

CBCS SCHEME

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BCHEE102/202

First/Second Semester B.E./B.Tech. Degree Examination, Dec.2023/Jan.2024 Chemistry for EEE Stream

Time: 3 hrs.

Max. Marks: 100

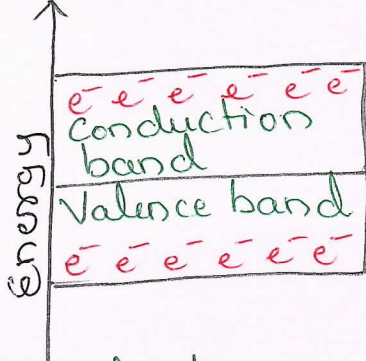
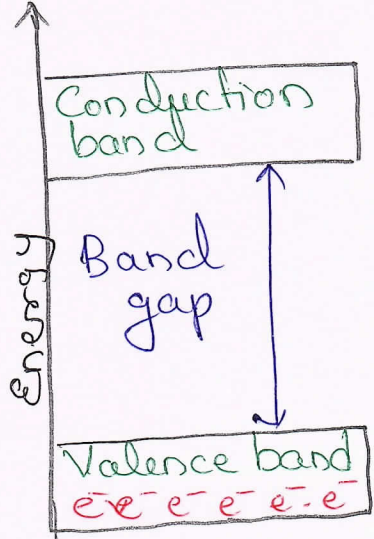
- Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
 2. VTU Formula Hand Book is permitted.
 3. M : Marks , L: Bloom's level , C: Course outcomes.*

Module - 1			M	L	C
Q.1	a.	Explain the band diagrams for conductors and insulators.	7	L2	CO1
	b.	Describe the production of electronic grade silicon from quartz by Czochralski method.	7	L2	CO1
	c.	Explain the preparation, properties and commercial applications of graphene oxide.	6	L2	CO1
OR					
Q.2	a.	What are conducting polymers? Explain the mechanism of polyacetylene.	7	L2	CO1
	b.	What is electroless plating? Describe electroless plating of copper in the manufacture of double-sided PCB.	7	L2	CO1
	c.	In a polymer sample 20% of molecules have molecular mass 15000 g/mol. 45% molecules have molecular mass 25000 g/mol remaining molecules have molecular mass 27,000 g/mol. Calculate number average and weight average molecular weight of the polymer.	6	L3	CO1
Module - 2					
Q.3	a.	What are batteries? Explain the classification of batteries with suitable examples.	7	L2	CO2
	b.	What are photovoltaic cells? Describe the construction and working of a photovoltaic cell.	7	L2	CO2
	c.	Explain the construction and working of li-polymer battery. Mention its applications.	6	L2	CO2
OR					
Q.4	a.	Explain the construction and working of vanadium redox flow battery. Mention its applications.	7	L2	CO2
	b.	What are fuel cells? Explain the construction and working of methanol-oxygen fuel cell. Mention its applications.	7	L2	CO2
	c.	Explain the construction and working of Na-ion battery.	6	L2	CO2
Module - 3					
Q.5	a.	What is metallic corrosion? Explain the electrochemical theory of corrosion, taking iron as an example.	7	L2	CO3
	b.	What is corrosion penetration rate? Calculate the CRR in both MPY and MMPY for a thick steel sheet of area 100 inch ² , which experience a weight loss of 485 g after one year (density of steel 7.9 g/cm ³).	7	L3	CO3
	c.	Describe the extraction of copper and gold from E-waste.	6	L2	CO3
OR					
Q.6	a.	Write notes on: (i) Differential metal corrosion (ii) Differential aeration corrosion	7	L2	CO3
	b.	Explain the sacrificial anode method for the corrosion control.	6	L2	CO3
	c.	What is e-waste? Describe the effects of e-waste on environment and human health.	7	L2	CO3

Module – 4					
Q.7	a.	What are nanomaterials? Explain the any two size dependent properties of nanomaterials.	7	L2	CO4
	b.	What are pervoskite materials? Mention the properties and applications of perovskite materials in opto electronic devices.	7	L2	CO4
	c.	Describe the synthesis of nanomaterials by co-precipitation method.	6	L2	CO4
OR					
Q.8	a.	Explain the synthesis of nanomaterials by sol-gel method.	7	L2	CO4
	b.	What are QLED's? Mention its properties and applications.	6	L2	CO4
	c.	Write notes on: (i) Nanophotonics (ii) Nanosensors	7	L2	CO4
Module – 5					
Q.9	a.	What are reference electrode? Explain the construction and working of calomel electrode.	7	L2	CO5
	b.	Explain the principle, instrumentation and applications of potentiometric sensor in the estimation of iron.	7	L3	CO5
	c.	The emf a cell $\text{Ag}/\text{AgNO}_3(0.001\text{M})//\text{AgNO}_3(\text{X}\text{M})/\text{Ag}$ is 0.059 V at 25°C, find the value of 'X'.	6	L3	CO5
OR					
Q.10	a.	What are ion selective electrodes? Explain the construction and working principle of glass electrode.	7	L2	CO5
	b.	Explain the principle and instrumentation colorimetric sensor, mention its applications.	7	L3	CO5
	c.	Explain how the strength of a weak acid determined using a conductometric sensor.	6	L2	CO5



Department: BSh (Chemistry) Qp Solution
Subject with Sub. Code: Applied Chemistry for EEE (BCHEE202) Semester / Division: I/II
Name of Faculty: Dr Sneha S. Kulkarni

Q.No.	Solution and Scheme	Marks
Q1	<p>Explain the band diagrams for conductors and insulators.</p> <p><u>Conductors</u>: These have overlapping valence and conduction bands or their valence band is partially filled. This overlap or partial filling allows electrons to move freely between energy levels and conduct electric current with little resistance.</p> <p><u>Insulators</u>: These have a relatively large band gap, typically on the order of several electron volts (eV). The electrons in the valence band are tightly bound and the energy required for them to transition to the conduction band is too high. As a result, insulators do not conduct electricity effectively. Ex: glass, wood, rubber.</p>  <p>Conductor Ex: Copper Silver gold Aluminium</p>  <p>Insulator</p>	7M 2M 2M 3M

1b

Describe the production of electronic grade silicon from quartz by Czochralski method

7

Single crystal silicon is obtained by crystal pulling technique or Czochralski method.

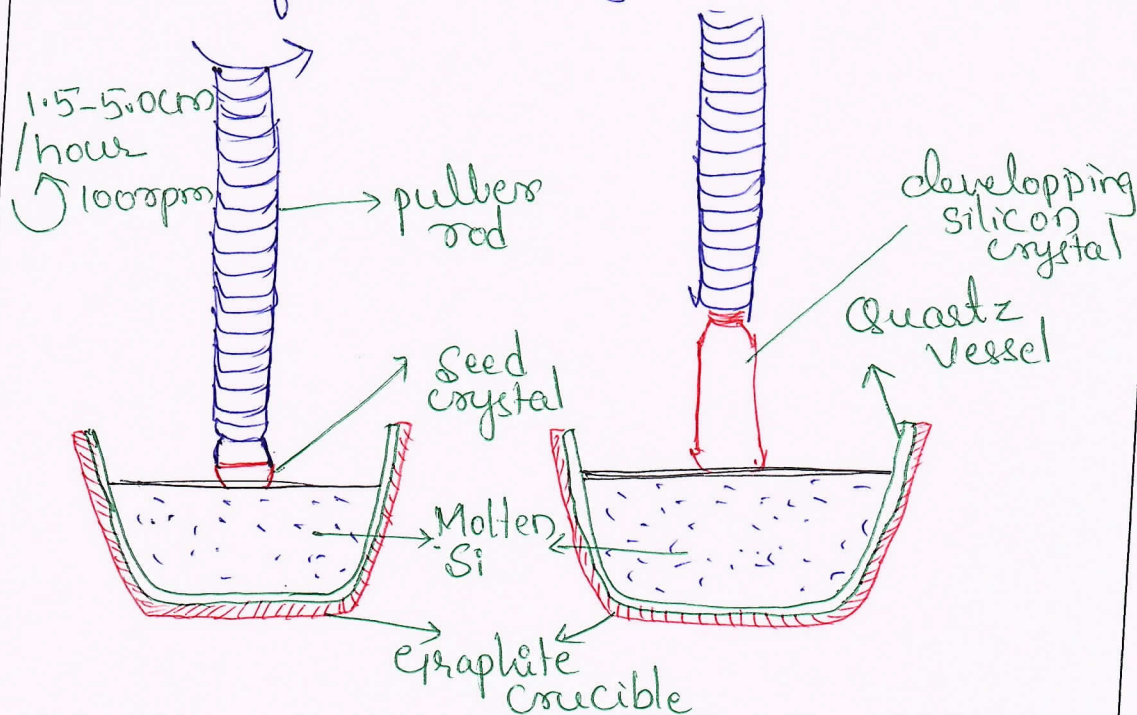
→ Polycrystalline silicon is heated using RF coil in a quartz vessel in an atmosphere of argon (inert noble gas) to get molten silicon.

→ The temperature is lowered and maintained at the melting point of silicon (1420°C)

→ A puller rod with seed crystal is just at the bottom is lowered such that the seed crystal just touches the surface of molten silicon.

→ The puller rod is pulled upwards at the rate of $1.5 - 5.0 \text{ cm/hour}$ and simultaneously rotated at the speed of 100 rpm .

→ As the rod is pulled away from the surface, silicon solidifies and a single crystal of silicon having the same crystal structure as that of the seed crystal is obtained.



2M

Q.No.

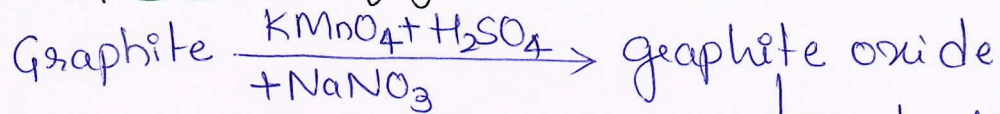
Solution and Scheme

Marks

1c Explain the preparation, properties and - commercial applications of graphene oxide

6M

Preparation of graphene oxide



↓ Exfoliation

Graphene Oxide

Graphene oxide is a derivative of graphite and is obtained by controlled oxidation of graphite. It is synthesized by Hummers and Offeman method. It refers treatment of graphite with an excess of KMnO_4 , H_2SO_4 and small amount of NaNO_3 .

4M

Properties:

→ It is biocompatible and can be functionalized easily.

→ Graphene oxide is hydrophilic due to the functional groups and can be dispersed in water or other polar solvents.

→ The structure will contain hydroxyl, carbonyl epoxide, carboxyl groups attached and there is no certain formula for graphene oxide.

3M

→ Exhibits high specific surface area and used in desalination of water and removing toxic heavy metals from effluent water

→ Applications.

1) GO membranes can be used for separation of gaseous components by selective diffusion

2) GO can be used for the large scale production of graphene

3) GO membranes are used for water purification

4) Functional group & biocompatibility make it useful in sensors, biosensors, components for medical applications including implants.

2M

Q.No.

