

3P

## Module - IV

### Chapter - Corrosion

#### Corrosion :-

Corrosion is the destruction of metals and alloys in the presence of an environment by chemical or electrochemical means.

- \* It is a process involve reaction of metals with environmental species.
- \* It is an irreversible interfacial reaction of a material (metal, ceramic and polymer) with its environment which results in its consumption or dissolution into the material of a component of the environment.
- \* Corrosion also called as weeping of metals.

#### Causes of corrosion :-

In nature, metals occur in two different forms.

1. Native state
2. Combined state

#### 1. Native state :-

The metals exist as such in the earth crust then the metals are present in a native state. Native state means free or uncombined state. These metals are non-reactive in nature. They are noble metals which have very good corrosion resistance.

Example - Au, Pt, Ag etc.

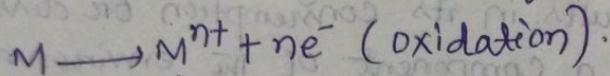
#### Combined state :-

Except noble metals, all other metals are highly reactive in nature which undergoes reaction with their environment to form stable compounds called ores and minerals. This is the combined state of metals.

Example:  $\text{Fe}_2\text{O}_3$ ,  $\text{ZnO}$ ,  $\text{PbS}$ ,  $\text{CaCO}_3$  etc.

Q5. Describe the process of electrochemical theory of corrosion :-

All metals have tendency to pass into solution. The tendency of metal to pass into solution when immersed in a solution of its salt is measured in terms of electrode potential. If a metal having lower reduction potential (higher electropositive) comes into contact with another metal having a higher electrode potential (higher electronegative) a galvanic cell. The metal having lower electrode potential becomes anodic and gets dissolved as corresponding metallic ions with the liberation of free electrons.

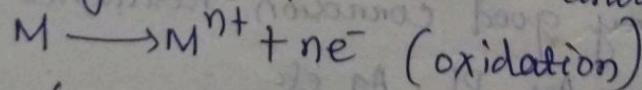


The metal with high electrode potential acts as cathode and gets protected during the process.

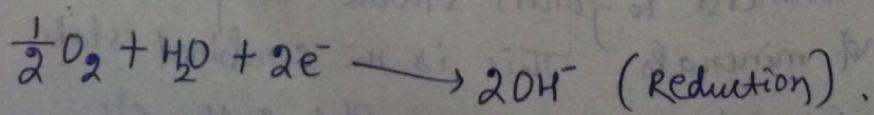
Mechanism of Electrochemical corrosion :-

(i) The existence of separate cathodic and anodic areas between which current flows through the conducting solution.

(ii) Oxidation (loss of electrons) takes place at the anodic area and the metal is destroyed by either dissolution or combination with oxygen. Hence, corrosion always takes place at the anode.



(iii) Reduction (gain of electrons) takes place at the cathode. The electrons from the anode are accepted by the dissolved oxygen forming ions such as  $\text{OH}^-$  or  $\text{O}_2^-$  ions.



The mechanism of electrochemical corrosion explained in terms of two processes :-

- (i) Evolving of hydrogen
- (ii) Absorption of oxygen

### 1. Evolution of Hydrogen :-

- (i) The process of corrosion in which  $H_2$  is liberated is called evolution of hydrogen type corrosion.
- (ii) This mechanism of corrosion follows usually in acidic environment.
- (iii) In acidic medium (absence of oxygen), hydrogen ion acquire electrons with the liberation of  $H_2$  gas in cathodic reaction and the anode is the metal which undergo oxidation and losses electrons to the environment and pass into solution.

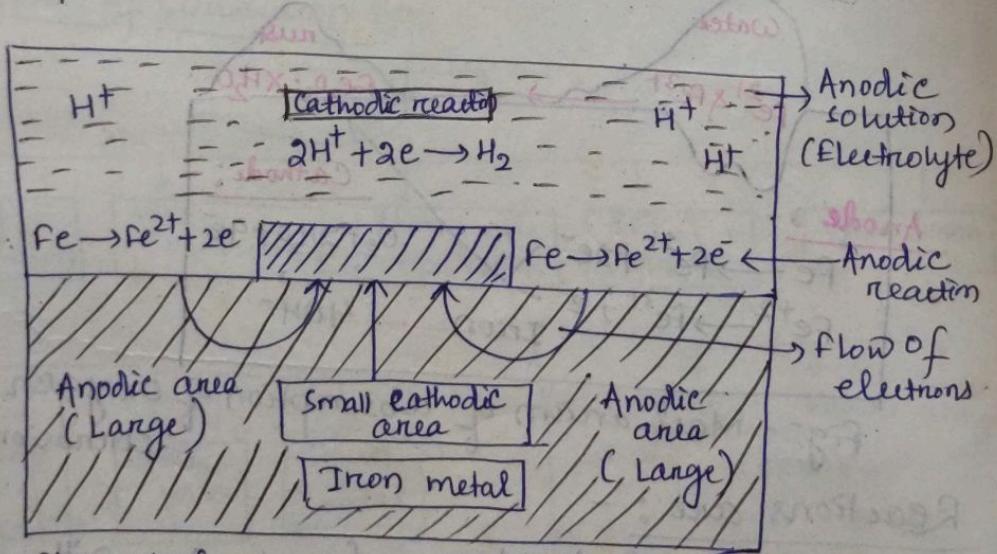
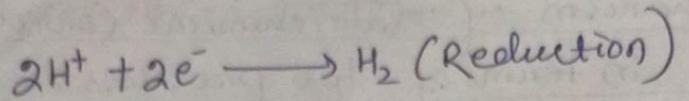


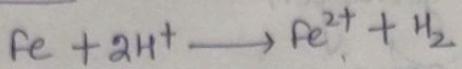
Fig:- Mechanism of wet corrosion by hydrogen evolution.

Example! - (i) If iron metal is used, the dissolution of iron as  $Fe^{2+}$ .  
 $Fe \longrightarrow Fe^{2+} + 2e^-$  (oxidation)

(ii) These electrons flow through the metal from anode to cathode, where  $H^+$  ions of acidic sol<sup>n</sup> accept these electrons and get reduced in the form of  $H_2$  gas.



overall reaction :-



## 2. Absorption of Oxygen :-

- (i) This type of corrosion occurs in basic or neutral environment (such as NaCl solution used as electrolyte).
- (ii) The corrosion of iron occurs by oxygen in the presence of aqueous solution of NaCl.
- (iii) The surface of iron is usually coated with a thin film of iron oxide. This iron oxide forms a crack on the surface.

