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Internal Assessment Test 1 – May 2025

Sub:	Applied Chemistry for CSE Stream				Sub Code:	BCHES202	Branch:	ISE, CSE (ML), AIML & AIDS		
Date:	05-05-2025	Duration:	90 min's	Max Marks:	50	Sem / Sec:	II / A, B, C, D, E, F, G & H			OBE
<u>Question no. 1 is COMPULSORY and answer any THREE FULL Questions from the rest.</u>								MARKS	CO	RBT
1 (a)	Define corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.							[7]	CO3	L3
(b)	What are photovoltaic cells? Explain construction and working of PV cells and mention its 2 disadvantages.							[7]	CO2	L2
2 (a)	What are reference electrodes? Describe the construction and working of calomel electrode. Mention its 2 applications.							[6]	CO3	L2
(b)	Explain the theory, instrumentation and applications of potentiometry by taking estimation of iron as an example.							[6]	CO4	L2
3 (a)	Define corrosion penetration rate (CPR). A thick steel sheet of area 650 cm ² is exposed to air near the ocean. After 6 months it was found to experience a weight loss of 385 gm due to corrosion. Calculate CPR in mpy and mmy. [Density of the metal is 7.9 gm/cm ³ , K(mpy) = 534 and K (mm/y) = 87.6].							[6]	CO3	L3
(b)	Identify and explain the types of corrosion taking place in following case							[6]	CO3	L3
	(i) A steel nut connected to copper bolt.									
	(ii) Uneven deposition of dust over the metal surface									

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4 (a)	Explain the conduction mechanism in polyacetylene. Mention its commercial applications.	[6]	CO1	L3
(b)	Define battery. Describe construction, working and applications of Li -ion battery.	[6]	CO3	L2
5(a)	What are ion selective electrodes? Explain determination of pH of solution using glass electrode and mention its 2 applications.	[6]	CO3	L2
(b)	What is galvanisation? Discuss the process of galvanisation and mention its applications.	[6]	CO3	L1
6 (a)	Define concentration cell. The EMF of concentration cell, constructed by combining two lithium rods immersed in lithium sulphate solution is 0.220 V at 25 °C. If concentration of anodic compartment is 0.006 M. Calculate the concentration of cathodic compartment. Represent the cell and write the cell reaction	[6]	CO3	L3
(b)	What are green fuels? Explain the generation of hydrogen using alkaline water electrolysis method.	[6]	CO2	L2
7 (a)	In a polymer sample, 20% of molecules have molecular mass of 15000 g/mol, 35% molecules have molecular mass of 20000 g/mol, and remaining molecules have molecular mass of 25000 g /mol, calculate the number average and weight average molecular mass of the polymer. Calculate its PDI and comment on it.	[6]	CO1	L2
(b)	Describe preparation, properties and commercial application of Kevlar.	[6]	CO1	L2

(Chief Course Instructor)

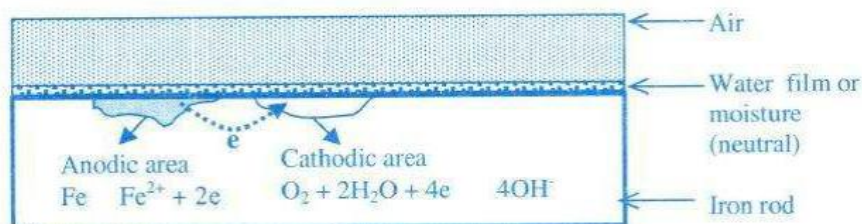
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1.a. Answer:

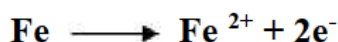
Destruction of metal surface in surrounding environment due to chemical or electrochemical reaction is known as corrosion. E.g., rusting of iron.

Electrochemical theory of corrosion:



(i) According to electrochemical theory, corrosion of metals takes place due to the formation of minute galvanic cells over the surface of metal. Thus anodic and cathodic regions are formed on the same metal surface or when two metals are in contact with each other in the presence of a conducting medium.

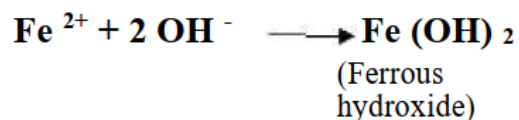
(ii) At the anodic region oxidation reaction takes place and the metal gets converted into its ions by liberating electrons. Consequently, metal undergoes corrosion at the anodic region.



