Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Radioactivity

Time allowed: 1 hour 10 minutes

Subject code **0625**

Physics

Questions from Paper 3 and Paper 4

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 70

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 70 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 A teacher determines the types of emission from a radioactive source. He uses different materials to absorb the emissions. Fig. 11.1 shows the equipment.

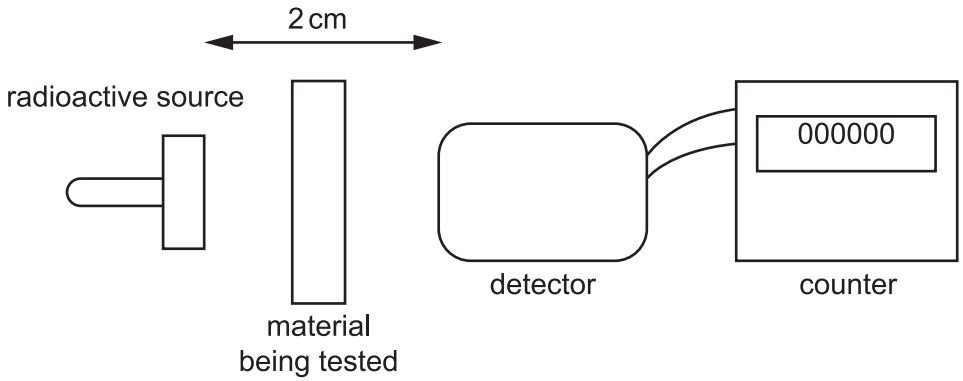


Fig. 11.1 (not to scale)

The teacher places a material between the radioactive source and the detector. The counter shows the count rate for the emission that reaches the detector. The teacher records the count rate. He repeats the experiment for different materials.

Table 11.1 shows the results.

Table 11.1

material being tested	count rate / counts / s
air (no object in gap)	480
thin sheet of paper	481
2 mm sheet of aluminium	479
10 mm block of lead	120

(a) State whether the source emits α (alpha)-particles.
Use information from Table 11.1 to give a reason for your answer.

.....

.....

..... [2]

(b) State whether the source emits γ (gamma)-rays.
Use information from Table 11.1 to give a reason for your answer.

.....

.....

..... [2]

[Total: 4]

Alpha, beta and gamma radiation Click for more variations

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2 A teacher is investigating radioactivity.

The teacher measures the background radiation in the laboratory.

(a) State **one** source of background radiation.

..... [1]

(b) A teacher measures the count rate of a radioactive isotope.

Fig. 12.1 shows the graph of her results.

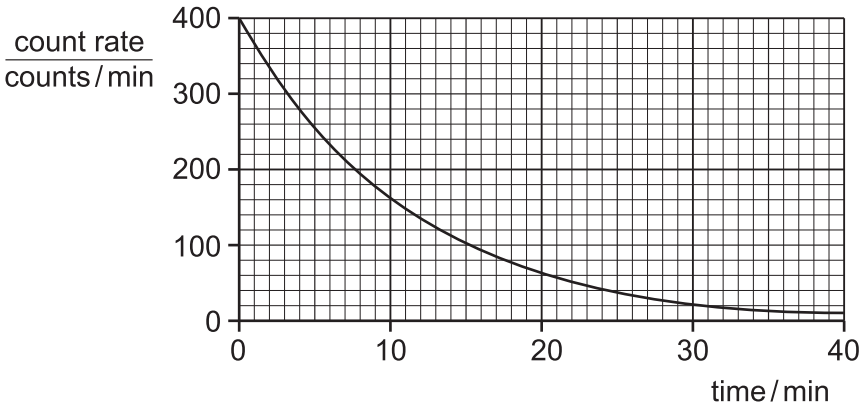


Fig. 12.1

(i) Determine the half-life of the radioactive isotope. Use information from Fig. 12.1.

