METALS AND NON METALS - II

METALS AND REACTIVITY

A very important way of organizing metals is in order of reactivity. This is easy for the metals in groups I; as you move down the group the metals get more reactive (as we have seen in Chapter 5). For the transition metals, the order of reactivity is not so easy to determine and must be determined by DISPLACEMENT REACTIONS. You will not need to know the position in the reactivity series (sometimes called the activity series) for all the metals but, for those that we meet most often, it is useful to have them listed.

Most Reactive ---> Least Reactive
K - Na - Li - Mg - Zn - Fe - Cu - Ag - Au

In a displacement reaction we take a solution of a salt of one of the metals and add a small piece of another metal to it. We may see a change. For instance:-

copper(II)sulphate solution + magnesium ==> magnesium sulphate solution + copper

$$CuSO_{4(aq)} + Mg_{(s)} \Longrightarrow MgSO_{4(aq)} + Cu_{(s)}$$

You would be able to see this reaction taking place, as magnesium is a white metal (to avoid confusion, chemists call 'white' what the rest of the world would describe as 'silver') while copper is pink. Copper sulphate solution is blue while magnesium sulphate is clear and colourless. So in the course of this reaction, the blue colour of the solution would fade and the white metal would be replaced by a pink metal.

If you discovered a new metal called X (I'm sure you would think of a much better name than that, but for the meantime, let's stick with X!!) you could place it in solutions of the salts of each of the metals in the reactivity series above until you found one that it displaced. If X did not react with Iron(II) sulphate solution (therefore did not displace iron) but did react with copper(II)sulphate solution (and therefore displaced copper from the solution) it would prove that the reactivity of X lies between iron and copper.

The reactivity series is the key to extracting metals. Metals are found in the Earth's crust in the form of rocks called 'ores'. If ores are heated with other metals which are more reactive than them, then the ore will break down and a metal will be extracted. You would not expect to find carbon in the reactivity series as it is not a metal, but it is good at extracting metals. Many ores need to be heated with carbon to extract them from their ores.

COPPER

As you can see from the reactivity series above, copper is not a very reactive metal. It can be extracted from its ores by heating them with carbon in the form of charcoal. Copper ores are quite complicated mixtures so we shall consider the case of copper(II)oxide.

copper(II)oxide + carbon ==> copper + carbon monoxide

$$CuO_{(s)} + C_{(s)} \Longrightarrow Cu_{(s)} + CO_{(g)}$$

In order for this reaction to take place, the ore and the charcoal must be heated together strongly in the absence of air. Copper has been made in this way for thousands of years but nowadays very pure copper is required, mainly for electrical cables and pipes. For this reason, the copper is treated by a process of ELECTROLYSIS (see chapter 20).

IRON

Iron is a much more difficult metal to extract because it is more reactive than copper. Extraction takes place in a BLAST FURNACE with temperatures up to 1500°C. A number of reactions take place in the blast furnace but these can be simplified into those given below. A number of ores of iron are used but the one used in the equations is iron(III)oxide (called haematite). In this case, the carbon is in the form of coke - heat treated coal. Limestone (calcium carbonate) is also added.

Stage 1. The formation of carbon dioxide

carbon + oxygen ==> carbon dioxide

$$C_{(s)} + O_{2(g)} \Longrightarrow CO_{2(g)}$$

Stage 2. The formation of carbon monoxide

carbon dioxide + carbon ==> carbon monoxide

$$CO_{2(g)} + C_{(s)} \Longrightarrow 2CO_{(g)}$$

Stage 3. Reduction of iron(III)oxide

iron(III)oxide + carbon monoxide ==> iron + carbon dioxide

$$Fe_2O_{3(s)} + 3CO_{(g)} \Longrightarrow 2Fe_{(s)} + 3CO_{2(g)}$$

Stage 4. Formation of slag (a waste product that removes the non useful parts of the ore) - silicon oxide

calcium carbonate (limestone) + silicon oxide ==> calcium silicate (slag)

$CaCO_{3(s)} + SiO_{2(s)}$ ==> $CaSiO_{3(s)}$

Iron produced in this manner is called CAST IRON and it must be further treated to become WROUGHT IRON and STEEL, both of which are much stronger and useful than cast iron. The diagram below illustrates clearly that the raw materials for iron making are added to the top of the furnace, while the molten iron and the slag that float upon it are drawn off at the bottom. Once a blast furnace has started operation, it will normally run continuously for every day of its working life.

Source : http://www.peoi.org/Courses/Coursesen/chem/frame6.html