OCR GCSE GATEWAY PHYSICS A · J249

# PHYSICS



EXAM QUESTION PACK

## P6.1 RADIOACTIVE EMISSIONS

| SCORE | PERCENTAGE |
| --- | --- |
| /167 | % |

STEMUP

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# Gateway Physics A (9-1)

## Radioactive emissions

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

**OCR supplied materials:**
Additional resources may be supplied with this paper.

**Other materials required:**
- Pencil
- Ruler (cm/mm)

**Duration:** Not set

| Candidate forename | | Candidate surname | |
|---|---|---|---|

| Centre number | | | | | | Candidate number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

## INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

## INFORMATION FOR CANDIDATES

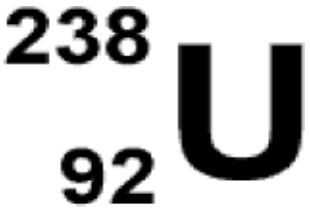
- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **167**.
- The total number of marks may take into account some 'either/or' question choices.

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1 What is the number of neutrons in this isotope of uranium?




A 92
B 119
C 146
D 238

Your answer

**[1]**

2 All radioactive sources have a half-life.

Which statement about the half-life of a source is correct?

A It is half the time for the radioactive source to become safe.
B It is half the time it takes for an atom to decay.
C It is half the time it takes the activity of the source to decrease to zero.
D It is the time it takes the activity of the source to decrease by half.

Your answer

**[1]**

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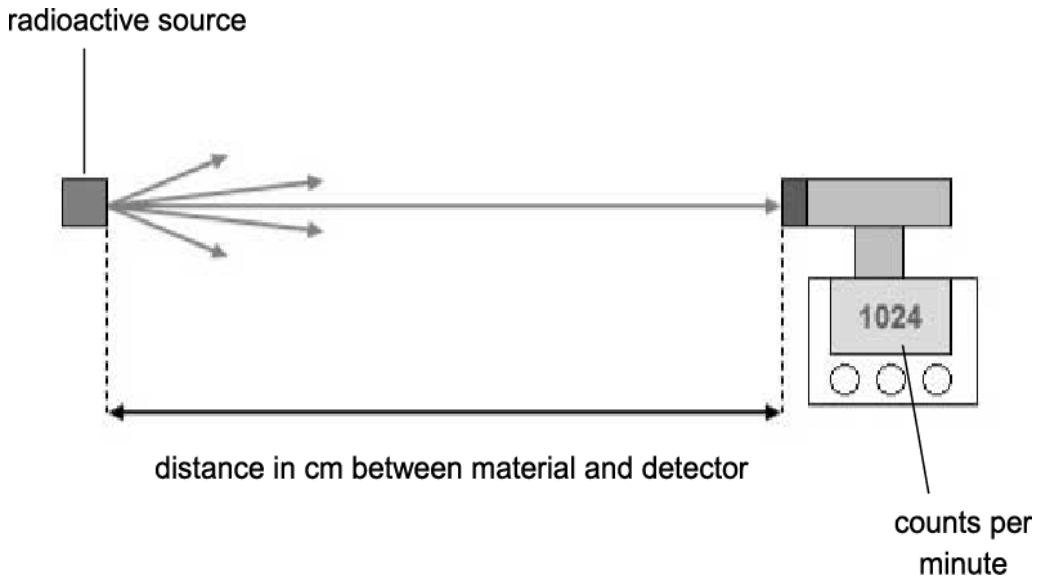
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3(a) Matt experiments with radioactive materials.

He investigates how the activity of radiation changes with distance.

The radiation moves from the source to a detector.

He measures the counts per minute from a radioactive source.




The table shows the results from the experiment.

| Distance between the source and the detector (cm) | Count rate (counts per minute) |
|---|---|
| 10 | 1000 |
| 20 | 240 |
| 40 | 60 |
| 80 | 20 |

Matt could **not** take an accurate reading at 0 cm.

Suggest a reason why.

[1]

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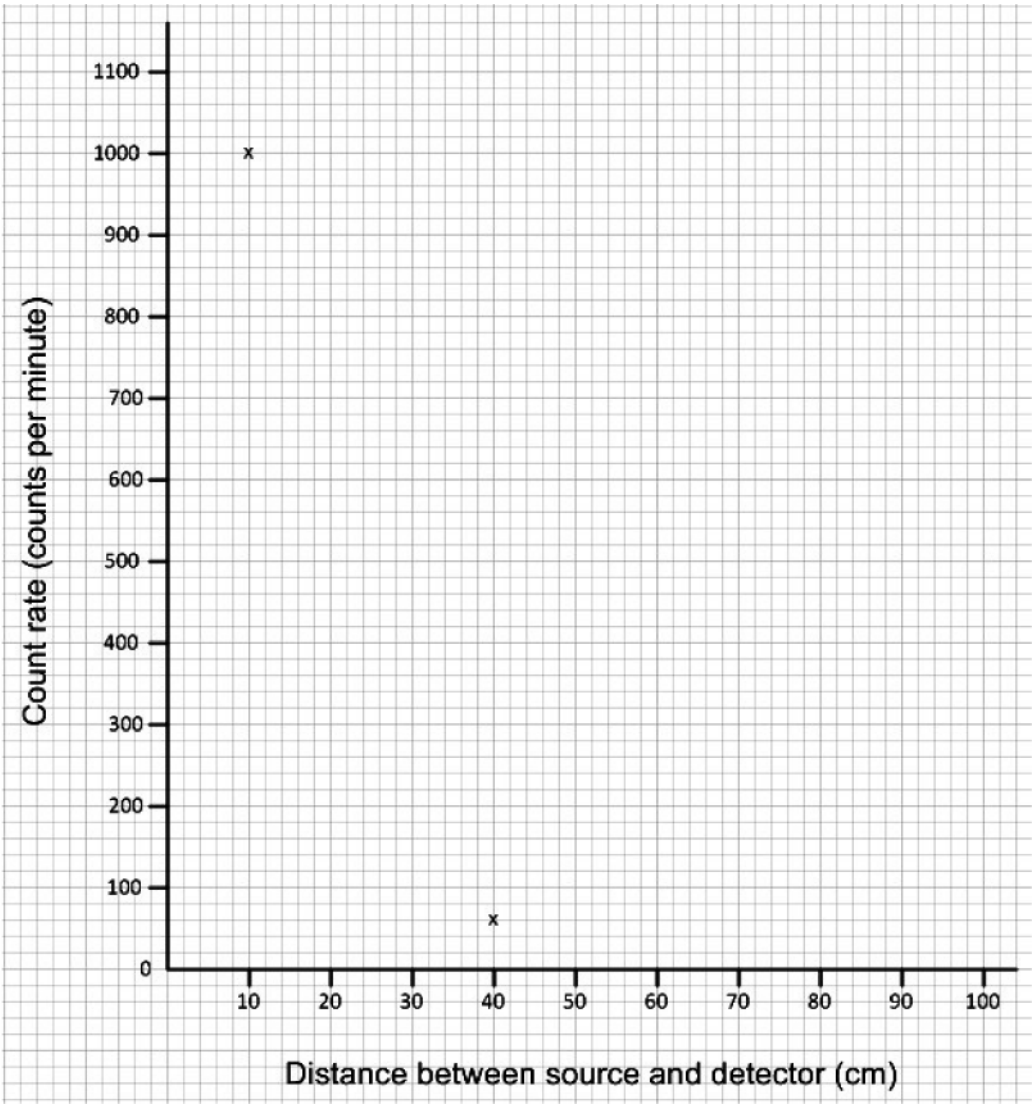
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(b)

(i) Two points for 10 cm and 40 cm have been plotted on the graph below.

Plot the rest of Matt's results and join the points with a smooth curve.




[2]

(ii) Use the graph to estimate the reading at **30 cm**.

**answer:** _____ counts per minute [1]

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(c)

(i) What pattern is shown by the results as the distance is increased from **20** cm to **40** cm?

_____

_____ **[2]**

(ii) Matt wants to find the count rate at 5 cm.

Estimate the count rate at a distance of 5 cm.

**answer:** _____ counts per minute **[1]**

4 An element has more than one isotope.

Which correctly describes the atoms of all isotopes of this element?

| | Numbers of electrons | Numbers of protons | Numbers of neutrons |
|---|---|---|---|
| A | different | different | different |
| B | same | different | different |
| C | same | same | different |
| D | same | different | same |

Your answer ☐

**[1]**

5 The most abundant form of radium is radium-226.

Its nuclear mass is 226 and its nucleus contains 138 neutrons.

Which is an **isotope** of radium?

