } 25^\circ\text{C}$$

- Thermodynamic efficiency  $\eta = \frac{\Delta G}{\Delta H} = -\frac{nFE}{\Delta H}$

- $\Delta G_3^\circ = \Delta G_1^\circ + \Delta G_2^\circ$  (when different number of electrons are involved)

$$-n_3FE_3^\circ = -n_1FE_1^\circ - n_2FE_2^\circ$$

$$n_3E_3^\circ = n_1E_1^\circ + n_2E_2^\circ$$

$$\text{or } E_3^\circ = \frac{n_1E_1^\circ + n_2E_2^\circ}{n_3}$$

$$\text{If } n_1 = n_2 = n_3, E_3^\circ = E_1^\circ + E_2^\circ$$

- $E_{\text{H}^+/\text{H}_2} = E^\circ_{\text{H}^+/\text{H}_2} - 0.0591 \log \frac{1}{[\text{H}^+]}$   
=  $0 - 0.0591(-\log[\text{H}^+]) = -0.0591 \text{ pH}$

$$\therefore \text{pH} = -\log[\text{H}^+]$$

As pH of the solution increases, electrode potential of hydrogen electrode decreases.

- For concentration cell  $\text{Zn} \mid \text{Zn}^{++}_{(C_1)} \parallel \text{Zn}^{++}_{(C_2)} \mid \text{Zn}$

$$E_{\text{cell}} = \frac{0.0591}{2} \log \left( \frac{C_2}{C_1} \right)$$

For gas concentration cell



$$E_{\text{cell}} = 0.0591 \log \frac{P_2}{P_1}$$

- ☞ Relation between free energy and cell potential

Type of reaction	$\Delta G$	<i>E</i>	Type of cell
Spontaneous	-ve	+ve	Galvanic
Non-spontaneous	+ve	-ve	Electrolytic
Equilibrium	0	0	Dead battery

### CHEMICAL KINETICS

- ☞ For the reaction  $x \rightarrow y$

- Rate of disappearance of  $x = -\frac{d[x]}{dt}$

- Rate of formation of  $y = \frac{d[y]}{dt}$

For the reaction  $x + y \rightarrow 2z$

$$\square \text{ rate} = -\frac{dx}{dt} = -\frac{dy}{dt} = \frac{1}{2} \frac{dz}{dt}$$

For a reversible reaction at equilibrium,

$$\left(\frac{dx}{dt}\right)_{\text{forward}} = \left(\frac{dx}{dt}\right)_{\text{backward}}$$

The overall rate of reaction,

$$\frac{dx}{dt} = \left(\frac{dx}{dt}\right)_{\text{forward}} - \left(\frac{dx}{dt}\right)_{\text{backward}} = 0$$

$$\square \text{ Average rate} = \frac{\text{Change in concentration}}{\text{Time interval}} = \frac{\Delta x}{\Delta t}$$

$$\square \text{ For zero order reactions, } k = \frac{x}{t}; \quad t_{1/2} = \frac{a}{2k}$$

$$\square \text{ For reactions of 1st order, } k = \frac{2.303}{t} \log \frac{a}{a-x}$$

where  $a$  is the initial concentration of the reactant and  $t$  is the time in which amount  $x$  has reacted.

$$\square \text{ Expression for half-life period for reactions of 1st order } t_{1/2} = \frac{0.693}{k}.$$

as  $T = n \times t_{1/2}$  where  $T$  = total time  
 at  $T = T_{75}$   $x = 3/4 a$  ( $a - x = a/4$ )  
 $\therefore T_{75} = 2 \times T_{50}$  and  $T_{87.5} = 3 \times T_{50}$   
 $T_{99.9} = 10 \times T_{50}$

$$\square \text{ For a second order reaction } k = \frac{1}{t} \cdot \frac{x}{a(a-x)}$$

$$\square \text{ Half-life period for a second order reaction } t_{1/2} = \frac{1}{ka}$$

$$\square \text{ For a third order reaction } k = \frac{1}{t} \cdot \frac{x}{2a^2(a-x)^2}$$

and half-life period for the third order reaction  $t_{1/2} = 3/2ka^2$

$$\square \text{ General expression for half-life period of a reaction of } n\text{th order } t_{1/2} \propto [A_0]^{1-n} \text{ or } t_{1/2} \propto \frac{1}{[A_0]^{n-1}}$$

