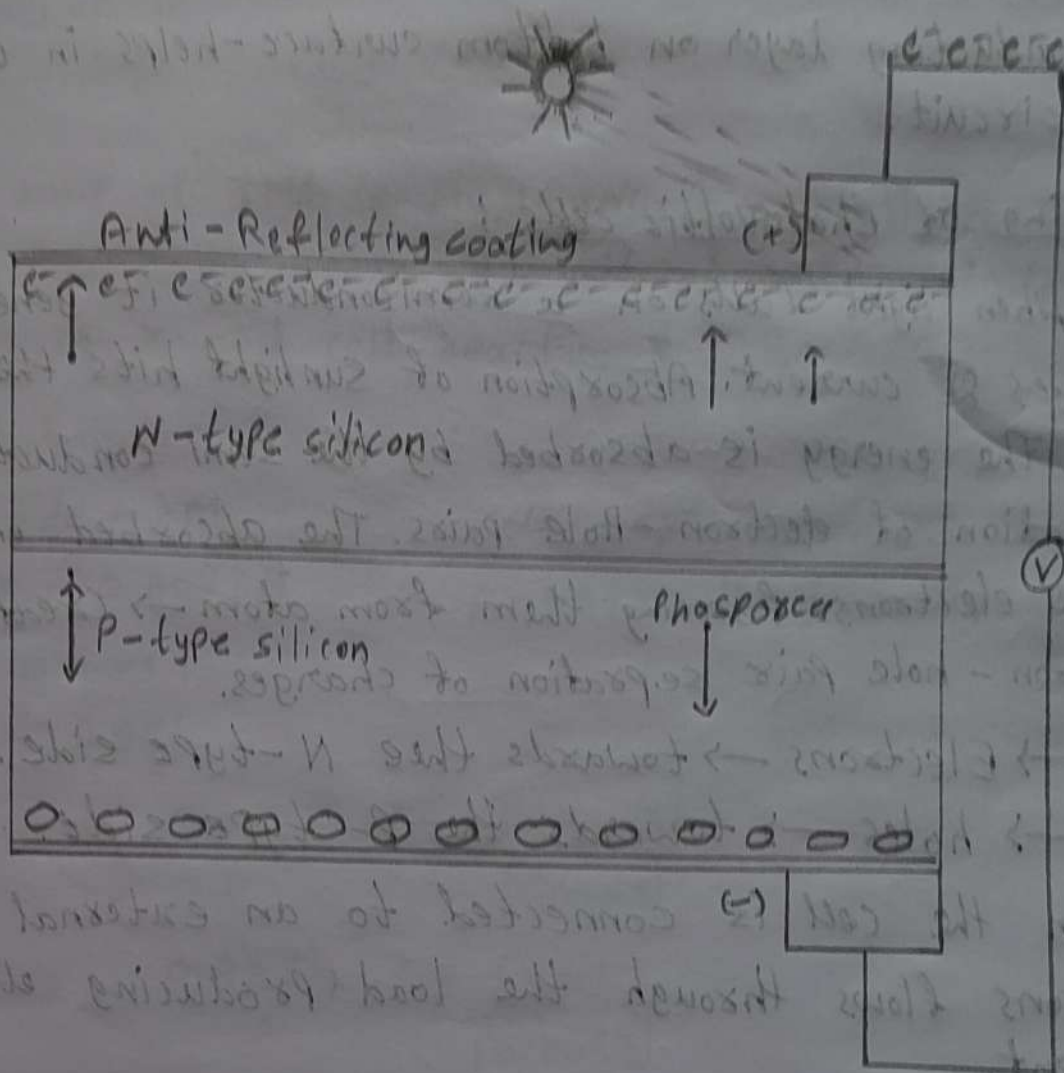


1) What are Photovoltaic cells. Describe the Construction and working Photovoltaic cell. Mention Advantages and disadvantage.

Defination: Photo voltaic solar cell is an device that converts solar energy into electricity by semiconductors.



Semiconductor Layers:

* The main material is silicon (Si), a semiconductor

* It has two layers:

1) P-type layer: Doped with boron [B] has +ve holes

2) N-type layer: Doped with Phosphorus with extra electrons

* The junction between these two layers is called P-N junction

2) Front contact (Metallic Grid)

- * A thin metallic grid on the top allows sunlight to enter while collecting electrons.

3) Reflective Coating:

- * Reduce the reflection of sunlight so that more light is absorbed.

4) Back contact:

- * A conducting layer on bottom surface - helps in completing the circuit.

