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Internal Assessment Test 1 – April 2024

Sub:	Applied Chemistry for CSE Stream				Sub Code:	BCHE202	Branch:	ISE, AIML, AI&DS, CS-AIML
Date:	10-04-2024	Duration:	90 min's	Max Marks:	50	Sem / Sec:	II / A,B,C, D, E, F, G & H	OBE

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

								MARKS	
								CO	RBT
1	(a)	What are conducting polymers? Explain the conduction mechanism in polyacetylene using either oxidative <b>or</b> reductive doping technique (Discuss any one). Mention its commercial applications.					[7]	CO1	L3
	(b)	Define metallic corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.					[7]	CO3	L3
2	(a)	What are ion selective electrodes? Explain determination of pH of a solution using glass electrode.					[6]	CO3	L2
	(b)	What are reference electrodes? Describe the construction and working of a calomel electrode.					[6]	CO3	L2
3	(a)	Define cathodic protection. Describe sacrificial method of corrosion control by taking suitable example. Mention its advantages and disadvantage.					[6]	CO3	L2
	(b)	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. Partially filled steel water tank					[6]	CO3	L3
4	(a)	Define anodizing. Explain anodizing of aluminium with electrode reactions and mention its applications.					[6]	CO3	L2
	(b)	Define corrosion penetration rate (CPR). A thick brass sheet of area 200 inch <sup>2</sup> is exposed to moist air. After 2 years it was found to experience a weight loss of 1.265 kg due to corrosion. Calculate CPR in mpy and mmy. [Density of the metal is 8.73 gm/cm <sup>3</sup> , K(mpy) = 534 and K (mm/y) = 87.6].					[6]	CO3	L3
5	(a)	What are concentration cells? The EMF of cell <b>Ag/Ag+ (x) // Ag+ (0.43 M)/Ag</b> is 0.056 V at 25 °C. Find the value of X and write cell reactions.					[6]	CO3	L3
	(b)	Briefly explain the principle, instrumentation and application of potentiometry taking estimation of iron as an example.					[6]	CO4	L2
6	(a)	Describe preparation, properties and commercial application of Kevlar.					[6]	CO1	L2
	(b)	In a polymer sample, 30% of molecules have molecular mass of 15000 g/mol, 25% 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	L2
7	(a)	Describe the theory, instrumentation and applications of conductometry by taking example of weak acid against NaOH.					[6]	CO4	L2
	(b)	Explain the preparation, properties and commercial application of Graphene oxide					[6]	CO1	L2

**1.a. What are conducting polymers? Explain the conduction mechanism in polyacetylene using either oxidative or reductive doping technique (Discuss any one). Mention its commercial applications.**

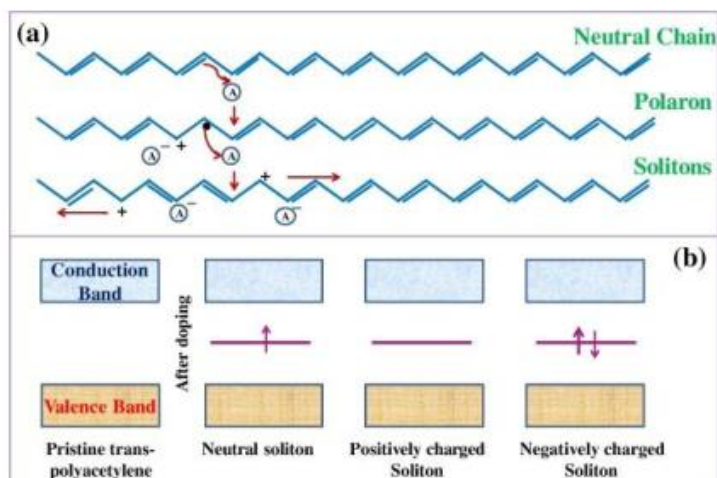
The polymers that can conduct electricity due to the presence of a conjugated system of delocalized electrons are called conducting polymers.

