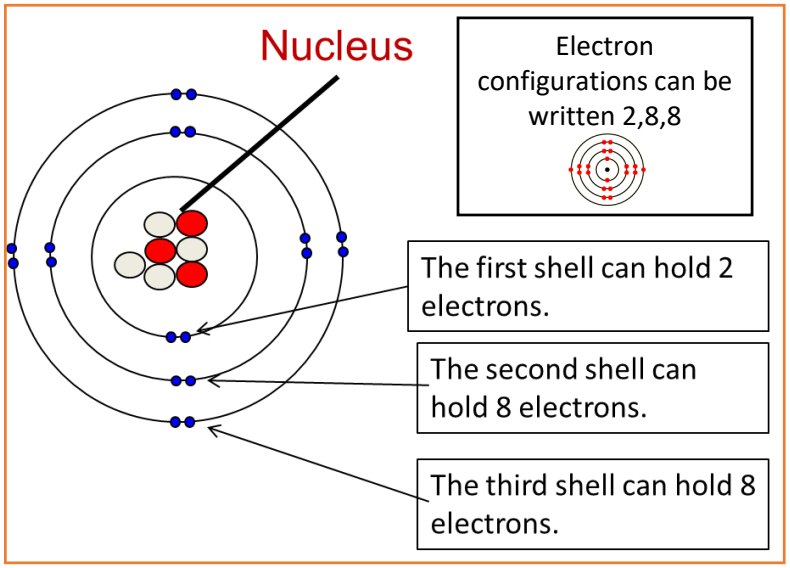
4.1 Atomic structure and the periodic table

GCSE Chemistry

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

All substances are made of **atoms** this is cannot be chemically broken down it is the smallest part of an **element**. **Elements** are made of only one type of atom. **Compounds** contain more than one type of atom. Compounds are held together by **bonds**. **Mixtures** contain elements and compounds.

STRUCTURE OF THE ATOM: Protons and neutrons are found in the **nucleus**. Electrons orbit the nucleus in **shells**.



An atom contains **equal** numbers of **protons** and **electrons**. All **atoms** of an **element** have the same **number** of **protons**. Atoms of **different** elements have **different numbers** of **protons**.

	Proton	Neutron	Electron
Mass	1	1	Negligible (very small)
Charge	Positive	Neutral	Negative
Location	Nucleus	Nucleus	Shells

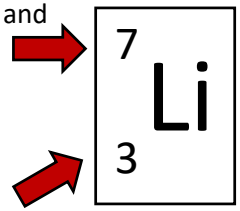
Atoms of each element are represented by a **chemical symbol** e.g. O for oxygen, Na for sodium.

Relative atomic mass – average value that takes account of the abundance of the isotopes of that element.

$$Relative\ atomic\ mass = \frac{sum\ of\ (isotope\ abundance\ x\ isotope\ mass\ number)}{sum\ of\ abundances\ of\ all\ the\ isotopes}$$

Mass number = Number of **protons** and **neutrons**

Atomic number = Number of protons



Number of neutrons = Mass Number – Atomic Number

Isotopes – atoms of the same element which have the same number of protons and electrons but different numbers of neutrons.

Radius of an atom = 0.1 nm (1×10^{-10} m)
Radius of a nucleus = 1/10000 of that of the atom (about 1×10^{-14} m)

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

When **elements react,** their **atoms join with other atoms** to form **compounds.** There are **two** types of **bonds** formed in a **chemical reaction.**

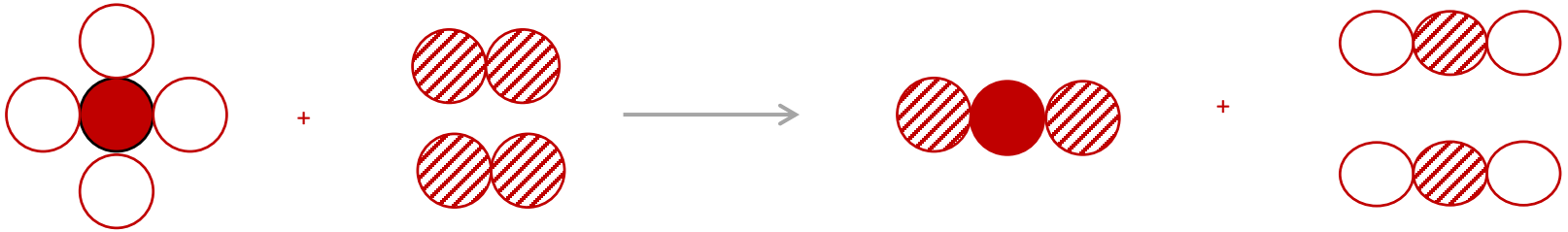
Chemical equations: They show the **reactants** (what we start with) and the **products** (what we end with). No **atoms** are **lost** or **made**. The **mass** of the **products** equals the **mass** of the **reactants**.

