

## AQA P4 Atomic Structure and Nuclear Radiation Triple Physics

There are no required practicals in this topic

**Radius of atom** –  $1 \times 10^{-10}$  metres

**Nucleus** – has a positive charge; it contains protons and neutrons. Radius is  $1/10\,000^{\text{th}}$  the size of the atom.

**Electron shells** – electrons are negative and orbit around the nucleus. If an electron absorbs electromagnetic radiation it will move further from the nucleus. If an electron moves closer to the nucleus it releases electromagnetic radiation.

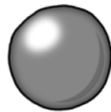
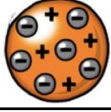
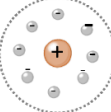
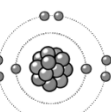
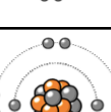
**Atom** – has no overall charge because the number of electrons is equal to the number of protons.

**Atomic number** – tells you the number of protons (and electrons)

**Atomic mass** – tells you the number of protons plus the number of neutrons

**Isotope** - same number of protons but different number of neutrons

### Development of the model of the atom

<b>Simple atom</b>		Believed to be tiny solid spheres that could not be divided	This was before the discovery of the electron
<b>'plum pudding' model</b>		A ball of positive charge with negative electrons embedded in it	Electron was discovered and it was smaller than an atom
<b>nuclear model</b>		Positively charged nucleus at the centre where the mass is concentrated and surrounded by negative electrons	Discovered by Rutherford's alpha particle scattering experiment where alpha particles were deflected by a tiny nucleus
<b>Nuclear model with electrons in shells</b>		Electrons orbit the nucleus at specific distances	Niels Bohr proposed that electrons orbited in fixed shells; this was supported by experimental observations.
<b>Nuclear model with Neutrons in the nucleus</b>		Discovered the nucleus contains neutrons as well as protons	Chadwick discovered the nucleus also contained neutrons 20 years after the nuclear model was accepted.

### Uses of radioactive isotopes

**Alpha** – easily blocked but highly ionising e.g. smoke alarms.

**Beta** – partially blocked by paper e.g. to check paper thickness.

**Gamma** – passes through and only weakly ionising e.g. medical tracers

**Short half life** – highly radioactive at start but will not stay dangerously radioactive for long.

**Long half life** – less radioactive but will stay radioactive for longer.

**Nuclear radiation** is a random process from unstable nuclei.

**Nuclear decay** – when radiation is released.

**Activity** – *total* number of decays per second measured in bequerels, Bq

**Count rate** - number of decays per second measured by an *instrument* in bequerels, Bq

**Half-life** – the time for half of the unstable nuclei to become stable OR the time for count rate (activity) to half

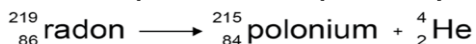
**Irradiation** - Exposure to radiation. The object does not become radioactive. Used to kill bacteria (sterilisation).

**Contamination** - Radioactive particles get on or into an object causing them to become radioactive.

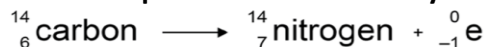
**Precautions** – reduce exposure time. Increase distance. Wear protective equipment.

Type	Made of..	Blocked by...	Range in air	Ionising (damage)
<b>alpha</b> $\alpha$	2 protons and 2 neutrons (helium nucleus, ${}^4_2\text{He}$ )	Skin, paper etc	$\sim 5\text{cm}$	Very
<b>beta</b> $\beta$	High speed electron ( ${}^0_{-1}\text{e}$ ) from nucleus (after a neutron turns into a proton)	Thin aluminium etc	$\sim 1\text{m}$	Medium
<b>gamma</b> $\gamma$	Electromagnetic wave of energy	Thick lead etc	infinite	weakly
<b>neutron</b> $n$	A neutron from the nucleus – no other details are needed			

### Nuclear equation with alpha decay



### Nuclear equation with beta decay



net decline ratios after

1 half life is  $\frac{1}{2}$

2 half lives is  $\frac{1}{4}$

3 half lives is  $\frac{1}{8}$

## AQA P4 Atomic Structure and Nuclear Radiation

### Triple only content

There are no required practicals in this topic

### Background radiation

- Natural sources such as rocks and cosmic rays from space
- Man-made sources such as fall out from nuclear weapons testing and nuclear accidents

