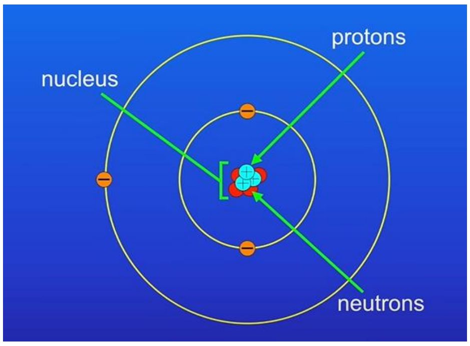
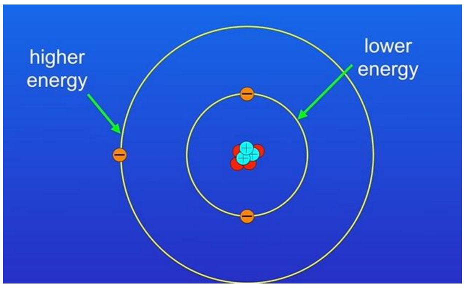
<u>Atomic structure:</u>

Radius of an atom = $1x10^{-10}$m

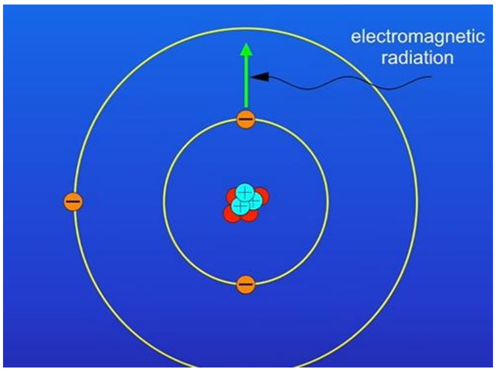
Radius of a nucleus = $1x10^{-14}$m



Nucleus has an overall positive charge because of the protons

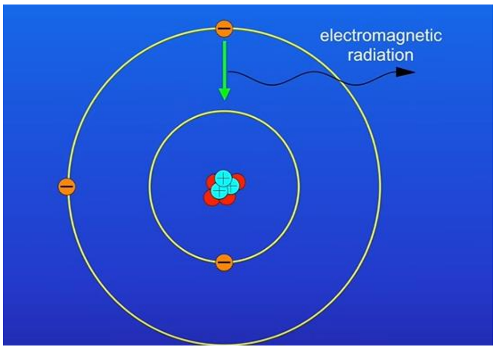


Energy levels or shells that are closer to the nucleus have lower energy than those that are further away from the nucleus



Electrons can change energy levels or shells if they gain or lose energy

If an atom absorbs electromagnetic radiation, an electron can move from a lower energy level to a higher energy level



The electron can emit electromagnetic radiation and the electron can return back to the lower energy level

Atomic and mass numbers:

Atomic number = Number of protons (and electrons)

Atoms have no overall charge because the charges of the electrons cancels out the charges of the protons

Mass number = Protons + Neutrons

Neutrons = Mass number – Proton number/Atomic number

Isotopes = Atoms of the same element with the same number of protons but different number of neutrons

Atoms can lose electrons from their outer shell or energy level (known as ion)

<u>Alpha scattering and the nuclear model:</u>

Ancient Greeks thought that atoms are tiny spheres which cannot be divided

1897: Scientists discovered that atoms contain electrons which showed that atoms are not spheres which cannot be divided. They have an internal structure

Scientists came up with the Plum Pudding Model

Alpha Scattering Experiment:

1. First scientists took gold foil

   They used gold because it could be hammered into very thin pieces of foil (only a few atoms thick)

2. They fired alpha particles at the gold foil

Alpha particles have a positive charge

Results:

- Most particles would mostly go straight through the foil: Atoms are made up of empty space
- Some particles were deflected: Centre of atom has a positive charge which repelled the alpha particles
- Some particles bounced back: Mass of an atom is concentrated in the nucleus

This made the proved the Plum Pudding Model wrong and thus created the nuclear model (present atom model)

Neils Bohr:

- Electrons orbit the nucleus at specific distances
- This is now called energy levels or shells

Later, scientists discovered protons which has a positive charge

James Chadwick:

- Discovered nucleus contains neutrons
- They are neutral so they don’t have any charge

1.Electrons

2.Protons

3.Neutrons

Note: This is written in date order

Radioactivity:

Some isotopes have an unstable nucleus so to become stable, the nucleus emits radiation. This is called radioactive decay.

