11	a)	Explain how nano metal oxides are prepared using stabilizing agents.	L3	CO3	5 M
	b)	Write a note on Langmuir adsorption isotherm.	L2	CO5	5 M

PVP 23

Code: 23BS1204

I B.Tech - II Semester – Regular Examinations - JULY 2024

ENGINEERING CHEMISTRY

(Common for CE, ME)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	Define Reverse osmosis.	L1	CO2
1.b)	What is BIS?	L1	CO2
1.c)	What is a fuel cell?	L1	CO1
1.d)	Define Pillingbedworth rule.	L1	CO1
1.e)	Define Functionality of monomer.	L1	CO2
1.f)	What is HCV & LCV?	L1	CO2
1.g)	What is a refractory?	L2	CO1
1.h)	Explain why Thick film lubricant mechanism is known as hydrodynamic mechanism.	L2	CO5
1.i)	What is a Micelle?	L1	CO3
1.j)	Write the equation of Freundlich adsorption isotherm.	L2	CO3

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Explain Estimation of hardness of water by EDTA method.	L2	CO2	5 M
	b)	Write a note on Electro dialysis.	L1	CO2	5 M
		OR			
3	a)	Illustrate ion exchange process with a neat labelled diagram.	L2	CO2	5 M
	b)	Write a note on Caustic Embrittlement.	L1	CO2	5 M
		UNIT-II			
4	a)	What is a battery? Explain construction, working and applications of Zinc-air battery.	L3	CO2	5 M
	b)	Explain Electro chemical corrosion by Evolution of Hydrogen mechanism.	L2	CO2	5 M
		OR			
5	a)	What is a fuel cell? Explain H_2-O_2 Fuel cell with a neat diagram.	L2	CO2	5 M
	b)	What is electro less plating? Explain it with an example.	L2	CO4	5 M
		UNIT-III			
6	a)	What is addition polymerization? Explain mechanism involved in preparation of polyvinyl chloride.	L3	CO4	5 M

	b)	Explain Fractional distillation method with a neat labelled diagram.	L3	CO4	5 M
		OR			
7	a)	List out the engineering applications of the composites.	L2	CO2	5 M
	b)	Write the characteristic of a monomer for step by growth polymerization with an example.	L2	CO4	5 M
		UNIT-IV			
8	a)	Explain boundary film and Extreme pressure lubricating mechanism.	L2	CO4	5 M
	b)	Describe the factors affecting refractory materials.	L2	CO5	5 M
		OR			
9	a)	What is Portland cement? Explain reactions involved in setting and hardening of cement.	L3	CO5	5 M
	b)	Write the applications of structural reinforced composites and fibres.	L2	CO5	5 M
		UNIT-V			
10	a)	Illustrate how colloids are prepared using Braggs method.	L2	CO5	5 M
	b)	Write the applications of nanomaterials in various fields.	L2	CO3	5 M
		OR			

PVP23

Code No: 23BS1204

PVP SIDDHARTHA INSTITUTE OF TECHNOLOGY
(Autonomous)
I B.Tech – II Semester Regular Examinations-JULY-2024
ENGINEERING CHEMISTRY
(Common to CE, ME)

Duration: 3 Hours **Max. Marks: 70**

KEY AND SCHEME OF VALUATION

PART-A

1.a) Reverse Osmosis -2M
1.b) BIS -2M
1.c) Fuel cell -2M
1.d) Pilling-Bedworth rule -2M
1.e) Functionality of monomer -2M
1.f) HCV and LCV-2M
1.g) Refractory-2M
1.h) Thick film lubricant mechanism is known as hydrodynamic mechanism-2M
1.i) Micelle -2M
1.j) The equation of Freundlich adsorption isotherm-2M

PART-B

UNIT-I

2.a) Estimation of hardness of water by EDTA method- Procedure-3M TH formula-2M
2.b) Electro dialysis- Procedure-3M, Diagram-2M

OR

3a) Ion exchange process with a neat labelled diagram- Procedure-3M, Diagram-2M
3b) Caustic Embrittlement – 5M

UNIT-II

4a) Battery definition- 1M construction -2M
working and applications of Zinc-air battery-2M
4b) Electro chemical corrosion -Evolution of Hydrogen mechanism- Procedure-3M, Diagram-2M

OR

5a) Fuel cell- 1M , H_2-O_2 Fuel cell diagram – 2M , Reactions -2M
5b) Electro less plating- 2M , electro less plating example-3M

UNIT-III

6a) Addition Polymerisation – 2M mechanism involved in preparation of polyvinyl chloride-Intiation-1M Propagation-1M Termination-1M
6b) Fractional distillation method Procedure -3M diagram-2M

OR

7a) Any five engineering applications of the composites-5M
7b) Characterization of a monomer for step by growth polymerization with an example-5M

UNIT-IV

8a) boundary film and Extreme pressure lubricating mechanism -5M
8b) any three factors affecting refractory materials-5M

OR

9a) Portland Cement definition-1M reactions involved in setting and hardening of cement -4 M
9b) Any five applications of structural reinforced composites and fibres-5M

UNIT-V

10a) Colloids are prepared using Braggs method-5M
10b) Any five applications of nanomaterials in various fields-5M

OR

11a) nano metal oxides are prepared using stabilizing agents – 5M
11b) Langmuir adsorption isotherm-5M

Code No: 23BS1204

PVP23

PVP SIDDHARTHA INSTITUTE OF TECHNOLOGY
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I B.Tech – II Semester Regular Examinations-JULY-2024
ENGINEERING CHEMISTRY
(Common to CE, ME)

Duration: 3 Hours **Max. Marks: 70**

KEY AND SCHEME OF VALUATION

PART-A

1.a) **Define Reverse Osmosis**

Ans: Reverse osmosis (RO) is a water purification process that uses a semi-permeable membrane to remove ions, molecules, and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property driven by chemical potential differences of the solvent, thus allowing pure water to pass through the membrane while contaminants are left behind. This process is commonly used for desalinating seawater, removing contaminants from wastewater, and producing high-purity water for various industrial processes.

1.b)**What is BIS?**

BIS stands for the Bureau of Indian Standards. It is the national standards body of India, responsible for the development of standards, certification, and quality assurance of goods and services.

