Oxidation and Reduction

The oxidation or iron, and the reduction of iron ore.

$\overset{0}{4Fe(s)} + \overset{0}{3O_2(g)} \rightarrow \overset{+3\ -2}{2Fe_2O_3(s)}$

The combustion of iron in which iron is oxidized.

$\overset{+3\ -2}{2Fe_2O_3(s)} + \overset{0}{3C(s)} \rightarrow \overset{0}{4Fe(s)} + \overset{+4\ -2}{3CO_2(g)}$

The reduction of iron ore, called hematite, by heating it with coke in a blast furnace, producing metallic iron.

Historically, oxidation and reduction referred to reactions of metals and their ores. Today we can define oxidation and reduction in terms of electrons and oxidation numbers. Look at the reactions above and fill in the spaces in the table below.

	Gain or loss of oxygen (historical)	**Gain or loss of electrons**	**Increase or decrease of oxidation number**
Oxidation			
Reduction			

Initially, oxidation and reduction were defined in terms of the gain or loss of oxygen, but that only tells half the story. Today we define oxidation and reduction in terms of the gain or loss of electrons. But sometimes the loss or gain of electrons is theoretical . We can always define oxidation as an increase in oxidation number and reduction as a decrease in oxidation number.

A common mnemonic for remembering one definition of oxidation and reduction. Fill in the blanks.

OILRIG = O_____ is L_____, R_____ is G_____

Rules for assigning oxidation numbers:

1. Elements in the elemental state are zero
2. Oxygen is always –2
3. Hydrogen is always +1
4. Groups IA, IIA and IIIB are +1, +2 and +3 respectively
5. Halides are –1
6. Sulfide, selenide, and telluride are –2,
7. Nitride, phosphide, are arsenide are –3
8. Al, Ga, In, Zn, Cd, and Ag are +3, +3, +3, +2, +2, and +1 respectively
9. Other oxidation numbers can be determined from the formulas of the compound and known oxidation numbers.
10. The sum of the oxidation numbers in a compound is zero. The sum of the oxidation numbers in a polyatomic ion is equal to the charge on the ion.

Redox reactions

The word "redox" is short for "oxidation-reduction". As you may have figured out by now, all single replacement reactions are redox reactions, but not all redox reactions are single replacement reactions. Some synthesis and decomposition reactions are redox reactions. All combustion of hydrocarbon reactions are redox, but no double replacement reactions are redox. And then there a number of redox reactions that don't fit any of the five simple reaction types.

We can recognize a redox reaction by changes in the oxidation numbers of at least two elements. Remember. If the oxidation number increases from the reactant side to the product side, that element has been oxidized. If the oxidation number decreases from the reactant side to the product side, that element has been reduced.

Here are some sample redox reactions. See if the type of reaction is familiar. Assign an oxidation number to each element, and look for changes. Then identify the element that has been oxidized and the element that has been reduced.

1. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

   Element oxidized _____ Element reduced _____

2. $2H_2O \rightarrow 2H_2(g) + O_2(g)$

   Element oxidized _____ Element reduced _____

3. $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

   Element oxidized _____ Element reduced _____

4. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

   Element oxidized _____ Element reduced _____

5. $3S(s) + 4HNO_3(aq) \rightarrow 3SO_2(g) + 4NO(g) + 2H_2O(l)$

   Element oxidized _____ Element reduced _____