A nuclear mass 226; 137 neutrons
B nuclear mass 226; 139 neutrons
C nuclear mass 227; 138 neutrons
D nuclear mass 227; 139 neutrons

Your answer ☐

**[1]**

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6 Radium-226, $^{226}_{88}Ra$, decays to become radon-222, $^{222}_{86}Rn$.

What is emitted when a nucleus of radium-226 decays?

A a beta particle
B an alpha particle
C four neutrons
D four protons

Your answer ☐

**[1]**

7 A radioactive source has a half-life of 80 s.

How long will it take for $^{7}/_{8}$ of the source to decay?

A 10 s
B 70 s
C 240 s
D 640 s

Your answer ☐

**[1]**

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8(a) The information below shows information on radioactive isotopes.

| Radioactive isotope | Type of radiation | Half-life | Penetration through human flesh |
|---|---|---|---|
| A | alpha | 300 years | 2mm |
| B | beta | 7 hours | 60mm |
| C | gamma | 7 hours | > 10m |
| D | alpha | 9 seconds | 2mm |
| E | gamma | 3 years | > 10m |

A doctor injects a patient with isotope **C** to track blood flow through the body.

Use the data to suggest why the doctor uses isotope **C**.

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**[1]**

(b) A doctor implants radioactive isotope **A** into a patient to treat a localised cancer which is a few mm in size.

She intends to remove the isotope in a few weeks.

Use the data to suggest **two** reasons why the doctor uses isotope **A**.

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**[2]**

9(a) Matt experiments with radioactive materials.

He investigates how the activity of radiation changes with distance.

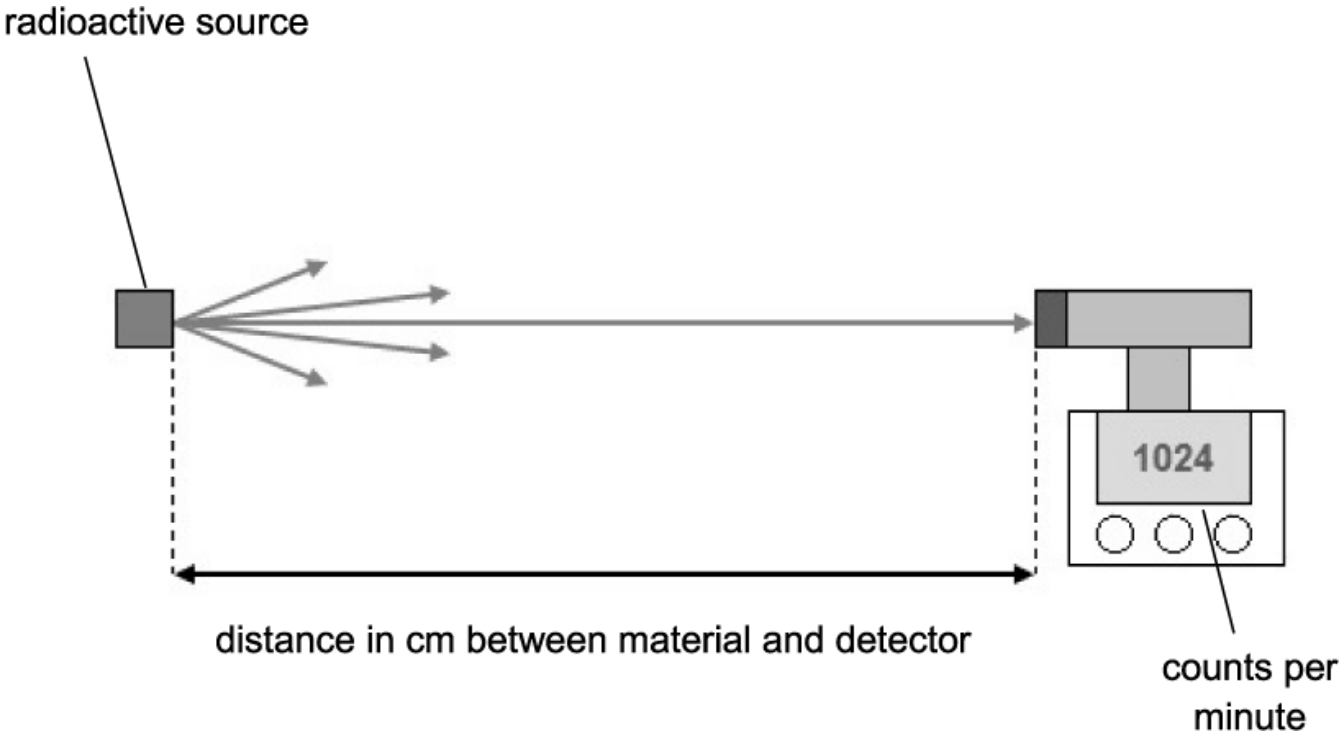
The radiation moves from the source to the detector.

He measures the counts per minute from a radioactive source.

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The table shows the results from the experiment.

| Distance between the source and the detector (cm) | Count rate (counts per minute) |
|---|---|
| 10 | 1024 |
| 20 | 256 |
| 40 | 64 |
| 80 | 16 |

Describe using the data in the table how the count rate changes as the detector is moved away from the source.

[2]

(b) Matt experiments with radioactive materials.

He investigates how the activity of radiation changes with distance.

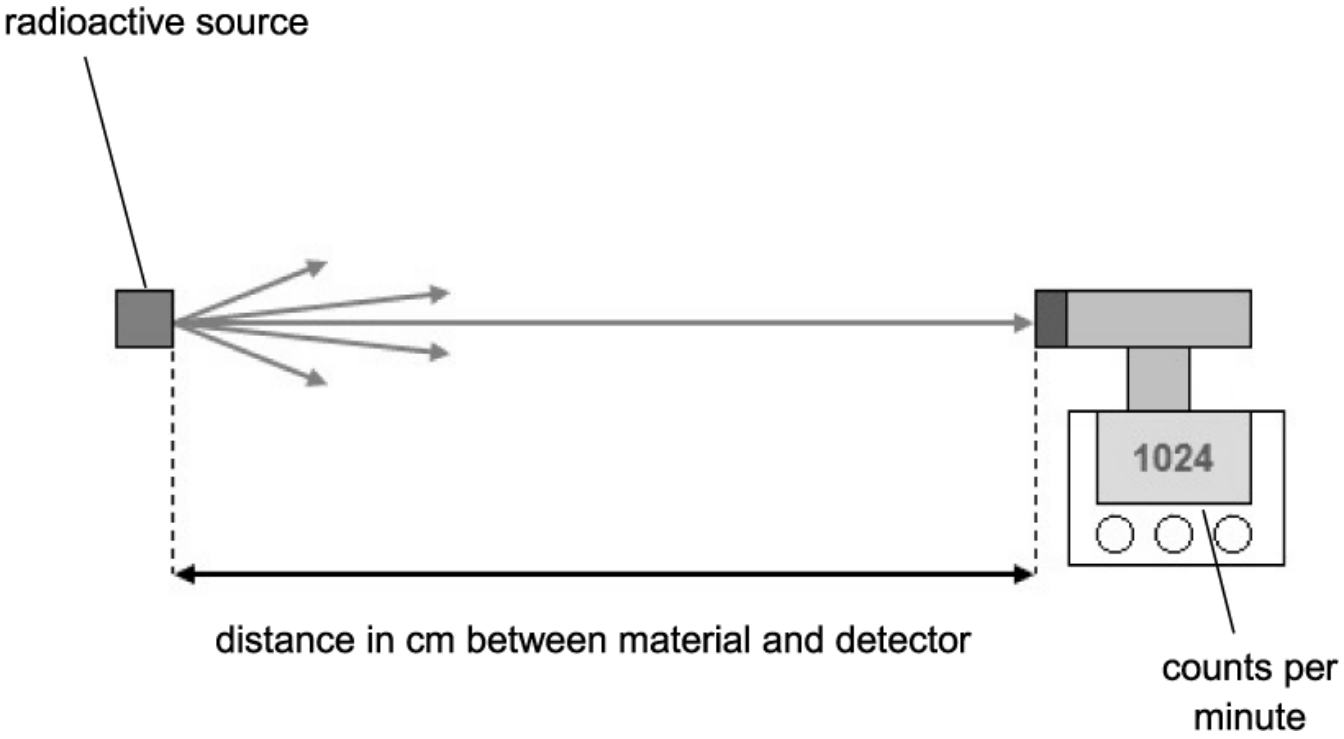
The radiation moves from the source to the detector.

He measures the counts per minute from a radioactive source.