Show on Fig. 12.1 how you obtained your value.

half-life = ... minutes
[3]

(ii) The radioactive isotope emits γ-radiation.

Describe **one** method of safely storing the radioactive isotope.

.....

..... [1]

[Total: 5]

Half-life Click for more variations

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3 Radioactive decay may include the emission of:

α-radiation
β-radiation
γ-radiation

(a) (i) From the list, state the type of radiation which has the **greatest** ionising effect.

.....[1]

(ii) From the list, state the type of radiation which has the **lowest** penetrating ability.

.....[1]

(b) In a factory, rollers press aluminium metal to make thin foil sheets. An automatic system for controlling the thickness of the foil uses a radioactive source. The automatic system changes the gap between the top and bottom roller. Fig. 12.1 shows the equipment.

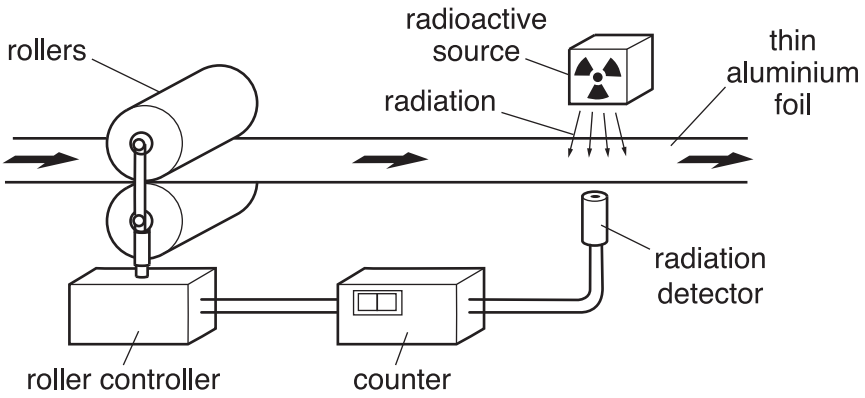


Fig. 12.1

(i) Use your ideas about the properties of radiation to suggest and explain the type of radiation used.

type of radiation .....

explanation .....

.....

.....

.....
[2]

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(ii) The aluminium foil passing the radiation detector is too thin. Describe how this fault affects the reading on the counter.

.....[1]

(iii) Suggest how the fault in **(b)(ii)** is corrected. State what happens to the rollers.

.....[1]

(iv) The source used is strontium-90. A nucleus of strontium-90 can be described as $^{90}_{38}Sr$. State the number of protons in a nucleus of strontium-90.

.....[1]

[Total: 7]

Half-life Click for more variations

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4 Fig. 11.1 shows a beam of radiation that contains α-particles, β-particles and γ-rays. The beam enters a very strong electric field between charged plates in a vacuum.

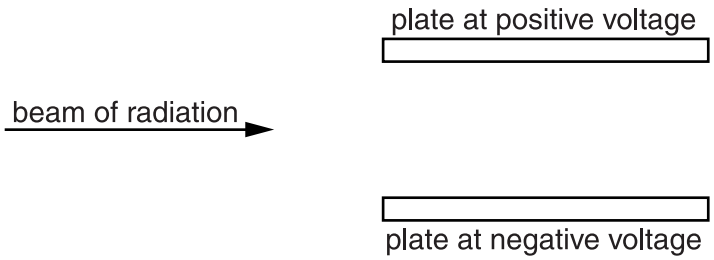


Fig. 11.1

(a) Indicate the deflection, if any, of the α-particles, β-particles and γ-rays, by placing **one** tick in **each** column of the table.

possible deflection	α-particles	β-particles	γ-rays
no deflection			
towards positive plate			
towards negative plate			
out of the paper			
into the paper			

[3]

(b) The radiation is said to be *ionising*. Explain what this means.

.....

.....[1]

(c) α-particles are more strongly ionising and have a shorter range in air than γ-rays.

Use your knowledge of the nature of these radiations to explain these differences.

