

Chemistry Formulas

Physical Quantities and SI Units

Physical Quantity	Symbol	Name of unit	Symbol of unit
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	seconds	s
Electric Current	I	Ampere	A
Temperature	T	Kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I_v	candela	cd

Prefices in SI system

Multiple	Prefix	Symbol
10^{-24}	yocto	y
10^{-21}	zepto	z
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	Pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	Centi	c
10^{-1}	dec	d

Multiple	Prefix	Symbol
10^{24}	Yotta	Y
10^{21}	Zetta	Z
10^{18}	Exa	E
10^{15}	Peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	Hecta	h
10	deca	da

Mole Concept

- * Mass of one atom = $\frac{\text{Gram at. mass}}{6.022 \times 10^{23}}$
- * Mass of one molecule = $\frac{\text{Gram molecular mass}}{6.022 \times 10^{23}}$
- * No. of moles of atoms = $\frac{\text{mass}}{\text{At. mass}}$
- * No of moles of atoms = $\frac{\text{No of atoms}}{6.022 \times 10^{23}}$
- * No of atoms = $\text{no. of moles} \times 6.022 \times 10^{23}$
- * No of atoms = $\frac{\text{mass}}{\text{At. mass}} \times 6.022 \times 10^{23}$
- * No of moles of molecules = $\frac{\text{mass}}{\text{molecular mass}}$
- * No of moles of molecules = $\frac{\text{no. of molecules}}{6.022 \times 10^{23}}$

- * No of moles of molecules = $\frac{\text{Vol}^{\%} \text{ of gas at STP in cm}^3}{22400 \text{ cm}^3}$
- * No of moles of molecules = $\frac{\text{Vol}^{\%} \text{ of gas at STP in dm}^3}{22.4 \text{ dm}^3}$
- * $\text{Vol}^{\%} \text{ of gas at STP} = \frac{\text{mass in gram} \times \text{gram molar Vol}^{\%}}{\text{Gram mole. mass}}$
- * No of molecules = $\frac{\text{Vol}^{\%} \text{ at STP} \times 6.022 \times 10^{23}}{\text{Gram molar Volume}}$

* Mass percent = $\frac{\text{mass of solute}}{\text{mass of solution}}$

* Mole fraction = $\frac{\text{no of moles of compound}}{\text{total no of moles of solute + solvent}}$

$n_1 \rightarrow$ No of moles of solvent

$n_2 \rightarrow$ No of moles of solute

$x_1 \rightarrow$ Mole fraction of solvent

$x_2 \rightarrow$ Mole fraction of solute

* $x_1 = \frac{n_1}{n_1 + n_2}$ $x_2 = \frac{n_2}{n_1 + n_2}$

* Molarity = $\frac{\text{mass in grams} / \text{dm}^3 \text{ of solution}}{\text{mol mass}}$

* Molarity = $\frac{\text{no of moles of solute}}{\text{Vol}^{\%} \text{ of sol}^{\%} \text{ in dm}^3}$

* Molarity = $\frac{\text{mass of solute}}{\text{mol. mass of solute} \times \text{Vol}^{\%} \text{ of sol in dm}^3}$

* Molarity = $\frac{w}{M \times V(\text{dm}^3)} = \frac{w \times 1000}{M \times V(\text{ml})}$

* Molarity = $\frac{\text{mass in grams} / \text{kg. solvent}}{\text{mol mass}}$

$$* \text{ Molality} = \frac{\text{No of moles of Solute}}{\text{Mass of solvent in kg}}$$

$$* \text{ Molality} = \frac{\text{mass Solute}}{\text{mol. mass of Solute} \times \text{mass of Solvent in kg}}$$

$$* \text{ Molality} = \frac{W_2}{M \times W_1}$$

$$* \text{ Molality} = \frac{W_2 \times 1000}{M \times W_1 \text{ (g)}}$$

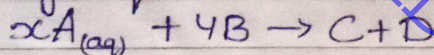
$$* \text{ Normality} = \frac{\text{mass in grms/dm}^3 \text{ Sol}^n}{\text{Equivalent mass}}$$

$$* \text{ Normality} = \frac{\text{mass of solute}}{\text{Equivalent mass of Solute} \times \text{Vol of Sol}^n \text{ in dm}^3}$$