Working of Photovoltaic cells:

When light falls on a semiconductor it generates voltages & current. Absorption of sunlight hits the solar cell. The energy is absorbed by the semiconductor. Generation of electron-hole pairs. The absorbed energy excites electrons, freeing them from atom \rightarrow creating electron-hole pair separation of charges.

1) \rightarrow Electrons \rightarrow towards the N-type side.

2) \rightarrow holes \rightarrow towards the P-type side.

When the cell is connected to an external circuit electrons flow through the load producing electric current.

Advantages of Photovoltaic cell:

1) Renewable & Clean energy

2) Low maintenance

3) Long life span

4) No moving parts (silent operations)

Disadvantages of Photovoltaic cell

- 1) Relatively low power conservation energy efficiency
- 2) Performance depends on sunlight availability, output drops on cloudy days.
- 3) Requires high purity silicons increasing manufacturing costs
- 4) Initial installation is more expensive compared some conventional energy sources.

2) The EMF of cell is $\text{Ag} | \text{AgNO}_3(0.0083\text{M}) || \text{AgNO}_3(x\text{M}) | \text{Ag}$ was found to be 0.074 volt at 298K. calculate the value of x and cell reaction & cell representation.

Given:

Cathode = $x\text{M}$

Anode = 0.0083M

$E_{\text{cell}} = 0.074$

$T = 298\text{K}$

cell Representation:

$\text{Ag} | \text{AgNO}_3 || \text{AgNO}_3 | \text{Ag}$

$$E_{\text{cell}} = \frac{0.0591}{n} \log \frac{[\text{Cathode}]}{[\text{Anode}]}$$

$$E_{\text{cell}} = \frac{0.0591}{1} \log \frac{[x\text{M}]}{[0.0083]}$$

$$0.074 = 0.0591 \log \frac{[x\text{M}]}{[0.0083]}$$

$$\frac{0.074}{0.0591} = \log \frac{[x\text{M}]}{[0.0083]}$$

$$1.252 = \log \frac{[x\text{M}]}{[0.0083]}$$

taking Anti log on both side

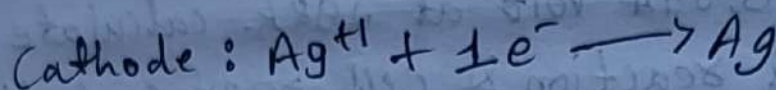
$$\text{Antilog } 1.252 = \frac{x}{0.0083}$$

