

## Short Answer Questions-I

---

### Short Answer Questions-I (PIQ)

**Q.1. Define the following terms:**

[CBSE (AI) 2014]

**Q. Molar conductivity ( $\Lambda_m$ )**

**Ans.** Molar conductivity,  $\Lambda_m$  of a solution at a dilution  $V$  is defined as the conductance of all the ions produced from one gram mole of the electrolyte dissolved in  $V \text{ cm}^3$  of the solution when the electrodes are one centimetre apart and the area of the electrodes is so large that the whole of the solution is contained between them.

$$\Lambda_m = k \times V \quad \text{or} \quad \Lambda_m = \frac{k \times 1000}{\text{Molarity}}$$

Molarity where  $k$  is the conductivity and  $V$  is the volume of the solution containing 1 mole of the electrolyte.

**Q. Secondary batteries**

**Ans.** Secondary batteries are those batteries which can be recharged by passing electric current through them and hence can be used over again e.g., lead storage battery.

**Q.2. Express the relation among cell constant, resistance of the solution in the cell and conductivity of the solution. How is molar conductivity of a solution related to its conductivity?**

[CBSE Delhi 2011; (AI) 2012]

**Ans.**

$$\text{Conductivity } (k) = \frac{1}{\text{Resistance } (R)} \times \text{Cell constant}$$

$$\text{Molar conductivity } (\Lambda_m) = \frac{\text{Conductivity } (k) \times 1000}{\text{Molarity } (M)}$$

**Q.3. State Kohlrausch law of independent migration of ions. Why does the conductivity of a solution decrease with dilution?**

[CBSE (AI) 2014]

**Ans.** Kohlrausch law states that the limiting molar conductivity of an electrolyte can be represented as the sum of the individual contributions of cation and anion of the electrolyte.

In general, if an electrolyte on dissociation gives  $\nu_+$  cations and  $\nu_-$  anions then its limiting molar conductivity is given by

$$\Lambda_m^o = \nu_+ \lambda_+^o + \nu_- \lambda_-^o$$

where  $\lambda_+^o$  and  $\lambda_-^o$  are the limiting molar conductivities of cations and anions respectively.

Conductivity of a solution decreases with dilution. This is due to the fact that the number of ions per unit volume that carry the current in a solution decreases with dilution.

**Q.4. Define the following terms:**

[CBSE (AI) 2014]

**Q. Fuel cell**

**Ans.** A fuel cell is a device which converts the energy produced during the combustion of fuels like hydrogen, methanol, methane etc. directly into electrical energy. One of the most successful fuel cell is  $\text{H}_2\text{—O}_2$  fuel cell.

**Q. Limiting molar conductivity**

$$(\Lambda_m^o)$$

**Ans.** When concentration approaches zero, the molar conductivity is known as limiting molar conductivity. It is represented by  $(\Lambda_m^o)$

$$\Lambda_m^o = (\Lambda_m)_{\text{when } c \rightarrow 0}$$

**Q.5. For the given cells:**

**Lead storage cell, Mercury cell, Fuel cell and Dry cell**

**Answer the following:**

- i. Which cell is used in hearing aids?
- ii. Which cell was used in Apollo space programme?
- iii. Which cell is used in automobiles and inverters?

iv. Which cell does not have long life?

[CBSE Delhi 2016; South 2016]

Ans.

- i. Mercury cell
- ii. Fuel cell
- iii. Lead storage cell
- iv. Dry cell

Q.6. What is the effect of catalyst on:

[CBSE Delhi 2017]

Q. Gibbs energy ( $\Delta G$ ) and

Ans. No effect

Q. Activation Rnergy of a Reaction?

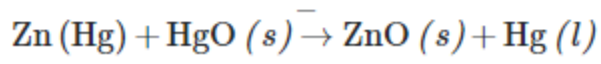
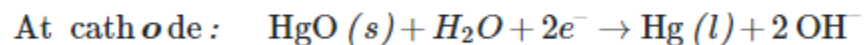
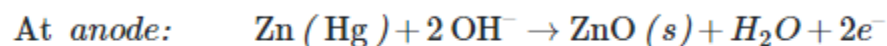
Ans. Decreases

Q.7. Write the name of the cell which is generally used in hearing aids. Write the reactions taking place at the anode and the cathode of this cell.

