

Internal Assessment Test 1 – July 2023									
Sub:	Applied Chemistry for CSE Stream			Sub Code:	BCHES202		Branch:	ISE, AIML, AI&DS, CS-AIML	
Date:	05-07-2023	Duration:	90 mins	Max Marks:	50	Sem:	II	Section:	A,B,C, D, E, F & G
Question no. 1 is COMPULSORY and answer any THREE FULL Questions from the rest									Marks
1 (a)	Define metallic corrosion. Explain the electrochemical theory of corrosion taking rusting of iron as example.								(7 M)
	Definition								1 M
	Formation of galvanic cell & Diagram								1 M
	Anodic Reaction								1 M
	All the cathodic reaction								2 M
	Formation of ferrous hydroxide								1 M
	Formation of Rust								1 M
(b)	What are conducting polymers? Explain the conduction mechanism in polyacetylene using either oxidative or reductive doping technique. Mention its commercial applications.								(7 M)
	Definition								1 M
	Explanation of conduction mechanism								2 M
	Structural representation of conduction mechanism								3 M
	Any 3 applications								1 M
2 (a)	Demonstrate the type of corrosion taking place in the following cases:								(6 M)
	(i) A steel screw in copper sheet for long time								
	(ii) Partially buried steel pipeline in soil								
	Type of corrosion								(0.5+0.5) M
	Definition with anode and cathode								(1+1) M
	Diagram								(1+1) M
	Reactions								1 M
(b)	Define galvanization. Discuss the process of galvanization with suitable diagram.								(6 M)
	Definition								1 M
	Diagram								2 M
	Process detail								3 M
3(a)	Define cathodic protection. Describe sacrificial anode method of corrosion control by suitable examples.								(6 M)
	Definition of cathodic protection								1 M
	Diagram								1 M
	Explanation								3 M
	Example								1M
(b)	Describe the construction, working and applications of glass electrode..								(6 M)
	Diagram								1 M
	Construction								1 M
	Working (Derivation of potential of Glass electrode ,E _G) with diagram								(2+1) M
	Application (any 2)								1 M
4(a)	What are reference electrodes? Describe the construction and working of calomel electrode.								(6 M)
	Definition								1 M
	Diagram								1 M

	Details of construction (Representation and construction) Working (Half-cell reactions)	2 M 2 M
(b)	What is CPR. A piece of corroded steel plate was found to be in a submerged ocean vessel. It was estimated that original area of plate was 120 inch² and it has experienced a wt. loss of 1.3 Kg due to corrosion over the period of 7 years.. Calculate CPR in mpy and mm/y. Given K(mpy) = 534 and K (mm/y) = 87.6 and density of the metal is 7.9 gm/cm³. Definition Formula for CPR Substitution and answer in mpy (11.94 mpy) Substitution and result in mm/y (0.303 mm/y)	(6 M) 1M 1 M (1+1) M (1+1) M
5 (a)	What are concentration cell? The cell potential of following concentration cell Ag/AgNO₃ (xM)// AgNO₃ (0.02M)/Ag is 0.045 V at 25 °C. Calculate the value of x. Also write the cell reactions. Definition Cell Reaction Formula of EMF of the cell Substitution Answer with proper unit (0.00346 M)	(6 M) 1 M 1 M 1 M 2M 1 M
(b)	Briefly explain the principle, instrumentation and application of potentiometry taking estimation of iron as an example. Theory Instrumentation Application (Procedure & Nature of graph)	(6 M) 2 M 2 M 2 M
6 (a)	Describe the preparation, properties and commercial application of kevlar. Preparation Properties (Any 4) Applications (Any 4)	(6 M) 2M 2 M 2 M
(b)	In a polymer sample, 25% of molecules have molecular mass of 15000 g/mol, 35% molecules have molecular mass of 27000 g/mol, and remaining molecules have molecular mass of 25000 g /mol, calculate the number average, weight average molecular masses of the polymer and calculate its polydispersity index. Formula for no average & wt average molecular wt Substitution for both Answer for both with proper unit (M_n = 23200 g/mol & M_w = 24198.27 g/mol, PDI calculation (Formula & Answer) (PDI = 1.043)	6 M) (1+1) M (1+1) M (0.5+0.5) M (0.5+0.5) M
7 (a)	Explain the preparation, properties and commercial application of Graphene oxide Preparation Properties (Any 4) Applications (Any 4)	(6 M) 2M 2 M 2 M
(b)	Describe the theory, instrumentation and applications of conductometry by taking example of weak acid against NaOH. Theory Instrumentation Application (Procedure & Nature of graph)	(6 M) 2 M 2 M 2 M

