UNIT- VI th

Corrosion :-

The process of conversion of metal surface into unwanted materials such as oxide, hydrated oxide, sulphate, carbonate etc when metal surface are exposed to air for long time is called corrosion

OR

The corrosion is defined as the destruction of metal by unwant unwanted, chemical or electrochemical reaction which occur bet^n the surface of metal and the environment.

Mechanism of corrosion :-

Due to the presence of moisture in the air, an oxidation reaction occurs on the metal surface. The high energized area of the metal surface acts as an anode and the low energized area on the metal surface acts as a cathode. Thus an electrochemical reaction stands on the surface bet^n anode and cathode.

$$Fe_2O_3 + H_2O \longrightarrow Fe_2O_3.H_2O$$

(ferric oxide) (Rust)

Types of corrosion :-

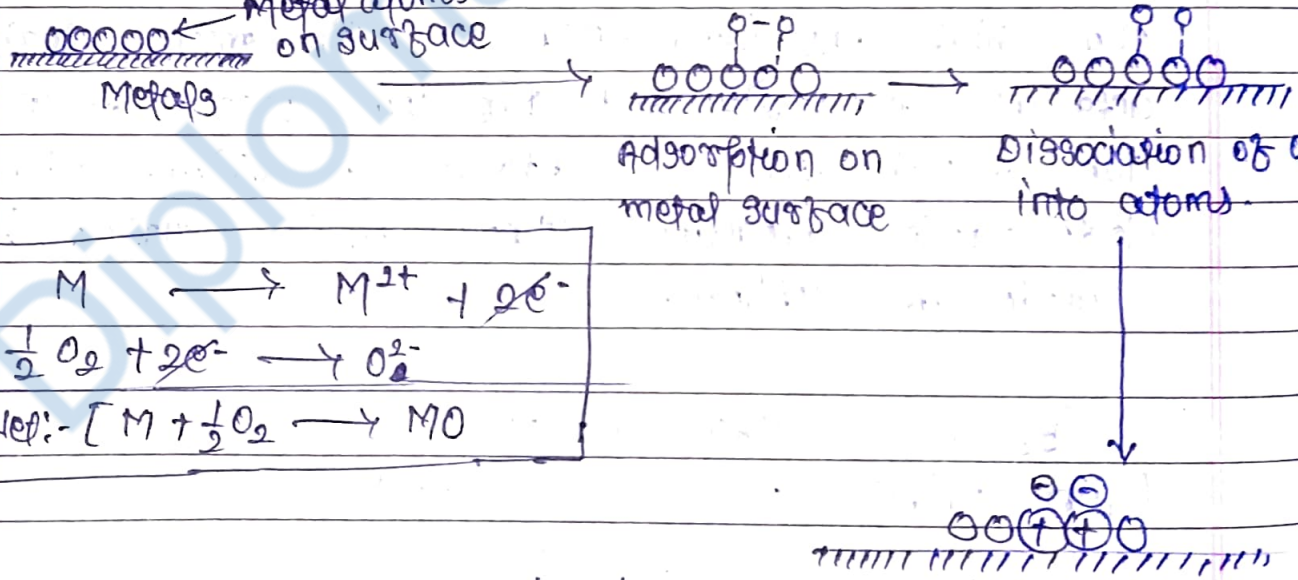
i) Dry corrosion
ii) Wet corrosion.

i) Dry / Atmospheric / Direct chemical corrosion :-

Destruction of metal due to chemical reactions occurring on metal surface due to direct attack of atmospheric gases like oxygen, carbon dioxide, sulphur dioxide, hydrogen sulphide, ammonia, chlorine, nitrogen oxides etc is called Dry corrosion.

Mechanism of dry-corrosion due to oxygen :-

O-O (O_2 molecules)