1.c) **What is a fuel cell?**

A fuel cell is a device that converts chemical energy from a fuel, such as hydrogen, into electrical energy through an electrochemical reaction with oxygen, typically producing water and heat as by-products.

1.d) **Define Pilling-Bedworth rule.**

The Pilling-Bedworth rule relates the volume of oxide formed during metal oxidation to the volume of the metal consumed. It helps predict whether an oxide layer will be protective or non-protective. If the volume ratio is close to 1, the oxide layer is usually protective.

1.e) **Define functionality of monomer.**

The functionality of a monomer refers to the number of reactive sites or bonds in a monomer molecule that can participate in polymerization reactions, determining the type and structure of the resulting polymer.

1.f) What is HCV and LCV?

HCV (Higher Calorific Value) and LCV (Lower Calorific Value) are measures of the energy content in fuel. HCV includes the total energy released, including the latent heat of vaporization of water, while LCV excludes it, providing a lower value.

1.g) What is a refractory?

A refractory is a material that retains its strength and chemical stability at high temperatures, often used to line furnaces, kilns, and reactors.

1.h) Explain why thick film lubricant mechanism is known as hydrodynamic mechanism.

The thick film lubricant mechanism is known as a hydrodynamic mechanism because it involves a continuous fluid film that fully separates two surfaces in relative motion, preventing direct contact and reducing friction and wear through the principles of fluid dynamics.

1.i)What is a Micelle?

A micelle is an aggregate of surfactant molecules dispersed in a liquid colloid. In water, micelles form when the surfactant molecules arrange themselves such that their hydrophobic (water-repelling) tails are shielded from the water by their hydrophilic (water-attracting) heads, creating a spherical structure. This organisation allows the micelle to trap oils and fats within its core, making it effective for cleaning and emulsifying purposes.

1.j)Write the equation of Freundlich adsorption isotherm.

The Freundlich adsorption isotherm equation is:

$$\frac{x}{m} = kP^{\frac{1}{n}}$$

- $\frac{x}{m}$: The amount of adsorbate (x) adsorbed per unit mass of adsorbent (m).
- k: Freundlich constant related to adsorption capacity.
- P: Equilibrium pressure of the adsorbate.
- n: Constant related to adsorption intensity.

PART-II

UNIT-I

2.a) Explain Estimation of hardness of water by EDTA method.

The estimation of hardness of water by the EDTA method is a common titration technique used to measure the concentration of calcium and magnesium ions, which contribute to water hardness. Here's a step-by-step explanation:

Materials Needed:

EDTA solution (standard solution), Ammonia buffer solution (pH 10), Eriochrome Black T indicator , Distilled water , Water sample , Burette, pipette, and conical flask

Procedure:

- Take a measured volume (usually 50 mL) of the water sample in a conical flask.
- Add a few millilitres (around 1-2 mL) of ammonia buffer solution to the flask to maintain the pH at around 10. This ensures that the metal ions remain in a suitable form for complexation with EDTA.
- Add a few drops of Eriochrome Black T indicator to the solution. The solution will turn wine-red in the presence of calcium and magnesium ions.
- Fill a burette with the standard EDTA solution.
- Slowly titrate the EDTA solution into the water sample, continuously swirling the flask.
- As EDTA reacts with the calcium and magnesium ions, the wine-red colour will change.
- Continue adding EDTA until the colour changes from wine-red to pure blue. This indicates that all the calcium and magnesium ions have complexed with EDTA.

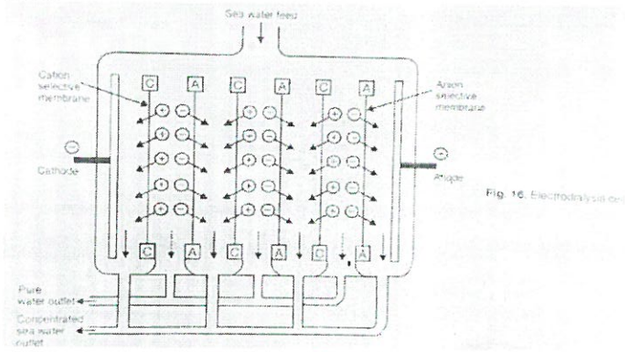
Calculations:

- Note the volume of EDTA solution used to reach the endpoint.
- The hardness of water (in ppm of $CaCO_3$) can be calculated using the formula:

Total hardness of water sample = Molarity of water sample X Mol.Wt of $CaCO_3$X1000mg/ml

2.b) Write a note on Electro dialysis.

Electro dialysis: Electro dialysis is based on the fact that the ions present in saline water migrate towards their respective electrodes, through ion - selective membranes (natural or synthetic) under the influence of applied emf.



Electrodialysis

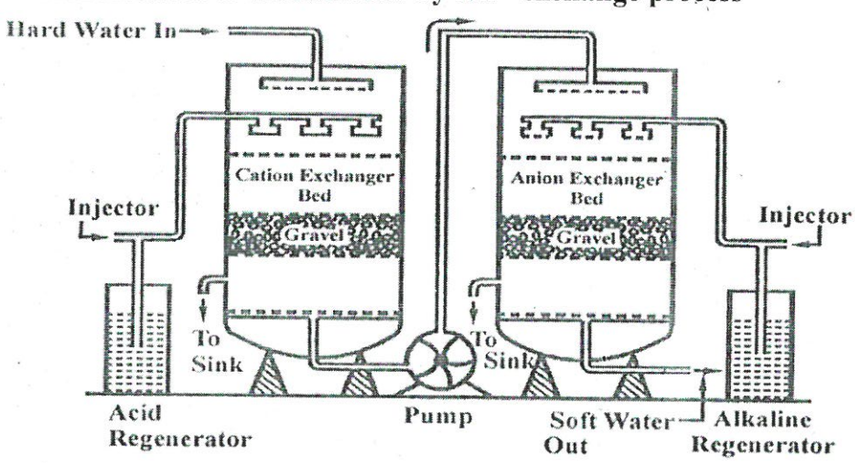
In this method ions are attracted towards anode and cathode on passing electricity through saline water.The ions pass through ion selective membrane towards the direction of the opposite electrodes.As a result containers witheven number are filled with the pure water andthecontainerswithoddnumberarewithconcentratedbrinesolution.Theion-selective membrane pores are lined with fixed charge, which exclusively permit flow of only one type ions through the pres and rejects the opposite charged ions.The cation selective membranes and the anion selective membranes are alternatively placed to make separate containers.On passing a direct current the containers between cation and anion selective membrane will have pure water, since both the cations and anions leave out through theion selective membrane in the opposite direction.