Solution and Scheme

Marks

2a What are conducting polymers? Explain the mechanism of polyacetylene

7M

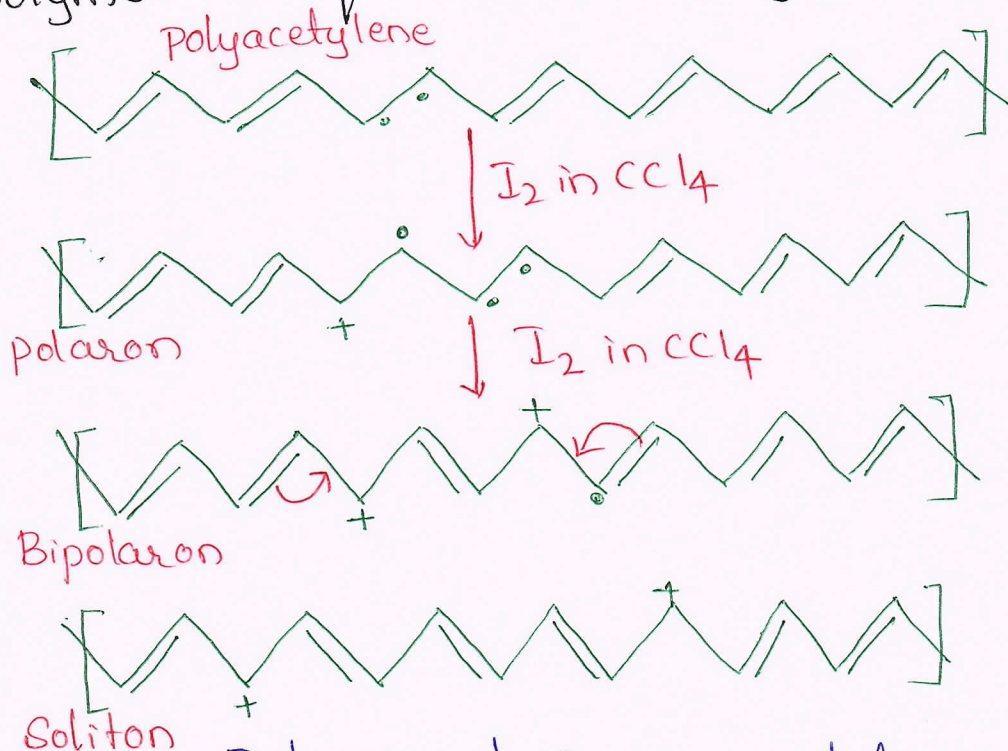
Linear, organic polymers with conjugate single and double bonds with suitable doping by oxidation or reduction or proton etc. with delocalized π -electron system, exhibiting conductivity equivalents of metals are referred to as conducting polymers.

4M

Mechanism of conductivity in polyacetylene
Oxidative doping

In the first step, oxidative doping by I_2 in CCl_4 removes an electron from the conjugated chain forming radical cation or polaron. Further oxidation gives bipolaron (biradical dication). Radicals converge & lead to formation of soliton. Delocalization of positive charge imparts conductivity to the polymer. Thus, the oxidative doping of the polymer is referred to as p-type doping.

2M



3M

Extensive doping or oxidation leads to higher conductivity to the polymer.

Q.No.

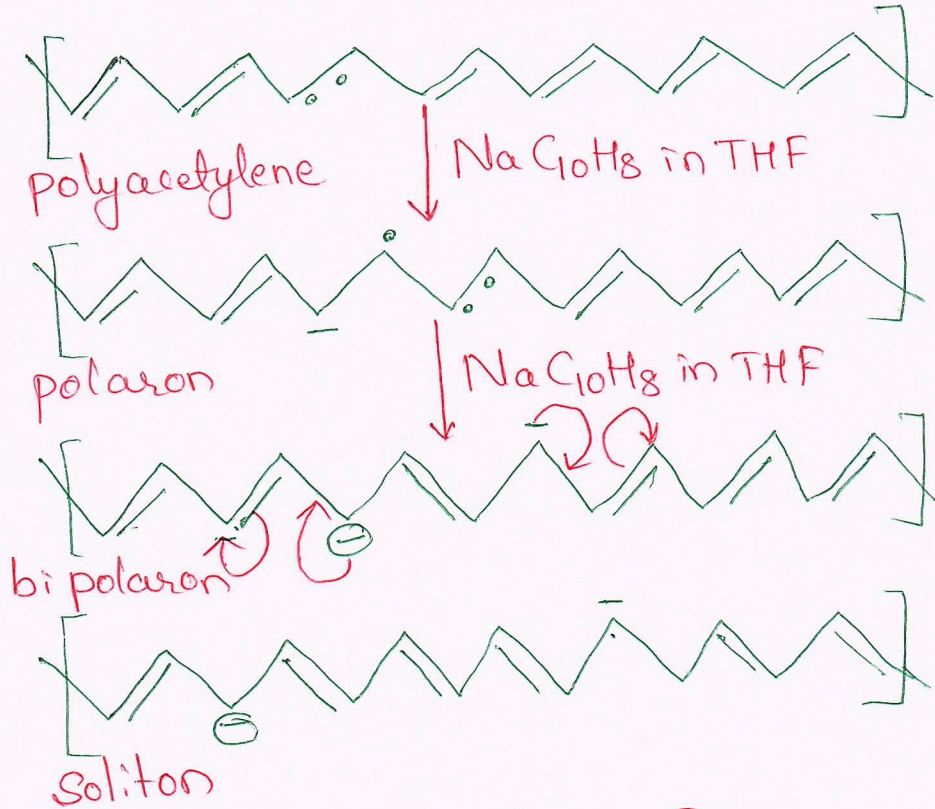
Solution and Scheme

Marks

Similarly, the reductive doping by dopant like sodium naphthalide in THF results in negative charge carriers in the polymer chain and is referred as n-type doping.

1M

Reductive doping mechanism.



2M

2b What is electroless plating? Describe electroless plating of copper in the manufacture of double sided PCBs

7M

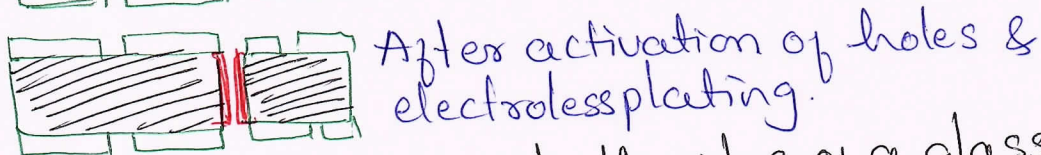
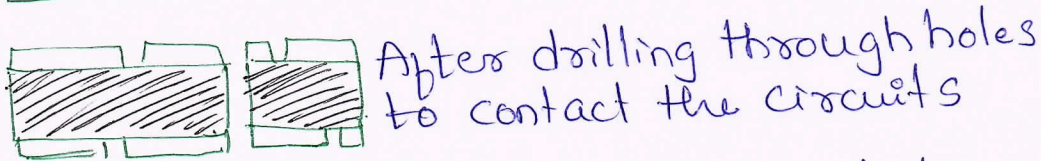
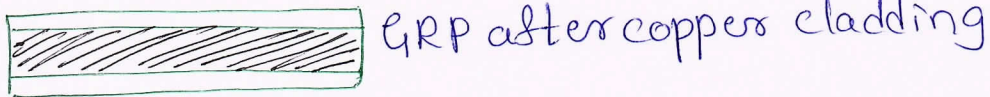
Deposition of metal or alloy over a conducting or nonconducting substrate surface by chemical reduction of metal ions by suitable reducing agent and without the use of electrical energy is called electroless plating.

1M

Metal ions + Reducing agent $\xrightarrow{\text{Catalytically active surface}}$

Metal atom + Oxidized product.

Making double sided PCBs



A coating of copper on both sides of a glass reinforced plastic sheet is accomplished by cladding two thin foils of copper

→ Necessary circuits are drawn on either sides using etch resistant ink.

→ The board is etched in acidified solution of $FeCl_3$. Only etch resistant circuit parts are left and rest of the copper is etched away.

→ Holes surfaces are drilled, wherever contact between the two circuits is necessary.

→ Hole surfaces are activated by treatment with acidified $SnCl_2$ and then with acidified $PdCl_2$

→ Electroless plating of copper is carried out in a suitable bath as mentioned above to establish the contact between the two circuits through holes.

2M

3M

1M

Q.No.

Solution and Scheme

Marks

2c. In a polymer sample 20% molecules, have molecular mass 15000 g/mol, 45% molecules have molecular mass 25000 g/mol remaining molecules have molecular mass 27000 g/mol. Calculate Number Average and Weight average mol. weight of polymer.

6M

$$\begin{aligned}
 N_1 &= 20\% & M_1 &= 15000 \text{ g/mol} \\
 N_2 &= 45\% & M_2 &= 25000 \text{ g/mol} \\
 N_3 &= 35\% & M_3 &= 27000 \text{ g/mol}
 \end{aligned}$$

2M

$$\begin{aligned}
 \sum N_i &= N_1 + N_2 + N_3 \\
 &= 20 + 45 + 35 \\
 &= 100
 \end{aligned}$$

$$\begin{aligned}
 \sum N_i M_i &= N_1(M_1) + N_2(M_2) + N_3(M_3) \\
 &= 20(15000) + 45(25000) + 35(27000) \\
 &= 2370000
 \end{aligned}$$

$$\begin{aligned}
 \sum N_i (M_i)^2 &= N_1(M_1)^2 + N_2(M_2)^2 + N_3(M_3)^2 \\
 &= 20(15000)^2 + 45(25000)^2 + 35(27000)^2 \\
 &= 4500000000 + 28125000000 + 25515000000 \\
 &= 581 \times 10^8
 \end{aligned}$$

2M

$$\begin{aligned}
 \bar{M}_n &= \frac{\sum N_i M_i}{\sum N_i} \\
 &= \frac{2370000}{100} \\
 &= 23700
 \end{aligned}$$

2M

$$\begin{aligned}
 \bar{M}_w &= \frac{\sum N_i (M_i)^2}{\sum N_i M_i} \\
 &= \frac{581 \times 10^8}{2370000} \\
 &= 24514.76
 \end{aligned}$$

Module - 2

3a What are batteries? Explain the classification of batteries with suitable examples 7M

Devices that store and release energy whenever required are called storage systems. Batteries are such devices and are portable sources of electrical energy.

"A battery is a union of two or more cells connected in series or parallel for necessary current or voltage."

Classification of batteries.

1) Primary batteries:

Irreversible, to be discarded on discharge. Function as galvanic cell during discharge.

Eg: $ZnMnO_2$, $LiMnO_2$

2) Secondary batteries:

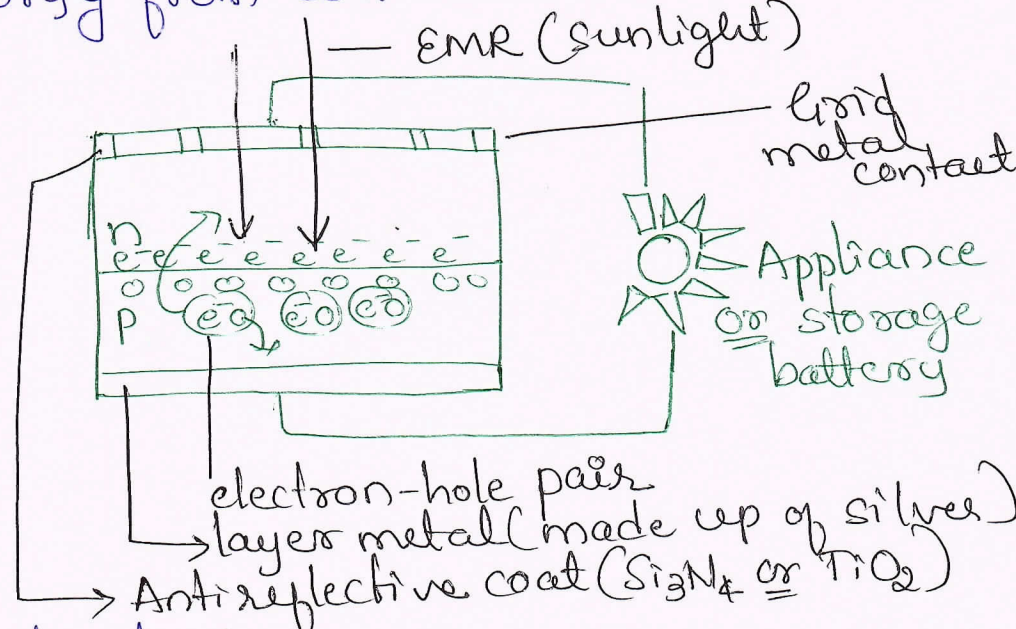
Reversible, are recharged after discharge from an external source of emf by reversal of polarity of the electrodes they are rechargeable. The cells function as galvanic cell during discharge and electrolytic cell during recharge with reversal polarity.

