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CMR INSTITUTE OF TECHNOLOGY, BENGALURU.
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Internal Assessment Test 1 – Jan 2023

Sub:	Applied Chemistry					Sub Code:	22CHES12	Branch:	CSE & CSE(DS)
Date:	20-01-2023	Duration:	90 min's	Max Marks:	50	Sem / Sec:	I / I,J, K & L		OBE

Question no. 1 is COMPULSORY and answer any THREE FULL Questions from the rest.

		MARKS	CO	RBT
1	(a) What are photovoltaic cells? Explain construction and working of PV cells with its advantages and disadvantages.	[7]	CO2	L3
	(b) Define corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.	[7]	CO3	L3
2	(a) Explain in detail the type of corrosion which takes place when iron is in contact with Cu. Support your answer with suitable diagram and reactions:	[6]	CO3	L3
	(b) Define galvanization. Discuss the process of galvanization with suitable diagram.	[6]	CO3	L2
3	(a) What are reference electrodes? Describe the construction and working of a calomel electrode.	[6]	CO3	L2
	(b) Define corrosion penetration rate. A thick steel sheet of area 60 $inch^2$ is exposed to air near the ocean and after 6 year it was found to experience a weight loss pf 455 gm due to corrosion. If the density of the metal is 7.9 gm/cm^3 calculate CPR in mpy and mmy. Given K(mpy) = 534 and K (mm/y) = 87.6.	[6]	CO3	L3
4	(a) Explain the theory, instrumentation and applications of potentiometry.	[6]	CO4	L3
	(b) What are concentration cell? The cell potential of copper concentration cell $Cu/CuSO_4(0.005M)//CuSO_4(xM)/Cu$ is 0.0295 at 30℃. Calculate the value of x and write the cell reactions. Given R = 8.314 J/mol·K and F = 96500 C/mole	[6]	CO3	L3
5	(a) What are ion selective electrodes? Explain the construction, working and applications of glass electrode.	[6]	CO3	L3
	(b) Explain the theory, instrumentation and applications of conductometry.	[6]	CO4	L3
6	(a) What are conducting polymers? Explain the preparation and conducting mechanism of polyacetylene. Mention its commercial applications.	[6]	CO1	L3
	(b) Describe the preparation, properties and commercial application of kevlar.	[6]	CO1	L2
7	(a) In a polymer sample, 20% of molecules have molecular mass of 15000 g/mol, 35% molecules have molecular mass of 25000 g/mol, and remaining molecules have molecular mass of 20000 g /mol, calculate the number average and weight average molecular masses of the polymer.	[6]	CO1	L3
	(b) Explain the electrolysis of water with neat diagram and mention any 4 advantages.	[6]	CO2	L3

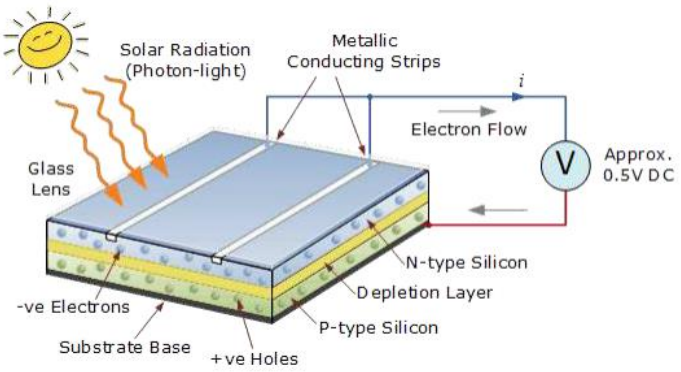
1.a. What are photovoltaic cells? Explain construction and working of PV cells with its advantages and Disadvantages.

Answer:

Photovoltaic cells or solar cells are semiconductor device that converts sunlight into direct current (DC) electricity. As long as light is shining on the solar cell, it generates electrical power. When light stops, electricity stops.

