MTG CLASS 12 CHEMISTRY FORMULA BOOK

THE SOLID STATE

☞ **Calculation of number of particles per unit cell**

❏ Contribution of each atom present on the corner $= \dfrac{1}{8}$

❏ Contribution of each atom present on the face $= \dfrac{1}{2}$

❏ Contribution of each atom present on the edge centre $= \dfrac{1}{4}$

❏ 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 × No. of atoms (ions) in the close packing
    = 2 × No. of octahedral voids.

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

❏ Simple $\qquad\qquad d = a$

❏ Body-centred $\qquad d = \dfrac{\sqrt{3}}{2} a = 0.866\,a$

❏ Face-centred $\qquad d = \dfrac{a}{\sqrt{2}} = 0.707\,a$

☞ **Relation between atomic radius r ($=\dfrac{d}{2}$ for pure elements) and edge (a) of cubic unit cell**

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

☞ **Calculation of density of a cubic crystal from its edge**

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

❏ **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 × distance between Na^+ and 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 Sr^{2+} when introduced into Na^+Cl^- creates one cation vacancy because for electrical neutrality, one Sr^{2+} replaces two Na^+ ions.

SOLUTIONS

❑ % by wt. = $\dfrac{\text{wt. of the solute in g}}{\text{wt. of the solution in g}} \times 100$

❑ % by wt./vol. = $\dfrac{\text{wt. of solute in g}}{\text{Vol. of solution in cc}} \times 100$

❑ % by volume = $\dfrac{\text{Vol. of solute in cc}}{\text{Vol. of solution in cc}} \times 100$

❑ Strength of a solution = $\dfrac{\text{wt. of the solution in g}}{\text{Vol. of solution in litres}}$

❑ Molarity = $\dfrac{\text{Moles of the solute}}{\text{Vol. of solution in cc}} \times 1000$

where moles = $\dfrac{\text{Mass of the solute in g}}{\text{Molecular mass of the solute}}$

❑ Normality = $\dfrac{\text{g. Eq. of the solute}}{\text{Vol. of solution in cc}} \times 1000$

where g eq. = $\dfrac{\text{Mass of the solute in g}}{\text{Eq. mass of the solute}}$

❑ Normality of a solution = Molarity × $\dfrac{\text{Mol. mass}}{\text{Eq. mass}}$

❑ Normality of an acid = Molarity × Basicity

❑ Normality of a base = Molarity × Acidity

❑ Molality = $\dfrac{\text{Moles of solute}}{\text{Mass of the solvent in g}} \times 1000$

❑ Mole fraction of solute in solution

$$\left(x_2\right) = \dfrac{n_2}{n_1 + n_2} = \dfrac{w_2/M_2}{w_1/M_1 + w_2/M_2}$$

❑ Mole fraction of solvent in solution

$$\left(x_1\right) = \dfrac{n_1}{n_1 + n_2} = \dfrac{w_1/M_1}{w_1/M_1 + w_2/M_2}$$

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.

$$\left(x_A\right) = \dfrac{n_A}{n_A + n_B + n_C + ...}$$ and so on.

$x_A + x_B + ... = 1$

❑ Mass fraction of component $A\left(x_A\right) = \dfrac{w_A}{w_A + w_B}$

❑ Mass fraction of component $B\left(x_B\right) = \dfrac{w_B}{w_A + w_B}$

$x_A + x_B = 1$

❑ Parts per million (ppm) of substance A

$= \dfrac{\text{Mass of } A}{\text{Mass of solution}} \times 10^6$ or $\dfrac{\text{Vol. of } A}{\text{vol. of solution}} \times 10^6$

❑ Normality equation (for dilution of a solution or for a complete reaction between two solutions)

$N_1V_1 = N_2V_2$.

❑ Molarity equation (for dilution of a solution)

$M_1V_1 = M_2V_2$.

❑ If two non-reacting solutions of different normalities are mixed, the normality of the final solution can be calculated using relations :

$N_1V_1 + N_2V_2 = N_3V_3$.

❑ 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,

$p_A = x_A p_A^{\circ}$ and $p_B = x_B p_B^{\circ}$.

