ELECTROCHEMISTRY

Electrochemistry is the branch of Physical chemistry which deals with the study of conversion of

- * chemical energy into electrical energy (Galvanic cell)
- * Electrical energy into chemical energy (Electrolytic cell)

PART – ONE – GENERAL POINTS

1. CONDUCTANCE

Those substances which can conduct electricity are called Conductors. Conductors are of two types

- * Metallic Conductors (electronic conductors)
- * Electrolytic conductors (Ionic conductors)

BOTH FOLLOW OHM'S LAW

METALLIC CONDUCTOR	ELECTROLYTIC CONDUCTOR
Flow of current due to movement of free electrons	Flow of current due to movement of ions
Doesnot involves transfer of matters	involves transfer of matters
Does not involve any chemical changes	Involves chemical changes
conducting Power is usually very High	conducting Power is comparatively less
Doesnot follow faraday's law of electrolysis	follows faradays' law of electrolysis
on increasing Temperature Resistance increases Conductivity decreases	on Increasing Temperature Resistance decreases Conductivity increases

2. CONDUCTANCE TERMS

2.A- CONDUCTANCE [C/G]

NCERT ने conductance के लिए [G] use किया हुआ है।

Reciprocal of Resistance is called as conductance

$$G = \frac{1}{R}$$

Unit = Ω^{-1} = ohm^{-1} = mho = siemens (S)

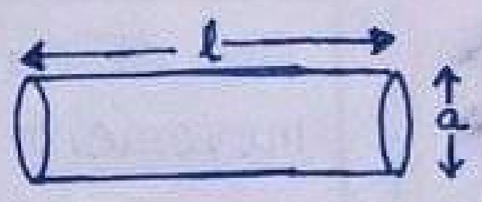
2.B- SPECIFIC CONDUCTANCE/CONDUCTIVITY [σ/K]

PHYSICS USES SIGN = σ
CHEMISTRY USES SIGN = K

IN PHYSICS CONCEPT OF [σ]

$$R = \rho \times \frac{l}{a} \Rightarrow \underset{\downarrow}{\rho} = \frac{Ra}{l}$$

SPECIFIC RESISTANCE
OR
RESISTIVITY



Reciprocal of resistivity is called conductivity
OR SPECIFIC RESISTANCE — OR SPECIFIC CONDUCTANCE

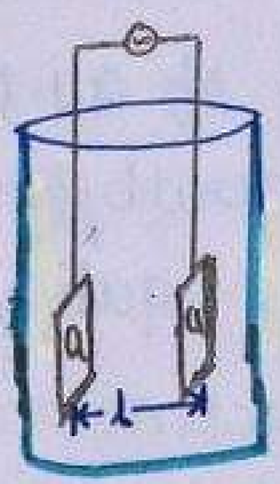
$$\sigma = \frac{1}{\rho}$$

$$\boxed{\sigma = \frac{1}{R} \times \frac{l}{a}}$$

unit - ρ (Resistivity) = Ωm OR Ωcm

σ (conductivity) = $\Omega^{-1}m^{-1}$ OR $\Omega^{-1}cm^{-1}$ OR Sm^{-1} OR Scm^{-1}

IN CHEMISTRY CONCEPT OF [K]



* l = distance between electrode (generally in cm)

Battery कोई metre या दो मीटर का generally नही होता है।

* a = Dipped surface area

ये surface area लेते वक्त दिमाग और आँख का बत्ती जला लो वरना सामने wrong answer खड़ा है।

* (l) and (a) donot depends upon nature of electrolysis.

* for a given cell (l) and (a) always remain same therefore $\frac{l}{a}$ is also called cell constant [C^*/ G^*]

Reason ये है कि Battery का size एक बार जो बन गया सो बन गया अब Battery थोड़े ना अपना length और area increase या decrease करेगा thats why $\frac{l}{a}$ is constant and called cell constant [C^*/ G^*]

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

$$\boxed{K = G \times G^*}$$

K = conductance x cell constant

if $l = 1cm$
$a = 1cm$

then $\boxed{K=G}$ so we can say that conductance of $1cm^3$/1ml solution is called as specific conductance or conductivity

2.C. EQUIVALENT CONDUCTANCE [λ_{eq} OR Λ_{eq}]

Conductance of all the ions produced by **1 gm equivalent** of an electrolyte **in given volume** of solution is called as equivalent conductance

∵ conductance of 1 cm^3 solution = K

∴ conductance of V cm^3 solution = K × V

$$\boxed{\lambda_{eq} = K \times V}$$

V → volm of solution (ml) which contain **1 gmeq** of an electrolyte

Suppose concentration is N eq / lit

∵ volm of solution containing N gmeq = 1000 ml

∴ volm of solution containing 1 gmeq = $\frac{1000}{N}$

$$\lambda_{eq} = K \times V$$

$$\boxed{\lambda_{eq} = K \times \frac{1000}{N}}$$

$\frac{1000}{N}$ → volm of solution (ml) which contain **1 gm eq** of an electrolyte

UNIT [λ_{eq} / Λ_{eq}] = $\Omega^{-1} cm^{-1} \times cm^3 eq^{-1}$

$= \Omega^{-1} cm^2 eq^{-1}$

$= S\ cm^2 eq^{-1}$

2. D- MOLAR CONDUCTANCE [λ_M OR Λ_M OR μ_M]

Conductance of all the ions produced by **1 mol** of an electrolyte in **given volume** of solution is called as MOLAR CONDUCTANCE

$\because$ conductance of 1 cm^3 solution = K

$\therefore$ conductance of V cm^3 solution = K × V

$$\boxed{\lambda_M = K \times V}$$

(V →) vol^m of solution (ml) which contain **1 mol** of electrolyte

$\because$ volume of solution containing M molar = 1000 ml

$\therefore$ " " " 1 molar = $\frac{1000}{M}$ ml

$$\boxed{\lambda_M = K \times V}$$

$$\boxed{\lambda_M = K \times \frac{1000}{M}}$$

($\frac{1000}{M}$ →) vol^m of solution (ml) which contain **1 mol** of electrolyte

UNIT [$\lambda_M / \Lambda_M / \mu_M$] $= \Omega^{-1} cm^{-1} \times cm^3 eq^{-1}$

$= \Omega^{-1} cm^2 mol^{-1}$

$= S\, cm^2 mol^{-1}$

RELATION BETWEEN λ_M AND λ_{eq}

$$\lambda_{eq} = K \times \frac{1000}{N}$$

$$\lambda_{eq} = K \times \frac{1000}{M \times v.f}$$

$$\lambda_{eq} = \frac{\lambda_M}{v.f}$$

$$\boxed{\lambda_{eq} \times v.f = \lambda_M}$$

Min^m value of v.f 1 तो होगा ही होगा so

$$\boxed{\lambda_M \geq \lambda_{eq}}$$

conductance and conductivity are additive property जैसे कि अगर कोइ electrolytic solution में several electrolytic ions है तो total conductance of solution will be

$$\boxed{C_{TOTAL} = \sum C_{ION} + \sum C_{WATER}}$$

FORMULAE

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

2. $K = \frac{1}{R} \cdot \frac{l}{a} = G \times G^{*} = \frac{G}{R}$

3. $\lambda_{eq} = K \times V = K \times \frac{1000}{N}$

4. $\lambda_{eq} = K \times V = K \times \frac{1000}{M}$

5. $\lambda_{M} = \lambda_{eq} \times V.f$

Qsn The resistance of 0.005M K_2SO_4 at 25°c is 200Ω cell constant (K) of conducting cell is 1 cm^{-1} then find equivalent conductance

Ans

$$\lambda_{eq} = K \times \frac{1000}{N}$$

$$= K \times \frac{1000}{M \times v.f}$$

$$= \frac{1}{R} \times G^* \times \frac{1000}{M \times v.f}$$

$$= \frac{1}{200} \times (1) \times \frac{1000}{0.005 \times 2}$$

$$= \underline{500\ \Omega^{-1} cm^2 equi^{-1}}$$

Qsn Resistance of Decinormal solution present between two platinum electrode that are 1.8 cm apart dipped and 5.4 cm^2 are found to be 50Ω then calculate λ_{eq} of solution

Ans

$$\lambda_{eq} = K \times \frac{1000}{N}$$

$$= \frac{1}{R} \times \frac{l}{a} \times \frac{1000}{N}$$

$$= \frac{1}{50} \times \frac{1.8}{5.4} \times \frac{1000}{1/10}$$

$$= 66.67\ \Omega^{-1} cm^2 eq^{-1}$$

Qsn HOME WORK

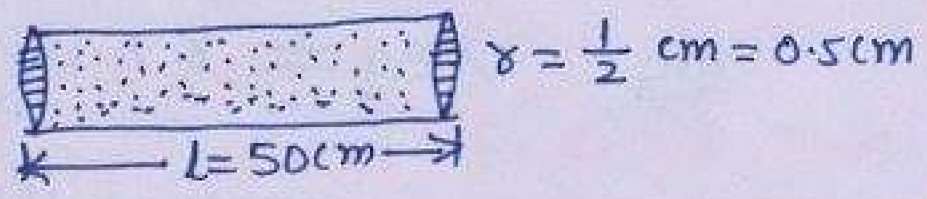
0.5 N $Al_2(SO_4)_3$ solution is present between two Platinum electrode that are 2cm X 4 cm the resistance of solution is 200Ω. then calculate molar conductance of solution

Hints

$$Al_2SO_4 \longrightarrow \underset{+6}{2Al^{+3}} + \underset{-6}{3SO_4^{-2}}$$

$$\lambda_M = \frac{K \times 1000 \times v.f}{N}$$

Qsn Resistance of a coloumn of 0.5 mole per litre NaOH solution of diametre 1cm and length 50 cm is $5.5 \times 10^{3} \Omega$. calculate its Resistivity, conductivity and molar conductivity



Ans $R = \rho \cdot \frac{l}{A}$

$$\rho = \frac{RA}{l} = \frac{R(\pi r^2)}{l}$$

$$\rho = \frac{5.5 \times 10^{3} \times 3.14 \times (0.5)^2}{50}$$

$$\boxed{\rho = 87.135 \ \Omega\text{-cm}}$$

$$K = \frac{1}{\rho} = \frac{1}{87.135 \Omega\text{-cm}} = 0.01148 \Omega^{-1} cm^{-1}$$

$$\Lambda_M = K \times \frac{1000}{M} = 0.01148 \Omega^{-1} cm^{-1} \times \frac{1000}{0.5}$$

OPTION मे ये तीनो मे से कोई एक रहेगा. जैसे नीचे दिया है।

$$\Lambda_M = 229.6 \ \Omega^{-1} (cm^2) mol^{-1}$$
$$= 229.6 \ \Omega^{-1} (10^{-4} m^2) mol^{-1}$$
$$= 229.6 \times 10^{-4} \Omega^{-1} m^2 mol^{-1}$$

(i) $\Lambda_M = 229.6 \ \Omega^{-1} (cm^2) mol^{-1}$

(ii) $\Lambda_M = 229.6 \ \Omega^{-1} (10^{-4} m^2) mol^{-1}$

(iii) $\Lambda_M = 229.6 \times 10^{-4} \Omega^{-1} m^2 mol^{-1}$

(iv) All are correct

Ans = (iv)

Qsn Equivalent conductance of 0.1M solution of $MgCl_2$ is 100 mho $cm^2 eq^{-1}$ at 25°c, A cell with electrode that are 1.5 cm is surface area and 0.5 cm apart is filled with 0.1N $MgCl_2$ solution. How much current will flow when the potential difference between electrode is 5V.

