One Two academy | Electro Chemistry

Maximum Mark: 25 **Chemistry** **Time: 50 minutes**

Choose the correct answer: **3 x 1 = 3**

1. The emf of standard Hydrogen Electrode (SHE) is

   a) -1 b) 0 c) 1.1 d) +1

2. The number of electrons that have a total charge of 9650 coulombs is

   a) 6.22×10^{23} b) 6.022×10^{24} c) 6.022×10^{22} c) 6.022×10^{-34}

3. Which of the following is secondary cell?

   a) Leclanche cell b) Lithium-ion battery
   c) Mercury button cell d) both (a) and (c)

Answer Any four of the following: **4 x 2 = 8**

4. Define Galvanic cell.
5. Define equivalent conductance
6. Why is AC current used instead of DC in measuring the electrolytic conductance?
7. Why does conductivity of a solution decrease on dilution of the solution?
8. Two metals M_1 and M_2 have reduction potential values of -xV and +yV respectively. Which will liberate H_2 and H_2SO_4.

Answer any three of the following: **3 x 3 = 9**

9. State Faraday's laws of electrolysis.
10. What is electrochemical series? How is it useful to predict corrosion?
11. State Kohlrausch Law. How is it useful to determine the molar conductivity of weak electrolyte at infinite dilution.
12. What are the factors affecting electrolytic conductance?

Answer the following: **1 x 5 = 5**

13. a) Derive an expression for Nerst Equation.

(Or)

b) 9.2×10^{12} litres of water is available in a lake. A power reactor using the electrolysis of water in the lake produces electricity at the rate of 2×10^6 Cs^{-1} at an appropriate voltage. How many years would it take to completely electrolyze the water in the lake. Assume that there is no loss of water except due to electrolysis.

All the Best

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Answer Key attached in the next page !!!

This page is to prevent seeing answer key

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Answer Key

Choose the Correct answer:

1. – b) 2. – c) 3. – c)

Answer any four of the following:

4. **Galvanic cell**: It is a device in which a spontaneous chemical reaction generates an electric current i.e., it converts chemical energy into electrical energy. It is commonly known as battery.
5. **Equivalent conductance:** Equivalent conductance is defined as the conductance of 'V' m3 of electrolytic solution containing one gram equivalent of electrolyte in a conductivity cell in which the electrodes are one metre apart.
6. In the measurement of specific resistance of a metallic wire, a DC power supply is used. Here, if we apply DC current through the conductivity cell, it will lead to the electrolysis of the solution taken in the cell. So, AC current is used for this measurement to prevent electrolysis.
7. Conductivity of a solution decrease with dilution because ions concentration decreases per unit volume and we know that ions are responsible for electrical conductivity.
8. Metals having higher oxidation potential will liberate H_2 from H_2SO_4. Hence, the metal M_1 having + xV, oxidation potential will liberate H_2 from H_2SO_4.

Answer any three of the following:

9. **Faraday's Laws of Electrolysis:**
   First Law: First Law The mass of the substance (m) liberated at an electrode during electrolysis is directly proportional to the quantity of charge (Q) passed through the cell.
   i.e. m α Q
   Second Law: When the same quantity of charge is passed through the solutions of different electrolytes, the amount of substances liberated at the respective electrodes are directly proportional to their electrochemical equivalents.
10. **Electrochemical series:**
    the standard single electrode potentials are measured using standard hydrogen electrode. The standard electrode potential at 298K for various metal - metal ion electrodes are arranged in the decreasing order of their standard reduction potential values. This series is called electrochemical series.
    The standard reduction potential (E^o) is a measure of the oxidising tendency of the species. The greater the E^o value, greater is the tendency shown by the species to accept electrons and undergo reduction. So higher the (E^o) Value, lesser is the tendency to undergo corrosion
11. **Kohlrausch Law:** At infinite dilution, the limiting molar conductivity of an electrolyte is equal to the sum of the limiting molar conductivities of its constituent ions.
    For example, the molar conductance of CH_3COOH, can be calculated using the experimentally determined molar conductivities of strong electrolytes HCl, NaCl and CH_3COONa.

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$$\Lambda^{o}_{CH_3COONa} = \lambda^{o}_{Na^+} + \lambda^{o}_{CH_3COO^-} \quad .....(1)$$

$$\Lambda^{o}_{HCl} = \lambda^{o}_{H^+} + \lambda^{o}_{Cl^-} \quad .....(2)$$

$$\Lambda^{o}_{NaCl} = \lambda^{o}_{Na^+} + \lambda^{o}_{Cl^-} \quad .....(3)$$

Equation (1) + Equation (2) – Equation (3) gives,

$$\left(\Lambda^{o}_{CH_3COONa}\right) + \left(\Lambda^{o}_{HCl}\right) - \left(\Lambda^{o}_{NaCl}\right) = \lambda^{o}_{H^+} + \lambda^{o}_{CH_3COO^-}$$

$$= \Lambda^{o}_{CH_3COOH}$$

12. **Factors affecting electrolytic conductance:**

If the interionic attraction between the oppositely charged ions of solutes increases, the conductance will decrease.

