

UNIT-4

CORROSION :-

* Corrosion :-

- It is the process of slowly disintegration / deterioration or decay of metallic materials from the metallic surface due to attack by atmospheric mass or any other chemical or electrochemical environment.
- The corrosion takes place only on the metallic surface because the metal extracted from ores are unstable. Hence, they react with environment to become stable.
- Due to corrosion the metal will loss its property like (i) conductivity, (ii) malleability (iii) ductility.
- A layer of reddish scale and powder in form on the surface of iron metal.

* Effect of corrosion :-

- The economic and social consequence of corrosion include due to the formation of corrosion products over machinery.
- The efficiency of the machine get reduced and fails to give good efficiency and leads to plant shut down.
- The product contamination or loss of product takes place due to corrosion.

* Prevention :-

- Metallic coating
- Organic coating
- Electro plating
- Galvanization

* Types of corrosion: (10 marks)

Corrosion of metal can be divided as two types:

(1) Wet corrosion

(2) Dry corrosion.

(I) DRY CORROSION:

- This type of corrosion occurs mainly through direct chemical attack of environment.
- The corrosion of metal due to direct chemical attack or react with O_2 , H_2S , SO_2 , N_2 etc. and fused material in the absence of moisture is called as dry corrosion.
- * Factors effecting Dry corrosion:- Date: 01/11/24

(i) Oxidation corrosion.

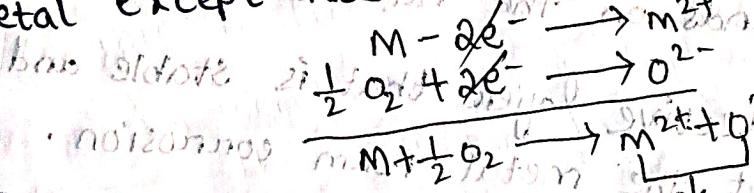
(ii) Corrosion due to gases other than oxygen.

(iii) Fused metal corrosion.

*(i) Oxidation corrosion:

- When metal react with surrounding oxygen, a thin layer of metal oxide is formed on its surface is called as oxidation corrosion.

→ Highly reactive metals like Alkyl (Lithium, Sodium, Potassium etc.) and alkalines metals (calcium, strontium, magnesium etc.) get oxidized at low temperature, and at high temperature other metal except Nobel metal get oxidized.



- When oxidation starts, a thin layer of oxide is formed which may be stable, unstable, corrosive or volatile and depending upon their nature further corrosion progress.

V.N.I
(2 marks)

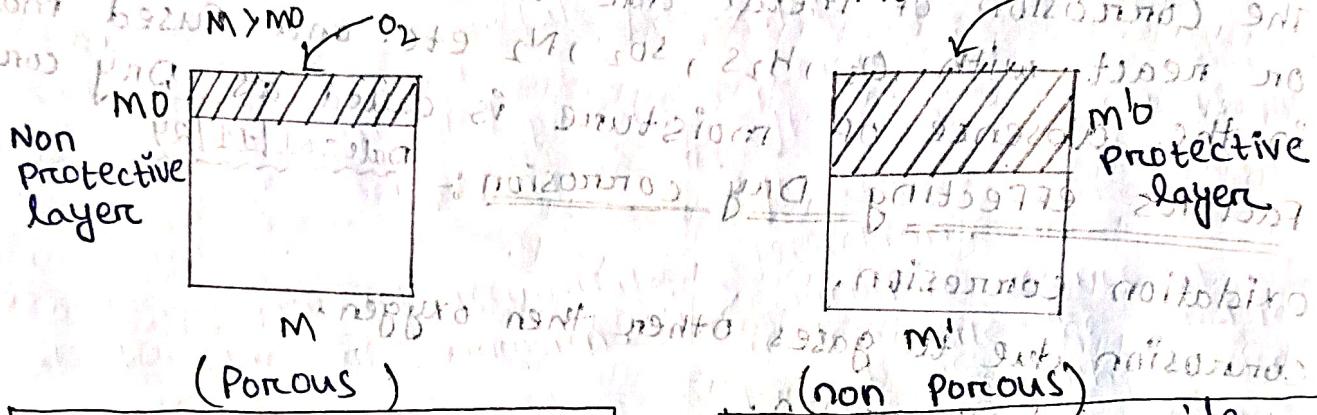
PILLING BED WORTH RULE:

- The ratio of the volume of the oxide formed to the volume of the metal consumed is called pilling bed worth rule.

