CBCS SCHEME

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BCHEM102/202

First/Second Semester B.E./B.Tech. Degree Examination, June/July 2023
Applied Chemistry for ME 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.	Organize the determination of calorific value of a solid fuel using Bomb Calorimeter.	7	L2	CO1
	b.	Sketch and explain the construction and working of photovoltaic cells and define solar cell.	6	L2	CO1
	c.	0.75 g of coal sample (carbon 90%, H_2 5% and 5% ash) was subjected to combustion in bomb calorimeter. Mass of water taken in calorimeter was 2.5 kg and the water equivalent of calorimeter is 0.65 kg. The rise in temperature was found to be 3.2°C. Calculate higher and lower calorific values of the sample. Latent heat of steam = 2457 kJ/kg and specific heat of water = 4.187 kJ/kg/°C.	7	L3	CO1
		OR			
Q.2	a.	Describe the construction and working of methanol oxygen fuel cell and its applications.	7	L2	CO1
	b.	Write notes on: (i) Power alcohol (ii) Bio-diesel	6	L2	CO1
	c.	Illustrate the production of hydrogen by electrolysis of water.	7	L2	CO1
		Module – 2			
Q.3	a.	Define corrosion. Describe the electrochemical theory of corrosion taking rusting of iron as an example.	7	L2	CO2
	b.	Explain: (i) Water-line corrosion (ii) Pitting corrosion	6	L2	CO2
	c.	What is electroless plating? Explain electroless of Nickel.	7	L2	CO2
		OR			
Q.4	a.	What is meant by metal finishing? Mention (any five) technological importance of metal finishing.	6	L2	CO2
	b.	Explain the process of (i) Galvanizing (ii) Anodizing of Al.	7	L2	CO2
	c.	What is electroplating? Explain electroplating of chromium. Mention why chromium cannot be used as anode.	7	L2	CO2
		Module – 3			
Q.5	a.	Illustrate about the number average and weight average molecular weight.	6	L3	CO3
	b.	Organize the properties and applications of lubricants.	7	L2	CO3
	c.	Organize the synthesis, properties and applications of polystyrene.	7	L2	CO3
		OR			
Q.6	a.	Organize the synthesis, properties and applications of Kevlar.	6	L2	CO3
	b.	Illustrate the synthesis, properties and applications of polyester.	7	L2	CO3
	c.	Organize the synthesis, properties and applications of PMMA.	7	L2	CO3
		Module – 4			
Q.7	a.	Sketch and explain the optical sensor (colorimetry) and write its applications.	7	L2	CO4
	b.	Organize the instrumentation of potentiometric sensor and its application in the estimation of iron.	6	L2	CO4
	c.	Explain the concept of phase, components, degree of freedom, phase rule equation.	7	L2	CO4

		OR			
Q.8	a.	Explain along with diagram Lead-Silver two component system.	7	L2	CO4
	b.	Explain the principle, instrumentation and working of pH sensor (Glass electrode).	7	L2	CO4
	c.	Organize the pH sensors applications in the determination of pH of beverages.	6	L2	CO4
		Module – 5			
Q.9	a.	Explain the properties and applications of carbon nanotubes and graphene.	6	L2	CO5
	b.	Define alloys. Explain the composition along with properties of AlNiCo.	7	L2	CO5
	c.	Explain the chemical composition, properties and applications of perovskites.	7	L2	CO5
		OR			
Q.10	a.	Explain the synthesis of nanomaterials by sol-gel method.	7	L2	CO5
	b.	Explain size dependant properties of nanomaterials with respect to surface area, catalytical and thermal.	6	L2	CO5
	c.	Define Alloys. Explain the composition along with properties of Brass.	7	L2	CO5

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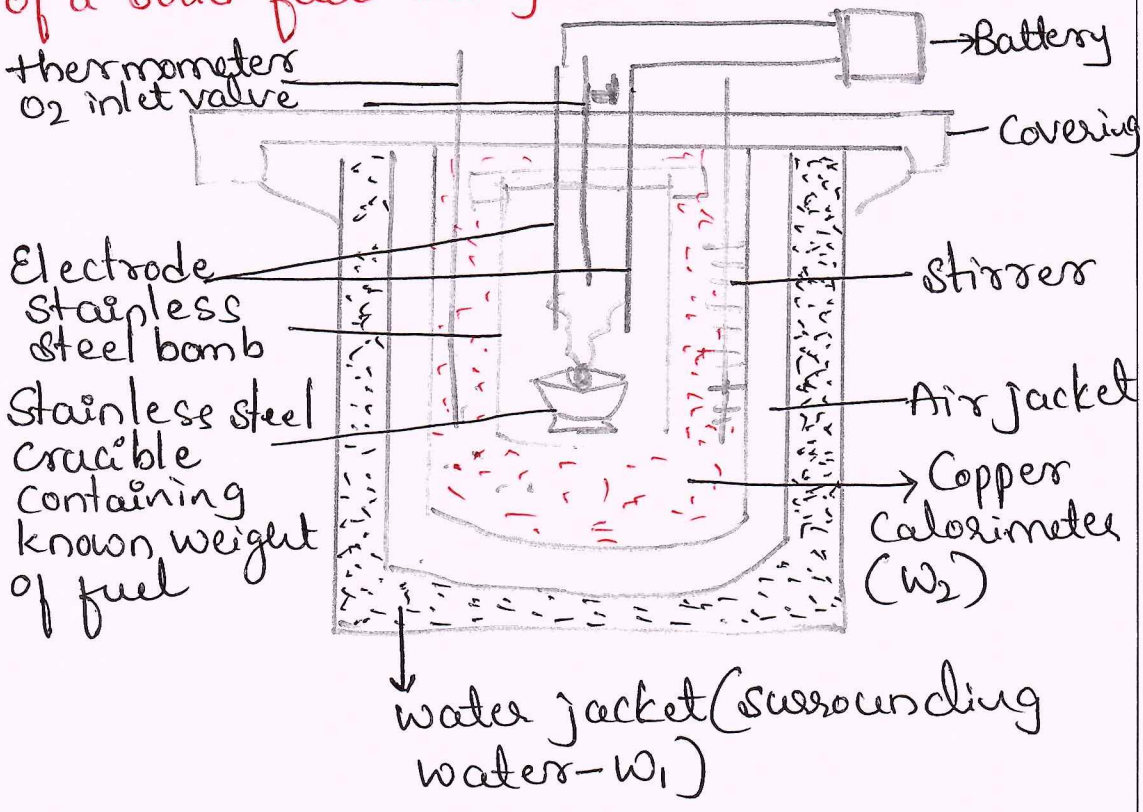
AY: 2023-24

Department: Chemistry Qp Solution :2nd sem 2023

Subject with Sub. Code:Applied Chemistry for Mechanical stream (BCHEM102)

Name of Faculty: **Prof. Sneha S Kulkarni**

Q.No.	Solution and Scheme	Marks
1a	Organize the determination of calorific value of a solid fuel using bomb calorimeter.	7



Principle:

Heat generated by combustion of fuel is equal to the heat absorbed by surrounding water and copper calorimeter.

Construction:

→ The calorimeter consists of a stainless steel bomb in which, known mass (=m kg) of the fuel is taken, excess of O_2 is filled & immersed in known mass of water contained in copper calorimeter.

→ Fuel is ignited by passage of electricity through a fuse coise tied to the fuel

Q.No.	Solution and Scheme	Marks

→ Heat liberated by fuel combustion, is absorbed by the surrounding water and copper calorimeter.

→ Temperature of water before fuel combustion (T_1 K) and maximum temperature it attains after fuel combustion (T_2 K) in the calorimeter, help in the calculation of GCV and NCV. Temperatures are measured by use of sensitive Bechman's thermometer.

Working

Heat generated by burning 'm' kg of fuel is

= Heat gained by (surrounding water + calorimeter)

$$= (W_1 + W_2)(T_2 - T_1)s$$

$$\therefore \quad m \times GCV = (W_1 + W_2)(T_2 - T_1)s$$

$$GCV = \frac{(W_1 + W_2)\Delta T s}{m} \quad \text{---- } KJkg^{-1}$$

where, GCV = gross calorific value of fuel and specific heat of water 's' = 4.187 $KJkg^{-1}K^{-1}$

And the net calorific value is given by ——

$$NCV = GCV - 0.09H \times L_v \; KJkg^{-1}$$

where, H is the percentage of hydrogen in the fuel. $L_v = 587 \times 4.187 \; KJkg^{-1}$ is the latent heat of condensation of steam.

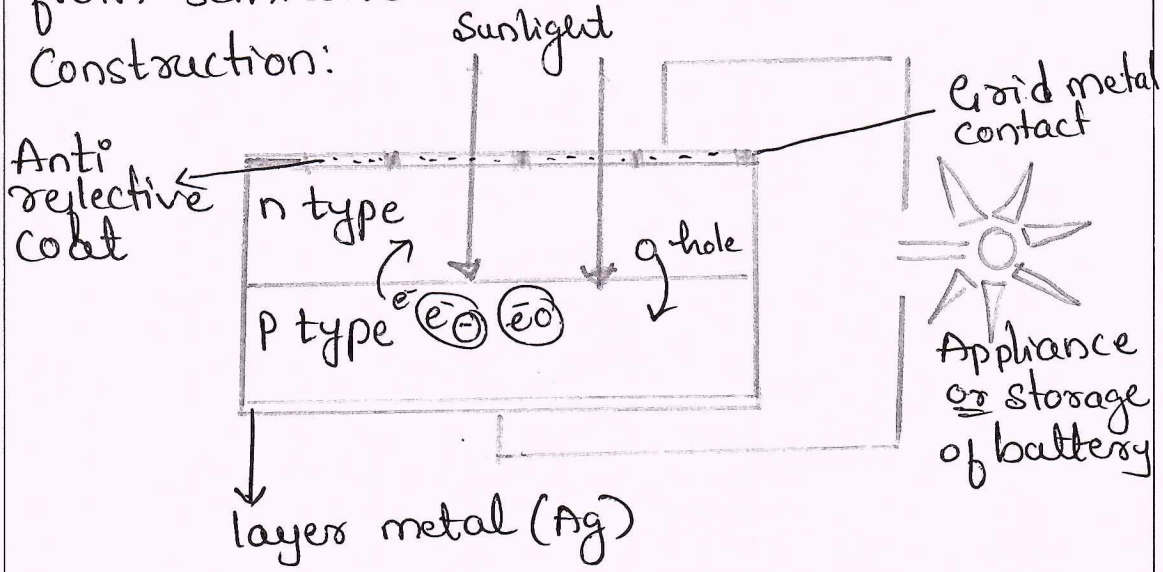
In this way the calorific value of ~~bomb~~ solid fuel determined using bomb calorimeter.