$$17.86 = \frac{x}{0.0083}$$

$$x = 17.86 \times 0.0083$$

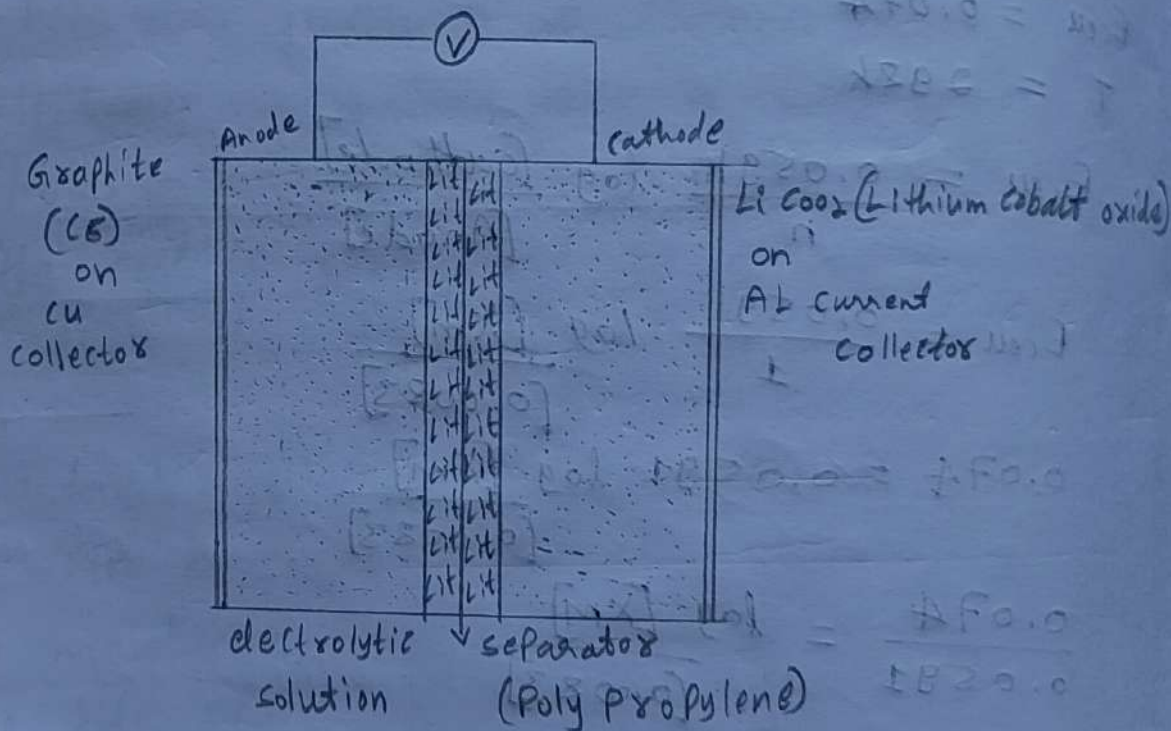
$$x = 0.1482 \text{ M}$$

Cell Reaction :

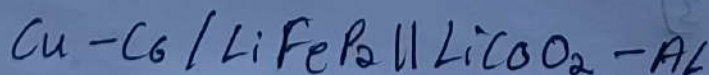


3) Explain the construction & working of lithium ion battery mention any four applications.

* Construction :

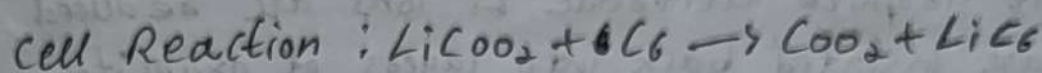
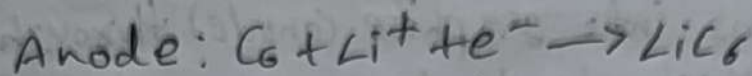
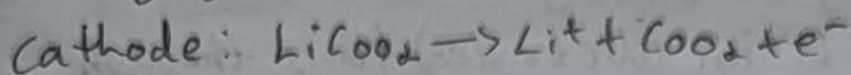


Cell Representation

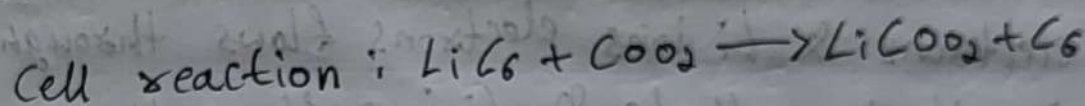
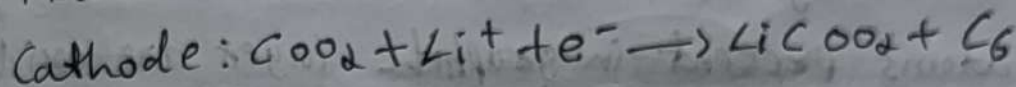
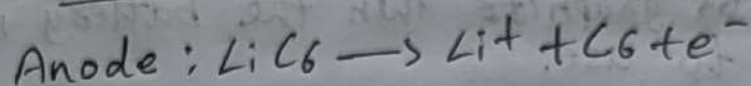


Working

Charging



Discharging



Construction

Lithium-ion Battery uses Lithium intercalated electrodes the following are battery components used in the construction of lithium ion battery.

- 1) Anode (-ve electrode): Anode compartment filled with graphite on the surface of copper current collector.
- 2) Cathode: cathode compartment filled with lithium cobalt oxide on the surface of Aluminium current collector.
- 3) Electrolyte Solution: lithium hexafluoro phosphate this can be dissolved in organic solvent like propylene carbonate or ethylene carbonate.
- 4) Separator: Polypropylene membrane which separates cathode & anode it prevents internal short circuits.
- 5) Container: steel or Aluminium

* Working :

During charging of battery Li atoms present in graphite (anode) liberates electrons & Li ions flows through external circuit & Li ions into graphite (anode) through electrolyte. At graphite electrode Li ions are reduced to Li atoms & are inserted back into layers of graphite. When all the lithium ions moved from cathode to anode & are stored in the layers of graphite then the battery is fully charged & ready to use.

At anode Li atoms present in graphite layer are oxidized liberating electrons & Li ions electrons flows through external circuit to cathode. & Li ions flows through electrolyte towards cathode at cathode Li ions are reduced to Li atoms & are inserted into the layer of graphite. When all the Li ions are moved back the battery is fully discharge & needs charging up again.

