AQA GCSE Physics | 8463

SPECIFICATION POINT 4.4.2.1

Radioactive decay and nuclear radiation

Past-paper questions

Tier	**Higher**
Question groups	**127**
Available paper years	**2003–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

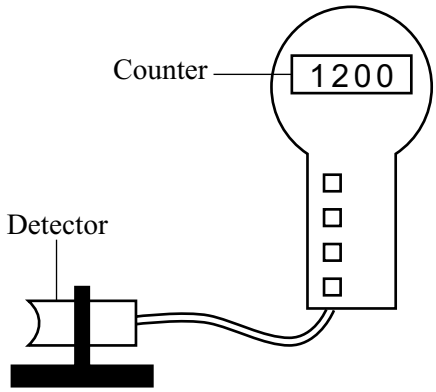
Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.4.2.1 Radioactive decay and nuclear radiation

Question 01

June 2003 | 3451H | Original Q3 | Legacy

3 (a) The diagram shows a radiation detector and counter being used to measure background radiation. The number shows the count ten minutes after the counter was reset to zero.



(i) Name **one** source of background radiation.

.....

(1 mark)

(ii) Calculate the average background radiation level, in counts per second. Show clearly how you work out your answer.

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Background radiation level = ...counts per second

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 01 · continued

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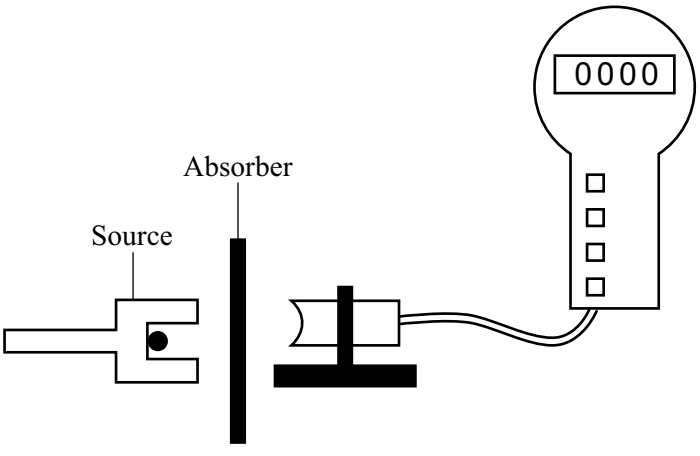
(b) The detector and counter are used in an experiment to show that a radioactive source gives out alpha and beta radiation only.



Two different types of absorber are placed one at a time between the detector and the source. For each absorber, a count is taken over ten minutes and the average number of counts per second worked out. The results are shown in the table.

Absorber used	Average counts per second
No absorber	33
Card 1 mm thick	20
Metal 3 mm thick	2

Explain how these results show that alpha and beta radiation is being given out, but gamma radiation is **not** being given out.

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(3 marks)

6

4.4.2.1 Radioactive decay and nuclear radiation

Question 02

June 2003 | 3451H | Original Q14 | Legacy

14 (a) The table gives information about six radioactive isotopes.

Isotope	Type of radiation emitted	Half-life
hydrogen-3	beta particle	12 years
iridium-192	gamma ray	74 days
polonium-210	alpha particle	138 days
polonium-213	alpha particle	less than 1 second
technetium-99	gamma ray	6 days
uranium-239	beta particle	24 minutes

(i) What is an alpha particle?

.....

(1 mark)

(ii) Two isotopes of polonium are given in the table. How do the nuclei of these two isotopes differ?

.....

(1 mark)

(iii) A doctor needs to monitor the blood flow through a patient's heart. The doctor injects a radioactive isotope into the patient's bloodstream. The radiation emitted by the isotope is then detected outside the body.

Which **one** of the isotopes in the table would the doctor inject into the bloodstream?

.....

Explain the reasons for your choice.

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(3 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 02 · continued

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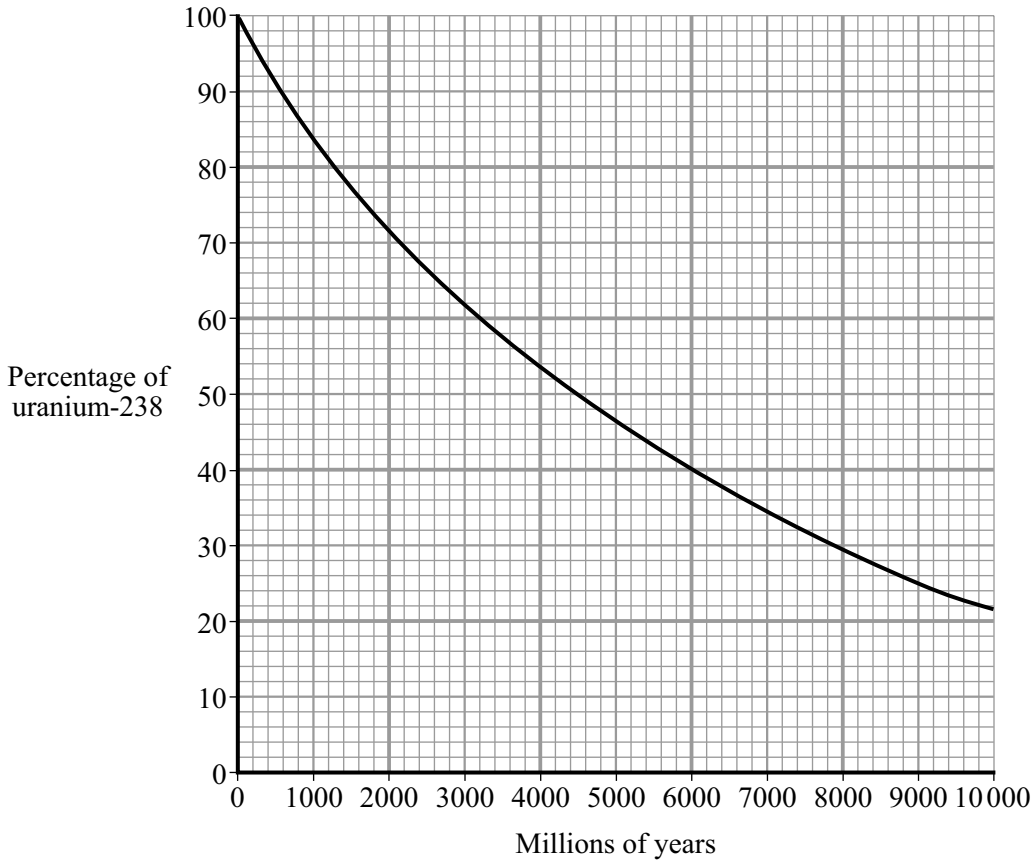
(b) Igneous rock contains uranium-238 which eventually changes to the stable isotope lead-206. The graph shows how the percentage of uranium-238 nuclei present in an igneous rock changes with time.



A rock sample is found to have seven atoms of uranium-238 for every three atoms of lead-206. Use the graph to estimate the age of the rock. Show clearly how you obtain your answer.

.....

.....

Age of rock = ...million years

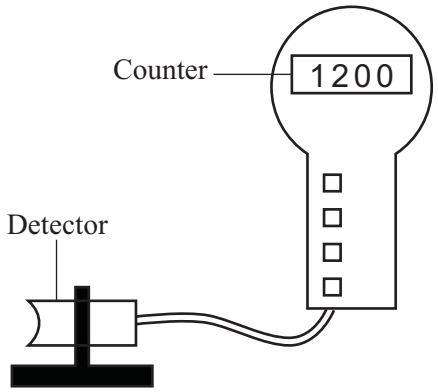
(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 03

3 (a) The diagram shows a radiation detector and counter being used to measure background radiation. The number shows the count ten minutes after the counter was reset to zero.



(i) Name **one** source of background radiation.

.....

(1 mark)

(ii) Calculate the average background radiation level, in counts per second. Show clearly how you work out your answer.

.....

.....

Background radiation level = ...counts per second

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 03 · continued

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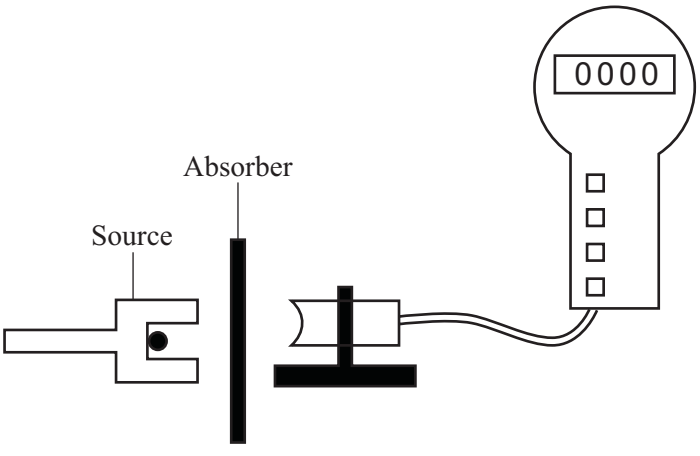
(b) The detector and counter are used in an experiment to show that a radioactive source gives out alpha and beta radiation only.



Two different types of absorber are placed one at a time between the detector and the source. For each absorber, a count is taken over ten minutes and the average number of counts per second worked out. The results are shown in the table.

Absorber used	Average counts per second
No absorber	33
Card 1 mm thick	20
Metal 3 mm thick	2

Explain how these results show that alpha and beta radiation is being given out, but gamma radiation is **not** being given out.

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.....

(3 marks)

6

4.4.2.1 Radioactive decay and nuclear radiation

Question 04

June 2003 | 3462H3 | Original Q12 | Legacy

12 (a) The table gives information about six radioactive isotopes.

Isotope	Type of radiation emitted	Half-life
hydrogen-3	beta particle	12 years
iridium-192	gamma ray	74 days
polonium-210	alpha particle	138 days
polonium-213	alpha particle	less than 1 second
technetium-99	gamma ray	6 days
uranium-239	beta particle	24 minutes

(i) What is an alpha particle?

.....

(1 mark)

(ii) Two isotopes of polonium are given in the table. How do the nuclei of these two isotopes differ?

.....

(1 mark)

(iii) A doctor needs to monitor the blood flow through a patient's heart. The doctor injects a radioactive isotope into the patient's bloodstream. The radiation emitted by the isotope is then detected outside the body.

Which **one** of the isotopes in the table would the doctor inject into the bloodstream?

.....

Explain the reasons for your choice.

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(3 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 04 · continued

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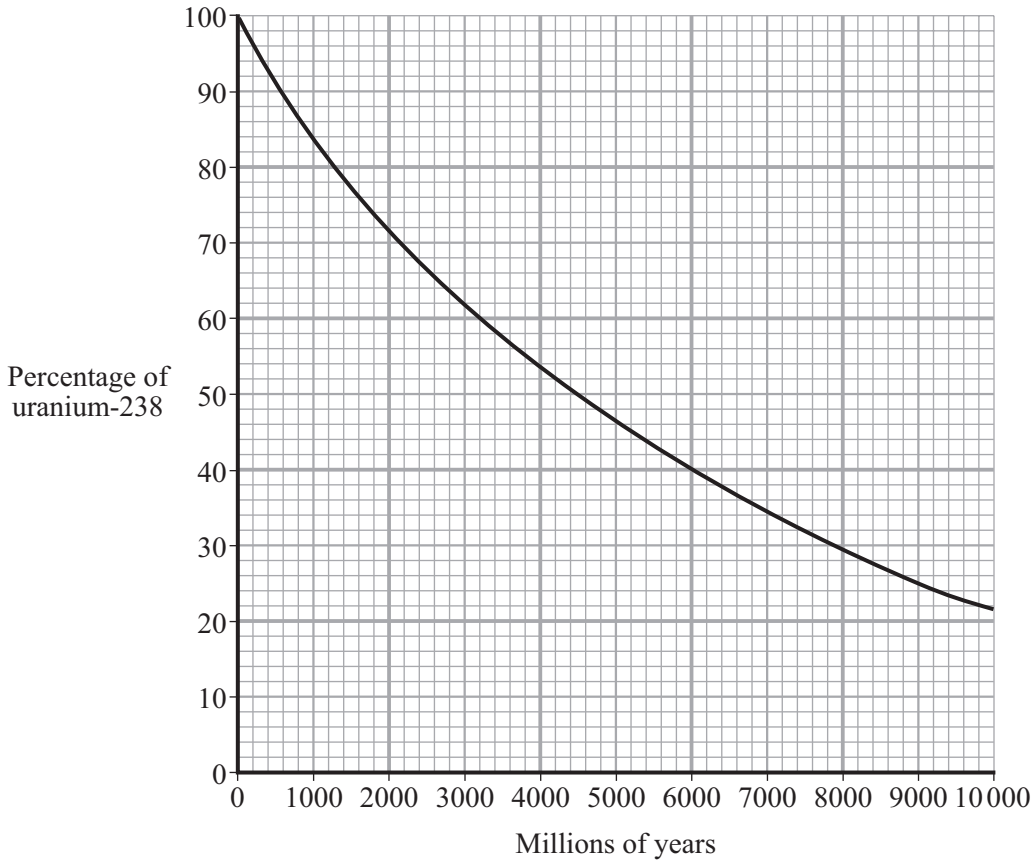
(b) Igneous rock contains uranium-238 which eventually changes to the stable isotope lead-206. The graph shows how the percentage of uranium-238 nuclei present in an igneous rock changes with time.



A rock sample is found to have seven atoms of uranium-238 for every three atoms of lead-206. Use the graph to estimate the age of the rock. Show clearly how you obtain your answer.

.....

.....

Age of rock = ...million years

(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 05

June 2004 | 3451H | Original Q2 | Legacy

2 The diagram represents the electromagnetic spectrum.

Gamma rays	X-rays	Ultraviolet	Visible light	Infra red	Microwaves	Radio waves

(a) Name the type of electromagnetic radiation that is used:

(i) to sterilise surgical instruments;

.....

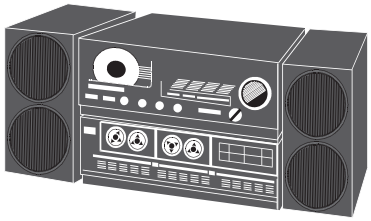
(1 mark)

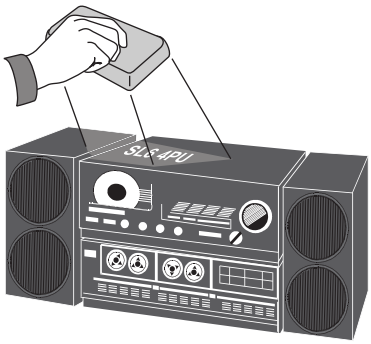
(ii) to send a signal to a TV from a remote control.

.....

(1 mark)

(b) Valuable items can be security marked using special ink. The ink can only be seen in ultraviolet radiation.





Explain what happens to make the ink visible.

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(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 05 · continued

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(c) Explain why skin cells need to be protected from ultraviolet radiation.

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.....

(2 marks)

(d) The following information is from an oven that combines a microwave and a grill.

Voltage	230 V
Microwave power	0.65 kW
Grill power	1.15 kW

(i) Name the **two** types of electromagnetic radiation that the oven can use to cook food.

..... and .....

(1 mark)

(ii) A joint of meat is cooked using both the microwave and the grill. Both are switched on at full power for half an hour.

Use the following equation to calculate the energy transferred, in kilowatt-hours, by the oven. Show clearly how you obtain your answer.

energy transferred = power × time

.....

.....

.....

energy transferred =.....kWh

(2 marks)

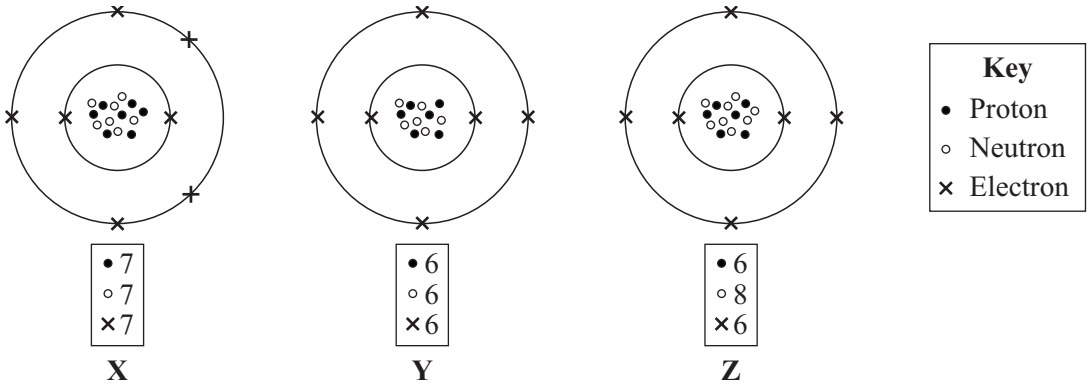
9

4.4.2.1 Radioactive decay and nuclear radiation

Question 06

June 2004 | 3451H | Original Q4 | Legacy

4 (a) The diagrams represent three atoms **X**, **Y** and **Z**.



Which **two** of the atoms are from the same element?

.....

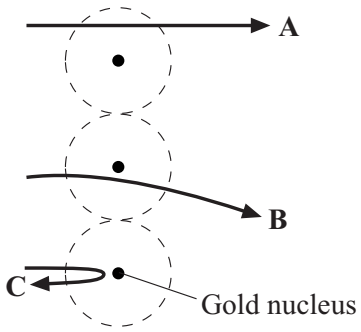
Give a reason for your answer.

.....

.....

(2 marks)

(b) In the early part of the 20th century some scientists investigated the paths taken by positively charged alpha particles into and out of a very thin piece of gold foil. The diagram shows the paths of three alpha particles.



Explain the different paths **A**, **B** and **C** of the alpha particles.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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.....

(3 marks)

5

4.4.2.1 Radioactive decay and nuclear radiation

Question 07

June 2004 | 3451H | Original Q17 | Legacy

17 (a) A beta particle is a high-energy electron.

(i) Which part of an atom emits a beta particle?

.....

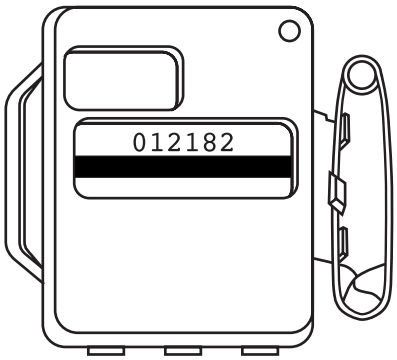
(1 mark)

(ii) How does the composition of an atom change when it emits a beta particle?

.....

(1 mark)

(b) The diagram shows a badge used to monitor radiation. It measures the amount of radiation a worker has been exposed to in one month.



(i) What is used inside the badge to detect radiation?

.....

(1 mark)

(ii) What would indicate that the worker has been exposed to a high level of radiation as opposed to a low level of radiation?

.....

.....

(1 mark)

(iii) Why is it important to monitor the amount of radiation the worker has been exposed to?

.....

.....

(1 mark)

5

4.4.2.1 Radioactive decay and nuclear radiation

Question 08

June 2004 | 3462H3 | Original Q2 | Legacy

2 The diagram represents the electromagnetic spectrum.

Gamma rays	X-rays	Ultraviolet	Visible light	Infra red	Microwaves	Radio waves

(a) Name the type of electromagnetic radiation that is used:

(i) to sterilise surgical instruments;

.....

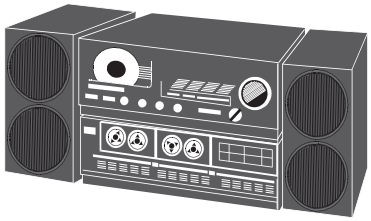
(1 mark)

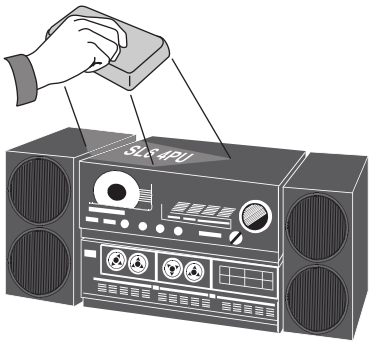
(ii) to send a signal to a TV from a remote control.

.....

(1 mark)

(b) Valuable items can be security marked using special ink. The ink can only be seen in ultraviolet radiation.





Explain what happens to make the ink visible.

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(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 08 · continued

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(c) Explain why skin cells need to be protected from ultraviolet radiation.

.....

.....

.....

.....

(2 marks)

(d) The following information is from an oven that combines a microwave and a grill.

Voltage	230 V
Microwave power	0.65 kW
Grill power	1.15 kW

(i) Name the **two** types of electromagnetic radiation that the oven can use to cook food.

..... and .....

(1 mark)

(ii) A joint of meat is cooked using both the microwave and the grill. Both are switched on at full power for half an hour.

Use the following equation to calculate the energy transferred, in kilowatt-hours, by the oven. Show clearly how you obtain your answer.

energy transferred = power × time

.....

.....

.....

energy transferred =.....kWh

(2 marks)

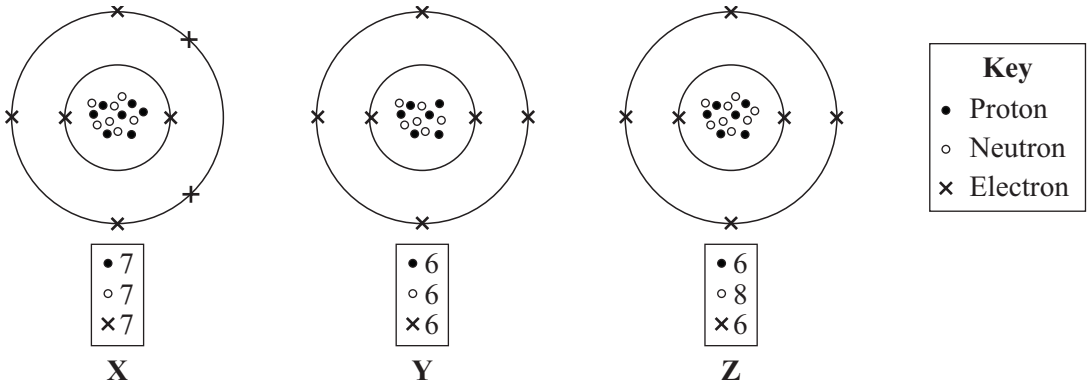
9

4.4.2.1 Radioactive decay and nuclear radiation

Question 09

June 2004 | 3462H3 | Original Q4 | Legacy

4 (a) The diagrams represent three atoms **X**, **Y** and **Z**.



Which **two** of the atoms are from the same element?

.....

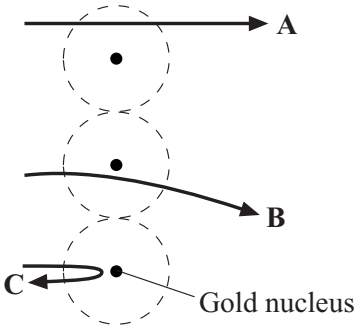
Give a reason for your answer.

.....

.....

(2 marks)

(b) In the early part of the 20th century some scientists investigated the paths taken by positively charged alpha particles into and out of a very thin piece of gold foil. The diagram shows the paths of three alpha particles.



Explain the different paths **A**, **B** and **C** of the alpha particles.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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.....

(3 marks)

5

4.4.2.1 Radioactive decay and nuclear radiation

Question 10

June 2004 | 3462H3 | Original Q13 | Legacy

13 (a) A beta particle is a high-energy electron.

(i) Which part of an atom emits a beta particle?

.....

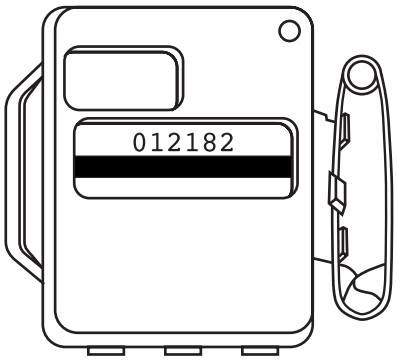
(1 mark)

(ii) How does the composition of an atom change when it emits a beta particle?

.....

(1 mark)

(b) The diagram shows a badge used to monitor radiation. It measures the amount of radiation a worker has been exposed to in one month.



(i) What is used inside the badge to detect radiation?

.....

(1 mark)

(ii) What would indicate that the worker has been exposed to a high level of radiation as opposed to a low level of radiation?

.....

.....

(1 mark)

(iii) Why is it important to monitor the amount of radiation the worker has been exposed to?

.....

.....

(1 mark)

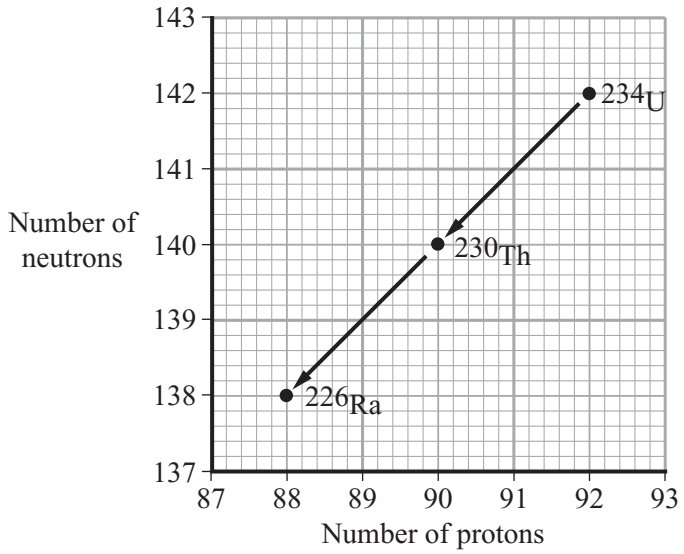
5

4.4.2.1 Radioactive decay and nuclear radiation

Question 11

June 2005 | 3451 | Original Q9 | Legacy

9 (a) Uranium-234 (^{234}U) is a radioactive element. The graph shows the number of protons and neutrons in the nuclei of the elements formed when uranium-234 decays.



