AQA P4 Atomic Structure and Nuclear Radiation
Triple Physics

There are no required practicals in this topic

Radius of atom – 1 x 10^{-10} metres
Nucleus – has a positive charge; it contains protons and neutrons. Radius is 1/10 000th the size of the atom.

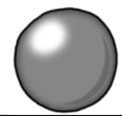
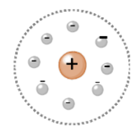
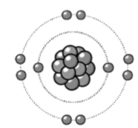
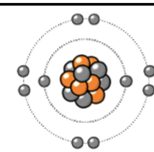
Electron shells – electrons are negative and orbit around the nucleus. If an electron absorbs electromagnetic radiation it will move further from the nucleus. If an electron moves closer to the nucleus it releases electromagnetic radiation.

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			
Simple atom		Believed to be tiny solid spheres that could not be divided	This was before the discovery of the electron
'plum pudding' model		A ball of positive charge with negative electrons embedded in it	Electron was discovered and it was smaller than an atom
nuclear model		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
Nuclear model with electrons in shells		Electrons orbit the nucleus at specific distances	Niels Bohr proposed that electrons orbited in fixed shells; this was supported by experimental observations.
Nuclear model with Neutrons in the nucleus		Discovered the nucleus contains neutrons as well as protons	Chadwick discovered the nucleus also contained neutrons 20 years after the nuclear model was accepted.

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

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 be come 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.

net decline ratios after
1 half life is ½
2 half lives is ¼
3 half lives is $1/8$

Nuclear equation with alpha decay

$$^{219}_{86}\text{radon} \longrightarrow {}^{215}_{84}\text{polonium} + {}^{4}_{2}\text{He}$$

Nuclear equation with beta decay

$$^{14}_{6}\text{carbon} \longrightarrow {}^{14}_{7}\text{nitrogen} + {}^{0}_{-1}\text{e}$$

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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

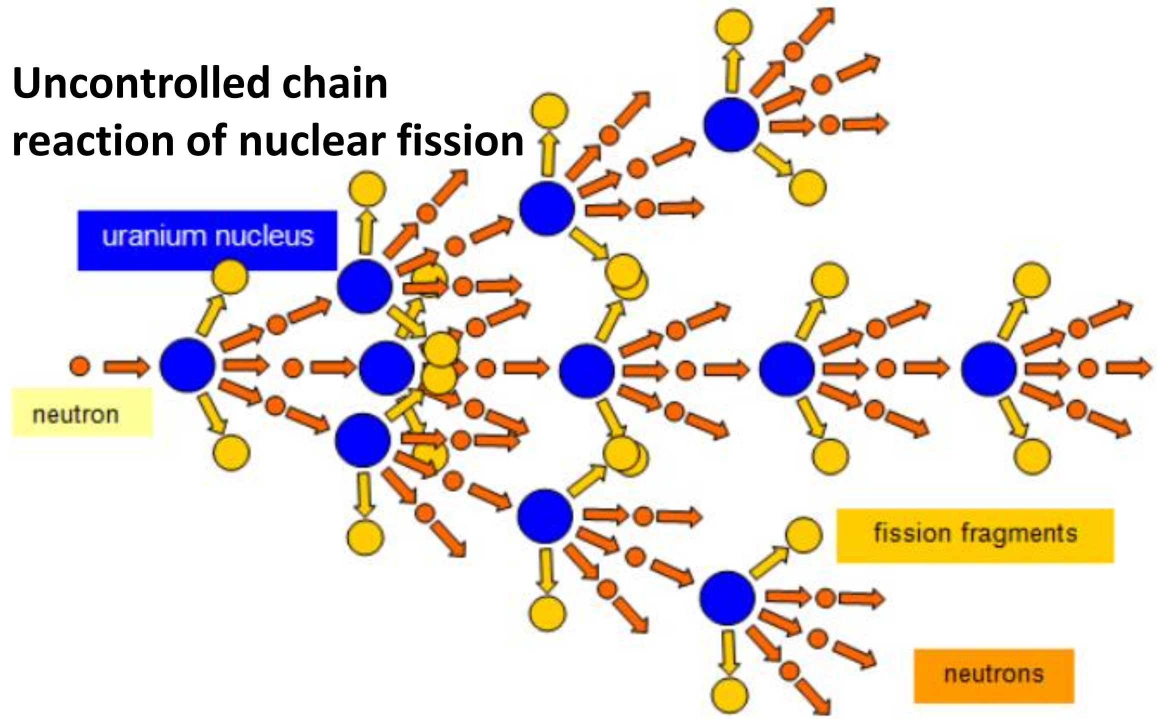
Splits larger unstable nuclei (e.g. uranium, plutonium) into smaller more stable nuclei.
Natural spontaneous nuclear fission is vary rare, so we induce it.

1st We fire a neutron at the large unstable.
2nd the large nuclei splits into 2 smaller nuclei of similar size.
3rd this emits 2 or 3 neutrons and gamma rays
4th energy is released.
5th all the fission particles have kinetic energy
6th 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.