CBCS SCHEME

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BCHEM102/202

First/Second Semester B.E./B.Tech. Degree Examination, June/July 2024
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. M : Marks , L: Bloom's level , C: Course outcomes.
3. VTU Formula Hand Book is permitted.

		Module – 1	M	L	C
Q.1	a.	Define Calorific value. Explain about the determination of Calorific value of fuel using Bomb calorimeter.	7	L2	CO1
	b.	Calculate GCV and NCV of a fuel from the following data : Mass of fuel = 0.75g , W = 350g , t = 3.02°C , Mass of water = 1150 and % H_2 = 2.8.	7	L3	CO1
	c.	Explain the construction and working of Lithium in Battery along with its applications.	6	L2	CO1
		OR			
Q.2	a.	Explain the production of Hydrogen by Electrolysis method and mention its advantages.	6	L2	CO1
	b.	Explain Construction , Working of Photovoltaic cell along with its advantages.	7	L2	CO1
	c.	What are the principles of Green Chemistry? What is Power Alcohol? Explain in brief.	7	L2	CO1
		Module – 2			
Q.3	a.	Explain the Electrochemical theory of corrosion in detail taking Iron as an example.	7	L2	CO2
	b.	Explain i) Differential Metal corrosion. ii) Differential Aeration corrosion.	6	L3	CO2
	c.	Describe Galvanizing and mention its application.	7	L2	CO2
		OR			
Q.4	a.	What is Sacrificial Anodic Protection? Explain.	6	L2	CO2
	b.	What is Metal Finishing? Mention any five of its Technological importance.	7	L2	CO2
	c.	Distinguish between Electro plating and Electro less plating. Explain Electro plating of Chromium (Decorative).	7	L3	CO2
		Module – 3			
Q.5	a.	What are Polymers? Explain the different methods of Polymerization.	7	L3	CO3

	b.	Explain the synthesis of CPVC and mention its applications (CPVC – Chlorinated Polyvinyl Chloride).	6	L2	CO3
	c.	Explain the synthesis , properties and industrial application of Kevlar Fiber.	7	L2	CO3
		OR			
Q.6	a.	Explain the synthesis of Polysterene and mention its applications.	7	L2	CO3
	b.	Describe the properties and applications of Lubricants.	6	L2	CO3
	c.	What are Composites? Explain the properties and application of Carbon – based Reinforced composites (Graphene / Carbon nanotube).	7	L2	CO3
		Module – 4			
Q.7	a.	Define Phase , Components and Degree of Freedom and Phase rule equation.	6	L2	CO4
	b.	Explain the Principle , Instrumentation and Application of Colorimetry.	7	L2	CO4
	c.	Explain the Principle , Instrumentation and Working of Glass Electrode.	7	L2	CO4
		OR			
Q.8	a.	Explain along with diagram Lead – Silver Two Components system.	7	L2	CO4
	b.	Explain the Principle , Instrumentation and Application of Potentiometry sensor.	7	L2	CO4
	c.	Explain the process of estimation of Copper in Industrial water by using Optical sensor.	6	L2	CO4
		Module – 5			
Q.9	a.	What are Alloys? Explain the composition along with properties of AlNiCo.	6	L3	CO5
	b.	Explain the synthesis of Nanomaterials by Sol – Gel method.	7	L2	CO5
	c.	Explain the Chemical composition , Properties and Application of Pervoskites.	7	L2	CO5
		OR			
Q.10	a.	Explain the composites along with properties of Brass and Stainless steel.	6	L3	CO5
	b.	Explain the size dependent properties of Nano materials and with respect to Catalytic , Thermal and Surface area.	7	L2	CO5
	c.	Explain the properties of application of Carbon Nano tunes and Graphene.	7	L2	CO5

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Applied Chemistry For NE Steam

First / Second Semester BE Examination

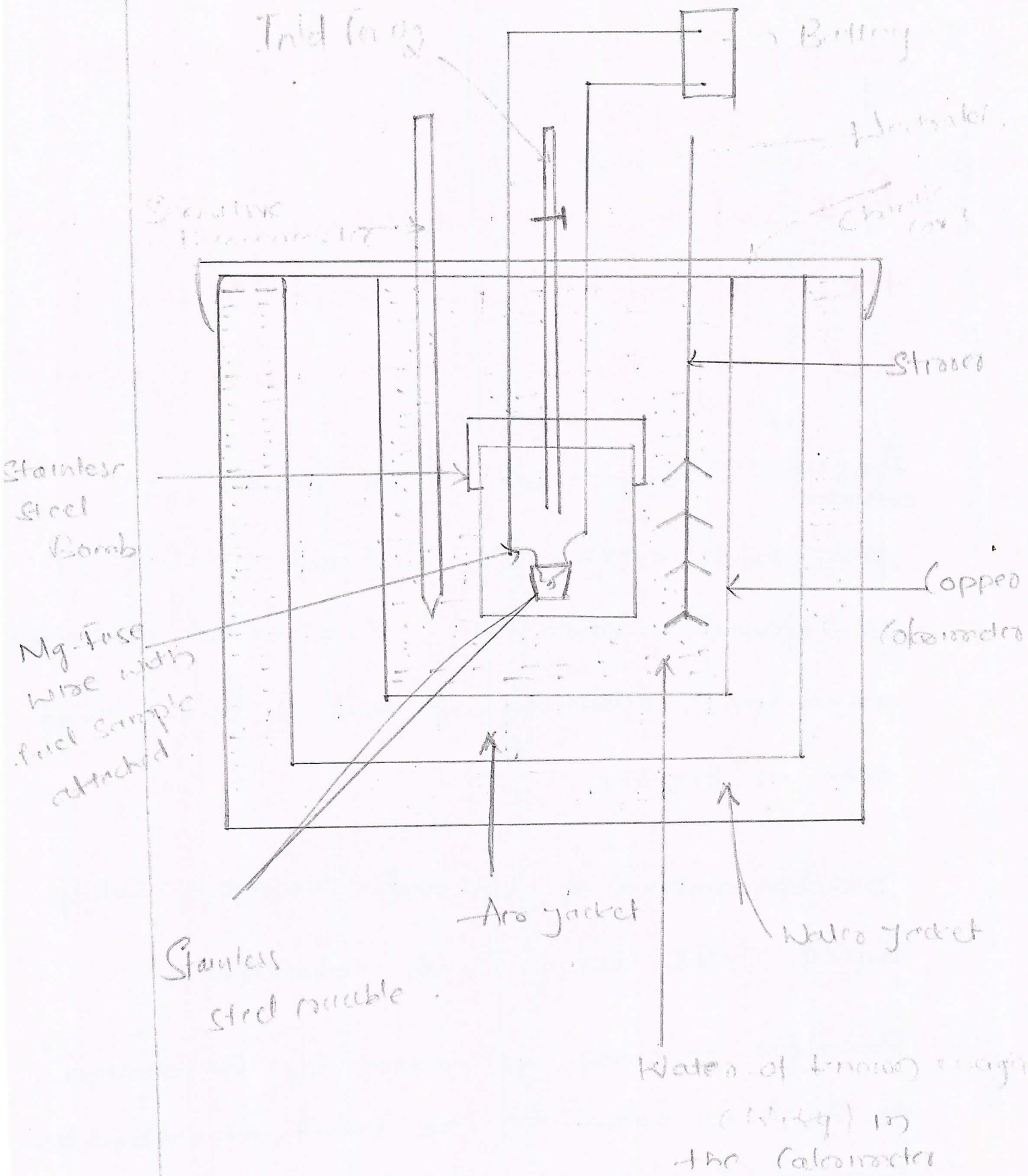
June / July -2024.

Q.1 a Define Calorific Value. Explain about the determination of Calorific Value of fuel using Bomb Calorimeter. (07 Marks)

Ans:- Energy released by Fuels is measured interms of Calorific Value. It is defined amount of heat energy released when unit quantity of fuel is burnt completely in oxygen.

Determination of Calorific Value of Solid/ liquid fuels using Bomb Calorimeter

Principle:- Heat generator by Combustion of fuel is equal to the heat absorbed by Surrounding water and Calorimeter.



The calorimeter consists of a stainless steel bomb in which known mass (=m kg) of the fuel is taken, excess of oxygen is filled

The Calorimeter consists of stainless steel Bomb in which known mass (=m kg) of the fuel is taken, excess of oxygen is filled (to 25 atm) pressure and immersed in known mass of water (W kg) contained in the copper calorimeter.

Fuel is ignited by passage of electricity through a fuse wire (such as magnesium) tied to the fuel (or immersed in liquid fuel contained in a crucible).

Heat liberated by fuel combustion is absorbed by the surrounding water with Mass = W kg and Copper Calorimeter (with water equavalent = W_2 kg). Temperature of water (Kept agitated using a stirrer) before combustion = (T_1 K) and Maximum temperature it attains fuel combustion = T_2 K in the Calorimeter, help in the Calculation of GCV and NCV. Temperature are measured by use of Sensitive Backmanns thermometer.

Heat generated by burning 1 m kg of fuel
= Heat gained by (Surrounding water + Calorimeter)

$$m \times GCV = (W_1 + W_2)(T_2 - T_1)(S)$$

Where GCV is gross calorific Value of the fuel and Specific heat of water S = 4.187 KJ/kg/K

$$GCV = \frac{(W_1 + W_2)(T_2 T_1) S}{m}$$

$$= \frac{(W_1 + W_2)(\Delta T)(S)}{m}$$

And Net Calorific Value

$$NCV = GCV - 0.09 \times H \times d_r \quad KJ/kg$$

5) Calculate GCV and NCV of a fuel from the following data

Mass of a Fuel = 0.75 g

W_1 = 350 g t = 3.02°C Mass of water = 1150 and % H_2 = 2.8.