Ans $V = IR$ $I = \frac{V}{R}$ [V दी है But R find करना है]

$$\Lambda_{eq} = \frac{K \times 1000}{N}$$

$$100 = \frac{1}{R} \times \frac{l}{a} \times \frac{1000}{N}$$

$$100 = \frac{1}{R} \times \frac{0.5}{1.5} \times \frac{1000}{0.1}$$

$$\boxed{R = \frac{100}{3}} \qquad I = \frac{V}{R} = \frac{5 \times 3}{100} = \frac{15}{100} = \boxed{0.15 \text{ Amp}}$$

Qsn The conductivity of 0.1N NaOH solution is 0.022 Scm^{-1}. when equal volume of 0.1N HCl Solution is added. The conductivity of resultant solution decreases to 0.0055 Scm^{-1}. then calculate equivalent conductivity of Resultant solution

Ans

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

0.1N 0.1N

let vol^m = 1 Lit 1 lit

gm eq = N × V N × V

= 0.1 gmeq 0.1 gmeq

After Reaction = 0 0 0.1 gm eq

$$N_{NaCl} = \frac{0.1\ gmeq}{(1+1)\ lit} = 0.05N$$

$$\Lambda_{eq} = \frac{K \times 1000}{N}$$

$$\Lambda_{eq} = 0.0055 \times \frac{1000}{0.050}$$

$$\boxed{\Lambda_{eq} = 110}$$

Qsn
HOME WORK

When a certain conductance was filled with 0.05 M KCl solution it had resistance of 400 Ω at 25°C when it is filled with $CaCl_2$ solution (11.1 gm in 500 mL solution). it had resistance of 900 Ω if conductivity of 0.05 N KCl solution is 0.00189 $S\,cm^{-1}$ calculate (Ans = 0.756

(a) cell constant (Ans = 0.756)

(b) Conductivity of $CaCl_2$ solution (Ans = $8.4 \times 10^{-4}\,S\,cm^{-1}$)

(c) Molar conductivity of $CaCl_2$ solution (Ans = $4.2\,S\,cm^2\,mol^{-1}$)

(d) equivalent conductivity of $CaCl_2$ solution (Ans = 2.1 Scm

FACTOR EFFECTING ELECTROLYTIC CONDUCTANCE

[I] INTERIONIC INTERACTION
[II] SOLVENT OR HYDRATION OF IONS
[III] VISCOCITY
[IV] TEMPERATURE
[V] DILUTION

[I] INTERIONIC INTERACTION

if interionic i[illegible] is more then mobility of ions will be decreases and thus conductance will decreases

[II] SOLVATION OR HYDRATION

* Solvent molecule का ION से जुड़ना solvation कहलाता है। अब जब ION को solvent पकड़ कर रखेगा तो ION move ही नही कर पाएगा या अगर move करेगा तो slowly move करेगा so conductance decreases.

* जो ion जितना छोटा होता है पानी मे उतना ही ज्यादा मोटा हो जाता है पानी पीकर नही But H_2O को जोड़कर

* SIZE OF ION = $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$

* HYDRATED SIZE = $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

[III] VISCOSITY

VISCOSITY बढ़ेगा तो IONS easily move नही कर पाएगा so VISCOCITY OF MEDIUM INCreases, conductance decreases

[IV] TEMPERATURE

on increasing Temp K.E of IONS increases and force of attraction become weak therefore mobility of ions increases. thats why –

Temperature increases (T)↑ = conductance (G)↑

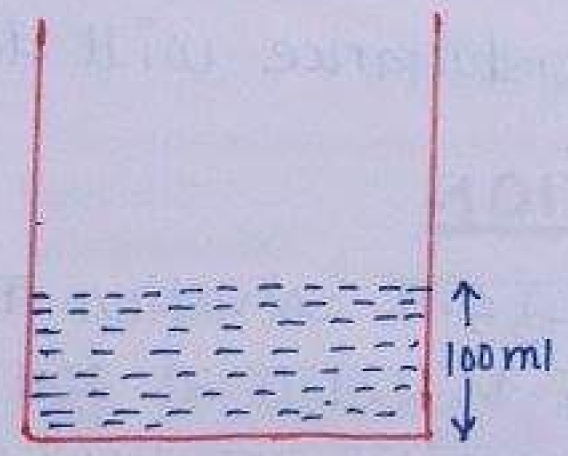
[iv] DILUTION

अब तक जो तीन effect था interionic interaction, solvation and temperature ये तीनो common concept था. But effect of dilution on conductance is so important concept.

DILUTION INCREASES = CONDUCTANCE INCREASES (G)
DILUTION INCREASES = CONDUCTIVITY DECRESES (K)

BEFORE DILUTION

1 mol present in 100 ml



Let

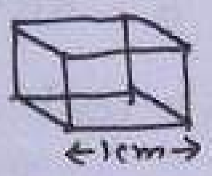
100 ml sol^n have = 50,00000 ions = G_1 = Λ_{M_1}

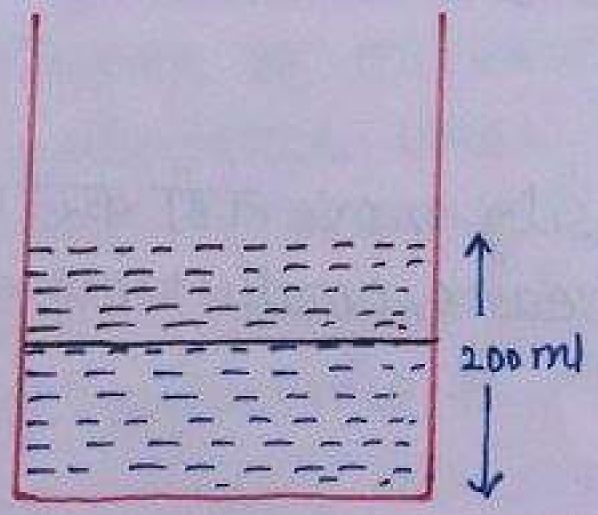
1 ml sol^n have = 50,00000 ions = K_1 [K Always 1ml के लिए होता है]

AFTER DILUTION

1 mol in 200 ml

1 ml =





$G_2 > G_1$
$K_1 > K_2$

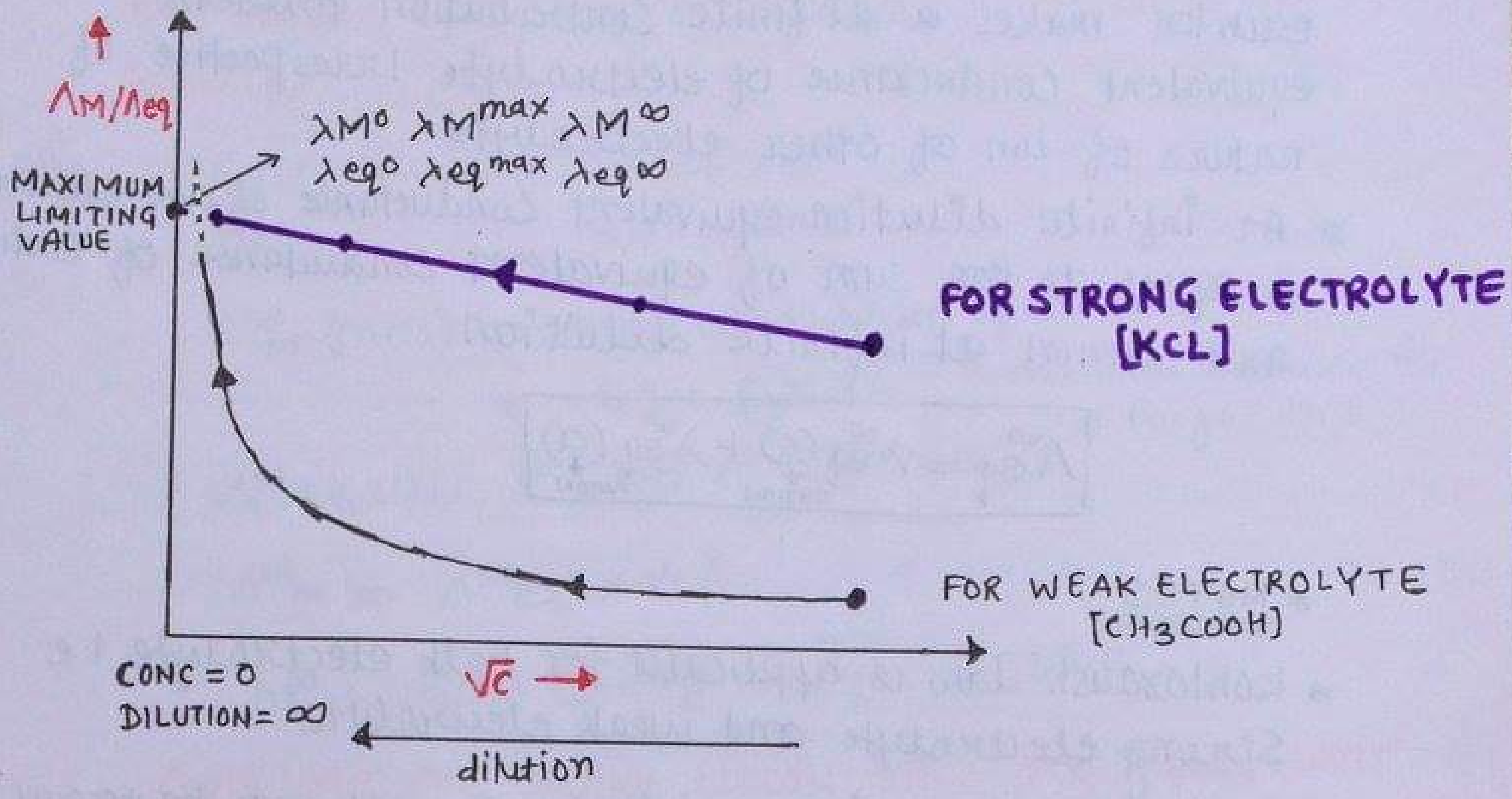
200 ml so^n contains 60,00000 ions = G_2 = Λ_{M_2}

