First Semester BE/ BTech Degree Examination . Jan/ Feb . 2023

Chemistry for EEE stream .

Module-1

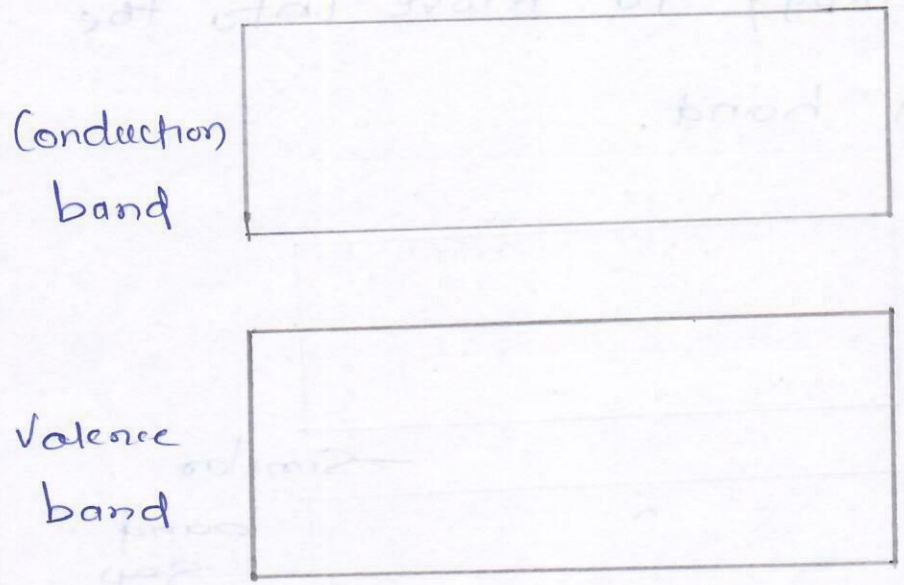
Q1 a Explain the classification of materials as Conductors, Insulators and Semiconductors along with a suitable example with the help of band theory. (7 marks)

Ans:

Conductors

In a Conductor there are no band gaps between the Valence and Conductor bands. In some metal the Conduction and Valence bands partially overlap. This means that electrons can move freely between the Valence band and the Conduction band The Conduction band is only partially filled.

band is empty. only the electrons in a conduction band can move easily. so because there aren't any electrons in an insulators conduction band, the material can't conduct.



Semiconductors

In a semiconductor, the gap between the valence band and the conduction band is smaller. At room temperature there is sufficient energy available to move some electrons from the valence band into the conduction band

Q-b Define the following with respect to polymers. i) conducting polymers ii) Number Average Molecular Weight iii) Weight average molecular weight. (6 Marks)

Ans :-

Conducting polymers :- Conducting polymers also known as conductive polymers, conjugated conductive polymers or organic polymeric conductors are polymeric materials that are innately conductive without the use of conductive fillers.

Number Average Molecular Weight :-

Mn is observed by the measurement of the colligative properties of the polymer by osometry or end group analysis and defined as

An alloy (Example stainless steel) is dipped in hot solution containing 1:1 H_2SO_4. Semiconductors and Insulators like plastics, glass, quartz wood, thread etc. followed by dipping in palladium chloride solution. When the object is dried layer palladium is obtained.

Electroless plating bath Composition

→ 1.2 g/L of Copper Sulphate (Electro Active metal).

→ 8 g/L of formaldehyde (Reducing Agent)

→ 20 g/L of EDTA (Complexing Agent and Exalting).

→ 15 g/L of NaOH + 145/L of Rochelle Salt (buffer)