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| Distance between the source and the detector (cm) | Count rate (counts per minute) |
|---|---|
| 10 | 1024 |
| 20 | 256 |
| 40 | 64 |
| 80 | 16 |
| 160 | 6 |
| 320 | 0 |

As the distance is increased to 160 cm and 320 cm the results do not follow the same pattern as the other results.

What do you think these results should have been?

Explain the anomalies in the last two results.

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[3]

10 Mrs Khan explains to her class how to identify the three types of nuclear radiation that can be emitted.

She investigates four different radioactive sources: **A, B, C** and **D**.

Mrs Khan has paper, aluminium and lead to use as absorbers.

She measures the radioactive count rate with and without the absorbers.

Look at her results.

| | Radioactive count rate in counts per minute | | | |
|---|---|---|---|---|
| **Radioactive source** | **No absorber** | **Paper** | **Aluminium** | **Lead** |
| **A** | 200 | 202 | 199 | 22 |
| **B** | 300 | 22 | 20 | 21 |
| **C** | 100 | 78 | 22 | 23 |
| **D** | 250 | 140 | 142 | 20 |

Use the data above to identify which radiations are emitted by each source. Justify your answers.



*The quality of written communication will be assessed in your answer to this question.*

[6]



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11 Nuclear radiation is used in hospitals.

Nuclear radiation from radioactive sources is used as a medical tracer.

Alpha emitters **cannot** be used as medical tracers.
Explain why.

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[1]

12(a) Nuclear radiation is used in hospitals.

Medical tracers must **not** remain active in the body for long periods of time.

(i) Why is it dangerous for a tracer to remain active in the body for long periods of time?

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[1]

(ii) What property of the tracer affects the time it remains active in the body?

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[1]

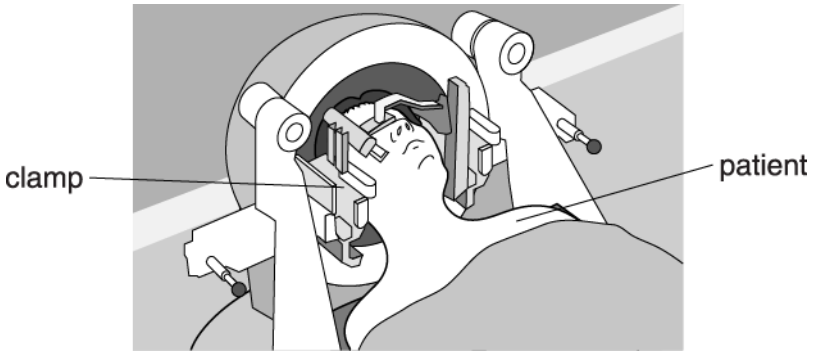
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(b) Gamma knife treatment is used to treat brain cancer.

A gamma knife uses many gamma beams that can be accurately focused on one place.




The patient's head is clamped to keep their head fixed in one position.

Explain why this is important.

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[2]

13 The radiation from tracers needs to be detected outside the body.

Only two types of **nuclear** radiation can pass through the skin.

Which **two** types?

Choose your answers from:

**alpha**

**beta**

**gamma**

**ultrasound**

**ultraviolet**

answer _____ and _____

[2]

14 Mrs Khan is doing some experiments using **radioactive** sources.

She wants to demonstrate the **three** different types of nuclear radiation to her class.

She asks the class about some of the **safety** precautions she should follow when using the radioactive sources.

Explain the safety precautions Mrs Khan should take and name the three different types of nuclear radiation.

*The quality of written communication will be assessed in your answer to this question.*

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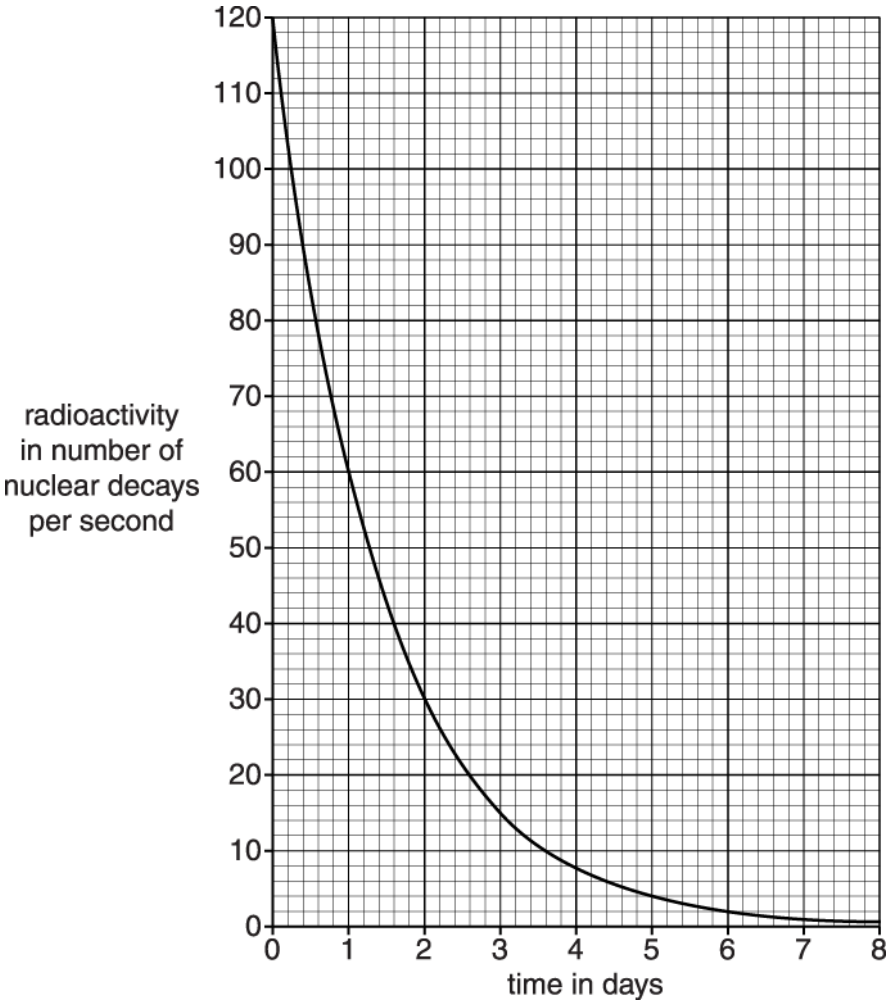
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**[6]**

15(a) Medical radioisotopes use radioactive elements.

Radioactivity is measured by the number of nuclear decays per second.

Look at the graph showing the radioactive decay of element **A**.




(i) What happens to the radioactivity of element **A** between day 1 and day 2?

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**[2]**

(ii) Doctor Hanif compares radioactive element **A** with radioactive element **B**.

Both elements start with the same radioactivity of 120 nuclear decays per second.

Element **B** has a **longer** half-life.

Draw a line on the graph to show the decay of element **B**.

**[1]**

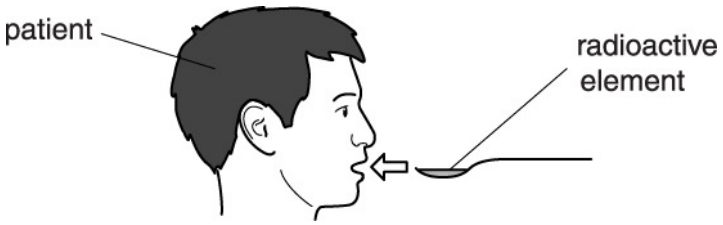
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(b) Doctor Hanif uses element in the hospital where he works.

(i) The patient swallows a liquid containing a small amount of radioactive element.

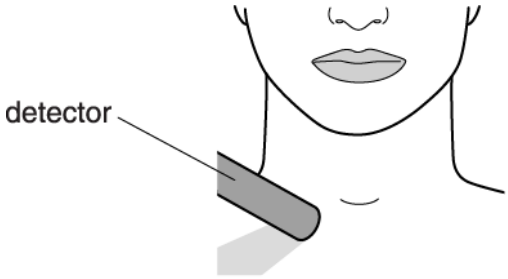



It is important to use a small amount of a radioactive element that decays quickly.

What is the risk of using a radioactive element with a **longer** half-life?

[1]

(ii) The amount of radioactivity near the patient's throat is measured.




What type(s) of radiation can pass through the skin to the detector?