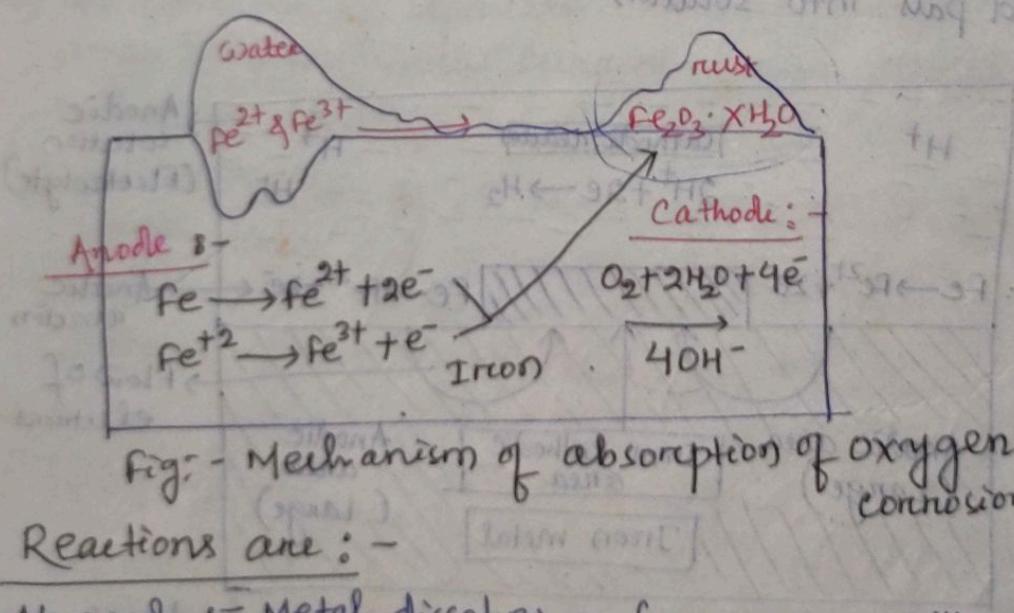
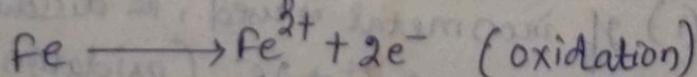


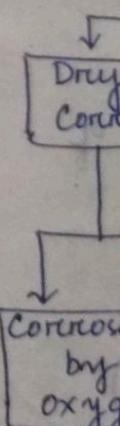
Fig: - Mechanism of absorption of oxygen corrosion.

Reactions are :-

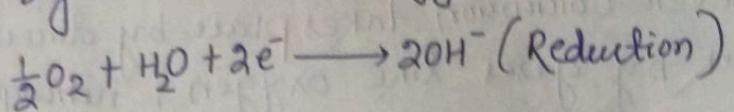
At anode :- Metal dissolves as ferrous ions with liberation of electrons.



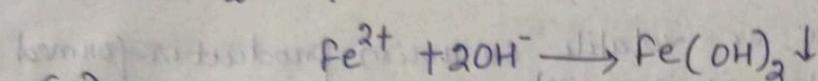
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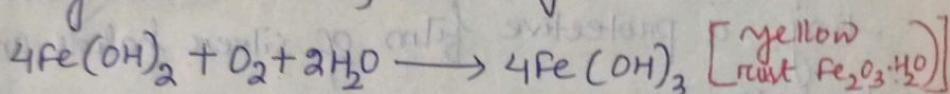
At cathode :- The liberated electrons are intercepted by the dissolved oxygen.



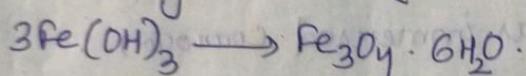
(iii) The  $Fe^{2+}$  ion &  $OH^-$  ion diffuse and when they meet, they combine to form ferrous hydroxide  $Fe(OH)_2$  is precipitate.



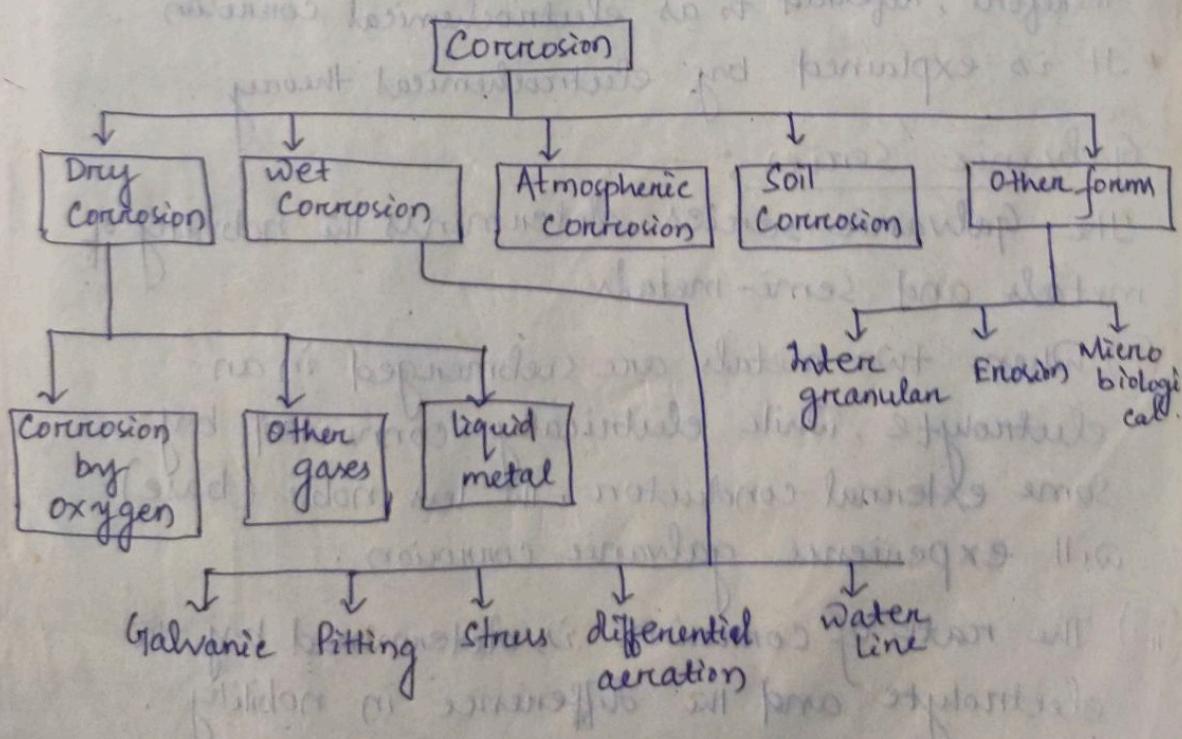
(iv) If enough oxygen is present, ferrous hydroxide is easily oxidized to ferric hydroxide.



(v) If the supply of oxygen is limited, the corrosion product may be black i.e., anhydrous magnetite.



### Types of corrosion :-



### Dry corrosion :-

Whenever corrosion takes place by direct chemical attack by gases like oxygen, nitrogen and halogens, a solid film of the corrosion product is formed on the surface of the metal which protects the metal from further corrosion.

- \* If a soluble or volatile corrosion product is formed, then the metal is exposed to further attack.

