PM SHRI STUDY MATERIAL (2025-26)
CLASS-12TH
CHEMISTRY

INDEX

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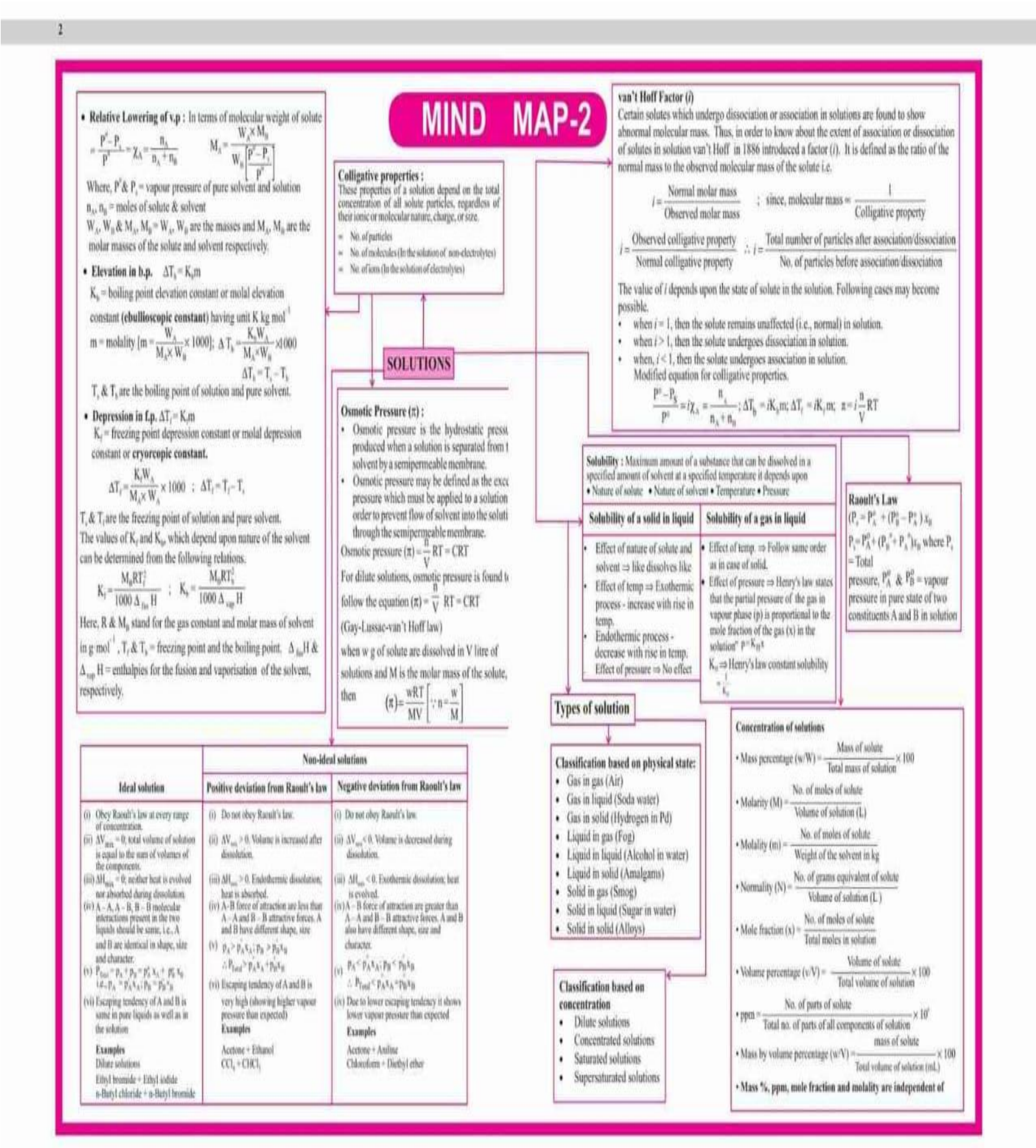
CHAPTER – SOLUTION
MIND MAP



MIND MAP-2

SOLUTIONS

- **Relative Lowering of v.p :** In terms of molecular weight of solute

$$= \frac{P^0 - P_s}{P^0} = \chi_A = \frac{n_A}{n_A + n_B} \qquad M_A = \frac{W_A \times M_B}{W_B \left[\frac{P^0 - P_s}{P^0}\right]}$$

Where, P^0 & P_s = vapour pressure of pure solvent and solution
n_A, n_B = moles of solute & solvent
W_A, W_B & M_A, M_B = W_A, W_B are the masses and M_A, M_B are the molar masses of the solute and solvent respectively.

- **Elevation in b.p.** $\Delta T_b = K_b m$

K_b = boiling point elevation constant or molal elevation constant **(ebullioscopic constant)** having unit K kg mol^{-1}

m = molality $\left[m = \frac{W_A}{M_A \times W_B} \times 1000\right]$; $\Delta T_b = \frac{K_b W_A}{M_A \times W_B} \times 1000$

$\Delta T_b = T_s - T_b$

T_s & T_b are the boiling point of solution and pure solvent.

- **Depression in f.p.** $\Delta T_f = K_f m$

K_f = freezing point depression constant or molal depression constant or **cryorcopic constant.**

$$\Delta T_f = \frac{K_f W_A}{M_A \times W_A} \times 1000 \ ; \ \Delta T_f = T_f - T_s$$

T_s & T_f are the freezing point of solution and pure solvent.
The values of K_f and K_b, which depend upon nature of the solvent can be determined from the following relations.

$$K_f = \frac{M_B R T_f^2}{1000 \, \Delta_{fus} H} \ ; \ K_b = \frac{M_B R T_b^2}{1000 \, \Delta_{vap} H}$$

Here, R & M_B stand for the gas constant and molar mass of solvent in g mol^{-1}, T_f & T_b = freezing point and the boiling point. $\Delta_{fus}H$ & $\Delta_{vap}H$ = enthalpies for the fusion and vaporisation of the solvent, respectively.

Colligative properties :
These properties of a solution depend on the total concentration of all solute particles, regardless of their ionic or molecular nature, charge, or size.

- No. of particles
- No. of molecules (In the solution of non-electrolytes)
- No. of ions (In the solution of electrolytes)

Osmotic Pressure (π) :

- Osmotic pressure is the hydrostatic press produced when a solution is separated from t solvent by a semipermeable membrane.
- Osmotic pressure may be defined as the exce pressure which must be applied to a solution order to prevent flow of solvent into the soluti through the semipermeable membrane.

Osmotic pressure $(\pi) = \frac{n}{V} RT = CRT$

For dilute solutions, osmotic pressure is found t follow the equation $(\pi) = \frac{n}{V} RT = CRT$

(Gay-Lussac-van't Hoff law)

when w g of solute are dissolved in V litre of solutions and M is the molar mass of the solute, then $(\pi) = \frac{wRT}{MV} \left[\because n = \frac{w}{M}\right]$

van't Hoff Factor (*i*)
Certain solutes which undergo dissociation or association in solutions are found to show abnormal molecular mass. Thus, in order to know about the extent of association or dissociation of solutes in solution van't Hoff in 1886 introduced a factor (*i*). It is defined as the ratio of the normal mass to the observed molecular mass of the solute i.e.

$$i = \frac{\text{Normal molar mass}}{\text{Observed molar mass}} \ ; \ \text{since, molecular mass} \propto \frac{1}{\text{Colligative property}}$$

$$i = \frac{\text{Observed colligative property}}{\text{Normal colligative property}} \ \therefore i = \frac{\text{Total number of particles after association/dissociation}}{\text{No. of particles before association/dissociation}}$$

The value of *i* depends upon the state of solute in the solution. Following cases may become possible.

- when $i = 1$, then the solute remains unaffected (i.e., normal) in solution.
- when $i > 1$, then the solute undergoes dissociation in solution.
- when, $i < 1$, then the solute undergoes association in solution.

Modified equation for colligative properties.

$$\frac{P^0 - P_S}{P^0} = i\chi_A = \frac{n_A}{n_A + n_B}; \Delta T_b = iK_b m; \Delta T_f = iK_f m; \ \pi = i\frac{n}{V}RT$$

Solubility : Maximum amount of a substance that can be dissolved in a specified amount of solvent at a specified temperature it depends upon
• Nature of solute • Nature of solvent • Temperature • Pressure

Solubility of a solid in liquid	Solubility of a gas in liquid
• Effect of nature of solute and solvent ⇒ like dissolves like • Effect of temp ⇒ Exothermic process - increase with rise in temp. • Endothermic process - decrease with rise in temp. Effect of pressure ⇒ No effect	• Effect of temp. ⇒ Follow same order as in case of solid. • Effect of pressure ⇒ Henry's law states that the partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution" $p = K_H x$ K_H ⇒ Henry's law constant solubility $= \frac{1}{K_H}$

Raoult's Law
$(P_s = P_A^o + (P_B^o - P_A^o) x_B$
$P_s = P_A^0 + (P_B^o + P_A^o) x_B$ where P_s = Total pressure, P_A^0 & P_B^0 = vapour pressure in pure state of two constituents A and B in solution

Types of solution

Classification based on physical state:

- Gas in gas (Air)
- Gas in liquid (Soda water)
- Gas in solid (Hydrogen in Pd)
- Liquid in gas (Fog)
- Liquid in liquid (Alcohol in water)
- Liquid in solid (Amalgams)
- Solid in gas (Smog)
- Solid in liquid (Sugar in water)
- Solid in solid (Alloys)

Classification based on concentration

- Dilute solutions
- Concentrated solutions
- Saturated solutions
- Supersaturated solutions

Concentration of solutions

- Mass percentage (w/W) $= \frac{\text{Mass of solute}}{\text{Total mass of solution}} \times 100$
- Molarity (M) $= \frac{\text{No. of moles of solute}}{\text{Volume of solution (L)}}$
- Molality (m) $= \frac{\text{No. of moles of solute}}{\text{Weight of the solvent in kg}}$
- Normality (N) $= \frac{\text{No. of grams equivalent of solute}}{\text{Volume of solution (L)}}$
- Mole fraction (x) $= \frac{\text{No. of moles of solute}}{\text{Total moles in solution}}$
- Volume percentage (v/V) $= \frac{\text{Volume of solute}}{\text{Total volume of solution}} \times 100$
- ppm $= \frac{\text{No. of parts of solute}}{\text{Total no. of parts of all components of solution}} \times 10^6$
- Mass by volume percentage (w/V) $= \frac{\text{mass of solute}}{\text{Total volume of solution (mL)}} \times 100$
- **Mass %, ppm, mole fraction and molality are independent of**

Ideal solution	Non-ideal solutions	
	Positive deviation from Raoult's law	Negative deviation from Raoult's law
(i) Obey Raoult's law at every range of concentration. (ii) $\Delta V_{mix} = 0$; total volume of solution is equal to the sum of volumes of the components. (iii) $\Delta H_{mix} = 0$; neither heat is evolved nor absorbed during dissolution. (iv) A – A, A – B, B – B molecular interactions present in the two liquids should be same, i.e., A and B are identical in shape, size and character. (v) $P_{total} = p_A + p_B = p_A^o x_A + p_B^o x_B$ i.e., $p_A = p_A^o x_A$; $p_B = p_B^o x_B$ (vi) Escaping tendency of A and B is same in pure liquids as well as in the solution **Examples** Dilute solutions Ethyl bromide + Ethyl iodide n-Butyl chloride + n-Butyl bromide	(i) Do not obey Raoult's law. (ii) $\Delta V_{mix} > 0$. Volume is increased after dissolution. (iii) $\Delta H_{mix} > 0$. Endothermic dissolution; heat is absorbed. (iv) A-B force of attraction are less than A – A and B – B attractive forces. A and B have different shape, size (v) $p_A > p_A^o x_A$; $p_B > p_B^o x_B$ $\therefore P_{total} > p_A^o x_A + p_B^o x_B$ (vi) Escaping tendency of A and B is very high (showing higher vapour pressure than expected) **Examples** Acetone + Ethanol $CCl_4 + CHCl_3$	(i) Do not obey Raoult's law. (ii) $\Delta V_{mix} < 0$. Volume is decreased during dissolution. (iii) $\Delta H_{mix} < 0$. Exothermic dissolution; heat is evolved. (iv) A – B force of attraction are greater than A – A and B – B attractive forces. A and B also have different shape, size and character. (v) $p_A < p_A^o x_A$; $p_B < p_B^o x_B$ $\therefore P_{total} < p_A^o x_A + p_B^o x_B$ (vi) Due to lower escaping tendency it shows lower vapour pressure than expected **Examples** Acetone + Aniline Chloroform + Diethyl ether

1. Henry's Law: Henry's Law states that the partial pressure (P) of a gas in the vapor phase is directly proportional to the mole fraction (x) of that gas in the solution.
2. Raoult's Law : Raoult's Law describes how the vapor pressure of a solvent is affected when a non-volatile solute is added. The law states that the relative lowering of the vapor pressure of the solvent is directly proportional to the mole fraction of the solute in the solution.
   $P_{total}= p_1^0x_1+p_2^0x_2$
3. Colligative Properties : Colligative properties are characteristics of solutions that depend on the number of solute particles (molecules or ions) in a given amount of solvent, rather than on the chemical nature of the solute

Quick Formulae

1. **Mole fraction (x)** $= \frac{Moles\ of\ solute}{Total\ moles\ of\ solute}$

1. **Molarity (M)** $= \left[\frac{Moles\ of\ Solute}{Vol.of\ Solution\ in\ mL}\right] X1000$

2. **Molality (m)** $= \left[\frac{Moles\ of\ Solute}{Vol.of\ Solvent\ in\ grams}\right] X1000$

3. **Normality (N)** $= \left[\frac{Equiv.of\ solute}{Vol.of\ solution\ in\ mL}\right] X1000$

4. **Henry's Law** = (m=K.p) or p = $\frac{1}{K'}x$ or $p=K_H.x$

5. **Henry Law gives relationship between solubility of gas in a liquid and pressure**

6. **Raoult's Law**

   $p_A = p^o_A x_A$ and $p_B=p^o_B x_B$

   and $p= p_A+p_B$

7. **Ideal Solution** = **a)** obeys Raoult's Law **b)** $\Delta_{mix}H$ and $\Delta_{mix}V = 0$

8. **Non-Ideal Solution** = **a)** donot obey Raoult's Law **b)** $\Delta_{mix}H$ and $\Delta_{mix}V \neq 0$

9. **Relative Lowering of Vapour Pressure**

   $$\frac{p_A^o - p_A}{p_A^o} = \frac{n_2}{n_1+n_2} \text{ and } M_B = \frac{w_B \times M_A}{w_A\left(\frac{P_A^0 - P_A}{P_A^0}\right)}$$

10. **Elevation in boiling point**

    $$M_B = \frac{K_b \times w_B \times 1000}{\Delta T_B \times w_A}$$

11. **Depression in Freezing point**

    $$M_B = \frac{K_f \times w_B \times 1000}{\Delta T_f \times w_A}$$

12. **Omotic pressure** $\pi = cRT = \frac{n}{V}RT$ and $M_B = \frac{w_B RT}{\pi V}$

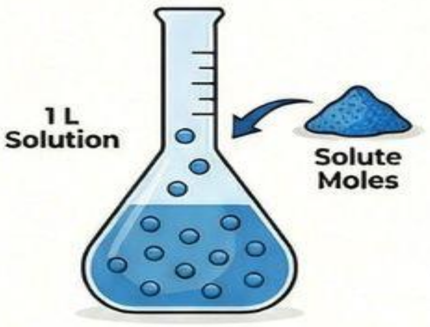
13. **Van't Hoff factor**

    $$i = \frac{Normal\ molar\ mass}{Observed\ molar\ mass} = \frac{Observed\ colligative\ property}{Normal\ colligative\ property}$$

A Quick Guide to
Chemical Concentration

MOLARITY (M)

Moles of Solute per Liter of Solution

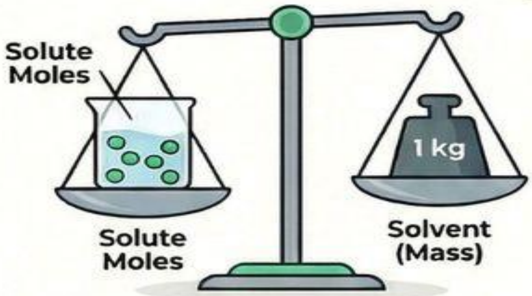


$$M = \frac{\text{Moles of Solute}}{\text{Volume of Solution (L)}}$$

Temperature Dependent: Because solution volume can change with temperature.

MOLALITY (m)

Moles of Solute per Kilogram of Solvent

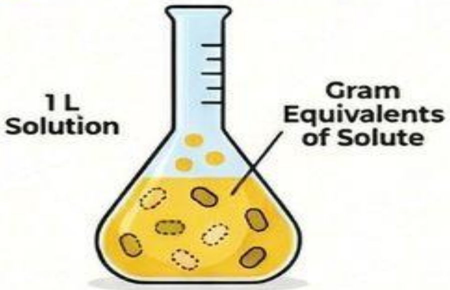


$$m = \frac{\text{Moles of Solute}}{\text{Mass of Solvent (kg)}}$$

Temperature Independent: Because mass does not change with temperature.

NORMALITY (N)

Gram Equivalents of Solute per Liter of Solution



Step 1
Calculate Molar Mass

Step 2
Find Equivalent Mass
(Molar Mass / n-factor)

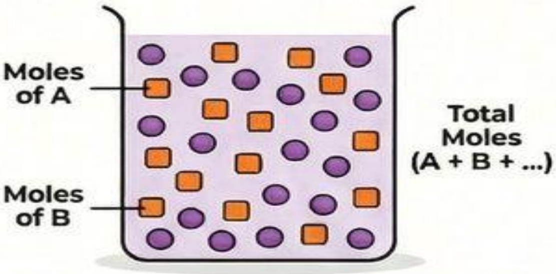
Step 3
Calculate Gram Equivalents
(Given Mass / Equivalent Mass)

$$N = \frac{\text{Gram Equivalents of Solute}}{\text{Volume of Solution (L)}}$$

Temperature Dependent: Because it is based on the volume of the solution.