The ion selective membranes are generally polystyrene based polymers containingsulfoni acid (cation selective) and tetrammonum chloride (anion selective).

OR

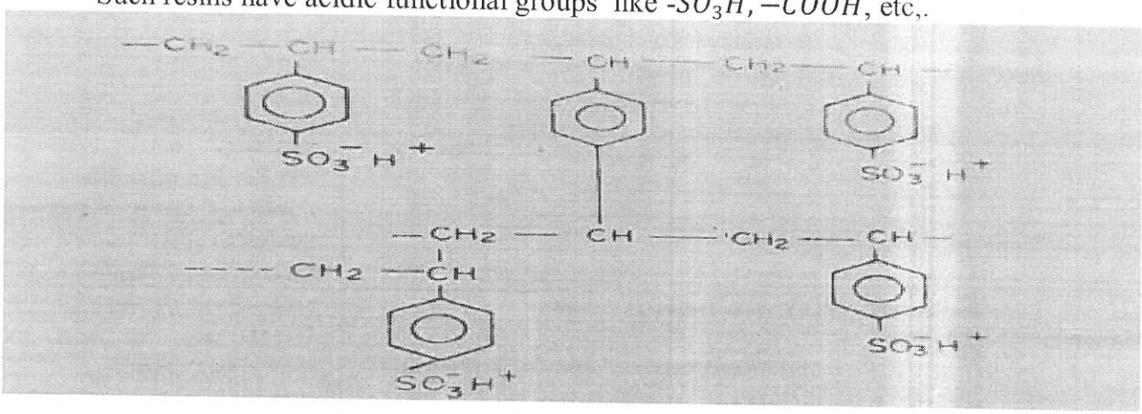
3a) Illustrate ion exchange process with a neat labelled diagram.

Demineralization or deionization by ion - exchange process



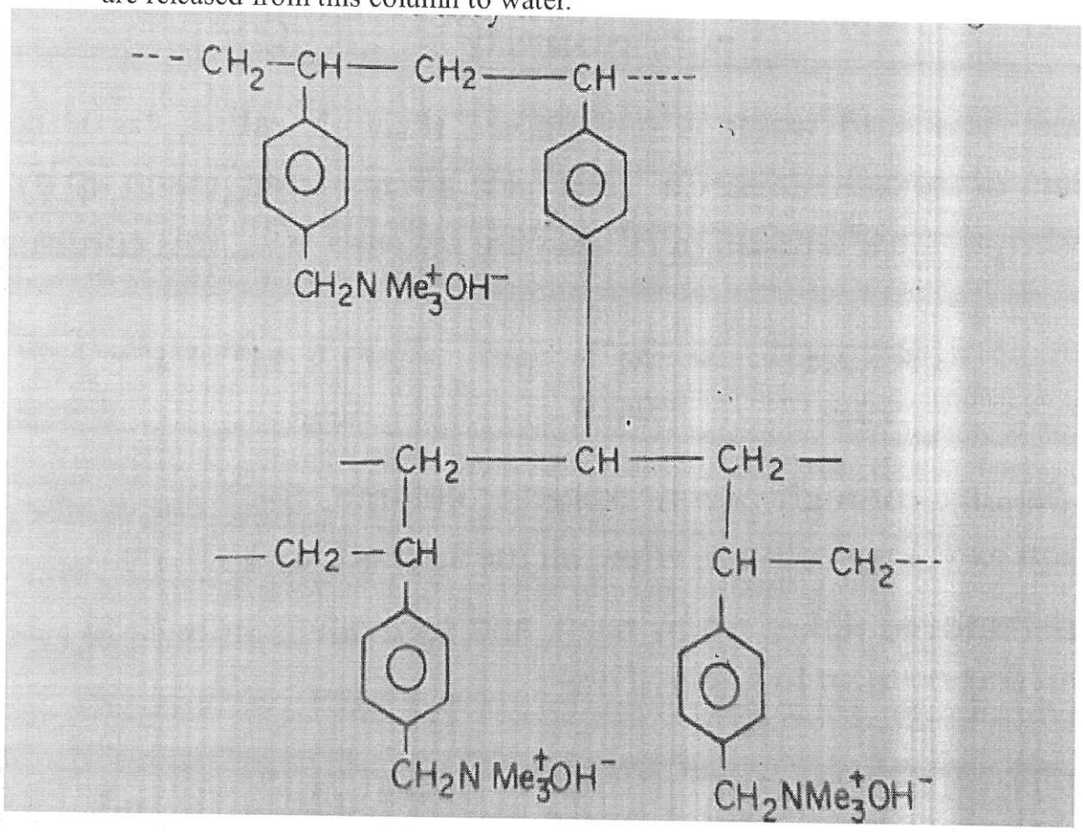
Cation exchange resins

- They are mainly styrene divinyl benzene co - polymers, which on sulfonation or carboxylation, become capable of exchange their hydrogen ions with the cations in the water.
- Such resins have acidic functional groups like -$SO_3H, -COOH$, etc,.



Anion exchange resins

- They styrene divinyl benzene co-polymers, which contain basic functional groups such as amino or quaternary ammonium hydroxide ($N^+R_3OH^-$) capable of exchanging anions present in the water
- The hard water is first passed through cation exchange column when all the cations likeCa^{2+}, Mg^{2+}.etc. are removed (taken up by the resin) from it, and equivalent amount of H^+ ions are released from this column to water.



- After passing through cation exchange column, the hard water is passed through anion exchange column, when all the anions likeSO_4^{2-}, Cl^-, etc. Present in the water are removed (taken up by resin) and equivalent amount of OH^-ions are released from this column to water.

$$2RH^+ + CaSO_4 \rightarrow R_2Ca + 2H^+ \qquad 2RH^+ + MgSO_4 \rightarrow R_2Mg + 2H^+$$

- When capacities of cation and anion exchangers are exhausted, then the cation exchange is regenerated by passing a solution of dil.HCL or dil. H_2SO_4

$$R_2Ca + 2H^+ \rightarrow 2RH^+ + Ca^{2+} \qquad R_2Mg + 2H^+ \rightarrow 2RH^+ + Mg^{2+}$$

- Anion is regenerated by passing a solution dil. NaOH.