1 ml sol^n Contains 30.00000 ions = K_2

★ ON DILUTION ⇒ G↑ BUT K↓

★ ON DILUTION ⇒ Λ_{eq}↑ AND Λ_M↑ [दोनों INCREASES]

DEBYE-HUCKEL-ONSAGAR GRAPH



FOR STRONG ELECTROLYTE

$$\boxed{\Lambda_m = \Lambda_M^{\infty} - b\sqrt{c}}$$

OR

$$\boxed{\Lambda_{eq} = \Lambda_{eq}^{\infty} - b\sqrt{c}}$$

→ DEBY-HUCKLE-ONSAGAR EQUATION

→ b = DHO constant

→ b depends upon - Nature of electrolyte
- Nature of solvent
- Temperature

OBSERVATION OF DHO-GRAPH

* Dilution को increase करने पर strong electrolyte की molar Conductance weak electrolyte की molar Conductance के जितना increase नहीं होता.
BUT strong electrolyte की conductance तो weak electrolyte की conductance से Always greater ही होगा.

* on increase dilution conduction of strong electrolyte तो gradually increase होती है! But conduction of weak electrolyte rapidly increase करती है!

* अगर Graph को extraplot किया जाए तो strong electrolyte की λM obtain किया जा सकता है! But weak electrolyte की maximum λM obtain नहीं किया जा सकता है, क्योंकि weak electrolyte की α is always less than 1

KOHLRAUSCH'S LAW

* At infinite dilution when dissociation is completed each ion makes a difinite contribution towards equivalent conductance of electrolyte Irrespective of nature of ion of other electrolyte

* At infinite dilution equivalent conductance of an electrolyte is equal to the sum of equivalent conductance of cation and anion at infinite dilution

$$\boxed{\Lambda^{\infty}_{eq} = \lambda^{\infty}_{eq}\underset{\substack{\downarrow\\ \text{CATION}}}{(c)} + \lambda^{\infty}_{eq}\underset{\substack{\downarrow\\ \text{ANION}}}{(a)}}$$

* NOTES

⇒ kohlarausch law is applicable for both electrolyte i.e Strong electrolyte and weak electrolyte

⇒ kohlraush has given original statement was in terms of equivalent conductance but according to I.U.P.A.C Convention now kohlraush law is expressed interms of molar conductanc

$$\boxed{\Lambda^{\infty}_{M} = m\lambda^{\infty}_{M}(c) + n\lambda^{\infty}_{M}(a)}$$

m= NO of moles of cation in 1 mol of electrolyte
n= NO of moles of anion in 1 mol of electrolyte

eg.-
$$\begin{array}{lcccc} K_2SO_4 & \longrightarrow & 2K^+ & + & SO_4^{-2} \\ 1\text{mol} & & 2\text{mol} & & 1\text{mol} \\ & & m=2 & & n=1 \\ 1\text{gmeq} & & 1\text{gmeq} & + & 1\text{gmeq} \end{array}$$

eg.
$$\begin{array}{lcccc} Al_2(SO_4)_3 & \longrightarrow & 2Al^+ & + & 3SO_4^{2-} \\ 1\text{mol} & & 2\text{mol} & & 3\text{mol} \\ & & m=2 & & n=3 \\ 1\text{gmeq} & & 1\text{gmeq} & + & 1\text{gmeq} \end{array}$$

Qsn ionic conductance at infinite dilution of Ca^{2+} and Cl^- are 119 and 76 cm² mol⁻¹ respectively. calculate the molar equivalent conductance of $CaCl_2$ at infinite dilution

Ans $CaCl_2 \longrightarrow Ca^{+2} + 2Cl^-$

1mol 1mol 1mol

$\Lambda^{\infty}_{M}(CaCl_2)$ = molar conductance of Cation + Anion

$= 119 + \textcircled{2}\times 76$ → maximum mistake ~~fn~~ we forget this

$\Lambda^{\infty}_{M}(CaCl_2) = 271\ \Omega^{-1}cm^2 mol^{-1}$

$\Lambda^{\infty}_{M} = \Lambda^{\infty}_{eq} \times v.f$

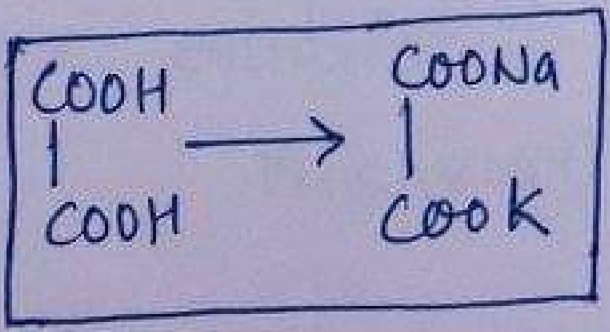
$\Lambda^{\infty}_{eq}(CaCl_2) = \frac{\Lambda^{\infty}_{M}}{v.f} = \frac{271}{2} = 135.5$

Qsn Calculate the molar Conductance and equivalent conductance at infinite dilution of the salt KOOC.COONa. Given the ionic conductance is at infinite dilution O^{2-} (oxalate ion), K^+ and Na^+ are 148.2, 50.1 and 73.5 $\Omega^{-1}cm^2 mol^{-1}$

Ans $KOOC.COONa \longrightarrow C_2O_4^{2-} + Na^+ K^+$

[Sodium pottassium oxalate] 1mol 1mol 1mol

↓



$$\begin{matrix} COOH \\ | \\ COOH \end{matrix} \longrightarrow \begin{matrix} COONa \\ | \\ COOK \end{matrix}$$

$\Lambda^{\infty}_{M} = \lambda^{\infty}_{M}(ox^{2}) + \lambda^{\infty}_{M} Na^+ + \lambda^{\infty}_{M} K^+$

$\Lambda^{\infty}_{M} = 148.2 + 50.1 + 73.5$

$\Lambda^{\infty}_{M} = 271.8\ \Omega^{-1}\ cm^2 mol^{-1}$

$\Lambda^{\infty}_{eq} = \frac{\Lambda^{\infty}_{M}}{v.f} = \frac{271.8}{2} = 135.9$

APPLICATION OF KOHLRAUSH LAW

[I] To Determine degree of ionisation (α)
[II] To determine dissociation constant [K]
[III] To determine Λ_M^∞ OR λ_{eq}^∞ for weak electrolyte
[IV] To determine solubility of sparingly soluble salt

[I] TO DETERMINE DEGREE OF IONISATION

$$\boxed{\alpha = \frac{\text{Dissociated moles}}{\text{Total moles}} = \frac{\text{ions obtained by dissociation of electrolyte}}{\text{Total ions present in electrolyte}}}$$

At constan "concentration c"

$$\boxed{\alpha = \frac{\Lambda_{eq}^{c}}{\Lambda_{eq}^{\infty}} \text{ or } \frac{\Lambda_M^{c}}{\Lambda_M^{\infty}}}$$

[II] TO DETERMINE DISSOCIATION CONSTANT [K]

eg- for CH_3COOH

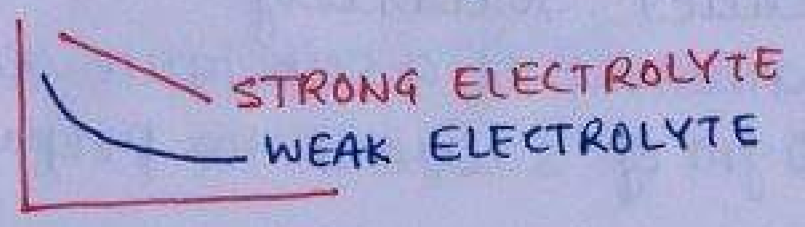
$$Ka = \frac{C\alpha^2}{(1-\alpha)} \quad \text{if } \alpha << 1 \text{ then } Ka = C\alpha^2$$

$$[H^+] = C\alpha$$
$$i = 1-\alpha+n\alpha$$

[III] TO DETERMINE Λ^{∞}_{M} OR Λ^{∞}_{eq} FOR A WEAK ELECTROLYTE

Qsn: $\Lambda^{\infty}_{M}(CH_3COOH) = ?$

* यहाँ CH_3COOH एक weak electrolyte है। और graph से weak electrolyte का Λ^{∞}_{M} find नही कर सकते है। Graph से तो सिर्फ strong electrolyte का ही Λ^{∞}_{M} find कर सकते



* But we can use Kohlrausch law because Kohlrausch law is applicable for both strong and weak electrolyte

$$\Lambda^{\infty}_{M}(CH_3COOH) = \boxed{\lambda^{\infty}_{M}(CH_3COO^-)} + \boxed{\lambda^{\infty}_{M}(H^+)} \text{ - - - - (i)}$$

$$\Lambda^{\infty}_{M}(CH_3COONa) = \boxed{\lambda^{\infty}_{M}(CH_3COO^-)} + \lambda^{\infty}_{M}(Na^+) \text{ - - - - (ii)}$$

$$\Lambda^{\infty}_{M}(HCl) = \boxed{\lambda^{\infty}_{M}(H^+)} + \lambda^{\infty}_{M}(Cl^-) \text{ - - - - (iii)}$$

$$\Lambda^{\infty}_{M}(NaCl) = \lambda^{\infty}_{M}(Na^+) + \lambda^{\infty}_{M}(Cl^-) \text{ - - - - (iv)}$$

* $\lambda^{\infty}_{M}(CH_3COO^-)$ की molar conductance चाहे equation (i) मे हो या equation (ii) मे हो दोनो जगह same ही होगी

* $\lambda^{\infty}_{M}(H^+)$ की molar conductance चाहे equation (i) मे हो या equation (iii) मे हो दोनो जगह same ही होगी

* equation (i) = equation (ii) + equation (iii) – equation (iv)

$$\Lambda^{\infty}_{M}(CH_3COOH) = \Lambda^{\infty}_{M}(CH_3COO^-) + \lambda^{\infty}_{M}(H^+) - \Lambda^{\infty}_{M}(NaCl)$$

$$\Lambda^{\infty}_{M}(CH_3COOH) = \Lambda^{\infty}_{M}(\underline{CH_3COO}Na + \underline{H}Cl + NaCl)$$

[IV] TO DETERMINE SOLUBILITY OF SPARINGLY SOLUBLE SALT

Eg- $AlCl$, $BaSO_4$, $PbSO_4$

Solubility

- Concentration of saturated solution at constant temperature called solubility
- The maximum amount of a substance which canbe dissolve in 100 gm of solvent to prepare its saturated solution

FUNDA:

- saturated solution of sparingly soluble salt canbe considered as infinitely diluted solution because these salt dissolve very less therefore

$$\underline{\text{saturated solution}} = \text{infinitely diluted solution}$$

$$\downarrow$$

$$\Lambda_M = \Lambda^\infty_M = K \times \frac{1000}{M}$$

$$\downarrow$$

By Kohlrausch law

$\boxed{\text{यहाँ पर } M=S}$

*if we add 500 gm $AgCl$ in 1 litre of H_2O then only upto 5g $AgCl$ is dissolve.

