TYPES OF MATTER

ELEMENTS, COMPOUNDS AND MIXTURES.

In the last chapter we spent some time looking at how substances can be classified. We now have to address a basic way of dividing every substance that we come across into one of three groups; elements, compounds and mixtures. These are referred to by chemists the world over in a very precise way, so let's start with the definitions of each;

- An ELEMENT is the simplest kind of substance in the universe, it is completely pure with all particles being of that substance. Elements cannot be broken down into any other simpler substance. A list of all known elements is contained in the PERIODIC TABLE. (**Figure 1** below). The smallest particle of an element is called an atom.

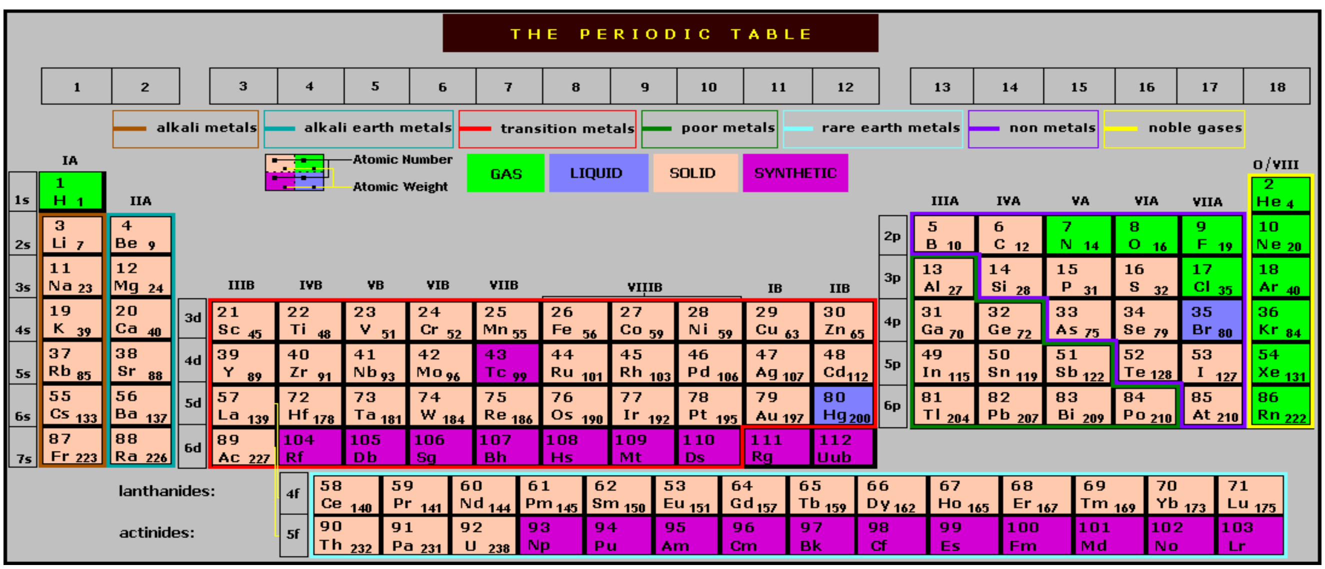

Fig. 1

- A COMPOUND is made up of two or more elements chemically combined. Compounds are also pure substances but unlike elements, they can be broken down into simpler substances. Each compound always has the same chemical composition, that is, they are always composed of elements in exactly the same proportions.
- A MIXTURE is a collection of elements and compounds which are not chemically combined. Mixtures are always impure and have no definite compositions.

These definitions are tricky at first and we need to work on these ideas to gain a greater understanding of them. You can easily understand that hydrogen and oxygen are both elements because you can find them both on the periodic table.
When hydrogen and oxygen combine to form water, it has a definite formula H_2O and, as it has two elements chemically combined, it must be a compound. If we take sea water however, we know that it contains water, salt, other dissolved substances and the odd living thing; therefore we know that sea water is a mixture. People tend to get confused when it comes to metals, so let's just say that elemental metals like iron, copper, sodium and gold are all elements (try to find them on the periodic table). Brass, pewter and bronze are all mixtures; different elemental metals that are mixed together when hot. For a metal to form a compound, it must do so only by combining with non-metals, such as copper oxide CuO, sodium chloride NaCl and iron(III) oxide Fe_2O_3. (Don't worry about how we come by these formulas, all will be explained in time).

On the written page, you can recognize elements by their simple formulas; K, Li, Ca, Br, Au, I etc. (find them on the periodic table). Compounds have more complex formulas (using the periodic table you can identify the elements that they contain) like $MgSO_4$ (magnesium sulphate), NH_3 (ammonia) and $AgNO_3$ (silver nitrate). Mixtures have no formula at all due to their variable composition. So air, tomato ketchup, blood and beer are all without a formula.