$$* \text{ Normality} = \frac{W}{E \times V \text{ (L/dm}^3)}$$

$$* \text{ Normality} = \frac{W \times 1000}{E \times V \text{ (L/dm}^3)}$$

* Molarity Equation



V_1 = Vol of A

V_2 = Vol of B

m_1 → Molarity of A

m_2 → Molarity of B

$$\frac{m_1 V_1}{x} = \frac{x}{x}$$

$$\frac{m_2 V_2}{4} = \frac{y}{4}$$

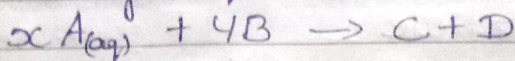
$$\frac{m_1 V_1}{x} = \frac{x}{x}$$

$$\frac{m_2 V_2}{4} = \frac{y}{4}$$

$$\frac{m_1 V_1}{x} = \frac{m_2 V_2}{4}$$

It is molarity of Equation

* Normality Equation



$V_1 \rightarrow$ Vol. A

$V_2 \rightarrow$ Vol of B

$N_1 \rightarrow$ Normality of A

$N_2 \rightarrow$ Normality of B

$$N_1 V_1 = 1$$

$$N_2 V_2$$

$$N_1 V_1 = N_2 V_2$$

* Relationship b/w Eq. mass & mole. mass

* Equivalent mass = $\frac{\text{Molecular mass}}{\text{Combining Capacity}}$

* Eq. mass of acid = $\frac{\text{molecular mass of acid}}{\text{Basicity}}$

* Eq. mass of base = $\frac{\text{molecular mass of base}}{\text{acidity}}$

* Relationship b/w Normality and Molarity

* Normality = Molarity \times 'n' factor

* n factor = acidity no / Basicity no / no of Valency of metal atoms

* no of equivalent = $\frac{\text{mass}}{\text{equivalent mass}}$

* no of moles = $\frac{\text{mass}}{\text{molecular mass}}$

* molecular mass = $2 \times$ Vapour density

* Estimation of Closest distance of approach of α particle

$$R = \frac{4KZe^2}{m_\alpha v_\alpha^2}$$

* Radius of nucleus $R = R_0(A)^{1/3}$ cm

* Planck's Quantum Theory

$$E = h\nu = \frac{hc}{\lambda}$$

* Photoelectric effect

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

* Bohr's model for hydrogen like atoms

$$* mvr = \frac{nh}{2\pi}$$

$$* E_n = -\frac{E_1}{n^2} Z^2 = 2.178 \times 10^{-18} \frac{Z^2}{n^2} \text{ J/atom}$$

$$* r_n = \frac{n^2}{Z} \times \frac{n^2}{4\pi^2 e^2 m}$$

$$* V = \frac{2\pi Ze^2}{nh}$$

* De-Broglie Wavelength

$$\lambda = \frac{h}{mc} = \frac{h}{p}$$

* Wavelength of emitted photon

$$\frac{1}{\lambda} = \bar{\nu} = RZ^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