$P_{Total} = p_A + p_B = x_A p_A^{\circ} + x_B p_B^{\circ}$

$= (1 - x_B)p_A^{\circ} + x_B p_B^{\circ} = (p_B^{\circ} - p_A^{\circ}) x_B + p_A^{\circ}$.

Mole fraction of A in the vapour phase

$= \dfrac{p_A}{p_A + p_B}$

❑ Raoult's law for non-volatile solutes :

$$\dfrac{p^{\circ} - p_s}{p^{\circ}} = \dfrac{n_2}{n_1 + n_2} \approx \dfrac{n_2}{n_1}$$

(if solution is dilute i.e. < 5%)

$$= \dfrac{w_2/M_2}{w_1/M_1 + w_2/M_2} \approx \dfrac{w_2/M_2}{w_1/M_1}$$

(if solution is dilute)

❑ Osmotic pressure, $\pi = \dfrac{n}{V}RT$ where $n = \dfrac{w}{M}$

❑ 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 $K_b = \Delta T_b/m$ = deg./molality = $\dfrac{K}{\text{mol kg}^{-1}}$

$= K\ kg\ mol^{-1}$.

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

- 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.

- $M_2 = \dfrac{1000\,K_f\,w_2}{w_1\,\Delta T_f}$ if K_f is per 1000 g of the solvent or $M_2 = \dfrac{100\,K_f\,w_2}{w_1\,\Delta T_f}$ if K_f is per 100 g of the solvent.

- $K_b = \dfrac{R T_0^2}{1000\,l_v} = \dfrac{M_1 R T_0^2}{1000\,\Delta H_v}$
  where T_0 = boiling point of the liquid (pure solvent) l_v = latent heat of vaporisation per g of the solvent ΔH_v = latent heat of vaporisation per mole of the solvent.
  M_1 = molecular mass of the solvent.
  R = gas const. = 8.314 JK^{-1} mol^{-1} if I_v or ΔH_v is in calories.
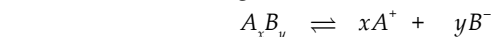
- $K_f = \dfrac{R T_0^2}{1000\,l_f} = \dfrac{M_1 R T_0^2}{1000\,\Delta H_f}$
  where T_0 = freezing point of the liquid (pure solvent) l_f = latent heat of fusion per g of the solvent
  ΔH_f = latent heat of fusion per mole of the solvent
  M_1 = molecular mass of the solvent
  R = gas const. 8.314 JK^{-1} mol^{-1}.

- Van't Hoff factor (i) =
  $\dfrac{\text{Observed value of Colligative property}}{\text{Calculated value of Colligative property}}$
  $= \dfrac{\text{Calculated mol. mass}}{\text{Observed mol. mass}} = \dfrac{M_c}{M_0}$
  $\left(\because \text{Mol mass} \propto \dfrac{1}{\text{Colligative property}} \right)$

- For solutes undergoing dissociation/association

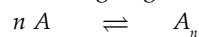- $\Delta T_b = i K_b m,\ \Delta T_f = i\,K_f m,\ \pi = i\dfrac{n}{V}RT$

- For an electrolyte $A_x B_y$ undergoing dissociation with degree of dissociation α.
  $$A_x B_y \rightleftharpoons xA^+ + yB^-$$
  Before dissociation 1 mole   0   0
  After dissociation $1 - \alpha$ $x\alpha$ ya
  Total $= 1 - \alpha + x\alpha + y\alpha = \alpha(x + y - 1) + 1$.
  $i = \alpha(x + y - 1) + 1$ or $\alpha = \dfrac{i-1}{x+y-1}$

- For a solute A undergoing association
  $$n A \rightleftharpoons A_n$$
  Initial   1 mole
  After assoc. $1 - \alpha$ (α/n)
  Total $= 1 - \alpha + \dfrac{\alpha}{n}$
  $i = 1 - \alpha + \dfrac{\alpha}{n}$ or $\alpha = \dfrac{i-1}{n-1}$

ELECTROCHEMISTRY

- According to Ohm's law (Resistance),
  $R = \dfrac{V}{I} = \dfrac{\text{volt}}{\text{amperes}} = \Omega$ (ohm)

- Conductance $(C) = \dfrac{1}{R} = $ Ohm^{-1} or Mho or Siemens (S)