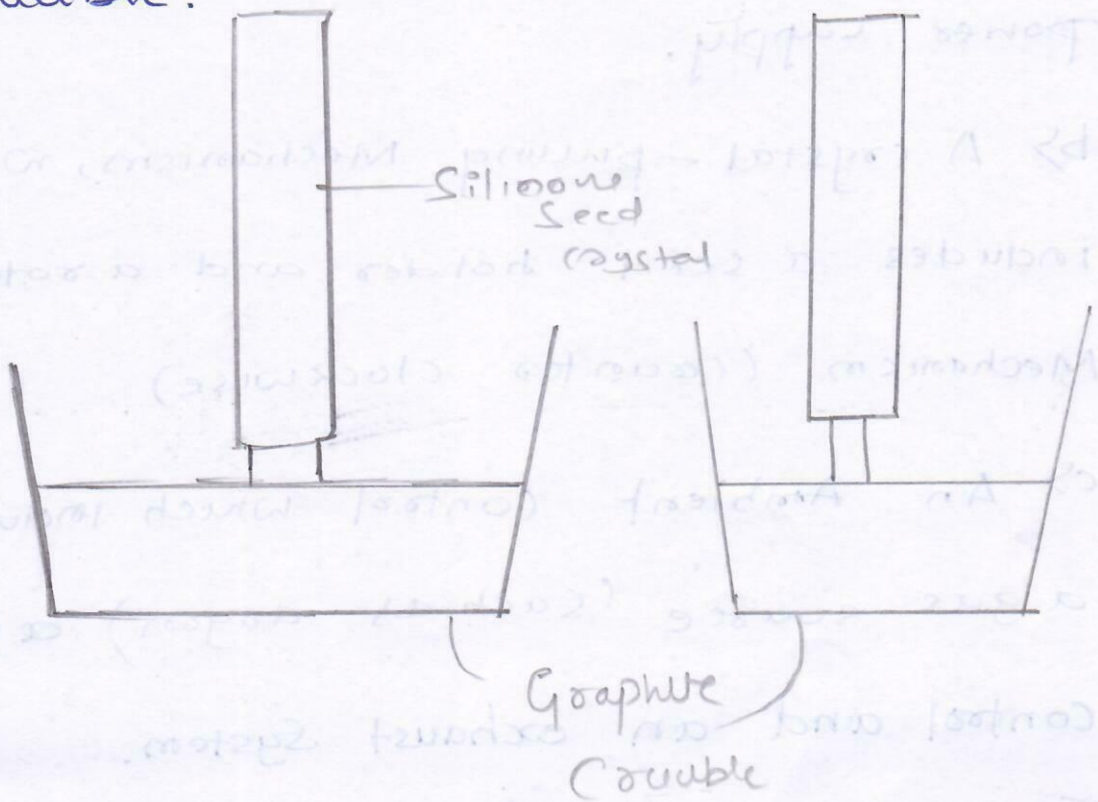
→ pH = 11.0

– Temperature 25°C.

Q2

a) Discuss the production of electronic grade silicon by Czochralski (CZ) process. (6 Marks).

Ans:- The ~~Bros~~ Czochraski Method is named after J - Czochraski who determined the crystallization velocity of metals. by pulling mono and polycrystals against gravity out of a melt which is held in a crucible.



The Czochralski method begins by melting high purity polysilicon (sgs) with additional dopants as required for the final resistivity in the rotating quartz crucible. A single crystal silicon seed is placed on the surface and gradually drawn upwards while simultaneously being rotated.

This draws the molten silicon after it which solidifies into a continuous crystal extending from the seed are adjusted to first neck the crystal diameter down to several millimetres.

b) What are polymers? In a sample of polymer 100 molecular have molecular mass 10^3 g/mol, 200 molecular have molecular mass 10^4 g/mol and 250 molecular have molecular mass 10^5 g/mol.

$250(10000000000)$

$= 5 \times 10^{29}$

Number Average Molecular Weight

$$\sum N_n = \frac{\sum M_i N_i}{\sum N_i}$$

$$= \frac{27100000}{550}$$

$$= 49272$$

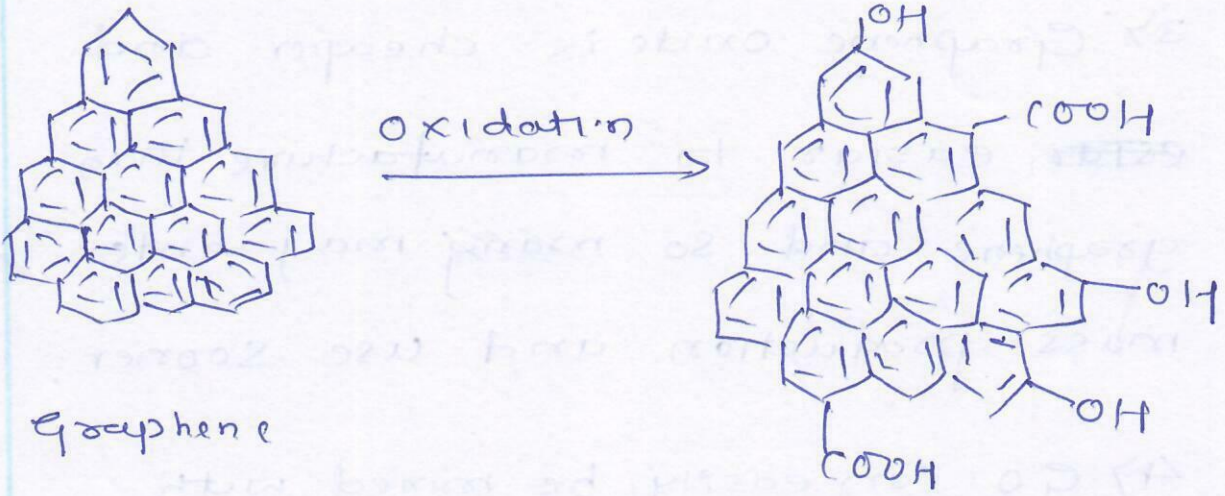
Weight Average Molecular Weight

$$\sum M_w = \frac{\sum N_i M_i^2}{\sum N_i}$$

$$= \frac{5 \times 10^{29}}{550}$$

$=$

Suspensions. Highly oxidised forms of GO are electric insulators with a bandgap of approximately 2.2eV.



