CBCS SCHEME

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BCHEC102/202

First/Second Semester B.E./B.Tech. Degree Examination, June/July 2023
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.	Discuss the production of cement by wet process.	7	L2	CO1
	b.	Define Refractories. Mention the properties and applications of refractory materials.	7	L2	CO1
	c.	Explain the properties and applications of Aluminium and its alloys.	6	L2	CO1
		OR			
Q.2	a.	What is glass? Describe the preparation of soda lime glass.	7	L2	CO1
	b.	Explain the testing of cement by EDTA method.	7	L2	CO1
	c.	Write the properties and applications of stainless steel and duralumin.	6	L2	CO1
		Module – 2			
Q.3	a.	Define secondary batteries. Explain construction and working of Li-ion Battery.	7	L2	CO2
	b.	What is anodizing? Explain the anodizing of aluminium.	7	L2	CO2
	c.	Explain the construction and working of methanol-oxygen fuel cell.	6	L2	CO2
		OR			
Q.4	a.	Describe the electrochemical corrosion of steel in concrete.	7	L2	CO2
	b.	Define PV cell. Illustrate the construction and working of photovoltaic cell.	7	L2	CO2
	c.	Define Batteries. Give the classification of batteries with suitable examples.	6	L2	CO2
		Module – 3			
Q.5	a.	What is hard water? Discuss the estimation of total hardness using EDTA solution.	7	L2	CO3
	b.	Define nano material. Explain the synthesis of nano material by Sol-gel method.	7	L2	CO3
	c.	Define COD. In a COD Test, 30 cm^3 and 15 cm^3 of 0.05 N FAS solutions are required for a blank and sample titration respectively. The volume of sample used was 25 cm^3. Find the COD of the sample solution.	6	L3	CO3
		OR			
Q.6	a.	What is Desalination? With a neat labelled diagram, describe the desalination of water by electrodialysis method.	7	L2	CO3
	b.	Explain the following size dependent properties of nano materials: (i) Surface area (ii) Catalytic property	7	L2	CO3
	c.	100 ml of sample water required 18 ml of 0.01 m EDTA for titration using EBT indicator. In another experiment 100 ml of the sample of water was boiled and precipitate was removed by filtration required 9.0 ml of 0.01 m EDTA using EBT indicator. Calculate: (i) Total Hardness (ii) Permanent Hardness (iii) Temporary Hardness	6	L3	CO3

		Module – 4			
Q.7	a.	What are adhesives? Give the synthesis, properties and applications of Epoxy Resin.	7	L2	CO4
	b.	A polymer sample contains 1, 2, 3 and 4 molecules having molecular mass 10^5, 2×10^5, 3×10^5 and 4×10^5 respectively. Calculate number average and weight average molecular mass of the polymer.	7	L3	CO4
	c.	Mention the properties and applications of geopolymer concrete.	6	L2	CO4
		OR			
Q.8	a.	Define biodegradable polymer. Explain the synthesis and applications of polylactic acid.	7	L2	CO4
	b.	Describe the synthesis, properties and applications of polyethylene.	7	L2	CO4
	c.	What are polymer composites? Mention the properties and application of FRP (Fiber Reinforced Polymer).	6	L2	CO4
		Module – 5			
Q.9	a.	Define the following terms with examples: (i) Phase (ii) Component (iii) Degree of freedom	7	L2	CO5
	b.	Illustrate the principle, instrumentation and working of potentiometric sensors.	7	L2	CO5
	c.	Explain the determination of pH of soil sample using pH sensors.	6	L2	CO5
		OR			
Q.10	a.	With the help of neat phase diagram, describe Lead-Silver system.	7	L2	CO5
	b.	Describe the instrumentation and application of conductometric sensors in the estimation of acid mixture.	7	L2	CO5
	c.	Describe the principle and instrumentation of potentiometric sensors.	6	L2	CO5

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AY: 2023-24

Department: Chemistry **Qp scheme -2023-24**
Subject with Sub. Code: Applied chemistry for civil stream (BCHEC202) **Semester: 2nd**
Name of Faculty: Prof. Sneha S Kulkarni

Q.No.	Solution and Scheme	Marks
1a	Discuss the production of cement by wet process 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 & ground to form a paste called slurry. This slurry contains about 38 to 40 percent water. The slurry is finally stored in storage tanks & 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	7

Q.No.	Solution and Scheme	Marks

actual chemical changes. The rotary kiln is a long steel cylinder with fire brick refractory which is chemically inert and can withstand high 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 & slow rotation of kiln.

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

→ The upper part of kiln is called drying zone where the temp is around 1400°C. Here, lime stone is decomposed to quick-lime & 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 & clay undergoes chemical fusion yeilding calcium aluminates & silicates

Q.No.	Solution and Scheme	Marks

$2CaO + SiO_2 \longrightarrow 2CaOSiO_2$

$3CaO + SiO_2 \longrightarrow 3CaO\,SiO_2$

$3CaO + Al_2O_3 \longrightarrow 3CaO \cdot Al_2O_3$

$4CaO + Al_2O_3 + Fe_2O_3 \longrightarrow 4CaO\,Al_2O_3\,Fe_2O_3$

These fused products are obtained in the form of hard, greyish stones of diameter of about 0.5 to 1cm 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 Define Refractories. Mention the properties and applications of refractory materials. 7

Refractories are ceramic materials which can withstand high temperatures with high abrasion & corrosion resistance with undergoing any change in their strength & shape

Properties:

→ A good refractory material must withstand very high temperature

→ It is used in surgical instruments.

Q.No.	Solution and Scheme	Marks

→ Load bearing capacity

Refractories must exhibit high load capacity at higher temp

→ Dimensional stability

Refractories must exhibit high load capacity & high dimensional stability.

→ Chemical inertness

The refractories material should be chemically inert at high temp & should not react with the reactants slags, furnace gases, fuel ashes & the products involved inside the furnace at higher temperature.

→ Resistance to corrosion & 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 & crucible furnaces.

→ Silica bricks are used in lining roofs of electric furnaces, glass furnaces wall of coke ovens.

4

Q.No.	Solution and Scheme	Marks
	→ 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	6
	Aluminium and its alloys properties → Aluminium is a silvery colute, non toxic, light weight metal commonly used everywhere → Aluminium is soft and malleable & ductile. It is the second most ductile and the 6th most malleable metal. → Aluminium has low density → It has high electrical & thermal conductivity → It has excellent corrosion resistance due to its ability to form protective oxide film onits surface. → Aluminium can be cast, machined & moulded quickly and easily. → Aluminium is non magnetic & 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	

Q.No.	Solution and Scheme	Marks

of heat & electricity
→ It is tough, ductile, easily castable & machinable.
→ Magnalumin alloy with lower Mg content (<20%) exhibit greater mechanical strength greater corrosion resistance & lower density than pure aluminium.
→ They are more easily workable & 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 & aeroplane parts.
→ They are used as an alloy with copper, Mn, Mg & silicon, which are light weight but strong. They are very important in the construction of aeroplanes & other forms of transport.
→ Al is used in electrical transmission lines, It is cheaper than copper & weight is almost twice as good a conductor.
→ Duraluminium & Magnaluminium are used in aircraft, automobile, locomotive industry in the form a clad.
→ Used in surgical instruments, fluroscent tube caps etc.

