



18CHE12

OR

- 6 a. Explain the preparation of solar grade Silicon by Union Carbide process. (07 Marks)  
b. Write a note on (i) Power alcohol (ii) Unleaded petrol. (06 Marks)  
c. 0.75 g of coal sample (Carbon 90%, H<sub>2</sub> 5% and ash 5%) was subjected to combustion in Bomb calorimeter. Mass of water taken in calorimeter was 2.5 kg and the water equivalent of calorimeter is 0.65 kg. The rise in temperature was found to be 3.2°C. Calculate higher and lower calorific values of the sample. Latent heat of steam = 2457 kJ/kg and specific heat of water = 4.187 kJ/kg/°C. (07 Marks)

**Module-4**

- 7 a. What are the causes, effects and disposal methods of e-waste? (07 Marks)  
b. What are the sources, effects and control of lead pollution? (Pb pollution). (07 Marks)  
c. In a COD test, 30.2 cm<sup>3</sup> and 14.5 cm<sup>3</sup> of 0.05 N FAS solutions are required for a Blank and Sample titration respectively. The volume test sample used was 25 cm<sup>3</sup>. Calculate the COD of the sample solution (06 Marks)

OR

- 8 a. Explain the sources, effects and control of oxides of nitrogen. (07 Marks)  
b. Explain softening of water by ion exchange method. (07 Marks)  
c. Explain the Activated sludge treatment of sewage water (06 Marks)

**Module-5**

- 9 a. Explain the theory, instrumentation and application of Atomic absorption spectroscopy. (07 Marks)  
b. Explain the theory and instrumentation of potentiometry. (07 Marks)  
c. Write a note on Fullerene. Mention its application. (06 Marks)

OR

- 10 a. What are Nanomaterials? Explain the synthesis of nanomaterials by precipitation method. (07 Marks)  
b. Explain the synthesis of Nano materials by Sol-Gel technique. (06 Marks)  
c. Explain the theory and instrumentation of conductometry. (07 Marks)

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First Semester BE - Degree Examination  
Dec - 2018/2019.

## Engineering Chemistry

1a. Define Terms (1) Free energy 2) Entropy  
3) Cell potential. (06 Marks)

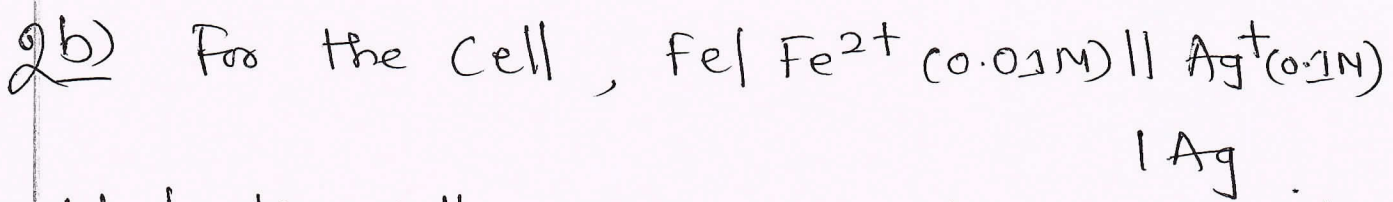
Ans:

Free energy (G): The Spontaneity of a process can't be predicted on the basis of enthalpy or entropy alone. For this purpose a new function called Gibbs free energy is defined. It is defined as the maximum amount of energy available to a system to perform useful work.

Entropy (S): It has been regarded as a measure of disorder or randomness of a system.

Cell potential: The potential difference between the two electrodes of a galvanic cell which.

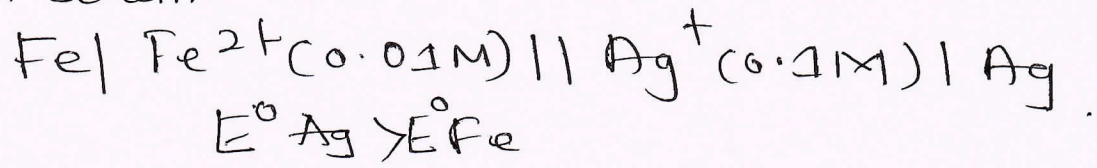
Causes the flow of current from one electrode (higher potential) to the other (lower potential) is called electromotive force (emf) of the cell or the cell potential.



Write the cell reaction and calculate the cell <sup>emf</sup> at 298 K. if standard potentials of Fe and Ag electrodes are -0.44V and +0.8V respectively. (07 marks)

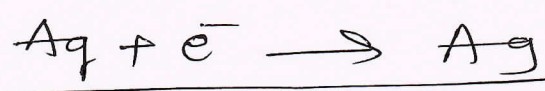
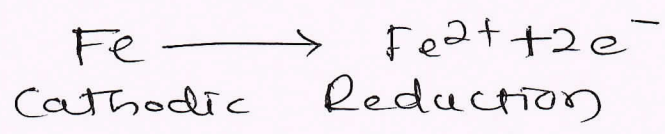
Ans:

Cell Scheme

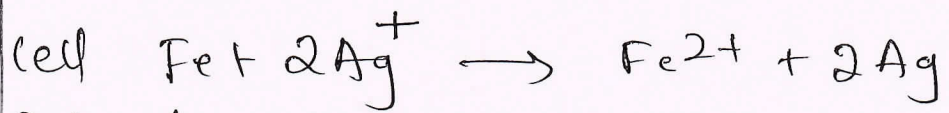
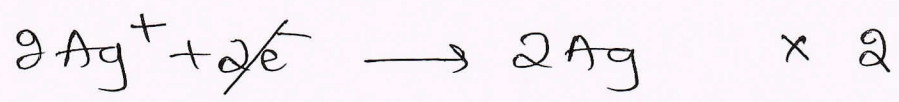
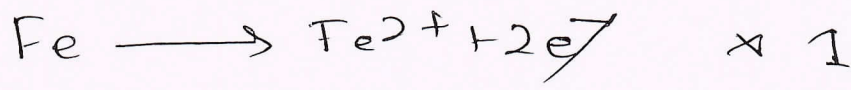


For Anodic Oxidation ..

Fe acts as Anode and Ag acts as Cathode.







Potential

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} + 2.303 \frac{RT}{nF} \log \frac{[\text{Reactant}]}{[\text{Product}]}$$

$$E_{\text{cell}} = E_R^{\circ} - E_L^{\circ} + 2.303 \frac{RT}{nF} \log \frac{[\text{Reactant}]}{[\text{Product}]}$$

$$E_{\text{cell}} = (0.8 - (-0.44)) + 2.303 \times \frac{8.314 \times 298}{2 \times 96500} \log \frac{[0.1]^2}{[0.01]}$$

$$E_{\text{cell}} = 1.24 + \frac{0.0591}{2} \log \frac{[0.1]^2}{[0.01]}$$

$$E_{\text{cell}} = 1.24 + 0.02955 \times \frac{0.01}{0.01} \log \frac{0.01}{0.01}$$

$$= 1.24 + 0.02955 \log(1)$$

$$= 1.24 + 0$$

$E_{\text{cell}} = 1.24 \text{ V}$

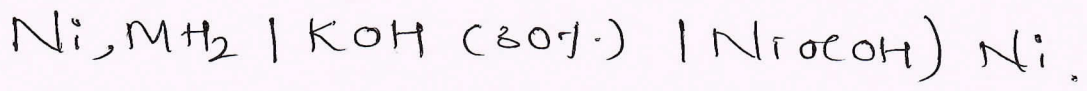
Qc. What are Secondary Batteries? Explain the construction and working of Nickel-MH metal hydride battery. Mention its applications. (07 Marks).

Ans: Reversible, are recharged, after discharge from an external source of emf by reversal of polarity of the electrodes.

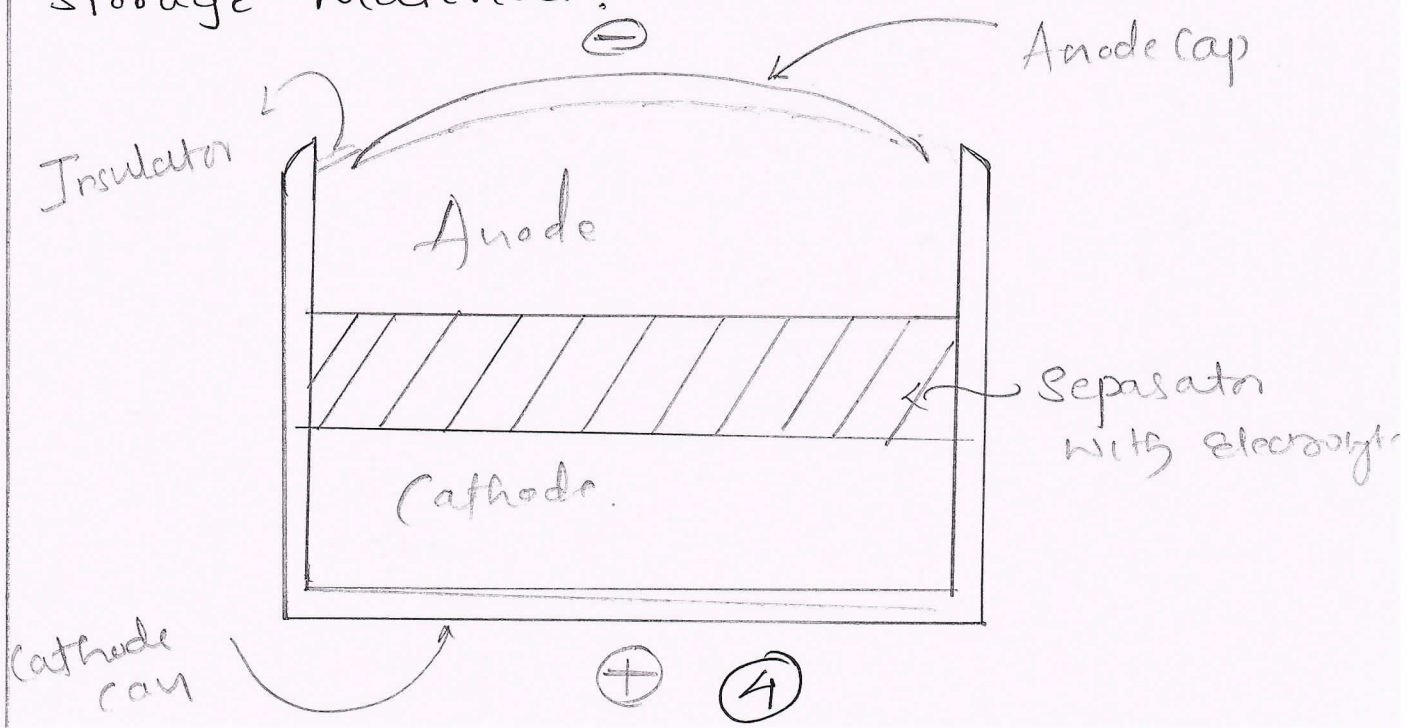
Nickel-Metal hydride battery.

Construction

The cell is schematically represented as



Where  $MH_2$  is a metal hydride with hydrogen storage material.





Anodic Material : Metal hydride such as  $VH_2$ ,  $ZrH_2$ ,  $TiH_2$  etc. with hydrogen storage alloy such as  $LaNi_5$ ,  $TiZr_2$ ,  $TiNi$  etc.