→ According to pilling bed worth rule, if the volume of

Oxide layer is greater than the volume of the metal layer. The oxide layer is protective & non porous. → on the other hand, if the volume of oxide layer is formed is less than the volume of metal, the oxide layer is non-protective and porous.

$$\text{Specific Volume ratio} = \frac{\text{Volume of metal oxide}}{\text{Volume of metal}}$$



$$\frac{\text{Volume of metal oxide}}{\text{Volume of metal}} < 1$$

$$\frac{\text{Volume of metal oxide}}{\text{Volume of metal}} > 1$$

→ Pilling bed worth rule describes the porous and non-porous nature of metallic oxide which is formed on it's during corrosion.

* (ii) Due to gases other than oxygen like H_2S , SO_2 , CO_2

→ When the metal react with the gases like H_2S , SO_2 , CO_2 , Cl_2 etc. A thin film is formed on it's surface. The rate of corrosion depends on the nature of thin film.

→ If the thin film is protective layer that is stable and adhering then it protect the metal from corrosion.

Example: When silver react with chlorine it form a protective layer of silver chloride and prevent corrosion but $SnCl_2$ (stannic chloride), Sn react with chlorine it form a non protective layer

because chlorine it is volatile in nature and causes severe corrosion.

* (iii) Fused metal corrosion:

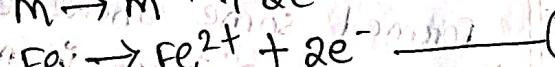
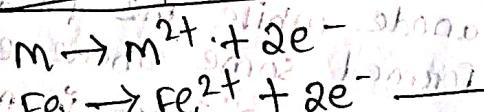
→ When fused metal is allowed to pass on the surface

of given metal but the metal get dissolved in fused metal and corrosion takes place.

Example: Use of Sodium metal as coolant in nuclear plant.

- (2) WET CORROSION:
- The decay or disintegration of metal surface due to the electrochemical attack by the surrounding environment in presence of moisture is called wet corrosion.
 - In wet corrosion anodic path (cathodic path and electrolytic medium is present).
 - At anode, oxidation reaction takes place and metal get corroded.

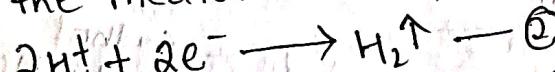
* At anode (oxidation):



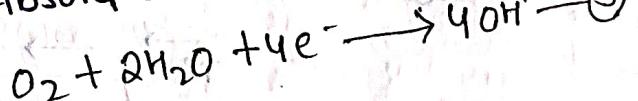
- At cathode, evolution of hydrogen and absorption of oxygen takes place.

* At cathode (reduction):

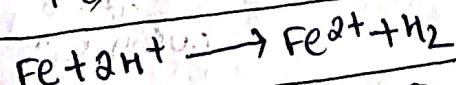
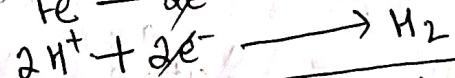
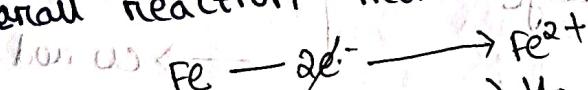
Evolution of Hydrogen
(if the medium acidic)



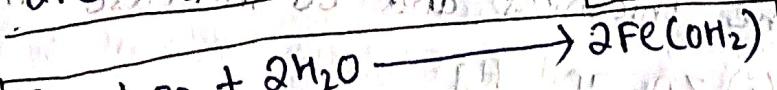
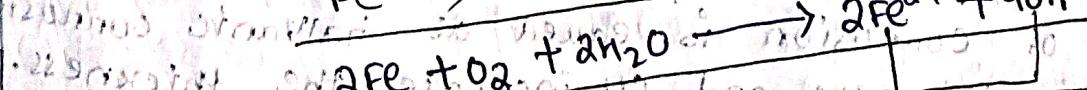
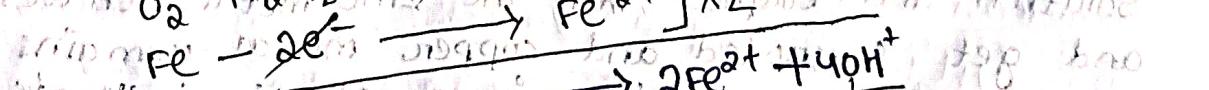
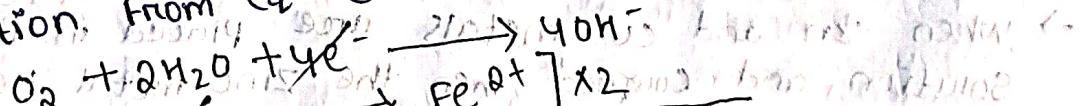
Absorption of oxygen



