Chemistry 201

Reactivity of metals

NC State University

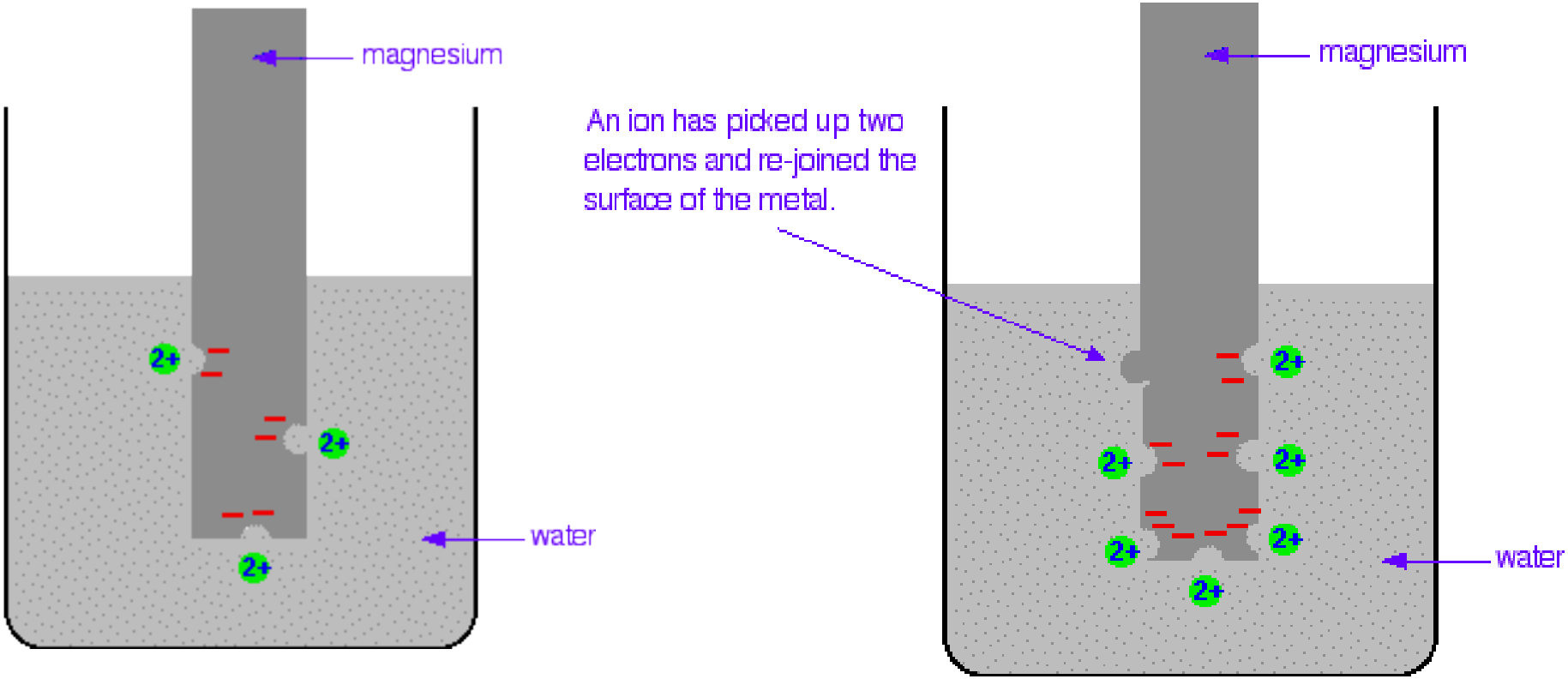
Understanding the differing reactivities of metals

When metals react, they give away electrons and form positive ions. The oxidation potential gives an ordering of how easy or difficult it is to remove the electron and generate the hydrated ions. For example, can compare $Mg^{2+}(aq)$ and $Cu^{2+}(aq)$.