- **$RCl + NaOH \rightarrow ROH + NaCl$**

Advantages

- The process can be used to soften highly acidic or alkaline waters.
- It produces water of very low hardness (say2ppm). So, The treated water is very good for use in high pressure boilers.

Disadvantages

- Capital cost is very high since chemical and equipment both are costly.
- If water contains turbidity then the efficiency of the process to reduced.

3b) Write a note on Caustic Embrittlement.

CAUSTIC EMBRITTLEMENT

The formation of brittle and in crystalline cracks in the boiler shell is called caustic embrittlement.
The main reason for this is the presence of alkali-metal carbonates and bicarbonates in feed water. In lime-soda process, it is likely that, some residual Na_2CO_3 is still present in the softened water. This Na_2CO_3 decomposes to give NaOH and CO_2, due to which the boiler water becomes "Caustic Soda".

$$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$$

The H_2O evaporates, the concentration of NaOH increase progressively creating a concentration cell as given below thus dissolving the iron of the boiler as sodium ferrate (Na_2FeO_2).

(-)Anode: 'Fe' at bents | Conc.NaOH || Dil.NaOH | 'Fe' at plane Surface: Cathode (+)

This causes embrittlement of boiler parts such as bends, joints, reverts etc, due to which the boiler gets fail. The iron at plane surfaces surrounded by dilute NaOH becomes cathodic while the iron at bends and joints surrounded by highly concentrated NaOH becomes anodic which consequently decayed or corroded.

Caustic embrittlement can be prevented:

a. By maintaining the pH value of water and neutralization of alkali.
b. By using Sodium Phosphate as softening reagents, in the external treatment of boilers.
c. Caustic embrittlement can also be prevented by adding Tannin or Lignin or Sodium sulphate which prevents the infiltration of caustic-soda solution blocking the hair-cracks.

UNIT-II

4.a) What is a battery? Explain construction, working and applications of Zinc-air battery

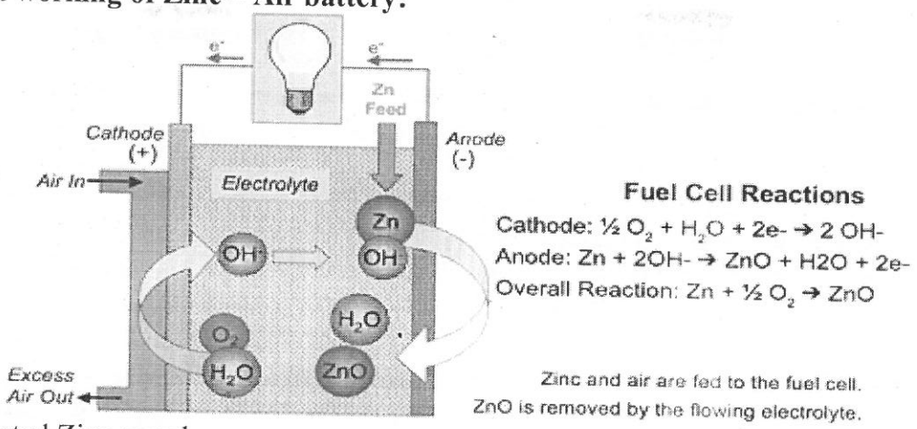
Battery may be defined as an electrochemical cell or often several electrochemical cells connected in series that can be used as a source of direct electric current at a constant voltage.

Zinc-air battery:-

Many commercial batteries are not able to meet the requirements of many applications.
These modern batteries are introduced with improved characteristics like (long life ,low cost little or no maintenance and safety.

E.g.: Zinc – Air battery

Construction and working of Zinc – Air battery:



Anode - Amalgamated Zinc powder
Cathode – Air|C
Electrolyte - KOH 6M

Representation of Zinc – Air battery: Zn| KOH|| Air C

1. Zinc – Air battery is a primary battery i.e. non-rechargeable and the reaction is irreversible.
2. It is also known as alkaline battery.
3. In this battery the cathode is made up of porous carbon plate which activated by manganese oxide. Anode is made up of rectangular An pellets which are placed between two cathodes.
4. Because it is alkaline battery we can use wither KOH or Noah as an electrolyte. But we have to use KOH only as the ionic conductance of KOH is higher than Noah.
5. The electrodes are separated by gascade insulating material. The whole assembly is Enclosed in glass or ebonite container coated with Teflon, which is hydrophobic i.e. it Allows only oxygen but not moisture.
6. At cathode the electro active species air i.e. oxygen. During the cell reactions in battery the electrolyte concentrations is remains constant.

The reactions occur are as follows:

At anode: At anode the Zn undergoes oxidation in presence of electrolyte to produce zinc oxide and eater.

$$Zn+2OH^- \longrightarrow ZnO+H_2O+2e^-$$

At cathode, water undergoes reduction reaction in presence of oxygen and electrons to give up hydroxyl ions, So the OH - ions consumed at anode and liberated at cathode, hence the overall concentration of electrolyte is constant.

$$1/2\ O_2 + H_2O + 2e^- \longrightarrow 2OH^-$$

The overall reaction is $Zn + 1/2\ O_2 \longrightarrow ZnO$

The output of the Zn-air battery is 1.65V

Advantages:

1. High energy density.
2. Low cost
3. Capacity is independent of load and temperature.

Applications:

1. Power source for hearing aids
2. Used in electric pagers
3. Used in military radio receivers
4. Used in voice transmitters

4b) Explain Electro chemical corrosion by Evolution of Hydrogen mechanism.

Electrochemical or wet corrosion: This type of corrosion occurs when moist air or any electrolytic solution comes in contact with a metal or two metals which are in contact with each other. Corrosion is caused due to the electrochemical reaction that occurs between the metal and wet atmospheric elements .Eg: corrosion of iron in moist atmospheric air.

