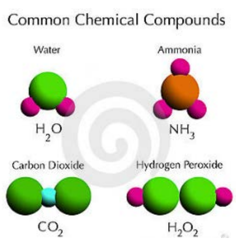
Chemistry 4.1 Atomic structure and the periodic table

4.1.1 A simple model of the atom, symbols, relative atomic mass, electronic charge and isotopes

4.1.1.1 Atoms, elements and compounds

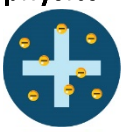


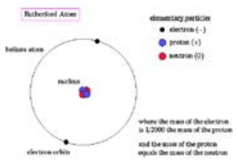
All substances are made of atoms. An atom is the smallest part of an **element** that can exist. Elements consist of **only one type of atom**.
Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen, Na represents an atom of sodium.
There are about 100 different elements. Elements are shown in the periodic table.
Compounds are formed from elements by chemical reactions. Chemical reactions always involve the formation of one or more new substances, and often involve a detectable energy change. Compounds contain **two or more elements chemically combined** in fixed proportions and can be represented by formulae using the symbols of the atoms from which they were formed. Compounds can only be **separated** into elements **by chemical reactions**. Chemical reactions can be represented by word equations or equations using symbols and formulae.

4.1.1.2 mixtures

A **mixture** consists of **two or more elements or compounds not chemically combined** together. The chemical properties of each substance in the mixture are unchanged.
Mixtures can be **separated** by physical processes such as **filtration, crystallisation, simple distillation, fractional distillation and chromatography.** These physical processes do not involve chemical reactions and no new substances are made.

4.1.1.3 the development of the model of the atom, also in physics





New experimental evidence may lead to a scientific model being changed or replaced.
Democratus 400AD - atoms were **tiny indivisible spheres**
Dalton 1803 - Matter is made up of extremely small particles called atoms. **All the atoms present in a substance are identical** in all respects such as mass and size but they **differ from atoms of other substances**.
JJ Thompson 1897 - **Discovered the electron.** This showed that the atom contained smaller pieces, whereas Dalton had thought that atoms could not be broken down into anything simpler. The discovery of the electron led to the **plum pudding model** of the atom. The plum pudding model suggested that the atom is a **ball of positive charge with negative electrons embedded** in it.
Rutherford 1911 - Used experimental evidence from the alpha particle scattering experiment to show that an atom must contain a **central nucleus** and that the nucleus was charged. This nuclear model replaced the plum pudding model.
Bohr 1913 - adapted the nuclear model by suggesting that **electrons orbit the nucleus** at specific distances.
Rutherford 1917 - Experiments led to the idea that the **positive charges** of any nucleus are made up of particles called **protons**.
Chadwick 1932 - Experimental work provided the evidence to show the existence of **neutrons within the nucleus**.

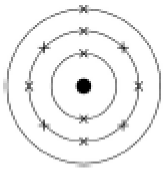
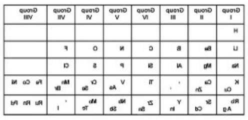
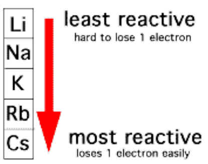
4.1.1.4 relative electrical charges of subatomic particles

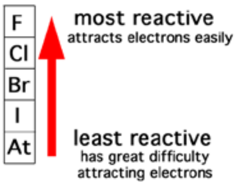
Name of particle	Relative charge
Proton	+1
Neutron	0
Electron	–1

In an atom, the **number of electrons is equal to the number of protons** in the nucleus. **Atoms have no overall electrical charge**.
The number of protons in an atom of an element is its atomic number. All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons.