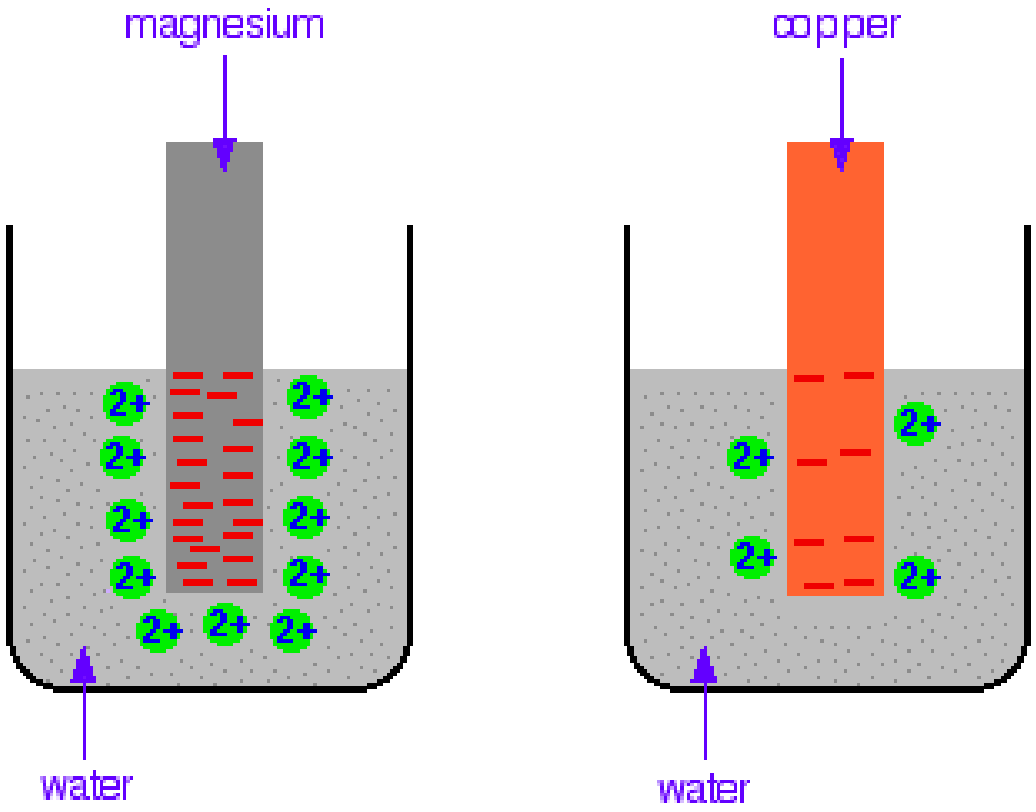
$$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$$

$$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$$

Because it has excess electrons in the 3s level Mg metal tends to shed electrons and go into solution. However, as shown here the reaction will reach equilibrium because those electrons have nowhere to go. There is no electron transfer (redox process) shown here.



Copper metal has the same tendency, but it is less reactive and so it goes into solution to a smaller extent. Electrochemical potentials allow us to quantify the extent to which each reaction will proceed.



We turn to the example of Zn and Cu. Zn is also "more reactive" than Cu meaning that it more readily gives up its electrons. This can be seen in the redox reaction:

