CBCS SCHEME

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BCHEC102/202

First/Second Semester B.E./B.Tech. Degree Examination, June/July 2024
Applied Chemistry for Civil Engineering Stream

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. VTU Formula Hand Book is permitted.
3. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Describe the manufacturing of cement by wet method.	7	L2	CO1
	b.	What are refractories? Mention the properties and applications of refractory materials.	7	L2	CO1
	c.	Mention the properties and applications of Aluminium and its alloys.	6	L2	CO1
		OR			
Q.2	a.	Describe the preparation of Soda-lime glass.	7	L2	CO1
	b.	Explain the testing of cement by EDTA method.	7	L2	CO1
	c.	Mention the properties and applications of Iron and its alloys.	6	L2	CO1
		Module – 2			
Q.3	a.	Explain construction, working and applications of methanol-oxygen fuel cell.	7	L2	CO2
	b.	Explain electrochemical corrosion of steel in concrete.	7	L2	CO2
	c.	Explain construction and working of Li-ion battery.	6	L2	CO2
		OR			
Q.4	a.	Discuss the following types of corrosion: (i) Differential metal corrosion. (ii) Differential aeration corrosion.	7	L2	CO2
	b.	Describe the following corrosion control methods : (i) Galvanization (ii) Sacrificial anode method.	7	L2	CO2
	c.	Explain construction, working and applications of photovoltaic cells.	6	L2	CO2
		Module – 3			
Q.5	a.	Explain softening of water by Ion exchange method.	7	L2	CO3
	b.	Define nanomaterials. Explain the synthesis of nanomaterials by Sol-gel method.	7	L2	CO3
	c.	In a COD test, 28.1 cm^3 and 14 cm^3 of 0.05 N FAS solutions were required for blank and sample titrations respectively. The volume of sample used is 25 cm^3. Find the COD of the sample solution.	6	L3	CO3
		OR			
Q.6	a.	50 ml of hard water sample is titrated with 0.015 M EDTA solution consumes 12 ml EDTA during titration. Now 250 ml of same hard water is boiled to 50 ml, filtered and diluted to 250 ml with distilled water. When 50 ml of boiled water titrated with 0.015 m EDTA, it consumes 8 ml EDTA during titration. Calculate temporary, permanent and total hardness of given water sample.	7	L3	CO3

	b.	Explain desalination of water by Electrodialysis method.	7	L2	CO3
	c.	What are carbon nano tubes? Mention the properties and applications of carbon nanotubes.	6	L2	CO3
		Module – 4			
Q.7	a.	What is Geo polymer concrete? Mention the properties and applications of Geo polymer concrete.	7	L2	CO4
	b.	A polymer sample contain 5 molecules having molecular weight 2000 g/mol, 4 molecules having molecular weight 3000 g/mol and 3 molecules having molecular weight 4000 g/mol. Calculate the number average and weight average molecular mass of the polymer.	7	L3	CO4
	c.	Explain synthesis, properties and applications of nylon fibers.	6	L2	CO4
		OR			
Q.8	a.	Define biodegradable polymers. Explain synthesis and applications of polylactic acid.	7	L2	CO4
	b.	Explain the properties and applications of fiber reinforced polymer composites.	7	L2	CO4
	c.	Describe synthesis properties and applications of epoxy resin.	6	L2	CO4
		Module – 5			
Q.9	a.	What is phase rule? Explain the terms involved in it with example.	7	L2	CO5
	b.	Explain the estimation of acid mixture using conductometric sensor.	7	L2	CO5
	c.	Explain the principle of pH sensor and describe the determination of pH of soil sample using pH sensor.	6	L2	CO5
		OR			
Q.10	a.	With the help of neat phase diagram, describe the lead-silver system.	7	L2	CO5
	b.	Describe the construction and working of pH sensor.	7	L2	CO4
	c.	Explain the estimation of Iron in FAS using potentiometric sensors.	6	L3	CO4

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Department: BSH (Chemistry) **Qp scheme 2024**
Subject with Sub. Code: Applied chemistry for Civil Engg Stream(BCHEC102/202)
Name of Faculty: Dr Sneha.S.Kulkarni

Q.No.	Solution and Scheme	Marks
1	Module-1	
1a.	Describe the manufacturing of cement by wet method Steps involved in production of cement by wet process Step 1: Mixing In wet process, limestone (CaO source) is powdered & stored in separate tank. Alumina, Silica source is washed with water to remove organic material and is stored in separate basin. Both these are allowed to flow in a channel, in the right proportion and led to grinding mills. Here they are mixed with water and ground to form a paste called slurry. This slurry contains about 38 to 40 percent of water. The slurry is finally stored in a storage tanks and kept ready for feeding to a rotary kiln. Step 2: Burning: The slurry is taken in a rotary kiln where it is subjected to burning. During burning it undergoes actual chemical changes. The rotary kiln is a long steel cylinder with fire brick refractory which is chemically inert and can withstand high	7M

Q.No.	Solution and Scheme	Marks

temperatures. Rotary kiln is kept in inclined position and it is rotatable. Different parts of kiln are maintained at different temperatures. Upper end is cooler and lower end is hotter. The slurry is introduced from upper end to lower end due to slope and slow rotation of kiln.

The following chemical changes occur in different parts of kiln based on temperatures.

→ The upper part of the kiln is called drying zone. where the temperature is around 1400°C. Here, lime stone is decomposed to quicklime & CO_2.

$$CaCO_3 \longrightarrow CaO + CO_2 \uparrow$$

→ The central part of kiln is called calcination zone where the temperature is around 1000°C. Here lime stone is decomposed.

→ The lower part of the kiln is called clinkering zone where temp is between 1500-1700°C. Here the lime and clay undergoes chemical fusion yielding calcium aluminates & silicates.

$$2CaO + SiO_2 \longrightarrow 2CaO SiO_2$$
$$3CaO + SiO_2 \longrightarrow 3CaO SiO_2$$
$$3CaO + Al_2O_3 \longrightarrow 3CaO Al_2O_3$$
$$4CaO + Al_2O_3 + Fe_2O_3 \longrightarrow 4CaO Al_2O_3 \cdot Fe_2O_3$$

These fused products are obtained in the form of hard, greyish stones of

Q.No.	Solution and Scheme	Marks
	diameter. They are called clinkers. Step 3: Grinding Cooled clinkers are subjected to grinding by ball milling or tube milling method, during grinding 2-3% of gypsum is added as retarding agent. Gypsum prevents early setting of cement when mixed with H_2O.	
1b	What are refractories? Mention the properties and applications of refractory materials. Refractories are ceramic materials which can withstand high temperatures with high abrasion and corrosion resistance with undergoing any change in their strength and shape. Properties: → A good refractory material must withstand very high temperature. → It is used in surgical instruments → Load bearing capacity Refractories must exhibit high load capacity at higher temperature. → Dimensional stability Refractories must exhibit high load capacity and high dimensional stability → Chemical inertness The refractories material should be chemically inert at high temp and should not react with reactants slags, furnace gases, fuel ashes & the products involved inside the furnace at higher temperatures.	7M

Q.No.	Solution and Scheme	Marks
	→ Resistance to corrosion and erosion → Thermal spalling → High thermal conductivity A good refractory material should have good co-efficient of thermal expansion. It must undergo least expansion when heated & least contraction when cooled. Applications: → Fire clay refractories are used in steel manufacturing industries as lining for blast furnaces, ovens and crucible furnaces. → Silica bricks are used in lining roofs of electric furnaces, glass furnaces wall of coke ovens. → Medium duty alumina refractories with Al_2O_3 content of 50-60% are used in applications requiring high abrasion resistance such as linings of cement rotary kilns.	
1c	Explain the properties and applications of aluminium and its alloys. Aluminium and its alloys properties → Aluminium is a silvery white, non toxic, light weight metal commonly used everywhere. → Aluminium is soft and malleable and ductile. It is the second most ductile and 6th most malleable metal. → Aluminium has low density.	6

Q.No.	Solution and Scheme	Marks
	→ It has high electrical and thermal conductivity → It has excellent corrosion resistance due to its ability to form protective oxide film on its surface. → Aluminium can be cast, machined and moulded quickly and easily. → Aluminium is non magnetic and non sparking. → Duraluminium has mechanical strength similar to steel but light weight with density only, one third of stainless steel. → Duraluminium is a good conductor of heat and electricity. → It is tough, ductile, easily castable and machinable. → They are more easily workable and easily weldable than pure Al. Applications: → They are used in a huge variety of daily used products like cans, foils, kitchen utensils, window frames, beer kegs and aeroplane parts. → They are used in as an alloy with Cu, Mn, Mg and Si, which are light weight but strong. They are very important in the construction of aeroplanes and other forms of transport. → Al is used in electrical transmission lines. It is cheaper than Cu and weight is almost twice as good as conductor. → Used in surgical instruments, fluroscent tube caps etc.	