Ans: W_1 = 1150 g = 1150×10^{-3} kg = 1.150 kg

W_2 = 350 g = 350×10^{-3} kg = 0.350 kg

t = 3.02°C = 3.02K.

m = 0.75 g = 0.75×10^{-3} kg = 0.00075 kg

% H_2 = 2.8 S = 4.2 KJ/Kg/K. l_v = 587 × 4.2.

$$GCV = \frac{(W_1 + W_2) \times S \times \Delta T}{m}$$

$$= \frac{(1.150 + 0.350) \times 4.2 \times 5.02}{0.00075}$$

$$= \frac{19.026}{0.00075}$$

$$= 25368 \text{ KJ/kg}$$

$$NCV = GCV - 0.09 \times H \times l_v$$

$$= 25368 - 0.09 \times 2.8 \times 587 \times 4.2$$

$$= 25368 - 621.3$$

$$= 24746 \text{ KJ/kg}.$$

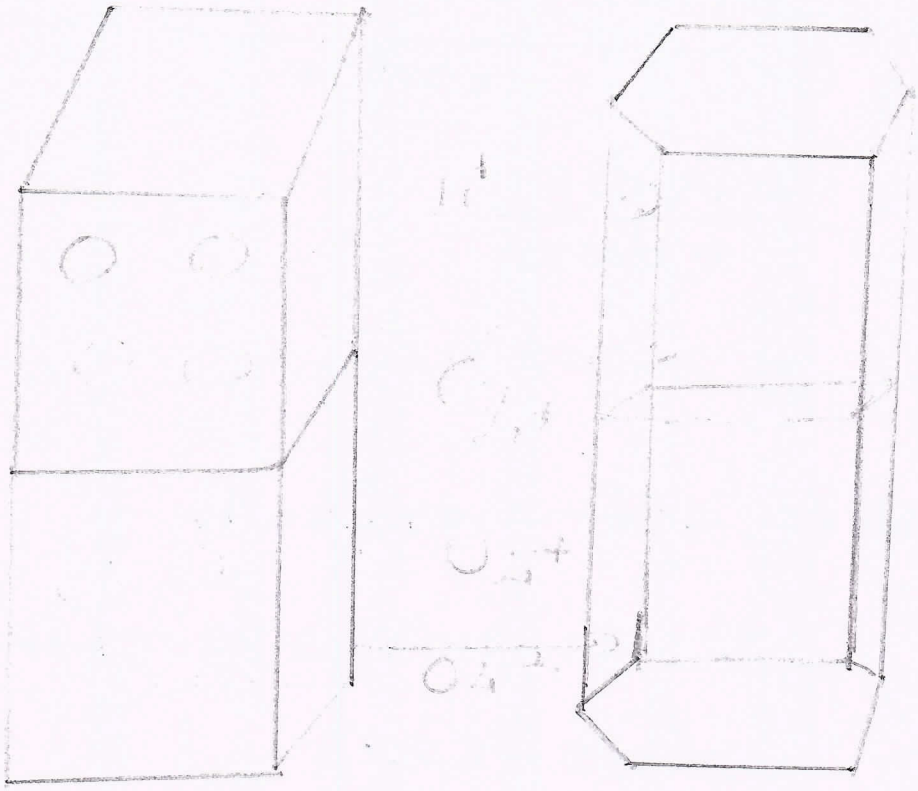
c) Explain the Construction and Working of Lithium in Battery along with its applications. (6 Marks)

Ans:- Li-ion Batteries are available with loading of $LiCoO_2$, $LiMnO_2$, $LiNiO_2$ etc as Cathodic Material

Construction

Li-ion cell when in charged condition is schematically represented as.

LiC_6 | Li Salt (in mixed organic Solvents) | $Li_{(1-x)}(Co^{+3})_{1-x}(Co^{+4})O_2$.



C_6 $LiCoO_2$

Before charging

After charging C_6Li_x $Li^{+}_{(1-x)}Co^{3+}_{1-x}Co^{4+}_{x}O_2$.

Anoding Material — highly crystallized Speciality Carbon

Cathodic Material — $LiCoO_2$

Electrolyte — $LiPF_6$, $LiBF_4$, $LiClO_4$

Seperator - Microporous poly propylene is used.

Charging Reaction

At Anode of electrolytic cell

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

Anode.

Cathode

$$C_6 + xLi^{+} + xe^{-} \rightleftharpoons C_6Li_x$$

Discharge Reaction

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 Reactions

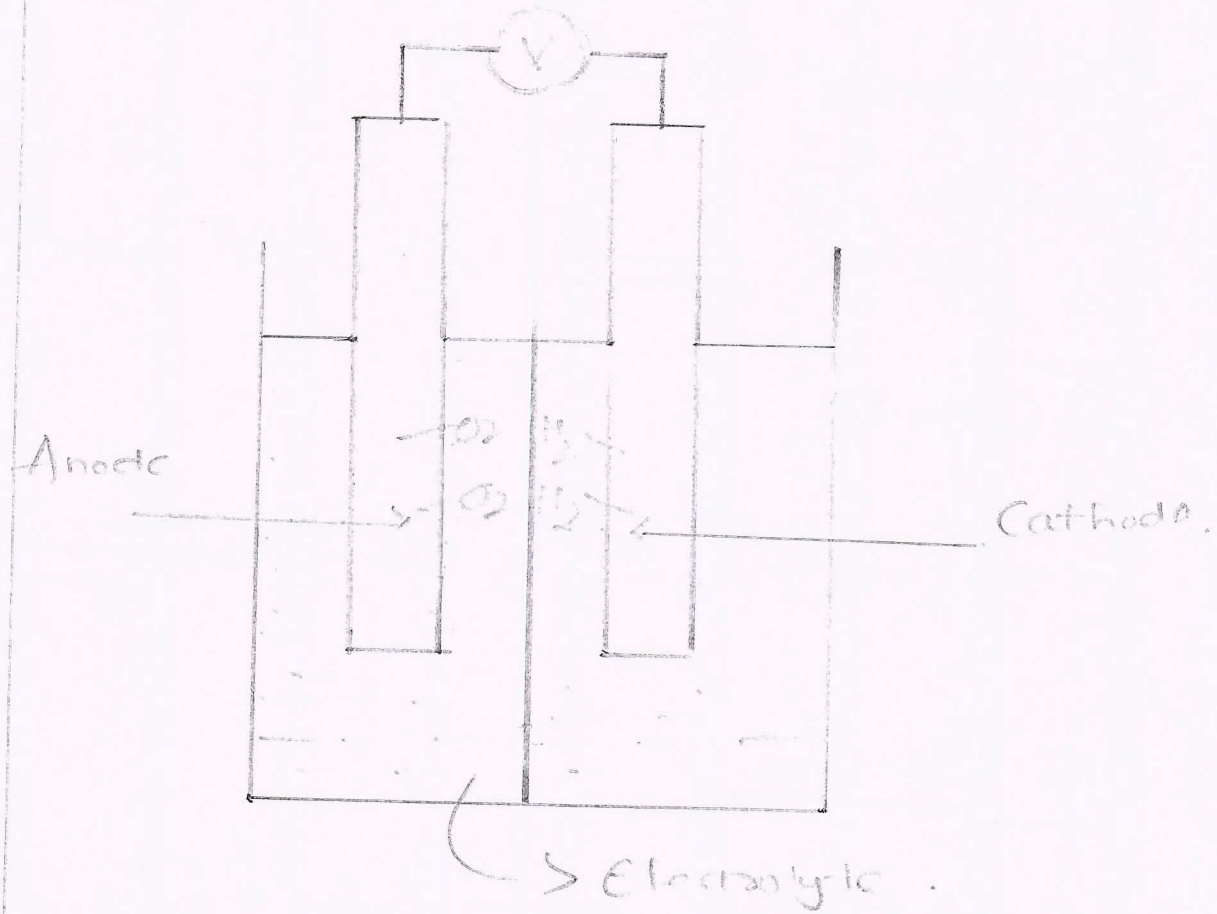
$$C_6 + LiCoO_2 \rightleftharpoons C_6Li_x + Li^{+}_{1-x}Co^{3+}_{1-x}Co^{4+}_{x}O_2$$

Applications

Used in Calculators, Cameras, Cellular phones, Medical Instruments, Communication Instrument portable radios, Laptop Computers.

Q_2

a Explain the production of hydrogen by Electrolysis Method and Mention its advantages (6 Marks).



It Consists of two electrodes ie anode and 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 Solution (25-35 %).

→ Both electrodes are seperated by porous diaphragm prevent gases crossover and allows only hydroxide ions.

→ Cell Voltage 1.3 - 2 V.

→ When electricity passed at anode hydroxide ions lose electrons and forms water Molecule.

Anode

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

At Cathode.

Water molecule accept electrons and liberate hydrogen gas. and forms hydroxide ions.

The hydroxide ions move from Cathode to anode through diaphragm and process continuous.

Cathode

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

Total Reaction

$$2H_2O \longrightarrow O_2 + 2H_2.$$

Q.) Explain Construction, Working of Photovoltaic cell along with its advantages. (07 marks).