Q.No.	Solution and Scheme	Marks
1b	Sketch and explain the construction and working of photovoltaic cells and define solar cell.	6

Solar cell:

These are the energy conversion devices convert solar energy into electrical energy from semiconductor diode.

Construction:



Construction:

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

→ The diode has two electrical contacts
1) A grid metal contact to facilitate light to pass through PV cell, is used ton the top side and a layer metal contact on the bottom side.

→ Grid metal or layer metal usually made by 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.

Q.No.	Solution and Scheme	Marks

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 created.

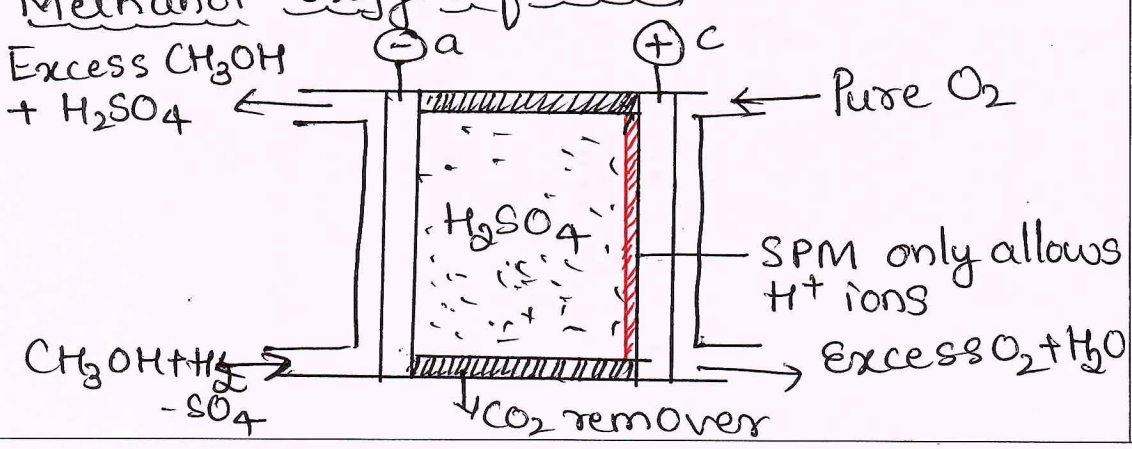
→ The electrons move towards the n-region and holes move towards p-region

→ When an appliance or battery is connected between the two contacts, circuit is 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 applications such as lightning, 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 an inverter for AC current and operation of electrical appliances is ensured.

1c 0.75g of a coal sample (C=90%, H_2=5% and 5% ash) was subjected to combustion in bomb calorimeter. Mass of water taken in calorimeter was 2.5kg and the water equivalent of calorimeter is 0.65kg. The rise in temperature was found to be 3.2°C. Calculate higher and lower Calorific values of the sample, latent heat of steam = 2457 KJ/kg & S = 4.187 KJ kg^{-1}K^{-1} 7

Q.No.	Solution and Scheme	Marks
	Soln $m_f = 0.75\,g = 0.75 \times 10^{-3}\,kg$ $W_1 = 2.5\,kg$ $W_2 = 0.65\,kg$ $\Delta T = 3.2^{\circ}C = 3.2\,K$ $L_V = 2457\,kJ/kg$ $S = 4.187\,kJ\,kg^{-1}K^{-1}$ $\%H = 5$ $GCV = \frac{(W_1+W_2)\Delta T S}{m}$ $= \frac{(2.5+0.65)3.2\times 4.187}{0.75\times 10^{-3}}$ $= 56,273.28\,kJ/kg$ $NCV = GCV - 0.09H \times L_V$ $= 56273.28 - (0.09\times 5)\times L_V$ $= 56273.28 - (0.09\times 5\times 2457)$ $= 56273.28 - 1,105.65$ $= 55167.63\,kJ\,kg^{-1}$	
2a	Describe the construction and working of methanol oxygen fuel cell and its applications. Methanol - oxygen fuel cell  	7

Q.No.	Solution and Scheme	Marks

Construction:

This fuel cell is represented as ——

Porous Carbon, $CH_3OH + H_2SO_4$ dispersed with Pt | H_2SO_4 (aq) | O_2, Porous Carbon 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:

Fuel: Methanol mixed with H_2SO_4 supplied at anode

Oxidant: Pure oxygen, supplied at cathode

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

Working: Following reactions occur during power generation

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

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

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

Water and CO_2 produced are removed as and when they are formed and do not harm the cell functioning.

Cell potential: 1.2 V

Application: Military and large scale power production.

Q.No.	Solution and Scheme	Marks
2b	Write notes on i) Power alcohol ii) Biodiesel	6

Power alcohol

A blend containing 10-85 % of ethanol & 15-90 % of gasoline, used as motor fuel is known as power alcohol.

Advantages:

→ Increases octane number and reduces knocking

→ Because, alcohol contains oxygen, it is referred as oxygenate which assist better combustion efficiency. Also VOC emissions are reduced or pollution is lessened.

→ Alcohol can be synthesized from plants. Thus, especially, with higher proportion of alcohol, one has a sustainable fuel.

→ When synthesized, helps in improved economy of a country because, oil imports are lowered and avoided.

Disadvantages:

→ Lowers the calorific value of the fuel

→ Atomization is difficult because of higher surface tension of alcohol.

→ Alcohol gets oxidized to acids & may corrode the engine equipment.

→ Modification of CR of the engine is required otherwise power output is reduced.

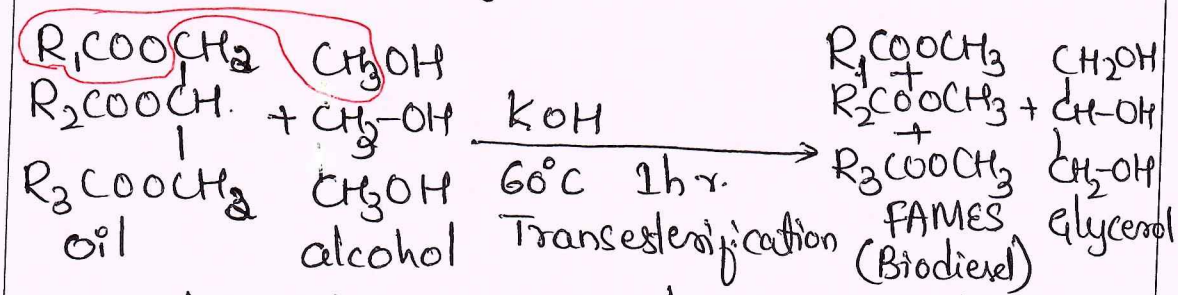
→ Alcohol as such has good affinity for water. Phase separation can be observed.

Biodiesel

Biodiesel is a man made diesel with biological origin and is mixture of fatty acid alkyl esters. It is made, mostly from vegetable oils or from animal fat.

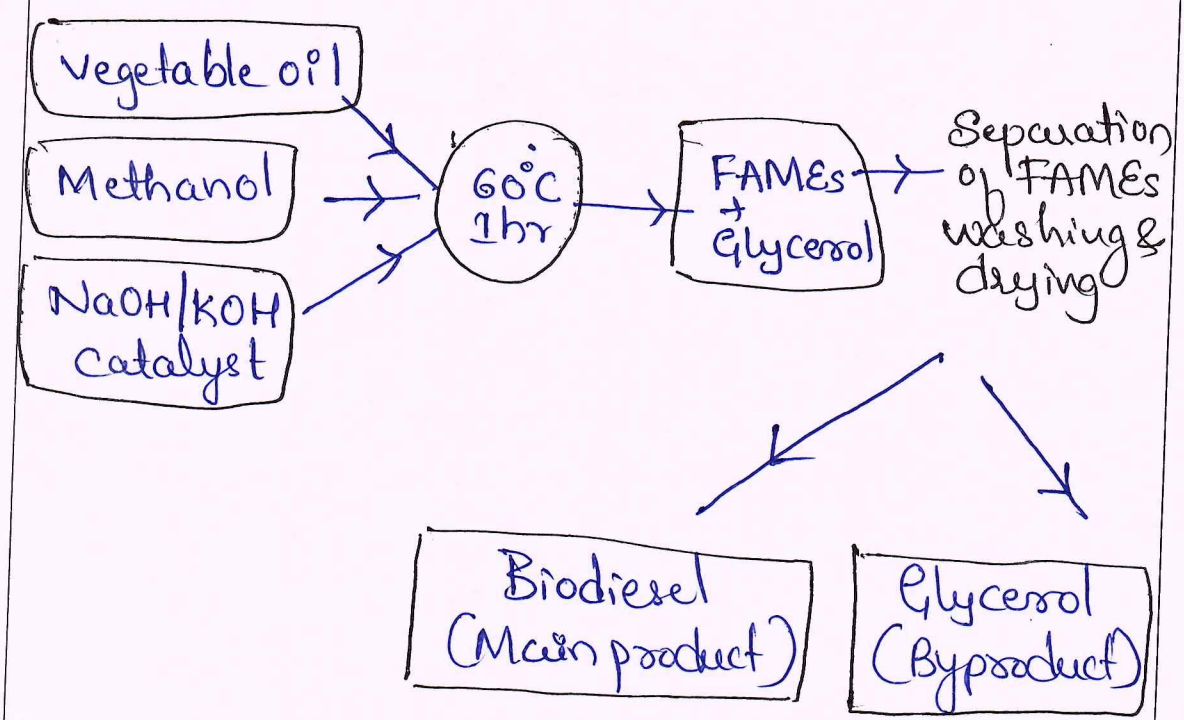
Q.No.	Solution and Scheme	Marks

Biodiesel is produced by the transesterification of vegetable oils. Vegetable oils are generally triglyceryl esters of fatty acids. Treatment of oil with mostly methanol and suitable catalyst like NaOH/KOH. A temperature of 60°C is maintained for about an hour converts the triglyceryl esters into biodiesel [Fatty acid methyl or ethyl esters] with by product glycerol



Glycerol is separated from the bottom of the reactor and organic layer containing mixture of FAMEs is washed with H_2O, dried over anhydrous Na_2SO_4. and used as biodiesel.

