Electrochemistry

Question 82.

(a) The conductivity of 0.001 mol L^{-1} solution of CH_3COOH is 3.905×10^{-5} S cm^{-1}. Calculate its molar conductivity and degree of dissociation (α).

Given: $\lambda^0(H^+)$ = 349.6 S cm^2 mol^{-1} and λ^0 (CH_3COO^-) = 40.9 S cm^2 mol^{-1}

(b) Define electrochemical cell. What happens if external potential applied becomes greater than E^0_{cell} of electrochemical cell? Answer:

(a) Concentration = 0.001 mol L^{-1}

$K = 3.905 \times 10^{-5}$ S cm^{-1} $\quad \Lambda^c_m = ?$

Using formula,

$$\Lambda^c_m = \frac{K \times 1000}{C} = \frac{3.905 \times 10^{-5} \times 1000}{0.001}$$

$= 39.05$ S cm^2 mol^{-1}

Molar conductivity at infinite dilution:

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

$$\Lambda^\circ_m = \lambda^\circ H^+ + \lambda^\circ CH_3COO^-$$

$$= (349.6 + 40.9)$$

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

Degree of dissociation:

$$\alpha = \frac{\Lambda^c_m}{\Lambda^\circ_m} = \frac{39.05}{390.5} \qquad \therefore \alpha = 0.1$$

(b) Electrochemical cell: It is a device which converts chemical energy into electrical energy i.e., produced as a result of redox reaction taking place in the electrolyte.

The reaction gets reversed and it becomes non-spontaneous. It starts acting as an electrolytic cell.

Question 83.

(a) Define the following :

(i) Molar conductivity (ii) Fuel cell

(b) The molar conductivity of a 1.5 M solution of an electrolyte is found to be 138.9 S cm^2 mol_{-1} Calculate the conductivity of the solution.

answer:

(a) (i) Molar conductivity Λ_m): Molar conductivity can be defined as the conductance of the volume V of electrolytic solution kept between two electrodes of a conducting cell at distance of unit length but having area of cross section large enough to accommodate sufficient volume of solution that contains one mole of the electrolyte. $\Lambda_m = KV$

(ii) Secondary batteries: Those cells which can be recharged on passing electric current through them in opposite direction and can be used again are called secondary batteries, e.g. Lead-acid storage cell.

(iii) Fuel cell : Galvanic cells that are designed to convert the chemical energy of combustion of fuels like hydrogen, methane etc. into electrical energy are called fuel cells, e.g. $H_2 - O_2$ fuel cell

(b) Λ_m = k×1000c S cm^2 mol_{-1}

138.9 = k×10001.5 k = 0.208 S cm^{-1}

Question 84.

(a) What are the two classifications of batteries? What is the difference between them?

(b) The resistance of 0.01 M NaCl solution at 25°C is 200 Ω. The cell constant of the conductivity cell is unity. Calculate the molar conductivity of the solution.

Answer:

(a) Two types of batteries are Primary batteries and Secondary batteries. Primary batteries are non-chargeable whereas secondary batteries are rechargeable.

$$(b)\ \Lambda_m = \frac{k \times 1000}{c}\ \text{S cm}^2\ \text{mol}^{-1}$$

$$k = \frac{1}{R}\left(\frac{l}{A}\right)$$

$$k = \frac{1}{200} \times 1\ \text{S cm}^{-1}$$

$$k = \frac{1}{200}\ \text{S cm}^{-1}$$

$$\Lambda_m = \frac{1 \times 1000}{200 \times 0.01}\ \text{S cm}^2\ \text{mol}^{-1}$$

$$\boldsymbol{\Lambda_m = 500\ \text{S cm}^2\ \text{mol}^{-1}}$$

Question 85.

(a) What are fuel cells? Give an example of a fuel cell.

(b) Calculate the equilibrium constant (log K_c) and $\Delta_r G°$ for the following reaction at 298 K. $Cu (s) + 2Ag^+ (aq) \rightleftharpoons Cu^{2+} (aq) + 2Ag (s)$

Given E^0_{cell} = 0.46 V and IF = 96500 C mol^{-1}

Answer:

(a) Cell which converts energy of combustion of fuel directly into electricity.

Example : $H_2 – O_2$ fuel cell.

Or

Those cells which convert fuel energy directly into electrical energy.