Ans:-

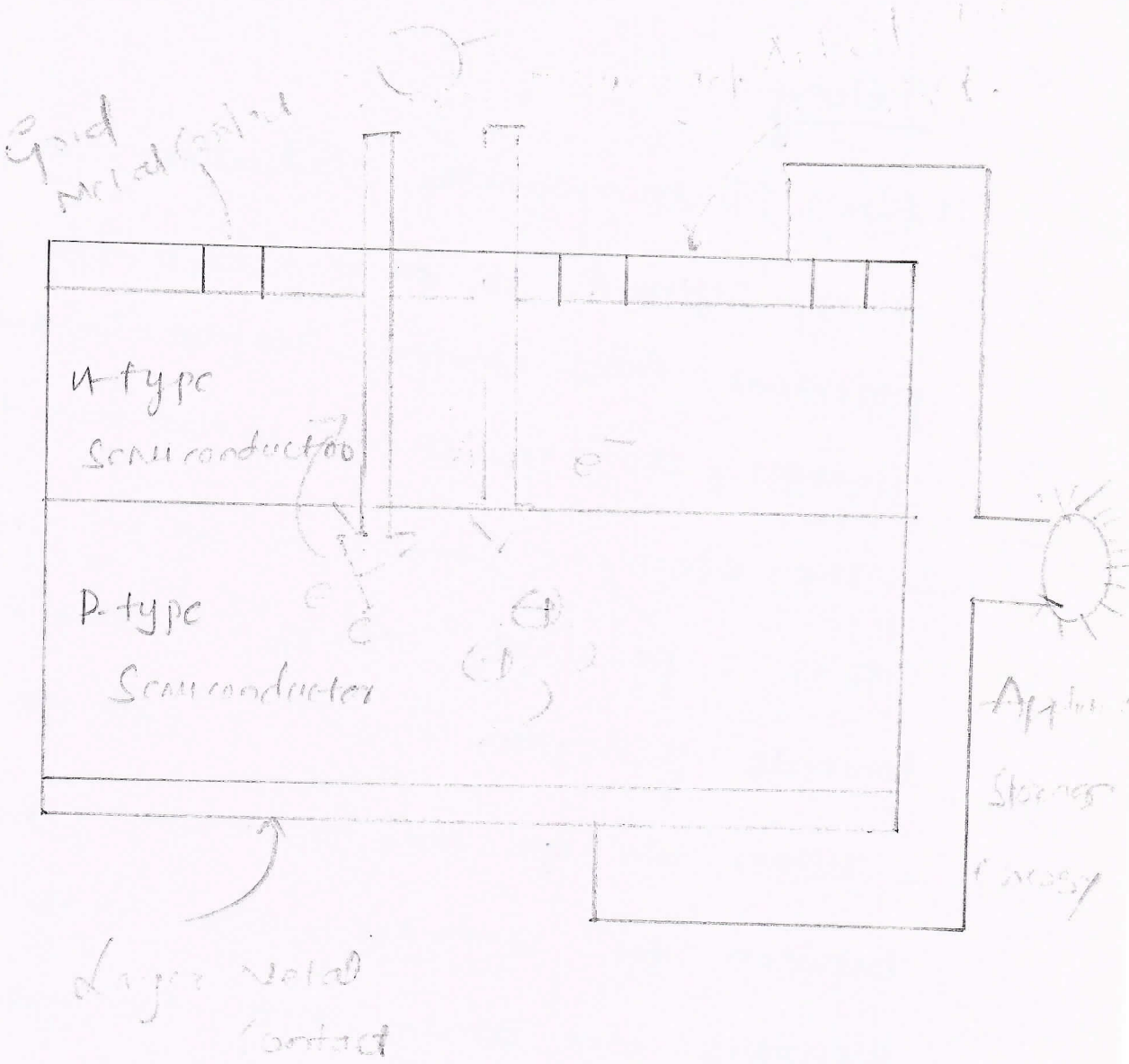
Construction

(1) Photovoltaic cell is made up of Semiconductor diode (p-n junction)

(2) The diode has two electrical contacts A grid metal contact C 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 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.



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

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 layer metal contact on the bottom side. layer metal used generally Silver.

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

Working :

1. When Electromagnetic radiation (Sunlight) having energy sufficient to ~~or~~ overcome the barrier potential falls normal to the surface of PN junction, electron-~~hole~~ hole pairs are formed.
2. The electrons move towards the n-region (as it is positively charged), and holes move towards p-region (as it is nagatively charged.
3. When an appliance or battery is connected between two contacts circuit 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 lighting, telecommunication etc.

Depending on the Energy requirement, PV cells are connected either a series (for increased voltage) or parallel (for increased current) and designed to make modules (with more PV cells) or panells (with more modules) or arrays (with more panels).

Applications

1. Domestic requirements for lighting, or running home appliances
2. Community services, Social, religious and cultural gathering, health centres. Setallite linking, agricultural Sector.

Q What are the principles of green chemistry what is power alcohol? Explain in brief. (7 marks).

Ans: (1) Prevention: Design chemical synthesis to prevent waste. Leave no waste to treat or clean up.

(2) Maximize Atom Economy.

Design Synthesis so that the final product contains

the maximum proportion of the starting Materials.

Atomic Economy is defined as the measure of the amount of reactants that end up directly into the desired product.

Power alcohol (or Gasohol)

A blend containing Containing 10 to 85%. of ethanol and 15-90%. of gasoline used as a motor fuel known as power alcohol.

Unless the ethanol employed is absolute alcohol. It does not mix with gasoline (Petrol) Commercial alcohol Containing up to 5%. water and 95%. ethanol is made into a uniform mixe with gasoline by using benzene and ether as bleaching reagent.

Advantages

(1) Increases octane Number (Octane Number of ethanol is 112) and reduces knocking

(2) Because of Increased octane Number higher CR with better power output is achieved

(3) Because of alcohol contains oxygen it is released as oxygenate which assist better combusting efficiency. Also VOC (volatile organic content). emission are reduced or pollution is lessened.

Disadvantages

(1) Lowers the Calorific Value of the Fuel

(2) Atomization is difficult because of higher Surface tension of alcohol

(3) Alcohol get oxidised to acids and may corrode the engine equipment

Q3c Explain the Electrochemical theory of corrosion in detail taking Iron as an example (07 Marks)

Ans:- Corrosion is an example of oxidation when a metal like Iron is exposed to atmosphere the following electrochemical change occur gradually.

Formation of Galvanic cells

Anodic and cathodic areas are formed resulting in a large number of minute galvanic cells.

Anodic Reactions

At an Anode metal undergoes oxidation with the release of electrons

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

Cathodic Reactions

At cathode area electrons are absorbed and cause reduction of constituents. The electrons flow from the anodic to cathodic area

~~Area~~. At the cathodic area chemical species present on the surface of the metal get reduced.

Liberation of hydrogen - It takes place in the absence of oxygen

In Acidic Medium

$$2H^+ + 2e^- \longrightarrow H_2\uparrow$$

Neutral/ Alkaline Medium

$$2H_2O \longrightarrow 2H^+ + 2O\bar{H}$$

$$2H^+ + 2e^- \longrightarrow H_2$$

$$2H_2O + 2e^- \longrightarrow 2O\bar{H} + H_2\uparrow$$

Absorption of oxygen

It takes place the presence of oxygen

Acidic Medium

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

Fe^{2+} ions are smaller in size they diffuse faster than $\bar{O}H$ ions and they combine near the cathodic area forming insoluble ferrous hydroxide a

$2Fe^{2+} + 4OH^- \longrightarrow 2Fe(OH)_2$

Ferrous hydroxide.

Ferrous hydroxide further combines with oxygen and water resulting hydrated ferric oxide.

$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 2[Fe_2O_3 \cdot 3H_2O]$

Hydrated Ferric oxide.

In the presence of limited oxygen ferric hydroxide is converted into magnetic oxide and it is known as black rust.

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

Magnetic oxide (Black Rust)

ii) Explain (1) Differential Metal Corrosion

(2) Differential Aeration Corrosion (Galvanic)

Differential aeration Corrosion

Corrosion arising out of difference in aeration of metal parts is called as differential aeration Corrosion. Part of the metal exposed to less oxygenated water acts as anode and undergoes corrosion. Part of the metal exposed to more oxygenated water acts as cathode and facilities reduction of oxygen to hydroxide. Driving force for the corrosion is the difference in oxygen concentration at two different metal parts.

Examples:

(I) Partially immersed metal in a aquous solution

(II) Water droplets over metal sheet.

(III) Dust or Rust or inert material deposit in metallic tanks.

(IV) Pitting Corrosion.

Ans:-

Galvanic Corrosion

Differential metal Corrosion

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

(1) Steel Vessel with brass tap.

Steel acts as anode and undergoes corrosion by oxidation

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

(2) Cathodic reduction reaction depends on the medium

$$2H^+ + 2e^- \longrightarrow H_2 \quad \text{(In Acidic medium)}$$

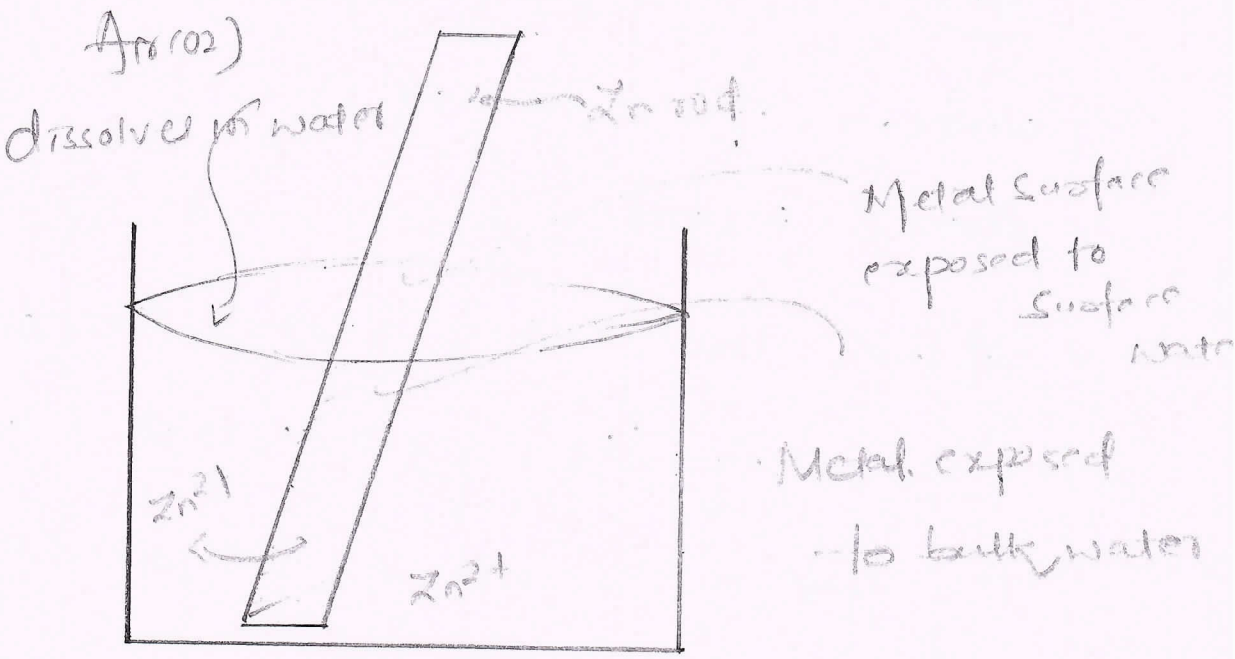
$$\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^- \quad \text{(Neutral or slightly alkaline medium)}$$

Some more example:

(1) Plumb lines at house steel pipe with brass taps. (steel is corroded)

(2) Brass hinges etc brass taps used for water storage

Suppose a zinc rod immersed partially in water.