Anodic material permits the reversible electrochemical storage and release of hydrogen during charging and discharging of the battery and is corrosion resistant.

Cathodic Material :  $Ni(OH)_2$  - Nickel oxy  
or hydroxide.

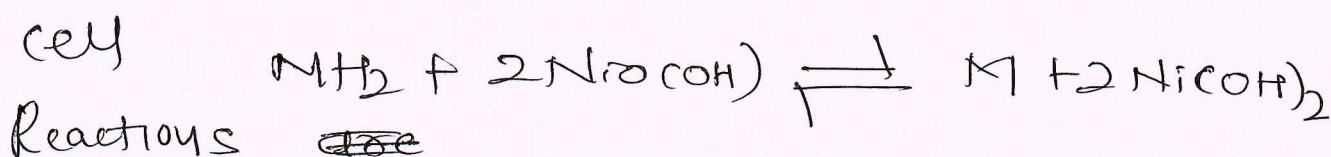
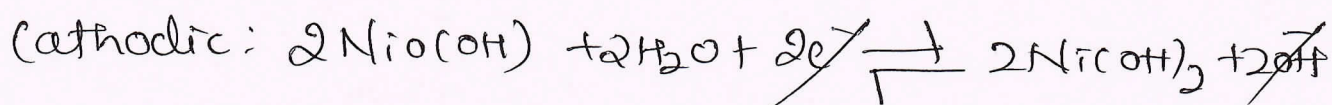
Electrodes : are made of porous Ni-foil or grid onto which the active materials are either coated or pasted.

Electrolyte : Aqueous solution of  $KOH$  (30%).

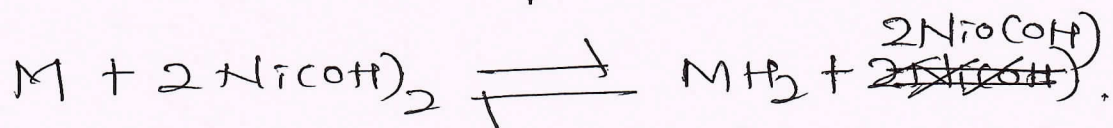
Separator : Synthetic non-woven ~~poly~~ polypropylene is used.

Working : The cell/battery works by following reactions during discharge and recharge.

During Discharge:



Reactions are reversed during discharge with opposite polarity.



Cell potential - 1.25 - 1.35 V.

Qa. Define Primary, Secondary and Reversible batteries with example. (06 Marks)

Ans:

(1) Primary battery: Irreversible, to be discarded on discharge. Function as galvanic cells during discharge

Eg: Zn-MnO<sub>2</sub> battery, Cu-MnO<sub>2</sub> battery.

(8)



## 2) Secondary batteries

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

Eg: Pb-H<sub>2</sub>SO<sub>4</sub> battery.

## 3) Reserve Batteries

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

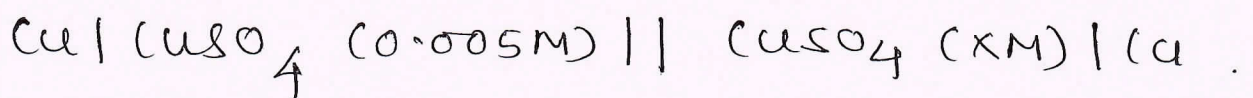
Pb | Acid | PbO<sub>2</sub> battery

Zn | KOH | Ag<sub>2</sub>O battery.

2b What are Concentration cells? The cell potential of Copper Concentration Cell

$\text{Cu} | \text{CuSO}_4 (0.005\text{M}) || \text{CuSO}_4 (x) | \text{Cu}$  is  $0.0295\text{V}$  at  $25^\circ\text{C}$ . Calculate the value of  $x$ . (6 Marks)

Ans: Def<sup>n</sup> of Concentration Cell  
A cell constructed by the combination of two electrodes made of the same chemical substance but with changing concentration of the electrolyte or electrode's concentration cell.



$$E_{\text{cell}} = 0.0295\text{V} \quad T = 25^\circ\text{C} + 273\text{K} = 298\text{K}$$

$$[x] = ? = C_1$$

$$[0.005\text{M}] = C_2$$

$$n = 2$$

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

$$0.0295 = 2.303 \times \frac{8.314 \times 298}{2 \times 96500} \log \frac{[x]}{[0.005]}$$



$$0.0295 = \frac{0.0591}{2} \log \frac{[X]}{[0.005]}$$

$$0.0295 = 0.02955 \log \frac{[X]}{[0.005]}$$

$$\frac{0.0295}{0.02955} = \log \frac{[X]}{[0.005]}$$

$$1 = \log \frac{[X]}{[0.005]}$$

$$\text{Ant } [1] = \frac{X}{[0.005]}$$

$$10 = \frac{X}{0.005}$$

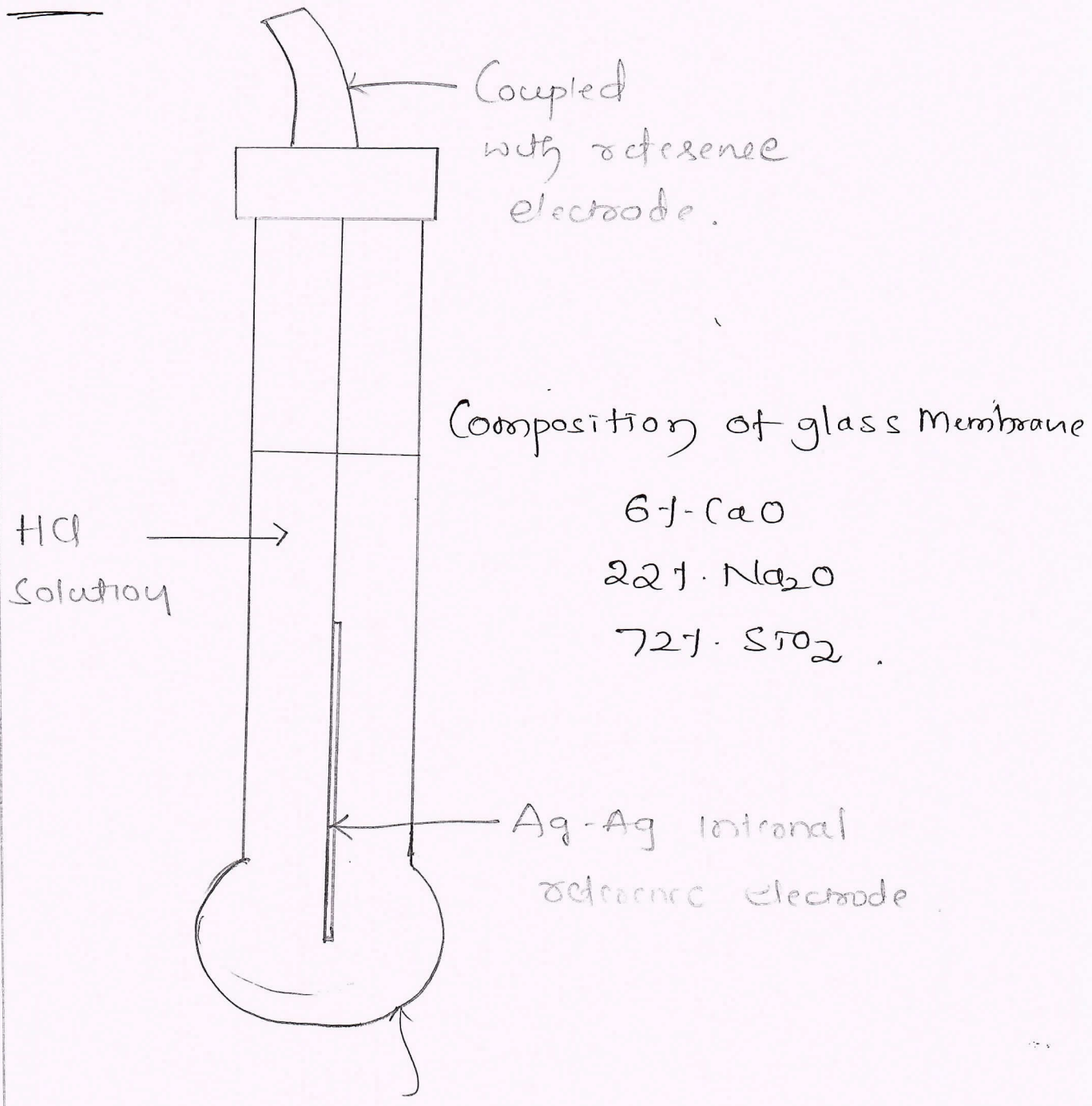
$$10 \times 0.005 = X$$

$$X = 0.05 \text{ M.}$$

$$\underline{C_2 = 0.05 \text{ M}}$$

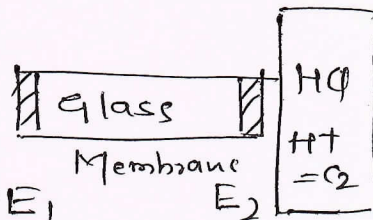
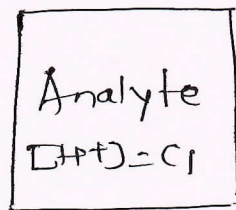
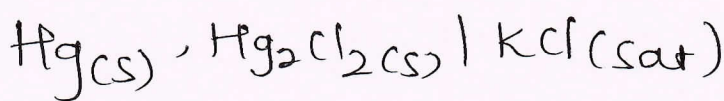
Q Explain the Construction and Working of glass electrode giving its application in determination of pH solution (08 marks)

Ans:



Glass Membrane bulb with special composition (H<sup>+</sup> ions)





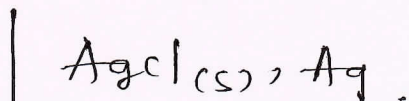
External Reference

Unknown

$E_b = E_1 - E_2$

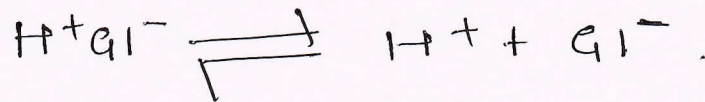
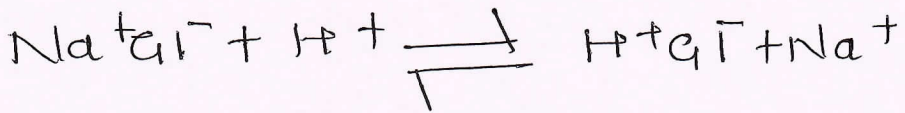
Electrode -1

(with known potential)



Internal Reference Electrode -2

Reactions:



Glass Membrane

$E_b = E_1 - E_2$

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

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

$= -0.0591 \log C_2 + 0.0591 \log C_1$  at 298K

for univalent ion H<sup>+</sup>  
n=1.

$$E_b = d - 0.0591(-\log c_1) \quad \text{Where}$$

$$d = -0.0591 \log c_2$$

$$E_b = L - 0.0591(-\log [H^+]) \quad \text{Because } c_2 \text{ becomes Constant.}$$

Thus boundary Potential

$$E_b = L - 0.0591 \text{pH}$$

Where pH is referred to the pH of test solution (Analyte).

$$E_R = E_G = E_{REF-2} + E_b + E_{asy}$$

$$E_G = E_{REF-2} + (d - 0.0591 \text{pH}) + E_{asy}$$

right side electrode potential or glass membrane electrode potential

$$E_R = E_G = (E_{REF-2} + d + E_{asy}) - 0.0591 \text{pH}$$

$$E_R = E_G = E_G^0 - 0.0591 \text{pH}$$

$$E_G^0 = E_{REF-2} - 0.0591 \log c_2 + E_{asy} \\ = \text{constant}$$

Glass Membrane electrode potential is thus a function of  $H^+$  ion concentration or pH of analyte.

$$E_L = E_{REF-1} = E_{SCE}$$

Cell potential is given by

$$E_{cell} = E_R - E_L$$

$$= E_q - E_{REF-1}$$

$$= E_q^{\circ} - 0.0591 \text{ pH} - E_{REF-1}$$

$$\text{pH} = \frac{E_q^{\circ} - E_{REF-1} - E_{cell}}{0.0591}$$

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

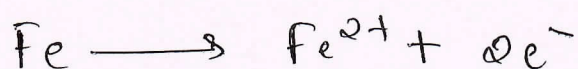
3a: Define Corrosion. Describe electrochemical theory of Corrosion taking rusting of iron as an example. (07 marks)



Ans: Electrochemical theory of Corrosion is called as wet Corrosion since aqueous medium or moist air is required for corrosion to take place. According to electrochemical theory of Corrosion of metal takes place due to the formation of anodic and cathodic regions on the same metal surface or when two different metals.