Eg: $Pb-H_2SO_4$, $Ni-Cd$, $Ni-MH_2$

3) Reserve batteries

Batteries with reserved activity with one of the essential battery component is kept isolated. Batteries can be activated by insertion of the isolated component during requirements of electric energy.

Eg: $Pb|acid|PbO_2$
 $Zn|KOH|Ag_2O$

Q.No.	Solution and Scheme	Marks
	<p>Reserve batteries are classified as</p> <ol style="list-style-type: none"> 1) Water activated (water as electrolyte) Mg sea water AgCl, Ag battery 2) Acid activated (acid as electrolyte) Pb Acid PbO₂ 3) Alkali activated Zn KOH Ag₂O 	
36	<p>What are photovoltaic cells? Describe the construction and working of a PV cell</p> <p>The Photovoltaic cells are the devices that convert solar energy into electrical energy from semiconductor diode.</p>  <p>Construction:</p> <ul style="list-style-type: none"> → The main component of photovoltaic cell is semiconductor diode → It has two electrical metal layer contact. Grid metal layer on upper side and layer metal contact on lower side. → Layer metal is usually made up of Silver → In between grid metal contact there 	7M 4M 4M 2M

Q.No.

Solution and Scheme

Marks

is antireflective coat, which increases the efficiency of light absorption.

→ The two metal layers are connected externally to the appliance or storage battery.

→ Working:

When the EMR falls on directly semiconductor diode, which overcomes the barrier potential the electron-hole pairs are created.

→ The electrons move towards positively charged n-region and holes move towards negatively charged p-region. The material starts working.

→ When an appliance or battery is connected between the two contacts, the circuit is completed & electrons are driven into external circuit enabling the functioning of appliances or charging of the battery. Charged battery is used for application such as lighting and telecommunication.

→ Depending on the energy requirement PV cells are connected either in series or parallel and designed to make modules or panels or arrays.

→ The solar cells or photovoltaic cells are ecofriendly in nature. No wear & tear.

→ As long as the sunlight is available the energy will be obtained.

3M

Q.No.

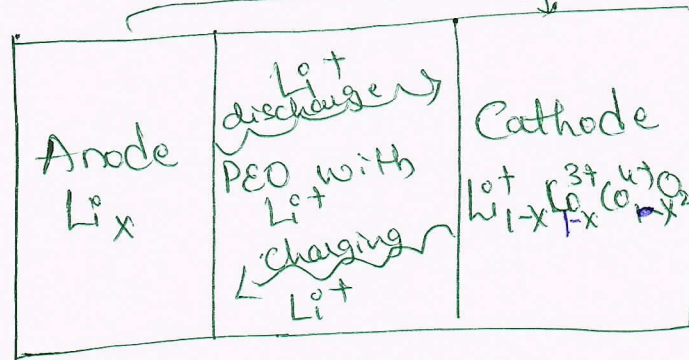
Solution and Scheme

Marks

3c Explain the construction and working of Li-polymer battery. Mention its applications.

6M

Li | PEO composited with Li⁺ ions / LiCoO₂
e⁻ during discharge.



2M

Components

Anode: Li or lithium alloy

Cathode: LiCoO₂

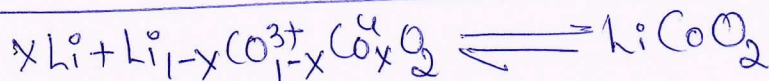
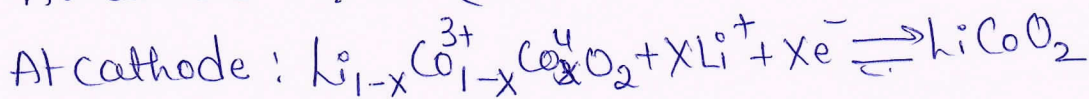
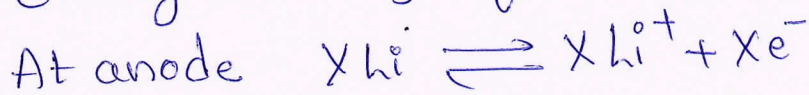
Electrolyte: PEO with Li-salts LiPF₆ dissolved in it. acts as Li⁺ ion conductor

but electronic insulator. PEO will also as separator between anode and cathode.

2M

Working:

Reactions in the forward direction occur during discharge of the battery



3M

Applications:

Batteries are used in

cellular phones

laptops

electric vehicles

Medical instruments etc.

Q.No.

Solution and Scheme

Marks

4a Explain the construction and working of Vanadium redox flow battery. Mention its applications.

7M

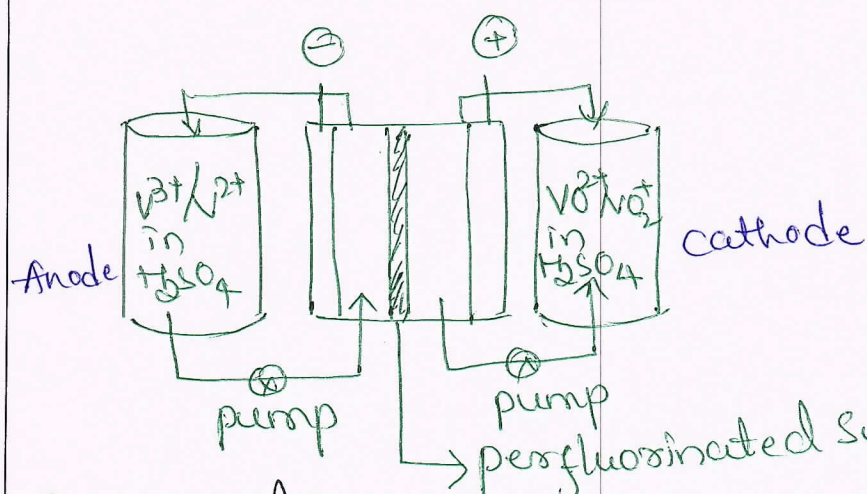
Cell representation

V^{3+}/V^{2+} redox system dissolved in H_2SO_4

proton exchange membrane
Perfluorinated sulfonic acid (Nafion)

VO_2^+/VO^{2+} redox system dissolved in H_2SO_4 .

1M



1M

Components

Anode: V^{2+}/V^{3+} redox system dissolved in H_2SO_4

Cathode: VO_2^+/VO^{2+} in H_2SO_4

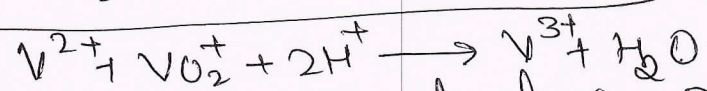
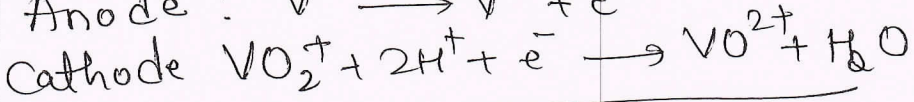
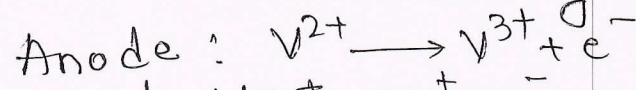
Electrode: Carbon based electrodes, carbon paper, carbon cloth, graphite & carbon nanotubes

1M

Separator: PEM - perfluorinated sulfonic acid (Nafion)

Working: Reactions in the forward direction occur during discharge

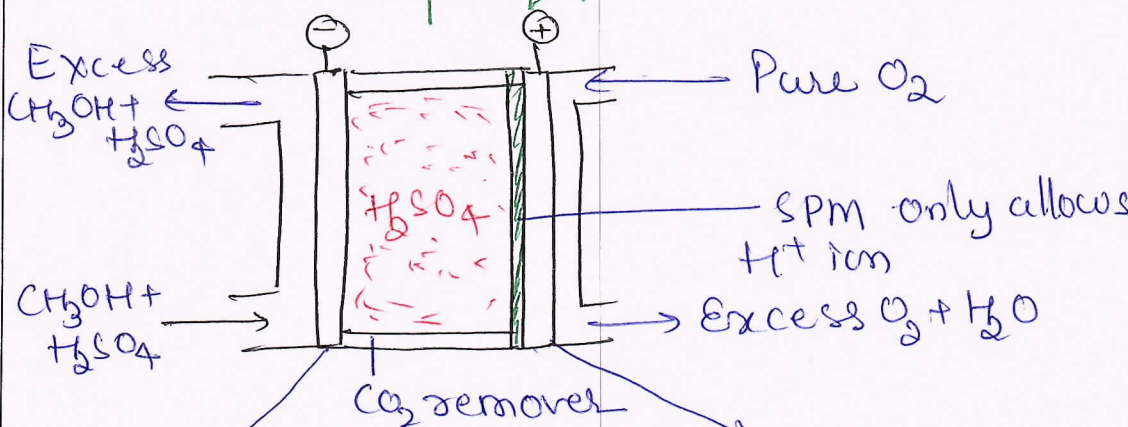
2M

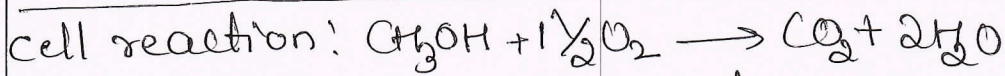
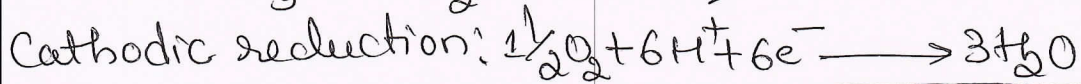
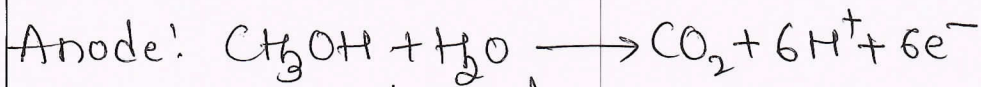


Reactions are reversed during recharge.
Cell potential 1.15 - 1.55 V

2M

Applications: military equipments, UPS applications, for microgrids etc

Q.No.	Solution and Scheme	Marks
4b	<p>What are fuel cells? Explain the construction and working of methanol oxygen fuel cell. Mention its applications.</p> <p>Fuel cells are galvanic cells that convert the chemical energy of a fuel-oxidant system directly into electrical energy, by oxidation of fuel at anode and reduction of oxidant at cathode.</p> <p>Methanol-O₂ fuel cell</p> <p>Porous C dispersed with Pt, CH₃OH + H₂SO₄ (aq) H₂SO₄ (aq) Porous carbon dispersed with Pt, O₂</p>  <p>Cell components:</p> <p>Anode: Porous carbon dispersed with Pt</p> <p>Cathode: Porous Carbon dispersed with Pt</p> <p>Electrolyte: H₂SO₄ (aq)</p> <p>Active components: Fuel - methanol mixed with H₂SO₄ Supplied at anode</p> <p>Oxidant: Pure O₂, Supplied at cathode</p> <p>Adjacent to cathode, towards electrolyte side, a semipermeable membrane is inserted to allow the diffusion of H⁺ ions but disallow the diffusion of CH₃OH to avoid methanol oxidation directly at cathode.</p> <p>Working:</p> <p>The reactions that occur during power generation are —</p>	<p>7M</p> <p>1M</p> <p>1M</p> <p>1M</p> <p>1M</p> <p>3M</p>



Water and CO_2 produced are removed as and when they are formed and do not harm the cell functioning. Water is removed by wicks. However, part of it comes out at cathode compartment along with excess of O_2 .