* Applications :

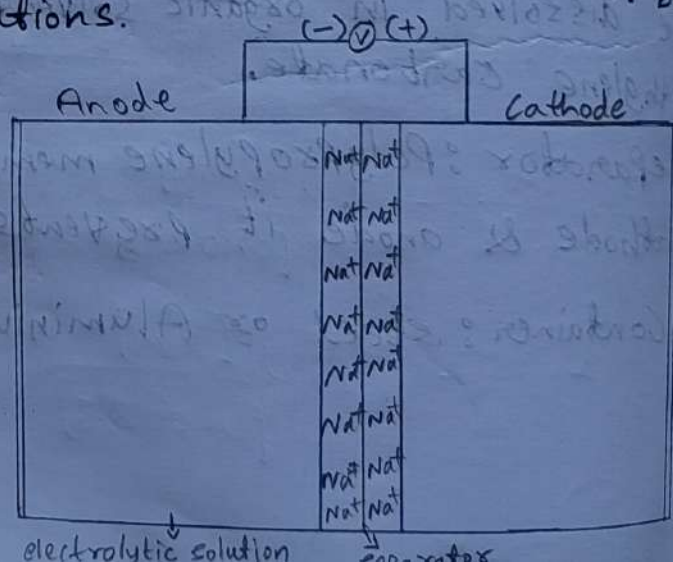
- Li ion Battery used in Electronic devices
- Li ion Battery used in aerospace applications
- Li ion Battery used in Laptops, CD players, Mobile phones

4) Explain the construction & working of Sodium ion battery mention any four applications.

* Construction :

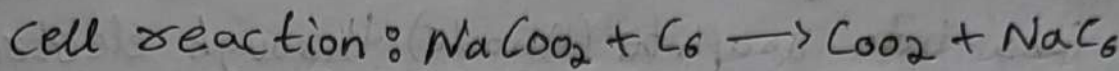
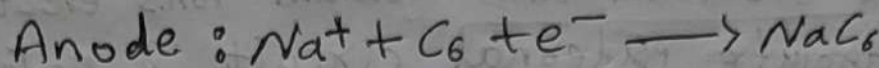
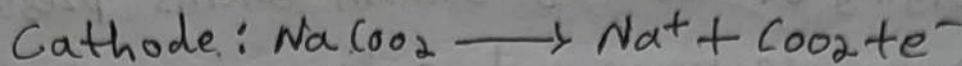
Graphite
(C₆) on
Cu collector

Sodium
tetrakis
phosphate
(Na₄FeP₄)

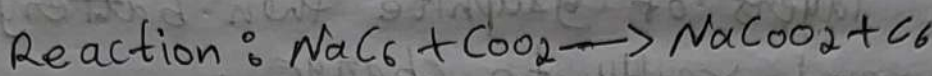
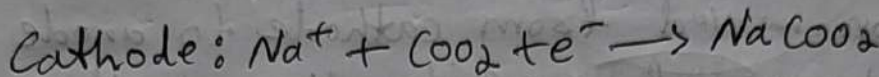
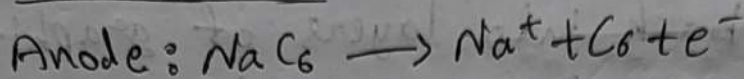


Working

* Charging



Discharging



* Construction:

Sodium ion battery uses sodium intercalated electrodes. The following are battery components used in construction of Na battery.

* Anode component:

Anode compartment filled with graphite on the surface of copper current collector.

* Cathode

Cathode compartment filled with sodium oxide on the aluminium current collector.

* Electrolyte Solution: Sodium hexa fluoro phosphate + can be dissolved inorganic solvent like propylene carbonate or Ethylene carbonate.

* separator

Polypropylene membrane which separates cathode & anode it prevents internal short-circuit.

* Container \longrightarrow Aluminium or steel.

Working:

During charging of battery sodium atoms in cathode liberate electrons and sodium ions flow through electrolyte external circuit & sodium ions into graphite (Anode) through electrolyte. At graphite electrodes sodium ions are reduced to sodium atoms & are inserted back into layers of graphite. When all sodium ion moved from cathode to anode all store in the layers of graphite then battery is fully charge and ready to charge.

During discharging ions of sodium present in graphite layer of are oxidised liberating electrons & sodium ion electrons & sodium ions flow through external circuit to cathode & sodium ions flow through electrolytes towards cathode at cathode sodium ions are reduced to sodium atoms are inserted into the layer of cobalt oxide. When all the sodium ions have moved back the battery is fully discharged & needs charging of again.

* Applications

- Used in Generators
- Used in Aerospace
- Used in bomb spot
- Used in Fire station.