MOLE FRACTION (χ)

Ratio of Moles of One Component to Total Moles

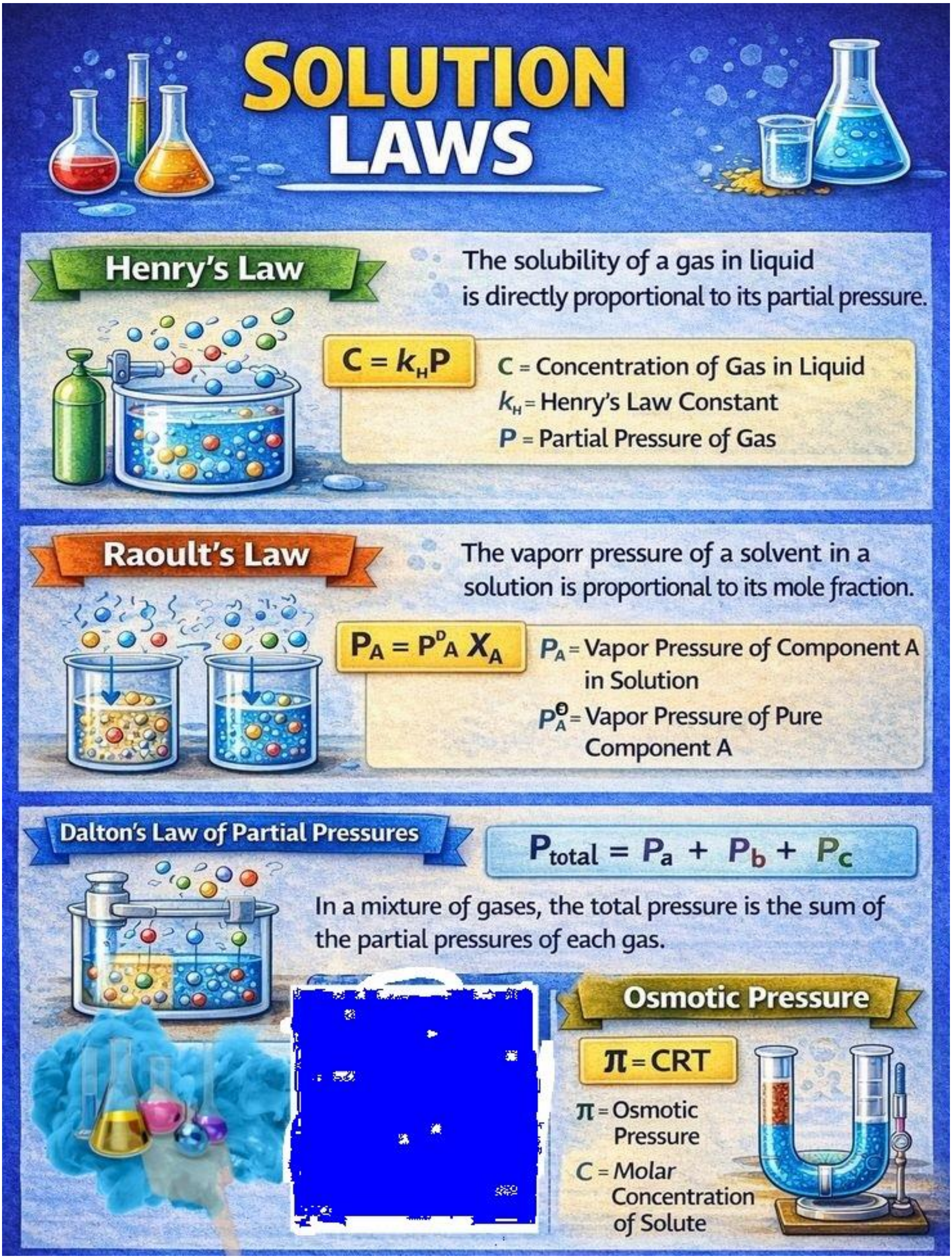


$$X_a = \frac{\text{Moles of A}}{\text{Moles of A + Moles of B + ...}}$$

Sum of All Mole Fractions is Always 1
$(\chi_a + \chi_e + ... = 1)$

Temperature Independent: Because it is based on moles, which relate to mass.

NotebookLM



SOLUTION LAWS

Henry's Law

The solubility of a gas in liquid is directly proportional to its partial pressure.

$C = k_H P$

C = Concentration of Gas in Liquid

k_H = Henry's Law Constant

P = Partial Pressure of Gas

Raoult's Law

The vaporr pressure of a solvent in a solution is proportional to its mole fraction.

$P_A = P^{D}_{A} X_A$

P_A = Vapor Pressure of Component A in Solution

$P^{\ominus}_{A}$ = Vapor Pressure of Pure Component A

Dalton's Law of Partial Pressures

$P_{total} = P_a + P_b + P_c$

In a mixture of gases, the total pressure is the sum of the partial pressures of each gas.

[redacted]

Osmotic Pressure

$\pi = CRT$

π = Osmotic Pressure

C = Molar Concentration of Solute

CHAPTER – ELECTROCHEMISTRY

1. An electrochemical cell consists of two metallic electrodes dipped in electrolytic solutions. The cells are of two types: (a) Electrolytic cells (b) Galvanic cells
2. A galvanic cell consists of two half cells. Each half cell contains an electrolytic solution and a metallic electrode.The electrode at which- oxidation takes place is called an anode and the electrode at which reduction takes place is called the cathode. The half-cells are separated from each other by means of a porous pot or a salt bridge.
3. Electrical energy = Emf (volts) x Quantity of electricity (coulombs)
4. If E0cell is positive, ΔG° would be negative and reaction would be spontaneous. If E0cell is negative, ΔG° would be positive and the reaction would be non-spontaneous.
5. Resistivity is defined as the resistance of a conductor of 1cm length and having an area of cross-section equal to $1cm^2$.

IMPORTANT FORMULAE

1. Resistance

   $R=\rho \frac{l}{a}$
2. Conductance

   $G=\frac{1}{R}$
3. Conductivity

   $K=\frac{1}{p}$ $K=\frac{1}{R}\frac{l}{a}$

   Here $\frac{l}{a}$ is called cell constant (G*) , K= G x G*
4. Molar Conductivity

   $\lambda_m = \frac{k x 1000}{C_m}$

   Unit $S\ cm^2\ mol^{-1}$
5. Equivalent Conductivity

   $\lambda_{eq} = \frac{k x 1000}{C_{eq}}$

   Unit $S\ cm^2\ (g\ equiv)^{-1}$ (or) $Ohm^{-1}\ cm2\ (g\ equiv)^{-1}$
6. Degree of dissociation

   $\alpha = \frac{\lambda^c_m}{\lambda^0_m}$
7. Kohlrausch law

   $\lambda^0_m = \nu_+ \lambda^0_+ + \nu_- \lambda^0_-$
8. EMF (Standard EMF)

   $E^0_{cell} = E^0_{cathode} - E^0_{anode}$
9. Nernst equation

   (a) $M^{n+}(aq) + ne^- \rightarrow M_{(s)}$

   $E(M^{n+}/M) = E^0(M^{n+}/M) - \frac{0.059}{n} \log \frac{[M]}{[M^{+n}]}$

(b) $aA+bB \rightarrow cC+dD$

$$E_{cell} = E^0_{cell} - \frac{0.059}{n} \log \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

where n is = the number of electrons transferred

10. Equilibrium constant from Nernst equation

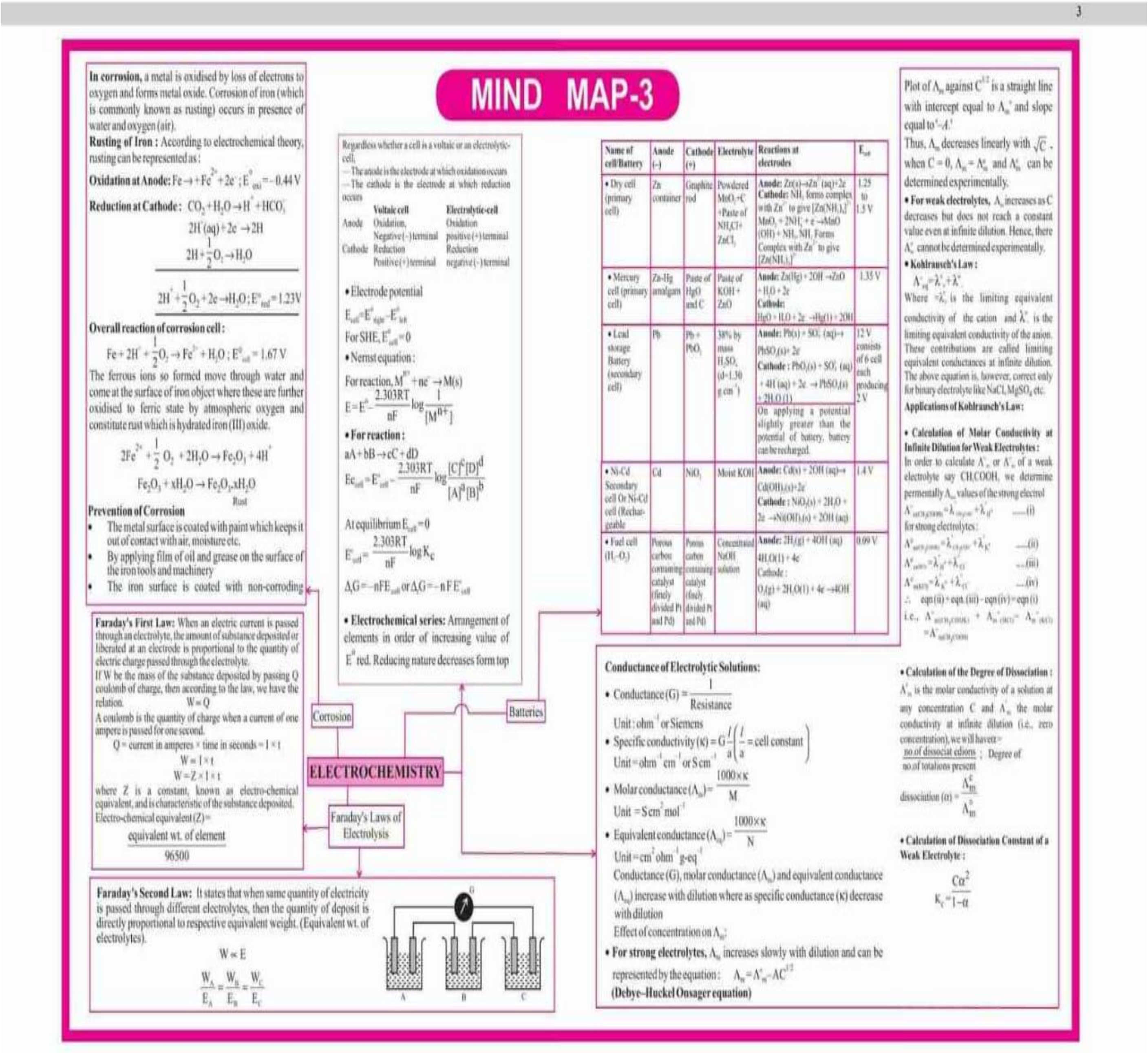
$$E_{cell} = \frac{0.059}{n} \log K_c \text{ (at 298 K)}$$

11. Standard change in Gibb's energy (ΔG^0) in an electrochemical cell.

$\Delta G^0 = -nFE^0_{cell}$

$\Delta G^0 = -RT \ln K_c$

$= -2.303\ RT \log K_c$



In corrosion, a metal is oxidised by loss of electrons to oxygen and forms metal oxide. Corrosion of iron (which is commonly known as rusting) occurs in presence of water and oxygen (air).

Rusting of Iron : According to electrochemical theory, rusting can be represented as :

Oxidation at Anode: $Fe \rightarrow Fe^{2+} + 2e^- ; E^0_{oxi} = -0.44\,V$

Reduction at Cathode: $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$

$$2H^+(aq) + 2e^- \rightarrow 2H$$

$$2H + \frac{1}{2}O_2 \rightarrow H_2O$$

$$2H^+ + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O ; E^0_{red} = 1.23\,V$$

Overall reaction of corrosion cell :

$$Fe + 2H^+ + \frac{1}{2}O_2 \rightarrow Fe^{2+} + H_2O ; E^0_{cell} = 1.67\,V$$

The ferrous ions so formed move through water and come at the surface of iron object where these are further oxidised to ferric state by atmospheric oxygen and constitute rust which is hydrated iron (III) oxide.

$$2Fe^{2+} + \frac{1}{2}O_2 + 2H_2O \rightarrow Fe_2O_3 + 4H^+$$

$$Fe_2O_3 + xH_2O \rightarrow \underset{\text{Rust}}{Fe_2O_3.xH_2O}$$

Prevention of Corrosion

- The metal surface is coated with paint which keeps it out of contact with air, moisture etc.
- By applying film of oil and grease on the surface of the iron tools and machinery
- The iron surface is coated with non-corroding

Faraday's First Law: When an electric current is passed through an electrolyte, the amount of substance deposited or liberated at an electrode is proportional to the quantity of electric charge passed through the electrolyte.

If W be the mass of the substance deposited by passing Q coulomb of charge, then according to the law, we have the relation. $W \propto Q$

A coulomb is the quantity of charge when a current of one ampere is passed for one second.

$$Q = \text{current in amperes} \times \text{time in seconds} = I \times t$$

$$W \propto I \times t$$

$$W = Z \times I \times t$$

where Z is a constant, known as electro-chemical equivalent, and is characteristic of the substance deposited.

Electro-chemical equivalent (Z) = $\frac{\text{equivalent wt. of element}}{96500}$

Faraday's Second Law: It states that when same quantity of electricity is passed through different electrolytes, then the quantity of deposit is directly proportional to respective equivalent weight. (Equivalent wt. of electrolytes).

$$W \propto E$$

$$\frac{W_A}{E_A} = \frac{W_B}{E_B} = \frac{W_C}{E_C}$$

Regardless whether a cell is a voltaic or an electrolytic-cell,

— The anode is the electrode at which oxidation occurs

— The cathode is the electrode at which reduction occurs

	Voltaic cell	**Electrolytic-cell**
Anode	Oxidation, Negative(−)terminal	Oxidation positive(+)terminal
Cathode	Reduction Positive(+)terminal	Reduction negative(−)terminal

- Electrode potential

$E_{cell} = E^0_{right} - E^0_{left}$

For SHE, $E^0_{cell} = 0$

- Nernst equation :

For reaction, $M^{n+} + ne^- \rightarrow M(s)$

$$E = E^0 - \frac{2.303RT}{nF} \log \frac{1}{[M^{n+}]}$$

- **For reaction :**

$aA + bB \rightarrow cC + dD$

$$Ec_{cell} = E^0_{cell} - \frac{2.303RT}{nF} \log \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

At equilibrium $E_{cell} = 0$

$$E^0_{cell} = \frac{2.303RT}{nF} \log K_c$$

$\Delta_r G = -nFE_{cell}$ or $\Delta_r G^0 = -nFE^0_{cell}$

- **Electrochemical series:** Arrangement of elements in order of increasing value of E^0 red. Reducing nature decreases form top

Name of cell/Battery	Anode (−)	Cathode (+)	Electrolyte	Reactions at electrodes	E_{cell}
• Dry cell (primary cell)	Zn container	Graphite rod	Powdered MnO_2+C +Paste of NH_4Cl+ $ZnCl_2$	**Anode:** $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ **Cathode:** NH_3 forms complex with Zn^{2+} to give $[Zn(NH_3)_4]^{2+}$ $MnO_2 + 2NH_4^+ + e^- \rightarrow MnO(OH) + NH_3$. NH_3 Forms Complex with Zn^{2+} to give $[Zn(NH_3)_4]^{2+}$	1.25 to 1.5 V
• Mercury cell (primary cell)	Zn-Hg amalgam	Paste of HgO and C	Paste of KOH + ZnO	**Anode:** $Zn(Hg) + 2OH^- \rightarrow ZnO + H_2O + 2e^-$ **Cathode:** $HgO + H_2O + 2e^- \rightarrow Hg(l) + 2OH^-$	1.35 V
• Lead storage Battery (secondary cell)	Pb	Pb + PbO_2	38% by mass H_2SO_4 (d=1.30 g cm^{-3})	**Anode:** $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$ **Cathode :** $PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$ On applying a potential slightly greater than the potential of battery, battery can be recharged.	12 V consists of 6 cell each producing 2 V
• Ni-Cd Secondary cell Or Ni-Cd cell (Rechargeable	Cd	NiO_2	Moist KOH	**Anode:** $Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$ **Cathode :** $NiO_2(s) + 2H_2O + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$	1.4 V
• Fuel cell (H_2-O_2)	Porous carbon containing catalyst (finely divided Pt and Pd)	Porous carbon containing catalyst (finely divided Pt and Pd)	Concentrated NaOH solution	**Anode:** $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$ Cathode : $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	0.09 V

Conductance of Electrolytic Solutions:

- Conductance (G) = $\frac{1}{\text{Resistance}}$

  Unit : ohm^{-1} or Siemens
- Specific conductivity (κ) = $G\frac{l}{a}\left(\frac{l}{a} = \text{cell constant}\right)$

  Unit = $ohm^{-1}\,cm^{-1}$ or $S\,cm^{-1}$
- Molar conductance (Λ_m) = $\frac{1000 \times \kappa}{M}$

  Unit = $S\,cm^2\,mol^{-1}$
- Equivalent conductance (Λ_{eq}) = $\frac{1000 \times \kappa}{N}$

  Unit = $cm^2\,ohm^{-1}\,g\text{-}eq^{-1}$

  Conductance (G), molar conductance (Λ_m) and equivalent conductance (Λ_{eq}) increase with dilution where as specific conductance (κ) decrease with dilution

  Effect of concentration on Λ_m:
- **For strong electrolytes,** Λ_m increases slowly with dilution and can be represented by the equation : $\Lambda_m = \Lambda^0_m - AC^{1/2}$

  (Debye–Huckel Onsager equation)

Plot of Λ_m against $C^{1/2}$ is a straight line with intercept equal to Λ^0_m and slope equal to '−A.'

Thus, Λ_m decreases linearly with $\sqrt{C}$, when C = 0, $\Lambda_m = \Lambda^0_m$ and Λ^0_m can be determined experimentally.

- **For weak electrolytes,** Λ_m increases as C decreases but does not reach a constant value even at infinite dilution. Hence, there Λ^0_m cannot be determined experimentally.
- **Kohlrausch's Law :**

  $\Lambda^0_{eq} = \lambda^0_+ + \lambda^0_-$

  Where λ^0_+ is the limiting equivalent conductivity of the cation and λ^0_- is the limiting equivalent conductivity of the anion. These contributions are called limiting equivalent conductances at infinite dilution. The above equation is, however, correct only for binary electrolyte like NaCl, $MgSO_4$ etc.

Applications of Kohlrausch's Law:

- **Calculation of Molar Conductivity at Infinite Dilution for Weak Electrolytes :**

  In order to calculate Λ^0_m or Λ^∞_m of a weak electrolyte say CH_3COOH, we determine permentally Λ_m values of the strong electrol

  $\Lambda^0_{m(CH_3COOH)} = \lambda^0_{CH_3COO^-} + \lambda^0_{H^+}$ —(i)

  for strong electrolytes:

  $\Lambda^0_{m(CH_3COOK)} = \lambda^0_{CH_3COO^-} + \lambda^0_{K^+}$ —(ii)

  $\Lambda^0_{m(HCl)} = \lambda^0_{H^+} + \lambda^0_{Cl^-}$ —(iii)

  $\Lambda^0_{m(KCl)} = \lambda^0_{K^+} + \lambda^0_{Cl^-}$ —(iv)

  $\therefore$ eqn (ii) + eqn. (iii) − eqn (iv) = eqn (i)

  i.e., $\Lambda^0_{m(CH_3COOK)} + \Lambda^0_{m(HCl)} - \Lambda^0_{m(KCl)} = \Lambda^0_{m(CH_3COOH)}$

- **Calculation of the Degree of Dissociation :**

  Λ^c_m is the molar conductivity of a solution at any concentration C and Λ^0_m the molar conductivity at infinite dilution (i.e., zero concentration), we will havetα = $\frac{\text{no.of dissociat edions}}{\text{no.of totalions present}}$; Degree of dissociation (α) = $\frac{\Lambda^c_m}{\Lambda^0_m}$

- **Calculation of Dissociation Constant of a Weak Electrolyte :**

$$K_c = \frac{C\alpha^2}{1-\alpha}$$

CHAPTER – CHEMICAL KINETICS

Important Key Points

1. Rate of reaction is the change in concentration of reactants or products per unit time. For a general reaction,
$A+B \rightarrow C+D$
The rate of reaction

$$= -\frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{\Delta t} = +\frac{\Delta[C]}{\Delta t} = +\frac{\Delta[D]}{\Delta t}$$

The negative sign indicates that the concentration is decreasing with time. Unit for reaction rate is mol $L^{-1}s^{-1}$.

