CLASS-12 BOARDS
FORMULA SHEET

SOLUTIONS

Mass Percentage $(w/w)\% = \dfrac{w_2}{w_1 + w_2} \times 100$

Volume Percentage $(v/v)\% = \dfrac{V_2}{V_1 + V_2} \times 100$

Mass by Volume Percentage $(w/v) = \dfrac{w_2}{V\ (in\ mL)} \times 100$

Mass Fraction
$$x_1 = \dfrac{w_1}{w_1 + w_2} \quad or \quad x_2 = \dfrac{w_2}{w_1 + w_2}$$

Parts Per million $(ppm) = \dfrac{w_2}{w_1 + w_2} \times 10^6$

Molarity $(M) = \dfrac{w_B}{M_B} \times \dfrac{1000}{V(mL)}$ — Unit = mol/litre

Molality $(m) = \dfrac{w_B}{M_B} \times \dfrac{1000}{w_A(g)}$ — Unit = moles/kg

↳ molarity is inversely proportional to temperature

Mole Fraction (χ)
$$\chi_A = \dfrac{n_A}{n_A + n_B} \qquad \chi_B = \dfrac{n_B}{n_A + n_B}$$

$\chi_A + \chi_B = 1$ mole fraction is a unitless quantity

Henry Law
$p = K_H\, \chi_B$
→ partial pressure of gas
← mole fraction of solute

RAOULT'S LAW
$$p_A \propto \chi_A \qquad\qquad p_B \propto \chi_B$$
$$p_A = p_A^{\circ} \times \chi_A \qquad p_B = p_B^{\circ} \times \chi_B$$
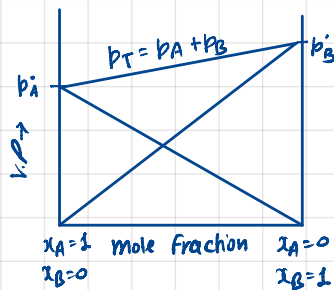
for Volatile Solute
$p_T = p_A + p_B$

for Non-Volatile Solute
$p_T = p_A$
$\quad = p_A^{\circ} \times \chi_A$

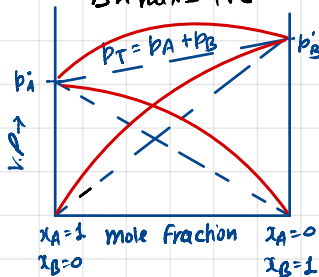Interaction of A-B are equal to interaction of A-A and B-B

$\Delta V_{mix} = 0$
$\Delta H_{mix} = 0$
e.g n-Hexane + n-Heptane

NON-IDEAL SOLUTION

Positive Deviation
A-B interaction are weaker than A-A and B-B interaction
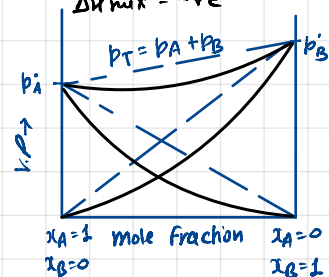
$\Delta V_{mix} = +ve$
$\Delta H_{mix} = +ve$

form minimum boiling Azeotropes
e.g Acetone + Ethanol

Negative Deviation
A-B interaction are stronger than A-A and B-B interaction

$\Delta V_{mix} = -ve$
$\Delta H_{mix} = -ve$

form maximum boiling azeotropes
e.g acetone + Chloroform

Colligative Properties — depends on number of solute

Relative lowering of V.P $\Rightarrow \dfrac{p_A^{\circ} - p_s}{p_A^{\circ}} = \chi_B$ or $i\,\chi_B$

Elevation in Boiling Point $\Rightarrow \Delta T_b = K_b m$ or $i\, K_b m$

Depression in freezing Point $\rightarrow \Delta T_f = K_f m$ or $i\, K_f m$

Osmotic Pressure $\Rightarrow \pi = CRT$ or $\dfrac{n}{V} RT$ or $\dfrac{i \times n}{V} \times R \times T$

Unit of K_b and K_f = K kg mol^{-1}

$\Delta T_b = T_b - T_b^{\circ}$

$\Delta T_f = T_f^{\circ} - T_f$

$\Delta T_b = K_b \times \dfrac{w_B}{M_B} \times \dfrac{1000}{w_A(g)}$

$\Delta T_f = K_f \times \dfrac{w_B}{M_B} \times \dfrac{1000}{w_A(g)}$

$\Delta T_b \rightarrow$ Elevation in B.Pt
$\Delta T_f \rightarrow$ Depression in f.Pt
$T_b \rightarrow$ B.Pt of solution
$T_b^{\circ} \rightarrow$ B.Pt of pure solvent
$T_f^{\circ} \rightarrow$ f.Pt of pure solvent
$T_f \rightarrow$ f.Pt of solution
$K_b \rightarrow$ molal elevation constant
$K_f \rightarrow$ molal depression constant