Choose from

**alpha only**

**alpha and beta**

**beta only**

**beta and gamma**



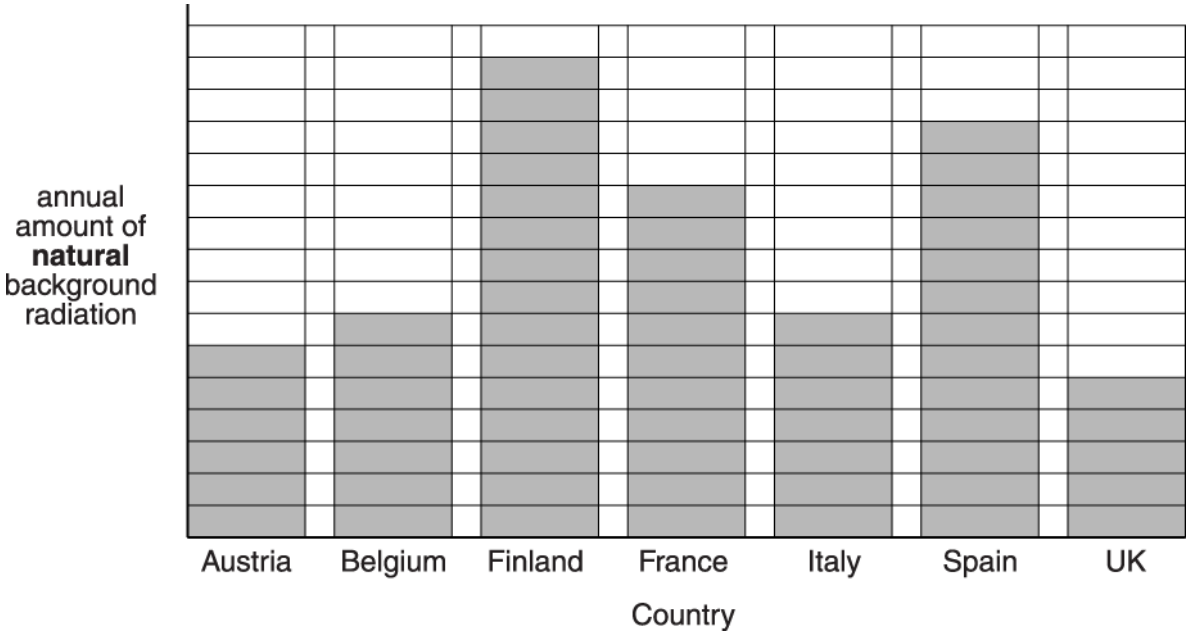
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gamma only

answer _____ [1]

16 This question is about natural and artificial background radiation.

Ben finds information on the internet about **natural** background radiation in different countries.




(i) What does the data show about the **natural** background radiation in different countries?

_____ [1]

(ii) Suggest why Finland has a high annual amount of **natural** background radiation.

_____ [1]

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17(a) Radiation comes from the nucleus of an atom that is unstable.

An alpha particle is a helium nucleus.

What is a beta particle?

Choose the **best** answer from

an electron

a fast moving electron

a proton

a fast moving proton

[1]

(b) What happens to a nucleus when a beta particle is emitted?

Put ticks (?) next to the **two** correct statements.

| | |
|---|---|
| mass number is unchanged | ☐ |
| nucleus has one more neutron | ☐ |
| nucleus has one more proton | ☐ |
| atomic number decreases by one | ☐ |

[1]

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(c) Radioactive americium (Am) is used in smoke alarms.

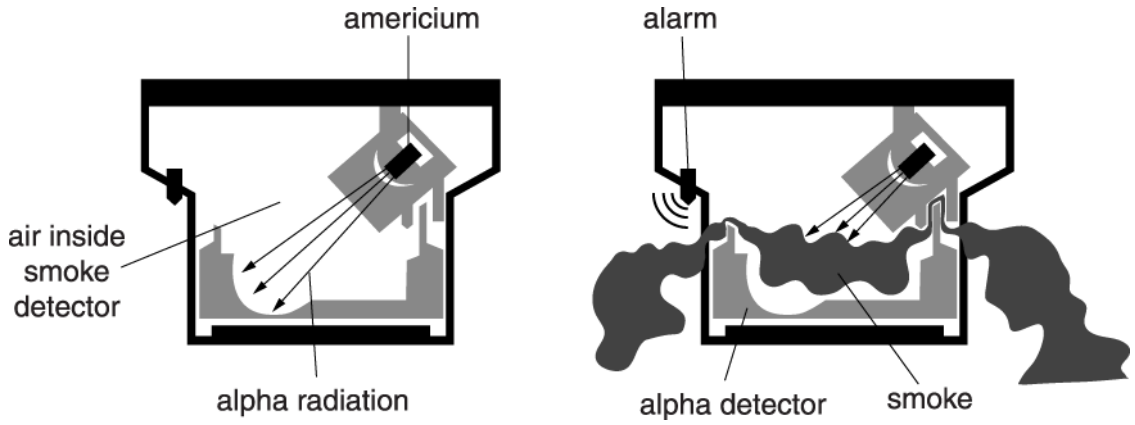
(i) Complete the equation for alpha decay.

An alpha particle is a helium nucleus.

$$^{241}_{95}\text{Am} \rightarrow {}^{\ldots\ldots}_{\ldots\ldots}\text{Np} + {}^{\ldots\ldots}_{\ldots\ldots}\text{He}$$

[2]

(ii) Here are two diagrams showing how a smoke detector works.




Use the diagrams to describe how a smoke detector works.

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[2]



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18 Scientists use several methods to find out when old plants lived.

Here is information about two methods.

| | Relative Dating | Absolute Dating |
|---|---|---|
| **Method** | Find out where plant fossils are in layers of rocks. Newer rocks are on top of older rocks. The method can be used in very old rocks. | This uses carbon dating.<br><br>The amount of radioactive Carbon-14 can be measured in dead plants. This can be compared with the amount of Carbon-14 in living plants to find the age. |
| **Problems** | Cannot find the exact age of the plant fossils. | Cannot be used for very old dead plants as the amount of Carbon-14 is too low. |

Describe why scientists might use both methods to find out when old plants lived.

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--- [2]

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19(a) Radioactivity is measured by the number of decays per second.

Here are measurements from three radioactive sources **A**, **B** and **C**.

| | Number of decays per second | | |
|---|---|---|---|
| Time in minutes | Source A | Source B | Source C |
| 0 | 2020 | 998 | 1034 |
| 100 | 998 | 251 | 862 |
| 200 | 496 | 63 | 674 |
| 300 | 252 | 16 | 566 |
| 400 | 174 | 4 | 472 |

Describe what happens to the measurements for **all** the sources.

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**[2]**

(b) Source **B** has the shortest half-life.

Explain how the measurements in the table show this.

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**[1]**

(c) Where does this radiation come from?

Choose the **best** answer from

**all atoms**

**all elements**

**electrons orbiting the nucleus**

**nucleus**

answer _____

**[1]**

20 Scientists use several methods to find out when old plants lived.

Here is information about two methods.

| | Relative Dating | Absolute Dating |
|---|---|---|
| **Method** | Find out where plant fossils are in layers of rocks. Newer rocks are on top of older rocks. The method can be used in very old rocks. | This uses carbon dating. The amount of radioactive Carbon-14 can be measured in dead plants. This can be compared with the amount of Carbon-14 in living plants to find the age. |
| **Problems** | Cannot find the exact age of the plant fossils. | Cannot be used for very old dead plants as the amount of Carbon-14 is too low. |

Describe why scientists might use both methods to find out when old plants lived.

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**[2]**

21 Dr Williams shows her class an experiment with radioactivity.

She uses three different radioactive sources

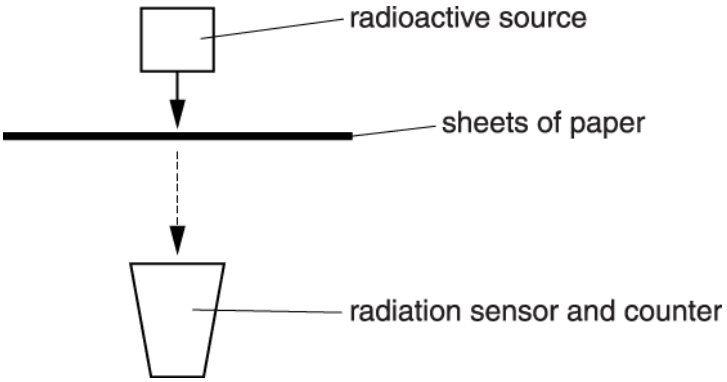
- an alpha emitter
- a beta emitter
- a gamma emitter.

She uses different thicknesses of sheets of paper between the source and the sensor.

Look at the diagram.