4.1.1.5 **Size and mass of atoms** The relative masses of protons, neutrons and electrons are:	Atoms are very small, having a radius of about 0.1 nm (1 x 10-10 m). The radius of a nucleus is less than 1/10 000 of that of the atom (about 1 x 10-14 m). Almost all of the mass of an atom is in the nucleus. The sum of the **protons and neutrons** in an atom is its **mass number.** Atoms of the same element can have **different numbers of neutrons**; these atoms are called **isotopes** of that element. Atoms can be represented as shown in this example of sodium: (Mass number) 23 (Atomic number) 11 Na so 11 protons, 11 electrons, 12 neutrons

Name of particle	Relative mass
Proton	1
Neutron	1
Electron	Very small

4.1.1.6 relative atomic mass	The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element.
4.1.1.7 electronic structure 	The electrons in an atom occupy the lowest available energy levels (innermost available shells). The electronic structure of an atom can be represented by numbers or by a diagram. For example, the electronic structure of sodium is 2,8,1 or showing two electrons in the lowest energy level, eight in the second energy level and one in the third energy level.
4.1.2	**The periodic table**
4.1.2.1 **The periodic table**	The elements in the **periodic table** are arranged in **order of atomic (proton) number** and so that elements with **similar properties** are in columns, known as **groups**. The table is called a periodic table because similar properties occur at regular intervals. Elements in the **same group** in the periodic table have the **same number of electrons in their outer shel**l (outer electrons) and this gives them similar chemical properties.
4.1.2.2 **Development of the periodic table** 	Before the discovery of protons, neutrons and electrons, scientists attempted to classify the elements by arranging them in order of their **atomic weights**. The **early periodic tables** were **incomplete** and some elements were placed in inappropriate groups if the strict order of atomic weights was followed. **Mendeleev** overcame some of the problems by **leaving gaps** for elements that he thought had not been discovered and in some places changed the order based on atomic weights. Elements with properties predicted by Mendeleev were discovered and filled the gaps. Knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct.
4.1.2.3 **Metals and non-metals**	**Elements** that react **to form positive ions are metals**. They lose outer shell electrons Elements that do not form positive ions are non-metals. The **majority of elements are metals.** Metals are found to the **left** and **towards the bottom** of the periodic table. Non-metals are found towards the right and top of the periodic table.
4.1.2.4 Group 0 **Noble gases**	The elements in **Group 0** of the periodic table are called the **noble gases**. They are **unreactive** and do not easily form molecules because their atoms have **stable arrangements of electrons.** The noble gases have eight electrons in their outer shell, except for helium, which has only two electrons. The **boiling points** of the noble gases **increase** with increasing relative atomic mass (going **down the group**).
4.1.2.5 Group 1 **Alkali metals** 	The elements in **Group 1** of the periodic table are known as the **alkali metals** and have characteristic properties because of the **single electron in their outer shell.** Describe the reactions of the first three alkali metals with oxygen, chlorine and water. Very reactive with water e.g. sodium + water → sodium hydroxide + hydrogen $2Na + 2H_2O \rightarrow 2\ NaOH + H_2$ In Group 1, the **reactivity** of the elements **increases** going **down the group. To react they have to lose 1 electron**

4.1.2.6 Group 7 Halogens 	The elements in **Group 7** of the periodic table are known as the **halogens** and have similar reactions because they all have **seven electrons in their outer shell**. The halogens are **non-metals** and consist of **molecules** made of **pairs of atoms**. Eg Cl_2, F_2 In Group 7, the **further down** the group an element is the **higher its relative molecular mass, melting point and boiling point**. In Group 7, the **reactivity of the elements decreases going down** the group. To react they need to gain 1 electron A **more reactive halogen** can **displace a less reactive halogen** from an aqueous solution of its salt.
4.1.3	Properties of transition metals (chemistry only)
4.1.3.1 comparison with group 1 metals	The transition elements are metals with similar properties which are different from those of the elements in Group 1. They are the central block of the periodic table. Examples include chromium, manganese, iron, cobalt, nickel and copper. Compared with Group 1 they have higher melting points, higher densities, are stronger, harder and less reactive with oxygen, water and halogens.
4.1.3.2 typical properties	Many transition elements **have ions with different charges**, form coloured compounds and are useful as **catalysts**.