Chapter 8. Electrolysis & Electrolytic conductance

Q1.

Sol: $I = 0.5$ amp, $Wt_{Al} = 27.0$ g

(i) gm eq of Al $= \dfrac{wt_{Al}}{gm\,eq.wt_{Al}} = \dfrac{27}{27/3} = 3$ **Ans** $(\therefore$ v.f. of Al in $Al^{3+} + 3c^{-} \rightarrow Al = 3)$

(ii) no. of gm atoms = no. of moles $\dfrac{wt}{Atwt} = \dfrac{27}{27} = 1$ **Ans**

(ii) no. of atoms = no. of moles × Avogadro's no.$= 1 \times 6.023 \times 10^{23} = 6.023 \times 10^{23}$ **Ans**

(iv) no. of e^{-} required $= 3 \times$ no. of atoms deposited $= 3 \times$ Avogadro's constant

(v) no. of Faraday of electricity consumed = no. of gm eq = 3 Faraday **Ans**

(vi) $W = Z.I.t$

$$27 = \frac{9}{16500} \times 0.5 \times t$$

$$t = \frac{27 \times 96500}{9 \times \frac{1}{2}} = 6 \times 96500\,sec = 6 \times 96500\,sec$$

$$= \frac{579000}{3600} = 160\,hr\,83 \times 60\,min = 160\text{ hr }49.8\text{ min}$$ **Ans**

(vii) gm equation of Cl_2 produced = gm equation of Al

$$\frac{V_{Cl_2}}{22.4/2} = 3$$

$V_{Cl2} = 3 \times 11.2$ lit $= 33.6$ lit **Ans**

Q2.

Sol: $I = 2$ amp,

Mass increases by 8 g ; so wt of Cr deposited = 8 g

$\therefore W = Z.\,I.\,t$

$$8g = \frac{gm.eq.wt}{96500} \times 2 \times t$$

$$8g = \frac{(52/3)g}{96500} \times 2 \times t \;\therefore Cr^{3+} + 3e^{-} \rightarrow Cr \;(gm\,eq\,wt = \frac{At\,wt\,of\,Cr}{3})$$

$$\frac{8 \times 96500 \times 3}{52 \times 2} = t$$

$t = 22269.23$ sec $= 6.186$ hr **Ans**

Q3.

Sol: $I = 0.2$ amp

$t = 1$ hr $= 3600$ sec

(a) It w is the wt of silver deposited, then

$$W = Z.\,I.\,t = \frac{(\text{gm eq wt})Ag}{96500} \times I \times t$$

$$W = \frac{108/1}{96500} \times 0.2 \times 3600 = 0.806\,g$$ **Ans**

(b) no. of e^- = no. of moles of $e^- \times N_A$

= no. of moles of Ag deposited $\times N_A$

$\because Ag^+ + e^- \rightarrow Ag$

(1 mole of Ag is deposited by 1 moles of e^-)

$$= \frac{0.806}{108} \times 6.023 \times 10^{23}\,e^- = 4.49 \times 10^{21}\,e^-$$ **Ans**

(c) gm eq of Cu deposited = gm eq of Ag deposited

$$\frac{Wcu}{63.5/2} = \frac{0.806}{108/1} \Rightarrow Wcu = 0.237\,g$$ **Ans**

Q4.

Sol: W = 0.5 g; t = 1 hr

$$W = Z.Q = \frac{\text{gm eq wt.Q}}{96500}$$

$$\text{No. of coulombs} = \frac{0.5 \times 96500}{108}\,\text{coulomb} = 444.676\ \text{coulombs}$$

$$\text{Gm eq. of } H_2 \text{ produced} = \frac{Q}{96500} = \frac{446.76}{96500}$$

$$\frac{V_{H_2}}{\frac{\text{molar volume}}{2}} = \frac{447.76}{96500}$$ [For H_2, eq. volume = $\frac{\text{molar volume}}{2}$]

$$VH_2 = 4.64 \times 10^{-3} \times \frac{\text{molar volume}}{2}$$

$$= 4.64 \times 10^{-3} \times \frac{0.0821 \times 300}{750/760 \times 2} = 0.0578\ \text{lit} = 57.8\ \text{ml}$$ **Ans**

Q5.

Sol: $H_2O \longrightarrow H_2 \longrightarrow NH_3 \xrightarrow{[O]} HNO_3$

$NH_3 + HNO_3 \longrightarrow NH_4OH$

Weight produced of NH_4NO_3 per day = 5000 kg $= 5 \times 10^6$ g

$$\text{Moles of } NH_4NO_3 \text{ produced per day} = \frac{5 \times 10^6}{80} = 6.25 \times 10^4$$

$\therefore$ Moles of NH_3 & moles of HNO_3, each should be 6.25×10^4 moles/day.

NH_3	&	HNO_3
6.25×10^4		6.25×10^4

So moles of hydrogen atom = $3\times$ moles of NH_3 + $1\times$ moles of HNO_3

$$= 3\times 6.25\times 10^4 + 1\times 6.25\times 10^4 \quad = 4\times 6.25\times 10^4$$

$\therefore$ moles of H_2 produced $= \dfrac{4\times 6.25\times 10^4}{2} = 12.5\times 10^4$

$\therefore$ moles of e^- required per day = $2\times$ moles of H_2 produced

$$= 25\times 10^4$$

$\therefore$ Charge required per day $= 25\times 10^4\times 96500$

$\therefore$ Current per day $= \dfrac{25\times 10^4\times 96500}{24\times 3600} = 2.79\times 10^5\ \text{amp/day}$

Ans

Q6.

Sol: From Faraday's second law

$$\frac{W_{Au}}{E_{Au}} = \frac{W_{Cu}}{E_{Cu}} \Rightarrow \frac{9.85}{197/3} = \frac{W_{Cu}}{63.5/2} \Rightarrow 0.15 = \frac{W_{Cu}}{63.5/2}$$

$W_{Cu} = 4.7625$ g **Ans**

Also gm equivalent of substance deposited = no. of Faraday

$$0.15 = \text{no. of Faraday} = \frac{Q}{96500}$$

$$0.15 = \frac{I\times 5\times 3600}{96500}$$

$$I = \frac{0.15\times 965}{180} = 0.804$$ **Ans**

Q7.