Overall reaction from eqn (1) and (2)



Overall reaction from eqn (1) and (3)



~~Smarts~~ at home with 100% self study

Difference between DRY CORROSION and WET CORROSION:

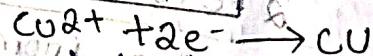
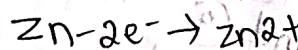
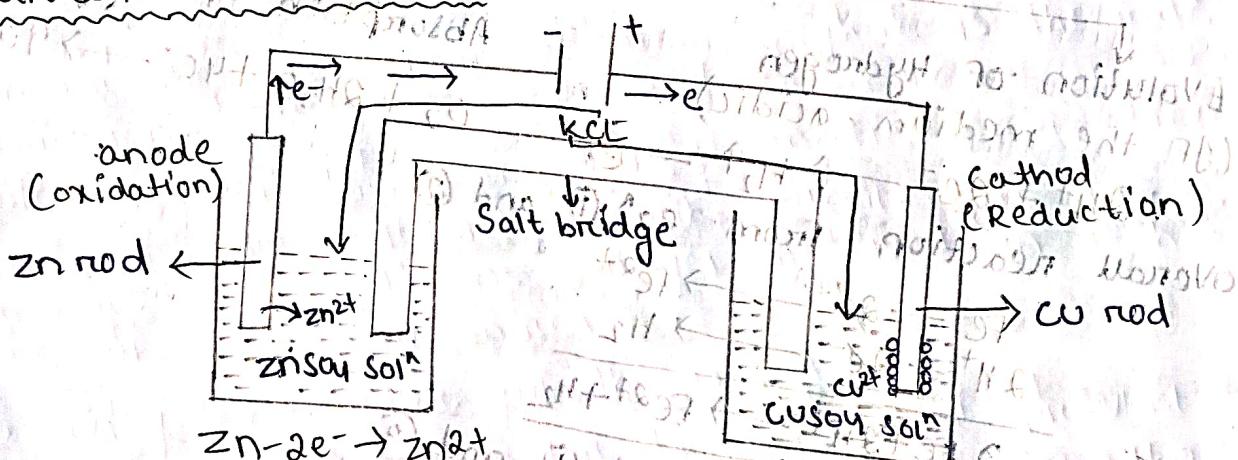
DRY CORROSION

- It is also known as chemical corrosion.
- It is due to direct chemical attack of metal by the environment.
- Even homogeneous metals get corroded.
- It is self controlled process.
- It adopts absorption mechanism.
- Corrosion product accumulate at the place of corrosion.
- Formation of mild scale on iron surface is an example.

WET CORROSION

- It is also known as electrochemical corrosion.
- It is due to the formation of large number of anodic and cathodic area.
- Heterogeneous surface get corroded.
- It is a continuous process.
- It follows electrochemical reaction.
- Corrosion occurs at the anode while the product are formed somewhere else.
- Rusting of iron in moist atmosphere is an example.

Galvanic Corrosion:



- When Zn and Cu metals are placed in its electrolytic solution and coupled then the Zinc metal behaves as anode and get corroded and copper metal remains protected. Such type of corrosion is called as Galvanic corrosion.
- Zn loss the thickness and Cu increase the thickness.

