# Chapter – 3 – ELECTRO CHEMISTRY

## LEVEL-1

1. **What is the unit of molar conductivity?**
   Ans: $Scm^2/mol$

2. **Write the relationship between conductivity and molar conductivity.**
   $\Lambda m = 1000 \times k/M$

3. **What is a fuel cell?**
   Ans: A device in which the heat produced as result of combustion of of fuels like hydrogen in presence of oxygen is converted into electrical energy.

4. **What is role of $ZnCl_2$ in dry cell?**
   Ans $ZnCl_2$ combine with the $NH_3$ produce to form the complex salt$[Zn(NH_3)_2Cl_2]$ otherwise the pressure developed due to $NH_3$ would crack the seal of the cell.

5. **What is meant by electrical protection?**
   Ans. The iron tank is connected to more reactive metal wire like Mg which acts as anode and iron acts as cathode. Mg wire is buried in the ground and minerals present in soil act as electrolyte.

   $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$
   $Mg - 2e^- \rightarrow Mg^{2+}$ (At anode)

   $H_2O + O_2 + 4e^- \rightarrow 4OH^-$
   $Fe^{2+} + 2e^- \rightarrow Fe$ (At cathode).

6. **$\Lambda_m^\infty$ of $Na^+$ and $SO_4^{2-}$ are 50 S $cm^2$ $mol^{-1}$ and 160 S $cm^2$ $mol^{-1}$ respectively. What will be**
   **$\Lambda_m^\infty$ $Na_2SO_4$?**
   Ans $Na_2SO_4 = 2\lambda Na^+ + \_\lambda SO_4^{2-}$
   $= 2 \times 50 + 160$
   $= 100 + 160$
   $= 260$ S $cm^2$ $mol^{-1}$.

7. **How does the fuel cell operate?**
   Ans- At anode $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$
   At cathode $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
   $2H_2 + O_2 \rightarrow 2H_2O$

8. **Which cell were used in the Apollo Space program? What was the product used for?**
   Ans $H_2$-$O_2$ fuel cell. The product $H_2O$ was used for drinking by the astronauts.

9. **Why does a dry cell become dead after a long time, even if it has not been used?**

Ans. Acidic $NH_4Cl$ corrodes the zinc container.

**10. Two metals A and B have reduction potential values -0.76 V and +0.34 V respectively. Which of these will liberate $H_2$ from dil. $H_2SO_4$?**

Ans: Metal A

**11. Why does a mercury cell give a constant voltage throughout it's life?**

Ans:-This is because the electrolyte KOH is not consumed in the reaction.

**12. What are the products of electrolysis of molten and aqueous sodium chloride?**

Ans- Molten sodium chloride:- Na, $Cl_2$, and aqueous sodium chloride:-$H_2$ and $Cl_2$.

**13. What is primary cell? Give an example.**

**Ans.** A primary cell is a cell that can be used only once. After use, it becomes dead and cannot be recharged, e.g., Leclanche cell.

**14. Define SPECIFIC CONDUCTIVITY**

It is the reciprocal of specific resistivity of an electrolytic solution.

$k = c \times l/A$ c = conductance of solution

**15. State Kohlrausch's law.**

It states that, at infinite dilution, when dissociation is complete, each ion makes a definite contribution towards molar conductance of the electrolyte irrespective of the nature of the other ion.

$$\Lambda_m^o = \lambda^o_+ + \lambda^o_-$$

**16. Define electrolysis.**

Ans: The phenomenon of chemical changes taking place by the passage of electrical energy is called electrolysis.

**17. What are the products of electrolysis of molten and aqueous sodium chloride?**

Ans:- Molten sodium chloride:- Na, $Cl_2$, and aqueous sodium chloride:-$H_2$ and $Cl_2$.

**18. Why is it not possible to determine the molar conductivity at infinite dilution for weak electrolytes by extrapolation?**

Ans:-Because the molar conductivity at infinite dilution for weak electrolytes does not increase linearly with dilution as for strong electrolytes.

**19. Why is alternating current used in place of direct current in measuring the electrolytic conduction?**

Ans:-Direct current results in the electrolysis of the electrolytic solution.

**20. What is the use of platinum foil in the hydrogen electrode?**

Ans:-Platinum foil is used for inflow and outflow of electrons.

**21. Is it safe to stir 1M $AgNO_3$ solution with a copper spoon? Given $E^0$ $Ag^+/Ag$=0.80 V, $E^0Cu^{2+}/Cu$=0.34 V. Explain.**

Ans:-No, Cu spoon will dissolve as $Cu^{2+}$ ions because copper has more tendency to oxidize than silver.

**22. How does concentration of $H_2SO_4$ change in lead storage battery when current is drawn from it?**

Ans:-Concentration of sulphuric acid decreases.

**23. Why does a mercury cell give a constant voltage throughout it's life?**

Ans:-This is because the electrolyte KOH is not consumed in the reaction.