For example:

When iron undergoes Corrosion

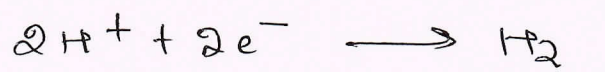


But the cathodic reactions are more complicated than anodic reactions, as the constituent of the Corrosion medium are involved in the reaction and is dependent on the nature of Corrosion Environment

At cathodic reaction (Region)

Liberation of hydrogen takes place in the absence of oxygen.

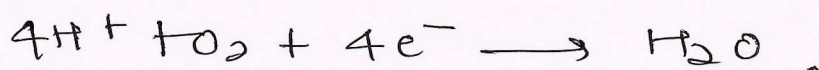
In acidic medium and in the absence of oxygen, the Cathodic reaction is.



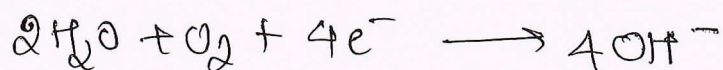
Neutral or alkaline, in the absence of oxygen, hydroxide ions are formed with simultaneous liberation of hydrogen



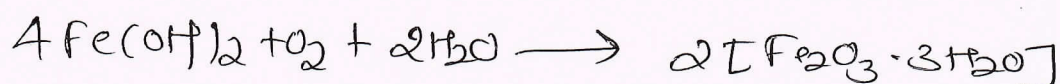
Absorption of oxygen takes place. In the presence of oxygen



In Neutral or alkaline medium and in the presence of oxygen, hydroxide ions are formed by the following reaction



Corrosion of iron produces  $\text{Fe}^{2+}$  ions and  $\text{OH}^-$  ions at the anode and cathode sites.



Rust.

3b) Explain a) Waterline Corrosion

b) Pitting Corrosion

(06 marks)

Ans:

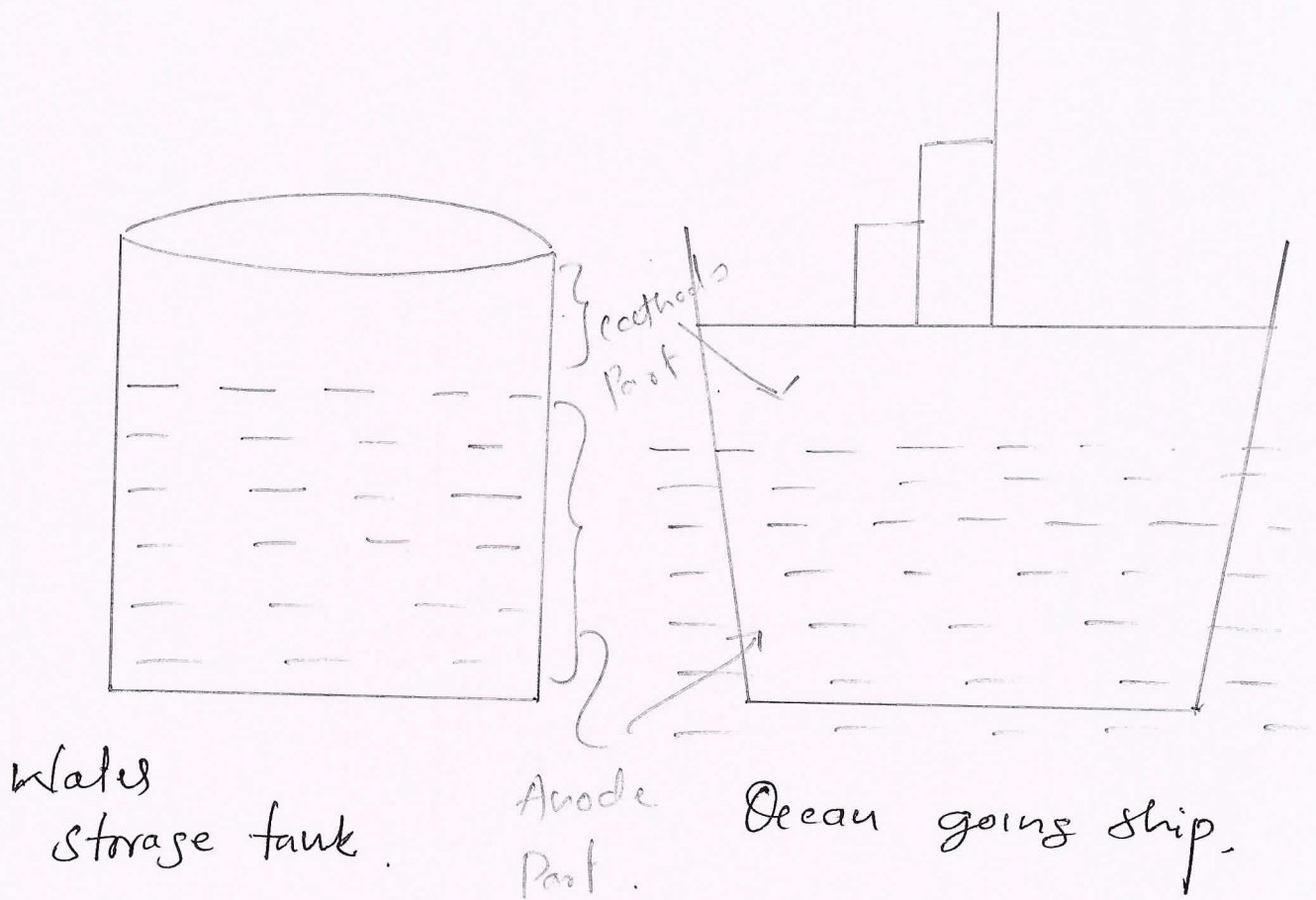
### Waterline Corrosion

The water line corrosion takes place due to the formation of differential oxygen concentration cells. The part of the metal below the water line is exposed only to dissolved oxygen while the part above water is exposed to higher oxygen concentration of the atmosphere.

Thus a part of the metal below the water acts as anode and undergoes corrosion and that part above the water line is free from corrosion.

Waterline corrosion is most common in water storage steel tanks, ocean going ships.



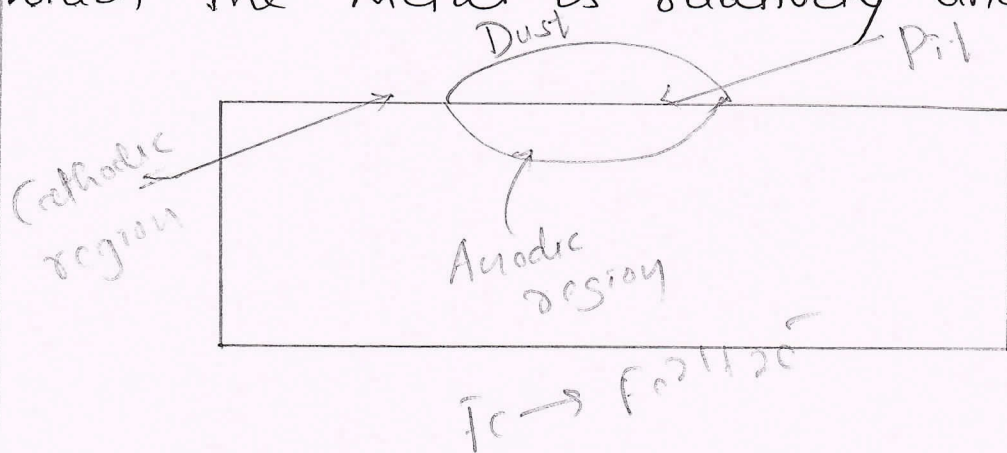


### Pitting Corrosion

Pitting Corrosion is generally due to the deposition of a drop of water or an electrolyte or dust particles placed on the surface of a clean sheet of metal.

The metal below the deposit is exposed to lower oxygen concentration, acts as anode and undergoes corrosion. The metal surrounding the deposit acts as cathode. Since it is

exposed to <sup>higher</sup> ~~lower~~ oxygen concentration, acts ~~as~~ anode. ~~and~~. Because, of the small anodic area and large cathodic area accelerated corrosion takes place below the deposit. Once the corrosion product formed, it further provides the conditions for differential aeration below the corrosion product and surrounding the metal part. The pit grows and ultimately may cause failure of the metal. Pitting corrosion is ~~total~~ localized and accelerated corrosion resulting in the formation of pits and or pin holes, around which the metal is relatively unattacked.



3c. What is electroless plating. Explain electroless plating of Nickel. (07 marks).

Def<sup>n</sup>: Electroless plating is an autocatalytic reduction of metal ions with the help of a reducing agent on a catalytic active substrate without using electricity.

Pretreatments Electroless plating of Nickel

Pretreatments: The surface to be plated is first degreased by using organic solvents or alkali followed by acid treatments.

→ Metals and alloys like Al, Cu, Fe etc by directly nickel plated without any activation

→ stainless steel surface is activated by dipping in hot solution of 50% dil  $H_2SO_4$

→ Activation of Mg Alloy surface is carried out by giving a thin coating of Zn and Cu over it.



Activation of Non-metallic articles is carried out by first dipping in  $\text{SnCl}_2$  solution containing  $\text{HCl}$ . Followed by dipping of palladium chloride solution. On drying of this activating layer of Pd is formed on surface.

### Composition:

- 1) Coating solution :  $\text{NiCl}_2$  solution 20 gm/litre.
- 2) Reducing Agent : sodium hypo phosphate 20 gm/litre.
- 3) Buffer : sodium acetate 10 gm/litre.
- 4) Complexing Agent : sodium Succinate 15 gm/litre.
- 5) Optimum pH = 4.5
- 6) Optimum temperature =  $93^\circ\text{C}$ .

4a. What is meant by Metal finishing?