Example:- Chlorine and iodide attack silver generally forming a protective film of silver halide on the surface.

### wet corrosion :-

- \* It is also known as immersed corrosion.
- \* It occurs mostly under wet or moist conditions through the formation of electrochemical cells and therefore, referred to as electrochemical corrosion.
- \* It is explained by electrochemical theory.

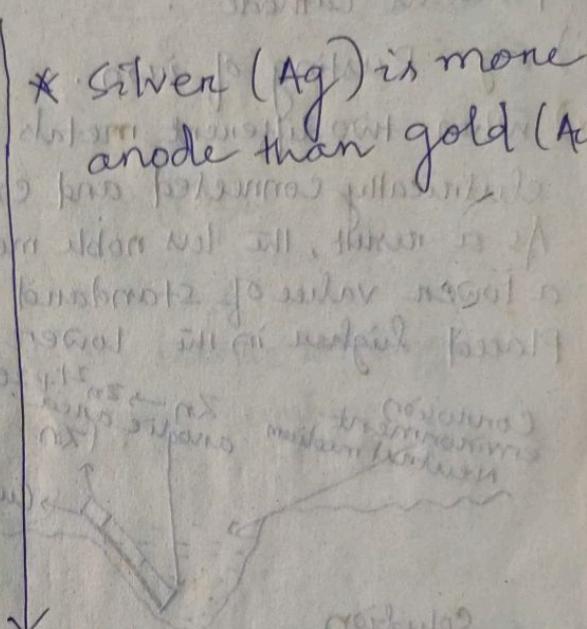
### Galvanic Series :-

The Galvanic series determines the nobility of metals and semi-metals.

- (i) When two metals are submerged in an electrolyte, while electrically connected by some external conductor, the less noble (base) will experience galvanic corrosion.
- (ii) The rate of corrosion is determined by the electrolyte and the difference in nobility.

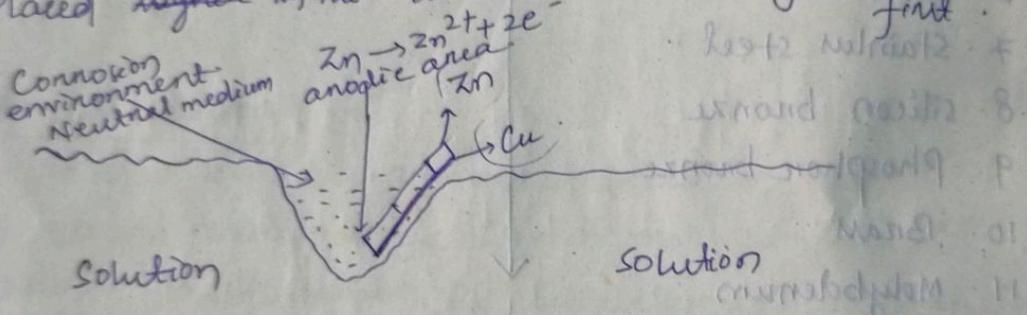
- (iii) Ohm's law  
(iv) The voltaic cell  
(v) Galvanic series  
1. Gr  
2. Pa  
3. Pl  
4. Gc  
5. Si  
6. Ti  
7. St  
8. Si  
9. Fe  
10.  
11.  
12.  
13.  
14.  
15.  
16.  
17.  
18.  
19.  
20.  
21.  
22.

- (iii) The difference can be measured as a difference in voltage potential: no other materials
- (iv) The less noble metal is the one with a lower electrode (i.e., more negative) will function as anode.
- Galvanic series :- (More anodic we goes below)

1. Graphite		* Silver (Ag) is more anode than gold (Au).
2. Palladium		
3. Platinum		
4. Gold		
5. Silver		
6. Titanium		
7. Stainless steel		
8. silicon bronze		
9. Phosphor bronze		
10. Brass		
11. Molybdenum		
12. Tungsten		* It means (Mg) is more anode than
13. Tin		
14. Lead - (-0.13)		
15. Chromium		
16. Nickel		
17. Cast Iron		
18. Aluminium		
19. Cadmium		
20. Beryllium		
21. Zinc		
22. Magnesium		→ More anode

## Differential metal corrosion :-

- (i) When two dissimilar metals or alloys are in contact with each other in the presence of a conducting medium (aqueous solution, moisture etc.).
- (ii) Oxidation takes place at anode and reduction takes place at cathode.
- (iii) E.g.: Rusting of iron.
- (iv) When two different metals (e.g. zinc & copper) are electrically connected and exposed to an electrolyte. As a result, the less noble metal (i.e., the metal having a lower value of standard reduction potential or placed higher in the lower is in series gets corroded first).

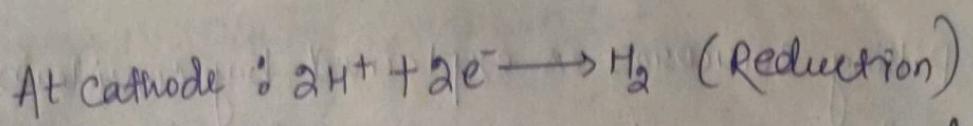


- (v) E.g.: Zn-Cu, Zn-Ag, Fe-Cu
- (vi) In Zn-Cu galvanic cell, Zinc ( $E^\circ = -0.76\text{V}$ ) has lower reduction potential. Cu ( $E^\circ = +0.34\text{V}$ ) acts as anode and the electrons flows from anodic metal Zn to Cathodic metal (Cu).
- (vii) The anodic metal is corroded, while cathodic metal remains protected.

## Mechanism :-

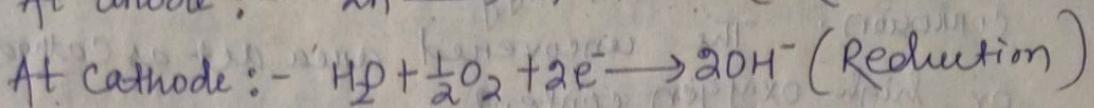
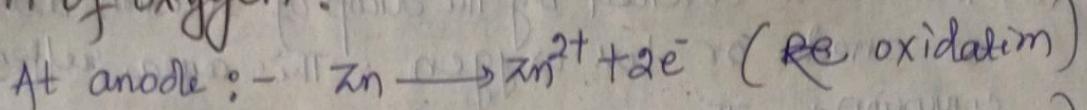
In acidic solution, occurs by evolution of Hydrogen.

At anode:  $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$  (oxidation)

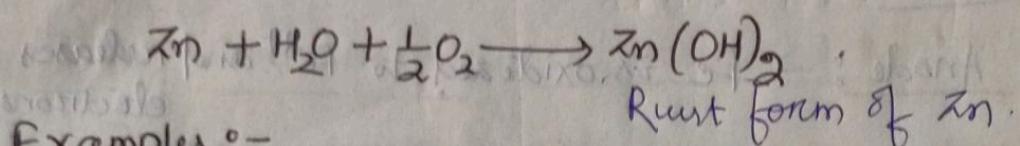


2. In neutral, the corrosion occurs by absorption

-n of oxygen :



overall reaction is ,



Examples :-

- (i) A steel propeller shaft in bronze bearing
- (ii) Steel pipe connected to copper Plumbing

### Pitting Corrosion :-

Pitting corrosion is a non-uniform corrosion which is caused by localized accelerated attack on metal surface and forms pits, cavities and pin holes in the metal.