Immersed position of zinc rod exposed to less aerated water acts as anode and undergoes corrosion.

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

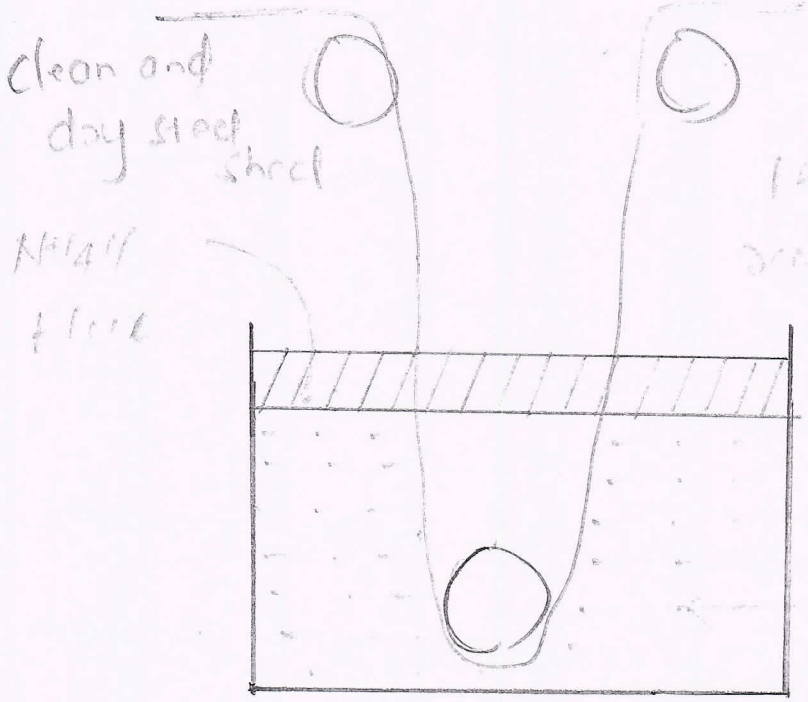
Metal exposed to more aerated surface water acts as cathode and oxygen undergoes reduction

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

Zn^{2+} ions and OH^- ions may react to form $Zn(OH)_2$ precipitate.

9.3c Describe Galvanizing and mention its applications (07marks)

Ans:- Galvanizing refers to hot dipping Method of Coating of zinc over iron anodic Metal coating and Control of Corrosion (of iron). Coated zinc metal sacrifies itself in protecting the object metal from Corrosion The Method is employed for corrosive metal sheets, wires pipes etc.



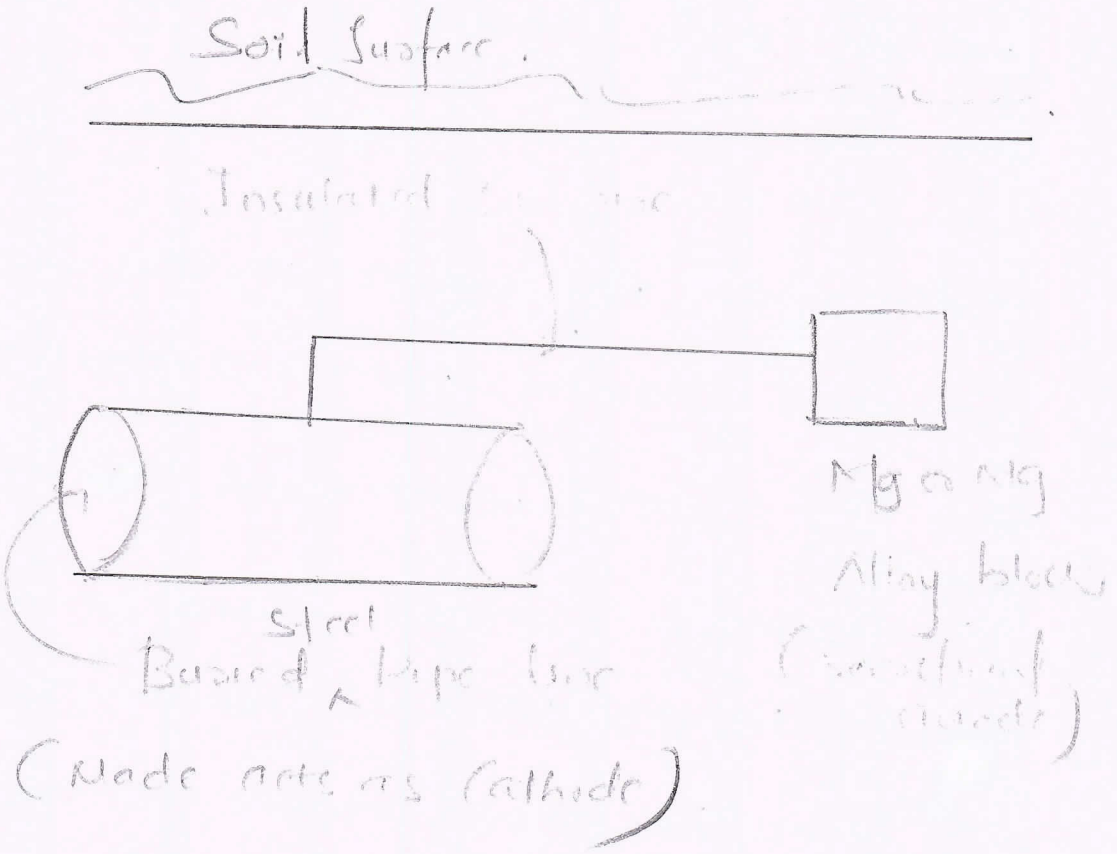
Object metal surface needs preparation Oil, grease, wax etc are removed by organic solvents. Then it is treated with hot dil H_2SO_4 (acid pickling) for removing the scales, washed with water and air dried

clean and dry metal sheets are then immersed into a bath containing molten Zn (mp = 419°C) maintained at 430 - 450°C. An ammonium chloride flux is used to avoid the oxidation of molten Zn. Excessive Zn from the sheets drawn is removed and uniformity achieved by passing it between two regulated hot rollers, Zn coated sheets are annealed to have from bonding between the metals with better surface characteristics. And what comes out is galvanized steel.

Applications: Roofing sheets, fencing wires pipes etc.

Q4a What is Sacrificial Anodic Protection Explain. (06 Marks)

Ans:-



Object metal (such as steel) is connected to a block of an anodic metal such as Zn, Al, Mg or there alloys.

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

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

Q4

b What is Metal Finishing? Mention any Five of its Technological Importance (07 Marks).

Ans:- Process of surface modification by way of deposition of another metal or alloy or polymer or ceramic or oxide layer to bring about intended surface characteristics is known as Metal Finishing.

Technological Importance

(1) Better Corrosion Resistance

(2) Better hardness, strength, wear or abrasion resistance, impact resistance

(3) Better thermal Conductance or resistance or reflectance etc.

(4) Better optical reflectance.

(5) Better electrical Conductance or insulation

c) Electroforming or reforming of articles

7) Manufacturing of printed circuit board.

Q4c Distinguish between Electro plating and Electroless plating. Explain Electroplating of Chromium (Decorative). (07 Marks)

Ans:-

Property	Electroplating	Electroless plating
1. Driving Force	Power Supply	Autocatalytic redox reaction
2. Site of Oxidation Reaction	Seperate anode	Object surface to be plated
3. Site of Reduction Reaction	Object surface to be plated	Surface activated Object
4. Oxidation Reaction	When anode is active $M \longrightarrow M^{n+} + ne^-$ When anode is inert $\frac{n}{2} H_2O \longrightarrow nH^+ + \frac{n}{2} O_2 + ne^-$	$R \longrightarrow O + ne^-$ R = Reducing Agent O = Oxidising Agent

5) Reduction Reaction	$M^{n+} + ne^- \rightarrow M$	$M^{n+} + ne^- \rightarrow M$
6) Time taken for deposition	Short	Long
7) Throwing Power	Low	High
8) Plating Cost	Low	High
9) Nature of deposit	Pure metal or definite alloy	Metal contaminated with R or O derived Species

Electroplating of ~~Chromium~~ Chromium

Chromium is employed for either decorative purpose (as a thinner coat) or Engineering purposes (as a thicker hard coat) ~~of Engineering~~

Mentioned below are coating Specifications.

Decorative thin Coating

Thickness — 0.25 – 0.75 μm

Bath Composition — 250 g/L Chromic acid
+ 2.5 g/L H_2SO_4 (in 100 : 1 ratio
+ 1 g/L Cr^{+3}

Temperature – 35 – 45°C

Current density – 145 – 430 A/ft2

156 – 463 mA/cm2

Current effiaency – 10 – 15 %.

Anodic Material – Insoluble lead Pb-Sb alloy or Pb-Sn alloy

Cathodic Material – Surface cleaned object metal

Reaction at Anode – $H_2O \longrightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$

Reaction at Cathode $Cr^{+3} + 3e \longrightarrow Cr$.