Mechanismofelectrochemicalcorrosion: Mechanism of electrochemical corrosion is explained on the basis of electrochemical theory. According to this theory when a metal comes in contact with moist environment, a series of electrochemical cells consisting of anode and cathodic area will form on the metal surface. The moisture containing atmospheric agents dissolved in it, acts as the electrolytic medium. At the anode, the metal undergoes oxidation and produces metal ions and electrons. These electrons migrate through the metal and reach the cathodic area. The cathode reactions do not affect the cathode since most of the metals cannot be further reduced. Hence at the cathodic area, the dissolved constituents of the conducting medium accept the electrons to form H_2orOH^-

Rusting of iron can be taken as a classical example to explain electro chemical corrosion.

a) At anode: - Iron oxidizes to give ferrous ions at anode.

$Fe \quad Fe^{+2} + 2e^-$ **(Oxidation)**

a)At cathode: - Two types of reduction reactions can occur at cathode depending upon the nature of corrosive environment.

i) **Evolution of hydrogen:** In the absence of oxygen and in acidic environment, the H+ ions of the acidic solution pickup electrons and eliminate as hydrogen gas.

$2H^+ + 2e^- \quad H_2$ **(reduction)**

$Fe + 2H^+ \quad Fe^{+2} + H_2$

Mechanism of corrosion by evolution of hydrogen

Thus this type of corrosion causes displacement of hydrogen ions by metal ions. Consequently all metals above hydrogen in electrochemical series have tendency to dissolve in acidic solution with the simultaneous evolution of hydrogen.

OR

5a) What is a fuel cell? Explain H_2-O_2 Fuel cell with a neat diagram.

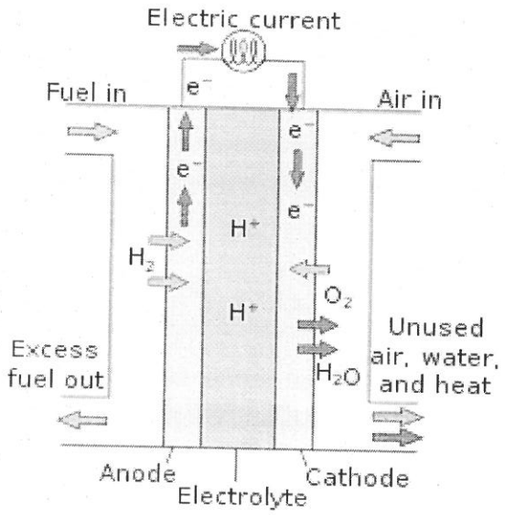
Fuel is a combustible substance containing carbon as major constituent, which gives out heat energy on burning. It contains carbon as the major constituent.

Fuel + O 2 ⟹ combustion products + heat

Construction and working ofH_2-O_2 fuel cell

1. It has two electrodes where the reactions take place and an electrolyte i.e., molten KOH which carries the charged particles from one electrode to the other.
2. E^O_{cell}Is positive, the cell reaction is spontaneous. The fuel cell produces power through redox reaction between hydrogen and oxygen.
3. At anode the hydrogen is oxidized through reaction with producing water and releasing two electrons.
4. The electrons flow through external circuit and returns to the cathode, reducing oxygen which consequently reacts with water to produce .

5. The fuel cell electrodes contain catalysts to speed up electrode reactions and the process is known electro catalysis. In the a mixture of Ni and NiO embedded in porous carbon electrodes which serves electro catalysts in the cell.



Hydrogen- Oxygen fuel cell

The corresponding reactions at anode cathode are;

At anode - $H2 \longrightarrow 2H + 2e-$ E0 =0V

At cathode - $½\ O2 + 2H+ + 2e- \longrightarrow H2O$ E0 =1.2291 V

The overall reaction $H2 + ½\ O2 \longrightarrow H2O$ E0 =1.2291 V

5b) What is electro less plating? Explain it with an example.

Electroless plating of Cu:

Without using electrical energy, the deposition of a metal fromits salt solution on a catalytically active surface by a suitable reducing agent is known as electroless plating. Metallic ions are reduced to the metal with the help of reducing agents.Once the metal atoms are formed, they get plated over a catalytic surface.

Metal ions + Reducing agent ⟶ Metal plated on a catalyst surface + Oxidized products

The following techniques are used for the preparation of the surface of the object so that an active surface is obtained.

Electrolessplatingofcopper:

The surface to be treated is degreased and etched in acid.On gold, silver, platinum, palladium, rhodium, iron, cobalt and nickel, electroless copper gets deposited spontaneously in presence of reducing agents.But insulators like plastics, printed circuit boards and glass are activated by dipping first in stannous chloride and then in palladium chloride.

A solution of copper sulphate (12 g/L), formaldehyde (8 g/L) as reducingagent, sodium hydroxide (15 g/L) and Rochelle salt (14 g/L) as buffer, EDTA as complexing agent (20 g/L) acts as plating bath solution for copper plating.For an effective plating of copper, the pH and temperature to be maintained are 11.0 and 25 °C respectively.The following reactions occur during plating:

Oxidation: $2HCHO + 4\ OH^- \longrightarrow 2HCOO^- + 2H_2O + H_2 + 2e^-$

Reduction: $Cu^{2+} + 2e^- \longrightarrow Cu$

Overallreaction: $2HCHO + 4OH^- + Cu^{2+} \longrightarrow Cu + 2HCOO^- + 2H_2O + H_2$

Cupric ions and formaldehyde consumed during plating are replenished periodically.

UNIT-III

6a) What is addition polymeriasation? Explain mechanism involved in preparation of polyvinyl chloride.

Addition polymerization:

Polymer is formed by addition of monomers without elimination of small molecules. No by-products are formed. Ex: PS, PVC etc

Polyvinyl chloride (PVC) is synthesized through addition polymerization, a process where monomer units are added sequentially to a growing polymer chain. The mechanism of PVC formation via addition polymerization involves three main steps: initiation, propagation, and termination.

1. Initiation

In the initiation step, a free radical initiator (e.g., benzoyl peroxide or azobisisobutyronitrile) decomposes under heat or light to produce free radicals. These free radicals are highly reactive species with an unpaired electron.

$$\text{Initiator} \rightarrow 2R^{\bullet}$$

The free radical then reacts with a vinyl chloride monomer ($CH_2=CHCl$), forming a new free radical at the end of the monomer.

$$R^{\bullet} + CH_2 = CHCl \rightarrow R\text{-}CH_2CHCl^{\bullet}$$

2. Propagation

During the propagation step, the newly formed radical reacts with another vinyl chloride monomer. This reaction continues, with each successive monomer addition transferring the radical to the end of the growing chain.

$$R\text{-}CH_2CHCl^{\bullet} + CH_2 = CHCl \rightarrow R\text{-}(CH_2CHCl)_2^{\bullet}$$

$$R\text{-}(CH_2CHCl)_2^{\bullet} + CH_2 = CHCl \rightarrow R\text{-}(CH_2CHCl)_3^{\bullet}$$

This chain propagation continues, resulting in a long polymer chain.