**24. Give four differences between electrochemical and electrolytic cell.**

| Electrochemical cell | Electrolytic Cell |
|---|---|
| (i) Chemical energy is converted into electrical energy. | (i) Electrical energy is converted into chemical energy. |
| (ii) Salt bridge or porous pot is used. | (ii) No salt bridge or porous pot is used. |
| (iii) Anode is –ve and cathode is +ve. | (iii) Anode is +ve and cathode is –ve. |
| (iv) $\Delta G$ is –ve. | (iv) $\Delta G$ is +ve. |

## LEVEL-2

1. **What is the basic reason that lead storage battery can be recharged?**
   Ans- $PbSO_4$ is deposited on the electrodes. So the electrodes reaction can be reversed.

2. **In an electrolytic cell, how many moles of copper will be deposited from a solution of $CuSO_4$ by 21425 C of electricity?**
   Ans:-$Cu^{2+} + 2e^- \rightarrow Cu$.
   2 mol of electrons are required to reduce 1 mol of $Cu^{2+}$ ions.
   Now 1 mol of electrons=96500C
   Therefore, 2 96500 of electricity are required to reduce 1 mol of $Cu^{2+}$ ions.
   Therefore, 24125 of electricity will reduce $Cu^{2+}$ ions = 24185/2 96500 =1/8mol.

3. **Calculate the e.m.f. of the following cell at 298 K:**
   **$Fe \mid Fe^{2+}$ (0.1 M) || $Ag^+$ (0.1 M) Ag(s).**
   **[Given $E^0_{Zn^{2+}/Zn}$= -0.44 V, $E^0_{Ag^+/Ag}$ = +0.80 V].**

   Ans . $Fe \rightarrow Fe^{2+} + 2e^-$
   $2Ag^+ + 2e^- \rightarrow 2Ag(s)$
   $Fe(s) + 2Ag^+(aq) \rightarrow Fe^{2+}(aq) + 2Ag(s)$

$E_{cell} = E^0_{cell} - (0.0591)/n \log[Fe^{2+}]/[Ag^+]^2$

$= [E^0_{Ag^+/Ag} - E^0_{Fe^{2+}/Fe}] - 0.0591/2 \log 0.1/(0.1)2$

$= + 0.80 V - (- 0.44) - 0.0591/2 \log 10$

$= +1.24 V - 0.0295$

$= + 1.2105 V.$

**4. How many Faradays are required to convert**

**(a) 1 mole of $MnO_4^-$ to $Mn^{2+}$ ion**

**(b) 1 mole of $Cr_2O_7^{2-}$ to $Cr^{3+}$?**

Ans. (a) $MnO_4^-$ to $Mn^{2+}$

$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$ i.e., 5 faradays are required.

(b) $Cr_2O_7^{2-}$ to $Cr^{3+}$

$6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$. i.e. 6F of electricity is reqd.

**5. State Faraday's laws of electrolysis.**

**Faraday's 1st Law of Electrolysis** - The mass of a substance altered at an electrode during electrolysis is directly proportional to the quantity of electricity transferred at that electrode. Quantity of electricity refers to electrical charge, typically measured in coulombs, and not to electrical current.

Mathematically, $m \alpha Q$ or $m \alpha It$ (since Q=It) or $m = ZIt$
where, Z is the electrochemical equivalent of the substance.

**Faraday's 2nd Law of Electrolysis** - For a given quantity of electricity (electric charge), the mass of an elemental material altered at an electrode is directly proportional to the element's equivalent weight. The equivalent weight of a substance is its molar mass divided by an integer that depends on the reaction undergone by the material.

Mathematically, $m \alpha E$ or $m/E$ = constant
Where, 'm' is the mass of substance decomposed or deposited by the passage of a certain quantity of electricity
And, E is the equivalent weight of substance.
Electrochemical equivalent = Gram equivalent mass / 96,500

## LEVEL-3

**1. Zinc electrode is constituted at 298K by placing a zinc rod in 0.1M solution of zinc sulphate which is 95% dissociated at this concentration. What will be the electrode potential ($E_{zn2+/zn}$)of the electrode, given that $E^-_{zn2+/zn}$= -0.76V**

***Ans.*** $[ZnSO_4] = 0.1M$

***% dissociation*** =95% ∴ $[Zn^{2+}]$=0.1 x 95/ 100 = 0.095

***The electrode reaction is***: $Zn^{2+} + 2e^- \rightarrow Zn$

***Accordingto Nernst equation***:

$E_{zn2+/zn} = E^{-}_{zn2+/zn} + 0.059 / 2 \log [Zn^{2+}]/Zn$

$= -0.76(V) + 0.059/2 \log (0.095)$ {[Zn] =1}

***=-0.79V***

**2.A solution containing 4.5mM of $Cu_2O_7^{2-}$ ions and 15mM of $Cr^{3+}$ ions shows a pH 2.0 .What is the potential of half reaction ?**