* Heisenberg's uncertainty principle

$$\Delta x \cdot \Delta p > \frac{h}{4\pi}$$

$$\Delta x \Delta v \geq \frac{h}{4\pi m}$$

* Quantum Numbers

* Principal quantum number

$$n = 1, 2, 3 \dots \infty$$

* Orbital angular momentum = $\frac{nh}{2\pi}$

* Azimuthal quantum number

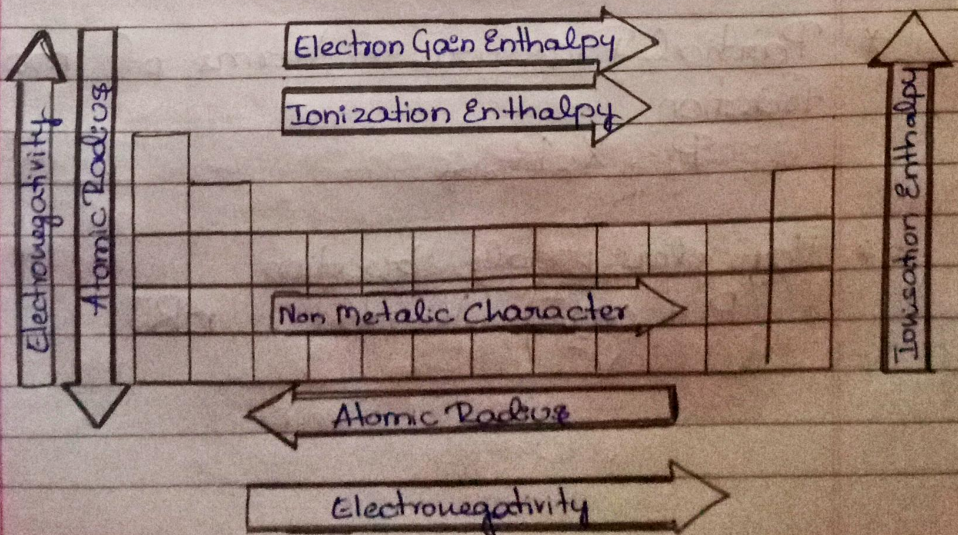
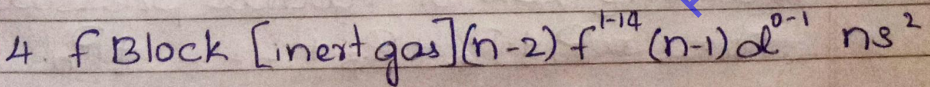
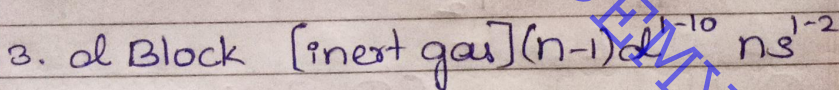
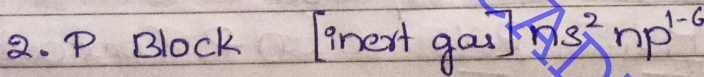
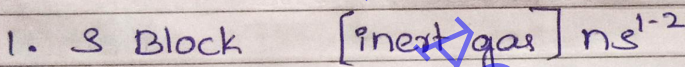
$$l = 0, 1, 2 \dots (n-1)$$

* No of Orbitals in Subshell = $2l + 1$

* Orbital angular momentum

$$L = \frac{h}{2\pi} \sqrt{l(l+1)}$$

* General Electronic Configuration



* Boyle's Law

$$P_1 V_1 = P_2 V_2 \quad [T \text{ and } n \text{ Constant}]$$

* Charles's Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad [P \text{ and } n \text{ Constant}]$$

* Avagadro's Law

$$V = kn \quad [P \text{ and } T \text{ Constant}]$$

* Ideal Gas Equation

$$PV = nRT$$

$$M = \frac{dRT}{P}$$

* Combined Gas Equation

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad [n, R \text{ Constant}]$$

* Dalton's Law of Partial pressure

$$P_{\text{Total}} = P_1 + P_2 + P_3 + \dots + P_n$$

* Partial Pressure in terms of mole fraction

$$P_i = X_i P_{\text{Total}}$$

* Van der Waals Equation

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

* Compressibility factor Z

$$Z = \frac{PV}{RT} \quad [\text{for 1 mole of gas}]$$

$$Z = \frac{nPV}{RT} \quad [\text{for } n \text{ mole of gas}]$$

* $W = F \times dx$

$W =$ Workdone

$F =$ force

$dx =$ distance moved

* $W = P_{\text{ext}} \Delta V$

$$\Delta V = V_2 - V_1$$

* $dW = P dV$

* $W = \int_{V_1}^{V_2} P_{\text{ext}} dV$

* Workdone by the system = -ve

Workdone on the system = +ve

* $Q = \Delta E + W$
 $q = dE + W$

first law of thermodynamics

* Heat absorbed by a system = +ve

Heat given out by a system = -ve

* $H = E + PV$

* $\Delta H = \Delta E + P \Delta V$

* $C_v = \left[\frac{\partial E}{\partial T} \right]_v$

$C_v =$ Heat capacity at const Vol^y

$\partial E =$ Change in internal Energy
 $\partial T =$ Change in Temp^y

* $C_p - C_v = R$

$R =$ Gas Constant
 C_p & $C_v =$ heat capacity at const P & Vol

* $\frac{C_p}{C_v} = \gamma$

* Exothermic reaction $\Delta H = -ve$
Endothermic reaction $\Delta H = +ve$

* Heat of Combustion = $Z \times \theta \times \frac{M}{m}$ (Cal)

$M =$ molecular weight
 $m =$ weight of substance
 $\theta =$ raise in temperature
 $Z =$ heat capacity

* Enthalpy of reaction
 $\Delta H = \sum \Delta_f H^\circ (\text{Products}) - \sum \Delta_f H^\circ (\text{Reactants})$