Q.No.	Solution and Scheme	Marks
2a.	Describe the preparation of soda lime glass Preparation of soda lime glass 4 steps are involved. a] Melting Raw materials such as sand, soda, ash and limestone are taken in proper proportions and mixed with cullets. The mixture is finelly powdered and taken in open heath furnace. maintained at about 1800°C. At this temp, the reaction mixture melts and fuses. $CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2\uparrow$ $Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2\uparrow$ Coloring salts are added at this stage, if a colored glass is desired. Heating is continued, till the molten mass is free from bubbles and glass balls. Then the mixture is cooled to about 800°C. b] Forming and shaping Molten glass is then subjected to forming and shaping to obtain required articles. This is done by blowing or moulding or pressing between rollers. c] Annealing The process of cooling glass articles slowly and gradually by passing through different chambers with descending temperature is called as annealing. Annealing of glass is an important step in manufacturing of a glass. If a glass	7

Q.No.	Solution and Scheme	Marks
	is cooled rapidly, since glass is a bad conductor of heat. The outer layer cools down first leaving the interior portion in a state of strain. Due to this unequal expansion, the articles are likely to crack to pieces. The longer the annealing period, the better is the quality of glass. d] Finishing: All glass article, after annealing are subjected to finishing processes such as cleaning, grinding, polishing, cutting, sand blasting etc.	
2b	Explain testing of cement by EDTA method Determination of CaO in cement by rapid EDTA method. CaO is the major component present in cement and which determines the quality of cement. Theory: Calcium ions present in the solution is determined by titrating a known volume of cement solution with EDTA. The solution is treated with diethyl amine to maintain the pH at 12-14. 0.04N NaOH is added to precipitate the Mg^{2+} present in the solution as $Mg(OH)_2$. So that Mg^{2+} does not interfere in the estimation of Ca^{2+}. The solution is then titrated against std EDTA using patton and Reeder's indicator. This indicator permits the determination of Ca in presence of Mg. Glycerol is added to get sharp end point.	7

Q.No.	Solution and Scheme	Marks

Procedure:

→ Transfer 25cm³ of the given cement solution into a clean titration flask using a pipette.

→ Add 5cm³ of diethylamine

→ Add one test tube full of 4N solution of NaOH followed by 5cm³ of 1:1 glycerol with constant shaking of the contents of the flask. Add pinch of PRR.

→ Titrate against the EDTA solution till color changes sharply from wine red to clear blue.

The titration should be performed rapidly in the beginning ~~of~~ and very slowly near the end point.

Calculations:

From the volume of EDTA consumed in titration and molarity of EDTA, % of CaO in cement can be calculated as given below ——

1 cm³ of 1M EDTA = 1 milli mole of CaO

$= 56.08 \times 10^{-3}$ g CaO

Y cm³ of ZM EDTA = (0.05608 × Y × Z) g CaO

= 0.05608 × ____ × ____

∴ % CaO in the cement sample

$= \frac{\text{Weight of CaO in 25mL solution}}{\text{Weight of cement in 25 cm}^3 \text{ of soln}} \times 100$

(8)

Q.No.	Solution and Scheme	Marks
2c	Mention the properties and applications of Iron and its alloys.	6

Properties of Iron metal

→ It is a malleable and ductile metal It is easy to work with and shape.

→ It is a soft metal, but its strength can be improved to great extent by adding carbon

→ Compounds of iron usually exhibit valence of +2 (ferrous) or +3 (ferric)

→ Iron is the only metal that can be tempered.

→ It is a good conductor of heat and electricity.

Application of Iron

→ It is used in machinery, tools and equipments.

→ It is used in transformers, electric motors, engines etc.

→ It is an essential nutrient to human body

→ It is used in making of steels of various types by alloying with carbon and various metals.

Properties and applications of alloys of iron.

1) Plain carbon steel

These steel contain carbon in various proportions from 0.15% to 1.5%, Accordingly, they are classified in to three types.

a) Low carbon steel:

Q.No.	Solution and Scheme	Marks

It contains 0.15 to 0.3% Carbon. It is also called as mild steel. It's strength hardness, toughness impact and shock resistance are lower than medium and high carbon steels.

They are used as round bars for reinforcement in cement concrete, sheets for covering, nuts, bolts, screws, angle plates.

b) Medium carbon steel:

→ It contains 0.3 to 0.8% carbon.

→ Its strength, hardness, toughness, impact and shock resistance are in between low and high carbon steels.

They are used as fittings for cylinders turbine rotors, gun parts, wheels, gear, clutch parts etc

c) High carbon steel

→ It contains 0.8 to 1.5% carbon

→ They are used as metal cutting tools, drilling tools, hammers etc.

2) Alloy Steels:

These steels are alloys of iron and carbon with metals like Cr, Ni, Mo etc.

→ Cr addition upto 1.5% of Cr enhances tensile strength. Addition of upto 12% of Cr imparts high corrosion resistance.

→ Mn addition of upto 1-1.5% increases toughness, strength and brittleness. Addition of Mn upto 11 to 14% imparts high degree of hardness.

→ Vanadium improves tensile strength ductility and shock resistance.

(10)

Q.No.	Solution and Scheme	Marks
	Module 2	
3a	Explain construction, working and application of methanol-oxygen fuel cell.	7

Construction:

This fuel cell is represented as—

Porous C, dispersed with Pt, CH_3OH-H_2SO_4	H_2SO_4 (aq)	O_2, Porous C dispersed with Pt

The cell consists of

Anode: Porous C with dispersed Pt

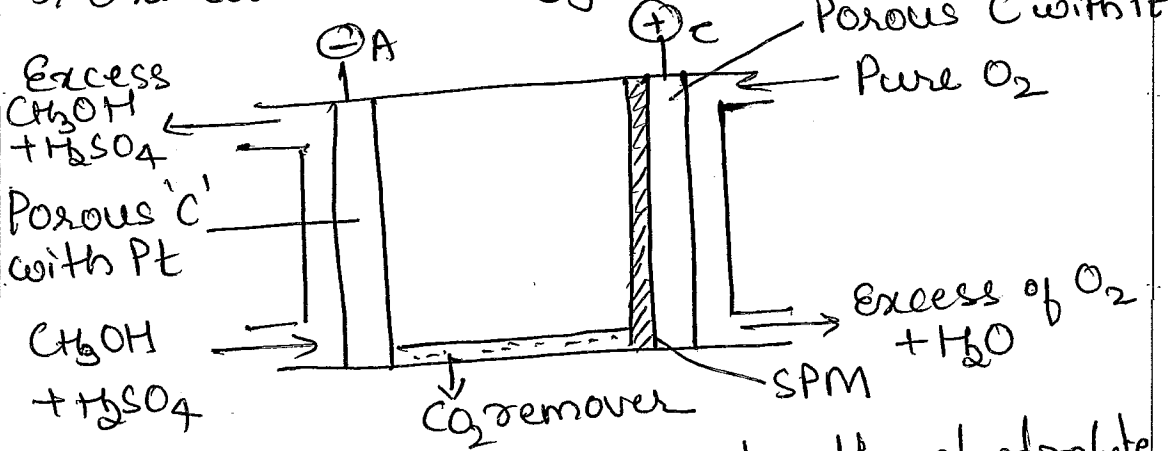
Cathode: Porous C with dispersed Pt

Electrolyte: Aqueous H_2SO_4

Active components:

a) Fuel: Methanol mixed with sulphuric acid, supplied at anode

b) Oxidant: Pure oxygen, supplied at cathode



Adjacent to cathode, towards the electrolyte side, a semipermeable membrane is inserted to allow the diffusion of H^+ ions but disallow the diffusion of methanol to avoid methanol oxidation directly at cathode

Working:

Anodic oxidation: $CH_3OH + H_2O \longrightarrow CO_2 + 6H^+ + 6e^-$

Q.No.	Solution and Scheme	Marks
	Cathodic reduction: $1\frac{1}{2}O_2 + 6H^+ + 6e^- \longrightarrow 3H_2O$	
	Cell reaction: $CH_3OH + 1\frac{1}{2}O_2 \longrightarrow CO_2 + 2H_2O$	
	Waters and CO_2 formed do not harm the cell functioning because, they are removed as and when they are formed Water is removed by using wicks.	
	cell potential 1.2V	
	Application:	
	Used in military applications	
	Large scale power production.	
3b	Explain electrochemical corrosion of steel in concrete.	7
	Electrochemical theory is characterized by the formation of small galvanic cells due to heterogeneities. Part of metal acts as anode and another part act as cathode.	
	Anodic part of the metal undergoes destruction by oxidation. Steel (iron) undergoes corrosion by following reaction	
	Anodic reaction: $Fe \longrightarrow Fe^{2+} + 2e^-$	
	Reduction can be explained by two important reactions.	
	H_2 evolution type	
	$2H^+ + 2e^- \longrightarrow H_2$ [when medium is acidic]	
	$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$ [when the medium is neutral or slightly alkaline]	
	It is characterized by large anodic area and small cathodic area	

Q.No.	Solution and Scheme	Marks
	Corrosion is uniform and less aggressive higher the acidity medium, higher is the corrosion rate O_2 absorption type $\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$ [neutral or alkaline) $\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$ [when the medium acidic] Oxygen absorption type is characterized by the presence of small anodic area and large cathodic area. Corrosion is localised and very aggressive. Higher is the oxygen contained in the medium higher is the corrosion rate. Ferrous hydroxide is formed as corrosion product. Excess of O_2 can oxidize it further to yellow rust or black rust. $Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2$ or $FeO \cdot H_2O$ (hydrated ferrous oxide) $2Fe(OH)_2 + H_2O + \frac{1}{2}O_2 \longrightarrow 2Fe(OH)_2$ or $Fe_2O_3 \cdot 3H_2O$ (hydrated ferric oxide or yellow rust) $3Fe(OH)_2 + \frac{1}{2}O_2 \longrightarrow Fe_3O_4 \cdot 3H_2O$ (magnetite; black rust)	
3c	Explain construction and working of Li-ion battery Li-ion battery construction and working construction: Secondary rechargeable, Li-ion when in charged condition is schematically	6

Q.No.	Solution and Scheme	Marks

represented as ——

Li_xC_6 | Li-salt in mixed org. solvents | ~~$LiCoO_2$, Al~~ $Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2$

However, actual construction refers to loading of crystallised carbon at anode and lithium cobalt oxide at cathode. Copper and aluminium are used as current collectors.