Graphene

Graphene Oxide.

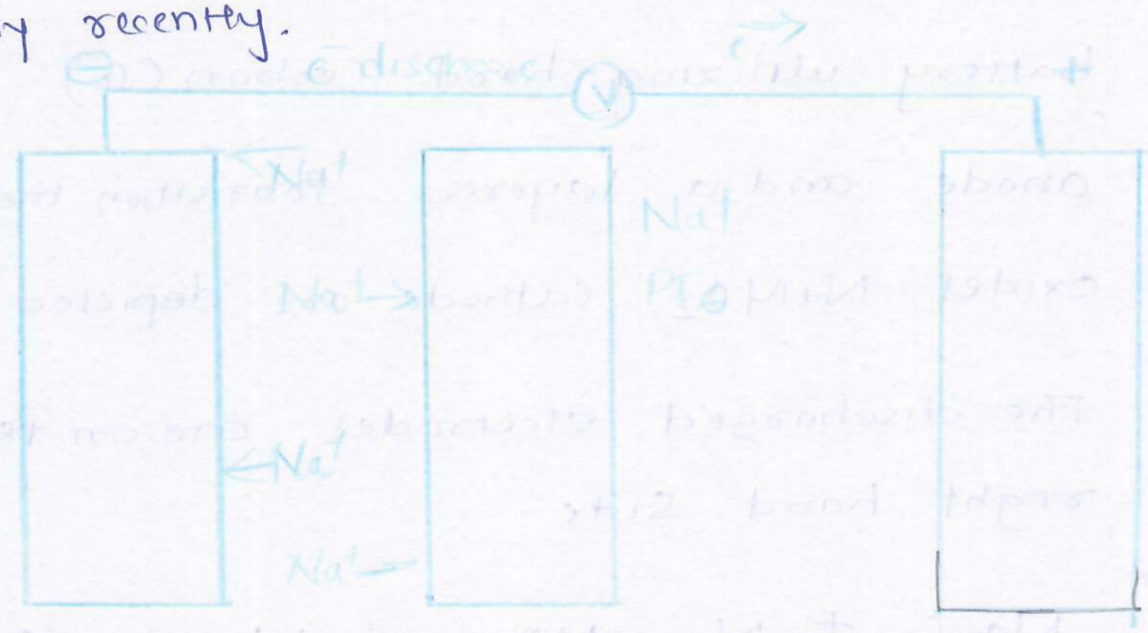
Simplistically, GO is monolayer sheet of graphite containing hydroxyl carboxyl and epoxy oxygen groups on its basal plane and edges. resulting in a mixture of Sp_2 and Sp3 hybridised Carbon atom.

Properties of Graphene Oxide

→ The Properties of graphene can be changed by the functionalization of graphene oxide The chemically-altered graphenes could possibly be used in several applications.

Sodium Ion battery

The Chemistry and electrochemistry of electrode materials for Na-ion batteries, are sufficiently different from that of their Li-ion counterparts that candidates suitable for practical batteries have become available only recently.



Cells have been built and evaluated with hard carbon anodes and cathode materials selected from layered transition metal oxides.

Transition metal flourophosphates (electrolyte) and prussian blue and its analogues are dissolved Propylene Carbonate (PC)

The reflect the multiple phase changes of the $NaCoO_2$ crystals as Na is deintercalated from it to form $Na_{1-x}CoO_2$ during charge and vice versa during discharge.

Q3b - What are Fuel cells? Explain the construction with a diagram and working of ~~Sodium-ion battery~~ Methanol-oxygen Fuel cell (7 Marks)

Ans: A fuel cell is defined as galvanic cell in which the electrical energy is directly derived by the combustion of chemical fuels supplied continuously. It is a device that oxidises a fuel (Hydrogen, Natural gas Methanol, gasoline etc) and an oxidant (Oxygen) into electricity.

A fuel cell may be represented as follows.

Electrode – Pt

Fuel : CH_3OH (Methanol)

Oxidant : Oxygen

Electrolyte : H_2SO_4

Methanol is preferred as a fuel because it is one of the most electro active organic fuels in low temperature range due to the following reasons.

It has low carbon content

It possesses is readily oxidisable –OH group

~~It~~ has high solubility in aqueous soln.

(construction) :–

→Methanol is fuel and O_2 is acts as oxidant

→Both Anode and Cathode is porous Nickel sheet coated with electro catalyst.

→Pt-Pd catalyst is deposited on anode and Ag is coated on Cathode.

→ Methanol mixed with water is passed through anode chamber

→ Pure oxygen is passed through cathode chamber.