(i) How does the graph show that uranium-234 (^{234}U) and thorium-230 (^{230}Th) emit alpha particles?

.....

(1 mark)

(ii) What makes uranium and thorium different elements?

.....

(1 mark)

(iii) Radioactive decay may also produce gamma radiation.

Why does the emission of gamma radiation **not** cause a new element to be formed?

.....

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(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 11 · continued

1 /

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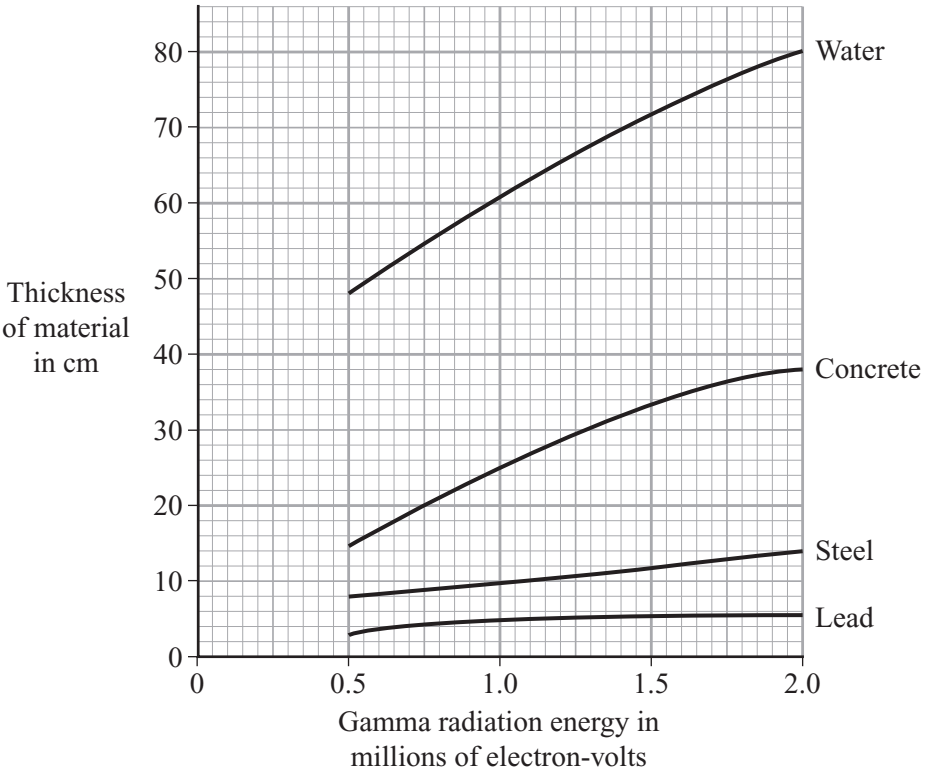
(b) The graph shows how the thickness of different materials needed to absorb 90% of the gamma radiation emitted by a source depends on the energy of the radiation. The energy of the gamma radiation is given in units called electron-volts.



(i) Which of the materials shown is least effective at absorbing gamma radiation? Use the information in the graph to give a reason for your answer.

.....

.....

(1 mark)

(ii) For gamma radiation of energy 1.5 million electron-volts, how many times more effective is steel than water at absorbing the radiation? Show clearly how you obtain your answer.

.....

.....

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(2 marks)

QUESTION 9 CONTINUES ON THE NEXT PAGE

4.4.2.1 Radioactive decay and nuclear radiation

Question 11 · continued

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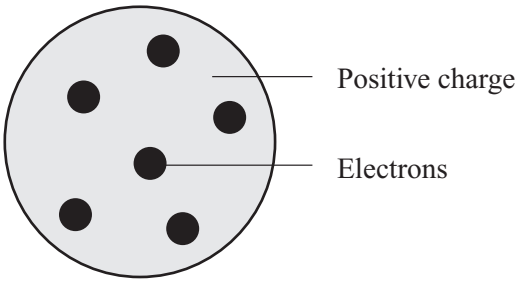
(c) Scientists in the early twentieth century thought that atoms were made up of electrons scattered inside a ball of positive charge. This was called the 'plum-pudding' model of the atom.



Plum pudding model

Rutherford and Marsden did an experiment, in which a beam of alpha particles was aimed at a thin sheet of gold.
Explain how the results of this experiment led to a new model of the atom. You may include one or more diagrams in your answer.

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(3 marks)

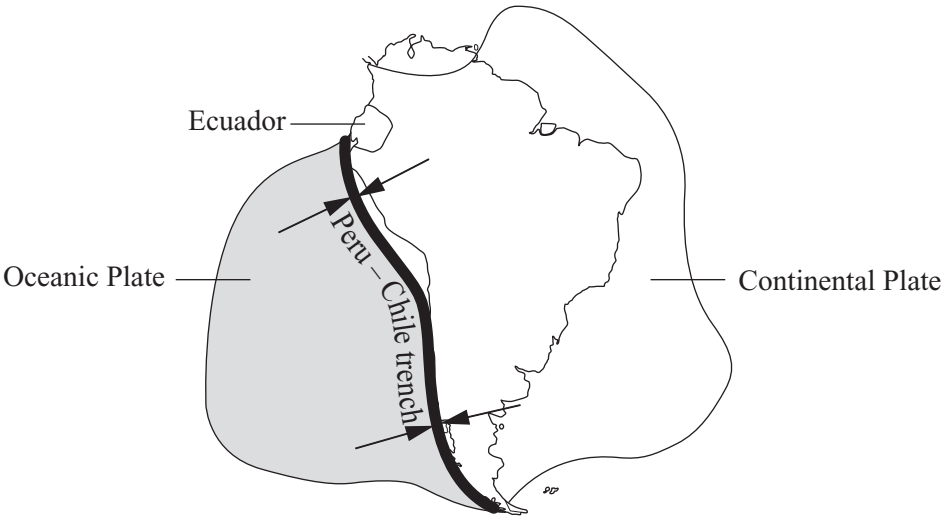
9

4.4.2.1 Radioactive decay and nuclear radiation

Question 12

June 2005 | 3451 | Original Q15 | Legacy

15 The Peru–Chile trench runs down the west coast of South America. It is the boundary between two tectonic plates that are slowly moving towards each other.



Source: WITNEY, DROZDOWSKA AND MAILE, *AQA GCSE Physics* (Hodder & Stoughton) 2002. Adapted and reproduced by permission of Hodder & Stoughton.

(a) Explain what causes the tectonic plates to move.

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.....

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.....

(2 marks)

Question 12 · continued

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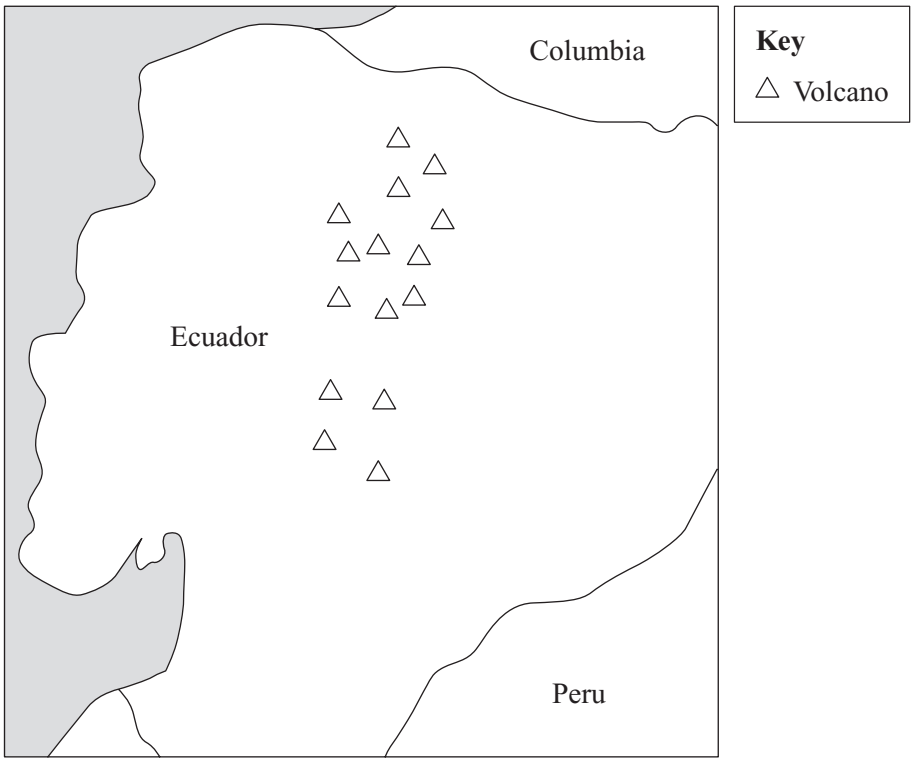
(b) The map shows the location of some of the volcanoes in Ecuador. The volcanoes are all close to the Peru–Chile trench.



Explain how the volcanoes were formed.

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(3 marks)

(c) The eruption of Mount St Helens in the USA is one of the few volcanic eruptions to have been accurately predicted by scientists. The scientists had been monitoring *seismic activity*, levels of sulphur dioxide and changes to the ground level.

(i) What is meant by *seismic activity*?

.....

(1 mark)

QUESTION 15 CONTINUES ON THE NEXT PAGE

4.4.2.1 Radioactive decay and nuclear radiation

Question 12 · continued

MARGIN BLANK

(ii) Suggest why scientists find it difficult to predict accurately when a volcano is going to erupt.

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.....

(2 marks)

(d) The molten rock flowing from an erupting volcano can reach a speed of 8 m/s.

(i) Write down the equation that links kinetic energy, mass and speed.

.....

(1 mark)

(ii) Calculate the kinetic energy of 1 tonne of molten rock flowing at 8 m/s.
(1 tonne = 1000 kg)

.....

.....

Kinetic energy = ... joules
(1 mark)

(e) Read the information in the box and then answer the questions.

> Igneous rocks contain potassium-40. This is a radioactive isotope. It has a half-life of 1300 million years.
>
> Potassium-40 decays into argon-40 which is stable.
>
> Argon escapes from molten rock. Any argon found in an igneous rock must have been produced since the rock solidified.
>
> A sample of an igneous rock has one atom of potassium-40 for every three atoms of argon-40.

(i) What fraction of the potassium-40 has not yet decayed?

.....

(1 mark)

(ii) Calculate the age of the rock.

.....

Age of rock = ... million years
(1 mark)

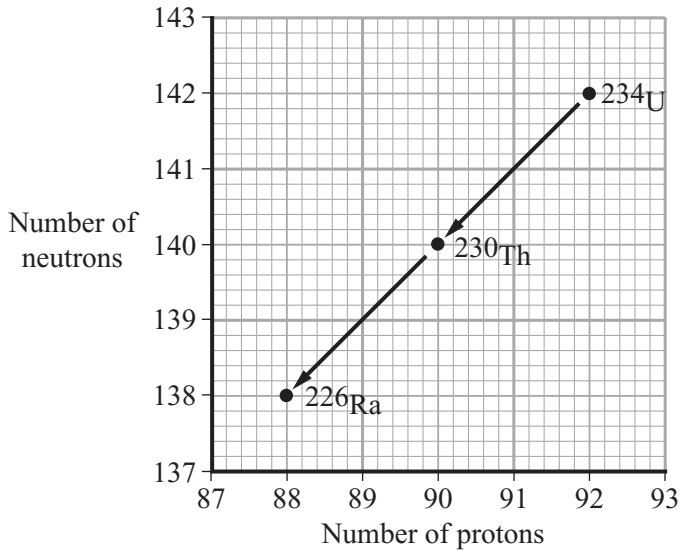
12

4.4.2.1 Radioactive decay and nuclear radiation

Question 13

June 2005 | 3462 | Original Q7 | Legacy

7 (a) Uranium-234 (^{234}U) is a radioactive element. The graph shows the number of protons and neutrons in the nuclei of the elements formed when uranium-234 decays.



(i) How does the graph show that uranium-234 (^{234}U) and thorium-230 (^{230}Th) emit alpha particles?

.....

(1 mark)

(ii) What makes uranium and thorium different elements?

.....

(1 mark)

(iii) Radioactive decay may also produce gamma radiation.

Why does the emission of gamma radiation **not** cause a new element to be formed?

.....

.....

(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 13 · continued

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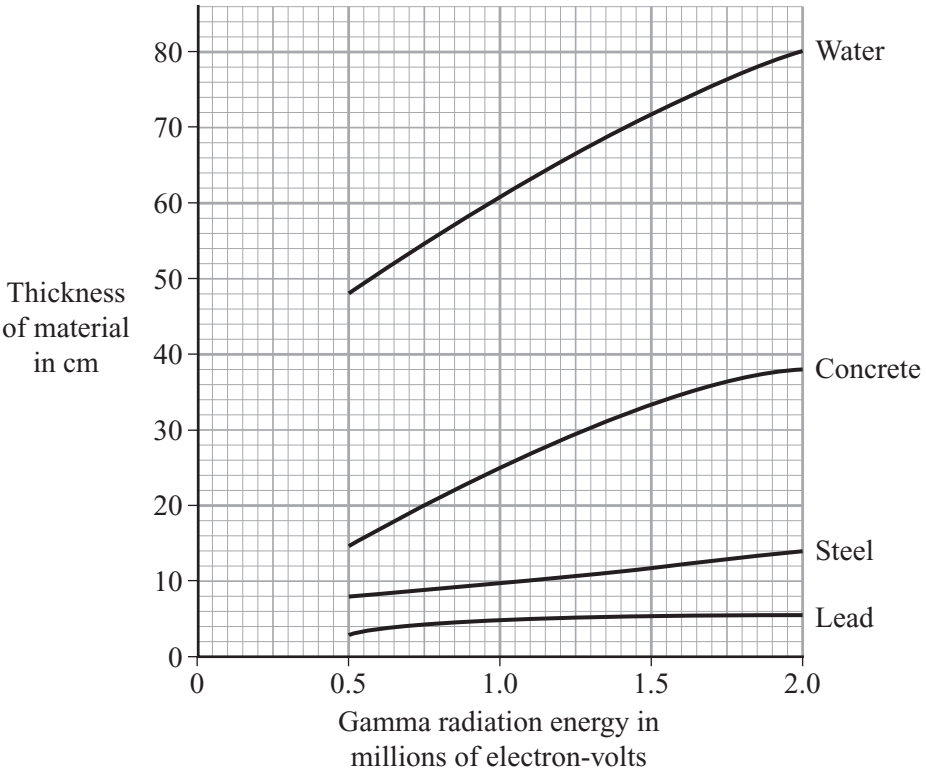
(b) The graph shows how the thickness of different materials needed to absorb 90% of the gamma radiation emitted by a source depends on the energy of the radiation. The energy of the gamma radiation is given in units called electron-volts.



(i) Which of the materials shown is least effective at absorbing gamma radiation? Use the information in the graph to give a reason for your answer.

.....

.....

(1 mark)

(ii) For gamma radiation of energy 1.5 million electron-volts, how many times more effective is steel than water at absorbing the radiation? Show clearly how you obtain your answer.

.....

.....

.....

(2 marks)

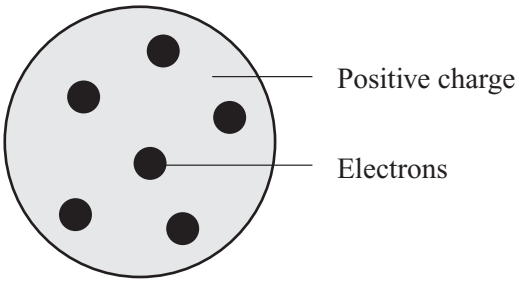
QUESTION 7 CONTINUES ON THE NEXT PAGE

4.4.2.1 Radioactive decay and nuclear radiation

Question 13 · continued

MARGIN BLANK

(c) Scientists in the early twentieth century thought that atoms were made up of electrons scattered inside a ball of positive charge. This was called the 'plum-pudding' model of the atom.



Plum pudding model

Rutherford and Marsden did an experiment, in which a beam of alpha particles was aimed at a thin sheet of gold.
Explain how the results of this experiment led to a new model of the atom. You may include one or more diagrams in your answer.

.....

.....

.....

.....

.....

.....

(3 marks)

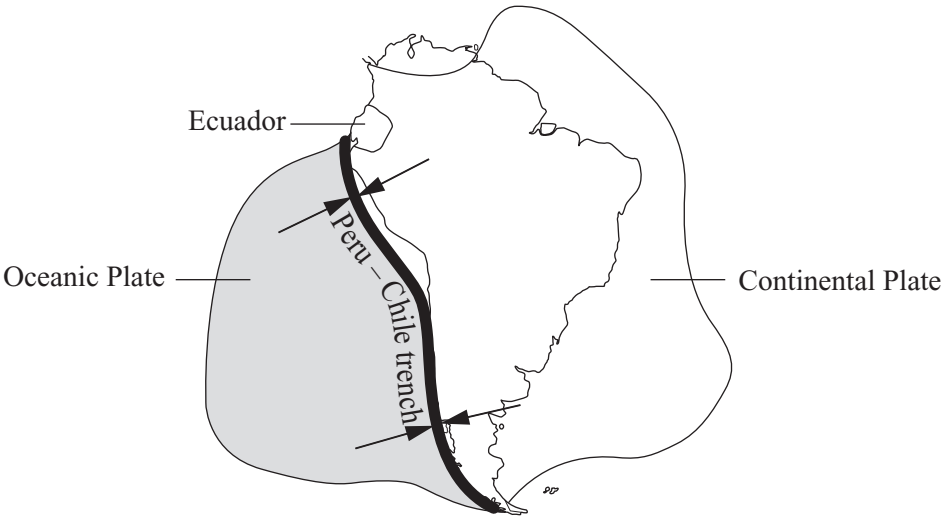
9

4.4.2.1 Radioactive decay and nuclear radiation

Question 14

June 2005 | 3462 | Original Q11 | Legacy

11 The Peru–Chile trench runs down the west coast of South America. It is the boundary between two tectonic plates that are slowly moving towards each other.



Source: WITNEY, DROZDOWSKA AND MAILE, *AQA GCSE Physics* (Hodder & Stoughton) 2002. Adapted and reproduced by permission of Hodder & Stoughton.

(a) Explain what causes the tectonic plates to move.

.....

.....

.....

.....

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 14 · continued

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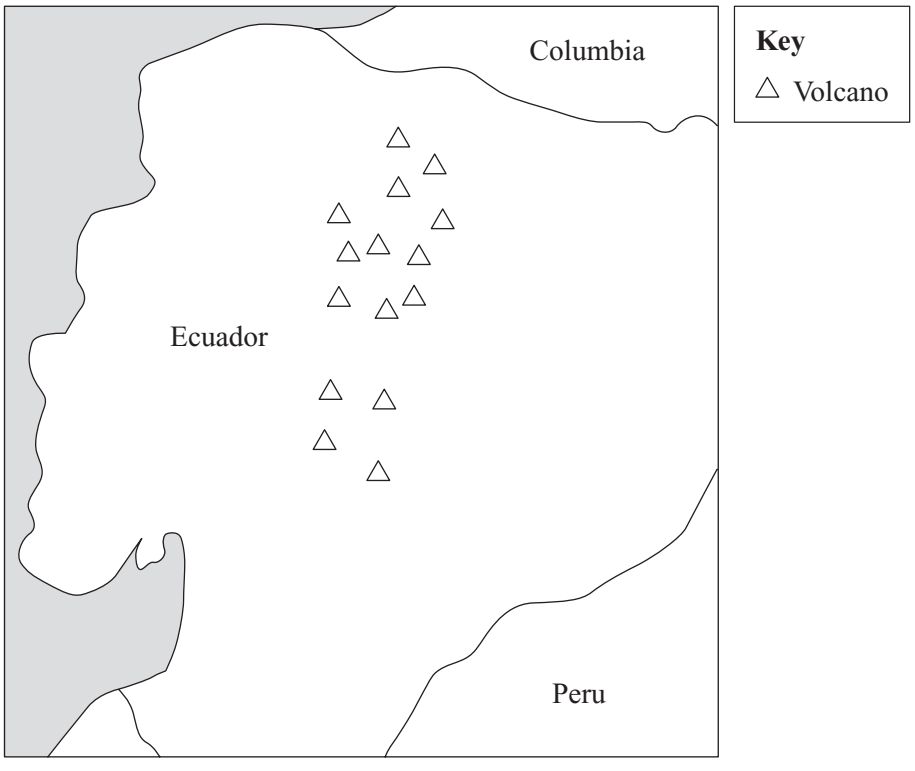
(b) The map shows the location of some of the volcanoes in Ecuador. The volcanoes are all close to the Peru–Chile trench.



Explain how the volcanoes were formed.

.....

.....

.....

.....

.....

.....

(3 marks)

(c) The eruption of Mount St Helens in the USA is one of the few volcanic eruptions to have been accurately predicted by scientists. The scientists had been monitoring *seismic activity*, levels of sulphur dioxide and changes to the ground level.

(i) What is meant by *seismic activity*?

.....

(1 mark)

QUESTION 11 CONTINUES ON THE NEXT PAGE

4.4.2.1 Radioactive decay and nuclear radiation

Question 14 · continued

MARGIN BLANK

(ii) Suggest why scientists find it difficult to predict accurately when a volcano is going to erupt.

.....

.....

.....

.....

(2 marks)

(d) The molten rock flowing from an erupting volcano can reach a speed of 8 m/s.

(i) Write down the equation that links kinetic energy, mass and speed.

.....

(1 mark)

(ii) Calculate the kinetic energy of 1 tonne of molten rock flowing at 8 m/s.
(1 tonne = 1000 kg)

.....

.....

Kinetic energy = ... joules
(1 mark)

(e) Read the information in the box and then answer the questions.

> Igneous rocks contain potassium-40. This is a radioactive isotope. It has a half-life of 1300 million years.
>
> Potassium-40 decays into argon-40 which is stable.
>
> Argon escapes from molten rock. Any argon found in an igneous rock must have been produced since the rock solidified.
>
> A sample of an igneous rock has one atom of potassium-40 for every three atoms of argon-40.

(i) What fraction of the potassium-40 has not yet decayed?

.....

(1 mark)

(ii) Calculate the age of the rock.

.....

Age of rock = ... million years
(1 mark)

12

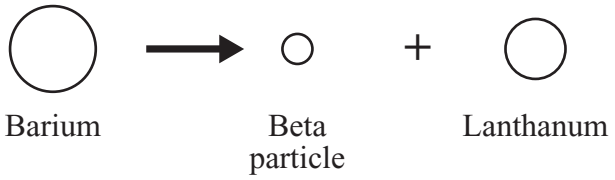
4.4.2.1 Radioactive decay and nuclear radiation

Question 15

June 2006 | 3451 | Original Q10 | Legacy

10 (a) When an unstable barium nucleus changes into a lanthanum nucleus, a beta particle is emitted.

Not to scale



(i) What is a beta particle?

.....

(1 mark)

(ii) How is the nucleus of a lanthanum atom different from the nucleus of a barium atom?

.....

.....

(1 mark)

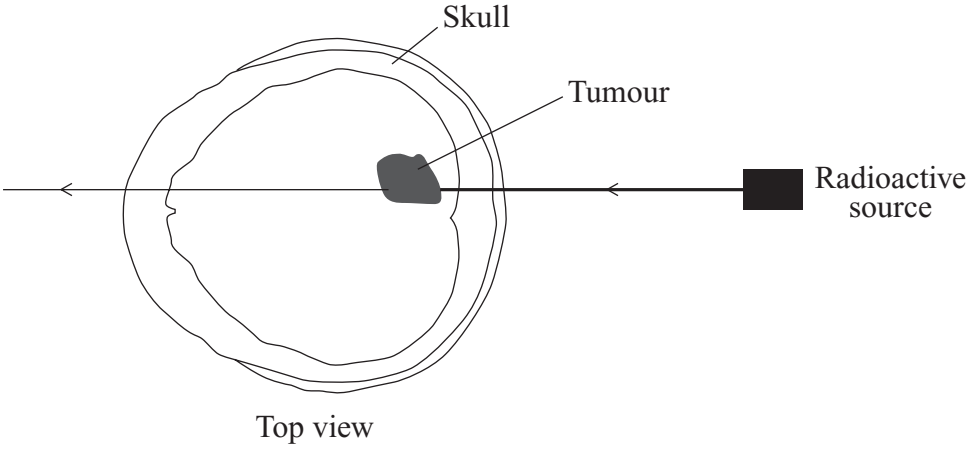
(iii) Describe how a neutral atom may be changed by a collision with a beta particle.

.....

.....

(1 mark)

(b) The diagram shows how radiation can be used to kill the cells of a brain tumour.



Top view

Why is a beta emitting radioactive source unsuitable for this purpose?

.....

.....

(1 mark)

Question 15 · continued

BLANK

(c) The table gives the average radiation dose which someone in the UK receives in one year from background radiation.

Source of radiation	Dose in millisieverts
the ground	0.30
radon gas	0.80
food	0.40
space	0.25
man-made sources	0.25

(i) What percentage of the background radiation comes from space?

.....

.....

(1 mark)

(ii) It is estimated that flying across the Atlantic exposes passengers to an additional radiation dose equivalent to one chest X-ray.

Suggest why flying increases radiation dose and give a possible effect this may have on the health of someone who flies a lot.

.....

.....

.....

.....