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

$$\frac{1}{2}O_2 + 2e^- \longrightarrow O^{2-}$$

Net :- $M + \frac{1}{2}O_2 \longrightarrow MO$

ii) wet / electrochemical / immersed corrosion:-

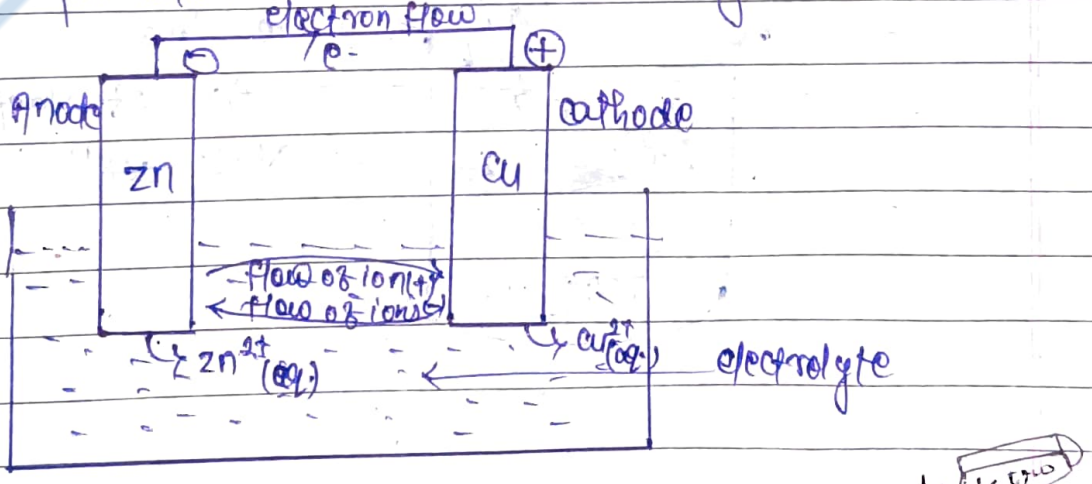
Destruction of a metal by electrochemical reaction occuring on metal in the presence of aqueous conducting medium with the formation of anodic and cathodic areas.

Two types of wet corrosion are:-

(A) Galvanic cell corrosion :- when two dissimilar metals (e.g. zinc and copper) are electrically connected and exposed to an electrolyte, then more electropositive metal undergoes corrosion. Here metal higher in the electrochemical series i.e zinc form the anode and while copper acts as a cathode due to lower electrochemical series. since, corrosion is due to the set up of a galvanic cell, it is known as galvanic cell corrosion.

OR.

The electrochemical corrosion of a metal by attack of an aqueous conduction medium, due to galvanic cell formation is known as galvanic corrosion.



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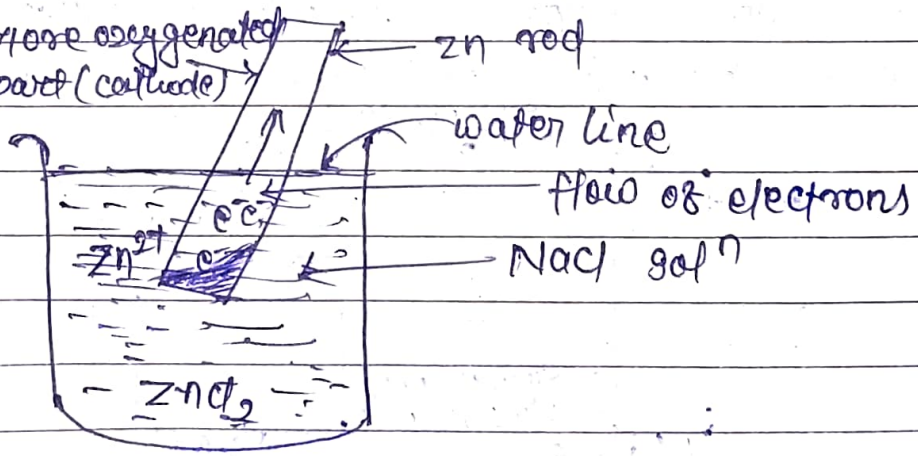
Mechanism :- when two metals come in contact in the presence of an electrolyte, the more reactive metals acts as an anode whereas the less reactive metals acts as a cathode. Thus the electron flow from anodic metal(zinc) to the ~~not~~ cathodic metal (Cu). Thus corrosion occurs at the anodic metal, while the cathodic part is protected from the attack.

Anode :- $Zn^{2+} + 2e^- \rightleftharpoons Zn$

Cathode :- $Cu^{2+} + 2e^- \rightleftharpoons Cu$

overall :- $Cu^{2+} + Zn \rightleftharpoons Cu + Zn^{2+}$

(b) Concentration cell :- This type of corrosion occurs ~~due~~ when a metal surface is exposed to an electrolyte of varing concentration. for example- when a metallic surface is partially immersed in an electrolyte and partially exposed to air, concentration cell corrosion takes place.



less oxygenated metallic part becomes anode when oxidation takes place.

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

More oxygenated metallic part becomes cathode when reduction takes place.