Word Equation: calcium carbonate → calcium oxide + carbon dioxide

Symbol Equation: $CaCO_3 \rightarrow CaO + CO_2$

Methane + Oxygen → Carbon dioxide and Water

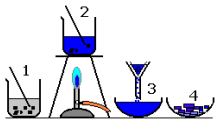
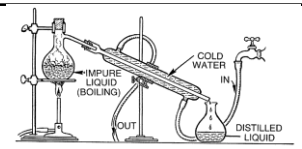
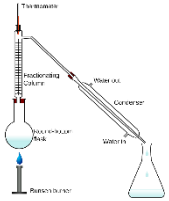
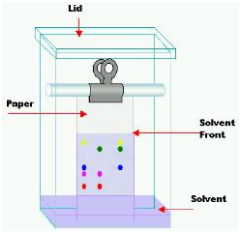
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$



- Equations **MUST** balance.
- We can **ONLY** add **BIG** numbers to the front of a substance.
- We can tell elements within a compound by **BIG** letters.
- We can check an equation is balanced by counting the number of each type of atom on either side.

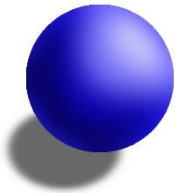
4.1.1 A simple model of the atom, symbols, relative atomic mass, electronic charge and isotopes

Mixture	Elements and compounds mixed together but NOT chemically bonded.

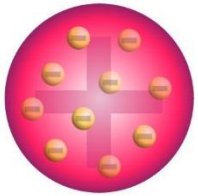
Separation technique	Diagram	What is it used to separate?	How does it work?
Filtration		An insoluble solid from a liquid	The mixture is poured through filter paper. The liquid goes through the filter paper and the solid remains in the filter paper.
Evaporation		A soluble solid from a solution	The solution is slowly heated until all of the liquid has evaporated. You are left with a dry solid.
Crystallisation		A soluble solid from a solution	The solution is slowly heated until the point of crystallisation. The concentrated solution is left to cool until crystals form. The crystals are filtered and dried.
Distillation		A liquid from a solution (can be two liquids or a soluble solid and a liquid).	The solution is heated until the part of the solution with the lowest boiling point evaporates. The vapour is condensed and the liquid collected.
Fractional distillation		A mixture of liquids with different boiling points.	The solution is heated until the part of the solution with the lowest boiling point evaporates. The vapour is condensed and the liquid collected. This is repeated at higher temperatures to collect fractions with higher boiling points.
Chromatography		A mixture of dissolved solids or liquids (such as dyes in inks or food).	A mixture of the dissolved substance is put onto chromatography paper. A solvent is added and this runs up the paper. The different substances in the mixture move at different speeds.

