Question and Answer

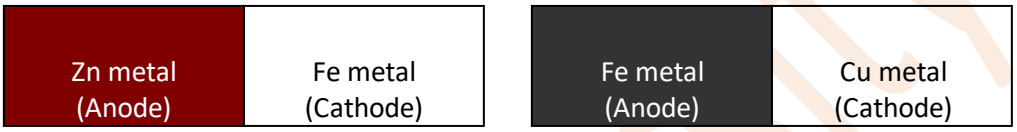
1. Define corrosion.

Corrosion is defined as the destruction of metals or alloys by the surrounding environment through chemical or electrochemical reactions.

Example: When iron is exposed to air in the presence of moisture, hydrated ferric oxide (rust) is formed. $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2\downarrow$

$2Fe(OH)_2 + {}^1/_2O_2 + H_2O \rightarrow Fe_2O_3 .3H_2O$ (rust)

2. Explain differential metal corrosion with suitable example.



This type of corrosion occurs when two dissimilar metals are in contact with each other and are exposed to a corrosive environment. The two metals differ in their electrode potentials. The metal with lower electrode potential acts as anode and the other metal with higher electrode potential acts as cathode.

The anodic metal undergoes oxidation and gets corroded. A reduction reaction occurs at the cathodic metal. The cathodic metal does not undergo corrosion.

The reactions may be represented as follows:

At anode: $M \rightarrow M^{n+} + n\ e^-$

At cathode: $2H_2O + O_2 + 4\ e^- \rightarrow 4OH^-$

Higher the potential difference between the anodic and cathodic metals, higher is the rate of corrosion.

Example: When iron is in contact with zinc, iron acts as cathode and zinc acts as anode because zinc has lower electrode potential compared to iron. Therefore zinc undergoes corrosion. On the other hand, when iron is in contact with copper, iron acts as anode because iron has lower electrode potential compared to copper. Hence iron undergoes corrosion.

Other examples:

1. Steel screws in copper sheet.
2. Steel pipe connected to copper plumbing.

3. Describe the effect of following factors on the rate of corrosion:
(i) Nature of the metal (ii) Nature of corrosion product
(iii) Difference in potential between anodic and cathodic regions

(i) Nature of the metal: Metals with lower electrode potentials are more reactive and are more susceptible to corrosion. For example, elements such as Mg and Zn, which have lower electrode potentials, are highly susceptible to corrosion. Noble metal such as gold and platinum, which have higher electrode potentials, are less susceptible to corrosion.
Exceptions: Metals and alloys which show passivity are exceptions for this general trend. Such metals form a protective coating on the surface which prevents corrosion.

(ii) Nature of corrosion product: If the corrosion product is insoluble, stable and non-porous, then it acts as a protective film which prevents further corrosion. The film acts as a barrier between the fresh metal surface and the corrosive environment. On the other hand, if the corrosion product is soluble, unstable and porous, then the corrosion process continues even after the formation of corrosion product.
Example: Aluminium, titanium and chromium form a protective film of metal oxide on the surface. Stainless steel forms a protective film of Cr_2O_3 on the surface. But in the case of Zn and Fe, the corrosion products formed do not form a protective film.

(iii) Difference in potential between anodic and cathodic regions: Larger the potential difference between the anodic and cathodic regions, higher is the rate of corrosion. When potential difference is more, higher corrosion current is produced and the free energy decrease accompanying the process is higher and the corrosion rate is also higher. Therefore when two different metals with large difference in their electrode potentials are in contact with each other, the more reactive metal undergoes corrosion very fast. For example, the potential difference between iron and copper is 0.78 V, and between iron and tin is 0.3 V. Therefore, corrosion is faster when iron is in contact with copper.
The use of dissimilar metals should be avoided wherever possible. Otherwise, the anodic metal gets corroded.

4. What is tinning? Explain the process of tinning.

Tinning is the process of coating the surface of a base metal (such as iron) with tin. Tinning of iron metal is an example of cathodic metal coating on anodic base metal.
Tinning of iron is carried out by hot dipping method. It involves the following steps.