[CBSE (AI) 2017]

Ans.

Mercury cell



Q.8. Answer the following questions

[CBSE Delhi 2015]

**Q. Following reactions occur at cathode during the electrolysis of aqueous silver chloride solution:**



**On the basis of their standard reduction electrode potential ( $E^\circ$ ) values, which reaction is feasible at the cathode and why?**

**Ans.** The reaction,  $\text{Ag}^+ (\text{aq}) + e^- \rightarrow \text{Ag} (s)$  is feasible at cathode as cathodic reaction is one which has higher standard reduction electrode potential ( $E^\circ_{\text{red}}$ ).

**Q. Define limiting molar conductivity. Why conductivity of an electrolyte solution decreases with the decrease in concentration?**

**Ans.** The value of molar conductivity when the concentration approaches zero is known as limiting molar conductivity. Conductivity of an electrolytic solution decreases with decrease in concentration as the number of ions per unit volume that carry the current in the solution decreases with decrease in concentration.

**Q.9. Answer the following questions**

[CBSE Panchkula 2015]

**Q. Following reactions occur at cathode during the electrolysis of aqueous sodium chloride solution:**



**On the basis of their standard reduction electrode potential ( $E^0$ ) values, which reaction is feasible at the cathode and why?**

**Ans.** The reaction  $\text{H}^+ (\text{aq}) + e^- \rightarrow \frac{1}{2} \text{H}_2 (g)$  is feasible at cathode as it has higher standard reduction potential than other reaction.

**Q. Why does the cell potential of mercury cell remain constant throughout its life?**

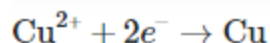
**Ans.** As the overall reaction does not involve any ion in the solution whose concentration changes during its life period.

**Q.10.** Calculate the time to deposit 1.27 g of copper at cathode when a current of 2 A was passed through the solution of  $\text{CuSO}_4$

(Molar mass of Cu =  $63.5 \text{ g mol}^{-1}$ ,  $1 \text{ F} = 96500 \text{ C mol}^{-1}$ )

[CBSE Allahabad 2015]

**Ans.**



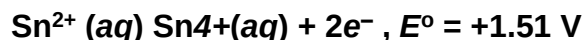
63.5 g of copper is deposited by  $2 \times 96500 \text{ C}$ .

$\therefore$  1.27 g of copper will be deposited by  $\frac{2 \times 96500 \times 1.27}{63.5} \text{ C} = 3860 \text{ C}$

$I = 2 \text{ A}$ ,  $Q = 3860 \text{ C}$

$$\therefore t = \frac{Q}{I} = \frac{3860}{2} = 1930 \text{ s}$$

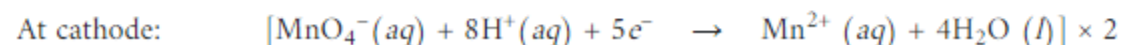
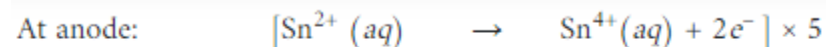
**Q.11.** Two half-reactions of an electrochemical cell are given below:



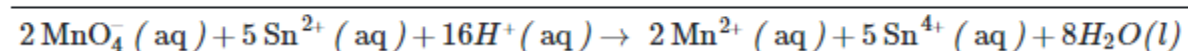
Construct the redox equation from the standard potential of the cell and predict if the reaction is reactant favoured or product favoured.

