

IDEAS ABOUT ATOMS

In chapter one we looked briefly at the ideas of the Ancient Greeks about atoms. You will remember that the main idea involved tiny particles of matter that could not be broken down. This idea was, like many Ancient Greek ideas, held up over the centuries that followed; Shakespeare used the word 'atomies' in *Romeo and Juliet* (Queen Mab speech). It was an idea that needed some refinement however, and in 1809, the English Quaker chemist JOHN DALTON came up with the ATOMIC THEORY. This theory has been at the heart of modern chemistry for almost two hundred years.

Dalton's Atomic Theory was developed to marry old ideas with the (then) modern discoveries of chemistry; in particular, Dalton was convinced that quantitative chemistry could throw new light on how elements combined with each other. The Atomic Theory is usually broken down into four statements:

1. Atoms can neither be created nor destroyed.
2. Atoms of the same element are the same as each other in terms of mass, colour and size.
3. Atoms of different elements are different from each other in terms of mass, colour and size.
4. Atoms join together in small whole numbers to form molecules.

Now, if you know a little chemistry, you will already see that that Dalton was wrong about a few things, but his Atomic Theory is basically sound. At the end of the chapter you should be able to list the ways in which current knowledge seems to contradict Dalton on each of the four statements listed above.

One big problem occurs when chemists and physicists talk about atoms - they are so small that we can not see them. All our ideas about atoms involve us in developing SCIENTIFIC

MODELS. Models help us picture what we cannot see, and build up an understanding of how things behave. Dalton's model of the atom pictured it pretty much as a solid, hard sphere, and because he believed them to be coloured (despite being colour-blind himself), this is often referred to as the BILLIARD BALL MODEL. Indeed, if you ask people to describe what they think of as an atom, most people will describe something approaching this model. Dalton also gave symbols to the elements to help him explain how they joined together. Some of the symbols can be seen in figure 1.

ATOMIC MASS

The mass of atoms is a difficult concept - if something is so small that you cannot see it, how can you find its mass? Of course, to use grams is not helpful as they are not small enough, so chemists use a very helpful measurement called ATOMIC MASS UNITS, or amu for short. We need a standard against which to measure atoms - the IUPAC (see chapter 1), have decided that the standard unit is carbon (it is the element present in more compounds than any other). One carbon atom has a mass of exactly 12 amu. This is used to compare other atoms; for instance, a magnesium atom has twice the mass of a carbon atom, so has a mass of 24 amu. One carbon atom has twelve times the mass of a single hydrogen atom, therefore hydrogen has a mass of 1 atomic mass unit. This is the basic idea of atomic mass, but we will need to refine it later on in this chapter and further investigate the concept in later sections.

PROTONS, NEUTRONS and ELECTRONS

Dalton's billiard ball model of the atom was the accepted idea for almost a hundred years. With increasing interest in electricity and the continued development of the vacuum pump however, new and more sophisticated models needed to be constructed. For one reason, it was becoming obvious that atoms were composed of even smaller units called SUB-ATOMIC PARTICLES. The main evidence for this comes from experiments involving gases at very low pressures that are subjected to high voltage charges. When this takes place, positive and negative parts of the atom can be detected. Quite a lot was discovered about these charges at the start of the 20th century; for instance, the negatively charged particles were called

ELECTRONS (chemists are quite happy to think of electrons as very small particles, but much of their behaviour is wave-like) and it was found that they were very small but with a quite large charge. The positive particles were called PROTONS and although they also had a fairly large charge, were found to be much larger than electrons. This meant that a new model was needed - for a short time it was thought that these protons and electrons were evenly distributed throughout each atom like the fruit in a cake. This was called the 'plum-pudding model'.

The mass of an atom is greater than the total mass of protons and electrons found within it. How can this be? Eventually, a third particle, called the NEUTRON, was found. It had a mass very much the same as a proton and no charge at all (the lack of charge made it difficult to detect). It was also established that protons and neutrons were to be found in the centre of the atom in a dense area called the NUCLEUS. It was discovered that electrons were found moving very quickly, in an area well away from the nucleus, called the SHELL. This model of atoms was like little solar systems, with the electrons orbiting the nucleus rather as planets orbit the sun. As it happens, this model is not very well supported by evidence, but it has captured peoples' imagination, so seems to be still around.

As chemists we are not too bothered by the fact that we can not see atoms or sub-atomic particles - we are more interested in how they behave. To understand this behaviour we need two models to help us.

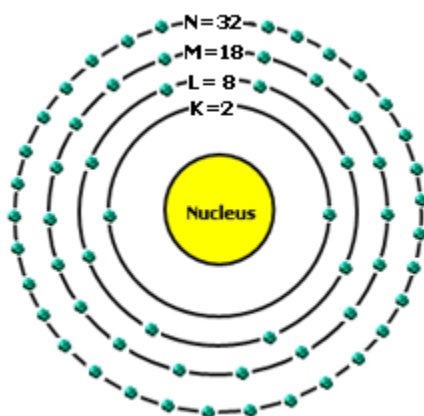
MODEL 1. Sub-atomic particles table. We cannot measure the mass of sub-atomic particles in any conventional unit - they are just too small. So, we use a.m.u. (as mentioned above). It is also difficult to measure the charge on these particles, so we compare them to the charge on one proton (which has a single positive charge, illustrated by +). This happens to be exactly equal and opposite to the charge on an electron (a single negative charge, illustrated by -). The following table is useful to compare the three particles in the atom.

Sub atomic	Mass in a.m.u.	Relative	Position in the
------------	----------------	----------	-----------------

particle		charge	atom
PROTON	${}^1\text{p}^+$	1	Nucleus
NEUTRON	${}^1\text{n}^0$	1	Nucleus
ELECTRON	e^-	1/1840 (almost 1/2000)	Shell

Note that the neutron must be given a zero. If we were to represent its charge as a dash, this would look like a negative sign which we already use for electrons.

MODEL 2. Electrons in shells model. While the table contains a lot of information, it is not a working model that can be used, neither does it lend itself to helping us understand how atoms join together.



We will be using this model very often in the coming chapters and it is a very good method for showing such things as bonding and the forming of ions. Note that the atom shows protons as P and neutrons as N in the nucleus. The nucleus is often not shown at all; the electrons are shown as green dots (crosses also can be used to show electrons) in KLMN shells. These shells have sub-shells or more accurately termed orbitals; s, p, d, f, etc

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