(2 marks)

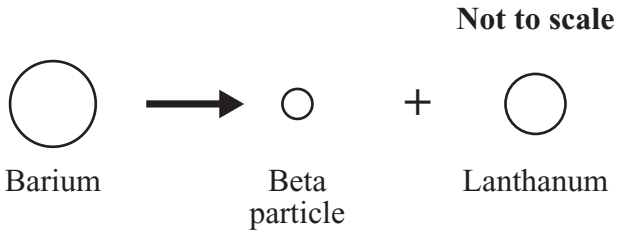
7

4.4.2.1 Radioactive decay and nuclear radiation

Question 16

June 2006 | 3462 | Original Q8 | Legacy

8 (a) When an unstable barium nucleus changes into a lanthanum nucleus, a beta particle is emitted.



(i) What is a beta particle?

.....

(1 mark)

(ii) How is the nucleus of a lanthanum atom different from the nucleus of a barium atom?

.....

.....

(1 mark)

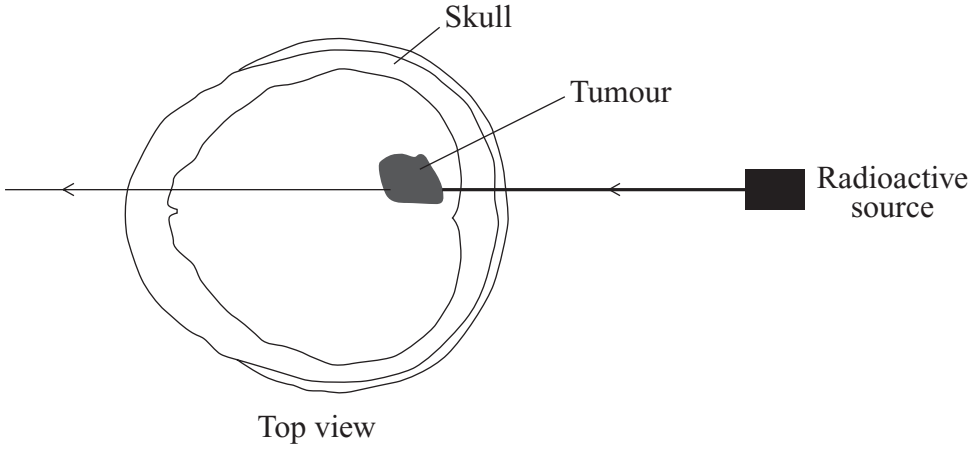
(iii) Describe how a neutral atom may be changed by a collision with a beta particle.

.....

.....

(1 mark)

(b) The diagram shows how radiation can be used to kill the cells of a brain tumour.



Why is a beta emitting radioactive source unsuitable for this purpose?

.....

.....

(1 mark)

Question 16 · continued

BLANK

(c) The table gives the average radiation dose which someone in the UK receives in one year from background radiation.

Source of radiation	Dose in millisieverts
the ground	0.30
radon gas	0.80
food	0.40
space	0.25
man-made sources	0.25

(i) What percentage of the background radiation comes from space?

.....

.....

(1 mark)

(ii) It is estimated that flying across the Atlantic exposes passengers to an additional radiation dose equivalent to one chest X-ray.

Suggest why flying increases radiation dose and give a possible effect this may have on the health of someone who flies a lot.

.....

.....

.....

.....

(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 17

November 2006 | PHY1B | Original Q4 | Legacy

QUESTION FOUR

Read this extract from a science magazine.

Stone Age campfire found in Norfolk

Material made from something which was once alive can be dated by measuring its radioactivity. This is because all living things contain a small proportion of radioactive carbon-14 atoms.

Carbon-14 decays by emitting beta (β) particles and its half-life is 5730 years.

4A An example of something which can be dated by using carbon-14 measurements is . . .

1 a copper coin.

2 a gold brooch.

3 a leather belt.

4 an iron horseshoe.

4B A sample of charcoal from the Stone Age campfire contains 12 billion carbon-14 atoms.

Approximately how many carbon-14 atoms would the sample have contained 6000 years ago?

1 6 billion

2 12 billion

3 24 billion

4 48 billion

4C Carbon-14 **cannot** be used to date samples more than 45 000 years old.

Four students discuss this.

Which student, **1**, **2**, **3** or **4**, has the correct explanation?

1 'It will take too long to make the measurements.'

2 'No carbon-14 atoms will be left in the specimen.'

3 'The proportion of carbon-14 atoms will be too small to measure.'

4 'There are no samples more than 45 000 years old.'

4D A beta (β) particle from an atom of carbon-14 is . . .

1 an electron from the inner part (nucleus) of the atom.

2 an electron from the outer part of the atom.

3 a helium nucleus.

4 a neutron.

4.4.2.1 Radioactive decay and nuclear radiation

Question 18

November 2006 | PHY1B | Original Q5 | Legacy

QUESTION FIVE

Some substances give out radiation from the nuclei of their atoms.

5A A radioactive source emits alpha, beta and gamma radiation.

Which row in the table is correct?

	Deflected by a magnetic field?		
	Alpha	**Beta**	**Gamma**
1	no	no	yes
2	no	yes	no
3	yes	yes	no
4	yes	yes	yes

5B Americium oxide is used in smoke alarms. Atoms of americium can exist as different isotopes.

Which row in the table correctly describes the number of particles in the nucleus of an atom of each of two different isotopes of americium?

	Particles in each isotope	
1	different number of neutrons	different number of protons
2	different number of neutrons	same number of protons
3	same number of neutrons	different number of protons
4	same number of neutrons	same number of protons

4.4.2.1 Radioactive decay and nuclear radiation

Question 18 · continued

5C The radioactive americium oxide used in a smoke alarm emits alpha particles.

These particles . . .

1 add electrons to the air.

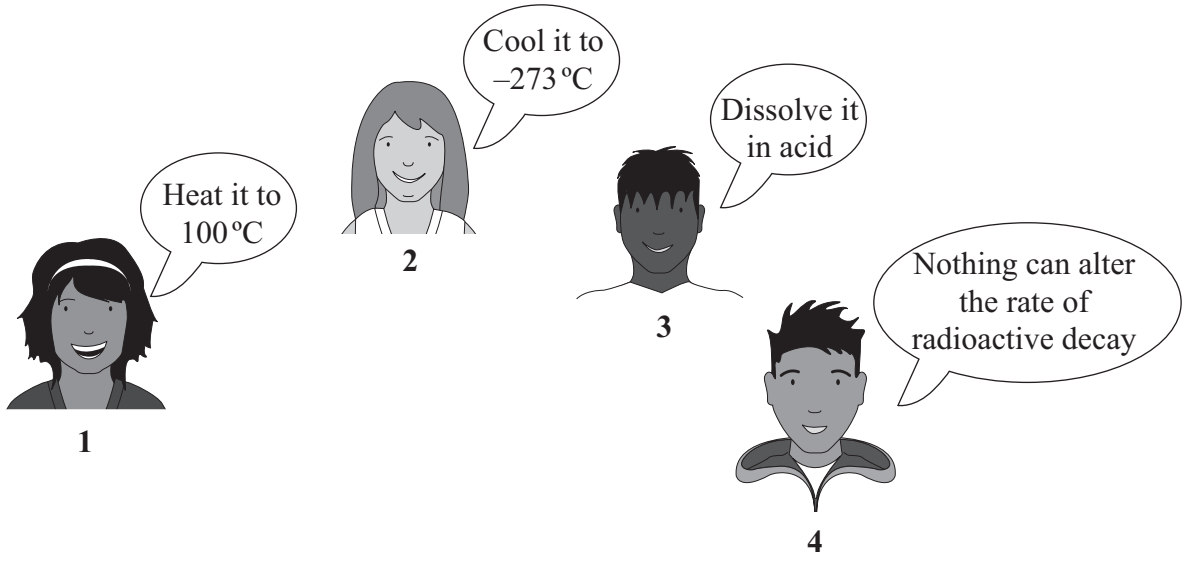
2 add neutrons to the air.

3 add protons to the air.

4 ionise particles in the air.

5D Four students discuss how to alter the rate of decay of a radioactive source.

Which student, **1**, **2**, **3** or **4**, is correct?



4.4.2.1 Radioactive decay and nuclear radiation

Question 19

4 (a) Alpha particles (α), beta particles (β) and gamma rays (γ) are types of nuclear radiation.

(i) Which of the three types of radiation is the most strongly ionising?

.....

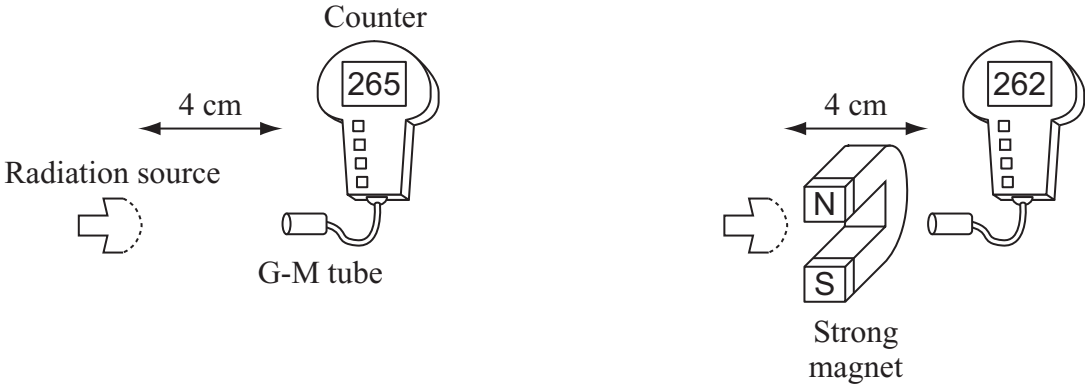
(1 mark)

(ii) What effect does nuclear radiation have on living cells?

.....

(1 mark)

(b) The diagrams show a G-M tube and counter used to measure the radiation emitted from a source. Both diagrams show the reading on the counter one minute after it was switched on.



Explain why the counter readings show that the source is giving out only gamma radiation.

.....

.....

.....

.....

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 19 · continued

BLANK

(c) The box gives information about the radioactive isotope technetium-99.

Type of radiation emitted: gamma
Half-life: 6 hours
Used as a medical tracer

What is meant by the term *half-life*?

.....

.....

(1 mark)

(d) To study the blood flow in a patient's lungs, a doctor injects a small quantity of a technetium-99 compound into the patient. The radiation emitted by the technetium-99 atoms is detected outside the patient's body.

Explain why a doctor would not use a radioactive isotope with a very short half-life, such as 2 seconds, as a medical tracer.

.....

.....

.....

.....

(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 20

March 2007 | PHY1B | Original Q2 | Legacy

QUESTION TWO

Match types of electromagnetic radiation, **A**, **B**, **C** and **D**, with numbers **1–4** in the table.

A gamma rays

B microwaves

C ultraviolet rays

D X-rays

	Properties of radiation
1	do not penetrate human tissue below skin depth but can cause severe burns
2	penetrate only a few centimetres into human tissue but produce a lot of heat
3	pass through all types of human tissue, including bones, and can kill all types of cell
4	pass easily through soft human tissue without much absorption

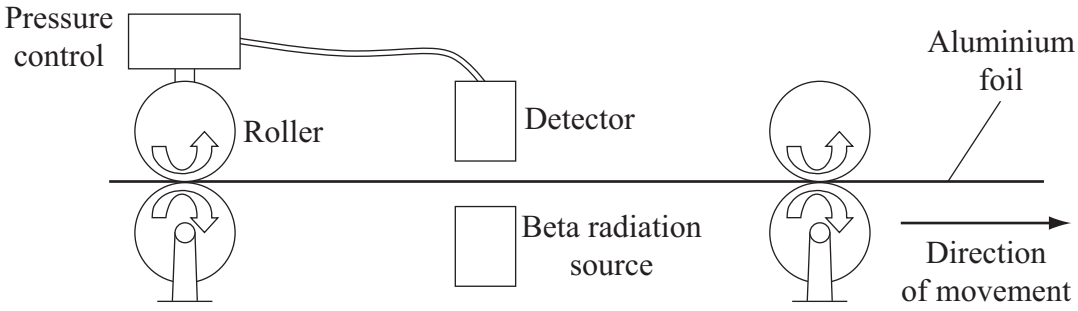
4.4.2.1 Radioactive decay and nuclear radiation

Question 21

March 2007 | PHY1B | Original Q5 | Legacy

QUESTION FIVE

The diagram shows how the thickness of aluminium foil is controlled during its manufacture. The thicker the aluminium foil, the more radiation it absorbs.



5A A beta particle consists of . . .

1 one electron.

2 one proton.

3 two protons.

4 two protons and two electrons.

5B Starting with the most penetrating radiation, which is the correct order?

1 alpha → beta → gamma

2 beta → alpha → gamma

3 beta → gamma → alpha

4 gamma → beta → alpha

5C Which sentence correctly explains why alpha and gamma radiation sources are unsuitable for use in this machine?

1 Alpha particles would be stopped by the foil but gamma rays would not be stopped.

2 Both would be stopped by the foil.

3 Gamma rays would be stopped by the foil but alpha particles would not be stopped.

4 Neither would be stopped by the foil.

5D A worker accidentally receives a short exposure to the beta radiation.

A day later, this is most likely to have caused . . .

1 cancer.

2 death.

3 hair loss.

4 skin burns.

Turn over for the next question

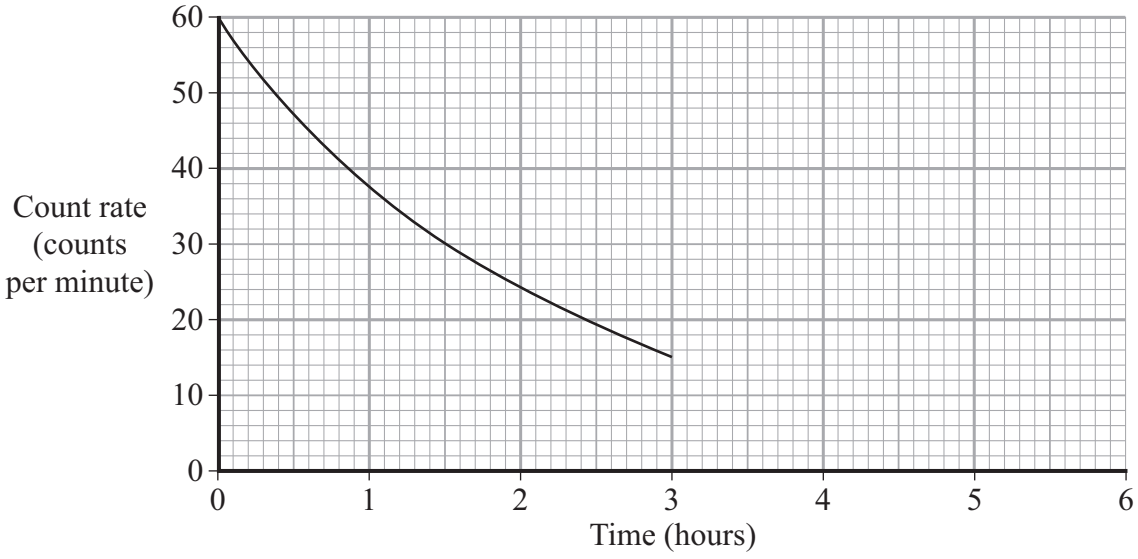
4.4.2.1 Radioactive decay and nuclear radiation

Question 22

March 2007 | PHY1B | Original Q6 | Legacy

QUESTION SIX

The graph shows how the count rate of a radioactive sample changes over a period of 3 hours.



6A The half-life of this isotope is . . .

1 $\frac{1}{2}$ hour

2 1 hour

3 $1\frac{1}{2}$ hours

4 3 hours

6B If the count rate of the sample was x counts per minute at the start of the experiment, what value would it have fallen to after 6 hours?

1 $\frac{x}{4}$

2 $\frac{x}{6}$

3 $\frac{x}{8}$

4 $\frac{x}{16}$

4.4.2.1 Radioactive decay and nuclear radiation

6C The radioactive sample used in the experiment . . .

1 must be an alpha particle emitter.

2 will become totally inactive after about 12 hours.

3 would emit radiation at a higher rate if heated.

4 would produce the same shape of graph if it had been reacted with acid before the start.

6D A radioactive isotope should **not** have a long half-life if it is used . . .

1 as a source of energy in a submarine.

2 as a tracer injected into someone's small intestine.

3 in a smoke detector.

4 to monitor the thickness of a roll of paper as it is being manufactured.

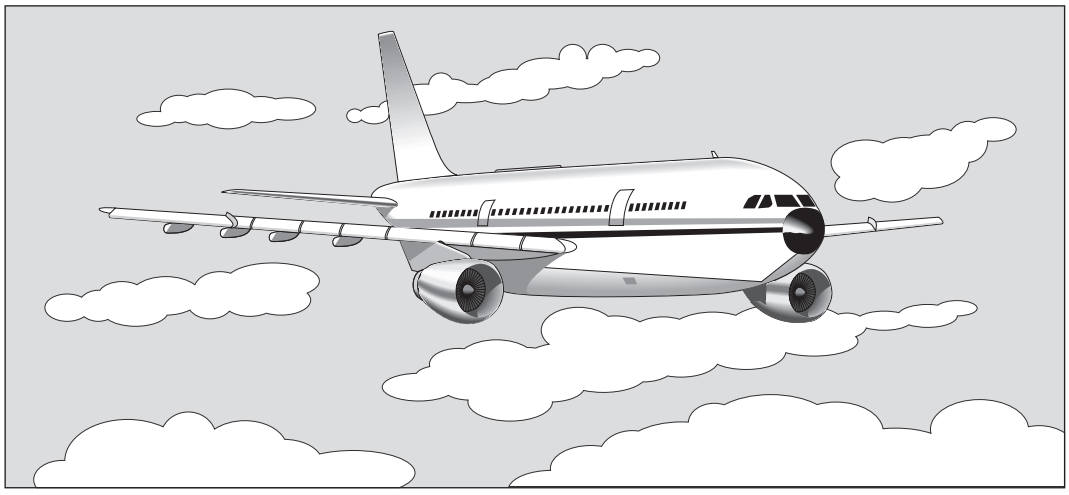
Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 23

March 2007 | PHY1B | Original Q9 | Legacy

QUESTION NINE



Everyone is exposed to some nuclear radiation.

Aircrews are exposed to extra nuclear radiation because they spend long periods of time at high altitudes. The doses they receive can be measured in millisieverts (mSv).

The average dose of extra nuclear radiation for cabin crew is 2 mSv per year. A pregnant member of crew will be given a flight schedule of work to avoid a dose higher than 1 mSv per year.

Here is a table of doses per flight from London to various destinations.

Destination	Flight time (h)	Dose (mSv)
Kiev	4	0.018
Los Angeles	13	0.069
Madrid	2	0.010
New York	7	0.042
Paris	1	0.004
Rome	3	0.014
Tokyo	14	0.078

4.4.2.1 Radioactive decay and nuclear radiation

Question 23 · continued

9A In order to compare the flight data, it must have been collected under controlled conditions.

Which is the most important factor to control?

1 air temperature

2 altitude

3 wind speed

4 colour of the aircraft

9B The connection, in the given data, between flight time and dose is . . .

1 longer flight, higher dose.

2 longer flight, lower dose.

3 shorter flight, higher dose.

4 that there is no connection.

9C The flight time to Dallas is 10 hours.

The most likely dose of radiation which a member of the air crew receives is . . .

1 0.045 mSv

2 0.050 mSv

3 0.055 mSv

4 0.065 mSv

9D How many times can a pregnant crew member fly **return** from London to Madrid before she has received 1 mSv of radiation?

1 20 times

2 40 times

3 50 times

4 100 times

END OF TEST

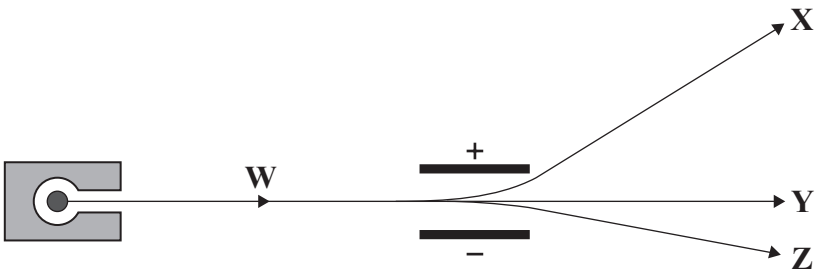
4.4.2.1 Radioactive decay and nuclear radiation

Question 24

June 2007 | PHY1B | Original Q2 | Legacy

QUESTION TWO

A source emits nuclear radiation. In front of it there is a gap in a powerful electrical field.



Match nuclear radiation types, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A alpha (α)

B beta (β)

C gamma (γ)

D alpha (α), beta (β) and gamma (γ)

Path **W** is the path of . . . **1** . . . radiation.

Path **X** is the path of . . . **2** . . . radiation.

Path **Y** is the path of . . . **3** . . . radiation.

Path **Z** is the path of . . . **4** . . . radiation.

4.4.2.1 Radioactive decay and nuclear radiation

Question 25

June 2007 | PHY1B | Original Q4 | Legacy

QUESTION FOUR

There was an accident at the Chernobyl nuclear power station in April 1986. This resulted in the release of radioactive materials into the environment. Some of these materials may cause cancer of the thyroid gland in children.

The table shows the number of cases of thyroid cancer in children in two regions near the Chernobyl power station. It also shows the number of cases per 100 000 children in those regions.

		Childhood thyroid cancer cases per year, 1986–1998												
Region \ Year		86	87	88	89	90	91	92	93	94	95	96	97	98
Belarus	Number of cases	3	4	6	5	31	62	62	87	77	82	67	73	48
	Number of cases per 100 000 children	0.2	0.3	0.4	0.3	1.9	3.9	3.9	5.5	5.1	5.6	4.8	5.6	3.9
Ukraine	Number of cases	8	7	8	11	26	22	49	44	44	47	56	36	44
	Number of cases per 100 000 children	0.2	0.1	0.1	0.1	0.2	0.2	0.5	0.4	0.4	0.5	0.6	0.4	0.5

4A By how many did the number of cases of childhood thyroid cancer per year increase in the Belarus region between the year of the Chernobyl accident and 1995?

1 2

2 3

3 79

4 82

4B A city in Ukraine has 200 000 children.

How many cases of childhood thyroid cancer would be expected in the city in 1992?

1 1

2 2

3 5

4 49

4.4.2.1 Radioactive decay and nuclear radiation

Question 25 · continued June 2007 | PHY1B | Original Q4 | Legacy

One of the radioactive materials responsible for producing childhood thyroid cancer is iodine-131. Children may take in iodine-131 in contaminated food. The iodine-131 is accumulated by the thyroid gland.

4C The half-life of iodine-131 is 8 days. 100 atoms of iodine-131 are taken into the thyroid gland.

How many of these radioactive iodine-131 atoms will there be after 16 days?

1 25

2 50

3 75

4 100

4D Which type of radiation is most likely to cause damage by ionisation once inside the body?

1 alpha radiation

2 beta radiation

3 gamma radiation

4 ultraviolet radiation

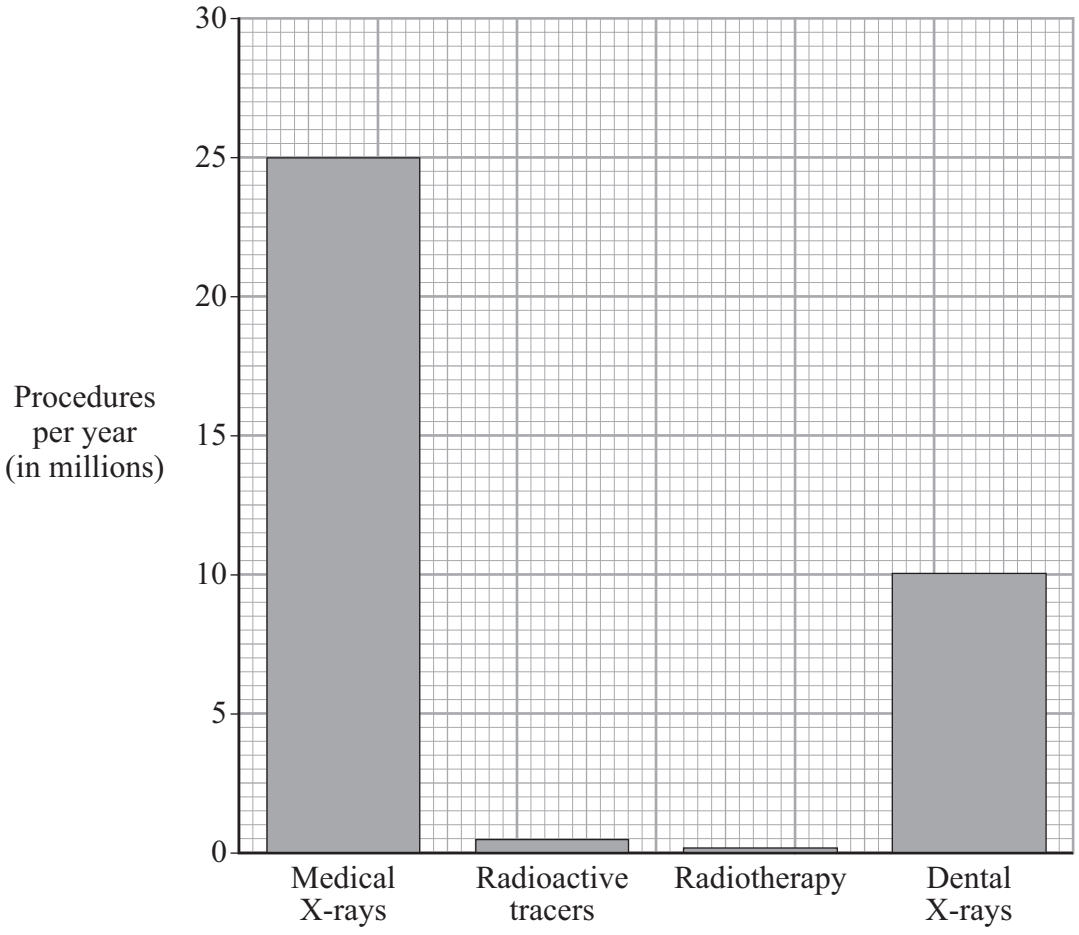
4.4.2.1 Radioactive decay and nuclear radiation

Question 26

June 2007 | PHY1B | Original Q5 | Legacy

QUESTION FIVE

The bar chart shows the number of medical procedures per year in the UK that involve exposure to electromagnetic and nuclear radiation.