2. A rate law expresses a mathematical relationship between the reaction rate and the molar concentration of one or more reactants.

$$\text{Rate} = k\,[A]^x\ [B]^y$$

$$-\frac{d[R]}{dt} = k[A]^x\,[B]^y$$

Where x and y are determined experimentally and represent the order of reaction with respect to A and B respectively, x + y represents the overall order of reaction.

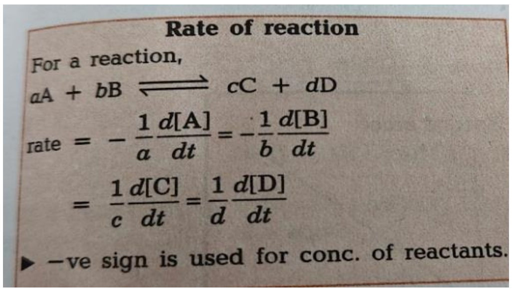
3. Rate constant is the rate of reaction when the concentration of each of reacting species is unity. It is represented by 'k' It is also called specific reaction rate or velocity constant of reaction.

4. Order of reaction is defined as the sum of the exponents to which the concentration terms are raised in the rate equation (or rate law) of the reaction. It can be fraction, zero or any whole number.

5. Molecularity of reaction is defined as the number of reacting particles (atoms or molecules or any other species), which collides simultaneously to bring about the chemical change.
It is a theoretical concept. Its value is always a whole number. It is never more than three. It cannot be zero.

Important Formulae :

- **Rate of reaction**



Rate of reaction

For a reaction,
$aA + bB \rightleftharpoons cC + dD$

$$\text{rate} = -\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = \frac{1}{c}\frac{d[C]}{dt} = \frac{1}{d}\frac{d[D]}{dt}$$

▶ −ve sign is used for conc. of reactants.

○ **Order of a reaction**

Rate = $k[A]^{\alpha}\,[B]^{\beta}\,[C]^{\gamma}$

Order = $\alpha + \beta + \gamma$

- **Order** **Units of k** **Integrated rate equation** **Half life period**

Order	Units of k	Integrated rate equation	Half life period
Zero ⇒	$molL^{-1}s^{-1}$ ⇒	$[A] = -kt + [A]_{\circ}$	⇒$[A]_{\circ}/2k$
First ⇒	s^{-1} ⇒	$\log [A] = -kt/2.303 + \log[A]_{\circ}$	⇒0.693/k
Second ⇒	L mol^{-1}s ⇒	$1/[A] = kt + 1/[A]_{\circ}$	⇒$1/[A]_{\circ}$

- **For nth order, units of k =$(mol\ L^{-1})^{1-n}s^{-1}$**

Arrhenius Equation $K = Ae^{-Ea/RT}$

$\text{Log } k_2/k_1 = Ea/2.303R\,[1/T_1 - 1/T_2]$

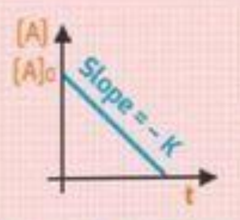
Law of Mass Action

$aA+bB \rightleftharpoons cC+dD$

$rate = k[A]^a[B]^b$

ORDER OF REACTION

Zero Order Reactions

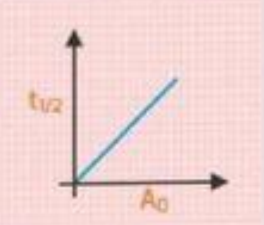


A zero order reaction has a constant rate that is independent of the concentration of the reactant(s); the rate law is simply. **Rate = k**

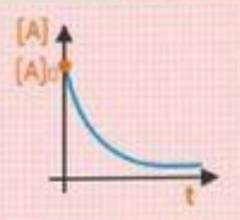
HALF LIFE ($t_{1/2}$)

Time in which half of inital amount is left.

$$t_{1/2} = \frac{[A]_0}{2k}$$



First Order Reactions

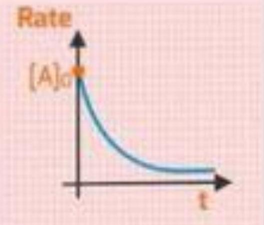


A first-order reaction is a reaction that proceeds at a rate that depends linearly on only one reactant concentration.

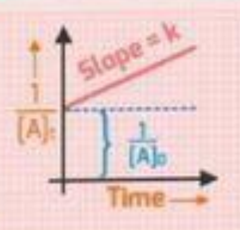
$$k = \frac{2.303}{t} \log \frac{[A]_0}{[A]}$$

HALF LIFE ($t_{1/2}$)

$$t_{1/2} = \frac{0.693}{k} \qquad [A] = \frac{[A]_0}{2^n}$$



Second Order Reactions

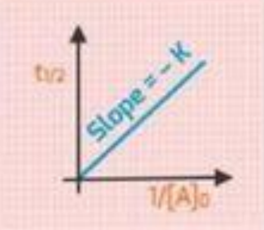


A chemical reaction in which the rate of the reaction is determined by the concentration of two chemical reactants involved or the square of the concentration of one chemical reactant.

$$k = \frac{1/[A] - 1/[A]_0}{t}$$

HALF LIFE ($t_{1/2}$)

$$t_{1/2} = \frac{1}{k[A]_0}$$

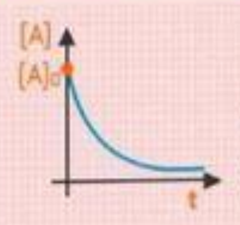


Pseudo first order reactions

If the concentration of a reactant remains constant (because it is a catalyst or it is in great excess with respect to the other reactants), its concentration can be included in the rate constant, obtaining a pseudo-first-order (or occasionally pseudo-second-order) rate equation.

For example, the hydrolysis of sucrose in acid solution rate r = k[sucrose]. The true rate equation is third-order, $r = k[\text{sucrose}][H^+][H_2O]$; however, the concentrations of both the catalyst H^+ and the solvent H_2O are normally constant, so that the reaction is pseudo-first-order.

N^{th} order reactions

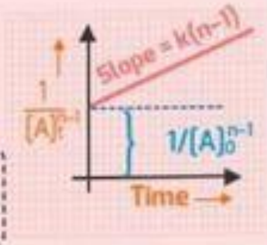


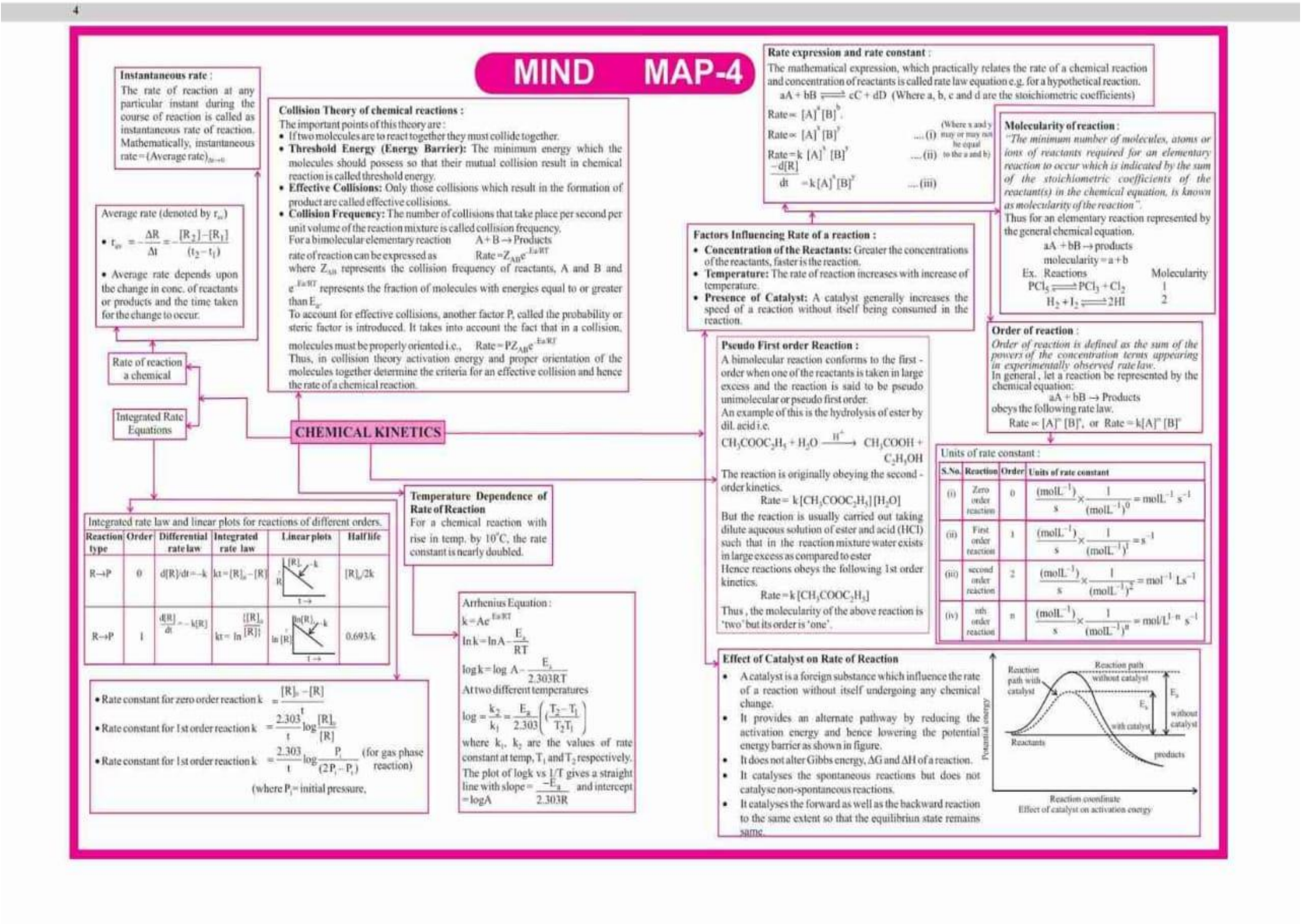
N_{th} order reaction is one which proceeds at the rate that depends on concentration of multiple reactants or on multiple steps.

$$\Rightarrow k = \frac{1}{(n-1)t}\left[\frac{1}{[A]_t^{n-1}} - \frac{1}{[A]_0^{n-1}}\right]$$

HALF LIFE ($t_{1/2}$)

$$t_{1/2} = \lim_{x \to n} \frac{2^{x-1}-1}{(x-1)k[A]_0^{x-1}}$$





MIND MAP-4

Instantaneous rate : The rate of reaction at any particular instant during the course of reaction is called as instantaneous rate of reaction. Mathematically, instantaneous rate = $(\text{Average rate})_{\Delta t \to 0}$

Average rate (denoted by r_{av})

- $r_{av} = -\frac{\Delta R}{\Delta t} = -\frac{[R_2]-[R_1]}{(t_2-t_1)}$
- Average rate depends upon the change in conc. of reactants or products and the time taken for the change to occur.

Rate of reaction a chemical

Integrated Rate Equations

Collision Theory of chemical reactions :

The important points of this theory are :

- If two molecules are to react together they must collide together.
- **Threshold Energy (Energy Barrier):** The minimum energy which the molecules should possess so that their mutual collision result in chemical reaction is called threshold energy.
- **Effective Collisions:** Only those collisions which result in the formation of product are called effective collisions.
- **Collision Frequency:** The number of collisions that take place per second per unit volume of the reaction mixture is called collision frequency.

For a bimolecular elementary reaction $A + B \rightarrow \text{Products}$

rate of reaction can be expressed as $\text{Rate} = Z_{AB}e^{-Ea/RT}$

where Z_{AB} represents the collision frequency of reactants, A and B and $e^{-Ea/RT}$ represents the fraction of molecules with energies equal to or greater than E_a.

To account for effective collisions, another factor P, called the probability or steric factor is introduced. It takes into account the fact that in a collision, molecules must be properly oriented i.e., $\text{Rate} = PZ_{AB}e^{-Ea/RT}$

Thus, in collision theory activation energy and proper orientation of the molecules together determine the criteria for an effective collision and hence the rate of a chemical reaction.

CHEMICAL KINETICS

Rate expression and rate constant : The mathematical expression, which practically relates the rate of a chemical reaction and concentration of reactants is called rate law equation e.g. for a hypothetical reaction.

$aA + bB \rightleftharpoons cC + dD$ (Where a, b, c and d are the stoichiometric coefficients)

$\text{Rate} \propto [A]^a[B]^b$.

$\text{Rate} \propto [A]^x[B]^y$ ....(i) (Where x and y may or may not be equal to the a and b)

$\text{Rate} = k[A]^x[B]^y$ ....(ii)

$\frac{-d[R]}{dt} = k[A]^x[B]^y$ ....(iii)

Molecularity of reaction : *"The minimum number of molecules, atoms or ions of reactants required for an elementary reaction to occur which is indicated by the sum of the stoichiometric coefficients of the reactant(s) in the chemical equation, is known as molecularity of the reaction".*

Thus for an elementary reaction represented by the general chemical equation.

$aA + bB \rightarrow \text{products}$

$\text{molecularity} = a + b$

Ex. Reactions	Molecularity
$PCl_5 \rightleftharpoons PCl_3 + Cl_2$	1
$H_2 + I_2 \rightleftharpoons 2HI$	2

Factors Influencing Rate of a reaction :

- **Concentration of the Reactants:** Greater the concentrations of the reactants, faster is the reaction.
- **Temperature:** The rate of reaction increases with increase of temperature.
- **Presence of Catalyst:** A catalyst generally increases the speed of a reaction without itself being consumed in the reaction.

Order of reaction : *Order of reaction is defined as the sum of the powers of the concentration terms appearing in experimentally observed rate law.*

In general, let a reaction be represented by the chemical equation:

$aA + bB \rightarrow \text{Products}$

obeys the following rate law.

$\text{Rate} \propto [A]^m[B]^n$, or $\text{Rate} = k[A]^m[B]^n$

Pseudo First order Reaction :

A bimolecular reaction conforms to the first-order when one of the reactants is taken in large excess and the reaction is said to be pseudo unimolecular or pseudo first order.

An example of this is the hydrolysis of ester by dil. acid i.e.

$CH_3COOC_2H_5 + H_2O \xrightarrow{H^+} CH_3COOH + C_2H_5OH$

The reaction is originally obeying the second-order kinetics.

$\text{Rate} = k[CH_3COOC_2H_5][H_2O]$

But the reaction is usually carried out taking dilute aqueous solution of ester and acid (HCl) such that in the reaction mixture water exists in large excess as compared to ester

Hence reactions obeys the following 1st order kinetics.

$\text{Rate} = k[CH_3COOC_2H_5]$

Thus, the molecularity of the above reaction is 'two' but its order is 'one'.

Units of rate constant :

S.No.	Reaction	Order	Units of rate constant
(i)	Zero order reaction	0	$\frac{(\text{molL}^{-1})}{s} \times \frac{1}{(\text{molL}^{-1})^0} = \text{molL}^{-1}s^{-1}$
(ii)	First order reaction	1	$\frac{(\text{molL}^{-1})}{s} \times \frac{1}{(\text{molL}^{-1})^1} = s^{-1}$
(iii)	second order reaction	2	$\frac{(\text{molL}^{-1})}{s} \times \frac{1}{(\text{molL}^{-1})^2} = \text{mol}^{-1}\text{Ls}^{-1}$
(iv)	nth order reaction	n	$\frac{(\text{molL}^{-1})}{s} \times \frac{1}{(\text{molL}^{-1})^n} = \text{mol/L}^{1-n}s^{-1}$

Integrated rate law and linear plots for reactions of different orders.

Reaction type	Order	Differential rate law	Integrated rate law	Linear plots	Half life
$R \rightarrow P$	0	$d[R]/dt = -k$	$kt = [R]_0 - [R]$	$[R]_0$, −k; R; t →	$[R]_0/2k$
$R \rightarrow P$	1	$\frac{d[R]}{dt} = -k[R]$	$kt = \ln\frac{[R]_0}{[R]}$	$\ln[R]_0$, −k; ln [R]; t →	0.693/k

- Rate constant for zero order reaction $k = \frac{[R]_0 - [R]}{t}$
- Rate constant for 1st order reaction $k = \frac{2.303}{t}\log\frac{[R]_0}{[R]}$
- Rate constant for 1st order reaction $k = \frac{2.303}{t}\log\frac{P_i}{(2P_i - P_t)}$ (for gas phase reaction)

(where P_i = initial pressure,

Temperature Dependence of Rate of Reaction

For a chemical reaction with rise in temp. by 10°C, the rate constant is nearly doubled.

Arrhenius Equation :

$k = Ae^{-Ea/RT}$

$\ln k = \ln A - \frac{E_a}{RT}$

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

At two different temperatures

$\log = \frac{k_2}{k_1} = \frac{E_a}{2.303}\left(\frac{T_2 - T_1}{T_2T_1}\right)$

where k_1, k_2 are the values of rate constant at temp, T_1 and T_2 respectively.

The plot of logk vs 1/T gives a straight line with slope = $\frac{-E_a}{2.303R}$ and intercept = logA

Effect of Catalyst on Rate of Reaction

- A catalyst is a foreign substance which influence the rate of a reaction without itself undergoing any chemical change.
- It provides an alternate pathway by reducing the activation energy and hence lowering the potential energy barrier as shown in figure.
- It does not alter Gibbs energy, ΔG and ΔH of a reaction.
- It catalyses the spontaneous reactions but does not catalyse non-spontaneous reactions.
- It catalyses the forward as well as the backward reaction to the same extent so that the equilibrium state remains same.

Effect of catalyst on activation energy

CHAPTER : COORDINATION COMPOUNDS

Quick Review

1. Addition compounds which retain their identity in solid as well as in the solution are called **complex compounds** or **coordination compounds.eg** .,$K_4[Fe(CN)_6]$;$[Cu(NH_3)]SO_4$
2. Polydentate ligands which form closed ring with metal on coordination are called **chelate** ligands and the corresponding complexes are called chelates.
3. Total number of electrons present with the central metal after coordination is called **effective atomic number**(EAN).

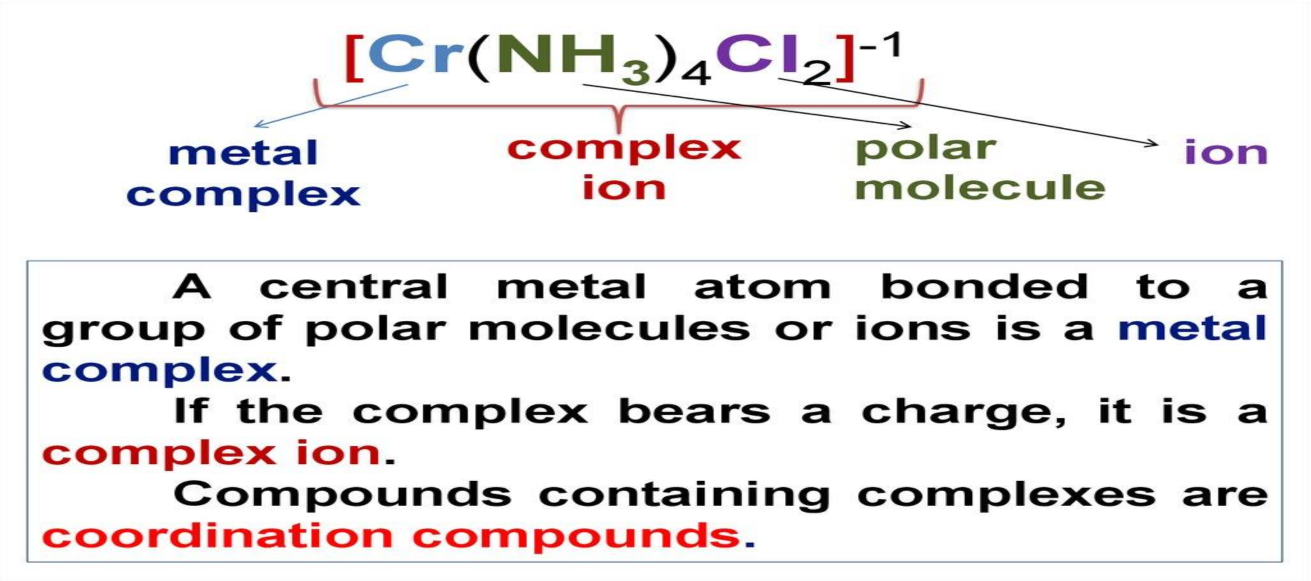
   EAN= Atomic number of central metal-Number of electrons lost during the formation of central metal ion+ number of electrons gained by the metal ion ligands during the coordination.
4. A complex which rotate the plane of polarized light either in clock wise or in anticlock wise direction are optically active. These complexes must be asymmetric and should not superimpose on its mirror image.
   1. Clock wise rotation →*Dextro complex*
   2. Anti clock wise rotation→*Laevo complex*

   Optical isomerism is quite common in the octahedral complexes.