Mention (any five) technological importance of metal finishing.

Ans: Definition :

It is process of modifying surface properties of metals by deposition of a layer of another metal or polymer on its surface by the formation of a oxide film.

Technological Importance

- 1) Imparting the metal surface to higher corrosion resistance
- 2) Imparting improved wear resistance
- 3) Providing electrical and thermal conducting surface
- 4) Imparting thermal resistance and hardness
- 5) Providing optical and thermal reflectivity.

4b Explain the process of 1) Galvanizing.  
2) Anodizing of Al. (07 marks)

Ans: Galvanizing is a process of coating a base metal (Iron) surface with zinc metal. It involves dipping the base metal into the molten anodic metal.

The coating metal should melt at relatively low temperature and the base metal must withstand this temperature without undesirable changes in its properties.

Galvanization is carried out by hot dipping method. This process involves the following steps.

1) The metal (Iron) surface is passed with organic solvents to remove organic matter on the surface

2) The metal sheet is passed through dilute sulphuric acid (pickling) to remove the rust and other deposits.



- 3) Finally the articles are well washed with water and air dried.
- 4) The article treated with mixture of aqueous solution of molten zinc chloride and ammonium chloride and dried to prevent the oxidation of zinc.
- 5) The treated sheet is dried and dipped in a molten Zn maintained at  $430-470^{\circ}\text{C}$ .
- 6) The excess zinc on the surface is removed by passing through a pair of hot rollers, which wipes out excess of zinc coating and produces a thin coating.

## Anodizing of Aluminium.

Degreased and polished aluminium metal object is made as anode, steel or copper is made the cathode. The electrolyte consist of 5-10% chromic acid. The temperature of the bath is maintained at 35°C. A potential is applied and gradually increased from 0 to 40V during the first 40 min. Anodizing is continued for 20 min at 40V. After 20 min the potential is increased to 50V and held at this potential for five minutes. A thin oxide layer ( $Al_2O_3$ ) of 2-8 microns thickness is formed. Higher thickness is obtained by addition of 10%  $H_2SO_4$  at 22°C, and maintaining current density at 24V gives 24 micron thickness.

Applications: Aircrafts, window frames, utensils as corrosion resistance.

Qc What is electroplating? Explain Electroplating of Chromium. Mention why Chromium cannot be used as anode (07 marks)

Ans: Definition,

It is a process of modifying Surface properties of metals by deposition of a layer of another metal or polymer on its surface by the formation of an oxide film.

Electroplating of Chromium (Hard and Decorative Chromium) Chromium is widely used metal ion

Electroplating. Two types of Chromium are used hard and decorative Chromium.

Reactions:



Components	Hard Chromium	Decorative Chromium
Anode	Lead with up to 7% Sn or Sb	Lead with up to 7% Sn or Sb
Cathode	Article to be plated	Article to be plated
Bath Composition	$H_2CrO_4$ (250-300g/liter) and $H_2SO_4$ (2.5 to 300g/l)	$H_2CrO_4$ (250 to 300g/L) and $H_2SO_4$ (2.5 to 300g/L)
Current density (mA/cm <sup>2</sup> )	290 - 380	150 - 430
Temperature	45 to 60	45 to 60
Current Efficiency	17 to 20	10 to 15
Applications	Extensively used in industrial and engineering applications such as hydraulic cylinders rods.	Provides durable and good finish on automobiles surgical instruments etc.

5a Define Calorific Value of Fuel. Explain the experimental determination of Calorific Value of solid/liquid fuel using Bomb Calorimeter. (08 marks).

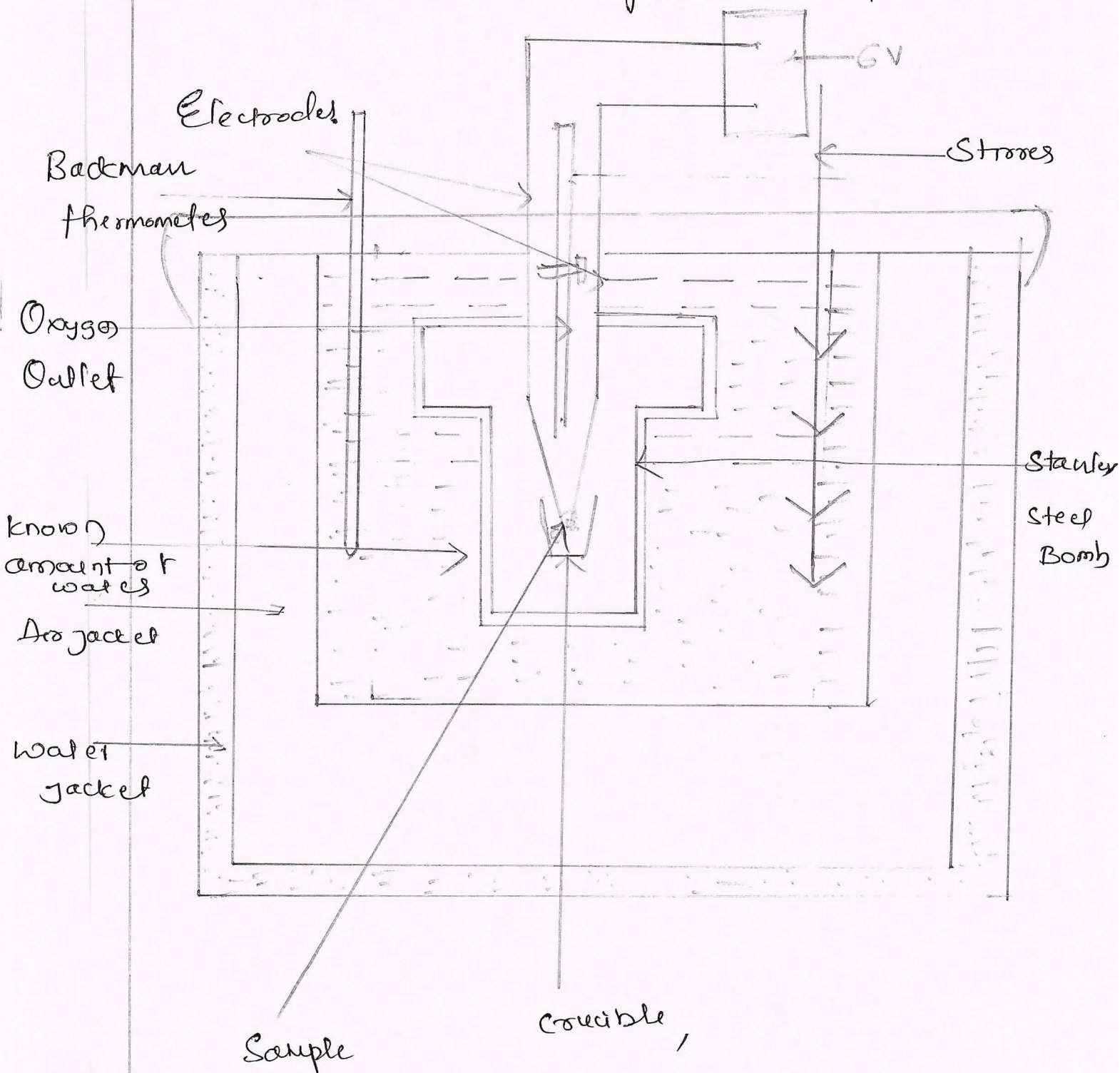
~~Determination~~

Ans: Principle: A known mass of the solid sample is burnt in excess oxygen. The surrounding water and the calorimeter absorbs the heat liberated. Thus the heat liberated by the fuel is equal to the heat absorbed by the water and the calorimeter.

Construction: The bomb calorimeter consists of a stainless steel vessel with an airtight lid. This vessel is called bomb. The bomb has an inlet valve for providing oxygen atmosphere inside the bomb, and an electrical ignition coil for starting of combustion of fuel. (27)



The Bomb placed in an insulated Copper Calorimeter. the Calorimeter has a mechanical Stirrer for dissipation of heat, and a thermometer for reading the temperature,





Working: A known mass of the solid fuel is placed in a crucible. The crucible is placed inside the Bomb. The lid is closed tightly. The Bomb is placed inside a copper calorimeter. A known mass of water is taken in the calorimeter. The bomb is filled with oxygen at a pressure of 25-30 atm. The temperature  $T_1$  in the thermometer is noted. On passing electric current through the ignition coil, the fuel gets ignited. The fuel burns liberating heat. The water is continuously stirred using the stirrer. The maximum temperature attained by the water  $T_2$  is noted.

Observations & Calculations.

$$\text{Gross Calorific Value} = \frac{(W_1 + W_2) \times \Delta T \times S}{m} \text{ J/kg}$$

Mass of Fuel =  $m$  kg

Mass of Water taken =  $W_1$  kg

Water Equivalent of Calorimeter =  $W_2$  kg

Initial temperature of water =  $T_1$  °C.

Final temperature of water =  $T_2^\circ\text{C}$

Change in temperature =  $t = (t_2 - t_1)^\circ\text{C}$

Specific heat of water =  $5 \text{ J kg}^{-1} \text{K}^{-1}$

$$= 4700 \text{ kJ/kg/K}$$

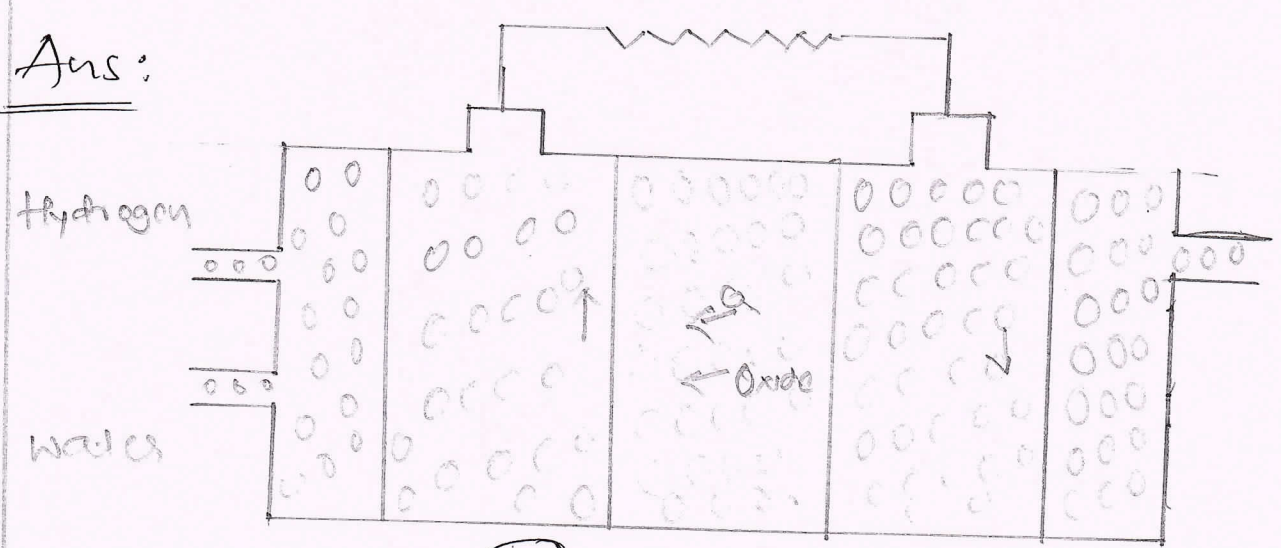
Therefore,  $\eta$  of hydrogen is given by,

$\text{NCV} = \text{GCV} - \text{Heat of condensation of steam formed from 1 kg of fuel.}$

$$= \text{GCV} - 0.09 \times 587 \times 4.187 \text{ kJ/kg}$$

5b) What are fuel cells? Describe the construction and working of solid oxide fuel cells. (SOFC) (06 marks)

Ans:



Anode: Porous cermet made of Nickel, and YSZ (YSZ is  $Y_2O_3$ ) stabilized Zirconia, ( $ZrO_2$ ).