5) Explain Difference between fuel cell & battery.

Fuel cell	Battery
<ul style="list-style-type: none">* Fuel cells are thermodynamically open system.* Fuel cells never discharge or stand down* Fuel cells have been unlimited life* Reactions are continuously supplied & products are continuously removed* Waste product in fuel cells are harmless (Eco friendly material)* More expensive & High efficiency	<ul style="list-style-type: none">* Batteries are thermodynamically closed system.* Must be discarded, when the fully discharged.* Batteries have limited life span.* Reactants & products form an integral part of batteries* Waste product in batteries may be harmful (Less Eco-Friendly) nature* Less expensive & less efficiency.

6) Explain production of hydrogen by photocatalytic water splitting using TiO_2 method & its advantages.

Photocatalytic water splitting is a solar dry process that mimics natural photosynthesis.

It uses semi-conductor catalyst such as titanium dioxide (TiO_2) to absorb light energy and speed the splitting of water into hydrogen & oxygen this generates green hydrogen a clean fuel with zero-carbon emission.



M_1 = Schottky Barrier

M_2 = Acceptor Level

M_3 = Donor Level

M_4 = Generation of gap states by reaction with TiO_2

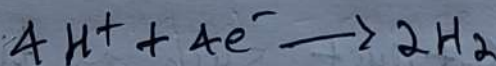
1) Light Absorption:



2) Water oxidation (oxygen - Evolution)



3) Hydrogen Evolution



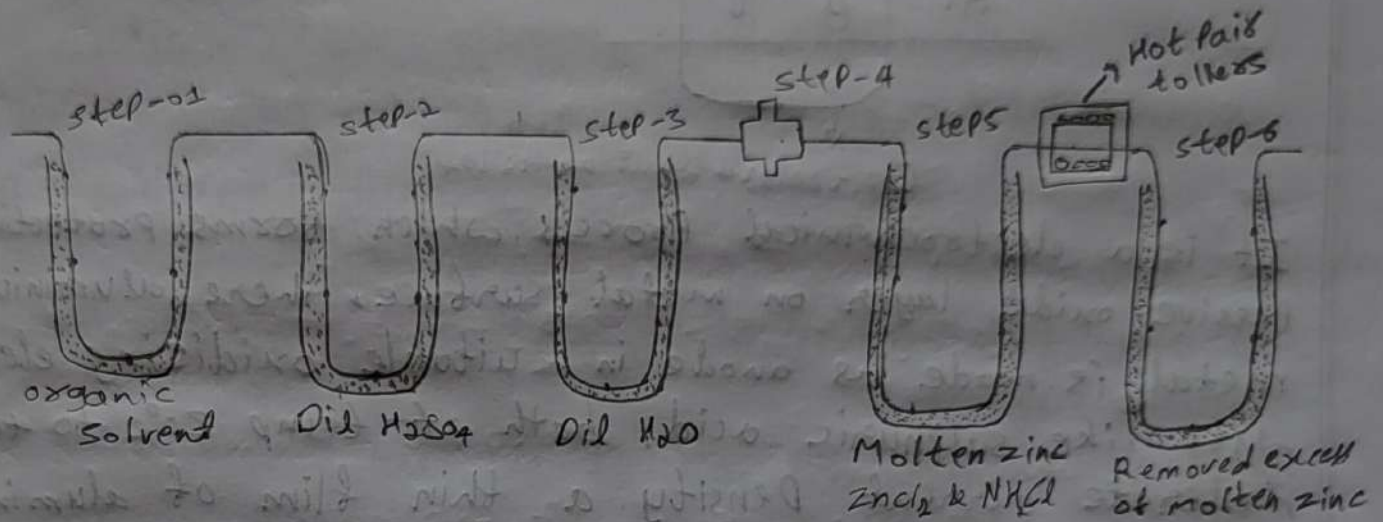
Advantages

- * Abundant & low cost titanium is easily available, etc. & non toxic.
- * It has high chemical stability.
- * Resistant to corrosion under UV rays & aqueous conditions
- * Environment Friendly
- * Reusable, Can be recycled over many cycles.

7) Describe Galvanisation and Anodisation for corrosion control methods & mention it's applications.

Galvanisation:

It is the process of coating of molten zinc on the surface of base metal or corroded metal.



step 01: Metal surface is washed with organic solvents to remove oily dusty particles or organic matter.

step 02: Rust and deposits removed by washing with dilute sulphuric acid (dil H_2SO_4) by pickling process.

step 03: Then it is washed with distilled water.

step 04: It is dried by passing Hot air.