5A In how many procedures were radioactive tracers used?

1 100 000

2 500 000

3 1 000 000

4 2 000 000

5B Which type of procedure is used to treat patients?

1 dental X-rays

2 medical X-rays

3 radioactive tracers

4 radiotherapy

4.4.2.1 Radioactive decay and nuclear radiation

5C What is the approximate total number of X-rays taken in the UK each year?

1 10 000

2 25 000

3 35 000

4 35 000 000

5D Medical X-rays are dangerous because . . .

1 they can pass through the body.

2 they cause burns to the skin.

3 they cause water inside cells to heat up.

4 they cause ionisation inside cells.

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

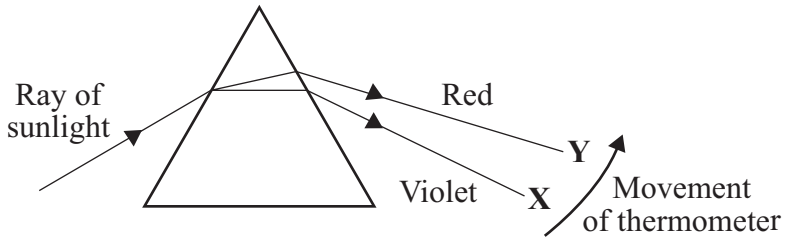
Question 27

June 2007 | PHY1B | Original Q6 | Legacy

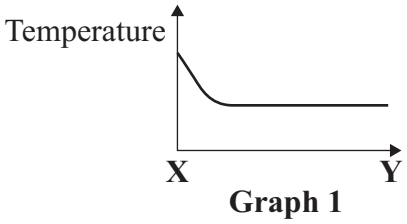
QUESTION SIX

When electromagnetic radiation is absorbed, the energy it carries makes the substance which absorbs it hotter and may create an alternating current of electricity.

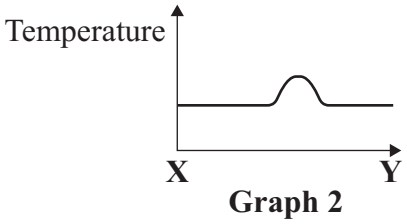
6A When sunlight passes through a prism, a visible spectrum forms. A thermometer is moved slowly from **X** to **Y**.



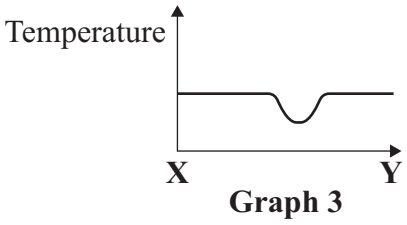
Which sketch graph shows the temperature change as the thermometer moves from **X** to **Y**?



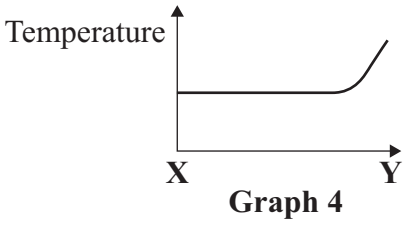
Graph 1



Graph 2



Graph 3



Graph 4

6B The absorption of electromagnetic radiation can create an alternating current in a wire.

This alternating current will have . . .

1 the same frequency as the electromagnetic radiation.

2 the same ionising power as the electromagnetic radiation.

3 the same speed as the electromagnetic radiation.

4 the same wavelength as the electromagnetic radiation.

4.4.2.1 Radioactive decay and nuclear radiation

Question 27 · continued

6C Which factors most affect the absorption of electromagnetic radiation by living cells?

1 speed and wavelength

2 speed, wavelength and size of dose

3 wavelength and size of dose

4 size of dose

6D During the solar eclipse of 2001, four students shared their observations.

Which student's observation was correct?

Student	Observation
1	"It went both cold and dark at the same time."
2	"It went cold, then it went dark."
3	"It went cold, then warm again, then dark."
4	"It went dark, then light again, then cold."

4.4.2.1 Radioactive decay and nuclear radiation

Question 28

June 2007 | PHY1B | Original Q8 | Legacy

QUESTION EIGHT

Americium-241 has a half-life of 432 years. A smoke detector uses the radiation from about 0.0002 g of americium-241 oxide. This substance emits alpha radiation. The alpha radiation ionises molecules in the air inside the smoke detector and this allows an electric current to flow. However, particles of smoke will absorb the radiation. This stops the electric current and causes the alarm to switch on.

8A When used as intended, a smoke detector is **not** a health hazard to humans.

This is because . . .

1 alpha particles are harmless.

2 alpha particles are the least harmful type of radiation.

3 alpha particles do **not** travel beyond the smoke alarm.

4 americium-241 has a long half-life.

8B Alpha particle emission is the most effective type of radiation for use in smoke detectors because . . .

1 alpha particles are heavier than beta particles.

2 alpha particles travel only short distances.

3 it is cheap to produce.

4 it is the most ionising type of radiation.

8C When an americium-241 atom emits an alpha particle, the new atom which is formed will have . . .

1 fewer protons only.

2 fewer neutrons only.

3 fewer electrons only.

4 fewer protons and fewer neutrons.

4.4.2.1 Radioactive decay and nuclear radiation

Question 28 · continued

8D The table shows the properties of four radioactive isotopes.

Isotope	Type of radiation emitted	Half-life
Californium-241	alpha	4 minutes
Cobalt-60	gamma	5 years
Strontium-90	beta	28 years
Technetium-99	gamma	6 hours

Which isotope would be the best to use as a tracer in the human body?

1 californium-241

2 cobalt-60

3 strontium-90

4 technetium-99

4.4.2.1 Radioactive decay and nuclear radiation

Question 29

June 2007 | PHY1H | Original Q1 | Legacy

1 Some types of food are treated with *gamma* radiation. Low doses of radiation slow down the ripening of fresh fruit and vegetables while higher doses of radiation kill the bacteria that make the food go off.

(a) (i) What is *gamma* radiation?

.....

(1 mark)

(ii) Food packed in crates or boxes can be treated using this method.

Why must a source that emits *gamma* radiation be used?

.....

.....

(1 mark)

(iii) A suitable source of gamma radiation is the isotope caesium 137.

Complete the following sentence by choosing the correct word from the box.

electrons	**neutrons**	**protons**

An atom of caesium 137 has two more ..... than an atom of caesium 135.

(1 mark)

Question 1 continues on the next page

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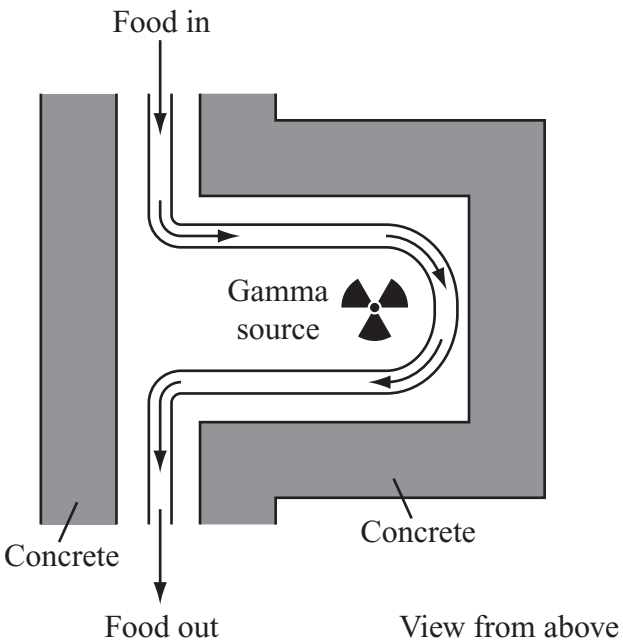
(b) The diagram shows how a conveyor belt can be used to move food past the radioactive source.



(i) How do the concrete walls reduce the radiation hazard to workers outside the food treatment area?

.....

.....

(1 mark)

(ii) Suggest **one** way that the dose of radiation received by the food could be increased other than by changing the radioactive source.

.....

.....

(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 29 · continued

BLANK

(c) Some people may not like the idea of eating food treated with radiation.

(i) What evidence could a food scientist produce to show that food treated with radiation is safe to eat?

.....

.....

.....

.....

(2 marks)

(ii) The diagram shows the sign displayed on food treated with radiation.



Why is it important for people to know which foods have been treated with radiation?

.....

.....

(1 mark)

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 30

November 2007 | PHY1B | Original Q3 | Legacy

QUESTION THREE

Radon is a radioactive gas which seeps up from the ground into houses in some parts of the country.

The table shows the results of a survey of radioactive emissions due to radon gas in four houses in one local authority.

House	Radioactive emissions in Bq per m^3 of air
1	11
2	33
3	15
4	21

3A What was the average of the radioactive emissions in the four houses?

1 20.0 Bq per m^3

2 26.6 Bq per m^3

3 40.0 Bq per m^3

4 80.0 Bq per m^3

3B The local authority wanted a more reliable average for the houses in their area.

Scientists could obtain more reliable results by . . .

1 increasing the number of houses sampled.

2 measuring radioactive emissions in 1 cm^3 of air in each house.

3 using a different unit for the radioactive emissions.

4 sampling the air outside the houses.

3C Radon gas causes cancer.

Which part of the body is most likely to be the site of a cancer caused by radon gas?

1 brain

2 legs

3 stomach

4 lungs

3D What advice would you give to a householder whose house has a high level of radioactive emissions from radon gas?

1 keep the house well ventilated

2 fit double glazing

3 take up all the carpets

4 place draught excluders around all the windows and doors

4.4.2.1 Radioactive decay and nuclear radiation

Question 31

November 2007 | PHY1B | Original Q5 | Legacy

QUESTION FIVE

There are different types of electromagnetic radiation and nuclear radiation.

5A Which one of the following types of radiation is **not** used for communication?

1 infra red radiation

2 microwaves

3 visible light

4 X-rays

5B Which one of the following types of radiation has the longest wavelength?

1 infra red radiation

2 microwaves

3 visible light

4 X-rays

5C Which one of the following statements is **not** true of **both** ultraviolet radiation and infra red radiation?

1 They can be seen by the human eye.

2 They are members of the electromagnetic spectrum.

3 Each can have a range of different wavelengths and frequencies.

4 They travel at the same speed in a vacuum.

5D Which type of radiation is emitted by the nucleus of an atom of a radioactive isotope?

1 gamma radiation

2 X-rays

3 microwave radiation

4 ultraviolet radiation

4.4.2.1 Radioactive decay and nuclear radiation

Question 32

November 2007 | PHY1B | Original Q6 | Legacy

QUESTION SIX

Nitrogen-16 is a radioactive isotope of nitrogen. It decays to stable oxygen-16 by beta (β) emission.

6A A beta particle is . . .

1 a helium nucleus.

2 a neutron.

3 a proton.

4 an electron.

6B The rate of emission of beta particles from the nitrogen-16 would . . .

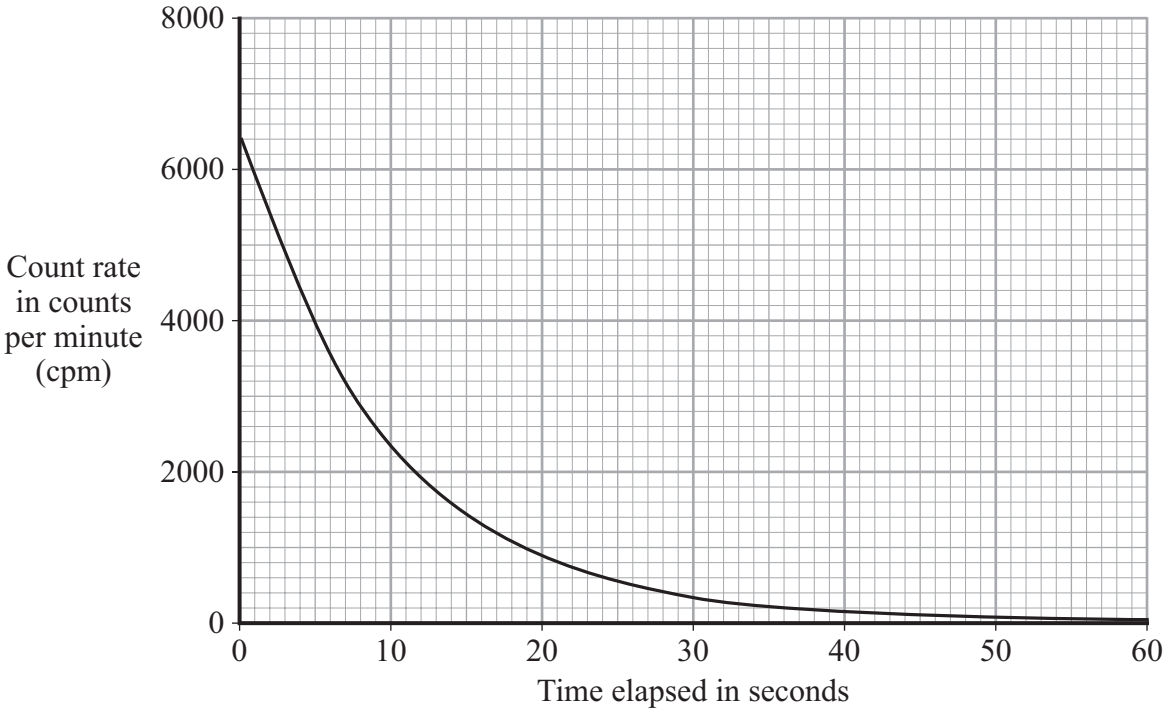
1 be increased by increasing its temperature.

2 be reduced by increasing the pressure of the air around it.

3 be reduced by liquefying it.

4 be unaffected by changes in temperature, pressure or its state.

The graph shows the decay curve for a sample of nitrogen-16.



4.4.2.1 Radioactive decay and nuclear radiation

Question 32 · continued

6C Using information from the graph, calculate the approximate half-life of nitrogen-16.

1 7 seconds

2 30 seconds

3 60 seconds

4 3200 seconds

6D According to the graph, what is the approximate value to which the count rate of the nitrogen-16 would have fallen after four half-lives?

1 3200 cpm

2 1600 cpm

3 800 cpm

4 400 cpm

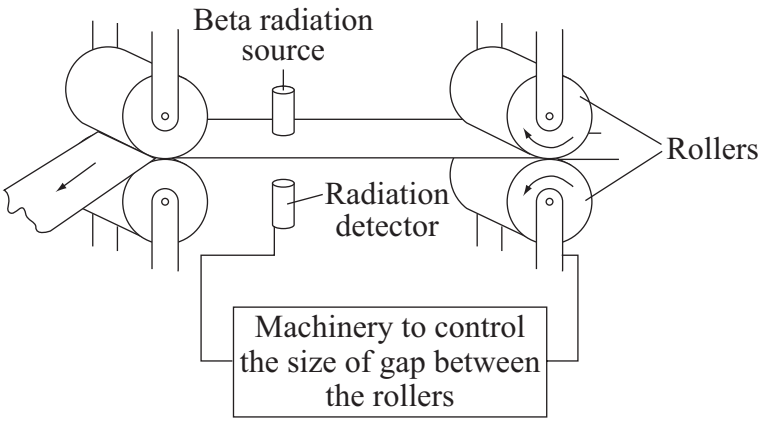
4.4.2.1 Radioactive decay and nuclear radiation

Question 33

November 2007 | PHY1B | Original Q7 | Legacy

QUESTION SEVEN

The diagram shows a system used in a paper mill to control the thickness of the paper.



The paper passes through a narrow gap between a beta (β) radiation source and a detector.

7A Beta radiation passes through the paper more easily than alpha radiation because beta radiation . . .

1 consists of smaller particles than alpha radiation.

2 has a negative charge.

3 has a shorter frequency than alpha radiation.

4 has a longer wavelength than alpha radiation.

7B A radioactive source producing only gamma rays would be unsuitable because . . .

1 gamma radiation consists of rays rather than particles.

2 the paper would **not** stop any of the gamma rays reaching the radiation detector.

3 gamma rays are **not** affected by magnetic fields.

4 gamma rays are too dangerous to use.

4.4.2.1 Radioactive decay and nuclear radiation

7C Beta particles are less dangerous to workers than alpha particles because they . . .

1 are deflected by magnetic fields.

2 are much less strongly ionising.

3 cannot penetrate skin.

4 have a much shorter range.

7D The most suitable half-life for the beta source in the system is . . .

1 six hours.

2 six days.

3 six months.

4 six years.

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 34

November 2007 | PHY1B | Original Q8 | Legacy

QUESTION EIGHT

A former spy was poisoned with the radioactive isotope polonium-210.

8A Some of the spy's friends were found to be contaminated with polonium-210. They were safe from the radiation unless they had taken some of the polonium-210 into their bodies.

This is because the radiation given off by polonium-210 is . . .

1 alpha particles.

2 beta particles.

3 gamma rays.

4 X-rays.

8B It is difficult to detect the radiation given off by polonium-210 using a detector outside the body because the radiation has . . .

1 high penetrating power.

2 a long range in air.

3 low ionising power.

4 low penetrating power.

8C Scientists carried out many tests at restaurants, hotels and airports. This caused much public anxiety.

Which one of the following statements is true?

1 The particles emitted by polonium-210 are radioactive.

2 Anyone too close to a polonium-210 source will become radioactive.

3 If you swallow polonium-210, it will damage cells in the body.

4 The radiation from polonium-210 makes clothes glow in the dark.

4.4.2.1 Radioactive decay and nuclear radiation

Question 34 · continued

8D Another isotope of polonium is polonium-208.

Compared with polonium-210, polonium-208 has . . .

1 more neutrons.

2 fewer neutrons.

3 more protons.

4 fewer protons.

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 35

January 2008 | PHY1H | Original Q4 | Legacy

4 (a) A radioactive source emits alpha (α), beta (β) and gamma (γ) radiation.

(i) Which **two** types of radiation will pass through a sheet of card?

.....

(1 mark)

(ii) Which **two** types of radiation would be deflected by an electric field?

.....

(1 mark)

(iii) Which type of radiation has the greatest range in air?

.....

(1 mark)

(b) A student suggests that the radioactive source should be stored in a freezer at –20 °C. The student thinks that this would reduce the radiation emitted from the source.

Suggest why the student is wrong.

.....

.....

(1 mark)

Question 4 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 35 · continued

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(c) Phosphorus-32 is a radioactive isotope that emits beta radiation.

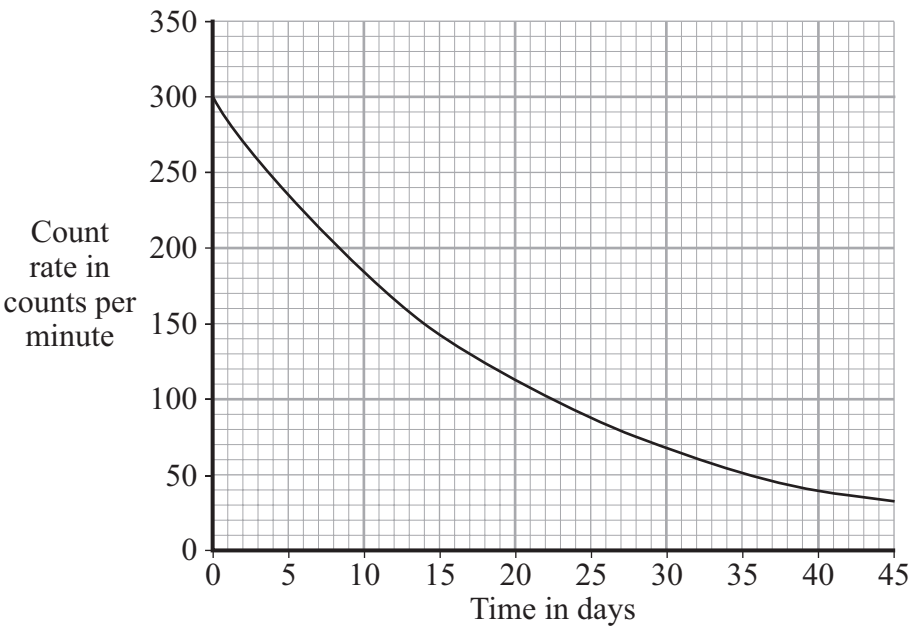
(i) How is an atom of phosphorus-32 different from an atom of the stable isotope phosphorus-31?

.....

.....

(1 mark)

(ii) The graph shows how the count rate of a sample of phosphorus-32 changes with time.



Use the graph to calculate the half-life of phosphorus-32.

Show clearly how you used the graph to obtain your answer.

.....

.....

Half-life = ... days

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 35 · continued

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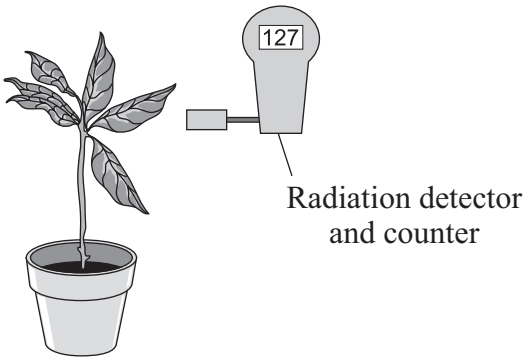
(iii) Plants use phosphorus compounds to grow. Watering the root system of a plant with a solution containing a phosphorus-32 compound can help scientists to understand the growth process.



Explain why phosphorus-32 is suitable for use as a tracer in this situation.

.....

.....

.....

.....

(2 marks)

9

4.4.2.1 Radioactive decay and nuclear radiation

Question 36

March 2008 | PHY1AP | Original Q2 | Legacy

QUESTION TWO

A geothermal power station uses the energy in hot rocks to produce electricity.

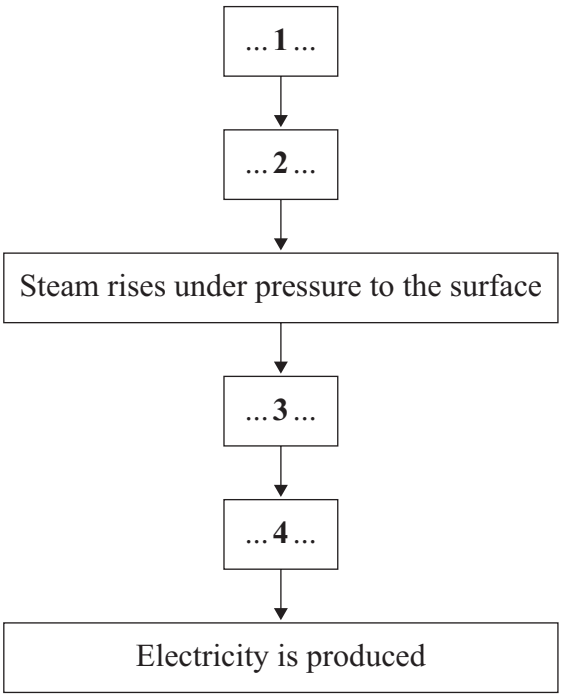
Match words, **A**, **B**, **C** and **D**, with the numbers **1–4** in the flow chart to explain how the power station works.

A cold water is pumped into the rocks

B steam drives turbines

C turbines drive generators

D water is heated by radioactive decay



4.4.2.1 Radioactive decay and nuclear radiation

Question 37

March 2008 | PHY1BP | Original Q2 | Legacy

QUESTION TWO

The electromagnetic spectrum is continuous but the wavelengths within it can be grouped into types.

Match words, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A gamma rays

B radio waves

C ultraviolet waves

D visible light

The type of electromagnetic radiation which can be used to send signals along optical fibres is . . . **1** . . . .

The type of electromagnetic radiation which has the highest frequency is . . . **2** . . . .

The type of radiation that has the longest wavelength is . . . **3** . . . .

The type of electromagnetic radiation used in sunbeds for tanning is . . . **4** . . . .

4.4.2.1 Radioactive decay and nuclear radiation

Question 38

March 2008 | PHY1BP | Original Q5 | Legacy

QUESTION FIVE

This question is about the structure of atoms and radioactive decay.

5A Where is an electron found in the basic structure of an atom?

1 in orbit around the nucleus

2 on its own in the nucleus

3 with neutrons in the nucleus

4 with protons in the nucleus

5B Which type of radiation consists of helium nuclei?

1 alpha radiation

2 beta radiation

3 delta radiation

4 gamma radiation

5C Which one of the following statements is true for alpha radiation?

1 It is emitted by all radioactive substances.

2 It is identical to an electron.

3 It is **not** deflected by an electric field.

4 It is deflected by a magnetic field.

5D The table shows the half-lives of four radioactive sources which all emit the same type of radiation.

Which source is the most suitable for use as a medical tracer?

Source	Half-life
1	6 hours
2	6 weeks
3	6 months
4	6 years

4.4.2.1 Radioactive decay and nuclear radiation

Question 39

March 2008 | PHY1BP | Original Q8 | Legacy

QUESTION EIGHT

Carbon-14 is a radioactive isotope of carbon. It is a beta (β) particle emitter with a half-life of approximately 5750 years. Carbon-14 makes up a tiny proportion of all naturally occurring carbon on our planet.

When living things die the carbon-14 they contain continues to decay and is not replaced. So the approximate age of the object which was once part of a living plant or animal, can be calculated by measuring the proportion of carbon-14 which it now contains.