Construction:

Photovoltaic cells consist of a semiconductor diode (p-n junction) made of a silicon. Silicon wafer or very thin silicon slices are made by silicon blocks and they are doped by p-type and n-type dopants to make p-n junction. It has two electrical contacts, on one of its sides, a metallic grid is used and on the other side a layer of noble metal (such as Ag) is used. The metal grid permits the light to fall on the diode between the grid lines. The part between the metallic grid is coated with antireflective compound. eg TiO_2



Working:

Electromagnetic radiation consists of particle called photon ($h\nu$). They carry 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 electromagnetic radiation (sunlight) falls normal to the plane of the solar cell, the photons which possess energy sufficient to overcome the barrier potential are absorbed, electrons are ejected and electron-hole pairs are formed. The electrons move towards the n-region (as it is positively charged). The electrons are driven into the external circuit and used for various applications or appliances.

Applications of PV cells:

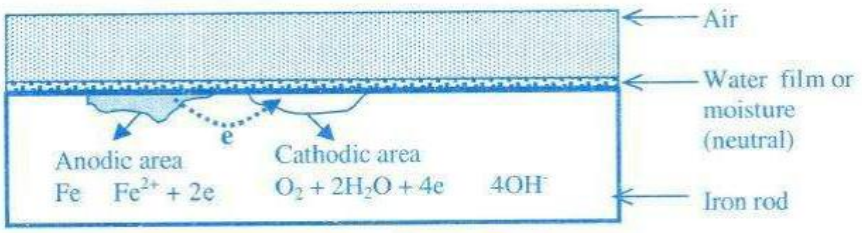
(i) For producing electricity
(ii) In space stations and artificial satellites.
(iii) In Street light in rural and remote areas.
(iv) Solar Cell for Transportation: used in electric vehicles
(v) For operating water pumps for domestic and agricultural purpose.
(vi) For toys, watches, calculators solar water heaters etc.

1.b Define corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.

Answer:

Destruction of metal surface in surrounding environment due to chemical or electrochemical reaction is known as corrosion. eg 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.

$$Fe \longrightarrow Fe^{2+} + 2e^-$$

(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 constitutions 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,
  - $O_2 + H_2O + 2e^- \longrightarrow 2OH^-$
- If the solution is deaerated and almost neutral:

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

- If the solution is deaerated and acidic:

$$2H^+ + 2e^- \longrightarrow H_2 \uparrow$$

(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 $Fe(OH)_2$.

$$Fe^{2+} + 2\,OH^- \longrightarrow Fe(OH)_2$$

(Ferrous hydroxide)

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

$$2Fe(OH)_2 + 1/2O_2 + H_2O \longrightarrow [Fe_2O_3.3H_2O]\ [Rust]$$

2.a Explain in detail the type of corrosion which takes place when iron is in contact with Cu. Support your answer with suitable diagram and reactions.

Answer:

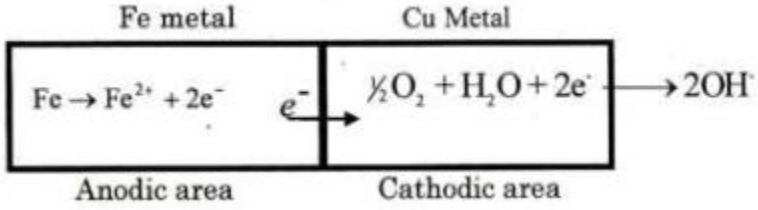
Differential metal corrosion: Galvanic corrosion or differential metal corrosion: This occurs when two dissimilar metals are in contact with each other in a corrosive conductive medium; a potential difference is set up resulting in a galvanic current. The two metals differ in their tendencies to undergo oxidation. The metal with lower electrode potential or more active metal acts as anode and the metal with higher electrode potential acts as cathode. The potential difference is main factor for corrosion to take place. The anodic metal undergoes corrosion whereas cathodic metal gets unattacked. Example: When iron contact with copper iron has lower electrode potential acts as anode and undergoes oxidation as,