3. Termination

The termination step occurs when two free radicals combine, effectively stopping the chain growth. There are two main ways termination can occur:

1. **Combination**: Two growing polymer radicals combine to form a single, non-radical polymer molecule.

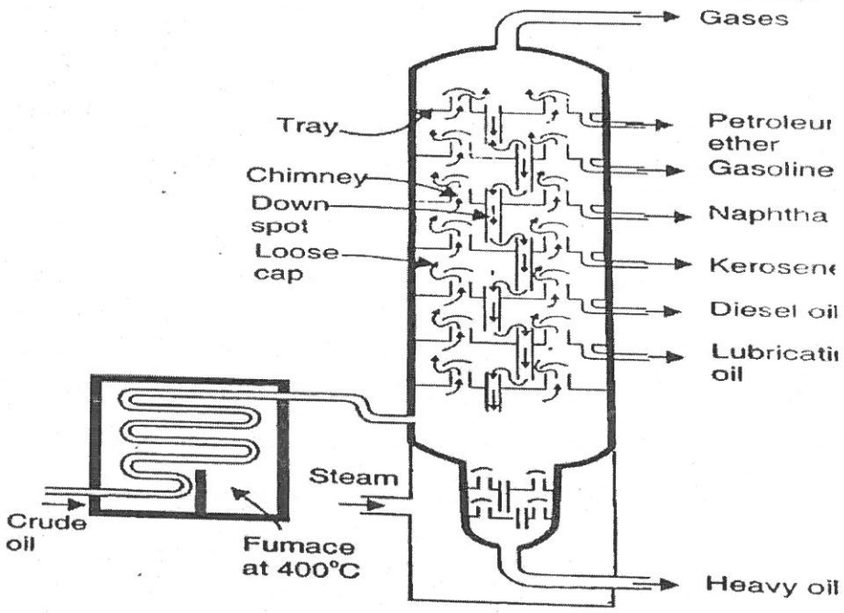
$$R\text{-}(CH_2CHCl)_n^{\bullet} + R'\text{-}(CH_2CHCl)_m^{\bullet} \rightarrow R\text{-}(CH_2CHCl)_n - (CH_2CHCl)_m - R'$$

2. **Disproportionation**: A hydrogen atom is transferred from one growing polymer radical to another, resulting in two stable polymer molecules.

$$R\text{-}(CH_2CHCl)_n^{\bullet} + R'\text{-}(CH_2CHCl)_m^{\bullet} \rightarrow R\text{-}(CH_2CHCl)_nH - R'\text{-}(CH{=}CHCl)_m$$

6b) Explain Fractional distillation method with a neat labeled diagram.

Fractional distillation:



The crude oil is fractionally distilled in a fractionating still, which is a tower like structure having a bubble tower laid inside. The crude oil or the petroleum enters through the bottom of the still by an inlet. This is made to pass through a pre-heater or it can heated with steam inside the still to a temperature of about 400$_0$C. As we move to the top fractionating still the temperature goes on decreasing. A number of side pipes are fitted at different heights of the column or still, to collect the fractions. As petroleum onters the still, it gets vaporized and the vapours move up the bubble tower. The bubble tower consists of number of horizontal trays, and each tray is provided with a number of small chimneys through which the vapours rise. The chimneys are covered with loose caps so that the vapours bubble through and get condensed, dropping back into the trays. So as the vapours go up, they become cooler and cooler and fractional condensation of the crude oil takes place at different levels of the bubble tower.

The vapours of the liquid having the highest boiling point are the first to condense and go out and those which have the lowest boiling points go last, along with the uncondensed gases. The constituents of each fraction and the temperature at which they are obtained is given in the table.

Name of fraction	*Boiling range*	*Composition*	*Uses*
1. Uncondensed gases	Below 30$_0$C	C_1 to C_4	As domestic or industrial fuel under the name L.P.G.
2. Petroleum ether	30 – 70$_0$C	C_5 to C_7	As a solvent
3. Gasoline or petrol(11,250 kcal/kg)	40 – 120$_0$C	C_5 to C_9	As a motor fuel in I.C. engine
4. Naphtha (11,000 kcal/kg)	120 – 180$_0$C	C_9 to C_{10}	As a solvent in dry cleaning
5. Kerosene oil (11,100 kcal/kg)	180 – 250$_0$C	C_{10} to C_{16}	As domestic fuel and jet engine fuel
6. Diesel oil	250 – 320$_0$C	C_{10} to C_{18}	Diesel engine fuel
7. Heavy oil This on refraction gives; (a) Lubricating oil (b) Petroleum jelly (Vaseline) (c) Grease (d) Paraffin wax	320 – 400$_0$C	C_{17} to C_{30}	As lubricant In cosmetics and medicines. As lubricant In candles and wax paper
8. Residue may be either; (a) Asphalt Or	Above 400$_0$C	C_{30} and above	Water proofing of roofs As a fuel

OR

7a) List out the engineering applications of the composites.

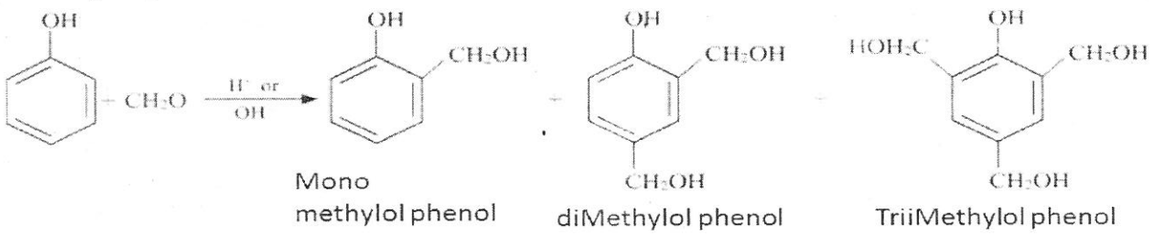
1. Aerospace: Composites are extensively used in aircraft and spacecraft components due to their lightweight and high strength properties, reducing fuel consumption and enhancing performance.
2. Automotive: In the automotive industry, composites find applications in body panels, chassis components, and interiors, contributing to fuel efficiency and crash safety.
3. Marine: Composites are used in boat hulls, masts, and other marine structures due to their resistance to water and corrosion.
4. Sports Equipment: From tennis rackets to bicycle frames, composites are widely employed in sports equipment for their lightweight and high-performance characteristics.
5. Infrastructure: Composites are used in bridges, pipelines, and buildings for their durability, corrosion resistance, and design flexibility. ,

7b) Write the characterization of a monomer for step by growth polymerization with an example.