8A An organism has been dead for 17 000 years.

Approximately how many half-lives of carbon-14 have passed during this time?

1 2

2 3

3 4

4 5

8B A small sample of material taken from a plant contains 32 billion atoms of carbon-14.

Approximately how many of these atoms will it contain in 13 000 years time?

1 4 billion

2 7 billion

3 15 billion

4 30 billion

8C It is difficult to date samples more than 50 000 years old using carbon-14.

This is because . . .

1 all the carbon-14 will have decayed away.

2 carbon-14 did not exist more than 50 000 years ago.

3 so little carbon-14 remains that it is very difficult to detect and measure.

4 from the start there was no carbon-14 in samples of this age.

8D Carbon-14 dating **cannot** be used for . . .

1 a cotton cloak.

2 a gold plate.

3 a paper scroll.

4 a wooden mast.

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 40

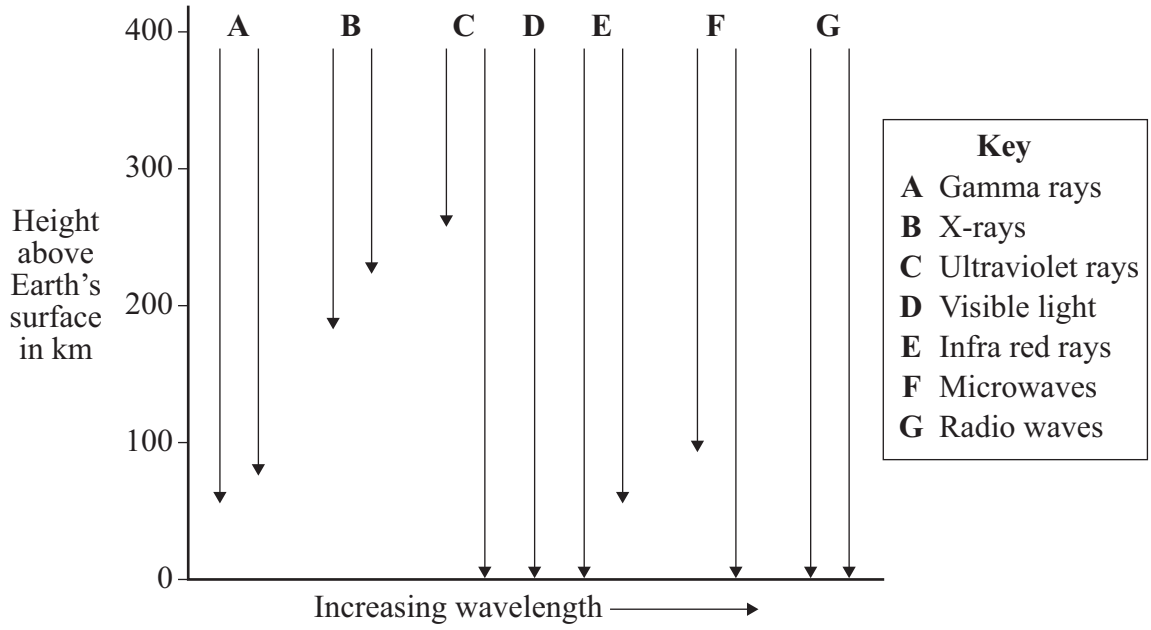
March 2008 | PHY1BP | Original Q9 | Legacy

QUESTION NINE

All forms of electromagnetic radiation from space are used by scientists to explore the Universe.

The diagram shows how far electromagnetic waves can penetrate the Earth's atmosphere.

Where two arrows are shown for a type of electromagnetic radiation, longer and shorter waves penetrate the atmosphere to different depths.



9A Which one of the following statements is true?

1 Gamma radiation penetrates the atmosphere further than all other types of electromagnetic radiation.

2 All frequencies of microwaves reach Earth's surface.

3 No frequencies of radio waves reach Earth's surface.

4 Higher frequencies of ultraviolet radiation are completely absorbed by the atmosphere.

9B What would be the minimum height above the Earth for a satellite carrying a telescope designed to detect gamma rays and X-rays of all wavelengths?

1 50 km

2 70 km

3 180 km

4 230 km

4.4.2.1 Radioactive decay and nuclear radiation

Question 40 · continued March 2008 | PHY1BP | Original Q9 | Legacy

9C Which one of the following correctly describes the data on the diagram?

1 The absorption of electromagnetic radiation by the atmosphere is directly proportional to wavelength.

2 The absorption of electromagnetic radiation by the atmosphere is inversely proportional to wavelength.

3 The shorter the wavelength of electromagnetic radiation, the greater the absorption by the atmosphere.

4 Absorption of electromagnetic radiation does **not** depend only on wavelength.

9D Electromagnetic radiation from distant galaxies is very weak and is therefore very difficult to detect.

The Spitzer space telescope uses liquid helium to keep its scientific instruments at a very low temperature.

Which type of weak electromagnetic radiation would best be detected by instruments kept at this very low temperature?

1 gamma rays

2 X-rays

3 infra red rays

4 ultraviolet rays

END OF TEST

4.4.2.1 Radioactive decay and nuclear radiation

Question 41

June 2008 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

The table gives some information about four radioactive isotopes, **P**, **Q**, **R** and **S**.

Radioactive isotope		Type of radiation emitted	Half-life
P	americium-237	alpha	78 minutes
Q	americium-241	alpha	432 years
R	technetium-99	gamma	6 hours
S	krypton-78	beta	10.7 years

4A Which isotope emits an electron from the nucleus?

1 **P**

2 **Q**

3 **R**

4 **S**

4B Which isotope emits radiation with the longest range in air?

1 **P**

2 **Q**

3 **R**

4 **S**

4C Which isotope would be the most suitable for use in a system for controlling paper thickness in a paper factory?

1 **P**

2 **Q**

3 **R**

4 **S**

4.4.2.1 Radioactive decay and nuclear radiation

Question 41 · continued

4D Which isotope would be most suitable for monitoring the flow of blood through the heart?

1 **P**

2 **Q**

3 **R**

4 **S**

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 42

June 2008 | PHY1BP | Original Q6 | Legacy

QUESTION SIX

This question is about a smoke detector which contains a radioactive source.

Americium-241 is used because it emits alpha particles and has a half-life of 432 years.

6A Why is an alpha source the safest one to use in a domestic smoke detector?

1 Alpha particles are absorbed by a few centimetres of air.

2 Alpha particles do not cause any ionisation.

3 Alpha particles are completely harmless to humans.

4 Alpha particles are not deflected by a magnet.

6B What is an alpha particle?

1 a helium nucleus

2 a hydrogen nucleus

3 a proton

4 an electron

6C Why is the half-life of americium-241 considered to be suitable for use in a smoke detector?

1 It has a long half-life, and so will not need replacing.

2 An isotope with a very short half-life would not provide enough energy.

3 An isotope with a much longer half-life would give off too much energy.

4 An isotope with a much shorter half-life would give off beta particles.

6D The half-life of americium-241 is 432 years.

A source contains 1 gram of americium-241.

How long will it be before only 0.25 g of americium-241 remains?

1 108 years

2 216 years

3 648 years

4 864 years

4.4.2.1 Radioactive decay and nuclear radiation

Question 43

June 2008 | PHY1H | Original Q3 | Legacy

3 The table gives data about two space telescopes. The Hubble telescope is already in space, but the James Webb telescope is still being built.

Name of telescope	Mirror diameter in metres	Launch Year	Orbit distance from the Earth in kilometres
Hubble	2.4	1990	575
James Webb	6.5	2013	1 500 000

3 (a) Explain why the Hubble telescope produces clearer images than optical telescopes positioned on the Earth.

.....

.....

.....

.....

(2 marks)

3 (b) After the Hubble telescope was launched into space, scientists found that it was not able to focus properly. Astronauts sent into space were able to repair the fault.

The James Webb telescope is to be fully assembled and tested before it is launched into space. Suggest why.

.....

.....

.....

.....

(2 marks)

3 (c) To get the large mirror for the James Webb telescope into space, it will be folded in segments, launched into space and then opened out. This is a complicated process so a working scale model of the optical system has been built.

Suggest **one** reason why building a scale model is a good idea.

.....

.....

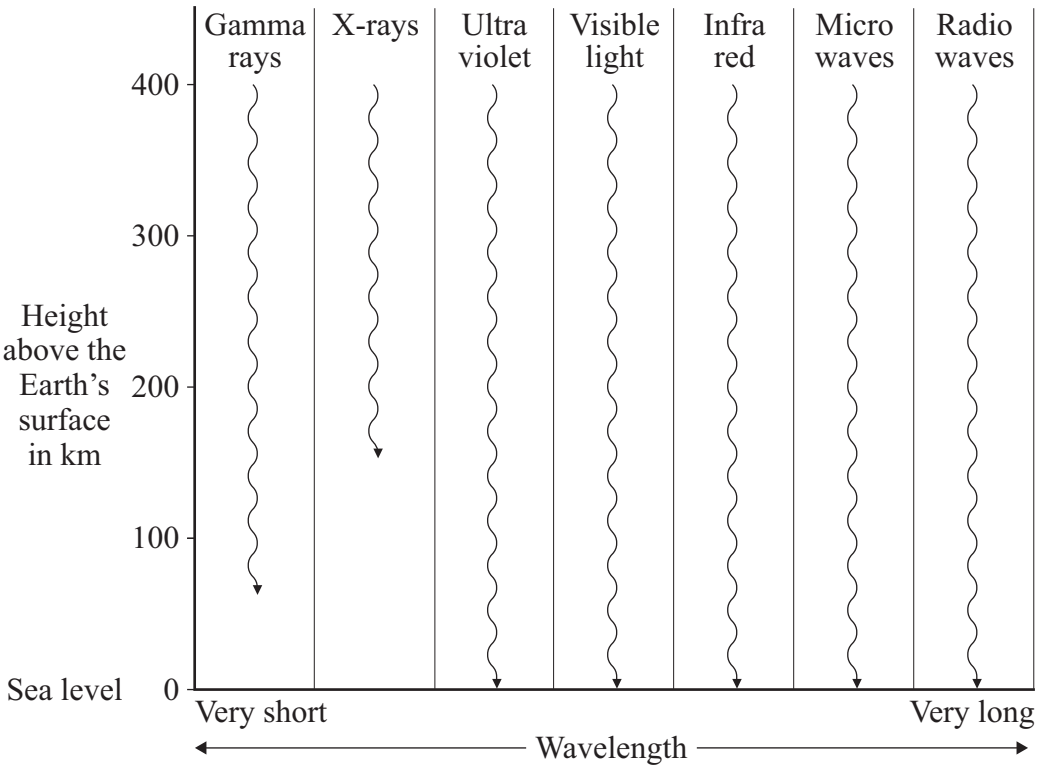
(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 43 · continued

for mark

3 (d) The diagram shows how far different types of electromagnetic wave can travel through the Earth's atmosphere before being absorbed.



Explain why an optical telescope can be positioned on the Earth but an X-ray telescope must be in space.

.....

.....

.....

.....

(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 44

June 2008 | PHY1H | Original Q6 | Legacy

6 In 1986, a nuclear reactor exploded in a power station at Chernobyl in the Ukraine.

6 (a) The table gives information about some of the radioactive substances released into the air by the explosion.

Radioactive substance	Half-life	Type of radiation emitted
Iodine-131	8 days	beta and gamma
Caesium-134	2 years	beta
Caesium-137	30 years	beta

6 (a) (i) How is the structure of a caesium-134 atom different from the structure of a caesium-137 atom?

.....

(1 mark)

6 (a) (ii) What is a beta particle and from which part of an atom is a beta particle emitted?

.....

.....

(1 mark)

6 (a) (iii) Once a radioactive substance is dissolved in rainwater, it can enter the food chain.

Following the Chernobyl explosion, some milk supplies were found to be radioactive.

If one litre of milk contaminated with iodine-131 gives a count rate of 400 counts/second, how long will it take for the count rate to fall to 25 counts/second?

Show clearly how you work out your answer.

.....

.....

.....

Time taken = ... days

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 44 · continued

for mark

6 (a) (iv) After 20 years, the caesium-137 emitted into the atmosphere is a more serious problem than the iodine-131.

Explain why.

.....

.....

.....

.....

.....

(2 marks)

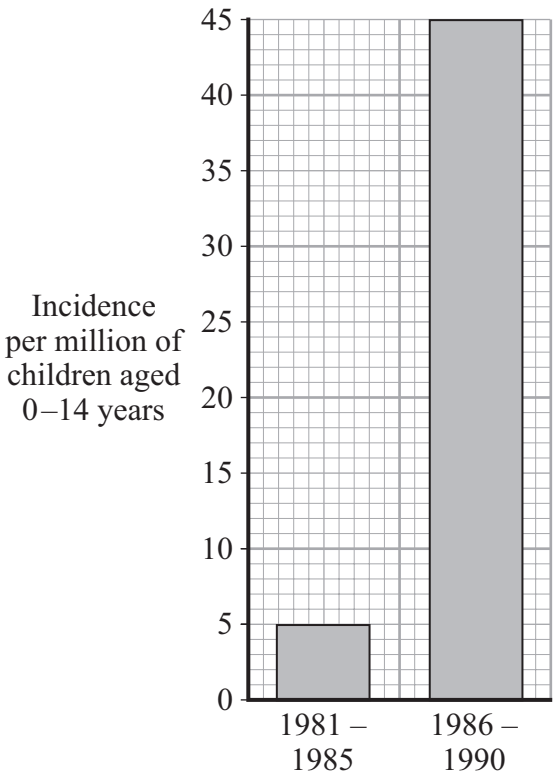
Question 6 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 44 · continued

for mark

6 (b) The bar chart compares the incidence of thyroid cancer in Ukrainian children, aged 0–14 years, before and after the Chernobyl explosion.



Of the children that developed thyroid cancer, 64% lived in the areas most contaminated by the radiation.

Considering this data, can you be certain that a child who developed thyroid cancer between 1986 and 1990 did so because of the Chernobyl explosion?

Explain the reason for your answer.

.....

.....

.....

.....

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 44 · continued

for mark

6 (c) In 1991, some scientists compared the health of two groups of people: a *control* group and a group that had been exposed to the radiation from Chernobyl.

What people would have been in the *control* group?

.....

(1 mark)

6 (d) Although there are some risks associated with nuclear power stations, it is likely that new ones will be built.

Give **two** reasons to justify the use of nuclear power.

1 .....

.....

2 .....

.....

(2 marks)

11

4.4.2.1 Radioactive decay and nuclear radiation

Question 45

June 2008 | PHY2H | Original Q2 | Legacy

2 (a) The table gives information about the radioactive isotope, radon-222.

mass number	222
atomic number	86
radiation emitted	alpha particle

2 (a) (i) Complete the following sentence.

The mass number is the total number of..... and

..... inside an atom.

(2 marks)

2 (a) (ii) Radon-222 is an isotope of radon.

How many protons are there in an atom of radon-222?

..... *(1 mark)*

2 (a) (iii) When an atom of radon-222 emits an alpha particle, the radon-222 changes into an atom of polonium-218.

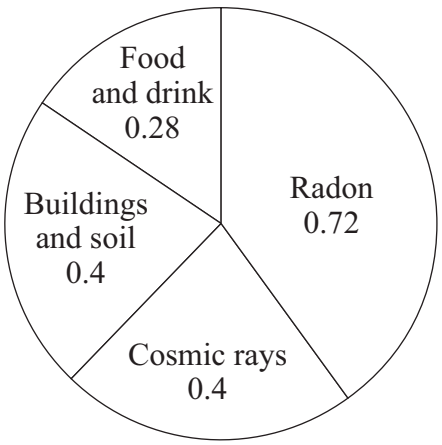
An alpha particle consists of 2 protons and 2 neutrons.

How is the structure of the nucleus of a polonium-218 atom different from the structure of the nucleus of a radon-222 atom?

.....

(1 mark)

2 (b) The pie chart shows the average radiation dose that a person in the UK receives each year from natural background radiation.
The doses are measured in millisieverts (mSv).



4.4.2.1 Radioactive decay and nuclear radiation

Question 45 · continued

for mark

2 (b) (i) Calculate the proportion of natural background radiation that comes from radon. Show clearly how you work out your answer.

.....

.....

Proportion of radon = ...

(2 marks)

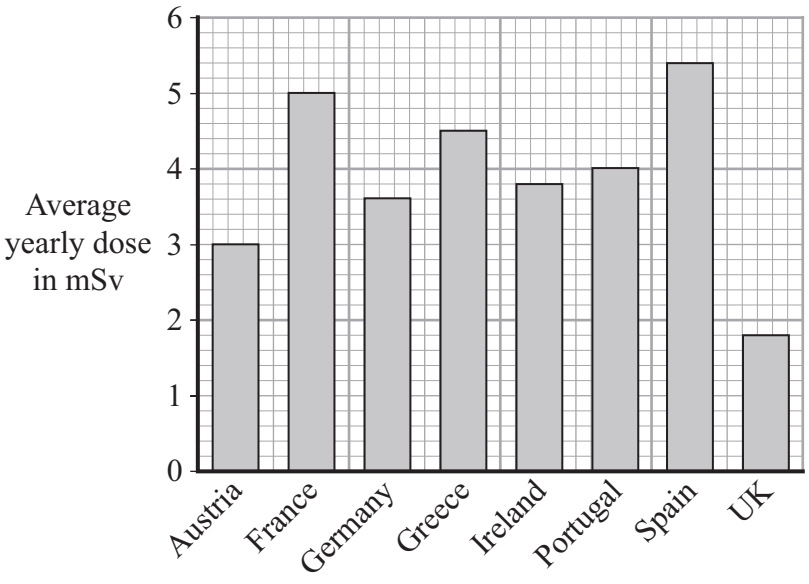
2 (b) (ii) Not all background radiation is from natural sources.

Name **one** source of background radiation that is not natural.

.....

(1 mark)

2 (c) The bar chart shows the average yearly dose from natural background radiation in different European countries.



2 (c) (i) How many times bigger is the average annual background dose in Germany compared to the UK?

.....

(1 mark)

Question 2 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 45 · continued

for mark

2 (c) (ii) The following table gives the effects of different radiation doses on the human body.

Radiation dose in mSv	Effects
10 000	Immediate illness; death within a few weeks
1 000	Radiation sickness; unlikely to cause death
50	Lowest dose with evidence of causing cancer

A family goes to Germany for a two-week holiday. Should they be concerned about the higher level of background radiation in Germany?

Draw a ring around your answer.

Yes **No**

Explain your answer.

.....

.....

.....

.....

(2 marks)

10

4.4.2.1 Radioactive decay and nuclear radiation

Question 46

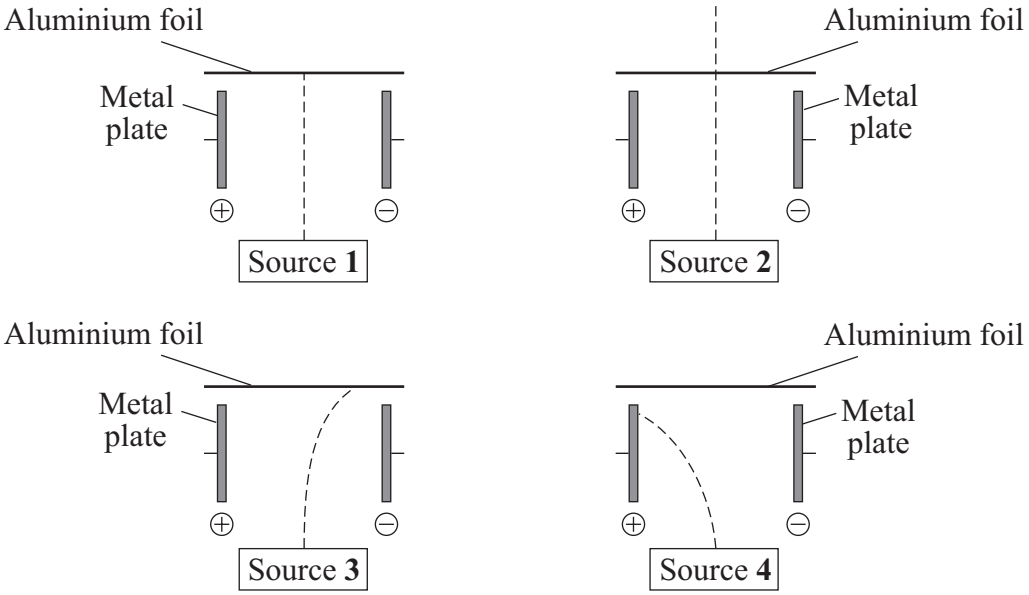
November 2008 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

Radiation from four sources, **1**, **2**, **3** and **4**, is directed into an electric field between two metal plates.

There is a sheet of aluminium foil after the gap between the metal plates.

Light waves are not deflected in electric fields.



In each diagram, the dashed line (----------) shows the path of the radiation.

Match the types of radiation, **A**, **B**, **C** and **D**, with the sources **1–4**.

A alpha radiation

B beta radiation

C gamma radiation

D visible light

4.4.2.1 Radioactive decay and nuclear radiation

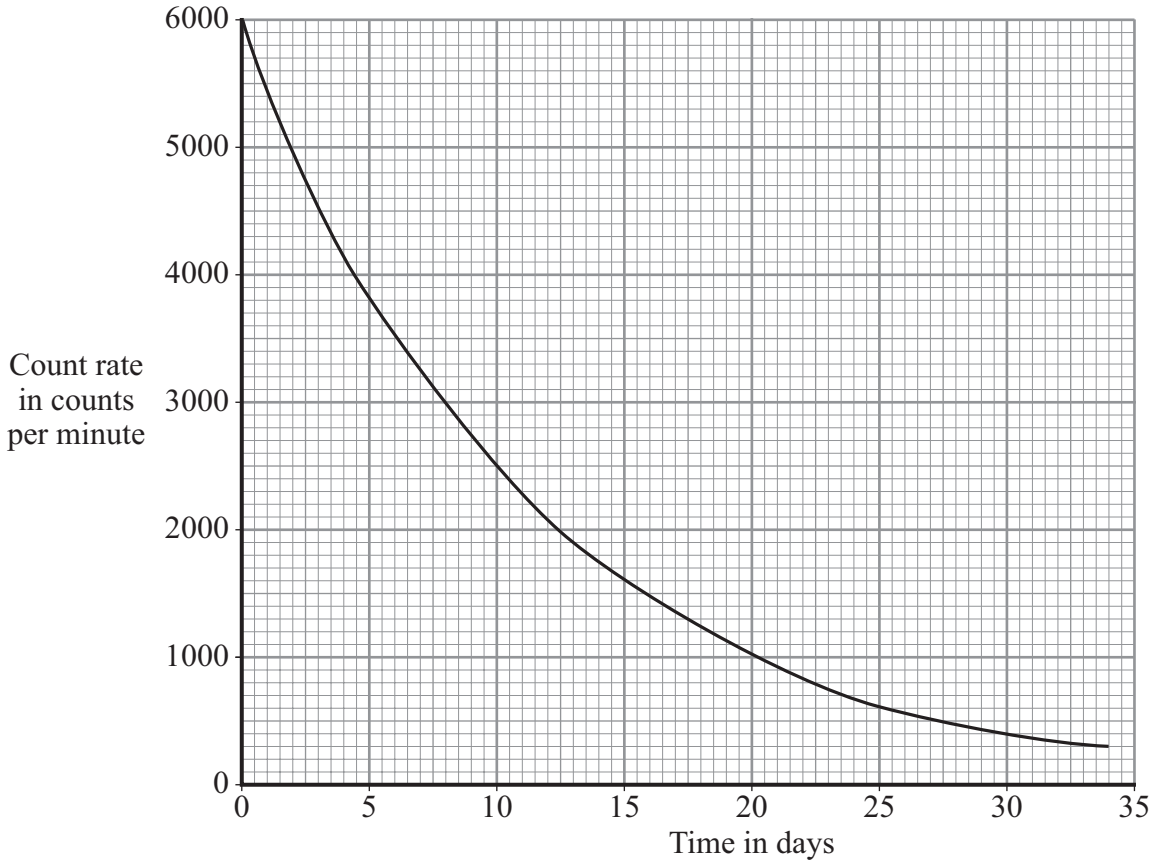
Question 47

November 2008 | PHY1BP | Original Q2 | Legacy

QUESTION TWO

Iodine-131 is a radioactive isotope. It is used in hospitals.

The graph shows how the count rate of a sample of iodine-131 changes with time.



Match figures, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A 4.5

B 8

C 24

D 400

The count rate after 30 days is . . . **1** . . . counts per minute.

The time taken for the count rate to fall to 4000 counts per minute is . . . **2** . . . days.

The half-life of iodine-131 is . . . **3** . . . days.

A patient is given 16 mg of iodine-131. This will decay to 2 mg in . . . **4** . . . days.

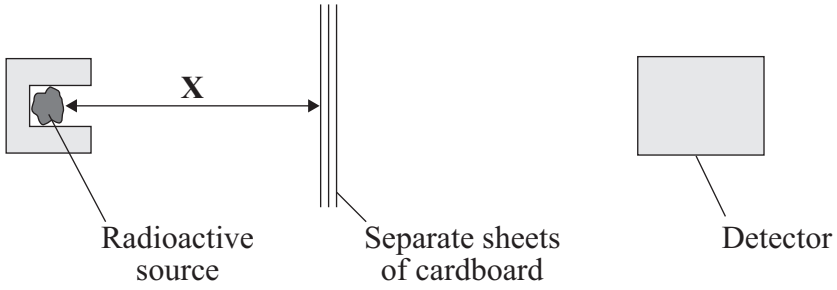
4.4.2.1 Radioactive decay and nuclear radiation

Question 48

November 2008 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

The diagram shows apparatus used by a scientist investigating the effectiveness of cardboard for absorbing radiation.