$$\square \text{ General expression for time taken for } n^{\text{th}} \text{ fraction of a reaction of 1st order to complete}$$

$$(\text{by putting } x = \frac{a}{n}, t = t_{1/n});$$

$$t_{1/n} = \frac{2.303}{k} \log \frac{n}{n-1}$$

$$\square \text{ Amount of the substance left after } n \text{ half-lives} = \frac{[A]_0}{2^n}$$

$$\square \text{ Arrhenius eqn. for effect of temperature on rate constant } k = Ae^{-E_a/RT} \text{ or } \ln k = \ln A - \frac{E_a}{RT}$$

$$\text{or } \log k = \log A - \frac{E_a}{2.303 RT}$$

$$\text{or, } \frac{d \ln k}{dT} = \frac{E_a}{RT^2}, \text{ where } k \text{ is rate constant, pre-exponential factor } A \text{ is collision frequency, } E_a \text{ is activation energy, } T \text{ is temperature in K and } R \text{ is gas constant. If } k_1 \text{ and } k_2 \text{ are rate constants at temperatures } T_1 \text{ and } T_2 \text{ respectively, then}$$

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303 R} \left( \frac{T_2 - T_1}{T_1 T_2} \right)$$

## SURFACE CHEMISTRY

$$\square \text{ Freundlich adsorption isotherm}$$

$$\left(\frac{x}{m}\right) = k(p)^{1/n}$$

$$\text{or } \left(\frac{x}{m}\right) = k(c)^{1/n}$$

where,  $x$  = amount of adsorbate

$m$  = gram of adsorbent at pressure

$c$  = concentration

$k$  and  $n$  are constant,  $n > 1$ .

$$\square \text{ Langmuir adsorption isotherm,}$$

$$\frac{x}{m} = \frac{aP}{1 + bP}$$

where  $a$  and  $b$  are constants.  $x/m$  and  $P$  are the terms similar to those expressed in Freundlich isotherm.

$$\bullet \text{ At low pressure, } \frac{x}{m} = aP$$

$$\bullet \text{ At high pressure, } \frac{x}{m} = \frac{a}{b}$$

## GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

### ☛ Summary of the Extraction of Metals

Metals	Main Occurrence	Main Method of Extraction
Magnesium	Carnallite, $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	Electrolysis of fused $\text{MgCl}_2$ with $\text{KCl}$
Aluminium	Bauxite, $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$	Electrolysis of $\text{Al}_2\text{O}_3$ in molten $\text{Na}_3\text{AlF}_6$ (cryolite)
Iron	Haematite, $\text{Fe}_2\text{O}_3$ Magnetite, $\text{Fe}_3\text{O}_4$	Reduction of oxide with carbon monoxide $\text{Fe}_2\text{O}_3 + 3\text{CO} \longrightarrow 2\text{Fe} + 3\text{CO}_2$
Copper	Copper pyrites, $\text{CuFeS}_2$	Partial oxidation of sulphide ore $2\text{Cu}_2\text{O} + \text{Cu}_2\text{S} \longrightarrow 6\text{Cu} + \text{SO}_2$
Tin	Cuprite, $\text{Cu}_2\text{O}$ Cassiterite, $\text{SnO}_2$	Reduction of $\text{SnO}_2$ with carbon $\text{SnO}_2 + 2\text{C} \longrightarrow \text{Sn} + 2\text{CO}$
Lead	Galena, $\text{PbS}$	Reduction of $\text{PbO}$ with carbon $\text{PbO} + \text{C} \longrightarrow \text{Pb} + \text{CO}$
Silver	Argentite, $\text{Ag}_2\text{S}$ Native silver	Hydrometallurgy $\text{Ag}_2\text{S} + 4\text{NaCN} \longrightarrow 2\text{NaAg}(\text{CN})_2 + \text{Na}_2\text{S}$ $2\text{NaAg}(\text{CN})_2 + \text{Zn} \longrightarrow \text{Na}_2\text{Zn}(\text{CN})_4 + 2\text{Ag}$