Cathode: Porous strontium doped Lanthanum Manganite.

Electrolyte: Yttria ( $Y_2O_3$ ) stabilized Zirconia ( $ZrO_2$ ).

Active Components

Fuel - Hydrogen ( $H_2$ ) or Carbon Monoxide ( $CO$ )  
or Methane ( $CH_4$ ).

Oxidant - Oxygen supplied at cathode.

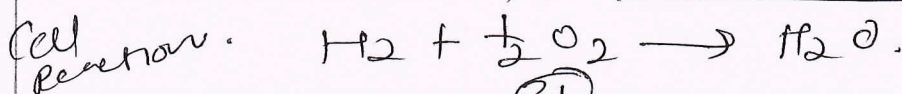
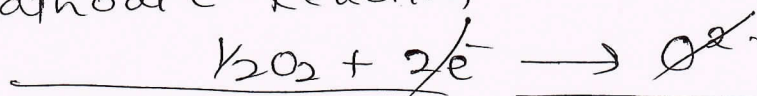
Working

Following reactions occur during the operation of the cell or battery at anodic and cathodic compartments.

Anodic Oxidation



Cathodic Reaction



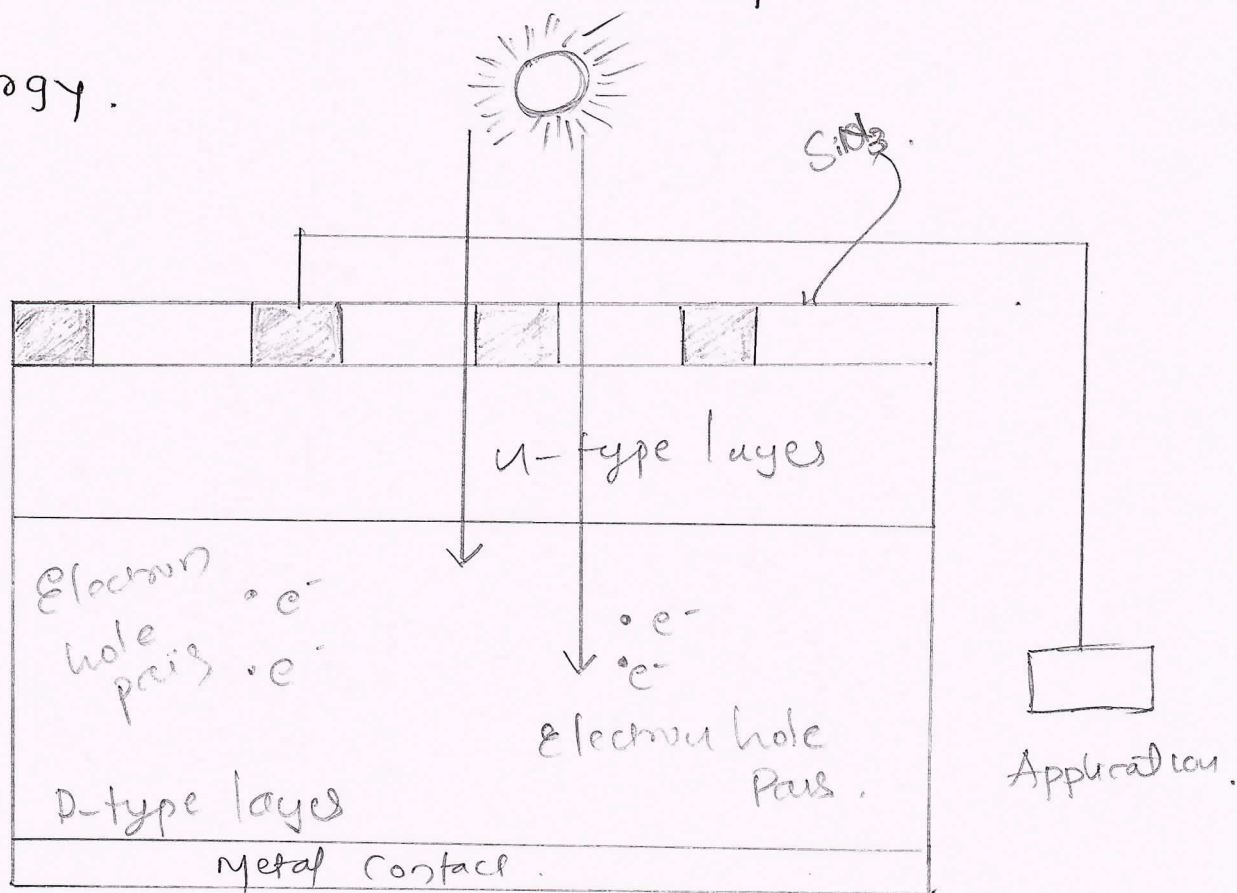


Cell potential = 0.98 V.

Application: large scale power production, plants, for industrial applications.

5c What are solar cells? Explain the construction and working of Photovoltaic cells (PV cell)? (06 marks).

Ans: Solar cells are semiconductor device which convert solar energy into electrical energy.



1) A typical silicon photovoltaic cell is composed of a thin wafer consisting of an ultra thin layer of phosphorous doped (n-type) silicon on top of the boron doped (p-type) silicon.

2) Hence p-n junction is formed between the two.

3) A metallic grid forms one of the electrical contacts of the ~~anode~~ diode and allows light to fall on the semiconductor between the grid lines.

4) An anti reflective layer between the grid lines increase the amount of light transmitted to the semiconductor.

5) The cells other electrical contact is formed by a metallic layer on the back of the solar cells.

6) When light radiation falls on the p-n junction diode, electron-hole pairs are generated by the absorption of the radiation.

7) Electrons are drifted to and collected at the n-type end and the holes are drifted to and collected at the p-type end.

8) When these two ends are electrically connected through a conductor, there is a flow of current between the two ends through the external circuit.

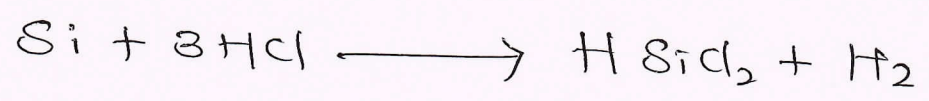
9) Thus photovoltaic current is produced and available for use.

6a. Explain the preparation of solar grade silicon by Union Carbide process. (07 marks)

Ans: The metallurgical grade silicon is treated with dry HCl gas at  $300^{\circ}\text{C}$  to form trichlorosilane and small amount of tetrachlorosilane. (34)



The mixture is distilled to get pure trichlorosilane



Trichlorosilane.



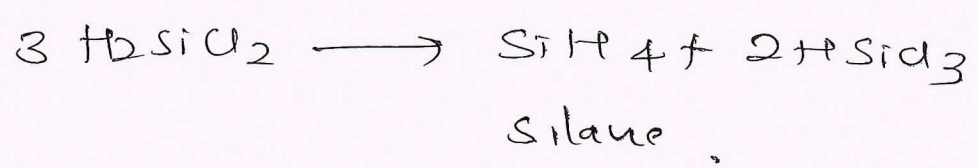
Tetrachlorosilane.

The mixture is distilled to get pure tetrachlorosilane (SiCl<sub>4</sub>), is reduced to trichlorosilane by heating with hydrogen at 1000°C in a reactor.



The trichlorosilane is then passed through fixed bed columns containing quaternary ammonium ion exchange resins catalysts

The products are separated by distillation



The products obtained in the above process are separated by distillation; tetrachlorosilane and trichlorosilane are again recycled to the hydrogenation reactor and the exchange resin respectively.



6b) Write a note on 1) Power alcohol  
2) Unleaded Petrol. (6 marks).

Ans: Power Alcohol - When ethyl alcohol is used as an additive to motor fuels to act as a fuel for internal combustion engines, it is called Power alcohol.

Absolute alcohol is mixed with ether benzene etc compounds and one volume of this is mixed with four volumes of petrol and is used as a fuel.

It's gasoline blend containing ethanol and can be used as fuel in internal combustion engines. Ethanol can be obtained from renewable plant resources.

Gasoline containing 6-12% ethanol was used during 1930's. Now ethanol is used as a fuel.

Gasohol is a blend of 10-85% of absolute ethanol and 90-95% of petrol by volume.

Alcohol containing higher percentage of oxygen than MBTE and hence brings about complete oxidation of petrol more effectively.

### Unleaded Petrol

An alternative to increase the octane rating of gasoline and employ higher CR or power output is <sup>to</sup> blend gasoline with compounds of higher octane rating.



6l. 0.75g of Coal Sample (Carbon 90%, H<sub>2</sub> 5% and ash 5%) was subjected combustion in Bomb Calorimeter. Mass of water taken in Calorimeter was 2.5 kg and the water equivalent of Calorimeter is 0.65 kg. The rise in temperature was found to be 3.2°C. Calculate higher and lower calorific values of the sample. Latent heat of steam = 2457 kJ/kg and Specific heat of water = 4.187 kJ/kg/°C.

Ans:

Mass of the Sample = 0.75 g = ~~0.00075~~ 0.00075 kg

Mass of water = W<sub>1</sub> = 2.5 kg

water equivalent of Calorimeter = 0.65 kg

Rise in temperature =  $\Delta T = T_2 - T_1 = 3.2^\circ\text{C} = 3.2\text{K}$

Specific heat of water =  $s = 4.187\text{ kJ/kg/}^\circ\text{C}$ .

Latent heat of steam =  $C_v = L_v = 2457\text{ kJ/kg}$

Ans. 
$$Q_{CV} = \frac{(W_1 + W_2) \Delta T s}{m}$$

Gasoline or Petrol with better anti-knock properties. However, without the presence of leaded compounds but with the presence of higher octane rating. Gasoline or Petrol with better anti-knock properties. However, without the presence of leaded compounds but with the presence of higher octane blending reagents is called unleaded Petrol.

Following some blending reagents.

- (1) Methyl tertiary butyl ether
- (2) Ethyl tertiary butyl ether
- (3) Methanol
- (4) Ethanol

All the above blending reagents have higher octane rating of nearly 100 or more. When blended with gasoline in proportions of more than 10%. (unlike 0.1% ethyl fluid) overall octane rating of the blend is increased.



$$GCV = \frac{(2.5 + 0.65) \times 8.2 \times 4.187}{0.45 + 0.00075}$$

$$= \cancel{56273} \quad 56,273.28 \text{ kJ/kg}$$

Net Calorific Value

$$NCV = GCV - 0.09 \times H_f \times Lv$$

$$= 56,273.28 - 0.09 \times 5 \times 2457$$

$$= 56273 - 1105.65$$

$$= 55167.63 \text{ kJ/kg}$$

7a What are the causes, effects and disposal methods of e-waste? (07 marks)

Ans:

Causes:

- 1) IT and Telecom equivalent.
- 2) Large and Small household equipments.
- 3) Monitoring and Control equipment
- 4) Medical Instruments
- 5) Toys and Sports equipments.
- 6) Electrical and Electronic tools.