**$Cr_2O_7^{2-} \rightarrow Cr^{3+}$**

**If its standard electrode potential of half life is 1.33V .**

Ans: the balance reduction equation for the reaction is –

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

$E^0 = E + 0.059/6 \log[Cr_2O_7^{2-}] [H^+]^{14}$

here $[H+] = 10^{-2}$ $[Cr_2O_7] = 4.5 (10)^{-3}$ M $[Cr^{3+}] = 15 (10^{-3})$ M

Substituting the values of the equation –

$=1.33 + 0.05 /6 \log(4.5 \times 10^{-3})[(10)^{-2}]^{14} / (15 \times 10^{-3})$

$= 1.33 - 0.262$

$= 1.06$ V

**3. Calculate the EMF of the cell Mg(s)/$Mg^{2+}$(0.2M) //Ag+(1X$10^{-3}$)/ Ag; EoMg2+/Mg = -2.37V, E0Ag+/Ag = +0.80V. What will be the effect on the EMF if concentration of $Mg2^+$ ion is decreased to 0.1M?**

Ans: The net reaction is Mg(s) + 2Ag(s) + Mg2+(aq)

According to Nernst equation

$E_{cell} = E^o_{cell} + 0.059/n \log[Mg^{2+}] / [Ag^+]^2$

$=0.80-(-2.37) + 0.059/2 \log(0.2) / (1X10^{-3})^2$

$=3.17 + 0.0295X05.3010$

$=3.32V$

When concentration of $Mg^{2+}$ is decreased to 0.1M, the new EMF is

$E_{cell}=3.17 + 0.0295 X \log 0.1 / (1X10^{-3})^2$

$=3.34V$

4. **If a current of 0.200 A is passed through 50 ml of M/10 NaCl sol$^n$ for 10 minutes. Calculate the concentration of $OH^-$ ions in the soln. after the electrolysis**.

Ans -:- Quantity of current passed = 0.2 X 10 X 60

= 120 C.

$2NaCl + 2H_2O$ (through electricity)→ $Cl_2(g) + H_2(g) + 2Na^+ + 2OH^-$

Moles of NaCl = 50 X 0.1 X $10^{-3}$ = 5 X $10^{-3}$

Moles of NaCl reacted = (2 X 120)/(2 X 96500) = 1.24 X $10^{-3}$ mol

Mol of $OH^-$ produced = 1.24 X $10^{-3}$

Molarity of $OH^-$ ions = $(1.24 \times 10^{-3} \times 10^3)/50$

= 0.0248 M

5. **250 ml of copper sulphate solution was electrolysed using platinum anode copper cathode. A constant current of 2mA was passed for 16 minutes. It was found that after electrolysis the absorbance of solution was reduced to 50% of its original value calculate concentration of copper sulphate solution to begin with.**

Ans : Quantity of electricity passed= $2\times10^{-3}$(amp)×16×16(sec) =1.96C

Copper deposited by 1.92C of electricity

$\frac{1.92C}{2\times96500}$ $=9.94\times10^{-6}$mol

Decrease in absorbance=Decrease in $[Cu^{2+}]$ =Copper deposited $=9.94\times10^{-6}$mol

Therefore moles of copper ions ($Cu^{2+}$)initially present $=2\times9.94\times10^{-6}$moles

Volume=250ml

Initial concentration of $Cu^{2+}$ $=\frac{2\times9.94\times10^{-6}\times1000}{250}$ $=7.95\times10^{-5}$ mol $L^{-1}$

6. **Conductivity of 0.00241 M acetic acid solution is $7.896 \times 10^{-5}$ S $cm^{-1}$. Calculate its molar conductivity in this solution. If $\lambda m^{\infty}$for acetic acid be 390.5 S $cm^2$ $mol^{-1}$, what would be its dissociation constant?**

**Ans.** Conductivity of acetic acid, $K = 7.896 \times 10^{-5}$ S $cm^{-1}$

$\lambda m^{\infty}$for acetic acid = 390.5 S $cm^2$ $mol^{-1}$

Molar conductivity,

$$\Lambda_M^C = \frac{k \times 100}{\text{Molarity}}$$

$$= \frac{7.896 \times 10^{-5} \times 1000}{0.00241} = \frac{789600 \times 1000 \times 10^{-5}}{241}$$

$$= 32.76 \text{ S cm}^2 \text{ mol}^{-1}$$

Degree of dissociation,

$$\alpha = \frac{\Lambda_M^C}{\Lambda_M^O} = \frac{32.76}{390.5} = 8.4 \times 10^{-2}$$

Dissociation constant of acetic acid,

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

$$= \frac{(0.00241) \times \left(8.4 \times 10^{-2}\right)^2}{1 - 0.084}$$

$$= 1.86 \times 10^{-5}$$