Sol: $I_2 \;+\; 2S_2O_3^{2-} \longrightarrow 2I^- \;+\; S_4O_6^{2-}$

Milimole of I_2 $\equiv$ 2 milimoles of $S_2O_3^{2-}$

$2\times$milimole of I_2 = milimoles of $S_2O_3^{2-}$

milimole of I_2 $= \dfrac{21.75\times 0.0831}{2} = 0.9037$

$\therefore$ milimole of e^- emitted out $= 0.9037\times 2 = 1.8074$

$\therefore$ Charge flown $= 1.8074\times 10^{-3}\times 96500$

$\therefore$ I.t = 1.8074 $\therefore$ 96.5

$$I = \frac{1.8074\times 96.5}{2\times 3600} = 0.0242\ \text{amp}$$

Ans

Q8.

Sol: gm eq of Cr deposited = gm eq of Cl_2 produced = no of faraday

No. of faraday passed $= \dfrac{6\times 1\times 3600}{96500} = 0.224$

$\therefore$ gm eq. of Cr deposited $= \dfrac{Wcr}{Ecr} = 0.024$

$$Wt_{Cr} = 0.024\times\frac{52}{2} = 3.88\,g$$

Ans

Gm eq of Cl_2 produced = 0.024

$$\frac{V_{Cl_2}}{Eq.volume} = 0.024 \Rightarrow \frac{Vcl_2}{\frac{22.4}{2}} = 0.224$$

$$Vcl_2 = 0.224\times\frac{22.4}{2} = 2.508\ \text{lit}$$

Ans

Q9.

Sol: O_2 in second cell has produced due to oxidation of oxygen present in water.

$$2O^{2-} \longrightarrow O_2 + 4e^-$$

∴ At anode in 2nd cell oxidation happen, so wt of anode won't change in 2nd cell.

In 2nd cell

$$\frac{W_{Ag}}{E_{Ag}} = \frac{V_{O_2}}{Eq.vol.} = \frac{40\,ml}{\frac{22400}{4}} = \frac{16}{2240}$$

$$WAg\ (produced) = \frac{16}{2240}\times 108\,g = 0.772\,g$$

So wt of cathode will increase by 0.772 g.

In 1st cell

Again Cu^{2+} will reduce at cathode, so wt of cathode will increase & at anode Cu will oxidise to form Cu^{2+}, so wt of anode deceases.

Also.

$$\frac{Wcu}{Ecu} = \frac{WAg}{EAg} = \frac{16}{2240}$$

$$W_{Cu} = \frac{16}{2240}\times\frac{63.5}{2} = 0.227\,g\,Cu$$

∴ At cathode, 0.227 g Cu deposit, so wt. will increases

At anode, 0.227 g Cu oxidise, so wt. of anode will decreases.

Q10.

Sol: $$W_{H_2O} = \frac{18/2}{96500}\times 100\times 12\times 3600\ (eq.wt.\ of\ water = \frac{Mol.wt}{2})$$

$$= 402.4\ g \approx 403\ g$$ **Ans**

Q11.

Sol: I = 1.30 amp

t = 5 hr = 5 × 3600 sec

$$H_2O \longrightarrow H_2 + \frac{1}{2}O_2$$

$$: 2H^+ + 2e^- \longrightarrow H_2$$

$: 2O^{2-} \longrightarrow O_2 + 4e^-$

$= Z_{H_2} \cdot I.t = \dfrac{1}{96500} \times 1.3 \times 5 \times 3600 = 0.244\,g$

Ans

$W_{O_2} = Z_{O_2} \cdot I.t = \dfrac{8}{96500} \times 1.3 \times 5 \times 3600 = 1.94\,g$ **Ans** $\left(\text{eq.wt of } O_2 = \dfrac{\text{Mol.wt}}{4}\right)$

$V_{H_2} = n_{H2} \times 22.4 \text{ lit} = \dfrac{0.244}{1} \times 22.4 \text{ lit} = 2.733 \text{ lit}$

Ans

$V_{O_2} = n_{O2} \times 22.4 \text{ lit} = \dfrac{1.94}{32} \times 22.4 \text{ lit} = 1.358 \text{ lit}$

Ans

Q12.

Sol: $W_{H_2} = Z_{H_2} \cdot Q$ --------(1)

$W_{O_2} = Z_{O_2} \cdot Q$ ------- (2)

$(1) \Rightarrow W_{H_2} = \dfrac{\text{gm eq wt of } H_2}{96500} \times Q = \dfrac{\frac{\text{mole wt}}{2}}{96500} \times Q$

$\Rightarrow \dfrac{W_{H_2}}{M_{H_2}} = \dfrac{Q}{2 \times 96500} \quad \Rightarrow n_{H2} = \dfrac{Q}{96500 \times 2} \Rightarrow V_{H_2} = \dfrac{Q}{96500 \times 2} \times 22400 \text{ mL}$

For O_2

$\Rightarrow W_{O2} = \dfrac{\text{gm.eg.wt } O_2}{96500} \times Q = \dfrac{\frac{\text{Mol.wt } O_2}{4}}{96500} \times Q$

$\Rightarrow \dfrac{W_{O_2}}{M_{O_2}} = \dfrac{Q}{96500 \times 4} \quad \therefore n_{O_2} = \dfrac{Q}{96500 \times 4}$

$\Rightarrow V_{O_2} = n_{O2} \times 22400 \text{ ml} = \dfrac{Q \times 22400}{96500 \times 4}$

A/q, $V_{H_2} + V_{O_2} = \dfrac{Q \times 22400}{96500 \times 2} + \dfrac{Q \times 22400}{96500 \times 4}$

$16.8 = \dfrac{Q}{965}(112 + 56) = \dfrac{Q}{965} \times 168$

$Q = \dfrac{16.8 \times 965}{16.8} = 96.5 \text{ Coulomb}$

Ans

Q13.