Q.No.	Solution and Scheme	Marks
2a	What is glass? Describe the preparation of soda lime glass Glass is an amorphous, hard brittle, transparent material. It is considered as super cooled liquid with very high viscosity. It is a non crystalline amorphous solid which possesses no sharp melting point. Preparation of soda lime glass 4 steps are involved a] Melting Raw materials such as sand, soda ash & limestone are taken in proper proportions and mixed with cullets. The mixture is finely powdered and taken in open hearth furnace maintained at about 1800°C. At this temp, the reaction mixture melts & 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 & glass balls. Then the mixture is cooled to about 800°C. b] Forming and shaping Molten glass is then subjected to forming & shaping to obtain	7

Q.No.	Solution and Scheme	Marks
	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 glass. If glass 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, griding, 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 & which determines the quality.	7

Q.No.	Solution and Scheme	Marks

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. ~~0.04~~ 4N 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 & Reeder's indicator. This indicator permits the determination of Calcium in the presence of Mg. Glycerol is added to get a sharp endpoint.

Procedure:

→ Transfer 25 cm^3 of the given cement solution into a clean titration flask using a pipette.

→ Add 5 cm^3 of diethylamine.

→ Add one test tube full of 4N soln of NaOH followed by 5 cm^3 of 1:1 glycerol with constant shaking of the contents of flask. Add a pinch of PRR.

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

The titration should be performed rapidly in the beginning and very slowly near the endpoint.

Q.No.	Solution and Scheme	Marks
	Calculations From the volume of EDTA consumed in titration & molarity of EDTA, % of CaO in cement can be calculated as given below —— $1\,cm^3$ of 1M EDTA = 1 milli mole of CaO $= 56.08 \times 10^{-3}$ g CaO $Y\,cm^3$ of ZM EDTA = $(0.05608 \times y \times z)$ g CaO $= 0.05608 \times \frac{---}{CaO} \times --- g$ % CaO in the cement sample $= \frac{\text{Weight of CaO in 25 ml soln}}{\text{Weight of cement in } 25cm^3 \text{ of soln}} \times 100$	
2c	Write the properties and applications of stainless steel & duralumin Properties of stainless steel → Stainless steel resist corrosion due to the formation of dense, tough film of chromium oxide at surface of metal. If this film is broken in service, it gets healed-up automatically by oxygen of air. These are also known as corrosion resistant steels. → Heat treatable stainless steels are tough magnetic & can be worked in cold state.	6

Q.No.	Solution and Scheme	Marks

→ They have satisfactory water & weather resistance & they can be used at temperatures upto 800°C.
→ Non heat treatable stainless steels have less strength but more corrosion resistance at higher temperatures. Their corrosion resistance is better than heat treatable stainless steels.
→ they can be forged, roiled or cold drawn.

Applications
→ Heat tretable stainless steels are used in making sugical instruments, scissors, blades & cutlery etc
→ Non heat treatable magnetic type stainless steel are used in making automobile parts & chemical equipments.

Duralumin Properties
→ It has mechanical strength similar to steel but light weight with density only one third of stainless steel.
→ It is a good conductor of heat & electricity
→ It is tough, ductile, easily castable & machinable.

Applications:
→ It is used in aircraft, automobile & locomotive industry in the form of a clad.
→ It is used in surgical instruments & in fluroscent tube caps etc.

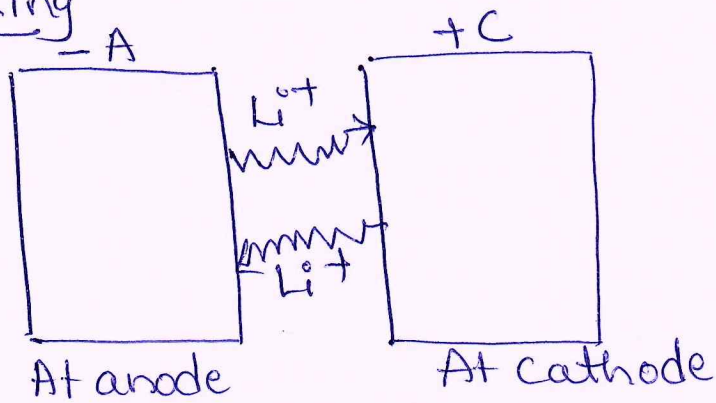
Q.No.	Solution and Scheme	Marks

Electrolyte: $LiPF_6$, $LiBF_4$, $LiClO_4$ etc mixed in organic solvents such as ether

Separator: Microporous polypropylene

The battery needs to be taken for charging before it is made available for discharge.

Working



Before charging

C_6 $\qquad$ $LiCoO_2$

After charging

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

The principle behind the working is that during charge, Li-ion in the cathode moves from layer to layer in crystallized carbon anode. Charge balancing in cathode is ensured by oxidation of Co^{3+} to Co^{4+}. Electrons released by such oxidation are transferred to anode through external circuit. During discharge, Li-ions from anode move to the cathode and Co^{4+} is reduced to Co^{3+}

Q.No.	Solution and Scheme	Marks
3a	Define secondary batteries. Explain construction and working of Li-ion battery.	7

Secondary batteries

Reversible, are recharged after discharge from an external source of emf by reversal of polarity of electrodes. Thus are rechargeable. The cells function as galvanic cell during discharge and electrolytic cell during recharge.

ex: $Pb-H_2SO_4$, Li-ion, Ni-Cd

Li-ion battery construction and working

Construction: Secondary rechargeable Li-ion cell when in charged condition is schematically represented as ___

$Li_xC_6 \mid Li$ - salt in mixed org. solvents $\mid Li_{1-x}Co^{+3}_{1-x}Co^{+4}_{x}O_2$

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

$Cu, C_6 \mid LiPF_6, LiBF_4, LiClO_4$ etc in org solvents $\mid LiCoO_2, Al$

Anodic material: highly crystallized Specialty carbon (Graphite with layer structure

Cathodic material: $LiCoO_2$

Q.No.	Solution and Scheme	Marks

Charging reactions

At anode of electrolytic cell

$$LiCoO_2 \rightleftharpoons Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_x O_2 + xLi^+ + xe^-$$

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: $Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_x O_2 + xLi^+ + xe^- \rightleftharpoons LiCoO_2$

Cell reaction during charge & discharge

$$C_6 + LiCoO_2 \rightleftharpoons C_6Li_x + Li^+_{1-x}Co^{3+}_{1-x}Co^{4+}_x O_2$$

Cell potential 3.7V

3b What is anodizing? Explain the anodizing of Aluminium. 7

Anodizing refers to chemical conversion coating over metal surfaces and control of corrosion.

→ The method is applicable to non ferrous metals. Anodizing of aluminium is explained below —

→ Aluminium articles is made an anode in an electrolytic bath containing oxidising agent such as chromic acid sulphuric acid, phosphoric acid, boric acid oxalic acid etc

→ Cathode is made of lead or stainless steel or copper.