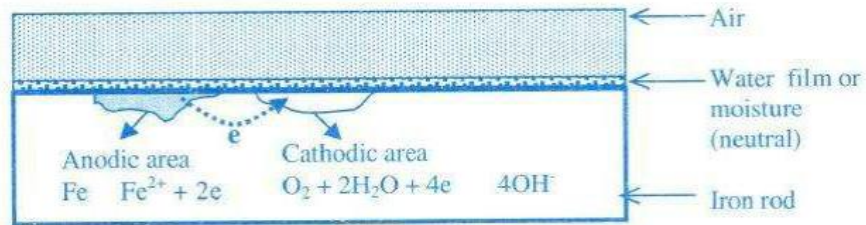
(Chief Course Instructor)

1.a. 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.



(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.

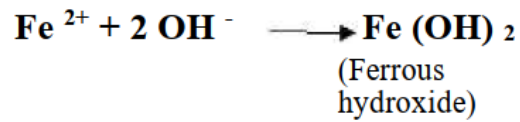
- If the solution is aerated and almost neutral,

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

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

$$2\text{H}^{+} + 2\text{e}^{-} \longrightarrow \text{H}_2 \uparrow$$

(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.



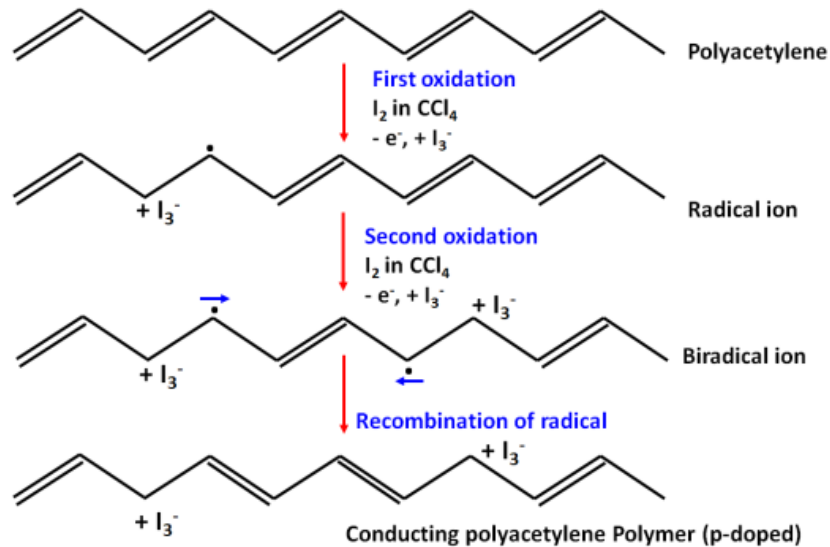
1.b. What are conducting polymers? Explain the conducting mechanism of polyacetylene using either oxidative or reductive doping technique. Mention its commercial applications.

Answer:

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

Mechanism of Conduction (Oxidative doping)

When the polymer is doped with an oxidant, it acquires a positive charge and the acceptor gets a negative charge. The oxidizing agent used in the p-doping of polyacetylene is iodine in CCl_4 .



Mechanism:

- The removal of an electron from the polymer pi-backbone using a suitable oxidising agent leads to the formation of a delocalized radical ion (polaron).
- Second oxidation of a chain containing polaron, followed by the radical recombination yields two positive charge carriers of each chain.

- Positive charge sites on the polymer chains are compensated by I^{3-} ions formed by the oxidizing agent.
- The delocalized positive charges on the polymer chain are mobile and are responsible for current carriers for conduction.

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.