Cu, C_6 | $LiPF_6, LiBF_4, LiClO_4$ etc in mixed org solvents | $LiCoO_2$, Al

Anodic material: highly crystallized specialty carbon (graphite with layered structure)

Cathodic material: $LiCoO_2$

Charging reactions:

At anode of electrolytic cell

$$LiCoO_2 \rightleftharpoons Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2 + xLi^+ + xe^-$$

At cathode of electrolytic cell

$$C_6 + xLi^+ + xe \rightleftharpoons C_6Li_x$$

Discharge reactions:

At anode: $C_6Li_x \rightleftharpoons C_6 + xLi^+ + xe^-$

At cathode: $Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2 + xLi^+ + xe^- \rightleftharpoons LiCoO_2$

cell reaction during charge and discharge

$$C_6 + LiCoO_2 \rightleftharpoons C_6Li_x + Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2$$

Cell potential 3.7.

Li salts mixed in organic solvents used as electrolyte solution

Non wooven polypropelene is used as separator.

Q.No.	Solution and Scheme	Marks
4a	Discuss the following types of corrossion i) Differential metal corrosion ii) Differential aeration corrosion	7

i) Differential metal corrosion

Corrosion arising out of formation of galvanic cell is galvanic corrosion. Two or more metals in contact and exposed together to corrosive form a galvanic cell. Anodic metal undergoes corrosion. Duriving force for the corrosion is the difference in electrode potentials of the two metals.

Examples:

i) Steel vessel with brass tap

ii) Brass vessel with steel tap

Steel acts as anode and undergoes corrosion by oxidation:

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

Cathodic reduction reaction depends on the medium

$2H^+ + 2e^- \longrightarrow H_2$ (in acidic medium)

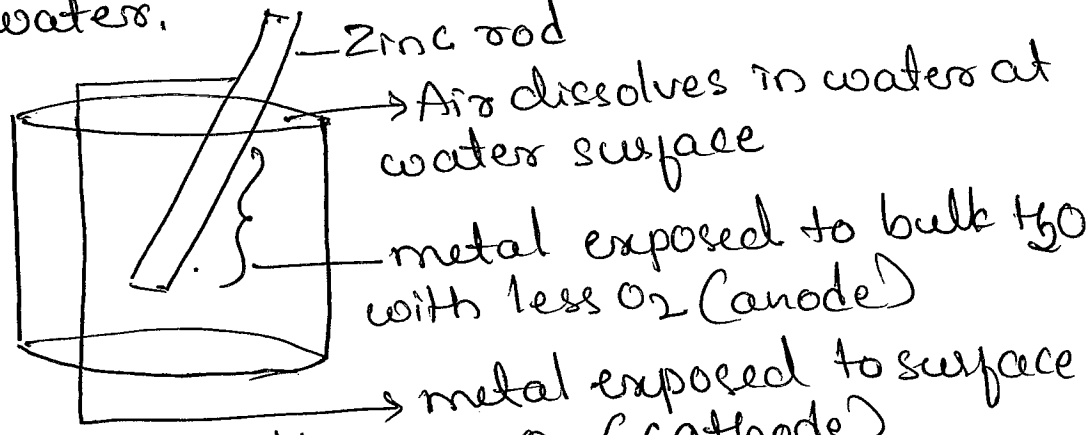
$\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$ (in neutral or sligetly alkaline medium)

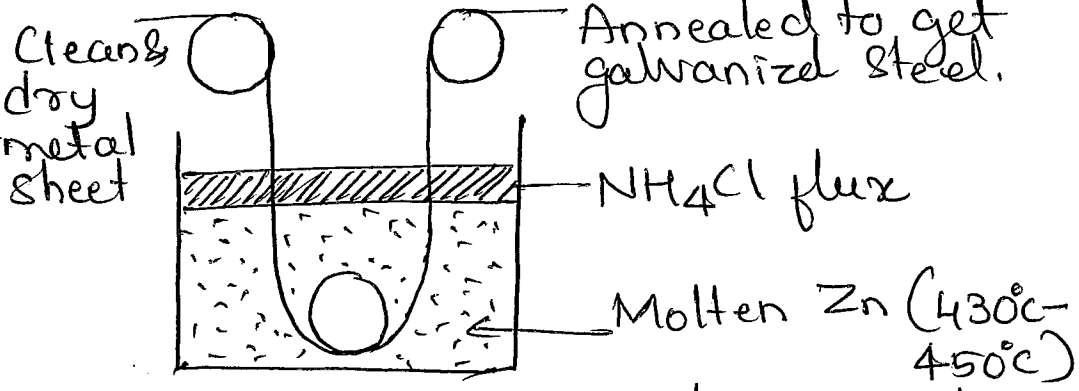
Larger difference in anodic and cathodic metal electrode potentials leads to aggressive corrosion. Higher concentration of corrosives and higher temperatures also can result in higher corrosion rates.

Ex:

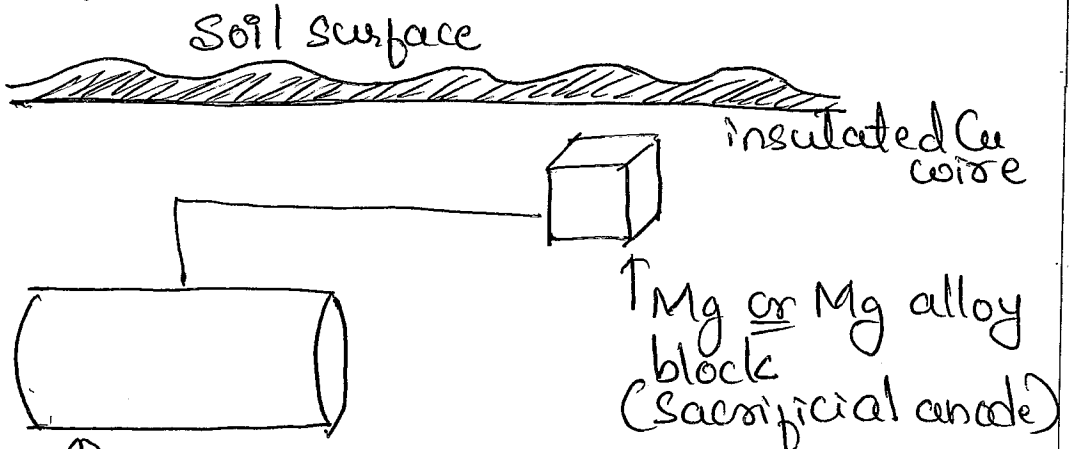
Brass hinges, latches etc with steel screws (steel is corroded)

Lead antimony solder around copper wire (lead is corroded)

Q.No.	Solution and Scheme	Marks
b)	Differential aeration corrosion Corrosion arising out of difference in aeration of metal parts is called as differential aeration corrosion. Part of metal exposed to less oxygenated water acts as anode and undergoes corrosion. Part of metal exposed to more oxygenated water acts as cathode. Driving force for the corrosion is the difference in oxygen concentration at two different metal parts. Ex: Suppose a zinc rod immersed partially in water.  Immersed portion of zinc rod exposed to less aerated water acts as anode and undergoes corrosion $Zn \longrightarrow Zn^{2+} + 2e^-$ Metal exposed to more aerated surface water, acts as cathode and oxygen undergoes reduction $\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$ Zn^{2+} ions and OH^- ions may react to form $Zn(OH)_2$ precipitate	9

Q.No.	Solution and Scheme	Marks
4b	Describe the following corrosion control methods i) Galvanization ii) Sacrificial anode method i) Galvanization: Galvanizing refers to the hot dipping method of coating of zinc over iron and control of corrosion. Coated zinc metal sacrifices itself in protecting the object metal from corrosion. The method is employed for continuous metal sheets, wires, pipes etc.  Object metal surface needs preparation, Oil, grease, wax are removed by organic solvents. Then, it is treated with hot dilute H_2SO_4 (acid pickling) for removing the scales washed with water and air dried Clean and dry metal sheets are then immersed into a bath containing molten Zn. An ammonium chloride flux is used to avoid the oxidation of molten Zn. Excessive Zn from sheets drawn is removed and uniformity achieved by passing it between two regulated hot rollers. Zn coated sheets are annealed to have film bonding between the metals with better surface characteristics. And galvanized steel obtained.	7

Q.No.	Solution and Scheme	Marks
b)	Sacrificial anodic protection method	



Object metal is connected to a block of an anodic metal such as Zn, Al, Mg or their alloys.

→ Whenever there is demand of electrons by the corrossives in the medium, anodic metal will sacrificially undergo oxidation and release the electrons. Thus, the object metal is protected.

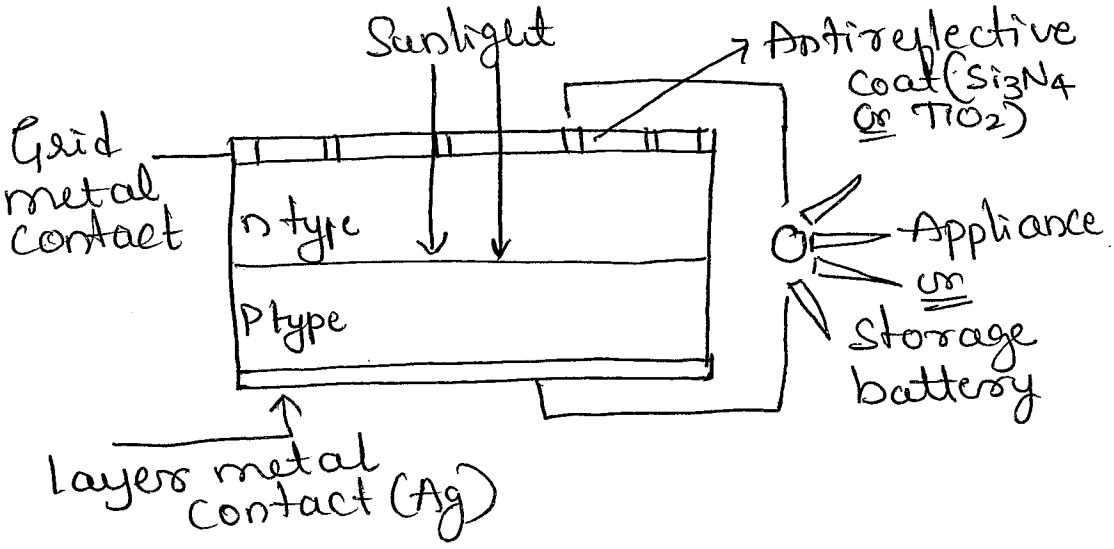
→ As long as anodic metal block is existent, protection is achieved. When it disappears, fresh block is replaced.