5. Geometry of the complexes is decided on the basis of the type of hybridization:

Sp	Linear	$[Ag(NH_3)_2]^+$
Sp^3	Tetrahedral	$[Ni(CO)_4]$;$[NiCl_4]^{2-}$;$[Zn(NH_3)_4]^{2+}$
dsp^2	Square planar	$[Cu(NH_3)_4]^{2+}$,$[Ni(CN)_4]^{2-}$
d^2sp^3	Inner orbital octahedral complex	$[Fe(CN)_6]^{3-}$,$[Cr(NH_3)_6]^{3+}$
sp^3d^2	outer orbital octahedral complex	$[CoF_6]^{3-}$,$[Fe(H_2O)_6]^{3+}$

All octahedral complexes of Ni^{2+},Cu^{2+},Cu^+,Zn^{2+} and $Co^{2+}$are outer octahedral complexes.



A central metal atom bonded to a group of polar molecules or ions is a **metal complex**.

If the complex bears a charge, it is a **complex ion**.

Compounds containing complexes are **coordination compounds**.

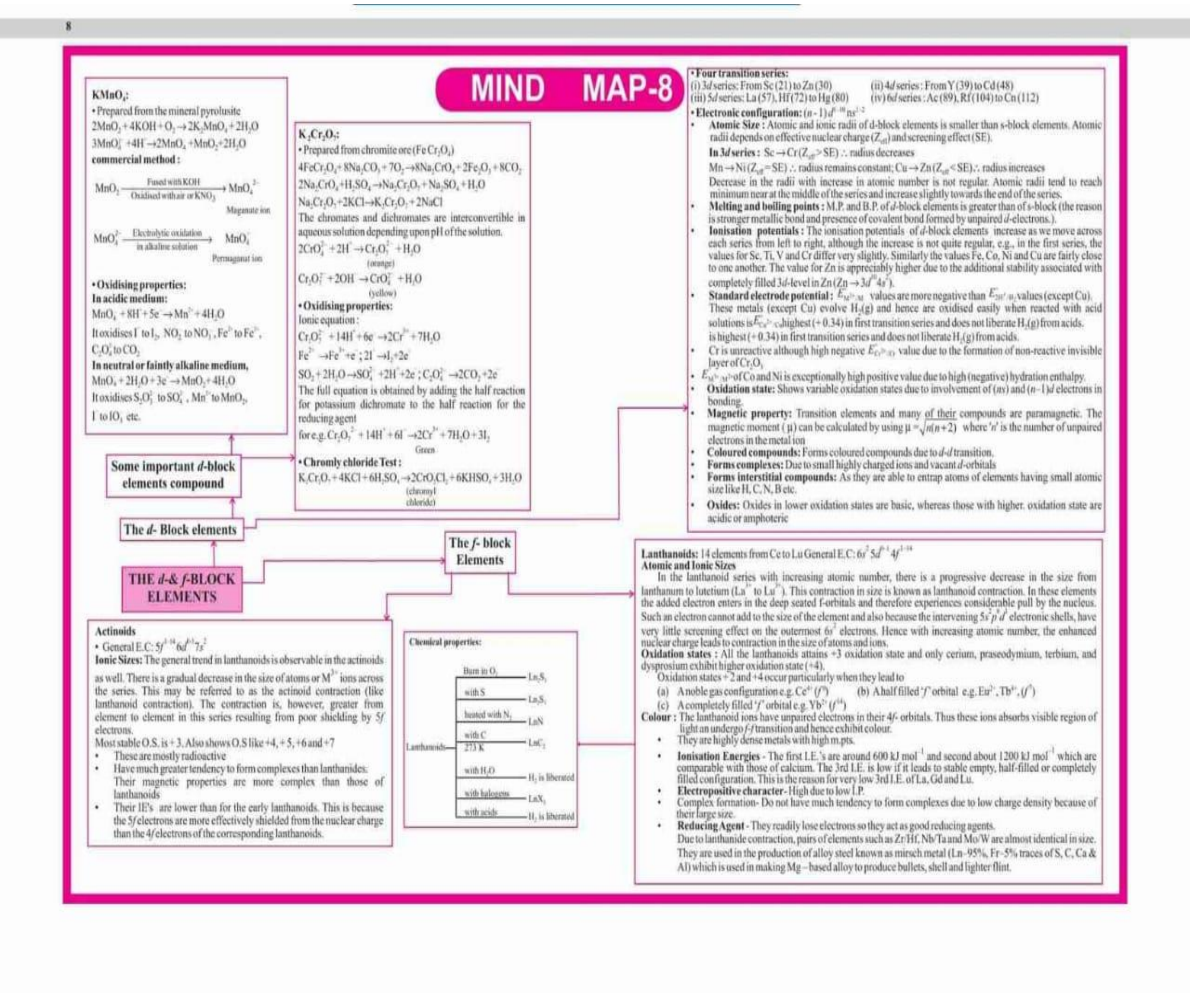
CHAPTER d AND f BLOCK ELEMENTS

D-Block Elements (Transition Metals)

- Position: Groups 3-12, center of the periodic table.
- Filling Orbitals: (n-1)d orbitals.
- Key Properties:
  - Variable Oxidation States: Due to involvement of (n-1)d and ns electrons.
  - Color: Many compounds are colored (due to d-d transitions).
  - Paramagnetism: Presence of unpaired d-electrons.
  - Catalytic Action: Good catalysts (e.g., Fe, V, Ni).
  - Alloy Formation: Form alloys with other metals.
- Series: 3d (Sc-Zn), 4d (Y-Cd), 5d (La, Hf-Hg), 6d (Ac, Rf-Cn).
- Exceptions: Zn, Cd, Hg are not always considered true transition metals as they have full d^{10} shells in common states.

F-Block Elements (Inner Transition Metals)

- Position: Two separate rows at the bottom (Lanthanides & Actinides).
- Filling Orbitals: 4f (Lanthanides) or 5f (Actinides) orbitals.
- Subgroups:
  - Lanthanides (4f): Elements Ce(58) to Lu(71).
  - Actinides (5f): Elements Th(90) to Lr(103) (many are radioactive).
- Key Properties:
  - Lanthanides: Similar chemical properties, used in magnets, lasers.
  - Actinides: Radioactive, important in nuclear energy (Uranium, Plutonium).



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MIND MAP-8

$KMnO_4$:

- Prepared from the mineral pyrolusite

$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

commercial method :

$MnO_2 \xrightarrow[\text{Oxidised with air or } KNO_3]{\text{Fused with KOH}} MnO_4^{2-}$
Maganate ion

$MnO_4^{2-} \xrightarrow[\text{in alkaline solution}]{\text{Electrolytic oxidation}} MnO_4^-$
Permaganat ion

- **Oxidising properties:**

In acidic medium:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

It oxidises I^- to I_2, NO_2^- to NO_3^-, Fe^{2+} to Fe^{3+}, $C_2O_4^{2-}$ to CO_2

In neutral or faintly alkaline medium,

$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4H_2O$

It oxidises $S_2O_3^{2-}$ to SO_4^{2-}, Mn^{2+} to MnO_2, I^- to IO_3^- etc.

$K_2Cr_2O_7$:

- Prepared from chromite ore ($FeCr_2O_4$)

$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$

$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

The chromates and dichromates are interconvertible in aqueous solution depending upon pH of the solution.

$2CrO_4^{2-} + 2H^+ \rightarrow \underset{\text{(orange)}}{Cr_2O_7^{2-}} + H_2O$

$Cr_2O_7^{2-} + 2OH^- \rightarrow \underset{\text{(yellow)}}{CrO_4^{2-}} + H_2O$

- **Oxidising properties:**

Ionic equation :

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$Fe^{2+} \rightarrow Fe^{3+} + e^-$; $2I^- \rightarrow I_2 + 2e^-$

$SO_2 + 2H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e^-$; $C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$

The full equation is obtained by adding the half reaction for potassium dichromate to the half reaction for the reducing agent

for e.g. $Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow \underset{\text{Green}}{2Cr^{3+}} + 7H_2O + 3I_2$

- **Chromly chloride Test :**

$K_2Cr_2O_7 + 4KCl + 6H_2SO_4 \rightarrow \underset{\text{(chromyl chloride)}}{2CrO_2Cl_2} + 6KHSO_4 + 3H_2O$

- **Four transition series:**

(i) 3*d* series: From Sc(21) to Zn(30)
(ii) 4*d* series : From Y(39) to Cd(48)
(iii) 5*d* series: La(57), Hf(72) to Hg(80)
(iv) 6*d* series : Ac(89), Rf(104) to Cn(112)

- **Electronic configuration:** $(n-1)d^{1-10}ns^{1-2}$
- **Atomic Size :** Atomic and ionic radii of d-block elements is smaller than s-block elements. Atomic radii depends on effective nuclear charge (Z_{eff}) and screening effect (SE).

  In 3*d* series : Sc → Cr (Z_{eff} > SE) ∴ radius decreases

  Mn → Ni (Z_{eff} = SE) ∴ radius remains constant; Cu → Zn (Z_{eff} < SE) ∴ radius increases

  Decrease in the radii with increase in atomic number is not regular. Atomic radii tend to reach minimum near at the middle of the series and increase slightly towards the end of the series.
- **Melting and boiling points :** M.P. and B.P. of *d*-block elements is greater than of s-block (the reason is stronger metallic bond and presence of covalent bond formed by unpaired *d*-electrons.).
- **Ionisation potentials :** The ionisation potentials of *d*-block elements increase as we move across each series from left to right, although the increase is not quite regular, e.g., in the first series, the values for Sc, Ti, V and Cr differ very slightly. Similarly the values Fe, Co, Ni and Cu are fairly close to one another. The value for Zn is appreciably higher due to the additional stability associated with completely filled 3*d*-level in Zn ($Zn \rightarrow 3d^{10}4s^2$).
- **Standard electrode potential :** $E^\circ_{M^{2+}/M}$ values are more negative than $E^\circ_{2H^+/H_2}$ values (except Cu). These metals (except Cu) evolve $H_2(g)$ and hence are oxidised easily when reacted with acid solutions is $E^\circ_{Cu^{2+}/Cu}$ highest (+0.34) in first transition series and does not liberate $H_2(g)$ from acids. is highest (+0.34) in first transition series and does not liberate $H_2(g)$ from acids.
- Cr is unreactive although high negative $E^\circ_{Cr^{3+}/Cr}$ value due to the formation of non-reactive invisible layer of Cr_2O_3
- $E^\circ_{M^{3+}/M^{2+}}$ of Co and Ni is exceptionally high positive value due to high (negative) hydration enthalpy.
- **Oxidation state:** Shows variable oxidation states due to involvement of (*ns*) and (*n*–1)*d* electrons in bonding.
- **Magnetic property:** Transition elements and many of their compounds are paramagnetic. The magnetic moment (μ) can be calculated by using $\mu = \sqrt{n(n+2)}$ where '*n*' is the number of unpaired electrons in the metal ion
- **Coloured compounds:** Forms coloured compounds due to *d*-*d* transition.
- **Forms complexes:** Due to small highly charged ions and vacant *d*-orbitals
- **Forms interstitial compounds:** As they are able to entrap atoms of elements having small atomic size like H, C, N, B etc.
- **Oxides:** Oxides in lower oxidation states are basic, whereas those with higher. oxidation state are acidic or amphoteric

Some important *d*-block elements compound

The *d*- Block elements

THE *d*-& *f*-BLOCK ELEMENTS

The *f*- block Elements

Lanthanoids: 14 elements from Ce to Lu General E.C: $6s^2 5d^{0-1} 4f^{1-14}$

Atomic and Ionic Sizes

In the lanthanoid series with increasing atomic number, there is a progressive decrease in the size from lanthanum to lutetium (La^{3+} to Lu^{3+}). This contraction in size is known as lanthanoid contraction. In these elements the added electron enters in the deep seated f-orbitals and therefore experiences considerable pull by the nucleus. Such an electron cannot add to the size of the element and also because the intervening $5s^2p^6d^1$ electronic shells, have very little screening effect on the outermost $6s^2$ electrons. Hence with increasing atomic number, the enhanced nuclear charge leads to contraction in the size of atoms and ions.

Oxidation states : All the lanthanoids attains +3 oxidation state and only cerium, praseodymium, terbium, and dysprosium exhibit higher oxidation state (+4).

Oxidation states +2 and +4 occur particularly when they lead to

(a) A noble gas configuration e.g. Ce^{4+} (f^0)
(b) A half filled '*f*' orbital e.g. Eu^{2+}, Tb^{4+}, (f^7)
(c) A completely filled '*f*' orbital e.g. Yb^{2+} (f^{14})

Colour : The lanthanoid ions have unpaired electrons in their 4*f*- orbitals. Thus these ions absorbs visible region of light an undergo *f*-*f* transition and hence exhibit colour.

- They are highly dense metals with high m.pts.
- **Ionisation Energies** - The first I.E.'s are around 600 kJ mol^{-1} and second about 1200 kJ mol^{-1} which are comparable with those of calcium. The 3rd I.E. is low if it leads to stable empty, half-filled or completely filled configuration. This is the reason for very low 3rd I.E. of La, Gd and Lu.
- **Electropositive character** - High due to low I.P.
- Complex formation- Do not have much tendency to form complexes due to low charge density because of their large size.
- **Reducing Agent** - They readily lose electrons so they act as good reducing agents.

  Due to lanthanide contraction, pairs of elements such as Zr/Hf, Nb/Ta and Mo/W are almost identical in size.

  They are used in the production of alloy steel known as mirsch metal (Ln-95%, Fr-5% traces of S, C, Ca & Al) which is used in making Mg – based alloy to produce bullets, shell and lighter flint.

Actinoids

- General E.C: $5f^{1-14}6d^{0-1}7s^2$

Ionic Sizes: The general trend in lanthanoids is observable in the actinoids as well. There is a gradual decrease in the size of atoms or M^{3+} ions across the series. This may be referred to as the actinoid contraction (like lanthanoid contraction). The contraction is, however, greater from element to element in this series resulting from poor shielding by 5*f* electrons.

Most stable O.S. is +3. Also shows O.S like +4, +5, +6 and +7

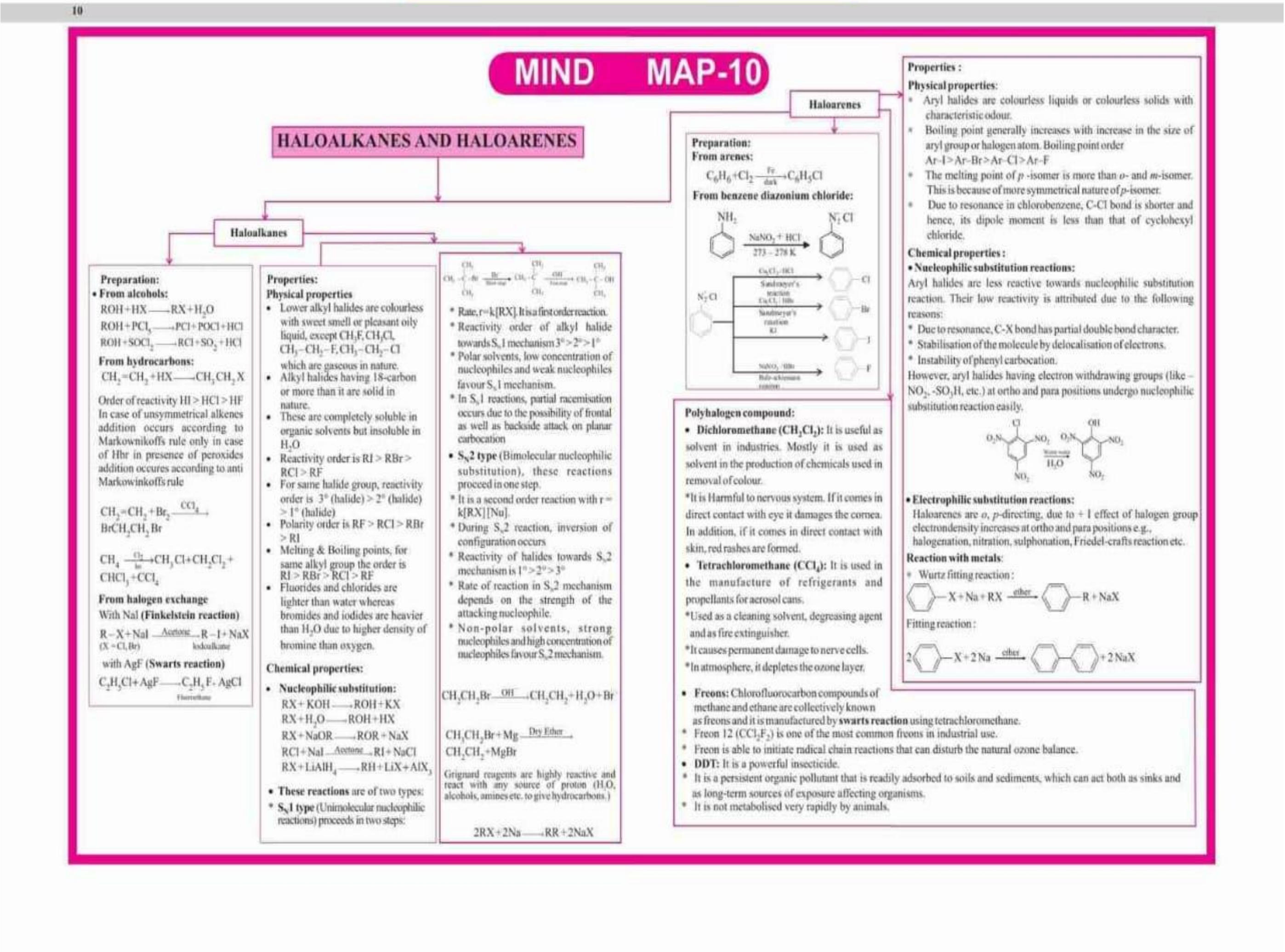
- These are mostly radioactive
- Have much greater tendency to form complexes than lanthanides. Their magnetic properties are more complex than those of lanthanoids
- Their IE's are lower than for the early lanthanoids. This is because the 5*f* electrons are more effectively shielded from the nuclear charge than the 4*f* electrons of the corresponding lanthanoids.