Flow diagram



Q.No.	Solution and Scheme	Marks

Advantages:

→ Biodiesel is non toxic and is biodegradable

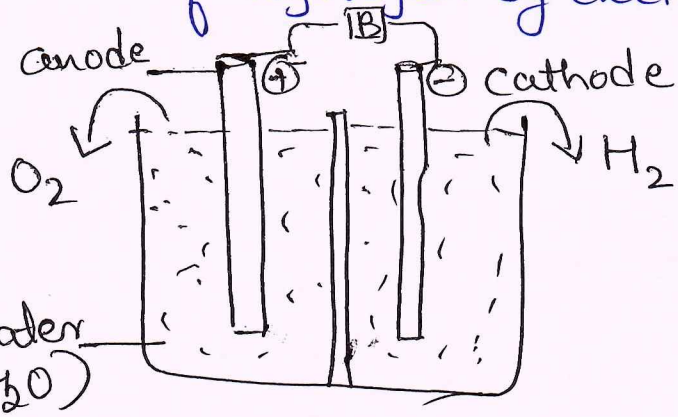
→ Raw materials are mainly from vegetable resources.

→ Has higher CN, flashpoint & fire point. Burns efficiently and safe to store & transport.

→ Has excellent lubricating properties, which reduces wear & tear and increases the life of engine.

2c. Illustrate the production of hydrogen by electrolysis of water. 4

Generation of hydrogen by electrolysis of H_2O



→ It is the process of splitting of H_2O into oxygen and hydrogen gas by electrolysis.

→ It consists of two electrode ie. anode & cathode

→ Both are separated by membranes.

→ When electricity is passed, oxidation takes place at anode, it gives H^+ ions and electrons, also liberates oxygen gas

At anode: $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$

→ The H^+ ions move into cathodic compartment through membranes & electrons move from anode to cathode through external circuit.

Q.No.	Solution and Scheme	Marks

→ ~~The~~ At cathode the H^+ ions accept electrons and forms H_2 gas. This liberated hydrogen gas is used as a fuel

At cathode: $4H^+ + 4e^- \longrightarrow 2H_2(g)$

Alkaline electrolysis

→ It consists of two electrodes anode & cathode

→ Both electrodes are made up of Ni based metal, because it is more stable during the oxygen evolution

→ These electrodes are immersed in KOH soln

→ These electrodes are immersed in KOH soln (25-35%)

→ Both electrodes are ~~made~~ separated by porous diaphargm prevent gases cross over and allows only hydroxide ions,

→ Cell voltage is 1.3 – 2V

→ When electricity is passed, at anode hydroxide ions lose electrons and forms water molecules.

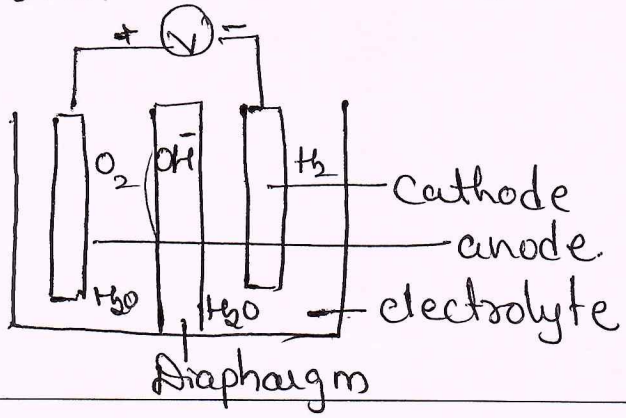
Anode: $2OH^- \longrightarrow \frac{1}{2}O_2 + H_2O + 2e^-$

→ At cathode, water molecules accept electrons and liberate H_2 gas & forms hydroxide ions,

→ These hydroxide ions move from cathode to anode through diaphargm & process continues

Cathode: $H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

Total reaction: $2H_2O \longrightarrow O_2 + 2H_2$



Q.No.	Solution and Scheme	Marks
2a.	Define corrosion. Describe the electrochemical theory of corrosion taking rusting of iron as an example.	7

Corrosion

Distruction or disintegration of metals when exposed to the surrounding corrosive stauting at their surface either by chemical or electrochemical means is metallic corrosion.

Electrochemical theory taking rusting of iron as an example

It is characterized by the formation of small galvanic cell due to heterogenities. Part of metal acts as cathode and part of metal acts as anode.

Anodic part of metal undergoes destruction by oxidation, steel undergoes corrosion by following reaction.

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

Reduction depends on the contents in the medium. Some important reactions are—

a] Hydrogen Evolution

$2H^+ + 2e^- \longrightarrow H_2$ [acidic medium]

$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$ [alkaline or neutral medium]

It is characterized by by presence of large anodic area & small cathodic area.

Corrosion is uniform and less aggressive

Higher acidity of medium higher is the corrosion rate.

b] Oxygen absorption

$\frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^-$

[alkaline or neutral medium]

$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$ [acidic]

It is characterized by presence of small anodic area and large cathodic area.

Corrosion is localised and very aggressive

Higher oxygen content in medium higher is 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 and black rust.

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

$$2Fe(OH)_2 + H_2O + \tfrac{1}{2}O_2 \longrightarrow \underset{\text{Yellow rust}}{2Fe(OH)_3 \text{ or } Fe_2O_3 \cdot 3H_2O}$$

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

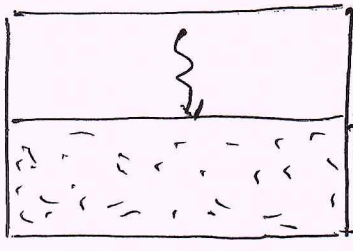
black rust.

3b Explain i) waterline corrosion ii) Pitting corrosion 6

Waterline corrosion

Metal corrosion that occurs along the waterline is called waterline corrosion.

Eg: When steel tank is used for storing water, there is formation of O_2 concentration cell. Steel metal part is exposed to more oxygenated surface water acts as cathode. Steel exposed to less oxygenated surface water acts as anode.



Suppose a steel tank partially filled with water following reaction occurs

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

Anodic corrosion reaction beneath the water surface level

Cathodic reduction reaction at H_2O surface level. $\tfrac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$

Fe^{2+} ions & OH^- ions react to form $Fe(OH)_2\downarrow$

Q.No.	Solution and Scheme	Marks

Pitting Corrosion

Corrosion of metals leading to the formation of pits or cavities or holes is called pitting corrosion. Pitting corrosion is very aggressive localised corrosion. It occurs when the metal is in contact with stagnant solution.

Changes in O_2 concentration in the medium is the cause for corrosion. Part of the metal exposed to lower concentration of O_2 acts as anode and undergoes corrosion.

Steel corrodes at less oxygenated point as

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

Cathodic reduction at more oxygenated metal surfaces

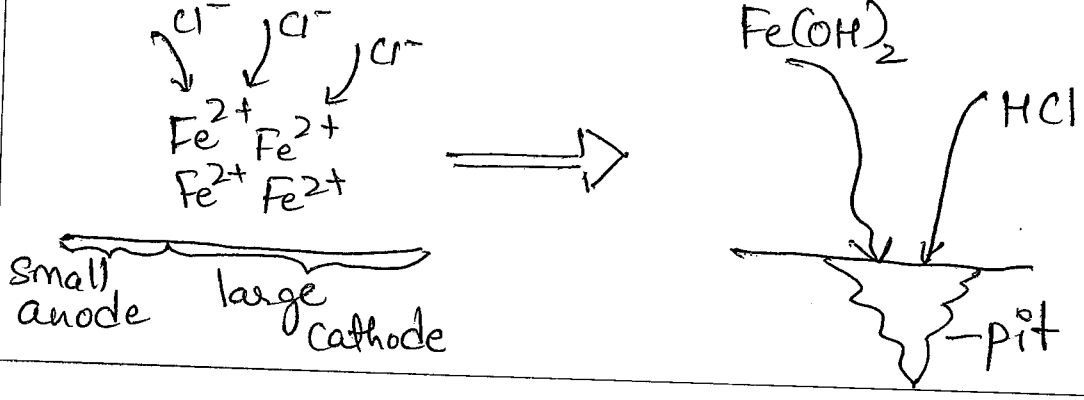
$$\tfrac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$$

Fe^{2+} ions at anodic area attract the oppositely charged ions. Say Cl^- ions & form the salt $FeCl_2$. The salt on hydrolysis ppts $Fe(OH)_2$ with the generation of HCl. Corrosion of steel is promoted beneath the deposit

Also acid formed accelerate the corrosion. Thus pitting corrosion is autocatalytic in nature.

Salt hydrolysis at anode

$$FeCl_2 + 2H_2O \longrightarrow Fe(OH)_2\downarrow + 2HCl$$



Q.No.	Solution and Scheme	Marks
2c	What is electroless plating? Explain electroless plating of nickel.	7

Electroless plating

Deposition of metal or alloy over conducting or non conducting substrate surface by chemical reduction of metal ions by use of reducing reagent and without the use of electrical energy is called electroless plating.