Radioactive decay is a random process. This means that scientists cannot predict when a nucleus will decay

Activity = The rate at which a source of unstable nuclei decay

Activity is measured in becquerel (Bq)

1 Bq = 1 decay per second

We can use a Geiger-Muller tube to measure the activity of a radioactive source

Count rate is the number of decays recorded each second by a detector (different to activity)

Alpha particles is the same as a helium nucleus

Alpha particles = α

Alpha particles have two protons and neutrons which is the same as helium nucleus

Beta particles are fast moving electrons ejected from the nucleus

Beta particle = β

Beta particles are formed inside the nucleus when a neutron changes into a proton and electron

Gamma radiation is an electromagnetic wave

Gamma rays = γ

Neutron emission is when an unstable nucleus gives out a neutron

Properties of Alpha, Beta and Gamma radiation:

Range in air:

- Alpha particles are large so they collide with air particles and stop (2-3 cm)
- Beta particles can travel further but then stop (1-2 m
- Gamma radiation can travel very far before stopping (several thousand meters)

Penetrating power:

- Alpha particles are stopped by a single sheet of paper, skin or air
- Beta particles are stopped by a few millimeters of Aluminium
- Gamma radiation is stopped by several centimeters of Lead

Ionising power (Radiation collides with atoms that causes atoms to lose electrons and form ions):

- Alpha particle: very strongly ionise
- Beta particle: quite strongly ionise
- Gamma radiation: Weakly ionise

Nuclear equations:

Alpha Decay: (Example)

$$^{226}_{88}\mathrm{Ra} \longrightarrow \, ^{222}_{86}\mathrm{Rn} + \, ^{4}_{2}\mathrm{He}$$

Radium Radon Alpha

Beta Decay: (Example)

$$^{131}_{53}\mathrm{I} \longrightarrow \, ^{131}_{54}\mathrm{Xe} + \, ^{0}_{-1}\mathrm{e}$$

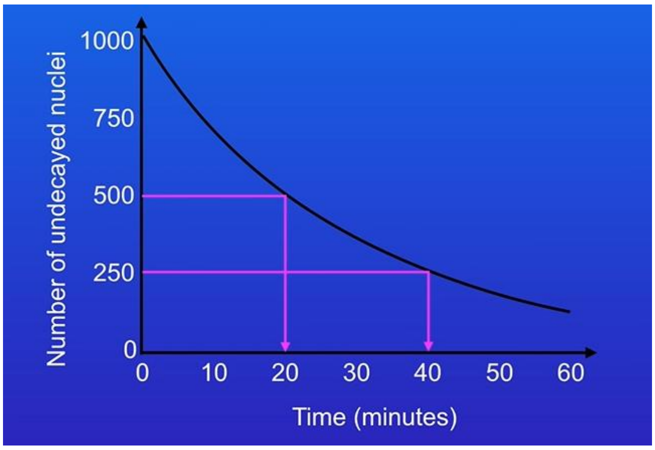
Iodine Xenon beta

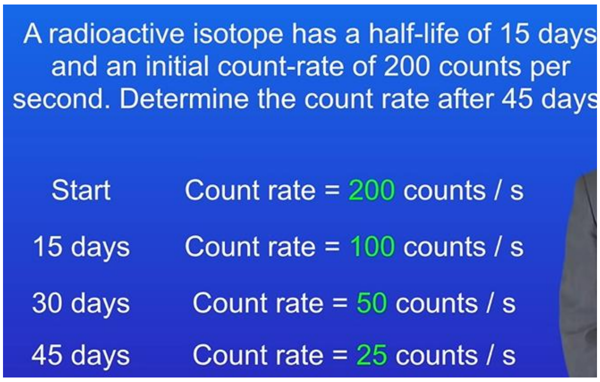
Gamma decay does not change anything

<u>Half life:</u>

Half life of a radioactive isotope is the time it takes for the number of nuclei of the isotope to half

Half life is the time it takes for the count rate (or activity) to half





Irradiation and contamination:

Ionising cells can cause cancer

Irradiation is exposing an object to nuclear radiation but does not cause the object to become radioactive

This is done for hospital equipment to sterlise it

How to protect against radiation:

- Gloves
- Lead apron
- Lead walls

- Radiation monitor
- Face mask

Contamination is when unwanted radioactive isotopes end up on other materials. (It has radioactive source) and emits radiation.