At the anode $Fe \rightarrow Fe^{2+} + 2e^-$

At the cathode $H_2O + ½\ O_2 + 2e^- \rightarrow 2OH^-$

Whereas copper which is having higher electrode potential acts as cathode gets unaffected. The rate of galvanic corrosion depends upon potential difference between anodic and cathodic

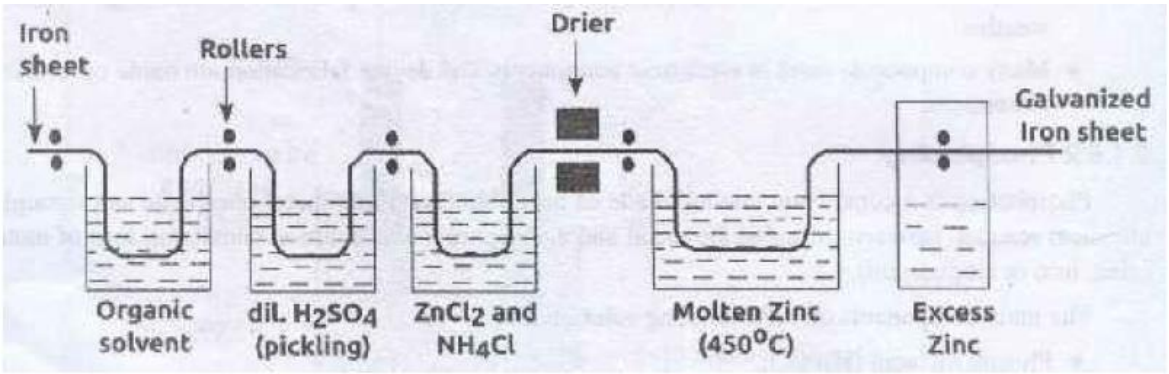
metals, ratio of anodic and cathodic area and environmental factors and tendency of the metal to undergo passivity etc.



2.b Define galvanization. Discuss the process of galvanization with suitable diagram.

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.

3.a What are reference electrodes? Describe the construction and working of a calomel electrode.

Answer:

Reference Electrodes: 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:

It is a metal-insoluble salt electrode, where metal in contact with its insoluble salt and the solution contains the anion of the salt. Mercury is placed at the bottom of the glass tube above which a paste of mercury and mercurous chloride are present. It is filled on the top with the saturated solution of KCl. A platinum wire sealed into a glass tube is dipped into mercury and used to provide the external electrical contact. Depending on the nature of the other electrode it can either acts as anode or cathode.

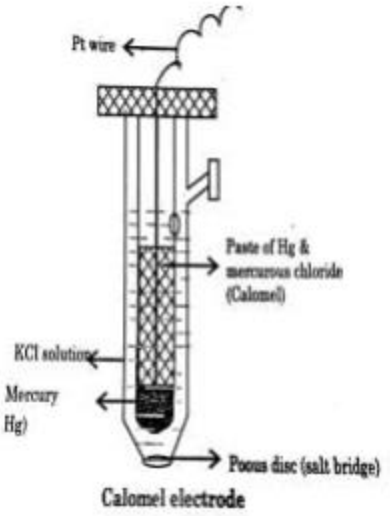
Electrode representation: $Hg(s)/Hg_2Cl_2$ (paste);Cl^-

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

$$2Hg_{(l)} \rightarrow Hg_2^{+2} + 2e^-$$

$$Hg_2^{+2} + 2Cl^- \rightarrow Hg_2Cl_{2(s)}$$

$$2Hg_{(l)} + 2Cl^- \rightarrow Hg_2Cl_{2(s)} + 2e^-$$



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

$$Hg_2^{+2} + 2e^- \rightarrow 2Hg_{(l)}$$

$$Hg_2Cl_{2(s)} \rightarrow Hg_2^{+2} + 2Cl^-$$

$$Hg_2Cl_{2(s)} + 2e^- \rightarrow 2Hg_{(l)} + 2Cl^-$$

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

Uses: It is used as a secondary reference electrode in the measurement of single electrode potential. It is the most commonly used reference electrode in all potentiometric determination.