Cell potential: 1.2V

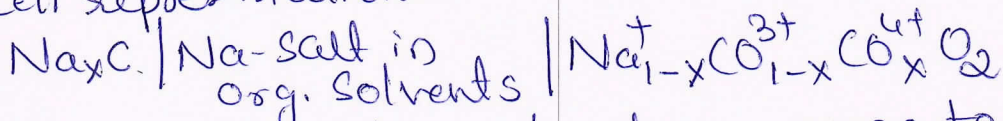
Applications:

Used in military applications and large scale power production.

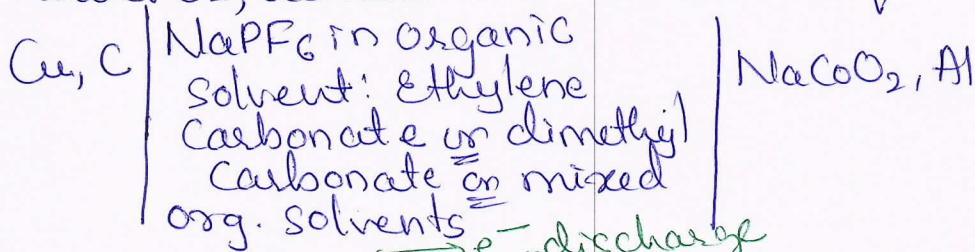
4c Explain the construction and working of Na-ion battery.

6M

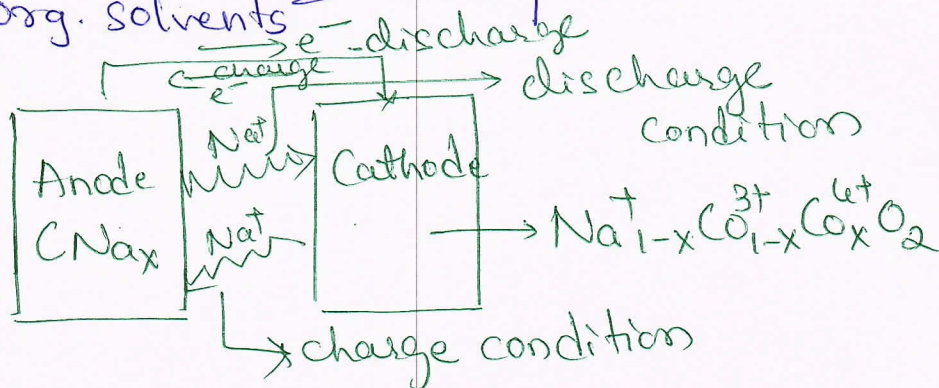
Cell representation:



However, actual construction refers to



3M



Cell components!

Anodic material! → Hard Carbon

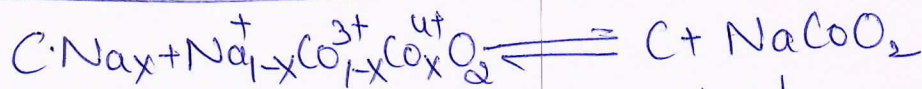
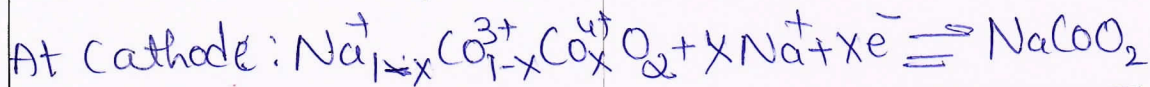
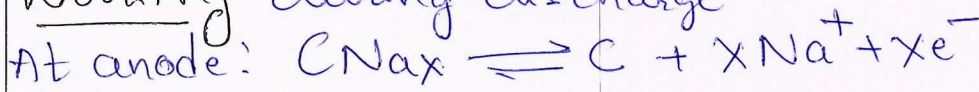
Cathodic material! → layered NaCoO₂

Q.No.	Solution and Scheme	Marks
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Electrolyte: NaPF_6 in mixed org solvent or ethylene carbonate or dimethyl carbonate.

Separator: Micro-porous polypropylene
This serves the purpose of an insulated separator between the electrodes and as electrolyte absorbent

Working during discharge

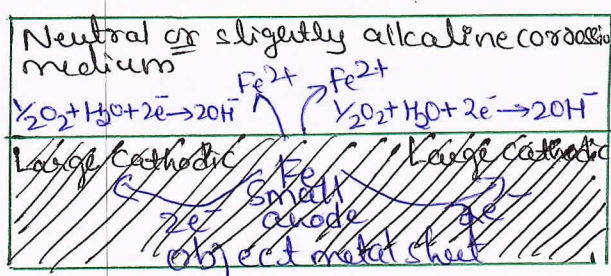
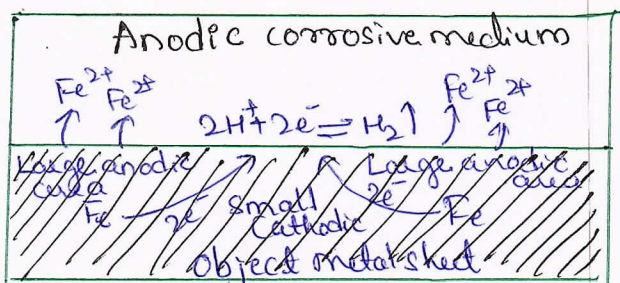


Applications: large scale grid storage

5a What is metallic corrosion? Explain electrochemical theory of corrosion, taking iron as an example. 7M

Corrosion:

Destruction or disintegration of metals when exposed to surrounding corrosive starting at their surface either by chemical or electrochemical means is metallic corrosion. 2M



3M

7M

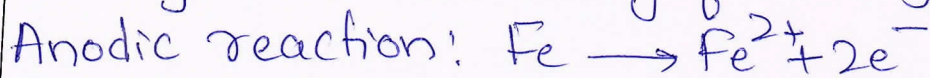
2M

1M

Electrochemical theory of corrosion by taking Iron as an example

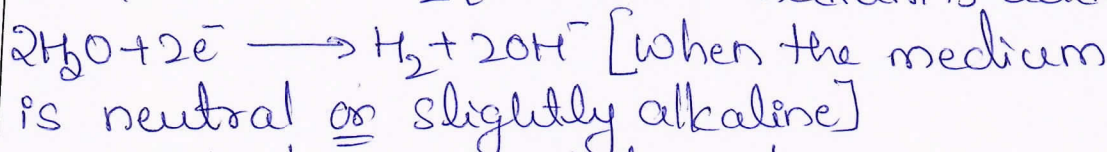
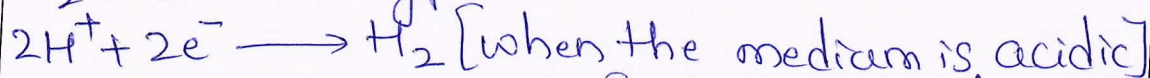
This corrosion is characterized by the formation of small galvanic cells due to heterogenities. Part of metal act as anode and another part act as cathode.

Anodic part of the metal undergoes destruction by oxidation. Steel (Iron) undergoes corrosion by following reaction.



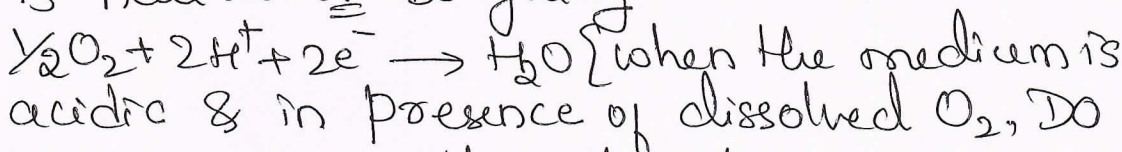
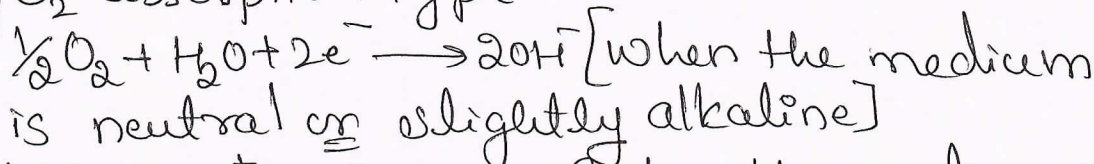
Reaction depends on the contents in the medium. Some important reactions are

H_2 evolution type



Hydrogen evolution type is characterized by the presence of large anodic area and a small cathodic area. Corrosion is uniform & less aggressive. Higher the acidity, higher is the corrosion rate.

O_2 absorption type.



Oxygen absorption type is characterized by the presence of small anodic area & large cathodic area.

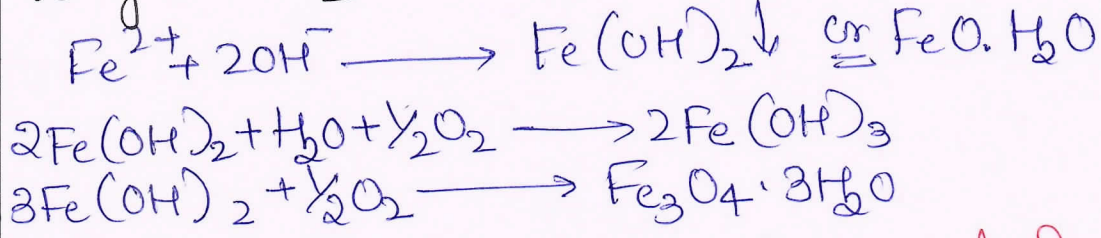
Corrosion is localised and very aggressive

1M

2.5
M

Higher is the oxygen contained in the medium, higher is the corrosion rate, Ferrrous hydroxide is formed as corrosion product. Excess O_2 can oxidize it further to yellow or black rust.

2.5M



5b What is corrosion penetration rate? Calculate the CPR in both mpy and mmpy for a thick steel sheet of area 100 inch², which experience a weight loss of 485g after one year (density of steel 7.9 g/cm³)

7M

It is also defined as the amount of weight loss per year in the thickness of a metal or alloy due to corrosion. It is also called as corrosion rate.

2M

To calculate CPR in mmpy

	Given	CPR in mmpy
K		87.6
W	485g	485 x 1000 mg
ρ or D	7.9 g/cm ³	7.9 g/cm ³
A	100 inch ²	100 x 6.45 cm ²
T	1 year	365 x 24 hrs

3M

$$CPR = \frac{KW}{DAT}$$

$$= \frac{87.6 \times 485 \times 1000}{7.9 \times 100 \times 6.45 \times 365 \times 24}$$

$$= 0.9518 \text{ mmpy.}$$

Q.No.

Solution and Scheme

Marks

To calculate CPR in mpy.

	Given	CPR in mpy
K		534
W	485g	$485 \times 1000 \text{ mg}$
ρ or D	7.9 g/cm^3	7.9 g/cm^3
A	100 inch^2	100 inch^2
T	1 year	$365 \times 24 \text{ hrs}$

$$\begin{aligned} \text{CPR} &= \frac{KW}{DAT} \\ &= \frac{534 \times 485 \times 1000}{7.9 \times 100 \times 365 \times 24} \\ &= 37.424 \text{ mpy.} \end{aligned}$$

5c Describe the extraction of copper and gold from E-waste.