The detector measured the count rate for different numbers of sheets of cardboard.
The distance **X** was kept constant.

3A Which is the control variable in the experiment?

1 the number of sheets of cardboard

2 the total thickness of the cardboard

3 the distance **X**

4 the count rate

4.4.2.1 Radioactive decay and nuclear radiation

Question 48 · continued

3B Which row of the table gives the correct variables?

	Independent variable	Dependent variable
1	count rate	number of sheets
2	number of sheets	count rate
3	distance **X**	count rate
4	count rate	distance **X**

3C The scientist recorded the results of the experiment in a table with the following headings:

Number of sheets of cardboard	Count rate in counts per second

These results were plotted on a graph.

The graph was a . . .

1 bar chart because both variables were categoric.

2 line graph because both variables were continuous.

3 line graph because one variable was categoric.

4 bar chart because one variable was continuous and the other was discrete.

3D Another scientist said that the data used for the graph was not reliable.

How could the reliability of the data be tested?

1 by measuring the distance in millimetres

2 by using sheets of card with different thicknesses

3 by measuring the time to the nearest second

4 by asking another group to carry out the same experiment

4.4.2.1 Radioactive decay and nuclear radiation

Question 49

November 2008 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

Many atoms have nuclei that decay and emit alpha particles. Some of these nuclei have very short half-lives, others have very long ones.

4A What is an alpha particle?

1 an electron from outside the nucleus

2 an electron from inside the nucleus

3 a helium nucleus

4 a proton from inside the nucleus

4B How can the rate, at which a particular radioactive substance decays, be changed?

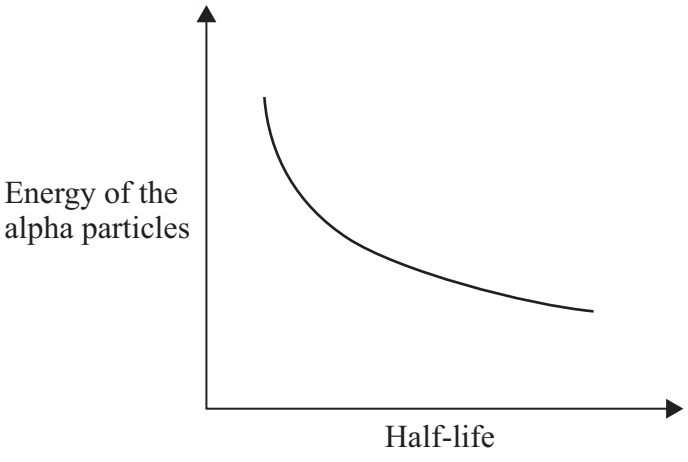
1 by changing the temperature of the nucleus

2 by changing the atmospheric pressure

3 by changing the amount of humidity

4 The rate cannot be changed.

The graph shows the relationship between the energy of the emitted alpha particles and the half-life of the nuclei from which they came.



4.4.2.1 Radioactive decay and nuclear radiation

4C What relationship does the graph show?

1 Alpha particles always have the same amount of energy.

2 The longer the half-life, the less energy the alpha particles have.

3 The longer the half-life, the more energy the alpha particles have.

4 There is no relationship between the half-life and the energy of the alpha particles.

4D What is the meaning of the term *half-life*?

1 half of the time taken for all the atoms originally present to decay

2 the time halfway between when an atom was formed and when it decays

3 the time taken for half of the atoms originally present to decay

4 the time taken for one atom to split in half

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 50

November 2008 | PHY1BP | Original Q6 | Legacy

QUESTION SIX

The tables show the types of radiation observed by different telescopes, and the types of radiation emitted by different parts of the universe.

Name of telescope	Type of radiation
Arecibo	Radio
COBE	Microwave
Hess	Gamma
Hopkins	Ultraviolet
Keck	Visible light
Spitzer	Infra red
XMM Newton	X-rays

Origin of radiation in universe	Main radiation emitted
Pulsars	Radio
Neutron stars	X-rays
Nebulae	Infra red
Stars	Visible light
Gamma ray bursts	Gamma
Big bang	Microwaves

6A Which telescope could be used to hunt for neutron stars in galaxies?

1 Arecibo

2 Spitzer

3 Hopkins

4 XMM Newton

6B Which telescope could be used to analyse the radiation of the universe left over from the 'big bang'?

1 COBE

2 Spitzer

3 Keck

4 Hopkins

4.4.2.1 Radioactive decay and nuclear radiation

6C Which one of the following emits the longest wavelength radiation?

1 Gamma ray bursts

2 Neutron stars

3 Pulsars

4 Stars

6D Which one of the following emits radiation with the highest frequency?

1 Nebulae

2 Neutron stars

3 Pulsars

4 Stars

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 51

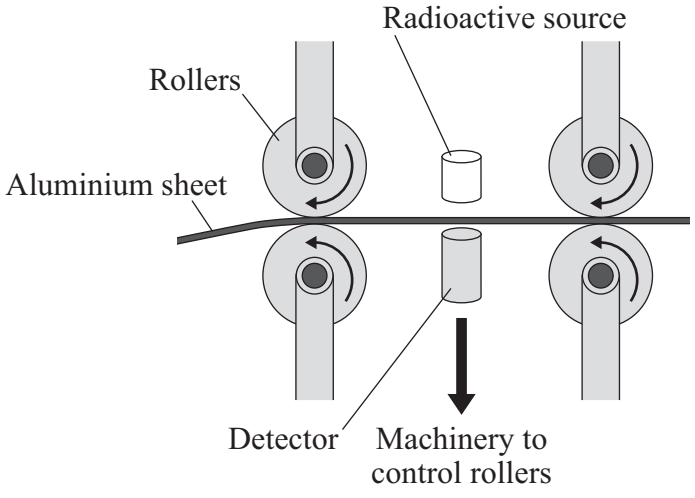
November 2008 | PHY1BP | Original Q7 | Legacy

QUESTION SEVEN

The table shows the type of radiation emitted by, and the half-life of four radioactive isotopes, **P**, **Q**, **R** and **S**.

Radioactive isotope	Radiation emitted	Half-life
P	beta	6000 years
Q	alpha	400 years
R	gamma	6 hours
S	beta	30 seconds

7A The diagram shows how a radioactive isotope is used to monitor the thickness of aluminium in the continuous manufacture of aluminium sheet.



Which of the isotopes should be used?

1 **P**

2 **Q**

3 **R**

4 **S**

4.4.2.1 Radioactive decay and nuclear radiation

Question 51 · continued November 2008 | PHY1BP | Original Q7 | Legacy

7B A smoke alarm uses a small mass of a radioactive isotope. So that the alarm can be used safely in a house, isotope **Q** is used.

This is because isotope **Q** is an alpha emitter . . .

1 with a short half-life; alpha particles have a short range in air.

2 with a short half-life; alpha particles have a long range in air.

3 with a long half-life; alpha particles have a short range in air.

4 with a long half-life; alpha particles have a long range in air.

7C Radioactive isotopes can be injected into the human body to act as tracers in medical diagnosis.

The isotope used is . . .

1 **P** because it has a very long half-life and beta particles can reach the detector.

2 **Q** because it has a long half-life and alpha particles are relatively safe outside the body.

3 **R** because it has a short half-life and gamma rays can reach the detector.

4 **S** because it has a short half-life and beta particles can reach the detector.

7D Trees contain the radioactive isotope carbon-14. After a tree has been chopped down, the count rate from the carbon-14 it contains gradually decreases. By measuring the count rate and knowing the half-life of the isotope, the age of the dead wood can be estimated.

Which isotope could be used to estimate the age of a wooden box thought to be about 18 000 years old?

1 **P** because its half-life is about 6000 years so the box has existed for 3 half-lives.

2 **Q** because its half-life is about 400 years which means that the box has existed for 45 half-lives.

3 **R** because its half-life is about 30 seconds which means that it is safe to do the estimation.

4 **S** because its half-life is about 6 hours which is enough time to do the estimation.

4.4.2.1 Radioactive decay and nuclear radiation

Question 52

January 2009 | PHY1H | Original Q4 | Legacy

4 Most elements have some *isotopes* which are *radioactive*.

4 (a) What is meant by the terms:

4 (a) (i) *isotopes*

.....

.....

(1 mark)

4 (a) (ii) *radioactive*?

.....

.....

(1 mark)

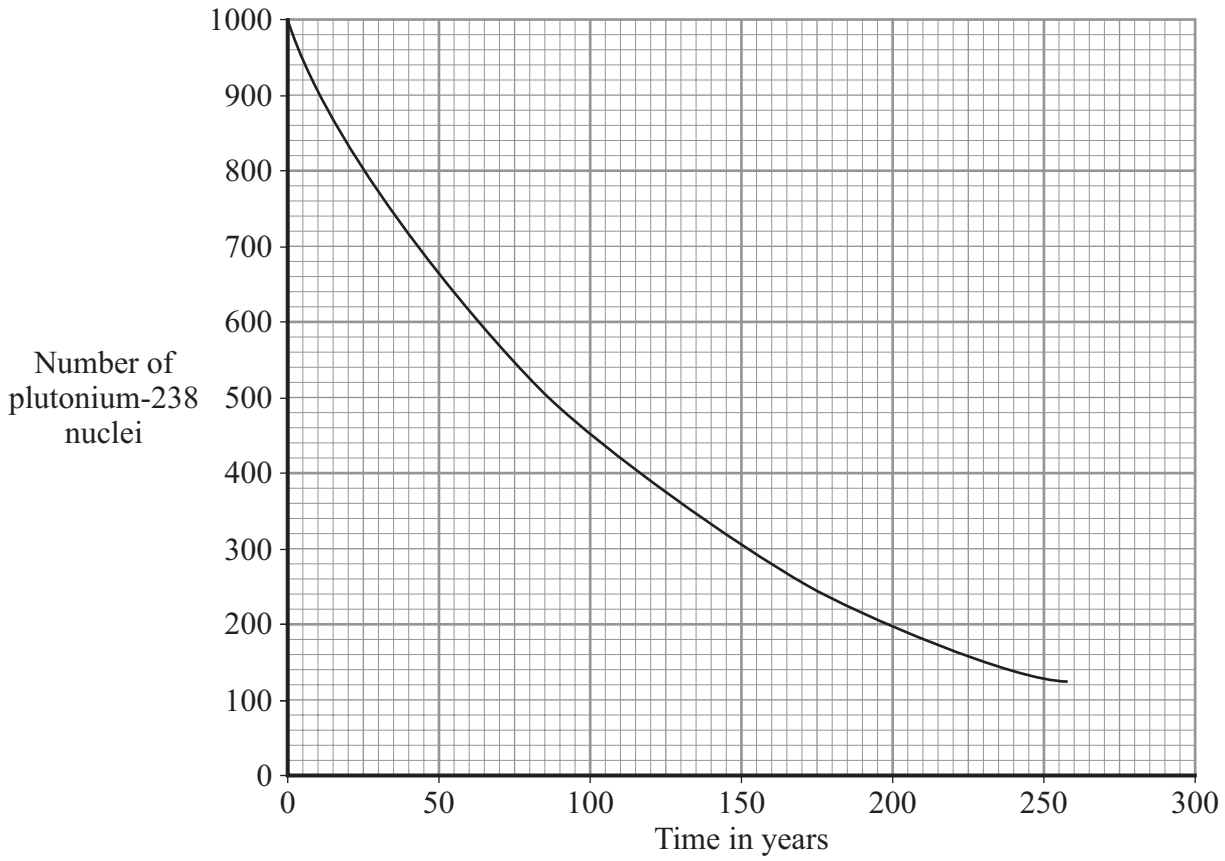
Question 4 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 52 · continued

for mark

4 (b) The graph shows how the number of nuclei in a sample of the radioactive isotope plutonium-238 changes with time.



Use the graph to find the half-life of plutonium-238.

Show clearly on the graph how you obtain your answer.

Half-life = ... years

(2 marks)

4 (c) The Cassini spacecraft launched in 1997 took seven years to reach Saturn.
The electricity to power the instruments on board the spacecraft is generated using the heat produced from the decay of plutonium-238.

4 (c) (i) Plutonium-238 decays by emitting alpha particles.

What is an alpha particle?

.....

(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 52 · continued

for mark

4 (c) (ii) During the 11 years that Cassini will orbit Saturn, the output from the generators will decrease.

Explain why.

.....

.....

.....

.....

(2 marks)

4 (d) Plutonium-238 is highly dangerous. A tiny amount taken into the body is enough to kill a human.

4 (d) (i) Plutonium-238 is unlikely to cause any harm if it is outside the body but is likely to kill if it is inside the body.

Explain why.

.....

.....

.....

.....

(2 marks)

4 (d) (ii) In 1964, a satellite powered by plutonium-238 was destroyed, causing the release of radioactive material into the atmosphere.

Suggest why some environmental groups protested about the launch of Cassini.

.....

.....

(1 mark)

10

4.4.2.1 Radioactive decay and nuclear radiation

Question 53

January 2009 | PHY2H | Original Q6 | Legacy

6 (a) Complete the following table for an atom of uranium-238 ($^{238}_{92}U$).

mass number	238
number of protons	92
number of neutrons	

(1 mark)

6 (b) Complete the following sentence.

The name given to the number of protons in an atom is the proton number or the

..... .

(1 mark)

6 (c) An atom of uranium-238 ($^{238}_{92}U$) decays to form an atom of thorium-234 ($^{234}_{90}Th$).

6 (c) (i) What type of radiation, alpha, beta or gamma, is emitted by uranium-238?

.....

(1 mark)

6 (c) (ii) Why does an atom that decays by emitting alpha or beta radiation become an atom of a different element?

.....

.....

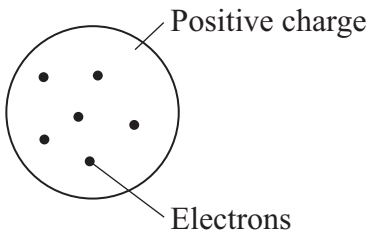
(1 mark)

4

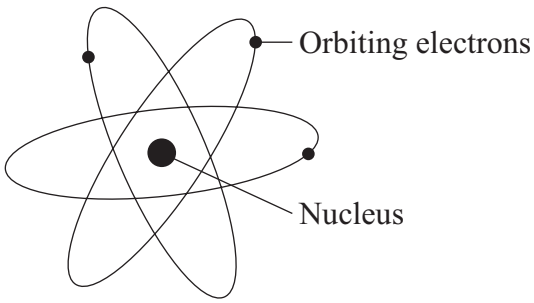
4.4.2.1 Radioactive decay and nuclear radiation

Question 54

7 In the early part of the 20th century, scientists used the 'plum pudding' model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the 'nuclear' model, was suggested.



7 (a) Describe the differences between the two models of the atom.

.....

.....

.....

.....

.....

.....

.....

.....

(4 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 54 · continued

for mark

7 (b) In their investigation, Rutherford and Marsden fired positively charged alpha particles at a very thin sheet of gold. Over a period of several months, the scientists made over 100 000 measurements. These measurements showed that:

- a very small number of alpha particles were deflected backwards from the gold foil.

Use the nuclear model to explain this experimental result.

.....

.....

.....

.....

(2 marks)

7 (c) Why did the work of Rutherford and Marsden convince many scientists that the 'plum pudding' model of the atom was incorrect?

.....

.....

.....

.....

(2 marks)

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 55

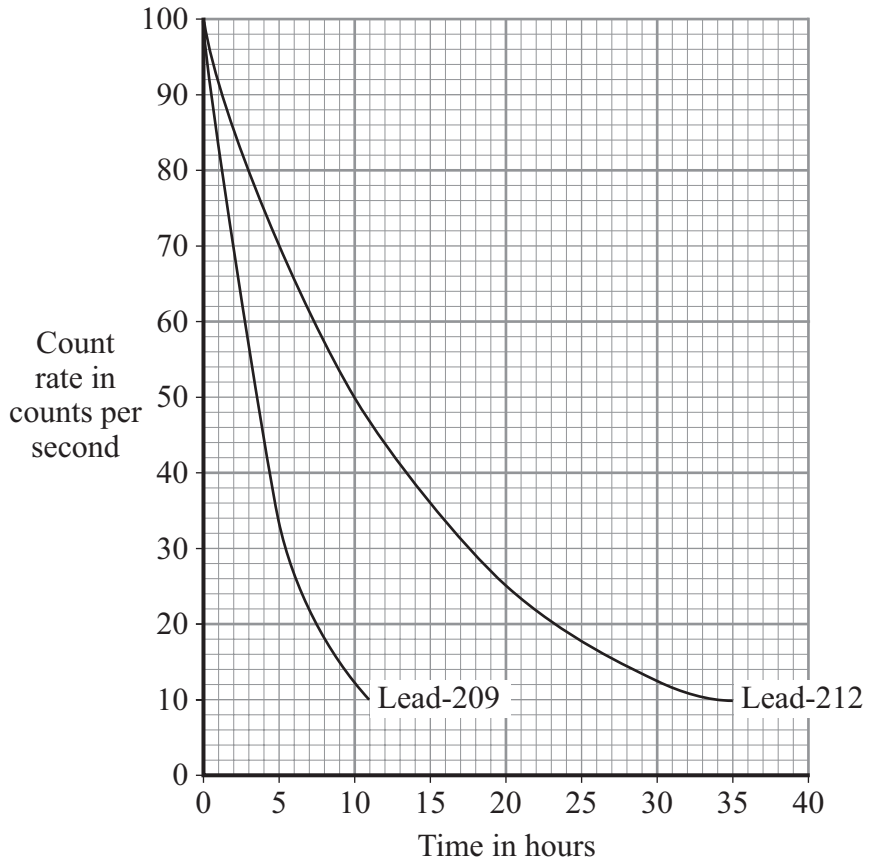
March 2009 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

The graph shows the radioactive decay of two isotopes of lead.

In lead-209, the total number of protons and neutrons is 209.

In lead-212, the total number of protons and neutrons is 212.



4.4.2.1 Radioactive decay and nuclear radiation

Question 55 · continued

Match values, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A 3

B 10

C 12

D 60

The half-life of lead-212 is . . . **1** . . . hours.

After 10 hours, the count rate of lead-209 is . . . **2** . . . counts per second.

When the count rate of lead-209 has dropped to 20 counts per second, the count rate of lead-212 has dropped to . . . **3** . . . counts per second.

Lead-212 has . . . **4** . . . more neutrons than lead-209.

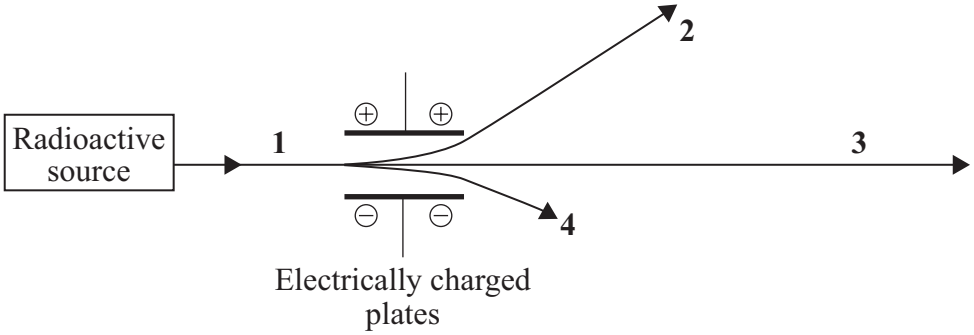
4.4.2.1 Radioactive decay and nuclear radiation

Question 56

March 2009 | PHY1BP | Original Q2 | Legacy

QUESTION TWO

A beam of radiation from a radioactive source is passed between two electrically charged plates. The paths taken by the radiation are shown in the diagram.



Match the types of radiation, **A**, **B**, **C** and **D**, with the paths **1–4** in the diagram.

A alpha particles

B beta particles

C gamma rays

D alpha, beta and gamma radiation

4.4.2.1 Radioactive decay and nuclear radiation

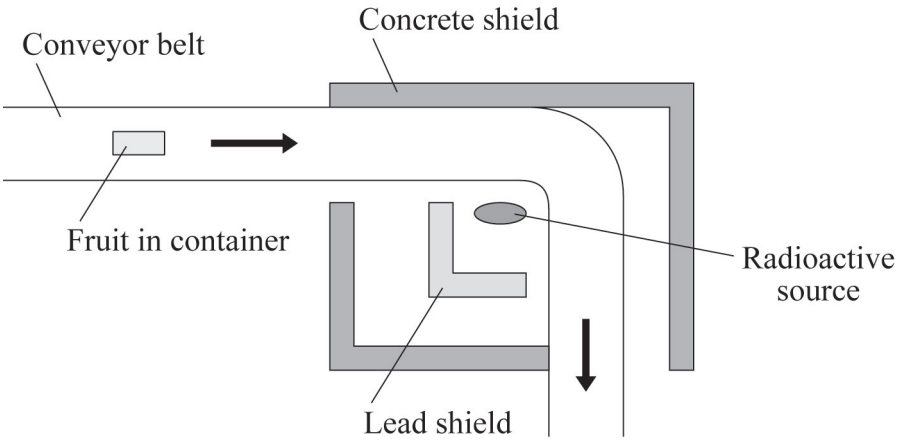
Question 57

March 2009 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

In some countries, fruit is passed in front of a radioactive source. The gamma radiation from the source kills bacteria. This keeps the fruit fresh for longer.

The main process is shown in the diagram.



3A Gamma radiation is used because it is . . .

1 able to penetrate the container and fruit.

2 stopped by the lead shield.

3 not harmful to people.

4 the only radiation that can kill bacteria.

3B The amount of radiation absorbed by the fruit can be increased by . . .

1 moving the source further from the fruit.

2 packing the fruit in thicker containers.

3 slowing down the conveyor belt.

4 speeding up the conveyor belt.

4.4.2.1 Radioactive decay and nuclear radiation

Question 57 · continued

3C Some fruit growers use X-ray machines instead of gamma ray sources.

The X-rays are safer to work with because . . .

1 gamma ray sources are used in hospitals.

2 X-ray machines can be switched on and off.

3 gamma rays have a lower frequency than X-rays.

4 X-rays have a shorter wavelength than gamma rays.

3D Some scientists investigated the effect of radiation on the vitamin C content of fruit.

They measured the amount of radiation absorbed by some fruit.

They also measured the amount of vitamin C in the fruit before and after the radiation treatment.

Which row of the table describes the variables for a fair test?

	Amount of radiation absorbed	Amount of vitamin C lost during irradiation	Size and type of fruit
1	independent	dependent	control
2	independent	control	dependent
3	dependent	independent	control
4	control	independent	dependent

4.4.2.1 Radioactive decay and nuclear radiation

Question 58

March 2009 | PHY1BP | Original Q6 | Legacy

QUESTION SIX

Radium is an element with many isotopes. All of the isotopes of radium are radioactive. Natural radium emits alpha, beta and gamma radiation.

6A Alpha radiation is . . .

1 a very fast electron from the nucleus.

2 an electromagnetic wave of very high frequency.

3 a particle containing protons and neutrons.

4 a particle containing only neutrons.

6B Beta radiation has a longer range in air than alpha particles.

One of the reasons is that beta radiation is . . .

1 more highly ionising than alpha due to its larger electric charge.

2 more highly ionising than alpha due to its smaller electric charge.

3 less highly ionising than alpha due to its larger electric charge.

4 less highly ionising than alpha due to its smaller electric charge.

6C Gamma radiation is not electrically charged.

We know that it is not electrically charged because gamma radiation is . . .

1 deflected in magnetic fields but not in electric fields.

2 deflected in electric fields but not in magnetic fields.

3 deflected in both electric and magnetic fields.

4 not deflected in either electric or magnetic fields.

4.4.2.1 Radioactive decay and nuclear radiation

Question 58 · continued

6D A sample of natural radium contains 8 g of isotope radium-211. Radium-211 has a half-life of 13 seconds.

After 26 seconds, . . .

1 half of the radium-211 atoms will have decayed.

2 all of the radium-211 atoms will have decayed.

3 only 2 g of radium-211 will remain.

4 the detected count rate from radium-211 will be zero.

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 59

March 2009 | PHY1BP | Original Q9 | Legacy

QUESTION NINE

Ultraviolet radiation is next to X-rays in the electromagnetic spectrum. Ultraviolet radiation consists of three regions: UVA, UVB, and UVC, as shown in the table.

	UVA	UVB	UVC	X-rays	

9A The UVA region of the spectrum has wavelengths between 315 and 400 nm. The visible light region of the spectrum extends to wavelengths of 700 nm.

In what wavelength region will violet light be found?

1 nanometre, 1 nm = 0.000 000 001 metre

1 360 – 400 nm

2 400 – 430 nm

3 620 – 700 nm

4 700 – 760 nm

9B Different types of electromagnetic radiation will penetrate materials to different depths. UVA will penetrate the top and middle layers of human skin. UVB will penetrate the top layer only.

This is surprising because gamma rays . . .

1 penetrate less than X-rays and have a lower frequency than X-rays.

2 penetrate less than X-rays and have a higher frequency than X-rays.

