# PREDICTING REDOX REACTIONS

Example 1
What spontaneous reaction occurs, if any, when zinc metal is put in hydrochloric acid?

Step 1: List all species in the mixture.
Note that hydrochloric acid is a strong acid and is completely ionized to hydrogen ions and chloride ions.
(This also applies to aqueous ionic compounds which are completely dissociated)
Also, hydrochloric acid is an aqueous solution (i.e., water is present).
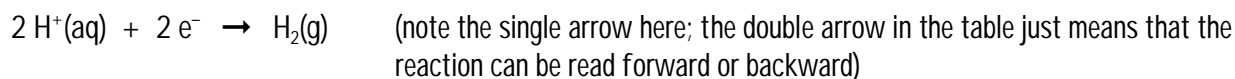
$Zn(s)$    $H^+(aq)$    $Cl^-(aq)$    $H_2O(l)$

Step 2: Use the redox table ("Standard Reduction Potentials") on page 20 of the course manual to determine the strongest oxidizing agent (SOA) in the mixture.
Oxidizing agents are on the left of the double arrows with the strongest oxidizing agent at the top ($F_2$).
Some oxidizing agents are combinations of species (e.g., $PbO_2 + SO_4^{2-} + 4\ H^+$)
The SOA is the hydrogen ions. They are located highest in the table.
The half reaction that could occur is . . .

$2\ H^+(aq) + 2\ e^- \longrightarrow H_2(g)$    (note the single arrow here; the double arrow in the table just means that the reaction can be read forward or backward)
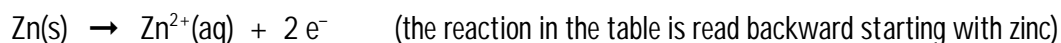
Step 3: Use the redox table to determine the strongest reducing agent (SRA) in the mixture.
Reducing agents are on the right of the double arrows with the strongest reducing agent at the bottom (Li).
Some reducing agents are combinations of species (e.g., $SO_3^{2-} + 2\ OH^-$)
The SRA is the zinc. It is located lowest in the table.
The half reaction that could occur is . . .

$Zn(s) \longrightarrow Zn^{2+}(aq) + 2\ e^-$    (the reaction in the table is read backward starting with zinc)

Step 4: Use the spontaneity rule to determine if the reaction will occur spontaneously.
Spontaneity Rule: An oxidizing agent will react spontaneously with any reducing agent lower in the redox table.
The SRA (zinc) is lower in the table than the SOA (hydrogen ions). Therefore the reaction is spontaneous.

Step 5: Add the half reactions to get the overall reaction.
Both half reactions involve two electrons which will cancel out.
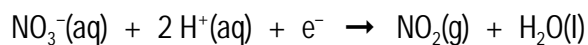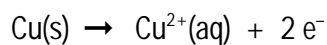The overall reaction is . . .

$2\ H^+(aq) + Zn(s) \longrightarrow H_2(g) + Zn^{2+}(aq)$
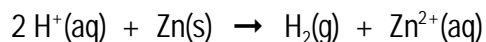
Example 2
What spontaneous reaction occurs, if any, when copper metal is put in nitric acid?

Step 1:  $Cu(s)$        $H^+(aq)$        $NO_3^-(aq)$        $H_2O(l)$

Step 2:  SOA is $NO_3^-(aq)$ and $H^+(aq)$ together.

$$NO_3^-(aq) + 2 H^+(aq) + e^- \longrightarrow NO_2(g) + H_2O(l)$$

Step 3:  SRA is $Cu(s)$

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

Step 4:  The SRA is lower in the table than the SOA. Therefore the reaction is spontaneous.

Step 5:  The nitrate/hydrogen ion reaction must be doubled to balance the charge transfer (two electrons lost; two electrons gained), then the half reactions can be added together to get the overall reaction.
The overall reaction is . . .

$$2 NO_3^-(aq) + 4 H^+(aq) + Cu(s) \longrightarrow 2 NO_2(g) + 2 H_2O(l) + Cu^{2+}(aq)$$