

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.

$$\Lambda_m = 1000 \times \kappa/M$$

3. What is a fuel cell?

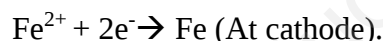
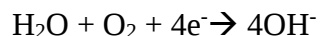
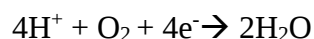
Ans: A device in which the heat produced as result of combustion of of fuels like hydrogen in presence of oxygen is converted into electrical energy.

4. What is role of ZnCl_2 in dry cell?

Ans ZnCl_2 combine with the NH_3 produce to form the complex salt $[\text{Zn}(\text{NH}_3)_2\text{Cl}_2]$ 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.



6. Λ_m^∞ of Na^+ and SO_4^{2-} are $50 \text{ S cm}^2 \text{ mol}^{-1}$ and $160 \text{ S cm}^2 \text{ mol}^{-1}$ respectively. What will be

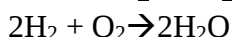
$\Lambda_m^\infty \text{ Na}_2\text{SO}_4$?

$$\begin{aligned} \text{Ans} \quad \text{Na}_2\text{SO}_4 &= 2 \lambda \text{Na}^+ + \lambda \text{SO}_4^{2-} \\ &= 2 \times 50 + 160 \\ &= 100 + 160 \\ &= 260 \text{ S cm}^2 \text{ mol}^{-1}. \end{aligned}$$

7. How does the fuel cell operate?

Ans- At anode $2\text{H}_2 + 4\text{OH}^- \rightarrow 4\text{H}_2\text{O} + 4\text{e}^-$

At cathode $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$



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 its 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.

$$\Lambda_m^\circ = \lambda_+^\circ + \lambda_-^\circ$$

- 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 AgNO₃ solution with a copper spoon? Given $E^0 \text{Ag}^+/\text{Ag}=0.80 \text{ V}$, $E^0 \text{Cu}^{2+}/\text{Cu}=0.34 \text{ V}$. 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 H₂SO₄ 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 its 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) ΔG is -ve.	(iv) ΔG 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:- $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$.

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.

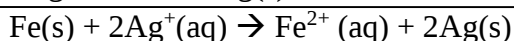
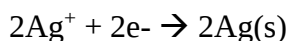
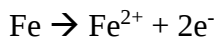
Therefore, 21425 of electricity will reduce Cu^{2+} ions = $21425/2 \times 96500 = 1/8\text{mol}$.

3. Calculate the e.m.f. of the following cell at 298 K:

$\text{Fe} | \text{Fe}^{2+} (0.1 \text{ M}) || \text{Ag}^+ (0.1 \text{ M}) | \text{Ag(s)}$.

[Given $E^0 \text{Zn}^{2+}/\text{Zn} = -0.44 \text{ V}$, $E^0 \text{Ag}^+/\text{Ag} = +0.80 \text{ V}$].

Ans .



$$\begin{aligned}
 E_{\text{cell}} &= E^{\circ}_{\text{cell}} - (0.0591)/n \log[\text{Fe}^{2+}]/[\text{Ag}^+]^2 \\
 &= [E^{\circ}_{\text{Ag}^+/\text{Ag}} - E^{\circ}_{\text{Fe}^{2+}/\text{Fe}}] - 0.0591/2 \log 0.1/(0.1)^2 \\
 &= +0.80 \text{ V} - (-0.44) - 0.0591/2 \log 10 \\
 &= +1.24 \text{ V} - 0.0295 \\
 &= +1.2105 \text{ V.}
 \end{aligned}$$

4. How many Faradays are required to convert

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

(b) 1 mole of $\text{Cr}_2\text{O}_7^{2-}$ to Cr^{3+} ?

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

$5e^- + 8\text{H}^+ + \text{MnO}_4^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$ i.e., 5 faradays are required.