→ Moderate temp and current densities

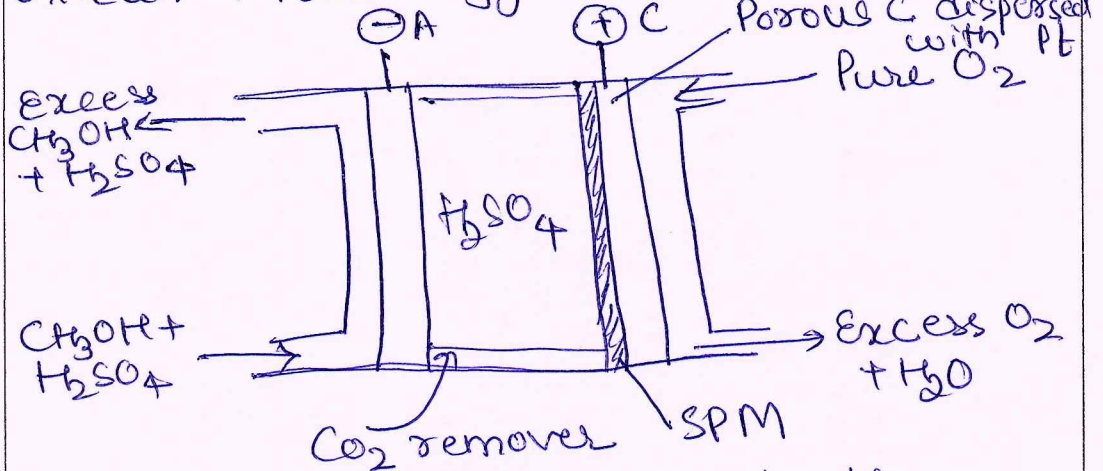
Q.No.	Solution and Scheme	Marks
	are maintained to have better barrier material between the metal & medium. → There is formation of Al_2O_3 coating over aluminium, which grows in thickness with time. $2Al + 3[O] \longrightarrow Al_2O_3 \downarrow$ → Outer, porous oxide film is made non porous "through" sealing process" by immersion into boiling water or metal salt solution. There is hydration of Al_2O_3 into $Al_2O_3 \cdot H_2O$, which will have expanded size and thus, seal the pores. Applications: Used for: many design or architectural purposes making window frames & soap boxes.	
3C	Explain the construction and working of methanol oxygen fuel cell. CH_3-OH-O_2 Fuel cell 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	6

Q.No.	Solution and Scheme	Marks

Active components

Fuel: Methanol mixed with sulphuric acid, supplied at anode

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 oxidn $CH_3OH + H_2O \longrightarrow CO_2 + 6H^+ + 6e^-$

Cathodic redn $1\frac{1}{2}O_2 + 6H^+ + 6e^- \longrightarrow 3H_2O$

Cell reaction $CH_3OH + 1\frac{1}{2}O_2 \longrightarrow CO_2 + 2H_2O$

water 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

Applications:

Used in military applications & large scale power production

Q.No.	Solution and Scheme	Marks
4a	Describe the 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]

Hydrogen evolution type is characterized by the presence of large anodic area and a small cathodic area. Corrosion is uniform and less aggressive. Higher the acidity of 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 is acidic

Oxygen absorption type is characterized by the presence of small anodic area and a large cathodic area. Corrosion is localised and very aggressive. Higher is the oxygen contained in the medium higher is the corrosion rate.

Q.No.	Solution and Scheme	Marks

Ferrous hydroxide is formed as corrosion product. Excess of O_2 can oxidize it further to yellow rust or black rust.

$$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2 \text{ or } FeO \cdot H_2O$$
(Hydrated ferrous oxide)

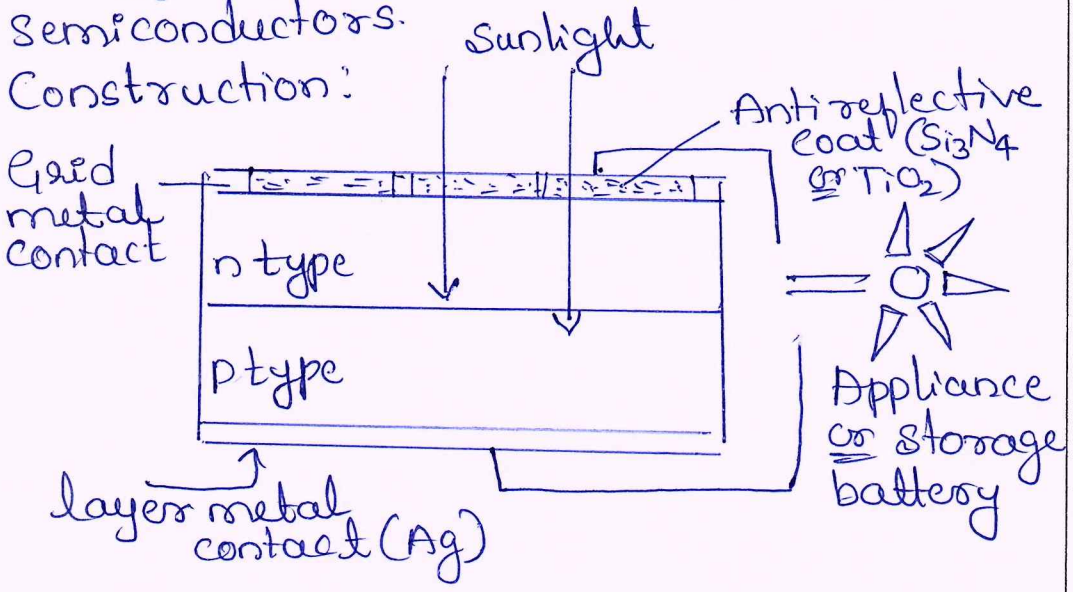
$$2Fe(OH)_2 + H_2O + \tfrac{1}{2}O_2 \longrightarrow 2Fe(OH)_3 \text{ or } Fe_2O_3 \cdot 3H_2O$$
(Hydrated ferric oxide yellow rust)

$$3Fe(OH)_2 + \tfrac{1}{2}O_2 \longrightarrow Fe_3O_4 \cdot 3H_2O$$
(magnetite; black rust)

4b. Define PV cell. Illustrate the construction and working of photovoltaic cell.

PV cells or solar cells are devices that convert solar energy into electrical energy (direct current, DC) from semiconductors.

Construction:



1) Photovoltaic cell is made of a semiconductor diode (p-n junction)

Q.No.	Solution and Scheme	Marks

2]. The diode has two electrical contacts. A grid metal contact (to facilitate light to pass through the PV cell) is used on top side and a layer metal contact on the bottom side. Layer metal used is generally silver.

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

4] An antireflective coat (Si_3N_4- silicon nitride or TiO_2- titanium dioxide) is used between the grid lines to increase the efficiency of light absorbance or energy conversion.

Working

1] 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.

2] The electrons move towards the n-region and holes move towards p-region (as it is -vely charged)

3] When an appliance or battery is connected between the two contacts, circuit is completed & electrons are driven into the external circuit enabling the functioning of the appliance or charging of the battery.