Applications: Employed for buried pipeline used for water or oil, water tanks, ocean going ships, pipes etc.

4c	Explain construction, working and application of photovoltaic cells	6

PV cells or solar cells are devices that convert solar energy into electrical energy from semiconductors.

Q.No.	Solution and Scheme	Marks



Construction:

→ PV cells are made of a semiconductor diode (p-n junction)

→ The diode has two electrical contacts A grid metal contact is used on top of side and a layer metal contact on bottom side. Layer metal is used is generally silver.

→ The metal grid permits the light to fall on the diode between the grid lines.

→ An antireflective coat (Si_3N_4 or TiO_2) is used between the grid lines to increase the efficiency of light absorbance or energy conversion.

Working:

→ When electromagnetic radiation having energy sufficient to overcome the barrier potential falls normal to the surface of the p-n junction, electron-hole pairs are formed.

→ The electrons move towards the n-region and holes move towards p-region

→ When appliance or battery is connected between the two contacts, circuit is

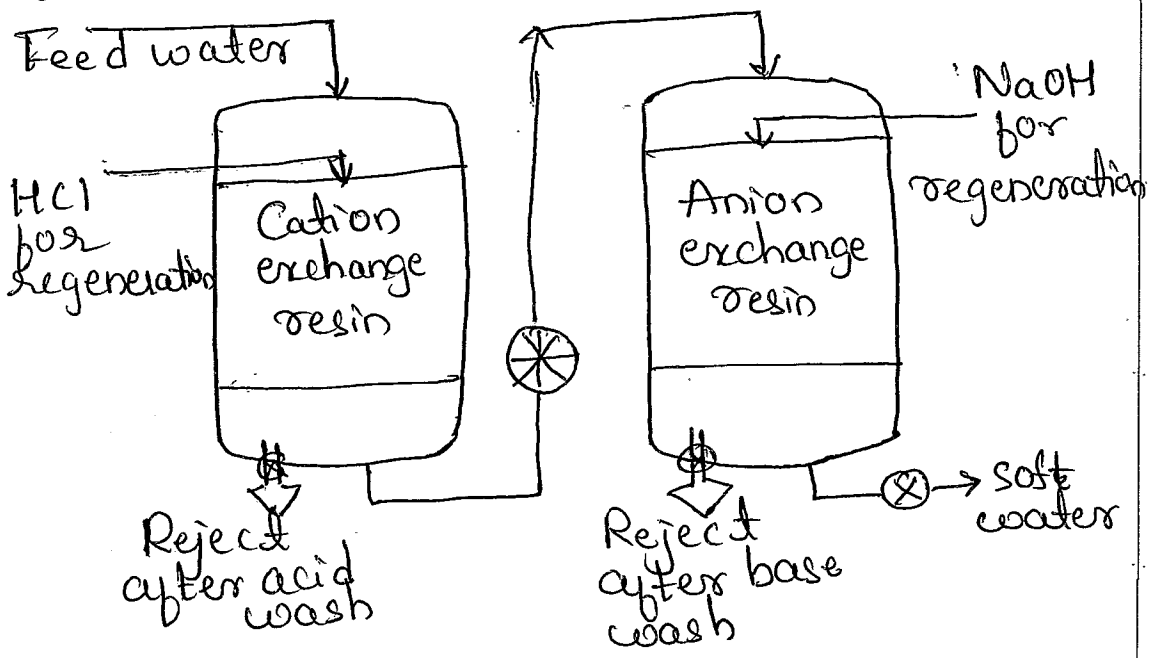
Q.No.	Solution and Scheme	Marks
	Completed and electrons are driven into the external circuit enabling the functioning of the appliance or charging of the battery. → Charged battery is used for application such as lighting, telecommunication etc. → Depending on the energy requirement PV cells are connected either in series or parallel and designed to make modules or panels or arrays. → It may be noted that the solar cells produce the direct current. PV arrays employ on inverter for AC current and operation of electrical appliances is used.	
	Module 3	
5a	Explain softening of water by Ion-exchange method. Removal of hardness causing constituents from water is called softening of water. Partial or complete removal of dissolved salts by reversible ion exchange resins is an efficient method of softening the water. Resins used are generally insoluble, cross linked organic polymers with micro-porous structure. The functional groups attached to the chains enable the reversible exchange of H^+ ions and OH^- ions for cations and anions in the feed water. Strongly basic functional groups like trimethylammonium hydroxide will contain replaceable OH^- ions and will exchange the ~~resins~~ anions in feed water	7

Q.No.	Solution and Scheme	Marks

Cations exchange resins generally, styrene-divinyl benzene copolymers with sulfonic acid groups and anion exchange resins are generally, styrene-divinyl benzene copolymers with quaternary ammonium hydroxide groups.

Process:

Feed water (hard water) is passed through cation exchanger and then through anion exchanger to get the soft water



Following reactions occur:

i) In cation exchanger, cations are exchanged by equivalent number of H^+ ions.

$RH^+ + M^+ \longrightarrow RM^+ + H^+$ where, M^+ is - monovalent cation. like Na^+, K^+ etc

$2RH^+ + M^{2+} \longrightarrow R_2M^{2+} + 2H^+$

M^{2+} is divalent cation like Ca^{2+}, Mg^{2+} etc

ex: $RH^+ + Na^+ \rightarrow RNa^+ + H^+$, $2RH^+ + Ca^{2+} \rightarrow R_2Ca^{2+} + 2H^+$

Q.No.	Solution and Scheme	Marks

ii) In anion exchanger, anions are exchanged by equivalent number of OH^- ions.

$ROH^- + X^- \longrightarrow RX^- + OH^-$ where, X^- is mono-valent anion like Cl^-, F^-, NO_3^- etc

Ex: $ROH^- + Cl^- \longrightarrow RCl^- + OH^-$

$2ROH^- + X^{2-} \longrightarrow R_2X^- + 2OH^-$

X^{2-} is divalent anion like SO_4^{2-} etc.

Ex: $2ROH^- + SO_4^{2-} \longrightarrow R_2SO_4^{2-} + 2OH^-$

With the continuous inflow of feed water into cation exchanger and anion exchanger, the corresponding resins get inactive or lose their ability to exchange the cations or anions. The cation exchanger resin and anion exchange resin are regenerated by washing with acid (HCl) and base (NaOH) respectively.

i) In cation exchanger, cations on the resin are exchanged by equivalent number of H^+ ions.

$RM^+ + H^+ \longrightarrow RH^+ + M^+$ ex: $RNa^+ + H^+ \rightarrow RH^+ + Na^+$

$R_2M^{2+} + 2H^+ \longrightarrow 2RH^+ + M^{2+}$ ex:- $R_2Ca^{2+} + 2H^+ \rightarrow 2RH^+ + Ca^{2+}$

ii) In anion exchangers, anions on the resin are exchanged by equivalent number of OH^- ions.

$RX^- + OH^- \longrightarrow ROH^- + X^-$ ex: $RCl^- + OH^- \rightarrow ROH^- + Cl^-$

$R_2X^{2-} + 2OH^- \longrightarrow 2ROH^- + X^{2-}$ ex: $R_2SO_4^{2-} + 2OH^- \rightarrow 2ROH^- + SO_4^{2-}$

Regenerated ion exchange resins will thus be ready for softning the fresh feed of hard water once again.

Q.No.	Solution and Scheme	Marks
5b	Define nanomaterials. Explain the synthesis of nanomaterials by sol-gel method	7

The nanomaterials having atleast one dimension in the nanoscale range of 1-100 nm are called as nano-materials.

Sol-gel process

Sol-gel process simple process of synthesis of nanomaterials

The principle is conversion of precursor solution into gel via hydrolysis and condensation reactions. Sol-gel method allow to synthesis of nanomaterials of high purity.

This process involves five steps

1] Preparation of soli

Sol is prepared by suspended particles in water during suspension hydrolysis reaction takes place.

$$MOR + H_2O \longrightarrow M\text{-}OH + R\text{-}OH$$

2] Conversion of sol into gel:

Sol is converted into gel by condensation reaction forming network between oxides. When networking takes place, the viscosity of the solution increases

$$MOH + MOH \longrightarrow MOM + H_2O \{\text{water condensation}\}$$

$$MOR + MOH \longrightarrow MOM + ROH \{\text{alcohol condens-cation}\}$$

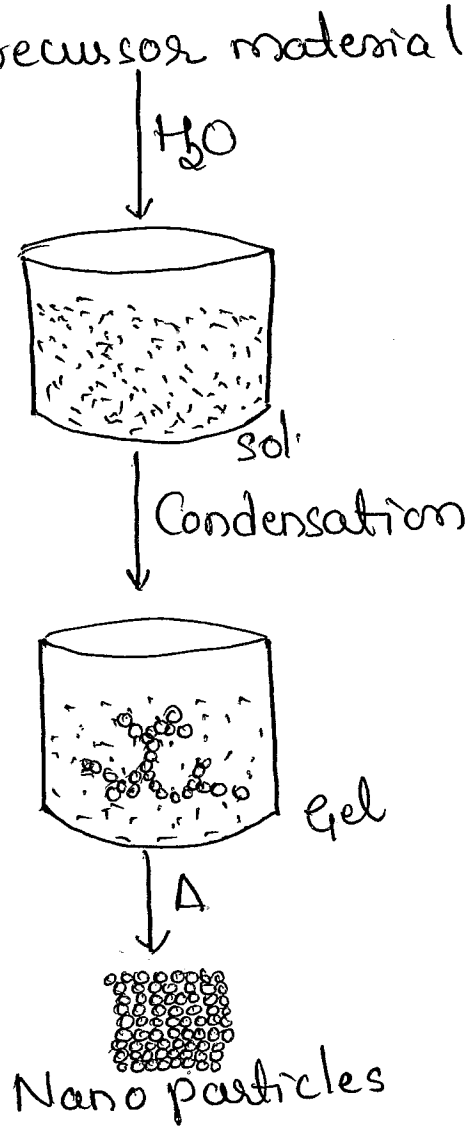
3] Aging of gel: during which poly condensation reaction continue until the gel is transformed into solid mass

Q.No.	Solution and Scheme	Marks

4] Removal of solvent:

Further the solid mass is isolated from the solvent by thermal evapouration. The product formed is xerogel.

