Roll No. | | | | |

CMR INSTITUTE OF TECHNOLOGY, BENGALURU.

ACCREDITED WITH A+ GRADE BY NAAC

Internal Assessment Test 1 – Oct 2023

Sub:	Applied Chemistry for CSE Stream				Sub Code:	BCHES102	Branch:	CSE & CSE(DS)
Date:	31-10-2023	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)	Explain the theory, instrumentation and applications of potentiometry by taking estimation of iron as an example.	[7]	CO4	L2
	(b)	Define corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.	[7]	CO3	L3
2	(a)	Explain the construction, working and applications of glass electrode.	[6]	CO3	L2
	(b)	Define galvanization. Discuss the process of galvanization with suitable diagram.	[6]	CO3	L1
3	(a)	Discuss in detail the type of corrosion taking place in the following cases: (i) A steel screw in tin sheet for a long time. (ii) Uneven deposition of dust over the metal surface	[6]	CO3	L3
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4	(a)	Define cathodic protection. Describe sacrificial method of corrosion control by taking suitable example.	[6]	CO3	L2

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6 (a)	Explain the preparation, properties and commercial applications of graphene oxide	[6]	CO1	L2
(b)	Explain the conduction mechanism in polyacetylene. Mention its commercial applications.	[6]	CO1	L3
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(Chief Course Instructor)

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(Chief Course Instructor)

1.a. Explain the theory, instrumentation and applications of potentiometry by taking estimation of iron as an example.

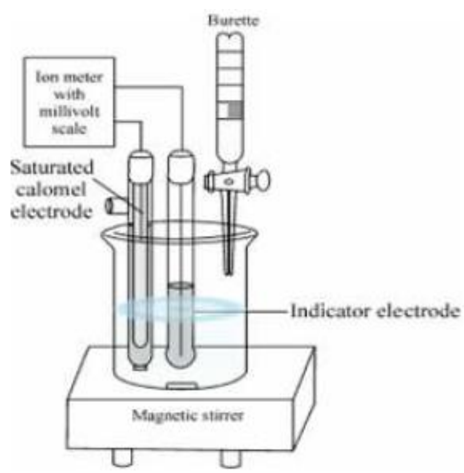
Answer:

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,

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

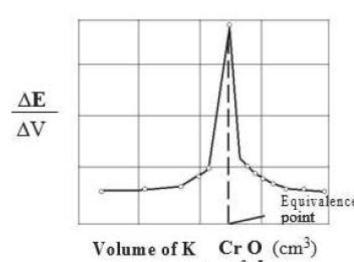
Thus, the concentration can be calculated, provided Eo of the electrode is known. The principle involved in potentiometric titration is the measurement of emf between two electrodes, an indicator electrode, (the potential of which is function of the concentration of the ion to be determined) and a reference 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.

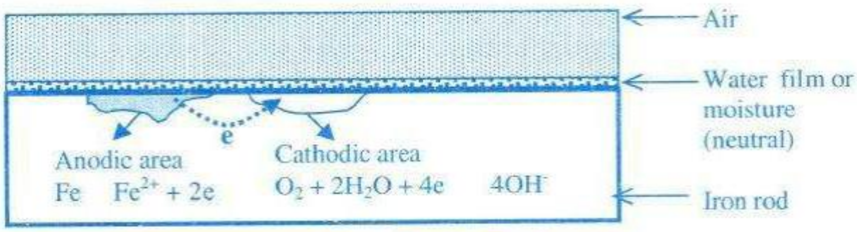


1.b. Define corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.

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 $(OH)_2$.

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

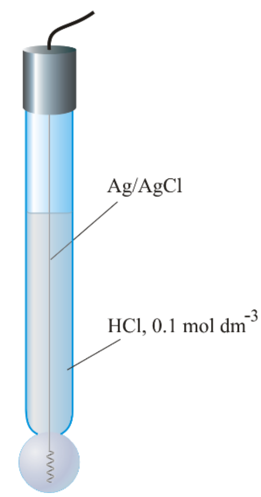
(Ferrous hydroxide)

(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 the construction, working and applications of glass electrode.

Construction:



- The glass electrode consists of a glass tube made up of a special type of glass with high electrical conductivity.
- The glass tube contain a solution of concentration C1 (0.1M HCl)
- An Ag-AgCl electrode is placed inside the solution which acts as internal reference electrode and also serves for the external electrical contact.
- The glass electrode is dipped in unknown solution of concentration C2.

