Introduction to Corrosion

1.1 Definitions

Several definitions of corrosion have been given and some of them are reproduced below:

- Corrosion is the surface wastage that occurs when metals are exposed to reactive environments.
- Corrosion is the result of interaction between a metal and environments which results in its gradual destruction.
- Corrosion is an aspect of the decay of materials by chemical or biological agents.
- Corrosion is the destructive attack of a metal by chemical or electrochemical reaction with the environment

1.2 Corrosive Environment

Corrosion cannot be defined without a reference to environment. All environments are corrosive to some degree. Following is the list of typical corrosive environments:

(1) Air and humidity.

(2) Fresh, distilled, salt and marine water.

(3) Natural, urban, marine and industrial atmospheres.

(4) Steam and gases, like chlorine.

(5) Ammonia.

(6) Hydrogen sulfide.

(7) Sulfur dioxide and oxides of nitrogen.

(8) Fuel gases.

(9) Acids.

(10) Alkalies.

(11) Soils.

1.3 Consequences of Corrosion

Some important consequences of corrosion are summarized below:

1. Plant shutdowns.
2. Loss of products
3. Loss of efficiency.
4. Contamination.
5. Nuclear hazards.

1.3 Cost of Corrosion

Corrosion is a major expense in estimating production cost and investments in any industry. According to a recent study, the direct cost of corrosion is estimated to be approximately $276 billion in the United States . These losses are sustained by industry and government and constitute 3.2% of the gross domestic product (GDP). The direct cost of corrosion is considered the cost of replacing corroded structures and labor. Indirect losses add billions of dollars. considered indirect costs: product loss, shutdown, efficiency loss, product contamination, metal and food and structure and equipment over design

1.4 Why metal corrode?

The corrosion occurs because of the natural tendency for most metals return to their natural state; e.g. , iron in the presence of moist air will revert to its natural state , iron oxide. Metals can be corroded by the direct reaction of metal to a chemical;e.g. , zinc will react with dilute sulfuric acid, and magnesium will react with alcohols.

Thermodenamically: corrosion is the ability of the metal to revert to compounds which are more stable, i.e. , present in the nature initially.

Metal atoms in nature are present in chemical compounds (i.e. minerals). The same amounts of energy needed to extract metals from their minerals are emitted during the chemical reactions that produce corrosion. Corrosion returns the metal to its combined state in chemical compounds that are similar or even identical to the minerals from which the metals were extracted. Thus corrosion has been called extractive metallurgy in reverse

1.5 Basic Concepts in Corrosion

for corrosion to take place, the formation of a corrosion cell is essential. A corrosion cell is essentially comprised of the following four components:-

- Anode
- Cathode
- Electrolyte
- Metallic path.

The elimination of any one of the four conditions will stop corrosion .An unbroken (perfect) coating on the surface of the metal will prevent the electrolyte from connecting the cathode and anode so the current cannot flow

■ **Anode :-** is the electrode at which the electron are released, is the more reactive metal , Electrons are insoluble in aqueous solutions and they only move, through the wire connection into the cathode

Anodic reaction (oxidation reaction):- is oxidation of the metal to its ion .

$$Zn \longrightarrow Zn^{+2} + 2e$$ Oxidation reaction anodic reaction

■ **Cathode :-** is the electrode at which current enters from the electrolyte

The common cathodic reaction are:-

$2H^{+} + 2e \longrightarrow$	$H_2\uparrow$	Hydrogen evolution(H ER)
$O_2 - 4H^{+} + 4e \longrightarrow$	$2H_2O$	O_2 reduction(acid solution)
$O_2 - 2H_2O + 4e \longrightarrow$	$4OH^{-}$	O_2 reduction(or basic solution)
$M^{+3} - e \longrightarrow$	M^{+2}	Metal ion reduction
$M^{+} + e \longrightarrow$	M	Metal deposition

■ **ElectrolyteIt :-** is the electrically conductive solution (e.g. salt solution) that must be present for corrosion to occur.

■ **Metallic path:-** The two electrodes are connected externally by a metallic conductor. In the metallic conductor, current flows from anode to cathode

1.6 Types of Corrosion Cells

There are several types of corrosion cells:

(1) Galvanic cells

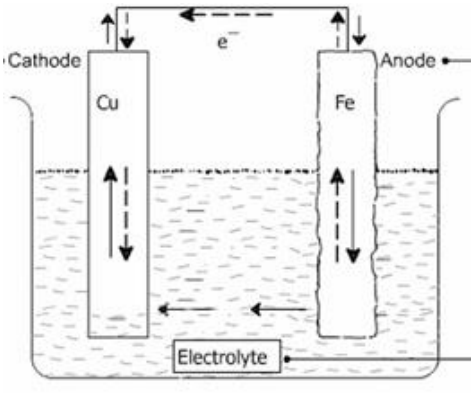
(2) Concentration cells

(3) Electrolytic cell

(4) Differential temperature cells

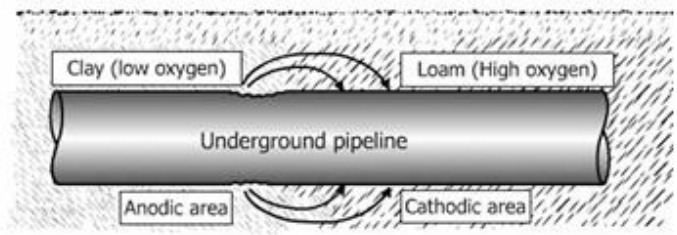
(1) Galvanic cells:-

The galvanic cell may have an anode or cathode of dissimilar metals in an electrolyte For example, steel and copper electrodes immersed in an electrolyte, represents a galvanic cell. The more noble metal copper acts as the cathode and the more active iron acts as an anode. Current flows from iron anode to copper cathode in the electrolyte.



(2) Concentration cells:-

This is similar to galvanic cells except with an anode and cathode of the same metal in a heterogeneous electrolyte. Concentration cells are commonly observed in underground corroding structures, such as buried pipes or tanks



(3) Electrolytic cell

This type of cell is formed when an external cur rent is introduced into the system. It may consist of all the basic components of galvanic cells and concentration cells plus an external source of electrical energy.