Q.No.	Solution and Scheme	Marks
	Charged battery is used for applications such as, lighting, telecommunication etc. 4] Depending on the energy requirement PV cells are connected either in series or parallel and designed to make modules or panels or arrays 5]. It may be noted that the solar cells produce the direct current. PV arrays employ an inverter for AC current and operation of electrical appliances is ensured.	
4C	Define batteries. Give the classification of batteries with suitable examples. A battery is a union of two or more cells connected in series or parallel for necessary current or voltage. The driving force behind the working of any cell or battery is spontaneous redox reaction. Classification of batteries 1] Primary battery Irreversible, to be discarded on discharge. Function as galvanic cells during discharge. Eg: Zn-MnO_2 battery Li-MnO_2 battery Primary batteries are designed for discharge alone. Attempt to recharge these cells / batteries results in explosion or fire hazard.	6

Q.No.	Solution and Scheme	Marks
	2] Secondary batteries Reversible, are recharged after discharge from an external source of emf by reversal of polarity of the electrodes, thus, are re-discharge able. The cells function as galvanic cells during discharge and as electrolytic cells during recharge. Eg: $Pb-H_2SO_4$ battery, Ni-MH battery NiCad battery etc. 3] Reserve batteries: Batteries with reserved activity with one of the essential battery component kept isolated, which can be activated by addition of the isolated component during requirements of electrico energy. Ex: $Pb|acid|PbO_2$ $Zn|KOH|Ag_2O$ Based on the electrolyte solution used the reserve batteries are classified as —— Water activated $Mg|seawater|AgCl, Ag$ Acid activated $Pb|acid|PbO_2$ battery Alkali activated $Zn|KOH|Ag_2O$ battery	
5a	What is hard water? Discuss the estimation of total hardness using EDTA solution.	7

Q.No.	Solution and Scheme	Marks

Hard water is one which will not give lather well with soap.

Estimation of Total hardness using EDTA solution.

It involves two steps —

A] Preparation of standard Na_2EDTA solution

Take the beaker containing about 1.0 g Na_2EDTA crystals and note down the beaker number. Add 5mL of 1:1 ammonia solution, a little of distilled water and dissolve the crystals. Transfer the solution into a 250mL capacity standard flask through a funnel. Rinse the beaker with little of distilled water at a time and transfer the rinsings into the std flask. Dilute the solution upto the mark with distilled water. Shake well to make the solution uniform.

B] Determination of total hardness of water.

Take a clean burette and rinse it with distilled water and then with std. EDTA solution prepared. Now, fill the burette with std EDTA solution. Take a clean conical flask and rinse it with distilled water. Take a clean pipette and rinse it with the given sample of hard water

Q.No.	Solution and Scheme	Marks

Pipette out 25mL of hard water into the conical flask. Add 2mL of buffer solution ($NH_4OH + NH_4Cl$) and a pinch or 2 or 3 drops of eriochrome black-T indicator (it is also known as, solochrome black). Titrate this solution against std Na_2EDTA solution adding 1.0mL at a time until the change in colour from wine red to clear blue (pilot reading). Repeat the titration adding 0.1mL towards the endpoint for two correct readings. Let the average of burette readings be PmL. Calculate the total hardness of given sample of water.

Calculation.

It is known that —

1000mL of 1M Na_2EDTA soln = 100g $CaCO_3$

1mL of 1M Na_2EDTA soln = 0.1g of $CaCO_3$

PmL of Y M Na_2EDTA soln = $0.1 \times P \times Y$ g $CaCO_3$

Z = ——— g $CaCO_3$

10^6 mL of hard water = $\frac{Z \times 10^6}{25}$

where P = Mean burette reading in mL

Y = Molarity of Na_2EDTA

= ——— g $CaCO_3$

Hence the total hardness of given sample of water = ——— grams per million gram or mg/L

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

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

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 nano materials of high purity.

This process involves five steps.

1] Preparation of sol:

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

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

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.

$$M\text{-}OH + M\text{-}OH \longrightarrow M\text{-}O\text{-}M + H_2O$$

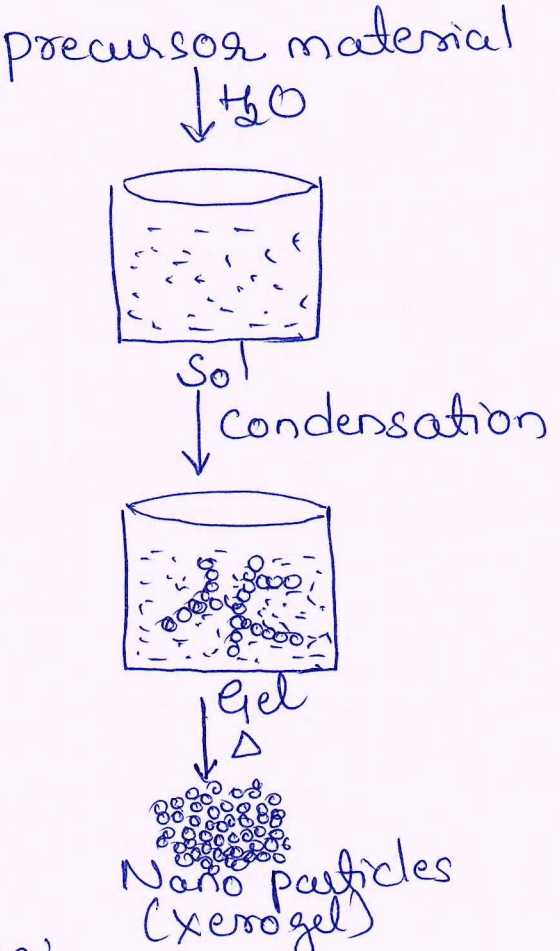
$$M\text{-}OR + MOH \longrightarrow M\text{-}O\text{-}M + ROH$$

Q.No.	Solution and Scheme	Marks

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

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 temp

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

Q.No.	Solution and Scheme	Marks
5c	Define COD. In a COD test, 30 cm^3 and 15 cm^3 of 0.05N FAS solutions are required for a blank and sample titration respectively. The volume of sample used was 25 cm^3. Find the COD of sample solution.	6

COD: The number of mg of O_2 required for the oxidation of pollutants present in 1L of waste water sample by using strong chemical oxidant such as acidified potassium dichromate solution and Ag^+ as the catalyst. It represents both biodegradable and nonbiodegradable pollutants present in the waste water sample.

Soln

Normality (Y) of FAS Soln = 0.05N

Blank titre value (Q) = 30 mL

Main titre value (P) = 15 mL

(Q-P) mL = 30-15

= 15 mL

Sample water taken = 25 mL

1000 mL of 1N FAS = 8g O_2

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

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

= $\frac{8}{1000} \times (15) \times 0.05$

25 mL sample water contains = 6×10^{-3} g O_2

10^6 mL waters contains = $\frac{6 \times 10^{-3}}{25} \times 10^6$

= $2.4 \times 10^{-4} \times 10^6$

= 2.4×10^2

= 240 ppm or mg/L

Q.No.	Solution and Scheme	Marks
6a.	What is desalination? With a neat labelled diagram, describe desalination of water by electrodialysis method	7

Desalination:

It is a process of partial or complete demineralization of highly saline H_2O such as the sea water.

