GCSE Physics Unit 2

2.7/6.5 Types of Radiation

All atoms contain a nucleus which contain a different combination of protons and neutrons. The number of protons and neutrons can be calculated from the atom's symbol.

Nucleon number = number of protons + number of neutrons

Proton number = number of protons

$${}^{12}_{6}C$$

The number of protons in a nucleus determines which element it is, e.g. if there are 6 protons in a nucleus it must be Carbon, if there are 8 it is oxygen.

Isotopes

$${}^{12}_{6}C \quad {}^{14}_{6}C$$

These nuclei are both carbon because they both have the same proton number, 6, but because their nucleon number is different, they have a **different number of neutrons**. They are known as **isotopes**.

Radioactive decay

Of the two isotopes of carbon shown above, only carbon-12 is stable. Carbon-14 is **unstable because of an imbalance between the number of protons and neutrons in its nucleus**. This means it will try to become more stable by releasing some radiation. This is called decaying.

This is a **random process** as it is impossible to guess when a nucleus will decay but estimations can be made from the probability. This is similar to throwing several dice, you cannot guess which will land on 6 each time but you would expect roughly one sixth to land on 6.

Due to its random nature, any measurements of radiation should be taken over a **long time** or **repeated** several times **to reduce the effect of random fluctuations**.

Background radiation

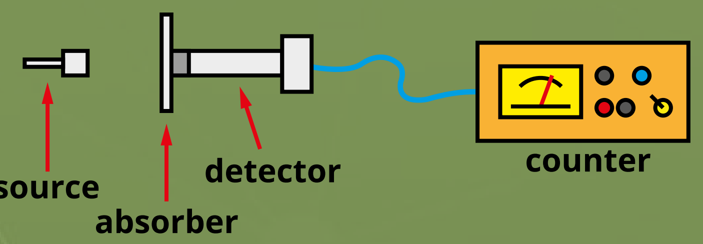
When measuring radiation, you must remember to adjust for background radiation. This low level of radiation is all around at all times. It is due to both natural and man-made sources.

Natural	Man-made
• Radon (a gas formed in rocks below the ground) • Rocks and buildings • Food • Cosmic rays	• Medicine e.g. X-rays • Nuclear power and testing (around 1%)

The level of background radiation **varies** from one place to another. This is due to the **different rocks** in each area, the types of buildings and **height above sea level** will affect how much radiation is emitted from cosmic rays.

Penetrating power

An investigation into a radioactive source such as the example below can be used to find the type of radiation emitted.



The following results were obtained:

Absorber	Reading (counts per minute)
None	350
Thin card	20
3mm of aluminium	20
20mm of lead	1

In this example, there would be:
330 cpm of alpha as this was blocked by the thin card
No beta as aluminium did not block any extra cpm
20 cpm of gama as 20 cpm could penetrate the aluminium.

There are three types of radiation produced from radioactive decay; alpha, beta and gamma.

Type	Alpha	Beta	Gamma
Symbol	${}^{4}_{2}He$ or ${}^{4}_{2}\alpha$	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	y
Make up	Helium nucleus (2 protons and 2 neutrons)	High energy electron	Electromagnetic wave
Penetrating power	Low Absorbed by paper	Medium Absorbed by aluminium	High Reduced by thick lead
Danger outside the body	Low Not very penetrating, is unlikely to reach the body or affect any cells	Medium	High Very penetrating, can penetrate the skin and affect internal organs
Danger inside the body	High Very ionising	Medium	Low Less ionising

Equations

There are two key things to remember when using an equation to represent nuclear decay.

1. **The total nucleon number must be the same before and after the reaction.**
2. **The total proton number must be the same before and after the reaction.**

For example, radium-226 decays to radon-222.

Nucleon number before = 226 Nucleon number after = 222 (4 fewer)

$${}^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn$$

Proton number before = 88 Proton number after = 86 (2 fewer)

This means that radium-226 must release an alpha particle when it decays, as it has the nucleon and proton number that will balance the equation.

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