(iii) The electrons flow from the anodic to cathodic area and at the cathodic region, reduction takes place. Since metal cannot be reduced further, metal atoms at the cathodic region are unaffected by the cathodic reaction. Some constituents of the corrosion medium take part in the cathodic reaction. There are three possible ways in which the reduction can take place.

- If the solution is aerated and almost neutral,
 - $\text{O}_2 + \text{H}_2\text{O} + 2e^- \longrightarrow 2\text{OH}^-$
- If the solution is deaerated and almost neutral:
$$2\text{H}_2\text{O} + 2e^- \longrightarrow \text{H}_2 + 2\text{OH}^-$$
- If the solution is deaerated and acidic:
$$2\text{H}^+ + 2e^- \longrightarrow \text{H}_2 \uparrow$$

(iv) Corrosion of iron produced Fe^{2+} ions and OH^- ions at the anode and cathode sites respectively. These ions diffuse towards each other and produce insoluble $\text{Fe}(\text{OH})_2$.



(v) In an oxidizing environment, it is oxidized to ferric oxide and the rust is hydrated ferric oxide.

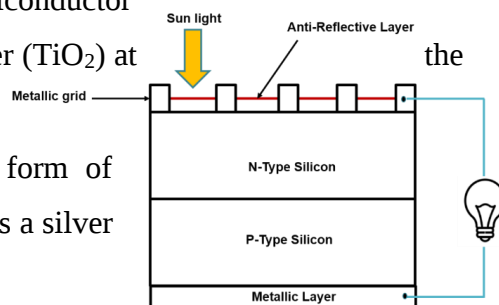


1.b. Answer:

The device, which converts solar energy into electrical energy, is called photovoltaic cell and the phenomenon is called photovoltaic effect.

Construction:

- Photovoltaic Cells consists of p-n junction semiconductor diode made of silicon coated with anti-reflective layer (TiO_2) at top.
- Two electrical contacts are provided, one in the form of metallic grid at the top of the junction and the other is a silver layer at the bottom of the cell
- The antireflective layer coated in between the metallic grids which allow light to fall on the semiconductor.



Working of photovoltaic cell:

- Electromagnetic radiation consists of particles called photons ($h\nu$). They carry a certain amount of energy given by the Plank quantum equation. $E = hc/\lambda$

Where, h = Planck's constant, c = velocity of light, λ = wavelength of the radiation

- The photons of solar radiations enter **n-type** semiconductor breaks barrier potential and moves to **p-type** semiconductor where photons knock the electrons in p-type to form electron-hole pair.
- The free electrons so formed will travels through the circuit from **n-type** and recombines with holes again in the **p-type** region.
- The movement of electrons from n-type to p-type generates electric current. The electrical energy produced by the solar cell is used for various applications

Advantages of PV cells:

- It is unlimited, inexhaustible and renewable source of energy.
- The solar cell operates reliably for a long period of time with no maintenance.
- Easy to operate

Disadvantages of PV cells:

- High installation cost.
- Energy can be produced only during the day-time.
- The efficiency of solar cells depends on climate.

2. a Answer:

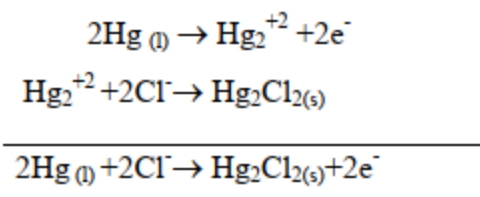
The electrodes whose potentials is known and constant and they are used to determine the potential of another unknown electrode are known as reference electrodes.