Conductivity can be increased by doping the polymer. The conducting polymers are synthesized by doping, in which charged species are introduced in polymeric pi-back bone. The important doping reactions are:

- Oxidative doping (p-doping)
- Reductive doping (n-doping)

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

- When the **oxidative dopant** such as iodine is added, it takes away an electrons from the  $\pi$ -back bone of the pollyacetylene chain and creates a positive centre (hole) on one of the carbon.
- The other  $\pi$ -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.
- 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).
- 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**

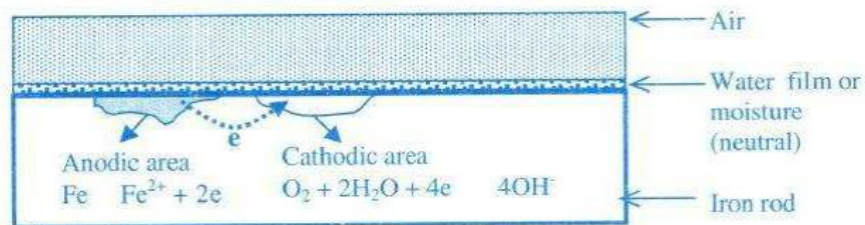
- Non-volatile memory devices based on organic transistors.

- Fabrication of organic photovoltaic cells.
- Fabrication of organic light-emitting devices (OLED).
- Conducting polymer actuators and Micropumps.

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

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.



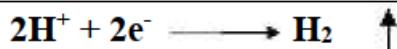
(iii) The electrons flow from the anodic to cathodic area and at the cathodic region, reduction takes place. Since metal cannot be reduced further, metal atoms at the cathodic region are unaffected by the cathodic reaction. Some constituents of the corrosion medium take part in the cathodic reaction.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

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

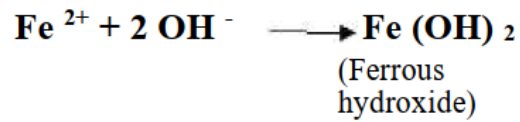
- If the solution is deaerated and almost neutral:



- If the solution is deaerated and acidic:



(iv) Corrosion of iron produced Fe<sup>2+</sup> ions and OH<sup>-</sup> ions at the anode and cathode sites respectively. These ions diffuse towards each other and produce insoluble Fe (OH)<sub>2</sub>.



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



**2.a. What are ion selective electrodes? Explain determination of pH of a solution using glass electrode.**

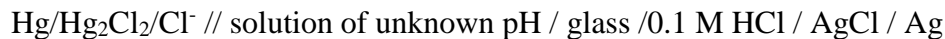
The ion-selective electrode generally consists of a membrane that selectively responds to a specific ion in a mixture of ions in solutions that ignore all other ions and develop a potential.

Example: Glass electrode.

**Determination of pH using glass electrode**

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

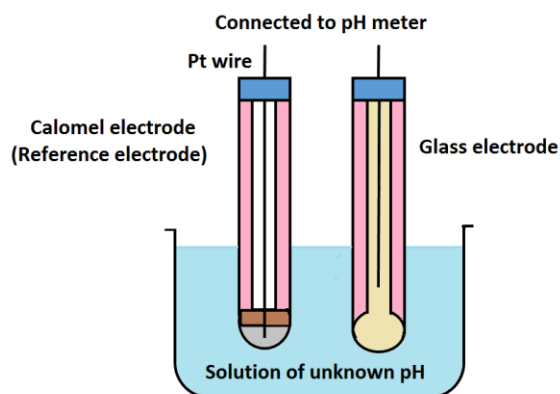
The cell assembly is represented as:



**E<sub>cell</sub>** is the difference between glass electrode potential **E<sub>G</sub>** and the calomel electrode potential **E<sub>cal</sub>**.