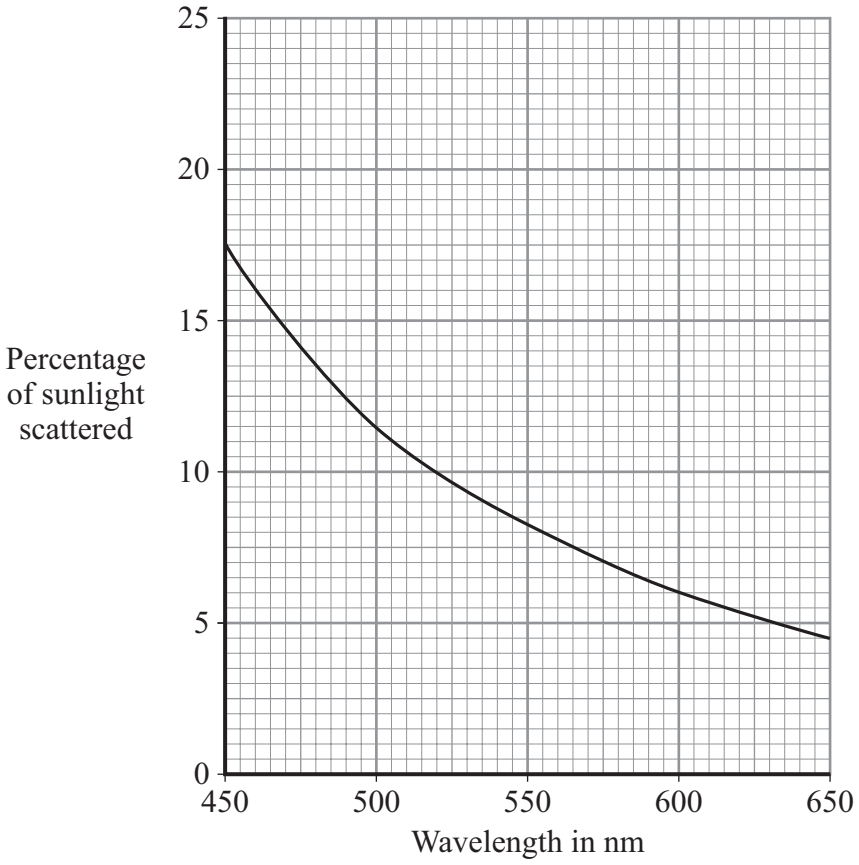
3 penetrate more than X-rays and have a shorter wavelength than X-rays.

4 penetrate more than X-rays and have a longer wavelength than X-rays.

4.4.2.1 Radioactive decay and nuclear radiation

Question 59 · continued March 2009 | PHY1BP | Original Q9 | Legacy

9C The scattering of sunlight by the atmosphere causes the daylight colour of the sky to be blue. The graph shows how the scattering of sunlight changes with the wavelength.



What percentage of direct sunlight reaches the Earth **unscattered** at a wavelength of 500 nm?

1 11.5 %

2 37.5 %

3 62.5 %

4 88.5 %

9D How much scattering would you expect from ultraviolet rays?

1 less scattering than from visible light because ultraviolet rays have a lower frequency than visible light.

2 less scattering than from visible light because ultraviolet rays travel more slowly than visible light.

3 more scattering than from visible light because ultraviolet rays have a shorter wavelength than visible light.

4 the same scattering as from visible light because they both travel at the same speed.

END OF TEST

4.4.2.1 Radioactive decay and nuclear radiation

Question 60

June 2009 | PHY1AP | Original Q2 | Legacy

QUESTION TWO

This question is about energy resources that can be used to produce electricity.

Match words, **A**, **B**, **C** and **D**, with the pairs of statements **1**–**4** in the table.

A coal

B nuclear

C tides

D wind

	Advantage	Disadvantage
1	no polluting gases produced	unpredictable supply of energy
2	no polluting gases produced	radioactive waste produced
3	plentiful supply of fuel in Britain	produces acid rain
4	no fuel needed	may destroy habitats of wading birds

4.4.2.1 Radioactive decay and nuclear radiation

Question 61

June 2009 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

Electromagnetic radiation can be grouped into types. Each type has a different range of wavelengths.

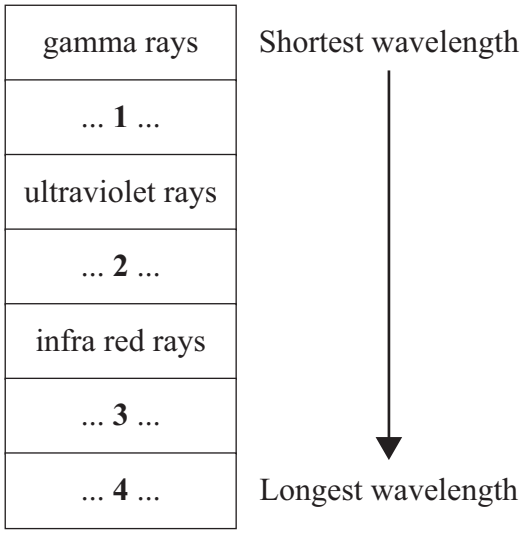
Match types of radiation, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table.

A microwaves

B X-rays

C visible light

D radio waves



4.4.2.1 Radioactive decay and nuclear radiation

Question 62

June 2009 | PHY1BP | Original Q2 | Legacy

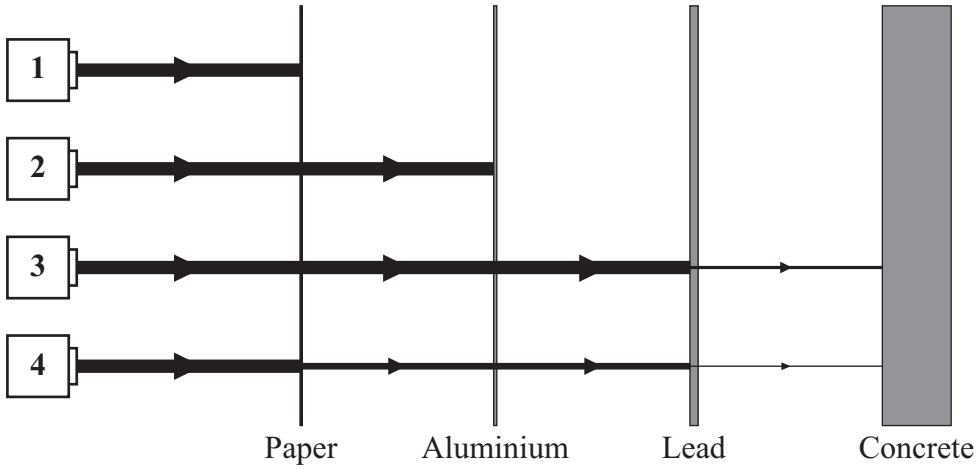
QUESTION TWO

The diagram shows four radioactive sources, **1**, **2**, **3** and **4**, each producing different types of nuclear radiation.

The thicker the horizontal lines in the diagram, the greater the intensity of the radiation.

Match the types of radiation, **A**, **B**, **C** and **D**, with the radioactive sources **1–4**.

Radioactive sources



A alpha only

B beta only

C gamma only

D alpha and gamma

4.4.2.1 Radioactive decay and nuclear radiation

Question 63

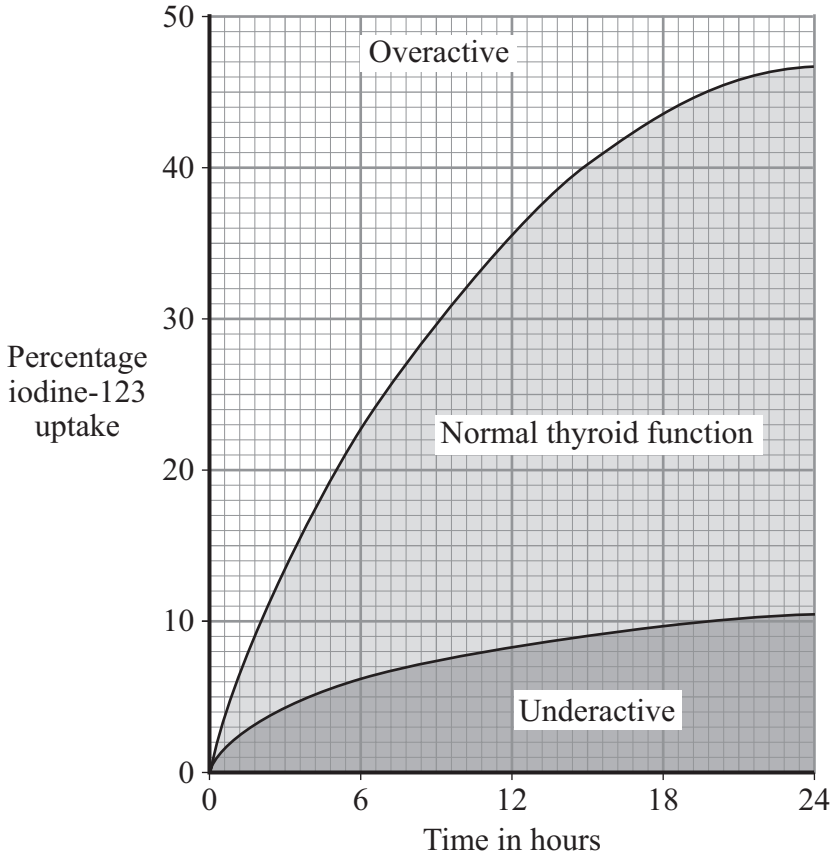
June 2009 | PHY1BP | Original Q5 | Legacy

QUESTION FIVE

The thyroid gland uses iodine to produce hormones (chemicals) which help to control the body's functions. If too much iodine is absorbed, the thyroid becomes overactive. If too little iodine is absorbed, the thyroid becomes underactive.

A radioactive isotope, iodine-123, is used as a tracer in the diagnosis of thyroid disease. Iodine-123 is a gamma emitter.

A patient having a diagnostic test is given a drink of sodium iodide which contains a small amount of iodine-123. A detector measures the gamma emission from the thyroid. The iodine uptake by the thyroid is measured and displayed, as shown in the graph.



5A A gamma emitter is used because gamma rays . . .

1 are not affected by electric fields.

2 can pass through body tissue easily.

3 travel at the speed of light.

4 have very long wavelengths.

Question 63 · continued

5B A patient is worried about drinking the radioactive liquid. The doctor tells him that the half-life of iodine-123 is 13 hours.

She explains that after 48 hours . . .

1 there will be no iodine-123 left in the body.

2 there will be less than 1/16 of the iodine-123 left in the body.

3 there will be less than 1/8 of the iodine-123 left in the body.

4 there will be no gamma radiation left in the body.

5C Three patients, **P**, **Q** and **R**, undergo the same diagnostic test. Their results are shown in the table.

Patient	Percentage of iodine-123 uptake after 6 hours	Percentage of iodine-123 uptake after 24 hours
P	1.0	5.0
Q	10.0	25.0
R	25.0	50.0

Using the graph, which one of the following statements is a correct conclusion?

1 All three patients are normal.

2 **P** and **Q** are normal; **R** is 'overactive'.

3 **P** and **R** are normal; **Q** is 'underactive'.

4 Only **Q** is normal.

5D Some medical students suggest that the rate of gamma emission from the iodine-123 is affected by different factors.

Which student is correct?

Student	Factor affecting rate of gamma emission
1	body temperature
2	age and sex of patient
3	length of time after the drink is taken
4	chemical composition of sodium iodide

4.4.2.1 Radioactive decay and nuclear radiation

Question 64

June 2009 | PHY1BP | Original Q7 | Legacy

QUESTION SEVEN

Some types of electromagnetic radiation from space are absorbed by the Earth's atmosphere.

	Short wavelength radio	Short wavelength microwaves	Infra red	Visible light	Ultraviolet	X-rays	Gamma rays
Percentage absorbed by atmosphere	0	95	96	5	98	100	100

Different objects or events in the universe emit different types of electromagnetic radiation.

	Gamma ray bursts	Nebulae	Pulsars	Stars	Universe background radiation
Radiation emitted	gamma rays	infra red	radio	all types	short wavelength microwaves

The planets and moons of the solar system reflect light from the Sun.

7A Early civilisations observed the sky with the naked eye.

Which objects did they see?

1 moons, nebulae and pulsars

2 gamma ray bursts, moons and planets

3 nebulae and pulsars

4 moons, planets and stars

7B Telescopes that could detect electromagnetic waves of the lowest frequency were built in the 20th century. These telescopes are on the surface of the Earth.

From the information in the tables, which of the following, which could not have been observed before, could then be easily observed from the Earth's surface?

1 pulsars

2 gamma ray bursts

3 nebulae

4 stars

4.4.2.1 Radioactive decay and nuclear radiation

Question 64 · continued June 2009 | PHY1BP | Original Q7 | Legacy

7C In 1989, the background radiation from the universe was mapped from a telescope in space.

Why was this **not** done with telescopes based on Earth?

1 Because only 2% of ultraviolet radiation penetrates Earth's atmosphere.

2 Because only 4% of infra red radiation penetrates Earth's atmosphere.

3 Because only 5% of short wavelength microwave radiation penetrates Earth's atmosphere.

4 Because only 95% of visible radiation penetrates Earth's atmosphere.

7D The first table suggests that, with the exception of . . .

1 radio, the percentage of radiation absorbed by the atmosphere, increases with increasing wavelength.

2 radio, the percentage of radiation absorbed by the atmosphere, decreases with increasing wavelength.

3 visible light, the percentage of radiation absorbed by the atmosphere, increases with increasing wavelength.

4 visible light, the percentage of radiation absorbed by the atmosphere, decreases with increasing wavelength.

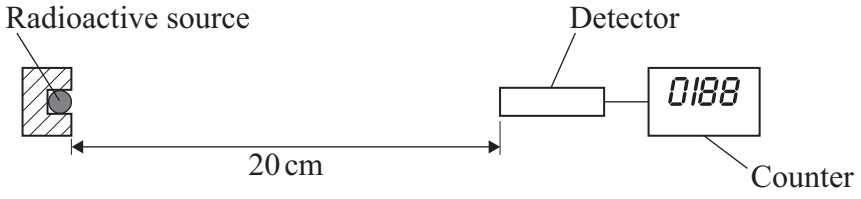
4.4.2.1 Radioactive decay and nuclear radiation

Question 65

June 2009 | PHY1BP | Original Q9 | Legacy

QUESTION NINE

A scientist investigated how the count rate of the nuclear radiation emitted by a particular radioactive source changed with time.



She placed a radiation detector 20 centimetres from the source.

She recorded the count rate every 10 minutes for 2 hours.

These are her results.

Time in min	10	20	30	40	50	60	70	80	90	100	110	120
Count rate in counts per minute	188	160	132	112	94	80	69	56	47	40	33	28

9A What is the half-life of the source?

1 30 minutes

2 40 minutes

3 50 minutes

4 60 minutes

9B The count rate at 70 minutes does not fit the same pattern as the other results.

Which one of the following is the most likely reason that this count rate does not fit the pattern?

1 The sensitivity of the detector is too low.

2 After 70 minutes, there was a rise in room temperature.

3 Radioactive decay is a random process.

4 After a certain time, the half-life of a source changes.

9C The scientist should have recorded the count rate at the beginning of the investigation at 0 minutes.

What was the count rate most likely to have been at 0 minutes?

1 192 counts per minute

2 188 counts per minute

3 224 counts per minute

4 376 counts per minute

9D Another radioactive material has a half-life of 6 years. A 64 g sample of the radioactive material is stored in a container.

What mass of this radioactive material will have decayed in 24 years?

1 4 g

2 16 g

3 48 g

4 60 g

END OF TEST

4.4.2.1 Radioactive decay and nuclear radiation

Question 66

June 2009 | PHY1H | Original Q1 | Legacy

1 (a) The table lists the names of seven telescopes. Each one of the telescopes is designed to detect a different one of the seven types of electromagnetic wave.
The table is incomplete.

Name of telescope	Type of wave detected
HESS	Gamma
XMM Newton	X-ray
FUSE	Ultraviolet
William Herschel	Visible light
Spitzer	
SPT	Microwave
Lovell	Radio

1 (a) (i) Which **one** of the telescopes is designed to detect the type of wave with the shortest wavelength?

.....

(1 mark)

1 (a) (ii) What type of wave is the Spitzer telescope designed to detect?

.....

(1 mark)

1 (b) The William Herschel telescope is on the Earth's surface. Another telescope, the Hubble telescope, which also detects visible light, orbits the Earth.

How is the image produced by the Hubble telescope better than the image produced by the William Herschel telescope?

.....

Give a reason for your answer.

.....

.....

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 66 · continued

for mark

1 (c) Some types of electromagnetic wave are absorbed by water.
The SPT telescope is located in the Antarctic, which is a dry environment.

Explain why it is better to have this type of telescope in a dry environment rather than in a wet, humid environment.

.....

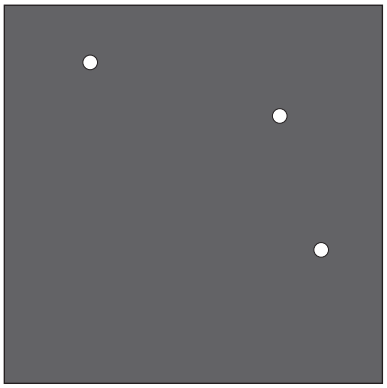
.....

.....

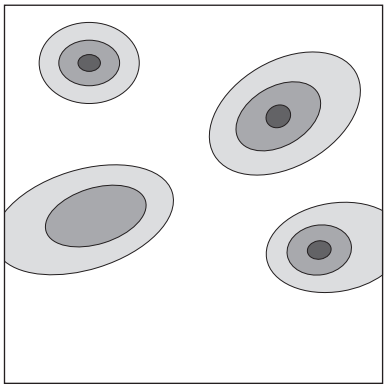
.....

(2 marks)

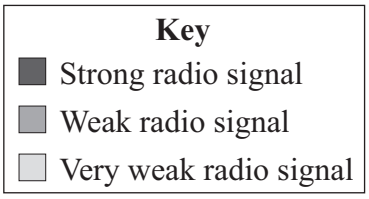
1 (d) The pictures represent the images produced using a visible light telescope and a radio telescope. Both images are of the same part of the sky. The shading on the radio telescope image represents the strength of the radio signals.



Visible light image



Radio telescope image



Suggest what extra information can be gained from the radio telescope image compared with the visible light image.

.....

.....

(1 mark)

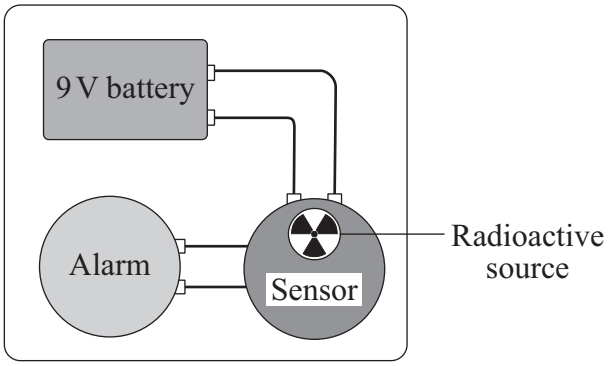
7

4.4.2.1 Radioactive decay and nuclear radiation

Question 67

June 2009 | PHY1H | Original Q6 | Legacy

6 (a) The diagram shows the parts of a smoke detector. The radioactive source emits alpha particles.



The alpha particles ionise the air inside the sensor which causes a small electric current. Any smoke getting into the sensor changes the current. The change in current sets the alarm off.

6 (a) (i) The smoke detector would **not** work if a radioactive source that emitted only gamma rays was used.

Why not?

.....

.....

(1 mark)

6 (a) (ii) Curium-242 is a radioactive isotope with a half-life of 160 days. It emits alpha particles.

Why is curium-242 **not** suitable for use inside smoke detectors?

.....

.....

(1 mark)

6 (a) (iii) Curium-242 and curium-244 are two of the isotopes of the element curium.

How is an atom of curium-242 different from an atom of curium-244?

.....

.....

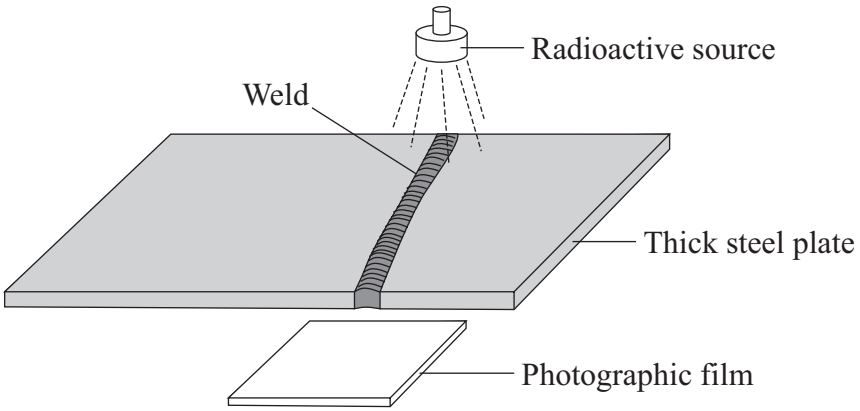
(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 67 · continued

for mark

6 (b) Sections of steel are often joined by welding them together. The diagram shows how a radioactive source can be used to check for tiny cracks in the weld.



Cracks in the weld will be shown up on the photographic film below the thick steel plate.

6 (b) (i) Which type of source, alpha, beta or gamma, should be used to check the weld?

.....

(1 mark)

6 (b) (ii) Give a reason why the other two types of source **cannot** be used.

.....

.....

(1 mark)

Question 6 continues on the next page

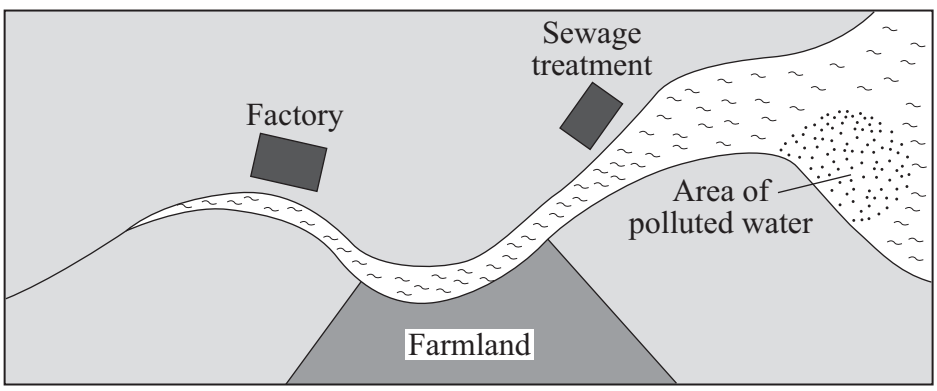
4.4.2.1 Radioactive decay and nuclear radiation

Question 67 · continued

for mark

6 (c) The diagram shows a map of a river and its estuary.

Environmental scientists have found that the water flowing into one part of the river estuary is polluted. To find where the pollution is coming from, the scientists use a radioactive isotope, gold-198.



6 (c) (i) Explain how the gold-198 is used to find where the pollution is coming from.

.....

.....

.....

.....

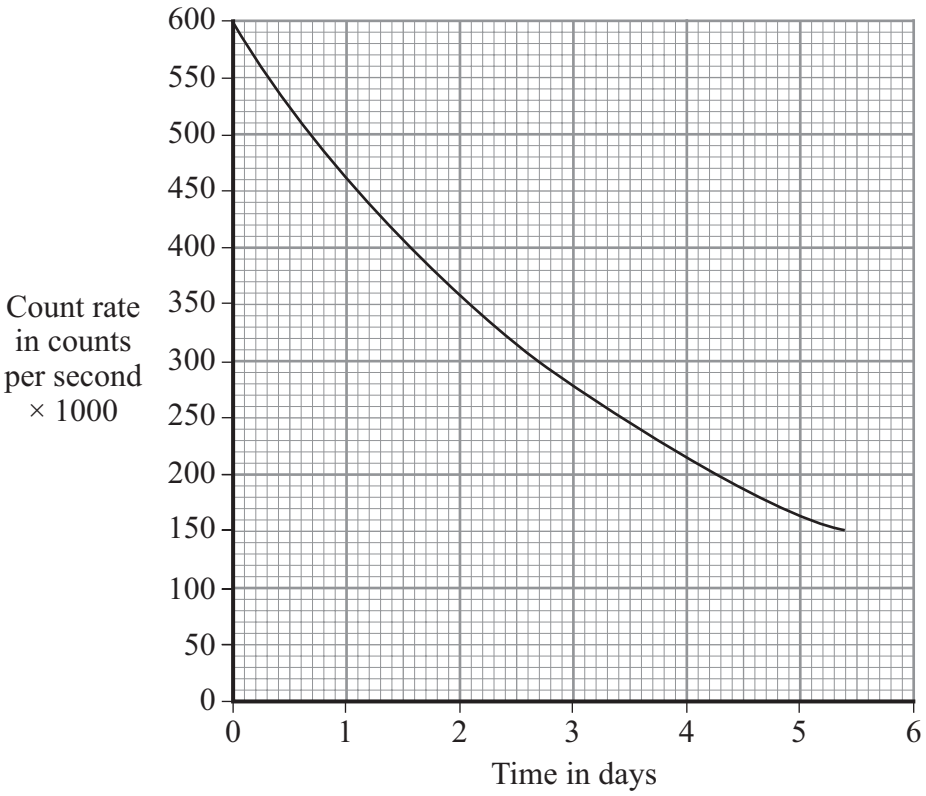
(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 67 · continued

for mark

6 (c) (ii) The graph shows how the count rate from a sample of gold-198 changes with time.



Use the graph to calculate the half-life of gold-198.

Show clearly on the graph how you obtain your answer.

.....

.....

Half-life = ... days

(2 marks)

9

4.4.2.1 Radioactive decay and nuclear radiation

Question 68

June 2009 | PHY2H | Original Q1 | Legacy

1 The table gives information about the three types of particle that make up an atom.

Particle	Relative mass	Relative charge
Proton		+1
Neutron	1	
Electron	very small	–1

1 (a) Complete the table by adding the **two** missing values. *(2 marks)*

1 (b) Use the information in the table to explain why an atom has no overall electrical charge.

.....

.....

.....

.....

(2 marks)

1 (c) Uranium has two natural isotopes, uranium-235 and uranium-238.
Uranium-235 is used as a fuel inside a nuclear reactor.
Inside the reactor, atoms of uranium-235 are split and energy is released.

