11.19: Common Reducing Agents

A good reducing agent must be able to donate electrons readily, meaning it must not have a high electronegativity. Among the elements, low electronegativity is characteristic of good reducing agents. Molecules and ions which contain relatively electropositive elements which have low oxidation numbers are also good reducing agents. Bear these general rules in mind as we examine examples of common reducing agents in the following paragraphs.

Reducing Agents

Metals

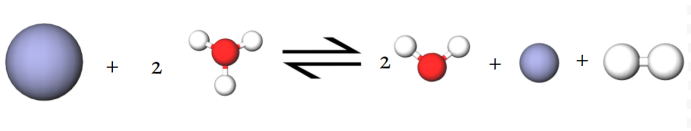
All metals have low ionization energies and are relatively electropositive, and so they lose electrons fairly easily. Therefore, most metals are good reducing agents. Metals on the left of the periodic table exhibit this property to the greatest extent, and some of them, such as Li or Na, can even reduce H_2O:

$$2\,Li(s) + 2\,H_2O(l) \longrightarrow 2\,Li^+(aq) + 2\,OH^-(aq) + H_2(g)$$

Skip to the 1 minute mark to get directly to the reaction.

Other metals, such as Fe or Zn, cannot reduce H_2O but can reduce hydronium ions, and so they dissolve in acid solution:

$$Zn(s) + 2\,H_3O^+(aq) \longrightarrow Zn^{2+}(aq) + 2\,H_2O(l) + H_2(g)$$



This is one of the characteristic reactions of acids. There are a few metals that will not dissolve in just any acid but instead require an acid like HNO_3 whose anion is a good oxidizing agent. Cu and Hg are examples:

$$3\,Hg(s) + 8\,H_3O^+(aq) + 2\,NO_3^-(aq) \longrightarrow 3\,Hg^{2+}(aq) + NO(g) + 12\,H_2O$$

Finally, a few metals, such as Au and Pt, are such poor reducing agents that even an oxidizing acid like HNO_3 will not dissolve them. This is the origin of the phrase “the acid test.” If a sample of an unknown yellow metal can be dissolved in acid, then the metal is not gold. Kings who collected tax payments in gold kept a supply of HNO_3 available to make sure they were not being cheated.