Cell representation

Ag / AgCl /HCl (0.1M) / unknown solution / Glass

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

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

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

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

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

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

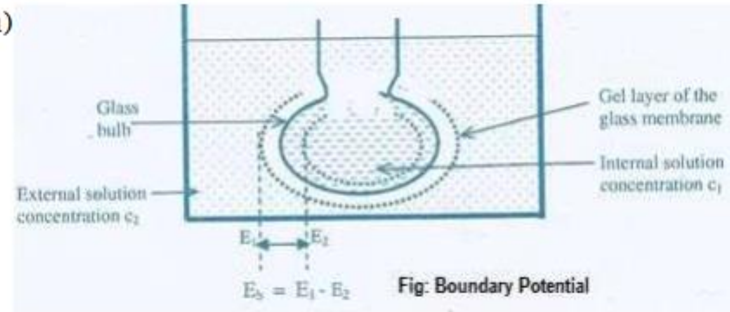


Fig: Boundary Potential

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)

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

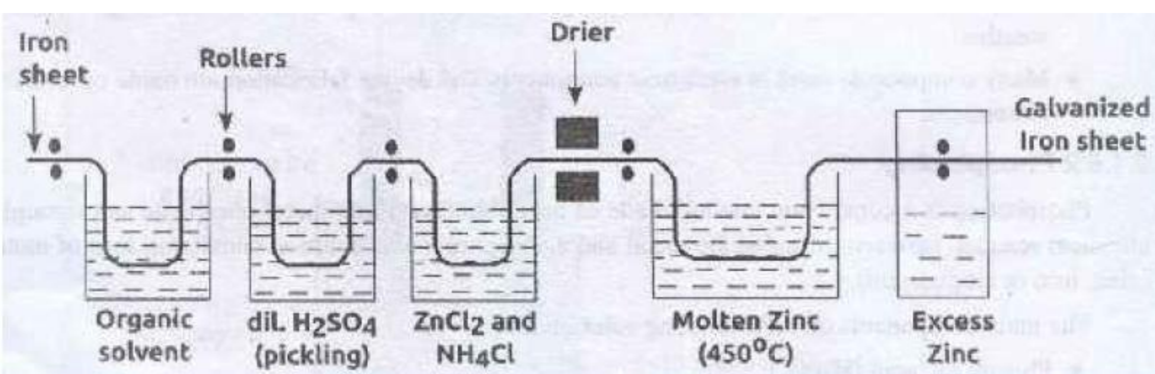
$E_G = E^\circ_G - 0.0591\ pH$

It is used to determine the pH of the unknown solution along with calomel electrode.

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 – 430ºC 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. Discuss in detail the type of corrosion taking place in the following cases:

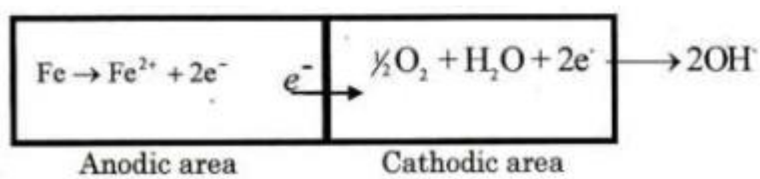
(i) A steel screw in tin sheet for a long time

(ii) Uneven deposition of dust over the metal surface Answer:

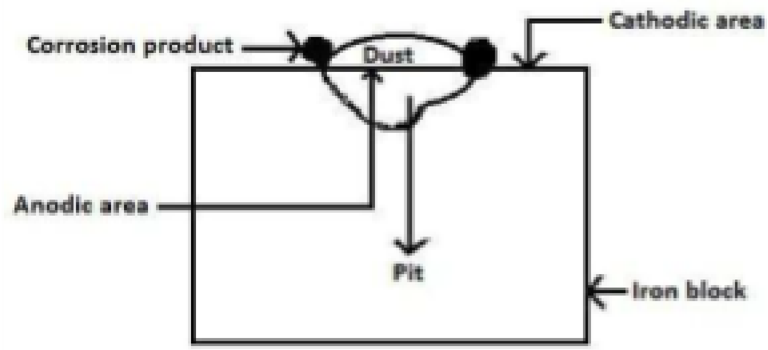
(i) Type of corrosion is **"Differential metal corrosion",** this occurs when two dissimilar metals are in contact with each other in a corrosive conductive medium; a potential difference is set up resulting in a galvanic current. The metal with lower electrode potential or more active metal acts as 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,

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

At the cathode $H_2O + \frac{1}{2} O_2 + 2e^- \rightarrow 2OH^-$



(ii) Type of corrosion in "**Pitting line 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): $O_2 + 2\ H_2O + 4e^- \rightarrow 4\ OH^-$

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

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

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

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.