Construction and working of calomel electrodes:

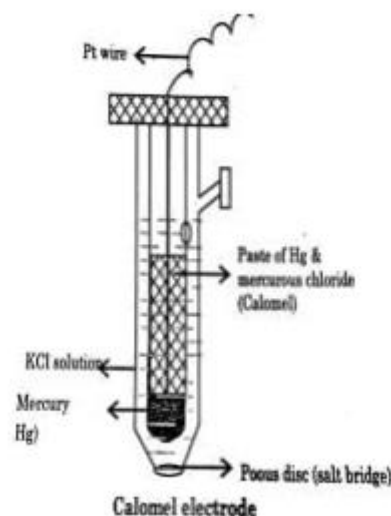
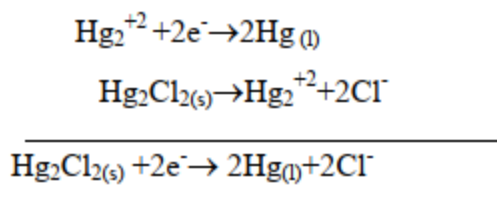
- The calomel electrode consists of two glass tube.
- At the inside glass tube, there is a paste (calomel) of mercury and mercurous chloride (Hg_2Cl_2) at the bottom of a narrow glass tube.
- Pure mercury is filled below the paste and connected with platinum wire for external electrical contact
- This narrow tube placed inside an outer glass tube filled with a saturated KCl solution.

Cell representation: $\text{Hg(s)}/\text{Hg}_2\text{Cl}_2 \text{ (paste)};\text{Cl}^-$

If the electrode behaves as anode, the electrode reaction is:



If the electrode behaves as cathode, the electrode reaction is:



The electrode potential of calomel electrode depends on concentration of chloride ions. For saturated KCl $E=0.2422\text{V}$ (called Saturated calomel electrode)

Applications:

1. It is used as a secondary reference electrode to measure single electrode potentials.
2. It is used in potentiometric analysis.

2.b Answer:

Aim: Determination of the weight of ferrous ammonium sulphate and ferrous iron in the given solution by potentiometric titration method.

Theory: In this titration the amount of substance in the solution is determined by measuring the emf between two electrodes that are dipped into the solution. When the metal M is immersed in the solution containing its own ions M^{n+} ions, the electrode potential is given by Nernst equation,

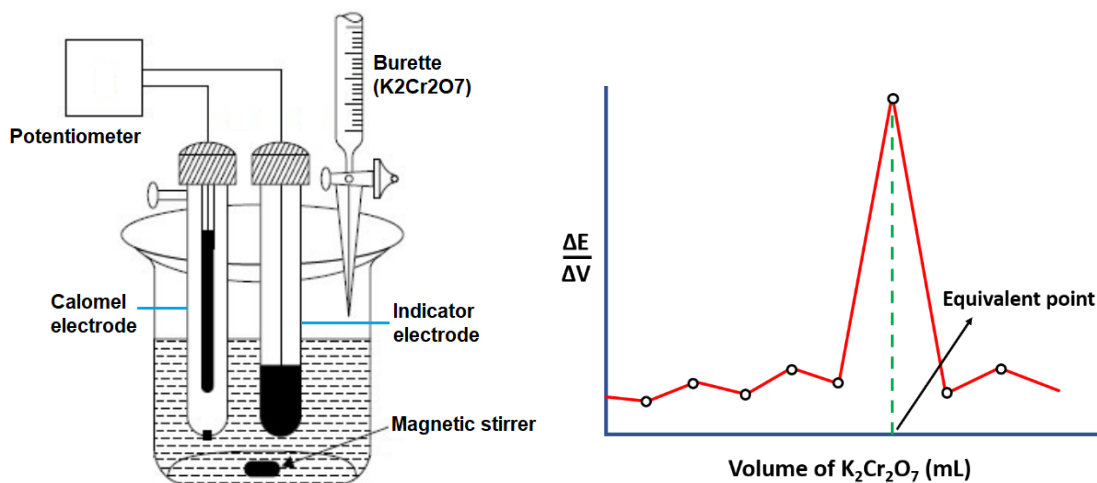
$$E_{\text{cell}} = E^\circ + \frac{0.0591}{n} \log [\text{M}^{n+}]$$

From this equation the potential of the electrode is directly proportional to the concentration of the ionic species present in the solution.

Instrumentation:

A potentiometer consists of an indicator electrode (e.g.: Platinum) and a saturated reference electrode (E.g.: Calomel electrode), stirrer & potentiometer to measure the potential values.

EMF of the solution can be measured by combining the reference electrode with an indicator electrode. The electrode which responds to the change in the concentration of the ion in the solution is called indicator electrode & reference electrode is one whose potential is constant. A known volume of the analyte is taken in beaker and its potential is measured. The titrant is added in increments of 0.5 ml and potential is measured each time. Near the equivalence point there is a sharp increase in the potential. The end point is determined by plotting change in potential against volume of the titrant.