## Effects :

- \* E-waste consists of both hazardous and non-hazardous substances.
- \* The hazardous substances contain mercury, lead, arsenic etc.
- \* This may lead to serious effects like mercury forming water pollution and soil pollution.

## Disposal :

Land filling - The E-waste are treated and harmful chemicals are excavated and then dumped in land by forming line of clay or some plastic or decomposed material so that it decomposes. But this method is not environmentally sound process. It may lead to the soil pollution and water contamination and the acid and oxides released by the equipments.

2) Disassembly - It is the systematic removal of components, parts a group of parts or a subassembly from a product which is in E-waste

3) Upgrading - It includes communicating and separation of materials using mechanics physical / metallurgical processing.

Qb. What are the sources, effects and control of lead pollution? (Pb pollution)  
(7 marks)

Ans:

Sources:

Sources of lead emissions vary from ~~are~~ one area to another. At the national level, major sources of lead in the air are ore and metal processing and piston-engine aircraft operating on leaded aviation fuel. Other sources are waste incinerations, utilities and lead acid battery manufacturers. The highest air concentrations of lead are usually found near lead smelters.

## Effects

Lead once enter into the body, lead distributes throughout the body in the blood and is accumulated in the bones. Depending upon the level of exposure, lead can adversely affect the nervous system, kidney function, reproductive and development systems and Cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood.

## Control of lead

- \* Lead Smelting plant should design their storage piles in such way that the movements of lead materials are minimized to lesser exposure to wind and air
- \* Fixed conveyors, rail cars and rail dampers in all transfer points should be enclosed using dry type dust collecting material and design.



Qc. In a COD test,  $30.2 \text{ cm}^3$  and  $14.5 \text{ cm}^3$  of  $0.05 \text{ N}$  FAS solutions are required for Blank and Sample titration respectively. The volume test sample used was  $25 \text{ cm}^3$ . Calculate the COD of the Sample solution.

Ans:

$$P = \text{Main Titration Reading} = P = 30.2 \text{ cm}^3$$

$$Q = \text{Blank Titration Reading} = Q = 14.5 \text{ cm}^3$$

$$Y = \text{concentration of FAS} = Y = 0.05 \text{ N}$$

$$Z = \text{Volume of Sample} = 25 \text{ cm}^3$$

$$\text{COD} = \frac{8}{1000} \times (Q - P) \times Y \times \frac{10^6}{Z}$$

$$= 0.008 \times (30.2 - 14.5) \times 0.05 \times \frac{10^6}{25}$$

$$= 0.008 \times (15.7) \times 0.05 \times \frac{10^6}{25}$$

$$= 0.00628 \times \frac{10^6}{25}$$

$$= 251.2 \text{ ppm}$$

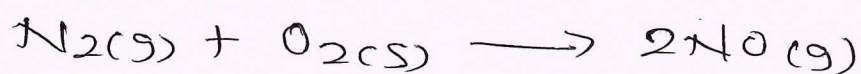
Qa :

Explain the Sources, effects and control of oxides of nitrogen (OT masks)

Ans: Sources :

Dinitrogen and dioxygen are the main constituents of air. These gases do not react with each other at the normal temperature. At high altitudes when light strikes, they combine to form oxides of nitrogen.

In an automobile engine (at high temperature) when fossil fuels are burnt - di-nitrogen and di-oxygen combine to yield significant quantity of nitric oxide and nitrogen dioxide are formed.



NO reacts instantly with oxygen to give  $\text{NO}_2$



## Effects

- 1) The irritant red cloud in the traffic and congested places is due to oxides of nitrogen
- 2) Higher concentration of  $\text{NO}_2$  damage the leaves of plants and retard the rate of photosynthesis
- 3) Nitrogen dioxide is a lung irritant that can lead to an acute respiratory disease in children.
- 4) It is toxic to living tissues also

## Control

Fuel switching : It is simplest and potentially the most economical way to reduce  $\text{NO}_x$  emissions. Fuel bound  $\text{NO}_x$  formation is most effectively reduced by switching to the fuel with reduced nitrogen content

Low  $\text{NO}_x$  burners . These burners designed to limit  $\text{NO}_x$  formation can reduce  $\text{NO}_x$  emissions. Greater reductory efficiency.



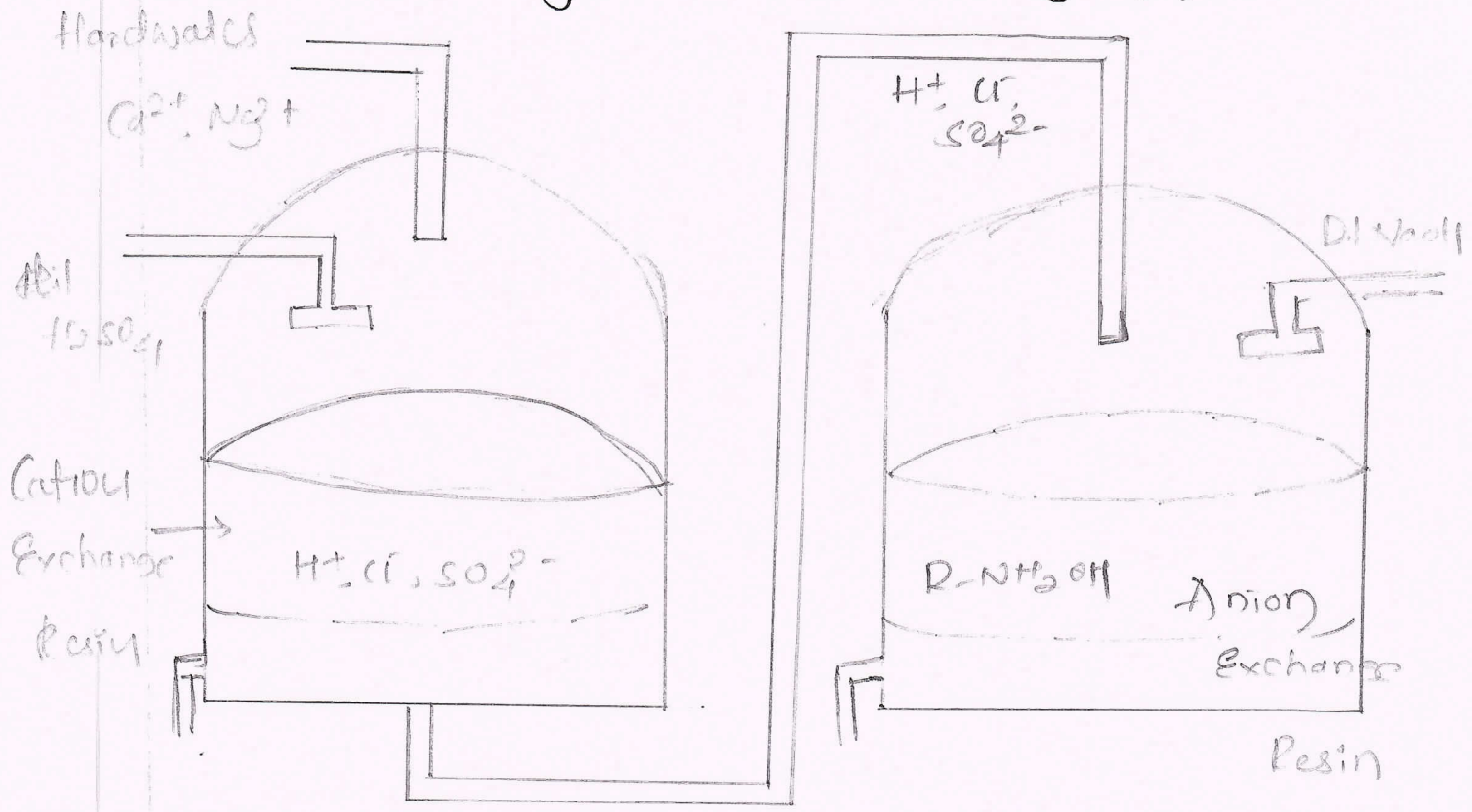
Can be achieved by combining a low  $\text{NO}_x$  burner with EGR though not additive to each of the reduction efficiencies.

Qb: Explain softening of water by ion-exchange method (07 marks)

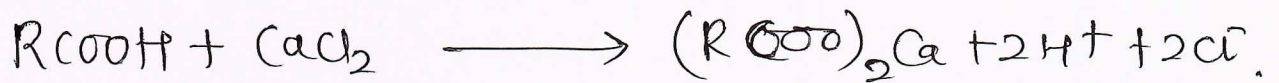
Ans: In this method, softening of water is done by exchanging the ions causing hardness of water with desired ions from an ion exchange resin. In ion exchange resins are high molecular weight, cross linked polymer with porous structure. The functional groups which are attached to the chains are responsible for ion exchange properties.

The resins containing acidic groups which are capable exchanging  $\text{H}^+(\text{Na}^+)$  ions for cations ( $\text{Ca}^{2+}$  or  $\text{Mg}^{2+}$ ) present in water are known as cation exchange resin ( $\text{RH}^+$ ),  $\text{RCOO}^-$

The resin containing basic groups which are capable of exchanging  $\text{OH}^-$  ions for anions ( $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ) present in water are known as anion exchange resins ( $\text{R-NH}_2\text{OH}$ ),  $\text{R-OH}$



Process: In this process, cation and anion exchange resins are packed in separate columns. Hard water is first passed through cation exchange resin where cation like  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  are removed from hard water by exchanging with  $\text{H}^+$  ions as follows.