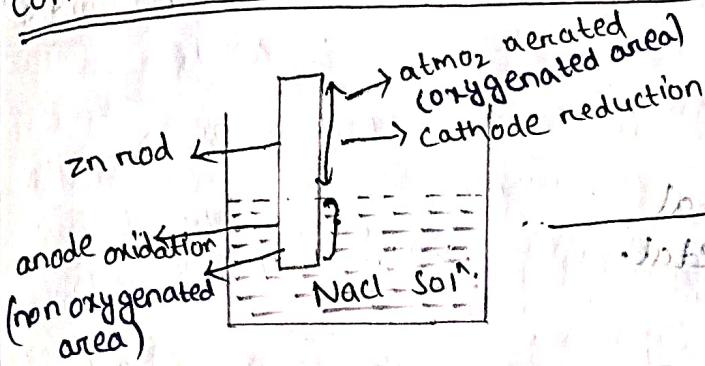
Example: (i) Zn and Ag

(ii) Steel Screw in a brass marine hardware

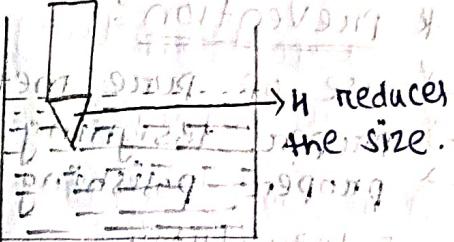
- Galvanic corrosion can be prevented by avoiding galvanic

Couples and providing insulating material between two metal.

Concentration cell / corrosion / Aeration corrosion



Oxygen.



When a metal is half dipped in water or aqueous media then corrosion takes place just below to water line, such type of corrosion is known as water line corrosion or concentration cell corrosion or Aeration corrosion.

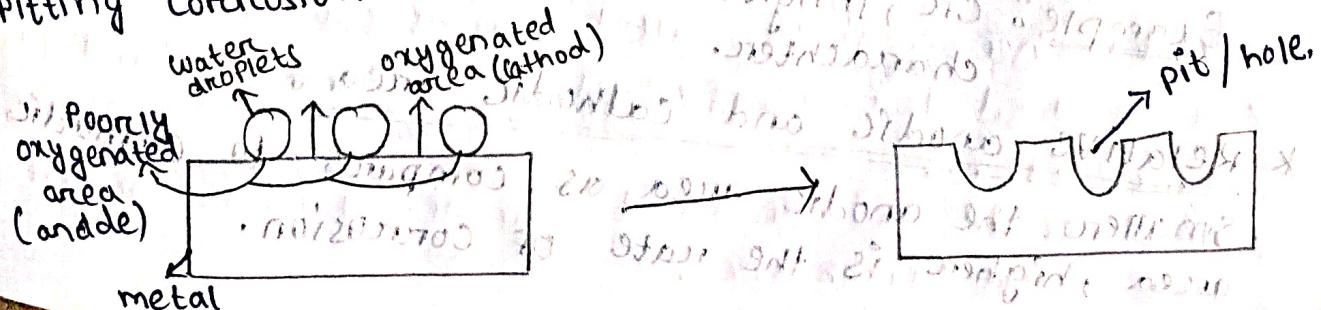
When a part of a metal exposed to a different aeration condition then the other part of same metal, the part of metal which is poorly oxygenated as anode and undergoes severe corrosion.

Example: Let us dip a Zn metal in NaCl solution the Zn ions at anode and at cathode absorption of oxygen takes place and hydroxide ion is formed as a result the Zn get dissolved in NaCl solution to form $\text{Zn}(\text{OH})_2$.

PITTING CORROSION

The corrosion takes place at the hole or pit of the metal surface due to vary in concentration of oxygen or air is known as pitting corrosion.

pitting corrosion is a non-uniform corrosion.



- The area covered by drop of salt solution exposed to less oxygen act as anode. This area suffer corrosion.
- The uncovered area acts as cathod due to high oxygen content.

* Prevention:

- use of pure metal
- proper designing of metal
- proper polishing of metal.

Date: 02/11/24



Cause of corrosion:

The corrosion takes place due to the nature of metal and nature of environment.



Nature of metal:

- * Purity of metal: If purity of metal is low or contains impurities, then it forms an electrochemical cell at the exposed part. Hence, corrosion of metal around the impurity takes place.
- Impurity in metal causes heterogenous and form an electrochemical cell at the exposed part.
- Corrosion of metal around the impurity takes place.
- Pure metal acts as anode and get corroded. Hence, rate of corrosion increases with impurity.

* Size of metal atom:

Smaller the size of metal atom, higher is the rate of corrosion.

* Solubility of the electrolyte:

Higher is the solubility of the electrolyte, larger numbers of metal ions can get dissolved in it hence rate of corrosion increases.