Van't Hoff factor (i)
$$= \dfrac{Normal\ Molecular\ Mass}{Observed\ Molecular\ Mass}$$

$i > 1$ solute undergoes dissociation
$i < 1$ solute undergoes association
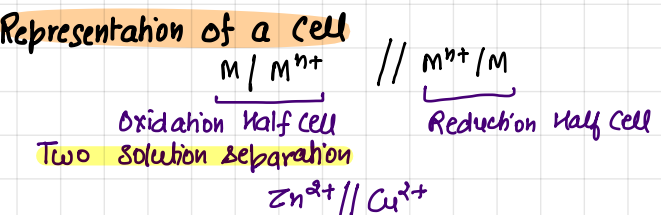$i = 1$ no association no dissociation

$\alpha_{dissociation} = \dfrac{i-1}{n-1}$ $\alpha_{association} = \dfrac{i-1}{\frac{1}{n} - 1}$

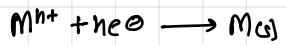# Electrochemistry

Cell- which convert one form of energy into another form of energy

Electrochemical Cell	Electrolytic Cell
Chemical → electrical	electrical → chemical

Representation of a Cell

$$M \mid M^{n+} \quad \underbrace{}_{} \quad M^{n+} \mid M$$

Oxidation Half Cell   Reduction Half Cell

Two Solution Separation

$$Zn^{2+} \parallel Cu^{2+}$$

NERNST EQUATION

$$M^{n+} + ne^{\ominus} \longrightarrow M_{(s)}$$

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log \frac{1}{[M^{n+}]}$$

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log \frac{[Oxi]}{[Red]} \quad at\ 298\,K$$

At Equilibrium $E_{cell} = 0$

$$E^{\circ}_{cell} = \frac{0.0591}{n} \log K_c \quad at\ 298\,K$$

Gibbs Free Energy

$$\Delta G^{\circ} = -nf\,E^{\circ}_{cell}$$

$$\Delta G^{\circ} = -2.303\,RT \log K_c$$

CONDUCTIVITY OF IONIC SOLUTIONS

Conductance (G) $= \frac{1}{R} = \frac{1}{\rho}\frac{A}{l} = K\frac{A}{l}$ Unit = ohm^{-1} or Ω^{-1} or Siemens

→ increases on dilution as larger no.of ions are produced

Specific Conductance [CONDUCTIVITY]

$$K = \frac{1}{\rho} \quad or\ G \times \frac{l}{A} \quad or\ G \times G^* \quad Unit = ohm^{-1}\,cm^{-1}\ or\ S\,cm^{-1}$$

→ decrease on dilution as number of ions per c.m^3 decrease

MOLAR CONDUCTIVITY

$$\Lambda_m = K \times V \quad or\ K \times \frac{1000}{M} \quad Unit = \Omega^{-1}\,cm^2\,mol^{-1}\ or\ S\,m^2\,mol^{-1}$$

→ Increase with dilution due to large increase in V.

Limiting Molar Conductivity (Λ_m° or Λ_m^{∞})

when concentration of electrolyte approaches zero

↳ **variation of molar conductivity with concentration**

strong electrolyte like KCl

weak electrolyte like CH$_3$COOH
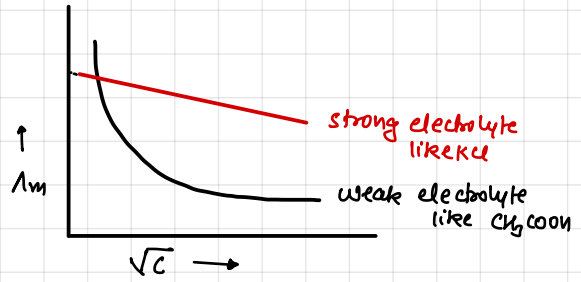
→ **Debye-Huckel Equation**

$$\Lambda_m = \Lambda_m^{\circ} - A\sqrt{C}$$

Λ_m = Molar conductivity at V dilution
C = concentration
A = constant which depends upon