### ☛ Important alloys and their components

Alloy	Components	Alloy	Components
Brass	$\text{Cu} + \text{Zn}$	Gun metal	$\text{Cu} + \text{Sn} + \text{Zn}$
Bronze	$\text{Cu} + \text{Sn}$	Muntz metal	$\text{Cu} + \text{Zn}$
Bell metal	$\text{Cu} + \text{Sn}$	Magnalium	$\text{Al} + \text{Mg}$
Coin alloys (red)	$\text{Cu} + \text{Zn} + \text{Sn}$	Solder	$\text{Pb} + \text{Sn}$
Coin alloys (white)	$\text{Cu} + \text{Ag} + \text{Zn} + \text{Ni}$	Type metal	$\text{Pb} + \text{Sb} + \text{Sn}$
Duralumin	$\text{Al} + \text{Cu} + \text{Mg} + \text{Mn}$	Wood metal	$\text{Bi} + \text{Pb} + \text{Sn} + \text{Cd}$ (low m.pt. $71^\circ\text{C}$ )
Electron	$\text{Mg} + \text{Zn}$ (95 : 5)	Y alloy	$\text{Cu} + \text{Al}$
German silver	$\text{Cu} + \text{Zn} + \text{Ni}$		

### THE P-BLOCK ELEMENTS (GROUP 15 TO 18)

- ❑ The electronic configuration of *p*-block elements is  $ns^2np^3$  to  $6$  ( $n = 2$  to  $7$ ).
- ❑ Order of basicity is  
 $\text{SbH}_3 < \text{AsH}_3 < \text{PH}_3 < \text{NH}_3$
- ❑ The bond angle decreases in the order  
 $\text{NH}_3 > \text{PH}_3 > \text{AsH}_3 > \text{SbH}_3$ .
- ❑ Oxyacid strength of nitrogen acids is  
 $\text{H}_2\text{N}_2\text{O}_2 < \text{HNO}_2 < \text{HNO}_3 < \text{HNO}_4$
- ❑ Order of acidic character of hydride is  
 $\text{H}_2\text{O} < \text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{Te}$ .

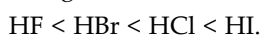
- ❑ Bond angle in hydrides shows the following order. They have V-shape structure.  

$$\begin{array}{cccc} \text{H}_2\text{O} & > & \text{H}_2\text{S} & > & \text{H}_2\text{Se} & > & \text{H}_2\text{Te} \\ 104.5^\circ & & 92.2^\circ & & 91.0^\circ & & 90^\circ \end{array}$$
- ❑ Reducing nature has order  
 $\text{H}_2\text{O} < \text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{Te} < \text{H}_2\text{Po}$ .
- ❑ The increasing order of acidic nature of trioxide is  
 $\text{TeO}_3 < \text{SeO}_3 < \text{SO}_3$ .
- ❑ The order of strength of oxyacids of lower oxidation state (+4) is  
 $\text{H}_2\text{TeO}_3 < \text{H}_2\text{SeO}_3 < \text{H}_2\text{SO}_3$ .

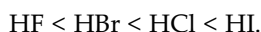
- ❑ The order of strength of oxyacids of higher oxidation state (+6) is



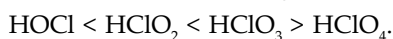
- ❑ All these elements form hydracids and order of strength of these acids is



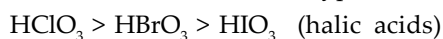
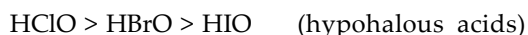
- ❑ The order of reducing character is



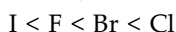
- ❑ Acid strength of oxyacids with some halogens increases with increase in oxidation number of halogen atom.



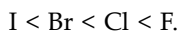
- ❑ Among the oxyacids of different halogens acid strength decreases with increase in atomic number.



- ❑ Increasing order of electron affinity is



- ❑ Increasing order of electronegativity is

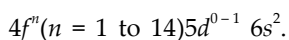


#### THE d-AND f-BLOCK ELEMENTS

- ❑ General electronic configuration of the transition elements is  $(n-1)d^{1-10}ns^{0-2}$  where  $n$  is the outermost shell.

- ❑ Magnetic moment ( $\mu$ ) =  $\sqrt{n(n+2)}$  BM where  $n$  = no. of unpaired electrons.