[CBSE (AI) 2009; Delhi 2011]

**Ans.**



Cell reaction:



$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}} = 1.51 \text{ V} - 0.15 \text{ V}$$

$$= 1.36 \text{ V}$$

As cell potential is positive therefore the reaction is product favoured.

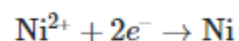
**Q.12. A solution of  $\text{Ni}(\text{NO}_3)_2$  is electrolysed between platinum electrodes using a current of 5.0 ampere for 20 minutes. What mass of nickel will be deposited at the cathode?**

**(Given: At. Mass of Ni = 58.7 g mol<sup>-1</sup>, 1 F = 96500 C mol<sup>-1</sup>)**

**[CBSE (F) 2014]**

**Ans.**

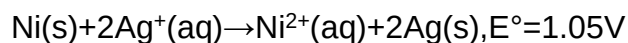
$$Q = I \times t = 5 \text{ A} \times 20 \times 60 \text{ s} = 6000 \text{ C}$$



$$2 \times 96500 \text{ C deposit Ni} = 58.7 \text{ g}$$

$$\therefore 6000 \text{ C will deposit Ni} = \frac{58.7 \text{ g mol}^{-1}}{2 \times 96500 \text{ C mol}^{-1}} \times 6000 \text{ C} = 1.825 \text{ g}$$

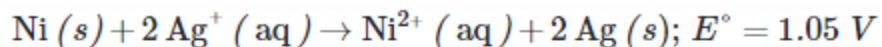
**Q.13. Determine the values of equilibrium constant ( $K_c$ ) and  $\Delta G^{\circ}$  for the following reaction:**



**(1 F = 96500 C mol<sup>-1</sup>)**

**[CBSE Delhi 2011]**

**Ans.**



Here,  $n = 2$

$$\log K_c = \frac{n}{0.059} E_{\text{cell}}^0$$

$$\log K_c = \frac{2}{0.059} \times 1.05 = 39.5932$$

$$K_c = \text{antilog } 39.5932 = 3.919 \times 10^{39}$$

$$K_c = 3.92 \times 10^{39}$$

$$\Delta G^0 = -n F E_{\text{cell}}^0$$

$$\Delta G^0 = -2 \times 96500 \times 1.05 = -202650 \text{ J}$$

$$\Delta G^0 = -202.65 \text{ kJ}$$

**Q.14.** The molar conductivity of a 1.5 M solution of an electrolyte is found to be  $138.9 \text{ S cm}^2 \text{ mol}^{-1}$ . Calculate the conductivity of this solution.

[CBSE (AI) 2012]

**Ans.**

$$\Lambda_m = \frac{k \times 1000}{M}$$

$$k = \frac{\Lambda_m \times M}{1000}$$

$$k = \frac{138.95 \text{ S cm}^2 \text{ mol}^{-1} \times 1.5 \text{ mol L}^{-1}}{1000 \text{ cm}^3 \text{ L}^{-1}}$$

$$= 0.208455 \text{ cm}^{-1}$$

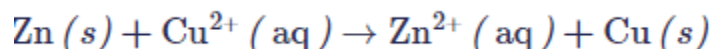
**Q.15.** The conductivity of 0.20 M solution of KCl at 298 K is  $0.025 \text{ S cm}^{-1}$ . Calculate its molar conductivity.

[CBSE Delhi 2013]

**Ans.**

$$\Lambda_m = \frac{k \times 1000}{C} = \frac{0.025 \text{ S cm}^{-1} \times 1000 \text{ cm}^3 \text{ L}^{-1}}{0.2 \text{ mol L}^{-1}} = 125 \text{ S cm}^2 \text{ mol}^{-1}$$

**Q.16. The standard electrode potential ( $E^\circ$ ) for Daniell cell is + 1.1 V. Calculate the  $\Delta G^\circ$  for the reaction**



(1 F = 96500 C mol<sup>-1</sup>).