Applications

1. Estimation of the concentration of the ionic species present in the given solution.
2. Coloured solution can also be titrated
3. Acid-base titration can also be done in this method.
4. In this method Oxidation-reduction titrations can also be carried out.
5. Precipitation reactions can also be carried out potentiometrically.

For example:

Procedure: Pipette out 25 cm^3 of FAS solution into a 50 cm^3 beaker. Add one test tube full of dil H_2SO_4 . Immerse Platinum. & calomel electrodes into the solution, & connect the electrodes to a potentiometer. Fill the burette with $K_2Cr_2O_7$ solution. Add $K_2Cr_2O_7$ solution from the burette with increment of 0.5 cm^3 , stir well and measure the potential after each addition. Continue the titration till the potential indicates a rapid jump with a drop of titrant. Plot the graph of $\Delta E / \Delta V$ v/s vol. of $K_2Cr_2O_7$.

3.a. Answer:

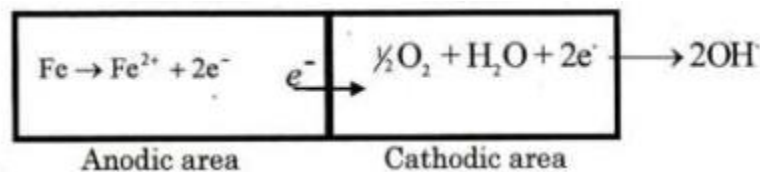
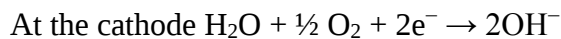
Corrosion Penetration Rate (CPR) is defined in three ways: (1) the speed at which any metal in a specific environment deteriorates due to a chemical reaction in the metal when it is

exposed to a corrosive environment, (2) the amount of corrosion lost per year in thickness, (3) the speed at which corrosion spreads to the inner portions of a material.

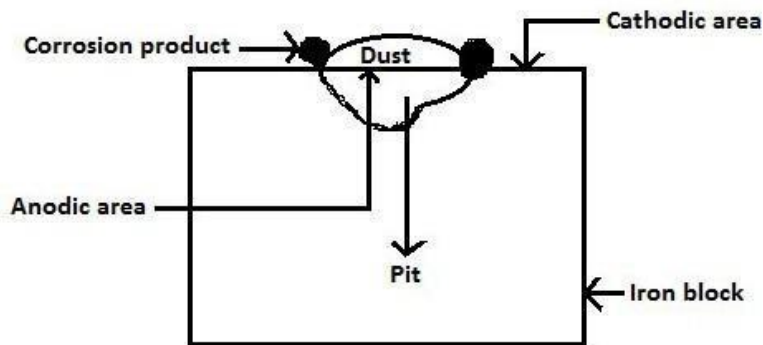
Corrosion penetrating rate in mpy $CPR = KW/DAT$ Weight loss, $W = 385 \times 10^3 \text{ mg}$ Density, $D = 7.9 \text{ g/cm}^3$; Time, $T = 6 \times 24 \times 30$ Area $A = 650/6.45 = 100.7752 \text{ inch}^2$ $CPR = \frac{534 \times 385 \times 10^3}{7.9 \times 100.7752 \times 4320}$ $CPR = 59.77 \text{ mpy}$	Corrosion penetrating rate in mm/y $CPR = KW/DAT$ Weight loss, $W = 385 \times 10^3 \text{ mg}$ Density, $D = 7.9 \text{ g/cm}^3$; Time, $T = 6 \times 24 \times 30$ Area $A = 650 \text{ cm}^2$ $CPR = \frac{87.6 \times 385 \times 10^3}{7.9 \times 650 \times 4320}$ $CPR = 1.52 \text{ mm/y}$
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3.b Answer:

(i) Type of corrosion is “**Differential metal corrosion**”, this occurs when two dissimilar metals are in contact with each other in a corrosive conductive medium; a potential difference is set up resulting in a galvanic current. The metal with lower electrode potential or more active metal acts as anode and the metal with higher electrode potential acts as cathode. The anodic metal undergoes corrosion whereas cathodic metal gets unattacked. In the given example steel act as a anode and tin act as a cathode and its reaction are as follows,



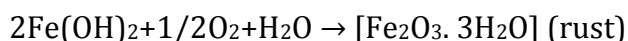
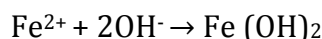
(ii) Type of corrosion is “**Pitting corrosion**”. It arises when a small portion of the metallic surface is covered by dust or scale or oil drops. The metal below the dust which is exposed to **lower concentration** of oxygen acts as anodic area. In the presence of suitable corrosive environment metal is lost at that place a pit is formed. The whole remaining part of the metal which is exposed to higher concentration of oxygen acts as cathodic area and remains unaffected. Once a pit is formed corrosion occurs rapidly because of small anodic area (pit) and large cathodic area.



