Balancing Redox Reactions

Many redox reactions are difficult to balance by the methods of inspection or trial and error that we have used until now. For example, try balancing the following equation, which is only moderately complex.

$$\_\_\_S(s)+\_\_\_HNO_3(aq)\rightarrow\_\_\_SO_2(g)+\_\_\_NO(g)+\_\_\_H_2O(l)$$

In order to balance this equation, and others like it, we need to use a systematic approach. We will now learn to apply our knowledge of oxidation numbers to balancing redox reactions.

The fundamental principle in balancing redox reactions is that the number of electrons lost in an oxidation process (increase in oxidation number) must equal the number of electrons gained in the reduction process (decrease in oxidation number).

The following steps can be used to balance any redox equation. We will use the above equation to illustrate each step.

1. Assign oxidation numbers to all atoms in the equation, writing them above the chemical symbol for each element.

$$\_\_\_S(s)+\_\_\_HNO_3(aq)\rightarrow\_\_\_SO_2(g)+\_\_\_NO(g)+\_\_\_H_2O(l)$$

2. Identify the element oxidized and the element reduced, and determine the change in oxidation number of each.

   oxidized: ____________________ change: _____________

   reduced: ____________________ change: _____________

3. Connect the atoms that change in oxidation numbers by an arrow, and write the change in oxidation number at the midpoint of each bracket.

$$\_\_\_S(s)+\_\_\_HNO_3(aq)\rightarrow\_\_\_SO_2(g)+\_\_\_NO(g)+\_\_\_H_2O(l)$$

4. Choose coefficients that make the total increase in oxidation number equal to the total decrease in oxidation number.

$$\_\_\_S(s)+\_\_\_HNO_3(aq)\rightarrow\_\_\_SO_2(g)+\_\_\_NO(g)+\_\_\_H_2O(l)$$

5. Balance the remaining elements by inspection, and then check the final equation.

$$\_\_\_S(s)+\_\_\_HNO_3(aq)\rightarrow\_\_\_SO_2(g)+\_\_\_NO(g)+\_\_\_H_2O(l)$$

Example 1
Balance the following equation using the oxidation number method.

$$\_\_\_H_2S+\_\_\_HNO_3\rightarrow\_\_\_S+\_\_\_NO+\_\_\_H_2O$$

Balancing Redox Equations in Acidic Solutions

When necessary, a reaction that occurs in an acidic water solution can be balanced by adding H_2O and H^+ to either side of the equation as necessary. In such cases:

1. Balance the O atoms by adding H_2O to the side of the equation that needs O atoms.

2. Balance the H atoms by adding H^+ ions to the side that needs H atoms.

Example 2
In an acidic water solution, the perchlorate ion (ClO_4^-) reacts with the iodide ion (I^-) to form the chloride ion (Cl^-) and iodine (I_2). Write a balanced chemical equation for this reaction.

Balancing Redox Equations in Basic Solutions

A reaction that occurs in an alkaline (basic) water solution can be balanced using a similar method. In such cases:

1. Balance the O atoms by adding H_2O to the side of the equation that needs O atoms.

2. Balance the H atoms by adding H^+ ions to the side that needs H atoms.

3. Add OH^- ions to both sides of the equation equal in number to the amount of H^+ ions present.

4. Combine H^+ and OH^- on the same side to form H_2O, and cancel the same number of H_2O on both sides.

Example 3
Methanol reacts with permanganate ions in a basic solution. The main reactants and products are shown below.

$$\_\_\_ CH_3OH(aq) + \_\_\_ MnO_4^-(aq) \rightarrow \_\_\_ CO_3^{2-}(aq) + \_\_\_ MnO_4^{2-}(aq)$$

Balance the equation for this reaction.