The concept of purity, as used in the definitions above, is fairly theoretical. If you had a real sample of magnesium (Mg) in your hand, it would undoubtedly have a trace of impurity in it but we would still class it as an element as this tiny trace of impurity would not affect the behaviour of the element. Likewise, your table salt (sodium chloride NaCl) is so close to purity that we accept it as being a compound.

Looking at your periodic table, you will see that only just over a hundred elements exist, yet when it comes to compounds there are millions representing the ways in which those elements can combine. Since purity is not a natural state for things to be found in, the vast majority of substances on earth are mixtures.

PHYSICAL CHANGE

Chemistry would not be much of a subject if people just had a range of substances with names; the business of a chemist is to change substances and make them more useful. The simplest type of change is called PHYSICAL CHANGE and it is purely a matter of altering one of a substance's PHYSICAL PROPERTIES.

State (see Chapter X), colour, density, melting point and boiling point are all examples of physical characteristics. If you take a block of ice and heat it up, it will change, first into water and, if you continue to heat it, eventually into steam. You will note that all of these changes are easily reversed; if you cool down steam it will change first into water and, if you continue to cool it, eventually back to ice. This helps us to come up with a definition of physical change.

- A change in the physical property of a substance is called physical change. Physical changes are easily reversible and no new substance is formed.

If you heat up a block of iron it will glow red, and when it cools down again, it will return to its starting colour - an example of physical change. At sea level, water boils at 100°C; if you climb up a very high mountain, it will boil at a much lower temperature (mountaineers find that it takes a long time to cook food) so moving the water up the mountain has altered a physical property - boiling point - and is therefore an example of physical change. As physical change does not involve a product, it is rare to use chemical equations to represent them, however sometimes it is useful to show a change of state:

$$H_2O_{(l)} \implies H_2O_{(g)}$$

Showing water as a liquid changing to a gas.
In chemical equations the small subscript in parentheses represent the state of the substance:- solid as $_{(s)}$, liquid as $_{(l)}$, and gas as $_{(g)}$.

CHEMICAL CHANGE

If you thought that physical changes were not very exciting, you're right! Chemists spend most of their time investigating the second kind of change called CHEMICAL CHANGE. Chemical change is what happens when you boil an egg, or a forest catches fire, or metal "dissolves" in acid, or plants photosynthesize, or you respire. All these changes involve one substance changing into another. Let's start with a definition and then examine these examples in more detail.

- A change which involves one substance being changed into another is called chemical change. Chemical change cannot be reversed easily and usually involves an input or output of energy.

Boiling that egg involves an input of energy in the form of heat; you cannot change a boiled egg back into a raw egg. A new substance has also been formed - 'boiled egg'. A forest fire gives off vast amounts of energy and the ashes cannot be turned back into a forest - chemical change. Metal "dissolving" in acid gives off heat energy and two new substances are formed; a salt and hydrogen gas (see Chapter 1) - chemical change. Photosynthesis involves plants using light energy from the sun to change carbon dioxide and water into sugar and oxygen - chemical change. In fact, respiration is the opposite of this reaction, taking sugar and oxygen and turning them into carbon dioxide and water. As you can see, from the last two examples it is not impossible to make these changes reverse but it is very difficult as compared to physical change.

Those examples of chemical change that result in a release of energy into the environment (like burning and respiration) are called EXOTHERMIC reactions. Chemical changes that take in energy from the environment are called ENDOTHERMIC reactions. Chemists have a symbol for exothermic change (you will find that chemists have a symbol for most things); exothermic change is shown as H-; and endothermic change is shown as H+ .

As the business of chemists is chemical change, you will not be surprised to find that all of these changes can be represented by equations; first a word equation and then a symbol equation.

iron + oxygen ==> iron oxide

$$4Fe_{(s)} + 3O_{2(g)} \Longrightarrow 2Fe_2O_{3(s)}$$

Notice that in the reactants we have 4 Fe and 6 O, and in the products 4 Fe and 6 O; a chemical equation MUST balance so that the number of atoms of each element are the same on both sides of the equation. Notice also that to find the number of oxygen atoms we multiplied the large number (in this case the '3' before the symbol), by the small number '$_2$' that comes after the symbol, giving us our total. of 6. Looking at the products, our total of 6 O comes from multiplying the large '2' by the small '$_3$' at the end of the formula. Another example which balances:

sodium + chlorine ==> sodium chloride

$$2Na(s) + Cl_{2(g)} \Longrightarrow 2NaCl_{(s)}$$

Source : http://www.peoi.org/Courses/Coursesen/chem/fram1.html