Sol: Surface area = 800 cm^2

$I = 0.2$ amp for $t = 3hr = 3 \times 3600$ sec

Let t is the thickness of Ag deposited, then it will happen on the one side of plate

$\therefore$ Volume = $A.t = 800 \times t \text{ cm}^3 = 800\,t \text{ cm}^3$

dAg= 10.47 g/cc

: $2O^{2-} \longrightarrow O_2 + 4e^-$

$$= Z_{H_2} . I.t = \frac{1}{96500} \times 1.3 \times 5 \times 3600 = 0.244\,g$$

Ans

$$W_{O_2} = Z_{O_2} . I.t = \frac{8}{96500} \times 1.3 \times 5 \times 3600 = 1.94\,g \quad \textbf{Ans} \quad \left(\text{eq.wt of } O_2 = \frac{\text{Mol.wt}}{4}\right)$$

$$V_{H_2} = n_{H2} \times 22.4 \text{ lit} = \frac{0.244}{1} \times 22.4 \text{ lit} = 2.733 \text{ lit}$$

Ans

$$V_{O_2} = no_2 \times 22.4 \text{ lit} = \frac{1.94}{32} \times 22.4 \text{ lit} = 1.358 \text{ lit}$$

Ans

Q12.

Sol: $W_{H_2} = Z_{H_2} . Q$ --------(1)

$W_{O_2} = Z_{O_2} . Q$ ------- (2)

$$(1) \Rightarrow W_{H_2} = \frac{\text{gm eq wt of } H_2}{96500} \times Q = \frac{\frac{\text{mole wt}}{2}}{96500} \times Q$$

$$\Rightarrow \frac{W_{H_2}}{M_{H_2}} = \frac{Q}{2 \times 96500} \quad \Rightarrow n_{H2} = \frac{Q}{96500 \times 2} \Rightarrow V_{H_2} = \frac{Q}{96500 \times 2} \times 22400 \text{ mL}$$

For O_2

$$\Rightarrow Wo_2 = \frac{\text{gm.eg.wt } O_2}{96500} \times Q = \frac{\frac{\text{Mol.wt } O_2}{4}}{96500} \times Q$$

$$\Rightarrow \frac{W_{O_2}}{M_{O_2}} = \frac{Q}{96500 \times 4} \quad \therefore no_2 = \frac{Q}{96500 \times 4}$$

$$\Rightarrow V_{O_2} = no_2 \times 22400 \text{ ml} = \frac{Q \times 22400}{96500 \times 4}$$

$$A/q, \; V_{H_2} + V_{O_2} = \frac{Q \times 22400}{96500 \times 2} + \frac{Q \times 22400}{96500 \times 4}$$

$$16.8 = \frac{Q}{965}(112 + 56) = \frac{Q}{965} \times 168$$

$$Q = \frac{16.8 \times 965}{16.8} = 96.5 \text{ Coulomb}$$

Ans

Q13.

Sol: Surface area = 800 cm^2

$I = 0.2$ amp for $t = 3hr = 3 \times 3600$ sec

Let t is the thickness of Ag deposited, then it will happen on the one side of plate

$\therefore$ Volume $= A.t = 800 \times t\ cm^3 = 800\ t\ cm^3$

dAg= 10.47 g/cc

$\therefore mAg = dAg.VAg = 800t \times 10.47 = 8376t$

$$mAg = ZAg.I.t = \frac{108/1}{96500} \times 3 \times 3600 \times 0.2$$

$$8376\,t = \frac{108 \times 108}{965} \times \frac{2}{10} = 12.087 \times \frac{2}{10}$$

$$t = \frac{12.087}{8376} \times \frac{2}{10}$$

Thickness of Ag deposited in the vessel = 2.88×10^{-4} cm **Ans**

Q14.

Sol: $I = 0.5$ amp

$t = 12$ min & 20 sec $= 12 \times 60 + 20 = 740$ sec

V_{H_2} collected = 50 ml

$T = 23^0C = 273 + 23 = 296\ K$

$$P = 740 \text{ mm of Hg} = \frac{740\text{ mm}}{760\text{ mm}} = \frac{74}{76}\text{ atm}$$

$\Rightarrow PV = nRT$

$$\therefore \text{No. of moles of } H_2 \text{ evolved} = \frac{74/76}{0.0821 \times 296} \times 50 \times 10^{-3} = 2 \times 10^{-3}$$

Charge transferred= $0.5 \times 740 = 370$ coulombs

Charge on single $e^- = 1.6 \times 10^{-19}$ coulomb

$$\text{So no. of } e^- \text{ transferred} = \frac{370}{1.6 \times 10^{-19}} = 2.3125 \times 10^{21}$$

Also $2H^+ + 2e^- \longrightarrow H_2$

moles of e^- required to transfer = $2 \times$ moles of H_2 evolved

$$\Rightarrow \frac{\text{no.of } e^-}{N_A} = 2 \times 2 \times 10^{-3}$$

$$N_A = \frac{2.3125 \times 10^{21}}{4 \times 10^{-3}} = 5.78 \times 10^{23}$$ **Ans**

Q15.

Sol: $I = 0.5$ amp, $t = 20$ min $= 20 \times 60 = 1200$ sec

(i) $W_{Cu} = ZCu.I.t$

$$= \frac{63.5/2}{96500} \times 0.5 \times 1200 \frac{63.5}{2 \times 96500} \times \frac{1200}{2} = 0.1975\text{ g}$$

$$\text{(2) no. of Cu atoms deposited} = \frac{0.1975}{63.5} \times N_A = 1.87 \times 10^{21}$$ **Ans**

Q16.

Sol: 1 mole of e^- has charge = 96500 coulomb

Time = 1hr = 3600 sec

$$\therefore I = \frac{Q}{t} = \frac{96500}{3600} = 26.8\,\text{amp}$$

$$W_{Al} = Z_{Al}Q = \frac{\frac{27}{3}}{16500} \times 96500 = 9\,g$$ **Ans**

$$W_{Cd} = Z_{Cd}.Q = \frac{112.4}{\frac{2}{96500} \times 96500} = 56.2g$$ **Ans**

Q17.

Sol: $I = 3$ amp

wt. of water decompose = 18 g

$$W_{H_2O} = Z_{H_2O}.I.t.$$

$$18 = \frac{18/2}{96500} \times 3 \times t \quad \Rightarrow \quad t = \frac{96500 \times 2}{3}\,\text{sec} = 64333.33\,\text{sec} = 17.89\,\text{hr}$$ **Ans**

Q18.