$\Delta_{sub} H^\circ = \Delta_{fus} H^\circ + \Delta_{vap} H^\circ$

* Heat Capacity Δ

$C = \frac{q}{\Delta T}$

specific heat capacity $C_s = \frac{q}{m \Delta T}$

molar heat capacity

$C_m = \frac{q}{m \Delta T}$

* Energy Changes

$\Delta U = q_v$ $q_v \Rightarrow$ Heat exchange at Const Vol^y
 $\Delta H = q_p$ $q_p \Rightarrow$ Heat exchange at Const P^y

* Enthalpy

$H = U + pV$

* Reaction b/w ΔH and ΔU

$\Delta H = \Delta U + P\Delta V$
 $\Delta H = \Delta U + \Delta n_g RT$

* $C_p - C_v = R$

$\Delta S = \frac{q_{rev}}{T}$

$\Delta G = \Delta H - T\Delta S$

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

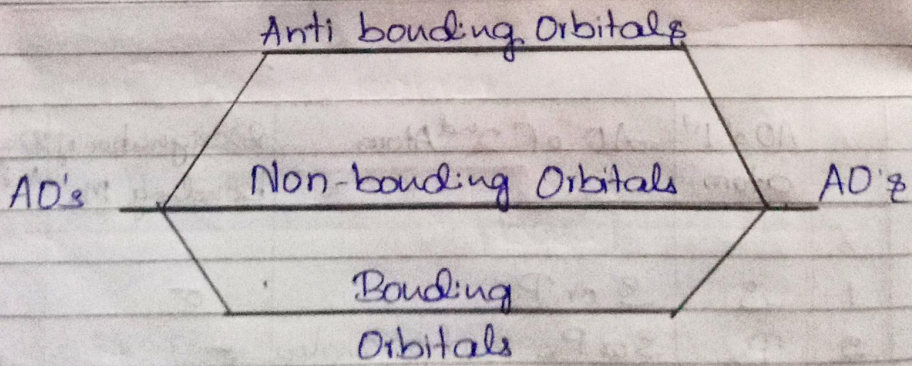
Atomicity	γ	C_p	C_v
Monoatomic	5/3	5R/2	3R/2
Diatomic	7/5	7R/2	5R/2
Triatomic non linear	4/3	4R	3R

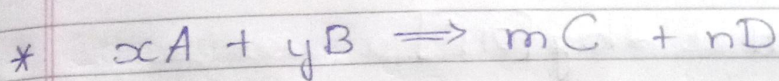
AO of 1 st atom	AO of 2 nd Atom	Designation of bonding M_o	Designation of Antibonding M_o
1 s	s or P_x	σ	σ^*
2 P_x	s or P_x end on overlap	σ	σ^*
3 P_y	P_y side overlap	π	πP_y^*
4 P_z	P_z side overlap	π	πP_z^*

* VSEPR Theory

	No. of Bond Pairs	No. of Lone Pairs	Formula	Molecular shape	Hybridization	Bond Angle
1	2	0	AB_2	Linear	sp	180°
	3	0	AB_3	Plane Triangle	sp^2	120°
	4	0	AB_4	Tetrahedron	sp^3	$109^\circ 28'$
	3	1	AB_3E	Trigonal Pyramid	sp^3	107° 102°
	2	2	AB_2E_2	Angular V-shaped	sp^3	104° 102°
	5	0	AB_5	Trigonal Bipyramidal	sp^3d	120° 90°
	2	3	AB_2E_3 A_3E_2	Linear	sp^3d	180°
	6	AB_6 0	AB_6	Octahedral	sp^3d^2	90°

* Molecular Orbital theory





$$K_c = \frac{[C]^m [D]^n}{[A]^x [B]^y} \quad K_c = \text{Equilibrium Const. in terms of Concentration}$$

$$K_p = \frac{P_C^m P_D^n}{P_A^x P_B^y} \quad K_p = \text{Equilibrium Constant in terms of partial p\%}$$

* Relation b/w K_p and K_c

$$K_p = K_c (RT)^{\Delta n}$$

Case 1 $\Delta n > 0 \Rightarrow K_p > K_c$

Case 2 $\Delta n < 0 \Rightarrow K_p < K_c$

Case 3 $\Delta n = 0 \Rightarrow K_c = K_p$

* Equilibrium Constant

$$K_c = \frac{\text{Rate Const. of forward react.}}{\text{Rate Const. of backward react.}} = \frac{K_f}{K_b}$$

$$* \quad K_a = \frac{C\alpha^2}{(1-\alpha)} \quad (\alpha \text{ Value in denominator is neglected})$$

$$K_a = C\alpha^2$$

$$* \quad \alpha = \sqrt{\frac{K_a}{C}}$$

$$* \quad K_b = \frac{C\alpha^2}{(1-\alpha)}$$

$$* \quad \alpha = \sqrt{\frac{K_b}{C}}$$

$$* \text{pOH} = -\log [\text{OH}^-]$$

$$* \text{pOH} = \log \frac{1}{[\text{OH}^-]}$$

$$* \text{pK} = -\log K$$

* 'N' of mixture of two strong acids or two strong bases

$$N_{\text{mix}} = \frac{N_1 V_1 + N_2 V_2}{V_1 + V_2}$$

* Henderson eq.