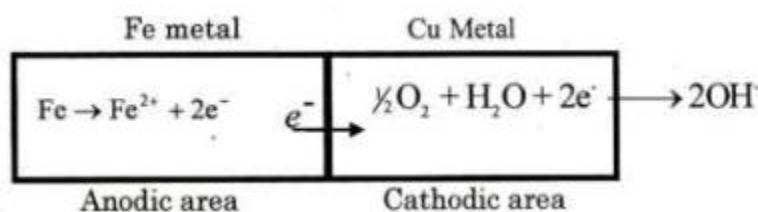
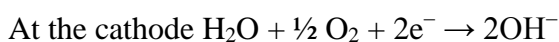
2. a. Demonstrate the type of corrosion taking place in the following cases:

(i) A steel screw in copper sheet for long time

(ii) Partially buried steel pipeline in soil

Answer:

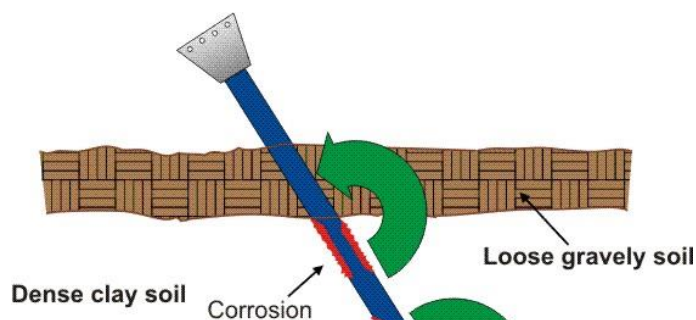
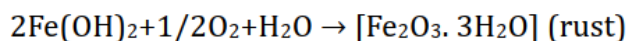
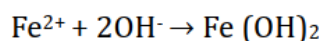
(i) Type of corrosion is “**Differential metal corrosion**”, this occurs when two dissimilar metals are in contact with each other in a corrosive conductive medium; a potential difference is set up resulting in a galvanic current. The metal with lower electrode potential or more active metal acts as 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 iron act as a anode and copper act as a cathode and its reaction are as follows,



(ii) Type of corrosion in “**Differential aeration corrosion**”, this occurs when a metal surface is exposed to differential air (or) oxygen. Part of the metal exposed to lower concentration of oxygen will have lower potential and therefore acts as anode. This part undergoes corrosion. The other part of the metal exposed to higher concentration of oxygen acts as cathode and remains unaffected.

At the anode (less O₂ concentration): $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$

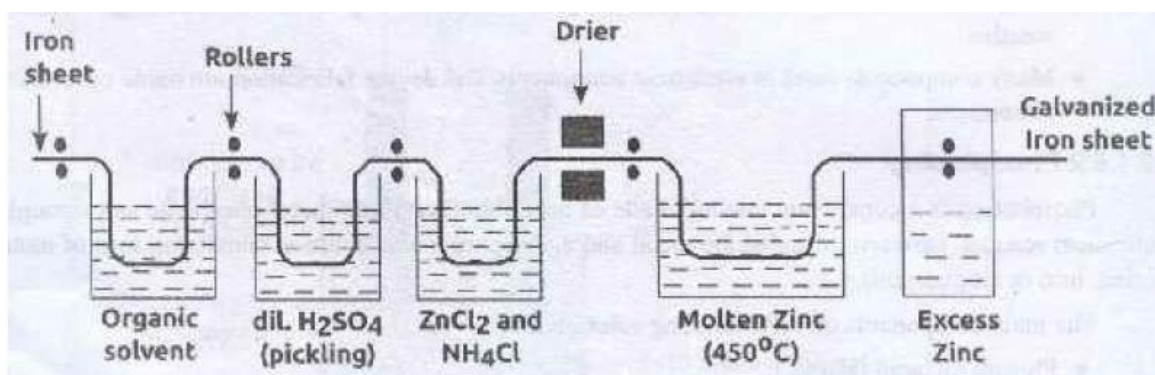
At the cathode (more O₂ concentration): $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$



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.