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

$$\text{pH} = \frac{K - E_{\text{cell}}}{0.0591} \quad \text{Where K is electrode assembly constant, } K = L_1 - E_{\text{cal}}$$



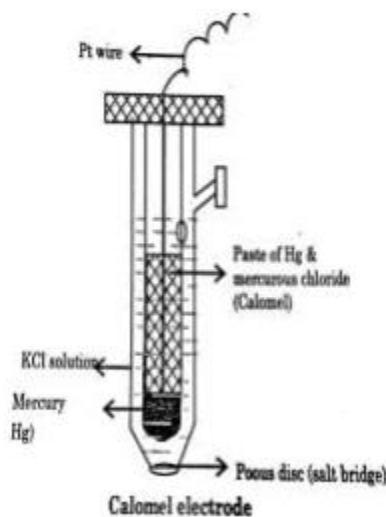
**2.b. What are reference electrodes? Describe the construction and working of a calomel electrode.**

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.

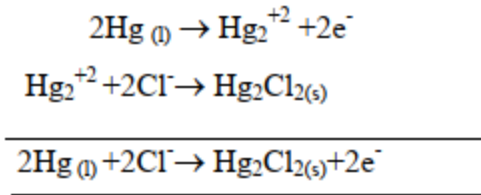
**Construction and working of calomel electrodes:**

- The calomel electrode consists of two glass tube.
- At the inside glass tube, there is a paste (calomel) of mercury and mercurous chloride ( $\text{Hg}_2\text{Cl}_2$ ) 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.

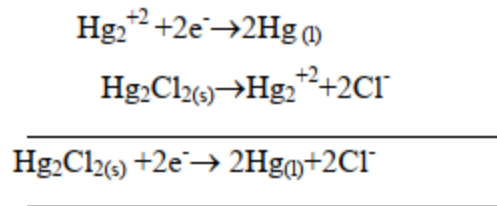
Cell representation:  $\text{Hg(s)}/\text{Hg}_2\text{Cl}_2 \text{ (paste)}; \text{Cl}^-$



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



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



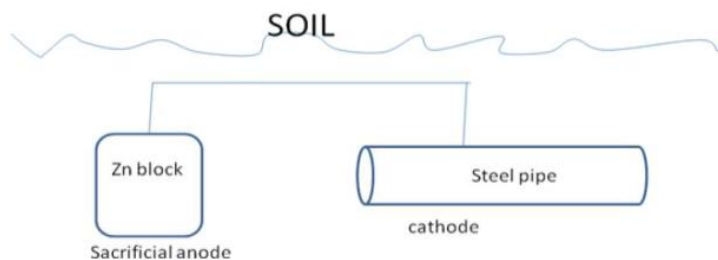
The electrode potential of calomel electrode depends on concentration of chloride ions. For saturated KCl  $E=0.2422\text{V}$  (called Saturated calomel electrode)

**3.a. Define cathodic protection. Describe sacrificial method of corrosion control by taking suitable example. Mention its advantages and disadvantage.**

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:**

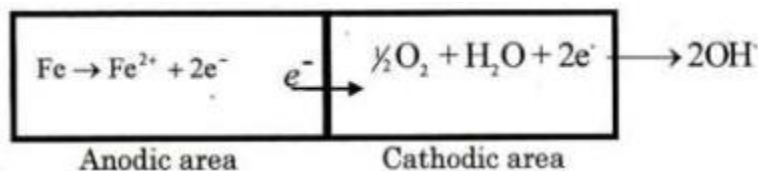
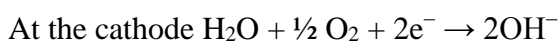
- The base metal is usually iron, copper or brass.
- The metal to be protected from corrosion is converted into cathode by connecting to a metal which is anodic to it.
- Metals like Mg, Al and Zn are more active and hence are used as anodes.
- Since the anodic metals are sacrificed to protect the metal 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.



**3.b. Discuss in detail the type of corrosion taking place in the following cases:**

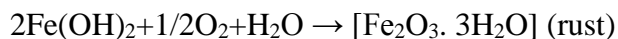
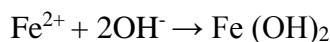
- i. A steel screw in tin sheet for a long time.**
- ii. Partially filled steel water tank.**