3.b Define corrosion penetration rate. A thick steel sheet of area 60 inch^2 is exposed to air near the ocean and after 6 year it was found to experience a weight loss of 455 gm due to corrosion. If the density of the metal is 7.9 gm/cm^3 calculate CPR in mpy and mmy. Given K(mpy) = 534 and K (mm/y) = 87.6.

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= 455×10^3 mg Density, D = 7.9 g/cm^3; Time, T = 6×24×365 Area A = 60 in^2 CPR = $\frac{534 \times 455 \times 10^3}{7.9 \times 60 \times 6 \times 24 \times 365}$ CPR = 9.75 mpy	Corrosion penetrating rate in mm/y CPR = KW/DAT Weight loss, W= 455×10^3 mg Density, D = 7.9 g/cm^3; Time, T = 6×24×365 Area A = 60 x 6.45 cm^2 CPR = $\frac{87.6 \times 455 \times 10^3}{7.9 \times 60 \times 6.45 \times 6 \times 24 \times 365}$ CPR = 0.248 mm/y

4.a Explain the theory, instrumentation and applications of potentiometry.

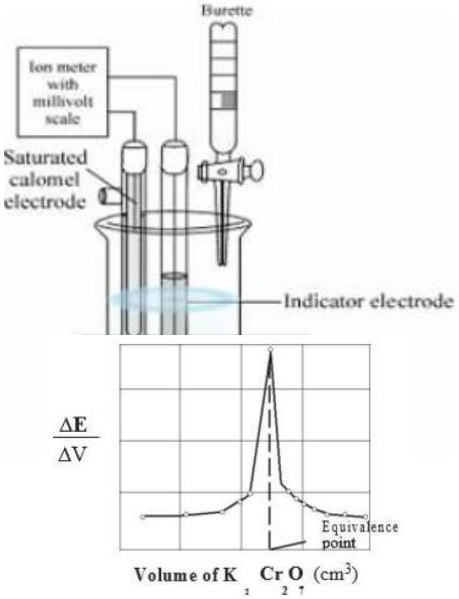
Answer:

Theory: The procedure of using measurement of emf to determine the concentration of ionic species in solution is called as potentiometry also known as potentiometric titration. When a metal M is immersed in a solution containing its own ions Mn^+, the electrode potential is given by Nernst equation,

$$E = E^o + \frac{0.0591}{n} \log \left[M^{n+}\right]$$

Thus, the concentration can be calculated, provided Eo of the electrode is known. The principle involved in potentiometric titration is the measurement of emf between two electrodes, an indicator electrode, (the potential of which is function of the concentration of the ion to be determined) and a reference electrode of constant potential. In this method, the measurement of emf is made while the titration is in progress. The equivalence point of the reaction is revealed by a sudden change in potential in the plot of emf readings against the volume of titrant.

Instrumentation: A potentiometer consists of: (i) Calomel electrode as a reference electrode, (ii) Platinum electrode as an indicator electrode, (iii) a device for measuring the potential and (iv) Magnetic stirrer.



Application:

1. Analysis of pollutants in water
2. Drug Analysis in Pharmaceutical industry
3. Food industry for analysis of quality
4. Potentiometric estimation of FAS using standard $K_2Cr_2O_7$ solution: Pipette out 25ml of FAS into a beaker. Add 1 t.t dil H_2SO_4, immerse calomel

electrode + platinum electrode into it. Connect the assembly to a potentiometer and measure the potential by adding $K_2Cr_2O_7$ in the increments of 0.5ml. Plot graph $\Delta E/\Delta V$ against volume of $K_2Cr_2O_7$, and determine the equivalence point. From the normality and volume $K_2Cr_2O_7$, solutions calculate the normality and the weight of FAS in the given solution.