[CBSE (AI) 2013]

**Ans.**

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

In the given equation,  $n = 2$ ,  $F = 96500 \text{ C mol}^{-1}$  and  $E_{\text{cell}}^\circ = 1.1 \text{ V}$

Therefore,  $\Delta_r G^\circ = -2 \times 96500 \text{ C mol}^{-1} \times 1.1 \text{ V}$

$$= -212300 \text{ J mol}^{-1} = -212.3 \text{ kJ mol}^{-1}$$

**Q.17. The chemistry of corrosion of iron is essentially an electrochemical phenomenon. Explain the reactions occurring during the corrosion of iron in the atmosphere.**

[CBSE Delhi 2011]

**Ans.** According to electrochemical theory of rusting the impure iron surface behaves like small electrochemical cell in the presence of water containing dissolved oxygen or carbon dioxide. In this cell pure iron acts as anode and impure iron surface acts as cathode. Moisture having dissolved CO<sub>2</sub> or O<sub>2</sub> acts as an electrolyte. The reactions are given below.

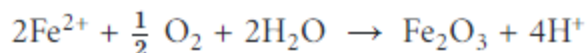
At anode:  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2e^-$ ;  $E_{\text{Fe}^{2+}/\text{Fe}}^\circ = -0.44 \text{ V}$

At cathode:  $2\text{H}^+ + \frac{1}{2}\text{O}_2 + 2e^- \rightarrow \text{H}_2\text{O}$ ;  $E_{\text{H}^+/\text{O}_2/\text{H}_2\text{O}}^\circ = 1.23 \text{ V}$

Overall reaction:  $\text{Fe} + 2\text{H}^+ + \frac{1}{2}\text{O}_2 \rightarrow \text{Fe}^{2+} + \text{H}_2\text{O}$ ;  $E_{\text{cell}}^\circ = 1.67 \text{ V}$

The Fe<sup>2+</sup> ions are further oxidised by atmospheric oxygen to Fe<sup>3+</sup> ions, which comes out in the form of hydrated ferric oxide (rust).





**Q.18. Calculate the degree of dissociation ( $\alpha$ ) of acetic acid if its molar conductivity ( $\Lambda_m$ ) is  $39.05 \text{ S cm}^2 \text{ mol}^{-1}$ .**

**[CBSE Delhi 2017]**

Given  $\lambda_{(\text{H}^+)}^o = 349.6 \text{ S cm}^2 \text{ mol}^{-1}$  and  $\lambda_{(\text{CH}_3\text{COO}^-)}^o = 40.9 \text{ S cm}^2 \text{ mol}^{-1}$

**Ans.**

$$\Lambda_{(\text{CH}_3\text{COOH})}^o = \lambda_{(\text{CH}_3\text{COO}^-)}^o + \lambda_{(\text{H}^+)}^o$$

$$= (40.9 + 349.6) \text{ S cm}^2 \text{ mol}^{-1}$$

$$= 390.5 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\alpha = \frac{\Lambda_m^c}{\Lambda_m^o} = \frac{39.05 \text{ S cm}^2 \text{ mol}^{-1}}{390.5 \text{ S cm}^2 \text{ mol}^{-1}} = 0.1 \quad \alpha = 10\%$$

### Short Answer Questions-I (OIQ)

**Q.1. Write electrode reactions taking place in**

- Ni–Cd cell,**
- Lead Acid Accumulator.**

**Ans.**

- $$\text{Cd(s)} + 2\text{OH}^-(\text{aq}) \rightarrow \text{Cd(OH)}_2(\text{s}) + 2\text{e}^-$$

$$\text{NiO}_2(\text{s}) + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Ni(OH)}_2(\text{s}) + 2\text{OH}^-(\text{aq})$$
- $$\text{Pb} \rightarrow \text{Pb}^{2+} + 2\text{e}^- \quad \text{(at anode)} \text{PbO}_2 +$$

$$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O} \quad \text{(at cathode)}$$

**Q.2. Account for the following:**

- Alkaline medium inhibits the rusting of iron.**
- Iron does not rust even if the zinc coating is broken in a galvanized iron pipe.**