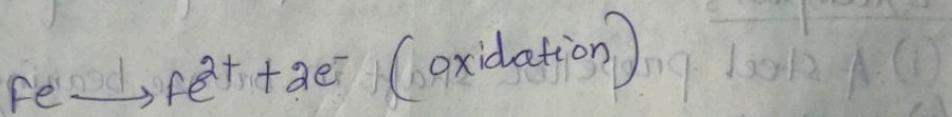
- (i) A pit is formed when the protective coatings on the metal surface breaks at specific points.
- (ii) Once the pit is formed, the process of corrosion becomes fast due to the differential amount of oxygen in contact with the metal surface.
- (iv) The portion with higher concentration of oxygen become cathode and that with lower oxygen concentration becomes anode. This causes corrosion of metal.

(v) Pitting corrosion is explained by considering a drop of water on a metal surface.

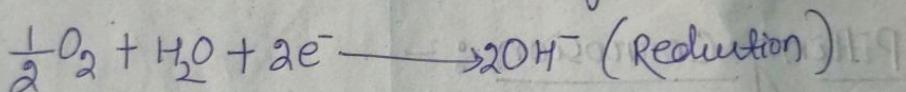
(vi) The area covered by the drop of solution act as anode or less oxygen. This area suffers corrosion. The uncovered area act as cathode or high oxygen content.

Mechanism :-

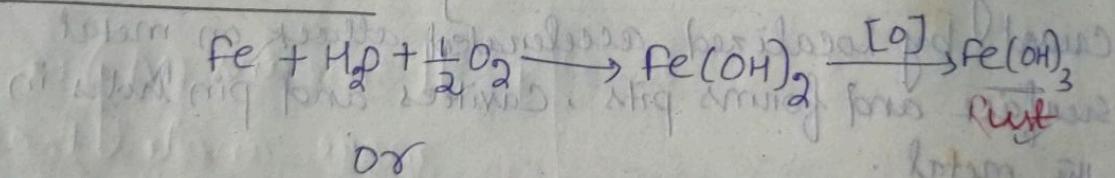
At Anode : - Fe is oxidized to  $Fe^{2+}$  and releases electrons



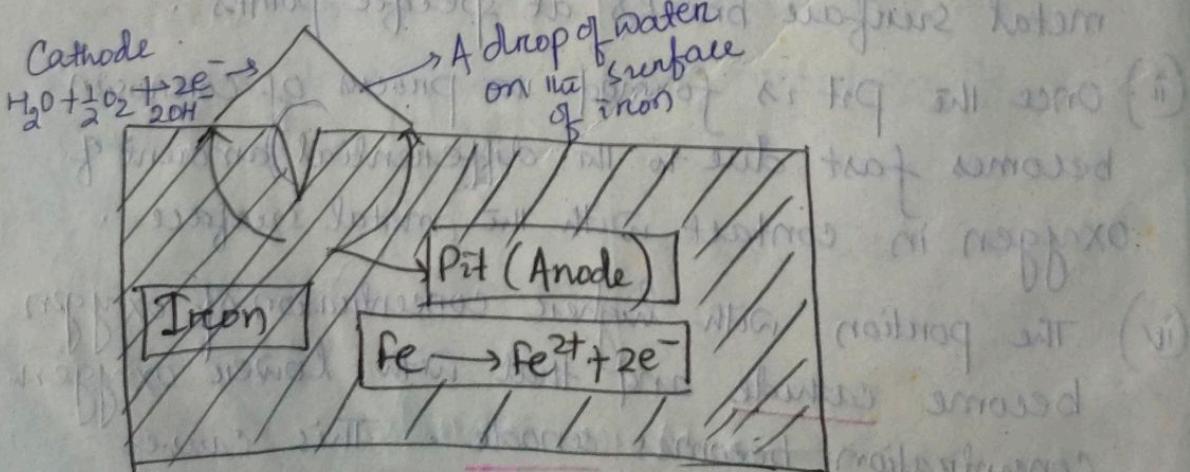
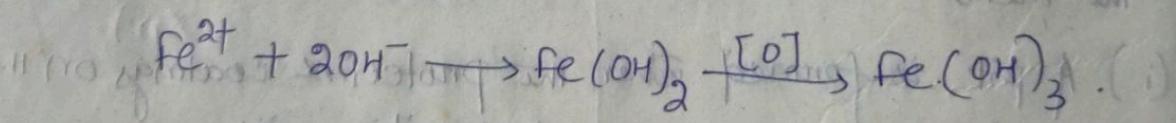
At Cathode : - oxygen is converted to hydroxide ion



Overall reaction :-



OR



## Causes of Pitting Corrosion :-

- (i) Surface roughness.
- (ii) Scratches on metal surface.
- (iii) Local strains of metal due to non-uniform stress.
- (iv) Presence of impurities (like sand, dust, or scale).
- (v) Presence of drop of salt solution.
- (vi) Non-uniform polishing of metal.

## Pitting Corrosion may be prevented by :-

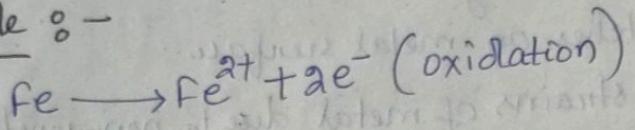
- (i) Proper designing of metal.
- (ii) Proper polishing of metal.
- (iii) Use of pure metal.

## Water-line Corrosion :-

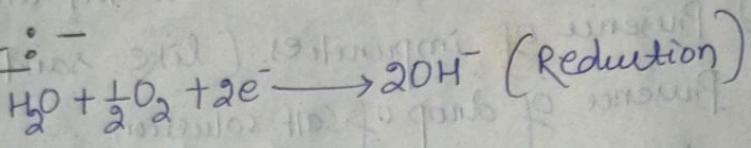
- (i) It is the type of differential aeration corrosion, which occurs when a metal is partly immersed in water. The corrosion takes place just below the waterline and hence it is known as Waterline corrosion.
- (ii) When water is kept stagnant in a steel tank for a long time, corrosion takes place just below the water level, it is due to the concentration of dissolved oxygen at the water surface is greater than that in the under surface. It forms an oxygen concentration cell.
- (iii) The area above the waterline (highly oxygenated) acts as cathodic and corrosion takes place along a line just beneath the level of water meniscus (anodic area).