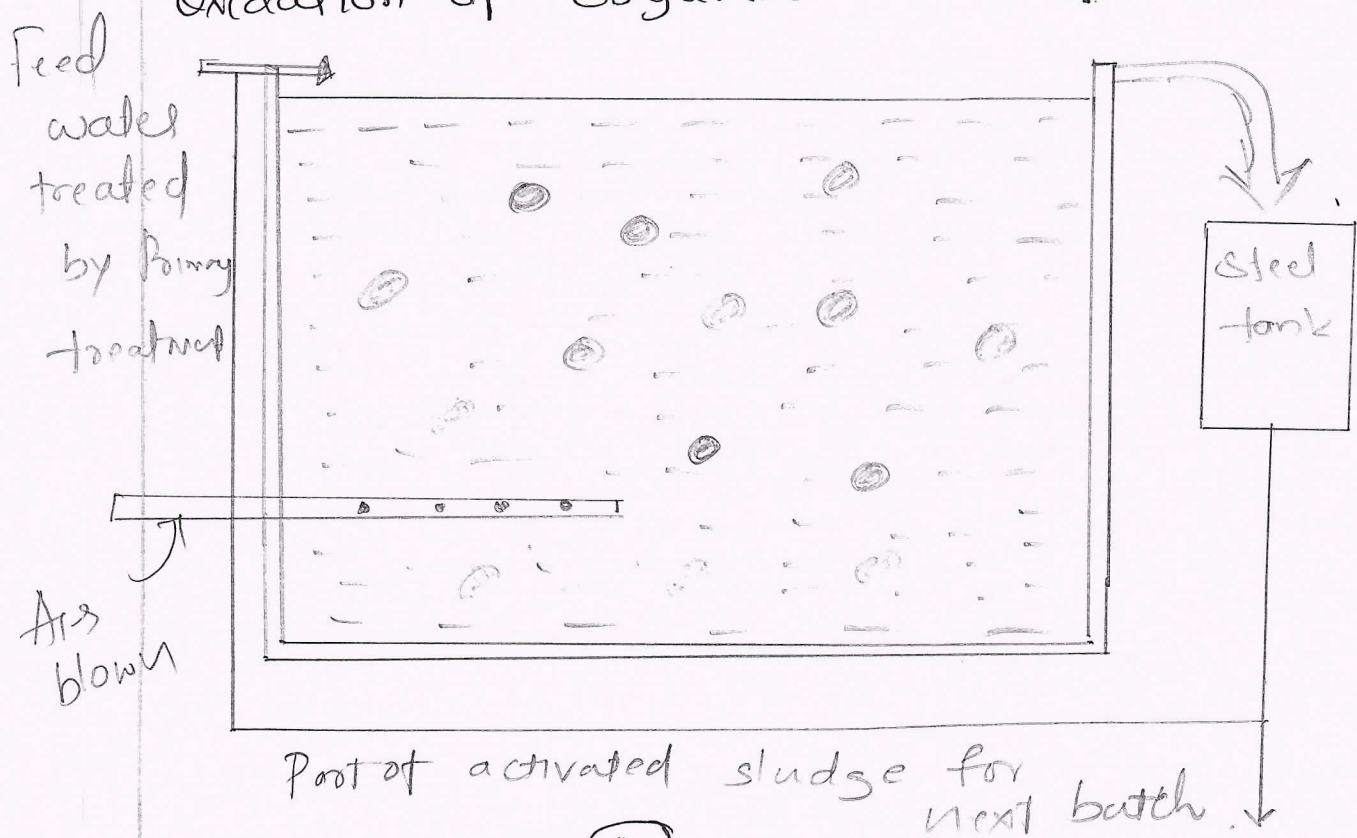
Hard water is passed through anion exchange resin where ions like  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$  are exchanged with  $\text{OH}^-$  ions as follows.



8c Explain the Activated sludge treatment of sewage water (06 Marks)

Ans:

Secondary process involves on aerobic oxidation of organic matter.





## Activated Sludge process

This process is due to remove biologically oxidisable impurities present in polluted water. Here waste water sample. After primary treatment is mixed with activated sludge (water sample containing higher concentration of microorganisms like Azobacteria, Bacillus, Zoophages etc) and taken into the large tank to maintain aerobic conditions. Under aerobic condition microorganisms oxidize Biological Oxidisable impurities into  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .

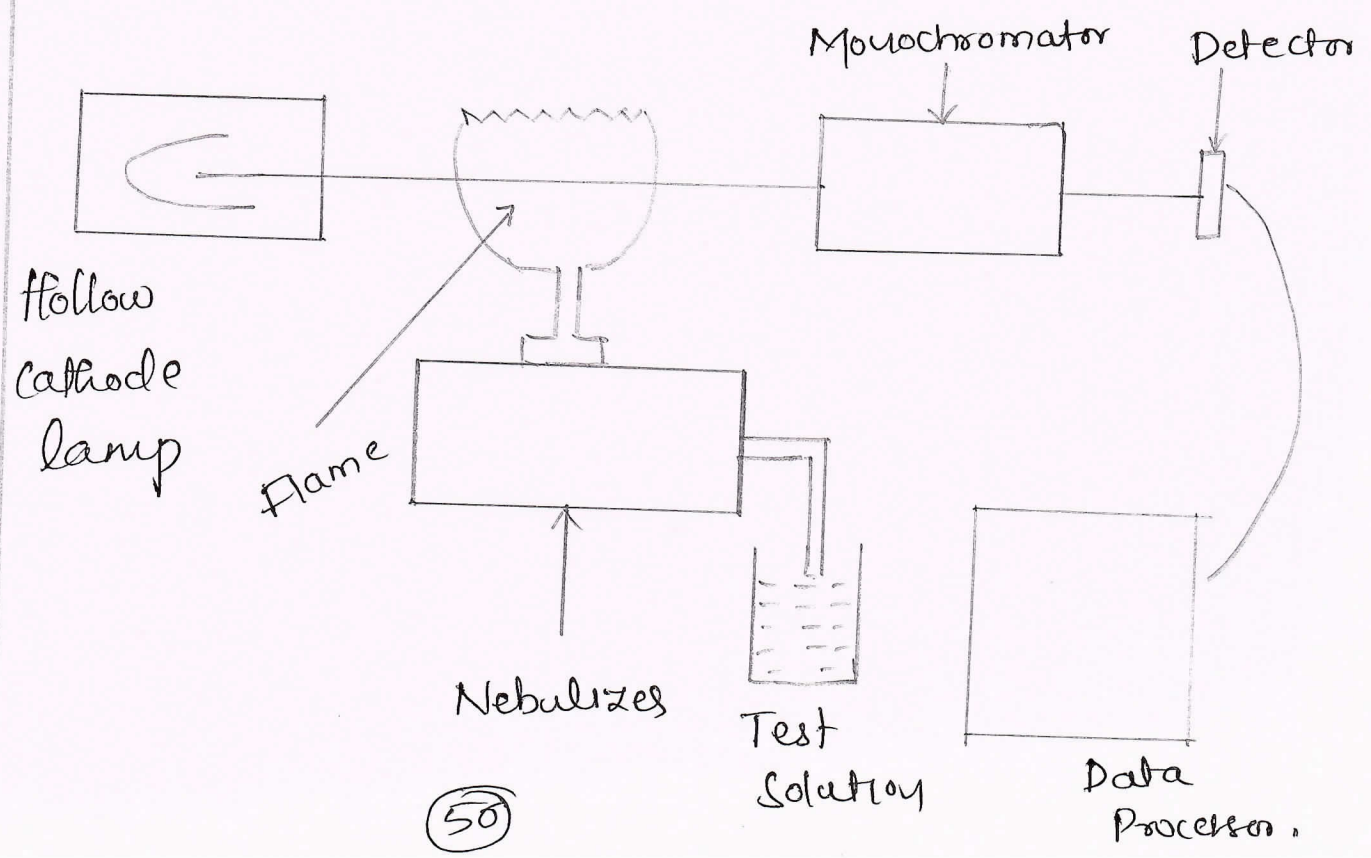
Q9) Explain the theory, Instrumentation and application of Atomic Absorption Spectroscopy (07marks).

Ans: Theory:

An electrically heated surface is used to vaporise through aspiration of solution

of the analyte sample into free atoms of a particular element in the atomic absorption spectroscopy.

When the analyte is free atoms a beam of light is passed through them. The atoms will absorb in the visible and ultraviolet region resulting in changes in electronic structure, (excited state). Only a particular wavelength of light is absorbed by the electrons of the atom to get to excited state, which is a measure the characteristic of the sample.



## Components :

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- 1) Light source : The light source emits the atomic spectrum of a particular element. To detect a particular element specific lamps are used in each case. The hollow cathode lamp (HCL) or electrodeless lamps (EDL) are widely used.
- 2) Sample cell : An atomic sample vapour is generated in the sample in the light beam from the cell by introducing the sample into a burner system (Flame AAS) or electrothermally heated furnace or platform arranged in the optical path of spectrophotometers.
- 3) Nebuliser : Suck the liquid sample at controlled rate creates a fine aerosol spray for the introduction of into flame mix the aerosol, fuel and oxidant thoroughly for introduction into flame.
- 4) Specific heat measurements its includes several components
- 5) A monochromator to disperse several wavelengths of light that are emitted from the light source to isolate a particular line of interest. (51)

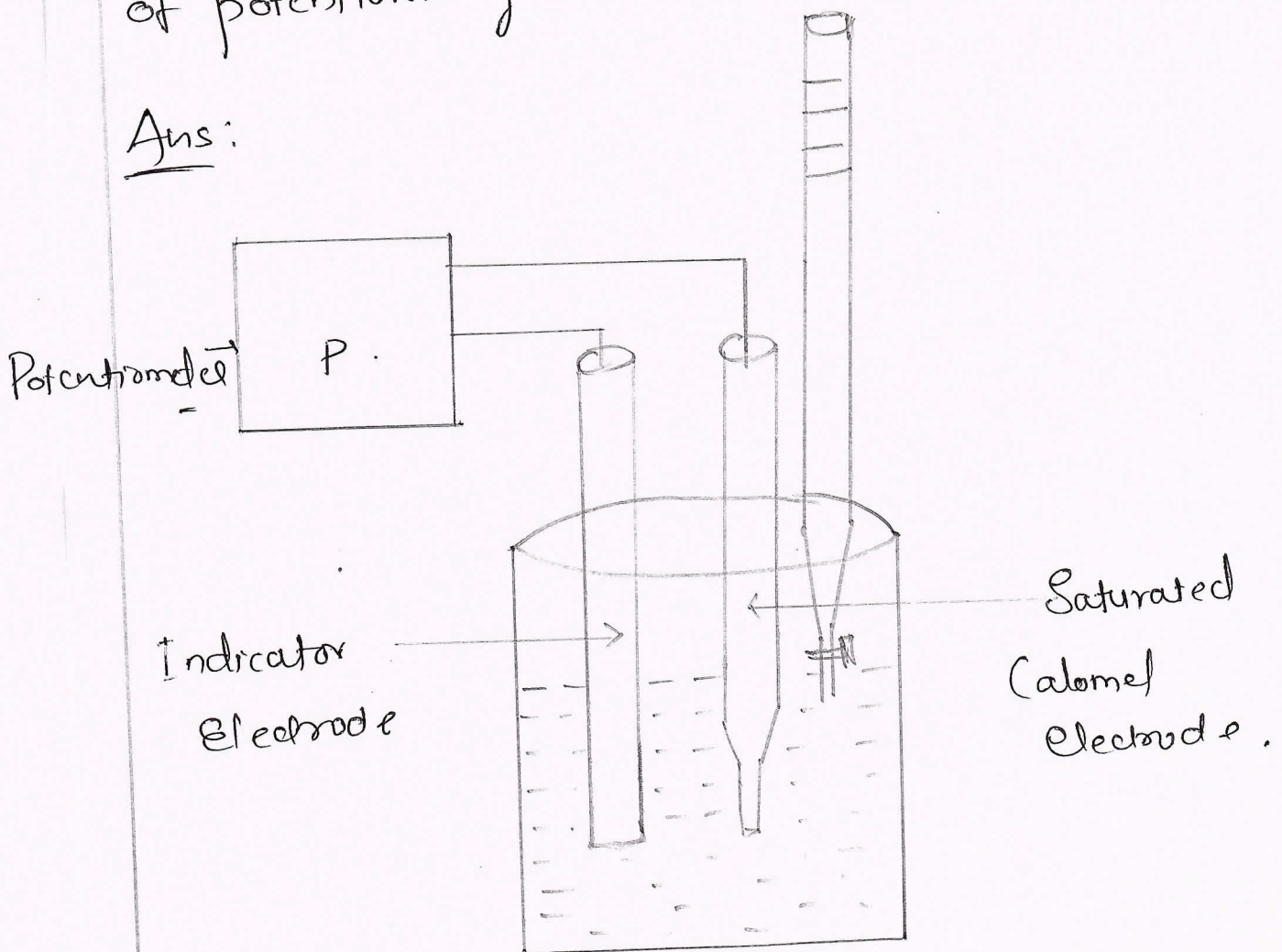


## Applications:

The most widely used technique for the quantitative determination of metals at trace level which present in various materials.