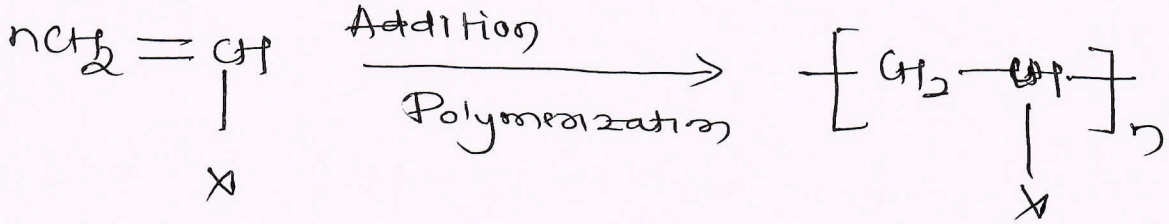
Q 5a What are Polymers? Explain the different Methods of polymerization. (07 marks).

Ans:-

Polymers are giant molecules or macromolecule formed by the Covalent union of several small chemical repeating units referred to as monomers.

Addition Polymerization

A polymerization reaction in which rapid self addition of several bifunctional monomers to each other takes place by chain reaction without the elimination of any by products is called addition or chain polymerization. The monomers containing double bonds (Vinyl Compounds) undergo addition polymerization



Vinyl monomer

Vinyl polymer

Condensation Polymerization

A polymerization reaction in which bifunctional or polyfunctional monomers undergo intermolecular condensation with continuous elimination of byproduct (H_2O, HCl, NH_3, CH_3OH, C_2H_5OH etc). is called condensation polymerisation. Since condensation reaction is rather slow and proceeds stepwise. It is often called step polymerisation.

(1) $n\ HOOC-(CH_2)_4-COOH + n\ H_2N-(CH_2)_6-NH_2$

Adipic Acid — Hexamethylene diamine

$$\longrightarrow HO\left[CO-(CH_2)_4-CO-NH-(CH_2)_6-NH\right]_n + (2n-1)\ H_2O$$

5b Explain the Synthesis of CPVC and mention it's applications (CPVC - Chlorinated polyvinyl chloride)

6 Marks

Synthesis

For the preparation of polyvinyl chloride

Poly vinyl chloride is prepared by addition polymerisation in which monomers are added in a chain.

Vinyl chloride is prepared by addition polymerisation in which monomers are added in a chain

Vinyl chloride is heated with peroxid under pressure and get poly vinyl chloride.

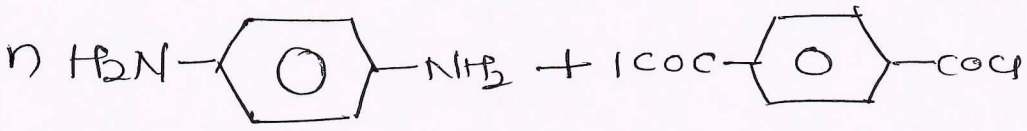
$$n[CH_2=CHCl] \xrightarrow[\text{Pressure}]{\text{Peroxid}} \left[CH_2-CHCl\right]_n$$

PVC is versatile material that offers many possible applications, these include window frames, drainage pipe, water service pipe, medical devices, blood storage bags, cable and wire insulation, resilient flooring, roofing membranes, stationary automotive interiors, seat coverings.

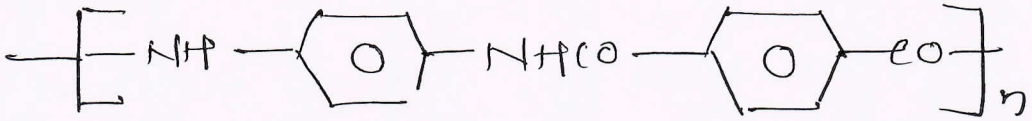
5c Explain the Synthesis, properties and Industrial applications of Kevlar Feber. (07 Marks)

Ans:- Synthesis

Condensation polymerization of 1,4 phenylene diamine (para phenylene diamine) and terephthaloyl chloride gives Kevlar. Hydrochloric acid is the by product of polymerization



1,4 phenylene diamine Terephthaloyl chloride



Applications:-

1) Used for light weight boat hulls, aircraft fuselage, race cars, pressure vessels.

2> Used as armour for making combat helmets, ballistic face masks

(3) Used for manufacture glove, sleeves, jackets etc.

(4) Used for motorcycling safety clothing

Properties

(1) It is polyamid like nylon

(2) Amide group link the aromatic ring

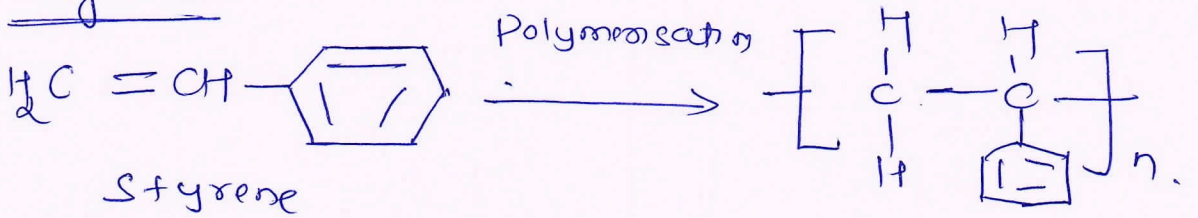
(3) It is an Aramid.

(4) Exhibits hydrogen bonding in lateral chains of polyamide which makes it relatively very strong fiber.

Q69 Explain the synthesis of polystyrene and mention it's applications (07 marks).

~~Sol~~ Ans :-

Stgrene



Poly vinyl styrene is produced by polymerization of vinyl benzene / styrene monomer.

Applications

(1) Due to its low cost and good mouldability it is extensively used to ~~mad~~ make molded articles. It is used to make household articles like toys, foamed plastics (thermocol) tea cups, pens, bottles, lid etc

(2) Styrene polymerized by cation polymerization is sulphonated and used in ion exchange resin

(3) Important co-polymer of styrene is Styrene acrylonitrile, acrylonitrile butadiene Styrene (ABS), high impact polystyrene containing 5-10% butadiene.

Q6

b Describe the Properties and applications of Lubricants. (6 marks)

Ans:- Properties of Lubricants

1> Cloud and Pour points :-

Cloud point - The temperature at which the impurities being to seperate from the solution and lubricating oil becomes cloudly or hazy in appearances is called cloud point.

2) Pour Point :-

The temperature at which the oil ceases to flow and pour is called pour point

3) Flash point :- The flash point of a Volatile material is the lowest temperature at which Vapours of the material will ignite given an ignition source.

4) Fire Point :- The fire point of a fuel is the lowest temperature at which the vapour of that

Fuel will continue to burn for at least 5 seconds after ignition by an open flame.

Viscosity

Viscosity is the property of a fluid that determines it's resistance to flow. It is an indicator to flow ability of Lubricating oil. The lower Viscosity greater the flow ability. If temperature increases Viscosity of Lubricating oil decreases.

Applications

Lubricants are typically used to separate moving parts in a system. The seperation has the benefit of reducing friction, wear and surface fatigue, together with reduced heat generation, operating noise and vibrations

Q6c What are Composites? Explain the properties and applications of Carbon-based Reinforced Composites (Graphene/Carbon nano tubes). (07 Marks)

Ans:- Harmonious Combination of two or more materials at least one of them being a polymer and another being a reinforcing material is refered to as polymer Composite.

Properties

(1) ~~Metals have~~ High Carbon Yeild

(2) Minimal Shrinkage during pyrolysis

(3) Amenable for all types of polymer composite manufacturing routes such as resin transfer molding, and filament winding

(4) low Solvent Content

(5) High degree of pre-polymerization with lowest Viscosity

(6) ✗ Availability from multiple Source.

Applications

(1) High performance braking System

(2) Refractory Material

(3) Hot - Pressed Dies (brakepads)

(4) Heating Elements

(5) Missile Nose - Tips

(6) Rocket - Motor Throats

(7) Heat shields.

(8) X-ray Targets.

Q1a Define Phase, Components and Degree of freedom and Phase rule equation. (6marks)

Ans:-

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 definate Surface

Component - It is the Smallest of independent Variable Constituents taking part in the state of equilibrium by means of which the composition of each phase can be expressed in the form of chemical equation.

Degree of freedom - It is defined as the smallest number of Independent Variables such as pressure temperature and concentration that must be Specified in order to define Completely the state of a System.

Phase Rule equation

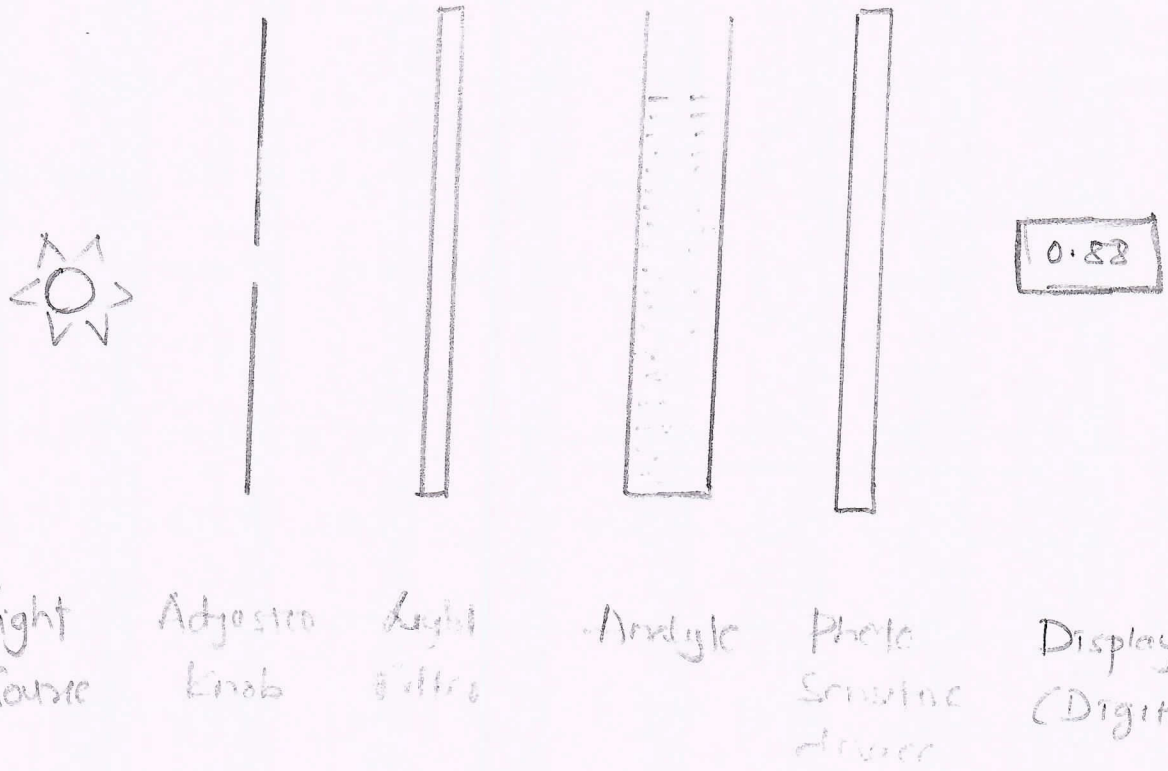
$$F = C - P + 2.$$

Q.7b Explain the Principle, Instrumentation and Application of Colorimetry (7 Marks)