5] Heat treatment: Solid mass (xerogel) obtained is dried at nearly to 800°C to get fine nano particle powder



Advantages:

→ Nano materials of high quality with good homogeneity can be obtained.

→ Samples can be prepared at low temperature

→ Easy to control the synthesis parameters like shape and size of resulting material.

Q.No.	Solution and Scheme	Marks
5c	In a COD test, 28.1 cm^3 and 14.0 cm^3 of 0.05N FAS solutions were required for blank and sample titrations respectively. The volume of sample used is 25 cm^3. Find the COD of the sample solution.	6

Soln:

Normality (Y) of FAS soln = 0.05N

Blank titre value (Q) = 28.1 mL

Main titre value (P) = 14.0 mL

(Q-P) mL = (28.1 − 14.0) mL

= 14.1 mL

Sample water taken = 25.0 mL

COD of sample solution = ?

1000 mL of 1N FAS = 8 g O_2

1 mL of 1N FAS = $\frac{8}{1000}$ g O_2

(Q-P) mL of YN FAS = $\frac{8}{1000} \times (Q-P) \times Y$

$= \frac{8}{1000} \times 14.1 \times 0.05$

$= 0.00564$ g O_2

25 mL of sample H_2O Contains = 0.00564 g O_2

10^6 mL of water contains = $\frac{0.00564}{25} \times 10^6$

= 225 ppm. Or mg/L

Q.No.	Solution and Scheme	Marks
6a	50mL of hard water sample is titrated with 0.015M EDTA solution consumes 12mL EDTA during titration. Now 250mL of same hard water is boiled to 50mL, filtered and diluted 250mL with distilled water. When 50mL of boiled water titrated with 0.015M EDTA, it consumes 8mL of EDTA during titration. Calculate temporary, permanent and total hardness of given water sample.	7M

Soln:

Sample water taken for analysis = 50mL (Z) = 50mL

Concentration of EDTA (Y) = 0.015 M

P = 12mL Q = 8mL

Total hardness $= 0.1 \times P \times Y \times \frac{10^6}{Z}$ ppm

$= 0.1 \times 12 \times 0.015 \times \frac{10^6}{50}$

$= 360$ ppm or mg/L

Permanent hardness $= 0.1 \times Q \times Y \times \frac{10^6}{Z}$ ppm

$= 0.1 \times 8 \times 0.015 \times \frac{10^6}{50}$

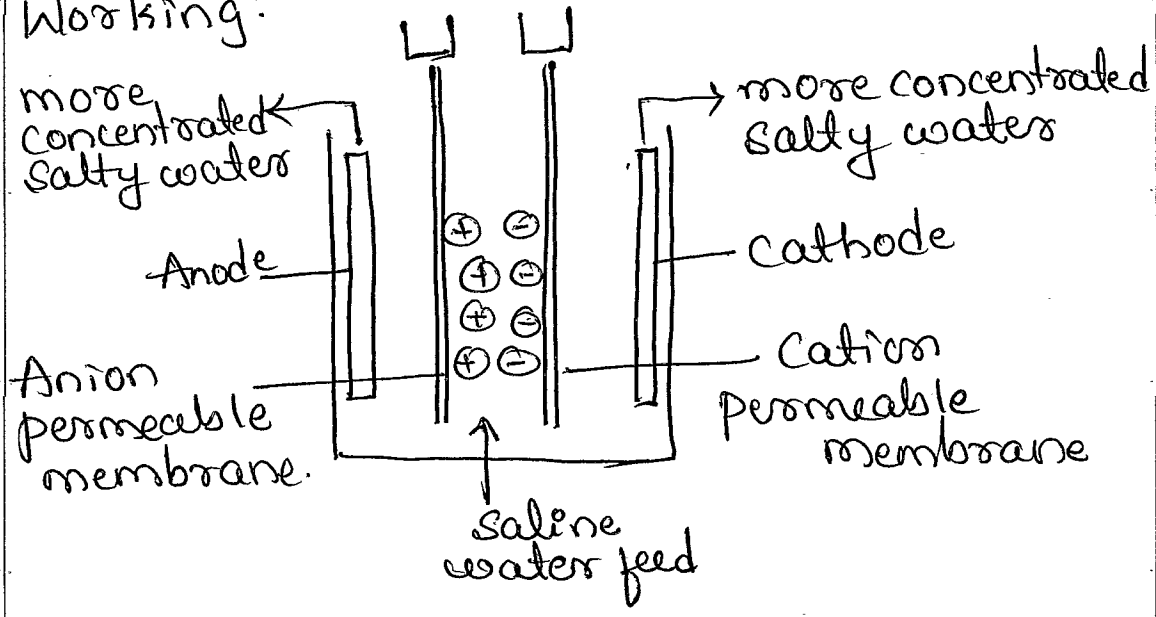
$= 0.00024 \times 10^6$

$= 240$ ppm or Mg/L

Temperory hardness = Total hardness − Permanent hardness

$= 360 - 240$

$= 120$ ppm or mg/L

Q.No.	Solution and Scheme	Marks
66	Explain desalination of water by electrodialysis method Electrodialysis: Principle: Application of an electric field across the salt solution results in migration of cations towards the cathode and anions towoords the anode. The use of pairs of SPM one which is permeable to only cations and another to only anions in an electrodialyser permits the separation of saline water into fresh water & concentrated saline water. An electrodialyser consists of a chamber carrying a series of compartments fitted with closely spaced alternate anion(A) and cation (C) permeable membranes between the anode and cathode An electrodialyser unit will have 200-1000 compartments for better efficiency. Working:  	7

Q.No.	Solution and Scheme	Marks

The brackish water or sea water is fed into the electrodialyser and an electric field is applied across the water using the electrodes. The ions move towards respective electrodes under the influence of applied electric field. Therefore between a pair of anion and cation semipermeable membranes, water becomes desalinated and freshwater is taken out. The electrodialyser will have a series of pairs of anion and cation semipermeable membranes. The concentrated salty water is discarded. Thus, in alternate compartments of semipermeable membranes, there is desalinated fresh water and enriched salty water which are drawn separately.

The enriched salty water is rejected. Fresh water is recycled to further reduce the salt content.

SPM

For anion: Polystyrene quaternary ammonium membrane

For cations: Polystyrene sulphonate membrane

Disadvantage:

The method has disadvantage of not removing the dissolved organics or suspended solids.

Q.No.	Solution and Scheme	Marks
6c	What are carbon nanotubes? Mention the properties and applications of carbon nano tubes Carbon nanotubes are long, thin cylinders of carbon were discovered in 1991 by Sumio Ijima. These are large macromolecules that are unique for their size, shape and remarkable physical properties. Properties: → They are less than 100nm in diameter and can be as thin as 1 or 2nm. → They are molecules that can be manipulated chemically and physically in very useful ways. → They open an incredible range of applications in material science, electronics, chemical processing, energy management and many other fields. Some properties include ↳ Extraordinary electrical conductivity, heat conductivity and mechanical properties but exhibit low density. → They are probably the best ~~selection~~ electron field emittor known, largely due to their high length to diameter ratios. → As pure carbon polymers, they can be manipulated using the well known and the tremendously rich chemistry of that element.	6

Q.No.	Solution and Scheme	Marks
	Some of the above properties provide opportunity to modify their structure, and to optimize their solubility and dispersion. These extraordinary characteristics give CNTs potential in numerous applications. Application: → Field emitter/emission → Conductive or reinforced plastics → Molecular electronics: CNT based non volatile RAM → CNT based transistors. → Energy storage (ex: Li-ion batteries) → CNT based fibers and fabrics → CNT based ceramics → Biomedical applications. Module - 4	
7a	What is Geo polymer concrete? Mention the properties and applications of Geo polymer concrete Geopolymer concrete is a type of concrete that is made by reacting aluminate and silicate bearing materials with caustic activator, such as fly ash or slag from iron and metal production. Properties: → The compressive strength of geopolymer concrete is similar to that of portland cement concrete → The unit weight of fly ash based geo polymer concrete is similar to that of portland cement concrete.	7

Q.No.	Solution and Scheme	Marks
	→ They exhibit low drying shrinkage and low creep compared to portland cement concrete. → Geopolymer concrete has an excellent resistance to the sulfate attack cohere as hydrated products of portland cement. → Geopolymers are used as fire protection coatings for crucise ships. Applications: 1) Due to high compressive strength geopolymer concrete can be used as a construction material in many applications. It can be a low CO_2 emission alternate to portland cement. 2) Geopolymers are used as resin in carbon fiber composites. 3) They are used to provide thermal protection to wooden structures. 4) Geopolymers are used as fire protection coatings for course ships.	
7b	A polymer sample contain 5 molecules having molecular weight 2000g/mol, 4 molecules having molecular weight 3000g/mol and 3 molecules having molecular weight 4000 g/mol. Calculate number average and weight average molecular mass of the polymers. $n_1 = 5$ $M_1 = 2000$ $n_2 = 4$ $M_2 = 3000$ $n_3 = 3$ $M_3 = 4000$	7

Q.No.	Solution and Scheme	Marks

$$\bar{M}_n = \frac{\sum N_i M_i}{\sum N_i}$$

$$= \frac{N_1M_1 + N_2M_2 + N_3M_3}{N_1 + N_2 + N_3}$$

$$= \frac{(5 \times 2000) + (4 \times 3000) + (3 \times 4000)}{5+4+3}$$

$$= 2833.33$$

$$\bar{M}_w = \frac{\sum N_i (M_i)^2}{\sum N_i M_i}$$

$$= \frac{N_1(M_1)^2 + N_2(M_2)^2 + N_3(M_3)^2}{N_1M_1 + N_2M_2 + N_3M_3}$$

$$= \frac{5(2000)^2 + 4(3000)^2 + 3(4000)^2}{(5 \times 2000) + (4 \times 3000) + (3 \times 4000)}$$

$$= 3058.82$$

7c Explain synthesis, properties and applications of nylon fibers. 6

Properties:

→ It is a high mechanical strength and high rigidity synthetic fiber.

