

corrosion

corrosion, atmospheric oxidation of metals (see [oxidation and reduction](#)). By far the most important form of corrosion is the rusting of [iron](#). Rusting is essentially a process of oxidation in which iron combines with water and oxygen to form rust, the reddish-brown crust that forms on the surface of the iron. Rust, a chemical compound, is a hydrated ferric oxide $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$, where n is usually $1 \frac{1}{2}$. The chemical mechanism of rusting is not fully known, but is thought to involve oxidation of metallic iron to ferrous ion (Fe^{++}) and reaction of the ferrous ion with oxygen and water to form rust. The reaction is catalyzed by water, acids, and metals (e.g., copper and tin) below iron in the [electromotive series](#). Because iron is so widely used, e.g., in building construction and in tools, its protection against rusting is important. Although metals (e.g., aluminum, chromium, and zinc) above iron in the electromotive series corrode more readily than iron, their oxides form a tenuous coating that protects the metal from further attack. Rust is brittle and flakes off the surface of the iron, continually exposing a fresh surface. Rusting can be prevented by excluding air and water from the iron surface, e.g., by painting, oiling, or greasing, or by plating the iron with a protective coating of another metal. Metals used for plating include chromium, nickel, tin, and zinc. Zinc plating is called galvanizing. Many alloys of iron are resistant to corrosion. Stainless steels are alloys of iron with such metals as chromium and nickel; they do not corrode because the added metals help form a hard, adherent oxide coating that resists further attack. The iron hulls of ships can be protected against rusting by attaching magnesium strips to the underside of the vessel. An electric current is generated, with the magnesium and iron acting as electrodes and seawater acting as the electrolyte. Because magnesium is above iron in the electromotive series, it serves as a “sacrificial anode” and is oxidized in preference to the iron. This is called cathodic protection, since the iron serves as the cathode and thus escapes oxidation. This method is also used to protect the pipes of electric generating plants where saltwater is used as a coolant.

electromotive series

electromotive series, list of [metals](#) whose order indicates the relative tendency to be oxidized, or to give up electrons (see [oxidation and reduction](#)); the list also includes the gas hydrogen. The electromotive series begins with the metal most easily oxidized, i.e., the metal with the greatest electron-donating tendency, and ends with the metal least easily oxidized. The tendency to be oxidized is not an absolute quantity; it can only be compared with the tendency of some other substance to be oxidized. In practice, the tendency to be oxidized, called the oxidation potential and expressed in volts, is measured relative to a standard hydrogen electrode, which is arbitrarily assigned an oxidation potential of zero. The oxidation potential measures the tendency of the half reaction $\text{M} \rightarrow \text{M}^{+n} + n\text{e}^-$ to occur, in which some metal M loses n electrons, e^- , and acquires a positive charge of $+n$. The more positive the oxidation potential, the more readily oxidation takes place. The electromotive series is thus a list of the metals in the order of their tendency to undergo the half reaction. The series is also called the

replacement series, since it indicates which metals replace, or are replaced by, other metals (or hydrogen) in compounds. In general, a metal will replace any other metal lower in the series and will be replaced by any metal higher in the series.

The order of some common metals in the electromotive series, starting with the most easily oxidized, is:

lithium,
potassium,
calcium,
sodium,
magnesium,
aluminum,
zinc,
chromium,
iron,
cobalt,
nickel,
lead,
hydrogen,
copper,
mercury,
silver,
platinum,
gold.

A list arranged according to oxidation potential and including not only metals but also all other elements and ions is called the electrochemical series.