→ To prevent the diffusion of Anode reactant Methanol into cathode chamber, a Proton conducting membrane is placed near cathode.

→ A membrane only allows Protons (H^+) to cathode.

Working

1) The cell operates below 100°C

2) In this cell both the electrodes are made up of porous nickel sheets impregnated with electro catalyst.

3) Pt-Pd catalyst is deposited on anode and silver is impregnated on cathode

4) Methanol is circulated through the anode chamber.

Q3

c List out at minimun three advantages and disadvantages of solar Photovoltaic cells. (6 marks)

Ans :-

Advantages

1) Solar power is pollution free

2) low operating costs (no fuel)

3) Facilities can operate with little maintanance

4) Solar power is economical except with initial setup

Disadvantages

1) Sunlight is a diffuse ie it is relatively low density energy

2) High Installation Costs

3) Energy is produced only during the day time.

Electrode Reactions

At the positive electrode V(IV) / V(V) redox couple are generally VO^{2+} and VO^{2-}.

$$VO^{2+} + H_2O + e^- \longrightarrow VO_2 + 2H^+$$

charging

$$VO_2^+ + 2H^+ + e^- \longrightarrow VO^{2+} + H_2O$$

Discharging

$E^\circ = +1.00$ V versus SHE.

At the nagative electrode V(II) / V(III) redox couples are either the vanadium (II) ion or vanadium (III) ion.

$V^{+3} + e^- \longrightarrow V^{2+}$ charged $V^{2+} + e^- \longrightarrow V^{+3}$

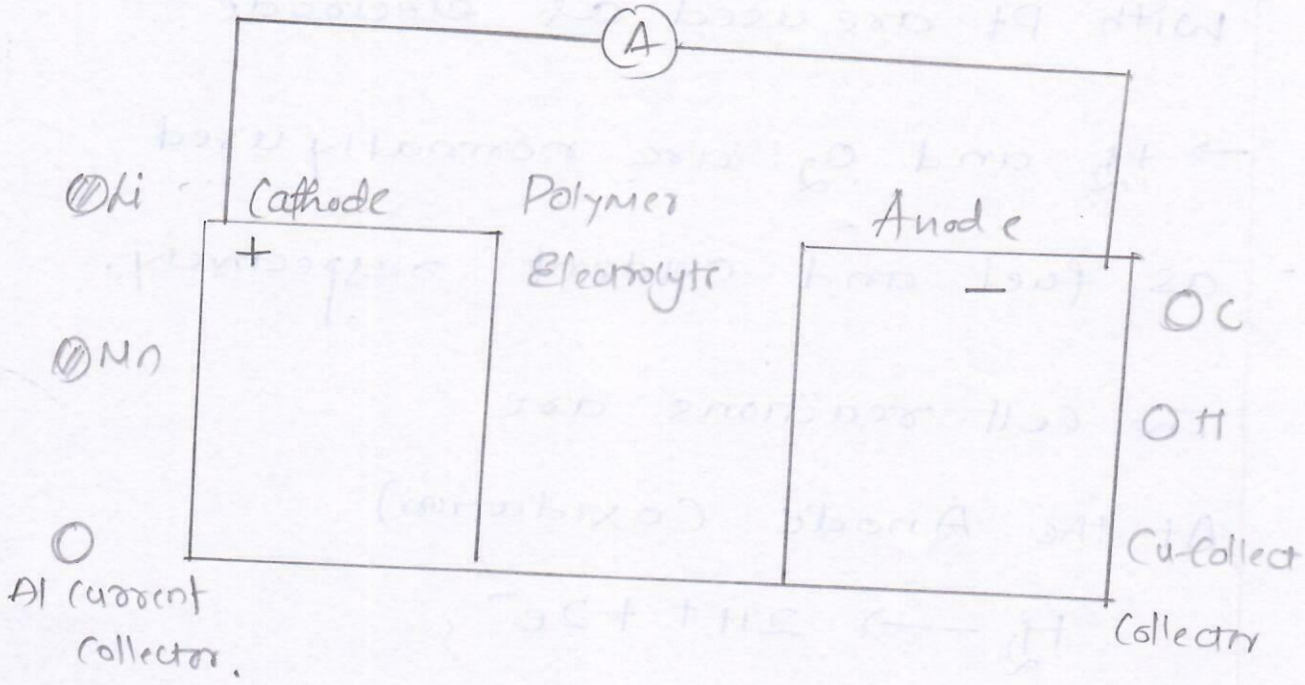
Discharge.

$E^\circ = -0.26$V versus SHE

c) The Standard opro circuit potential of all vanadium systems is 1.26V but the practical open circuit potential depends on the operation.

Ans:

Polymer electrolyte fuel cell



→ It is relatively new and fast growing technology.

→ These cells operate at low temperature.