*495 gm $AgCl$ remain undissolve. so actual solubility = 5g/L

Qsn At a certain temperature the saturated solution of AgCl has conductivity (K) 1.8×10^{-6} mho cm^{-1}. The ionic conductance is of Ag^+ and Cl^- at infinite dilution are 54.5 and 65.5 mho cm^2 mol^{-1}. Find the solubility of AgCl at this temperature

Ans $\Lambda^\infty_M\ AgCl = 54.5 + 65.5$

$= 120$

$$\Lambda^\infty_M = 1.8 \times 10^{-6} \times \frac{1000}{S}$$

$$120 = 1.8 \times 10^{-6} \times \frac{1000}{S}$$

$$S = \frac{1.8 \times 10^{-6} \times 1000}{120}$$

$$S = 1.5 \times 10^{-5} \text{ mol/litre}$$

$$K_{sp} = S^2 = 2.25 \times 10^{-10}$$

Qsn The molar conductance for acetic acid at 0.2 M Molar conductance at infinite dilute are 4.8 and 400 Ω^{-1} cm^2 mol^{-1} respectively. calculate degree of dissociation and dissociation constant of CH_3COOH.

Ans $C = 0.2\ M\ CH_3COOH$

$$\Lambda^c_M = 4.8$$

$$\Lambda^\infty_M = 400\ \Omega^{-1} cm^2 mol^{-1}$$

$$\alpha = \frac{\Lambda^c_M}{\Lambda^\infty_M} = \frac{4.8}{400} \times 100 = 1.2\% = 1.2 \times 10^{-2}$$

$$K_a = C\alpha^2$$

$$= 0.2\,(1.2 \times 10^{-2})^2$$

$$\simeq 2.88 \times 10^{-5}$$

Qsn The molar conductance of an infinitely diluted solution of Ammonium chloride (NH_4Cl) is $150 \Omega^{-1} cm^2 mol^{-1}$ and ionic conductance is ($OH^- = 198$), ($Cl^- = 76 \Omega^{-1} cm^2 mol^{-1}$) what will be the molar conductance of the solution of NH_4OH (Ammonium Hydroxide) at infinite dilution. If the conductivity of 0.01M solution of NH_4OH is $9.52 \times 10^{-5} \Omega^{-1} cm^2$ what will be its degree of dissociation

Ans $NH_4Cl = 150\ Ohm^{-1} cm^2 mol^{-1}$

$OH^- = 198$

$Cl^- = 76 \Omega^{-1} cm^2 mol^{-1}$

$$\Lambda^\infty_M (NH_4OH) = \Lambda^\infty_M (\underline{NH_4Cl} + \underline{OH^-} - Cl^-)$$

$$\Lambda^\infty M (NH_4OH) = \Lambda^\infty_M (150 + 198 - 76)$$

$$\Lambda^\infty_M (NH_4OH) = 272 \Omega^{-1} cm^2 mol^{-1}$$

$C = 0.01M$

$K = 9.52 \times 10^{-5} \Omega^{-1} cm^{-1}$

$$\Lambda^c_M = K \times \frac{1000}{M}$$

$$\Lambda^c M = \frac{9.52 \times 10^{-5} \times 1000}{0.01} = 9.52$$

$$\alpha = \frac{\Lambda^c M}{\Lambda^\infty M} = \frac{9.52}{272} \times 100$$

$$\underline{\alpha = 3.5\%}$$

Qsn Conductivity of saturated solution of AgCl is $2.2\times10^{-6}\,\Omega^{-1}\,cm^{-1}$ and conductivity of water is $0.8\times10^{-6}\,\Omega^{-1}\,cm^{-1}$. Molar conductance at infinite dilution of $AgNO_3$, HCl and HNO_3 are 135, 426 and 421 $\Omega^{-1}\,cm^2\,mol^{-1}$ respectiv calculate solubility product of AgCl

Ans

$AgNO_3 = 135$

$HCl = 426$

$HNO_3 = 421$

$$\Lambda^{\infty}_{M}(AgCl) = \Lambda_M^{\infty}(AgNO_3 + HCl - HNO_3)$$
$$= \Lambda^{\infty}_{M}(135 + 426 - 421)$$

$$\Lambda^{\infty}_{M}(AgCl) = 140\,\Omega^{-1}\,cm^2\,mol^{-1}$$

K_{AgCl} solution $= 2.2\times10^{-6}\,\Omega^{-1}\,cm^{-1}$

K_{H_2O} solution $= 0.8\times10^{-6}\,\Omega^{-1}\,cm^{-1}$

$K_{\text{solution of electrolyte}} = K_{\text{electrolyte}} + K_{H_2O}$

It should neglect

$$= K_{\text{solute electrolyte}} + \boxed{K_{H_2O}}$$
$$= 2.2\times10^{-6} - 0.8\times10^{-6}$$

$$\underline{K_{AgCl} = 1.4\times10^{-6}}$$

Qsn specific conductance of 0.03M aquas solution of weak base BOH is $1.5\times10^{-4}\,S\,cm^{-1}$. also the molar conductance at infinite dilution is $250\,S\,cm^2\,mol^{-1}$ find ionisation constant of weak base

Ans

$C = 0.03M$

$K = 1.5\times10^{-4}\,S\,cm^{-1}$

$\Lambda^{\infty}_{M} = 250\,S\,cm^2\,mol^{-1}$

$$\Lambda^{c}_{M} = K\times\frac{1000}{M}$$

$$\Lambda^{c}_{M} = 1.5\times10^{-4}\times\frac{1000}{0.03}$$

$$\Lambda^{c}_{M} = 5$$

$$\alpha = \frac{\Lambda_M^{c}}{\Lambda_M^{\infty}} = \frac{5}{250} = 0.02$$

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

$$K_b = 0.03\,(0.02)^2$$

$$\underline{K_b = 1.2\times10^{-5}}$$

AIIMS

ELECTROLYTE	KCl	KNO_3	HCl	NaOAc	NaCl
Λ^∞ (Scm^2mol^{-1})	149.9	145.0	426.2	91.0	126.5

calculate Λ^∞_{HOAc} using appropriate molar conductance of electrolyte listed above at infinite dilution in H_2O at 25°C

Ans $\Lambda^\infty_{HOAc} = \Lambda^\infty_{NaOAc} + \Lambda^\infty_{HCl} - \Lambda^\infty_{NaCl}$

$= 91.0 + 426.2 - 126.5 \ Scm^2mol^{-1}$

$= 390.7 \ Scm^2mol^{-1}$

Qsn AIIMS Hydro Fluoride acid is weak acid. At 25°C the molar conductivity of 0.002 M HF is $176.2 \ \Omega^{-1}cm^2mol^{-1}$ if its $\Lambda^\circ_m = 405.2 \ \Omega^{-1} cm^2 mol^{-1}$. Equillibrium constant at the given concentration is

Ans $\alpha = \frac{\Lambda_c}{\Lambda^\infty_m} = \frac{176.2 \ \Omega^{-1} cm^2 mol^{-1}}{405.2 \ \Omega^{-1} cm^2 mol^{-1}} = 0.435$

$$K = \frac{[H^+][F^-]}{[HF]} = \frac{C\alpha^2}{1-\alpha} = \frac{(0.002M)(0.435)^2}{1-0.435}$$

$\underline{K = 6.70 \times 10^{-4} M}$

ELECTROCHEMISTRY – PART TWO

ELECTRODE POTENTIAL

When a metal is placed in aquas solution of its ion Its acquires either negative or positive charge with respect to solution and potential is developed between metal and solution which is called electrode potential of metal.

explanation :

- * अगर cu को उसके aquas solution $CuSO_4$ मे डुबाया जाए तो Potential developed हो जाएगा.
- * अगर zn को उसके aquas solution $ZnSO_4$ मे डुबाया जाए तो Potential developed हो जाएगा

