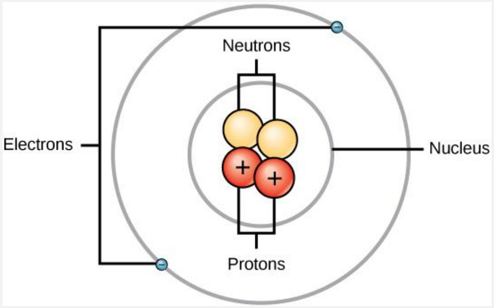
Atoms are made up of smaller particles called **protons, neutrons** and **electrons**.

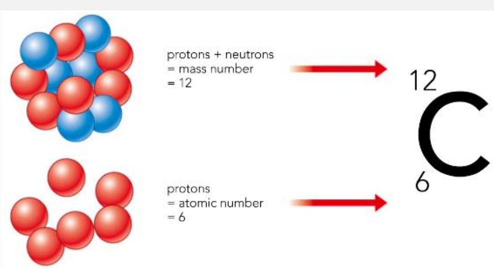


- The **nucleus** is the centre of the atom made from neutrons and protons bonded together
- **Protons** have a mass of 1 and a charge of +1 (positive)
- **Neutrons** have a mass of 1 and a charge of 0 (no charge)
- **Electrons** have a mass of 0 (no mass) and a charge of -1 (negative)

An atom always has a equal number of protons and electrons so it has no over all charge (0).

Atoms of the same element have the same number of protons - for example all carbon atoms have 6 protons. Some atoms have different numbers of neutrons – these are called **isotopes**.

Isotopes of an element have the same number of protons but different numbers of neutrons.



When using chemical symbols the larger number is the **mass number**. This tells us the number of protons **and** neutrons.

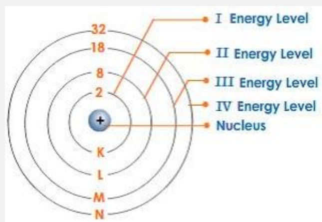
The smaller number tells us the number of protons. This is the **atomic number**. This also tells us the number of electrons.

The number of neutrons can be worked out by doing the mass minus the atomic number (big number minus small number).

E.g. Carbon has a mass of 12 and an atomic number of 6. Therefore it has:

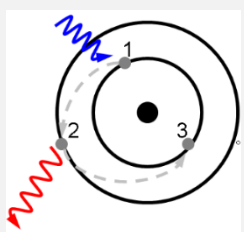
- 6 protons
- 6 electrons
- 6 neutrons (12-6=6)

The electrons of an atom orbit around the nucleus in energy levels. These energy levels are specific distances from the nucleus



Electrons can be knocked off by ionising radiation. This causes the atom to become **charged** and is now called an **ion**. Ions are atoms with a charge.

When electrons absorb or emit electromagnetic radiation they can change energy levels:



Some unstable nuclei will undergo radioactive decay – these are called **radioisotopes**.

The amount of radioactivity is measured in **Becquerel's** (Bq).

The decay of radioisotopes is a **random** process which means it is impossible to predict when a nucleus will decay and emit radiation.

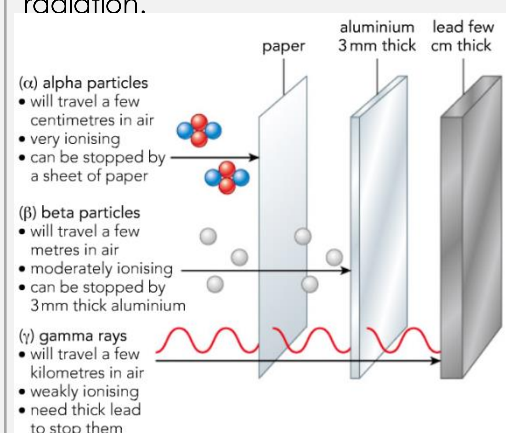
There are four types of nuclear radiation:

Nuclear radiation is where high speed neutrons are released from the nucleus.

Alpha particles are the largest radiation particles (2 protons, 2 neutrons) so they have a very low penetration, stopped by a few centimetres of air. They are also the most ionising and have +ve charge.

Beta particles are electrons and are less ionising. They have a –ve charge.

Gamma particles have no charge and are a form of radiation. They have the most penetration of any radiation (several meters of concrete) and travel at the speed of light. They are the least ionising radiation.



Background radiation is the ionising radiation this is around us all the time. This radiation can come from:

- **Radon gas**
- Rocks and soil
- Cosmic rays
- Medical uses (X-rays etc)

Some of these sources are natural, others are man-made.

The amount of background radiation varies from place to place. It is important to measure the background radiation before you measure the radiation of a radioactive source so you know exactly how much radiation comes from the source and how much is from background radiation.

A radiation dose is measured in Sieverts (Sv).

We can represent nuclear decay using nuclear equations.