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

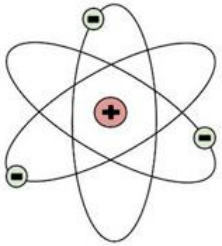
Dalton



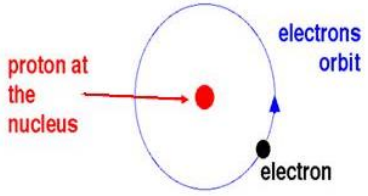
Thomson



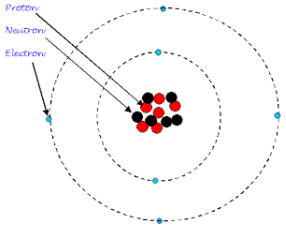
Rutherford



Bohr



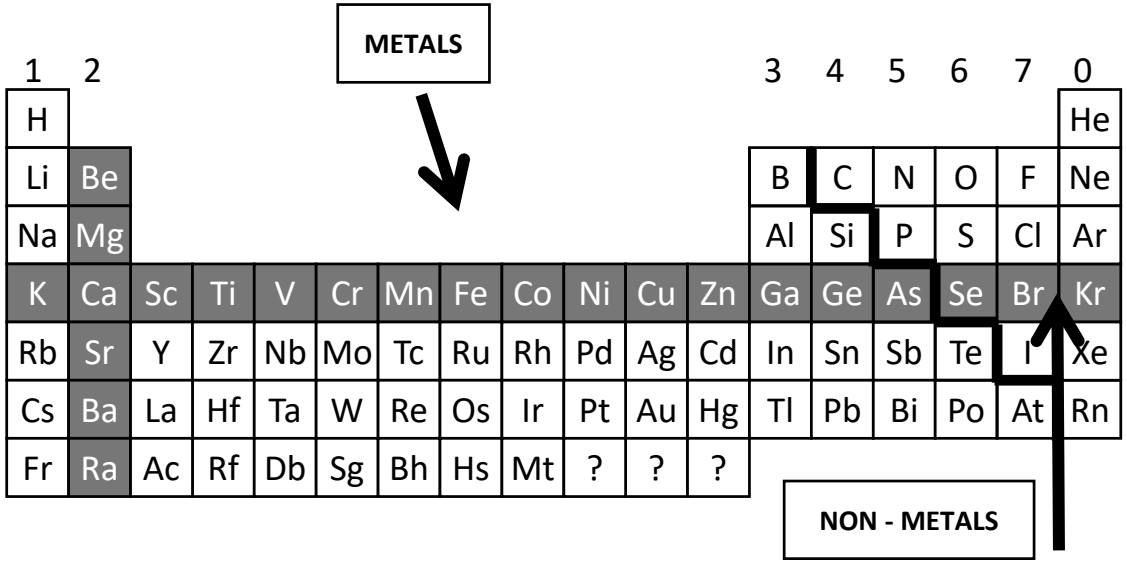
Chadwick



Dalton	**Thomson**	**Rutherford**	**Bohr**	**Chadwick**
Described atoms as solid spheres and said that different spheres made up different elements.	'Plum pudding model' – ball of positive charge with electrons spread throughout it.	Alpha scattering experiment – Nuclear model – positive nucleus with electrons around the outside.	Electrons are in fixed shells around the nucleus.	Discovered neutrons.

4.1.2 The periodic table

Elements are arranged in order of atomic (proton) number.



Each **element** has its own **symbol**. **Columns** are called **groups. Elements** in a group have **similar** properties. **Rows** are called **periods**. The staircase line splits **metals** (LEFT) from **non-metals** (RIGHT).

Elements in the same **group** have the same number of electrons in their outer shell.
Elements in the same **period** have the same number of shells.

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 (Dalton and Newlands).
- 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 The periodic table

Metals and non-metals

- Elements that react to form positive ions are metals.
- Elements that do not form positive ions are non-metals.
- The majority of elements are metals. Metals are found on the left and towards the bottom of the periodic table.
- Non-metals are found towards the right and the top of the periodic table.

Group	Properties	Trends (going down the group)	Reactions
0	• Unreactive and do not easily form molecules because their atoms have stable arrangements of electrons (monatomic). • Colourless gases. • Non-flammable. • The noble gases have 8 electrons in their outer shell, except for helium, which only has 2 electrons.	• Boiling points increase. • Relative atomic mass increases.	• Unreactive
1	• Low density (the first three elements in the group are less dense than water). • Soft. • 1 electron in outer shell. • Very reactive.	• Reactivity increases (electron is more easily lost). • Melting and boiling points decrease. • Relative atomic mass increases.	• React with water to produce a metal hydroxide and hydrogen. • React with chlorine to produce a metal chloride salt. • React with oxygen to produce a metal oxide.
7	• Exist as pairs of atoms (e.g. Cl_2). • Have 7 electrons in their outer shell.	• Reactivity decreases (it is harder to gain an electron). • Melting and boiling points increase. • Relative atomic mass increases.	• Share electrons with other non-metals in covalent bonding (e.g. HCl). • Form ionic bonds with metals (e.g. NaCl). • More reactive halogens will displace less reactive ones.

Properties of transition metals (chemistry only)

Compared with the elements in Group 1, transition elements:

- have **higher melting points** (except for mercury) and **higher densities**
- are **stronger** and **harder**
- are much **less reactive** and so do not react as vigorously with water or oxygen

Many transition elements have **ions with different charges**, form **coloured compounds** and are useful as **catalysts.**