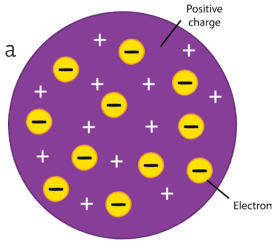
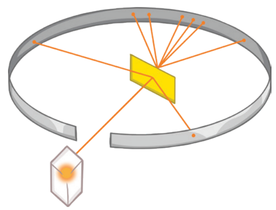
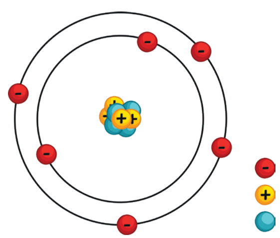
Atomic Structure Knowledge Organiser – Foundation and Higher Separate Science

Developing the Model of the Atom

Scientist	Time	Contribution
John Dalton	Start of 19th century	Atoms were first described as solid spheres.
JJ Thomson	1897	Thomson suggested the plum pudding model – the atom is a ball of charge with electrons scattered within it.  Plum pudding model
Ernest Rutherford	1909	Alpha Scattering experiment – Rutherford discovered that the mass is concentrated at the centre and the nucleus is charged. Most of the mass is in the nucleus. Most atoms are empty space. 
Niels Bohr	Around 1911	Bohr theorised that the electrons were in shells orbiting the nucleus. 
James Chadwick	Around 1940	Chadwick discovered neutrons in the nucleus.

Isotopes

An isotope is an element with the same number of protons but a different number of neutrons. They have the same atomic number, but different mass numbers.

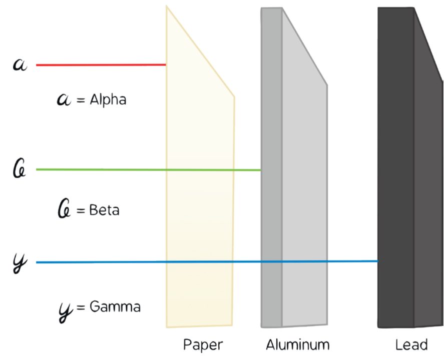
Isotope	Protons	Electrons	Neutrons
$^{1}_{1}H$	1	1	0
$^{2}_{1}H$	1	1	1
$^{3}_{1}H$	1	1	2

Some isotopes are unstable and, as a result, decay and give out radiation. Ionising radiation is radiation that can knock electrons off atoms. Just how ionising this radiation is, depends on how readily it can do that.

Beta

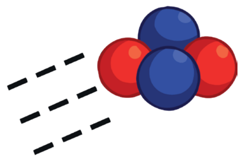
Beta radiation is a fast moving electron that can be stopped by a piece of aluminium. Beta radiation is emitted by an atom when a neutron splits into a proton and an electron.

$^{0}_{-1}e$



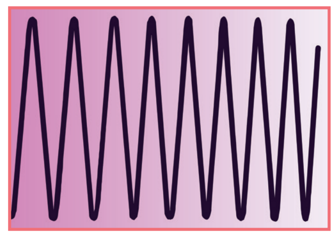
Alpha

Alpha radiation is an alpha particle emitted from the nucleus of a radioactive nuclei. It is made from two protons and two neutrons. They can't travel too far in the air and are the least penetrating – stopped by skin and paper. However, they are highly ionising because of their size.



Gamma

A gamma wave is a wave of radiation and is the most penetrating – stopped by thick lead and concrete.



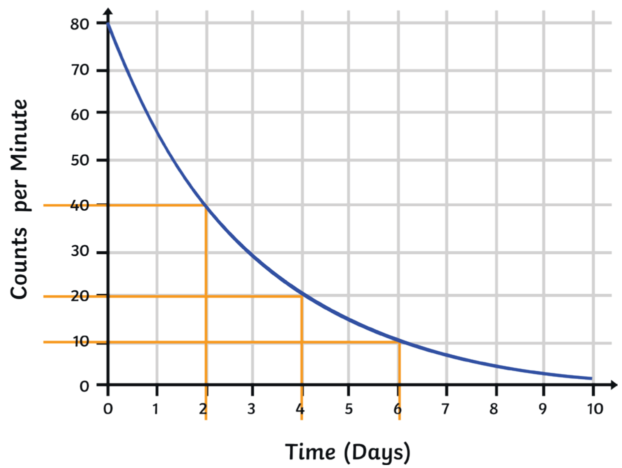
Half-life

The half-life is the time taken for the number of radioactive nuclei in an isotope to halve.

Radioactivity is a random process – you will not know which nuclei will decay. Radioactive decay is measured in becquerels Bq. 1 Bq is one decay per second.

