N5 WAVES & RADIATION

1. Radiation

Ionisation

The process by which nuclear radiation damages cells is known as ionisation. This is where electrons are removed from or added to an atom to leave a charged particle called an ion.

Alpha radiation causes more ionisation than beta or gamma radiation.

Background radiation

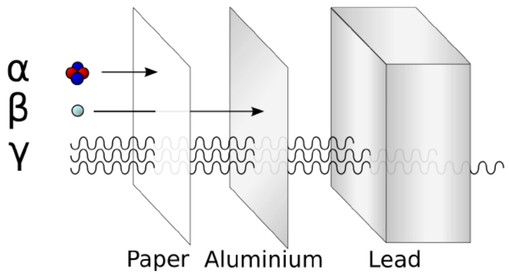
Background radiation is the name given to radiation that is always present in our atmosphere. Everyone is exposed to this radiation. Background radiation can come from natural sources and from man-made sources.

- Radon gas - NATURAL
- Soil and rocks- NATURAL
- Cosmic rays- NATURAL
- Nuclear power – ARTIFICIAL
- Nuclear weapons – ARTIFICIAL
- Medical uses – ARTIFICIAL
- Food and drink – ARTIFICIAL

The current measurements for background and safety limits for the UK are: **MUST KNOW THESE!**

- Average annual background radiation in UK: **2·2 mSv.**
- Annual effective dose limit for member of the public: **1 mSv.**
- Annual effective dose limit for radiation worker: **20 mSv.**

2. Properties of Radiation and their Uses



Medical	Industrial
Destroying cancerous tumours, (gamma radiation)	Nuclear power stations
Diagnosing problems inside the body (gamma cameras)	Finding faults in building materials and sources of pollution/leaks
Sterilising medical equipment	Smoke alarms

Gamma rays travel at the speed of light and have the lowest ionisation density.

type of radiation	nature	Minimum absorber
alpha	two protons and two neutrons (helium nucleus)	sheet of paper, few centimetres of air
beta	fast-moving electron	few cm of aluminium
gamma	electromagnetic wave	Several cm of lead

4. RADIATION PART 1

Revision Questions for Next week

Now complete the Nuclear Radiation Key Area questions on the past paper bank on google classroom.

3. Activity (A)

The Activity (A) of a radioactive source is the number of disintegrations (decays) per second and is measured in Becquerels (Bq).

$$A = \frac{N}{t}$$

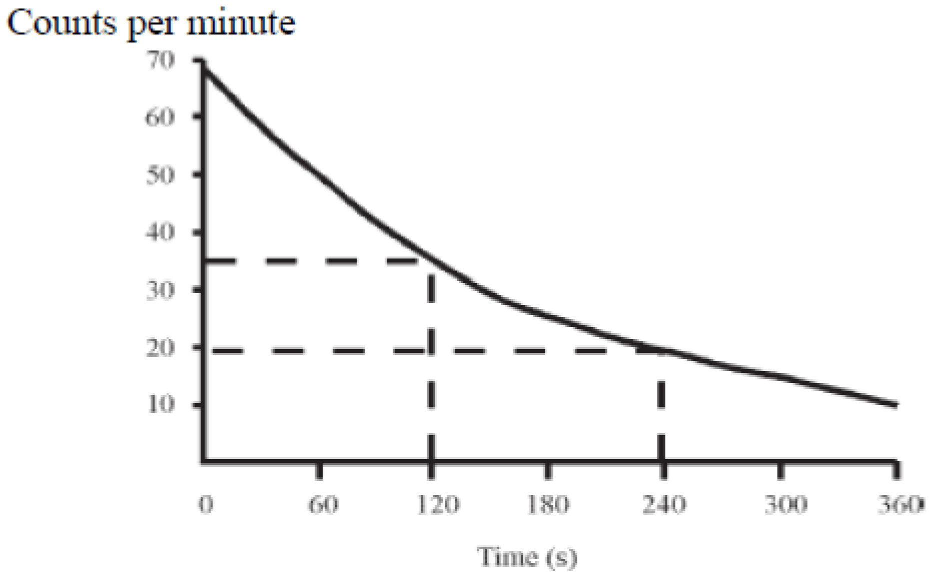
Example

In a radioactive source 24000 nuclei disintegrate in one minute. Calculate the activity of the source.

A = ?
N = 24000
t = 1 x 60 = 60s

A = N/t
A = 24000/60
A = 400Bq

Answer for Half Life Graph Example



- In graph type examples a number of results should be taken from the graph before the half-life is stated.
- For the above graph the time taken for the count rate to fall from 70 counts per minute to 35 counts per minute is 120s. When other results are analysed, for example, the time taken for the count rate to fall from 35 counts per minute to 17.5 counts per minute is also approximately 120s.
- When enough examples have been taken from the graph we can state that the half-life for the Cs- 140 will be 120s.

4. Absorbed Dose (D)

When radiation reaches the body or our tissues it is absorbed. This is called the Adorbed Dose (D).

The aborbed dose is measured in Grays (Gy) where one Gray is equal to one joule of energy absorbed by one kilogram of tissue.

$$D = \frac{E}{m}$$

Example

A part of the body of mass 0.5kg is exposed to radiation. The energy absorbed is 0.3J. calculate the absorbed dose received by this part of the body.

D = ?
E = 0.3J
m = 0.5kg

D = E/m
D = 0.3 / 0.5
D = 0.6Gy

5. Equivalent Dose (H)

All ionising radiation can cause damage to the body. The risk of biological harm from an exposure to radiation depends on:

- ✓ the absorbed dose, D, which is the energy absorbed per unit mass
- ✓ the type of radiation
- ✓ the body organs or tissues exposed

This means that two different organs exposed to the same absorbed dose of alpha or gamma will experience a different biological effect. To solve this problem a radiation weighting factor, w_r, is given to each type of radiation.

...5. Equivalent Dose (H)

Dose equivalent = absorbed dose x radiation weighting factor

$$H = D \times w_r$$

where,
H – the dose equivalent is measured in Sieverts(Sv)
D – the absorbed dose is measured in Grays (Gy)
wr – the radiation weighting factor is just a number and has no units

Various precautions will reduce the harmful biological effects of radiation:

- Increasing the distance between the radiation source and person.
- Reducing the exposure time to radiation source.
- Wearing shielding e.g. lead apron

6. Equivalent Dose Rate (H)

The time of exposure (t) to ionising radiation is also important. An equivalent dose of 100 mSv received in one day is more dangerous than the same equivalent dose received over the course of one year.

$$H = \frac{H}{t}$$

4. RADIATION PART 2

Nuclear Fission and Fusion
see higher notes.

7. Half-life

The half-life of a radioactive source is the time for the activity to fall to half its original value.

Example One

The activity of a source falls from 80MBq to 5MBq in 8days. Calculate its half-life.

Each arrow represents one half-life. *80 → 40 → 20 → 10 → 5*
There are four arrows, so in 8days there are four half-lives.
The half-life will be 8 / 4 = 2days.

Example Two

A Geiger-Muller tube and a ratemeter were used to measure the half-life of Cs-140. The count rate was noted every 60seconds. The results are shown in the table:

Time (s)	0	60	120	180	240	300	360
Count rate (counts per minute)	70	50	35	25	20	15	10

By plotting a suitable graph, find the half-life of Cs-140.