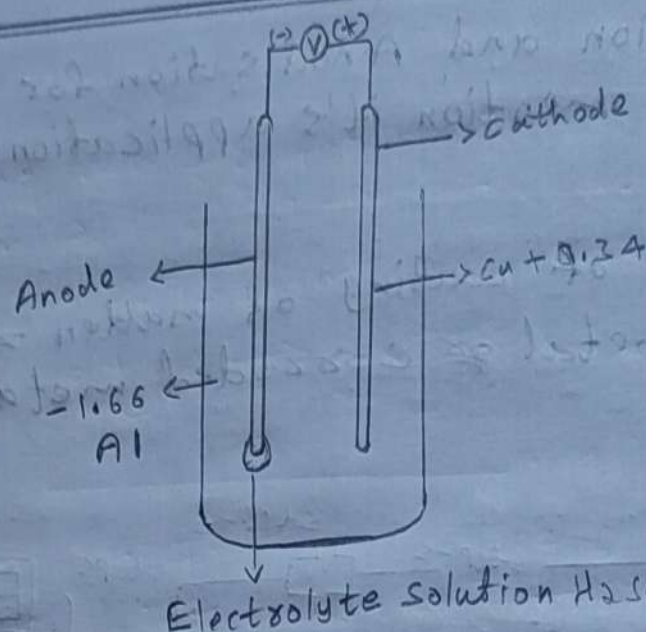
step 05: Then it is dipped in molten size zinc maintained at $430^\circ C$ to $450^\circ C$ & covered with ammonium chloride & zinc chloride to increase adhesion property.

step 06: Excess of zinc on surface is removed by passing a pair of hot rollers which removes excess of zinc & produces thin coating.

Applications:

Galvanised materials are used in finishing wires, buckets, nuts, nails, screw etc.

Anodizing



It is a electrochemical process which forms passive oxide layer on metal surface, there metal is made as anode in suitable oxidising electrolyte like sulphuric acid, both at temp $30^\circ C$ to moderate current density a thin film of oxide (Al_2O_3) is deposited on surface this protective layer preventing the corrosion this tends to be porous & provides good adherence paint & dyes.

Application:

Used in soap boxes. Tiffin box.

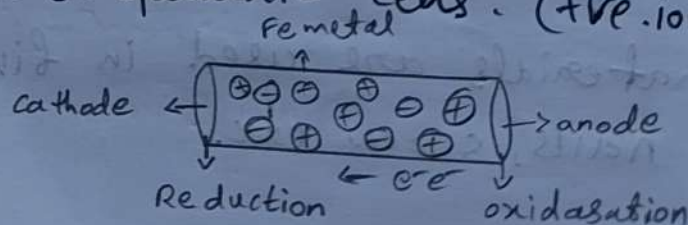
Used in window frames & anodic film.

Used in cosmetic effects.

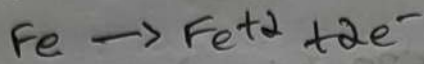
- 5) Define metallic corrosion describe electrochemical of corrosion taking iron as an example.

It explains Mechanism (Mxn) of corrosion by the reaction

→ Formation of Galvanic cells. (+ve ions, & -ve ions)

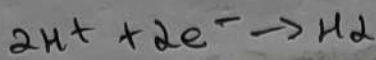


1) At anode region:



2) At cathodic Region: I) Hydrogen Liberation (in absence of O_2)

1) Acidic medium

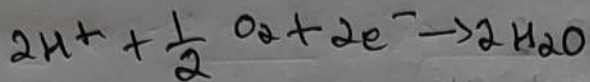


2) Neutral medium

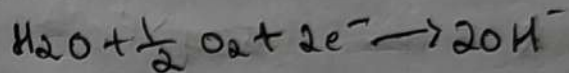


II) oxygen absorption

1) Acidic medium

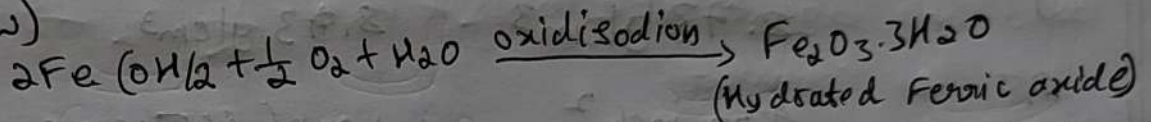


2) Neutral medium



III) Rust Formation:

In an oxidising stable $\text{Fe}^{2+} + 2\text{OH}^{-} \rightarrow \text{Fe}(\text{OH})_2$ (Ferrous Hydroxide yellow)



→ Corrosion occurs due to the formation of anodic & cathodic regions on the same or different metals in a conducting medium.