4.b What are concentration cell? The cell potential of copper concentration cell $Cu/CuSO_4(0.005M)//CuSO_4(xM)/Cu$ is 0.0295 at 30℃.

Answer:

A concentration cell is an electrolytic cell that is comprised of two half-cells with the same electrodes, but differing in concentrations.

Under the given condition (T=30℃ =303K),

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

Where C_2 = Concentration of electrolyte at cathodic compartment = x M

C_1 = Concentration of electrolyte at anodic compartment = 0.005M
E = 0.0295V
n = 2

Substituting the above values in above formula,

$0.0295 = 0.0591/2 [\log x/0.005]$

$0.0295 = 0.02955 [\log x - \log 0.005]$

$0.0295 = 0.02955 [\log x - (-2.30)]$

$0.9983 = \log x + 2.30$

$\log x = -1.3017$

$x = 0.0479$ M

Thus, the value of x = **0.0479 M**.

5.a What are ion selective electrodes? Explain the construction, working and applications of glass electrode.

Answer:

Ion selective electrodes selectively respond to a specific ion in a mixture and potential developedis a function of concentration of that ion in the solution. Eg. Glass electrode.

Glass Electrode:

Construction: The glass electrode consist of glass tube, the bottom of the glass tube is glass bulb covered with glass membrane made up of special glass of low melting point and high electrical conductivity (SiO_2,Na_2O,Al_2O_3 etc., and it allows only H^+ ions). Glass bulb consists of 0.1 N HCl (Assume concentration is C2) and Ag/AgCl electrode, which serves as internal reference electrode.

Working: The glass electrode is dipped into any solution containing H^+ ions then glass electrode develops potential called as glass electrode potential. It is represented as EG.

Then, $EG = E_b + E_{Ag/AgCl} + E_{assy}$ ..... (1)

Where, E_b= Boundary potential, $E_{Ag/AgCl}$ = Potential due to Ag/AgCl and E_{assy}= asymmetric potential.

Boundary potential (Eb); It is a potential developed across the glass membrane when concentration of the solution inside and outside the glass membrane are different.

Mathematically it is represented as, $\mathbf{E_b = E_1 - E_2}$

Where, E_1= Potential due to H+ present inside the bulb (Unknown solution)

E_2 = Potential due to H+ present in outside solution (Unknown solution)

According to Nernst equation

$$= E^\circ + \frac{0.0591}{n} \log C_2 - \left(E^\circ - \frac{0.0591}{n} \log C_1\right)$$

$$= \frac{0.0591}{n} \log C_2 - \frac{0.0591}{n} \log C_1$$

Where, $C_1 = 0.1$ M and $n = 1$ (H^+)

$$= \frac{0.0591}{n} \log C_2 - \mathbf{K} \text{ or}$$

$$= \mathbf{K} + \frac{0.0591}{n} \log C_2$$

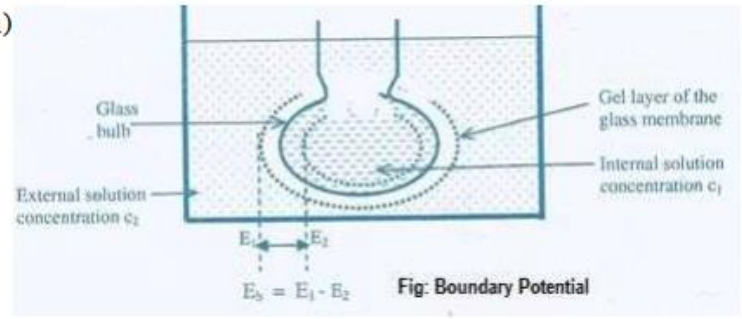


Fig: Boundary Potential

Glass selects only H^+ ions ignoring other ions.