$$Zn + Cu^{2+} \rightarrow Cu + Zn^{2+}$$

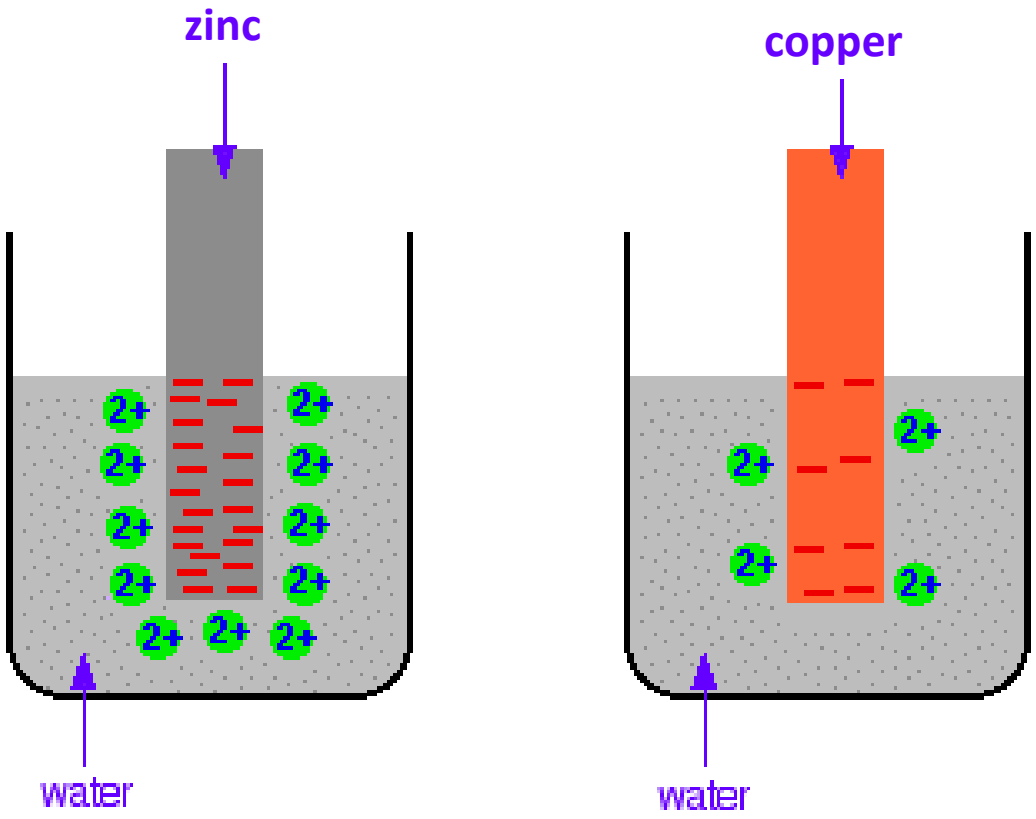
We can obtain a number value for the potential of this reaction from the standard reduction potentials for each half reaction.

$$Cu^{2+} + 2e^{-} \rightarrow Cu \quad E^{o} = +0.340\ V$$

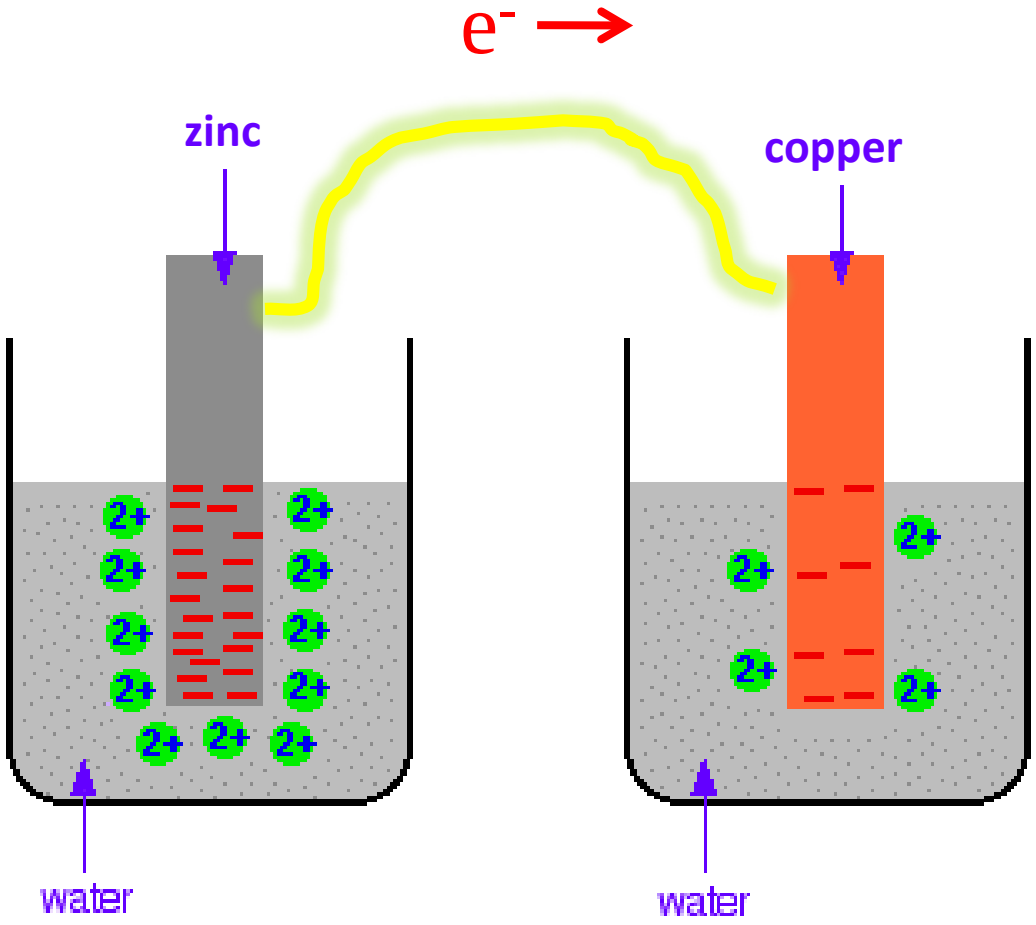
$$Zn^{2+} + 2e^{-} \rightarrow Zn \quad E^{o} = -0.763\ V$$