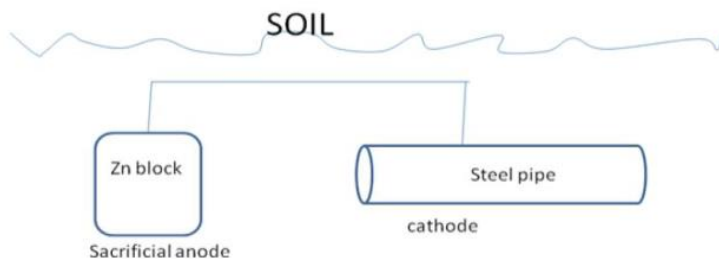
3.a Define cathodic protection. Describe sacrificial anode method of corrosion control by suitable examples.

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:

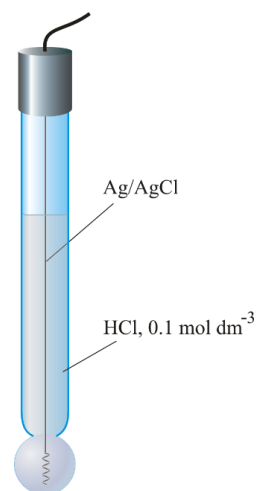
- The base metal is usually iron, copper or brass.
- The metal to be protected from corrosion is converted into cathode by connecting to a metal which is anodic to it.
- Metals like Mg, Al and Zn are more active and hence are used as anodes.
- Since the anodic metals are sacrificed to protect the metal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



3.b. Describe 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, $E_b = E_1 - E_2$

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

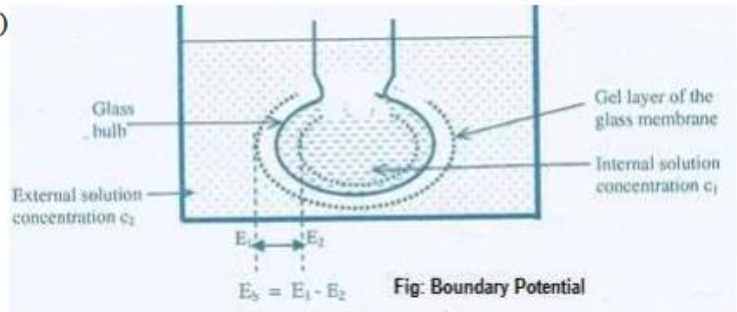
$$= E^\circ + \frac{0.0591}{n} \log C_2 - (E^\circ - \frac{0.0591}{n} \log C_1)$$

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

Where, $C_1 = 0.1 \text{ M}$ and $n = 1 \text{ (H}^+)$

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

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



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)

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

$$E_G = E^\circ_G - 0.0591 \text{ pH}$$

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

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

Answer:

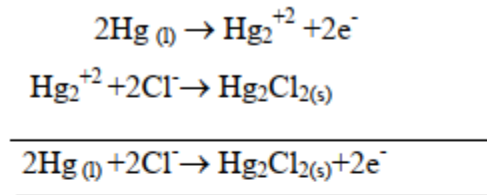
The electrodes whose potentials is known and constant and they are used to determine the potential of another unknown electrode are known as reference electrodes.

Construction and working of calomel electrodes:

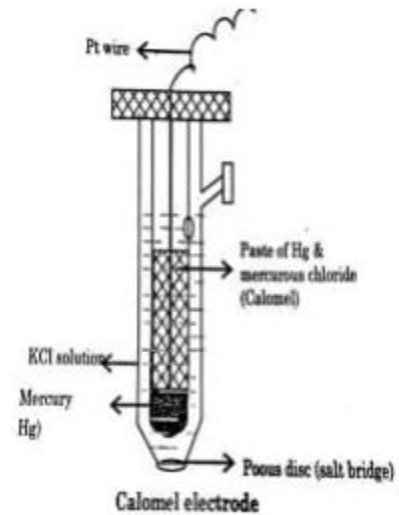
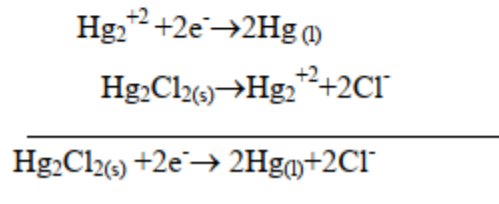
- The calomel electrode consists of two glass tube.
- At the inside glass tube, there is a paste (calomel) of mercury and mercurous chloride (Hg_2Cl_2) at the bottom of a narrow glass tube.
- Pure mercury is filled below the paste and connected with platinum wire for external electrical contact
- This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

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

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)

4.b What is CPR. A piece of corroded steel plate was found to be in a submerged ocean vessel. It was estimated that original area of plate was 120 inch² and it has experienced a wt. loss of 1.3 Kg due to corrosion over the period of 7 years. Calculate CPR in mpy and mm/y. Given $K(\text{mpy}) = 534$ and $K(\text{mm/y}) = 87.6$ and density of the metal is 7.9 gm/cm^3 .