- $R = \rho \times \dfrac{l}{a}$
  where l = distance between electrodes in cm, a = area of cross-section of electrodes in cm^2
  ρ = specific resistance, where $\dfrac{l}{a} = \dfrac{R}{\rho}$ cell constant (cm^{-1})

- Specific conductance, $\kappa = \dfrac{1}{\rho}$ or
  $\kappa = \dfrac{1}{R} \cdot \dfrac{l}{a} = C \times$ cell constant
  $=$ ohm^{-1} cm^{-1} or S cm^{-1}

- Equivalent conductance,
  $\Lambda_{eq} = \kappa \times V = \dfrac{\kappa \times 1000}{C_{eq}} = \dfrac{\kappa \times 1000}{\text{normality}}$
  Unit = ohm^{-1} cm^2 g equi^{-1} or S cm^2 g equi^{-1}

- Molar conductance,
  $\Lambda_m = \kappa \times V = \dfrac{\kappa \times 1000}{C_m} = \dfrac{\kappa \times 1000}{\text{molarity}}$
  Unit = ohm^{-1} cm^2 mol^{-1} or S cm^2 mol^{-1}

- For a sparingly soluble salt *e.g.* AgCl, BaSO$_4$, etc.

    Solubility (mol l^{-1}) $= \dfrac{\kappa \times 1000}{\Lambda^\circ_m}$

- Debye Huckel-Onsager equation is $\Lambda_m = \Lambda^\circ_m - b\sqrt{C}$ [Λ_m = molar conductivity at C concentration, Λ°_m is molar conductivity at infinite dilution, b = constant.]

- According to Kohlrausch's law

    molar conductance $\Lambda^\circ_m = x\lambda^\circ_c + y\lambda^\circ_a$

    where λ°_c and λ°_a are molar conductivities of cation and anion respectively.

    Equivalent conductance at infinite dilution

    $\Lambda^\infty_{eq} = \lambda^\circ_c + \lambda^\circ_a$

- Degree of dissociation $\alpha = \dfrac{\Lambda^c_m}{\Lambda^\circ_m}$

    $= \dfrac{\text{Molar conductance at a given concentration}}{\text{Molar conductance at infinite dilution}}$

- Molar conductivity at infinite dilution for weak electrolytes

    $e.g. \Lambda^\circ_{CH_3COOH} = \Lambda^\circ_{CH_3COONa} + \Lambda^\circ_{HCl} - \Lambda^\circ_{NaCl}$

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

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

- Faraday's second law :

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

- 1 F = 96500 C

- Electrochemical equivalent of a substance

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

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

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

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

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

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

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

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

    $\quad\quad = \dfrac{0.0591}{n}\log K$ at 25°C

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

- $\Delta G^\circ_3 = \Delta G^\circ_1 + \Delta G^\circ_2$ (when different number of electrons are involved)

    $-n_3 F E^\circ_3 = -n_1 F E^\circ_1 - n_2 F E^\circ_2$

    $n_3 E^\circ_3 = n_1 E^\circ_1 + n_2 E^\circ_2$

    or $E^\circ_3 = \dfrac{n_1 E^\circ_1 + n_2 E^\circ_2}{n_3}$

    If $n_1 = n_2 = n_3$, $E^\circ_3 = E^\circ_1 + E^\circ_2$

- $E_{H^+/H_2} = E^\circ_{H^+/H_2} - 0.0591\log\dfrac{1}{[H^+]}$

    $= 0 - 0.0591(-\log[H^+]) = -0.0591\ \text{pH}$

    $\because$ pH $= -\log[H^+]$

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

- For concentration cell Zn | $\underset{(C_1)}{Zn^{++}}$ || $\underset{(C_2)}{Zn^{++}}$ | Zn

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

    For gas concentration cell

    $\underset{P_1}{Pt\,(H_2)}$ | HCl | $\underset{P_2}{Pt(H_2)}$

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

☞ Relation between free energy and cell potential

Type of reaction	ΔG	E	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 $x = -\dfrac{d[x]}{dt}$