- Solvent of higher dielectric constant show high conductance in solution.
- Conductance is inversely proportional to the Viscosity of the medium. i.e., conductivity increases with the decrease in viscosity.
- If the temperature of the electrolytic solution increases, conductance also increases. Increase in temperature increases the kinetic energy of the ions and decreases the attractive force between the oppositely charged ions and hence conductivity increases.

Molar conductance of a solution increases with increase in dilution. This is because, for a strong electrolyte, interionic forces of attraction decrease with dilution. For a weak electrolyte, degree of dissociation increases with dilution.

Answer the following:

13. a) **Nerst Equation**:

Nernst equation is the one which relates the cell potential and the concentration of the species involved in an electrochemical reaction. Let us consider an electrochemical cell for which the overall redox reaction is,

$$xA + yB \rightleftharpoons lC + mD$$

The reaction quotient Q for the above reaction is given below

$$Q = \frac{[C]^l\ [D]^m}{[A]^x\ [B]^y} \quad \ldots(1)$$

We have already learnt that,

$$\Delta G = \Delta G^{\circ} + RT \ln Q \quad \ldots(2)$$

The Gibbs free energy can be related to the cell emf

$\Delta G = -nFE_{cell}$; $\Delta G^{o} = -nFE^{o}_{cell}$

Substitute these values and Q from (1) in the equation (2)

$$\Rightarrow -nFE_{cell} = -nFE^{o}_{cell} + RT \ln \frac{[C]^l[D]^m}{[A]^x\ [B]^y} \quad \ldots(3)$$

Divide the whole equation (3) by (-nF)

$$\Rightarrow E_{cell} = E^{\circ}_{cell} - \frac{RT}{nF} \ln \frac{[C]^l[D]^m}{[A]^x\ [B]^y}$$

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(or) $E_{cell} = E^{\circ}_{cell} - \frac{2.303RT}{nF} \log \frac{[C]^l[D]^m}{[A]^x\ [B]^y}$ …(4)

The above equation (4) is called the Nernst equation At 25° C (298K), the above equation (4) becomes,

$$E_{cell} = E^{o}_{cell} - \frac{2.303 \times 8.314 \times 298}{n(96500)} \log \frac{[C]^l[D]^m}{[A]^x\ [B]^y}$$

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log \frac{[C]^l[D]^m}{[A]^x\ [B]^y} \qquad \left[\begin{array}{l} \therefore\ R = 8.314\ JK^{-1}\ mol^{-1} \\ T = 298\ K. \\ 1\ F = 96500\ C\ mol^{-1} \end{array}\right]$$

(Or)

b)

Electrolysis of water

At anode:

$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$.....(1)

At cathode:

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Overall reaction $6H_2O \rightarrow 4H^+ + 4OH^- + 2H_2 + O_2$

(or)

Equation (1) +(2) ×2 $\Rightarrow 2H_2O \rightarrow 2H_2 + O_2$

∴ According to faradays Law of electrolysis, to electrolyse two mole of Water $(36g \simeq 36\ mL\ of\ H_2O)$, 4F charge is required alternatively, when 36 mL of water is electrolysed, the charge generated = $4 \times 96500\ C$.

∴ When the whole water which is available on the lake is completely electrolysed the amount of charge generated is equal to $\frac{4 \times 96500\ C}{36\ mL} \times 9 \times 10^{12} L$

$$= \frac{4 \times 96500 \times 9 \times 10^{12}}{36 \times 10^{-3}} C$$

$$= 96500 \times 10^{15}\ C$$

∴ Given that in 1 second, $2 \times 10^6\ C$ is generated therefore, the time required to generate $96500 \times 10^{15}\ C$ is $= \frac{1\ S}{2 \times 10^6 C} \times 96500 \times 10^{15} C$

$$= 48250 \times 10^9\ S$$

∴ Number of years $= \frac{48250 \times 10^9}{365 \times 24 \times 60 \times 60}$

$= 1.5299 \times 10^6$ years

1 year = 365 days

$= 365 \times 24$ hours

$= 365 \times 24 \times 60$ min

$= 365 \times 24 \times 60 \times 60$ sec.