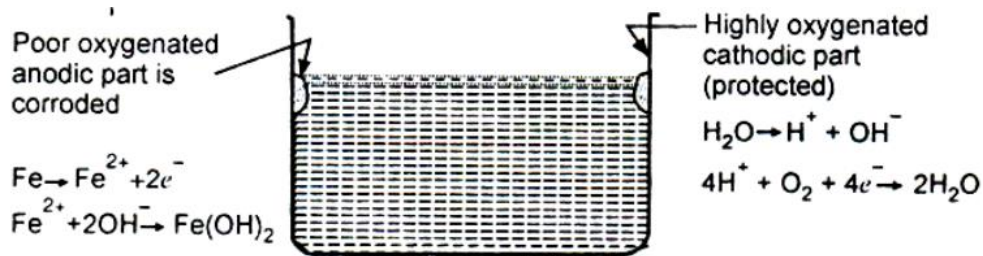
(i) Type of corrosion is “**Differential metal corrosion**”, this occurs when two dissimilar metals are in contact with each other in a corrosive conductive medium; a potential difference is set up resulting in a galvanic current. The metal with lower electrode potential or more active metal acts as 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 “**Differential aeration corrosion**”, this take place due to the formation of different oxygen concentration. The part of metal exposed to **lower concentration** of oxygen (dissolved oxygen) acts as anodic area and undergoes corrosion. The part of the metal above the water level is exposed to **higher concentration** of oxygen acts as cathodic are and remains unaffected. A **distinct brown line** is formed just below the **water line** due to the deposition of rust. Water line corrosion is observed usually in steel water tanks and ships floating in sea water for a long time.

**Cell Reaction:**

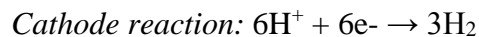




**4.a. Define anodizing. Explain anodizing of aluminium with electrode reactions and mention its applications.**

Anodizing is the process of oxidation of outer layer of metal to its metal oxide by electrolysis. Metal oxide layer formed over the metal itself acts as protective layer.

In anodization of aluminium, clean and polished aluminium is taken as anode and immersed in an electrolytic cell containing chromic acid. Inert electrode like lead is generally used as cathode. The anodic oxide film formed on Al in bath as aluminium oxide, which is porous. The pores are finally sealed by dipping in hot water to produce  $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ , which acts as a non-porous protective layer preventing corrosion.



**Advantages:**

1. Anodized  $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$  act as a protective layer, increasing the corrosion resistivity of the surface as it prevents further oxidation.
2. They have harder and durability than normal aluminium.

**4.b. Define corrosion penetration rate (CPR). A thick brass sheet of area 200 inch<sup>2</sup> is exposed to moist air. After 2 years it was found to experience a weight loss of 1.265 kg due to corrosion. Calculate CPR in mpy and mmy. [Density of the metal is 8.73 gm/cm<sup>3</sup>, K(mpy) = 534 and K (mm/y) = 87.6].**

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= 1.265 × 10 <sup>6</sup> mg Density, D = 8.73 g/cm <sup>3</sup> ; Time, T = 2×24×365 Area A = 200 inch <sup>2</sup> CPR = $\frac{534 \times 1.265 \times 10^6}{8.73 \times 200 \times 2 \times 24 \times 365}$ CPR = 21.996 mpy	Corrosion penetrating rate in mm/y CPR = KW/DAT Weight loss, W= 1.265 × 10 <sup>6</sup> mg Density, D = 8.73 g/cm <sup>3</sup> ; Time, T = 2×24×365 Area A = 200 x 6.45 cm <sup>2</sup> CPR = $\frac{87.6 \times 1.265 \times 10^6}{8.73 \times 200 \times 6.45 \times 2 \times 24 \times 365}$ CPR = 0.559 mm/y
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**5.a. What are concentration cells? The EMF of cell Ag/Ag<sup>+</sup> (x) // Ag<sup>+</sup> (0.43 M)/Ag is 0.056 V at 25°C. Find the value of X and write cell reactions.**

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

**Cell representation:** Ag/Ag<sup>+</sup> (x) // Ag<sup>+</sup> (0.43 M)/Ag

Cell reaction:

Anode: Ag → Ag<sup>+</sup> ( x M) + e<sup>-</sup>

Cathode : Ag<sup>+</sup> (0.43M) + e<sup>-</sup> → Ag

**Under the given condition (T=25°C)**

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

Where C<sub>2</sub> = Concentration of electrolyte at cathodic compartment = 0.43 M

