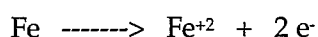


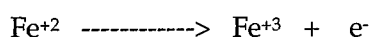
Corrosion

► Millions of dollars are lost each year because of corrosion. Much of this loss is due to the corrosion of iron and steel, although many other metals may corrode as well. The problem with iron as well as many other metals is that the oxide formed by oxidation does not firmly adhere to the surface of the metal and flakes off easily causing "pitting". Extensive pitting eventually causes structural weakness and disintegration of the metal. (It should be noted, however, that certain metals such as aluminum, form a very tough oxide coating which strongly bonds to the surface of the metal preventing the surface from further exposure to oxygen and corrosion). Corrosion occurs in the presence of moisture. For example when iron is exposed to moist air, it reacts with oxygen to form rust, $Fe_2O_3 \cdot X H_2O$

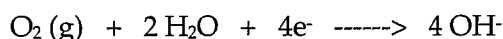
► The amount of water complexed with the iron (III) oxide (ferric oxide) varies as indicated by the letter "X". The amount of water present also determines the color of rust, which may vary from black to yellow to orange brown. The formation of rust is a very complex process which is thought to begin with the oxidation of iron to ferrous (iron "+2") ions.



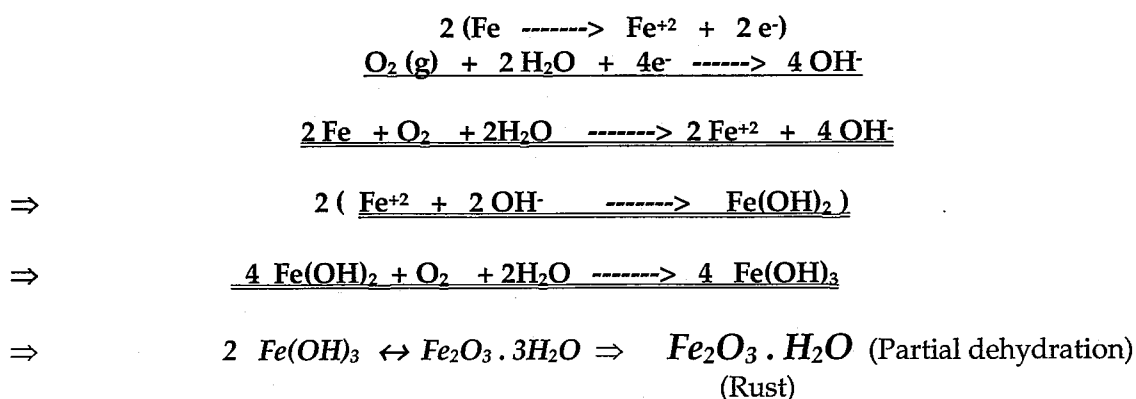
• Both water and oxygen are required for the next sequence of reactions. The iron (+2) ions are further oxidized to form ferric ions (iron "+3") ions.



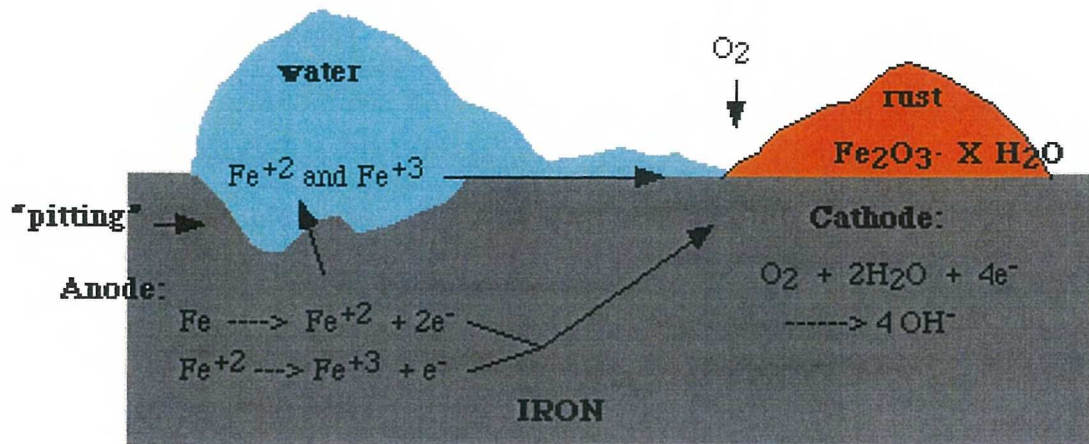
• The electrons provided from both oxidation steps are used to reduce oxygen as shown.



