THE PHYSICS QUESTION BANK · AQA GCSE PHYSICS

Hospital Radiation Officer – Radioactivity

A one-hour lesson. Learn about alpha, beta and gamma radiation and half-life, then choose the right radioactive source for each hospital job.

Name: ______________________________ Class: ____________ Date: ____________

How to use this worksheet: work through the steps in order and write your answers in your exercise book. Copy every blue 📝 box neatly – these are your revision notes. When you have finished a step, check your work against the **Answers** at the end and correct anything in a different colour.

📝 COPY INTO YOUR BOOK

By the end of this lesson I will be able to:

1. describe alpha, beta and gamma radiation

2. use half-life in calculations

3. explain contamination and irradiation

4. choose the right radioactive source for a job.

Step 1: Starter (5 minutes)

Radiation: helpful or harmful? Write down two ways radiation can harm people and two ways it is useful. Guess if you're not sure!

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Nuclear radiation can damage cells and cause cancer – but choosing the right type, with the right half-life, makes it safe and useful.

Step 2: Read and write (10 minutes)

Copy these three questions into your book. Then read the text and answer them in full sentences.

1. What is an alpha particle made of?
2. What stops alpha, beta and gamma radiation?
3. What does "half-life" mean?

📖 READ

Alpha, beta, gamma and half-life

Some atoms have unstable nuclei. They give out radiation to become more stable – this is **radioactive decay**. An **alpha particle** is two protons and two neutrons (a helium nucleus). It is strongly ionising but only travels a few centimetres in air and is stopped by paper or skin. A **beta particle** is a fast-moving electron from the nucleus. It travels about a metre in air and is stopped by a few millimetres of aluminium. **Gamma rays** are electromagnetic waves. They are weakly ionising, travel a long way, and are only reduced by thick lead or concrete.

We can't predict when one nucleus will decay – it's random. But we can measure the **half-life**: the time it takes for the number of unstable nuclei in a sample to halve, or for the count-rate to fall to half its starting value.

📝 **COPY AND COMPLETE**

Half-life is the time it takes for the number of __________ __________ in a sample to __________, or for the __________ to fall to half its starting value.

Step 3: Key facts (8 minutes)

Your task: copy this table neatly – you'll need it for the main task.

Radiation	What it is	Ionising?	Range in air	Stopped by
Alpha (α)	2 protons + 2 neutrons	Strongly	A few cm	Paper or skin
Beta (β)	Fast electron from the nucleus	Moderately	About 1 m	A few mm of aluminium
Gamma (γ)	Electromagnetic wave	Weakly	Very far	Reduced by thick lead or concrete

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Ionising: knocks electrons off atoms. This is what damages cells.

Contamination: radioactive atoms get onto or into something, so it becomes radioactive.

Irradiation: something is exposed to radiation but does NOT become radioactive.

Remember: alpha is the most dangerous INSIDE the body, but from outside it can't get through your skin.

Step 4: Quick check (5 minutes)

Q1 Which radiation is stopped by a sheet of paper? **Q2** Which radiation is an electromagnetic wave? **Q3** Which is the most ionising?

Q4 A patient has an X-ray. Are they contaminated or irradiated? **Q5** Why does a source with a short half-life become safe quickly?

Step 5: Half-life practice (7 minutes)

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Half-life calculations: keep halving, one half-life at a time. Count the halvings. Time = number of halvings × half-life.

Q1 A source has a count-rate of 1200 counts per minute and a half-life of 2 hours. What is the count-rate after 6 hours?

Q2 A source has a half-life of 5 days. How long does its count-rate take to fall from 640 to 40 counts per minute?

Q3 (Higher) What fraction of a radioactive sample is left after 3 half-lives?

Step 6: Main task – Hospital Radiation Officer (12 minutes)

You're the new radiation officer! Four departments need a radioactive source. Choose from:

Source	Radiation	Half-life
P	Alpha	430 years
Q	Beta	28 years
R	Gamma	6 hours
S	Gamma	5 years
T	Alpha	3 days

1. Medical tracer – injected so a camera outside the body can see the kidneys working. **2. Smoke alarm** – ionises the air inside the alarm and should last for years. **3. Thickness gauge** – radiation passes through paper to a detector. **4. Sterilising** sealed packs of surgical instruments.

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Choosing a radioactive source:

1. Does the radiation need to get THROUGH something? → choose the type.

2. Should it last a LONG time or disappear QUICKLY? → choose the half-life.

Your task: for each job write: Source chosen · Why this type of radiation? · Why this half-life?

Step 7: Exam practice (10 minutes)

Q1 (2 marks) Explain why an alpha source in a smoke alarm is safe for people in the room.

Q2 (4 marks) A worker handles a gamma source. Describe two precautions they should take and explain how each reduces the risk.

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Staying safe with radiation – DISTANCE (use tongs), SHIELDING (use lead), TIME (as short as possible).

Q3 (4 marks, Higher) A tracer's count-rate is 800 counts per minute. Six hours later it is 400. How long after the start will it be 50 counts per minute? Explain your answer.

✅ Add up your marks out of 10.

Step 8: Exit ticket (3 minutes)

- The type of radiation I'd least like to swallow is… because…
- A medical tracer needs a short half-life because…
- One thing I'm still not sure about is…

Answers

Only look at these once you have written your own answer!

Step 1: Starter (5 minutes)

Harmful: damages cells and causes mutations that can lead to cancer; high doses cause burns and radiation sickness. Useful: medical tracers; radiotherapy; sterilising instruments; smoke alarms; thickness gauges.

Step 2: Read and write (10 minutes)

(1) Two protons and two neutrons. (2) Alpha: paper or skin; beta: a few mm of aluminium; gamma: reduced by thick lead or concrete. (3) The time for the number of unstable nuclei to halve, or for the count-rate to fall to half.

Gaps: unstable nuclei · halve · count-rate

Step 4: Quick check (5 minutes)

Q1 Alpha. Q2 Gamma. Q3 Alpha. Q4 Irradiated. Q5 Its nuclei decay quickly, so its activity falls to a low level in a short time.

Step 5: Half-life practice (7 minutes)

Q1 6 h = 3 half-lives: 1200 → 600 → 300 → 150 counts per minute. Q2 640 → 320 → 160 → 80 → 40 = 4 half-lives × 5 = 20 days. Q3 $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$.

Step 6: Main task – Hospital Radiation Officer (12 minutes)

1. Tracer – R (gamma, 6 h): gamma passes out of the body to the camera and is weakly ionising; short half-life so the patient isn't radioactive for long.

2. Smoke alarm – P (alpha, 430 years): strongly ionising and stays inside the alarm; long half-life so it lasts for years.

3. Thickness gauge – Q (beta, 28 years): beta partly passes through paper, so thickness changes the count-rate; long half-life gives steady readings.

4. Sterilising – S (gamma, 5 years): passes through packaging to kill bacteria; instruments are irradiated, not contaminated; long half-life.

Step 7: Exam practice (10 minutes)

Q1: Alpha only travels a few cm in air / is stopped by the casing (1), so it can't reach people (1).

Q2: Use long-handled tongs (1) so the source is further from the body (1); store in a lead-lined container / use lead shielding (1) because lead absorbs gamma (1). Also accept: minimise time of exposure.

Q3: Half-life = 6 hours (1); 800 → 400 → 200 → 100 → 50 (1) = 4 half-lives (1); 4 × 6 = 24 hours (1).