Cell Reaction:

At the anode (less O_2 concentration): $Fe \rightarrow Fe^{2+} + 2e^-$

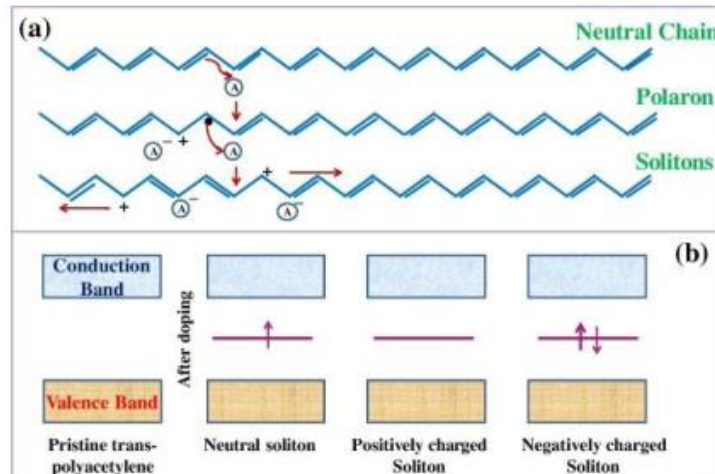
At the cathode (more O_2 concentration): $O_2 + 2 H_2O + 4e^- \rightarrow 4 OH^-$



4.a Answer:

Mechanism of Conduction: (Oxidative doping (p-doping))

- i. When the **oxidative dopant** such as iodine is added, it takes away an electrons from the π -back bone of the polyyacetylene chain and creates a positive centre (hole) on one of the carbon.
- ii. The other π -electron resides on the other carbon making it a radical. The radical ion formed is called Polaron. A dipolar on (soliton) is formed on further oxidation.
- iii. These radicals migrate and combine to establish a backbone double bond. As the two electrons are removed, the chain will have two positive centre (holes).
- iv. The chain as a whole is neutral, but holes are mobile and when a potential is applied the migrate from one chain as a whole is neutral but holes are mobile and when a potential is applied they migrate from one carbon to another and account for conductivity. This depicted by the sequence of reaction.



Application

- Non-volatile memory devices based on organic transistors.
- Fabrication of organic photovoltaic cells.
- Fabrication of organic light-emitting devices (OLED).
- Conducting polymer actuators and Micropumps.

4.b Answer:

Battery is a device that converts chemical energy directly into electrical energy via electrochemical oxidation and reduction reaction

Construction

Anode: Lithium intercalated graphite layer (Li_xC_6)

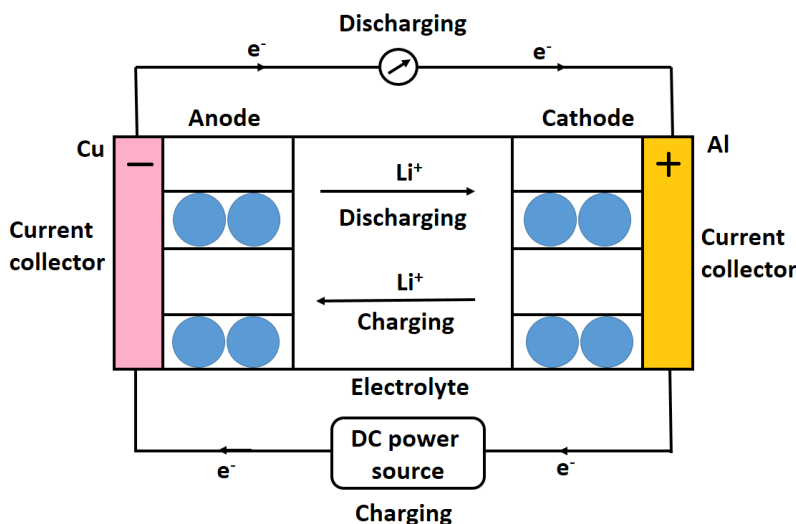
Anode current collector: Copper foil

Cathode: Partially lithiated transition metal oxide (LiCoO_2)