* Passivity character of the metal:

The characteristic of metal to resists or prevent corrosion is known as passivity. Higher is the passivity of metal, lower is the rate of corrosion.

Example: Cr, Tungsten (W) possess high passivity.

* Relative anodic and cathodic area:

Smaller the anodic area as compare to cathodic area, higher is the rate of corrosion.

Example: Pitting corrosion.

Reactivity of the metal:

The metal atom having lower standard reduction potential value are highly active and forms the ion rapidly. Hence it gets corroded.

Nature of oxide film:

If the metal oxide is stable and adhering to the metal surface then it protects the metal from corrosion; if the thin film is volatile and porous then severe corrosion takes place.

NATURE OF ENVIRONMENT:

Temperature: With increase in temperature, the rate of corrosion increases. because with increase in temperature, decrease the intermolecular force of attraction and increase the dissolution of ions.

Example: Boiler Corrosion, Rustic embrittlement.

Humidity: With increase in moisture content in atmosphere, the rate of corrosion increases as the atmospheric gases like H_2S , SO_2 , CO_2 , Cl_2 get dissolved in moisture and form an electrolytic medium. It allows the flow of ion in it and cause the corrosion of metal.

Presence of atmospheric gases: Due to the presence of gases like H_2S , CO_2 , Cl_2 etc., metal get corroded and rate of corrosion depends on the nature of thin film formed on the metal surface.

Example: $2Ag + Cl_2 \rightarrow 2AgCl$ Silver chloride forms a particular layer on the metal where the silver chloride ($AgCl$) is volatile in nature and destroy metal completely.

Difference concentration: When a metal is exposed to varying concentration of ion, oxygen or air less aerated part of the metal gets corroded.

Example: pitting corrosion.

* prevention:

(i) Proper designing and modifying environment.

(ii) Cathodic protection.

* (i) Proper designing and modifying environment.

→ Avoiding heterogeneity in metal.

→ Using less soluble electrolyte.

→ Increase the size of anodic part as compare to cathodic part.

→ Taking the metal atoms at room temperature.

→ Allowing the metal with passive metal.

→ Avoiding the formation of electrolytic medium by

moisture, allowing the metal equally aerated.

* (ii) Cathodic protection:

In this process, the metal is forced to behave as cathod and remains protected from corrosion. It can be explained by sacrificial anodic protection.

impressed current cathodic protection.

* Sacrificial anodic protection:

→ In this method the given metal is coupled with a new metal of lower standard reduction potential

value as a result a new metal gets corroded and given metal remains protected since new metal

sacrifice its metal surface to protect the given metal hence it is called sacrificial anodic protection.

→ It is used for the protection of underground pipe, tanks etc...

→ When anode is consumed completely it is replaced by new metal (fresh one).

* Impressed current cathodic protection:-

During corrosion electrons flows from anode to cathod and current flows opposite direction. If current is allowed to flow in the same direction of flow of electron, then it neglects the charge and restricts or prevent the operation.

* Cathodic Coating :-

In this process base metal is coated with a more nobel metal (high standard reduction potential value) the coating protect the metal from the corrosion.

Example: (i) Coating of tin on iron.

(ii) Coating of Cu on iron (Fe)

→ Because tin and Cu having high standard reduction potential value than iron.

(iii) Coating of Gold is another example.

→ This type of coating provides effective protection to the base metal only when the base metal is completely free from pores. If the coating develops pores on iron is not protected.

* Galvanization and Tining :- (5 marks on 2marks)

Galvanization :-

The process of coating of a layer of zinc on iron metal is known as Galvanization.

→ The iron metal is cleaned properly by dipping with concentrated H_2SO_4 and wash continuously with distilled water then it is dry and immersed in used zinc metal then it pass through a roller to get the uniform thickness of metal to avoid corrosion.

Disadvantages :-

→ It cannot be used in acidic medium because it get dissolved in acidic medium.

→ Food cannot be stored in Galvanized utensil.

- ~~2 more~~
- ## Tinning
- The coating of tin on iron metal to prevent corrosion is known as Tinning.
- The iron metal is cleaned properly by dipping with concentrated H_2SO_4 and wash continuously with distilled water then it is dry and immersed in fused tin metal then it pass through roller to get the uniform thickness of metal to avoid corrosion.

Advantages :-

- It can be used in acidic, neutral & basic medium.
- It can be used for food storage.

UNIT-4

completed