→ At the anode oxidation takes place and metals corrodes into ions by releasing electrons.

→ At the cathode reduction occurs by consuming the liberated electrons keeping the cathodic region protected.

→ Corrosion continues as long as anodic & cathodic reactions are proceed simultaneously influenced by impurities & oxygen concentration difference.

What is corrosion protection a thick brass sheet of area 400 cm^2 is exposed to moist air after 2 years of period it was found to experienced a weight loss 375 g due to corrosion if the density of brass is 8.73 g/cm^3 calculate the CPR in MPY & mmpy.

Given

$$\text{Area} = 400 \text{ inch}^2 \rightarrow 400 \times 6.4516 = 2580.64 \text{ cm}^2$$

$$\text{Weight loss (W)} = 375 \text{ g} \rightarrow 375 \times 1000 \rightarrow 375000 \text{ mg}$$

$$\text{Density (S)} = 8.73 \text{ g/cm}^3$$

$$\text{Time (T)} = 2 \text{ years} \rightarrow 2 \times 365 \times 24 \rightarrow 17,520 \text{ hours}$$

CPR

MPY

mmpy

k

534

87.6

W

3,75,000 mg

3,75,000 mg

S

8.73 g/cm³

8.73 g/cm³

A

400 inch²

400 x 6.4516 = 2580.64 cm²

T

17,520 hours

17,520 hours

$$\text{CPR}_{\text{mpy}} = \frac{k \times W}{S \times A \times T}$$

$$= \frac{534 \times 3,75,000}{8.73 \times 400 \times 17,520}$$

$$= \frac{200250000}{61186560}$$

$$= 3.27 \text{ mpy}$$

$$\text{CPR}_{\text{mmpy}} = \frac{k \times W}{S \times A \times T}$$

$$= \frac{87.6 \times 3,75,000}{8.73 \times 2580.64 \times 17520}$$

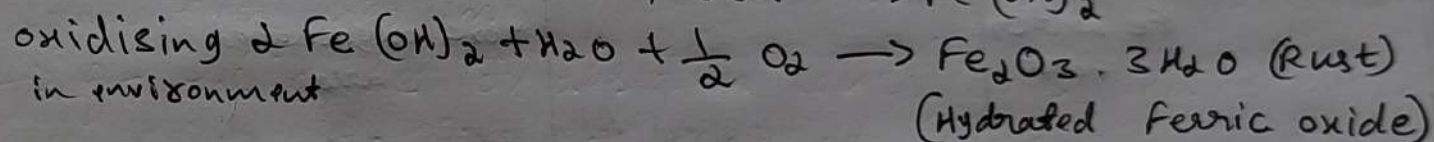
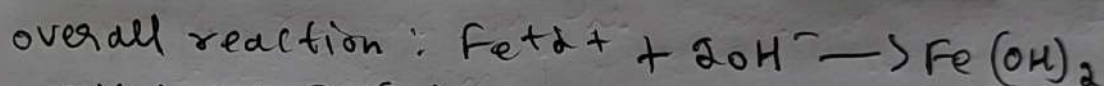
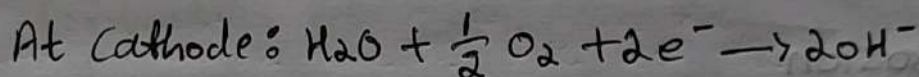
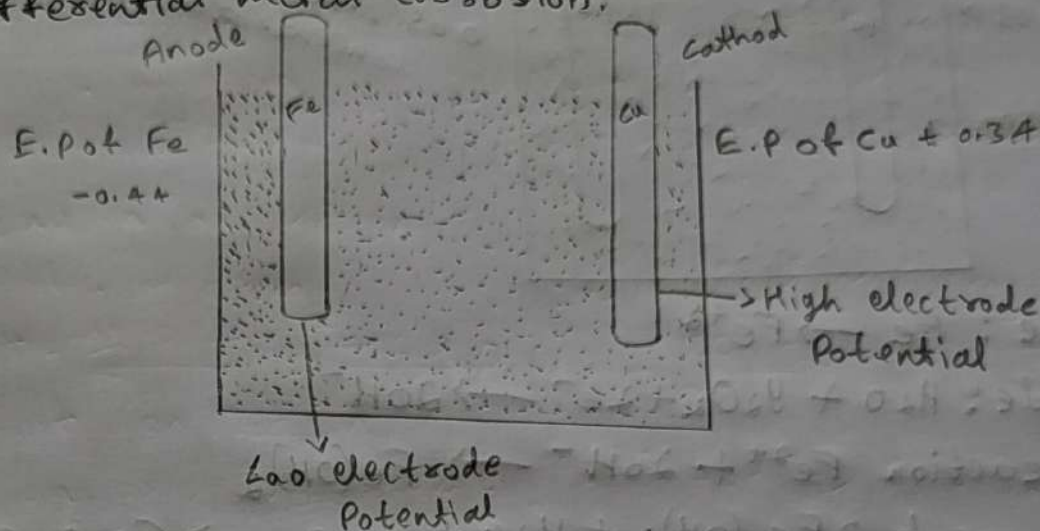
$$= \frac{32850000}{394248859.4}$$