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Dr Williams measures the nuclear radiation from each source using the sensor.
Each radioactive source emits only one type of radiation.
This can be alpha, beta or gamma.
Look at her results for each source.

| Thickness of sheets of paper in mm | Average count rate in counts per second | | |
|---|---|---|---|
| | Radioactive source X | Radioactive source Y | Radioactive source Z |
| 0 | 30 | 68 | 65 |
| 0.2 | 32 | 36 | 60 |
| 0.4 | 31 | 21 | 57 |
| 0.6 | 33 | 5 | 52 |
| 0.8 | 34 | 1 | 48 |
| 1.0 | 29 | 0 | 45 |
| 1.2 | 31 | 1 | 41 |
| 1.4 | 30 | 0 | 39 |
| 1.6 | 31 | 0 | 38 |
| 1.8 | 30 | 2 | 35 |
| 2.0 | 31 | 1 | 33 |

Use the data to identify and explain which radiation comes from sources X, Y and Z. Comment on how useful each source is for detecting the thickness of sheets of paper up to 2 mm.

*The quality of written communication will be assessed in your answer to the question.*

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[6]

22 Radioactive substances decay naturally.

Look at the information about two different radioactive substances.

| Time in hours | Activity of substance X in counts per second | Activity of substance Y in counts per second |
|---|---|---|
| 0 | 8 070 | 12 810 |
| 1 | 6 801 | 6 385 |
| 2 | 5 697 | 3 221 |
| 3 | 4 808 | 1 594 |
| 4 | 4 027 | 807 |
| 5 | 3 390 | 392 |
| 6 | 2 861 | 197 |
| 7 | 2 410 | 102 |
| 8 | 2 008 | 51 |

Use the data in the table to compare the half-life of substance **X** and the half-life of substance **Y**.

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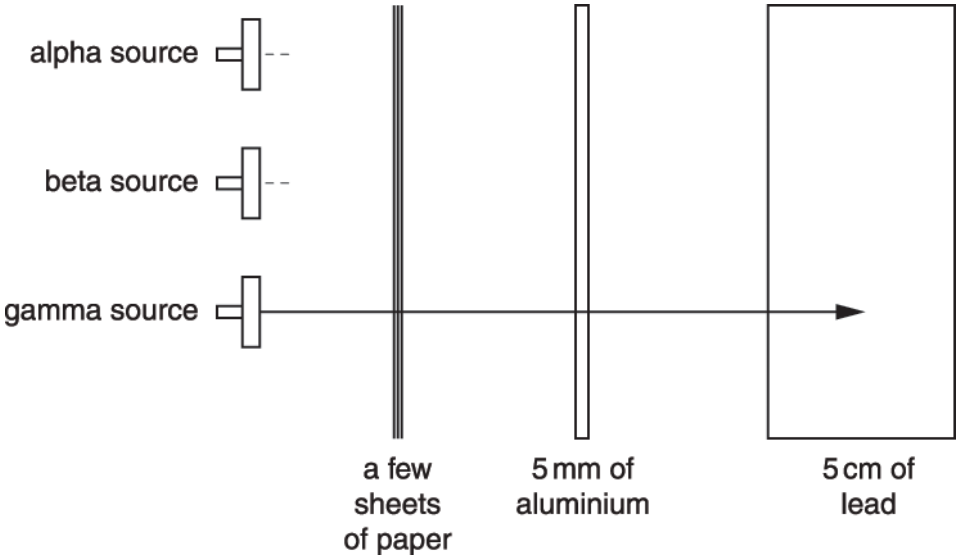
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[2]

23 This question is about nuclear radiation.

Complete the diagram to show the penetrating power of alpha **and** beta radiation.

Gamma radiation has been completed for you.




**[1]**

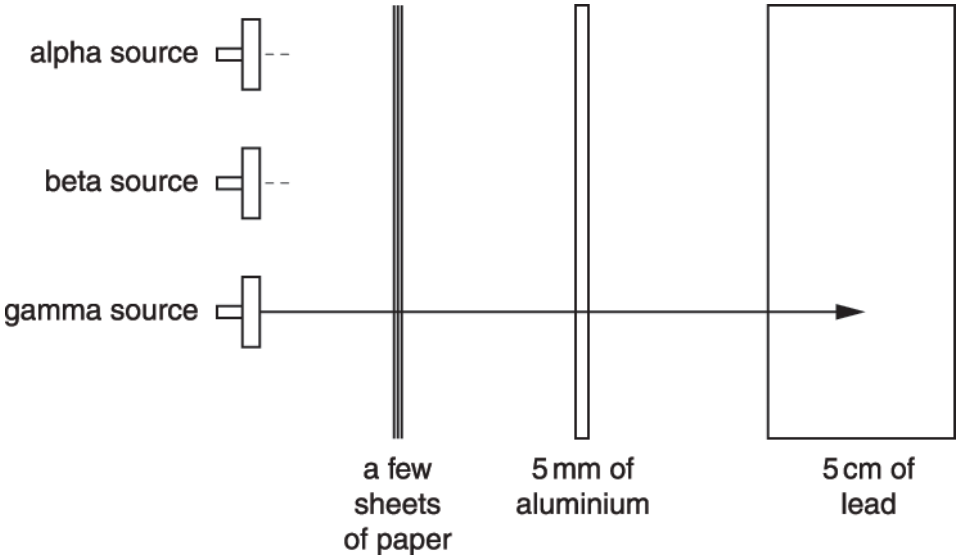


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24 This question is about nuclear radiation.

Complete the diagram to show the penetrating power of alpha **and** beta radiation.

Gamma radiation has been completed for you.




**[1]**



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25 There are three types of nuclear radiation: alpha, beta and gamma.

The three types of radiation have different penetrating powers. They are stopped by different materials.

Mrs Brown shows a gamma source to her class. Her class are not convinced it is a gamma source. She needs to prove it emits gamma radiation only.

Explain how she can **safely** demonstrate to the class that it emits **gamma** radiation but not alpha or beta radiation.

You may draw a diagram to show your answer.

The quality of written communication will be assessed in your answer to this question.

[6]

26

The amount of carbon in dead plants is used to find their age.

When they were alive they took in Carbon-14 (C-14) and Carbon-12 (C-12).

Scientists measure the amount of these two types of carbon.

| Percentage of C-14 remaining | Percentage of C-12 remaining | Number of years dead (Age) |
|---|---|---|
| 100 | 100 | 0 |
| 50 | 100 | 5 730 |
| 25 | 100 | 11 460 |
| 12.5 | 100 | 17 190 |

(i) Use the information in the table to explain what happens to the two types of carbon when the plant dies.

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[2]

(ii) Calculate the age of a dead plant with 6.25 percentage of C-14 remaining.

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[1]

27

Different hydrogen isotopes can undergo fusion.

Complete the **three** gaps in the nuclear equations.

$$^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{\ldots\ldots}_{2}He$$

$$^{2}_{\ldots\ldots}H + {}^{\ldots\ldots}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

**[3]**

28 Emily collects information about different substances used in hospitals.

| Substance | Passes through skin | Used to treat cancer | Harmful to healthy cells |
|---|---|---|---|
| A | yes | yes | very harmful |
| B | yes | no | not harmful |
| C | yes | yes | harmful |
| D | no | yes | harmful |
| E | no | no | not harmful |

(i) Which **two** substances emit gamma radiation?

Explain your answer.

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[3]

(ii) A radiographer uses substances that emit gamma radiation.

Write down **one** safety precaution the radiographer must take.

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[1]

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29 Ralph investigates radioactive sources.

He puts different barriers between the sources and the radiation detector.

He measures the count rate from each source with the different barriers.

Look at the table.

| Source | Amount of radiation (counts per minute) | | | |
|---|---|---|---|---|
| | No barrier | Paper barrier | Thin aluminium barrier | Thick lead barrier |
| A | 542 | 541 | 10 | 10 |
| B | 257 | 255 | 255 | 9 |

Write down the type of radiation emitted by source **A** and source **B**.

Source **A** emits ---------- radiation.

Source **B** emits ---------- radiation. **[2]**

30 Beta radiation is used to check the thickness of thin aluminium foil at a factory.

Why is beta radiation used?