• The ferric ions then combine with oxygen to form ferric oxide [iron (III) oxide] which is then hydrated with varying amounts of water. The overall equations for the rust formation may be written as :



► The formation of rust can occur at some distance away from the actual pitting or erosion of iron as illustrated below. This is possible because the electrons produced via the initial oxidation of iron can be conducted through the metal and the iron ions can diffuse through the water layer to another point on the metal surface where oxygen is available. This process results in an electrochemical cell in which iron serves as the anode, oxygen gas as the cathode, and the aqueous solution of ions serving as a "salt bridge" as shown below:

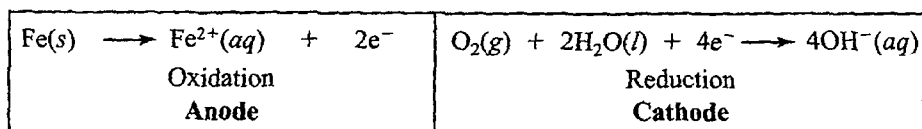
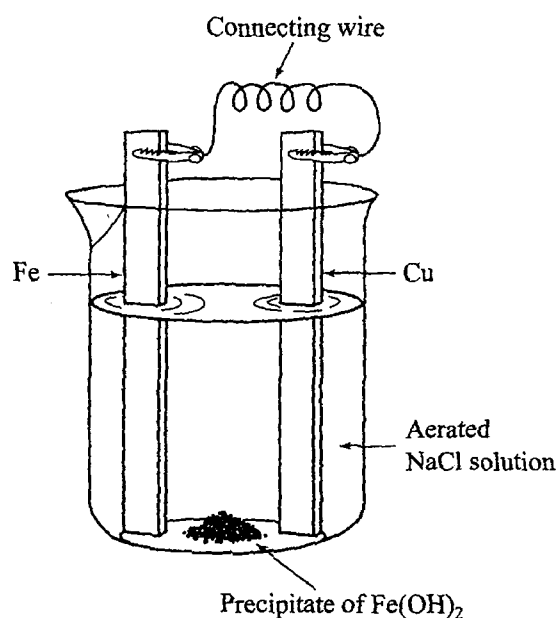


► The involvement of water accounts for the fact that rusting occurs much more rapidly in moist conditions as compared to a dry environment such as a desert. Many other factors affect the rate of corrosion. For example the presence of salt greatly enhances the rusting of metals. This is due to the fact that the dissolved salt increases the conductivity of the aqueous solution formed at the surface of the metal and enhances the rate of electrochemical corrosion. This is one reason why iron or steel tend to corrode much more quickly when exposed to salt (such as that used to melt snow or ice on roads) or moist salty air near the ocean.

Corrosion

Corrosion is the redox reaction where metals react with oxygen to form an oxide. A number of metals, for example zinc, form an impervious layer of the oxide on the surface of the metal which serves to protect the metal from further oxidation. When iron oxidises, its oxide is porous, hence the oxidation continues. The most significant form of corrosion, economically, is the rusting of iron.

Electrochemically, iron reacts when another substance higher on the reduction potential table acts as a cathode.

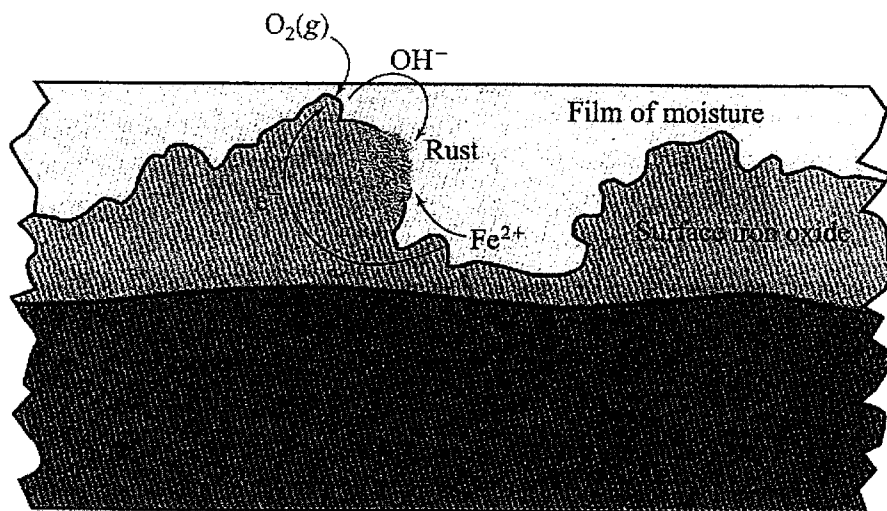


In the presence of water, iron reacts to form green iron (II) hydroxide which slowly further reacts to give the brown iron (III) hydroxide which can further partially