corrosion takes place at anodic part :-

At Anode :-



At Cathode :-



Overall reaction :-

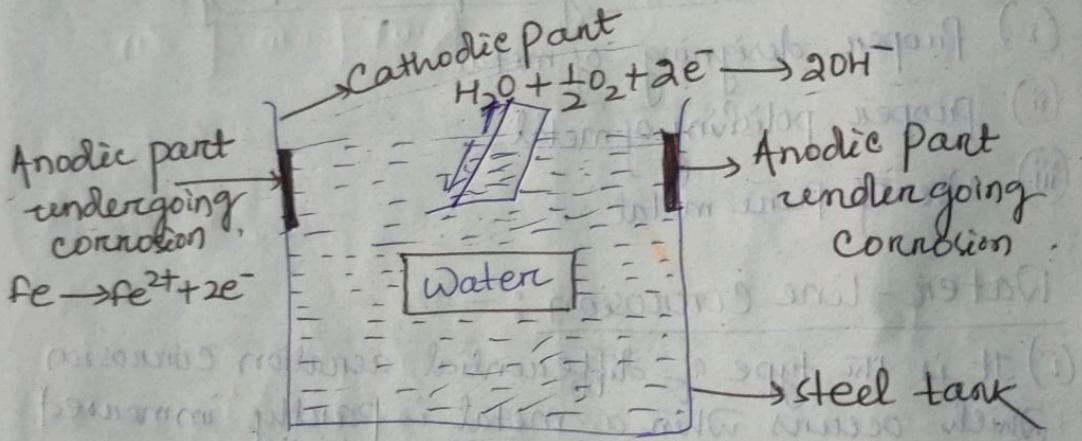
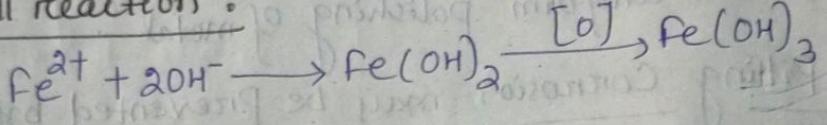


fig:- Water-line corrosion

Causes :-

- (i) When water is acidic in nature.
- (ii) When there will be presence of salts like Chlorides, bromides etc.
- (iii) When marine plants attach themselves to side of the ships.
- (iv) Presence of different salts.

## Prevention of water-line corrosion :-

- (i) It can be reduced when the water is free from impurities.
- (ii) Use of special anti-foaming paints minimizes such type of corrosion.
- (iii) By using anodic inhibitors like phosphates, carbonates, silicates. Water-line corrosion can be reduced.
- (iv) Avoid water in acidic nature and presence of salts like chlorides, bromides etc.

## Differential Aeration Corrosion :-

When a metal is exposed to an electrolyte of different concentration or to varying aeration, it undergoes an electrochemical attack due to formation of miniature concentration cells on its surface and get corroded.

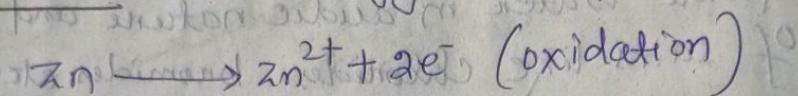
- (i) This type of cell is formed when the metal is kept in different air concentration i.e., two ends of metal surface are at different concentration of air.
- (ii) The part of metal which is poorly oxygenated acts as anode and other part of the metal which is highly oxygenated acts as cathode. This develops electrode potential and hence, the metal gets corroded.

### Mechanism :-

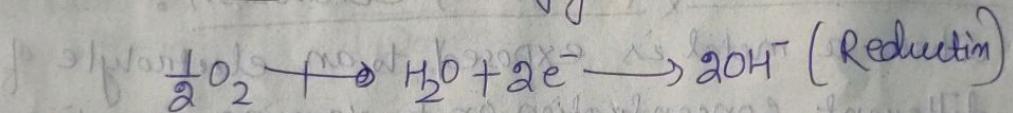
let us consider the zinc (Zn) rod which is immersed in NaCl solution.

The part of the rod which is at greater depth acts as anode (less oxygenated) and that is above the surface acts as cathode (more oxygenated) and zinc corrodes due to electrode potential.

At anode :- less oxygenated part



At cathode :- More oxygenated part



Overall reaction :-

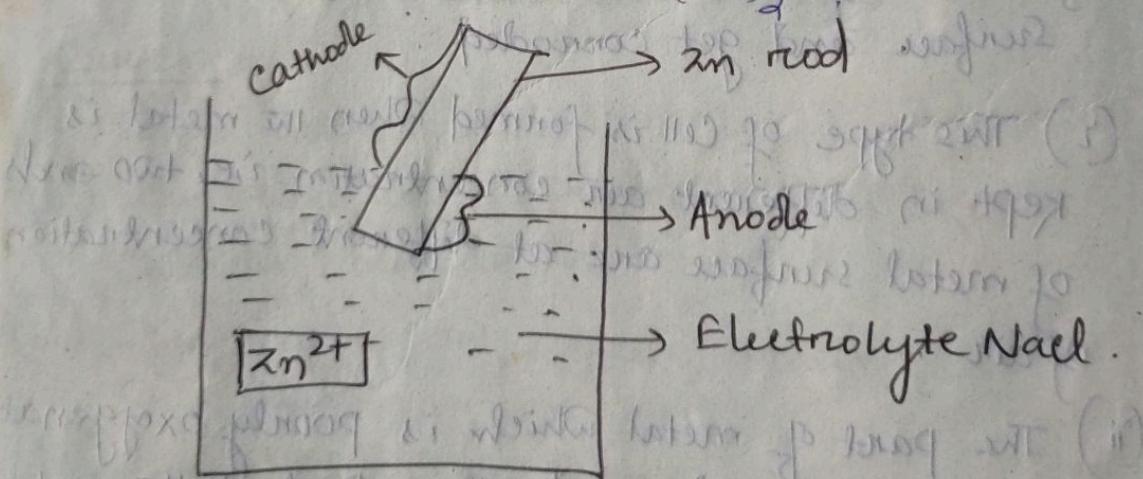
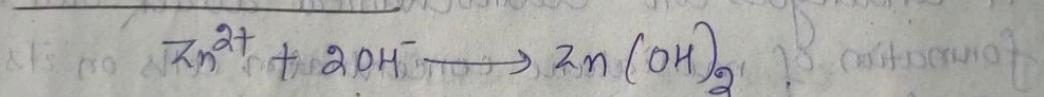


Fig:- Differential aeration corrosion

which finds application in ships & aircrafts with following steps taken :-

## Characteristic of Differential Aeration Corrosion :-

- (i) The metal having low oxygen concentration part act as anode and metal having high oxygen concentration act as cathode.
- (ii) Corrosion may be accelerated in accessible places because of the deficiency of oxygen at some part.
- (iii) This type of corrosion also get accelerated under accumulation of dirt, sand, scale or other contamination, because such covered Part act as anode due to difference in air concentration.
- (iv) It is a localized attack on some oxygen deficient areas such as metal exposed to aq. media corrode under blocks of wood or pieces of glass which screen that portion of metal from oxygen access, resulting into localized pitting.