Sol: 50 ml of 0.1 M $CuSO_4$

Time = 12 minutes and I = 0.06 amp.

No. of moles of O_2 produced

(1): $2H_2O \longrightarrow C_2 + 4H^+ + 4e^-$

$$n_{O_2} = \frac{\text{no. of faraday of charge}}{\text{v.f.}} = \frac{0.06 \times 12 \times 60}{96500 \times 4} = 1.12 \times 10^{-4}$$

$\therefore$ From reaction (1)

Moles of H^+ produced = $4 \times$ no. of moles of O_2 produced

$$= 4 \times 1.12 \times 10^{-4} = 4.48 \times 10^{-4}$$

$$\therefore M_{H^+} = \frac{4.48 \times 10^{-4}}{50 \times 10^{-3}} = 8.96 \times 10^{-3} M$$

$$[SO_4^{2-}] = \frac{\text{moles of Cu deposited}}{\text{Volume}} \quad (\because \text{moles of } SO_4^{2-} = \text{moles of } Cu^{2+} \text{ removed from solution})$$

$$= \frac{\frac{1}{2} \times \frac{0.06 \times 12 \times 60}{96500}}{50 \times 10^{-3}} = \frac{2.24 \times 10^{-4}}{50 \times 10^{-3}} = 4.48 \times 10^{-3} M.$$

Now, $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$, ; $Ka = 1.32 \times 10^{-2}$

$\therefore H^+ + SO_4^{2-} \rightleftharpoons HSO_4^-$; $Ka = \frac{10^2}{1.32}$

	H^+	SO_4^{2-}	HSO_4^-
Initially	8.96×10^{-3} M	4.48×10^{-3} M	0
	4.48×10^{-3} M	0	4.42×10^{-3} (since $Ka \approx 10^2$, So reaction is complete)

$$\therefore pH = -\log H^+ = -\log(4.48 \times 10^{-3}) = 2.35$$ **Ans**

Q19.

Sol: $ClO_3^- + H_2O \longrightarrow ClO_4^- + 2H^+ + 2e^-$

(i) To, produce 1 mole of ClO_4^-, 3 mole of e^- are required

∴ no. of Faraday for production of 1 mole of $NaClO_4$ = 2F

(ii) $\Rightarrow \dfrac{W_{NaClO_4}}{E_{NaClO_4}} = \dfrac{V_{H_2}}{eq.Vol.H_2}$

$\Rightarrow \dfrac{12.25}{122.5/2} = \dfrac{V_{H_2}}{22.4/2} \Rightarrow V_{H_2} = 2.24\,lit$

Ans

Q20.

Sol: (i) **In cell A:**

Ag_2SO_4 solution, so we have ions Ag^+ & H^+ for reduction at cathode.

Since Hg^+ has higher reduction potential, so it will reduce first.

At cathode: $Ag^+ + e^- \longrightarrow Ag$

At anode, SO_4^{2-} & O^{2-} ions are for oxidation since reduction potential of SO_4^{2-} is higher, :

O^{2-} will oxidise first. So

At anode: $H_2O \longrightarrow O_2 + 4H^+ + 4e^-$

In cell B:

At cathode: $Cu^{2+} + 2e^- \longrightarrow Cu$ (again Cu^{2+} has higher R.P. than H^+ so reduce first)

At anode: $Cu \longrightarrow Cu^{2+} + 2e^-$ (In presence of Cu electrode, we will oxidise as well as reduc

first)

(ii)

$$\frac{W_{O_2}}{Eq.wt_{O_2}} = \frac{W_{A.g}}{Eq.wtAg} = \frac{W_{Cu}}{Eq.wt\,cu}$$

$$\frac{1.6}{8} = \frac{W_{Ag}}{108/1}$$

$\Rightarrow W_{Ag}$ deposited = 21.6 g **Ans**

$\Rightarrow W_{Cu}$ deposited= $0.2 \times \dfrac{63.5}{2} = 6.35\,g$ **Ans**

Q21.

Sol: V= 100 ml, M = 0.8 M $CuSO_4$ solution

time = 30 min with current I = 5 amp

Wt of Cu deposited = $\dfrac{63.5/2}{96500} \times 5 \times 30 \times 60$ (W = Z.I.t)

= 2.96 g

∴ Initially the wt of $CuSO_4$ in solution = $100 \times 10^{-3} \times 0.8 \times 159.4 = 12.76$ g

$\therefore$ wt of SO_4^{2-} combined with 296 g of Cu $= \left(\frac{2.96}{63.5}\right)\times 96 = 4.37\,g$

$\therefore$ wt of $CuSO_4$ remaining in the solution $= 12.76 - (2.96 + 4.37) = 5.31$ g **Ans**

Q22.

Sol: $I = 1$ amp, $t = 60$ min $= 60 \times 60$ sec

$$C_{14}H_{10} + \frac{3}{2}O_2 \longrightarrow C_{14}H_8O_2 + H_2O^{-2}$$

V.f = 6

Eq. wt of $C_{14}H_8O_2 = \frac{\text{Mol.wt}}{6}$

$\therefore$ wt deposited $= \frac{\text{Eq.wt.of } C_4H_8O_2}{96500} \times 1 \times 3600 = \frac{208}{6 \times 96500} \times 3600 = 1.2932\,g$ **Ans**

Q23.

Sol: $C_6H_5NO_2 \longrightarrow C_6H_5NH_2$

20 g (v.f. = 6 since oxid. No. of N changes from +3 to – 3)

Current passed = 26.5 amp.hr

It W is the critical wt. produced, then

$W = Z.I.t$

$$= \frac{93}{\frac{6}{96500} \times 26.5 \times 3600} = \frac{93 \times 26.5 \times 36}{6 \times 965} = 15.323\text{ g}$$

Actual wt produced = 12.76 g

Current yield $= \frac{\text{wt. actually produced}}{W} \times 100 = \frac{12.76}{15.323} \times 100 = 83.28\%$ **Ans**

Q24.