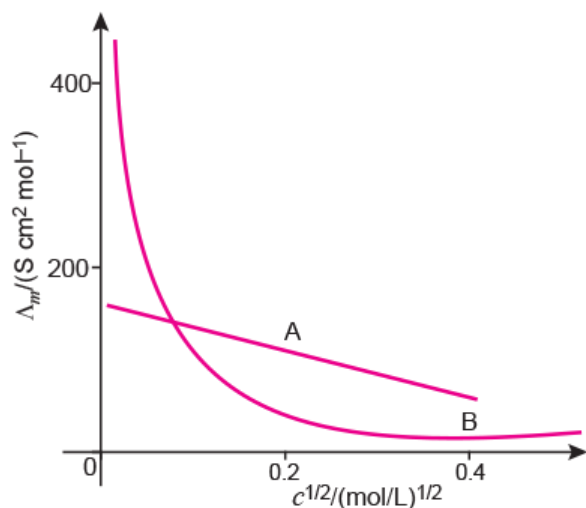
**Ans. (i)** The alkalinity of the solution prevents the availability of  $H^+$  ions.

**(ii)** Zinc has lower reduction potential than iron. Therefore, zinc coating acts as anode and the exposed iron portions act as cathode. If zinc coating is broken, zinc still undergoes oxidation, protecting iron from rusting. No attack occurs on iron till all the zinc is corroded.

**Q.3.** The following curve is obtained when molar conductivity ( $\Lambda_m$ ) is plotted against the square root of concentration,  $c^{1/2}$  for two electrolytes A and B.

- How do you account for the increase in the molar conductivity of the electrolyte A on dilution?
- As seen from the graph, the value of limiting molar conductivity ( $\Lambda_m^0$ ) for electrolyte B cannot be obtained graphically. How can this value be obtained?

[CBSE Sample Paper 2016]



**Ans.**

- As seen from the graph, electrolyte 'A' is a strong electrolyte which is ionised almost completely in solutions. For strong electrolyte 'A', the number of ions does not increase appreciably on dilution and only mobility of ions increases due to decrease in interionic attraction. Therefore, molar conductivity increases a little as shown in graph by a straight line.
- Limiting molar conductivity ( $\Lambda_m^0$ ) for weak electrolyte 'B' can be obtained by using Kohlrausch law of independent migration of ions which says that limiting molar conductivity of an electrolyte is equal to the sum of the individual contribution of the cation and anion of the electrolyte.

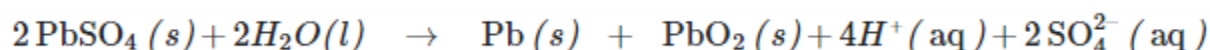
**Q.4.** Answer the following questions

**Q. For a weak electrolyte, molar conductance in dilute solution increases sharply as its concentration in solution is decreased. Give reason.**

**Ans.** Because with dilution, there is increase in degree of dissociation and consequently the number of ions in total volume of solution increases and hence molar conductivity increases sharply.

**Q. Write overall cell reaction for lead storage battery when the battery is being charged.**

**Ans.**



**Q. 5. When a current of 0.75 A is passed through a  $\text{CuSO}_4$  solution for 25 min, 0.369 g of copper is deposited at the cathode. Calculate the atomic mass of copper.**

**Ans.**

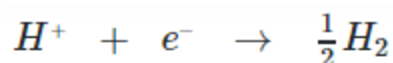
$$W = Z \times I \times t$$

$$0.369 = \frac{M}{2 \times 96500} \times 0.75 \times 25 \times 60 \quad (M = \text{molar mass of copper})$$

$$M = 63.3 \text{ g/mol}$$

**Q.6. At what pH of HCl solution will hydrogen gas electrode show electrode potential of  $-0.118 \text{ V}$ ?  $\text{H}_2$  gas is passed at  $298 \text{ K}$  and  $1 \text{ atm}$  pressure.**