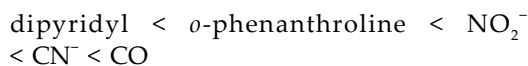
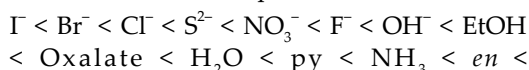
- ❑ The general electronic configuration of lanthanoids is



- ❑ The electronic configuration of actinoids is  $[\text{Rn}] 5f^{0-14}, 6d^{0-2}, 7s^2$  where  $[\text{Rn}]$  stands for radon core.

#### COORDINATION COMPOUNDS

- ❑ The ligands can be arranged in ascending order of crystal field splitting  $\Delta$  and this series is called the spectrochemical series.



$$\Delta_t = \frac{4}{9} \Delta_o$$

$$\text{CFSE} = (-0.4x + 0.6y) \Delta_o$$

where,  $x$  = no. of electrons occupying  $t_{2g}$  orbitals

$y$  = no. of electrons occupying  $e_g$  orbitals.

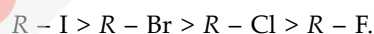
- ❑ EAN = Atomic number of the metal – No. of electrons lost in ion formation + No. of electrons gained from the donor atoms of the ligands.

#### HALOALKANES AND HALOARENES

- ❑ The general formula is  $\text{R}-\text{X}$  or  $\text{C}_n\text{H}_{2n+1}\text{X}$  where  $\text{R}$  = alkyl group;  $\text{X} = \text{Cl}, \text{Br}$  or  $\text{I}$ .

- ❑ The order of reactivity of alkyl halides is  $\text{RI} > \text{RBr} > \text{RCl}$ .

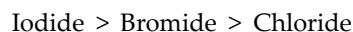
- ❑ For the same alkyl group, the boiling point of alkyl halides increase in the following order :



- ❑ Reactivity of halides towards  $\text{S}_{\text{N}}1$  mechanism is  $3^\circ > 2^\circ > 1^\circ$ .

- ❑ Reactivity of halides towards  $\text{S}_{\text{N}}2$  mechanism is  $1^\circ > 2^\circ > 3^\circ$ .

- ❑ The ease of formation of a Grignard reagent for a given alkyl group follows the order:



- ❑ Total number of optical isomers =  $2^n$  where  $n$  = no. of asymmetric carbon atom. (In general)

- ❑ Total number of optical isomers =  $2^{(n-1)} + 2^{(n/2-1)}$  where  $n$  = No. of asymmetric carbon atom is even.

- ❑ Total number of optical isomers =  $2^{(n-1)}$   $n$  = No. of asymmetric carbon atom is odd.

#### ALCOHOLS, PHENOLS AND ETHERS

- ❑ Monohydric alcohols have general formula  $\text{C}_n\text{H}_{2n+1}\text{OH}$ .



- Dihydric alcohols have general formula  $C_nH_{2n+2}O_2$  or  $(CH_2)_n(OH)_2$ .
- Order of reactivity for O – H cleavage is Primary > Secondary > Tertiary
- Order of reactivity for C – O cleavage is Tertiary > Secondary > Primary
- Order of reactivity for alcohols  $CH_3OH > 1^\circ > 2^\circ > 3^\circ$

#### ☛ Victor Meyer Test

- Primary alcohols produce a blood red colour.
- Secondary alcohols produce blue colour.
- Tertiary alcohols produce no colour.

#### ☛ Oxidation of alcohols

- Primary alcohol  $\xrightarrow{[O]}$  aldehydes  $\xrightarrow{[O]}$  carboxylic acids (same number of carbon atoms as the parent alcohol)
- Secondary alcohol  $\xrightarrow{[O]}$  Ketones  $\xrightarrow{[O]}$  Acids  
(same number of carbon atom) (less number of carbon atoms)

- Tertiary alcohol  $\xrightarrow{[O]}$  Ketones  $\xrightarrow{[O]}$  Acids  
(Less number of carbon atoms as the parent alcohol)

☛ Lucas reagent is a solution of HCl with  $ZnCl_2$ , with Lucas reagent,

- Primary alcohol - no cloudiness
- Secondary alcohol - cloudiness in 5 minutes
- Tertiary alcohol - cloudiness immediately

#### ☛ Nature of Different types of alcohols

Types	Composition
Absolute alcohol	100% ethanol
Rectified spirit	95% alcohol + 5% water
Denatured spirit	95% ethanol + 5% methanol
Methylated spirit	90% ethanol + 9% methanol + 1% other poisonous substances
Power alcohol	80% petrol + 20% absolute alcohol