① for Acidic buffer

$$\text{pH} = \text{pK}_a + \log \frac{[\text{salt}]}{[\text{acid}]}$$

② for Basic buffer

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{salt}]}{[\text{base}]}$$

* pH of basic buffer

$$\text{pH} = \text{pK}_a - \log \frac{[\text{salt}]}{[\text{base}]}$$

* Classification of Crystal into 7 System

Crystal System	Unit Cell dimensions and Angles
Cubic	$a = b = c$ $\alpha = \beta = \gamma = 90^\circ$
Orthorhombic	$a \neq b \neq c$ $\alpha = \beta = \gamma = 90^\circ$
Tetragonal	$a = b \neq c$ $\alpha = \beta = \gamma = 90^\circ$
Monoclinic	$a \neq b \neq c$ $\alpha = \gamma = 90^\circ \neq \beta$
Rhombohedral	$a = b = c$ $\alpha = \beta = \gamma \neq 90^\circ$
Triclinic	$a \neq b \neq c$ $\alpha \neq \beta \neq \gamma \neq 90^\circ$
Hexagonal	$a = b \neq c$ $\alpha = \beta = 90^\circ \neq \gamma = 120^\circ$

* Analysis of Cubical System

Property	SC	BCC	FCC
1 Atomic radius	$\frac{a}{2}$	$\frac{\sqrt{3}a}{4}$	$\frac{a}{2\sqrt{2}}$
2 No of atom/unit Cell	1	2	4
3 Coordination No.	6	8	12
4 Packing efficiency	52%	68%	74%
5 No Voids	-	-	4
(a) Octahedral	-	-	8
(b) Tetrahedral	-	-	-

* Neighbourhood of a particle

1. Simple Cubic Structure

$$\text{Distance} = a$$

$$\text{No of neighbours} = 6$$

2. BCC

$$\text{Distance} = 2r = \frac{a\sqrt{3}}{2}$$

$$\text{No of neighbours} = 8$$

3. FCC

$$\text{Distance} = \frac{a}{\sqrt{2}}$$

$$\text{No of neighbours} = \frac{3 \times 8}{2} = 12$$

* Density of lattice

$$d = \frac{Zm}{a^3 N_A}$$

$$N_A = \text{Avogadro No.}$$

$$m = \text{At. mass}$$

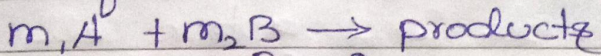
* Ionic Crystals

C.No	Limiting radius ratio
3	0.155 - 0.225 [Triangular]
4	0.225 - 0.414 [Tetrahedral]
6	0.414 - 0.732 [Octahedral]
8	0.732 - 0.999 [Cubic]

* Rate / Velocity of Chemical reaction

$$\text{Rate} = \frac{\Delta C}{\Delta t} = \frac{\text{mol/lit}}{\text{Sec}}$$

* Order of Reaction



$$R \propto [A]^p [B]^q$$

* Zero Order reaction

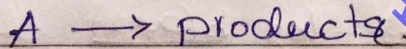
$$\text{Rate} = k [\text{Conc.}]^0$$

$$\text{Rate} = k = \frac{C_0 - C_t}{t'}$$

$$C_t = C_0 - kt$$

$$t_{1/2} \propto C_0$$

* First Order Reaction



$$t = \frac{2.303}{k} \log \frac{a}{a-x}$$

$$k = \frac{2.303}{t} \log \frac{C_0}{C_t}$$

$$t_{1/2} = \frac{\log 2}{k} = \frac{0.693}{k}$$

$$t_{\text{avg}} = \frac{1}{k} = 1.44 t_{1/2}$$

$$t = -\frac{2.303}{k} \log C_t + \frac{2.303}{k} \log C_0$$

* Second Order reaction

Type 1	Type 2
$A + A \rightarrow \text{products}$	$A + B \rightarrow \text{products}$
a	$a \quad b$
$(a-x)(a-x)$	$(a-x)(b-x)$
$\therefore \frac{dx}{dt} = k(a-x)^2$	$\frac{dx}{dt} = k(a-x)(b-x)$
$\frac{1}{(a-x)} - \frac{1}{a} = kt$	$k = \frac{2.303}{t(a-b)} \log \frac{b(a-x)}{a(b-x)}$