→ Solid polymer membranes capable of H^+ migration used.

→ Teflon-based ion-exchanger membranes containing sulphonic acid group ($-SO_3H$) are frequently used.

→ The cell is compact as the membrane can be very thin

Applications of PEM Fuel cell

Proton Exchange membrane fuel cells (PEMFC) also known as polymer electrolyte membrane (PEM) fuel cells. are a type of fuel cell being developed mainly for, Transport applications, as well as Stationary fuel cell applications and portable fuel cell applications.

C Discuss the construction and working of photovoltaic cells. (6 Marks).

Ans:-

Construction :- 1) A typical silicon photovoltaic cell is composing of a thin water consisting of an ultra thin of phosphorous doped (n-type) silicon on the top and boron doped (p-type) silicon at the bottom.

2) Hence P-N junction is formed between the two.

Working:

1) Electromagnetic radiation consists of photon. The photon carries a certain amount of energy. It is given by the Planks constant equation is. $E = hc/\lambda$ where h is called Planck's constant C is the velocity of light and λ is the wavelength of radiation.

2) When the electromagnetic radiation falls on the p-n junction diode, electron pair hole is generated. Electrons move and collect at the n-type end and the holes moves towards the p-type end on connecting these two ends trough conductor flows between them to an external circuit.

5a: What is corrosion? Explain the electrochemical theory of corrosion taking iron as an example.

Ans:- Electrochemical theory of corrosion
Wet corrosion

Anodic Reactions

At the 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 ~~form~~ from the anodic to cathodic area. At the cathodic area chemical species present on the surface of the metal get reduced.

Liberation of hydrogen : It takes places in the absence of oxygen

In Acedic Medium

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

Neutral / Alkaline medium

$$2H_2O \longrightarrow 2H^+ + 2OH^-$$

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

Hydrated Ferric Oxide

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

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

Magnetic oxide (Black Rust).

b Define Corrosion penetration ratio (CPR) Calculate the CPR in both mpy and mmpy for steel sheet of area 150 inch^2 which experienced a weight loss of 490 g after one year. Given density of steel = 7.9 g/cc. (6 Marks)

Ans:- Corrosion penetration ratio (CPR) is defined in three ways 1) the speed at which any metal in a specific environment.

Q5 C Discuss sources, types and effects of ewaste on environment and human health. (7 marks)

Sources :-

(1) Large household appliances like refrigerators /freezers, washing machines, dishwashers, televisions

(2) Small household appliances which include toasters, coffee makers, irons, ~~hair~~ hair dryers

(3) Information technology (IT) and Telecommunications equipment namely personal computers telephones, mobile phones, laptops, printers Scanners, photocopiers etc.

4) Light equipment such as fluorescent lamps.

Types :- Valuable metals like gold, platinum, silver and palladium

effects of E-waste on water

Heavy metals like mercury, lithium, lead present in electronics (found in mobile phones and Computer batteries) etc. When not disposed properly, these heavy Metals penetrate from soil to groundwater which then run to the surface as streams.

Q6a Demonostrate the types of corrosion taking place in the following cases

A) A steel screw in copper sheet for a long time

B) Partially buried pipelines in soil.

(6 marks)

Ans:-

(1) Let us Consider a ~~##~~ bimatallic Sample of steel screw and Copper

$Fe \longrightarrow Fe^{+} + e^{-}$ (Anodic Site)

$Cu^{+} + e^{-} \longrightarrow Cu$ (Cathodic site.)

The standard electrode potential of Fe is -0.44V which is less than that of Cu whose standard electrode is 0.34V

Hence in this case iron acts an anode and undergoes corrosion whereas copper acts as ~~anode~~ cathode and remains un attacked.

The following are the reactions which occur during differential metal corrosion when Fe is in contact with Cu.

At Anode

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

At Cathode either hydrogen evolution or oxygen absorption

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

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

Sacrificial Anodic protection

In this Method the Metal to be protected from Corrosion is converted into cathode by

Q6

b. What is e-waste ? Explain the methods of e-waste disposal. (4 marks).

Ans: Electronic Waste or E-waste describes rejected electrical or electronic devices All Items of electrical and electronic equipment and it's parts that have been discarded by the user as waste without the purpose of re-use or re-cycle is called Electronic waste.

Disposal of E-waste.

(1) Land Filling :- Disposal of Electronic waste is mainly through land filling Mostly, the discarded electronic goods finally end up in land fil sites along with other municapal waste or are openly burnt releasing toxic and carcinogenic substances into the atmosphere.

(2) Incineration — In this complete combustion process the waste material is

C - Describe the extraction of Copper from e-waste. Mention any two advantages of recycling.

Ans: Leaching Method

Leaching - gold dissolution a variety of Methods were evaluvated to leach the gold from the residue that arose from the stage one leaching.

It was found that Sulphuric acid alone is not suitable for gold dissolution, with only 7%. leached.