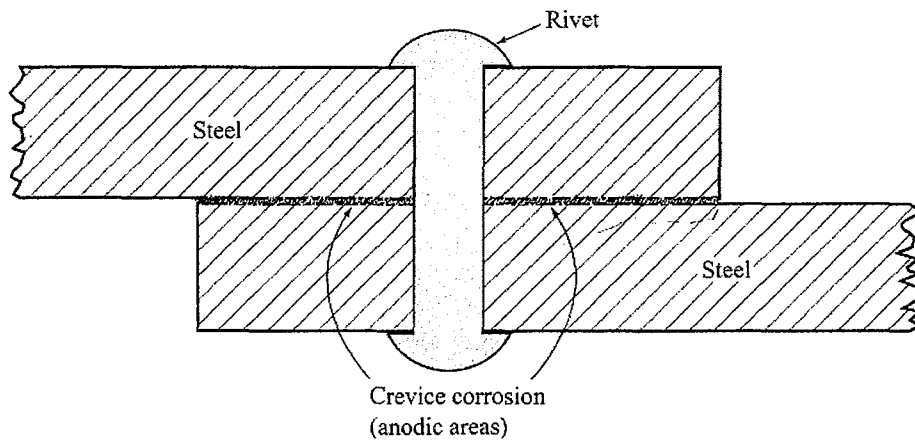
dehydrate to form 'rust' – $\text{Fe}_2\text{O}_3 \cdot x(\text{H}_2\text{O})$, usually represented with $x = 1$.

In the presence of other metals, iron can react when water/moisture allows the flow of ions, resulting in the formation of a cathodic site connected electrically by the water. This is called a galvanic couple.

Iron can also rust in the absence of other metals if a film of moisture allows migration of ions. The area of the iron most exposed to oxygen will become cathodic and the areas less exposed will become anodic, and hence rust.



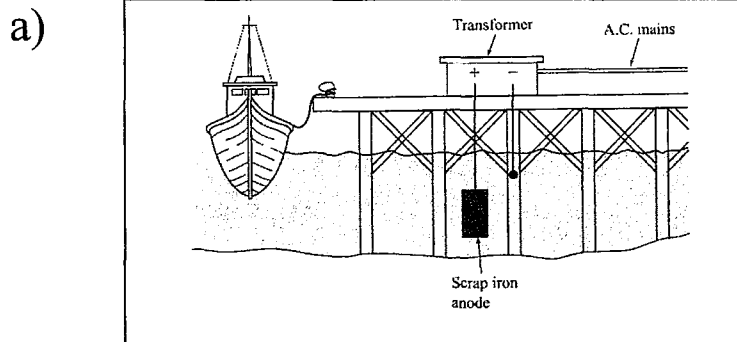
This can also occur in areas where the iron is protected from oxygen by being sealed. This is called the differential aeration principle.



Prevention of Rusting

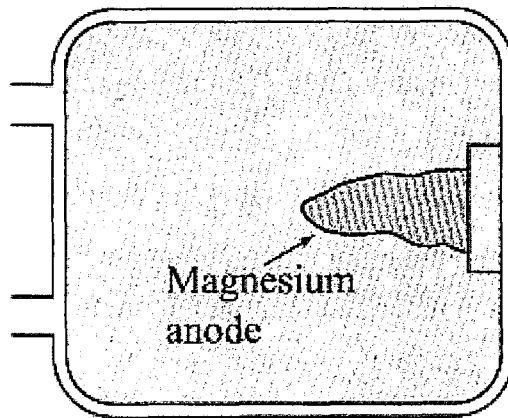
Rusting is prevented by removing one or more of the corrosion causing conditions.

- 1 modify the environment
- 2 modify the iron
- 3 cathodic protection – connect the iron electrically to something else that becomes the anode, hence making the iron the cathode, hence preventing it being oxidised.

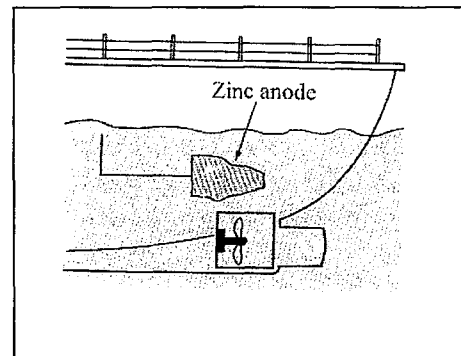
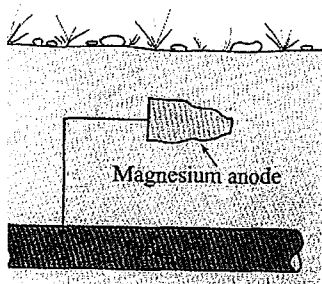


Run a current through the scrap iron, making it the anode.

b)



Use a sacrificial anode, by electrically connecting a more reactive metal which oxidises in preference to iron.



4) Metallic coatings – metals like Zn that form protective oxide coatings

5) Non-metallic coatings – paints and similar that exclude oxygen and moisture.