Ans:- Principle:

Change in the colour, and colour intensity with changing sample or sample concentration and corrosponding quantitative change in absorbance of light is the principle behind colorimetric analysis.

Instrumentation



Light source - Tangsten lamp - Normally happens to be white light source

Light intensity adjuster - One can adjust the amount of light that passes through solution ~~the~~s.
Knob
Zero setting of the colorimeter is possible.

Light filter — White light is filtered to allow arange of wavelength or colour.

Slot for standard or test solution

Cuvette filled with the solution to be placed for absorbance of light.

Photosensitive device - To measure absorbance (OD) ~~/.~~ transmitance.

Applications

Colorimetric applications of Copper.

A Series of standard solutions of Cupro ammonium Complexes is prepared by ~~mixed~~ mixing cupric solution with excess of ammonia.

$$Cu^{2+} + 4NH_3 \longrightarrow Cu(NH_3)_4^{2+}$$

light blue — Deep blue.

from Beer Lambert's law

Absorbance $A = \epsilon ct$.

Procedure :

→ Known Volumes of (2, 4, 6, 8, 10 mL etc) of Stock Solution of Copper Sulphate (say of Strength 0.05M) are taken in Seperate 50mL Standard flasks.

→ 4mL of ammonia is added to each of these flasks and diluted upto the mark with distilled water, shaken well to get homogeneous solution.

→ Absorbance of each of the Standard Solutions and analyte is measured against blank (4 mL ammonia diluted with distilled water in 50mL standard flask) at 620nm using Colorimeter.

Q7c Explain the Principle, Instrumentation and Working of Glass Electrode. (07 marks).

Ans:- Construction of Glass electrode.

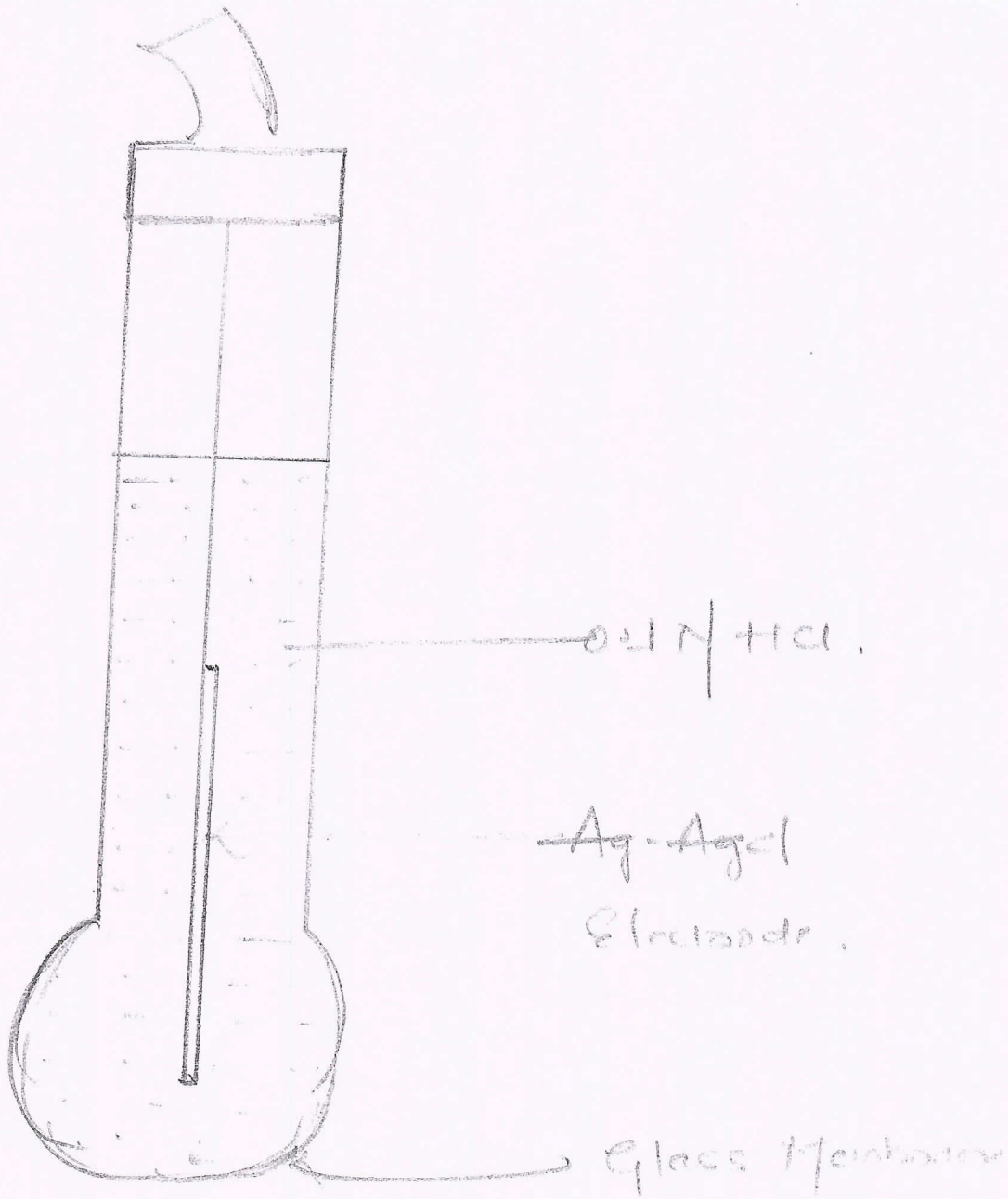
1) Glass electrode is constructed by immersing Ag-AgCl internal reference electrode in a glass bulb containing 0.1M HCl solution

2) The Glass bulb is made up of a long glass tube with a thin film highly Conducting glass membrane at the bottom.

3. The glass membrane is selective to H^+ Ions in the solution and is made up of Silicate glass having Composition of 72% of SiO_2, 22% of Na_2O, and 6% CaO.

The Electrode can be represented as

Ag | AgCl (0.1N) HCl | Glass Membrane.



Working of glass electrode.

When a glass bulb containing 0.1 M HCl is immersed in a acidic solution of different concentration, a boundary potential (ϵ_b) is developed across the gel layers of the glass Membrane

The boundary potential (Eb) arises due to the difference in concentration of H^+ ions inside and outside of the glass bulb.

$$Eb = 0.0591 \log \frac{C_2}{C_1}$$

C_1 - Concentration of H^+ ion inside the bulb is a Constant

C_2 - Concentration of H^+ outside the bulb

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

Substitute.

$$-0.0591 \log [a] = K \text{ a constant}$$

Then the equation becomes

$$\therefore Eb = K + 0.0591 \log C_2$$

$$= K + 0.0591 \log [H^+]$$

Substitute $\log [H^+] = -pH$

Final equation for Eb is obtained as

$$Eb = K - 0.0591\, pH$$

The potential of glass electrode [Eg] includes contributions from three factors.

→ Boundary potential [Eb]

→ Potential of Ag-AgCl reference electrode dipped inside the bulb $E_{Ag/AgCl}$.

→ Assymetric potential due to slight in homogeneity of the inner and outer surface of the glass membrane E_{asy}

$$E_g = E_b + E_{Ag/AgCl} + E_{asy}$$

$$E_g = K - 0.0591\,pH + E_{Ag/AgCl} + E_{asy}$$

$$E_g = \lambda - 0.0591\,pH$$

Where constant

$$\lambda = K + E_{Ag/AgCl} + E_{asy}$$

The cell formed is represented as.

Hg | Hg_2Cl_2 | KCl || solution of Unknown pH | Glass Electrode.