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.

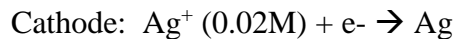
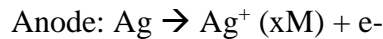
Corrosion penetrating rate in mpy CPR = KW/DAT Weight loss, W= 1.3×10^6 mg Density, D = 7.9 g/cm^3 ; Time, T = $7 \times 24 \times 365$ Area A = 120 in^2 CPR = $\frac{534 \times 1.3 \times 10^6}{7.9 \times 120 \times 7 \times 24 \times 365}$ CPR = 11.94 mpy	Corrosion penetrating rate in mm/y CPR = KW/DAT Weight loss, W= 1.3×10^6 mg Density, D = 7.9 g/cm^3 ; Time, T = $7 \times 24 \times 365$ Area A = $120 \times 6.45 \text{ cm}^2$ CPR = $\frac{87.6 \times 1.3 \times 10^6}{7.9 \times 120 \times 6.45 \times 7 \times 24 \times 365}$ CPR = 0.303 mm/y
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5.a What are concentration cell? The cell potential of following concentration cell Ag/AgNO₃(xM)// AgNO₃ (0.02M)/Ag is 0.045 at 25°C. Calculate the value of x. Also write the cell reactions.

Answer:

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

Cell reactions:



Under the given condition (T=25°C =298K),

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

Where C_2 = Concentration of electrolyte at cathodic compartment = 0.02 M

C_1 = Concentration of electrolyte at anodic compartment = xM

$$E = 0.045\text{V}$$

$$n = 1$$

Substituting the above values in above formula,

$$0.045 = 0.0591/1 [\log 0.02/x]$$

$$0.045 = 0.0591 [\log 0.02 - \log x]$$

$$0.045 = 0.0591 [-1.699 - \log x]$$

$$0.7614 = -1.699 - \log x$$

$$\log x = -1.699 - 0.7614 = -2.4604$$

$$x = 0.00346 \text{ M}$$

Thus, the value of $x = 0.00346 \text{ M}$.

5.b. Briefly explain the principle, instrumentation and application of potentiometry 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 M^{n+} , the electrode potential is given by Nernst equation,

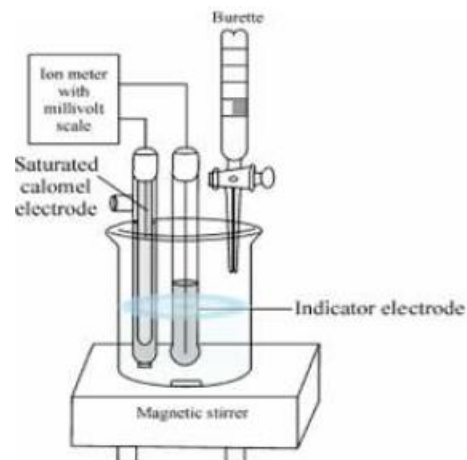
$$E = E^{\circ} + \frac{0.0591}{n} \log [M^{n+}]$$

Thus, the concentration can be calculated, provided E° 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.

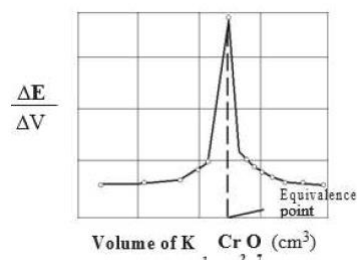
Instrumentation: A potentiometer consists of: (i) Calomel electrode as a reference electrode, (ii) Platinum electrode as an indicator electrode, (iii) a device for measuring the potential and (iv) Magnetic stirrer.

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.