.....

.....

.....

..... [3]

[Total: 7]

Alpha, beta and gamma radiation Click for more variations

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5 Strontium-90 is a radioactive isotope of strontium. The nuclide notation for strontium-90 is:

$$^{90}_{38}Sr$$

(a) (i) Explain what isotopes are.

.....

..... [1]

(ii) Complete Table 9.1 for strontium-90.

Table 9.1

particle	number in one atom	location
	38	outside nucleus
neutron		
	38	inside nucleus

[2]

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(b) Strontium-90 is used to measure the thickness of metal sheets in industry.
Strontium-90 decays by emitting beta (β) particles which pass through a metal sheet to a detector.

(i) One metal sheet is 0.75 mm thick. Suggest why strontium-90 is a suitable radioactive source to measure the thickness of the metal sheets.

.....

.....

..... [2]

(ii) The half-life of strontium-90 is approximately 27 years. Fig. 9.1 shows the shape of a decay curve.

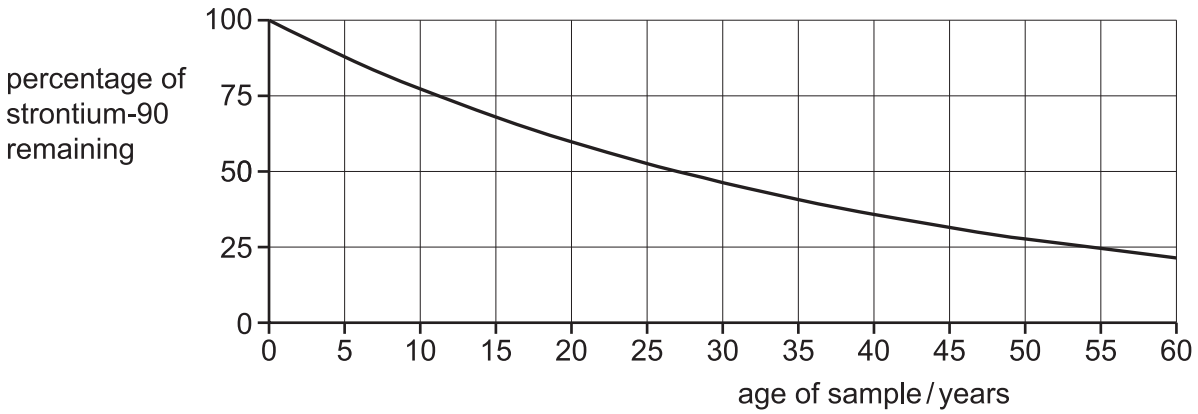


Fig. 9.1

The strontium-90 source is replaced with a new source after 15 years. Using Fig. 9.1, suggest why a strontium-90 source that is more than 15 years old needs to be replaced with a new source.

.....

..... [2]

[Total: 7]

Half-life Click for more variations

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6 A radiation detector is placed on the bench in a laboratory. It detects a background count rate of 40 counts / minute.

(a) State what is meant by background radiation. Suggest one source for it.

.....

.....

..... [2]

(b) A sample containing atoms of the radioactive isotope polonium-208 is removed from a lead container and brought close to the detector. The average count rate increases to 890 counts / minute.

When two sheets of paper are inserted between the sample and the detector, the average count rate returns to 40 counts / minute.

Polonium-208 is represented by the symbol $^{208}_{84}Po$. It decays to an isotope of lead (Pb).

(i) Deduce the type of radiation emitted by polonium-208. Explain your answer.

.....

.....

.....

..... [2]

(ii) Write down the nuclide equation for the decay of polonium-208.

[3]

[Total: 7]

Alpha, beta and gamma radiation Click for more variations

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7 Fig. 10.1 represents a neutral atom of an isotope of element X.