Electrode potential mainly depends upon

(a) Nature of electrode
(b) Concentration of ions in solution
(c) Temperature

NCERT

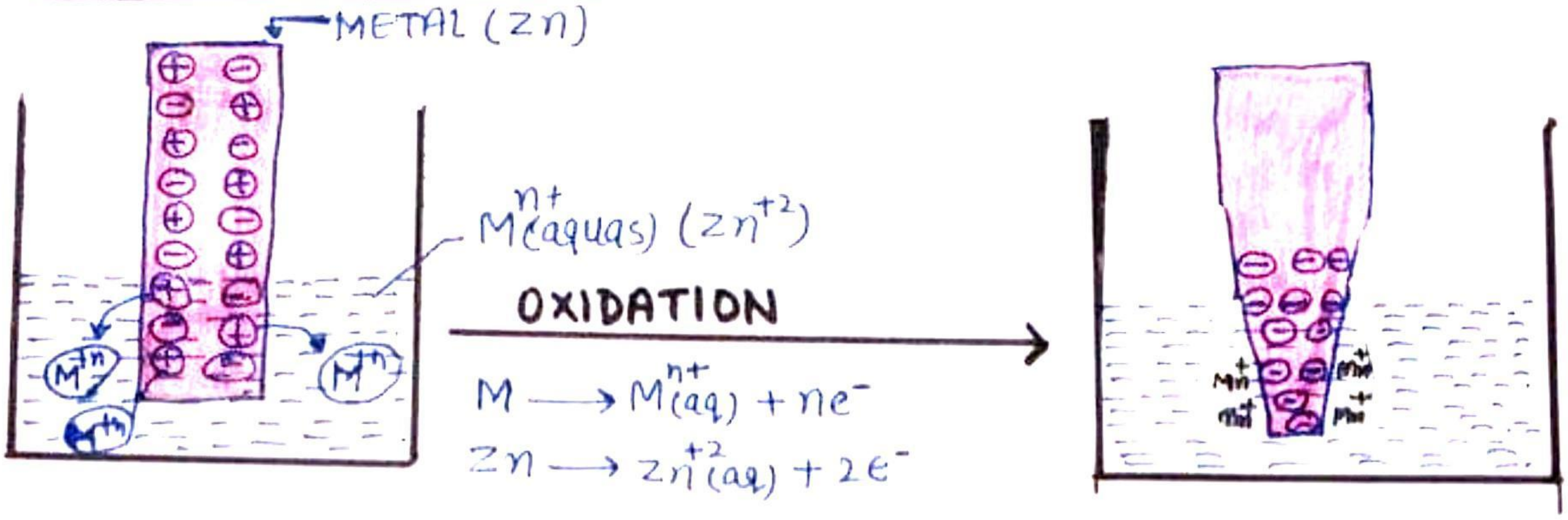
A large number of
- Metals
- Sodium hydroxide
- Fluorine
- chlorine
- and many other chemicals

are produced by electrochemical method.

ELECTRODE POTENTIAL ARE OF TWO TYPES:

(I) OXIDATION POTENTIAL
(II) REDUCTION POTENTIAL

(I) OXIDATION POTENTIAL



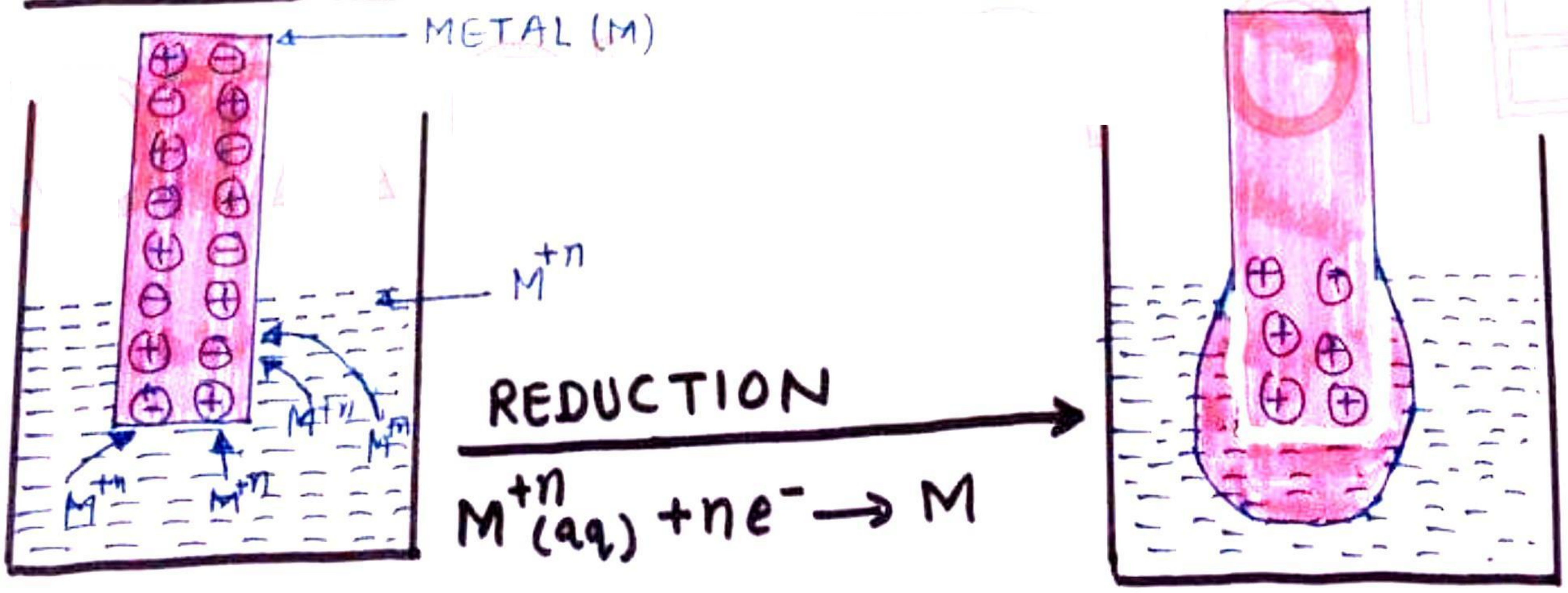
$M \longrightarrow M^{n+}_{(aq)} + ne^-$

$Zn \longrightarrow Zn^{+2}_{(aq)} + 2e^-$

* Metal atom of electrode have tendency to go into the solution as ions. and leave behind the electrons at the electrode trying make it negatively charged.

* यहाँ electrode का oxidation हो रहा है। और potential develop हो रहा है। so called oxidation potential

(II) REDUCTION POTENTIAL



$M^{+n}_{(aq)} + ne^- \longrightarrow M$

$$\boxed{M \underset{\text{REDUCTION}}{\overset{\text{OXIDATION}}{\rightleftharpoons}} M^{n+}_{(aq)} + ne^-}$$

IF OXID > RED THEN OXID-POTENTIAL
IF RED > OXID THEN RED-POTENTIAL

CE ELECTRODE

ttery at least दो Half cell को

we want measure potential

neasure नही कर पाएगे इसके लि

की requirement होगी

EFERENCE ELECTRODE [SH

ndard Hydrogen electrode

electrode represented by = P

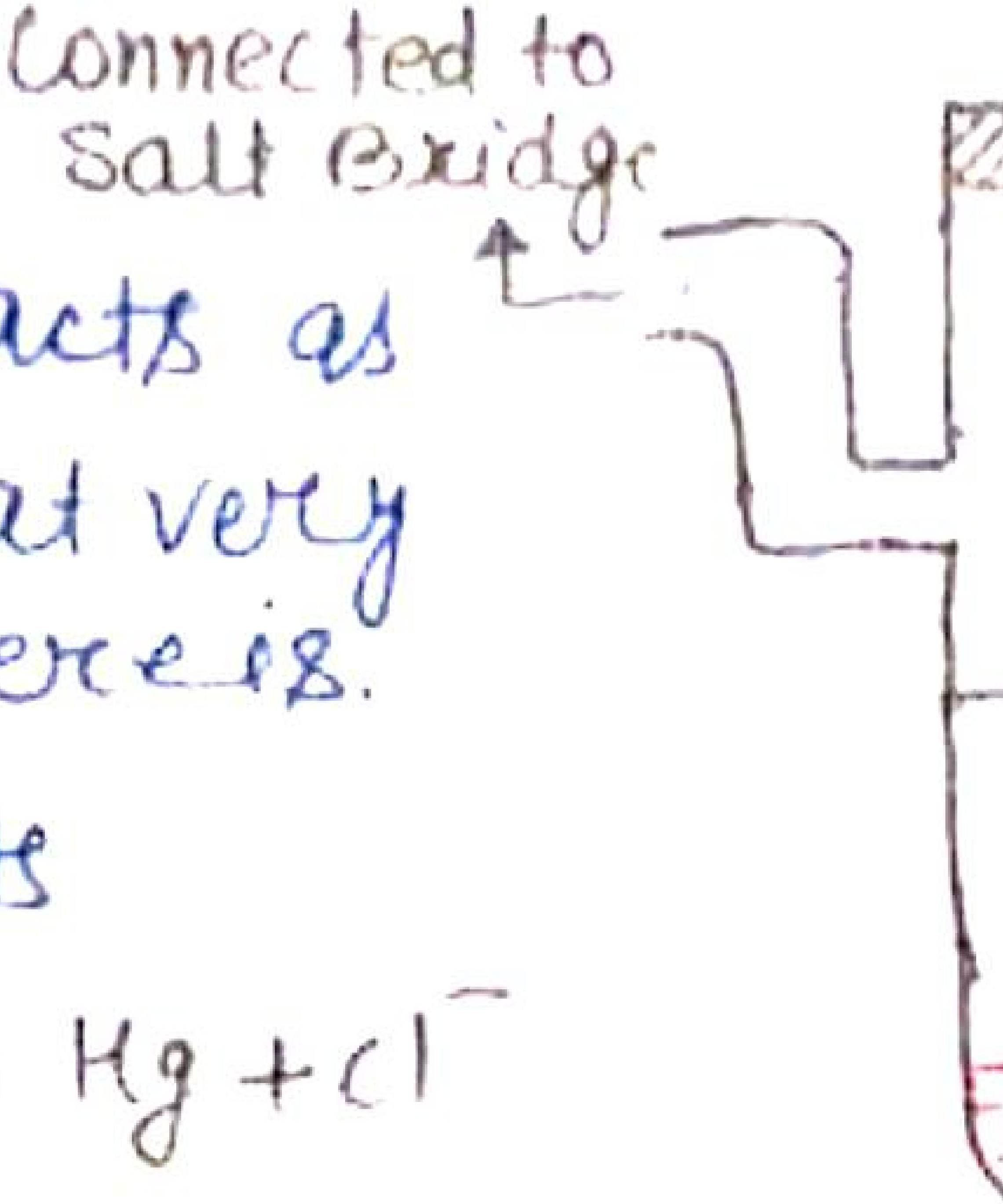
ned to <u>ZERO POTENTIAL</u> at all te

action

$H^+_{(aq)} + e^- \rightarrow \frac{1}{2}(H_2)g$

REFERENCE ELECTRODE

ELECTRODE



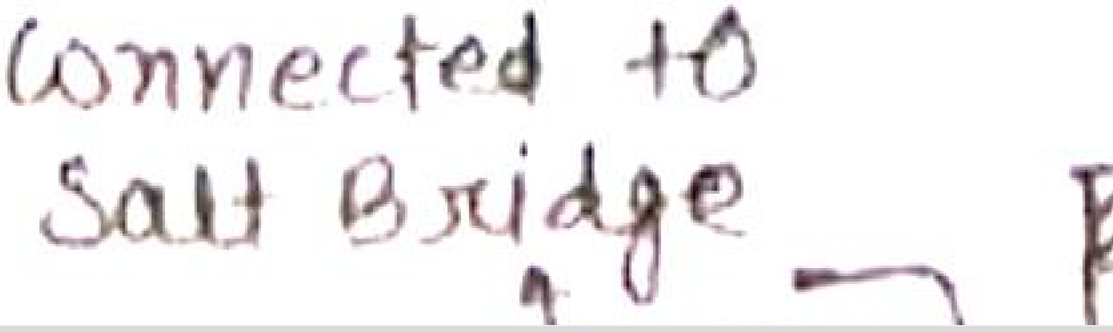
ode is commonly acts as use it is situated at very Electrochemical sereis.