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

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

- rate $= -\dfrac{dx}{dt} = -\dfrac{dy}{dt} = \dfrac{1}{2}\dfrac{dz}{dt}$

- For a reversible reaction at equilibrium,

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

  The overall rate of reaction,

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

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

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

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

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

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

  as $T = n \times t_{1/2}$ $\quad$ where T = total time

  at $T = T_{75}$ $x = 3/4\ a$ $\quad (a - x) = a/4$

  $\therefore\ T_{75} = 2 \times T_{50}$ $\quad$ and $\quad T_{87.5} = 3 \times T_{50}$

  $T_{99.9} = 10 \times T_{50}$

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

- Half-life period for a second order reaction

  $t_{1/2} = \dfrac{1}{k.a}$

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

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

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

  $t_{1/2} \propto \dfrac{1}{[A_0]^{n-1}}$

- General expression for time taken for n^{th} fraction of a reaction of 1st order to complete

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

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

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

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

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

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

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

SURFACE CHEMISTRY

- Freundlich adsorption isotherm

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

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

  where, x = amount of adsorbate

  $\quad m$ = gram of adsorbent at pressure

  $\quad c$ = concentration

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

- Langmuir adsorption isotherm,

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

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

- At low pressure, $\dfrac{x}{m} = aP$

- At high pressure, $\dfrac{x}{m} = \dfrac{a}{b}$

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

☞ **Summary of the Extraction of Metals**

Metal	Main Occurrence	Main Method of Extraction
Magnesium	Carnallite, $KCl \cdot MgCl_2 \cdot 6H_2O$	Electrolysis of fused $MgCl_2$ with KCl
Aluminium	Bauxite, $Al_2O_3 \cdot 2H_2O$	Electrolysis of Al_2O_3 in molten Na_3AlF_6 (cryolite)
Iron	Haematite, Fe_2O_3	Reduction of oxide with carbon monoxide
	Magnetite, Fe_3O_4	$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
Copper	Copper pyrites, $CuFeS_2$	Partial oxidation of sulphide ore
	Cuprite, Cu_2O	$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$
Tin	Cassiterite, SnO_2	Reduction of SnO_2 with carbon
		$SnO_2 + 2C \longrightarrow Sn + 2CO$
Lead	Galena, PbS	Reduction of PbO with carbon
		$PbO + C \longrightarrow Pb + CO$
Silver	Argentite, Ag_2S	Hydrometallurgy
	Native silver	$Ag_2S + 4NaCN \longrightarrow 2NaAg(CN)_2 + Na_2S$
		$2NaAg(CN)_2 + Zn \longrightarrow Na_2Zn(CN)_4 + 2Ag$

☞ **Important alloys and their components**

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

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

❑ The electronic configuration of *p*-block elements is $ns^2np^{3 \text{ to } 6}$ (*n* = 2 to 7).

❑ Order of basicity is
   $SbH_3 < AsH_3 < PH_3 < NH_3$

❑ The bond angle decreases in the order
   $NH_3 > PH_3 > AsH_3 > SbH_3$.

❑ Oxyacid strength of nitrogen acids is
   $H_2N_2O_2 < HNO_2 < HNO_3 < HNO_4$

❑ Order of acidic character of hydride is
   $H_2O < H_2S < H_2Se < H_2Te$.

❑ Bond angle in hydrides shows the following order. They have V-shape structure.
   $$H_2O > H_2S > H_2Se > H_2Te$$
   $$104.5^{\circ} \quad 92.2^{\circ} \quad 91.0^{\circ} \quad 90^{\circ}$$

❑ Reducing nature has order
   $H_2O < H_2S < H_2Se < H_2Te < H_2Po$.

❑ The increasing order of acidic nature of trioxide is
   $TeO_3 < SeO_3 < SO_3$.

❑ The order of strength of oxyacids of lower oxidation state (+4) is
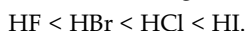 $H_2TeO_3 < H_2SeO_3 < H_2SO_3$.

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

  $H_2TeO_4 < H_2SeO_4 < H_2SO_4$.

- All these elements form hydracids and order of strength of these acids is
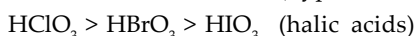
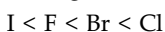 $HF < HBr < HCl < HI$.
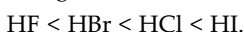
- The order of reducing character is

  $HF < HBr < HCl < HI$.