**Ans.**



Applying Nernst equation,

$$E_{\text{H}^+/\frac{1}{2}\text{H}_2} = E_{\text{H}^+/\frac{1}{2}\text{H}_2}^o - \frac{0.059}{n} \log \frac{1}{[\text{H}^+]}$$

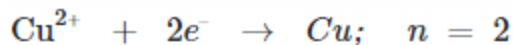
$$-0.118 = 0 - \frac{0.059}{1} \log \frac{1}{[\text{H}^+]}$$

$$-0.118 = 0.059 \log [H^+] \text{ or } -0.118 = -0.059 \text{ pH}$$

$$\text{pH} = 2$$

**Q.7. Calculate the electrode potential of copper electrode dipped in 0.1 M CuSO<sub>4</sub> solution at 298 K. Given that  $E^\circ_{\text{Cu}^{2+}/\text{Cu}} = 0.34\text{V}$ .**

**Ans.**



$$E_{\text{Cu}^{2+}/\text{Cu}} = E^\circ_{\text{Cu}^{2+}/\text{Cu}} - \frac{0.059}{n} \log \frac{1}{[\text{Cu}^{2+}]}$$

$$E_{\text{Cu}^{2+}/\text{Cu}} = 0.34 - \frac{0.059}{2} \log \frac{1}{0.1}$$

$$E_{\text{Cu}^{2+}/\text{Cu}} = 0.34 - 0.0295 = 0.3105\text{V}$$

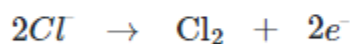
**Q.8. How many molecules of chlorine should be deposited from molten sodium chloride in one minute by a current of 300 milliampere?**

**Ans.**

$$Q = I \times t$$

$$\text{Here, } I = \frac{300}{1000} = 0.3 \text{ A}; \quad t = 60 \text{ s}; \quad Q = 0.3 \text{ A} \times 60 \text{ s} = 18 \text{ C}$$

$$2 \times 96500 \text{ C deposit Cl}_2 = 1 \text{ mol}$$



$$\therefore 18 \text{ C will deposit Cl}_2 = \frac{1\text{mol} \times 18 \text{ C} \times 6.022 \times 10^{23}}{2 \times 96500 \text{ C}} \text{ molecules mol}^{-1}$$

$$= 5.616 \times 10^{19} \text{ molecules}$$

**Q.9. A current of 5 ampere is flowing through a wire for 193 seconds. Calculate the number of electrons flowing through the cross section of wire for 193 seconds.**

**[HOTS]**

$$\text{Ans. } Q = I \times t = 5 \text{ A} \times 193 \text{ s} = 965 \text{ C}$$

96500 C is equivalent to flow of  $6.022 \times 10^{23}$  electrons.

$\therefore$  965 C will be equivalent to flow of electrons

$$= \frac{6.022 \times 10^{23}}{96500} \times 965 = 6.022 \times 1021.$$

**Q.10. Calculate the equilibrium constant for the reaction**



$$\text{If } E_{\text{Cd}^{2+}/\text{Cd}}^{\circ} = -0.403 \text{ V}; E_{\text{Zn}^{2+}/\text{Zn}}^{\circ} = -0.763 \text{ V}$$

**Ans.**

$$E_{\text{cell}}^{\circ} = E_{\text{Cd}^{2+}/\text{Cd}}^{\circ} - E_{\text{Zn}^{2+}/\text{Zn}}^{\circ} = -0.403 \text{ V} - (-0.763 \text{ V}) = 0.360 \text{ V}, n = 2$$

$$\log K_c = \left( \frac{nE_{\text{cell}}^{\circ}}{0.059} \right) = \left( \frac{2 \times 0.360}{0.059} \right) = \left( \frac{0.720}{0.059} \right) = 12.20$$

$$K_c = \text{antilog} (12.20) = 1.585 \times 10^{12}$$