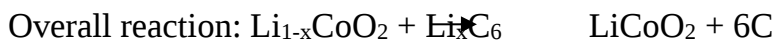
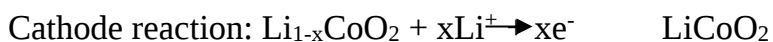
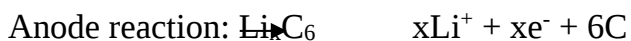
Cathode current collector: Aluminum foil

Electrolyte: Lithium salts like LiCl , LiBr dissolved in propylene carbonate

Separator: Polyolefin polymer



Working



During **discharge**, Li^+ ions are dissociated from the anode and then migrate from the anode to cathode through the electrolyte. Electrons travel through an external circuit. This process creates an electric current that can power a device or system.

During **Charging**: Li^+ ions move from the cathode to the anode through the electrolyte.

Application of Lithium-ion battery

- They are commonly used in smart phones, tablets, laptops
- They are used in medical devices
- They are used in spacecraft and satellites
- They are used in electric cars.

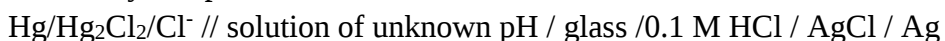
5.a Answer:

The ion-selective electrode generally consists of a membrane that selectively responds to a specific ion in a mixture of ions in solutions that ignore all other ions and develop a potential.

Determination of pH using glass electrode

The potential of a glass electrode depends on the concentration of H^+ ions. Hence, pH of a solution can be determined by using glass electrode and calomel electrode assembly.

The cell assembly is represented as:

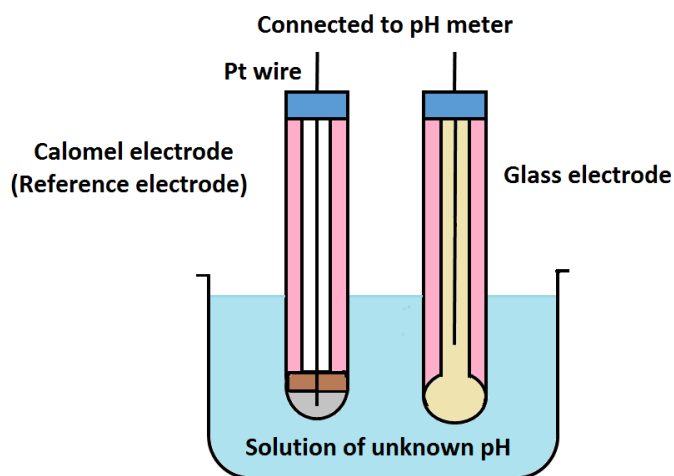


E_{cell} is the difference between glass electrode potential E_G and the calomel electrode potential E_{cal} .

$$\begin{aligned} E_{\text{cell}} &= E_{\text{Cathode}} - E_{\text{Anode}} \\ &= E_G - E_{\text{Cal}} \\ &= L_1 - 0.0591 \text{ pH} - E_{\text{Cal}} \end{aligned}$$