as cathode then its

ion = $\frac{1}{2} Hg_2Cl_2 \rightarrow Hg + Cl^-$

n = $Hg_2Cl_2 / Hg + Cl^-$

LVER CHLORIDE ELECTRODE



rode generally

TROCHEMICAL SEREIS

Best reducing agent
SRP = $-3.04V$

= $-0.76V$

* As we go down t

Reactivity of Non-me

Reactivity of met

* $Li \xrightarrow{Oxid} Li^+ + e$

$Li^+ + e^- \xrightarrow{Red} Li$

* As we go from

strength of oxidis

ONCLUSION FROM E.C.S

ENT OF METAL IONS BY METAL

ed higher in E.C.S displaces meta
ow them in E.C.S from their sol

4 $\longrightarrow ZnSO_4 + Cu$

4 $\longrightarrow$ NO REACTION * Ag तो Cu से

Zn तो Cu से ऊपर है इसलिए Zn
डाले तो वो Cu को displace कर

MENT OF NON-METAL ION BY NON

l displaces the anion of non-met
ctrochemical sereis from thei

$_2 \longrightarrow 2KCl + Br_2$

basis of following chemical J
of Metal ABCDE and H_2 in E

$SO_4 \longrightarrow ASO_4 + H_2$

$Cl_2 \longrightarrow CCl_2 + A$

ed

$Cl_2 \longrightarrow$ NO RXN

isplace

$H_2SO_4 \longrightarrow$ NO RXN

$2BU \longrightarrow DCl_2 + 2B$

E
C
A
H_2
D
B

e these metals in increasin
ducing power

TAL	E°(SRP/SEP)
	-1.5V

LECTROCHEMICAL CELL

two types of electrochemica

lvanic cell OR VOLTAIC CELL

ECTROLYTIC CELL

NIC CELL OR VOLTAIC CE

hich convert chemical energ
called galvanic cell.

vanic cell में Anode को zn
और cathode को copper से
cell DANIEL CELL कहलाएग

तो cell बनाया था उसको Dani
नाया और dipped किया था

servations are observed duri

ll reaction electric curren
anode in external circuit
ows from anode to cathode

ll reaction weight of anodi
whereas weight of cathodi

cell reaction concentration
lution increases whereas
on in cathodic solution de
ctions are spontaneous a

Liquid- liquid junction potenti

different electrolytic so

direct contact with each o

of potential is developed

liquid-liquid junction pote

is always such that it

f of cell

to thermodynamics ΔG i

k by the system

$W_{useful} = - W_{electrical}$

$Q\,dv = - nF \times E_{cell}$

$\boxed{nF E_{cell}}$

n = no of moles of

F = Faraday const

l was dipped in $Pb(NO_3)_2$ solu

ipped in $AgNO_3$ solution then

action and cell representatio

$\longrightarrow$ $Pb(NO_3)$ = cathode

$\longrightarrow$ $Ag(NO_3)$ = Anode

$\longrightarrow Pb^{+2} + \cancel{2e^-}$] ×1

$e^- (\cancel{2}) \longrightarrow Ag$] ×2

$2Ag^+ \longrightarrow Pb^{+2} + 2Ag$

---

presentation = $Pb/Pb^{+2} // A$

e cell $Al/Al^{+3} // Ni^{+2}/Ni$

ES

electrode potential doesnot

lied/devided by a co-efficie

potential is an intrinsic

electrode potential doesnot c

metallic rod

for two different electrode

ant to calculate E° for 3

these two electrude then f

ΔG° and then apply HEISS l

$/Cl^- = x$

$/\frac{1}{2}Cl_2 = y$

$/ 1\ Cl = ?$

$e^{+2}/Fe = 0.26\ V$

$e^{+3}/ Fe = 0.76\ V$

$e^{+2}/ Fe^{+3} = ?$

$+ 2e^- \longrightarrow Fe \quad \Delta G_1^\circ = -2F$

$+ 3e^- \longrightarrow Fe \quad \Delta G_2^\circ = -3$

$\longrightarrow Fe^{+3} + e \quad \Delta G_3^\circ = -1$

1) − eq (2) = eq (3)

$- \Delta G_2^\circ = \Delta G_3^\circ$

$F + 2.28 = -F \times E_3$

$+ 1.76 = - E_3$

ude of SRP of two metals

$e^- \longrightarrow Y \quad |E^\circ| = 0.34$ volt

$2e^- \longrightarrow X \quad |E^\circ| = 0.25$ v

and Y are connected then

to Y and if X is connect

crossed from X to SHE th

the cell made up by X a

CATHODE ANODE

$\longrightarrow Y$ X —

(+0.34V) (−0.25V

$= (E^\circ red)_c - (E^\circ red)_A$

ERST EQUATION

assumed in the previous sec

ation of the species involve

• This need not be always

showed that for the electro

$$q) + ne^{-} \longrightarrow M(s)$$

trode potential at any conc

with respect SHE canbe

$$\boxed{- \frac{RT}{nF} \log_e \frac{[\text{Product}]}{[\text{Reactant}]}}$$

OF NERST EQUATION

late electrode potential

ulate electrode potential of H

ulate e.m.f of cell

CULATE ELECTRODE POTE

ectrode potential given then

$$M^{+n}/M) = ?$$

Red

$$e^{-} \xrightarrow{Red} M_{(s)}$$

$$E^{\circ}red - \frac{0.591}{n} \log_{10} \frac{[M]}{[M^{n+}]} \rightarrow 1 \; B$$

$$E^{\circ}red + \frac{0.591}{} \log [M^{n+}]$$

ate electrode potential of a
in a 0.1M solution of CuSO
dard electrode potential Cu^{2}
K

is a salt and α is not given
tion occur

$$\longrightarrow Cu^{+2} + SO_4^{-2}$$

0.M

$$= c\alpha = 0.1 \times \frac{100}{100} = 0.1$$

$$+2e^{-} \longrightarrow Cu(s)$$

$$[Cu] \longrightarrow 1$$

CULATE ELECT. POTENTIAL

$$- \xrightarrow{\quad} H_2(g)$$

$$E^\circ_{red} - \frac{0.0591}{2}\log\frac{[P_{H_2}]}{[H^+]^2}$$

equation concentration term

pressure of gas (Atmosphe

g $[P_{H_2}]$ is Pressure while

tion मगर ये गलत नहीं है। ये

एक unitless है। इसे replace

electrode potential of follo

of acidic solution is ?

pH of following Half cel

Eoxi = 0.25V)

$H_2(g) / HCl$

$\xrightarrow{\text{oxid}} 2H^+ + 2e^-$

$$\underset{0}{\cancel{\text{axi}}} - \frac{0.0591}{2} \log \frac{[H^+]^2}{\cancel{[PH_2]}} \Rightarrow 2$$