1. The metal surface is washed with organic solvents to remove organic matter on the surface.
2. Rust is removed by washing with dilute sulphuric acid.
3. Finally, the article is washed with water and air-dried.
4. It is then passed through molten zinc chloride flux. The flux helps the molten tin to adhere strongly on the metal surface.
5. It is then dipped in a bath of molten tin at 230^0C.

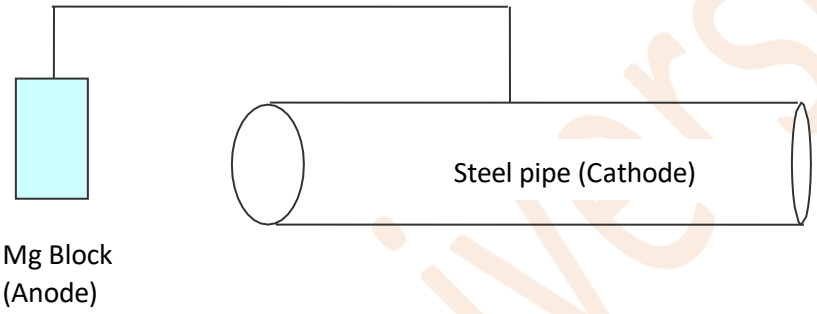
6. The excess tin on the surface is removed by passing through a series of rollers immersed in palm oil. The oil prevents the oxidation of tin coating.

Applications: Tin-coated steel is used for manufacturing containers is used for storing food stuffs such as jam, instant food, milk products, pickles etc.

5. What are corrosion inhibitors?

Corrosion inhibitors are chemical substances which are added in small quantities to the corrosive environment to decrease the rate of corrosion. Inhibitors slow down the anodic reaction or the cathodic reaction generally by forming a protective film on the anodic region or the cathodic region.

6. Explain cathodic protection by sacrificial anode method.



Cathodic protection is a method of protecting a metal or alloy from corrosion by converting it completely into cathodic and no part of it is allowed to act as anode. Since cathodes do not undergo corrosion, the metal is protected against corrosion.

In this method, the protected metal structure is converted into a cathode by connecting it to a more active metal (less noble) metal. This active metal acts as an auxiliary anode.

Zinc, magnesium and aluminium are the common auxiliary anodes used in this method.

These metals being more active act as anode and undergo preferential corrosion, protecting the metal structure. Since the anodic metals are sacrificed to protect the metal structure, the method is known as sacrificial anode method. Exhausted sacrificial anodes are replaced by new ones as when required.

Other examples:

Mg bars are fixed to the sides of ocean going ships to act as sacrificial anodes.

Mg blocks are connected to buried pipe lines.

7. Account for the following, when an iron article is exposed to acid medium in the absence of oxygen,

i) Iron becomes brittle

ii) Corrosion control can be achieved by the addition of antimony oxide as an inhibitor.

(i) Iron becomes brittle: Hydrogen liberation at cathode by accepting electrons from anodic part is called hydrogen embrittlement.

(ii) Corrosion control can be achieved by the addition of antimony oxide as an inhibitor: As_2O_3 acts as cathodic corrosion inhibitor. Inhibition of Hydrogen liberation Adding substances like thiourea can prevent the diffusion of H^+ ions to the cathode, amine etc., which forms protective film on cathode and prevents the diffusion of H^+ ions. Increasing hydrogen over voltage by adding AS_2O_3, Antimony or salts like sodium metal arsenate, can prevent the evolution of hydrogen gas at cathode.

8. What type of corrosion taking place in the following cases?

i) Gaps on the surface of a tinned iron sheet.

ii) Brass article exposed to ammonical vapors.

(i) Gaps on the surface of a tinned iron sheet: Pitting corrosion, smaller the anodic area larger the cathodic area intense corrosion takes place.

(ii) Brass article exposed to ammonical vapors: Stress corrosion
Cracking of brass was shown to occur most severely in ammonia vapor. This increase of the amount of ammonia and copper ions in the form of copper sulphate was found to increase the corrosion of the brass sample.