Metal ions + Reducing agent $\xrightarrow[\text{active surface}]{\text{Catalytically}}$ Metal atom + Oxidized product

Electroless plating of Nickel

Substrate surface needs to be cleaned by suitable cleansing methods acid pickling, mechanical polishing. However when the object is non conducting or insulator material such as plastic, glass etc it needs to be activated by treatment with acidified $SnCl_2$ and then with acidified $PdCl_2$

Bath composition

constituents	Amount	Purpose
NiCl	20g/L	Provides metal ions
Sodium hypo-phosphite (NaH_2PO_2)	20g/L	Reducing reagent
Sodium acetate (CH_3COONa)	10g/L	Buffer
Sodium succinate	15g/L	complexing agent & exaltant
~~Sodium~~ pH	4.5	
Temperature	93°C	

Reactions: Oxidn of reducing agent

$$H_2PO_2^- + H_2O \longrightarrow H_2PO_3^- + 2H^+ + 2e^-$$

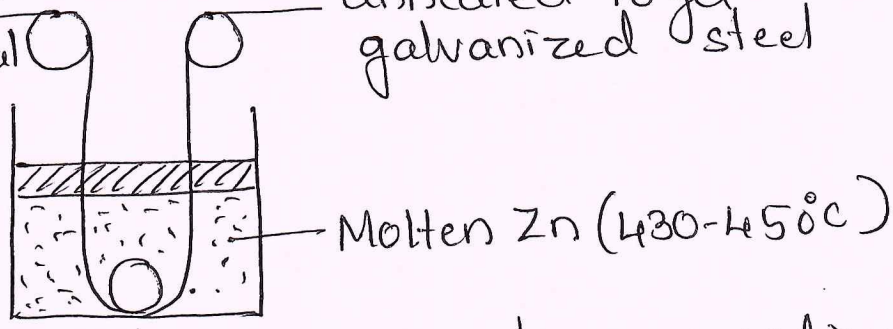
Reduction of metal ion over object surface

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

Overall Reaction $Ni^{2+} + H_2PO_2^- + H_2O + 2e^- \longrightarrow H_2PO_3^- + 2H^+ + 2e^-$

Q.No.	Solution and Scheme	Marks
4a	What is metal finishing? Mention any five technological importance of metal finishing Metal Finishing Process of surface modification by way of deposition of another metal or alloy or polymeric substance or ceramic oxide layer to bring about intended surface characteristics known as metal finishing. Technological importance → Better corrosion resistance → Better hardness, strength, wear or abrasion resistance, impact resistance etc. → Better thermal conductance or resistance or reflectance etc → Better optical reflectance → Better electrical conductance or insulation → Electroforming or reforming of particles → Manufacturing printed circuit boards, capacitors, contacts etc → Electrochemical machining, electropolishing and electrochemical etching.	6
4b	Explain the process of i) Galvanizing ii) Anodizing of Al Galvanizing It refers to hot dipping method of coating of zinc over iron and control of corrosion. Coated zinc metal sacrifice itself in protecting the object metal from corrosion. The method is employed for continuous metal sheets, wires, pipes etc.	

Q.No.	Solution and Scheme	Marks



Object metal surface needs preparation
→ oil, grease, wax etc 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 (mp = 419°C, maintained at 430-450°C)
→ An ammoniumchloride flux is used to avoid the oxidation of molten Zn.
→ Excessive Zn from the sheets drawn is removed and uniformity is achieved by passing it between two regulated hot rollers. Zn coated sheets are annealed to have firm bonding between the metals with better surface characteristics. And what comes out is galvanized steel.

Applications: Roofing sheets, fencing wires, pipes
Limitation: Can not be used for making food containers.

4c What is electroplating? Explain electroplating of chromium. Mention why chromium cannot be used as anode — 7

Electroplating:

The process of deposition of a thin and

Q.No.	Solution and Scheme	Marks

and uniform layer of metal or metal alloy on the electrically conducting object surface by electrolysis is known as electroplating.

Electroplating of chromium.

	Decorative coating	Engineering hard coating
Thickness	0.25 – 0.75 μm	2.5 – 300 μm
Hardness	–	835 – 925 VPN
Bath composition	250 g/L chromic acid + 2.5 g/L H_2SO_4 + 1 g/L Cr^{3+}	250 g/L chromic acid + 2.5 g/L H_2SO_4 + 1 g/L Cr^{3+}
Temp	35 – 45°C	50 – 65°C
Current density	145 – 430 A/ft^2	290 – 580 A/ft^2
Current efficiency	10 – 15%	17 – 21%
Anode material	Insoluble lead sb-alloy or Pb-Sn alloy	Insoluble Pb-Sb alloy or Pb-Sn alloy
Cathode material	Surface cleaned object metal	Surface cleaned object metal
Reaction at anode	$H_2O \longrightarrow \frac{1}{2}O_2\uparrow + 2H^+ + 2e^-$	$H_2O \longrightarrow \frac{1}{2}O_2\uparrow + 2H^+ + 2e^-$
Reaction at cathode	$Cr^{3+} + 3e^- \longrightarrow Cr$	$Cr^{3+} + 3e^- \longrightarrow Cr$

Active chromium anode is not used because; the anode efficiency is nearly 100% and that of the cathode is only around 20% at the best. There will be more in concentration of Cr^{3+} ions which result in poor quality electrodeposition

Q.No.	Solution and Scheme	Marks
5a.	Illustrate about the number average and weight average molecular weight.	6

Number average Molecular Weight $\bar{M}_n$

It is the mass obtained when total mass of all the molecules of a sample is divided by the total number of molecules.

Ex: In a particular sample

N_1 molecules have molecular mass M_1 each

N_2 molecules have molecular mass M_2 each

N_3 molecules have molecular mass M_3 each

and so on

Then we have ——

Total mass of all the N_1 molecules $= N_1M_1$

Total mass of all the N_2 molecules $= N_2M_2$

Total mass of all the N_3 molecules $= N_3M_3$.

& so on

Therefore, total mass of all the molecules

$= N_1M_1 + N_2M_2 + N_3M_3 \cdots\cdots = \Sigma N_iM_i$

Total number of all molecules

$= N_1 + N_2 + N_3 + \cdots\cdots = \Sigma N_i$

Hence the number average molecular mass is given by ——

$$\bar{M}_n = \frac{N_1M_1 + N_2M_2 + N_3M_3 + \cdots\cdots}{N_1 + N_2 + N_3 + \cdots\cdots}$$

$$\bar{M}_n = \frac{\Sigma N_iM_i}{\Sigma N_i}$$

M_n is usually determined by osmotic pressure method.

Weight average molecular weight

Mass or Weight average molecular mass is the mass obtained when sum

Q.No.	Solution and Scheme	Marks

of the products of total mass of groups of molecules (having different molecular masses) and their respective molecular masses is divided by total weight of all molecules.

Ex: In a particular sample,
N_1 molecules have molecular mass M_1 each
N_2 molecules have molecular mass M_2 each
N_3 molecules have molecular mass M_3 each
and so on
Then we have
Total mass of all the N_1 molecules $= N_1M_1$
Total mass of all the N_2 molecules $= N_2M_2$
Total mass of all the N_3 molecules $= N_3M_3$ &
so on

The products of total mass of different groups of molecules with their respective molecular masses will be $(N_1M_1 \times M_1)$, $(N_2M_2 \times M_2)$, $(N_3M_3 \times M_3)$ etc.
That is —
$N_1M_1^2$; $N_2M_2^2$, $N_3M_3^2$ etc

Sum of products $= N_1M_1^2 + N_2M_2^2 + N_3M_3^2 \text{----}$

$= \Sigma N_i(M_i)^2$

Total mass of all the molecules
$= N_1M_1 + N_2M_2 + N_3M_3 + \text{------}$
$= \Sigma N_iM_i$

Hence, mass or weight average molecular mass is given by —

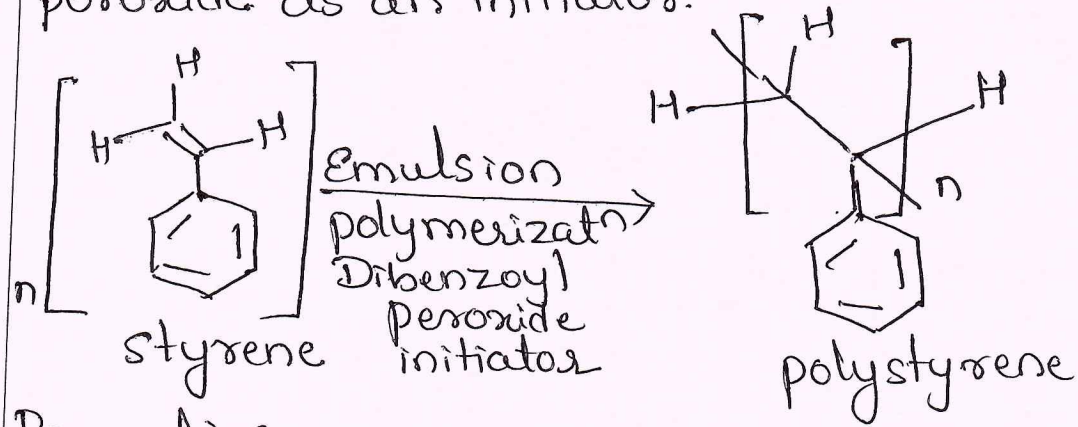
$$\overline{M}_w = \frac{N_1M_1^2 + N_2M_2^2 + N_3M_3^2 + \text{------}}{N_1M_1 + N_2M_2 + N_3M_3 + \text{-------}}$$

$$\overline{M}_w = \frac{\Sigma N_i(M_i)^2}{\Sigma N_iM_i}$$

Q.No.	Solution and Scheme	Marks
5b	Organize the properties and applications of lubricants Properties of lubricants → Oiliness: It is the ability of lubricant to wet and adhere as a thin layer in between two moving parts. → A good lubricant must have adequate viscosity for particular service conditions → A good lubricant must have higher flashpoint. → Wide operation range of temperature with high boiling point & low freezing point. → High chemical resistance to oxidation & non corrosiveness. → Stability to decomposition at high temperature. → Free of wax and other undesirable impurities. Applications → Palm oil is used to lubricate scientific equipments → Lubricating oils are used to lubricate ordinary machine parts. → They are used to lubricate light machinery like clocks, sewing machine. → Vegetable oils are used for bearing & machinery operating at high speeds like racing cars. → Solid molybdenum sulphide is used as lubricant in space vehicles. → Poly alkylene glycol has high thermal, chemical & mechanical stability and it is used as an aircraft turbine lubricant.	7

Q.No.	Solution and Scheme	Marks
5c	Organize the synthesis, properties and applications of polystyrene.	7

Polystyrene (PS) is an aromatic polymer obtained from polymerization of the monomer styrene. It is synthesized by emulsion polymerization using dibenzoyl peroxide as an initiator.



styrene

polystyrene

Properties

It is a transparent polymer with high refractive index and looks very bright

→ It is an amorphous rigid polymer with glass transition temperature (T_g) of 100°C

→ It has moderate chemical resistance

→ It can be expanded to foam by blowing air

→ It is a very good electrical insulator and poor absorber of moisture.