#### ☛ Reducing nature of different reagents

Conversions	$LiAlH_4$ /ether	$NaBH_4/C_2H_5OH$	$H_2$ /Metal	$B_2H_6/THF$
$CHO \longrightarrow CH_2OH$	✓	✓	✓	✓
$>CO \longrightarrow >CHOH$	✓	✓	✓	✓
$COOH \longrightarrow CH_2OH$	✓	✗	✗	✓
$COCl \longrightarrow CH_2OH$	✓	✓	✗	✓
$(RCO)_2O \longrightarrow RCH_2OH$	✓	✗	✓	✓
$COOR \longrightarrow CH_2OH$	✓	✗	✓	✓
$>C=C< \longrightarrow >CH-CH<$	✗	✗	✓	✓

- **Ethers** are organic compounds in which two alkyl groups are attached to an oxygen atom and have general formula  $R-O-R$  or  $R-O-R'$ .
- According to IUPAC names, ethers are called **alkoxy hydrocarbons**.

#### ALDEHYDES, KETONES AND CARBOXYLIC ACID

- Aldehydes are compounds of the general formula  $RCHO$  and ketones are compounds of the general formula  $RCOR'$ . The groups  $R$  and  $R'$  may be aliphatic or aromatic.



- ❑ IUPAC names of carboxylic acids are derived from alkanes by replacing the terminal **e** by the suffix **oic acid**.

☛ **Important Saturated Dicarboxylic Acids**

Formula	Common name	IUPAC name
1. HOOC COOH	Oxalic acid	Ethanedioic acid
2. HOOC-CH <sub>2</sub> -COOH	Malonic acid	Propanedioic acid
3. HOOC(CH <sub>2</sub> ) <sub>2</sub> COOH	Succinic acid	Butanedioic acid

4. HOOC(CH <sub>2</sub> ) <sub>3</sub> COOH	Glutaric acid	Pentanedioic acid
5. HOOC(CH <sub>2</sub> ) <sub>4</sub> COOH	Adipic acid	Hexanedioic acid
6. HOOC(CH <sub>2</sub> ) <sub>5</sub> COOH	Pimelic acid	Heptanedioic acid
7. HOOC(CH <sub>2</sub> ) <sub>6</sub> COOH	Suberic acid	Octanedioic acid
8. HOOC(CH <sub>2</sub> ) <sub>7</sub> COOH	Azelaic acid	Nonanedioic acid
9. HOOC(CH <sub>2</sub> ) <sub>8</sub> COOH	Sebacic acid	Decanedioic acid.

☛ **Some Important Reactions**

	Name of reaction	Starting material	Reagent and other condition, if any	Application (used in)
1.	Wurtz reaction	2 moles of alkyl halides (RX)	Metallic Na, dry ether	Alkanes
2.	Friedel- Crafts reaction	C <sub>6</sub> H <sub>6</sub> +RX or RCOCl	Anhydrous AlCl <sub>3</sub>	Alkyl benzenes and acyl benzenes
3.	Kolbe electrolytic	Sod. or Pot. salt of carboxylic acids	Electrolysis	alkanes, alkenes, alkynes
4.	Williamson synthesis	Alkyl halides (RX) + alkoxides (RONa)	Heat	Ether
5.	Clemmensen reduction	Aldehyde or ketone (> C = O)	Amalgamated zinc (Zn-Hg) and conc. HCl	Hydrocarbons
6.	Rosenmund reduction	Acid chlorides (RCOCl)	H <sub>2</sub> in presence of Pd/BaSO <sub>4</sub> and quinoline	Aldehydes
7.	Cannizzaro reaction	Aldehydes not having α-hydrogen atom	Aq. of alc. alkali	Alcohol + Acid
8.	Tishchenko reaction	All Aldehydes	Aluminium ethoxide Al(OC <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>	Esters
9.	Aldol condensation	Aldehydes having α - hydrogen atom	Strong solution of alkali	Resin
10.	Benzoin condensation	Aromatic aldehydes	KCN	Benzoin
11.	Haloform reaction	CH <sub>3</sub> CHO, methyl ketones (CH <sub>3</sub> CO-), CH <sub>3</sub> CH <sub>2</sub> OH and RCHOHCH <sub>3</sub>	Alkaline halogen (NaOH + X <sub>2</sub> ) or Sod. hypohalites (NaOX)	Haloform (test of -COCH <sub>3</sub> group)
12.	Kolbe-Schmidt reaction	Phenol (C <sub>6</sub> H <sub>5</sub> OH)	CO <sub>2</sub> , 125°C, 5-7 atm.	Salicylic acid