Hence $C_2 = H^+$

$E_b = K + 0.0591 \log [H^+]$, Where, $\log [H^+] = -pH$

Hence $E_b = K - 0.0591pH$ ----------(2)

Substituting eqn (2) in (1)

$E_G = K - 0.0591\ pH + E_{Ag/AgCl} + E_{assy}$

$E_G = E^o_G - 0.0591\ pH$

5b. Explain the theory, instrumentation and applications of conductometry.

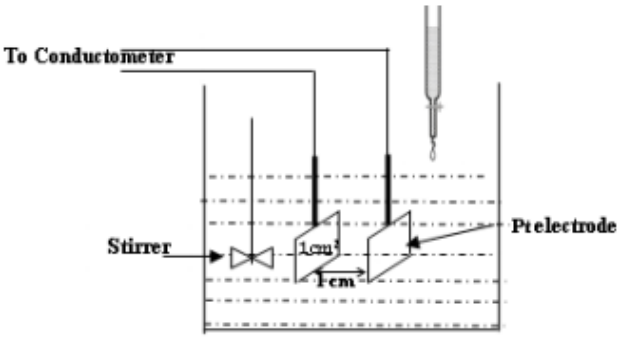
Answer:

Theory: Conductometry is based on Ohm's law which states that the current i (amperes) flowing in a conductor is directly proportional to the applied electromotive force, E (volts), and inversely proportional to the resistance R (ohms) of the conductor.

$$i = E/R$$

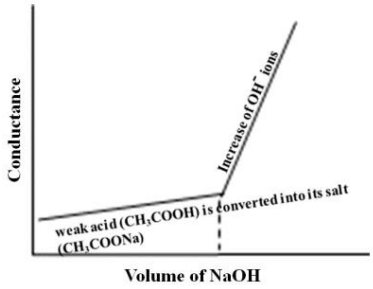
The reciprocal of the resistance is called the conductance (Ease with which electric current flows through a conductor). Specific conductance of a solution is defined as the conductance of a solution present between two parallel electrodes which have $1cm^2$ area of cross section and which have kept 1 cm apart. The conductance of solution depends on the number and mobility of ions. The substitution of ions with different ionic mobility affects the electrolytic conductivity. Therefore, the equivalence point can be determined by means of conductivity measurement for a neutralization reaction between an acid and a base. Equivalence point is determined graphically by plotting conductance against titer values.

Instrumentation: Conductometer consists of: (1) conductivity cell having two platinum electrodes; and a (ii) conductometer. A simple arrangement of conductometric titration is depicted in figure. The solution to be titrated is taken in the beaker.



Application: (i) used to check water pollution in lakes as well as rivers. (ii) used to check the alkalinity of the fresh water (iii) Purity of distilled water and deionized water can determined.

Pipette out 50ml of sample (weak acid) into a beaker. Immerse the conductivity cell into it. Connect the conductivity cell to a conductivity meter and measure the conductance by adding NaOH from the burette by increment of 1 ml. Plot a graph of conductance against volume of NaOH. Determine the neutralization point from the graph as shown below.



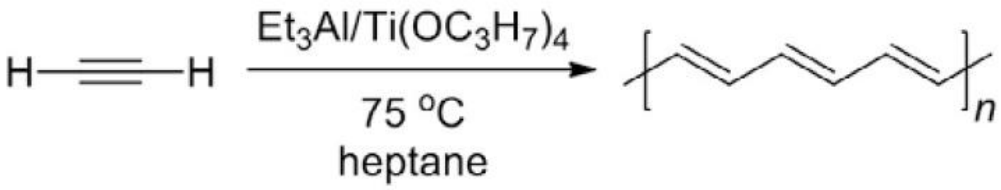
6a. What are conducting polymers? Explain the preparation and conducting mechanism of polyacetylene. Mention its commercial applications.