Plot of Λ_m and against $\sqrt{C}$ is a straight line with intercept equal to Λ_m° and slope equal to $-A$.

for weak electrolyte, On dilution very large increase conductance in
for strong electrolyte, on dilution only a small increase conductance in

---

Kohlrausch's Law

$$\Lambda_m^{\circ}\ Electrolyte = \lambda_m^{\circ}\ Cation + \lambda_m^{\circ}\ Anion$$

↳ degree of dissociation

$$\alpha = \frac{\Lambda_m}{\Lambda_m^{\circ}} \quad \begin{bmatrix}Molar\ conductivity\ at\ concentration\ c\\ Molar\ conductivity\ at\ infinite\ dilution\end{bmatrix}$$

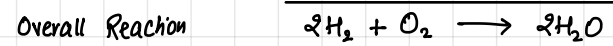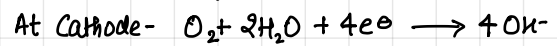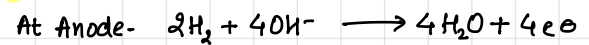↳ Dissociation Constant $(K_c) = \frac{C\alpha^2}{1-\alpha}$

Faraday's First Law

$$\omega = Z \times I \times t = \frac{Molar\ Mass}{n \times f} \times I \times t$$

Faraday's Second Law

$$\frac{\omega_1}{\omega_2} = \frac{E_1}{E_2} \quad [where\ E\ is\ equivalent\ weight]$$
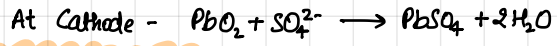
Fuel Cell

At Anode- $2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^{\ominus}$

At Cathode- $O_2 + 2H_2O + 4e^{\ominus} \longrightarrow 4OH^-$

Overall Reaction $2H_2 + O_2 \longrightarrow 2H_2O$

Dry Cell

At Anode - $Zn \longrightarrow Zn^{2+} + 2e^{\ominus}$

At Cathode $2MnO_2 + 2NH_4^+ + 2e^{\ominus} \longrightarrow 2MnO(OH) + 2NH_3$

Overall Rxn $Zn + 2NH_4^+ + 2MnO_2 \longrightarrow Zn^{2+} + 2MnO(OH) + 2NH_3$

Lead-Storage Battery -

At Anode- $Pb + SO_4^{2-} \longrightarrow PbSO_4 + 2e^{\ominus}$

At Cathode - $PbO_2 + SO_4^{2-} \longrightarrow PbSO_4 + 2H_2O$

Corrosion of iron...

At Anode - $2Fe \longrightarrow 2Fe^{2+} + 4e^{\ominus}$

At Cathode $O_2 + 4H^+ + 4e^{\ominus} \longrightarrow 2H_2O$

Overall reaction $2Fe + O_2 + 4H^+ \longrightarrow 2Fe^{2+} + 2H_2O$
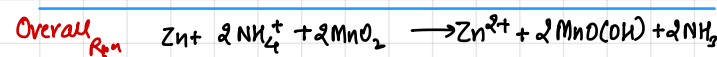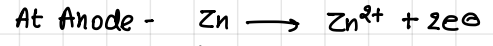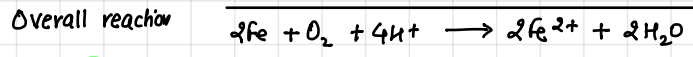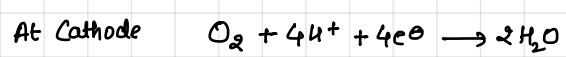
Formula of rust - $Fe_2O_3 \cdot xH_2O$

CHEMICAL KINETICS

$$R \longrightarrow P$$

Rate of Reaction $\quad -\frac{\Delta[R]}{\Delta t} = +\frac{\Delta[P]}{\Delta t}$

UNIT OF RATE   mol L^{-1} sec^{-1} or mol L^{-1} min^{-1}

Average rate	Instantaneous rate
change in concentration at large time interval	change in concentration at any instant of time