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

  $HOCl < HClO_2 < HClO_3 > HClO_4$.
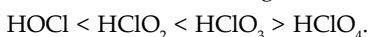
- Among the oxyacids of different halogens acid strength decreases with increase in atomic number.

  $HClO > HBrO > HIO$ (hypohalous acids)

  $HClO_3 > HBrO_3 > HIO_3$ (halic acids)

  $HClO_4 > HBrO_4 > HIO_4$ (perhalic acids)

- Increasing order of electron affinity is

  $I < F < Br < Cl$

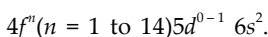- Increasing order of electronegativity is

  $I < Br < Cl < F$.
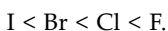
THE d-AND f-BLOCK ELEMENTS

- 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
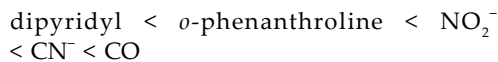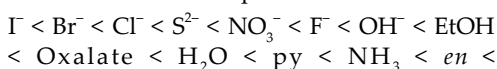
  where n = no. of unpaired electrons.

- The general electronic configuration of lanthanoids is

  $4f^n (n = 1 \text{ to } 14) 5d^{0-1} 6s^2$.

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

COORDINATION COMPOUNDS

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

  $I^- < Br^- < Cl^- < S^{2-} < NO_3^- < F^- < OH^- < EtOH < $ Oxalate $< H_2O < py < NH_3 < en <$ dipyridyl $< o$-phenanthroline $< NO_2^- < CN^- < CO$

- $\Delta_t = \dfrac{4}{9}\Delta_o$

- 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 donar atoms of the ligands.

HALOALKANES AND HALOARENES

- The general formula is $R - X$ or $C_nH_{2n+1}X$ where R = alkyl group; X = Cl, Br or I.

- The order of reactivity of alkyl halides is

  $RI > RBr > RCl$.

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

  $R - I > R - Br > R - Cl > R - F$.
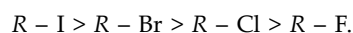
- Reactivity of halides towards S_N1 mechanism is $3° > 2° > 1°$.

- Reactivity of halides towards S_N2 mechanism is $1° > 2° > 3°$.

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

  Iodide > Bromide > Chloride
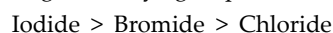
- Total number of optical isomers = 2^n

  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 $C_nH_{2n+1}OH$.

- 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
  $CH_3OH > 1° > 2° > 3°$

☞ **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   (less number
  of carbon atom)   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 cloudness
- Secondary alcohol - cloudness in 5 minutes
- Tertiary alcohol   - cloudness 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$_2$H$_5$OH	H$_2$/Metal	B$_2$H$_6$/THF
CHO $\longrightarrow$ CH$_2$OH	✓	✓	✓	✓
>CO $\longrightarrow$ >CHOH	✓	✓	✓	✓
COOH $\longrightarrow$ CH$_2$OH	✓	✗	✗	✓
COCl $\longrightarrow$ CH$_2$OH	✓	✓	✗	✓
(RCO)$_2$O $\longrightarrow$ RCH$_2$OH	✓	✗	✓	✓
COOR $\longrightarrow$ CH$_2$OH	✓	✗	✓	✓
>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_2–COOH	Malonic acid	Propanedioic acid
3. HOOC$(CH_2)_2$COOH	Succinic acid	Butanedioic acid
4. HOOC$(CH_2)_3$COOH	Glutaric acid	Pentanedioic acid
5. HOOC$(CH_2)_4$COOH	Adipic acid	Hexanedioic acid
6. HOOC$(CH_2)_5$COOH	Pimelic acid	Heptanedioic acid
7. HOOC$(CH_2)_6$COOH	Suberic acid	Octanedioic acid
8. HOOC$(CH_2)_7$COOH	Azelaic acid	Nonanedioic acid
9. HOOC$(CH_2)_8$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_6H_6+RX or RCOCl	Anhydrous $AlCl_3$	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_2 in presence of Pd/$BaSO_4$ and quinoline	Aldehydes
7.	Cannizzaro reaction	Aldehydes not having α-hydrogen atom	Aq. of alc. alkali	Alcohol + Acid
8.	Tischenko reaction	All Aldehydes	Aluminium ethoxide Al$(OC_2H_5)_3$	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_3CHO, methyl ketones (CH_3CO–), CH_3CH_2OH and RCHOHCH_3	Alkaline halogen (NaOH + X_2) or Sod. hypohalites (NaOX)	Haloform (test of –$COCH_3$ group)
12.	Kolbe-Schmidt reaction	Phenol (C_6H_5OH)	CO_2, 125°C, 5-7 atm.	Salicylic acid

