Core focus

All learners

HT only

Triple science only

Radioactivity

Big idea: Radiation transfers energy

Key Vocabulary	
Nucleus	The central part of an atom. Contains Protons and Neutrons. The nucleus is positively charged and has the vast majority of the atoms mass
Neutron	A neutral (no charge) particle found in the nucleus of an atom.
Proton	A positively charged (+1) particle found in the nucleus of atoms. Can be found by looking at the atomic number of an element on the periodic table.
Electron	A negatively charged (-1) particle found 'orbiting' a nucleus. Very low mass.
Alpha Particle	Emitted from a nucleus during radioactive decay. Consists of two protons and two neutrons, also known as a helium nucleus.
Beta Particle	An electron emitted from the nucleus of an atom when a neutron turns into a proton
Gamma radiation	A very high frequency electromagnetic wave emitted from the nucleus
Ion	an atom which has gained or lost electrons making it have a charge.
Isotope	An atom with more or less neutrons but the same number of protons.
Nuclear Fission	When a very large nucleus splits into smaller 'daughter' nuclei, releasing energy in the process. Currently usedin nuclear power stations.
Nuclear Fusion	When two small nuclei join together into a larger nucleus, releasing energy in the process. The fusion of Hydrogen nuclei into helium nuclei is what is currently powering our Sun.

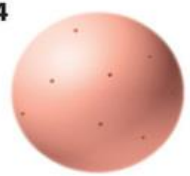
Atomic theory

Over time our understanding of the atom has changed. With each new piece of evidence the model has been updated to better reflect the true structure of atoms. Our understanding has developed beyond Bohr's model however this is not covered until A-Level Physics.

1803

Dalton proposes the indivisible unit of an element is the atom.

1904



Thomson discovers electrons, believed to reside within a sphere of uniform positive charge (the plum pudding model).

1911

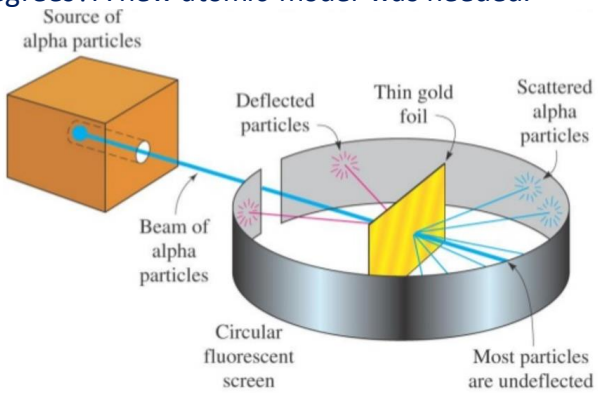
Rutherford demonstrates the existence of a positively charged nucleus that contains nearly all the mass of an atom.

1913

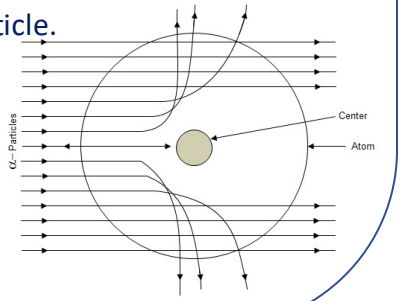
Bohr proposes fixed circular orbits around the nucleus for electrons.

The discovery of the nucleus.

Ernst Rutherford devised an experiment to test the structure of the atom. At the time of the experiment the Atomic model was Thompson's 'Plum Pudding' where there was a positively charged sphere with negative electrons arranged inside. Rutherford's experiment involved firing positive alpha particles at a thin sheet of gold foil, if the plum pudding model was correct then you would expect to see all of the alpha particles pass straight through.
What was actually observed during the experiment was that most of the alpha particles passed through the foil as expected but some were deflected by a small angle and a very small percentage were deflected over 90 degrees! A new atomic model was needed.



Rutherford realised that his results could only be explained by the atom having a very small positively charged centre, or nucleus, which could deflect the positively charged alpha particle.
This experiment also demonstrated that an atom is mostly empty space. The width of a typical nucleus is approximately 1/100000th of the width of the atom!



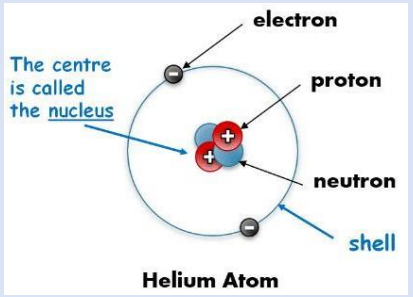
Core focus
All learners
HT only
Triple science only

Radioactivity

Big idea: Radiation transfers energy

Atomic structure

An atom is made of protons, neutrons, and electrons. Protons and neutrons are found in the nucleus at the centre of the atom whilst the electrons 'orbit' around the nucleus. In a neutral atom the number of electrons will be equal to the number of protons



On the periodic table you can tell how many protons and neutrons an atom has.

the mass number tells you the number of protons plus the number of neutrons.

The Atomic number tells you how many protons there are.

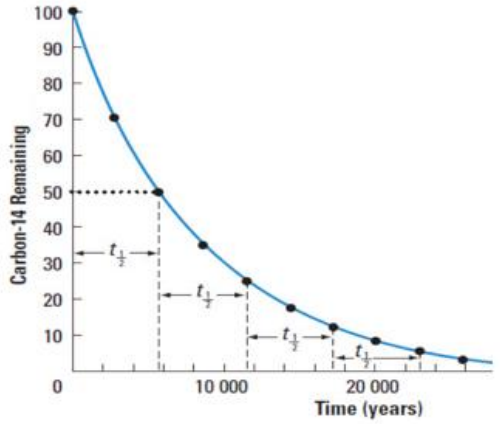
$^{7}_{3}Li$

This atom has three protons and four neutrons.

Half-life

The half-life of a radioactive isotope is the average time it takes for the number of nuclei of the isotope to halve.

We can find the half-life from a graph by drawing across from half of the starting value until you hit the line of best fit and then drawing a line vertically down until it hits the time axis. You can check your value by halving again (ni this example from 50 to 25) and repeating the process. Each time you do this the interval should be, approximately, the same.



$$number\ of\ nuclei\ after\ n\ halflives = \frac{initial\ number\ of\ nuclei}{2^n}$$

Nuclear decay

When a nucleus decays it emits either an alpha particle, a beta particle, or a gamma wave. When an alpha or beta particle is emitted it changes the nucleus left behind.

Alpha decay

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}\alpha$$

The mass number is reduced by 4 and the atomic number is reduced by 2. This is because two protons and two neutrons are emitted.

Beta decay

$$^{14}_{6}C \longrightarrow ^{14}_{7}N + ^{0}_{-1}\beta$$

Beta decay occurs when a neutron turns into a proton by emitting an electron (simplified from the actual process). This means the total number of particles in the nucleus does not change as there is one less neutron but an extra proton. The extra proton causes the atomic number to increase by 1.

Gamma radiation

Gamma radiation is a very high frequency electromagnetic wave emitted by the nucleus. As the structure of the nucleus does not change we do not make a different element.

Types of Radiation	Mass	Charge	Stopped By
Alpha	4	+ 2	Thin Sheet of Paper
Gamma Ray	No Mass	No Charge	Several Inches of Lead or Steel
Beta	1/2000	- 1	Thin Aluminum