**A** All electromagnetic radiation is reflected by aluminium foil.

**B** Beta radiation will **not** pass through aluminium foil.

**C** Beta radiation will partially pass through aluminium foil.

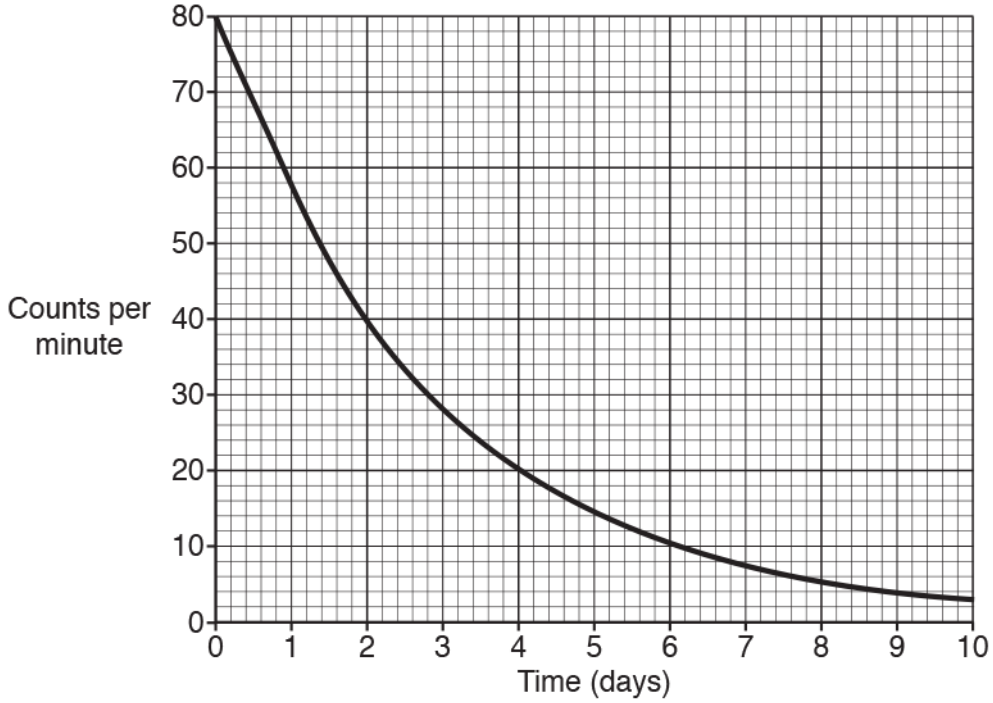
**D** Beta radiation is reflected by aluminium foil.

Your answer ☐ **[1]**



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31 A teacher measures the radiation from a radioactive source for 10 days.




What is the half-life of this radioactive source?

**A** 1 day

**B** 2 days

**C** 4 days

**D** 5 days

Your answer ☐ [1]

32 An alpha particle collides with an atom to produce a positive ion.

What happens to the atom for it to become a positive ion?

A It loses an electron from inside the nucleus.

B It loses an electron from outside the nucleus.

C It loses a neutron from inside the nucleus.

D It loses a proton from outside the nucleus.

Your answer [ ] [1]

33(a) Carbon is a common element. Carbon has two different isotopes called carbon-12 and carbon-14. Both of these isotopes have six protons in the nucleus.

(i) Carbon-14 is radioactive and carbon-12 is **not** radioactive.

Explain why some isotopes are radioactive.

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---

[1]

(ii) Describe how the nucleus of carbon-12 is different to the nucleus of carbon-14.

---

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[1]

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(b) Decay equations are used to show the type of emission from different radioactive elements.

(i) Complete the decay equation for **alpha** emission.

$$^{230}_{92}U \rightarrow {}^{4}_{2}He + {}^{.....}_{.....}Th$$

[2]

(ii) Complete the decay equation for **beta** emission.

$$^{214}_{83}Bi \rightarrow {}^{.....}_{.....}\beta + {}^{214}_{84}Po$$

[2]

(iii) Complete the decay equation for **gamma** emission.

$$^{235}_{.....}U \rightarrow {}^{0}_{0}\gamma + {}^{.....}_{92}U$$

[2]

34 Which statement is true about the **nucleus** of an atom?

**A** It contains neutrons and ions and has a negative charge.

**B** It contains neutrons and ions and has a neutral charge.

**C** It contains neutrons and protons and has a neutral charge.

**D** It contains neutrons and protons and has a positive charge.

Your answer ☐

[1]

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35 Which equation shows a correct alpha decay?

A $^{241}_{95}Am \rightarrow {}^{239}_{91}Np + {}^{2}_{4}He$

B $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{0}_{2}He$

C $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}He$

D $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{0}_{1}He$

Your answer ☐ [1]

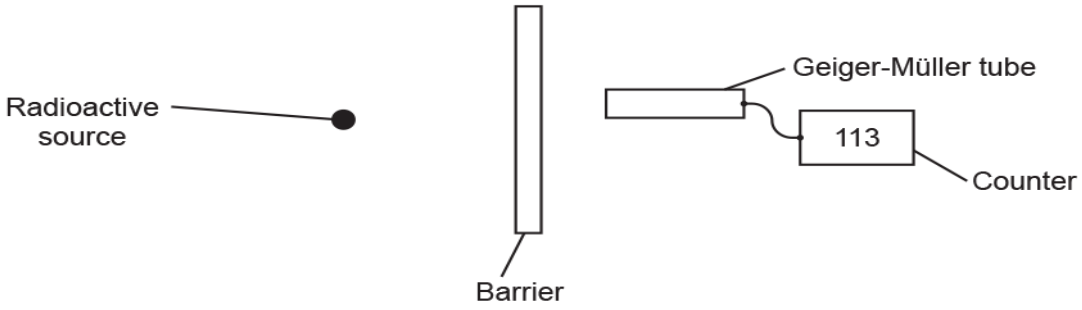
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36(a) A teacher demonstrates an experiment about radioactivity. He demonstrates how different types of radiation can be absorbed.

He puts different barriers between the source and the Geiger-Müller tube. He uses four different radioactive sources **A**, **B**, **C** and **D**.




Suggest two safety **precautions** that the teacher should use when demonstrating this experiment.

1. ---

---

2. ---

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**[2]**

(b) The teacher chooses source **A** and uses the Geiger-Müller tube to measure the count rate (counts per minute) for different barriers. He repeats the experiment with source **B**, source **C** and then source **D**.

Look at his results.

| Source | Count rate using different barriers | | | |
|---|---|---|---|---|
| | Paper | Aluminium | Lead | No barrier |
| **A** | 113 | 112 | 22 | 112 |
| **B** | 20 | 21 | 20 | 182 |
| **C** | 162 | 23 | 21 | 164 |
| **D** | 282 | 78 | 24 | 280 |

He also finds that the **average count rate** with no sources and no barriers is 20.

(i) Which source **A**, **B**, **C** or **D** emits **gamma** radiation only?

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Explain your answer.

Source ---------- because ----------

---

---[2]

(ii) Which source **A**, **B**, **C** or **D** emits **alpha** radiation only?

Explain your answer.

Source ---------- because ----------

---

---[2]

(iii) Which source **A**, **B**, **C** or **D** could emit both **beta and gamma** radiation?

Explain your answer.

Source ---------- because ----------

---

---[2]

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(c) The teacher notices that the count rate behind the lead barrier ranges from 20 to 24.

Give **two** reasons why there are a wide range of results around 22 counts per minute.

1. ---

---

2. ---

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**[2]**

(d) The teacher decides to repeat the experiment.

This time he records the number of counts for a much longer time interval for each source.

Explain why this is an improvement to the experiment.

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**[2]**

37 **Fig. 20.1** shows thinking, braking and stopping distances for the same car travelling at different speeds.

| Speed (m/s) | Thinking distance (m) | Braking distance (m) | Stopping distance (m) |
|---|---|---|---|
| 8 | 6 | 6 | 12 |
| 16 | 12 | 24 | 36 |
| 32 | 24 | 96 | 120 |

**Fig. 20.1**

* Explain why the stopping distances are different for each speed in **Fig. 20.1.**

[6]

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38 The table gives some information about four radioactive isotopes.

Which isotope is the best to use as a medical tracer?

| | Half life | Radiation emitted |
|---|---|---|
| A | 6 hours | alpha |
| B | 6 hours | gamma |
| C | 6 minutes | gamma |
| D | 6 years | beta |

Your answer ☐ [1]

39 Which statement is **true** for isotopes of the same element?

$N_p$ = number of protons and $N_n$ = number of neutrons.

**A** $N_p = N_n$

**B** $N_p$ is the same but $N_n$ is different

**C** $N_p$ is always greater than $N_n$

**D** The total ($N_p + N_n$) is always the same

Your answer ☐ [1]

40(a) A teacher measures the activity of different radioactive isotopes.

