ATOMIC STRUCTURE

Everything in the world is made from about 100 elements. Each element has a name and a symbol. Elements are classified in different ways e.g.

- naturally occurring or man-made
- solid, liquid or gas
- metal or non-metal.

Chemists have classified elements by arranging them in the Periodic Table part of which is shown below:

1	2											3	4	5	6	7	8
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr																

Metals | non-metals

Horizontal strips are known as 'periods' e.g. Li -> Ne

Vertical strips are known as 'groups' e.g.

GP 1	H -> Fr	'Alkali metals'	Very reactive metals
GP 7	F -> At	'Halogens'	Very reactive non-metals
GP 8	He -> Rn	'Noble gases'	Very unreactive non-metals

Elements in any one group show similar chemical properties.

The transition metals lie between groups 2 and 3 e.g. Sc - Zn

Compounds are formed when elements react together. Bonds are formed between the atoms.

All chemical reactions involve the formation of one or more new substances. Some examples follow.

EXPERIMENT

React Magnesium with Sulphur.

Magnesium + Sulphur -> Magnesium sulphide

The ending '-ide' tells us that Magnesium sulphide contains only the two elements indicated by the name.

Endings '-ite' or '-ate' would indicate that the compound contains the additional element Oxygen e.g. Magnesium sulphate contains Magnesium, Sulphur AND Oxygen.

In the above reaction between Magnesium and Sulphur we can observe a colour change: the silvery metal, Magnesium, and the yellow powder, Sulphur, are replaced by a white powder, Magnesium sulphide.
We also note that energy is given out: heat and a brilliant, white light. Reactions which give out energy, like this one, are described as **exothermic** - the products have LESS energy than the reactants. Reactions which take in energy are described as **endothermic** - the products have MORE energy than the reactants.

EXPERIMENT

Heat together a mixture of Ammonium sulphate and Calcium hydroxide.

Ammonia gas is given off. The gas has a pungent smell.

EXPERIMENT

Add dilute Hydrochloric acid to powdered Calcium carbonate.

Fizzing (effervescence) occurs. Carbon dioxide gas is given off. Unlike Ammonia, this gas has no smell.

EXPERIMENT

Mix together solutions of Lead(II) nitrate and Potassium iodide.

A beautiful, yellow precipitate of Lead(II) iodide is formed.

REACTIONS IN THE WORLD AROUND US

The following all involve chemical change: frying an egg, burning wood, rusting of Iron, paint drying, setting of cement, hair perming, making toast, home brewing, digesting food and taking indigestion tablets!

MIXTURES

Compounds should not be confused with mixtures. The substances in a mixture are not reacted together. Some everyday mixtures include sea-water, air and petrol.

A **solution** is the mixture formed when a solute is dissolved in a solvent. When a substance dissolves we say that it is **soluble**; when a substance does not dissolve we say that it is **insoluble**.

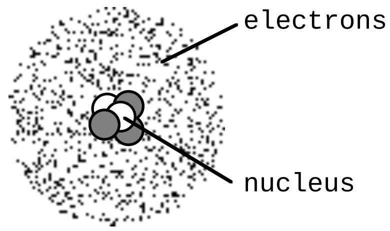
If we add very little solute then we get a **dilute** solution. If we go on adding more solute then we get a more **concentrated** solution. If we continue to add more solute there will come a point when the solution cannot hold any more - we call this a **saturated solution**.

Some solutions must be **diluted** before use e.g. concentrated fruit juice, insect sprays etc.

THE STRUCTURE OF THE ATOM

Every element is made up of very small particles called atoms. The atom has a nucleus which contains protons and neutrons with electrons moving around outside the nucleus.

- ● Protons have a charge of 1+
- ○ Neutrons are neutral
- Electrons have a charge of 1-



Since the number of protons and electrons is equal, the overall atom is neutral.

Protons and neutrons each weigh about the same: 1.67 x 10^{-27} kg

We call this mass 'one atomic mass unit' or 1 amu.

Electrons are very much lighter. We will assume they have no mass at all!

Each element is set apart from every other element by the number of protons in its atoms e.g. Hydrogen atoms have one proton, Helium atoms have two and Lead atoms have 82 !

The number of protons in the atom is called the **ATOMIC NUMBER**. The elements in the Periodic Table are arranged in order of atomic number.

ISOTOPES

Unlike the protons, the number of neutrons in atoms of the same element can vary.

e.g. Hydrogen atoms always have 1 proton but they can have 0, 1 or 2 neutrons

Atoms with the same number of protons but a different number of neutrons are known as **ISOTOPES**.

The total number of protons and neutrons in an atom is called the **MASS NUMBER**.

Symbols for isotopes are written thus:

$$^{\text{mass number}}_{\text{atomic number}}X$$

The three isotopes of Hydrogen mentioned above therefore have symbols:

$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

PROBLEM:

Fill in the blanks in the table below:

Symbol	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{35}_{17}Cl$					
	18	40			

RELATIVE ATOMIC MASS

Most elements exist as mixtures of isotopes e.g. Boron

Isotope	Percentage
$^{10}_{5}B$	20
$^{11}_{5}B$	80

The mass of ^{10}B is 10 amu.

The mass of ^{11}B is 11 amu.

PROBLEM:

What is the average mass of a Boron atom ?

The answer is not 10.5 !

ANSWER:

Imagine we have 100 Boron atoms

20 would each weigh 10 amu ; 80 would each weigh 11 amu.

Mass of 20 ^{10}B = 20 x 10 = 200 amu

Mass of 80 ^{11}B = 80 x 11 = 880 amu

=> Total mass of 100 B atoms = 1080 amu

=> Average mass of B atom = $\frac{1080}{100}$ = <u>10.8 amu</u>

This 'average mass' is known as the 'relative atomic mass'. For obvious reasons, it is rarely a whole number.