* Pseudo first Order reaction
For $A + B \rightarrow \text{Products}$

$$\text{Rate} = k [A]^1 [B]^1$$

$$k = \frac{2.303}{t(a-b)} \log \frac{b(a-x)}{a(b-x)}$$

If $b \gg a$

$$k = \frac{2.303}{bt} \log \frac{a}{a-x}$$

$$kb = \frac{2.303}{t} \log \frac{a}{a-x}$$

$$k' = \frac{2.303}{t} \log \frac{a}{a-x}$$

k' is pseudo first Order reaction.

* For Any Electrode
Oxidation potential = - Reduction potential.

* $E_{\text{cell}} = \text{R.P. of Cathode} - \text{R.P. of anode}$

* $E_{\text{cell}} = \text{R.P. of Cathode} + \text{O.P. of Anode}$

* Gibbs free Energy Change

$$\Delta G = -nFE_{\text{cell}}$$

$$\Delta G^{\circ} = -nFE_{\text{cell}}^{\circ}$$

* Nernst Equation

$$\Rightarrow \Delta G = \Delta G^{\circ} + RT \ln Q$$

$$\Delta G^{\circ} = -RT \ln K_{\text{eq}}$$

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{RT}{nF} \ln Q$$

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} = \frac{2.303RT \log Q}{nF}$$

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591 \log Q}{n} \quad (\text{At } 298\text{K})$$

At Chemical equilibrium

$$\Delta G = 0$$

$$E_{\text{cell}} = 0$$

$$* \log K_{\text{eq}} = \frac{nE_{\text{cell}}^{\circ}}{0.0591}$$

$$E_{\text{cell}}^{\circ} = \frac{0.0591 \log K_{\text{eq}}}{n}$$

* Electrolyte Concentration Cell

$$E = \frac{0.0591}{2} \log \left[\frac{C_2}{C_1} \right]$$

* Electrode Concentration Cell

$$E = \frac{0.0591}{2} \log \left[\frac{P_1}{P_2} \right]$$

Calculation of different Thermodynamics

* $\Delta G = -nFE_{cell}$

* $S = - \left[\frac{dG}{dT} \right]_p$

* $\Delta S = - \left[\frac{d\Delta G}{dT} \right]_p = nF \frac{d[E_{cell}]}{dt}$

* $\Delta H = nF \left[T \left(\frac{\partial E}{\partial T} \right)_p - E \right]$

* ΔC_p of Cell reaction

$$C_p = \frac{dH}{dT}$$

$$\Delta C_p = \frac{d}{dT} (\Delta H)$$

$$\Delta C_p = nFT \frac{d^2 E_{cell}}{dT^2}$$

Faraday's Law of Electrolysis

* First law

$$W = Zq \quad W = Z$$

* Second law

$$W \propto E \quad \frac{W}{E} = \text{Constant}$$

$$\frac{W}{E} = \frac{i \times t \times \text{current efficiency factor}}{96500}$$

* Current Efficiency = $\frac{\text{actual mass deposited}}{\text{Theoretical mass deposited}} \times 100$

* Conductance

$$\text{Conductance} = \frac{1}{\text{Resistance}}$$

* Specific conductance or Conductivity

$$K = \frac{1}{\rho}$$

* Equivalent Conductance

$$\lambda_e = \frac{K \times 1000}{\text{Normality}}$$

* Molar conductance

$$\lambda_m = \frac{K \times 1000}{\text{Molarity}}$$

$$\text{Specific conductance} = \text{conductance} \times \frac{l}{a}$$

* Kohlrausch law

① Strong electrolyte

$$\lambda_m^0 = \lambda_m^{\infty} - b\sqrt{C}$$

② Weak electrolyte

$$\lambda_b = n_+ \lambda_+^{\infty} + n_- \lambda_-^{\infty}$$

* To Calculate degree of dissociation of a weak electrolyte

$$\alpha = \frac{\lambda_m^0}{\lambda_m^{\infty}}$$

$$\therefore K_{eq} = \frac{C\alpha^2}{1-\alpha}$$

* Ionic mobility

$$u = \frac{V}{(V/l)}$$

V = Speed of

V/l = potential gradient.