## Stress Corrosion :-

Stress corrosion is the type of corrosion which occurs due to combined effect of tensile stresses and the corrosive environment on metal. When metal is exposed to corrosive environment

- (i) Pure metal generally does not undergo stress corrosion whereas fabricated metal components or an article of certain alloys like zinc & nickel undergoes such type of corrosion.

### Tensile stress :-

The stress developed on metal surface may be internal or external. Internal stress is caused by manufacturing process (quenching, bending, annealing etc..), or fabrication process or heat treatment process. In such cases, metal under stress becomes more anodic and that area undergoes corrosion.

### Corrosive environment :-

The specific and selective environment play important role in stress corrosion.

### For Example :-

- Mild steel undergoes stress corrosion in the presence of caustic alkalis and strong nitrate solution.
- Stainless steel in the presence of acid chloride solution.
- Braze in the presence of traces of ammonia.

### Mechanism :-

- Stress corrosion is a localized electrochemical phenomenon.
- The area under stress as well as grain boundaries act as electrochemical cell which occurs generally due to internal stresses of the metallurgical operations such as bending, pressing, rolling, quenching, annealing etc.
- The presence of stress area it forms anodic part in localized zone.
- The part of area at metal surface act as cathodic part.

unstrained part  
act as cathode

Part under stress  
act as anode

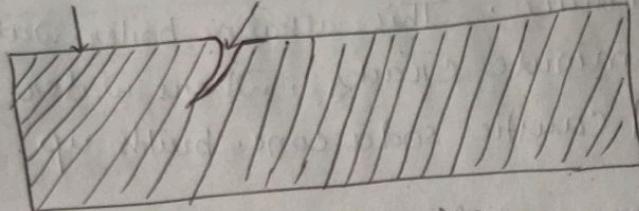
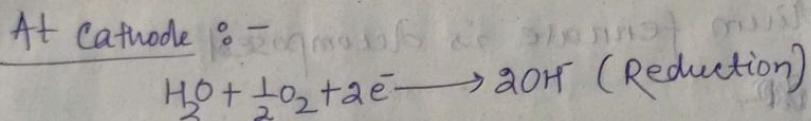
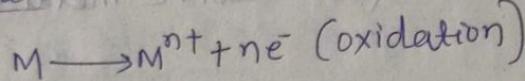


fig:- stress corrosion



### Caustic embrittlement :-

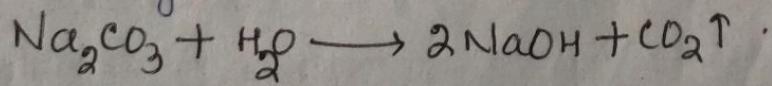
This type of corrosion generally occurs in mild steel, which undergoes stress corrosion in caustic alkalies at high temperature and pressure.

- (i) It is a very dangerous form of stress corrosion that generally occurs in steam-boilers and heat transfer equipment in which water of high alkalinity attack mild steel plants, particularly by bends, joints etc.

### Methods :-

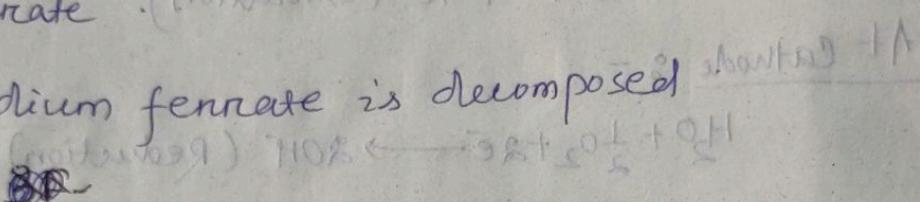
- (ii) for water-softening purpose of boiler-water, we generally added a certain proportion of sodium carbonate ( $Na_2CO_3$ ) into it.

- (iii) In high pressure boilers, this breaks up to give sodium hydroxide and carbon dioxide.



Q. 2. Define  
Factor

- (iii) The formation of NaOH makes boiler-water alkaline in nature. This alkaline boiler-water flows into the minute cracks, where water evaporates and caustic soda conc. builds up.
- (iv) The area where metal is stressed and conc. of alkali is much higher than that in the body of the boiler, alkali dissolve metal as sodium ferrate. (minerals)  $\text{Na}_2\text{FeO}_4 + \text{Me} \rightarrow \text{M}$
- (v) sodium ferrate is decomposed



Sodium hydroxide is regenerated and magnetite is ( $\text{Fe}_3\text{O}_4$ ) is precipitated, it enhances further dissolution of iron.

### Prevention :-

- (i) Use of sodium sulphate in boiler-water  
(ii) Use of tannins or lignin, as additive boiler-water

Q.3. Describe the factors influencing corrosion?

### Factors Influencing Corrosion :-

There are two factors that influence the rate of corrosion, because the rate of corrosion is different in different atmosphere.

1. Nature of the metal
2. Nature of the corroding environment

#### 1. Nature of the Metal :-

a) Physical state :-

The rate of corrosion is influenced by physical state of the metal (such as size, orientation of crystals, stress, etc..).

The smaller the size of the metal, the greater will be its solubility and hence greater will be its corrosion.

#### b. Purity of metal :-

Impurities in a metal cause different forms and the anodic parts get corroded.

#### c. Over voltage :-

The over voltage of a metal in a corrosive environment is inversely proportional to corrosion rate.

Example - The over voltage of hydrogen is 0.7V. When zinc metal is placed in 1M Sulphuric acid and the rate of corrosion is low.

When we add small amount of copper sulphate to dil. Sulphuric acid, the hydrogen over voltage is reduced to 0.33V. This results increase in corrosion of zinc.

#### d. Nature of surface film :-

In aerated atmosphere, all metals get covered with a thin surface film of metal oxide. The greater the specific volume of ratio, lesser is the oxidation corrosion rate.

Example:- The specific volume ratios of Ni, Cr & are 1.6, 2.0 respectively.

#### e. Relative areas of the anodic & cathodic parts :-

When two dissimilar metals are in contact, the corrosion of the anodic part is directly proportional to the ratio of areas of the cathodic part & the anodic part.

If anodic area is small, corrosion is more rapid & highly localized.

#### f. Position in galvanic series :-

It also depends upon the position of metal in galvanic series. The rate of corrosion depends upon the difference in their positions, the greater is the difference, the faster is the corrosion of the anodic metal alloy.

#### g. Passive character of metal :-

It is a phenomenon in which a metal or an alloy exhibits a much higher corrosion resistance than expected from its position in the electrochemical series.

### i). Solubility of Corrosion Products :-

If the corrosion product is soluble in the corroding medium, corrosion of metal will take place at a higher rate. But if the corrosion product is insoluble in the corroding medium, it forms a protective layer on the metal surface and inhibits further corrosion of the metal.