The positive sign means that the process is spontaneous in the direction it is written. Thus, copper readily forms the metal and Zu readily forms ions.

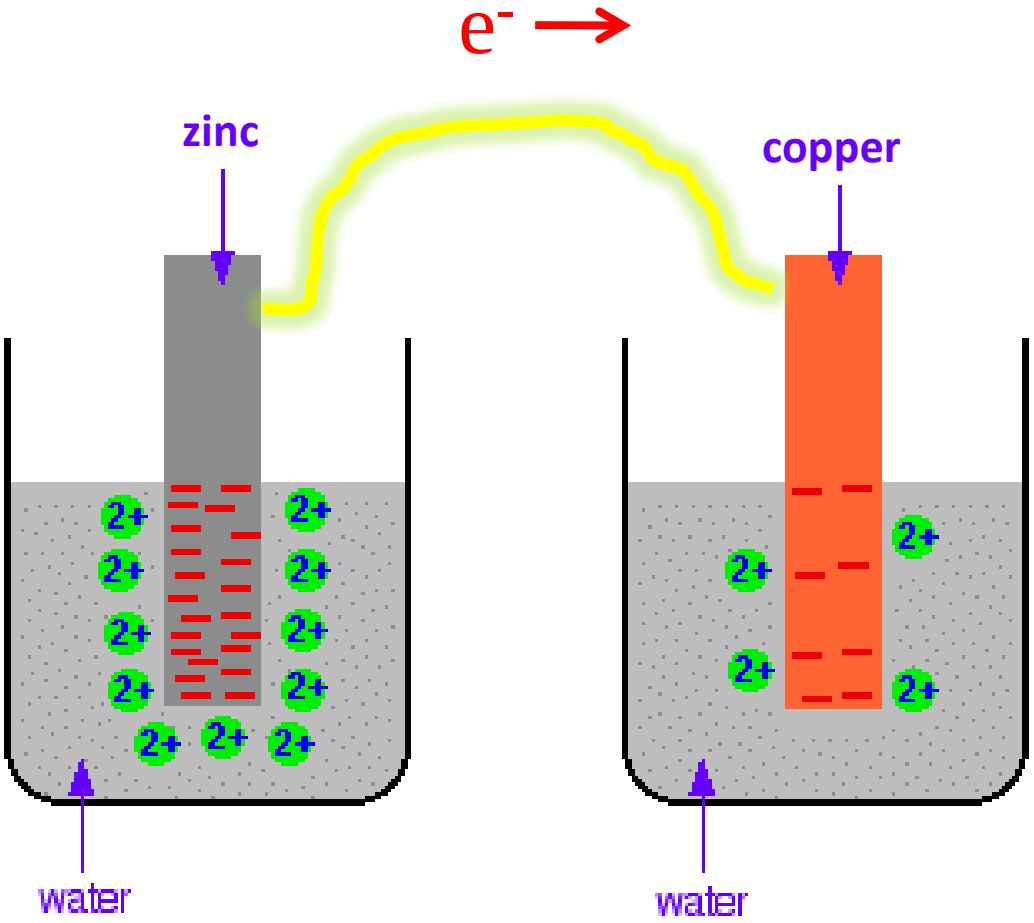
If we place two strips of metal in water then we can see the reactivity as indicated below. If we were to connect the two strips with a wire….