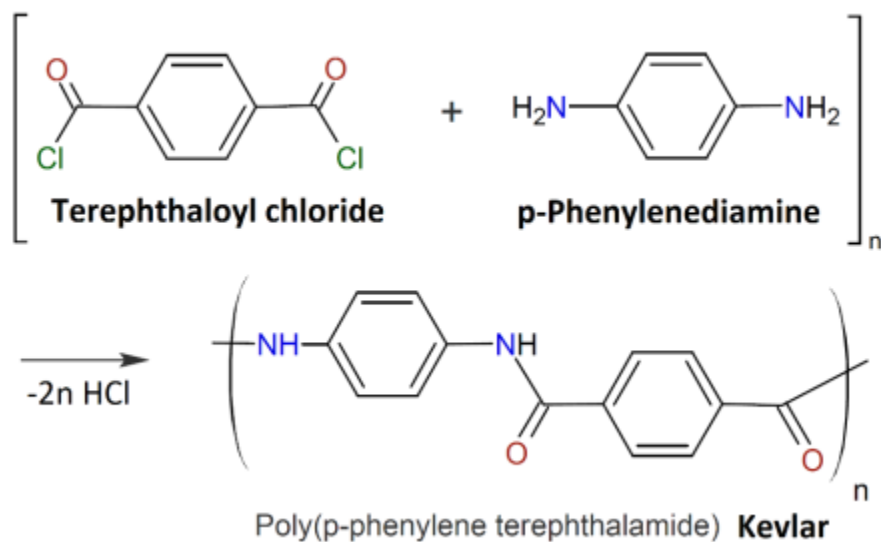


6.a. Describe the preparation, properties and commercial application of Kevlar.

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.

6.b. In a polymer sample, 25% of molecules have molecular mass of 15000 g/mol, 35% molecules have molecular mass of 27000 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:

$$\text{Total weight} = (25 \times 15000) + (35 \times 27000) + (40 \times 25000) = 375000 + 945000 + 1000000 = 2320000$$

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

$$M_n = \frac{\sum M_i N_i}{\sum N_i} \quad M_n = 2320000 / 100 = \mathbf{23200 \text{ g/mol}}$$

Weight average molecular mass:

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

$$M_w = \frac{[(25 \times (15000)^2) + [(35 \times (27000)^2] + [(40 \times (25000)^2]}{(25 \times 15000) + (35 \times 27000) + (40 \times 25000)}$$

$$M_w = \mathbf{24198.27 \text{ g/mol}}$$

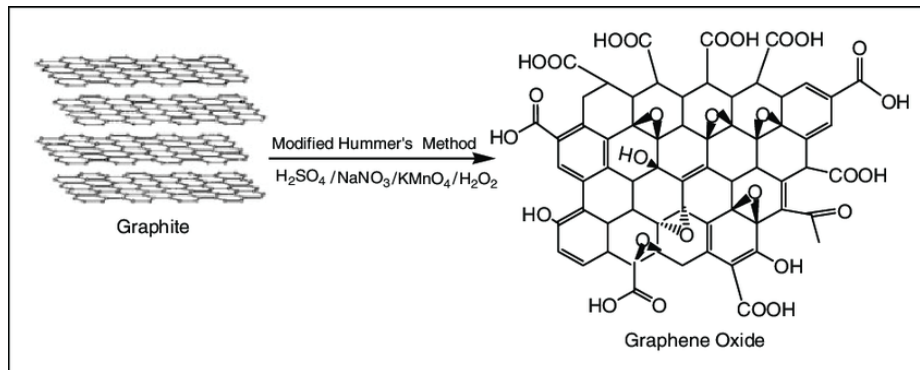
$$PDI = M_w / M_n = 24198.27 / 23200 = 1.043$$

7.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 (NaNO_3), potassium permanganate (KMnO_4), and concentrated sulfuric acid (H_2SO_4) in a round-bottom flask.
- Stir the mixture at a low temperature (around $0-5^\circ\text{C}$) 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.

7.b. Describe the theory, instrumentation and applications of conductometry by taking example of weak acid.

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 1cm 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 1ml . Plot a graph of conductance against volume of NaOH . Determine the neutralization point from the graph as shown below.