$\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH$

The Zinc ion and hydroxide ions combine to form $Zn(OH)_2$. Hence corrosion occurs at anode.

Difference betn chemical or electrochemical corrosion.

	Chemical corrosion	Electrochemical corrosion
i)	It occurs in dry condition	it occurs in the presence of moisture or electrolyte.
ii)	it is due to the direct chemical attack of the metal by the environment.	it is due to the formation of a large no. of anodic and cathodic areas.
iii)	it is a self controlled process	it is a continuous process
iv)	it follows adsorption mechanism	it follows electrochemical reaction.
v)	it is slow process	it is Rapid process.
vi)	It takes place on homogeneous and heterogeneous surface	It takes place on heterogeneous metal surface only.
vii)	uniform corrosion takes place	Non-uniform corrosion takes place.

factors affecting the rate of corrosion :-

i) presence of Air
ii) presence of Moisture
iii) presence of electrolytes.
iv) Reactivity of Metal :- If metal is more reactive then it undergoes corrosion more fast or rapidly.
v) Strain in metal :- corrosion takes place readily at cuts and bends area of metal.
vi) presence of electrolyte :- In saline water (electrolyte) metal corrodes easily and quickly.
vii) Effect of pH :- The rate of corrosion is more in acidic (i.e pH<7) than alkaline or neutral medium.
viii) Temperature :- As temperature increases, the rate of corrosion increases.

~~ix) Corrosion of~~

control / Methods of preventions of corrosions :-

i) Barrier protection :-
(a) Metal surfaces are cover with a thin layer of greece or oil to protect from corrosion.
(b) Metal surfaces are coated with paints, varnishes and some chemical (phenols)
ii) Sacrificial protection :- In this method, a thin layer of highly reactive metal such as zinc is coated over surface of metal.

iii) Galvanisation process :- The process of coating a thin layer of zinc(Zn)-metal on the metal surface is called galvanisation.

iv) Electrical protection :- The metallic surface is connected with more active metal like magnesium or zinc. The more active metal has lower reduction potential than metal surface, and will lose electron. This method is used for protecting the metal from the water.

v) Alloying :- creating alloys that more resistant to corrosion, like stainless steel.

vi) cathodic protection :- it is a technique used to control the corrosion of a metal surface by making it the cathodic side of an electrochemical cell. it is widely used on carbon-steel structures as well as other structural metal.

vii) Anodic protection :- It is technique used to control the corrosion of a metal surface by making it the anodic side of an electrochemical cell.

#Non-Electrolyte :- The substance which do not dissociate into ions, when dissolved in water or in aqueous ~~me~~ solution.

→ if aq. soln acts as a insulator.

eg :- i) $C_6H_{12}O_6(s) \xrightarrow{water} C_6H_{12}O_6(aq.)$
(Glucose)

ii) $NH_2CONH_2(s) \xrightarrow{water} NH_2CONH_2(aq.)$

Electrolyte :- The substance which dissociates partially or completely into ions, when dissolved in water or aq. medium are called electrolyte.

→ If aq. soln acts as a conductor.

eg :- $NaCl(s) \xrightarrow{water} Na^+(aq.) + Cl^-(aq.)$

There are two types of electrolyte :-

i) Strong electrolyte :- The electrolytes which dissociates completely into ions, when dissolved in water is called strong electrolyte.
eg :- NaOH, HNO_3, H_2SO_4, HCl etc.