However, the addition of 2M NaCl to the Sulphuric acid increases the leaching of gold to 31%. while the addition of 2M NaBr results in 88%. gold leaching.

→ The effect of varying the concentration of NaBr was studied further and shows an increas in gold leaching from 57 to 90%. over the range 1-3M, no further leaching of gold is observed after 4h.

Representation of two stage leaching and solvent extraction process adhered to the upper portion of the reactor. Based on these studies the most effective leaching of gold (95%) is observed using 3M Sulphuric acid with 3M NaBr, for 1-h residence time at 70°C and 500 rpm stirring speed.

→ It should be noted that this second stage leach solution also contains tin and silver so further purification is required.

Q7a What are Nano-Materials? Explain the following size dependent properties of nano-materials

(1) Surface Area,

(2) Catalytic property

(3) Conducting property (7marks)

Ans: Surface Area - When a bulk material is subdivided into individual nanomaterials

2) If the size of the particles reduces from bulk to Nano-scale surface to volume increases drastically, that leads to very high catalytic activity of the same material.

Example: Catalytic properties of gold nano-particles

Although bulk gold samples are practically inert, nanometer sized gold particles have been proven to be highly active for several reactions, including

low temperature oxidation of CO

Partial Oxidation of hydrocarbons

The water gas shift reactions

Reduction of nitrogen oxides when dispersed over certain oxides and Carbides.

$$M-O-R + H_2O \longrightarrow M-OH + R-OH\uparrow$$

(hydrolysis)

Metal alkoxide

$$M-O-R + M-OR \longrightarrow M-O-M + R-OH\uparrow$$

Metal alkoxide (Condensation

2 Conversion of Sol to Gel

Further condensation of sol into a three dimensional network produce a gel material

3. Aging of the Gel

Poly condensation reaction continue until the gel transforms into a solid mass accompanied by contraction of the gel networks and expulsion of solvent from gel pores. The aging process of gels can exceed 7 days.

Q.4c What are liquid crystals? Explain the classification, properties and applications of liquid crystals in display systems (7 marks)

Ans: Liquid crystals (LC's) are composed of moderate size organic molecules having properties between solids and liquids.

Classification of LCD's

(1) Twisted Nematic (TN):- Which are inexpensive while having high response time. However, TN displays have low contrast ratios, viewing angles and colour contrasts.

(2) In Panel Switching displays (IPS Panels), which boast much better contrast ratio's, viewing angles and colour contrast when compared to TN LCD's.

2) Substances that are most likely to form liquid crystal phase at a certain temperature are molecules that are Elongated and have some degree of rigidity.

Applications

(1) Liquid Crystals are ~~evey~~ everywhere

(2) They are used in all kinds of display devices including computer monitors and laptop screens.

(3) TV's, clocks, visors and navigation systems

(4) LCD's are available to display arbitrary images (as in a general-purpose computer display) of fixed images with low information content which can be displayed and hidden

4) Carbon nano fibers, polymer nano fibers graphite nano fibers, collagen nano fibers cellulose nano fibers etc

5) Nano fibers are used in making different textile materials with desired characteristics.

Applications of Nano fibers

(1) CNF's are very suitable for electrical and thermal conductivity applications due to their high degree of crystalline orientation.

(2) The various CNF-based composites as gas sensors to detect, H_2S, NH_3, NO_2 and explosive gases (CO, CH_4, H_2 and ethanol) at low ppm concentration.

3) They proved that this fibro mat has better drug delivery properties with excellent clearance and undelivered fibers with homo compatibility and low toxicity post intravenous administration.

Applications of Nano-Sensors.

→ To detect various chemicals in gases for pollution monotoring

→ For medical diagnostic purposes either as blood borne sensors or in lab on a chip type devices

→ To monitor physical parameters such as temperature, displacement and flow

→ To monitor plant signaling and metabolism to understand plant biology

→ To study neuro transmitters in brain for understanding neurophysiology.

8b Mention the properties and applications of

(1) Organic Light Emitting Diodes (OLED's)

(2) Quantum Light Emitting Diodes (QLED's)

(7marks)

Application of OLED

(1) Broadly speaking you can used OLED displays wherever, you can use LCD's in such things as TV and computer screens and MP_3 and cell phone displays.

(2) Their thinners, greater brighteners, and better colour reproduction suggests they will find many other exciting applications in future.

(2) QLED's

Property :

(1) Quantum dots (QD's) are promising materials for the emissive component of self-emissive diodes (LEDs) due to their high colour saturation in a narrow wavelength range, easy colour tunability

Q8c What are perovskite material? Give the properties and applications of perovsite materials in optoelectronic devices. (7 marks)

Ans:- Perovskite materials have emerged as the most promising and efficient low cost energy materials for various optoelectronic and photonic device applications

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.