PROBLEM:

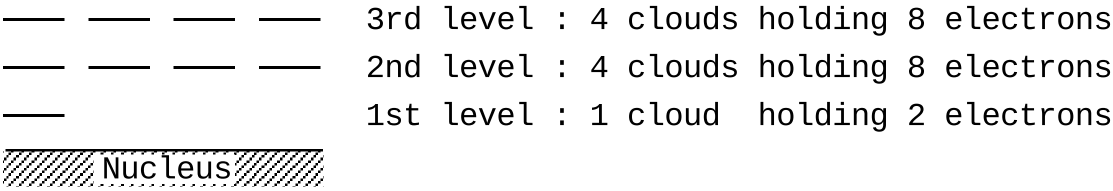
Calculate the relative atomic mass of Rubidium from the following data:

Isotope	Percentage
$^{85}_{37}Rb$	72
$^{87}_{37}Rb$	28

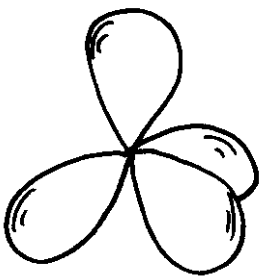
The answer is 85.56 amu. Did you get it right?

ELECTRON STRUCTURE

The electrons exist around the nucleus in clouds. Each cloud can hold a maximum of two electrons. The electrons are arranged in energy levels ; the nearer the nucleus the lower the energy level.

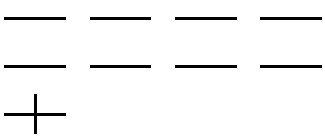


Within one energy level the electrons keep as far apart as possible by occupying different clouds since electrons repel each other. This repulsion results in the 2nd and 3rd energy level clouds adopting a tetrahedral arrangement:



Example : HYDROGEN

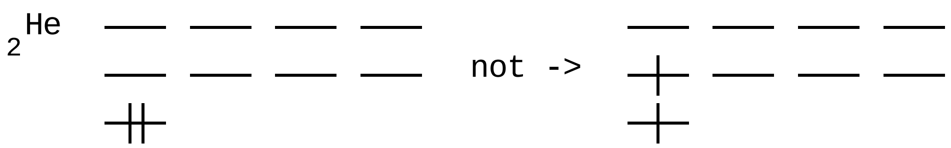
$_1H$



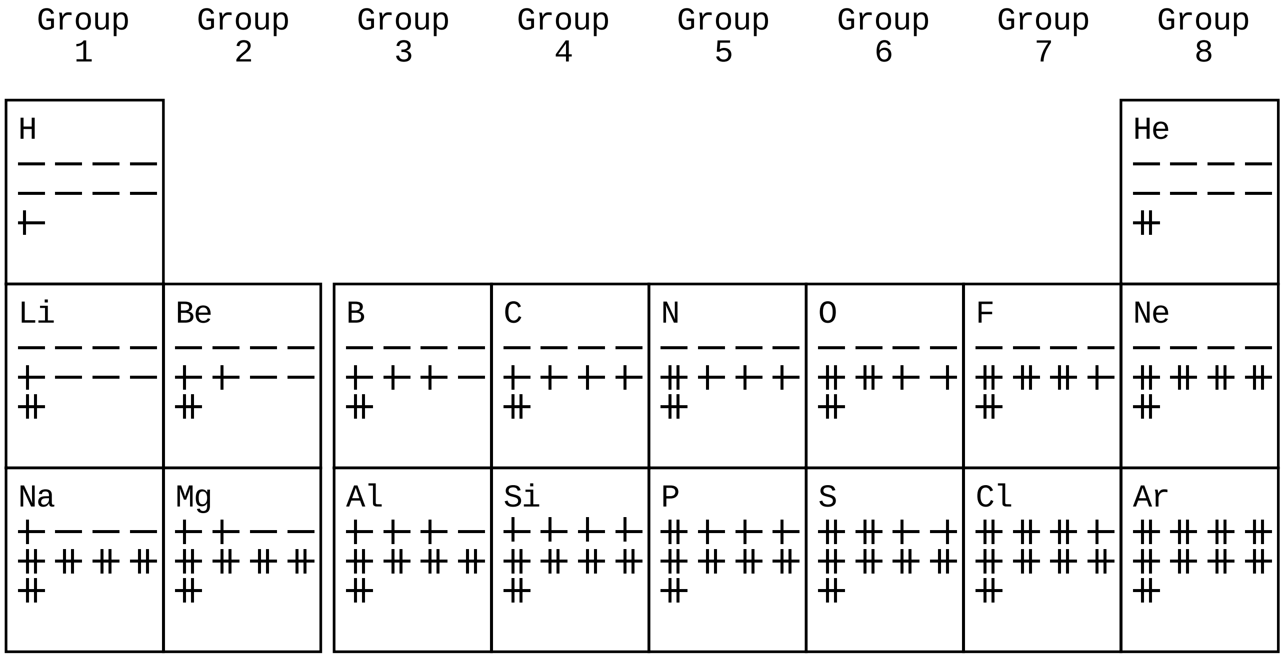
The electronic structure of Hydrogen is written 1)

Sometimes the electron is forced into sharing a cloud when having a cloud of its own would mean moving up to a higher energy level :

Example : HELIUM



The electron structures of the first 18 elements are shown below:



Some examples show another way of writing electron structures:

Nitrogen 2)5

Chlorine 2)8)7

Calcium 2)8)8)2

We note that the number of unpaired electrons, the **valency**, is the same within each group e.g. the valency of all the elements in group 6 is 2. All the elements within a particular group have similar chemical properties so these properties must be determined, at least in part, by the valency.