Extraction of copper and gold from E waste involves 3 stages.

1] Pretreatment stage

In this step, electronic waste is manually dismantled to separate various fractions like metals, ceramics, plastics, wood and paper. Techniques such as electrostatic separation, magnetic separation, gravity separation and eddy current separation are used to separate metals from other fractions.

2] Chemical treatment stage

In this stage, targeted metals are leached into solution by treating with appropriate chemical reagents. Several leaching agents such as thiosulfate alkali cyanide and many acids such as nitric acid, hydrochloric acid, sulfuric acid can be used to leach gold into solutions.

3M

6M

1M

2M

Acid leaching is the common method used to extract copper. H_2SO_4 / HNO_3 in presence of H_2O_2 is used in the process



Cyanide leaching is the most common method used to extract gold metal.

Sodium salt of 3-nitrobenzene sulfonic acid with KCN in presence of O_2 is used as leaching agent. A water soluble dicyanurate gold complex is obtained in the process.



3) Metal recovery stage.

In this step, metal is recovered from leach solutions. Various methods like electrodeposition, solvent extraction, ion exchange, adsorption, precipitation and cementation are used to recover metals from leached solutions. On passage of electricity, copper. Selective recovery is possible for most processes.

Copper is extracted from leached solution by electrodeposition. Pure Cu cathode and inert anode are used in leached solution. On passage of electricity, Copper gets deposited at cathode.

Gold can be extracted from leaching solution by electrodeposition from gold complex dicyanurate. Pure gold metal taken as cathode and inert anode are dipped in leach solution.

When current is applied gold is electrodeposited on cathode.

2M

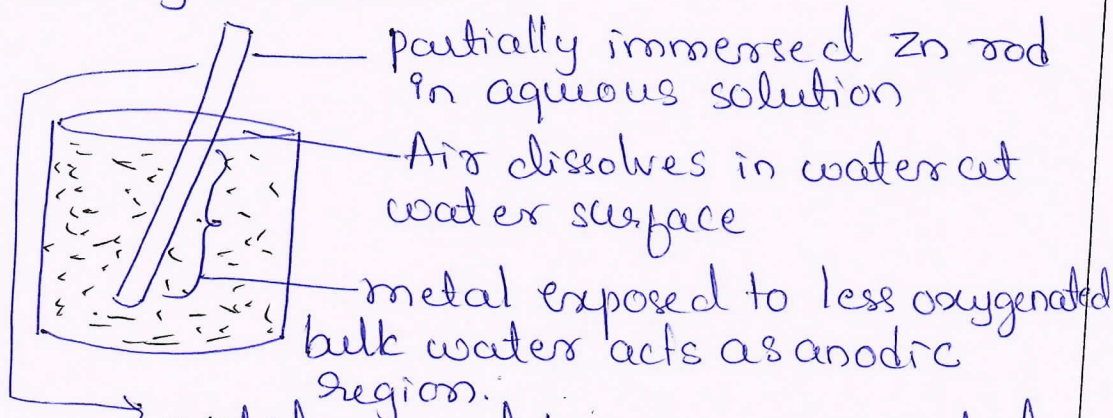
2M

Q.No.	Solution and Scheme	Marks
5a	<p>Write note on i) Differential metal corrosion ii) Differential aeration corrosion</p> <p>i) Differential metal Corrosion. Corrosion arising out of difference formation of galvanic cell. 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 two metals. Ex: i) steel vessel with brass tap ii) brass vessel with steel tap Steel acts as anode and undergone corrosion by oxidation. $\text{Fe} \rightarrow \text{Fe}^{2+} + 2e^{-}$ Brass acts as cathode and facilitates reduction reaction over its surface. $2\text{H}^{+} + 2e^{-} \rightarrow \text{H}_2 \uparrow \text{ [acidic medium]}$ $\frac{1}{2}\text{O}_2 + \text{H}_2\text{O} + 2e^{-} \rightarrow 2\text{OH}^{-} \text{ [neutral or alkaline]}$ Smaller surface area of Cathode (brass) and larger surface area of anode (steel) ensure little corrosion. Larger difference in anodic & cathodic metal electrode potential leads to aggressive corrosion. Higher concentration of corrosive and higher temp also result in higher corrosion rates.</p> <p>ii) Differential aeration Corrosion. Corrosion arising out of difference in aeration of metal part 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 facilitates reduction of oxygen to hydroxide. Driving force for the corrosion is the difference in oxygen concentration at two different metal parts.</p>	<p>7M</p> <p>1M</p> <p>2.5</p> <p>1M</p> <p>2.5M</p>

Ex:
partially immersed metal in an aqueous solution.

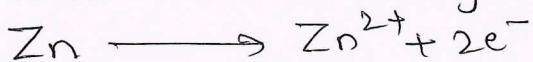
Water droplets over metal sheet.

Suppose a zinc rod immersed partially in water

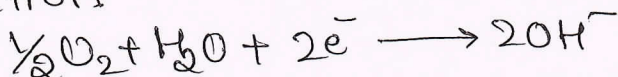


metal exposed to more oxygenated surface water acts as cathodic region.

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

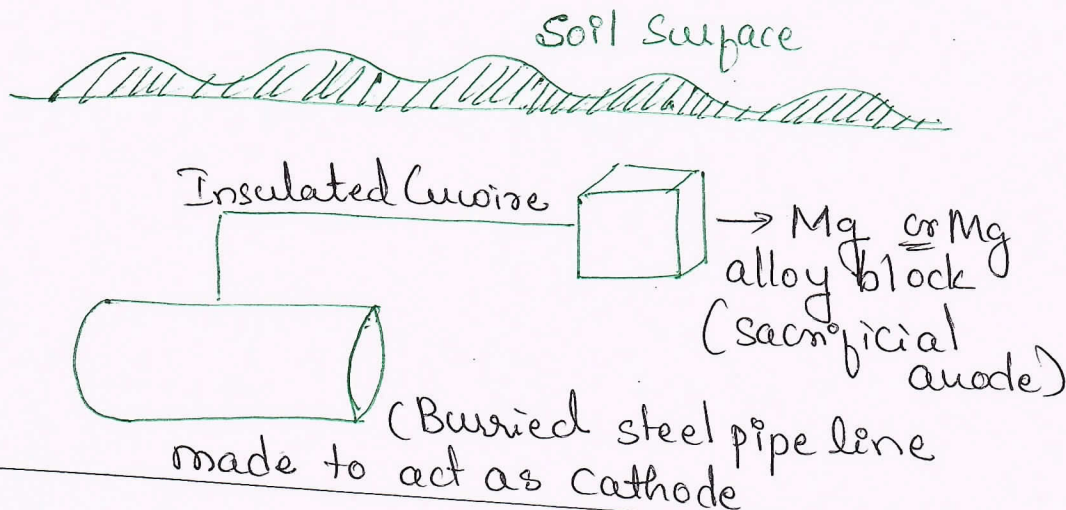


Metal exposed to more aerated surface H_2O acts as cathode and oxygen undergoes reduction



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

6b Explain the sacrificial anode method for corrosion control 6M



1M

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

Whenever there is demand of electrons by the corrosives in the medium, anodic metal will sacrificially undergoes corrosion (oxidation) & release the electrons. Thus, the object metal is protected.

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

Application:

Employed for buried pipeline & used for water or oil, water tank, ocean going ships etc

5M

6c What is e-waste? Describe the effects of e-waste on environment and human health 7M

Major problem with the e-waste is passing off toxic metals and organic compounds present in e-waste into ecosystem that is air, water and soil & ultimately living beings. Contamination of ecosystem by e-waste hazards is mainly due to

1M

1) Unscientific dumping: of e-waste. The effluent from e-waste dumping sites is rich in heavy metals and suspended particulate matters. It is a major transport pathway for contamination of aquatic systems.

2) Informal e-waste recycling techniques: employed for metal recovery from printed circuit boards. Although the recycling is responsible to remove or delay the release of contaminants into the environment, unscientific ways are used for recycling may result in accumulation in landfills and end up within the environment.

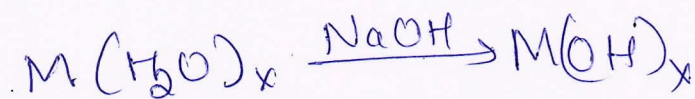
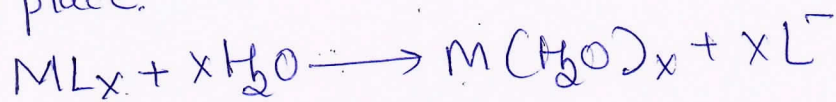
Q.No.	Solution and Scheme	Marks
	<p>3) The use of primitive methods to process e-waste has resulted in contamination of soil. Many of the effluents are acidic and responsible for changing the pH of the natural soil and result in reduction of agricultural yields. Concentration of Pb, Ba, Cd, Hg, Cr and Zn is found to be much higher near dumping sites. Toxic elements are found to disturb the N and K absorption by plants which are important components in plant growth and development. Many of these heavy metals are carcinogenic. Toxic substances gradually enter ecosystem through crops.</p> <p>4) Open burning of PCBs and electric cables to recover Cu. This releases dioxins, persistent organic pollutants, Polyaromatic hydrocarbons (PAHs), PCBs, halogens and halogenated organics into the environment.</p> <p>5) Toxic substances are entering human body from air, water and soil through inhalation, ingestion and dermal contact pathways. They are having different types of serious health impacts.</p> <p>→ People living nearby to e-waste collection dumping and incineration sites are direct victims for the toxic contaminants. There are higher number of incidences with skin damages, headache, vertigo, chronic gastritis, gastric ulcers and duodenal ulcers.</p> <p>→ Placentas collected from mothers who live near e-waste dumping sites have shown very high concentration of toxic chemicals.</p> <p>→ Cd-metal can damage kidneys and Pb-metal can have a direct influence toward central nervous system as well as deterioration of intelligence quotient in children. Hg is a potential mutagenic compounds and affects neurons.</p>	6M

Q.No.	Solution and Scheme	Marks
7a	<p>What are nanomaterials? Explain the any two size dependent properties of nanomaterials.</p> <p>(Definition of nanomaterials)</p> <p>1) Surface area.</p> <p>Many physical and chemical properties of a material depend on its surface properties. If a bulk material is subdivided into individual nanomaterials, the total volume remains the same, but collective surface area is greatly increased.</p> <p>Ex: The collective surface area of cube (each side of 1m) is 6m^2. If this cube is progressively cut into smaller and smaller cubes, the surface area will increase to 6000km^2. Thus, surface area is enormously increased on moving from bulk to nano scale.</p> <p>Properties like catalytic activity, gas adsorption and chemical reactivity depends on surface area, therefore, nanomaterials can show specific surface related properties that are not observed in bulk materials.</p> <p>Ex: bulk gold is catalytically inactive but the gold nanoparticles are catalytically very active for selective redox reaction.</p> <p>2) Catalytic properties.</p> <p>The catalytic properties of materials depends on particle size.</p> <p>→ If the size of the particles reduces from bulk to nanoscale, surface area increases, that leads to very high catalytic activity of the same material.</p> <p>Ex: Bulk gold is catalytically inactive, but gold nanoparticles are catalytically very active for selective redox reactions.</p>	<p>7M</p> <p>1M</p> <p>2M</p> <p>2M</p> <p>2M</p>