Chemical properties:

Lanthanoids

Burn in O_2	Ln_2S_3
with S	Ln_2S_3
heated with N_2	LnN
with C 273 K	LnC_2
with H_2O	H_2 is liberated
with halogens	LnX_3
with acids	H_2 is liberated

CHAPTER HALOALKANE AND HALOARENES



10

MIND MAP-10

HALOALKANES AND HALOARENES

Haloalkanes

Preparation:
- **From alcohols:**

$ROH + HX \longrightarrow RX + H_2O$
$ROH + PCl_5 \longrightarrow PCl + POCl + HCl$
$ROH + SOCl_2 \longrightarrow RCl + SO_2 + HCl$

From hydrocarbons:

$CH_2=CH_2 + HX \longrightarrow CH_3CH_2X$

Order of reactivity HI > HCl > HF
In case of unsymmetrical alkenes addition occurs according to Markownikoffs rule only in case of Hbr in presence of peroxides addition occures according to anti Markowinkoffs rule

$CH_2=CH_2 + Br_2 \xrightarrow{CCl_4} BrCH_2CH_2Br$

$CH_4 \xrightarrow[hv]{Cl_2} CH_3Cl + CH_2Cl_2 + CHCl_3 + CCl_4$

From halogen exchange
With NaI (**Finkelstein reaction**)

$\underset{(X=Cl,Br)}{R-X} + NaI \xrightarrow{Acetone} \underset{Iodoalkane}{R-I} + NaX$

with AgF (**Swarts reaction**)

$C_2H_5Cl + AgF \longrightarrow \underset{Fluoroethane}{C_2H_5F} + AgCl$

Properties:
Physical properties
- Lower alkyl halides are colourless with sweet smell or pleasant oily liquid, except CH_3F, CH_3Cl, CH_3-CH_2-F, CH_3-CH_2-Cl which are gaseous in nature.
- Alkyl halides having 18-carbon or more than it are solid in nature.
- These are completely soluble in organic solvents but insoluble in H_2O
- Reactivity order is RI > RBr > RCl > RF
- For same halide group, reactivity order is 3° (halide) > 2° (halide) > 1° (halide)
- Polarity order is RF > RCl > RBr > RI
- Melting & Boiling points, for same alkyl group the order is RI > RBr > RCl > RF
- Fluorides and chlorides are lighter than water whereas bromides and iodides are heavier than H_2O due to higher density of bromine than oxygen.

Chemical properties:
- **Nucleophilic substitution:**

$RX + KOH \longrightarrow ROH + KX$
$RX + H_2O \longrightarrow ROH + HX$
$RX + NaOR \longrightarrow ROR + NaX$
$RCl + NaI \xrightarrow{Acetone} RI + NaCl$
$RX + LiAlH_4 \longrightarrow RH + LiX + AlX_3$

- **These reactions** are of two types:
* S_N1 **type** (Unimolecular nucleophilic reactions) proceeds in two steps:

* Rate, r = k[RX]. It is a first order reaction.
* Reactivity order of alkyl halide towards S_N1 mechanism 3° > 2° > 1°
* Polar solvents, low concentration of nucleophiles and weak nucleophiles favour S_N1 mechanism.
* In S_N1 reactions, partial racemisation occurs due to the possibility of frontal as well as backside attack on planar carbocation
- S_N2 **type** (Bimolecular nucleophilic substitution), these reactions proceed in one step.
* It is a second order reaction with r = k[RX][Nu].
* During S_N2 reaction, inversion of configuration occurs
* Reactivity of halides towards S_N2 mechanism is 1° > 2° > 3°
* Rate of reaction in S_N2 mechanism depends on the strength of the attacking nucleophile.
* Non-polar solvents, strong nucleophiles and high concentration of nucleophiles favour S_N2 mechanism.

$CH_3CH_2Br \xrightarrow{OH^-} CH_2CH_2 + H_2O + Br^-$

$CH_3CH_2Br + Mg \xrightarrow{Dry\ Ether} CH_3CH_2MgBr$

Grignard reagents are highly reactive and react with any source of proton (H_2O, alcohols, amines etc. to give hydrocarbons.)

$2RX + 2Na \longrightarrow RR + 2NaX$

Haloarenes

Preparation:
From arenes:

$C_6H_6 + Cl_2 \xrightarrow[dark]{Fe} C_6H_5Cl$

From benzene diazonium chloride:

$NaNO_2 + HCl$, 273 – 278 K

Sandmeyer's reaction

Polyhalogen compound:
- **Dichloromethane (CH_2Cl_2):** It is useful as solvent in industries. Mostly it is used as solvent in the production of chemicals used in removal of colour.

*It is Harmful to nervous system. If it comes in direct contact with eye it damages the cornea. In addition, if it comes in direct contact with skin, red rashes are formed.

- **Tetrachloromethane (CCl_4):** It is used in the manufacture of refrigerants and propellants for aerosol cans.

*Used as a cleaning solvent, degreasing agent and as fire extinguisher.

*It causes permanent damage to nerve cells.

*In atmosphere, it depletes the ozone layer.

- **Freons:** Chlorofluorocarbon compounds of methane and ethane are collectively known as freons and it is manufactured by **swarts reaction** using tetrachloromethane.
* Freon 12 (CCl_2F_2) is one of the most common freons in industrial use.
* Freon is able to initiate radical chain reactions that can disturb the natural ozone balance.
- **DDT:** It is a powerful insecticide.
* It is a persistent organic pollutant that is readily adsorbed to soils and sediments, which can act both as sinks and as long-term sources of exposure affecting organisms.
* It is not metabolised very rapidly by animals.

Properties :
Physical properties:
* Aryl halides are colourless liquids or colourless solids with characteristic odour.
* Boiling point generally increases with increase in the size of aryl group or halogen atom. Boiling point order Ar-I > Ar-Br > Ar-Cl > Ar-F
* The melting point of *p*-isomer is more than *o*- and *m*-isomer. This is because of more symmetrical nature of *p*-isomer.
* Due to resonance in chlorobenzene, C-Cl bond is shorter and hence, its dipole moment is less than that of cyclohexyl chloride.

Chemical properties :
- **Nucleophilic substitution reactions:**

Aryl halides are less reactive towards nucleophilic substitution reaction. Their low reactivity is attributed due to the following reasons:
* Due to resonance, C-X bond has partial double bond character.
* Stabilisation of the molecule by delocalisation of electrons.
* Instability of phenyl carbocation.

However, aryl halides having electron withdrawing groups (like – NO_2, -SO_3H, etc.) at ortho and para positions undergo nucleophilic substitution reaction easily.

- **Electrophilic substitution reactions:**

Haloarenes are *o*, *p*-directing, due to + I effect of halogen group electrondensity increases at ortho and para positions e.g., halogenation, nitration, sulphonation, Friedel-crafts reaction etc.

Reaction with metals:
* Wurtz fitting reaction :

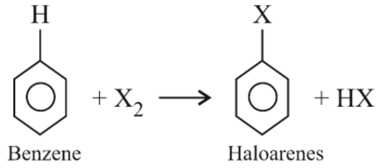
Fitting reaction :

A one-step reaction that occurs through a transition state. The nucleophile attacks the carbon attached to the halogen, replacing the halogen. SN2 reactions lead to a predictable configuration of the stereocenter

1. Boiling **Haloalkanes :** These are the organic compound which are formed by substituting the Hydrogen of corresponding alkane by a Halogen atom as

$$\underset{(alkane)}{R-H+X_2} \rightarrow \underset{(Haloalkane)}{R-X+HX}$$

2. **Haloarenes :** These are the argonic compound which are formed by substituting one or more hydrogen atom of benzene ring with Halogen atom as



3. **Classification of Haloalkanes :** These are of three types :

    (a) **1° Haloalkanes :** It is a Haloalkane in which the carbon which is attached to Halogen atoms attaches to one carbon atom only.

(b) **2º Haloalkanes :** It is a Haloalkane in which the carbon which is attached to Halogen atom attaches to two alkyl group.

(c) **3º Haloalkanes :** These are the Haloalkanes in which the carbon which is attached to Halogen atom attaches to three alkyl group.

4. **SN1 Reaction**

   A two-step reaction that involves the formation of a carbocation. The halogen leaves the haloalkane, and the nucleophile attacks the positive charge on the carbon. SN1 reactions are faster than SN2 reactions.

   SN2 Reaction
5. point orders
   1. R-I > R – Br > R-Cl > R -F
   2. $CH_3–(CH_2)_2–CH_2Br > (CH_3)_2CHCH_2Br > (CH_3)_3CBr$
   3. $CH_3CH_2CH_2 > CH_3CH_2X > CH_3X$
6. Bond strength of haloalkanes decreases as the size of the halogen atom increases. Thus, the order of bond strength is $CH_3F > CH_3Cl > CH_3Br > CH_3I$.
7. Dipole moment decreases as the electronegativity of the halogen decreases.
8. Haloalkanes though polar but are insoluble in water as they do not form hydrogen bonding with water.
9. Density order is RI> RBr > RCl > RF (for the same alkyl group) $CH_3I > C_2H_5I > C_3H_7I$
10. Relative reactivity of alkyl halides for same alkyl group is RI > RBr > RCI> RF

CHAPTER - ALCOHOL, PHENOL AND ETHER

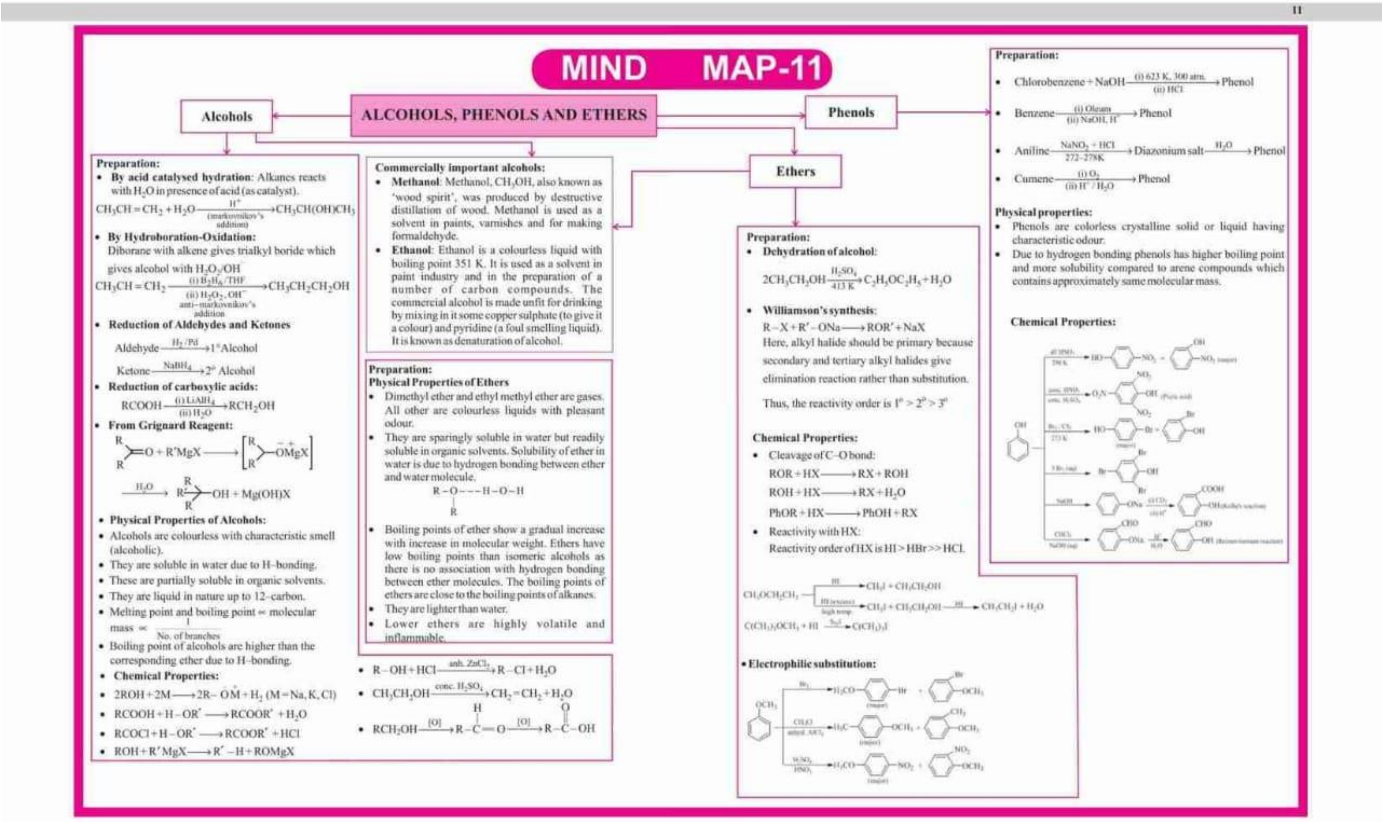
Quick Review

1. Alcohols give red colour with ceric ammonium nitrate but phenol does not.
2. Phenol gives violet colour with $FeCl_3$, but alcohols do not.
3. 3. Primary, secondary, and tertiary alcohols are distinguished by Lucas test and Victor Meyer test.
4. For Lucas reagent reactivity lies in following sequence.

   3° alcohol > 2° alcohol > 1° alcohol

   (turbidity Shows immediate) (Turbidity within 5 min) (Turbidity after long time on heating)
5. Methanol and ethanol are distinguished by iodoform test. Ethanol gives yellow residue of iodoform on treatment with I_2 and NaOH. However, methanol does not give this test.
6. Alcohol and phenol both are synthesized by nucleophilic substitution of alkyl and aryl halide.

   $$R\text{-}CH_2Cl + NaOH\,(aq) \rightarrow RCH_2\,OH + NaCI$$
7. Dehydrogenation of lº alcohols give aldehyde while 2°alcohols give ketone, it takes place on heating with copper metal at 300°C. Tertiary alcohols have no a-hydrogen hence they undergo dehydration at the place of dehydrogenation.



11

MIND MAP-11

ALCOHOLS, PHENOLS AND ETHERS

Alcohols

Phenols

Ethers

Preparation:
- **By acid catalysed hydration**: Alkanes reacts with H_2O in presence of acid (as catalyst).
$CH_3CH=CH_2 + H_2O \xrightarrow[\text{(markovnikov's addition)}]{H^+} CH_3CH(OH)CH_3$
- **By Hydroboration-Oxidation:**
Diborane with alkene gives trialkyl boride which gives alcohol with H_2O_2/OH^-
$CH_3CH=CH_2 \xrightarrow[\text{(ii) } H_2O_2,\ OH^- \text{ anti-markovnikov's addition}]{\text{(i) } B_2H_6/THF} CH_3CH_2CH_2OH$
- **Reduction of Aldehydes and Ketones**
Aldehyde $\xrightarrow{H_2/Pd}$ 1° Alcohol
Ketone $\xrightarrow{NaBH_4}$ 2° Alcohol
- **Reduction of carboxylic acids:**
$RCOOH \xrightarrow[\text{(ii) } H_2O]{\text{(i) } LiAlH_4} RCH_2OH$
- **From Grignard Reagent:**
$R_2C=O + R'MgX \longrightarrow [R_2C-\overset{-}{O}\overset{+}{Mg}X] \xrightarrow{H_2O} RR'RC-OH + Mg(OH)X$
- **Physical Properties of Alcohols:**
- Alcohols are colourless with characteristic smell (alcoholic).
- They are soluble in water due to H-bonding.
- These are partially soluble in organic solvents.
- They are liquid in nature up to 12-carbon.
- Melting point and boiling point ∝ molecular mass ∝ $\frac{1}{\text{No. of branches}}$
- Boiling point of alcohols are higher than the corresponding ether due to H-bonding.
- **Chemical Properties:**
- $2ROH + 2M \longrightarrow 2R-\overset{-}{O}\overset{+}{M} + H_2$ (M = Na, K, Cl)
- $RCOOH + H-OR' \longrightarrow RCOOR' + H_2O$
- $RCOCl + H-OR' \longrightarrow RCOOR' + HCl$
- $ROH + R'MgX \longrightarrow R'-H + ROMgX$

Commercially important alcohols:
- **Methanol**: Methanol, CH_3OH, also known as 'wood spirit', was produced by destructive distillation of wood. Methanol is used as a solvent in paints, varnishes and for making formaldehyde.
- **Ethanol**: Ethanol is a colourless liquid with boiling point 351 K. It is used as a solvent in paint industry and in the preparation of a number of carbon compounds. The commercial alcohol is made unfit for drinking by mixing in it some copper sulphate (to give it a colour) and pyridine (a foul smelling liquid). It is known as denaturation of alcohol.

Preparation:
Physical Properties of Ethers
- Dimethyl ether and ethyl methyl ether are gases. All other are colourless liquids with pleasant odour.
- They are sparingly soluble in water but readily soluble in organic solvents. Solubility of ether in water is due to hydrogen bonding between ether and water molecule.
$R-\underset{|\atop R}{O}---H-O-H$
- Boiling points of ether show a gradual increase with increase in molecular weight. Ethers have low boiling points than isomeric alcohols as there is no association with hydrogen bonding between ether molecules. The boiling points of ethers are close to the boiling points of alkanes.
- They are lighter than water.
- Lower ethers are highly volatile and inflammable.

- $R-OH + HCl \xrightarrow{\text{anh. } ZnCl_2} R-Cl + H_2O$
- $CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4} CH_2=CH_2 + H_2O$
- $RCH_2OH \xrightarrow{[O]} R-\overset{H}{\overset{|}{C}}=O \xrightarrow{[O]} R-\overset{O}{\overset{\|}{C}}-OH$

Preparation:
- **Dehydration of alcohol**:
$2CH_3CH_2OH \xrightarrow[413\ K]{H_2SO_4} C_2H_5OC_2H_5 + H_2O$
- **Williamson's synthesis**:
$R-X + R'-ONa \longrightarrow ROR' + NaX$
Here, alkyl halide should be primary because secondary and tertiary alkyl halides give elimination reaction rather than substitution.
Thus, the reactivity order is 1° > 2° > 3°

Chemical Properties:
- Cleavage of C–O bond:
$ROR + HX \longrightarrow RX + ROH$
$ROH + HX \longrightarrow RX + H_2O$
$PhOR + HX \longrightarrow PhOH + RX$
- Reactivity with HX:
Reactivity order of HX is HI > HBr >> HCl.

$CH_3OCH_2CH_3 \xrightarrow{HI} CH_3I + CH_3CH_2OH$
$CH_3OCH_2CH_3 \xrightarrow[\text{high temp}]{\text{HI (excess)}} CH_3I + CH_3CH_2OH \xrightarrow{HI} CH_3CH_2I + H_2O$
$C(CH_3)_3OCH_3 + HI \xrightarrow{S_N1} C(CH_3)_3I$

• Electrophilic substitution:

Preparation:
- $\text{Chlorobenzene} + NaOH \xrightarrow[\text{(ii) } HCl]{\text{(i) } 623\ K,\ 300\ atm.} \text{Phenol}$
- $\text{Benzene} \xrightarrow[\text{(ii) } NaOH,\ H^+]{\text{(i) Oleum}} \text{Phenol}$
- $\text{Aniline} \xrightarrow[272-278K]{NaNO_2 + HCl} \text{Diazonium salt} \xrightarrow{H_2O} \text{Phenol}$
- $\text{Cumene} \xrightarrow[\text{(ii) } H^+/H_2O]{\text{(i) } O_2} \text{Phenol}$

Physical properties:
- Phenols are colorless crystalline solid or liquid having characteristic odour.
- Due to hydrogen bonding phenols has higher boiling point and more solubility compared to arene compounds which contains approximately same molecular mass.