$$\text{pH} = \frac{K - E_{\text{cell}}}{0.0591}$$

Where K is electrode assembly constant, $K = L_1 - E_{\text{cal}}$

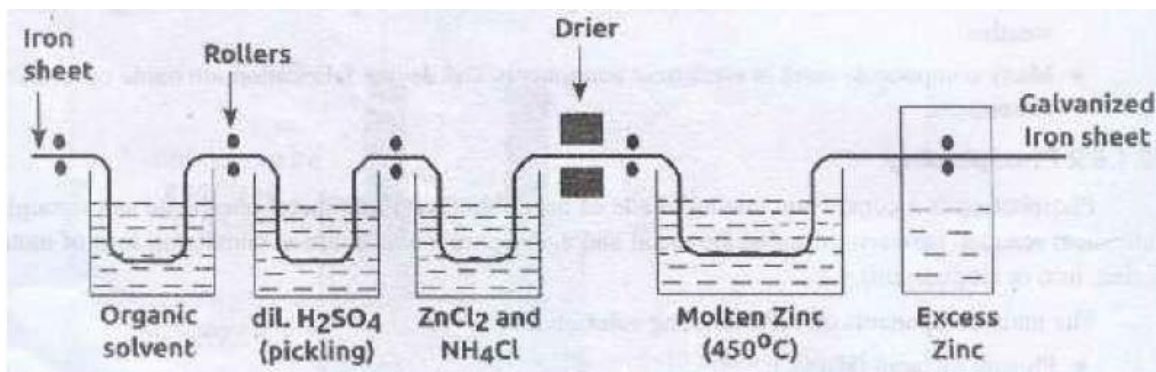


Applications:

1. This electrode can be used to determine PH in the range 1-9, with special type of glass even up to 12 can be calculated.
2. It can be used even in the case of strong oxidising agents.

5.b. Answer:

Galvanisation is a process of coating a base metal surface with Zinc metal. Galvanisation is carried out by hot dipping method.



The galvanization process involves the following steps.

1. The metal surface is washed with organic solvents to remove organic matter on the surface.
2. Rust and other deposits are removed by washing with dilute sulphuric acid.
3. Finally the article is well washed with water and air-dried.
4. The article is then dipped in a bath of molten zinc, maintained at 425 – 430°C and covered with a flux of ammonium chloride to prevent the oxidation of molten Zinc.
5. The excess Zinc on the surface is removed by passing through a pair of hot rollers, which wipes out excess of Zinc coating and produces a thin coating.

Applications:

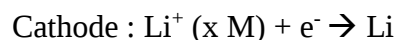
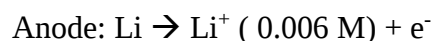
Galvanization is used to protect roofing sheets, water pipes, barbed wire, buckets etc. Galvanised articles are not used for preparing and storing foodstuffs, since zinc dissolves in dilute acids producing toxic zinc compounds.

6.a Answer:

The concentration cells consist of identical electrodes immersed in the solutions of the same electrolytes but with varying concentrations. Potential difference arises due to difference in electrolyte concentration.

Cell representation: $\text{Li}/\text{Li}^+ (0.006\text{M}) // \text{Li}^+ (x \text{ M})/\text{Li}$

Cell reaction:



Under the given condition (T=25°C)

$$E_{\text{cell}} = 0.0591/n \log [C_2/C_1]$$

Where C_2 = Concentration of electrolyte at cathodic compartment = $x \text{ M}$

C_1 = Concentration of electrolyte at anodic compartment = 0.006 M

$n = 1$

Substituting the above values in above formula,

$$0.220 = 0.0591/1 [\log x/0.006]$$

$$0.220 = 0.0591 [\log x - \log (0.006)]$$

$$0.220 / 0.0591 = \log (x) + 2.2218$$

$$3.7225 - 2.2218 = \log (x)$$

$$x = \text{Antilog} (1.5)$$

$$x = 31.623 \text{ M}$$

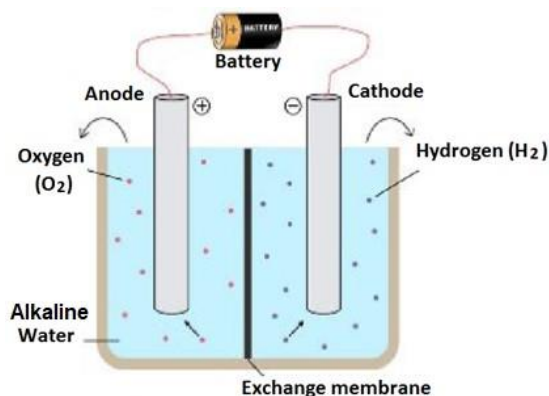
6.b Answer:

Green fuels are energy sources that can be used as substitutes for traditional fuels, such as diesel and natural gas. Due to lower carbon emissions green fuels are considered more environmentally friendly.

Example: Biodiesel, hydrogen gas, and solar power.