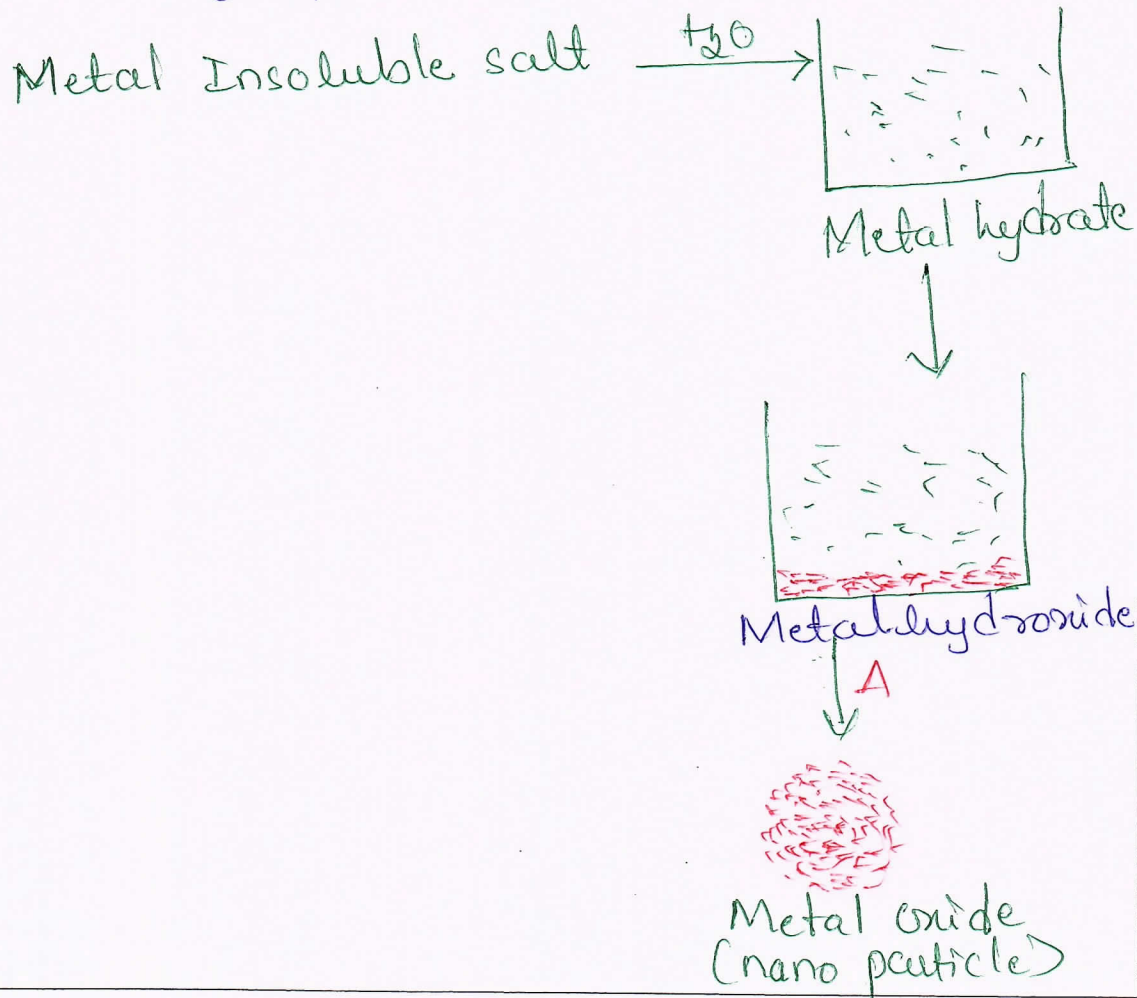
Q.No.	Solution and Scheme	Marks
7b	<p>What are perovskite materials? Mention the properties and applications of Perovskite materials in opto electronic devices.</p> <p>Perovskite material is a three dimensional ABX₃ type material where A is an organic cation commonly methyl ammonium cation, B is a metal cation, either Pb or Sn and X is a halide ion, Chloride, bromide or iodide. This material has cubic structure.</p> <p>Properties and applications of perovskite material in opto electronic devices.</p> <ul style="list-style-type: none"> a) long electron hole diffusion lengths (100nm) b) ultra-fast charge transportation. c) high dielectric constant d) Swift charge recombination e) long carrier lifetimes f) direct bandgap for stronger and broader adsorption with large absorption coefficients g) low-cost production and ease of processing and fabrication. <p>All these properties have made these materials as the best in thin film PV technologies.</p>	<p>7M</p> <p>1M</p> <p>6M</p>
7c	<p>Describe the synthesis of nanomaterials by co-precipitation method.</p> <p>The Principle involved in the precipitation of precursor materials at constant pH via condensation.</p> <p>Process:</p> <p>In this method inorganic metal salt such as chloride, sulphate, nitrate ions etc are used as precursor.</p> <p>Precursor materials is dissolved</p>	<p>6M</p> <p>1M</p> <p>3M</p>

in water and undergo hydrolysis where metal ions exist in metal hydrates form. On adding base like NaOH/NH₄OH, pH of the solution changes and reaches super saturation level leading to condensation of precursor to form metal hydroxide precipitate.

The precipitate is washed with water, filtered and finally calcinated at higher temperature to convert metal hydroxide into metal oxide by dehydrogenation takes place.



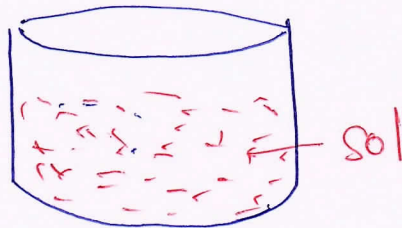
2M



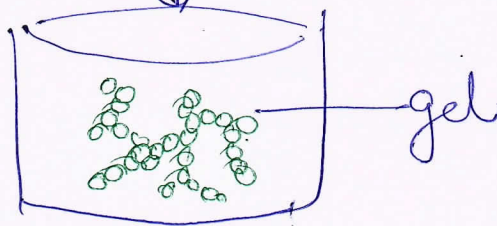
Q.No.	Solution and Scheme	Marks
8a	<p>Explain the synthesis of nanomaterials by sol-gel method.</p> <p>It is a bottom up approach of synthesis of nanomaterials.</p> <p>Sol-gel processes principle is conversion of precursor solution into gel via hydrolysis and condensation reactions.</p> <p>Sol gel processes allow to synthesis of nanomaterials of high purity.</p> <p>It involves 3 steps</p> <p>Step 1: hydrolysis</p> <p>Sol is prepared by suspended particles in water during suspension hydrolysis reaction takes place.</p> $M-OR + H_2O \longrightarrow M-OH + R-OH$ <p>Step 2: Polycondensation.</p> <p>Sol is converted into gel by condensation reaction forming network between oxides. When networking takes place, the viscosity of the solution increases</p> $MOR + MOH \longrightarrow MOM + ROH \text{ (alcohol condensation)}$ $MOH + MOH \longrightarrow MOM + H_2O \text{ (water condensation)}$ <p>Step 3: drying, Aging, Calcination</p> <p>During Aging, poly condensation reaction continue until the gel is transformed into solid mass.</p> <p>Further the solid mass is isolated from the solvent by thermal evaporation. The product formed is xerogel.</p> <p><u>Calcination:</u></p> <p>Solid mass is obtained is dried at nearly 800°C to get fine nano particle powder.</p>	<p>7M</p> <p>4M</p> <p>4M</p> <p>2M</p> <p>3M</p>

precursor material
(metal alkoxide
or
bimetallic alkoxide)

↓ +H₂O



↓ calcination



↓ Δ

Nano particles
(xerogel)

Advantages

- 1) Nano materials of high purity with good homogeneity can be obtained.
- 2) Samples can be prepared at low temperature
- 3) Easy to control the synthesis parameters like shape and size of resulting material.

Q.No.

Solution and Scheme

Marks

8b. What are QLED's? Mention its properties and applications

6M

QLEDs are superior to other display technologies like LCDs, OLEDs and plasma displays due to ideal blend features.

1M

Properties

- high brightness
- high efficiency with ^{long} life time
- More flexibility
- high quality lighting with superior color
- high color rendering index
- low process cost
- high quantum yields
- high molar extinction co-efficients
- large effective Stokes shifts

3M

Applications

QLEDs displays are commonly used in Televisions, monitors, smartphones & other electronic devices.

2M

- QLEDs can also be used as a source of lighting in various applications, including automotive lighting, streetlighting & architectural lighting.
- QLEDs can be used in medical imaging applications, such as in MRI machines, to produce high resolution & accurate images
- QLED displays can be used in advertising displays, such as digital billboards & signage, to produce high quality & eye catching visuals.

Q.No.	Solution and Scheme	Marks
8C	<p data-bbox="175 129 1308 246">Write notes on i) Nanophotonics ii) Nano sensors</p> <p data-bbox="175 246 1308 481">Nanophotonics It is the science and engineering of interaction of light and matter at the nanoscale range.</p> <p data-bbox="175 481 1308 548">Applications</p> <ul data-bbox="175 548 1308 1064" style="list-style-type: none"> → Nanophotonics are used to add precision to disease diagnosis, → Biomolecule sensing → Biomolecule sensing in low concentrations → Used in low power photonic switches which exhibit low power dissipation during operation. → Used in manufacturing thin film photovoltaic cells. <p data-bbox="175 1064 1308 1131">Nanosensors.</p> <p data-bbox="175 1131 1308 1489">Nanosensor is a nanoscale device that is capable of interacting with a specific chemical or biological analyte, detect it & produce the signal proportional to its quantity which can be measured and analyzed. They are quick, portable selective and sensitive.</p> <p data-bbox="175 1489 1308 1556">Applications:</p> <ul data-bbox="175 1556 1308 2116" style="list-style-type: none"> → It can be used for the detection of contaminants in water → Nanosensors can be used in the defence for the detection of explosives and toxic gases. → Used in detection of different types of environmental pollutants. → Plasmonic nanosensors are used in chemical warfare agents. → It can be used to detect contaminants in the food like toxins, bacteria, antibiotics. 	<p data-bbox="1340 145 1428 190">7M</p> <p data-bbox="1340 324 1428 414">$\frac{1M}{2}$</p> <p data-bbox="1340 638 1428 694">3M</p> <p data-bbox="1340 1220 1428 1299">$\frac{1M}{2}$</p> <p data-bbox="1340 1624 1428 1680">3M</p>

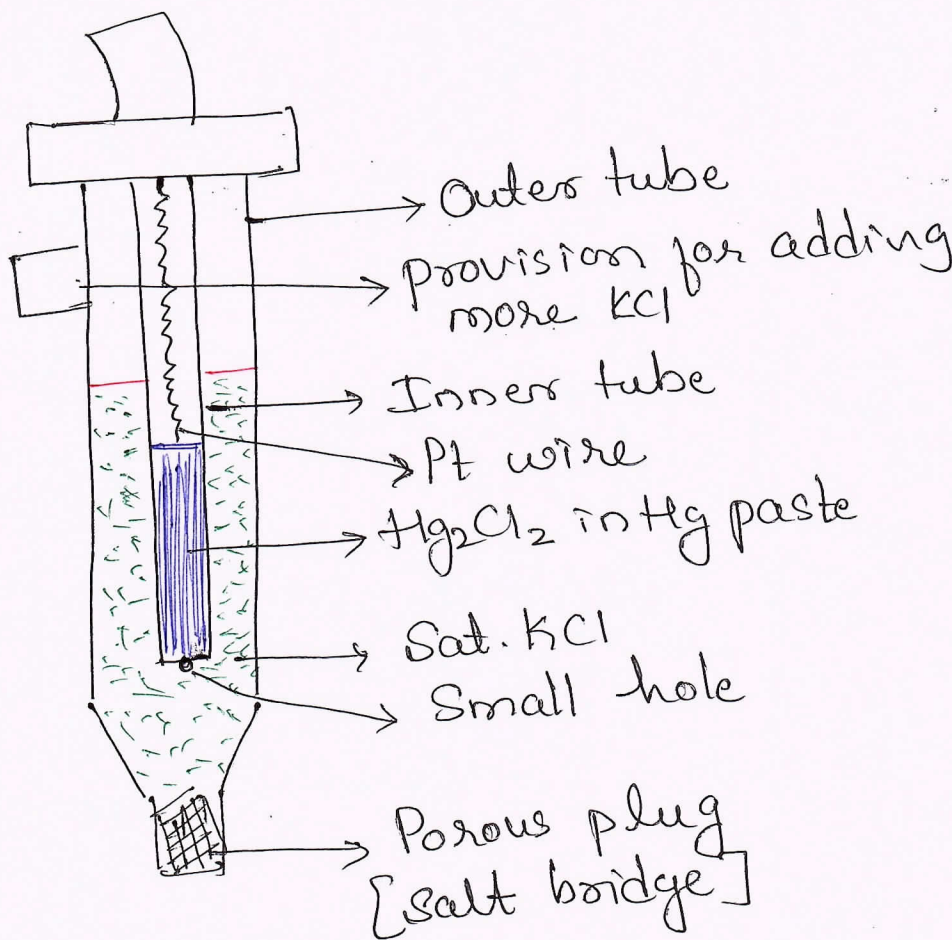
9a What are reference electrodes? Explain the construction and working of calomel electrode.