13.	Reimer -Tiemann reaction	Phenol	$\text{CHCl}_3$ or $\text{CCl}_4$ (NaOH)	Salicylaldehyde or Salicylic acid (Asprin)
14.	Hofmann-bromamide reaction	Acid amides ( $-\text{CONH}_2$ )	$\text{Br}_2$ + Alkali	Primary amines
15.	Carbylamine reaction	Primary amines ( $-\text{NH}_2$ )	$\text{CHCl}_3$ + Alkali	Carbylamine (test or $-\text{NH}_2$ group)
16.	Diazotisation	Aromatic primary amines	Conc. HCl, $\text{NaNO}_2$ -HCl, $0-5^\circ\text{C}$	Benzenediazonium salts.
17.	Sandmeyer reaction	Benzenediazonium salts	$\text{CuCl}-\text{HCl}$ , $\text{CuBr}-\text{Br}$ , $\text{CuCN}$	Halogenobenzenes
18.	Gattermann reaction	Benzenediazonium salts	$\text{Cu}$ powder + HCl	Halogenobenzenes
19.	Coupling reaction	Benzenediazonium salt + Phenol or aniline	Alkali (in case of phenol), acid (in case of aniline), low temp.	Azo-dyes (detection of phenolic and amino group)

### AMINES

- Aliphatic amine are called as alkanamines in which 'e' of alkane is replaced by amine. where  $\text{X}^- = \text{Cl}^-, \text{Br}^-$ , etc.

#### Basicity of Amines

Nature of alkyl group	Order of basic strength
$-\text{CH}_3$ (methyl group)	$2^\circ > 1^\circ > 3^\circ > \text{NH}_3$
$-\text{CH}_2-\text{CH}_3$ (ethyl group)	$2^\circ > 1^\circ > \text{NH}_3 > 3^\circ$
$-\text{CH}-\text{CH}_3$   $\text{CH}_3$ (iso-propyl group)	$1^\circ > \text{NH}_3 > 2^\circ > 3^\circ$ amine
$-\text{C}(\text{CH}_3)_3$ (tert-butyl group)	$\text{NH}_3 > 1^\circ > 2^\circ > 3^\circ$ amine

#### Diazonium salts

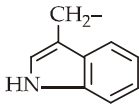
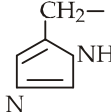
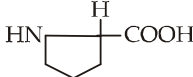
General formula :  $\text{ArN}_2^+\text{X}^-$   
where  $\text{X}^- = \text{Cl}^-, \text{Br}^-$ , etc

### BIOMOLECULES

- The name 'carbohydrate' was given as earlier studies of these compounds led to their being classified as "hydrates of carbon", with general formula  $\text{C}_x(\text{H}_2\text{O})_y$ .
- There are about 20 amino acids which make up the bioproteins. Out of these 10 amino

acids (*non-essential*) are synthesised by our bodies and rest are essential in the diet (*essential amino acids*) and supplied to our bodies by food which we take because they cannot be synthesised in the body.

	Name of amino acid	Structure of R	Three letter symbol
1	Glycine	$-\text{H}$	Gly
2	Alanine	$-\text{CH}_3$	Ala
*3	Valine	$-\text{CH}(\text{CH}_3)_2$	Val
*4	Leucine	$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	Leu
*5	Isoleucine	$-\text{CH}-\text{CH}_2\text{CH}_3$   $\text{CH}_3$	Ile
*6	Arginine	$-(\text{CH}_2)_3\text{NH}-\text{C}-\text{NH}_2$    $\text{NH}$	Arg
*7	Lysine	$-(\text{CH}_2)_4\text{NH}_2$	Lys
8	Glutamic acid	$-\text{CH}_2\text{CH}_2\text{COOH}$	Glu
9	Aspartic acid	$-\text{CH}_2\text{COOH}$	Asp
10	Glutamine	$-\text{CH}_2\text{CH}_2\text{CONH}_2$	Gln
11	Asparagine	$\text{CH}_2\text{CONH}_2$	Asn
*12	Threonine	$-\text{CHOH}.\text{CH}_3$	Thr
13	Serine	$-\text{CH}_2\text{OH}$	Ser
14	Cysteine	$-\text{CH}_2\text{SH}$	Cys
*15	Methionine	$-\text{CH}_2\text{CH}_2\text{SCH}_3$	Met
*16	Phenylalanine	$-\text{CH}_2\text{C}_6\text{H}_5$	Phe
17	Tyrosine	$-\text{CH}_2\text{C}_6\text{H}_4\text{OH}(p)$	Tyr