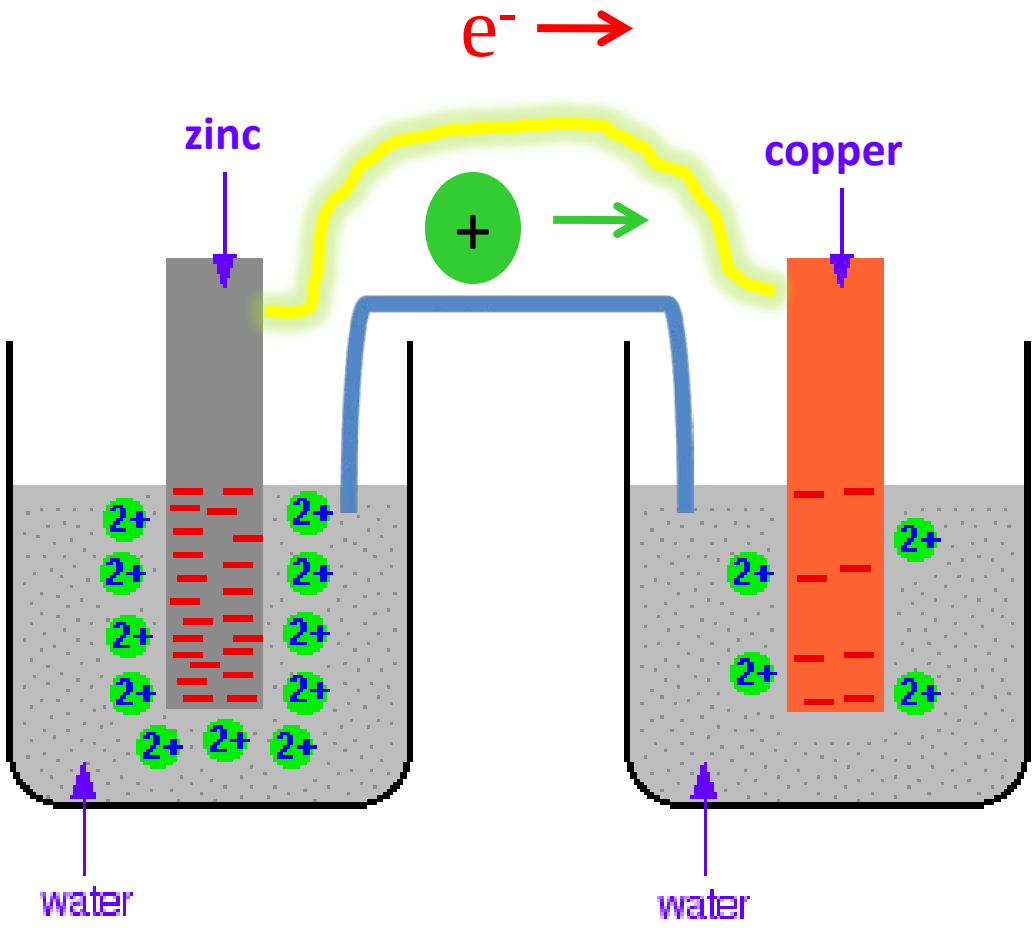
If we place two strips of metal in water then we can see the reactivity as indicated below. If we were to connect the two strips with a wire, then electrons could flow from the more negative to the the less negative strip.



However, the electrochemical cell shown below does not make a complete circuit so the current would lead to a small net transfer of charge, and then it would stop.



If we added a tube that connects the two solutions, then ions can flow between the two half-cells. This makes a complete circuit. The tube is a “salt bridge”.



The process that we have described is the construction of an electrochemical cell. The two electrodes have different potentials, which sets up a cell potential.