→ It exhibits high thermal stability with high melting point

→ It has high chemical resistance

→ It has high resistance for abrasion

P.T.O

Q.No.	Solution and Scheme	Marks

Preparation:

Nylon 6,6 is obtained by condensation polymerization of hexamethylenediamine and adipic acid under high pressure and temperature. (553 K)

$$n\left[HOOC-(CH_2)_4-COOH\right] + n\left[H_2N-(CH_2)_6-NH_2\right] \rightarrow -\left(C(=O)-(CH_2)_4-C(=O)-NH-(CH_2)_6-NH\right)_n + (2n-1)H_2O$$

Applications

1. It is very good fiber and used in textile industry
2. Due to its high tensile strength it is used in high speed mill processing, tyre applications.
3. Due to excellent abrasion resistance, it is used in conveyor belts, carpets and upholstery.
4. It is also used in making tents, sleeping bags, ropes, bristles for brushes etc

Q.No.	Solution and Scheme	Marks
8a.	Define biodegradable polymers. Explain synthesis and applications of polylactic acid	7

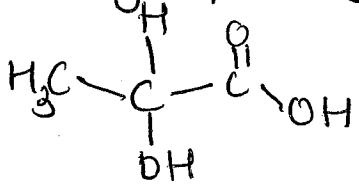
The polymers which breakdown after their intended use by microbial decomposition into biocompatable CO_2, nitrogen, methane, water biomass and inorganic compounds are called biodegradable polymers.

Synthesis of polylactic acid.

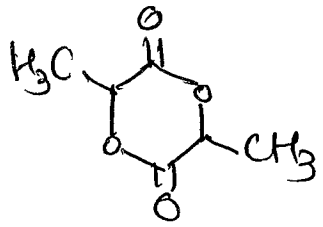
It is a thermoplastic polyester polymer extensively used as biodegradable polymer.

There are many methods, two important routes are discussed below—

1) Condensation polymerization of lactic acid
2) Ring opening polymerization of lactide

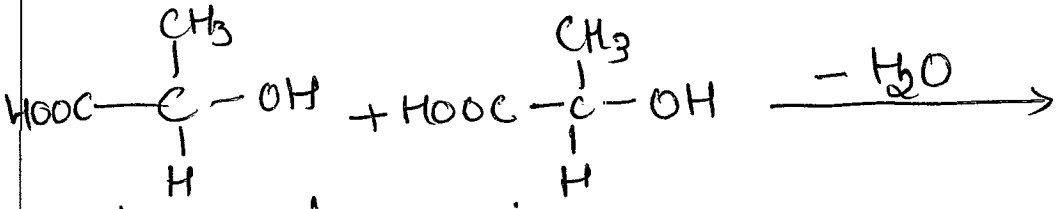


Lactic acid.

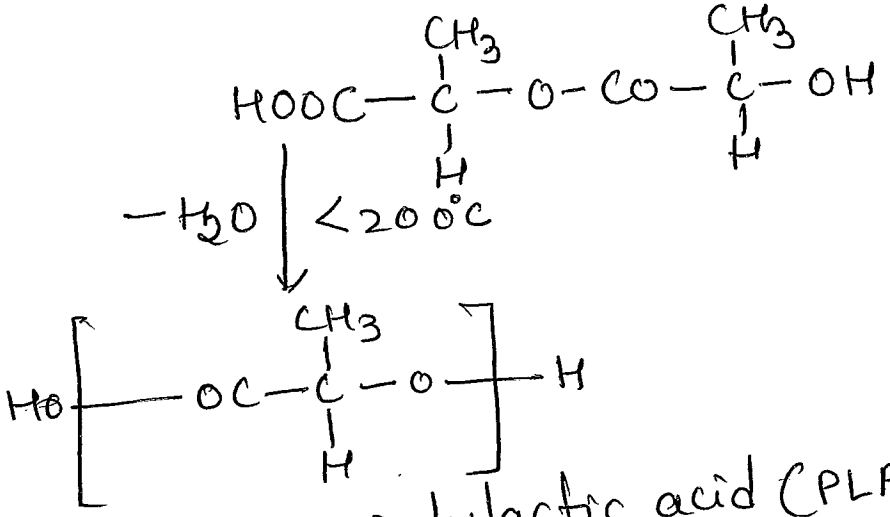


Lactic acid has a carboxylic group & a hydroxyl group attached to the same carbon atom. The acid group of another reactant result in condensation of H_2O molecule. The reaction is reversible and forward reaction is favored by removal of H_2O

Q.No.	Solution and Scheme	Marks

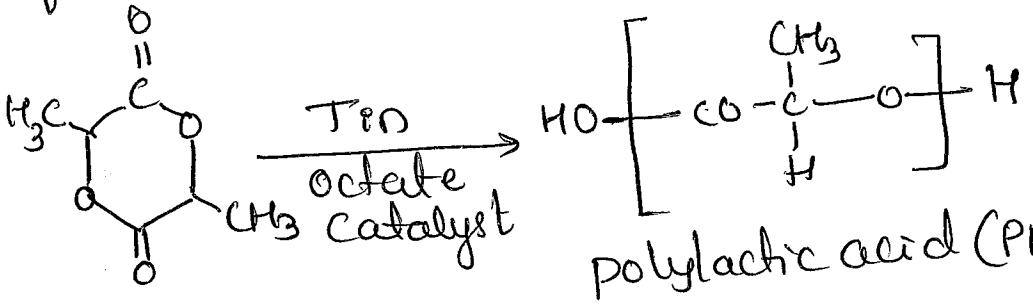


lactic acid



polylactic acid (PLA)

Cyclic diester, lactide can be polymerized by ring opening mechanism in the presence of a tin octate catalyst.



polylactic acid (PLA)

Applications:

→ High surface energy results in good printability making it widely used in 3D printing.

→ Fibers for textiles industry or sutures films and nonwooven textile for clothes.

→ PLA based materials are empolyed for biomedical, textile & packaging purposes.

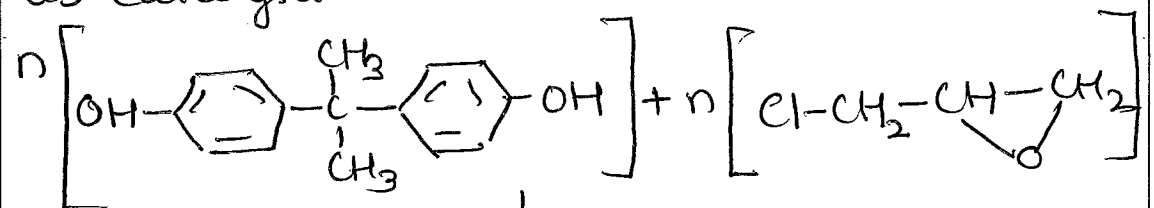
Q.No.	Solution and Scheme	Marks
8b	Explain the properties and applications of fiber reinforced polymer composites → FRPC also plastic is a composite material made of polymer matrix reinforced with fibers. → The fibers are usually glass, carbon or aramid although other fibers such as paper or wood asbestos have been some times used. Properties: → Higher strength → Lighter weight → Higher performance → longer lasting → Rehabilitating existing structures and extending their life. → Seismic upgrades, good corrosion resistance → Ocean environments. Applications: → Composites of phenolic resin and nylon are used in heat sheilds for space crafts. → They are used in aircraft or space industry. → They are suitable in automotive & railway applications. → They are used in civil construction work also.	7

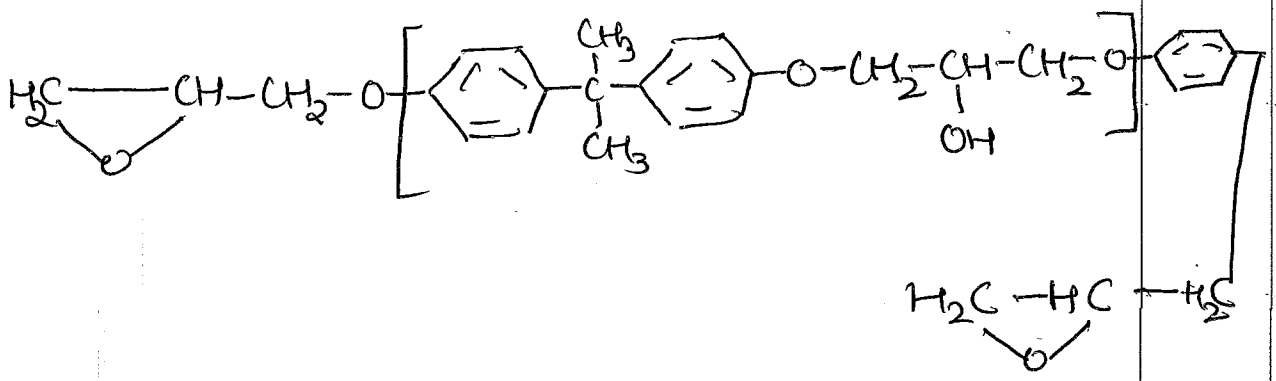
Q.No.	Solution and Scheme	Marks
8c	Describe synthesis properties and applications of epoxy resin.	6

Epoxy resins (Araldite)

Synthesis:

These are the polymers contain epoxy group on both the ends. The most common epoxy resin is obtained by condensation reaction of epichlorohydrin and bisphenol-A in the presence of NaOH as catalyst.





epoxy resin

Properties:

1) Epoxy resins are resistant to water, acids, alkalides and various solvents.
2) Cured epoxy resins have more toughness adhesion & heat resistance
3) They possess good electrical insulating property
4) They offer very good skid wearing & abrasion resistance.