Chemical Properties:

CHAPTER - ALDEHYDE KETONE AND CARBOXYLIC ACID

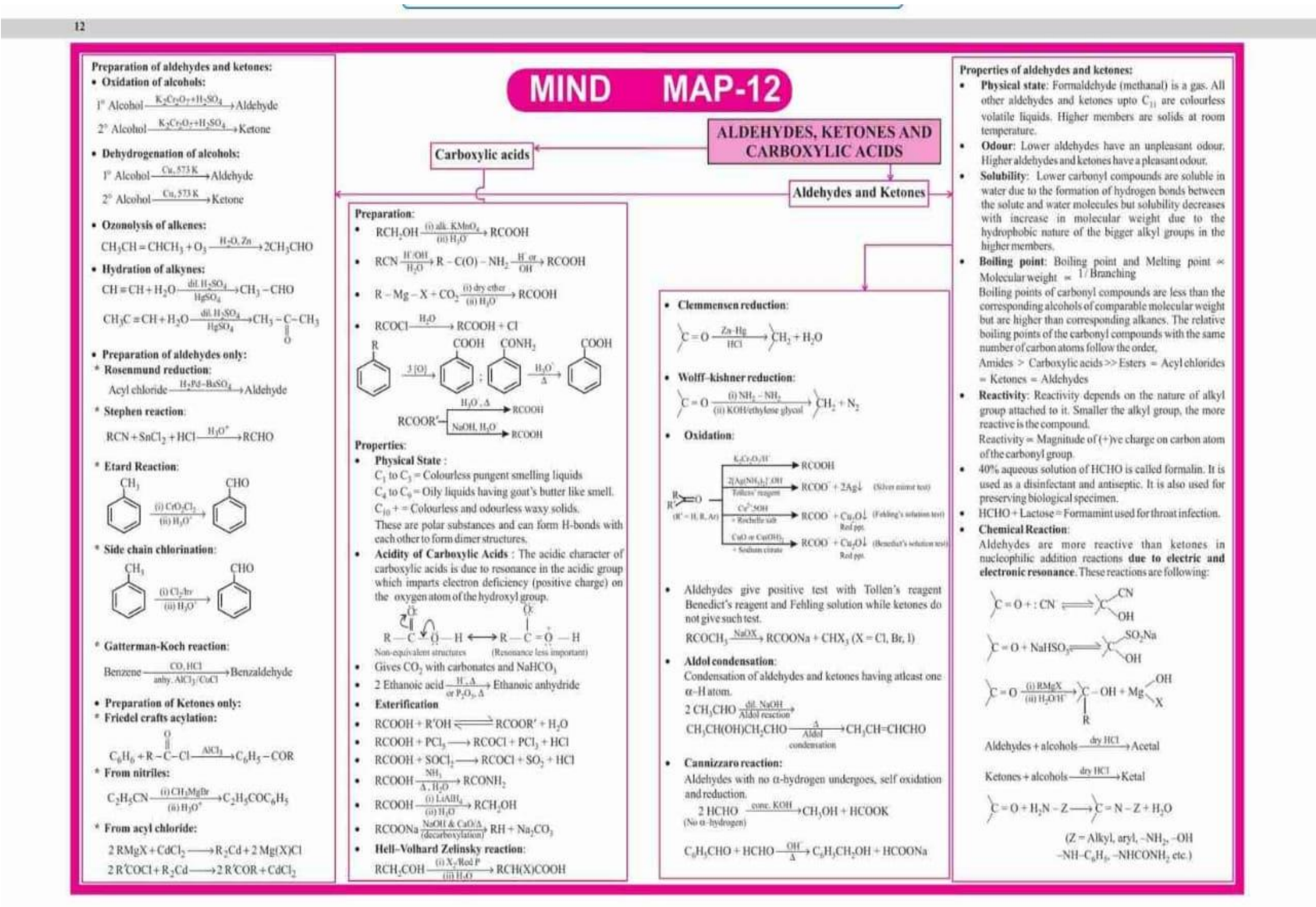
Quick revision

- Both Aldehydes and Ketones are carbonyl compounds. Carbonyl carbon lies in sp2-hybrid state. Similarly in carboxylic acids also the carbon of carboxylic group lies in sp2-hybrid state.
- Aldehydes and ketones are synthesized by oxidation of 1° and 2° alcohol respectively, which are further oxidised to form carboxylic acids.
- **Aldehydes and ketones are also synthesized by following methods**:
  i) Pyrolysis of carboxylic acids.
  ii) Dry distillation of calcium salts of acids.
  iii) Reductive hydrolysis of cyanides give aldehyde and the reaction is called Stephen's reaction.
  iv) Reaction of Grignard reagent with alkyl cyanide followed by acid hydrolysis gives carbonyl compound.
  v) Reduction of acid halides with H_2 in presence of Lindlar's catalyst gives aldehyde.
- **Aromatic aldehydes and ketones are synthesised by following specific methods:**
  i) Partial oxidation of Toluene in presence of chromyl chloride and acetic acid gives benzaldehyde. It is called Etard reaction.
  ii) In Gattermann Koch aldehyde synthesis, benzaldehyde is obtained by reaction of benzene with carbon mono oxide in presence of HCl and $AlCl_3$.
  iii) Aromatic ketones like acetophenone and benzophenone are obtained by Friedel Crafts acylation.

iv) In Gattermann aldehyde synthesis, benzaldehyde is obtained when benzene is treated with HCN and HCl, followed by hydrolysis.

- ➢ Aldehydes and ketones are more reactive than carboxylic group towards nucleophile. Itis because the positive charge of carboxylic carbon is reduced by resonance.
- ➢ Aromatic aldehydes and ketones are less reactive than aliphatic aldehydes and ketones because positive charge of carbonyl carbon is reduced in aromatic aldehydes and ketones due to resonance.
- ➢ Aldehydes and ketones when reduced in following conditions we get hydrocarbons:
- ➢ (a) Clemmensen reduction: Zn/Hg conc. HCI (Reducing agent)
- ➢ (b) Wolf Kishner reduction: NH_2-NH2 (NaOH aq)
- ➢ (c) Red P/HI: Strong reducing agent.
- ➢ In presence of mild reducing agents like $LiAlH_4$, $NaBH_4$, H_2/Pd, Ni etc. the aldehydes and ketones are reduced to primary alcohol and secondary alcohol respectively.
- ➢ Aldehydes and ketones having (CH_3CO-) group give yellow residue of iodoform , when treated with l_2 in presence of NaOH.
- ➢ Aldehydes give positive test to Tollen's reagent and Fehling's solution but ketones do not give any response to these reagents:

  i) HCN ii)$NaHSO_3$ iii) NH_2OH iv) NH_2-NH2 v) $C_6H_5NHNH_2$ vi) 2,4-Dinitrophenyl hydrazine vii) $NH_2CONHNH_2$ Semicarbazide



12

MIND MAP-12

ALDEHYDES, KETONES AND CARBOXYLIC ACIDS

Carboxylic acids

Aldehydes and Ketones

Preparation of aldehydes and ketones:

- **Oxidation of alcohols:**

  1° Alcohol $\xrightarrow{K_2Cr_2O_7+H_2SO_4}$ Aldehyde

  2° Alcohol $\xrightarrow{K_2Cr_2O_7+H_2SO_4}$ Ketone

- **Dehydrogenation of alcohols:**

  1° Alcohol $\xrightarrow{Cu,\ 573\ K}$ Aldehyde

  2° Alcohol $\xrightarrow{Cu,\ 573\ K}$ Ketone

- **Ozonolysis of alkenes:**

  $CH_3CH=CHCH_3+O_3 \xrightarrow{H_2O,\ Zn} 2CH_3CHO$

- **Hydration of alkynes:**

  $CH\equiv CH+H_2O \xrightarrow[HgSO_4]{dil.\ H_2SO_4} CH_3-CHO$

  $CH_3C\equiv CH+H_2O \xrightarrow[HgSO_4]{dil.\ H_2SO_4} CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3$

- **Preparation of aldehydes only:**

  * **Rosenmund reduction:**

  Acyl chloride $\xrightarrow{H_2\text{-}Pd\text{-}BaSO_4}$ Aldehyde

  * **Stephen reaction:**

  $RCN+SnCl_2+HCl \xrightarrow{H_3O^+} RCHO$

  * **Etard Reaction:**

  CH_3 $\xrightarrow[(ii)\ H_3O^+]{(i)\ CrO_2Cl_2}$ CHO

  * **Side chain chlorination:**

  CH_3 $\xrightarrow[(ii)\ H_3O^+]{(i)\ Cl_2/h\nu}$ CHO

  * **Gatterman-Koch reaction:**

  Benzene $\xrightarrow[anhy.\ AlCl_3/CuCl]{CO,\ HCl}$ Benzaldehyde

- **Preparation of Ketones only:**

  * **Friedel crafts acylation:**

  $C_6H_6+R-\overset{\overset{\displaystyle O}{\|}}{C}-Cl \xrightarrow{AlCl_3} C_6H_5-COR$

  * **From nitriles:**

  $C_2H_5CN \xrightarrow[(ii)\ H_3O^+]{(i)\ CH_3MgBr} C_2H_5COC_6H_5$

  * **From acyl chloride:**

  $2RMgX+CdCl_2 \longrightarrow R_2Cd+2Mg(X)Cl$

  $2R'COCl+R_2Cd \longrightarrow 2R'COR+CdCl_2$

Preparation:

- $RCH_2OH \xrightarrow[(ii)\ H_3O^+]{(i)\ alk.\ KMnO_4} RCOOH$
- $RCN \xrightarrow[H_2O]{H^+/OH^-} R-C(O)-NH_2 \xrightarrow[OH^-]{H^+\ or} RCOOH$
- $R-Mg-X+CO_2 \xrightarrow[(ii)\ H_3O^+]{(i)\ dry\ ether} RCOOH$
- $RCOCl \xrightarrow{H_2O} RCOOH+Cl^-$

R $\xrightarrow{3[O]}$ COOH ; $CONH_2$ $\xrightarrow[\Delta]{H_3O^+}$ COOH

$RCOOR' \xrightarrow{H_3O^+,\ \Delta} RCOOH$

$RCOOR' \xrightarrow{NaOH,\ H_3O^+} RCOOH$

Properties:

- **Physical State :**

  C_1 to C_3 = Colourless pungent smelling liquids

  C_4 to C_9 = Oily liquids having goat's butter like smell.

  C_{10} + = Colourless and odourless waxy solids.

  These are polar substances and can form H-bonds with each other to form dimer structures.

- **Acidity of Carboxylic Acids** : The acidic character of carboxylic acids is due to resonance in the acidic group which imparts electron deficiency (positive charge) on the oxygen atom of the hydroxyl group.

  $R-\overset{\overset{\displaystyle \ddot{O}:}{\|}}{C}-\ddot{O}-H \longleftrightarrow R-\overset{\overset{\displaystyle \ddot{O}:^-}{|}}{C}=\overset{+}{\ddot{O}}-H$

  Non-equivalent structures (Resonance less important)

- Gives CO_2 with carbonates and $NaHCO_3$
- 2 Ethanoic acid $\xrightarrow[or\ P_2O_5,\ \Delta]{H^+,\ \Delta}$ Ethanoic anhydride
- **Esterification**
- $RCOOH+R'OH \rightleftharpoons RCOOR'+H_2O$
- $RCOOH+PCl_5 \longrightarrow RCOCl+PCl_3+HCl$
- $RCOOH+SOCl_2 \longrightarrow RCOCl+SO_2+HCl$
- $RCOOH \xrightarrow[\Delta,\ H_2O]{NH_3} RCONH_2$
- $RCOOH \xrightarrow[(ii)\ H_3O^+]{(i)\ LiAlH_4} RCH_2OH$
- $RCOONa \xrightarrow[(decarboxylation)]{NaOH\ \&\ CaO/\Delta} RH+Na_2CO_3$
- **Hell-Volhard Zelinsky reaction:**

  $RCH_2COH \xrightarrow[(ii)\ H_2O]{(i)\ X_2/Red\ P} RCH(X)COOH$

- **Clemmensen reduction:**

  $>C=O \xrightarrow[HCl]{Zn\text{-}Hg} >CH_2+H_2O$

- **Wolff-kishner reduction:**

  $>C=O \xrightarrow[(ii)\ KOH/ethylene\ glycol]{(i)\ NH_2-NH_2} >CH_2+N_2$

- **Oxidation:**

  $R'(R)C=O$ (R' = H, R, Ar)

  $\xrightarrow{K_2Cr_2O_7/H^+} RCOOH$

  $\xrightarrow[Tollens'\ reagent]{2[Ag(NH_3)_2]^+OH^-} RCOO^-+2Ag\downarrow$ (Silver mirror test)

  $\xrightarrow[+\ Rochelle\ salt]{Cu^{2+}\ 5OH^-} RCOO^-+Cu_2O\downarrow$ Red ppt. (Fehling's solution test)

  $\xrightarrow[+\ Sodium\ citrate]{CuO\ or\ Cu(OH)_2} RCOO^-+Cu_2O\downarrow$ Red ppt. (Benedict's solution test)

- Aldehydes give positive test with Tollen's reagent Benedict's reagent and Fehling solution while ketones do not give such test.

  $RCOCH_3 \xrightarrow{NaOX} RCOONa+CHX_3$ (X = Cl, Br, I)

- **Aldol condensation:**

  Condensation of aldehydes and ketones having atleast one α-H atom.

  $2\,CH_3CHO \xrightarrow[Aldol\ reaction]{dil.\ NaOH}$

  $CH_3CH(OH)CH_2CHO \xrightarrow[Aldol\ condensation]{\Delta} CH_3CH{=}CHCHO$

- **Cannizzaro reaction:**

  Aldehydes with no α-hydrogen undergoes, self oxidation and reduction.

  $2\,HCHO \xrightarrow{conc.\ KOH} CH_3OH+HCOOK$
  (No α-hydrogen)

  $C_6H_5CHO+HCHO \xrightarrow[\Delta]{OH^-} C_6H_5CH_2OH+HCOONa$

Properties of aldehydes and ketones:

- **Physical state**: Formaldehyde (methanal) is a gas. All other aldehydes and ketones upto C_{11} are colourless volatile liquids. Higher members are solids at room temperature.
- **Odour**: Lower aldehydes have an unpleasant odour. Higher aldehydes and ketones have a pleasant odour.
- **Solubility**: Lower carbonyl compounds are soluble in water due to the formation of hydrogen bonds between the solute and water molecules but solubility decreases with increase in molecular weight due to the hydrophobic nature of the bigger alkyl groups in the higher members.
- **Boiling point**: Boiling point and Melting point ∝ Molecular weight ∝ 1/Branching

  Boiling points of carbonyl compounds are less than the corresponding alcohols of comparable molecular weight but are higher than corresponding alkanes. The relative boiling points of the carbonyl compounds with the same number of carbon atoms follow the order,

  Amides > Carboxylic acids >> Esters ≈ Acyl chlorides ≈ Ketones ≈ Aldehydes

- **Reactivity**: Reactivity depends on the nature of alkyl group attached to it. Smaller the alkyl group, the more reactive is the compound.

  Reactivity ∝ Magnitude of (+)ve charge on carbon atom of the carbonyl group.

- 40% aqueous solution of HCHO is called formalin. It is used as a disinfectant and antiseptic. It is also used for preserving biological specimen.
- HCHO + Lactose = Formamint used for throat infection.
- **Chemical Reaction**:

  Aldehydes are more reactive than ketones in nucleophilic addition reactions **due to electric and electronic resonance**. These reactions are following:

  $>C=O+:CN^- \rightleftharpoons >C(CN)(OH)$

  $>C=O+NaHSO_3 \rightleftharpoons >C(SO_3Na)(OH)$

  $>C=O \xrightarrow[(ii)\ H_2O/H^+]{(i)\ RMgX} >C(R)-OH+Mg(OH)X$

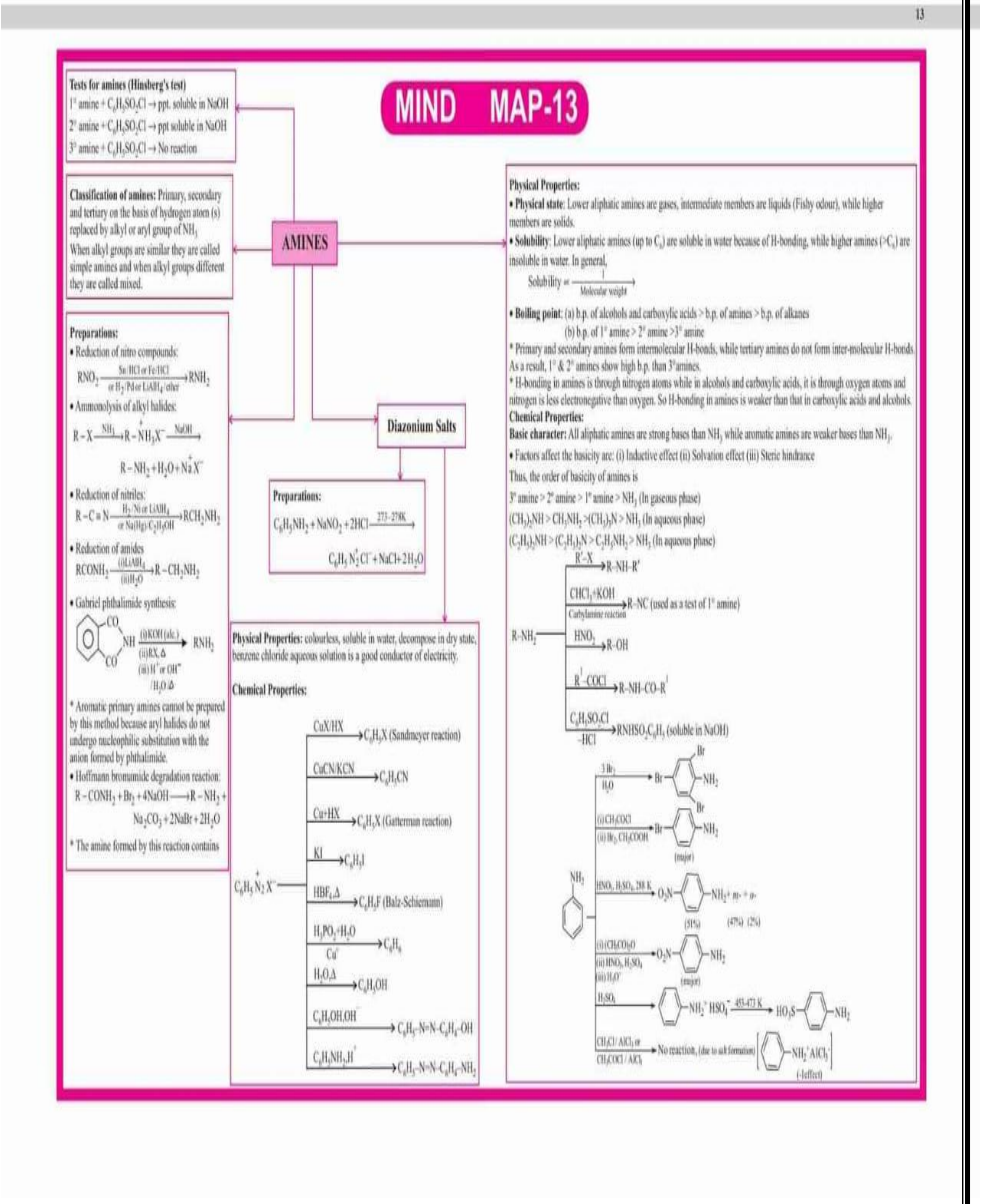
  Aldehydes + alcohols $\xrightarrow{dry\ HCl}$ Acetal

  Ketones + alcohols $\xrightarrow{dry\ HCl}$ Ketal

  $>C=O+H_2N-Z \longrightarrow >C=N-Z+H_2O$

  (Z = Alkyl, aryl, $-NH_2$, $-OH$, $-NH-C_6H_5$, $-NHCONH_2$ etc.)