Applications:

→ It is used in solid foam in cushions and for building insulation

→ It is used in medical single use and disposable applications like catheter trays, heart pump trays, syringe hubs

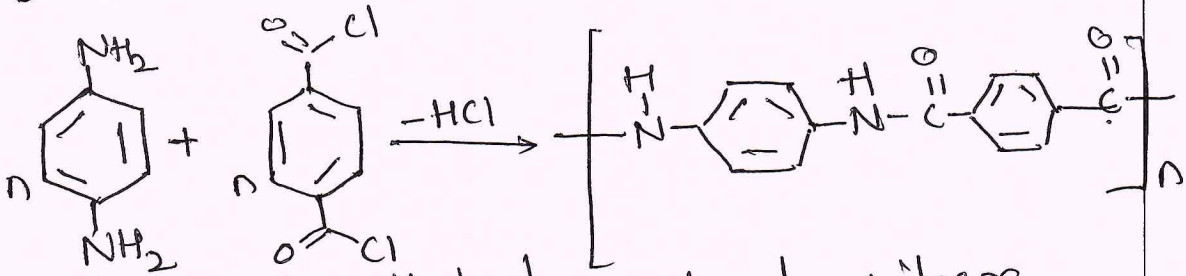
→ It is a food grade polymer and used as meat, egg, cake trays, dinnerware & fast-food packaging

→ It is used in audio and video CDs

Q.No.	Solution and Scheme	Marks
6a.	Organize the synthesis properties and applications of kevlar	6

Synthesis of Kevlar

It is an aromatic polyamide with the name poly (para-phenyleneterephthamide) It is prepared by condensation reaction of para-phenylenediamine & terephthalyl chloride.



Para-phenylene diamine

terepthaloyl chloride

Kevlar fiber

Kevlar is used as fiber in preparing polymer composite materials with epoxy resin as matrix.

Properties:

→ It has very low density and it is light weight
→ It has high strength & stiffness
→ It has very good abrasion & corrosion resistance

Applications:

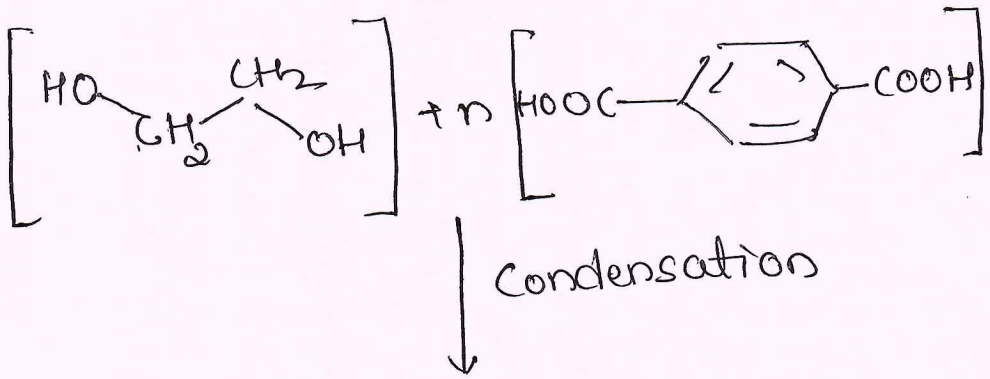
→ It is used in the light weight boat hulls, aircraft panels & race cars
→ It is used in bridge structures & bullet proof vests
→ It is used in puncture resistant bicycle tyres.

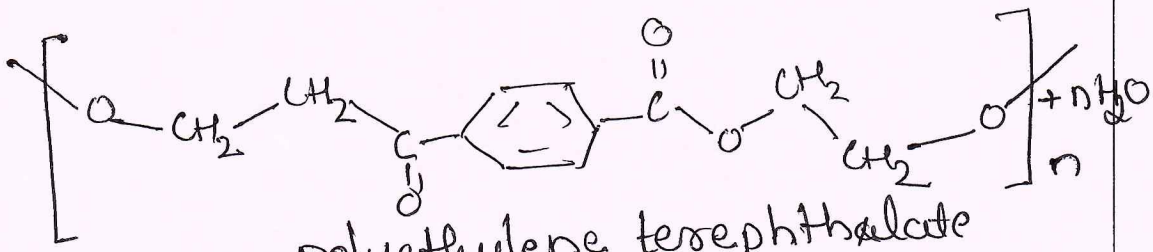
Q.No.	Solution and Scheme	Marks
6b	Illustrate the synthesis, properties and applications of polyester.	7

Classes of polymers in which two monomers are bonded together by ester group are called as polyesters. It is obtained by condensation of a diacid and dihydroxy alcohol. Ex:——

Synthesis of PET

Polyethylene terephthalate (PET) is the most commonly used polyester. It is an aromatic polyester. It is also known as Dacron or Terylene. Polyethylene terephthalate is obtained by condensation reaction of ethylene glycol with terephthalic acid.





polyethylene terephthalate

Properties

→ It is a strong and durable fiber
→ It has a very good resistance to streching & shrinking
→ Its glass transition temp (T_g) is 145°C
→ It has good chemical resistance.

Q.No.	Solution and Scheme	Marks

Applications

→ It is used in polyester clothing like shirts, pants, jackets, hats bedsheets, bed spreads, curtains, pillow and carpets

→ It is used in food packaging containers and PET bottles

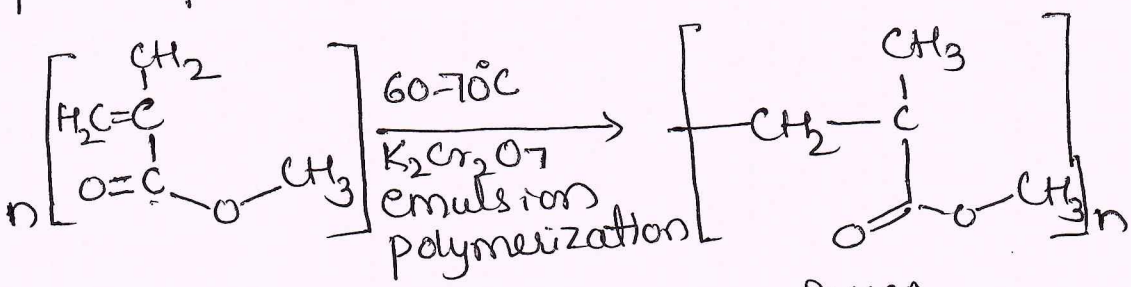
→ It is used as industrial fiber

→ It is used as liquid crystal displays.

6c. Organize the synthesis properties and applications of PMMA — 7

Synthesis of polymethyl methacrylate (PMMA)

It is obtained by emulsion polymerization of methylmethacrylate (MMA) at 60-70°C in the presence of potassium persulphate as an initiator



MMA PMMA

Properties

→ It is an amorphous and transparent plastic

→ It has good optical clarity (RI = 1.4), but poor scratch resistance

→ It is resistant to water, alkalies & inorganic salts but dissolves in organic solvents

→ It is resistant to acids & environmental deterioration

P.T.O

Q.No.	Solution and Scheme	Marks

Applications:

→ It is the manufacturing of automotive lenses, aircraft windows, light fixtures & signal boards.

→ It is used for making artificial teeth & contact windows, light fixtures & signal boards.

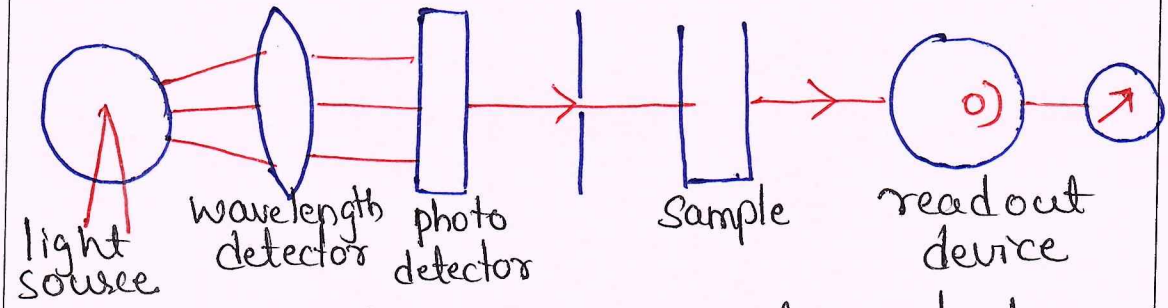
→ It is used for making artificial teeth & protecting coatings & plastic jewelry

→ It is also used as paint & adhesive.

7a Sketch and explain the optical sensor (colorimetry) and write its applications. 7

Optical sensors are electronic components designed to detect and convert incident rays of light into electrical signals.

Ex: colorimetric sensor



The basic components include a light source, a wavelength detector a photodetector and a readout device.

A monochromatic light is made to pass through analyte solution where certain quantity of light is absorbed and it is a function of concentration of analyte.

Q.No.	Solution and Scheme	Marks

The change in the intensity of light is detected by photodetector. The light source generates an intense & stable radiation signal need to probe an intense ~~& stable radiation~~ optical property of the molecular recognition element in the sensor. The amount of absorption is governed by Beer lambert's law

Applications:

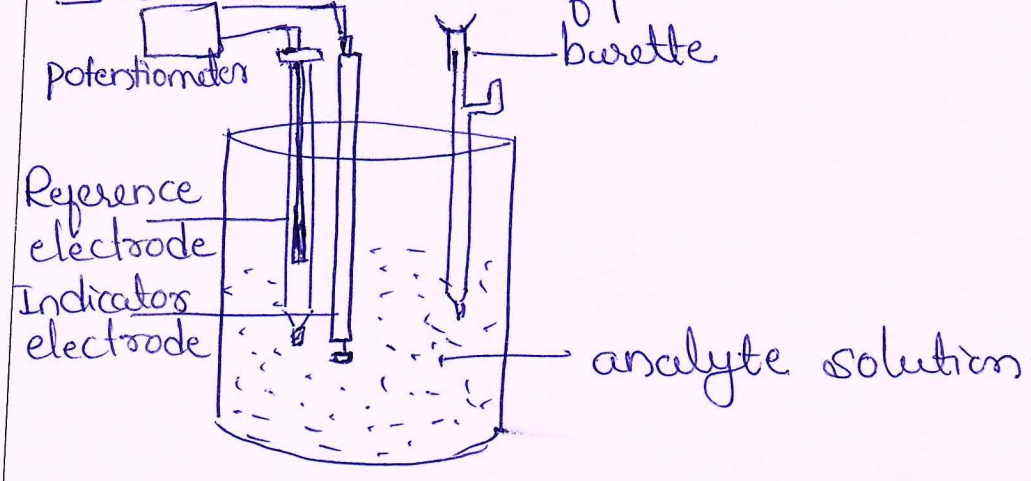
→ Used to determine the concentration of flouride, chloride, zinc, iron in water samples

→ Used to determine the nitrates phosphorous and ammonia in fertilizers and soil. Hb in blood samples etc.