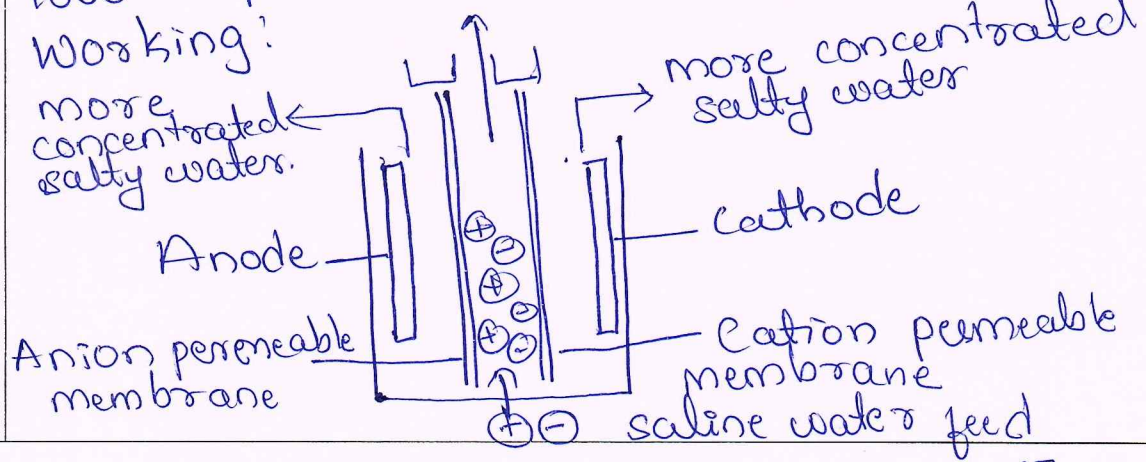
Electrodialysis:

Principle:

Application of an electric field across the salt solution results in migration of cations towords the cathode and anions towords 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 & cathode. An electrodialyser unit will have 200-1000 compartments for better efficiency.

Working:



Q.No.	Solution and Scheme	Marks

The brackish water or sea water is fed into the electrodialyser & 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 semi permeable membrane, 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 H_2O which are drawn separately.

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

SPM

For anions: Polystyrene quaternary ammonium membrane

For cations: Polystyrene sulphonate membrane

Disadvantage:

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

Q.No.	Solution and Scheme	Marks
6b	Explain the following size dependent properties of nano materials. a) Surface area b] Catalytic property.	7

a] Surface area:

When a bulk material is subdivided into individual nanomaterials, the total volume remains the same, but the collective surface area is enormously increased.

Nanomaterials have large proportion of atoms existing at the surface. Properties like catalytic activity gas adsorption and chemical reactivity depend on the surface area.

Therefore nanomaterials can show specific surface related properties that are not observed in bulk materials.

Ex:
Bulk gold is catalytically inactive, but gold nanoparticles are catalytically very active for selective redox reactions.

b] Catalytic properties

The catalytic property of materials depends on particle size. If the size of the particles reduces from bulk to nanoscale surface to volume ratio increases drastically that leads to very high catalytic activity of same material

Ex: Catalytic properties of gold nano particles. Although bulk gold samples are practically inert, nanometer sized gold particles have been proven to be highly active for several reactions

Q.No.	Solution and Scheme	Marks

including —
→ low temp oxidation of CO
→ Partial oxidation of HCs
→ The water gas shift reactions
→ Reduction of nitrogen oxides when dispersed over certain oxides and carbides.

6c 100mL of sample water required 18mL of 0.01M EDTA for titration using EBT indicator. In another experiment 100mL of the sample of water was boiled and precipitate was removed by filteration required 9.0mL of 0.01M EDTA using EBT indicator. Calculate i) Total hardness ii] Permanent hardness iii] Temperory hardness — 6

Soln:

Sample water taken for analysis (Z) = 100mL

Concentration of EDTA (Y) = 0.01M

P = 18mL Q = 9.0mL

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

$= 0.1 \times 18 \times 0.01 \times \frac{10^6}{100}$

$= 1.8 \times 10^{-4} \times 10^6$

$= 1.8 \times 10^2$

$= 180$ ppm

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

$= 0.1 \times 9 \times 0.01 \times \frac{10^6}{100}$

$= 9.0 \times 10^{-5} \times 10^6$

$= 90$ ppm.

Q.No.	Solution and Scheme	Marks

Temperory hardness = Total hardness − Permanent hardness

= 180 − 90

= 90 ppm.

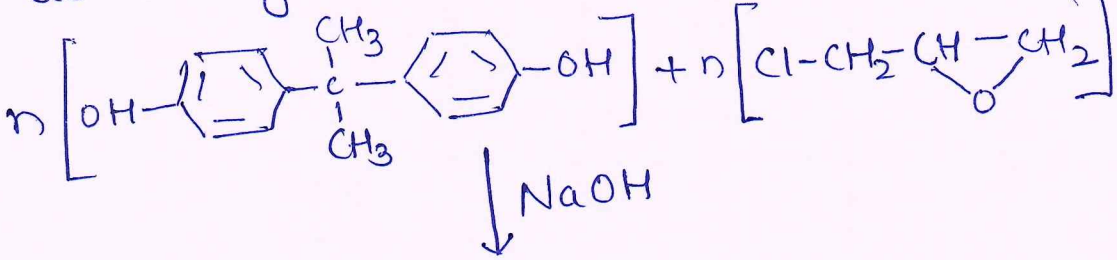
7a. What are adhesives? Give the synthesis, properties and applications of epoxy resins. 7

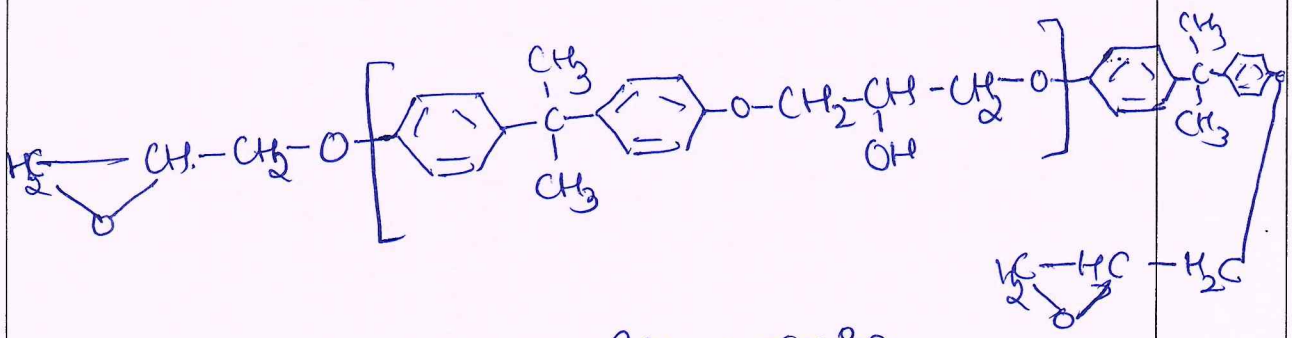
An adhesive is a polymeric material used to bind two or more similar or dissimilar materials together so that the resulting material can be used as single piece.