Alkaline Water Electrolysis

- It consists of two electrodes i.e. anode and cathode.
- Both electrodes are made up of Ni based metal, because it is more stable during the oxygen evolution.
- These electrodes are immersed in KOH solution (25-35%).
- Both electrodes are separated by porous diaphragm prevent gases crossover and allows only hydroxide ions.
- When electricity is passed, at anode hydroxide ions lose electrons and forms water molecules.
- At cathode, water molecules accept electrons and liberate hydrogen gas and forms hydroxide ions.
- These hydroxide ions move from cathode to anode through diaphragm and process continues.



Anode Reaction (Oxidation process): $4 \text{OH}^- (\text{aq}) \rightarrow \text{O}_2 (\text{g}) + 2\text{H}_2\text{O} + 4 \text{e}^-$

Cathode Reaction (Reduction process): $4 \text{H}_2\text{O} + 4 \text{e}^- \rightarrow 2\text{H}_2 (\text{g}) + 4 \text{OH}^- (\text{aq})$

Overall cell reaction: $2\text{H}_2\text{O} (\text{aq}) \rightarrow 2\text{H}_2 (\text{g}) + \text{O}_2 (\text{g})$

Advantages

- Well established technology
- Low cost technology
- The energy efficiency is 70–80%
- Commercialized

7.a. Answer:

Number average molecular mass:

$$\text{Total weight} = (20 \times 15000) + (35 \times 20000) + (45 \times 25000) = 300000 + 700000 + 1125000 = 2125000$$

$$\text{Total number} = 20 + 35 + 45 = 100$$

$$M_n = \frac{\sum M_i N_i}{\sum N_i} \quad M_n = 2125000 / 100 = \mathbf{21250 \text{ g/mol}}$$

Weight average molecular mass:

$$M_w = \frac{\sum N_i (M_i)^2}{\sum N_i M_i}$$

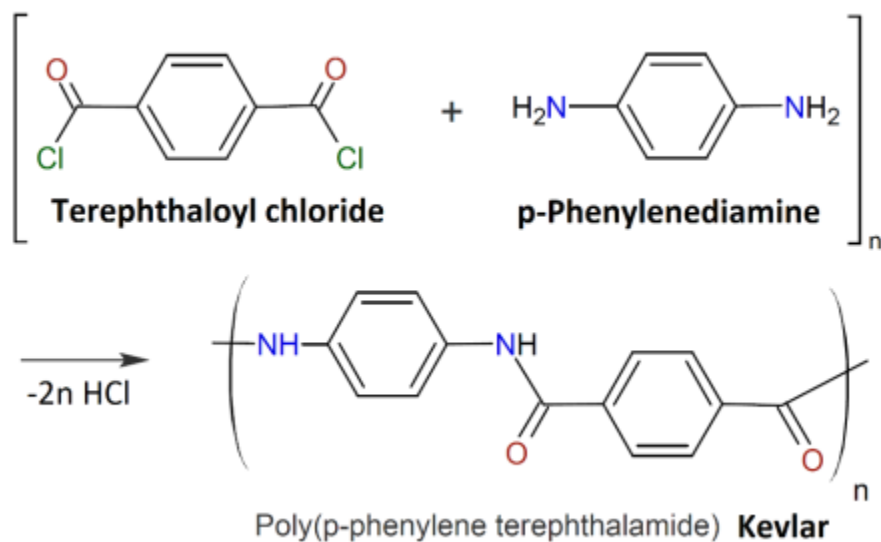
$$M_w = \frac{\{[20 \times (15000)^2] + [35 \times (20000)^2] + [45 \times (25000)^2]\}}{2125000}$$

$$M_w = \mathbf{21941.17 \text{ g/mol}}$$

7.b Answer:

Preparation of Kevlar

Kevlar is prepared by polycondensation between aromatic dichloride like terephthaloyl acid chloride and aromatic diamines like p-phenylenediamine.



Properties of Kevlar

1. It is exceptionally strong, 5 times stronger than steel and 10 times stronger than aluminium.
2. It is thermally stable up to 450°C.
3. It is also stable at very low temperatures (up to -196°C)
4. Kevlar can resist attacks from many different chemicals

Applications

1. Kevlar is widely used in the production of bulletproof vests, military helmets and body armour.
2. Kevlar is used in protective clothing for military personnel, law enforcement officers and firefighters.
3. Kevlar is used in various industrial applications, such as conveyor belts, hoses, and gaskets
4. Kevlar is employed in the aerospace and aviation industries for its lightweight properties and ability to withstand high temperatures.