7M

The electrode with known potential used to determine the potential of unknown or test electrode is known as reference electrode.

1M

Construction and working of calomel electrode.

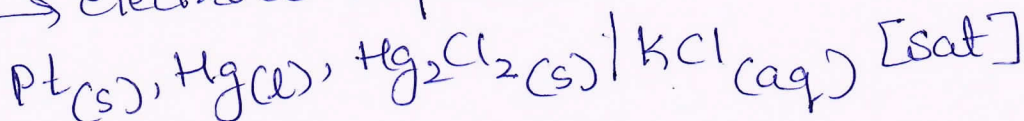


1M

Construction

→ Calomel electrode is secondary reference electrode

→ Electrode representation



2M

Construction

- Calomel electrode consists of two concentric tubes namely inner tube & outer tube
- Inner tube contains Pt wire coated with mercurous chloride in Hg. Small hole at the bottom of inner tube establish the contact between external KCl soln and Hg_2Cl_2 in Hg paste.
- Outer tube contains saturated KCl & hole at the bottom of outer tube is called as porous plug which establish the contact between external analyte solution with that of internal saturated KCl solution.
- There is a provision for adding more KCl

1M

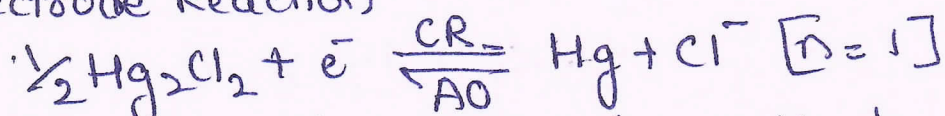
Working:

Depending on the electrode to which the calomel electrode connected, it acts as anode or cathode.

The electrode is reversible to chloride ions and it depends on the concentration of KCl solution.

1M

Electrode Reaction



1M

Forward reaction indicates cathodic reduction & backward reaction indicates anodic oxidation.

As the KCl concentration increases, the electrode potential decreases. At 298 K sat. KCl soln the electrode potential observed is 0.244 V. It obeys Nernst Equation.

$$E = E^\circ - 0.0591 \log [Cl^-] \quad \text{where } n=1$$

1M

9b Explain the principle, instrumentation and applications of potentiometric sensors in estimation of iron.

7M

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

1M

Principle:

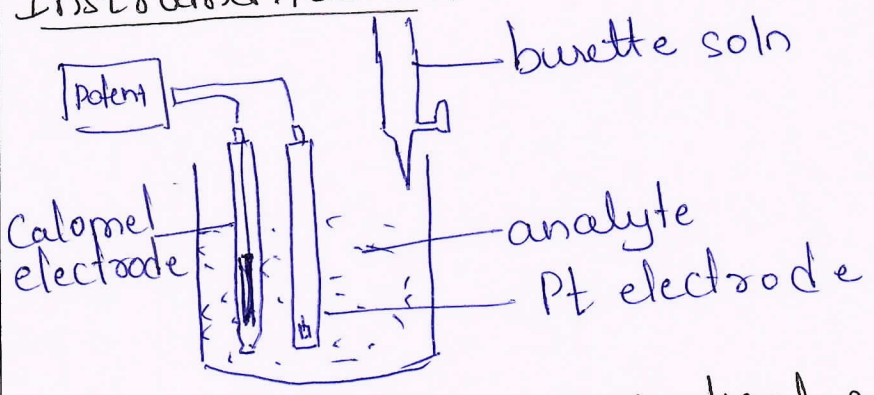
Redox titrations can be carried out potentiometrically using Pt and calomel electrode.

Potentiometry is based on Nernst equation

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

2M

Instrumentation:



Pt electrode: It is an indicator electrode, used to measure the potential of the analyte solution comparing with that of reference electrode.

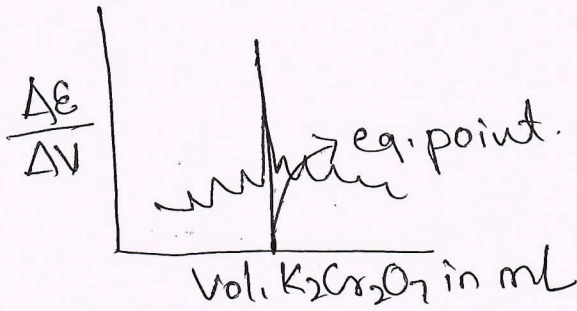
Calomel Electrode: It is reference electrode and used for determination of analyte by maintaining the fixed potential

Burette: std $K_2Cr_2O_7$ soln

Beakers: Test soln (FAS) and 5ml of dilute H_2SO_4

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

2M



- By the plot volume $K_2Cr_2O_7$ is obtained.
- Apply the formula $N_1V_1 = N_2V_2$ and calculate the concentration of FAS (analyte)
- The concentration of FAS thus obtained is multiplied with eq. weight of FAS to get the amount of FAS in given soln.

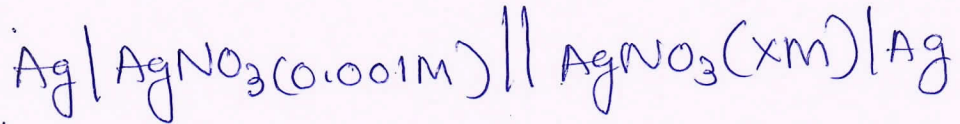
2M

9c The emf of a cell $Ag|AgNO_3(0.001M)||AgNO_3(6M)(xM)|Ag$ is 0.059V at 25°C, find the value of x.

6M

Soln

Given cell is electrolyte concentration cell.



where

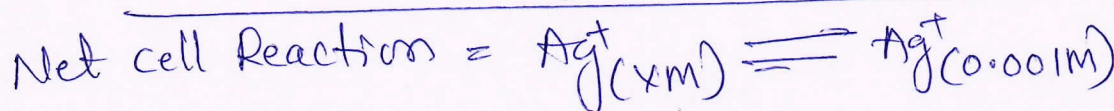
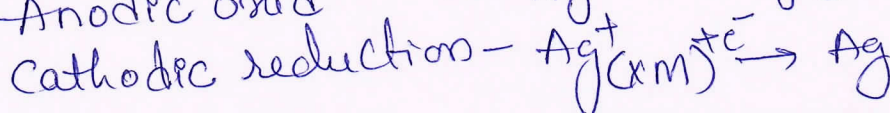
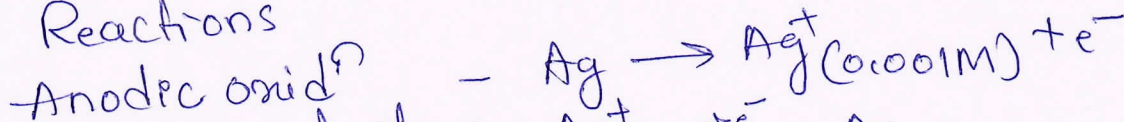
$$C_1 = 0.001 \text{ M}$$

$$C_2 = x \text{ M}$$

$$E_{\text{cell}} = 0.059 \text{ V}$$

$$T_{\text{amp}} = T = 25^\circ \\ = 25 + 273 \Rightarrow 298 \text{ K}$$

Reactions



$$n = 1$$

$$E_{\text{cell}} = \frac{2.303 RT}{nF} \log \frac{[C_2]}{[C_1]}$$

$$0.059 = \frac{2.303 \times 8.314 \times 298}{1 \times 96500} \log \frac{[x \text{ M}]}{[0.001]}$$

$$\frac{0.059}{0.0591} = \log \frac{[x \text{ M}]}{[0.001 \text{ M}]}$$

$$0.9983 = \log \frac{[x \text{ M}]}{[0.001 \text{ M}]}$$

$$\frac{[x \text{ M}]}{[0.001 \text{ M}]} = \text{Antilog} (0.9983)$$

$$= 9.960$$

$$[x \text{ M}] = 9.960 \times 0.001$$

$$= 0.00996 \text{ M}$$

$$\approx 0.01 \text{ M}$$

$$\therefore [x = 0.01 \text{ M}] \text{ or } [x = 0.00996 \text{ M}]$$

1M

1M

2M

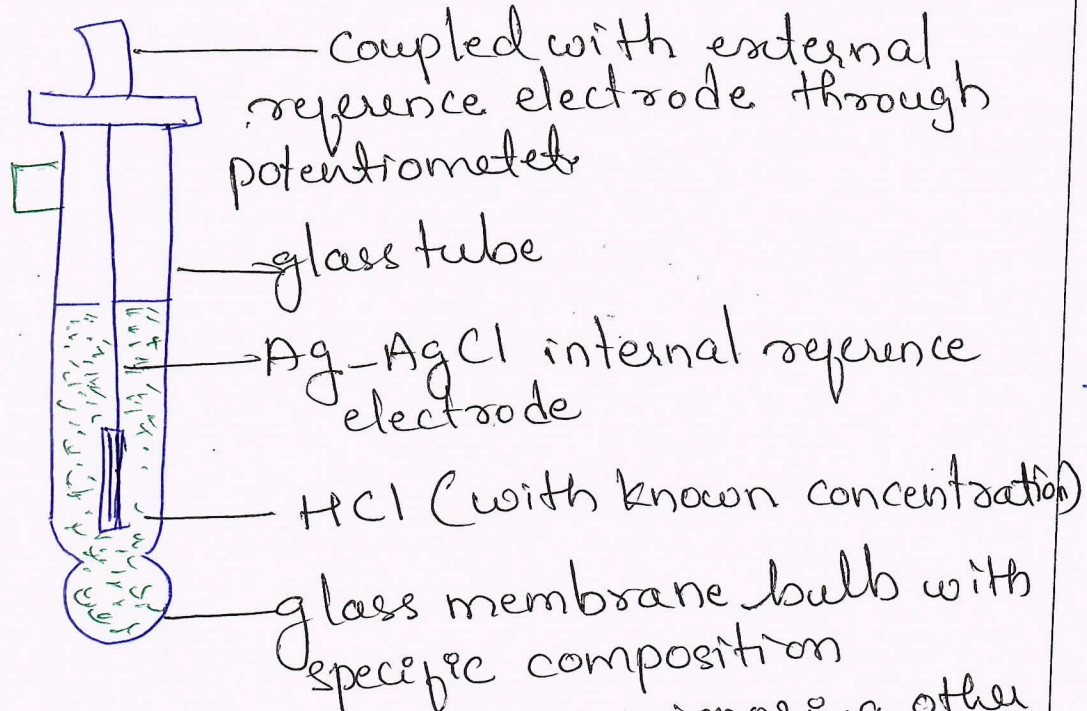
2M

10a) What are ion selective electrodes?