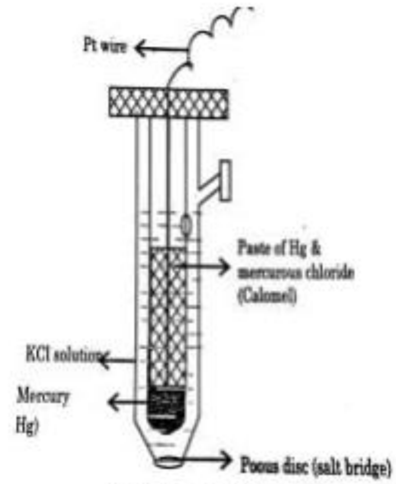
Cell representation: Hg(s)/Hg_2Cl_2 (paste);Cl-

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

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

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

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



Calomel electrode

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)

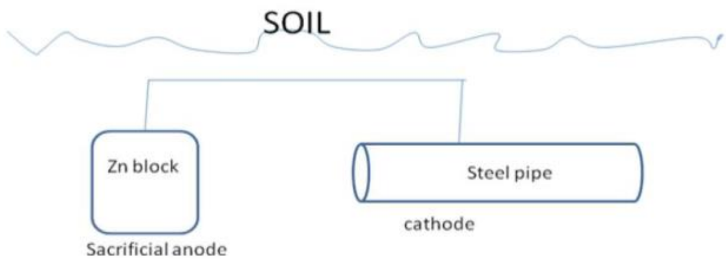
4.a Define cathodic protection. Describe sacrificial anode method of corrosion control by suitable examples.

Answer:

Cathodic protection is a method of protecting a metal or alloy from corrosion by converting it completely into cathodic and no part of it is allowed to act as anode.

Sacrificial anodic protection:

- The base metal is usually iron, copper or brass.
- The metal to be protected from corrosion is converted into cathode by connecting to a metal which is anodic to it.
- Metals like Mg, Al and Zn are more active and hence are used as anodes.
- Since the anodic metals are sacrificed to protect the metal structure, the method is known as sacrificial anode method.
- These metals being more active acts as anode undergo corrosion and supply electrons to the target metal.
- In this way the protected metals acts as cathode.



4.b. Define corrosion penetration rate (CPR). A thick steel sheet of area 450 cm^2 is exposed to air near the ocean. After 2 years it was found to experience a weight loss pf 365 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].

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	Corrosion penetrating rate in mm/y
CPR = KW/DAT	CPR = KW/DAT
Weight loss, W= 365×10^3 mg	Weight loss, W= 365×10^3 mg
Density, D = 7.9 g/cm^3; Time, T = 2×24×365	Density, D = 7.9 g/cm^3; Time, T = 2×24×365
Area A = 450 / 6.45 $inch^2$	Area A = 450 cm^2
CPR = $\frac{534 \times 365 \times 10^3}{7.9 \times 69.8 \times 2 \times 24 \times 365}$	CPR = $\frac{87.6 \times 365 \times 10^3}{7.9 \times 450 \times 2 \times 24 \times 365}$
CPR = 20.185 mpy	CPR = 0.5134 mm/y

5.a. What are concentration cells? Two cadmium rods immersed in cadmium sulphate solution of concentration 0.02 M and 0.4 M. Write the cell representation, cell reaction and calculate the EMF at 25ºC

Answer:

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

Cell representation: $Cd/Cd^{2+}(0.02M)//Cd^{2+}(0.4M)/Cd$

Cell reaction:

Anode: $Cd \rightarrow Cd^{2+}$ (0.02M) + $2e^-$

Cathode : Cd^{2+} (0.4M) + $2e^-$ → Cd

Under the given condition (T=25℃)