The Complete potential established at the glass ~~fecto~~ electrode is higher than that of the Calomel electrode hence glass electrode is taken as cathode

$$E_{cell} = E_{cathode} - E_{anode}$$

$$E_{cell} = E_q - E_{SCE}$$

Substituting for E_q

$$E_{cell} = (L - 0.0591 pH) - E_{SCE}$$

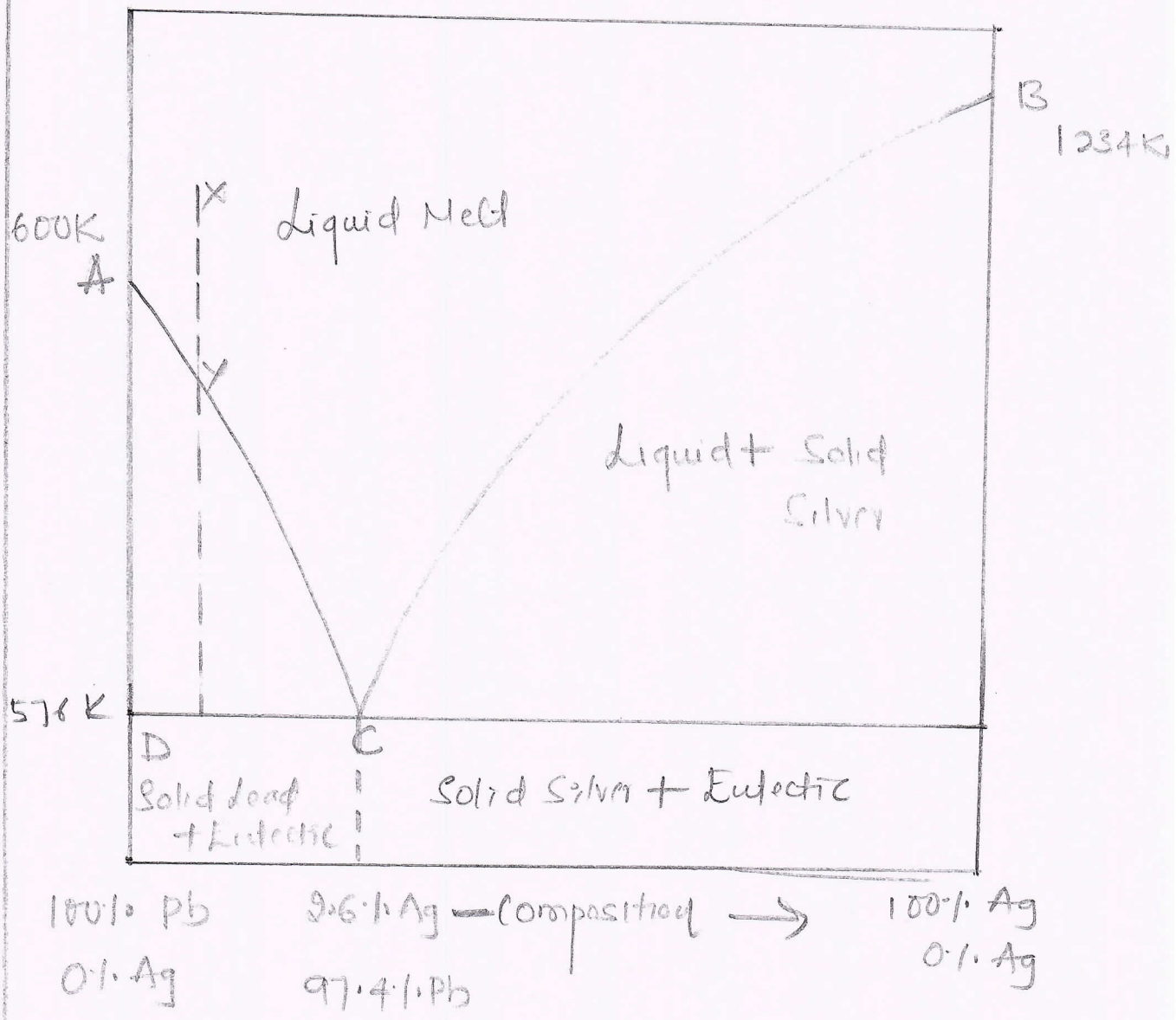
The above equation is arranged to obtained the expression for pH

$$pH = \frac{L - E_{SCE} - E_{cell}}{0.0591}$$

Q.a Explain along with diagram lead - Silver two Component System (7 Marks)

Ans:- It is two component system. the two metals are completely miscible in liquid state. and does not form any compound.

There is almost no effect of pressure on this system. The temperature composition (T-C) Phase diagram is shown below.



Lead - Silver Systems contains

1. Curve AC
2. Curve BC
3. Eutectic Point C.
4. Area

Curve Ac

The curve Ac is the freezing point curve of pure lead. The melting point of lead decreases gradually along the curve Ac. with the continuous addition of Silver. Thus the curve Ac is showing the effect of addition of Silver on the melting point of pure lead. All along the curve Ac two phases – solid lead and liquid are in equilibrium

Applaying the ~~Reducing~~ Reduced Phase rule eqn

$$F = C - P + 1$$

$$F = 2 - 2 + 1$$

$$F = 1$$

Thus, it is an univarient System.

Curve BC

Curve BC is the freezing point curve of pure Silver and represents the effect of addition of pure lead on the melting point of pure silver All along the curve BC two phases. – solid Silver and liquid are in equilibrium. Applaying the Reduced Phase rule equation

$F = C - P + 1$

OR $F = 2 - 2 + 1$

$F = 1$

$F = 1$

Thus, it is a univarient system

Point C

Point C is the Eutectic point where solid Silver, solid lead and their solution co-exist. The Curve AC and BC Meet at point C. since the experiment is carried out at constant pressure

$F = C - P + 1$

$F = 2 - 3 + 1$

$F = 0$

Thus, it is a non-varient or invarient System and the number of degree of freedom for the system at the eutectic pointe is zero.

Areas

The Area above the line AEB has a single Phase (molten Pb + Ag). Applaying the Rodueed Phase rule equation

$F = C - P + 1$

$F = 2 - 1 + 1$

$F = 2$.

Thus, the system is bivalent

Both the temperature and composition have to be specified to define the system completely.

The area below the line AC (solid Pb + liquid melt), below the line BC (solid Ag + liquid melt) and below the eutectic point 'C' have two phases and the system is univalent.

Applaying the Reduced Phase rule equation

$F = C - P + 1$

$F = 2 - 2 + 1$

$F = 1$

The system is univarient.

5) Explain the principle, Instrumentation and Application of Potentiometric Sensor (07 Marks)

Ans:- Potentiometric Sensor.

Theory:- The measured of emf (Electromotive force) to determine the concentration of ionic speced

in solution is referred to as potentiometry the relation between electrode potential and metal ion concentration is given by Nernst equation

$$E = E^{\circ} + \frac{0.0591}{n} \log \frac{Fe^{2+}}{Fe^{3+}}$$

1. Potentiometer consists of a reference electrode and indicator electrode and a device for measuring the potential

2. The Indicator electrode respond rapidly to the changes in the potential due to the concentration changes of the analyte.

3. A known volume of the analyte is taken in a beaker and its potential is determined by connecting the assembly to a potential

4. The titrant is added in increments of 0.5mL and the potential is measured each time.

5. The equavalent point there is a sharp increase in the potential against the Volume of titrant.

6) Redox titration is that of ferrous ammonium sulphate ($\Delta E/\Delta V$) against $K_2Cr_2O_7$ OR $KMnO_4$.

The oxidizing agent is useally taken in the burette.

Applications

(1) It is used in oxidation, reduction titrations to estimate the concentration of analyte in a sample solution

(2) The potential of the electrode depends on the concentration of the substance being oxidised or reduced.

8c Explain the process of estimation of Copper in Industrial water by using optical Sensor (6 marks)

Ans:-

Colorimetry is used in the estimation of Copper in Sample Solutions.

Cu^{2+} ions are treated with NH_3 to form a deep blue colored Cuproammonium complex ion.

1.) From a burette add 2, 4, 6 and 8 cm^3 of given Copper Sulphate Solution into four Seperate 50cm^3 in Volumetric flask.

2.) From another burette add 5cm^3 of ammonia to each one of them, to the Unknown Solution and blank Solution flask

3) To the entire Size flasks add water upto the mark. Mix well wait for 10 minutes.

4) In the Colorimeter set the wavelength of light to be 620nm

5) Using blank solution, set absorbance of colourimeter is zero

6) Record optical density values for all the solutions including test.

7) Plot a graph of absorbance against Volume of $CuSO_4$. Determine the volume of $CuSO_4$ is unknown Solution from the graph

Q) What are alloys? Explain the composition along with properties of AlNiCo (6 marks)

Ans:-

An Alloy is a material composed of a metallic base, usually the large majority component and additional metal or non-meta components that added as property modifiers.

Composition of AlNiCO

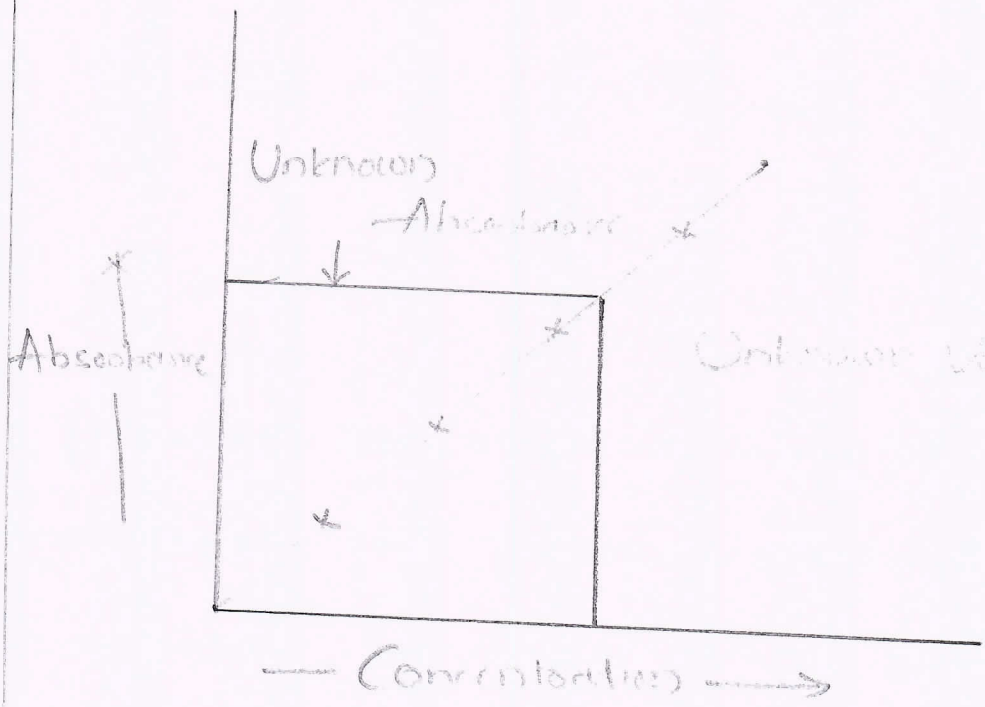
Alcano alloys is

Al - 8-12%. Ni:-15-26%. and Co-5-24%.