Sol: wt of Cu deposited = 0.2964 g

$I = 0.5$ am for & 30 min $= 30 \times 60$ sec

$W = Z.\,I.\,t.$

$\Rightarrow 0.2964 = \frac{\text{gm.eq.wt}}{96500} \times 0.5 \times 30 \times 60$

$\Rightarrow 0.2964 = \frac{\text{At.wt.}}{2 \times 965} \times \frac{18\ 9}{2} \left(\text{gm eq. wt. of Cu} = \frac{\text{At. wt.}}{2}\right)$

At. wt. cu $= \frac{0.2964 \times 2 \times 965}{9}\,g = 63.56\,g$ **Ans**

Q25.

Sol:- $Z_{Cu} = 0.00033$ g / coulomb

If wt of Cu deposited = 1 kg = 1000 g

Then $Q = \frac{W}{Zu} = \frac{1000}{0.00033} = 3\times10^6$ coulomb

Cost of electricity = 0.25 Rs per Kwh.

In 1 Kwh, $E = 1\times10^3 \frac{J}{sec}.3600\ sec = 3.6\times10^6\ J$

Now, $QV = E$

$Q = \frac{E}{V} = \frac{3.6\times10^2 J}{0.2} = 1.8\times10^7$ colomb

Now, $\because$ 1.8×10^7 coulomb cost 0.25 rupees

$\therefore 1$ ———————— $\frac{0.25 \text{ rupees}}{1.8\times10^{+}}$

$\therefore 3\times10^6$———————— $\frac{0.25\times3\times10^6}{18\times10^6} = \frac{0.25}{6} = \underline{0.0416}$ rupees = 4.16 paise **Ans**

Q26.

Sol: Let time t sec required for pH to become equal to 12

$PH = 12$

$[H^+] = 10^{-12}M$

At anode: $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$ ---------(1)

$\therefore$ No. of moles of H^+ present = Molarity × volume (in lit)

$= 10^{12}\times50\times10^{-3} = 5\times10^{-10}$

$\therefore$ No. of moles of e^- required $= 5\times10^{-10}$ [From reaction(1)]

$\therefore$ Charge required $= 5\times10^{-10}\times96500$ coulomb

$\Rightarrow$ $0.5\times t = 5\times10^{-10}\times96500$

$\Rightarrow$ $t = \frac{5\times10^{-10}\times96500}{5\times10^{-1}} = 96.5\mu sec$

Ans

Q27.

Sol: $V = 8.2\times10^{12}$ lit $= 8.2\times10^{15}$ mL

Rate of charge production $= 1.5\times10^6$ coulomb per sec

Density of water = 1gm /cc

Mass of water $= v\times d = 8.5\times10^{15}$ g

$\Rightarrow m_W = Z_W.Q.T$

$\Rightarrow 8.5\times10^{15} g = \frac{18g}{2\times96500}\times1.5\times10^6\times t$

$\Rightarrow t = \frac{8.5\times10^{15}\times2\times96500}{18\times1.5\times10^6} = 6.07\times10^{13}$ sec

$= 1.687\times10^{10}$ hr $= 7.03\times10^8$ days

$= 1.925\times10^6$ years = 1.925 million years.

Ans

28.

Sol: Energy delivered per sec = 200 J/sec

Charge delivered per sec $= \frac{E}{V} = \frac{200\,J}{110} = \frac{20}{11}$ coulomb/sec

$$\therefore W = Z_{Zn}.\,{}^{Q}\!/_{t_{sec}}$$

$$W = \frac{63.5}{2\times96500}\times\frac{20}{11}\times30\times60$$

wt. produced = 1.0768 g **Ans**

Q29.

Sol: At. Cathode: Ni^{2+} & H_2O ions are present, but Ni^{2+} will reduce because it has higher reduction potential

So at cathode: $Ni^{2+} + 2e^- \longrightarrow Ni$

At Anode: SO_4^{2-} & H_2O are present to oxidise in the H_2O will oxidise first because of less reduction potential

At Anode: $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$

(ii) no. of coulombs passed $= 0.05\times40\times60 = 120$ **Ans**

(iii) $W_{Ni} = Z_{Ni}.I.t = \frac{58.7}{2\times96500}\times120 = 0.037\,g$

Ans

(iv) moles of Ni present $= 40\times10^{-3}\times0.125 = 5\times10^{-3}$

$$\therefore n_{Ni} = \frac{1}{2\times96500}\times0.05\times t$$

$$t = \frac{5\times10^{-3}\times2\times96500}{0.05} = \frac{965}{0.05} = 19300\,s$$

(v) wt. produced at cathode = nNi × At.wt.

$$= 5\times10^{-3}\times58.7 = 0.293\text{ g}$$

wt. produced at anode :-

$$WO_2 = \frac{\text{gm.eq. wt of } O_2}{96500}\times0.05\times19300$$

$$= \frac{8}{96500}\times\frac{19300\times5}{100} = 0.08\,g$$

Q30.

Sol: From Faraday's 2nd law

$$\Rightarrow \frac{W_{Ag}}{Eg\,wt_{Ag}} = \frac{Wcu}{Eg.wt_{Cu}} \Rightarrow \frac{1.307g}{({}^{108}\!/_{1})g} = \frac{Wcu}{63.5/2}$$

$$\Rightarrow W_{Cu} = \frac{63.5\times1.307\,g}{2\times108} = 0.384\,g$$

Now wt. present initially = (moles of $CuSO_4.\ 5H_2O$). At wt cu

$$= \frac{10}{249.5} \times 63.5\,g = 2.545\ g$$

$\therefore$ Amount of Cu^{2+} remained in the solution = 2.545 g − 0.384 g = 2.16 g

$$\therefore \text{ wt. of Cu / lit present now} = \frac{2.16}{500} \times 1000 = 4.32\ g/\text{lit} \qquad \textbf{Ans}$$

Q31.