Example : $H_2 – O_2$ fuel cell

(b) $\log K_c = \frac{nE^0 cell}{0.059}$ $\quad \log K_c = \frac{2 \times 0.46V}{0.059}$

$\log K_c = \frac{0.92}{0.059}$ $\quad \log K_c = 15.59$

$\Delta_r G^0 = -nF\ E^0_{cell}$

$= -2 \times 96500\ C\ mol^{-1} \times 0.46\ V$

$= -88{,}780\ J\ mol^{-1}$ or $-88{,}78\ kJ\ mol^{-1}$

Question 86.

(a) When a bright silver object is placed in the solution of gold chloride, it acquires a golden tinge but nothing happens when it is placed in a solution of copper chloride. Explain this behaviour of silver.

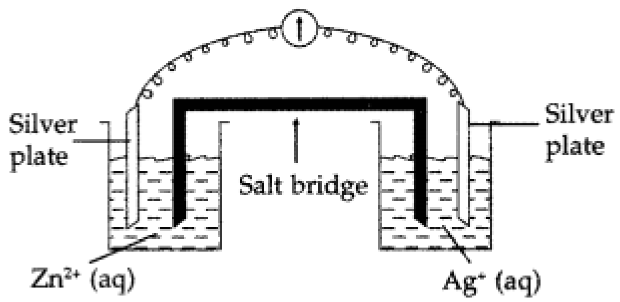
[Given : E^0Cu2+/Cu =+0.34V,E^0Ag+/Ag =+0.80V, E^0Au3+/Au = +1.40V]

(b) Consider the figure given and answer the following questions :

(i) What is the direction of flow of electrons?

(ii) Which is anode and which is cathode?

(iii) What will happen if the salt bridge is removed?



(iv) How will concentration of Zn2+ and Ag+ ions be affected when the cell functions?

(v) How will concentration of these ions be affected when the cell becomes dead? (

Answer:

(a) The standard electrode potential, E° for silver is 0.80 V and that of gold is 1.5 V, hence silver can displace gold from its solution. The replaced gold is deposited on silver object due to which golden tinge is obtained. On the other hand E° for Cu is 0.34 V which is lower than that of silver, thus silver cannot replace copper from its solution.

(b)

(i) Electrons flow from anode (Zinc plate) to cathode (Silver plate).

(ii) Zinc plate where oxidation occurs acts as anode and silver plate where reduction occurs acts as cathode.

(iii) If the salt bridge is removed then electrons from zinc electrode will flow to the silver electrode where they will neutralize some of Ag^+ ions and the SO2−4 ions will be left and the solution will acquire a negative charge. Secondly the Zn^{2+} ions from zinc plate will enter into $ZnSO_4$ solution producing positive charge. Thus due to accumulation of charges in two solutions, further flow of electrons will stop and hence the current stops flowing and the cell will stop functioning.

(iv) As silver from silver sulphate solution is deposited on the silver electrode and sulphate ions migrate to the other side, the concentration of $AgSO_4$ solution decreases and of $ZnSO_4$ solution increases as the cell operates.

(v) When the cell becomes dead, the concentration of these ions become equal due to attainment of equilibrium and zeros EMF.

Question 87.

(a) What is limiting molar conductivity? Why there is steep rise in the molar conductivity of weak electrolyte on dilution?

(b) Calculate the emf of the following cell at 298 K :

Mg (s) | Mg^{2+} (0.1 M) || Cu^{2+} (1.0×10^{-3}M) | Cu (s)

[Given = E0 Cell = 2.71 V].

Answer:

(a) The molar conductivity of a solution at infinite dilution is called limiting molar conductivity and is represented by the

symbol Λ°_m

There is steep rise in the molar conductivity of weak electrolyte on dilution because as the concentration of the weak electrolyte is reduced, more of it ionizes and thus increase in the number of ions in the solution.

(*b*) Mg (s) | Mg^{2+} (0.1 M) || Cu^{2+} (1.0×10^{-3} M) | Cu (s)

Given: $E^0_{Cell} = 2.71$ V

Applying Nernst equation

$$Mg + Cu^{2+} \longrightarrow Mg^{2+} + Cu$$

$$E_{Cell} = E^0_{Cell} - \frac{0.0591}{n} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$$

$$= 2.71 - \frac{0.0591}{2} \log \frac{0.1}{1 \times 10^{-3}}$$

$$= 2.71 - \frac{0.0591}{2} \log \frac{0.1}{0.001}$$

$$= 2.71 - 0.02955 \log 100$$

$$= 2.71 - 0.02955 \times 2$$

$$= 2.71 - 0.0591$$

$\therefore$ $\mathbf{E_{Cell} = 2.65\ V}$

****