Answer:

Conducting polymers are organic polymers that conduct electricity. Example: Poly(acetylene).

Synthesis of polyacetylene:

- A variety of methods have been developed to synthesize polyacetylene, from pure acetylene and other monomers.
- One of the most common methods uses a Ziegler–Natta catalyst, such as $Et_3Al/Ti(OC_3H_7)_4$, with gaseous acetylene. This method allows control over the structure and properties of the final polymer by varying temperature and catalyst.



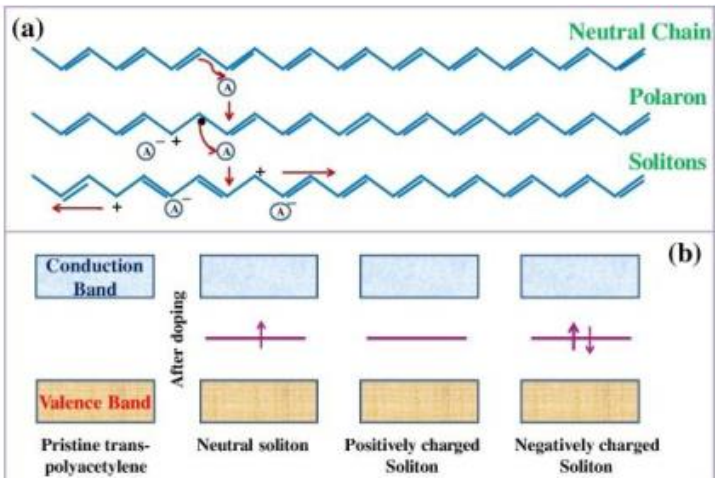
Mechanism of Conduction:

i. When the oxidative dopart such as iodine is added, it takes away an electrons from the π-back bone of the pollyacetylene 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.



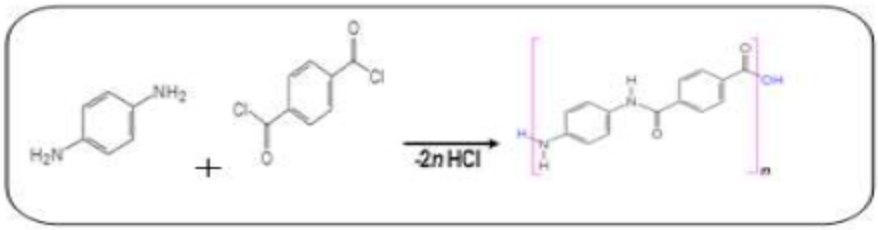
Application

The most extensively studied and is widely investigated computationally and experimentally for use in electronic devices such as light-emitting diodes, water purification devices, hydrogen storage, and biosensors.

6b. Describe the preparation, properties and commercial application of kevlar.

Answer:

Synthesis of Kevlar: Kevlar is made by a condensation reaction of an amine (1, 4-phenylene-diamine) and acid chloride (terephthaloyl chloride). The Kevlar chains are relatively rigid and tend to form mostly planar sheets, similar to those of silk. This is due to the Para-orientation of the benzene rings. When Kevlar is spun the chains lock together via H-bonds to form a sheet that has a very high tensile strength. The sheets also stack radically, like the spokes on a wheel, allowing additional interactions between the face-to-face aromatic groups on neighbouring sheets to help to increase the strength of the overall fibre.



