Section 17.6
Corrosion

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Learning Objectives

- Define corrosion
- List some of the methods used to prevent or slow corrosion

Corrosion

- **Corrosion** is usually defined as the degradation of metals by a naturally occurring electrochemical process.
  - Rust on iron
  - Tarnish on silver
  - The blue-green patina on copper
- The total cost of corrosion remediation in the United States is estimated to be in excess of half a trillion dollars a year.

Rust

- Iron will rust when it is exposed to oxygen and water.
- The process begins with the following redox reactions:

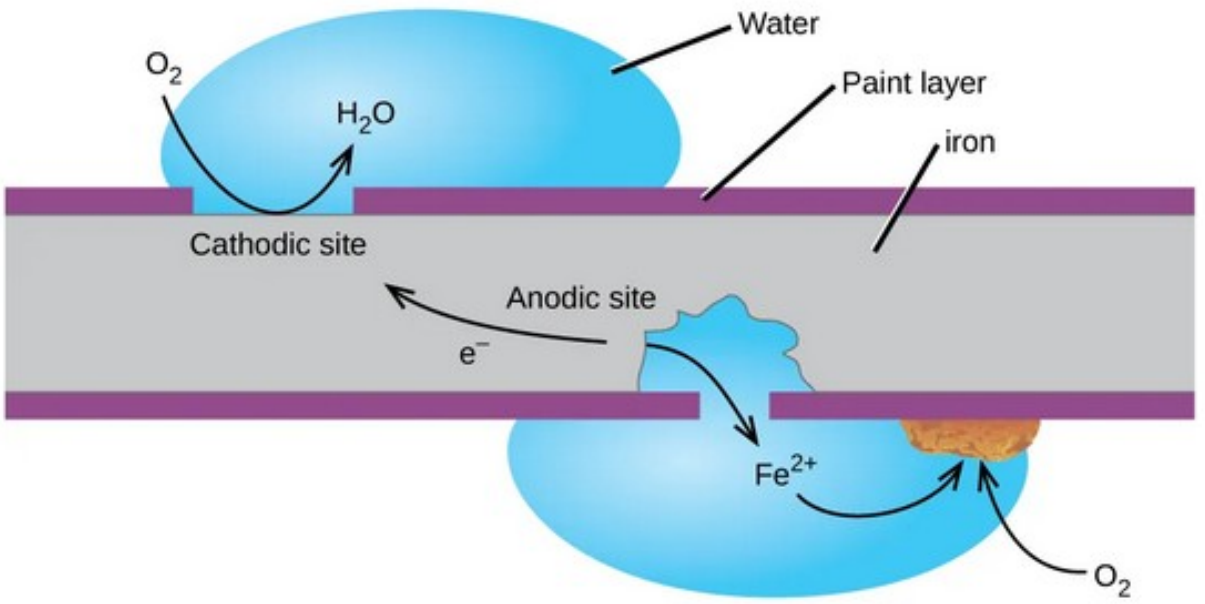
$$\begin{array}{lll} \text{anode:} & \mathrm{Fe}(s) \longrightarrow \mathrm{Fe^{2+}}(aq) + 2\mathrm{e^-} & E^\circ_{\mathrm{Fe^{2+}/Fe}} = -0.44\ \mathrm{V} \\ \text{cathode:} & \mathrm{O_2}(g) + 4\mathrm{H^+}(aq) + 4\mathrm{e^-} \longrightarrow 2\mathrm{H_2O}(l) & E^\circ_{\mathrm{O_2/O^2}} = +1.23\ \mathrm{V} \\ \text{overall:} & 2\mathrm{Fe}(s) + \mathrm{O_2}(g) + 4\mathrm{H^+}(aq) \longrightarrow 2\mathrm{Fe^{2+}}(aq) + 2\mathrm{H_2O}(l) & E^\circ_{\mathrm{cell}} = +1.67\ \mathrm{V} \end{array}$$

- Further reaction of the iron(II) product in humid air results in the production of an iron(III) oxide hydrate known as rust:

$$4\mathrm{Fe^{2+}}(aq) + \mathrm{O_2}(g) + (4+2x)\,\mathrm{H_2O}(l) \longrightarrow 2\mathrm{Fe_2O_3}\cdot x\mathrm{H_2O}(s) + 8\mathrm{H^+}(aq)$$

Rust

- Rust formation involves the creation of a galvanic cell at an iron surface



Protective Layers

- Corrosive layers on some metals form a protective layer preventing air from reaching metal below the corrosion layer.
  - The patina on copper
  - The oxidation layer on aluminum
- The formation of rust on iron does not create a protective layer
- Corrosion continues as the rust flakes off and exposes fresh iron to the atmosphere.
- This is a big problem due to the ubiquity of steel.

Preventing Rust

- There are many ways to control the formation of rust.
- Painting the surface
  - The paint will prevent air from reaching the metals surface
- Alloying iron with another metal
  - Stainless steel is an alloy containing chromium, iron, and carbon
- **Galvanization**, a process in which the metal to be protected is coated with a layer of a more readily oxidized metal, usually zinc.
  - Even when the protective coating is compromised the iron may still be protected from corrosion by a **cathodic protection process**

Cathodic Protection

- **Cathodic Protection** is a method of protecting metal by making it the cathode in a galvanic cell.
- This done by exposing the metal to metal with a lower reduction potential called a **sacrificial anode**.