Radioactive dose measured in Sieverts, Sv

### Each radioactive isotope has a specific half life

**Short half life** – highly radioactive at start but will not stay dangerously radioactive for long.

**Long half life** – less radioactive but will stay radioactive for longer.

### Medical uses of radiation

- imaging is exploration of internal organs needs to penetrate through body and be weakly ionising so **gamma** is used. Also should have a short half life so it does not remain radioactive for long in the body. But needs to have a half life long enough to carry out the imaging.
- Radiotherapy is treating tumours by concentrating gamma rays to control or destroy unwanted tissue

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### Nuclear fission

Splits larger unstable nuclei (e.g. uranium, plutonium) into smaller more stable nuclei.

Natural spontaneous nuclear fission is very rare, so we induce it.

1<sup>st</sup> We fire a neutron at the large unstable.

2<sup>nd</sup> the large nuclei splits into 2 smaller nuclei of similar size.

3<sup>rd</sup> this emits 2 or 3 neutrons and gamma rays

4<sup>th</sup> energy is released.

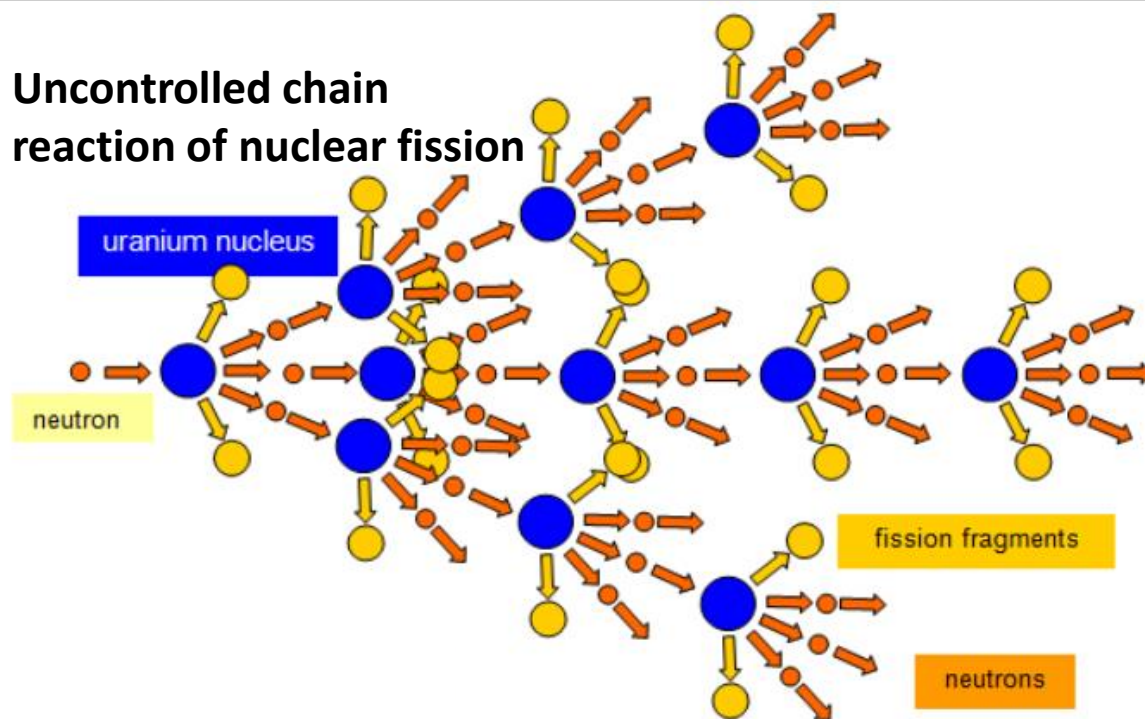
5<sup>th</sup> all the fission particles have kinetic energy

6<sup>th</sup> the neutrons released may go on to cause further fission and a chain reaction

Nuclear reactors in power stations control the chain reaction and so control the amount of energy released.

Nuclear weapons are uncontrolled chain reactions and release energy as an explosion

### Uncontrolled chain reaction of nuclear fission



### Nuclear fusion

The joining of 2 light nuclei to form one heavier nucleus.

The mass after is less because the 'missing' mass has turned into energy.

Nuclear fusion happens in stars where there is enough temperature and pressure.