Sol: Volume of H_2 reacted at STP – 67.2 lit

$$\therefore n_{H_2} = \frac{67.2\,\text{lit}}{22.4\,\text{lit}} = 3$$

$$V \times H_2 = \frac{\text{gm eq of } H_2}{96500} \times I.t$$

$$WH_2 = \frac{\text{Mol.wt of } H_2}{v.f \times 96500} \times I.t.$$

$$nH_2 = \frac{WH_2}{MH_2} = \frac{1}{2 \times 96500} \times I \times 15 \times 60$$

$$I = \frac{3 \times 2 \times 96500}{15 \times 60} = 643.34\,\text{amp} \qquad \textbf{Ans}$$

$$WCu = ZCu\,.I.t$$

$$= \frac{63.5}{2 \times 96500} \times 643.34 \times 15 \times 60 = 190.5\ g \qquad \textbf{Ans}$$

Q32.

Sol: I = 3 amp

wt of Pd^{n+} deposited = 2.977

$$W_{Pd} = Z_{Pd}.I.t.$$

$$2.977 = \frac{\text{gm eq.wt pd}}{96500} \times 3 \times 1 \times 3600$$

$$2.977 = \frac{106.40}{n \times 96500} \times 3 \times 3600 \quad \Rightarrow n = \frac{106.40 \times 108}{2.977 \times 965} = 4 \qquad \textbf{Ans}$$

Q33.

Sol: $W_M = Z_M.I\,t = Z.Q$

$$37.7\ g = \frac{M}{3 \times 96500} \times 69500 \quad \Rightarrow M = \frac{965 \times 3 \times 37.7}{695} = 157.0\,g \qquad \textbf{Ans}$$

Q34.

Sol: Total wt precipitated = 0.175 g

% of Cu ppt = 72.8 %

$$\therefore \text{ Wt of cu ppt} = 0.175 \times \frac{72.8}{100} = 0.1274\,g$$

% of Ni precipitated = 4.3%

wt of Ni ppt $= 0.175\times\frac{4.3}{100} = 7.5\times10^{-3}\,g$

% of Zn precipitated = 22.9%

wt Zn precipitated $= 0.175\times\frac{22.9}{100} = 0.04\,g$

For Cu

$$W_{Cu} = \frac{\text{gm eq Cu}}{96500}\times Q_{Cu}$$

$$Q_{Cu} = \frac{0.1274\,g\times96500}{63.5/1} = 193.6\,\text{colomb}$$

For Ni

$$WNi = \frac{\text{gm eq of Ni}}{96500}\times QNi$$

For Zn

$$WZn = \frac{\text{Gm eq of Zn}}{96500}\times Q_{Zn}$$

$$\therefore\ QZn = \frac{0.04\times96500}{65.4/2} = 118.04\,\text{coulomb}$$

$\therefore$ Q total = QCu(I) + QNi + QZn

= 193.6 + 24.66 + 118.04 = 336 coulomb **Ans**

Q35.

Sol: WMg = ZMg.Q

$$1\text{x }10^3 g = \frac{24/2}{96500}\times Q$$

$$Q = \frac{10^3\times96500}{12} = 8.04\times10^6\,\text{coulomb}$$

Energy required = QV

$= 8.04\times10^6\times5 = 4.021\times10^7$ J

In 1 Kwh $= 1\times10^3\times3600\,J = 3.6\times10^6\,J$

$\therefore$ no. of Kwh $= \frac{4.04\times10}{3.6\times10^6} = 11.16\,\text{Kwh}$

Ans

Q36.

Sol: $W_{Al} = Z_{Al}.I.t = \frac{27}{\frac{3}{96500}\times1.2\times3600} = \frac{9\times1.2\times3600}{96500} = 0.403\,g$ **Ans**

$$\frac{Wo_2}{Eq.wt\,O_2} = \frac{Wt\,Al}{Eq\,wt\,Al} \Rightarrow WO_2 = \frac{0.403}{9}\times8 = 0.358\,g$$

Now, 32 g of O_2will form 44 g of CO_2

$\therefore$ 1 ——————— $\frac{44}{32}$

$\therefore$ 0.358 g ——————— $\frac{44\times0.358}{32}$g =0.4924 g **Ans**

Molarity $= \dfrac{\dfrac{0.624}{249.5}}{100/1000} = 2.5\times10^{-2}$. $\lambda_m = \dfrac{2.95\times10^{-3}}{2.5\times10^{-2}}\times1000 = 115\,\text{mho cm}^2$ **Ans**

Q41.

Sol: $K = 0.0227\ \text{mho cm}^{-1} = 2.7\times10^{-3}\ \text{mho cm}^{-1}$

$C = 2$ volts

$l = 2\times r = 2.\times0.01\ \text{cm} = 2\times10^{-2}\ \text{cm}$

$a = \pi r^2 l = 25\times3.14\times10^{-4}\text{cm}^2$

$$K = C\left(\frac{l}{a}\right) = \left(\frac{2\times10^{-2}}{25\times3.14\times10^{-4}}\right)$$

$$\Rightarrow \frac{2.7\times10^{-3}\times25\times3.14\times10^{-4}}{2\times10^{-2}} = C$$

$C = 1.059\times10^{-3}$ mho

$I = CV = 1.059\times10^{-3}\times2 = 2.13\times10^{-3}$ amp **Ans**

Q42.

Sol: $\lambda^\infty C_3H_7COONa = 83\,\text{mho cm}^2$; $\lambda^\infty NaCl = 127\,\text{mho cm}^2$

$\lambda^\infty HCl = 426\,\text{mho cm}^2$

$\lambda^\infty C_3H_7COOH = \lambda^\infty C_3H_7COONa + \lambda^\infty_{HCl} - \lambda^\infty_{NaCl} = 83 + 426 - 127 = 382\ \text{mho cm}^2$ **Ans**

Q43.

Sol: $l = 10$ cm

$\Delta V = 6$ volt

$\lambda^\infty K^+ = 73.52\,\text{mho cm}^2$

$\lambda^\infty K^+ = U^\infty_{K^+}.F$

$$U^\infty_{K^+} = \frac{\lambda^\infty_{K^+}}{F} = \frac{73.52}{96500} \Rightarrow \frac{V_{K^+}}{\Delta V/l} = \frac{73.52}{96500}$$

$$V_{K^+} = \frac{73.52}{96500}\times\frac{6}{10} = 4.57\times10^{-4}\,\text{cm/sec}$$

Distance in 2hr $= V_{K^+}.t = V_{K^+}\times2\times3500\,\text{sec} = 4.57\times10^{-4}\times7200 = 3.29$ cm **Ans**

Q44.