$$- \frac{0.0591}{\cancel{2}} \times \cancel{2} \log [H^+]$$

$$- \log [H^+]$$

$$\frac{\text{Eoxi}}{} = \frac{-\text{Ered}}{0.0591}$$

LATE e.m.f OF THE CELL

Potential of Anode + Red Po

$\boxed{E_{cathode} - E_{anode}}$

rd condition

$$\boxed{\underbrace{E^\circ_C}_{} - \underbrace{E_A}_{}}$$

Reduction potential

$aq)) // (Ag^+_{(aq)} / Ag) \times 2$ Ecel

$E_{cell} = ?$

$3(10^{-2}M) \,||\, Co^{2+}(10^{-1}M)/Co$

$Al = -1.66V$

$Co = -0.28V$

A B C

$+3\,(10^{-2}M) \,||\, 3\times(Co^{+2}\,(10^{-2}M)/Co$

$e^- = 6e$ $\quad 3\times 2e^- = 6e^-$

$Al = -1.66V$,

↗

ode) (Bridge) (Cathod

A B C

$) / Br^- (0.01M) \,||\, H^+ (0.01M) / H_2(g)$ (

$E_{cell} = ?$

$E^\circ_{Pt/Br_2/Br^-} = 1.09\,V)$

rod पर Br^- को absorb करा

मे dipped किया

rod पर H_2 absorb कर कर

किया

$- E^\circ_A$

$- 1.09$

y a system = ↓ in Free energy o

btained by cell = in the form of

$$W = Q \times V$$

$$\boxed{W = nF \times E_{cell}}$$

ell $= -\Delta G$

$\boxed{FE}$ n = no of moles of tra

d condition

$\boxed{FE^\circ_{cell}}$

pontaneoty of reaction in Da

Ⓐ Ⓑ Ⓒ

$Zn^{+2}(1M) \,//\, Cu^{+2}(1M)/Cu$

$E^\circ_{Zn^{+2}/Zn} = -0.76$ volt

$E^\circ_{Cu^{+2}/Cu} = 0.34$ volt

reaction $Zn + Cu^{+2} \longrightarrow Zn$

$l = E^\circ_c - E^\circ_A$

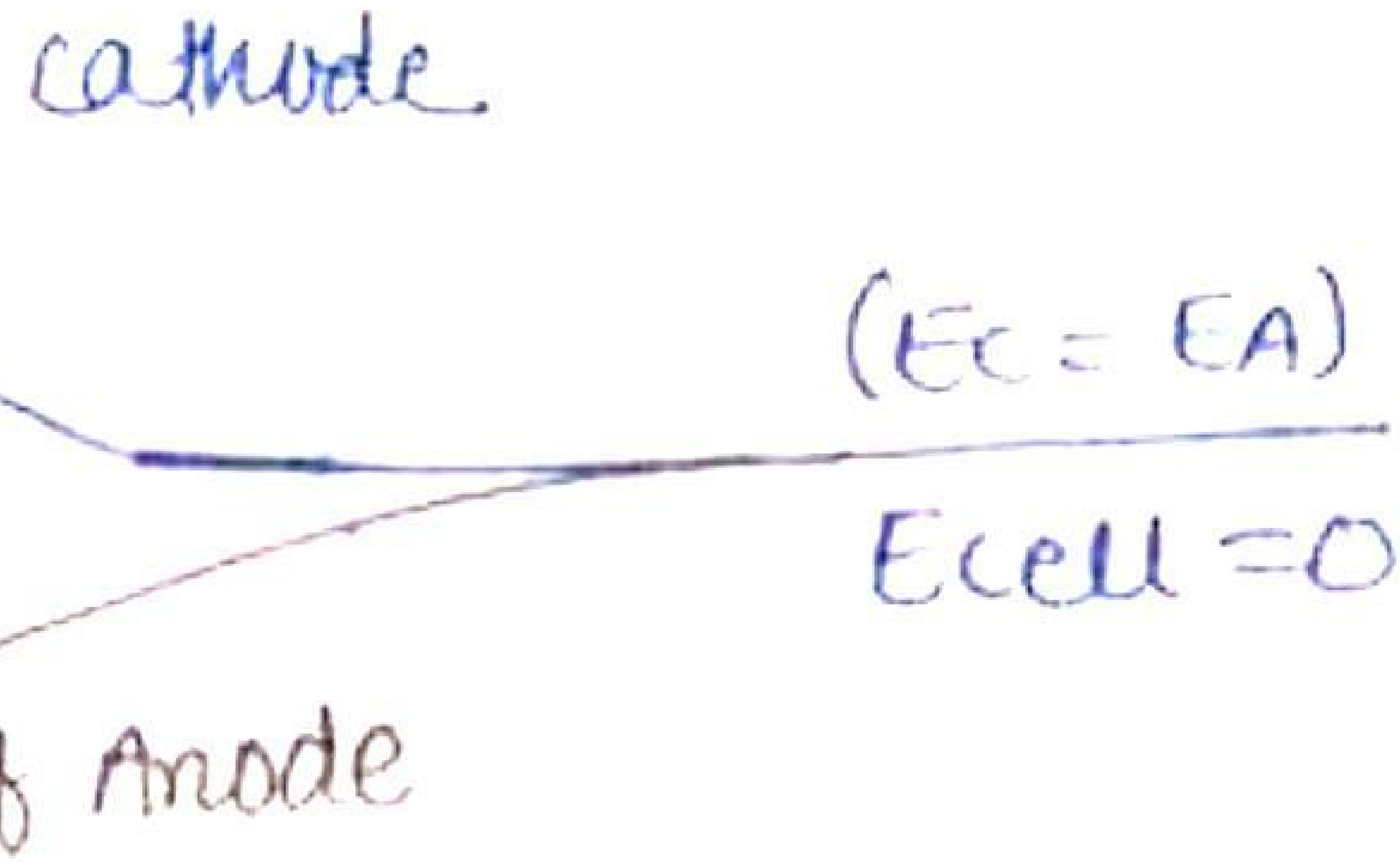
$= (Cu) - (Zn)$

$= 0.34 - (-0.76v)$

$l = +1.1$ volt OR $\Delta G = -$

EQUILLIBRIUM

eaction occurs concentratio
ution decreases therefore its
lso decreases but concentra
olution increases therefore i
lso increases.



* E°cell
E°cell
ΔG

* ΔG =

e equillibrium constant for

Ce^{+4} $\longrightarrow$ Ce^{+3} + Fe^{+3}

$E^\circ_{Ce^{4+}/Ce^{3+}} = 1.45V$

RED

$E^\circ_{Fe^{3+}/Fe^{2+}} = 0.67V$

RED

$= E^\circ_c - E^\circ_A$

$= (Ce) - (Fe)$

$= 1.45 - 0.67$

$= 0.78V$

$\frac{0.0591}{1} \log_{10} K$

tandard electrode potential

Fe) $= -0.4V$

$Fe^{2+}) = 0.8V$

/ Mn) $= -1.2V$

/ $Mn^{+2}) = 1.5V$

t on relative stability of t

state of Iron and mangn

of the two metal is more

(+2) state

$^{+}$/ Fe) $= -0.4V$

$/ Fe^{2+}) = ?$

$Fe^{3+}/Fe) = -0.036V$

$Fe^{+2}/ Fe) = -0.440V$

$3e^- \longrightarrow Fe \quad E^\circ_1 = -0.036$

$2e^- \longrightarrow Fe \quad E^\circ_2 = -0.440$

$e^- \longrightarrow Fe^{2+} ; \quad E_3 = ?$

an intrinsic property इसलि

मे convert करेंगे क्यों कि ΔG°

property means ΔG° is addit

$/ MnO_2) = ?$

$(MnO_4^- / Mn^{+2}) = 1.51V$

$(MnO_2 / Mn^{+2}) = 1.23V$

$\xrightarrow{n_1 = 5} \overset{(+2)}{Mn^{2+}}$; $E_1^\circ = 1.51V$

$\xrightarrow{n_2 = 2} \overset{(+2)}{Mn^{2+}}$; $E_2^\circ = 1.23$

$\xrightarrow{n_3 = 3} \overset{(+4)}{MnO_2}$; $E^\circ = ?$

eqn ② = Eqn ③

$n_2 E_2^\circ = n_3 E_3^\circ$

NTRATION CELL

milar electrode having diffe
of ion in solution are comb
ned which is called concentra

$(c_1) // M^{+n}(c_2)/M$ $E_{cell} = ?$

$\longrightarrow M^{+n} + ne^-$

$+ ne^- \longrightarrow M$

$+ M^{n+}(c_2) \longrightarrow M^{+n}(c_1) + M$

$= 0.0591 \log_{10} \left[\frac{c_1}{}\right]$

1bar) / HA$_1$ || HA$_2$ / H$_2$ (1bar) / Pt ;

$e = H_2(P_1) \xrightarrow{oxid} 2H^+($

$e = 2H^+(C_2) + 2e^- \xrightarrow{Red} H_2\ ($

---

tion $H_2(P_1) + 2H^+(C_2) \xrightarrow{n=2}$

$$\underset{0}{\cancel{E^\circ_{cell}}} - \frac{0.0591}{2} \log_{10} \frac{(C_1)^2}{(C_2)^2}$$

ll for concentration cell = 0

$$- \frac{0.0591}{2} \log \left(\frac{C_1}{C_2}\right)$$

$/H^+(c_1) \,||\, H^+(c_2) / H_2(g) / Pt$;

$$H_2(P_1) \xrightarrow{Oxid} 2H^+(c_1)$$

$$2H^+(c_2) + 2e^- \xrightarrow{Red} H_2(P_2)$$

$$H_2(P_1) + 2H^+(c_2) \xrightarrow{n=2} 2H^+$$

$$ell - \frac{0.0591}{2} \log \frac{(C_1)^2 (P_2)}{(C_2)^2 (P_1)}$$

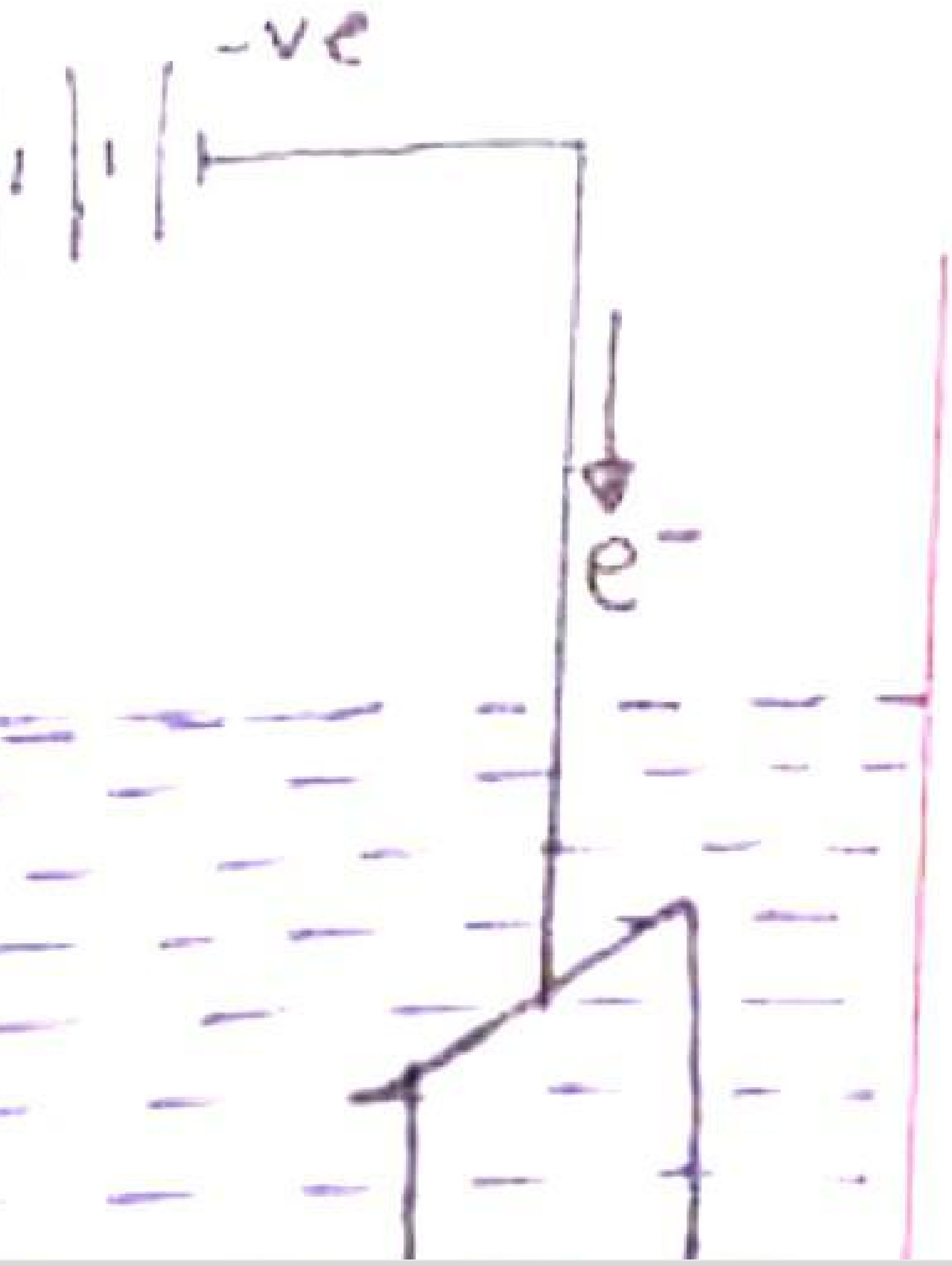
$P_1 = P_2 = 1$ bar but $C_1 \neq C_2$

$$l = 0 - \frac{0.0591}{2} \log \frac{C_1^2}{C_2^2}$$

THREE - ELECTROLYSIS

of decomposition of an ele
passed through its aquas sol
ed electrolysis

e in which electrolysis is c
rolytic cell



Elect

CATION (+

↓

CATHODE (−

↓

Reduction

trolysis mainly depends upon

LECTROLYTE (STRONG OR WEAK)