Alpha particles are stopped by dead cells on the skin but can be inhaled

Beta particles can penetrate the skin

Gamma radiation can go through the body and out

Peer review:

- Scientists explore effects of radiation
- These results should be published and shared with other scientists
- Findings are checked

<u>Background radiation:</u>

Natural background radiation:

- Certain rocks (granite)
- Cosmic rays from space

Man made background radiation:

- Nuclear weapons testing

- Nuclear accidents
- Location and occupation
- Hospital procedures

Radiation dose:

- Dose of radiation measured in sieverts (SV)
- 1 sievert = 1000 millisievert

Nuclear radiation in medicine:

Doctors use tracers to explore internal organs

Problems with tracers:

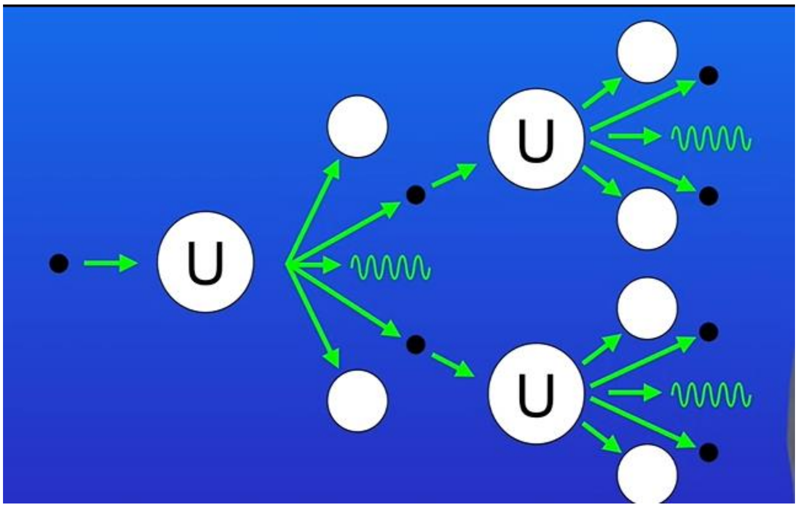
- Tracer must emit radiation that can pass out of the body and be detected (gamma/beta)
- Not be strongly ionising
- Must not decay into another radioactive isotope
- Must have a short half life

Another use is controlling or destroying unwanted tissue

A problem with this is that it may damage healthy tissue

Nuclear fission and Nuclear fusion:

In nuclear fission, the nucleus splits

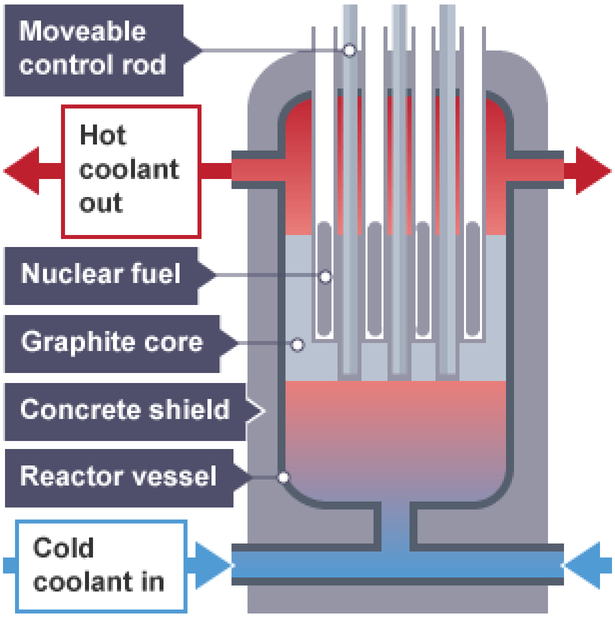


What happens in nuclear fission:

1. Fast moving neutron is fired and absorbed by a uranium nucleus
2. Uranium nucleus oscillates (vibrates) and then splits
3. The nucleus splits into two smaller daughter uranium nuclei and also emits two or three neutrons and energy which is emitted as gamma radiation
4. The neutrons emitted triggers a chain reaction

A controllable chain reaction is used to release energy in a nuclear reactor

Uncontrollable fission chain reaction causes bombs



Control rods – Change speed of chain reaction

Nuclear fuel – Isotope which splits in the fission process (Uranium/Plutonium)

Graphite core – Slows neutrons down so it can be absorbed by the rods

Coolant - Water heated up the energy released

Concrete shield – Reduces hazard

How a nuclear reactor works:

1. Nuclear fission happens
2. Energy released by the reaction heats up the coolant/water
3. Coolant is transported through pipes to the heat exchanger and boils
4. The steam produced is used to turn a turbine which turns a generator which generates electricity

Nuclear fusion:

Two light nuclei (hydrogen) are joined to form a heavier nucleus

Some of the mass of the nuclei can be converted into energy which is released as radiation