### (ii). Volatility of Corrosion products :-

If corrosive product is volatile in nature, they volatile as soon as they are formed. Hence, the underlying metal surface is exposed for further attack, resulting rapid & continuous corrosion.

## 2. Nature of the Corroding Environment :-

### a) Temperature :-

The rate of corrosion is directly proportional to temperature i.e. rise in temp. increases the rate of corrosion. This is because the rate of diffusion of ions increases with rise in temp.

### b) Humidity of air :-

The rate of corrosion will be more than when the relative humidity of the environment is high. The moisture acts as a solvent for oxygen,  $\text{CO}_2$ ,  $\text{SO}_2$  in the air to produce the electrolyte which is required for setting up a corrosion cell.

### c. Presence of impurities in atmosphere :-

Atmosphere in industrial areas contains corrosive gases like  $\text{CO}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{SO}_2$  and fumes of  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$ . In presence of these gases, the acidity of the liquid adjacent to the metal surfaces increases and its electrical conductivity also increases. The rate of corrosion increases.

### d. Presence of suspended particles in atmosphere :-

The suspended particles like  $\text{NaCl}$ , Ammonium sulphate, they absorb moisture & act as strong electrolytes, causes corrosion.

If suspended particles inactive in nature (e.g. charcoal), they absorb both sulphur gases and moisture and slowly enhances the corrosion rate.

### e. Influence of pH :-

The acidic substance ( $\text{pH} < 7$ ) are corrosive in nature and the alkaline substances, ( $\text{pH} > 7$ ), they are also corrosive in nature.

### f. Formation of oxygen concentration cell :-

Differential aeration concentration cell is set up due to change in the concentration of oxygen. Rate of corrosion increases with increase in concentration of oxygen.

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- The region where oxygen concentration is lesser becomes anodic and oxygen concentration rich portion becomes cathodic.
- The anodic portion suffers corrosion.
- Rate of corrosion increases due to the formation of differential aeration cell.

### Galvanization :-

Galvanization is the process of applying a protective zinc coating to steel or iron, to prevent rusting. The most common method is hot-dip galvanizing, in which parts are submerged in a bath of molten zinc.

- Galvanising protects the base metal in 3 ways:
- (i) It forms a coating of Zn which, when intact, prevents corrosive substances from reaching the underlying steel or iron.
- (ii) The Zn serves as a sacrificial anode so, that if the coating is scratched, the exposed steel will still be protected by the remaining zinc.

### Galvanization method :-

- The Iron sheet first Pickled (washed) ie with dil.  $H_2SO_4$  acid to remove traces of rust, dust or any other impurities at 60-90°C for about 15 - 20 minutes.

- Then the metal is dipped in a molten Zn bath at  $430^{\circ}\text{C}$ . The surface of the bath is covered with ammonium chloride flux to prevent oxide formation on the molten Zn.
- When the article taken out, it is found to have been coated with a thick layer of Zn. It is then passed through a pair of hot rollers. To remove excess Zn and produce a thin film of uniform thickness.
- Now, the coated article is annealed at a temp. of  $650^{\circ}\text{C}$  and cooled to room temperature slowly. Then the Galvanized Sheet formed.

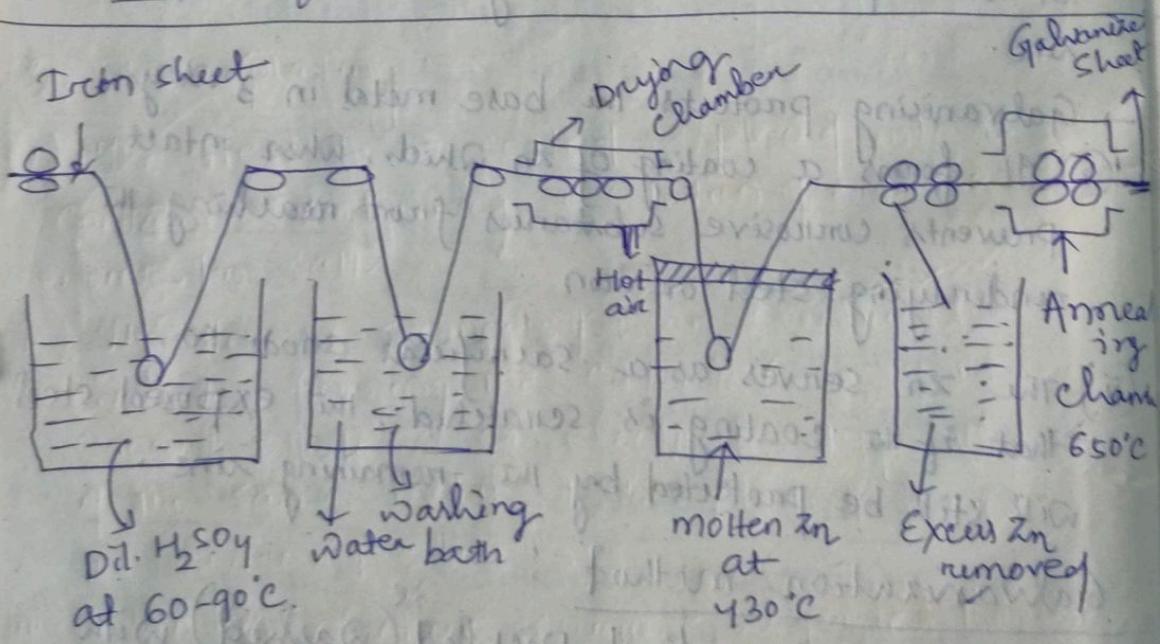


fig:- Galvanization of Iron Sheet

### Tinning

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### Uses

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Tinning: It is the process of thinly coating sheets of wrought iron or steel with tin and the resulting product is known as tinplate.

- (i) It is used to prevent rust.
- (ii) It is applied to the end of stranded wire used as electrical conductors to prevent oxidation (which increases electrical resistance) and to keep them from fraying or unravelling when used in various wire connectors like twist-ons, binding posts or terminal blocks, where stray strands can cause a short circuit.

### Uses

- Tinplate was consumed in vast quantities for the manufacture of the tin cans in which preserved meat, fish, fruit, biscuits, cigarettes and other products are packed.
- For household utensils of various kinds.

### Tinning Process:

There are two processes for the tinning of the black plates.

1. Hot dipping.

2. Electroplating.

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## 1. Hot dipping :-

- (i) Tinplate made by hot-dipped tinplating is made by cold rolling steel or iron.
- (ii) Pickling to remove any scale.
- (iii) Annealing to remove any strain hardening.
- (iv) Then coating it with a thin layer of tin.
- (v) Originally this was done by producing individual or small packs of plates, which became known as the pack mill process.
- (vi) In the late 1920's strip mills began to replace pack mills, because they could produce raw plates in larger quantities.