Sol: At conc –" 0.0128 N of CH_3COOH

$\lambda_{CH_3COOH} = 1.4\,\text{mho cm}^2\text{eg}^{-1}$; $\lambda^\infty_{CH_3COOH} = 391\,\text{mho cm}^2\ \text{eg}^{-1}$

$$\propto = \frac{\lambda_{CH_3COOH}}{\lambda^\infty_{CH_3COOH}} = \frac{1.4}{391} = 3.58\times10^{-3}$$

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

0.0128 M $\quad 0 \quad 0$

$0.0128(1-\alpha) \quad 0.0.128\,\alpha \quad 0.0128\alpha$

$$\therefore Ka = \frac{(0.0128\alpha)^2}{0.0128(1-\alpha)} = \frac{(3.58\times10^{-3}\times0.0128)^2}{0.0128(1-3.58\times10^{-3})}$$

$$= \frac{(3.58\times10^{-3}\times0.0128)^2}{0.0128\times0.996} = \frac{0.0128\times(3.58\times10^{-3})^2}{0.996}.$$

$Ka = 1.647\times10^{-7}$ **Ans**.

Q45.

Sol: Specific conductance of AgCl = 1.828 × 1

$K_{AgCl} = 1.826\times10^{-6}\ \text{mho cm}^{-1}$

$\lambda^{\infty}_{AgCl} = 138.26\ \text{mho cm}^2$

$$AgCl \rightleftharpoons Ag^+(aqs) + Cl^-(aqs)$$

For S be the solubility of AgCl

$Ksp = [Ag^+][Cl^-] = S.S = S^2$

∴ S will be the mole / lit ions present in the solution. Also since Ag^+ & Cl^- have 1 unit charge on it. So mole / lit will be equal to eq / lit

∴ X eq of ions present in 1 lit of solution

$$\therefore 1 \underline{\qquad\qquad} \frac{1000\,ml}{x}$$

$\therefore \lambda_{AgCl}$ = sp. conductance × volume containing 1 eq

$$= 1.826\times10^{-6}\times\frac{1000}{X}$$

Also AgCl is sparingly soluble in water, so

$\lambda_{AgCl} \square \lambda^{\infty}_{AgCl}$ (∴ dilution doesn't affect much)

$$\therefore \frac{1.826\times10^{-3}}{x} = 138.26$$

$$x = \frac{1.826\times10^{-3}}{138.26} = 1.32\times10^{-5}\,M$$

∴ Solubility in g/lit $= 1.32\times10^{-5}\times143.5$

$= 1.89\times10^{-3}$ g / lit **Ans**

Q46.

Sol: $K_{H_2O} = 0.58\times10^{-7}\ \text{mho cm}^{-1}$

$\lambda^{\infty}_{H^+} = 350\ \text{mho cm}^2;\ \lambda^{\infty}_{OH^-} = 198\ \text{mho cm}^2$

Let H_2O dissociates to give x mole / lit of H^+ & OH^- ions. The same amount of H^+ & OH^- will be present as eg / lit

So, $H^+ = x$ eq/lit & $OH^- = x$ eq/lit

Volume contains 1 eq. of H^+ or $OH^- = \frac{1000}{x}$ ml

$\therefore$ Eq. conductance of water = Sp. conductance × volume contain 1 eq of ions

$$= 0.58\times10^{-7}\times\frac{1000}{x}$$

Since dissociation of H_2O doesn't change by taking less on more amount of water.

So $\lambda_{H_2O} = \lambda^{\infty}_{H_2O}\cdot\ \lambda^{\infty}_{H} + \lambda^{\infty}_{OH^-}$

$$= 350 + 198 = 548$$

$$0.58\times10^{-7}\times\frac{1000}{x} = 548$$

$$X = \frac{5.8\times10^{-5}}{548} = 1.05\times10^{-7}$$

$\therefore Kw = [H^+][OH^-] = x^2 = (1.0510^{-7})^2 = 1.1\times10^{-14}$ **Ans**

Objective Questions:-

Q1: Ans - (c)

because 1 faraday 96500 coulomb is the charge on one mole of electrons

In other words;

$$n\times1.6\times10^{-19}\ C = 96500\ C$$

$$n = \frac{96500}{1.6\times10^{-19}} = 6.02\times10^{23}$$

Ans

Q2: Ans - (c)

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

$$63.5\ g\ = 1\ mole$$

For deposition of 1 mole of Cu, 2 mole of e's are required

$\therefore$ no. of e's $= 12.044\times10^{23}$

Q3: Ans - (c)

$$W = \frac{\text{gm eq wt}}{96500}\times Q\ (\text{First law})$$

$$W_1/E_1 = W_2/E_2\ (\text{2nd law}: E_1\ \&\ E_2\ \text{are eq.wt.})$$

Q4: Ans - (b)

$$W = \frac{\text{gm eq.wt}}{96500}\times Q$$

$$\frac{W}{\text{gm eq wt}} = \frac{Q}{96500} = 1 \Rightarrow Q = 96500\ \text{coulomb}$$

Q5: Ans - (b)

$W = Ƶ - Q \quad \Rightarrow Ƶ = m\times 10^3$

Q7: Ans - (b)

$W = Z.Q$

$$13.5 = \frac{9}{-}\frac{Q}{96500}$$

$$\frac{Q}{96500} = \text{no.of faraday} = \frac{13.5}{9} = 1.5$$

Q8: Ans - (d)

$$W = \frac{\text{gm eq wt}}{96500}\times 0.1\times 96500$$

$$\frac{3.17}{0.1} = \text{gm eq wt} \Rightarrow \text{gm eq wt} = 31.7$$

Q9: Ans - (b)

$$0.108 = \frac{\text{gm eq wt}}{96500}\times 0.5\times 193$$

gm eq wt = 108 g

Q10: Ans - (c)

pH is increased, so OH^- conc-^{n} increases at anode

Also, At anode, oxidation will happen & Cl^- will oxidise first than the OH^- ion

$$\text{In} \left.\begin{matrix} Cl^- \\ OH^- \end{matrix}\right\} \rightarrow Cl^- \text{ will oxidise because it has less reduction potential}$$

At cathode in $H^+, K^+ \rightarrow H^+$ will reduce because it has high reduction pot.