$R \longrightarrow P$

$$-\frac{\Delta[R]}{\Delta t} = +\frac{\Delta[P]}{\Delta t} \qquad -\frac{d[R]}{dt} = +\frac{d[P]}{dt}$$
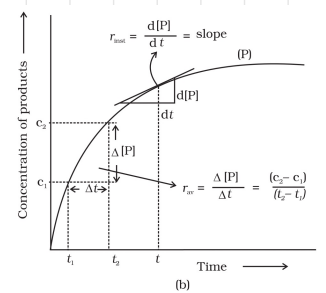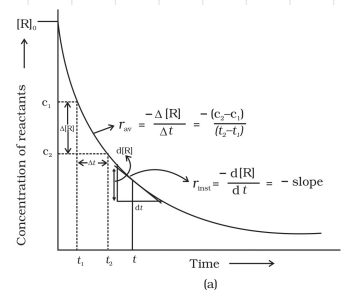
Fig. 4.1: Instantaneous and average rate of a reaction

Rate Law -

$$aA + bB \longrightarrow Product$$
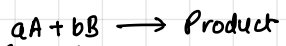
$\underbrace{a}_{actual\ used}\ \alpha \quad \underbrace{b}_{}\ \beta$

rate constant or Specific reaction rate

$$Rate\ of\ Reaction = K[A]^{\alpha}[B]^{\beta}$$

$$Order = \alpha + \beta$$

Half life $t_{1/2} \propto \dfrac{1}{a^{n-1}}$; where n is order of rxⁿ

Zero Order

rate $= K[A]^0$

$[A]_t = -Kt + [A]_0$

$t = \dfrac{R_0 - R}{K}$

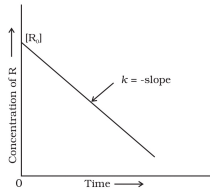$t_{1/2} = \dfrac{R_0}{2K}$

Unit of $K = mol\ L^{-1} s^{-1}$

Fig. 4.3: Variation in the concentration vs time plot for a zero order reaction

fist Order

Rate $= K[A]^1$

$\ln[A]_t = -Kt + \ln[A]_0$

$t = \dfrac{2.303}{K} \log \dfrac{R_0}{R_t}$
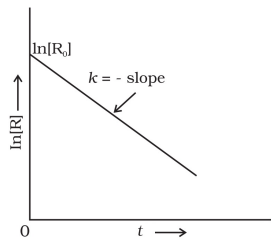
$t_{1/2} = 0.693/K$

Unit of $K = $ sec^{-1}

Fig. 4.4: A plot between ln[R] and t for a first order reaction
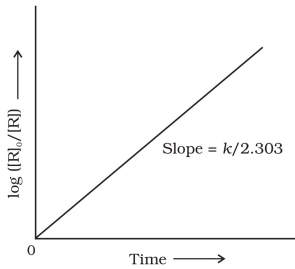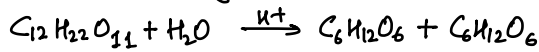

Fig. 4.5: Plot of log [R]₀/[R] vs time for a first order reaction

PSEUDO FIRST ORDER –
Those reaction which are not truely of first order but under certain conditions becomes of first order

inversion of sugar

$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\ H^+\ } C_6H_{12}O_6 + C_6H_{12}O_6$

Rate $= K[C_{12}H_{22}O_{11}]$

Arrhenius Equation

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

$\log K = \log A - \dfrac{Ea}{2.303\ RT}$

where $K = $ Rate constant

$A = $ Pre-exponential factor

$Ea = $ Activation Energy T→Temp

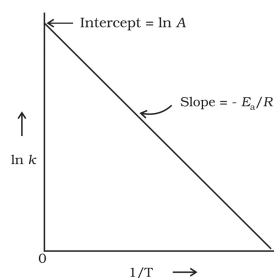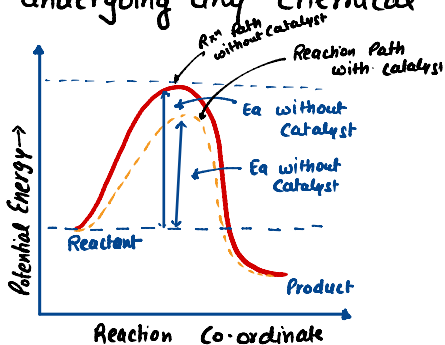$\log \dfrac{K_2}{K_1} = \dfrac{Ea}{2.303\ R}\left[\dfrac{T_2 - T_1}{T_1 T_2}\right]$

Fig. 4.10: A plot between ln k and 1/T

Role of Catalyst : a chemical substance which alters the rate of reaction without undergoing any chemical change

COLLISION THEORY

The number of collision b/w the reacting molecules taking place per second per unit volume is known as **Collision frequency**

$$rate = PZ_{AB}\ e^{-Ea/RT}$$

P → P called the probability or steric factor

Z_{AB} → Collision Frequency for reactant A & B.