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

Where C_2 = Concentration of electrolyte at cathodic compartment = 0.4 M

C_1 = Concentration of electrolyte at anodic compartment = 0.02 M
n = 2

Substituting the above values in above formula,

E_{cell} = 0.0591/2 [log 0.4/0.02]

E_{cell} = 0.02955 [log 20]

E_{cell} = 0.02955 x 1.301

E_{cell} = 0.0384 V

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

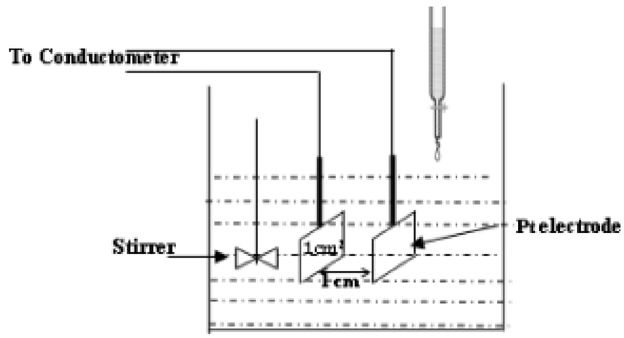
Answer:

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.

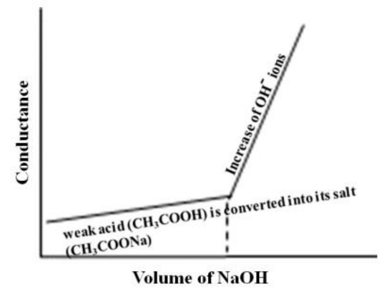
$$i = E/R$$

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.



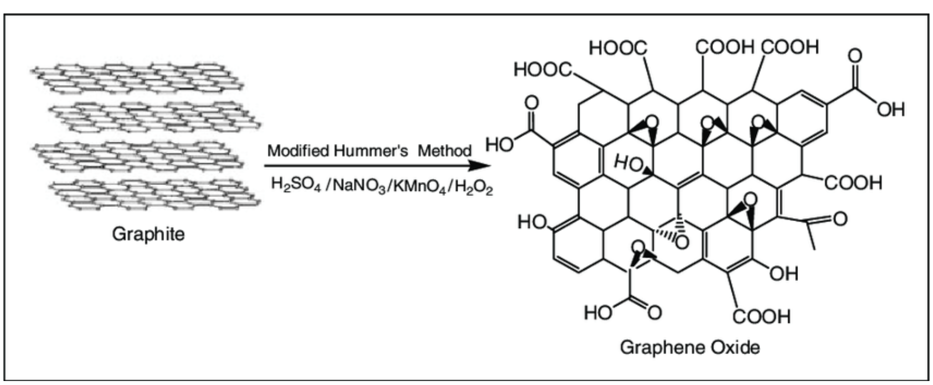
Pipette out 50 ml of sample (weak acid) into a beaker. Immerse the conductivity cell into it. Connect the conductivity cell to a conductivity meter and measure the conductance by adding NaOH from the burette by increment of 1 ml. Plot a graph of conductance against volume of NaOH. Determine the neutralization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

6.a. Explain the preparation, properties and commercial application of Graphene oxide

The synthesis of graphene oxide (GO) involves the oxidation of graphene, typically using strong oxidizing agents.

Hummers' method.

- In a fume hood, mix graphite powder, sodium nitrate (NaNO3), potassium permanganate ($KMnO_4$), and concentrated sulfuric acid (H_2SO_4) in a round-bottom flask.
- Stir the mixture at a low temperature (around 0-5°C) for few hours.
- Slowly add deionized water or ice to the reaction mixture to quench the reaction and obtain graphite oxide suspension.
- Wash the resulting graphite oxide suspension with acid and water to remove impurities and unreacted chemicals.



Properties:

1. Graphene oxide possesses a large surface area makes it suitable for various applications, including energy storage, catalysis, and sensors.

2. The presence of oxygen functional groups on the surface of graphene oxide makes it highly hydrophilic which disperse readily in water and forms stable colloidal suspensions, enabling its use in aqueous-based applications.

3. Electrical and thermal conductivity of graphene oxide is significantly lower than pristine graphene.

4. Graphene oxide is more brittle and mechanically weaker than graphene due to the presence of oxygen functional groups, which disrupt the strong carbon-carbon bonds in graphene.