→ Even at lower concentration accurate results are obtained.

7b - Organize the instrumentation of potentiometric sensor and its application in estimation of iron. 6

Instrumentation of potentiometric sensor



Q.No.	Solution and Scheme	Marks

The reference electrode used is saturated calomel electrode consists of Hg in Hg_2Cl_2 in contact with sat. KCl solution & Pt wire for electrical contact. The reduction potential of this electrode is a platinum electrode which responds rapidly to oxidation-reduction couples & senses the potential which depends upon the concentration ratio of reactants & products of redox titrations. Here the platinum electrode is in contact with Ferrous ferric couple.

Estimation of FAS using std $K_2Cr_2O_7$ soln

Reaction:

$$2FeSO_4 + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow Fe(SO_4)_3 + Cr_2(SO_4)_3 + K_2SO_4 + 7H_2O$$

Procedure:

→ 25 ml of given FAS soln is taken into clean beaker. 10mL of H_2SO_4 is added. Calomel and platinum electrodes connected to potentiometer are dipped into FAS soln in the beaker.

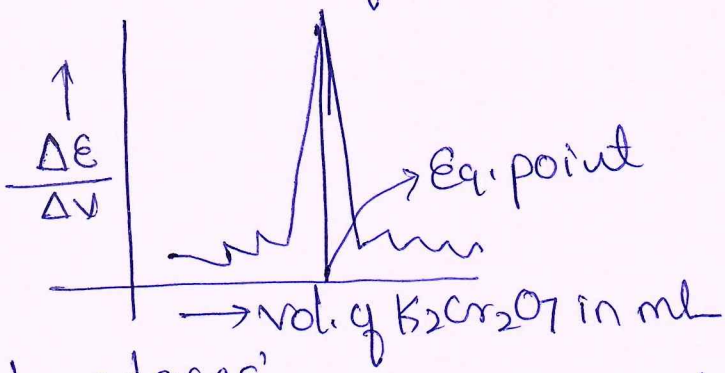
→ Pt electrode potential is a function of concentration of Fe^{2+} & Fe^{3+} ions before the reach of equivalence point.

→ After the equivalence point, it is function of concentration of Cr^{3+} & $Cr_2O_7^{2-}$ ions.

→ Cell potential is measured, while a soln of standard $K_2Cr_2O_7$ is added from a burette in increments of small volume.

Q.No.	Solution and Scheme	Marks

→ Cell potential increases steeply at the equivalence point and later, it remains almost constant. A differential graph of $\frac{\Delta E_{cell}}{\Delta V}$ against volume of dichromate is plotted. The peak gives the equivalence point. From the equivalence concentration and amount of FAS is calculated.



Advantages:
→ Can also be used for colored solutions
→ Turbid, fluorescent, or opaque solutions can also be analyzed.

7c Explain the concept of phase, components and degree of freedom, phase rule equation. 7

A phase diagram is a graphical representation of chemical equilibrium. Since equilibrium is dependent on the composition of system, pressure & temp, a phase diagram should able to tell us what phases are in equilibrium for any composition at any temperature & pressure of the system.

P.T.O

Q.No.	Solution and Scheme	Marks

Phase:

In a heterogeneous system, a number of phases are involved.

A phase is defined "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] A completely miscible homogeneous mixture of gases mixture of gases (O_2 & N_2) & liquids (H_2O & alcohol) gives phase ie. ($P = 1$) one.

b] Any pair of immiscible liquids (H_2O and kerosene) gives rise to two phases ie. $P = 2$

→ At a specified condition, all the three phases of H_2O co-exists ice water & vapour $P = 3$.

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 of chemical equations.

P.T.O

Q.No.	Solution and Scheme	Marks

Ex:

1) In water system, the composition of all the 3 phases can be defined in terms of only water. Therefore it is a one component system, C=1

2) Lead-silver are miscible in all proportions in the molten state & gives a homogeneous solution of two constituents. Therefore, it is a two component system, C=2.

Degrees of freedom or varience

The state of a system is equilibrium can be defined interms of thermodynamic variables like the pressure(P), temperature(T), composition(c) Therefore, 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

$H_2O(s)$ or $H_2O(l)$ or $H_2O(g)$

The state of any single phase in water system can be defined by specifying two variable like pressure & temperature

Q.No.	Solution and Scheme	Marks

In other words, any single phase of water system has two degrees of freedom.
Hence $F=2$ or f (P and T)

Phase Rule

In simple terms, the number of variables are the number of chemical components in the system plus the extensive variables, temperature & pressure.

The number of phases present will depend on the varience of degrees of freedom of system.

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

phase rule defined as follows —

For a heterogeneous system in equilibrium, the number of phases plus the number of degrees of freedom equal to number of components plus 2.

P.T.O

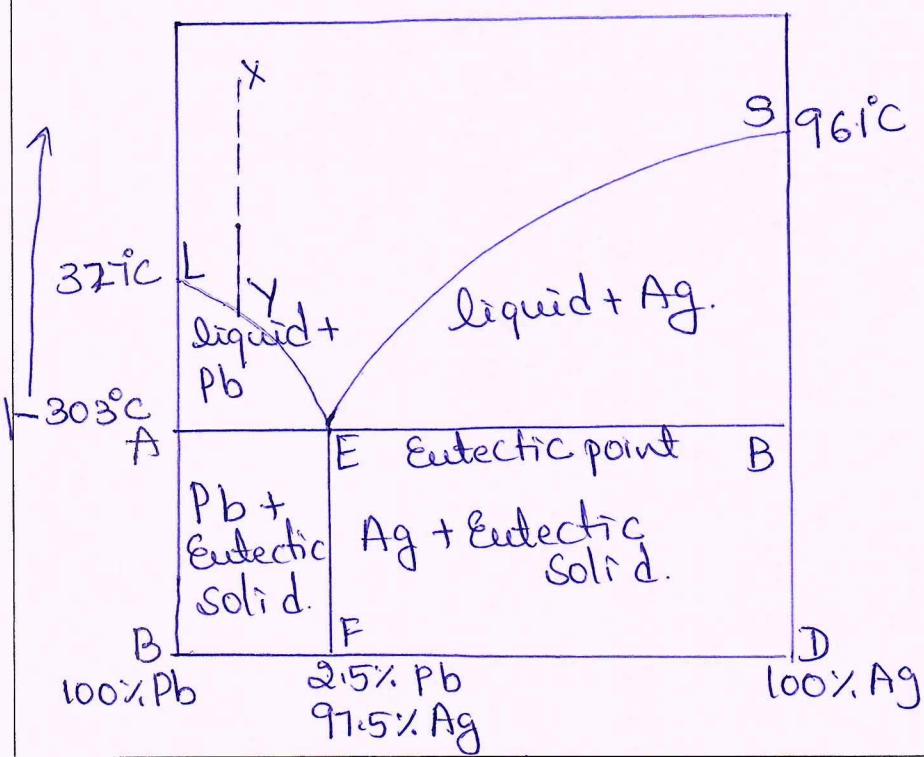
Q.No.	Solution and Scheme	Marks
8a.	Explain along with diagram lead silver two component system.	7

Lead-Silver system.

Number of components, C=2

The condensed phase rule, $F = C - P + 1$ becomes $F = 3 - P$ where, P is the number of phases.

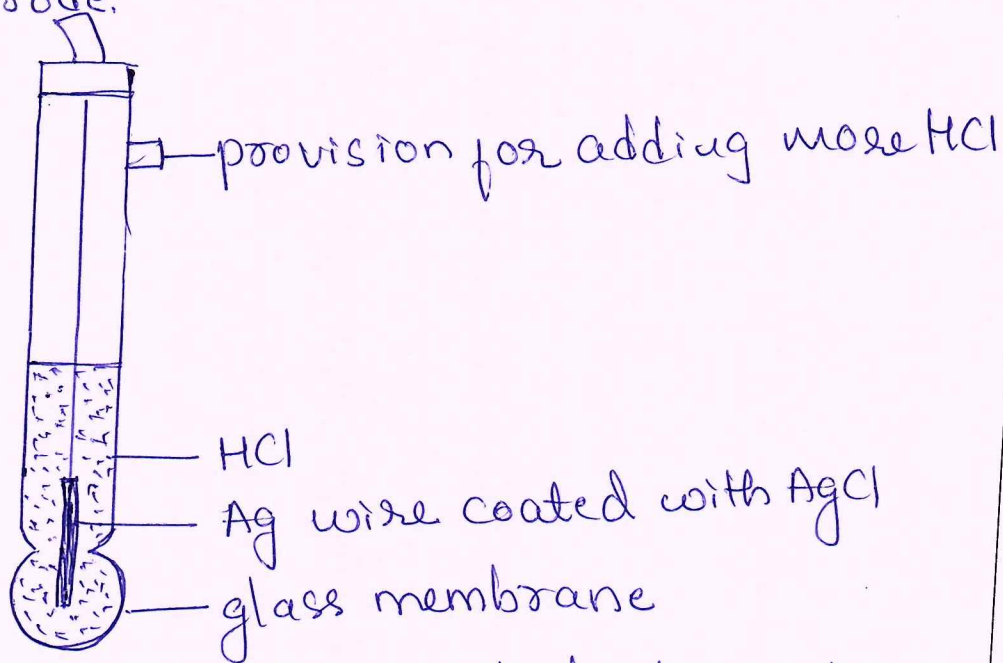
Parts of phase diagram	phases in equilibrium	P	Degrees of freedom $F = 3 - P$		variants.
Region above LES	Melt containing Pb & Ag	1	3-1=2	Bi variant	Temp & composition
Curve LE	solid Pb ⇌ liquid melt of Pb & Ag	2	3-2=1	Mono variant	Either temp or composition
Region LEA	Solid Pb ⇌ liquid melt of Pb & Ag	2	3-2=1	Mono variant	"
Curve SE	Solid Ag ⇌ liquid melt of Pb & Ag	2	3-2=1	Mono variant	"
Region SEB	Solid Ag ⇌ liquid melt of Pb & Ag	2	3-2=1	Mono variant	"
Point E Eutectic Point	Solid Ag ⇌ Solid Pb ⇌ liquid melt of Ag & Pb	3	3-3=0	In variant	Self defined temp = 303°C & composition = 2.5% Ag or 97.5% Pb



Q.No.	Solution and Scheme	Marks
8b	Explain the principle, instrumentation & working of pH sensor (Glass electrode)	7

Principle:

A membrane, selective to specific ion, used to separate the test solution from standard solution, develops two different potentials, one on each surface of membrane depending on the concentration of ionic species on either side. This forms the principle behind working of such electrode.