$\therefore$ KOH remain in solution, so pH increases

Q11: Ans - (d)

Using Cu electrode, at anode: $Cu \longrightarrow Cu^{2+} + 2e^-$

So same amount of Cu will go into the solution as the amount of Cu deposited at cathode.

Q12: Ans - (d)

$$0.1 = \frac{1}{96500}\times 10\times I \Rightarrow I = 965\,\text{amp}$$

Q13: Ans - (d)

Q per sec $= I = 10^{-16}$

$$\text{no of } e^- \text{ passing per sec} = \frac{10^{-16}}{1.6\times 10^{-19}} = \frac{10^3}{1.6}$$

Q14: Ans - (c)

$Ag^+ + e- \longrightarrow Ag$

107.9 gm = 1 mole

1 mole deposition will require 1 mole of e^-

Q15: Ans - (c)

$W = Z.I.t$

$$22.2\ g = \frac{\text{gm eq.wt.of tin}}{96500} \times 2 \times 5 \times 3600$$

$$= \frac{118.7}{n \times 96500} \times 10 \times 3600$$

$$n = \frac{1187 \times 36}{965 \times 22.2} = 2$$

Ans

Q16: Ans - (b)

$1\ Kwh = 1 \times 10^3\ J/s \times 3600 = 3.6 \times 10^6 J$

Q in (8hr) $= 8 \times 3600 \times 15 = 4.32 \times 10^5$ coulomb

$\therefore E = QV = 4.32 \times 10^5 \times 110 = 4.752 \times 10^7\ J$

$\therefore 3.6 \times 10^6$ H cost 5 paise

$$\therefore 1 \text{———} \frac{5}{3.6 \times 10^{-6}}$$

$$\therefore 4.752 \times 10^7 \text{———} \frac{5 \times 4.752 \times 10^7}{3.6 \times 10^6} = 66 \text{ paise}$$

Q17: Ans - (a)

1 faraday will deposit eq. wt of each metal

For Ag^+, eq. wt $= \frac{108}{1} = 108$

For Cu^{2+}, eq. wt $= \frac{58.4}{2} = 29.59$

For Cr^{3+}, eq. wt $= \frac{52}{3} = 17.4$

Q18: Ans - (c)

$\frac{1}{4}$ moles of Ag $= \frac{1}{4} \times 0.2 \times 0.1 = \frac{0.02}{4}$ g eg of Ag^+ because v.f = 1)

gm eq of $Ag^+ = \frac{I.t}{96500} \Rightarrow t = \frac{96500 \times 2 \times 10^{-2}}{4 \times 10^{-1}} = \frac{311.6\,min}{4} = 80$ minutes

Q19: Ans - (c)

(1) $2H_2SO_4 \longrightarrow H_2S_2O_8 + H_2$

(2) $2H_2O \longrightarrow 2H_2 + O_2$

2.35 lit

$\therefore$ Volume of H_2 librated from reaction (2) $= 2 \times 2.35$ lit

$= 4.7$ lit

Volume of H_2 evolved from reaction (1) = total volume evolved – volume of H_2 liberated from reaction(2)

$= 9.72 - 4.7 = 5.02$ lit

Now for reaction (1)

Eq. of H_2 evolved from reaction (1) = gm eq. of $H_2S_2O_8$ produced

$$\frac{5.02}{22.4/2} = \text{g eq. of } H_2S_2O_8 \text{ produced.}$$

∴ 0.448 = gm eq. of $H_2S_2O_8$ produced,

Q20: Ans - (d)

gm eq of H_2 evolved = gm eq of evolved

$$\frac{V_{H_2}}{eq.vol.H_2} = \frac{V_{O_2}}{eq.Vol.O_2} = \frac{Vo_2}{\frac{22.4}{4}\text{lit}}$$

⇨ $VO_2 = 5.7$ lit

Q21: Ans -(a)

$10^{16} \times t = 96500$ col. (charge on 1 mole of e^-)

$$t = \frac{96500}{10^{-16}} \Rightarrow 9.65\times10^{20}\text{ sec}$$

Q22: Ans -(a)

$$18 = \frac{18/2}{96500}\times 3\times t \quad \Rightarrow t = \frac{96500\times 2\text{sec}}{3} = 18\text{ hr}$$

Q23: Ans - (a)

At Pt cathode

Ag^+ will reduce first: $Ag^+ + e^- \longrightarrow Ag$.

but at Ag anode, the same amount of Ag will oxidise to produce to Ag^+.

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

So the amount of Ag^+ in solution doesn't change effectively

Q24: Ans - (a)

For alkali metal & alkaline earth metal fused salt electrolysis is the way to get metal.

Q25: Ans - (d)

∵ Ag^+ has higher reduction potential than H^+ so it will reduce first so H_2 can't produce similarly

NO_3^- will oxidise first because it has lower reduction potential.

Q26: Ans - (a)

pH won't change if H_2O will reduce & H_2O doesn't oxidise. Which will happen increase of $AgNO_3$.

Q27: Ans - (c)

Q28: Ans - (d) ∴ $K = C\left(\frac{l}{a}\right)$

Specific conductance = conductance × cell constant

Q29: Ans - (a)

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

λ_{eg} will be lowest if N is maximum

Q30: Ans - (d)

$$\therefore \lambda_{eg} = \frac{K}{N} \times 1000$$

For 1 eq present in 1cc

$$N = \frac{1}{1} \times 1000 = 1000 \quad \therefore \lambda_{eg} = \frac{K \times 1000}{1000} = K$$

Also for 1 cc, $1/a = 1/2 = 1 \therefore C = K$

Q32: Ans (b)

Q33: Ans (d)

For $N/10$, Normality $= \frac{1}{10}$

For 1 equation, 10 lit of solution require

V = 10 lit = 10,000 ml

Q34: Ans

$$\lambda^{\infty}_{NaCl} = \lambda^{\infty}_{CH_3COONa} + \lambda^{\infty}_{HCl} - \lambda^{\infty}_{CH_3COOH}$$

$$= 91 + 426 - 391 = 126 \text{ mho cm}^2$$ **Ans**