ELECTRODE

- attacked) electrode

ode doesnot react with solu
or with product of electro
des are used for electrolysi

PPA , C(graphite)

electrodes

ctrodes are not used in e

TION OF SOLUTION

of Fused (MOLTEN) NaCl usin

: $Na^+ + e^- \longrightarrow Na$

; $2Cl^- \longrightarrow Cl_2\uparrow + 2e$

s of Aq. Soln of NaCl using

$\longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

e × $Na^+ + e^- \longrightarrow Na$, $E^\circ_{red} = -$

✓ $2H_2O + 2e^- \longrightarrow H_2\uparrow + 2OH^-$,

× $H^+ + e^- \longrightarrow H_2$; E_{red}

✓ $2Cl^- \longrightarrow Cl_2\uparrow + 2e^-$ E

s of aq solution of $AgNO_3$

$\longrightarrow Ag^{+}(aq) + NO_3^{-}(aq)$

$Ag^{+} + e^{-} \longrightarrow Ag$

$2H_2O \longrightarrow O_2\uparrow + 4H^{+} + 4$

is of aquas solution of N

$\longrightarrow Na^{+}(aq) + SO_4^{-2}(aq)$

× ×

$H_2O \longrightarrow H_2\uparrow$

$H_2O \longrightarrow O_2\uparrow$

lysis of water

EXAMPLE OF ELECTROLYSIS

lysis of very dil aq NaCl usin

$\longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

. $H_2O \longrightarrow H_2\uparrow$

$H_2O \longrightarrow O_2\uparrow$

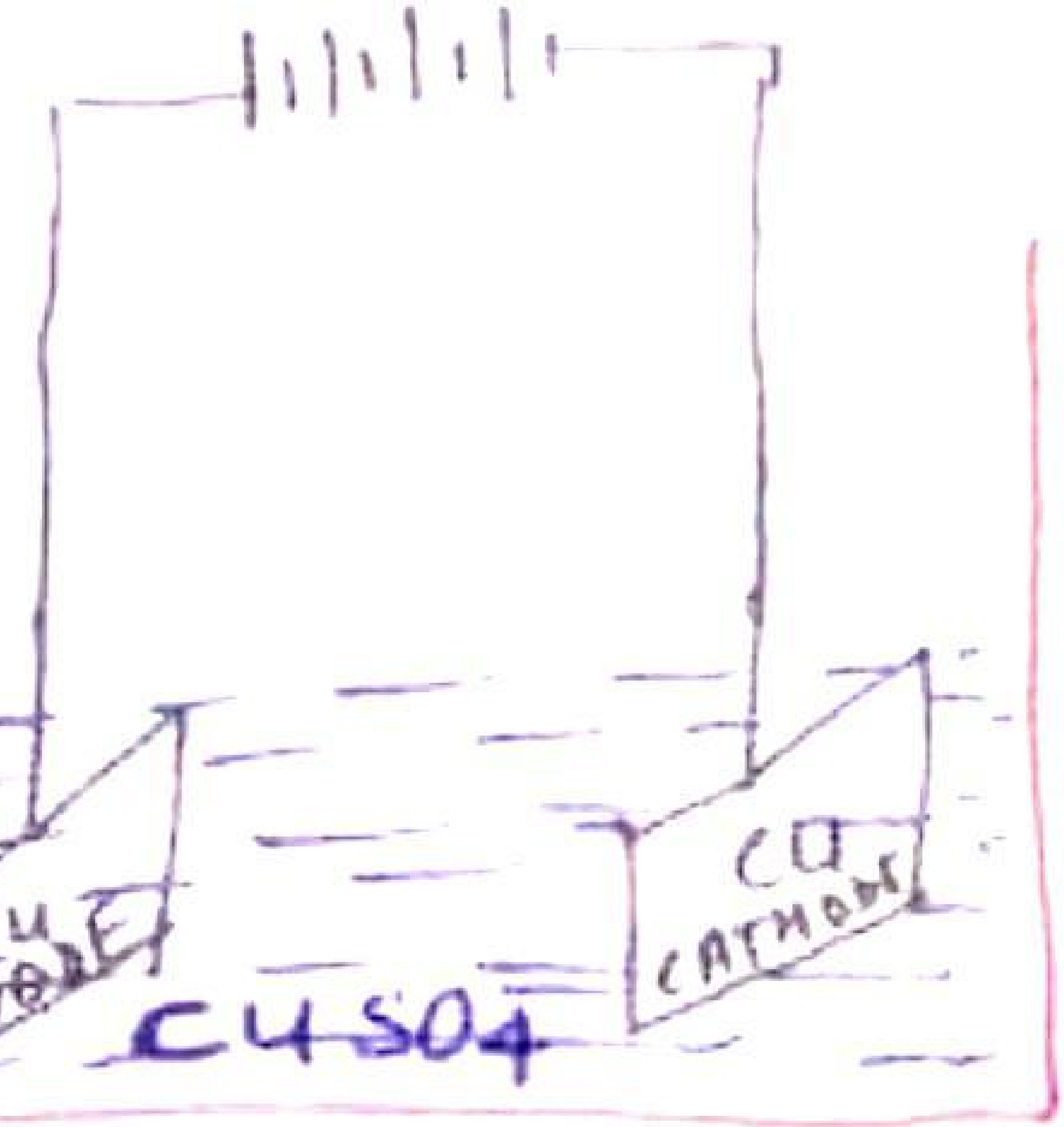
के कम concentration पर d

से ज्यादा चाहिए

lysis of aq solution of NaC

$\longrightarrow Na^+(aq) + Cl^-(aq)$

ysis of aquas solution of cop
rode



$\longrightarrow Cu^{+2}(aq) + SO_4^{2-}$

$Cu \longrightarrow Cu^{2+} + 2e^-$ E°

LAW OF ELECTROLYSIS

W OF FARADAY'S LAW OF

icity is passed through elect
bstance discharged on elect
oportional to the quantity o
ough electrolyte

$W \propto Q$

$W \propto it$

$\boxed{W = Zit}$ $Z =$ electrochem

1cb then

$\boxed{W = Z}$ gm

equivalence

W OF FARADAY'S LAW O
IS

of charge is passed thr
ectrolyte then amount of
electrode will be
ivalent weight

$$\boxed{\frac{W_1}{E_1} = \frac{W_2}{E_2} = \frac{W_3}{E_3} \ldots C}$$

the weight of Cu dep
mb of charge is pass
ion (Atomic weight of

$\to Q$

n current is necessary
t the rate of 1ml/sec

1 ml

1 sec

$\frac{1}{22400} \times 32$ gm

$\frac{EO_2}{96500} \times it$

GAs	Mu
O_2	32
H_2	2
Cl_2	71

$= \frac{8}{96500} \times i \times 1 \text{sec}$

7.23 amp

of 1 M $AgNO_3$ solution an

acl solution are connected

electricity is passed 54

osited on cathode in $AgNO$

lculate volume of H_2 gas c

ed at cathode in Nacl sol

54 gm of Ag

$$\frac{}{g} = \frac{EH_2}{EAg}$$

$$\frac{l_2}{4} = \frac{1}{108} \Rightarrow WH_2 = \frac{1}{2} =$$

$0.5 \times 22.4 = 5.6$ litr

t of electricity producing

x. what is the cost of

ctricity of producing x

ss of Al = 27) (At mass of

f deposition ∝ charge (Q)

$$W = \frac{E}{96500} \times Q$$

$$\frac{W_{mg}}{W_{Al}} = \frac{E_{mg} \times Q_{mg}}{E_{Al} \times Q_{Al}}$$

$$\frac{W_{mg}}{W_{Al}} = \frac{E_{mg} \times (\text{Cost})\, M}{E_{Al} \times (\text{Cost})\, A}$$

$$x \quad 24/2 \times (\text{Cost})\, m$$

ent of 3 Amp was passed

a Solution of $CuSO_4$. 3

e discharged at cathode .c

fficiency for this process (

$$\frac{E \times i \times t}{96500}$$

$$\frac{63.5}{2 \times 96500} \times i_{used} \times 2 \times 60 \times 6$$

$$= 1.266 \text{ Amp}$$

ficiency $= \frac{i_{used}}{i_{passed}} \times 100$

$$1.266$$

e charge require for ox

FeO to Fe_2O_3

Fe_2O_3 to FeO

H_2O to O_2

$\longrightarrow \frac{1}{2} Fe_2O_3 + \underset{\text{(1F)}}{e^-}$

$\longrightarrow Fe^{+3}$

$\longrightarrow x = +3$

eased in oxi. no = ①

solution of $AuCl_3$, $AgNO_3$,
in sereis when 3F charge
lculate the ratio of mole
d on electrode

thod

$AgNO_3$
↓
Ag^+
↓
3gmeq

$\frac{3mol}{1}$

$CuSO_4$
↓
Cu^{+}
↓
3gm

$\frac{3\ m}{2}$

tween ionic Conductance

v

$\lambda_c \propto U_c$

$\lambda_a \quad U_a$

$$\boxed{\begin{aligned}\lambda_c &= F U_c \\ \lambda_a &= F U_a\end{aligned}}$$

n (u).

$$\boxed{\frac{\text{ocity of ion (v)}}{\text{ential gradient}}}$$

$$\Downarrow$$

CELL	ELECTROLYTIC
cal energy al energy	* Converts elect into chemical
on is	* cell reaction Non- spontan
ve +ve	* Anode = +ve cathode = -ve
substances ode	* Deposition of both electrode anode
is used	* salt Bridge is

	ANODE	CATHODE
CELL EABLE)	Zn	Carbon Rod Coated with MnO_2
e	Pb	Pb rod Coated with PbO_2
) e	Cd	Ni rod Coated with Nickel Powder
u cell	H_2 gas Passing through	O_2 Passing through Porous Carbon