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

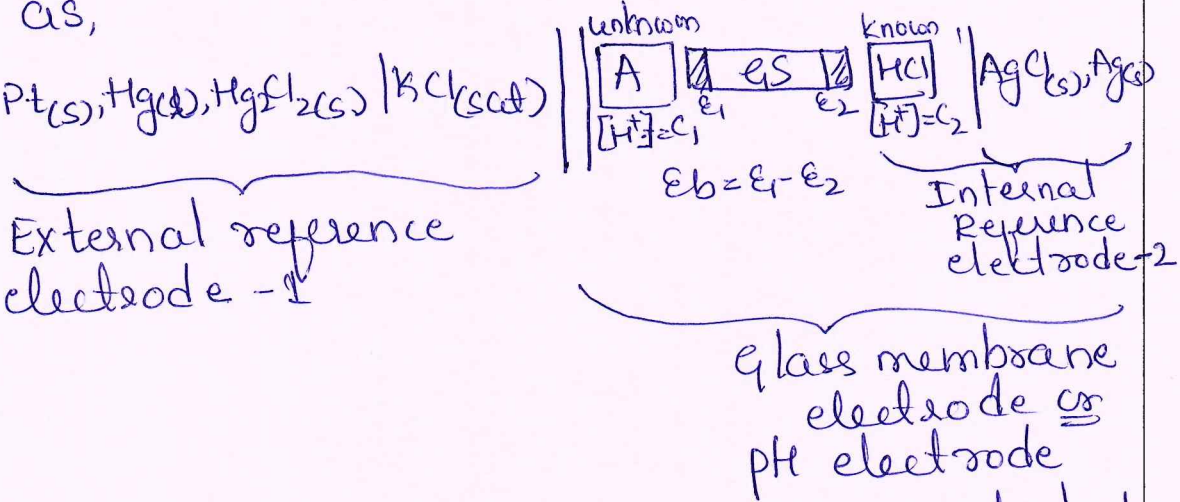
→ Composition of glass membrane is

6% CaO
22% Na_2O
72% SiO_2

Q.No.	Solution and Scheme	Marks

→ Glass electrode is coupled with calomel electrode or silver chloride electrode and immersed into analyte, forming a cell.
→ Cell potential measured will assist the determination of pH of test solution.

By convention, membrane electrode is made cathode. Systematically written as,



Very soon after immersion of electrode into analyte, an equilibrium is reached,

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

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

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

Let ε_1 and ε_2 are the potentials developped at the membrane surfaces on the external side (analyte side) and internal side respectively. From thermodynamic considerations potential developed across the membrane, boundary potential is given by

$$E_b = E_1 - E_2$$

Q.No.	Solution and Scheme	Marks

$$E_b = E_1 - E_2$$

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

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

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

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

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

Thus, boundary potential

$$E_b = L - 0.0591 pH$$

where, pH is referred to the pH of the test solution.

Glass membrane electrode potential is given by —

$$E_g = E_{Ref2} + E_b + E_{asy}$$

$$= E_{Ref2} + L - 0.0591 pH + E_{asy}$$

$$= E_{Ref2} + L + E_{asy} - 0.0591 pH$$

$$= E^\circ_g - 0.0591 pH$$

where, $E^\circ_g = E_{Ref2} - 0.0591 \log C_2 + E_{asH}$

= constant.

Cell potential is given by.

$$E_{cell} = \mathcal{E}_R - \mathcal{E}_L$$

$$= \mathcal{E}_g - \mathcal{E}_{Ref-1}$$

$$= \mathcal{E}^\circ_g - 0.0591 pH - \mathcal{E}_{Ref-1}$$

$$pH = \frac{E^\circ_g - \mathcal{E}_{Ref-1} - \mathcal{E}_{cell}}{0.0591}$$

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

k' is called glass electrode assembly constant.

Q.No.	Solution and Scheme	Marks
8C.	Organize the pH sensors applications in the determination of pH of beverages.	6

→ Acids may be present in foods and drinks naturally, developped during processes such as fermentation, or added during processing as a standard means of prevention. pH value below 4.6 limit the growth of microorganisms such as clostridium botullium, the causative agent of botulism.

Therefore, acidity testing is important throughout the entire food processing value chain.

pH measurement.

→ pH indicates a food or beverage's degree of acidity or alkalinity. A pH-meter measures this acid strength interms of the potential difference between a reference electrode (like calomel or Ag/AgCl) and pH electrode (glass electrode)

→ This difference is then related to the concentration of H^+ ions in the solution & corresponds to the acidity of the solution.

Q.No.	Solution and Scheme	Marks

→ Food and drinks display a broad range of pH values, which relate to the sample's acidity or alkalinity.

Measurement of the pH of a beverage using glass pH electrode

Commercially available beverages with a pH < 4.0 are acidic and can potentially damage teeth. The pH of commercial beverages range from 2.1 to 7.4. Carbonated beverages have pH 2.5 to 3.5.

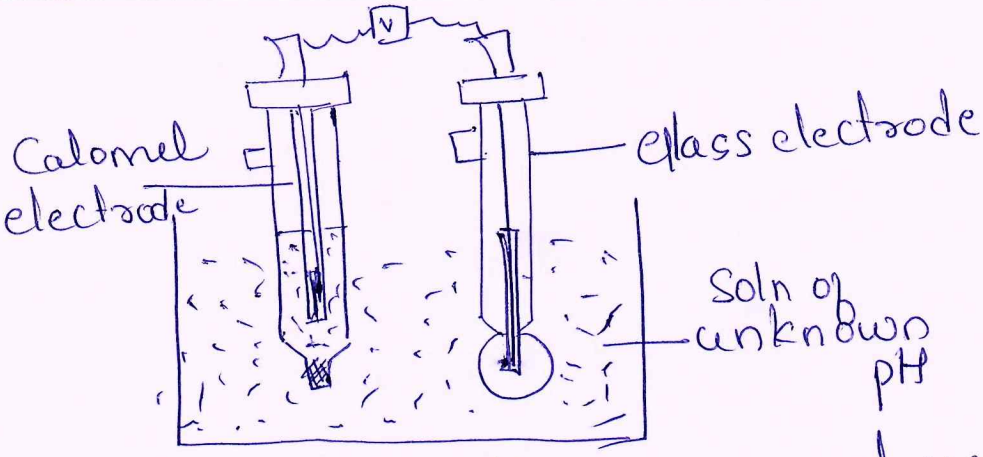
Acids give right flavor and aroma to the drink. Thus comprehensive pH assessment of beverages available for human consumption is required to assess their danger to health.

In order to measure pH of the beverage, a galvanic cell is conducted by combining glass electrode with saturated calomel electrode (SCE). The galvanic cell obtained is represented as —

$Hg(l), Hg_2Cl_2 | KCl | soln\ of\ unknown\ pH | Glass\ membrane | HCl | AgCl | Ag(s)$

Schematic representation of the cell is given below

Q.No.	Solution and Scheme	Marks



EMF of the cell is measured using highly sensitive electronic voltmeter, EMF of the cell is measured twice, first immersing cell assembly in a solution of unknown pH and second time immersing cell assembly in a buffer solution of known pH.

EMF of above cell is measured using highly sensitive electronic voltmeter. EMF of the cell is measured twice.

EMF of the above cell, Ecell when immersed in a soln of unknown pH i.e. pH(x) is

$$E_{cell_{(x)}} = E_R - E_L$$
$$= E_q - E_{SCE}$$
$$= L' - 0.0591\, pH_{(x)} - E_{SCE}$$

$$E_{cell_{(x)}} = K - 0.0591\, pH(x) \quad \text{——(1)}$$

The value of constant K can be determined by measuring EMF of the above galvanic cell immersed in std buffer soln of known pH

Q.No.	Solution and Scheme	Marks

EMF of the above cell, E_{cell}, when immersed in a buffer solution of known pH; ($pH_{(b)}$), is ——

$$E_{cell_{(b)}} = K - 0.0591\, pH_{(b)}$$

$$K = E_{cell_{(b)}} + 0.0591\, pH_{(b)}$$

Substituting the value of K in equn 1

$$E_{cell_{(u)}} = E_{cell(b)} + 0.0591\, pH_{(b)} - E_{cell(u)}$$

$$pH_{(u)} = pH_{(b)} + \frac{E_{cell(b)} - E_{cell(u)}}{0.0591} \text{ at } 298\,K$$

Thus pH of beverage soln can be determined by measuring EMF of the above galvanic cell immersed in buffer soln and then in soln of unknown pH.

9a. Explain the properties and applications of carbon nanotubes and graphenes. 6

Carbon nanotubes

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 is very useful ways.

→ They open an incredible range of applications in material science, electronics chemical processing.

Q.No.	Solution and Scheme	Marks

→ Extraordinary electrical conductivity heat conductivity, mechanical properties but exhibit low density.
→ They are probably best electron field-emitter 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.

Applications of carbon nanotubes
→ Field emitter / emission
→ Conductive or reinforced plastics
→ Molecular electronics. CNT based non volatile RAM
→ CNT based transistors
→ Energy storage
→ CNT based fibers and fabrics
→ CNT based ceramics
→ Biomedical applications

Properties of Graphene
→ Harder than diamond yet more elastic than rubber, tougher than steel yet lighter than aluminium. Graphene is the strongest known material
→ The unique arrangement of the carbon atoms in graphene allows its electrons to easily travel at extremely high velocity without the significant chance of scattering, saving precious energy typically lost in other conductors

Q.No.	Solution and Scheme	Marks

→ The impressive intrinsic mechanical propeties of graphene, its stiffness, strength and toughness are the reasons that make graphene standout both as an individual material and as a reinforcing agent in composites. They are caused by the stability of sp^2 bonds that form the hexagonal lattice and oppose a variety of in-plane deformations.