CHAPTER - ORGANIC COMPOUNDS CONTAINING NITROGEN COMPOUNDS



13

MIND MAP-13

AMINES

Tests for amines (Hinsberg's test)

1° amine + $C_6H_5SO_2Cl \rightarrow$ ppt. soluble in NaOH

2° amine + $C_6H_5SO_2Cl \rightarrow$ ppt soluble in NaOH

3° amine + $C_6H_5SO_2Cl \rightarrow$ No reaction

Classification of amines: Primary, secondary and tertiary on the basis of hydrogen atom (s) replaced by alkyl or aryl group of NH_3

When alkyl groups are similar they are called simple amines and when alkyl groups different they are called mixed.

Preparations:

- Reduction of nitro compounds:

$$RNO_2 \xrightarrow[\text{or } H_2/Pd \text{ or } LiAlH_4/\text{ether}]{Sn/HCl \text{ or } Fe/HCl} RNH_2$$

- Ammonolysis of alkyl halides:

$$R-X \xrightarrow{NH_3} R-\overset{+}{N}H_3X^- \xrightarrow{NaOH} R-NH_2 + H_2O + \overset{+}{Na}X^-$$

- Reduction of nitriles:

$$R-C\equiv N \xrightarrow[\text{or } Na(Hg)/C_2H_5OH]{H_2/Ni \text{ or } LiAlH_4} RCH_2NH_2$$

- Reduction of amides

$$RCONH_2 \xrightarrow[(ii) H_2O]{(i) LiAlH_4} R-CH_2NH_2$$

- Gabriel phthalimide synthesis:

* Aromatic primary amines cannot be prepared by this method because aryl halides do not undergo nucleophilic substitution with the anion formed by phthalimide.

- Hoffmann bromamide degradation reaction:

$$R-CONH_2 + Br_2 + 4NaOH \longrightarrow R-NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$$

* The amine formed by this reaction contains

Diazonium Salts

Preparations:

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{273-278K} C_6H_5\overset{+}{N_2}Cl^- + NaCl + 2H_2O$$

Physical Properties: colourless, soluble in water, decompose in dry state, benzene chloride aqueous solution is a good conductor of electricity.

Chemical Properties:

$C_6H_5\overset{+}{N_2}X^-$

$\xrightarrow{CuX/HX} C_6H_5X$ (Sandmeyer reaction)

$\xrightarrow{CuCN/KCN} C_6H_5CN$

$\xrightarrow{Cu+HX} C_6H_5X$ (Gatterman reaction)

$\xrightarrow{KI} C_6H_5I$

$\xrightarrow{HBF_4, \Delta} C_6H_5F$ (Balz-Schiemann)

$\xrightarrow[Cu^+]{H_3PO_2+H_2O} C_6H_6$

$\xrightarrow{H_2O, \Delta} C_6H_5OH$

$\xrightarrow{C_6H_5OH, OH^-} C_6H_5-N=N-C_6H_4-OH$

$\xrightarrow{C_6H_5NH_2, H^+} C_6H_5-N=N-C_6H_4-NH_2$

Physical Properties:

- **Physical state**: Lower aliphatic amines are gases, intermediate members are liquids (Fishy odour), while higher members are solids.
- **Solubility**: Lower aliphatic amines (up to C_6) are soluble in water because of H-bonding, while higher amines ($>C_6$) are insoluble in water. In general,

  $$\text{Solubility} \propto \frac{1}{\text{Molecular weight}}$$

- **Boiling point**: (a) b.p. of alcohols and carboxylic acids > b.p. of amines > b.p. of alkanes
  (b) b.p. of 1° amine > 2° amine > 3° amine

* Primary and secondary amines form intermolecular H-bonds, while tertiary amines do not form inter-molecular H-bonds. As a result, 1° & 2° amines show high b.p. than 3° amines.
* H-bonding in amines is through nitrogen atoms while in alcohols and carboxylic acids, it is through oxygen atoms and nitrogen is less electronegative than oxygen. So H-bonding in amines is weaker than that in carboxylic acids and alcohols.

Chemical Properties:

Basic character: All aliphatic amines are strong bases than NH_3 while aromatic amines are weaker bases than NH_3.

- Factors affect the basicity are: (i) Inductive effect (ii) Solvation effect (iii) Steric hindrance

Thus, the order of basicity of amines is

3° amine > 2° amine > 1° amine > NH_3 (In gaseous phase)

$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$ (In aqueous phase)

$(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$ (In aqueous phase)

$R-NH_2$

$\xrightarrow{R'-X} R-NH-R'$

$\xrightarrow[\text{Carbylamine reaction}]{CHCl_3+KOH} R-NC$ (used as a test of 1° amine)

$\xrightarrow{HNO_2} R-OH$

$\xrightarrow{R^1-COCl} R-NH-CO-R^1$

$\xrightarrow[-HCl]{C_6H_5SO_2Cl} RNHSO_2C_6H_5$ (soluble in NaOH)

Quick Overview

Amines are organic compounds that are produced from ammonia (NH3) in which alkyl or aryl groups have taken the place of one or more hydrogen atoms. A classifier for amines is the number of substituents on nitrogen; 1°, 2°, or 3° indicates a primary amine. Depending on the type of carbon chain that is joined to the nitrogen atom, they can be either aromatic or aliphatic. Because nitrogen has a single pair of electrons that can take protons, amines have basic characteristics. The type of the solvent and substituents affects how basic they are.

Here are some important points about organic compounds containing nitrogen:

- **Nitriles**

These molecules have a triple bond between nitrogen and carbon, making them highly unsaturated. Nitriles are versatile and can act as electrophiles in reactions like nucleophilic addition or substitution.

- **Carbylamine reaction**

This reaction is used to identify primary amines. When primary amines are heated with chloroform and ethanolic potassium hydroxide, carbylamines are formed. These carbylamines have an unpleasant odor.

- **Diazonium compounds**

Also known as diazonium salts, these compounds have the functional group RN+2X, where R can be any chemical group and X is halogen.

- **Hofmann bromamide reaction**

Also known as Hofmann's Rearrangement, this reaction is used to convert amides into primary amines.

- **Amino acids**

These organic molecules contain both an amino group (-NH2) and a carboxyl group (-COOH). They are the building blocks of proteins.

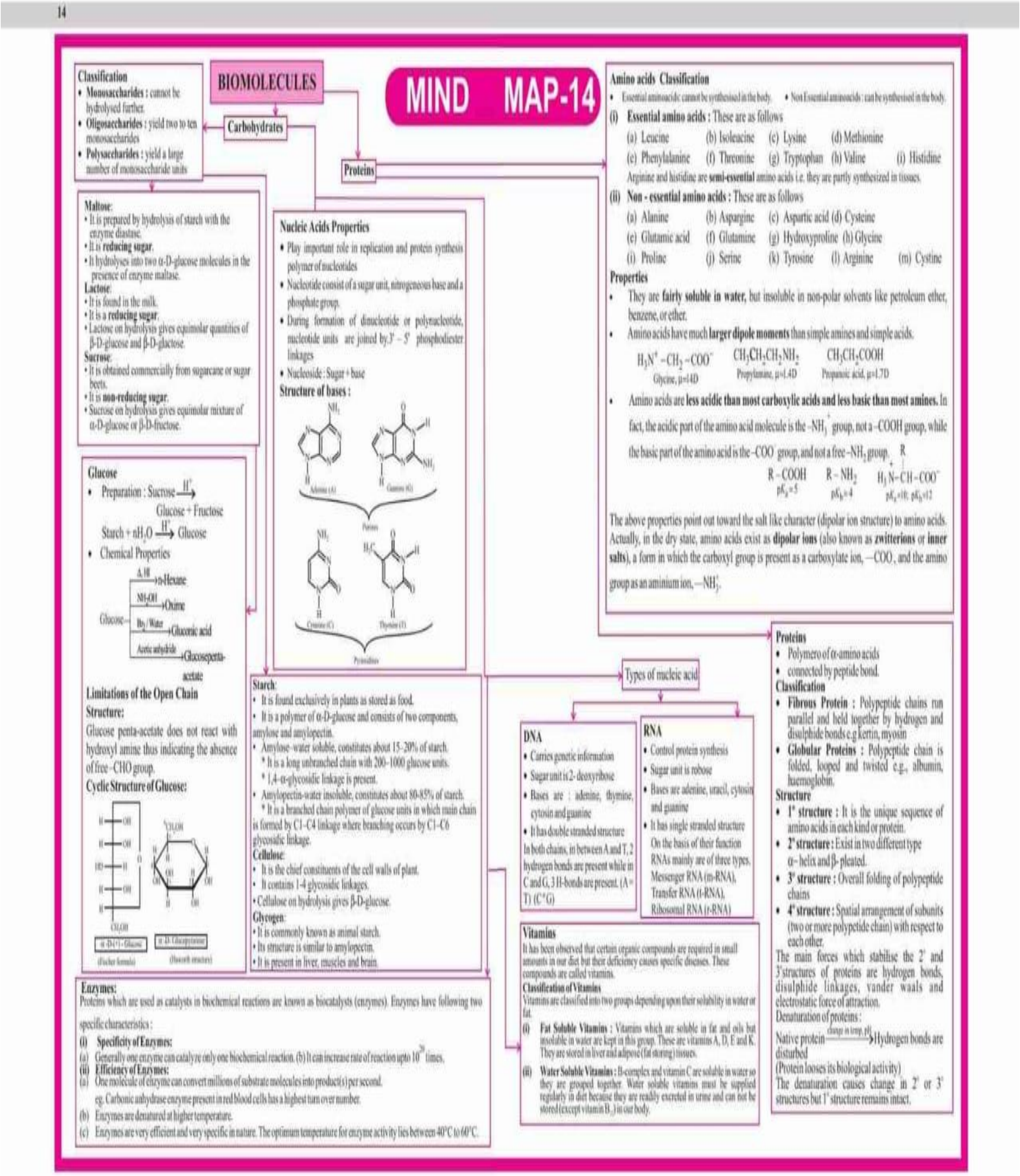
- **Organic compounds**

These are important constituents of many products, including paint, food, plastic, explosives, medicine, petrochemicals, and pesticides.

Other organic compounds containing nitrogen include:

- Amines
- Amino alcohols
- Amides and lactams
- Nitro compounds
- Imines
- Hydrazides
- Carbazides
- Oximes
- Heterocyclic compounds such as imidazole, triazole, and tetrazole

CHAPTER – BIOMOLECULES



BIOMOLECULES

MIND MAP-14

Carbohydrates

Proteins

Classification
- **Monosaccharides :** cannot be hydrolysed further.
- **Oligosaccharides :** yield two to ten monosaccharides
- **Polysaccharides :** yield a large number of monosaccharide units

Maltose:
- It is prepared by hydrolysis of starch with the enzyme diastase.
- It is **reducing sugar**.
- It hydrolyses into two α-D-glucose molecules in the presence of enzyme maltase.

Lactose:
- It is found in the milk.
- It is a **reducing sugar**.
- Lactose on hydrolysis gives equimolar quantities of β-D-glucose and β-D-glactose.

Sucrose:
- It is obtained commercially from sugarcane or sugar beets.
- It is **non-reducing sugar**.
- Sucrose on hydrolysis gives equimolar mixture of α-D-glucose or β-D-fructose.

Glucose
- Preparation : Sucrose $\xrightarrow{H^+}$ Glucose + Fructose

  Starch + $nH_2O \xrightarrow{H^+}$ Glucose
- Chemical Properties

  Glucose $\xrightarrow{\Delta,\ HI}$ n-Hexane

  Glucose $\xrightarrow{NH_2OH}$ Oxime

  Glucose $\xrightarrow{Br_2/Water}$ Gluconic acid

  Glucose $\xrightarrow{\text{Acetic anhydride}}$ Glucosepenta-acetate

Limitations of the Open Chain Structure:
Glucose penta-acetate does not react with hydroxyl amine thus indicating the absence of free –CHO group.

Cyclic Structure of Glucose:

Nucleic Acids Properties
- Play important role in replication and protein synthesis polymer of nucleotides
- Nucleotide consist of a sugar unit, nitrogeneous base and a phosphate group.
- During formation of dinucleotide or polynucleotide, nucleotide units are joined by 3' – 5' phosphodiester linkages
- Nucleoside : Sugar + base

Structure of bases :

Starch:
- It is found exclusively in plants as stored as food.
- It is a polymer of α-D-glucose and consists of two components, amylose and amylopectin.
- Amylose-water soluble, constitutes about 15-20% of starch.
  - * It is a long unbranched chain with 200-1000 glucose units.
  - * 1,4-α-glycosidic linkage is present.
- Amylopectin-water insoluble, constitutes about 80-85% of starch.
  - * It is a branched chain polymer of glucose units in which main chain is formed by C1–C4 linkage where branching occurs by C1–C6 glycosidic linkage.

Cellulose:
- It is the chief constituents of the cell walls of plant.
- It contains 1-4 glycosidic linkages.
- Cellulose on hydrolysis gives β-D-glucose.

Glycogen:
- It is commonly known as animal starch.
- Its structure is similar to amylopectin.
- It is present in liver, muscles and brain.

Enzymes:
Proteins which are used as catalysts in biochemical reactions are known as biocatalysts (enzymes). Enzymes have following two specific characteristics :

(i) **Specificity of Enzymes:**

(a) Generally one enzyme can catalyze only one biochemical reaction. (b) It can increase rate of reaction upto 10^{20} times.

(ii) **Efficiency of Enzymes:**

(a) One molecule of enzyme can convert millions of substrate molecules into product(s) per second.
eg. Carbonic anhydrase enzyme present in red blood cells has a highest turn over number.

(b) Enzymes are denatured at higher temperature.

(c) Enzymes are very efficient and very specific in nature. The optimum temperature for enzyme activity lies between 40°C to 60°C.

Amino acids Classification
- Essential aminoacids: cannot be synthesised in the body.
- Non Essential aminoacids : can be synthesised in the body.

(i) **Essential amino acids :** These are as follows

(a) Leucine (b) Isoleucine (c) Lysine (d) Methionine
(e) Phenylalanine (f) Threonine (g) Tryptophan (h) Valine (i) Histidine

Arginine and histidine are **semi-essential** amino acids i.e. they are partly synthesized in tissues.

(ii) **Non - essential amino acids :** These are as follows

(a) Alanine (b) Aspargine (c) Aspartic acid (d) Cysteine
(e) Glutamic acid (f) Glutamine (g) Hydroxyproline (h) Glycine
(i) Proline (j) Serine (k) Tyrosine (l) Arginine (m) Cystine

Properties
- They are **fairly soluble in water,** but insoluble in non-polar solvents like petroleum ether, benzene, or ether.
- Amino acids have much **larger dipole moments** than simple amines and simple acids.

  $H_3N^+-CH_2-COO^-$ (Glycine, μ=14D) $CH_3CH_2CH_2NH_2$ (Propylamine, μ=1.4D) CH_3CH_2COOH (Propanoic acid, μ=1.7D)
- Amino acids are **less acidic than most carboxylic acids and less basic than most amines.** In fact, the acidic part of the amino acid molecule is the $-NH_3^+$ group, not a –COOH group, while the basic part of the amino acid is the $-COO^-$ group, and not a free $-NH_2$ group.

  $R-COOH$ ($pK_a=5$) $R-NH_2$ ($pK_b=4$) $H_3\overset{+}{N}-\underset{}{\overset{R}{\overset{|}{C}}}H-COO^-$ ($pK_a=10$, $pK_b=12$)

The above properties point out toward the salt like character (dipolar ion structure) to amino acids. Actually, in the dry state, amino acids exist as **dipolar ions** (also known as **zwitterions** or **inner salts**), a form in which the carboxyl group is present as a carboxylate ion, $-COO^-$, and the amino group as an aminium ion, $-NH_3^+$.

Proteins
- Polymero of α-amino acids
- connected by peptide bond.

Classification
- **Fibrous Protein :** Polypeptide chains run parallel and held together by hydrogen and disulphide bonds e.g kertin, myosin
- **Globular Proteins :** Polypeptide chain is folded, looped and twisted e.g., albumin, haemoglobin.

Structure
- **1° structure :** It is the unique sequence of amino acids in each kind or protein.
- **2° structure :** Exist in two different type α– helix and β- pleated.
- **3° structure :** Overall folding of polypeptide chains
- **4° structure :** Spatial arrangement of subunits (two or more polypetide chain) with respect to each other.

The main forces which stabilise the 2° and 3° structures of proteins are hydrogen bonds, disulphide linkages, vander waals and electrostatic force of attraction.

Denaturation of proteins :

Native protein $\xrightarrow{\text{change in temp, pH}}$ Hydrogen bonds are disturbed

(Protein looses its biological activity)

The denaturation causes change in 2° or 3° structures but 1° structure remains intact.

Types of nucleic acid

DNA
- Carries genetic information
- Sugar unit is 2- deoxyribose
- Bases are : adenine, thymine, cytosin and guanine
- It has double stranded structure

In both chains, in between A and T, 2 hydrogen bonds are present while in C and G, 3 H-bonds are present. (A = T) (C ≡ G)

RNA
- Control protein synthesis
- Sugar unit is robose
- Bases are adenine, uracil, cytosin and guanine
- It has single stranded structure

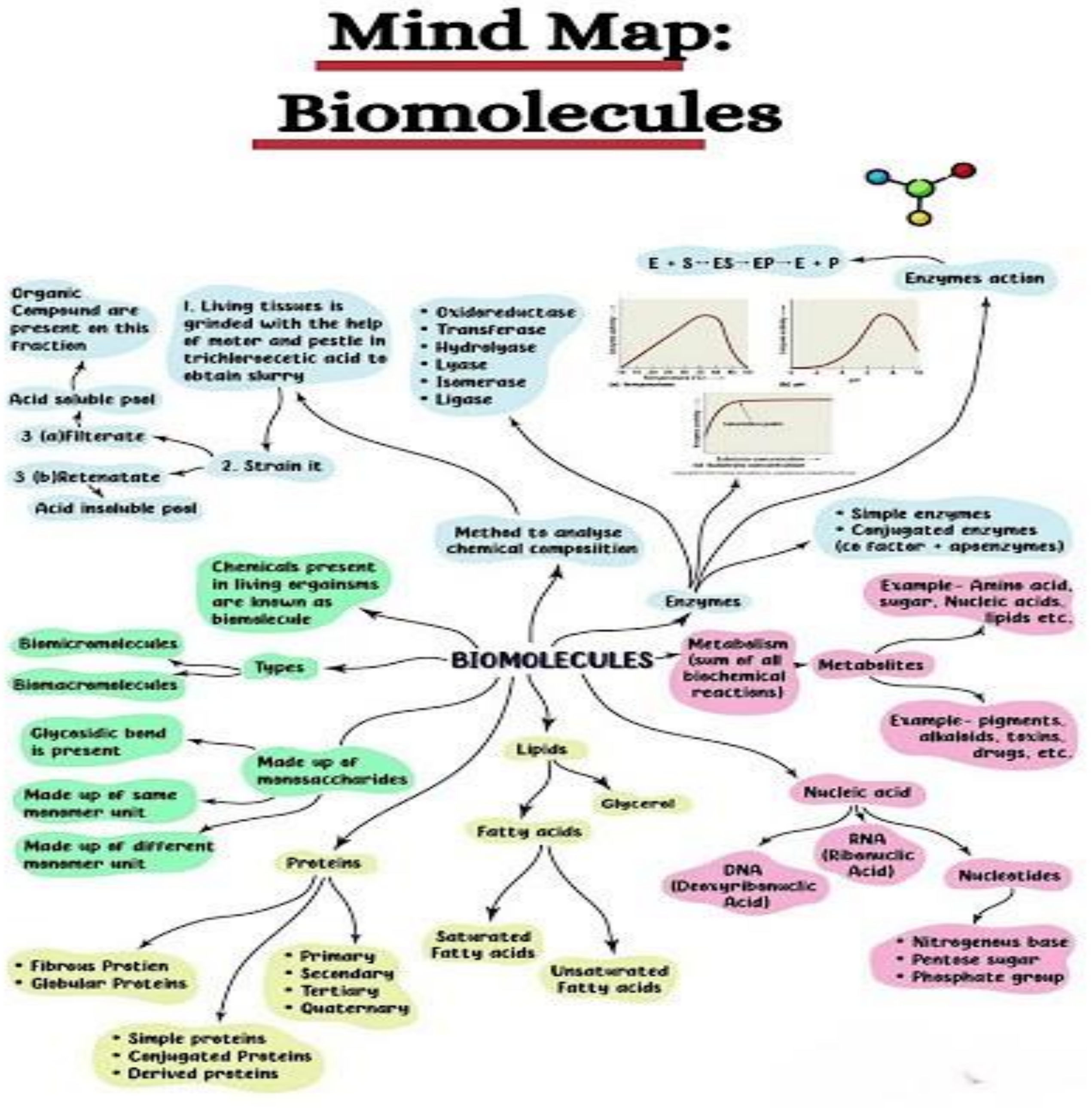
On the basis of their function RNAs mainly are of three types. Messenger RNA (m-RNA), Transfer RNA (t-RNA), Ribosomal RNA (r-RNA)

Vitamins
It has been observed that certain organic compounds are required in small amounts in our diet but their deficiency causes specific diseases. These compounds are called vitamins.