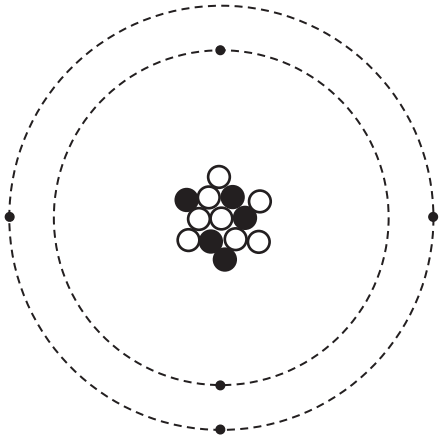


Fig. 10.1

(a) State **one** similarity between this atom and a neutral atom of a different isotope of element X.

.....

..... [1]

(b) The isotope of element X is radioactive. It decays to form an isotope of element Y by emitting a β-particle.

(i) Using Fig. 10.1 deduce the nuclide notation for the isotope of Y produced by this decay.

nuclide notation: .....Y..... [3]

(ii) β-particles ionise the air they pass through less strongly than the same number of α-particles.

Suggest why this is so.

.....

.....

..... [3]

[Total: 7]

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Alpha, beta and gamma radiation Click for more variations

8 The isotope thallium-208 ($^{208}_{81}Tl$) is radioactive. It decays by β-decay.

(a) Thallium-208 decays to an isotope of lead (Pb).

(i) Complete the equation for this decay.

$$^{208}_{81}Tl \longrightarrow \text{.....}^{\text{.....}}\text{Pb} + \text{.....}^{\text{.....}}\beta$$

[3]

(ii) The β-emission of thallium-208 is accompanied by γ-emission from the nucleus.

Explain why this γ-emission does **not** affect the numbers in the equation in **(a)(i)**.

.....

..... [1]

(iii) Suggest **one** reason why a nucleus of thallium-208 is unstable.

.....

..... [1]

(b) A sample of thallium-208 is placed in a thick lead container. Fig. 8.1 shows a narrow beam of β-particles and γ-radiation emerging from a small hole in one side of the container.

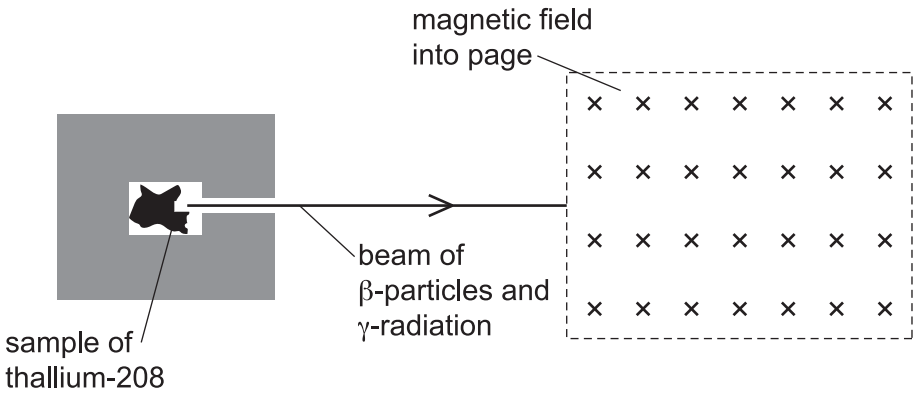


Fig. 8.1

The narrow beam enters a region where there is a magnetic field that is directed into the page.

On Fig. 8.1:

- draw a line **labelled β** to indicate the path of the β-particles in the magnetic field
- draw a line **labelled γ** to indicate the path of the γ-radiation in the magnetic field.

[3]

[Total: 8]

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Alpha, beta and gamma radiation Click for more variations

9 In a research laboratory, a radioactive sample is placed close to a radiation detector. The graph in Fig. 11.1 shows the decay of the sample.