**Fig. 23.1** is a graph of her results for isotope **A**.



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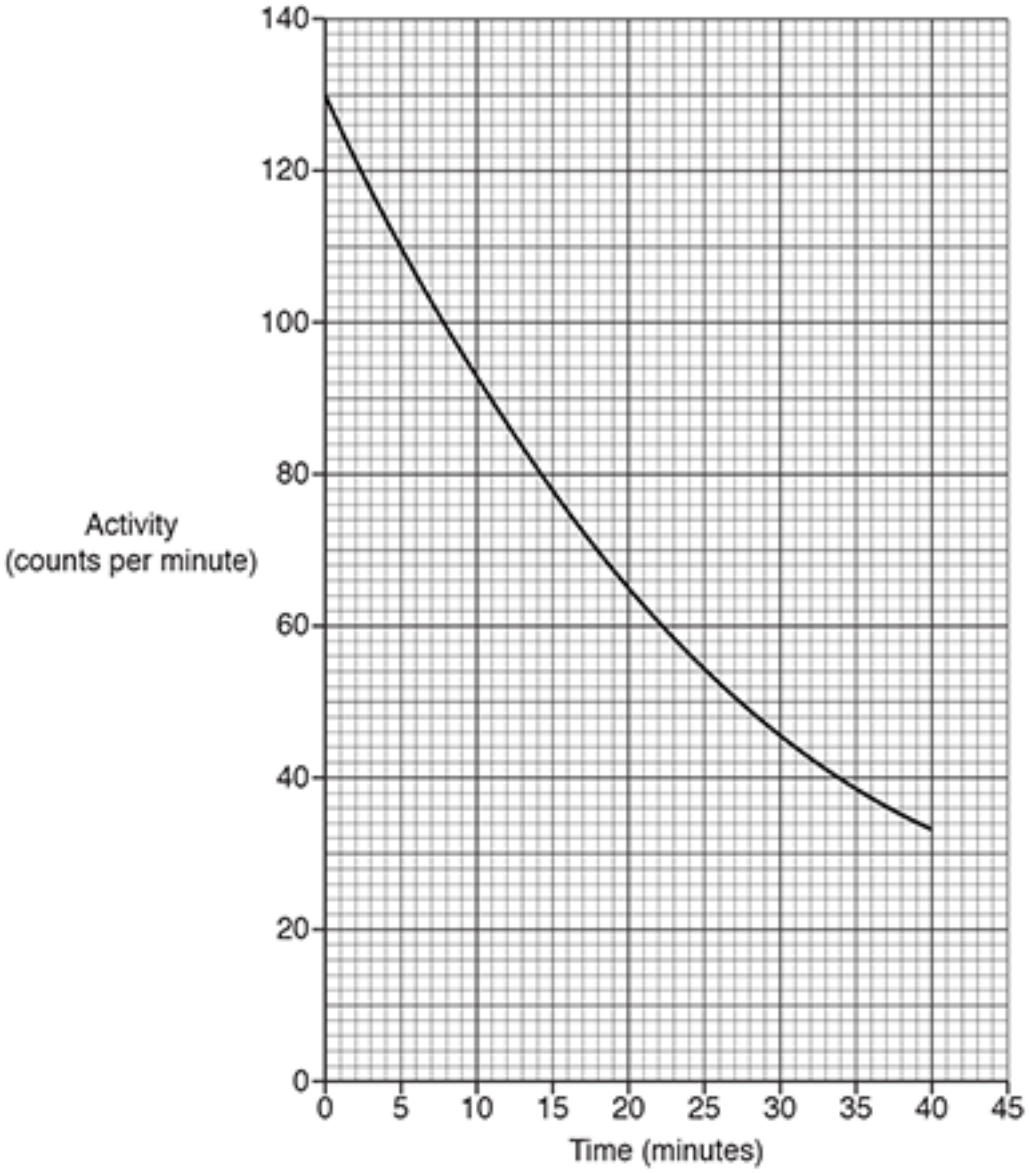



Fig. 23.1

Use Fig. 23.1 to calculate the half-life of isotope A.

Show your working on the graph in Fig. 23.1.

Half-life = ..... minutes **[2]**

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(b) The teacher measures the activity of isotope **B**.

She starts taking activity measurements after 20 minutes.

**Table 23.1** shows her results for isotope **B**.

| Time (minutes) | Activity (counts per minute) |
|---|---|
| 0 | |
| 10 | |
| 20 | 84 |
| 30 | 64 |
| 40 | 52 |
| 50 | 40 |
| 60 | 32 |
| 70 | 25 |
| 80 | 20 |
| 90 | 16 |

**Table 23.1**

Predict the activity of isotope **B** at 0 minutes.

Use the information in **Table 23.1** to help you.

Activity = ..... counts per minute **[2]**

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(c) The teacher measures the activity of isotope **C**.

**Fig. 23.2** is a graph which shows how activity varies with time for isotope **C**.

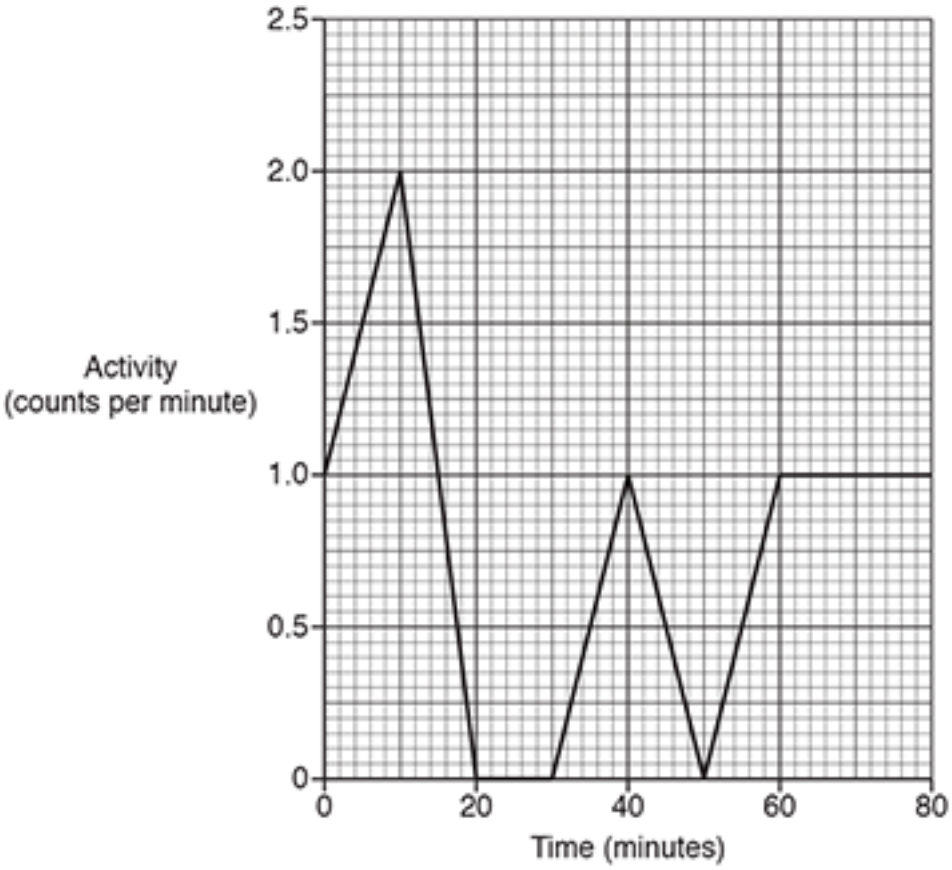



**Fig. 23.2**

A student makes two conclusions from the graph in **Fig. 23.2**:

**Conclusion 1:** I think the results are very inaccurate.
The isotope stops being radioactive and then gets more radioactive again.

**Conclusion 2:** I do **not** think the isotope has a half-life.

Is the student correct?

Evaluate **each** conclusion and explain your answer.

**Conclusion 1**

Conclusion 2 ----------

---

---

---------- [2]

41 Which radioactive decay equation is correct?

A $^{14}_{6}C \rightarrow {}^{10}_{4}Be + {}^{0}_{-1}e$

B $^{14}_{6}C \rightarrow {}^{10}_{4}Be + {}^{0}_{0}\gamma$

C $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{4}_{2}He$

D $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

Your answer [ ] [1]

42(a) Atoms can absorb and emit electromagnetic radiation.

Describe **two** possible effects on an electron in an atom when it absorbs electromagnetic radiation.

1 ----------

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2 ----------

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[2]

(b) Alpha radiation is **not** emitted in the processes in part **(a)**.

Explain why.