Alpha decay is the same as having a helium nucleus emitted:

$$^{235}_{92}U \rightarrow ^{231}_{90}Th + ^{4}_{2}He$$

- Check the mass numbers add up correctly (235 = 231 +4)
- Check the atomic numbers add up (92 = 90 + 2)

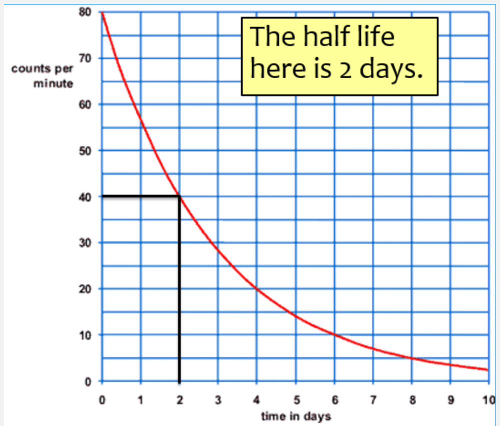
During beta decay an electron is emitted:

$$^{231}_{90}Th \rightarrow ^{231}_{91}Pa + ^{0}_{-1}e$$

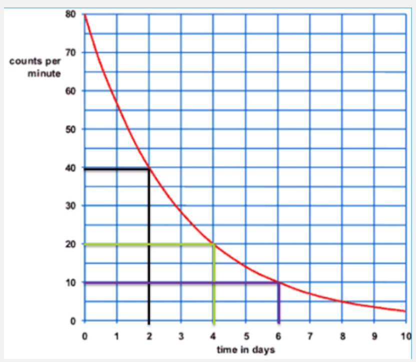
In this case the proton number increases by one to ensure the atomic numbers balance on either side of the equation.

This means the number of protons has changed and therefore the

Half life is the amount of time it takes for half the radioactive nuclei in a sample to decay. Short half lives mean more radiation is emitted in a given period of time.
Half life is useful because we cannot predict when an individual nucleus will decay, but we can estimate how many will decay in a given period of time.
We can work out the half life of a radioactive substance using a graph showing how the amount of radiation produced changes over time.
Find half the original radiation count, and read off the time take to drop to this level.



The half will be the same each time:



Radiation can also be useful in medical situations such as cancer diagnosis and treatment. **Tracers** can be used to locate tumours by the radiation they emit, and gamma radiation can be used to kill tumours in a specific region of the body. Gamma rays can also be used to sterilise food.
Smoke alarms use **alpha radiation** to detect smoke – smoke particles absorb the radiation and stop a signal being sent, causing the alarm to sound.
Paper thickness can be check by measuring the amount of beta radiation passing through. This because it has enough penetration to pass through paper, but not be completely absorbed.
Gamma radiation can be used to detect underground leaks because it has high penetration.

Irradiation is where an object is exposed to nuclear radiation.
Irradiation of cells will cause damage to the DNA leading to a **mutation**. These mutations can lead to serious conditions such as cancer.

It is important when doing scientific research to be published – particularly when the research is medical. When a scientist thinks they have discovered something, other scientists try to repeat the results and check them. This is called **peer review**.

X-rays and gamma rays can be used in medical diagnosis. Gamma sources used in humans must have a suitable half life – usually short so it doesn't persist.

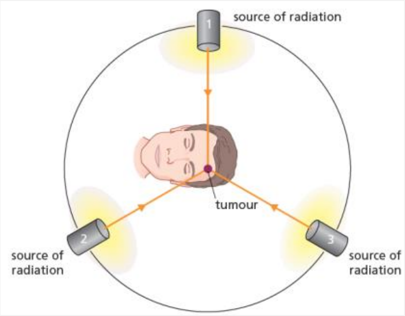
Radiotherapy can be used to treat cancer. Cobalt-60 emits gamma rays which can be used, or X-rays are used where possible. This is because:

- They can be made only when needed
- Rate at which they are made can be controlled
- The energy of them can be changed

Using X-rays to destroy tumours is dangerous because it can also damage healthy tissue. To prevent this:

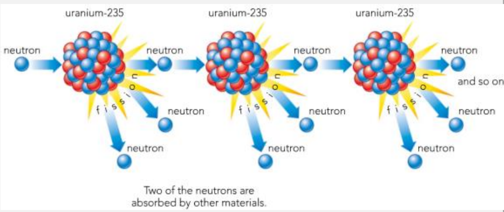
- The source is rotated around the patient
- Three different sources are used around a target area

This means that the target area receives a large dose where the radiation overlaps, but healthy tissue receives a much lower dose.

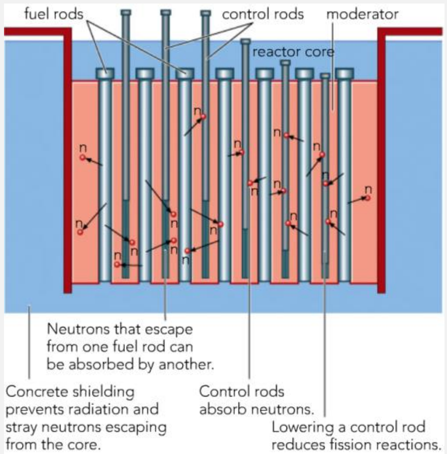


Brachytherapy is where a radioactive source is placed inside the tumour so it receives a high dose, but healthy tissue does not. This is mainly used for prostate and cervix cancer.
When using radiation for treatment the benefits must outweigh the risks. We have to make sure the treatment will do more good than harm.

Nuclear fission is where an unstable isotope (e.g. Uranium-236) breaks into two daughter nuclei and releases a large amount of energy. This process can be exploited to form a **chain reaction**:



Uncontrolled chain reactions are the basis of atomic bombs.
Controlled chain reactions can be used to release heat for generating electricity:



Nuclear fusion is where 2 small nuclei are fused together to make a larger one and release even more energy. This process requires extreme temperatures so nuclei move with enough kinetic energy to overcome the **electrostatic repulsion** forces and collide with enough force to fuse. Higher temperature and pressure also mean more collisions. Creating these conditions is incredibly difficult.