

Chem12 Corrosion : Notes/W.S. - 80

Corrosion of Iron

An important problem for chemists is the corrosion of metals. This is a redox reaction. An example is the rusting (or oxidation) of iron. Iron is oxidized in the presence of oxygen and water. The reactions below take place in a drop of water placed on a piece of iron. The anode is the iron at the center of the drop. The cathode is the iron at the outer edge of the drop. An electrochemical cell is set up.



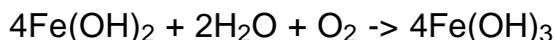
The reduction of oxygen occurs under slightly basic conditions.

The overall reaction is :



then : $\rightarrow \text{Fe}(\text{OH})_2(\text{s})$, a precipitate forms.

This compound will oxidize further :



then : $2\text{Fe}(\text{OH})_3 \rightarrow \text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ (red-brown rust)

Compounds such as Fe_2O_3 , hydrated Fe_2O_3 and $\text{Fe}(\text{OH})_3$ all form the red substance that we call rust. There are several other reactions that take place. The compounds FeO , Fe_3O_4 and hydrated Fe_3O_4 will also form. They form black rust. This rust forms if there is a deficiency of oxygen.

Corrosion at the Junction of Two Metals

Another important type of corrosion is that which takes place at the contact point between two different metals in the presence of water (which contains ions and usually O_2). Again, an electrochemical cell is set up and one metal becomes the anode (which corrodes) and the other becomes the cathode. The water becomes the "salt bridge".

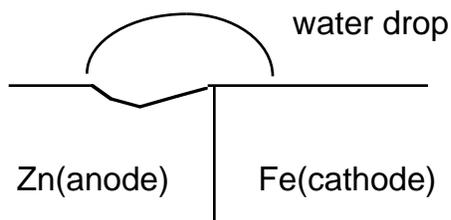
Preventing Corrosion

There are several ways to prevent corrosion.

- 1) Prevent water and oxygen from coming in contact with the metal.
- 2) Coat the metal with paint, grease or plastic.
- 3) Some metals such as aluminum and zinc, will form a thin oxide coating which protects the metal from further oxidation.
- 4) Some alloys are very resistant to corrosion. Stainless steel (which contains iron and nickel and also a significant amount of chromium) is an example, but it is expensive.
- 5) Coat with another metal such as zinc or tin. If Fe is coated with zinc it is said to be "galvanized".
- 6) Attach an easily oxidized metal (anode) to the metal to be protected (cathode). The anode will corrode instead of the cathode. This is called "cathodic protection".

Cathodic Protection

The best way to protect a metal is with cathodic protection, although this may not be practical or economical in some cases. The example below illustrates the basic principle behind cathodic protection.



The zinc is the "sacrificial" anode. It corrodes instead of the iron which is the cathode. The reaction at the anode is $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ and zinc ions go into solution. At the surface of the iron, at the edge of the drop, oxygen is reduced. The cathode reaction is $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$. The compound $\text{Zn}(\text{OH})_2$ forms on the surface. This protects the iron from further corrosion.

Questions : 1) An aluminum boat has strips of magnesium attached to the hull. Explain.

2) A solution of copper sulfate cannot be stored in an aluminum container. Explain. Find a metal in which the solution can be stored.

3) Iron can be protected by coating it with tin, copper or zinc. Which metal is preferred? Explain.

4) An iron pipe is connected to a copper pipe. Explain what happens at the junction.

5) How can you protect a buried iron (or steel) tank from corrosion ?

Answers : 1) This is an example of cathodic protection. The Mg is the sacrificial anode as it is more easily oxidized than Al and corrodes instead of the Al hull which is the cathode., 2) Al can be oxidized by Cu^{2+} and so will corrode. Ag cannot be oxidized by Cu^{2+} and will make a suitable container., 3) Coating Fe with any metal will protect it by keeping oxidizing agents away from it, but Zn is preferred. Zn has an oxide coat which protects it and if the Zn coating is scratched and the Fe is exposed, the Zn can still act as a sacrificial anode protecting the Fe from oxidation., 4) When water flows in the pipe, an electrochemical cell is set up near the junction. The Fe corrodes as it is more easily oxidized than Cu. It acts as a sacrificial anode which protects the Cu., 5) Use cathodic protection. Attach a sacrificial anode of a metal that is more easily oxidized than Fe, like Zn or Mg.