Properties of Kevlar

i. It is strong but light in weight; 2. It is crystalline and non-flammable; 3. It has good impact and abrasion resistance.
ii. It is thermally stable and withstand high temperatures; Not affected by very low temperatures.
iii. Long exposure to ultraviolet light causes discoloration & degradation of the fibers.

iv. It can resist chemical attacks, however long exposure to strong acids/bases causes degradation.
v. Kevlar remains unaffected by hot water & moisture.
vi. Kevlar fibre is five times stronger than steel and have high tensile strength

Applications

i. **Military Body Armor & Jackets**: Kevlar fibre is five times stronger than steel on an equal weight basis, offering superior protection in military body armour and flak jackets.
ii. **Protection Vests**: From higher-level bullets to knives, needles and explosions, protection vests made with Kevlar.
iii. **Military Helmets**: Kevlar meet demanding requirements for protection against a wide range of threats, including bullets, shrapnel and fragmentation.
iv. **Automotive Uses**: It is not uncommon for a new vehicle to have several crucial parts that employ products Belts, Brake pads, Clutches, Gaskets, Hoses made of Kevlar brand fibre.
v. **Kevlar as a Composite**: Formula 1 cars and HANS Device uses Kevlar straps to supports the driver's head and neck— Kevlar absorbs impact forces that are strong enough to pulverize neck vertebrae.
vi. **Kevlar in Fiber Optics**: Kevlar is used to safeguard against mechanical stresses in optical fibre cables.
vii. **Ropes and Cables**: Its resistance to chemicals and temperature extremes make it an ideal component for ropes and cables under severe loads in harsh environments.

7a. In a polymer sample, 20% of molecules have molecular mass of 15000 g/mol, 35% molecules have molecular mass of 25000 g/mol, and remaining molecules have molecular mass of 20000 g /mol, calculate the number average and weight average molecular masses of the polymer.

Answer :

Number average molecular mass:

Total weight = (20 x 15000) + (35 x 25000) +(45 x 20000) = 300000 + 875000 + 900000 = 2075000

Total number = 20 + 35 + 45 = 100

$$M_n = \frac{\Sigma M_i N_i}{\Sigma N_i}$$

Mn = 2075000 / 100 = **20750 g/mol**

Weight average molecular mass:

$$M_W = \frac{\Sigma N_i (M_i)^2}{\Sigma N_i M_i}$$

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

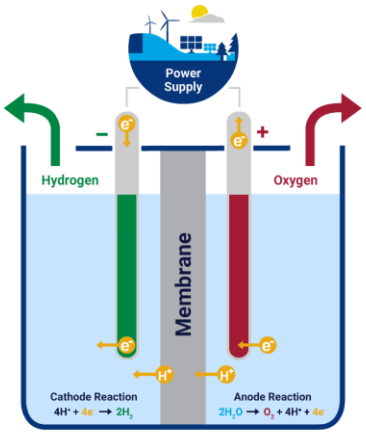
M_w = 21385 g/mol

7b. Explain the electrolysis of water with neat diagram and mention any 4 advantages.

Answer:

Electrolysis is the process of using electricity to split water into hydrogen and oxygen. Electrolysis processes take place in a unit called electrolyzer, which functions much like a fuel cell.

- It consisting of an anode and a cathode connected through an external power supply and immersed in a conducting electrolyte.
- A direct current (DC) is applied to the unit; electrons flow from the negative terminal of the DC power source to the cathode, where they are consumed by hydrogen ions (protons) to form hydrogen atoms.
- In the general process of water electrolysis, hydrogen ions move toward the cathode, whereas hydroxide ions move toward the anode.
- A diaphragm is used to separate the two compartments.



$$\text{Cathode } 2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)} \quad (E^0 = 0.00 \text{ V } vs. \text{ SHE}) \quad (1)$$

$$\text{Anode } H_2O_{(l)} \rightarrow \tfrac{1}{2} O_{2(g)} + 2H^+_{(aq)} + 2e^- \quad (E^0 = 1.23 \text{ V } vs. \text{ SHE}) \quad (2)$$

$$\text{Overall } H_2O \rightarrow H_2 + \tfrac{1}{2} O_2 (E_0 = -1.23 \text{ V } vs. \text{ SHE}) \quad (3)$$

Advantages:

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