STEP GROWTH POLYMERIZATION MECHANISM

Step-1

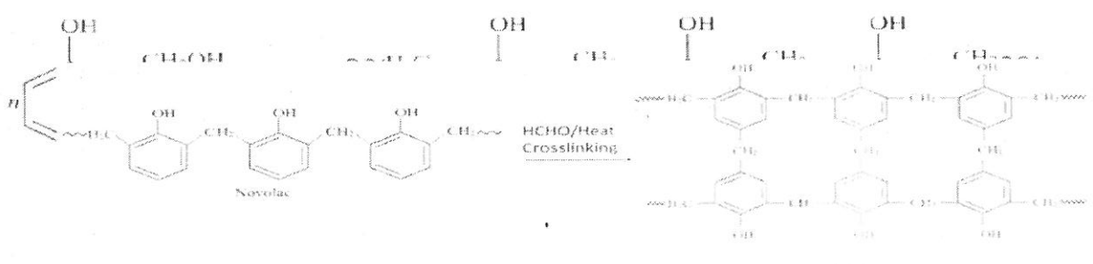
The first step is reaction between phenol and formaldehyde to form mono, di and tri-methylol phenols.



Step-II

When methylol phenols are heated with excess of phenol in presence of acid catalyst, the methylol phenols condense with phenol through methylene linkages to **from linear product novolac** with the elimination of water molecule.

Step-III



Further heating novolac and phenol in the presence of a catalyst (hexamethylenetetramine) leads to formation of hard, rigid, infusible cross linked polymer called Bakelite.

UNIT-IV

8a) Explain boundary film and Extreme pressure lubricating mechanism.

Lubrication Mechanisms:

Three mechanisms have been proposed to explain the action of lubricants they are

a) Thin film (or) Boundary Lubrication:

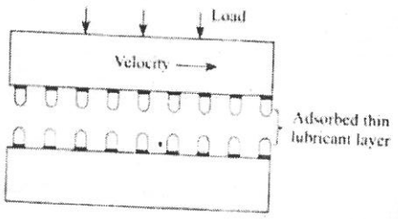


Fig 2.7Boundary film lumbrication

In this type of lubrication a thin film of lubricant is absorbed on the surface and held by vandarwaals forces. When the lubricant is not viscous enough to generate a film of sufficient thickness for the separation of surfaces under heavy loads, friction is reduced by thin film lubrication. Thin film lubrication is applied when the speed is very low, the loading heavy, the oil has low viscosity.

Some peaks may have higher thickness than the film of lubricant which results in wearing and tearing. Hence the chemical or physical forces on some metal surfaces would avoid the direct contact of metals and absorb a thin layer of lubricating oil. The co-efficient of friction is reduced due to oiling.

8b) Describe the factors affecting refractory materials.

- **Composition:** Determines resistance to different environments and thermal properties.
- **Microstructure:** Influences properties like porosity, density, and mechanical strength.
- **Manufacturing Process:** Parameters like firing temperature and cooling rate affect final properties.
- **Service Conditions:** Operating temperature, atmosphere, and chemical composition affect selection and performance.

OR

9a) What is Portland Cement ? Explain reactions involved in setting and hardening of cement?

Portland cement: It is most widely used non-metallic material of construction. It is a mixture of calcium silicates and calcium aluminates with small amount of gypsum.

The name Portland cement is used because this powder on mixing with water gives a hard, stone like mass which resembles Portland rock.

Setting and Hardening of cement:-

Cement when mixed with water forms a plastic mass called cement paste. During hydration reaction, gel and crystalline products are formed.

The inter-locking of the crystals binds the inert particles of the aggregates into a compact rock like material.

This process of solidification comprises of

(i) setting and then

(ii) hardening

Setting is defined as stiffening of the original plastic mass due to initial gel formation. Hardening is development of strength, due to crystallisation.

Due to the gradual progress of crystallisation in the interior mass of cement, hardening starts after setting. The strength developed by cement paste at any time depends upon the amount of gel formed and the extent of crystallisation. The setting and hardening of cement is due to the formation of inter locking crystals reinforced by rigid gels formed by the hydration and hydrolysis of the constitutional compounds.

Reactions involved in setting and hardening of cement:-

When cement is mixed with water, the paste becomes rigid within a short time which is known as initial setting. This is due to the hydration of tricalcium aluminate and gel formation of tetra calcium alumino ferrite.

$$3\ CaO.Al_2O_3 + 6\ H_2O \longrightarrow 3\ CaO.Al_2O_3.6\ H_2O + 880\ KJ/Kg$$

$$C_3A + 6\ H_2O \longrightarrow C_3A.\ 6\ H_2O + 880\ KJ/Kg$$

tricalcium aluminate — hydrated tricalcium aluminate (crystalline)

$$4\ CaO.Al_2O_3.Fe_2O_3 + 7\ H_2O \longrightarrow 3\ CaO.Al_2O_3.6\ H_2O + Cao.Fe_2O_3.H_2O + 420\ KJ/Kg$$

$$C_4AF + 7\ H_2O \longrightarrow C_3A.\ 6\ H_2O + CF.H_2O + 420\ KJ/Kg$$

tetracalcium alumino ferrite — (crystalline) gel

Dicalcium silicate also hydrolyses to tobermonite gel which contributes to initial setting.

$$2(2\ CaO.SiO_2) + 4\ H_2O \longrightarrow 3\ CaO.2SiO_2.6H_2O + Ca(OH)_2 + 250\ KJ/Kg$$

$$2\ C_2S + 4\ H_2O \longrightarrow C_3S_2.6H_2O + Ca(OH)_2 + 250\ KJ/Kg$$

Dicalcium silicate — tobermonite gel

9b) Write the applications of structural reinforced composites and fibres.