C<sub>1</sub> = Concentration of electrolyte at anodic compartment = x M

n = 2

Substituting the above values in above formula,

$$0.056 = 0.0591/1 [\log 0.43/x]$$

$$0.056 = 0.0591 [\log (0.43) - \log (x)]$$

$$0.056 / 0.0591 = (-0.3665) - \log (x)$$

$$-0.9475 - 0.3665 = \log (x)$$

$$x = \text{Antilog} (-1.314)$$

$$\mathbf{x = 0.0485 M}$$

**5.b. Briefly explain the principle, instrumentation and application of potentiometry taking estimation of iron as an example.**

**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  $M^{n+}$ , the electrode potential is given by Nernst equation,

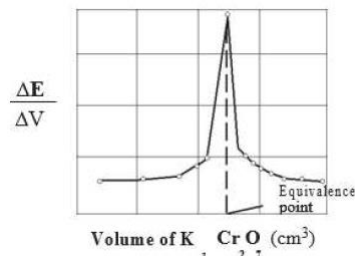
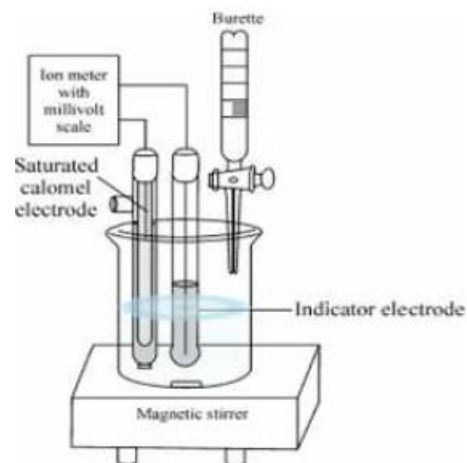
$$E = E^{\circ} + \frac{0.0591}{n} \log [M^{n+}]$$

Thus, the concentration can be calculated, provided  $E^{\circ}$  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:**

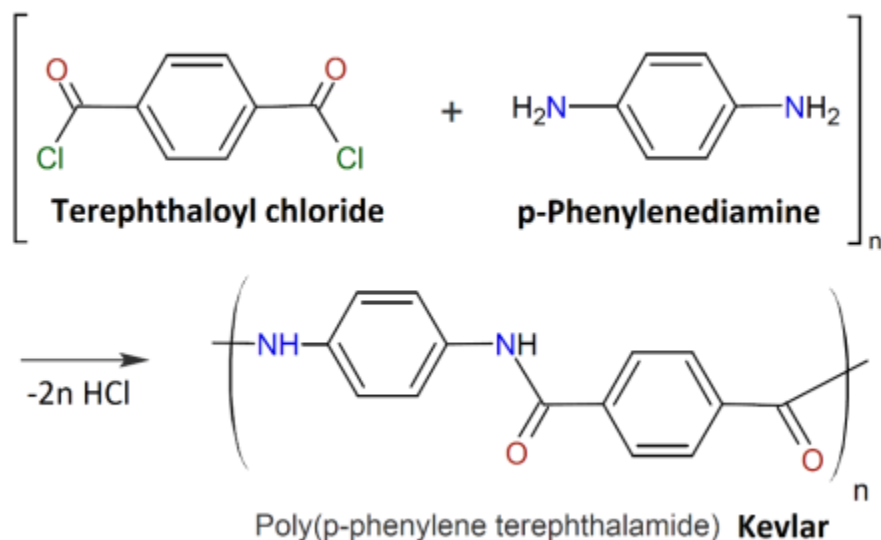
1. Analysis of pollutants in water
2. Drug Analysis in Pharmaceutical industry
3. Food industry for analysis of quality
4. Potentiometric estimation of FAS using standard  $K_2Cr_2O_7$  solution: Pipette out 25ml of FAS into a beaker. Add 1 t.t dil  $H_2SO_4$ , immerse calomel electrode + platinum electrode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



## 6.a. Describe the preparation, properties and commercial application of Kevlar.

### 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  $450^{\circ}\text{C}$ .
3. It is also stable at very low temperatures (up to  $-196^{\circ}\text{C}$  )
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.

