Elements and Atomic Structure

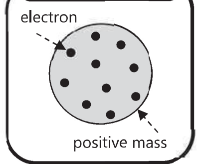
History of the Atom

500 BC The word 'atom' comes from the Greek word **'atomos'**, which means 'undivided'. **Ancient Greeks** believed everything was made up of **tiny objects** that could not be split apart.

1800s **John Dalton** suggested that elements were made of atoms of a **unique single type**, and atoms of different elements could combine to form compounds.

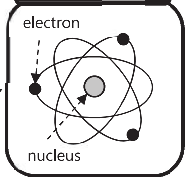
1897 **J J Thomson** discovered the electron. He devised the **plum pudding model** of the atom, which had negative electrons embedded in a mass of positive charge.

Plum pudding model



1911 **Geiger and Marsden's** gold foil experiment showed something inside the atom reflecting alpha particles. **Ernest Rutherford** concluded there must be a tiny positive **nucleus** at the centre (**the nuclear model**). The nucleus contained positively charged **protons**.

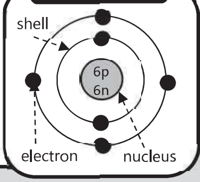
Nuclear model



1913 **Niels Bohr** refined the model so the electrons **orbit around** the nucleus in shells (**the Bohr model**).

1932 **James Chadwick** discovered that the nucleus also contains uncharged **neutrons**.

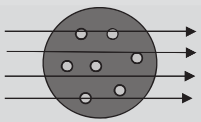
Bohr model



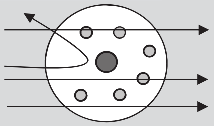
The scientific model of the atom has changed a lot over time. This happens when new discoveries are made that don't match with the current model, and the model needs to be updated or completely remade to fit the new information.

The 1911 gold foil experiment

Geiger and Marsden fired **alpha particles** (helium nuclei) at very thin gold foil. They expected the particles to **pass right through** so were surprised when some of them **bounced back**. We now know that the positive alpha particles got reflected back by **repulsion** from the positive **nucleus**.



Plum pudding model (predicted)
-ve electrons embedded in a +ve mass



Nuclear model (actual)
-ve electrons surrounding a tiny +ve nucleus

What is an Element?

An element is a substance that only contains **one type of atom**. Elements cannot be broken down into simpler substances, and make up all materials by combining to form **compounds**. There are **over 100** elements in the universe. Each is identified by a unique symbol, a mass number and an atomic number.

- An atom is the **smallest** part of an element that can exist.
- Atoms of different elements have different **atomic numbers** and **mass numbers**.
- All atoms are **neutral** so the number of positive protons must **equal** the number of negative electrons.

Mass number → 7
Atomic number → 3
Li ← **Element symbol**

Atomic number = number of protons
Mass number = number of protons + neutrons
Number of protons = number of electrons

EXAMPLE!

Element	Mass no.	Atomic no.	No. protons	No. electrons	No. neutrons
$^{9}_{4}$Be	9	4	4	4	5
$^{14}_{7}$N	14	7	7	7	7
$^{39}_{19}$K	39	19	19	19	20

Exam Tip!
The number of neutrons in an element is not always the same as the number of protons! Work it out using mass no. – atomic no. = no. neutrons

Isotopes

Isotopes are atoms of the same element that have the same number of protons but a **different number of neutrons**, and, therefore, different mass numbers. If an element has isotopes, a relative atomic mass must be calculated. **Relative atomic mass** is an average mass that accounts for the abundance of different isotopes.

Relative atomic mass (A_r) = $\frac{(\text{mass of isotope 1} \times \text{\% of isotope 1}) + (\text{mass of isotope 2} \times \text{\% of isotope 2}) + \ldots}{100}$

EXAMPLE!

^{10}B has an isotopic abundance of 20 %. ^{11}B has an isotopic abundance of 80 %. Calculate the relative atomic mass of boron.

$$A_r = \frac{(10 \times 20) + (11 \times 80)}{20 + 80} = \frac{1080}{100} = 10.8$$

Subatomic Particles

Exam Tip! $1 \times 10^{-10}\,\text{m} = 0.1\,\text{nm}$

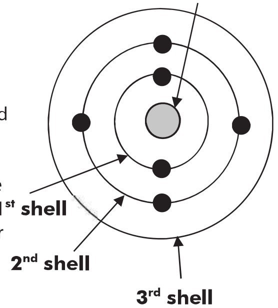
- Atoms are very small (1×10^{-10} m radius).
- The nucleus is 1/10,000 of the size of the atom but contains almost all the mass.
- Compared to protons and neutrons, electrons barely weigh anything.

	Proton	Neutron	Electron
Relative mass	1	1	Very small
Relative charge	+1	0	-1

Electronic Structure

Electrons orbit the nucleus in **shells**, which have different energy levels. The lowest energy electrons are in the first shell, closest to the nucleus. The second shell is further away, and so on.

Electrons fill the nucleus from the **lowest** energy shell first, and each shell holds a certain number of electrons.

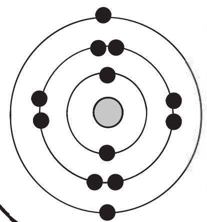


Shell	Max. no. electrons
1	2
2	8
3	8
4	18

The electron configuration of an atom can be written in numbers, or drawn as a diagram.

EXAMPLE!

Magnesium has 12 electrons. Show its electron configuration in both forms.



Shell	No. electrons
1	2
2	8
3	2
4	0

Electron configuration = 2, 8, 2