## 2. Electroplating :-

- (i) The item to be coated is placed into a container containing a solution of one or more tin salts.
- (ii) The item is connected to an electrical circuit, forming the cathode (-ve) of the circuit while an electrode typically of the same metal to be plated forms the anode (positive).
- (iii) When an electric current is passed through the circuit, metal ions in the solution are attracted to the item.
- (iv) To produce a smooth, shiny surface the electroplated sheet is then briefly heated.

## Corrosion

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- above the melting point of tin
- (v) Co thin layer are provided to prevent dulling of the surface from oxidation of the tin.

### Corrosion inhibitors :-

Inhibitors are chemical substances which on adding in small portion to the corrosive medium decreases the corrosion rate.

→ Pickling is a metal surface treatment used to remove impurities such as stains, inorganic - contaminants, rust or scale from ferrous metals, Cu, Al alloys.

(i) A solution called pickle liquor which contains strong acids is used to remove the surface impurities.

(ii) It is commonly used to clean steel in various steel making process.

(iii) Pickling inhibitors are used to protect metal components from corrosive action against acid effect while maintaining the pickling performance of the system.

→ Corrosion concentrations inhibitors can vary from 1 to 15,000 P.P.M.

→ Corrosion inhibitors can be solids, liquids & gases

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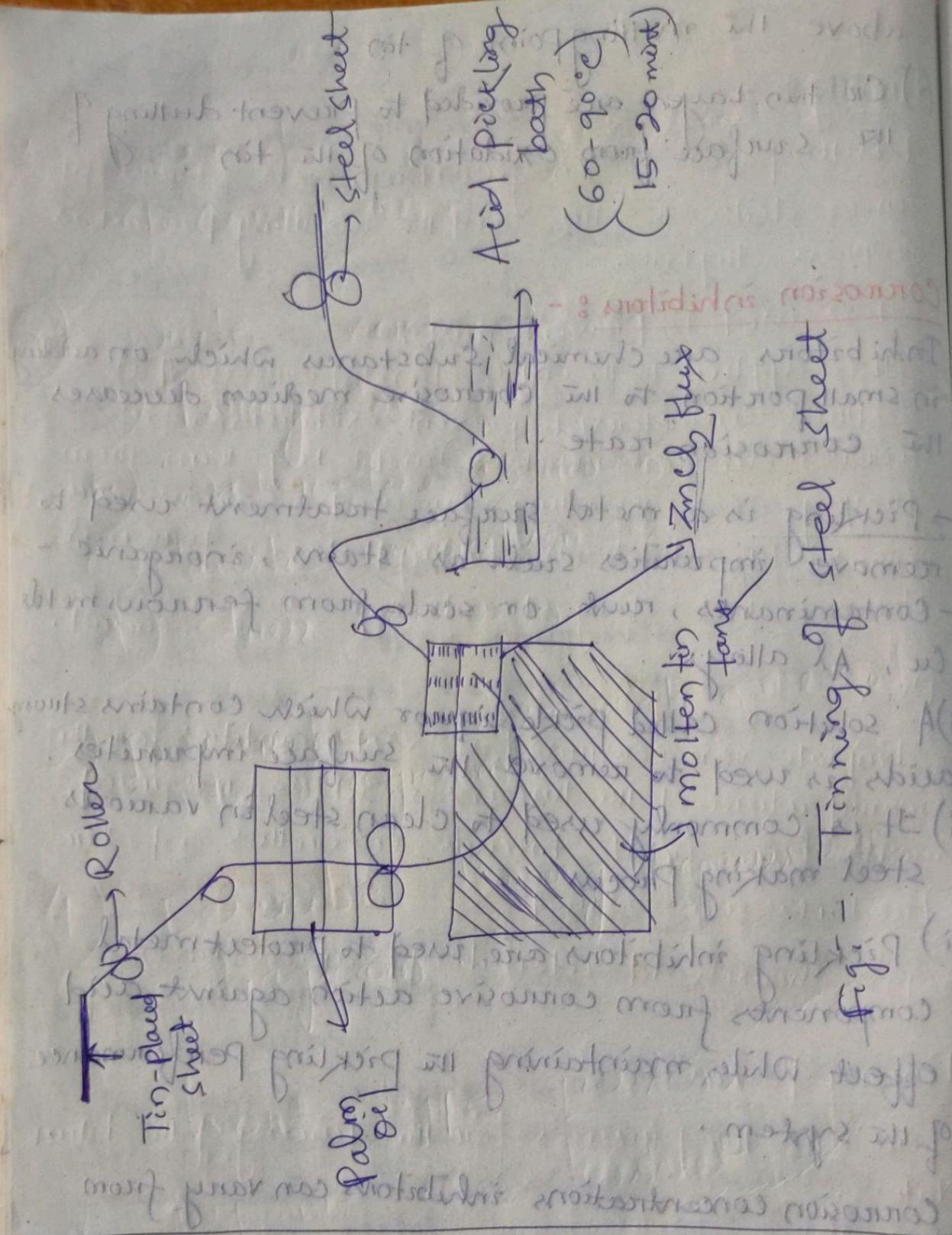
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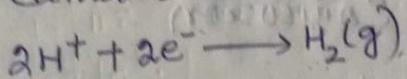


at 15,000 rpm.

## Cathodic inhibitor's -

This type of inhibitors slow down the corrosion reaction by considerably decreasing the diffusion of hydrated  $H^+$  ion to the cathode and can be used in acidic as well as in neutral medium.

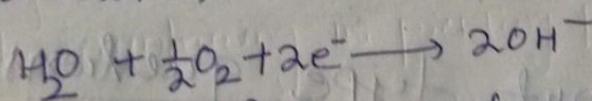
In acidic solution, the corrosion process involves the following Cathodic reaction:



The corrosion of a metal can be reduced by slowing down the rate of diffusion of  $H^+$  ions through the cathode.

- It can be done by using organic compounds such as mercaptans, amines, substituted arenes, heavy metal-soaps, heterocyclic nitrogen compounds etc.
- They absorb to the metal surface and act as cathodic inhibitors.
- Antimony and arsenic oxides deposit adherent film of metals at the cathode and slow down the overvoltage for hydrogen evolution.

In a neutral solution, cathodic reaction is written as,



- The hydroxide ( $OH^-$ ) ions are formed due to the presence of  $O_2$ .
- The corrosion can be controlled by either eliminating  $O_2$  from the corroding environment or by retarding its movement to the cathodic areas.
- The oxygen is eliminated by adding reducing agents like  $Na_2SO_3$  or using  $Mg$ ,  $Ni$ ,  $Zn$  salts.
- These salts react with hydroxide ion to form insoluble  $OH^-$  which deposit on the cathodic areas to form a impermeable barrier.

## Important questions

- 1) Describe the electrochemical theory of corrosion.
- 2) Write short note on:
  - a) Pitting Corrosion.
  - b) Water-line corrosion.
  - c) Caustic embrittlement.
  - d) Stress corrosion.
- 3) Describe galvanisation method with diagram.
- 4) Describe tinning process with diagram.

## Short type questions:-

\* Why we use tin sheet for