**6.b. In a polymer sample, 30% of molecules have molecular mass of 15000 g/mol, 25% 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.**

**Number average molecular mass:**

$$\text{Total weight} = (30 \times 15000) + (25 \times 25000) + (45 \times 20000) = 450000 + 625000 + 900000 = 1975000$$

$$\text{Total number} = 30 + 25 + 45 = 100$$

$$M_n = \frac{\sum M_i N_i}{\sum N_i} \quad M_n = 1975000 / 100 = \mathbf{19750 \text{ g/mol}}$$

**Weight average molecular mass:**

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

$$M_w = \frac{\{[(30 \times 15000)^2] + [(25 \times 25000)^2] + [(45 \times 20000)^2]\}}{(30 \times 15000) + (25 \times 25000) + (45 \times 20000)}$$

$$M_w = \mathbf{20443.04 \text{ g/mol}}$$

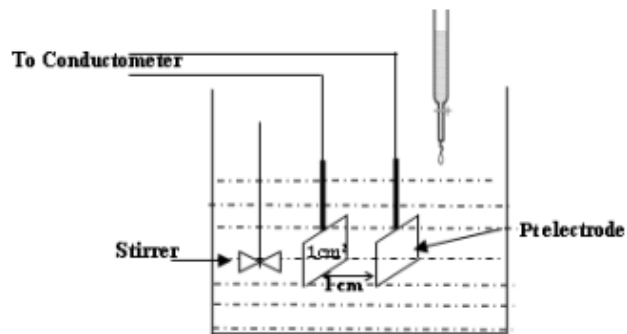
**7.a. Describe the theory, instrumentation and applications of conductometry by taking example of weak acid against NaOH.**

**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.

$$i = E/R$$

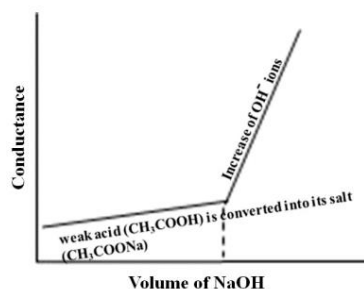
The reciprocal of the resistance is called the conductance (Ease with which electric current flows through a conductor). Specific conductance of a solution is defined as the conductance of a solution present between two parallel electrodes which have  $1\text{cm}^2$  area of cross section and which have 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.

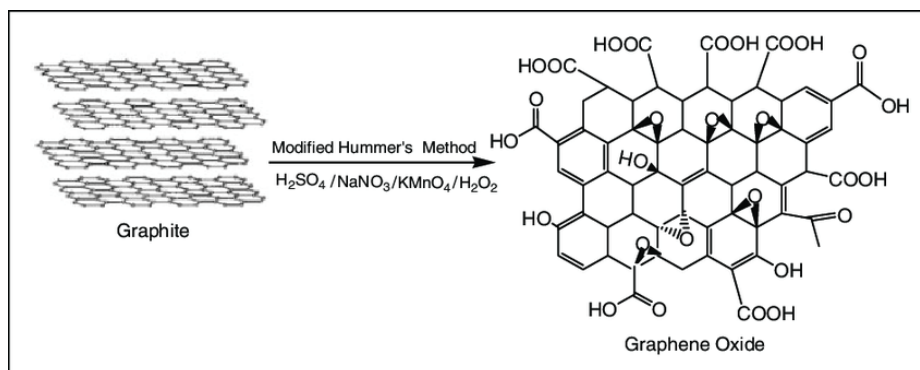


## 7.b Explain the preparation, properties and commercial application of Graphene oxide.

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 ( $\text{NaNO}_3$ ), potassium permanganate ( $\text{KMnO}_4$ ), and concentrated sulfuric acid ( $\text{H}_2\text{SO}_4$ ) in a round-bottom flask.
- Stir the mixture at a low temperature (around  $0\text{-}5^\circ\text{C}$ ) 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.