GCSE C1 – Atomic Structure & Periodic Table

science chemistry

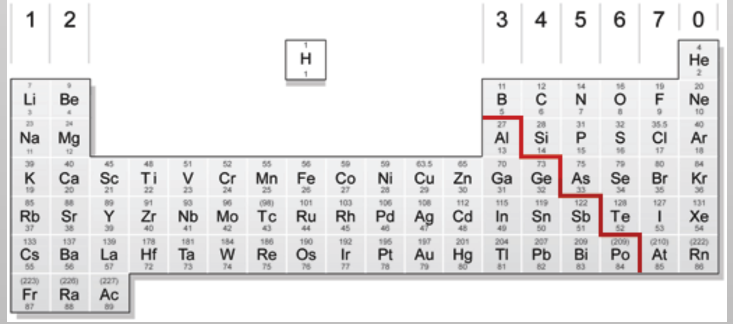
1) What is an element?
A pure substance containing only one type of atom. It can not be broken down chemically into anything simpler.

2) Compounds & Mixtures
– Compounds contain 2 or more elements chemically combined. They cannot be separated by physical processes (i.e. filtering, boiling etc).
Mixtures can be separated because the substances are not chemically joined together. They are usually separated by filtering, crystallisation (see topic 4), distillation (see topic 7) and chromatography (see topic 8). Filtering is used to separate soluble substances (ones that dissolve) from insoluble substances (sand).

3) Developing The Periodic Table
- The table is called a periodic table because similar properties occur at regular intervals.
Early scientists (e.g. Newlands and his law of octaves) arranged the elements in order of their **atomic weights**. However, it was **Mendeleev** who finally solved the puzzle…

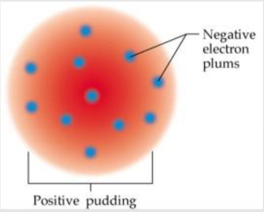
- Mendeleev changed the order based on atomic weights for some elements so they fitted into the groups with similar properties.
- He left gaps for elements that had not been discovered.
- He predicted the properties of these missing elements which were later discovered & their properties matched his predictions.

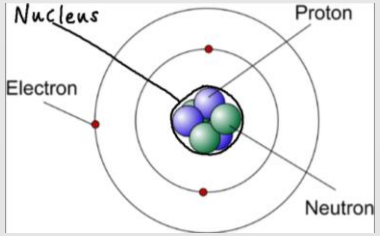
4) The Modern Periodic Table
Elements are now in order of atomic number (number of protons).
Group number – tells us the number of electrons in the outer shell
Period number – tells us the number of shells.



5) Structure of the atom
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 000th of that of the atom (about 1 x 10^{-14} m).

In 1897 J J Thomson discovered the electron which led to **the plum-pudding model** of the atom. The plum pudding model suggested that the atom was a ball of positive charge with negative electrons embedded in it.





In 1909, Geiger & Marsden bombarded gold leaf with alpha particles and whilst most particles passed straight through, (suggesting most of the atom was empty space), a few (1 in 8000) deflected back.

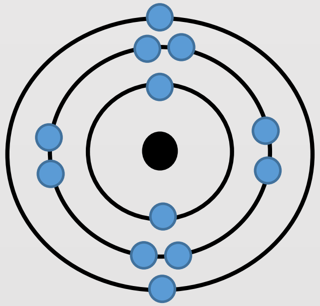
In 1911, Rutherford suggested existence of a nucleus carrying most of the mass of the atom and carrying a positive charge leading to the **nuclear model** of the atom. Niels Bohr adapted this model with electrons orbiting a nucleus at fixed distances i.e. in electron shells (known as the **Bohr model**).

In 1932 James Chadwick discovered neutrons. This discovery led to knowledge of isotopes.

6) Isotopes
Isotopes are atoms with the same number of protons but a different number of neutrons.
e.g.