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.

Q.No.	Solution and Scheme	Marks

Properties of epoxy resins

→ Epoxy resins are resistant to water, acids, alkalides and various solvents.

→ Cured epoxy resins have more toughness adhesion & heat resistance.

→ They possess good electrical insulating property.

→ They offer very good skid, wearing & abrasion resistance.

Applications:

→ It is used as an adhesive to bind metallic, wood, glass, concrete, ceramic & 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.

7b A polymer sample contains 1, 2, 3 and 4 molecules having molecular mass 10^5, 2×10^5, 3×10^5 and 4×10^5 respectively. Calculate number average and weight average molecular mass of polymer. 7

Soln

$N_1 = 1$ $M_1 = 10^5$

$N_2 = 2$ $M_2 = 2\times10^5$

$N_3 = 3$ $M_3 = 3\times10^5$

$N_4 = 4$ $M_4 = 4\times10^5$

Q.No.	Solution and Scheme	Marks

$$N_i = N_1 + N_2 + N_3 + N_4$$
$$= 1 + 2 + 3 + 4$$
$$= 10$$

$$\Sigma N_i M_i = N_1 M_1 + N_2 M_2 + N_3 M_3 + N_4 M_4$$
$$= (1 \times 10^5) + (2 \times 2 \times 10^5) + (3 \times 3 \times 10^5) + (4 \times 4 \times 10^5)$$
$$= 10^5 (1 + 4 + 9 + 16)$$
$$= 30 \times 10^5$$

$$\Sigma N_i (M_i)^2 = N_1 (M_1)^2 + N_2 (M_2)^2 + N_3 (M_3)^2 + N_4 (M_4)^2$$
$$= 1 \cdot (10^5)^2 + 2 (2 \times 10^5)^2 + 3 (3 \times 10^5)^2 + 4 (4 \times 10^5)^2$$
$$= (10^5)^2 (1 + 8 + 18 + 64)$$
$$= 91 \times 10^{10}$$

$$\bar{M}_n = \frac{\Sigma N_i M_i}{\Sigma N_i}$$
$$= \frac{30 \times 10^5}{10}$$
$$= 3 \times 10^5 \text{ (Number average Mwt)}$$

$$\bar{M}_w = \frac{\Sigma N_i (M_i)^2}{\Sigma N_i M_i}$$
$$= \frac{91 \times 10^{10}}{30 \times 10^5}$$
$$= 3.03 \times 10^5 \text{ (Weight average Mwt)}$$

Q.No.	Solution and Scheme	Marks
7c	Mention the properties and applications of geopolymer concrete.	6

Geopolymer properties

→ The compressive strength of geopolymer concrete is similar to that of portland cement concrete.

→ The unit weight of fly ash based geopolymer concrete is similar to that of portland cement concrete.

→ They exhibit low drying shrinkage and low creep compared to portland cement concrete.

→ Geopolymer concrete has an excellent resistance to the sulfate attack where as hydrated products of portland cement

→ Geopolymers are used as fire protection coatings for cruise 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 alternative 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 protectrin coatings for cruise ships.

Q.No.	Solution and Scheme	Marks
8a	Define biodegradable polymer. Explain the synthesis and applications of poly-lactic acid.	7

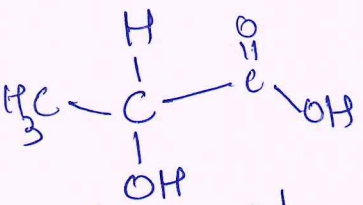
The polymers which breakdown after their intended use by microbial decomposition into biocompatiable CO_2, nitrogen, methane, water biomass & inorganic compounds are called biodegradable polymers.

Synthesis of polylactic acid

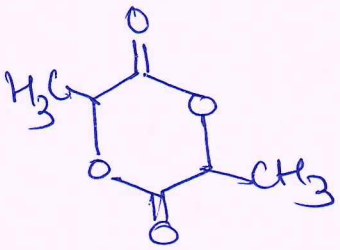
It is a thermoplastic polyester polymer extensively used as biodegradable polymer.

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

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

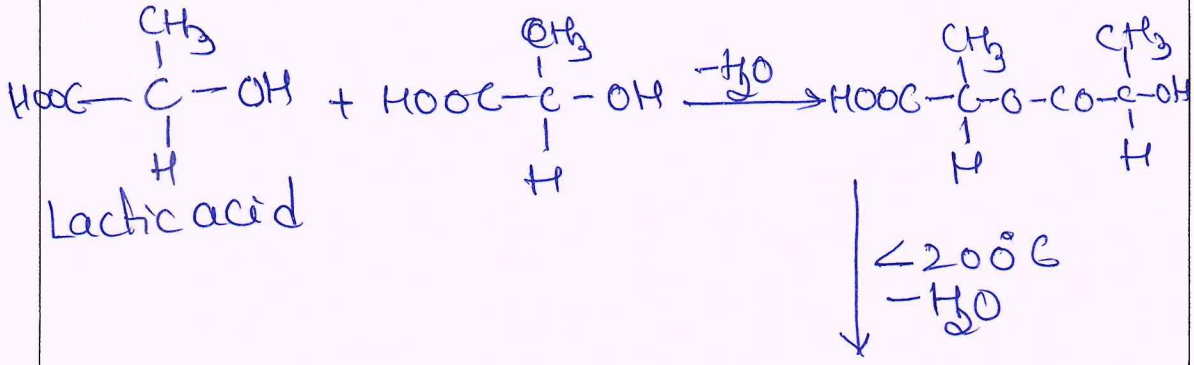


Lactic acid

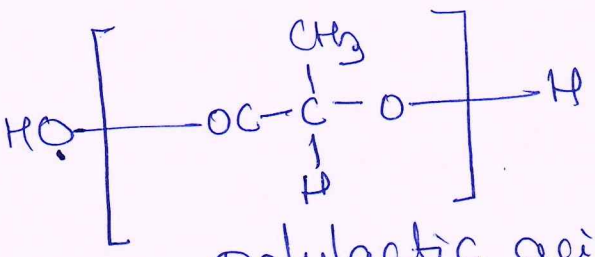


Lactic acid has a carboxylic group & a hydroxyl group attached to the same carbon atom. The acid group of another reactant result in condensation of H_2O molecule. The reaction is reversible and forward reaction is favored by removal of H_2O

Q.No.	Solution and Scheme	Marks

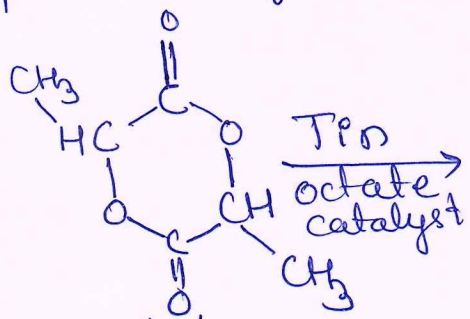


Lactic acid

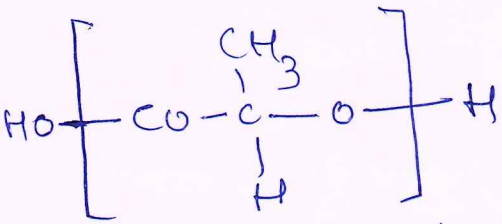


polylactic acid (PLA)

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



lactide



polylactic acid (PLA)

Applications

→ PLA-based materials are employed for the biomedical, textile & packaging purposes.