Q.No.	Solution and Scheme	Marks
	Applications: → It is used as an adhesive to bind metallic, wood, glass, concrete, ceramic and leather materials. → It is used in skid resistant industrial floorings & highway surfacing. → Epoxy resins are applied over cotton rayon and beached fabrics to impart grease resistance and shrinkage control. → Moulds made from epoxy resins are used in the production of aircraft and automobile components. → They are used as laminating materials for electrical equipments.	
	Module-5	
9a	What is phase rule? Explain the terms involved in it with example. Phase rule: For a heterogenous system in equilibrium the number of phases plus the number of degrees of freedome equal to number of components plus 2. The general form of the phase rule is stated as follows $P+F=C+2$ where, P = number of phases involved in equilibrium C = number of components in system F = the degree of freedom of a state of a system.	7

Q.No.	Solution and Scheme	Marks

Phase:

A phase is defined as any homogeneous physically distinct and mechanically separable portion of a system, which is separated from other parts of the system by definite boundary surface.

Ex:

A completely miscible homogeneous mixture of gases mixture of gases (O_2 & N_2) and liquids (water and alcohol) gives phase=1 (P=1)

Components:

The components of a system is defined as the smallest number of independently variable constituents taking part in a state of equilibrium by means of which the composition of each phase can be expressed in the form chemical equations.

Ex:

In water system, the composition of all the three phases can be defined in terms of only H_2O. Therefore it is a one component system, C=1

Degrees of freedom or varience

The degree of freedom of a system is defined as the number of independently variable such as pressure, temperature and composition which must be specified in order to define the state of a system.

Q.No.	Solution and Scheme	Marks
	Ex: Consider any single phase in water system can be defined by specifying two variables like pressure & temperature In other words, any single phase of water system has two degrees of freedom Hence $F = 2$ or f (P and T)	
9b.	Explain the estimation of acid mixture using conductometric sensor. Mixture of strong acid and weak acid against strong base. ($HCl + CH_3COOH$) V/s NaOH The reactions $(H^+ + Cl^-) + (Na^+ + OH^-) \longrightarrow (Na^+ + Cl^-) + H_2O$ $CH_3COOH + (Na^+ + OH^-) \longrightarrow (CH_3COO^- + Na^+) + H_2O$ Initially, stronger acid, HCl is neutralized by NaOH and only after its complete neutralization, weak acid, CH_3COOH starts getting neutralized. Specific conductance decreases in the beginning of titration owing to the replacement of highly mobile H^+ ions by less mobile cations (Na^+) of the base (until neutralization of HCl) Conductivity starts increasing when the neutralization of CH_3COOH gets started. However, the increase is slow because, the sodium acetate salt formed	7

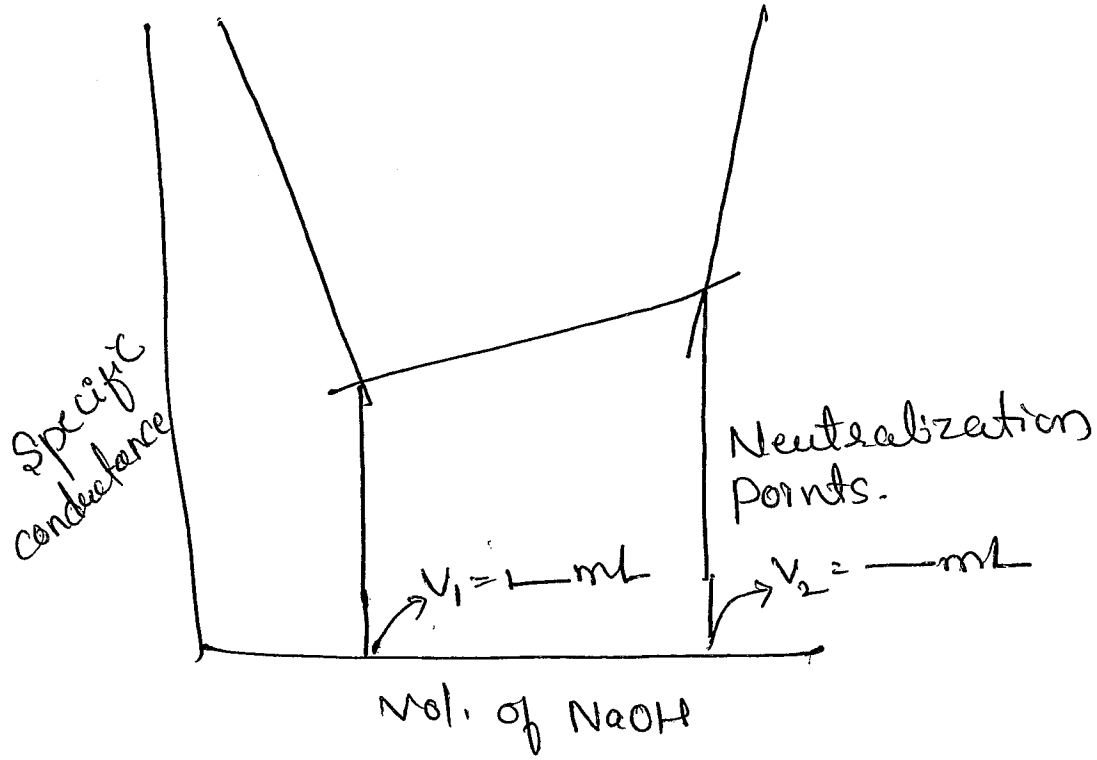
Q.No.	Solution and Scheme	Marks

releases less mobile Na^+ ions and CH_3COO^- ions, Conductivity continues increasing slowly until complete neutralization of CH_3COOH.

After neutralization of CH_3COOH, the specific conductance rises rapidly with further additions of strong base because of increased concentration of relatively more mobile OH^- ions.

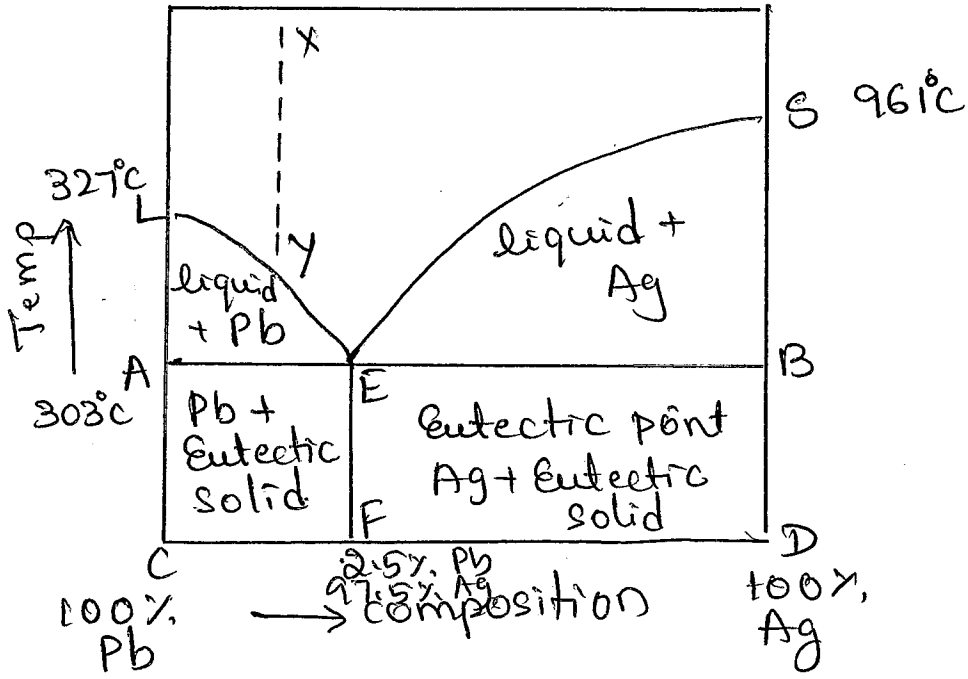
A plot of conductance against volume of base added gives three straight lines The points of interaction of three lines gives neutralization points.

Thus, on titration of known volume of mixture of HCl & CH_3COOH against NaOH neutralization points help in calculating the quantity of HCl & CH_3COOH in test soln.