(b) $\text{Cr}_2\text{O}_7^{2-}$ to Cr^{3+}

$6e^- + 14\text{H}^+ + \text{Cr}_2\text{O}_7^{2-} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$. 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, $m \propto Q$ or $m \propto It$ (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, $m \propto E$ or $m/E = \text{constant}$

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 ($E_{\text{Zn}^{2+}/\text{Zn}}$) of the electrode, given that $E^{\circ}_{\text{Zn}^{2+}/\text{Zn}} = -0.76\text{V}$

Ans. $[\text{ZnSO}_4] = 0.1\text{M}$

% dissociation = 95% $\therefore [\text{Zn}^{2+}] = 0.1 \times 95/100 = 0.095$

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

According to Nernst equation:

$$E_{\text{Zn}^{2+}/\text{Zn}} = E_{\text{Zn}^{2+}/\text{Zn}}^{\circ} + 0.059 / 2 \log [\text{Zn}^{2+}] / [\text{Zn}]$$

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

$$= -0.79\text{V}$$

2. A solution containing 4.5mM of $\text{Cu}_2\text{O}_7^{2-}$ ions and 15mM of Cr^{3+} ions shows a pH 2.0

.What

is the potential of half reaction ?



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

Ans: the balance reduction equation for the reaction is –



$$E^0 = E + 0.059/6 \log [\text{Cr}_2\text{O}_7^{2-}] [\text{H}^+]^{14}$$

$$\text{here } [\text{H}^+] = 10^{-2} \quad [\text{Cr}_2\text{O}_7] = 4.5 (10)^{-3} \text{ M} \quad [\text{Cr}^{3+}] = 15 (10)^{-3} \text{ M}$$

Substituting the values of the equation –

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

$$= 1.33 - 0.262$$

$$= 1.06 \text{ V}$$

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

Ans: The net reaction is $\text{Mg(s)} + 2\text{Ag(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{Ag(s)}$

According to Nernst equation

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

$$= 0.80 - (-2.37) + 0.059/2 \log (0.2) / (1 \times 10^{-3})^2$$

$$= 3.17 + 0.0295 \times 0.3010$$

$$= 3.32\text{V}$$

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

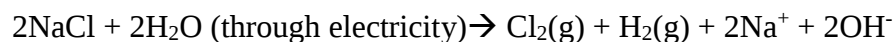
$$E_{\text{cell}} = 3.17 + 0.0295 \times \log 0.1 / (1 \times 10^{-3})^2$$

$$= 3.34\text{V}$$

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

Ans :- Quantity of current passed = $0.2 \times 10 \times 60$

$$= 120 \text{ C.}$$



$$\text{Moles of NaCl} = 50 \times 0.1 \times 10^{-3} = 5 \times 10^{-3}$$

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

$$\text{Mol of OH}^- \text{ produced} = 1.24 \times 10^{-3}$$

$$\begin{aligned}\text{Molarity of OH}^- \text{ ions} &= (1.24 \times 10^{-3} \times 10^3)/50 \\ &= 0.0248 \text{ M}\end{aligned}$$

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 = $2 \times 10^{-3}(\text{amp}) \times 16 \times 60(\text{sec}) = 1.92\text{C}$

Copper deposited by 1.92C of electricity

$$\frac{1.92\text{C}}{2 \times 96500} = 9.94 \times 10^{-6} \text{ mol}$$

Decrease in absorbance = Decrease in $[\text{Cu}^{2+}] = \text{Copper deposited} = 9.94 \times 10^{-6} \text{ mol}$

Therefore moles of copper ions (Cu^{2+}) initially present = $2 \times 9.94 \times 10^{-6} \text{ moles}$

Volume = 250 ml

$$\text{Initial concentration of Cu}^{2+} = \frac{2 \times 9.94 \times 10^{-6} \times 1000}{250} = 7.95 \times 10^{-5} \text{ mol L}^{-1}$$

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

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

λ_m^∞ for acetic acid = $390.5 \text{ S cm}^2 \text{ mol}^{-1}$

Molar conductivity,

$$\begin{aligned}\Lambda_M^c &= \frac{k \times 100}{\text{Molarity}} \\ &= \frac{7.896 \times 10^{-5} \times 1000}{0.00241} = \frac{789600 \times 1000 \times 10^{-5}}{241} \\ &= 32.76 \text{ S cm}^2 \text{ mol}^{-1}\end{aligned}$$

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,

$$\begin{aligned}K_a &= \frac{C\alpha^2}{1-\alpha} \\&= \frac{(0.00241) \times (8.4 \times 10^{-2})^2}{1-0.084} \\&= 1.86 \times 10^{-5}\end{aligned}$$

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