→ Micro and nanoparticles are an important category of delivery systems used in medicine controlled drug delivery and fracture fixation devices like screws, resorbable sutures, plates, pins, rods, wires.

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

→ Fibers for textiles industry or sutures, films and non woven textile for clothes.

Q.No.	Solution and Scheme	Marks
8b.	Describe the synthesis, properties and applications of polyethylene.	7

Synthesis of polyethylene

It is obtained by addition reaction of ethylene monomers

$$n(CH_2=CH_2) \longrightarrow -(CH_2-CH_2)_n-$$

ethylene → polyethylene

Polymerization can be carried out by free radical polymerization using dimethoxy peroxide as an initiator. Polymer obtained by this method has more branches with less close packing and it is called as low density polyethylene (LDPE). When polymerization is carried out by Ziegler Natta catalyst using $TiCl_4$ & $AlCl_3$. Polyethylene with less number of branches with more close packing is obtained. This is called as high density poly ethylene (HDPE).

Properties:

→ LDPE has high degree of branching with low crystallinity (<50-60% crystalline) and lower density in the range of 0.910 - 0.925 g/mL

→ LDPE exhibits good flexibility, transparency, good moisture barrier properties

→ HDPE has very low degree of branching with high crystallinity (>90% crystalline) & higher density in the range 0.941-0.965 g/mL.

Q.No.	Solution and Scheme	Marks
	Applications → LDPE is used as carry covers, shrink wrap films, squeezable bottles, garbage, bags extrusion moldings & laminates. → HDPE are used in injection moldings to make film products, hollow plastic products & pipes.	
8 C	What are polymer composites? Mention the properties & applications of FRP (Fiber Reinforced polymer) Composite materials are engineered or naturally occuring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate & distinct within the finished structure. → FRPC also plastic is a composite material made of polymer matrix reinforced with fibers. → The fibers are usually glass, carbon or aramed although other fibers such as paper or wood asbestos have been sometimes used Properties → Higher strength → Lighter weight → Higher performance → Longer lasting → Rehabilitating existing structures & extending their life. → Seismic upgrades, good corrosion resistance → Ocean environments.	6

Q.No.	Solution and Scheme	Marks
	Applications: → Composites of phenolic resins and nylon are used in heat sheilds for space crafts. → They are used in aircraft & space industry. → They suitable in automotive & railway applications. → They are used in civil construction work also.	
9a	Define the help of neat following terms with example i) Phase ii) Component iii) Degree of freedom 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 boundry surface. Ex: A completely miscible homogenous mixture of gases (O_2 & N_2) and liquids (H_2O and alcohol) gives phase ($P=1$) b) Any pair of immiscible liquids (H_2O & kerosene) gives rise to two phases ie. $p=2$ 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	7

Q.No.	Solution and Scheme	Marks
	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 iii] Degrees of freedom or varience The degree of freedom of a system is defined as the number of independently variable such as pressure, temperature & composition which must be specified in order to define the state of a system. Ex: Consider any single phase in water system $H_2O(s) \rightleftharpoons H_2O(l) \rightleftharpoons H_2O(g)$ The state of 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	Illustrate the principle, instrumentation and working of potentiometric sensors. Principle: The procedure of using a measurement of emf to determine the concentration of ionic species in the solution is called	7

Q.No.	Solution and Scheme	Marks

potentiometry. The principle involved in potentiometric titration is the measurement of emf between two electrodes, an indicator electrode and a reference electrode of constant potential. In this titration, the measurement of emf is made while the titration is in progress. The equivalence point of the reaction is revealed by a sudden change in potential in the plot of emf readings against the volume of titrant.

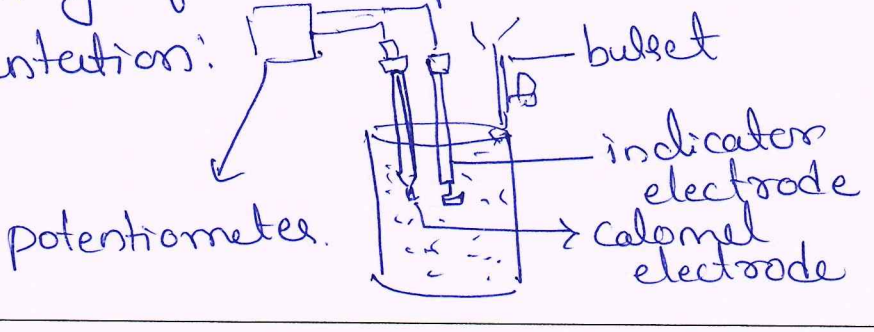
The determining factor in oxidation & reduction reactions is the ratio of the concentration of oxidized and reduced forms of certain species.

$$E_{cell} = E_0 + \frac{0.0591}{n} \log \left[\frac{\text{oxidized form}}{\text{reduced form}} \right]$$

where E_0 = is the std electrode potential.

The potential of the immersed electrode is controlled by the ratio of these concentrations. During the oxidation of a reducing agent or the reduction of an oxidizing agent, the ratio changes, hence the emf changes more rapidly in the viscinity of the end point.

Instrumentation:



Q.No.	Solution and Scheme	Marks

A potentiometer consists of a reference electrode, an indicator electrode and a device for measuring the potential. Calomel electrode is commonly used as reference electrode and platinum electrode is used as an indicator electrode.

Indicator electrode is also called as sensor electrode or working electrode change in potential during titration is detected by indicator electrode which is converted to electrical signal & displayed as numerical value on the display of potentiometer.

9c Explain the determination of pH of soil sample using pH sensors. 6

Determination of pH of the soil sample.

→ Place the soil sample about 3/4 full in sample jar. and add distilled water to cover soil

→ Cap the jar and shake the soil vigorously a few times.

→ Let the mixture stand 10mins to dissolve the salts in the soil.

→ Calibrate 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.