Q.No.	Solution and Scheme	Marks
	The concentration of analyte in above experiments is determined by using the formula $N_1V_1 = N_2V_2$ and the amount is calculated as $\text{Amount of substance} = [\text{Normality of substance}] \times [\text{eq. weight of substance}]$ g/L	
9c	Explain the principle of pH sensor and describe the determination of pH of the soil sample using pH sensor. [For principle of pH sensor refer 10b answers] Determination of pH of the soil sample → place the soil sample about 3/4 full in sample jar and distilled H_2O to cover soil → Cap the jar and shake the soil vigorously few times. → Let the mixture stand 10 mins to dissolve the salts in the soil. → Caliberate the pH tester with a pH 7 and a pH 10 buffer solution → Remove the cap & place the pH sensor into the wet soil slurry. → Measure pH and record measurement. A minor ($< \pm 0.5$ pH) difference between results of the soil sample indicates good technique & high confidence results	6

Q.No.	Solution and Scheme	Marks
10a	With the help of neat phase diagram, describe lead-silver system.	7

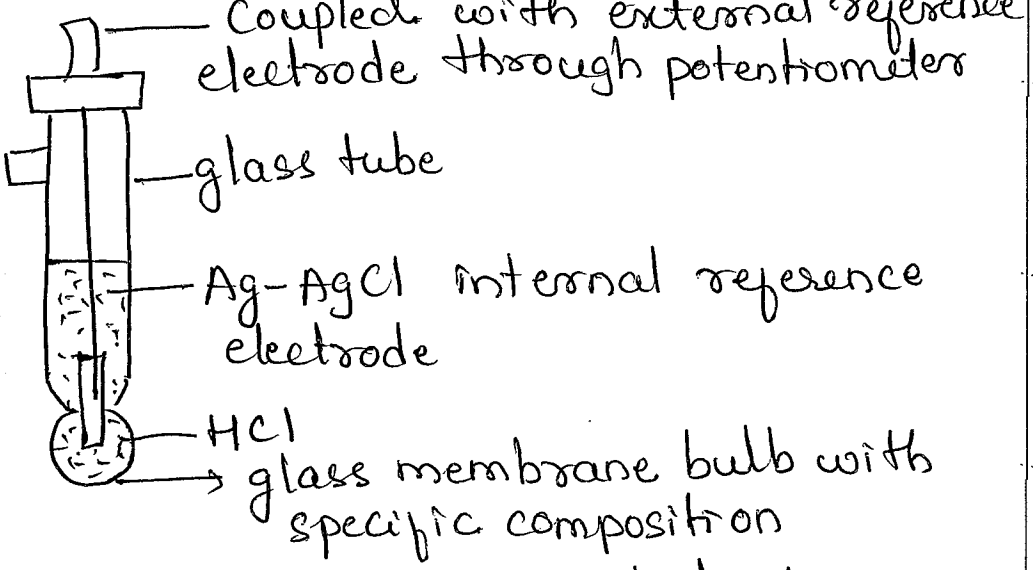


Parts of phase diagram	Phases in equilibrium	P	Degrees of freedom F = 3 − P	Variance	Variable
Region above LES	Melt containing Pb & Ag	1	3 − 1 = 2	Bivariant	Temp & Composition
Curve LE	Solid Pb ⇌ liquid melt containing Pb & Ag	2	3 − 2 = 1	Mono variant	either temp or composition
Region LEA	Solid Pb ⇌ liquid melt containing Pb & Ag	2	3 − 2 = 1	Mono variant	"
Curve SE	Solid Ag ⇌ liquid melt containing Pb & Ag	2	3 − 2 = 1	"	"
Region SEB	Solid Ag ⇌ liquid melt containing Pb & Ag	2	3 − 2 = 1	"	"
Point E Eutectic Point	Solid Ag ⇌ Solid Pb ⇌ liquid melt of Pb & Ag	3	3 − 3 = 0	In variant	Self defined temp & composition 2.5% Pb 97.5% Ag

Q.No.	Solution and Scheme	Marks
10b	Describe construction and working of pH sensor.	7

Electrode, which responds selectively to the presence of specific ion ignoring other ions is ion selective electrode.

Construction



A glass membrane electrode consists of a specially made glass membrane extending out as bulb at the end of the plane glass tube containing Ag-AgCl electrode immersed in a solution of HCl. composition of glass membrane is

6% CaO, 22% Na_2O and 72% SiO_2

Glass electrode is coupled with calomel electrode and immersed into analyte forming a cell.

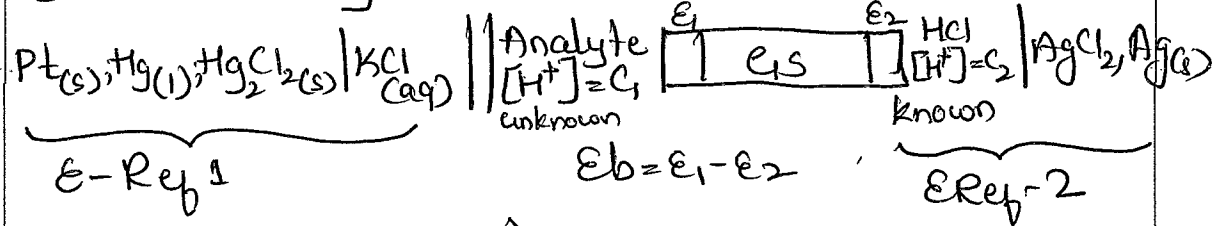
Cell potential measured will assist the determination of pH of test solution.

Working

By convention, membrane electrode is made of cathode

Q.No.	Solution and Scheme	Marks

Schematically written as —



Very soon after immersion of electrode into analyte (test solution) an equilibrium is reached,

$$Na^+Gl^- + H^+ \rightleftharpoons H^+Gl^- + Na^+$$

H^+Gl^-, further dissociates to different magnitudes on two sides & results in development of boundary potential.

$$H^+Gl^- \rightleftharpoons H^+ + Gl^-$$

Let ε_1 & ε_2 are the potentials developed at the membrane surfaces on external side and internal side respectively.

From the thermodynamic considerations, potential developed across the membrane, is boundary potential. is given by —

$$\varepsilon_b = \varepsilon_1 - \varepsilon_2$$

$$= \frac{RT}{nF} \ln \frac{C_1}{C_2}$$

$$= \frac{2.303RT}{nF} \log \frac{C_1}{C_2}$$

$$= 0.0591 \log C_2 + 0.0591 \log C_1$$

$$= L - 0.0591 (-\log C_1)$$

$$= L - 0.0591 (-\log [H^+])$$

$$= L - 0.0591\, pH$$

Q.No.	Solution and Scheme	Marks

Glass membrane potential is calculated as

$$E_R = E_{cell} = E_{Ref2} + E_b + E_{assy}$$
$$= E_{Ref2} + L - 0.0591\,pH + E_{assy}$$
$$= E_{Ref2} + L + E_{assy} - 0.0591\,pH$$
$$= E^\circ_{cell} - 0.0591\,pH$$

where, E_{assy} is the assymetric potential

$E_{assy} = E_b$ when $C_1 = C_2$

$E^\circ_{cell} = E_{Ref2} + L + E_{assy} = \text{constant}$

Cell potential is given by

$$E_{cell} = E_R - E_L$$
$$= E_{cell} - E_{Ref1}$$
$$= E^\circ_{cell} - 0.0591\,pH - E_{Ref1}$$

$$pH = \frac{E^\circ_{cell} - E_{Ref1} - E_{cell}}{0.0591}$$

$$= \frac{k' - E_{cell}}{0.0591} \text{ at } 298\,K$$

k' is a constant, glass electrode assembly constant.

10c Explain the estimation of Iron in FAS using potentiometric sensors. 6

Potentiometric sensors measures the potential difference between working electrode and reference electrode, where potential of working electrode depends on analyte solution.

Principle

Redox titrations can be carried out potentiometrically using Pt and calomel electrode

Q.No.	Solution and Scheme	Marks

Potentiometrycally is based on Nernst equation

$$E = E^\circ + \frac{0.0591}{n} \log \frac{[\text{oxidized form}]}{[\text{Reduced form}]}$$

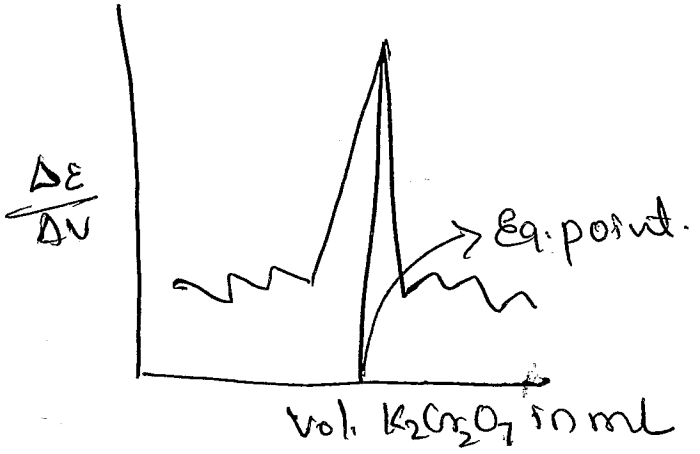
Estimation of FAS using potentiometer.

Burette: Std $K_2Cr_2O_7$ soln

Beaker: Test soln (FAS) and 5mL of dilute H_2SO_4 + calomel & Pt electrode immersed

$K_2Cr_2O_7$ is added in the increments of 0.5mL, until a ~~solution~~ sudden jump in potential and five additional readings are taken after jump. A plot of change in potential against volume is characterized by a sudden change of potential at eq. point.

At the end point, potential is determined by large jump in the potential value



By the plot, volume of $K_2Cr_2O_7$ is obtained

→ Apply the formula $N_1V_1 = N_2V_2$ and calculate the concentration of FAS

→ The concentration of FAS thus obtained is multiplied with eq. weight of FAS to get amount of FAS in given solution

Q.No.	Solution and Scheme	Marks

In this way the estimation of amount of FAS is carried out using potentiometer.

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