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---

**[2]**

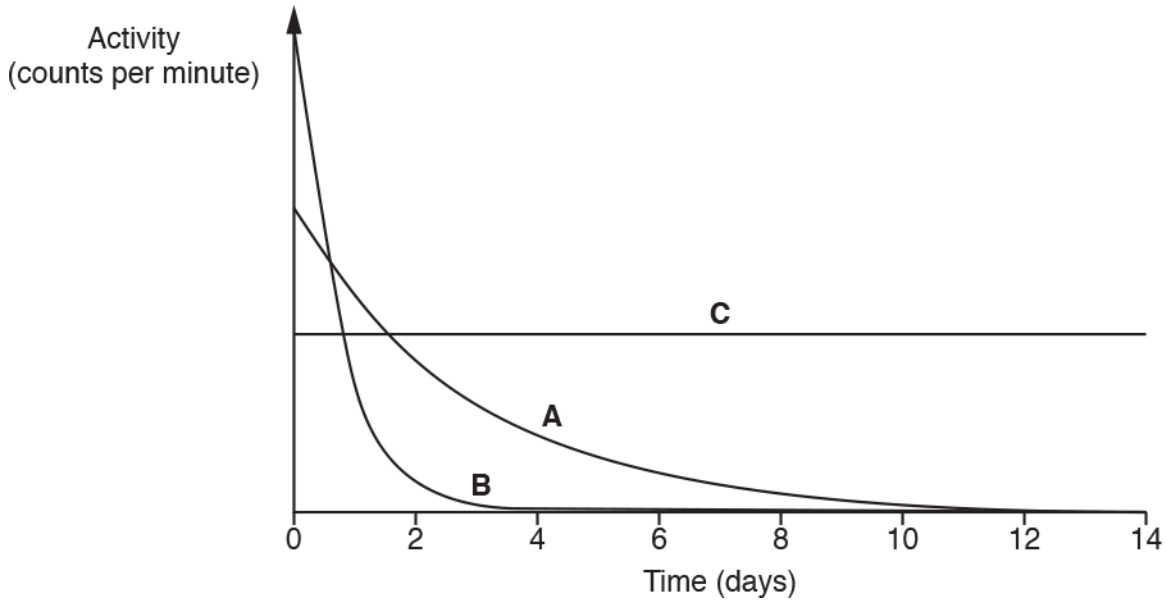
43(a) A radioactive isotope has a half-life of 6 hours.

50 g of the isotope are put in a container.

What mass of the isotope is left after 6 hours?

Mass = ..... g **[1]**

(b) This is a graph showing the radiation emitted from samples of three different isotopes **A**, **B** and **C**.




(i) Which isotope, **A**, **B** or **C**, takes the longest time to decay?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

**[1]**

| | |
|---|---|
| | |

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Do you agree with the views of scientist 1 and scientist 2?

Use the graph and ideas about radioactivity and half-life to explain your answer.

Scientist 1 _____

_____

_____

_____

Scientist 2 _____

_____

_____

_____

**[4]**

(iii) **Scientist 1** wants to identify the type of radiation emitted by isotope **A**.

This is a list of equipment **Scientist 1** has in his laboratory:

- radiation detector
- piece of thick lead
- piece of cardboard
- piece of aluminium.

(ii) Two scientists discuss the isotopes in the graph.

| Scientist 1 | Scientist 2 |
|---|---|
| 'I think isotope **A** is more hazardous than **B**. **A** has a higher activity than **B**.' | 'I think isotope **B** is more hazardous than **A**. **B** has a longer half-life than **A**.' |

Describe how **Scientist 1** does the experiment and explain how they can work out the type of radiation emitted.

You may include a diagram in your answer.

[4]

44 Which statement about alpha particles is correct?

A They are fast moving electrons.
B They are less penetrating than beta particles.
C They can pass through lead.
D They have less mass than beta particles.

Your answer [1]

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45(a) Some isotopes of cobalt are radioactive.

The isotope cobalt-60 (Co-60) has the symbol:

$^{60}_{27}Co$

The isotope cobalt-57 (Co-57) has the symbol:

$^{57}_{27}Co$

(i) State the number of protons in a nucleus of Co-60.

Number of protons = ..... **[2]**

(ii) Give **one** similarity and **one** difference between the nucleus of Co-57 and the nucleus of Co-60.

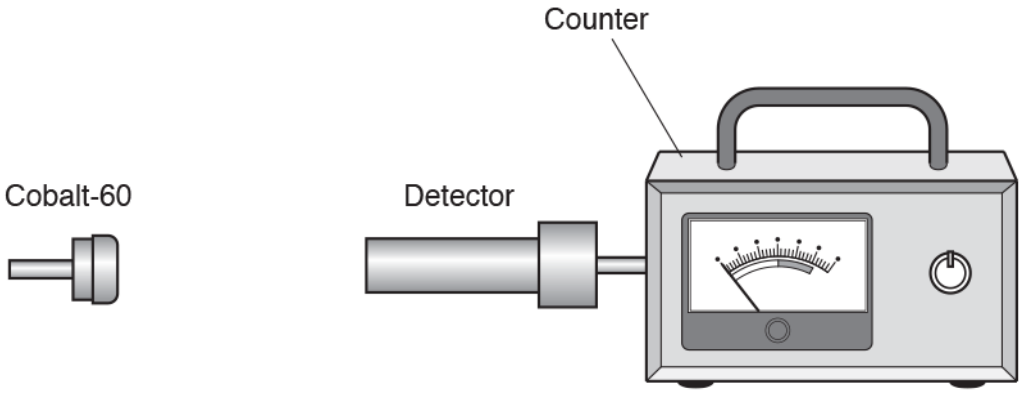
Similarity ----------

Difference ----------

**[2]**

(b) A teacher measures the radiation emitted by Co-60.

She uses this equipment:




The teacher's results are shown in **Table 18.1**.

| | **Count-rate (counts per minute)** |
|---|---|
| **Measurement 1** | 191 |

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| | |
|---|---|
| **Measurement 2** | 224 |
| **Measurement 3** | 212 |

**Table 18.1**

(i) Explain why the teacher's three measurements are **not** the same.

---

---

**[1]**

(ii) Use the teacher's results in **Table 18.1** to calculate the mean count-rate for Co-60.

Count-rate = ..... counts per minute **[2]**

(iii) Co-60 emits gamma radiation.

The teacher puts thin aluminium foil between Co-60 and the detector.

State what happens to the count-rate.

---

**[1]**



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(c)

(i) Explain what is meant by the half-life of a radioactive isotope.

---

---

**[1]**

(ii) The half-life of Co-60 is 5 years.

The count-rate of a sample of Co-60 is 160 counts per minute.

Calculate the count-rate of the Co-60 after 10 years.

Count-rate = ..... counts per minute **[3]**

46 When an electron in an atom changes energy level, it emits electromagnetic radiation.

Which row in the table is correct?

| | Energy level of the electron | Type of radiation emitted |
|---|---|---|
| **A** | Decreases | Almost any electromagnetic radiation. |
| **B** | Decreases | Visible light only. |
| **C** | Increases | Almost any electromagnetic radiation. |
| **D** | Increases | Visible light only. |

Your answer ☐ **[1]**

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47(a) Americium-241 is a radioactive source that is used in smoke detectors.

This is the symbol for americium-241:

$$^{241}_{95}\mathrm{Am}$$

Describe the structure of an americium-241 **nucleus**.

---

---

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**[2]**

(b) Americium-241 decays by emitting alpha radiation to form neptunium (Np).

Complete the balanced symbol equation for the decay.

$$^{241}_{95}\mathrm{Am} \longrightarrow {}^{\ldots\ldots}_{\ldots\ldots}\mathrm{Np} + {}^{4}_{2}\ldots\ldots$$

**[3]**

(c) The half-life of americium-241 is 432 years.

(i) Explain what is meant by **half-life**.

---

---

[1]

(ii) Explain why the half-life of americium-241 is suitable for a smoke detector.

---

---

[1]

(iii) The table shows some data for two radioactive sources.

| Source | Half-life (years) | Radiation emitted |
|---|---|---|
| Americium-241 (Am-241) | 432 | Alpha |
| Thorium-228 (Th-228) | 2 | Alpha |

Both sources start with the same number of radioactive nuclei.

Which source is a greater health risk? Explain your answer.

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[2]

(d) Read the information below about smoke detectors.

In smoke detectors, fine particles of americium-241 are rolled into a metallic foil. The americium-241 cannot be inhaled or move around.

The amount of radiation emitted is very small compared with the natural radioactivity in 1 $m^3$ of soil.

Americium-241 also emits a small amount of gamma rays.

A scientist says, '**There is no risk from the disposal of smoke detectors in household waste**.'

Do you agree with this statement? Give **two** reasons for your answer.

**Yes** ☐

**No** ☐

1 ---

---

2 ---

---

**[2]**

## END OF QUESTION PAPER