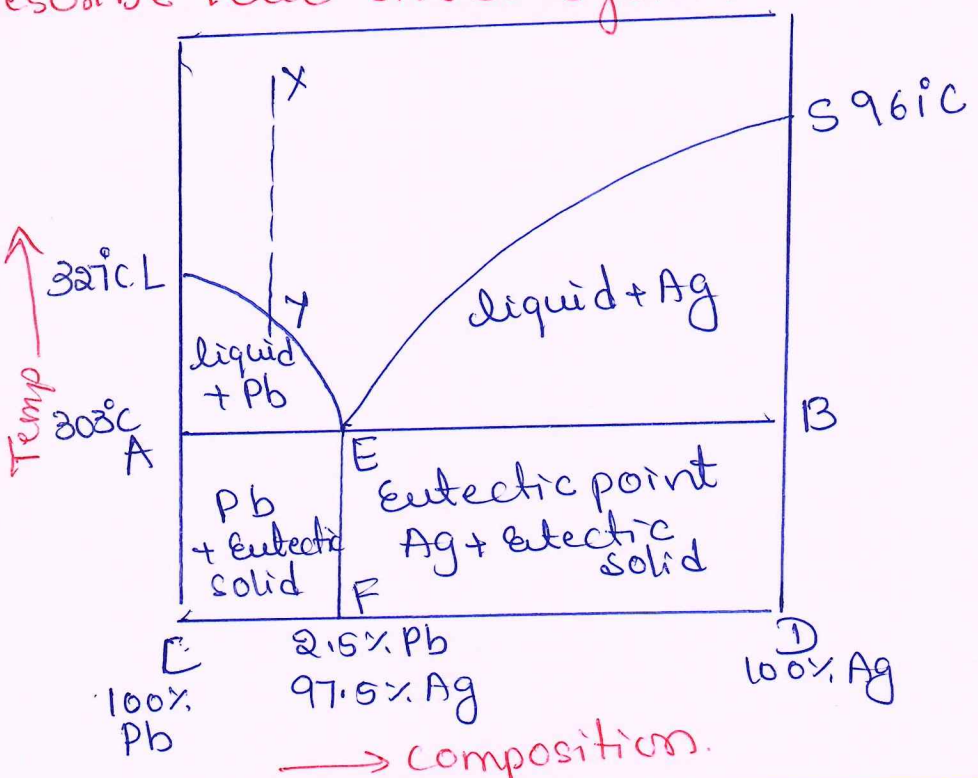
→ Measure pH and record measurement.

Result:

Q.No.	Solution and Scheme	Marks

A minor ($< \pm 0.5$ pH) difference between results of the soil sample indicates good technique & high confidence in results.

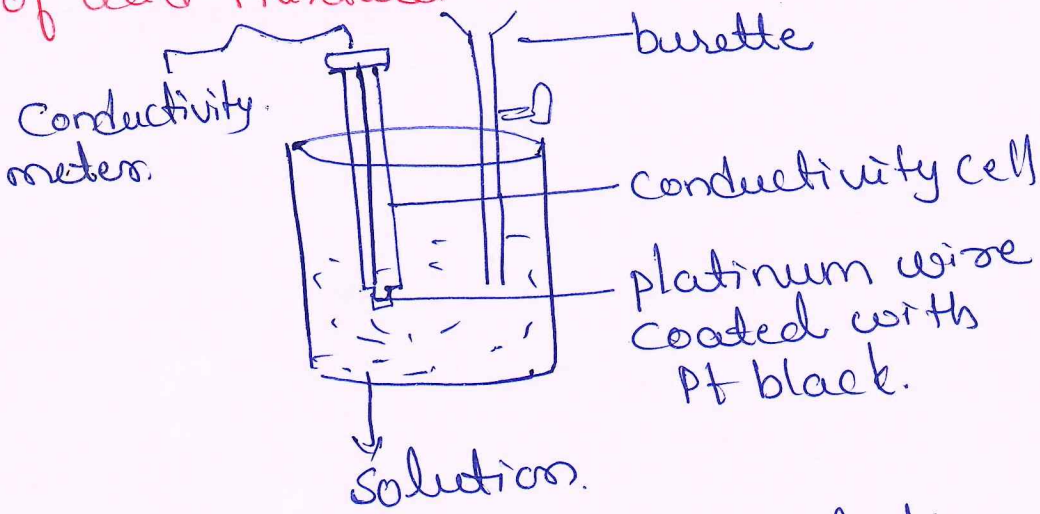
10a With the help of neat phase diagram, describe lead silver system. 7



Parts of phase diagram	Phases in equilibrium	P	Degrees of freedom F = 3 − P / Variance		Variables
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	Mono variant	"
Region SEB	Solid Ag ⇌ liquid melt containing Pb & Ag	2	3−2=1	Mono variant	"
Point E Eutectic point	Solid Ag ⇌ solid Pb ⇌ liquid melt of Pb & Ag	3	3−3=0	In variant	Self defined temp = 303°C & Composition 2.5% Pb 97.5% Ag

(44)

Q.No.	Solution and Scheme	Marks
10b	Describe the instrumentation & application of conductometric sensors in the estimation of acid mixture.	7



The conductance of a solution is explained by considering ohm's law $C = I/R$. It has the units of $ohm^{-1}cm^{-1}$ or Scm^{-1}, Conductivity of the solution depends on mobility of the ion & number of ions.

The conductometric sensor consists of conductivity cell. The cell is made up of two platinum electrodes coated with platinum black and connected through a glass loop.

Application of conductometric sensors in the estimation of acid mixture

$(HCl + CH_3COOH)$ Vs $NaOH$.

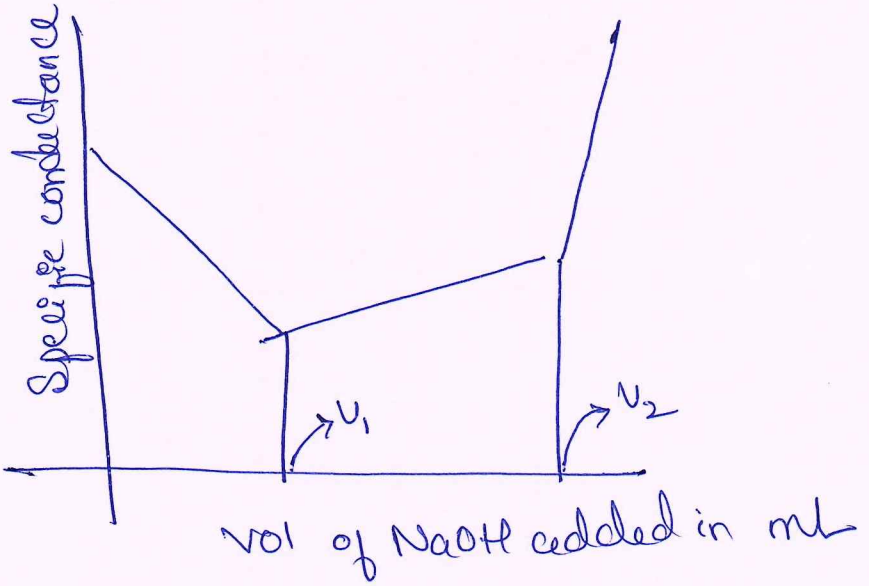
In this curve there are two break points. The first break point corresponds to the neutralization of strong acid. When the strong acid has been completely neutralized only then the weak acid starts neutralising

Q.No.	Solution and Scheme	Marks

The second break point corresponds to neutralisation of weak & after that conductance increases due to the excess of OH^- ions incase of a strong base as the titrant. However, when the titrant is a weak base it remains almost constant after the endpoint.

$$H^+Cl^- + Na^+OH^- \longrightarrow Na^+Cl^- + H^+OH^-$$

$$CH_3COO^-H^+ + Na^+OH^- \longrightarrow CH_3COO^-Na^+ + H^+OH^-$$



10c Describe the principle & instrumentation of potentiometric sensors 6

(Refer 9b answer)

Staff incharge
Sneha S. Kulkarni
25/11/2023

27/11/24.