*18	Tryptophan		Trp
*19	Histidine		His
20	Proline		Pro

\*Essential aminoacid

- Base + Sugar = Nucleoside
- Base + Sugar + Phosphate = Nucleotide
- For RNA, ribose (sugar) + uracil (base) = Nucleoside.
- For DNA, deoxyribose (sugar) + thymine (base) = Nucleoside.

☛ Some common enzymes

Enzymes	Reactions which is catalysed
Amylase	Starch $\rightarrow n \times$ glucose
Maltase	Maltose $\rightarrow 2 \times$ glucose
Lactase	Lactose $\rightarrow$ glucose + galactose
Invertase	Sucrose $\rightarrow$ glucose + fructose
Pepsin	Proteins $\rightarrow$ Amino acid
Trypsin	Proteins $\rightarrow$ Amino acid
Nucleases	DNA, RNA $\rightarrow$ Nucleotides
Urease	Urea $\rightarrow$ $\text{NH}_3 + \text{CO}_2$
Carbonic anhydrase	$\text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

### POLYMER

- Number average molecular mass ( $\overline{M}_N$ )

$$= \frac{N_1M_1 + N_2M_2 + N_3M_3 + \dots}{N_1 + N_2 + N_3 + \dots}$$

Where  $N_1, N_2, N_3, \dots$  are the number of molecules with molecular masses  $M_1, M_2, M_3, \dots$  respectively.

$$\text{or } \overline{M}_N = \frac{\sum(N_iM_i)}{\sum N_i}$$

Where  $N_i$  is the number of molecules of the  $i^{\text{th}}$  type with molecular mass  $M_i$ .

- Weight average molecular mass ( $\overline{M}_w$ )

$$= \frac{m_1M_1 + m_2M_2 + m_3M_3 + \dots}{m_1 + m_2 + m_3 + \dots}$$

Where  $m_1, m_2, m_3, \dots$  are the masses of species with molecular mass  $M_1, M_2, M_3, \dots$  respectively, then the weight average molecular mass is

$$\text{or } \overline{M}_w = \frac{\sum(m_iM_i)}{\sum m_i}$$

$$\text{But } m_i = N_iM_i, \text{ so that } \overline{M}_w = \frac{\sum(N_iM_i^2)}{\sum(N_iM_i)}$$

- Poly dispersity index (PDI)

$$= \frac{\text{Weight average molecular mass}}{\text{Number average molecular mass}} = \frac{\overline{M}_w}{\overline{M}_n}$$

### CHEMISTRY IN EVERYDAY LIFE

- Therapeutic index (TI)

$$= \frac{\text{Maximum tolerated dose (MTD)}}{\text{Maximum curative dose (MCD)}}$$

☛ Chemicals in cosmetics

Chemical	Cosmetics
Acetone	: Cologne, nail enamel remover
Benzaldehyde	: Perfumes, cologne, hair spray, vaseline, shaving cream, shampoo, soaps
Benzyl acetate	: Perfumes, detergent, soaps, after shave lotions, deodorants
Benzyl alcohol	: Cologne, nail enamel remover, fabric softener
Camphor	: Perfumes, shaving cream, nail polish
Methylene chloride	: Shampoo, cologne
Ethanol	: Shampoo, hair spray, perfumes, shaving creams

Toluene : Lacquers and nail moisturizers

Benzoic acid : Cream and lotion

Cetyl alcohol : Moisturising cream, lotions

Hydroquinone : Moisturising cream

Linalool : Perfumes, bar soaps, hand lotions

Terpinene : Cologne, perfume, air freshener

Terpineol : Perfumes and cologne

*p*-Chlorometaxylenol: Deodorants

Dichlorometaxylenol: Deodorants



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