Qb Explain the theory and instrumentation of potentiometry. (07 marks).

Ans:



Theory: A potentiometric titration may be defined as a titration in which the end point is detected by measuring the change in potential of suitable electrode during the titration. The electrode which responds to change in concentration of ions in the solution is called the indicator electrode. The indicator electrode combined with the reference electrode to form the cell and the emf of the cell changes gradually till the end point and changes rapidly at very close to the end point and again the changes is gradually after the end point. When emf is plotted as ordinate and the volume of titrant added abscissa the point of inflection of the curve corresponds to the equivalence point or end point of the titration.

## Instrumentation :

Potentiometer method consist of potentiometer and two electrodes in which one electrode is indicator electrode (Ex: platinum electrode) and reference electrode.

Instrument : Potentiometer or pH meter.

Electrode : Indicator electrode Ex-platinum

## Reference Electrode :

Calomel electrode for potentiometer  
glass electrode for pH meter.

- (1) The solution to be titrated is taken in a beaker and titrant is taken in the micro burette.
- (2) Immerse the electrodes in the beaker along with a stirrer
- (3) The electrodes are connected to the potentiometer which gives the emf values.



Q6 Write a note on fullerenes. Mention its applications.

Ans: Fullerenes :

Carbon, the common element in organic compounds, is known to exist in two allotropic forms, viz diamond and graphite. In 1985, a third form of carbon called fullerenes was discovered. The group of scientists led by Smalley, Kroto and Curl attempted to simulate the conditions under which carbon nucleates in the atmosphere of red giant stars. The abundant form of fullerenes is Buckminsterfullerenes ( $C_{60}$ ) with 60 carbon atoms arranged in a spherical structure. The shape of the molecule known as truncated icosahedrons resembles that of a soccer ball, other higher fullerenes discovered later with different carbon atoms like ( $C_{70}$ ,  $C_{74}$ ,  $C_{76}$ ,  $C_{78}$  and  $C_{84}$ ) have

been prepared and investigated but most common is the  $C_{60}$  fullerene called Buckminster fullerene.

### Structure and Properties:

- 1) Fullerenes consists of fused Pentagons and Hexagons
- (2)  $C_{60}$  fullerene consist of 12 Pentagons and 20 hexagons, 90 edges and 60 vertices.
- (3) All 60 Carbon atoms are located at the vertices of a truncated icosahedron.

### Applications

- (1) Fullerenes may be used for drug delivery systems in the body
- (2) In lubricants and as Catalyst
- (3) Tube Fullerenes are called nanotubes
- (4) It can be use cleave DNA

10a) What are nanomaterials? Explain the synthesis of nanomaterials by precipitation method.

Ans: Nano-materials, are very small materials, indeed branch of science or technology deals with materials having atleast one special dimension in the size range of 1 to 100nm.

Precipitation Method

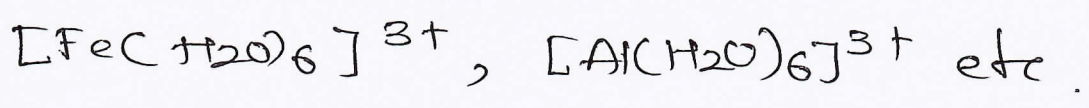
In this strategy the size is control by arrested by precipitation technique. The basic trick as been to synthesize and studies the nano material in the same liquid medium avoiding the physical changes and aggregation of tiny crystallites various steps involved as follows.



Step-1 : In this technique the precursors

(Inorganic metal salts such as nitrate, chlorides or acetates) is dissolved in water

Step-2: Metal cations exists in the form of hydrated species for example.



Step-3, The metal hydrated species are added to precipitating agent like NaOH and  $NH_4OH$ , it causes condensation of metal hydrated species.

Step 4: Thus concentration of solution increases and reaches a critical level called super saturation. At this concentration nucleation formation is initiated thus further grows into particles, which get precipitated.

Step: 5. the precipitated is filtered washed with water and finally calcined at high temperature to get crystalline metal oxide.  
(SR)

10b Explain the Synthesis of Nano-materials by sol-gel technique. (06 Marks)

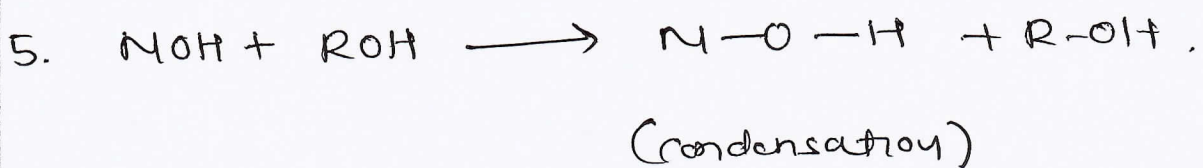
Ans:

1. In sol-gel Synthesis, either a metal salt or metal alkoxide is used as precursor, in solvent

2. (In alcohol or water) in acid or basic Conditions



4. Conversion of sol to gel: sol is further converted into gel by polycondensation results in the formation of oxide bridge network is called gel.



6. Aging of the gel: gel on aging for a known period of time, finally condenses to nano-scale clusters of metal hydroxides.

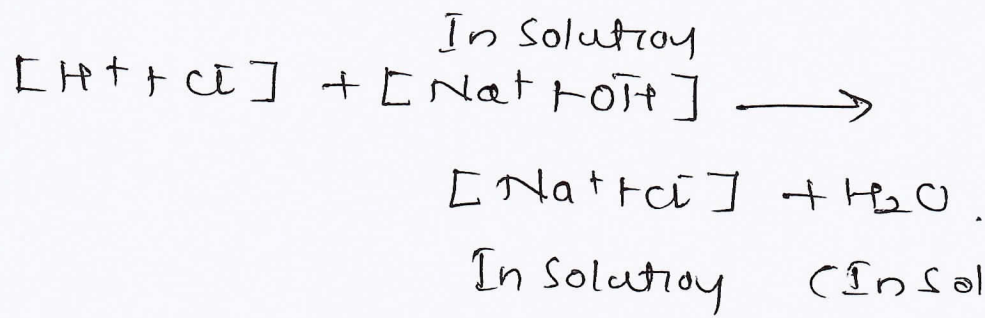
QOC : Explain the theory and instrumentation of Conductometry. (07 marks).

Theory: A titration in which the equivalence point or end point of the reaction is determined with the help of measurements of conductivity of the reaction mixture is known as Conductometric titration. As that the specific conductivity of a solution depends on number and nature of the ions, which changes gradually during the titration, and lets one to know the end points. Conductivity of unit volume ( $1\text{ cm}^3$ ) of the electrolyte solution at specified temperature is known as Specific Conductivity.

It is expressed in units of milli Siemens per centimeter ( $\text{mS cm}^{-1}$ ). When a mixture of  $\text{HCl}$  and  $\text{CH}_3\text{COOH}$  is titrated against  $\text{NaOH}$ , stronger acid  $\text{HCl}$  is neutralized first followed by the neutralization of weak acid,  $\text{CH}_3\text{COOH}$  while  $\text{HCl}$  is neutralized highly mobile  $\text{H}^+$  ions of acid are replaced, less mobile  $\text{Na}^+$  ions.



of the base and Specific Conductivity decreases. The trend continues until the reach of neutralization of HCl.



After the complete neutralization of strong acid, NaOH added will be neutralize weak acid



Weak  
Electrolyte

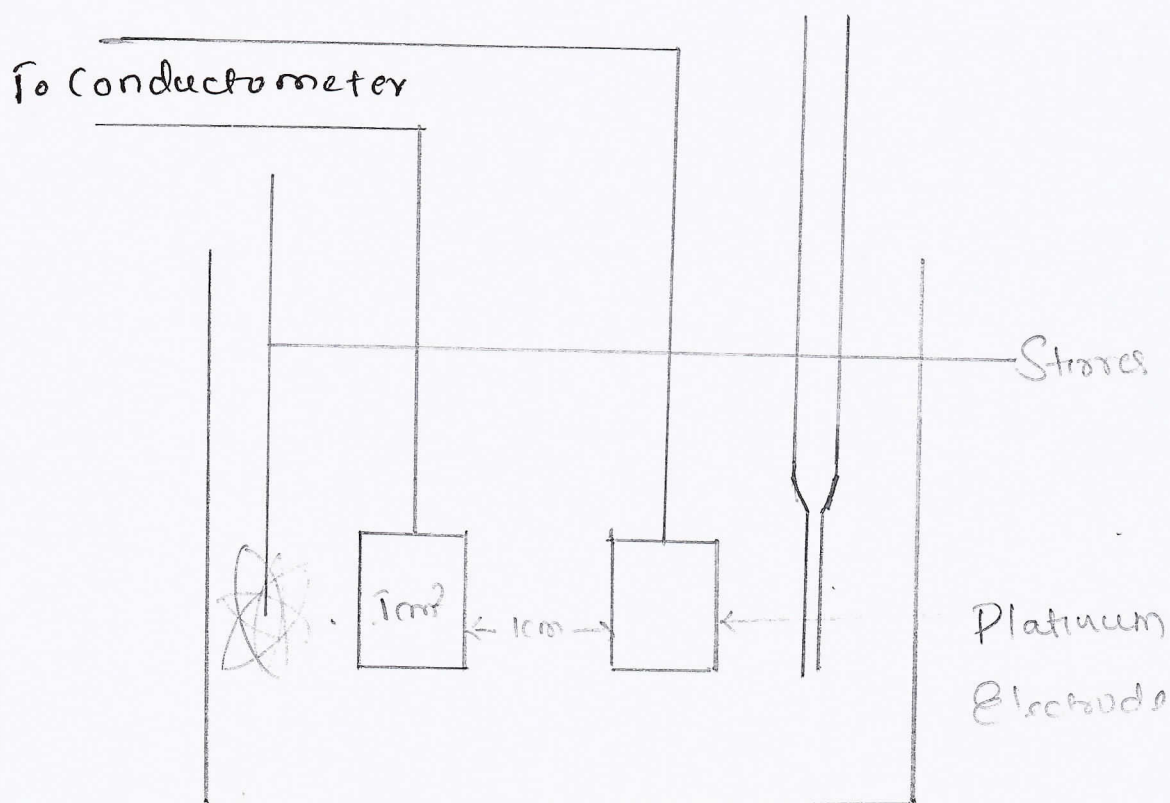
(In Solution)

### Instrumentation

Conductometer consists of 2 platinum electrodes and a conductance measuring device.

The two electrodes have unit area of cross section and are placed unit distance apart.

The solution to be estimated is taken <sup>33</sup> in a beaker. The system responds readily to changes in concentration of analyte.



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