Explain construction & working principle of gas electrode

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

Construction



(responds to specific ion ignoring other ions)

Construction:

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

6% CaO

22% Na₂O

72% SiO₂

Q.No.

Solution and Scheme

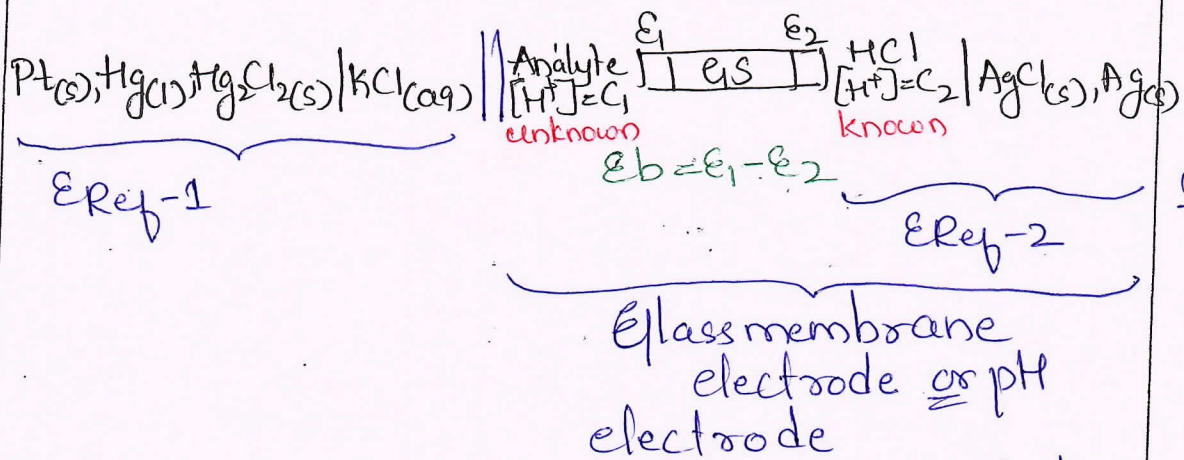
Marks

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

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

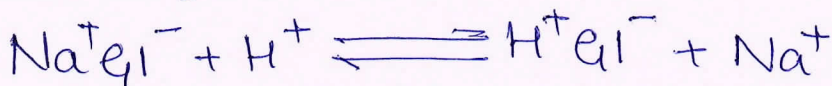
Working

By convention, membrane electrode is made cathode. Schematically written as—

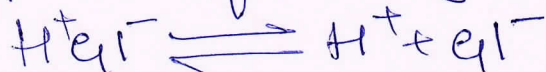


1M

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



$\text{H}^+ \text{eI}^-$, further dissociates to different magnitudes on two sides & results in development of boundary potential



Let E_1 & E_2 are the potentials developed at the membrane surfaces on external side (analyte side) and internal side respectively

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

Q.No.	Solution and Scheme	Marks
	<p> $E_b = E_1 - E_2$ $= \frac{RT}{nF} \ln \frac{C_1}{C_2}$ $= \frac{2.303 RT}{nF} \log \frac{C_1}{C_2}$ $= 0.0591 \log C_2 + 0.0591 \log C_1$ $= L - 0.0591 (-\log C_1) \quad \text{because } C_2 \text{ remains constant.}$ $= L - 0.0591 (-\log [H^+])$ $= L - 0.0591 \text{ pH}$ </p> <p> where, $L = -0.0591 \log C_2$ is constant </p> <p> Glass membrane potential is calculated as </p> <p> $E_R = E_4 = E_{Ref 2} + E_b + E_{assy}$ $= E_{Ref 2} + L - 0.0591 \text{ pH} + E_{assy}$ $= E_{Ref 2} + L + E_{assy} - 0.0591 \text{ pH}$ $= E_4^\circ - 0.0591 \text{ pH}$ </p> <p> where, E_{assy} is the asymmetric potential $E_{assy} = E_b$ when $C_1 = C_2$ $E_4^\circ = E_{Ref 2} + L + E_{assy} = \text{constant.}$ </p> <p> Cell potential is given by $E_{cell} = E_R - E_L$ </p> <p> $E_{cell} = E_4 - E_{Ref 1}$ $= E_4^\circ - 0.0591 \text{ pH} - E_{Ref 1}$ </p> <p> $\therefore \text{pH} = \frac{E_4^\circ - E_{Ref 1} - E_{cell}}{0.0591}$ </p> <p> $\text{pH} = \frac{k' - E_{cell}}{0.0591} \text{ at } 298 \text{ K}$ </p> <p> k' is a constant, glass electrode assembly constant. </p>	<p>3M</p>
10b	<p> Explain the principle and instrumentation colorimetric sensor, mention its applications. </p> <p> Colorimetric sensor is applicable for colored solutions. </p>	7M

Colorimeter works on principle
Beer Lambert's Law

Absorbance is directly proportional to concentration and thickness.

$$A = \epsilon ct$$

ϵ = molar absorptivity constant

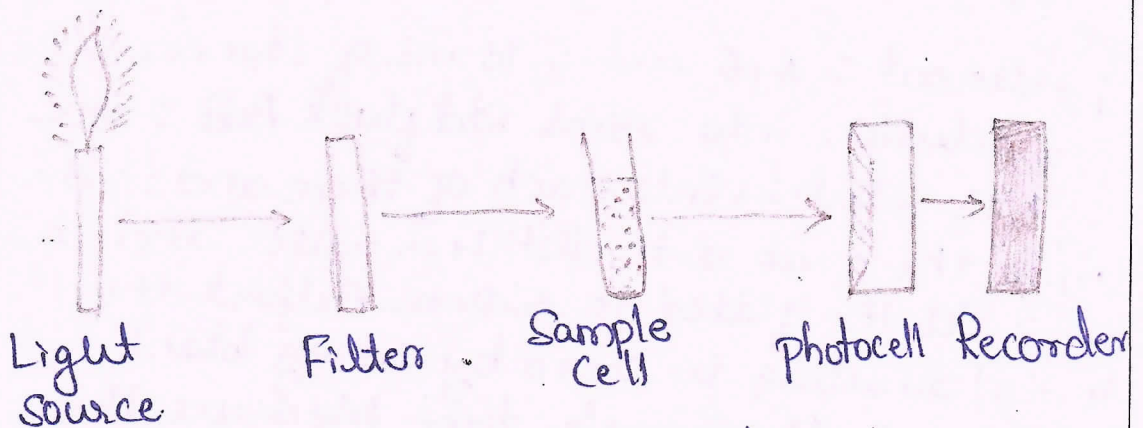
A = Absorbance of light

t = path length

C = concentration of the solution.

1M

Instrumentation:



2M

The instrument is used to measure the absorbance of a solution is called colorimeter. It consists of source: tungsten bulb or lamp is used as a light source

Filter: It is a device to provide desired wavelength range

2M

Sample cell: Sample is held in glass cell.
Photo cell: Converts the emitted light into electrical signal.

When light is allowed to fall on the sample cell at particular wavelength. The blank solution is taken in the sample cell and placed in the path of light beam. Its absorbance

is adjusted to zero. Then the analyte solution is placed in path of light and its absorbance is measured. A plot of absorbance against standard concentrations of analyte is used to find the unknown concentration of analyte in the samples.

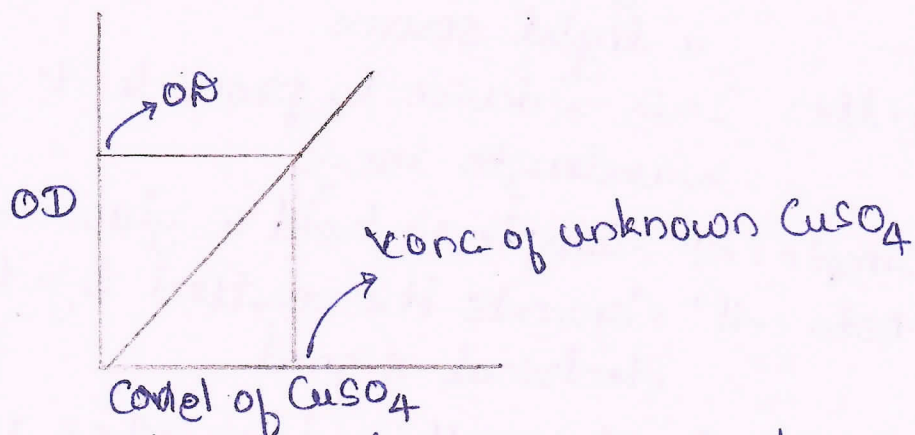
Applications.

Determination of composition of colored complex or concentration of colored complex

Ex:

pipette out 2, 4, 6 and 8, 10 mL of standard CuSO_4 solution into 25 mL std flask. Add 2.5 mL of NH_3 solution into each of them and make up to the mark with distilled water and shake well. Set the filter to 620 nm. Adjust the initial reading to zero by using blank solution in the sample tube. Measure the absorbance for each standard flask solution and plot graph of absorbance vs concentration of CuSO_4 .

2m



- 2) In quantitative analysis: large number of metal ions, anions and cations compounds can be determined.
- 3) photometric titration also it is used.

Q.No.

Solution and Scheme

Marks

10c Explain how the strength of weak acid determined using conductometric sensor

6M

Consider the titration of weak acid [acetic acid (CH_3COOH)] against NaOH . The conductance of acid will be initially low since acetic acid is a weak acid, or weak electrolyte.

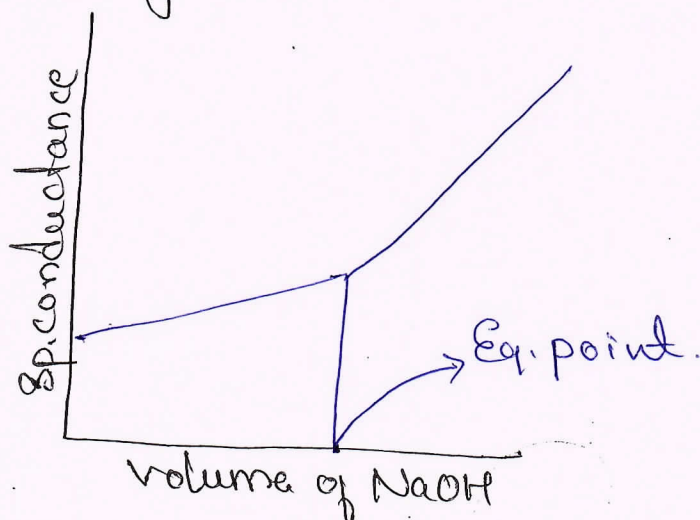
2M

When NaOH is added to the acid the salt formed is highly ionized and conductance slowly increases. On complete neutralization of acid, further addition of base leads to an increase in number of mobile OH^- ions, hence the conductance increases sharply.



2M

A plot of conductance against the volume of base added is as shown in the figure. The point of intersection of two curves gives the neutralization point



Q.No.	Solution and Scheme	Marks
	<p>From the graph the volume of weak NaOH required for the neutralization CH_3COOH is obtained.</p> <p>→ By applying $N_1V_1 = N_2V_2$, the concentration of weak acid is calculated.</p> <p>→ Once the concentration of weak acid is obtained, is multiplied with its equivalent weight to get the strength of weak acid by conductometric method.</p> <p><u>Zeebo</u> Staff in charge Dr. Sneha. S. Kulkarni</p> <p><u>AS</u> 21/07/24 Dean academics</p> <p><u>HOR (BSH)</u></p>	<p>2M</p>