Classification of Vitamins
Vitamins are classified into two groups depending upon their solubility in water or fat.

(i) **Fat Soluble Vitamins :** Vitamins which are soluble in fat and oils but insoluble in water are kept in this group. These are vitamins A, D, E and K. They are stored in liver and adipose (fat storing) tissues.

(ii) **Water Soluble Vitamins :** B-complex and vitamin C are soluble in water so they are grouped together. Water soluble vitamins must be supplied regularly in diet because they are readily excreted in urine and can not be stored (except vitamin B_{12}) in our body.



KEY POINTS

Biomolecules are the organic substances that constitute the building blocks of life; they are in charge of the development and upkeep of living systems.

The sequence that relates biomolecules to living organism is

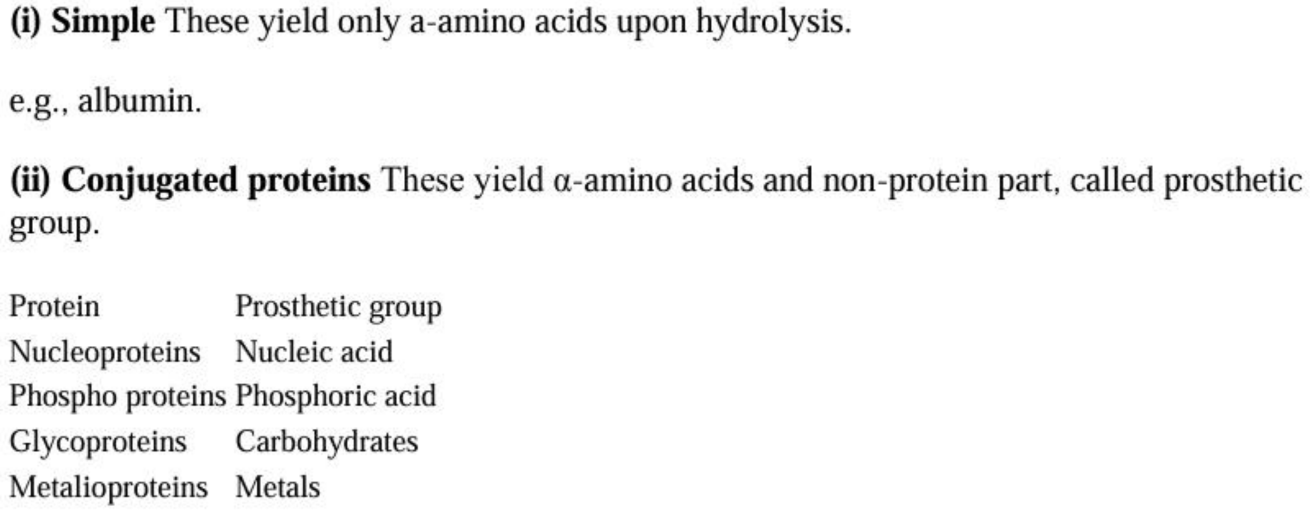
Biomolecules → Organelles → Cells → Tissues → Organs → Living organism.

6. Carbohydrates

Carbohydrates are optically active polyhydroxy aldehydes (aldcses), ketones (ketoses), or chemicals that hydrolyse to produce these units. There are three types of carbohydrates, based on how they behave when hydrolysed

Monosaccharides, **Oligosaccharides**, **Polysaccharides**

7. **Proteins**: **Classification on the Basis of Hydrolysis Products**

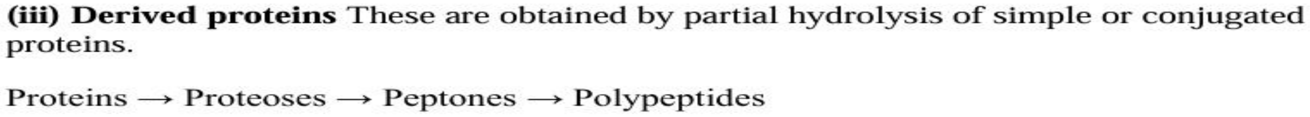


(i) Simple These yield only a-amino acids upon hydrolysis.

e.g., albumin.

(ii) Conjugated proteins These yield α-amino acids and non-protein part, called prosthetic group.

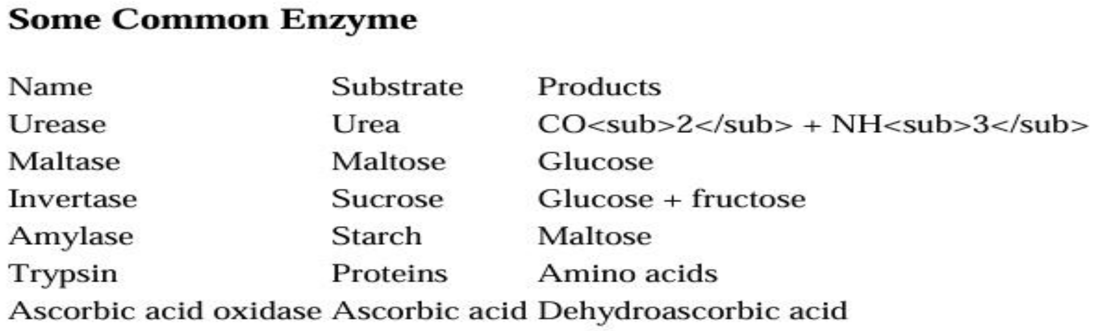
Protein	Prosthetic group
Nucleoproteins	Nucleic acid
Phospho proteins	Phosphoric acid
Glycoproteins	Carbohydrates
Metalioproteins	Metals



(iii) Derived proteins These are obtained by partial hydrolysis of simple or conjugated proteins.

Proteins ⟶ Proteoses ⟶ Peptones ⟶ Polypeptides

8. **Enzymes**



Some Common Enzyme

Name	Substrate	Products
Urease	Urea	CO₂ + NH₃
Maltase	Maltose	Glucose
Invertase	Sucrose	Glucose + fructose
Amylase	Starch	Maltose
Trypsin	Proteins	Amino acids
Ascorbic acid oxidase	Ascorbic acid	Dehydroascorbic acid

9. **DNA and RNA:** Polynucleotides known as nucleic acids are found in live cells, bacterial cells devoid of a nucleus, and virus-free cells.

Comprehension based questions:

1. Carbohydrates are optically active polyhydroxy aldehydes and ketones. They are also called saccharides. All those carbohydrates which reduce Fehling's solution and Tollen's reagent are referred to as reducing sugars. Glucose, the most important source of energy for mammals, is obtained by the hydrolysis of starch. Vitamins are accessory food factors required in the diet. Proteins are the polymers of amino acids and perform various structural and dynamic functions in the organisms. Deficiency of vitamins leads to many diseases.

Read the given passage carefully and give the answer of the following questions:

Q1. What are reducing sugars?
Q2. What is the basic structural unit of proteins?
Q3. Define Glycosidic linkage as related to carbohydrates.
Q4. Name the disease caused by deficiency of vitamin C.
Q5. What is the food reserve in plants?

2. Vitamins are a group of biomolecules that are essential for maintaining good health. They are organic compounds that are not produced by the body in sufficient amounts, so they must be obtained through the diet. Vitamins can be classified into two main categories: fat-soluble and water-soluble. Fat-soluble vitamins, such as vitamins A, D, E, and K, are stored in fatty tissues and liver, while water-soluble vitamins, such as vitamins B and C, are not stored in the body and excess amounts are excreted in the urine. Vitamins play a crucial role in various bodily functions, including energy production, immune function, and bone health.

1. What is the primary function of vitamins in the body?
2. How are vitamins classified?
3. What is the difference between fat-soluble and water-soluble vitamins?
4. Which vitamin is essential for bone health?
5. What is the chemical name of vitamin A?

3. Enzymes are biological catalysts that speed up chemical reactions in living organisms. They are highly specific, meaning they only catalyse one specific reaction or a small group of related reactions. Enzymes have an active site, which is the region of the enzyme where the substrate binds and the reaction takes place. The shape and chemical properties of the active site determine the specificity of the enzyme.

1. What is the primary function of enzymes in living organisms?
2. What is meant by the specificity of an enzyme?
3. What is the role of the active site in enzyme function?
4. How do enzymes speed up chemical reactions?
5. What is the significance of enzyme inhibition in living organisms?

4. Nucleotides are biomolecules composed of a nitrogenous base, a sugar molecule, and one or more phosphate groups. They serve as the building blocks of nucleic acids, including DNA and RNA. Adenine (A), guanine (G), cytosine (C), and thymine (T) are the four nitrogenous bases found in DNA, while RNA contains the base uracil (U) instead of thymine.

1. What are the three components of a nucleotide?
2. What is the role of nucleotides in the structure of nucleic acids?
3. What is the difference between the nitrogenous bases found in DNA and RNA?
4. How do nucleotides link together to form nucleic acids?
5. What is the significance of nucleic acids in living organisms?

5. Starch is a complex carbohydrate composed of long chains of glucose molecules. It is the primary energy storage molecule in plants and is found in high concentrations in seeds, tubers, and roots. Starch is composed of two main components: amylose and amylopectin. Amylose is a linear chain of glucose molecules, while amylopectin is a branched chain of glucose molecules. Starch is broken down into glucose during digestion, which is then absorbed and utilized by the body for energy.

1. What is the primary function of starch in plants?
2. What are the two main components of starch?
3. What is the difference between amylose and amylopectin?
4. How is starch broken down during digestion?
5. What is the significance of starch in the human diet?

6. There are three macro nutrients, carbohydrates, protein and fats. The three macronutrients all have their own specific roles and functions in the body and supply us with calories or energy. For their reason, the body requires these nutrients in relatively large amount to grow, develop and repair. All macronutrients must be obtained through diet, the body cannot produce macronutrients on its own.
Q. 1. List some important sources of proteins.
Q.2. Why are proteins required?
Q.3. What are the three macronutrients?
Q. 4. Define carbohydrates.
Q. 5. List some important source of carbohydrate.

7 .Proteins are large, complex molecules that play may critical roles in our body. They do most of the work in cell and are required for the structure, function and regulation of the body's tissues and organs. Proteins are made up of hundreds or thousands of smaller units called amino acids, which are attached to one another in long chain. There are 20 different types of amino acids that can be combined to make a protein. The sequence of amino acids determines each protein unique 3-dimensional structure and its specific functions.
Q.1. Are proteins polymers?
Q2. Give two examples of denaturation of proteins.
Q3. What do you mean by primary structure of Proteins?
Q.4.What are non-essential amino acids?
Q 5 By which linkage amino acids are linked in a protein?

8. Carbohydrates are polyhydroxy aldehydes and ketones and those compounds which on hydrolysis give such compounds are also carbohydrates. The carbohydrates which are not hydrolysed are called monosaccharides. Monosaccharides with aldehydic group are called aldoses and those which free ketonic groups are called ketoses. Carbohydrates are optically active. Number of optical isomers = 2". Where n = number of asymmetric carbons. Carbohydrates mainly synthesised by plants during photosynthesis. The monosaccharides give the characteristic reactions of alcohols and carbonyl group (aldehydes and ketones). It has been found that these monosaccharides exist in the form of cyclic structures. In cyclization, the - OH groups (generally Cs or Ca in aldohexoses and Cs or C6 in ketohexoses) combine with the aldehyde or keto group. As a result, cyclic structures of five or six membered rings containing one oxygen atom are formed, eg. glucose forms a ring structure, Glucose contains one aldehyde group, one 1° alcoholic group and four 2° alcoholic groups in its open chain structure.
Q1. What are carbohydrates?
Q2. What are monosaccharides?
Q3. What are aldoses?
Q4. How many chiral or asymmetric carbon atoms are there in glucose molecule?
Q. 5. Give the formula to calculate the number of optical isomers.

SAMPLE PAPER – 2026 (10+2 CHEMISTRY)

TOTAL MARKS=70 **TIME=3HR**

1. Questions carrying one-mark MCQ

i. A colligative property of a solution depends on the
(a)Number of solute particles (c) Total number of solute and solvent molecule
(b)Number of atoms in solute molecules (d) mass of solute particles

ii. The molal elevation constant depends upon
(a) nature of solute (b)nature of the solvent
(c) vapour pressure of the solution (d)enthalpy change

iii. The number of moles of NaCl in 3 litres of 3M solution is:
(a) 1 (b) 3 (c) 9 (d) 27

iv. Rusting of iron is quicker in
(a) Saline water (*b*)Ordinary water (*c*)Distilled water (*d*)All of these

v. The unit of rate constant for a zero order reaction is
(a)mol $L^{-1}s^{-1}$ (*b*) s^{-1} (*c*) L mol^{-1} s^{-1}(*d*)$L^2mol^{-2}s$

vi. What kind of isomerism exist between $[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_5Cl]Cl_2.H_2O$:
(a)Linkage isomerism (c) Ionisation isomerism
(b)Solvate isomerism (d) Coordination isomerism

vii. Haloarenes are less reactive than haloalkanes due to
(a)Resonance Effect (b)Difference in hybridisation state of carbon atoms
©both a and b (d) None of these

viii. Which of the following reactions will not result in the formation of C-C bond?
(a)Cannizzaro Reaction (c) Reimer-Tiemann Reaction
(b)Wurtz Reaction (d) Friedal Crafts Reaction

ix. The strongest acid among the following compound is.
(a)HCOOH (*b*)CH_3COOH (*c*) $(CH_3)_3CHCOOH$ (*d*)$(CH_3)_3CCOOH$

x. Which of the following do not give aldol condensation reactions?
(a)Formaldehyde (*b*) Acetaldehyde (*c*)Dimethylketone (*d*)Propionaldehyde

TRUE/FALSE

xi. Aldehydes and ketones react with electrophiles but not with nucleophiles .

xii. Wolff Kishner reduction of acetophenone gives toluene

xiii. Phenol have higher boiling than toluene

xiv. $[Fe(CO)_5]$ is most stable because CO is weak field ligand.

xv. The energy difference between the two sets of *d*-orbitals is called crystal field splitting energy denoted by Δ_0

COMPREHENSION

When a protein in its native form, is subjected to physical changes like change in temperature or chemical changes like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and protein loses its biological activity. This is called denaturation of protein.The denaturation causes change in secondary and tertiary structures but primary structures remains intact. Examples of denaturation of protein are coagulation of egg white on boiling, curding of milk, formation of cheese when an acid is added to milk.

(xvi) What is denaturation of protein?

(xvii) Give examples of denaturation of protein?

(xviii) Primary structures remain during denaturation of protein.

(xix) The denaturation of protein causes change in structure.

(xx) During denaturation protein loses its activity

SECTION-B QUESTIONS CARRYING TWO MARKS

2. Which colligative property is preferred to measure molar mass.

3. Calculate the mole fraction of ethanol and water in a sample which contain 95% ethanol by mass? Or

A commercially available sample of sulphuric acid is 38% HCl by weight (density = 1.19 g ml^{-1}) .Calculate Molarity of acid

4. Calculate half life of a first order reaction having K = 4.93×10^{-4} s^{-1}. Or

Calculate two third life a first order reaction having K = $5.48 \times \mathbf{10^{-14}}$ s^{-1}

5. Define the Pseudo first order reaction. Give its example

6. Define cell constant and write their units..

7. Define Ambident ligands ?

8. Write short note on coupling reaction. Or

Ethers possess a dipole moment even if the alkyl radicals in the molecule are identical. Explain

9. What is formalin solution give its one use ? Or

How does > C = C< differ from >C = O group in Chemical reactions.

10. What is carbylamine reaction ?

11. What is the chemical name of Vitamin A and which disease is caused by its deficiency ?

12. Give one example of Gattermann reaction.

13. Write difference between Weak field ligand and Strong field ligand

14. Why is Cu considered as transition metal ?

15. Conductivity of 0.00214 M acetic acid is 7.8×10^{-5} S cm^{-1}. (i) Calculate its molar conductivity. Given that cm^2 mol^{-1} . (ii) Calculate degree of dissociation.

SECTION-CQUESTIONS CARRYING THREE MARKS

16. A cell reaction is Mg (s) | $Mg^{2+}_{(0.001M)}$ // $Cu^{2+}_{(0.0001M)}$/ $Cu(s)$. Calculate $E_{cell}$of a reaction and also write Nernst equation. Given: E° (Mg^{2+} | Mg) = – 2.37 V and E° (Cu^{2+} | Cu) = 0.34 V. Or

A cell reaction is Sn (s) | $Sn^{2+}_{(0.50M)}$ // $H^{+}_{(0.020M)}$/ $H_2(g)$. Calculate $E_{cell}$of a reaction and also write Nernst equation.

Given : E° (Sn^{2+} | Sn) = – 0.14 V and E° (H^{1+} | H) = 0.00 V.

17. A first order is completed 50% in 30 minutes. How much time it will take to complete 75% of the reaction?

18. Why is C – O – C bond angle in ether is more than H – O – H bond angle in water though oxygen atom is $\mathbf{sp^3}$ hybridised in both the cases ? Or

Write the Lucas test to distinguish between 1°, 2° and 3° alcohols

1.Write a Hinsberg's test to distinguish between 1°, 2° and 3° amines.

SECTION-DQUESTIONS CARRYING FIVE MARKS

20. (How would you account for the following? (i) Transition metals exhibit variable oxidation states. (ii) Zr (Z = 40) and Hf (Z = 72) have almost identical radii. (iii) Transition metals and their compounds act as catalyst. Or

Give reasons : (a) E° value for $Mn^{3+/}Mn^{2+}$ couple is much more positive than that for $Fe^{3+/}Fe^{2+}$. (b) Iron has higher enthalpy of atomization than that of copper. (c) Sc^{3+} is colourless in aqueous solution whereas Ti^{3+} is coloured .

21. Explain the following reactions:(i) Fittig reaction (ii) Sulphonation of haloarene (iii)Hunsdicker reaction (iv) Nitration of haloarene (v)Wurtz reaction (1X5=5) Or

(i) Difference between Haloalkane and Haloarenes. (3)

(ii) What is Iodoform Test ? (2)

(ii). Give two uses of chloroform.