It is also contain upto 6%. Copper and 1%. of titanium.

Properties of alcano

(1) Strong Magnetic fields
(2) High Magnetic Flux density
(3) Excellent temperature stability
(4) High Coecivity
(5) Electrically conductive.



1) Monochromatic light of suitable wavelength can fall on the sample cell

I) First blank solution is taken in the sample cell and placed in the path of light beam

2) If absorbance is adjusted to zero

3) Then the analyte solution is placed in the path of light and it's absorbance is measured

4) A plot of absorbance V/s standard concentration of analyte it used to find the unknown concentration of analyte in the sample.

Q9

b Explain the Synthesis of Nanomaterials by sol-gel Method. (07 Marks)

Ans:- The sol-gel route offers a degree of control of Composition and Structure, at the Molecular level. The process involves the generation of a Colloidal Suspension (sol) which is Subsequently converted to Viscous gel and Solid Material.

The Different steps in sol-gel method are briefly outlined below,

1. Formation of different stable Solutions of the alkoxide or solvated metal salt precursor.

2. Genelation resulting from the formation of an oxide or alcohol bridged network by a polycondensation reaction which result in increased Viscosity of the Solution

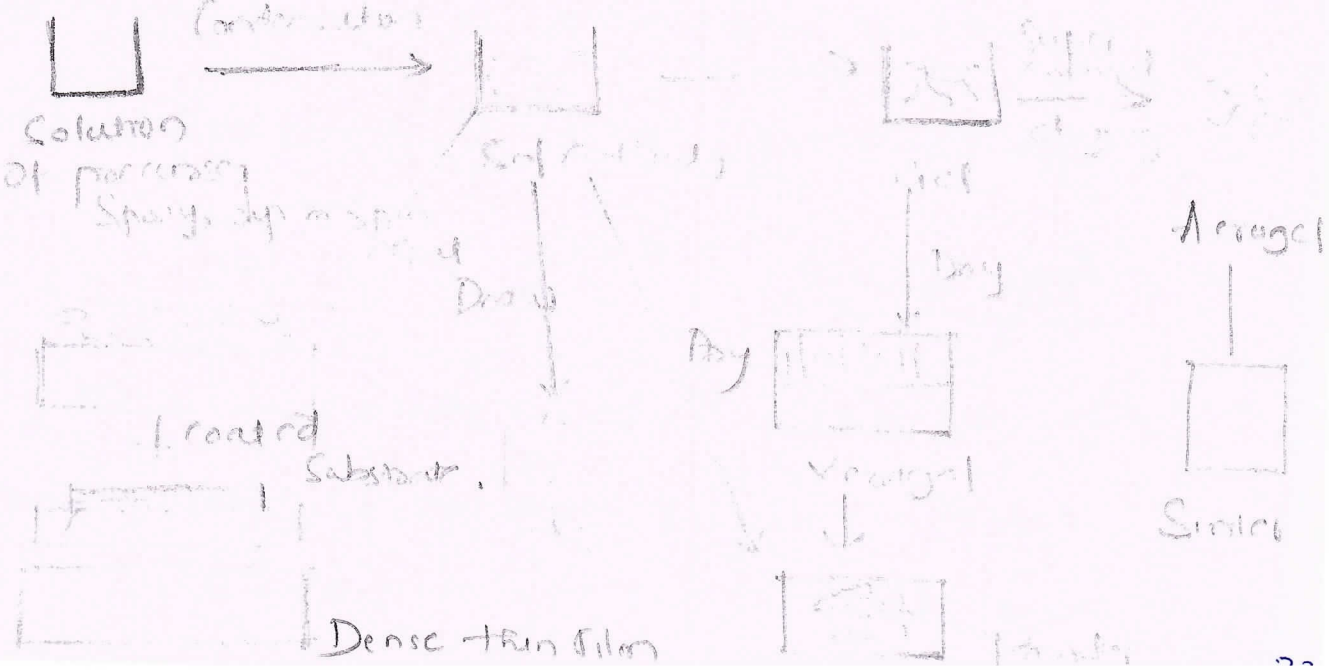
3. Aging of the gel (syneresis) during which the polycondensation reactions reactions continue until the gel transforms into a solid mass, accompanied by contraction of the gel network and expulsion of solvent from gel pores. Ostwald ripening (also referred to as coarsening) is the phenomenon by which smaller particles are consumed by larger particles during the growth process) Smaller particles are consumed by larger particles during the growth process). and phase transformations may occur concurrently with Syneresis. The Aging process ~~of gels~~ of gels is critical to the prevention of cracks in gels.

4. Drying of the gel, when water and other volatile liquids are removed from the gel network. The process is completed due to fundamental changes in the structure of the gel. If isolated by thermal evaporation, the resulting

monolith is termed a xerogel. If the solvent (such as water) is extracted under super critical or near super critical conditions the product is an aerogel.

5) Dehydration during which surface bound M-OH groups are removed, thereby stabilizing the gel against rehydration. This is normally achieved by calcining the monolith at temperatures upto ~~to~~ 800°C

6) Densification and decomposition of the gels at high temperatures (T > 800°C) The pores of the gel network are collapsed and remaining organic spaces are volatised.



Sqc Explain the Chemical Composition, Properties and Applications of Perovskites (7 Marks)

Ans:- $CaTiO_3$

Chemical Composition of ~~Perov~~ Perovskite.

Properties

→ The Unique physical properties of perovskite material such as

→ High ~~absorption~~ coefficient

→ Long-range ambipolar charge transport

→ Low-exciton-binding energy

→ High dielectric constant

→ Ferroelectric properties etc have gained a huge interest in these materials for optoelectronic and Photovoltaic applications.

Applications

(1) The first break through in methylammonium halide (MAX_3) ~~perov~~ perovskites occured with their use as light-absorbing materials in

the Photovoltaic device.

The high absorption coefficient long diffusion length, Superior charge-transport properties. low-non-radiative emissions and Solution processibility make them Suitable materials for photovoltaic applications.

Q10

(a) Explain the Composites along with properties of Brass and Stainless Steel (06marks).

Ans:-

Brass has a higher Composition of Copper and lower composition of Zinc

The Composition is 80% Copper, 20% Zinc (Zn)

(Ca)

Brass Property

(1) Brass often has a bright gold appearance, however it can also be reddish gold or silvery white. A higher percentage of Copper yeilds a rosy tone while more Zinc makes the alloy appear. Silver.

2) Brass has higher malleability than either bronze or Zinc

3) Brass is desirable acoustic properties appropriate for use in musical instruments

4) The metal exhibits low friction

5) Brass is soft metal that may be used in cases when a low chance of Sparking is necessary.

Stainless steel

Stainless steels are steel containing atleast 10.5% Chromium, less than 1.2% Carbon and other alloying elements.

Properties

→ Corrosion resistance
→ High tensile strength
→ Very durable
→ Temperature Resistant
→ Easy formability and fabrication
→ Low maintanance
→ Attractive Appearance
→ Environmentally friendly.

10 b Explain the size dependent properties of Nano materials and with respect to Catalytic Thermal and Surface area (07 marks).

Ans:-

1> Catalytic property

A catalyst is a substance which increases the chemical reaction rate without being consumed or chemically altered (however, may undergo physical alteration - like bulk solid may become powder at the end of reaction). The catalytic property of nano materials depends on their size. As the size decreases, the surface to volume ratio increases (as already depicted in the table above under Surface Area) and the active surface on the catalyst will also increase (reactivity and & catalytic activity of the material increases). Gold is inert in its bulk size, but it becomes reactive in the nanoscale and is used as catalyst in low temperature oxidation of carbon monoxide (CO).

Surface Area

When a bulk material is divided into smaller fragments, its total volume remains the same but the total surface increases. If a cubic meter is progressively cut into smaller cubes until it forms cubic nanometers. The increased surface to volume or surface area to mass ratio results in very interesting physical and chemical properties of the nano materials. One such property is the increase in the catalytic activity of substances per unit volume or mass at nano scale. Also the reactivity of substances will increase at nano-scale dimensions.

Thermal

Q.10

© Explain the properties of application of Carbon Nano tubes and Graphene (07 Marks).

Ans:- Carbon - Nano Tubes.

Properties

CNT's have very high Surface Areas, aspect ratio's and Mechanical strength. The tensile strength of CNT's is nearly 100 times greater when compared to steel.

The electrical conductivity reaches that of copper and thermal conductivity reaches that of diamond.

Applications

→ CNT's are used for reinforcing different structures where lightness and strength of materials is required.

→ CNT's are used as hydrogen storage material for fuel cells and some secondary batteries.

3) They catalyse many organic reactions.

4) functionalized CNT's are used as sensors and used for diagnosis and therapeutic applications.

5) Cotton fabrics, which otherwise have perfect water absorbality.

Graphenes.

→ 2-dimensional honeycomb like one atom thick (0.345 nm) graphite structure which is flexible and stretchable (~20%).

→ Sp^2 hybridised carbon atoms bonded to three neighbouring C-atoms. with alternate double bonds impart conductivity into the material. Exhibits high charge carrier mobility with ballistic transport in the micrometer range exhibits conductivity better than that of copper.

→ Graphene conducts heat 10 times better than copper.

Applications

→ Due to electron mobility, mechanical flexibility, and optical transparency used in transparent electrode, solar cells, ultrafast photodetectors. phototransistors. Used in the making of lithium-ion batteries.

→ The mobility of graphene is very high which makes the material very interesting for electronic high-frequency applications.

→ Transparancy has made it useful in applications such as touch screens (ATM) touch screens) light panels etc where it can replace indium tin oxide (ITO).

→ Flexible electronics and gas sensors are other potential applications.

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