Applications:

1. Graphene oxide has been explored for use in supercapacitors batteries.

2. Graphene oxide membranes have shown promise in water filtration and desalination processes.

3. Graphene oxide-based sensors have demonstrated excellent sensitivity and selectivity for detecting various analytes.

4. Graphene oxide exhibits unique properties that make it suitable for biomedical applications. It can be used as a drug delivery vehicle, due to its ability to encapsulate and release therapeutic agents.

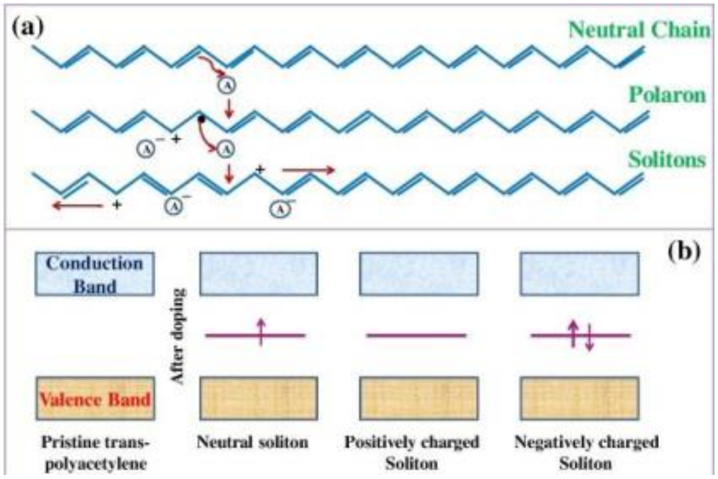
6.b. Explain the conduction mechanism in polyacetylene. Mention its commercial applications.

Answer:

Mechanism of Conduction:

i. When the **oxidative dopant** 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

- 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.

7.a. In a polymer sample, 30% of molecules have molecular mass of 18000 g/mol, 45% 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 masses of the polymer and calculate its polydispersity index.

Answer:

Number average molecular mass:

Total weight = (30 x 18000) + (45 x 20000) + (25 x 25000) = 540000 + 900000 + 625000 = 2065000

Total number = 30 + 45 + 25 = 100

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

Mn = 2065000 / 100 = **20650 g/mol**

Weight average molecular mass:

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

$$\mathbf{M_w = \{[}(30 \times 18000)^2] + [(45 \times 20000)^2] + [(25 \times 25000)^2] \over (30 \times 18000) + (45 \times 20000) + (25 \times 25000)$$

M_w = 20990.31 g/mol

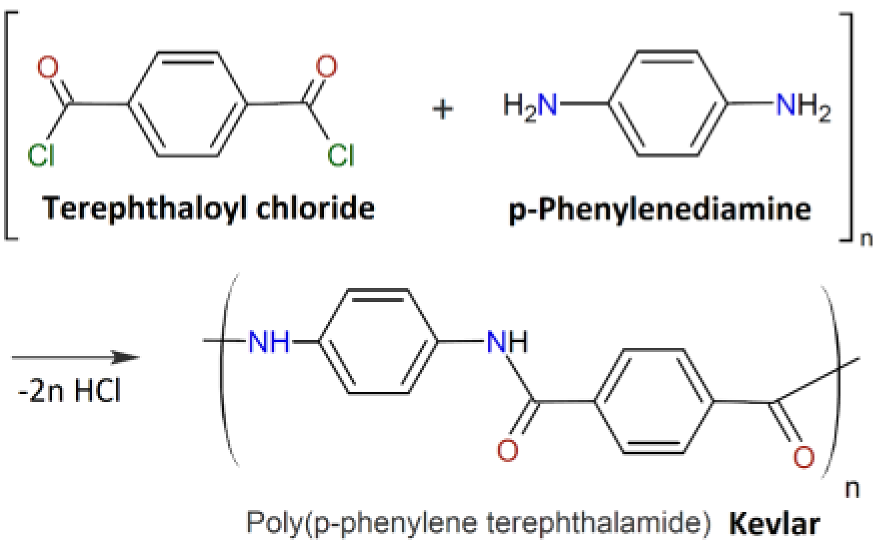
PDI = M_w / M_n = 20990.31 / 20650 = 1.016

7.b. Describe the preparation, properties and commercial application of Kevlar.

Kevlar is a manmade manufactured fibre in which the fibre-forming substance is a long-chain synthetic polyamide (-CONH) attached directly to two aromatic rings.

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.