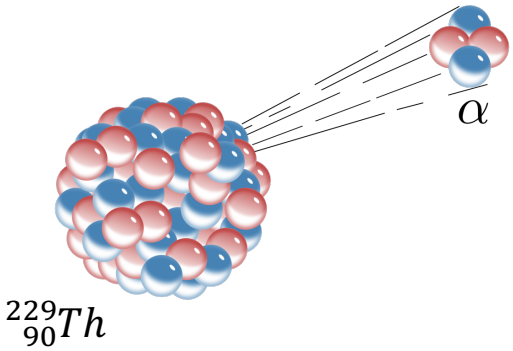
4.4.1 Radioactive decay

videos

Some atomic nuclei are unstable. Unstable nuclei decay by emitting alpha and beta particles, and gamma rays. They do this to become more stable.

Alpha emission



Thorium-229 is unstable. To become more stable, it emits an alpha(α) particle.

An alpha particle consists of 2 protons and 2 neutrons.

(1) What charge (in coulombs) does an alpha particle have? What is its 'relative charge' compared to a proton? (The charge on one proton = $+1.6 \times 10^{-19} C$*.)*

We can use 'α' as the symbol for an alpha particle.
(2) Sometimes the symbol $^{4}_{2}He$ *is used instead. Why do you think that is?*

Because the thorium-229 loses two protons (and 2 neutrons), it moves two places down in the periodic table and becomes an isotope of radium ($^{225}_{88}Ra$, or radium-225).

(3) Radium-226 decays by alpha particle emission. What isotope is it converted into? (Hint: It loses 2 protons, and so moves down two places in the periodic table. It loses 4 particles from its nucleus, so its nucleon number (or mass number) decreases by 4.)

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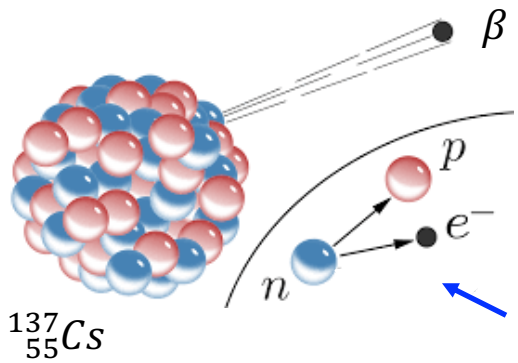
Beta emission



Caesium-137 is unstable. To become more stable, a neutron in the nucleus changes to a proton + an electron. The electron is emitted. This is called a 'beta(β) particle'.

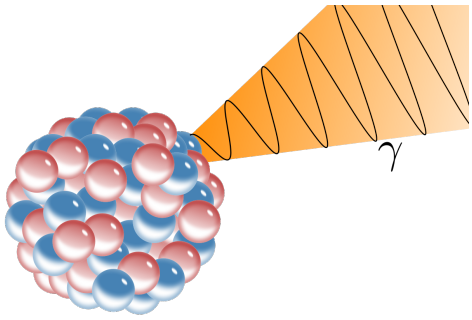
This happens in the nucleus.

A beta particle consists of an electron moving a high speed.

(4) What charge (in coulombs) does beta particle have? What is its 'relative charge' compared to a proton?

(5) Carbon-14 decays by beta emission. What isotope does it change into? (Hint: It gains one proton, so moves up one place in the periodic table. Because a neutron changes to a proton, the nucleon number (or mass number) remains the same.)

Gamma ray emission



Gamma ray emission often accompanies alpha or beta decay. Alpha and beta decay often leave the nucleus in an excited state. The nucleus transitions to a lower energy state by emitting a gamma(γ) ray photon. Gamma rays are high energy, electromagnetic radiation.

The particle composition of the nucleus is unchanged by the emission of a gamma ray.

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Detecting emissions

We can use a device called a Geiger Counter to detect alpha, beta and gamma emissions.

The Geiger Counter consists of a detector tube connected to a counter. When ionising radiation enters through the mica window on the end of the detecting tube, a pulse of current is produced. This is recorded a 'count' on the counter. 'Count rate' is the number of counts per second.

Properties of alpha, beta and gamma

The following table summarises the properties of the 3 radioactive emissions:

Emission	Range in air	Stopped by	Ionising power
alpha	< few cm	sheet of paper	high
beta	< 1m	thin sheet of aluminium	medium
gamma	unlimited	few cm of lead	low

The 'range in air' is how far each of the emissions will travel in air.

(6) What do you think causes alpha and beta particles to be stopped by air?

The emissions can be 'stopped by' materials put in their path.

(7) Using the equipment (above), describe a method to show that a radioactive material is not emitting alpha particles.

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'Ionising power' is the ability of the radiation to produce ions in the materials that they penetrate.

(8) What are 'ions'?

(9) What do you think could happen if the material absorbing the ionising radiation is the part of the human body?

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