Structural Reinforced Composites - Applications:

Aerospace: Used in aircraft wings and fuselages to improve fuel efficiency.

Automotive: Applied in body panels and bumpers for weight reduction.

Construction: Utilized in bridges and beams for high strength and durability.

Sports Equipment: Employed in tennis rackets and golf clubs for lightweight strength.

Marine: Used in boats and offshore platforms for corrosion resistance.

Fibres in Structural Reinforced Composites

Glass Fibres: Commonly used for their strength and low cost in automotive and marine applications.

Carbon Fibres: Known for high strength and low weight, used in aerospace and sports equipment.

Aramid Fibres: High impact resistance makes them suitable for ballistic protection and aerospace.

Natural Fibres: Eco-friendly options used in automotive interiors and construction materials.

UNIT-V

10a) Illustrate how colloids are prepared using Braggs method.

The synthesis of colloids can be achieved through various methods, one of which is the Braggs method. The Braggs method involves the use of X-ray diffraction to produce colloidal particles. Here's a brief overview of the process:

1. Preparation of Sol: A sol is a colloidal suspension of solid particles in a liquid. In the Braggs method, a sol is typically prepared by dispersing a solid substance in a suitable liquid medium. This can be achieved through methods such as chemical reduction or precipitation.
2. X-ray Diffraction: Once the sol is prepared, it is subjected to X-ray diffraction. X-rays are directed at the sol, and the scattered X-rays are analyzed. The diffraction pattern produced provides information about the size, shape, and arrangement of the colloidal particles in the sol.

- Particle Characterization: The diffraction pattern obtained from X-ray diffraction allows researchers to characterize the colloidal particles in the sol. By analyzing the pattern, information about the size distribution and crystalline structure of the particles can be obtained.
- Control of Colloidal Properties: The parameters of the Braggs method can be adjusted to control the properties of the colloidal particles, such as their size and shape. This allows for the synthesis of colloids with specific characteristics tailored to various applications.
- the Braggs method is a technique used for the synthesis of colloids by utilizing X-ray diffraction to characterize the particles in a colloidal sol. This method provides valuable information about the size, shape, and arrangement of colloidal particles, allowing for the controlled synthesis of colloids with desired properties.

10b) Write the applications of nanomaterials in various fields.

Applications of Nanomaterials

- Medicine: Used in targeted drug delivery systems to improve treatment efficacy and reduce side effects.
- Electronics: Employed in the development of smaller, faster, and more efficient transistors and memory devices.
- Energy: Utilized in solar cells to enhance energy conversion efficiency and in batteries for improved energy storage.
- Environmental Protection: Applied in water purification systems to remove contaminants and in air filters to capture pollutants.
- Construction: Integrated into concrete and coatings to increase strength, durability, and resistance to wear.
- Textiles: Incorporated into fabrics to impart antimicrobial properties and enhance durability.
- Agriculture: Used in fertilizers and pesticides to increase efficiency and reduce environmental impact.

- Food Industry: Employed in packaging to extend shelf life and improve food safety.
- Cosmetics: Utilized in skincare products for better penetration and effectiveness.
- Automotive: Applied in lightweight materials to improve fuel efficiency and in coatings for scratch resistance.

OR

11a) Explain how nano metal oxides are prepared using stabilizing agents.

Preparation of Nano Metal Oxides Using Stabilizing Agents
Nano metal oxides can be synthesized using various methods, with stabilizing agents playing a crucial role in controlling the size, shape, and stability of the nanoparticles. steps in the preparation process:
Selection of Metal Precursors:
Metal salts (e.g., nitrates, sulfates, chlorides) are commonly used as starting materials.
Choice of Stabilizing Agent:
Stabilizing agents such as surfactants, polymers, or ligands are chosen based on their ability to prevent agglomeration and control particle size.
Synthesis Methods:
Sol-Gel Method:
Metal precursors are hydrolyzed and condensed in the presence of stabilizing agents to form a gel, which is then dried and calcined to produce nano metal oxides.

- Preparation of Homogeneous solution
- 'Sol' formation by hydrolysis
- 'gel' formation by condensation
- Drying of gel

Reaction : **1) Hydrolysis**

$$\underset{\text{Metal alkoxide}}{\text{M-OR}} + \text{H}_2\text{O} \rightarrow \underset{\text{Metal Hydroxide}}{\text{M-OH}} + \text{ROH}$$

2) Condensation

$$\text{M-OR} + \text{H O-M} \rightarrow \text{M-O-M} + \text{R-OH}$$

- Role of Stabilizing Agents
- 1. Electrostatic Stabilization: Provides surface charge to particles, causing repulsion and preventing aggregation. Example: Ionic surfactants like SDS (Sodium dodecyl sulfate (SDS) is an anionic surfactant used commonly for core-shell nanoparticle synthesis in which the concentration of the selected surfactant exceeds the critical micelle concentration (CMC) where the surfactants act as a soft template to control the particle growth.)
- 2.Steric Stabilization: Adsorbs onto particles, creating a physical barrier. Example: Polymers like PEGPolyethylene glycol .
- 3.Electrosteric Stabilization: Combines charge and physical barrier, using polyelectrolytes.
- 4. Hydration Layer Formation: Attracts water molecules to form a protective layer. Example: Polysaccharides like gum arabic.

11b) Write a note on Langmuir adsorption isotherm.

Langmuir Adsorption Isotherms

The Freundlich adsorption isotherm is followed by another two isotherms, Langmuir adsorption isotherms and BET theory. The Langmuir adsorption isotherms predict linear adsorption at low adsorption densities and a maximum surface coverage at higher solute metal concentrations.

The Langmuir adsorption isotherm has the form:

$$\theta = \frac{Kp}{1+Kp}$$

Where

θ is the fraction of the surface covered by the adsorbed molecule

K is an equilibrium constant known as the adsorption coefficient.

{ K= ka/kd = rate constant for adsorption/ rate constant for desorption}

p is the pressure.

The Langmuir adsorption is applicable for monolayer adsorption onto a homogeneous surface when no interaction occurs between adsorbed species.