Applications of Perovskite materials.

→ Perovskite materials are also widely used in LED's, Photodetectors, nanolasers

Ans: An electrode having fixed potentials which can be used as a reference to measure the potential of another electrode

Construction :- The saturated calomel electrode (SCE) is a reference electrode based on the reaction between elemental mercury and mercury chloride.

The calomel electrode consists of two glass tube. At the inside the glass tube there is a paste of mercury and mercurous chloride (calomel) (Hg_2Cl_2) at the bottom of a narrow glass tube having a porous plug at the bottom. Pure mercury is filled above paste and connected with platinum wire for electrical connections. This narrow tube placed inside an outer glass tube filled with a saturated KCl solution. KCl soln of 0.1M or of 1M can also be used.

When it acts as anode, the electrode reaction is

$$2Hg + 2Cl^- \longrightarrow 2Hg_2Cl_2 + 2e^-$$

Thus oxidation takes place when it is coupled with another electrode having lower oxidation potential.

When it is acts as cathode, the electrode reaction is

$$2Hg_2Cl_2 + 2e^- \longrightarrow 2Hg + 2Cl^-$$

Thus reduction takes place when it is coupled with another electrode having greater oxidation potential.

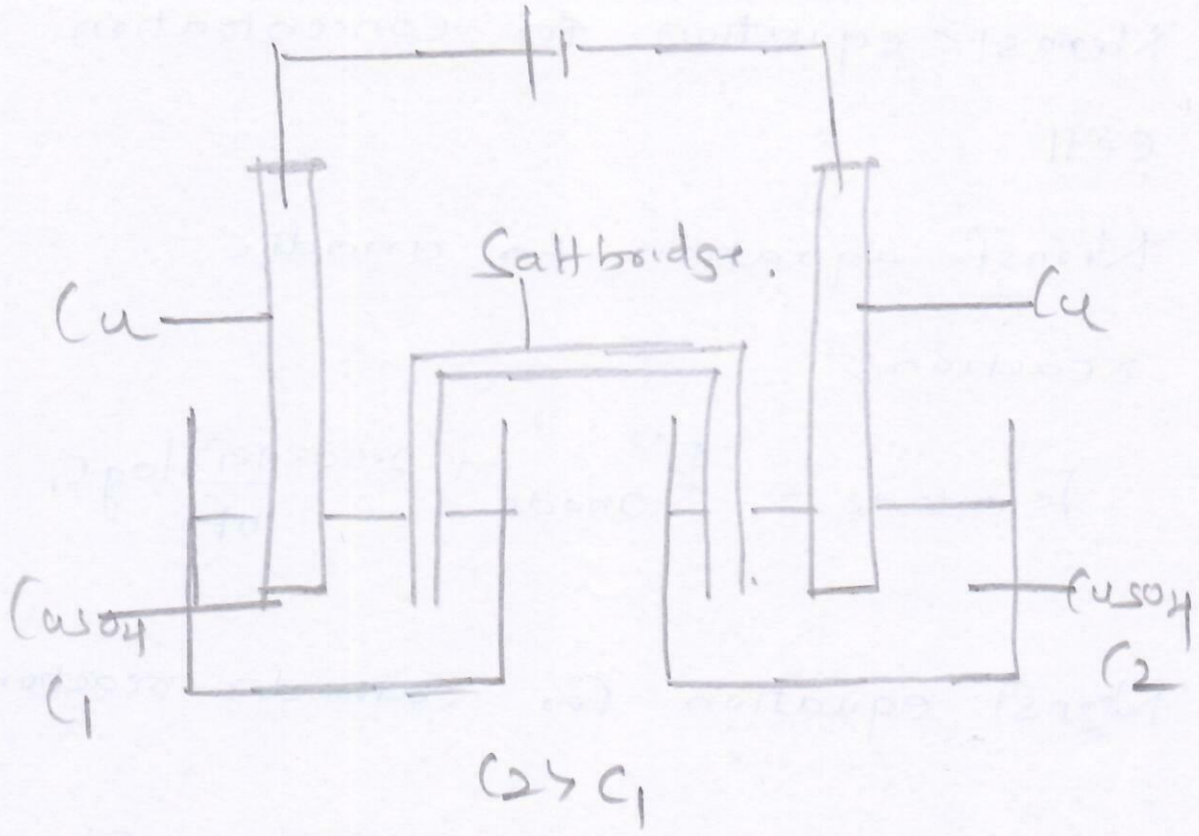
The net reversible electrode reaction

$$2Hg_2Cl_2 + 2e^- \longrightarrow 2Hg + 2Cl^-$$

Electrode potential

$$E = E^\circ - 2.303 \frac{RT}{2F} \log [Cl^-]^2$$

$$E = E^\circ - 0.0591 \log [Cl^-] \text{ at } 298K.$$



$C_2 > C_1$

Cell Representation

$$Cu|Cu^{2+}(C_1 = 0.001M) \,||\, Cu^{2+}(C_2 = 0.1M)|Cu$$

Cell Reaction

At Anode

$$Cu \longrightarrow Cu^{2+}(C_1 = 0.001M) + 2e^-$$

At Cathode

$$Cu^{2+}(C_2 = 0.1M) + 2e^- \longrightarrow Cu$$

Net Reaction

$$Cu^{2+}(C_2 = 0.1M) \longrightarrow Cu^{2+}(C_1 = 0.001M)$$

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

$$E_{cell} = \frac{0.0591}{n} \log \frac{C_2}{C_1} \text{ at } 298K.$$

9c What are optical sensors ? Explain the principle and instrumentation of colorimetric sensor (7 marks)

Ans: Optical sensors have two basic Methods, to obtain ~~sens~~ sensor data from target molecules that are label based and label free method.

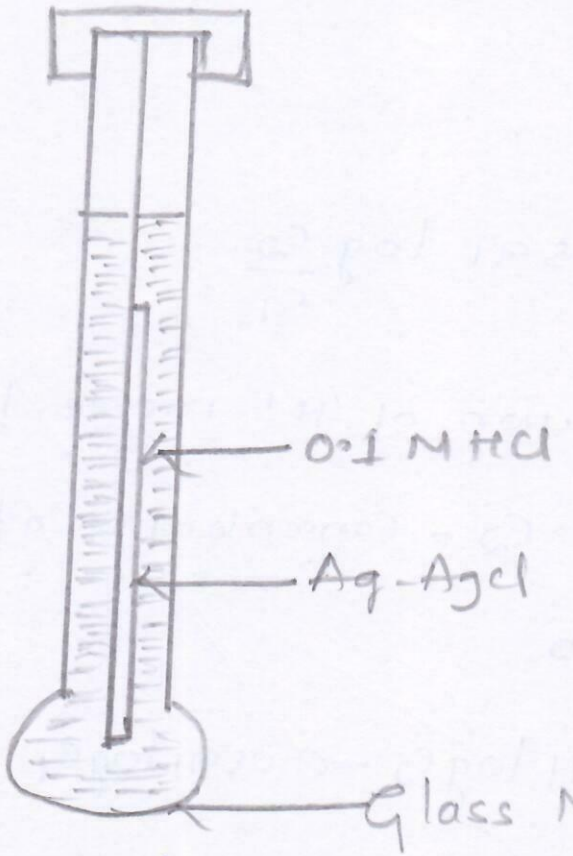
Optical Sensors use visible or ultraviolet light to interrogate Sensors for analysis Optical sensors can be represented in general terms as a wavelength-selectable light source the sensor material itself interacting with analytes, and a light detector.