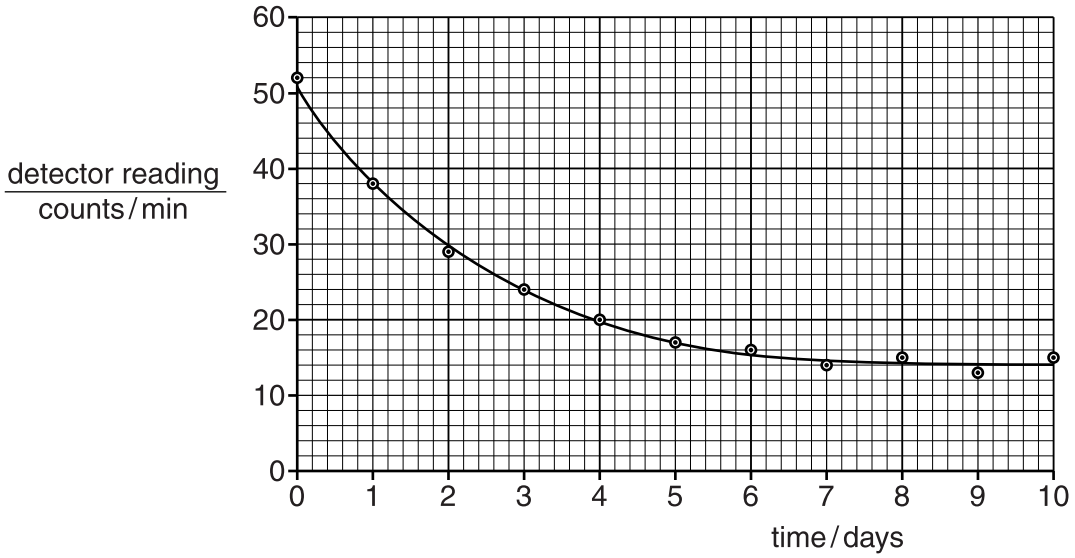


Fig. 11.1

(a) After 6 days the count rate hardly decreases and, in fact, increases a little at times. Explain these observations.

.....

.....

.....

..... [2]

(b) Use the graph to determine the half-life of the sample. Explain your working carefully.

half-life = ... [4]

(c) Another radioactive sample is a strong emitter of α-particles and γ-rays. A junior researcher suggests that a sufficient safety precaution, when working with this sample, would be to hold the sample with long forceps. Explain why this suggestion, although helpful, may be insufficient.

.....

.....

.....

..... [2]

[Total: 8]

Half-life Click for more variations

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10 Many household smoke alarms contain a sample of the radioactive isotope americium-241 (Am).

(a) Americium-241 is the isotope of the element americium that has the nucleon number (mass number) 241.

(i) State how the composition of a nucleus of americium-241 differs from that of a nucleus of americium-242.

.....

..... [1]

(ii) An atom of a different element has a nucleon number of 241.

State **two** differences between the composition of a nucleus of this atom and a nucleus of americium-241.

1 .....

2 .....

[2]

(b) Americium-241 decays to an isotope of neptunium (Np) by alpha-particle (α-particle) emission.

(i) Complete the equation for this decay.

$$^{241}_{\ldots\ldots}\mathrm{Am} \longrightarrow {}^{\ldots\ldots}_{93}\mathrm{Np} + {}^{\ldots\ldots}_{\ldots\ldots}\alpha$$

[3]

(ii) One reason for using an isotope that emits α-particles in a smoke detector is that α-particles are more strongly ionising than beta-particles (β-particles).

Explain why α-particles are more strongly ionising than β-particles.

.....

.....

..... [2]

(iii) The isotope of neptunium produced by americium-241 is also radioactive.

The decay of this isotope of neptunium produces an isotope of protactinium which decays by β-emission. β-particles are more penetrating than α-particles.

The half-life of neptunium is longer than two million years.

Using this information, explain the advantage of this long half-life for the use and safe disposal of a household smoke alarm.

.....

.....

..... [2]

[Total: 10]

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