Chemistry

13.	Reimer -Tiemann reaction	Phenol	$CHCl_3$ or CCl_4 (NaOH)	Salicylaldehyde or Salicylic acid (Asprin)
14.	Hofmann-bromamide reaction	Acid amides (–$CONH_2$)	Br_2 + Alkali	Primary amines
15.	Carbylamine reaction	Primary amines (– NH_2)	$CHCl_3$ + Alkali	Carbylamine (test or –NH_2 group)
16.	Diazotisation	Aromatic primary amines	Conc. HCl, $NaNO_2$-HCl, 0-5°C	Benzenediazonium salts.
17.	Sandmeyer reaction	Benzenediazonium salts	CuCl–HCl, CuBr - Br, CuCN	Halogenobenzenes
18.	Gattermann reaction	Benzenediazonium salts	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 $X^- = Cl^-$, Br^-, etc.

❑ **Basicity of Amines**

Nature of alkyl group	Order of basic strength
—CH_3 (methyl group)	$2° > 1° > 3° > NH_3$
—CH_2—CH_3 (ethyl group)	$2° > 1° > NH_3 > 3°$
— CH— CH_3 | CH_3 (*iso*-propyl group)	$1° > NH_3 > 2° > 3°$ amine
—$C(CH_3)_3$ (*tert*-butyl group)	$NH_3 > 1° > 2° > 3°$ amine

❑ **Diazonium salts**
General formula : $ArN_2^+X^-$
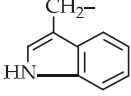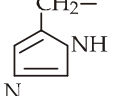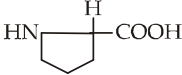where $X^- = Cl^-$, Br^-, etc

BIOMOLECULES

❑ The name 'carbohydrate' was given as earlier studies of these compounds led to their being classified as "hydrates of carbon", with general formula $C_x(H_2O)_y$.

❑ 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	–H	Gly
2	Alanine	–CH_3	Ala
*3	Valine	–$CH(CH_3)_2$	Val
*4	Leucine	–$CH_2CH(CH_3)_2$	Leu
*5	Isoleucine	– CH – CH_2CH_3 | CH_3	Ile
*6	Arginine	– $(CH_2)_3$NH– C – NH_2 || NH	Arg
*7	Lysine	–$(CH_2)_4NH_2$	Lys
8	Glutamic acid	–CH_2CH_2COOH	Glu
9	Aspartic acid	–CH_2COOH	Asp
10	Glutamine	–$CH_2CH_2CONH_2$	Gln
11	Asparagine	CH_2CONH_2	Asn
*12	Threonine	–$CHOH.CH_3$	Thr
13	Serine	–CH_2OH	Ser
14	Cysteine	–CH_2SH	Cys
*15	Methionine	–$CH_2CH_2SCH_3$	Met
*16	Phenylalan-ine	–$CH_2C_6H_5$	Phe
17	Tyrosine	–$CH_2C_6H_4OH(p)$	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 $\rightarrow NH_3 + CO_2$
Carbonic anhydrase	$H_2CO_3 \rightarrow CO_2 + H_2O$

POLYMER

❑ Number average molecular mass $\left(\overline{M}_N\right)$

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

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

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

Where N_i is the number of molecules of the ith type with molecular mass M_i.

❑ Weight average molecular mass $\left(\overline{M}_w\right)$

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

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

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

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

❑ 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
Banzaldehyde	:	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	Linalool	: Perfumes, bar soaps, hand lotions
Benzoic acid	: Cream and lotion	Terpinene	: Cologne, perfume, air freshener
Cetyl alcohol	: Moisturising cream, lotions	Terpineol	: Perfumes and cologne
Hydroquinone	: Moisturising cream	*p*-Chlorometaxylenol	: Deodorants
		Dichlorometaxylenol	: Deodorants

☺ ☺ ☺