Colorimetry (Quantitative Measurement of absorbance or reflectance spectra) is of course, one of the oldest of analytical techniques and colorimetric sensors stretch back even before the beginnings of chemistry.

→ Colorimetric detection is a fairly simple technique and the advent of universal digital imaging has given it new and exciting possibilities

→ We will use the general term colorimetry to include simple colour (RGB) imaging hyperspectral imaging (more colour channels) full spectrophotometry ie hundreds of colour channels with nano-meter resolution.

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% of CaO.



The electrode can be represented as

Ag | AgCl | 0.1 M HCl | glass Membrane.

Working of glass electrode

When a glass bulb containing 0.1 M HCl is immersed in an acidic solution of different concentration, a boundary potential (E_b)

The final equation for Eb is obtained as

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

The potential of glass electrode [E_g] includes contribution from 3 factors.

→ Boundary Potential (E_b)

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

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

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

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

$$E_g = L - 0.0591\,pH.$$

Where Constant

$$L = K + E_{Ag/AgCl} + E_{asy}$$

The cell formed is represented as

$Hg \mid Hg_2Cl_2 \mid KCl \,||\, Solution\ of\ unknown\ pH \mid Glass$ electrode

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

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

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

Substituting for E_g

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

The above equation is arranged to obtain the expression for pH

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

b) What are potentiometric sensors? Explain working principle instrumentation and application of potentiometric sensor (7 marks)

~~The~~ Mea
to a potential meter.

4) The titrant is added in increments of 0.5 ml 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 $K_2Cr_2O_7$ of $KMnO_4$. The oxidizing agent is useally taken in the burette.

Applicatoins:

1. It is used in oxidation reduction titrations to estimate the concentration of analyte in the sample solution
2. The potential of the electrode depends on the concentration of the substance being oxidised or reduced.

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

$$= \frac{0.0591}{1} \log \frac{C_2}{C_1}$$

$$= 0.0591 \log \frac{0.1}{0.01}$$

$$= 0.0591 \log 10$$

$$= 0.0591 \times 1$$

$$= \underline{0.0591 \text{ V}}.$$

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