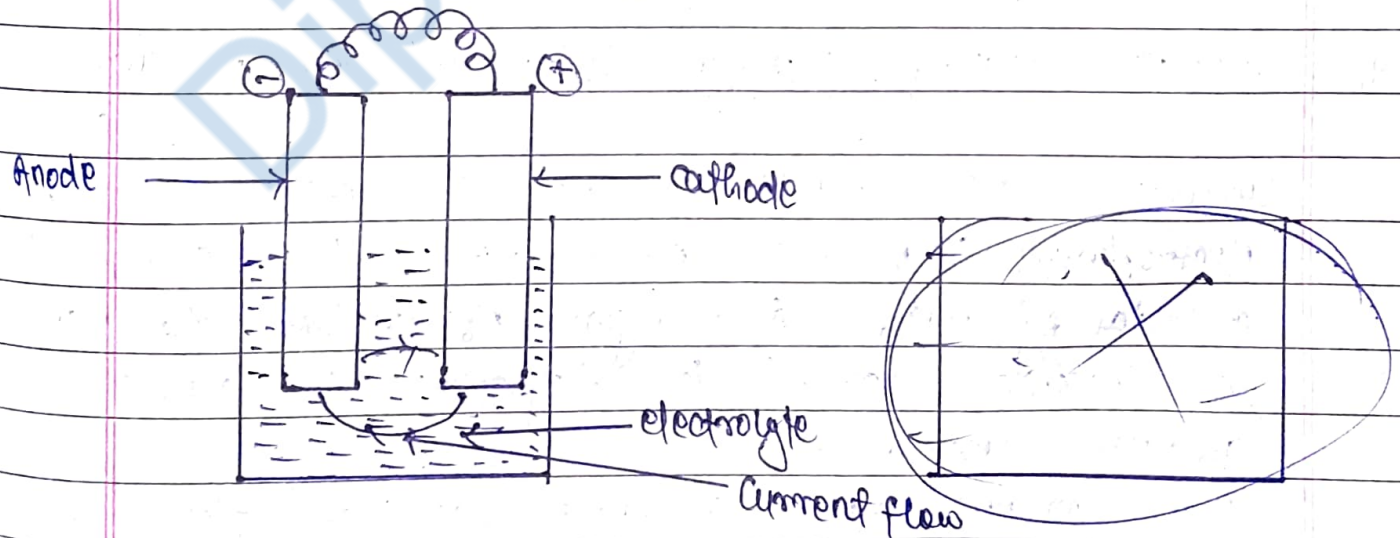
ii) Weak electrolyte :- The electrolytes which dissociates partially into ions when dissolved in water is called weak electrolyte.

eg :- CH_3COOH, NH_4OH, $CuCl_2$ etc.

construction and working of electrochemical cell :-

- **Electrochemical cell :-** An electrochemical cell is a device that convert the chemical energy into electrical energy through electrochemical redox reaction.
- it is used to produced electricity from spontaneous chemical reaction.
- This process is reversible and spontaneous
- In this cell, cathode is positive and anode is negative.

Construction :- An electrochemical cell typically consist of a vessel containg electrolyte (a substance that allows the flow of ions beth two electrodes or. This can be a liquid solution) and it consist of two dissimilar electrodes known as anode and cathode and a metallic wire connecting the two electrods as shown in fig.

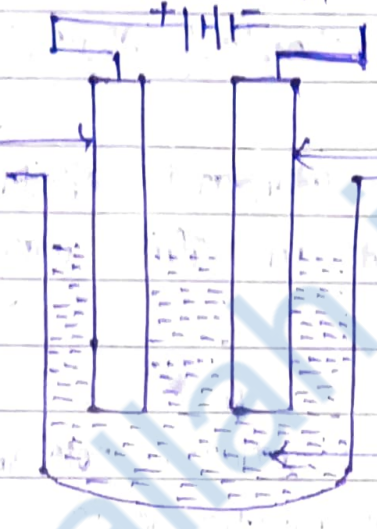


Working:- It operates/work on redox (reduction-oxidation) reaction. The reaction takes place at the anode (known as anodic reaction) are always oxidation reactions and the reaction taking place at the cathode (known as cathodic reaction) are always reduction reaction. These two electrodes are immersed in an electrolyte. one electrode undergoes an oxidation reaction (losses electrons) and other undergoes a (gain electron) reduction reaction. These are called half-reactions. An electron released during oxidation flow through a metallic wires (connecting the two electrodes) to the reduction site. A salt-bridge or electrolyte are connected betn anode and cathode to maintain charge balance and allow to flow ions.
The flow of electrons from the anode to cathode through metallic wire creates electrical energy, which can be used to power devices.

Surface coating through electrolysis and working:-

Surface coating through electrolysis, also known as electroplating is a process in which a of coating a metal by with thin layer of another metal using an electric current. to improve the metals corrosion resistance.
The metals most commonly used in plating are- copper, Nickel, Gold, Silver etc.

Working:- The surface coating of a metal through electrolysis process is as shown in its setup and working in fig:-



It is a process of depositing a very thin layer of metal coating on the base metal by passing the direct current through an electrolyte soln containing some salt of a coating metal. In this process there are two electrods are immersed in the electrolytic soln, one is anode and another is cathode. where cathode act as a base metal and anode act as a coating metal in a solution. Now a direct current is passed for a known time to obtain the coating of desired thickness on a base metal. when the current is passed anode starts dissolving in the soln due to anodic reactn, the dissolve metal (electrolyte) gets deposited over the base metal at the cathode. The thickness of coating is depends upon the time up to which the current is passing.