Radioactive substances give out radiation from their nucleus.

A graph of half-life can be used to calculate the half-life of a material and will always have this shape:



Judging from the graph, the radioactive material has a half-life of two days.

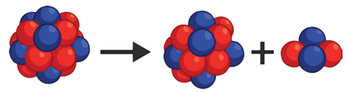
Irradiation

Irradiation occurs when materials are near a radioactive source. The source is sometimes placed inside a lead-lined box to avoid this.

People who work with radioactive sources will sometimes stand behind a lead barrier, be in a different room or use a remote-controlled arm when handling radioactive substances.

Alpha Decay Equations

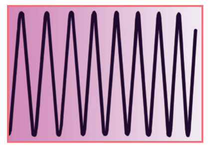
An alpha particle is made of two protons and two neutrons. The atomic number goes down by two and its mass number decreases by four.



$^{226}_{88}Ra \quad ^{222}_{86}Rn \quad ^{4}_{2}He$

Gamma rays

There is no change to the nucleus when a radioactive source emits gamma radiation. It is the nucleus getting rid of excess energy.



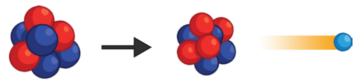
Contamination

When unwanted radioactive atoms get onto an object, it is possible for the radioactive particles to get inside the body.

Protective clothing should be worn when handling radioactive material.

Beta Decay Equations

A neutron turns into a proton and releases a an electron. The mass of the nucleus does not change but the number of protons increases.



$^{8}_{3}Li \quad ^{8}_{4}Be \quad ^{0}_{-1}e$

Alpha radiation is more dangerous inside the body. It is highly ionising and able to cause a lot of damage. Outside the body it is less dangerous because it cannot penetrate the skin.

Beta radiation is less dangerous inside the body as some of the radiation is able to escape. Outside the body it is more dangerous as it can penetrate the skin.

Gamma radiation is the least dangerous inside the body as most will pass out and it is the least ionising. Gamma is more dangerous outside the body as it can penetrate the skin.

Background Radiation

This comes from natural sources like rocks, food and air. It also comes from man-made sources such as nuclear weapons, nuclear waste or nuclear accidents. The dose of radiation people receive varies dependent on how close they are to the source. Too much exposure to radiation can cause radiation poisoning. Radiation dosage is measured in **sieverts (Sv).**

1000 millisieverts (mSv) = 1 sievert (Sv)

Uses of Nuclear Radiation

Although radiation can be dangerous, it also has its uses. The risks are always considered when using radiation. Gamma sources can be used as a medical tracer in the human body; isotopes can be injected or swallowed. As the isotope goes around the body, it can be monitored and medical issues can be spotted. Gamma radiation is emitted out of the body and does not cause the cells to become ionised. The isotope used will have a short half-life so it does not stay inside the body for too long. Tracers can be used to diagnose potentially life-threatening conditions which otherwise would not be spotted. The risk of using the radioactive tracer is much less than the risk of the condition they may diagnose.

Different Half-Lives of Radioactive Isotopes

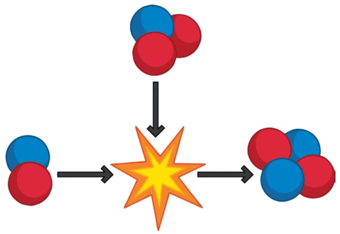
All radioactive isotopes have different half-lives. Some are very short and others are much longer. The uses of these will depend on the half-life. For example, you would use an isotope with a short half-life as a medical tracer so it is not in the body for too long.

Radiotherapy

High doses of radiation can be used to treat cancer. Gamma rays are focused directly onto the cancer cell, killing the cancer cell but not killing too many healthy cells. The damage to the healthy cells that may be close to the cancer can cause the patient to feel ill. However, killing the cancer cell makes it worth it.

Fusion

Nuclear fusion is the joining together of smaller radioactive nuclei to make a larger atom. Fusion occurs in the sun. This whole process releases a lot of energy, much more than fission. However, a very high temperature and pressure is needed for fusion to occur, so it is not used in the production of energy yet.



Fission

Nuclear fission is the splitting of large radioactive nuclei into smaller ones. A neutron is absorbed by a large unstable radioactive nucleus. Next, the nucleus splits into smaller nuclei. As this happens, more neutrons and energy are released. The neutrons released go on to cause more reactions. This is called a chain reaction.

Fission is carried out in a nuclear reactor in order to generate energy. It is controlled by control rods which, when they are lowered down, slow down the reaction process. When they are raised, the reaction speeds up again. If this process is not controlled, then a nuclear weapon has been produced.