→ The breaking force obtained experimentally and from simulation was almost identical & the experimental value of second order elastic stiffness was equal to $340 \pm 50\ N m^{-1}$. This value corresponds to Young's modulus of 1.0 ± 0.1 Tpa, assuming an effective thickness of 0.335nm.

→ Defect free, monolayer graphene is considered to be the strongest material ever tested with strength of $42\ N m^{-1}$, which equates to an intrinsic strength of 130 GPa.

→ Toughness: Fracture toughness, which is a property very relevant to engineering applications, is one of the most important mechanical properties of graphene and was measured as a critical stress intensity factor of 4.0 ± 0.6 MPa.

Applications

P.T.O

Q.No.	Solution and Scheme	Marks

→ Energy storage and solar cells

Graphene electrodes may lead to a promising approach for making solar cells that are inexpensive, light weight and flexible and multifunctional graphene mats are promising substrates for catalytic systems.

→ Sensor applications

Functionalized graphene holds exceptional promise for biological and chemical sensors. Already, researchers have shown that distinctive 2D structure of graphene oxide combined with its superpermeability to water molecules, leads to sensing devices with an unprecedented speed.

→ Graphene has a unique combination of properties that is ideal for next generation electronics, including mechanical flexibility, high electrical conductivity & chemical stability.

→ Some of the most promising applications of graphene are in electronics detectors and thermal management.

→ Graphene's remarkable conductivity strength and elasticity has also made it a promising choice for strechable electronics. - a technology that aims to produce circuits on flexible plastic substrates for applications like bendable solar cells.

Q.No.	Solution and Scheme	Marks
9b	Define alloys. Explain the composition along with properties of AlNiCo. Alloy is homogeneous mixture of two or more metals, sometimes non metals also. Composition of AlNiCo AlNiCo is an alloy, consisting of Al, Ni & Co, Cu & sometimes Ti as the major costituents. Based on chemical composition & magnetic properties these are number of commercially available AlNiCo alloy like AlNiCo 3, AlNiCo 5, AlNiCo 8Hc etc. Properties :— → These are ferromagnetic. They can be magnetised to produce strong magnetic fields. After magnetization, they show strong resistance to demagnetization. This property is called as coervicity. → AlNiCo magnets produce strong magnetic field upto 1500 gauss. This is about 3000 times the strength of Earth's magnetic field. → AlNiCo magnets have highest curie temperatures of around 800°C. This is highest for any magnetic material. → AlNiCo are only magnets exhibiting	7

Q.No.	Solution and Scheme	Marks
	useful magnetism even when heated red hot. → AlNiCo magnets are most stable magnets and are electrically conductive, unlike ceramic magnets.	
10a	Explain the chemical composition, properties and applications of perovskites.	7
	Perovskites are the class of compounds with the general formula ABO_3, where A is a rare or alkaline earth metal & B is a first-row transition metal. Among Ti based perovskite type oxides, $CaTiO_3$ is a naturally occuring mineral and first discovered member of perovskite family. Properties: → $CaTiO_3$ is an n-type chemically stable semiconductor with a wide bandgap of 3-3.5 eV → It exhibits dielectric response in the microwave range & hence it is also known as microwave ceramics → Calcium titanate is kinetically stable in extreme conditions up to temp of 900°C & pressure of 5000 bar. → Perovskites have been used in biochemical applications due to low	

Q.No.	Solution and Scheme	Marks

Young's modulus & high elastic limit.

Applications:

→ $CaTiO_3$ is used in radio frequency and microwave circuits as frequency filters, capacity, inductors and antennas for communications.

→ Also in radar and global positioning systems operating at microwave frequencies.

→ $CaTiO_3$ can react with rare earth metals at temp between 700°C & 1000°C forming stable rare earth titanate solid solutions. Thus $CaTiO_3$ can be used for safe disposal of radioactive wastes.

→ $CaTiO_3$ based materials are used as catalysts for partial oxidation of light hydrocarbons

→ As a photocatalysts in degrading the organic dyes waste in the aqueous environment. & water splitting for H_2 production, CO_2 reduction.

→ $CaTiO_3$ increases the adherence of hydroxyapatite which is basis for bones or teeth to Ti prostheses

Hence it is developed as an important material in composites with hydroxy apatite for biomedical applications.

Q.No.	Solution and Scheme	Marks
10a	Explain the synthesis of nanomaterials by sol-gel method.	7

Sol-gel processes

Sol-gel processes principle is conversion of precursor solution into gel via hydrolysis and condensation reactions.

Sol-gel processes allow to synthesis of nanomaterials of high purity.

This process involve 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.

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

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

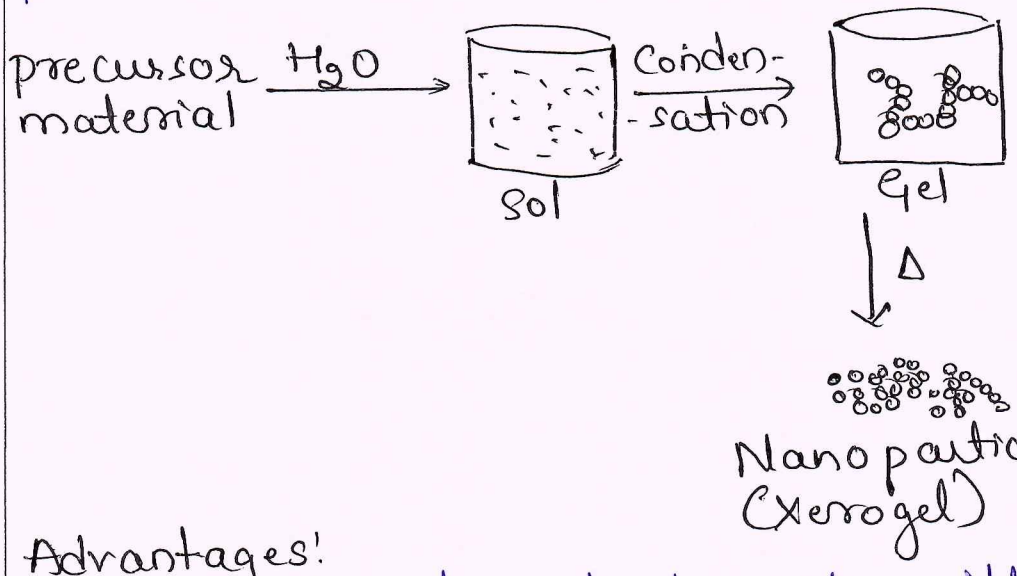
4] Removal of solvent:

Further the solid mass is isolated from the solvent by thermal evaporation. The product formed is Xerogel

Q.No.	Solution and Scheme	Marks

5] Heat treatment:

Solid mass obtained is dried at nearly to 800°C to get fine nano particle powder.



Advantages:

→ Nanomaterials of high purity with good homogeneity can be obtained.

→ Samples can be prepared at low temperatures.

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

10b Explain size dependant properties of nanomaterials with respect to surface area, catalytic and thermal. 6

Size dependent properties of nanomaterials

1] Surface area.

Surface area of the nano materials increases vastly. Therefore properties like catalytic activity, chemical reactivity & gas absorption increases.

Q.No.	Solution and Scheme	Marks

Ex:

When TiO_2 nanoparticles are doped with metals like Ag, Au, Pt are used as very good photocatalytic materials to absorb the pollutants.

Bulk gold is catalytically inactive gold nanoparticles are catalytically active

→ Thermal properties

In case of bulk materials, thermal conductivity is due to transportation of heat carriers called as phonons and is independent on size of materials.

However in case of nanostructured materials thermal properties are size dependent. This is because the characteristic length scales associated with the heat carriers, phonons are comparable to characteristic length of nanostructures.

And also due to the high surface to volume ratio, scattering of phonons plays a more important role in thermal conductivity of nanostructured materials than it does in bulk materials.

Decrease in size increases the surface energy, decreases the melting point. This is because surface atoms require less energy to move

Q.No.	Solution and Scheme	Marks
	because they are in contact with less number of atoms of the substances. Ex: Silicon nanowire processes less thermal conductivity than bulk silicon.	
	→ Catalytic properties The catalytic properties of materials depend on particle size. If the size of 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 nanoparticles, Although bulk nanoparticles are practically inert, nanowire sized particles have been proven to be active for several reactions including low temperature oxidation of Co, partial oxidation of hydrocarbons, the water gas shift reaction.	
10c	Define Alloys. Explain the composition along with properties of Brass Alloy is homogeneous mixture of two or more metals sometimes non metal also.	7

P.T.O

Q.No.	Solution and Scheme	Marks

Chemical composition of brass

It is an alloy of Cu & Zn.

→ Commercial brass or Guilding metal or French gold.

% composition: Cu-90%, Zn-10%

→ Low brass or Dutch metal

% composition: Cu-80%, Zn-20%

→ Cartridge brass: Cu-70%, Zn-30%

→ Admiraly brass (Tobin bronze)

% composition: Cu=59-62%,
Zn = 0.5 to 1.2%

→ German silver

% composition: Cu=25-50%
Zn = 10-35%
Sn = 5-35%

Properties & applications.

→ Commercial brass is golden in color harder & stronger than pure Cu.

It is used in jewellery, costumes, hardwares, rivets, screws etc

→ Low brass is golden in color, good formability & ductility

It is used in cheap jewellery, name plates, musical instruments battery caps etc

→ Admiraly brass has high abrasion & corrosion resistance.

It is used in propellers & marine works.

→ Cartridge brass is harder & stronger than Cu. It is ductile

Q.No.	Solution and Scheme	Marks

in the annealed state and can be cold deformed by pressing drawing & extrusion.

It is used in cartridge cases, fabrication of sheets and household articles, condenser tubes.

→ German silver.

It looks like silver with excellent ductility & malleability. It possesses good strength & corrosion resistance to salt water

It is used in ornaments, coinage, decorative articles utensils, table wares, cutlery & corrosion resistance implements.

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