Copper, Nickel, silver, gold, chromium, cadmium and Tungsten etc are commonly used as a protecting coating.

Electrochemical series and galvanic series :-

- **Electrochemical series :-** The arrangement of different elements in decreasing order of their standard electrode potential (E°_{cell}) the series obtained in this way is called electrochemical series.

Cations

→ Increase in oxidation potential of metal and decrease in reduction potential of metal.

→ Increase in electropositively of metal

K^+
Ca^{2+}
Na^+
Mg^{2+}
Al^{3+}
Zn^{2+}
Fe^{2+}
Pb^{2+}
H^+
Cu^{2+}
Ag^+

→ Decrease in oxidation potential of metal and increase in reduction potential of metal ion.

→ Decrease in electropositively of metal.

Anions

→ Increase in reduction potential and decrease in oxidation potential

→ Increase in electro-negativity.

SO_4^{2-}
NO_3^-
Cl^-
Br^-
I^-
OH^-

→ Decrease in reduction potential and increase in oxidation potential

→ Decrease in electronegativity

Application of electrochemical series (ECS) :-

i) In the determination of Reducing agent
ii) " " " " oxidising agent.
iii) " " " " reactivity of metal.
iv) " " " " reactivity of non-metal.

- **Galvanic series :-**

The galvanic series are those series in which the arrangement of metals and non-metals are according to their nobility and electrochemical reaction (corrosion potential)
Nobels metal are Au, pt, Ag etc.

OR

The galvanic series is an arrangement of metals and alloys in order of their corrosion potentials in the environment.

Cathode (+)
Most Noble

platinum
Gold
Silver
Titanium
Stainless steel
Brass plating
Tungsten
Nickel
Copper
Cast iron
Steel

Lead
Tin
Aluminium
Cadmium
Galvanized steel
zinc
Magnesium

least noble
anode (−)

Q. What is surface protection treatment? State the necessary of surface treatments?

Ans→ Surface protection treatment :- Surface protection treatment is a process where the metal parts are prepared to prevent or reduce the rate of corrosion and wear and to increase the life of the metal.

Surface of the metal can be protected by means of metallic coating and non-metallic coating.

Surface treatment may be necessary in order to :-

- improve resistance to wear and corrosion.
- Reduce friction such as on sliding surfaces of tools, dies, bearing and machine.
- Improve resistance to corrosion and oxidation.
- Improve fatigue resistance
- To rebuild the surfaces, on worn tools, dies molds and machine component.
- To modify surface texture appearance, dimensional accuracy and frictional characteristics
- For decorative features such as texture or color.

The different method is used for surface treatment are :-

Metallic coating :-

i) Electroplating
ii) dipping
iii) Spraying
iv) cementation

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ii) Electroplating :-

iii) Dipping :- In this process, the component to be coated, is cleaned and then dipped in a bath of molten metal. The components is then taken out from the bath and then finished properly. The most common process of dipping are :-

(a) Galvanising :- It is a process of providing a thin layer of zinc coating on iron and steel component by dipping them in bath of molten zinc. The galvanising improves the resistance against corrosion due to atmosphere and water.

(b) Tinning :- It is a process of providing a very thin layer of tin coating on steel parts, by dipping them in a bath of molten tin.

iii) Spraying :- The spraying is a process of providing a thin coating by depositing an automised metal on the metal surface.

(a) wire gun method :- In this case, the coating metal is melted by oxyacetylene flame, then compressed air is used to sprayed the coating metal uniformly over the surface.

Coating metals are - Aluminum, Brass, Copper, zinc, Tin etc.

iv) By appling paint, varnish, greece or oil on the metal surface to from avoid the Corrosion.

iv) Electrochemical treatment:- using an electric current to modify the surface.
e.g - electroplating or anodizing.

v) Mechanical method:-
- Grinding and polishing:- Abrasive tools are used to remove dust material from the surface, improving its smoothness and finish.

vi) chemical conversion coating:- Chemical reaction creates a protective layer on the surface, enhancing corrosion resistance (e.g phosphating, chromating).

vii) Heat treament methods:-

viii) Chromising :- it is a process of providing a thin coating of chromium on steel parts. to resist against oxidation. It is also used for steam turbine buckets.

xi) Calorizing:- It is a process of providing a thin coating of aluminum on steel parts. It improves the resistance to ~~corrosion~~ oxidation at high temperatures.