$$= 0.0833 \text{ mmpy}$$

$$= 0.0833 \text{ mmpy}$$

10) Explain types of metal corrosion with a diagram & explanation.

1) Differential metal corrosion.



Differential metal corrosion occurs when two dissimilar metals are in contact with each other & are exposed to a corrosive environment. The two metals differ in their electrode potential. The metal with lower electrode potential acts as an anode, and the metal with higher electrode potential acts as a cathode. The potential difference between the two metals is a driving force for corrosion. Here, the anode metal undergoes corrosion.

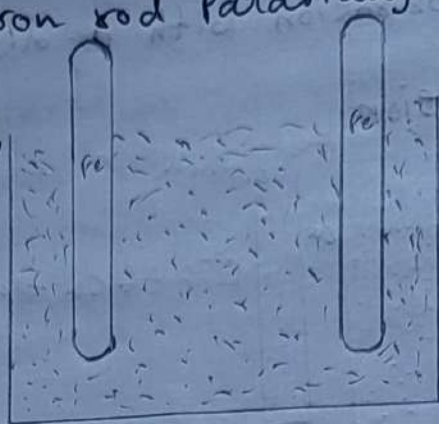
Ex: When Iron is in contact with copper.

2) Differential Aeration Corrosion

→ Differential aeration corrosion occurs when a metal surface is exposed to different oxygen concentrations. The part of the metal exposed to higher oxygen concentration acts as a cathode, and the part exposed to lower oxygen concentration acts as an anode. The anodic region undergoes oxidation & gets corroded.

Ex: When iron rod partially dipped in water.

Anode 0.01 N
oxygen
concentration



Cathode
0.05 N₂O₂
concentration

At anode: $\text{Fe} \rightarrow \text{Fe}^{2+}$

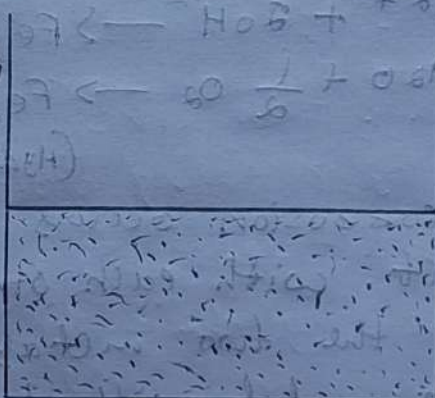
At cathode: $\text{H}_2\text{O} + \frac{1}{2}\text{O}_2 + 2e^- \rightarrow 2\text{OH}^-$

overall reaction $\text{Fe}^{2+} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2$

oxidising agent $2\text{Fe}(\text{OH})_2 + \text{H}_2\text{O} + \frac{1}{2}\text{O}_2 \rightarrow \text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$
if environment

3) Water Line corrosion

Fe Water
tank



More oxygenated
area

When a steel or Fe tank is partially filled with a water for a long time the inner portion of the tank the water line is exposed only to dissolved oxygen whereas the portion above water line is exposed to more oxygen. The portion below the water act as anode and under goes corrosion. The upper portion act as cathode and it is unaffected.

At anode: $\text{Fe} \rightarrow \text{Fe}^{2+} + 2e^-$

At cathode: $\text{H}_2\text{O} + \frac{1}{2}\text{O}_2 + 2e^- \rightarrow 2\text{OH}^-$

overall reaction $\text{Fe}^{2+} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2$

oxidising environment $2\text{Fe}(\text{OH})_2 + \text{H}_2\text{O} + \frac{1}{2}\text{O}_2 \rightarrow \text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$