$^{7}_{3}Li$	$^{8}_{3}Li$
3 protons	3 protons
3 electrons	3 electrons
4 neutrons	5 neutrons

7) Electronic Structure
Electrons are found in shells (energy levels) that orbit the nucleus.
Electrons fill the shells from the inner shell outwards.
2 electrons in the 1st shell
8 electrons in the 2nd shell
8 electrons in the 3rd shell
So if an atom has 12 electrons, we can write its electron arrangement as 2.8.2.
We would draw it like so…..



We always fill the electrons top and bottom in the first shell, then fill top, right, bottom, left and then pair up again.

8) Atomic Number & Mass Number
Each element on the Periodic Table has two numbers.
The atomic number or proton number (number of protons).

The mass number is the number of protons and neutrons added together (since electrons have no mass).

In atoms the number of protons is equal to the number of electrons (atoms have no overall electrical charge).

Name	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	0 (or very small)	-1

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9) Group 1 – Alkali Metals

- Have normal metal properties (e.g. good conductors) except
- They are soft silvery white metals
- Have lower melting points compared to other metals.
- Less dense so float on water.

- React with cold water to produce an alkaline solution and fizz to produce hydrogen gas:
- Lithium – fizzes on the surface
- Sodium – more reactive, fizzes and melts into a ball
- Potassium – even more reactive, sets on fire (a lilac flame)

e.g. $2K + 2H_2O \rightarrow 2KOH + H_2$

- React with oxygen to form oxides (which is why the alkali metals are shiny on the inside but dull on the outside).

e.g. $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

- React violently with chlorine gas to produce white solids called metal chlorides.

$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ (yellow flame & white solid seen at end)

- As you go down group 1 the metals get more reactive.

- **As you down the group, there are more shells (shielding).**
- **So the outer shell is further away from the nucleus.**
- **The outer shell is less strongly attracted to the nucleus (weaker force of attraction).**
- **The electron in the outer shell is more easily lost.**

(Remember group 1 metals lose one electron when they react to make +1 ions).

10) Group 7 – The Halogens

- The halogens are a group of coloured non-metals whose melting points increase down the group
- fluorine (F_2) is a pale-yellow gas,
- chlorine (Cl_2) is a green gas,
- bromine (Br_2) is a red-brown liquid,
- iodine (I_2) is a dark grey solid.

- Halogens react with metals to make metal halides.
- Halogens react with non-metals by sharing electrons

e.g. with hydrogen

fluorine + hydrogen → hydrogen fluoride

$$F_2 + H_2 \rightarrow 2HF$$

- Halogens become less reactive as you go down the group (opposite way round to the alkali metals in group 1).

- **As you go down the group, there are more shells (shielding).**
- **So the outer shell is further away from the nucleus.**
- **The outer shell is less strongly attracted to the nucleus (weaker force of attraction).**
- **An incoming electron is less easily gained**

(Remember atoms in group 7 gain one electron when they react with metals to make -1 ions).

- Halogens react with solutions of halide ions to give “displacement reactions”. A more reactive halogen will displace a less reactive halogen from one of its compounds, but the reaction does not work the other way round.

chlorine + potassium bromide → potassium chloride + bromine

$$2Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$

11) Group 0 – The Noble Gases

- Noble gases are INERT (unreactive).
- This is because their atoms have full outer shell of electrons.
- The boiling points and densities of the noble gases increase down the group.
- Because they are unreactive, this explains the uses of the noble gases e.g. argon is used in welding to stop the hot metal reacting with oxygen in the air.

12) Transition Metals – (SINGLE CHEMISTRY ONLY)

- The transition elements are metals with similar properties.
- Like group 1 the transition metals are good conductors of heat and electricity.
- However transition metals are generally harder, denser, have much higher melting points, and are not as reactive.

e.g. copper doesn’t react with water

- Many transition elements have ions with different charges, (e.g. Cu^+ and Cu^{2+})

- They form highly coloured compounds (compared to group 1 which form white solid compounds)

- They are often used as catalysts (see topic 6).

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