1 (c) (i) How is the structure of an atom of uranium-235 different from the structure of an atom of uranium-238?

.....

.....

(1 mark)

1 (c) (ii) The nucleus of a uranium-235 atom must absorb a particle before the atom is able to split.

What type of particle is absorbed?

.....

(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 68 · continued

for mark

1 (c) (iii) The nucleus of an atom splits into smaller parts in a reactor.

What name is given to this process?

.....

(1 mark)

7

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

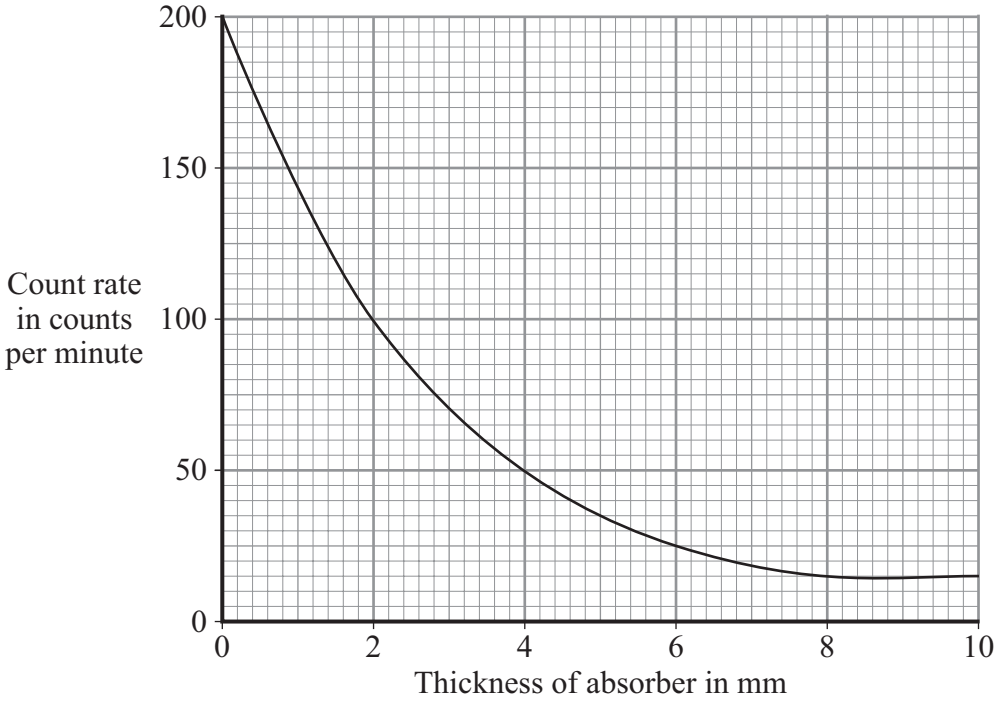
Question 69

November 2009 | PHY1BP | Original Q2 | Legacy

QUESTION TWO

A source of beta radiation is placed in front of a detector. Pieces of aluminium of different thicknesses are placed between the source and the detector. The thickness of the absorber and the count rate are measured.

The results are shown on the graph.



Match the figures, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A 2

B 9

C 70

D 200

The count rate with no absorber is . . . **1** . . . counts per minute.

The count rate when the absorber is 3 mm thick is . . . **2** . . . counts per minute.

The thickness needed to reduce the count rate by half is . . . . **3** . . . mm.

The thickness needed to absorb all the radiation from the source is . . . **4** . . . mm.

4.4.2.1 Radioactive decay and nuclear radiation

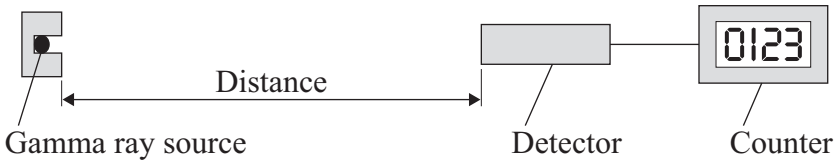
Question 70

November 2009 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

Harmful Gamma Radiation? .... Keep safe, keep away!

A sixth form student decided to test the truth of the newspaper headline. She used a gamma ray source and a detector to measure the amount of radiation reaching the detector per second. She repeated the experiment and calculated the mean count rates. She then moved the detector further away from the source and repeated the procedure.



Her results are shown in the table.

Distance from source in metres	Count rate in counts per second		
	Test 1	Test 2	Mean
0.2	480	484	482
0.4	121	127	124
0.6	55	55	55
0.8	30	32	31
1.0	20	18	19

4.4.2.1 Radioactive decay and nuclear radiation

Question 70 · continued

3A The results with the greatest range of count rate occur at a distance from the source of . . .

1 0.2 m

2 0.4 m

3 0.8 m

4 1.0 m

3B She repeated the experiment and calculated the mean to make her results more . . .

1 accurate.

2 controlled.

3 varied.

4 reliable.

3C A valid conclusion based on her results would be that . . .

1 1.0 m is a safe distance to be from the source.

2 the count rate decreases as the distance from the source increases.

3 the count rate will be almost zero at a distance of 1.2 m from the source.

4 there is no such thing as a safe distance from a gamma source.

3D Another way in which the count rate could be reduced would be to . . .

1 reduce the air temperature between the source and detector.

2 place a thick sheet of lead between the source and detector.

3 produce a strong electric field between the source and detector.

4 produce a strong magnetic field between the source and detector.

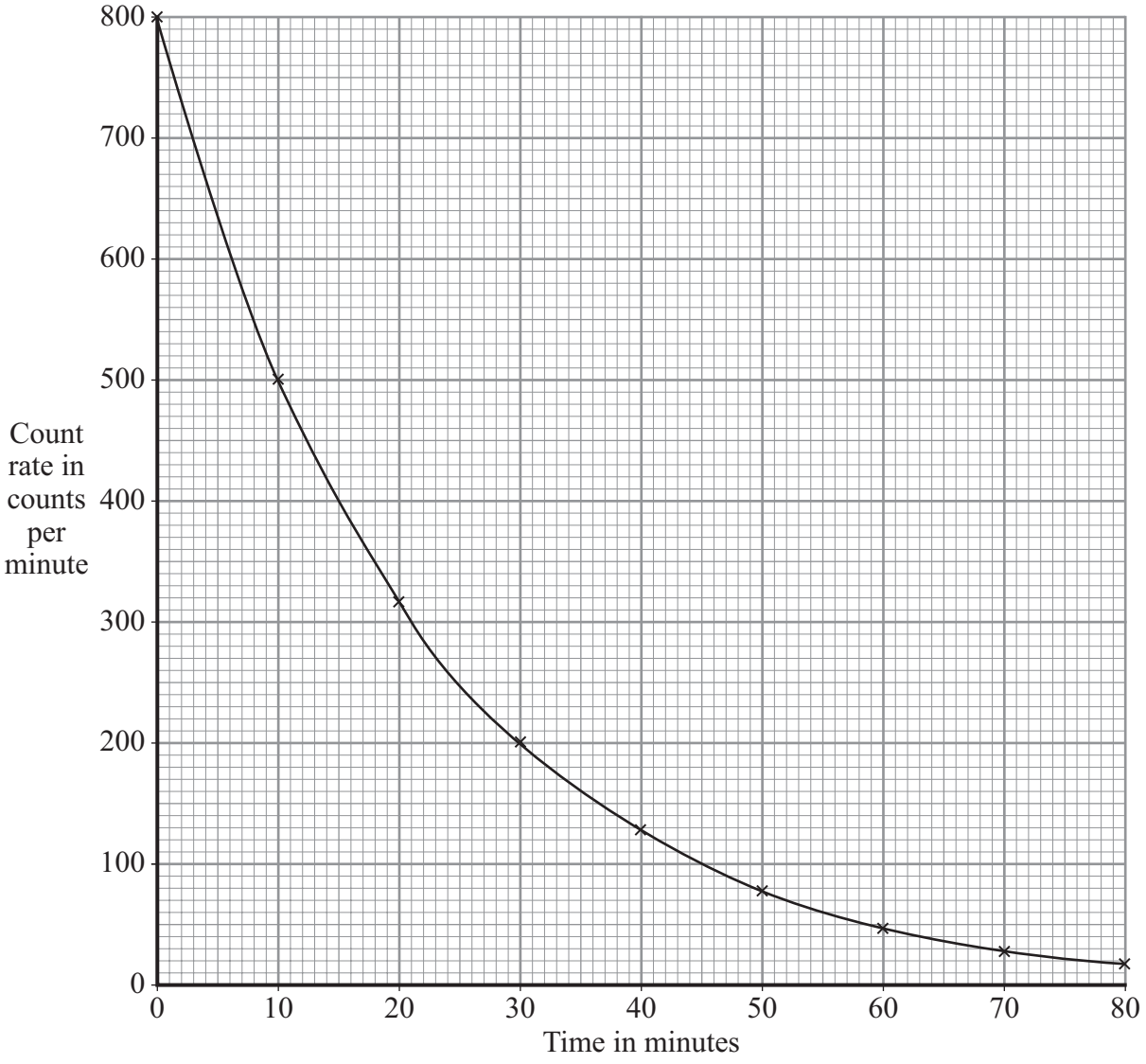
4.4.2.1 Radioactive decay and nuclear radiation

Question 71

November 2009 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

The graph shows how the count rate of a radioactive isotope varies with time.



4A What is the half-life of the isotope?

1 10 minutes

2 15 minutes

3 20 minutes

4 80 minutes

4.4.2.1 Radioactive decay and nuclear radiation

4B The person who plotted the graph has drawn a line graph rather than a bar chart.

What is the reason for this?

1 Both the count rate and time are continuous variables.

2 Time is a discrete variable and count rate is a continuous variable.

3 Time is a continuous variable and count rate is a categoric variable.

4 Both the count rate and time are discrete variables.

4C The government recommends that all homes are fitted with smoke alarms. Americium-241 is used in these alarms. Americium-241 emits alpha particles and has a half-life of 460 years.

The americium-241 is safe to use in homes because . . .

1 it has a long half-life.

2 alpha particles travel only a few centimetres in air.

3 smoke alarm batteries are replaced regularly.

4 its nucleus has 146 neutrons.

4D This information is about the isotope technetium-99.

- It emits gamma radiation.
- Its half-life is 6 hours.
- It decays to a stable isotope of rubidium.
- It is used for diagnostic medical studies.
- It is put into the body.

A doctor wants to convince a patient that technetium-99 is safe to use to diagnose a medical problem.

Which of the following should he use to reassure the patient?

1 Rubidium is a rare metallic element.

2 Gamma radiation is part of the electromagnetic spectrum.

3 The half-life of the technetium-99 isotope is relatively short.

4 There is no risk in using radioactive materials.

4.4.2.1 Radioactive decay and nuclear radiation

Question 72

November 2009 | PHY1BP | Original Q9 | Legacy

QUESTION NINE

Visible light from space can be gathered and focused by optical telescopes.

9A Optical telescopes used to observe objects in space are limited because they can only be used . . .

1 as ground-based telescopes.

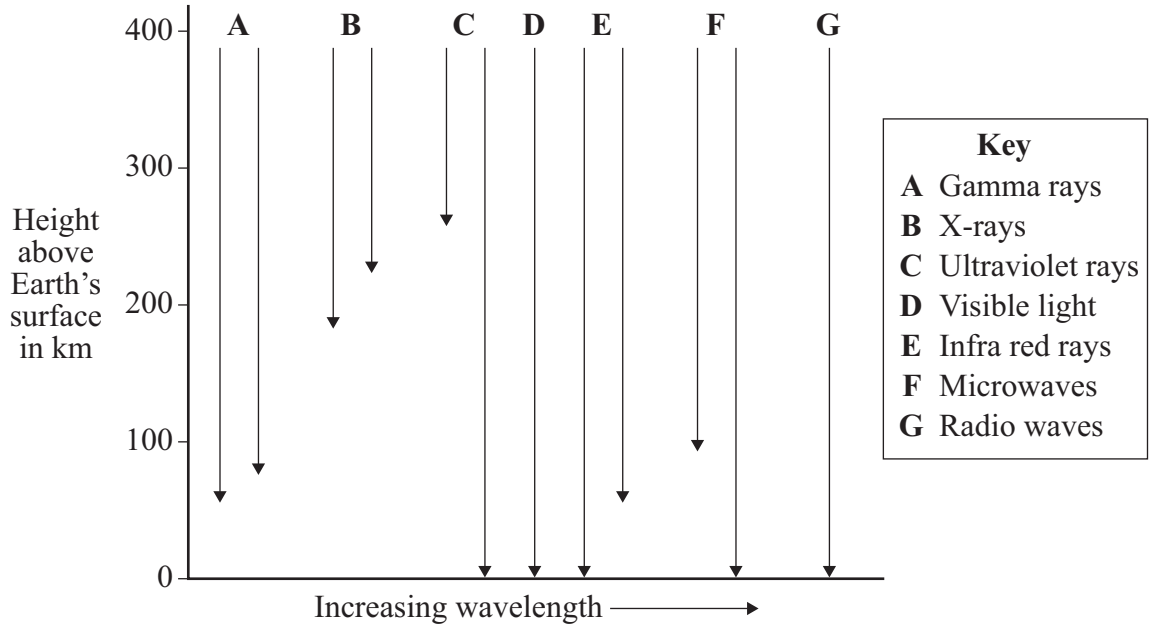
2 at night.

3 to observe a small region of the electromagnetic spectrum.

4 to observe one region of the sky.

The diagram shows how far electromagnetic waves can penetrate the Earth's atmosphere.

Where two arrows are shown for a type of electromagnetic radiation, longer and shorter waves penetrate the atmosphere to different depths.



9B Radio telescopes are sited on the ground.

This is because radio waves . . .

1 are emitted by many stars.

2 can penetrate the atmosphere.

3 have a shorter wavelength than microwaves.

4 have more energy than infra red waves.

4.4.2.1 Radioactive decay and nuclear radiation

Question 72 · continued

9C The types of radiation collected by four telescopes, **M**, **N**, **P** and **Q**, are given in the table.

Telescope	Radiation collected
M	infra red waves
N	gamma rays
P	X-rays
Q	microwaves

Which telescopes could be operated from an aircraft flying at an altitude of 12 km?

1 **M** and **N**

2 **N** and **P**

3 **P** and **Q**

4 **Q** and **M**

9D What is the minimum height above the Earth for a satellite to be able to use telescope **P**?

1 50 km

2 70 km

3 180 km

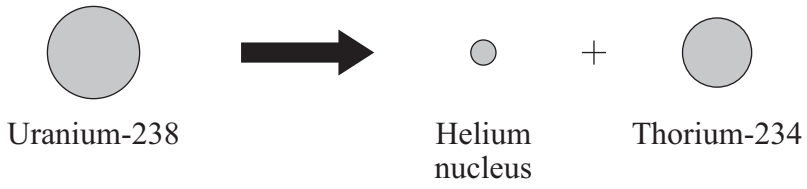
4 250 km

END OF TEST

4.4.2.1 Radioactive decay and nuclear radiation

Question 73

4 (a) Some rocks inside the Earth contain uranium-238, a radioactive isotope of uranium. When an atom of uranium-238 decays, it gives out radiation and changes into a thorium-234 atom.



4 (a) (i) What type of radiation is emitted when a uranium-238 atom decays?

.....

(1 mark)

4 (a) (ii) From which part of a uranium-238 atom is the radiation emitted?

.....

(1 mark)

4 (a) (iii) Uranium-235 is another isotope of uranium.

How is an atom of uranium-235 similar to an atom of uranium-238?

.....

(1 mark)

4 (b) Uranium-238 has a half-life of 4500 million years.

4 (b) (i) When the Earth was formed, there was twice as much uranium-238 in the rocks as there is now.

What is the age of the Earth?

.....

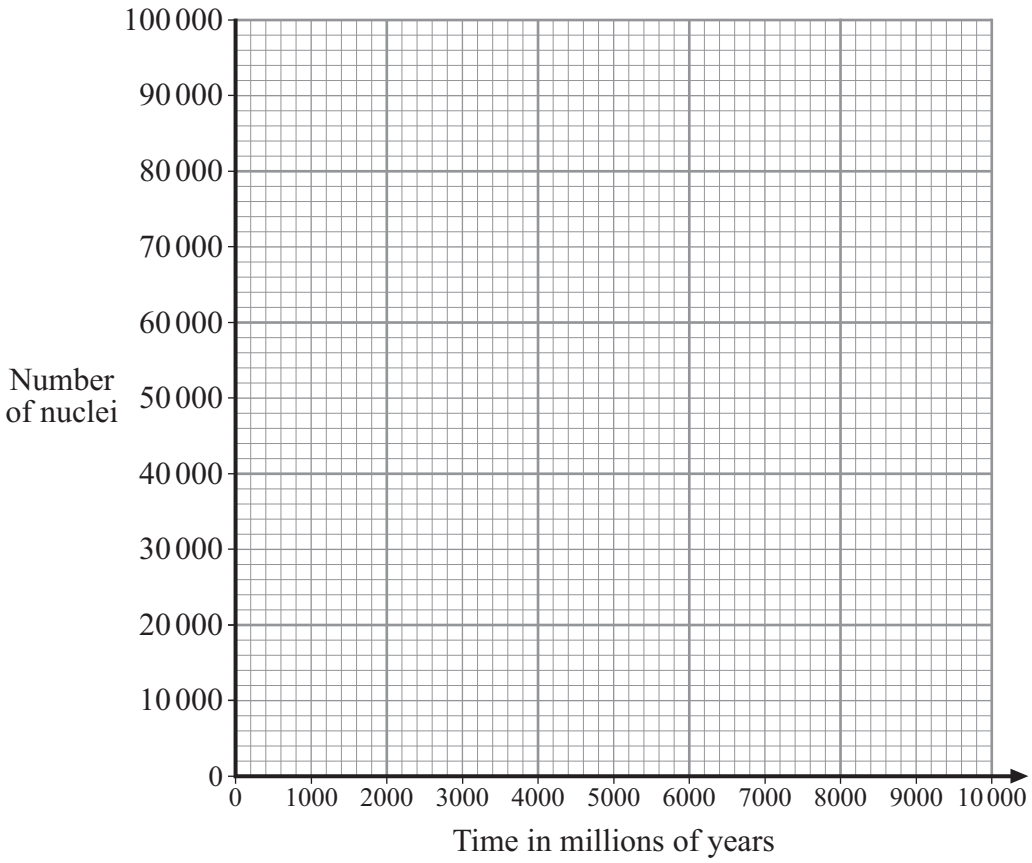
(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 73 · continued

for mark

4 (b) (ii) Complete the graph to show how the number of nuclei in a sample of uranium-238 will change with time.
Initially, there were 100 000 nuclei in the sample.



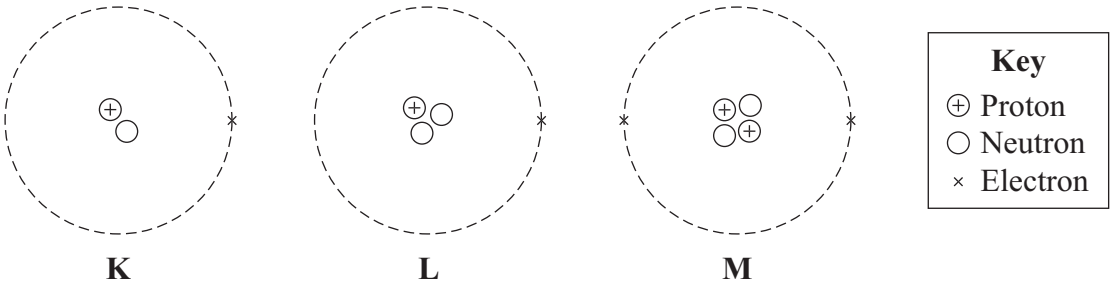
(2 marks)

6

4.4.2.1 Radioactive decay and nuclear radiation

Question 74

3 (a) The diagram represents 3 atoms, **K**, **L** and **M**.



K **L** **M**

3 (a) (i) Which **two** of the atoms are isotopes of the same element?

..... and .....

(1 mark)

3 (a) (ii) Give a reason why the **two** atoms that you chose in part (a)(i) are:

(1) atoms of the same element .....

.....

(2) different isotopes of the same element. .....

.....

.....

(2 marks)

3 (b) The table gives some information about the radioactive isotope thorium-230.

mass number	230
atomic number	90

3 (b) (i) How many electrons are there in an atom of thorium-230?

.....

(1 mark)

3 (b) (ii) How many neutrons are there in an atom of thorium-230?

.....

(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 74 · continued

for mark

3 (c) When a thorium-230 nucleus decays, it emits radiation and changes into radium-226.

$$^{230}_{90}\text{Th} \longrightarrow {}^{226}_{88}\text{Ra} + \boxed{\text{Radiation}}$$

What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

.....

Explain the reason for your answer.

.....

.....

.....

.....

.....

(3 marks)

8

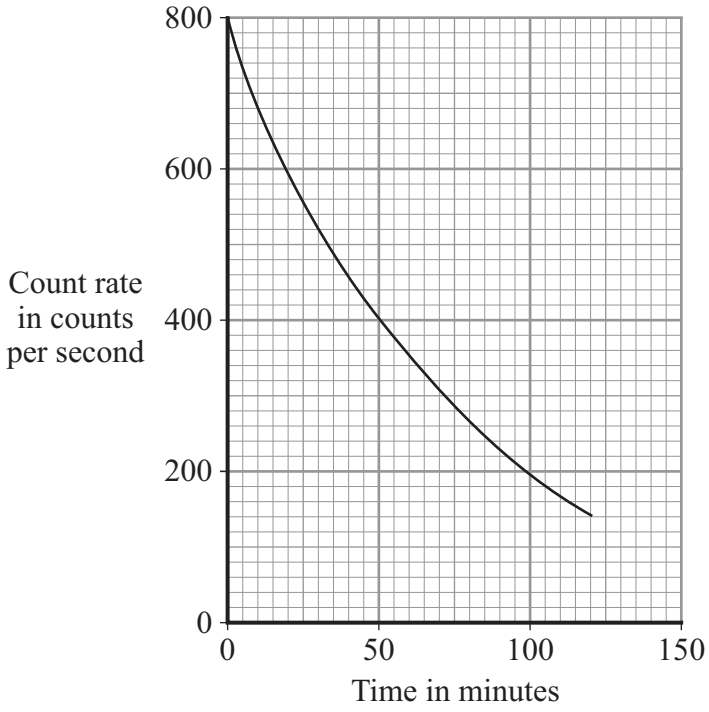
4.4.2.1 Radioactive decay and nuclear radiation

Question 75

March 2010 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

The graph shows how the count rate of a radioactive substance changes with time.



4.4.2.1 Radioactive decay and nuclear radiation

Question 75 · continued

Match figures, **A**, **B**, **C** and **D**, with the statements **1–4** in the table.

A 50

B 100

C 400

D 800

1	the initial count rate of the substance
2	the count rate after one half-life
3	the half-life of the substance in minutes
4	the count rate after three half-lives

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 76

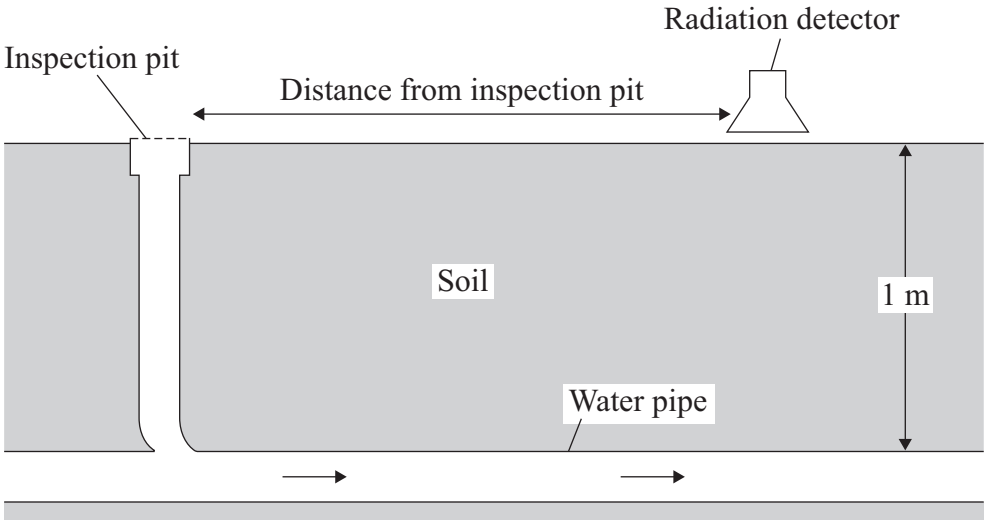
March 2010 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

Some engineers investigated a problem with the flow of water through an underground pipe.
The pipe was 1 metre below the ground.

The engineers put a small amount of radioactive liquid into the pipe through an inspection pit.
The radioactive liquid had a half-life of two days.

A radiation detector was used to measure the count rate at different distances from the inspection pit.



The results are shown below.

Distance from the inspection pit in metres	Count rate in counts per minute
1	23
2	21
3	23
4	28
5	32
6	27
7	20
8	18
9	19
10	20

4.4.2.1 Radioactive decay and nuclear radiation

Question 76 · continued March 2010 | PHY1BP | Original Q3 | Legacy

3A The engineers would use a radioactive liquid that emits . . .

1 alpha radiation.

2 beta radiation.

3 gamma radiation.

4 X-radiation.

3B The readings suggest that . . .

1 the pipe was clear and water was flowing normally.

2 the pipe was not level.

3 the pipe had a leak.

4 the pipe had a blockage.

3C To improve the reliability of the data, the engineers should . . .

1 use a more sensitive counter.

2 re-calibrate the counter.

3 repeat their investigation and calculate the means.

4 decide whether the variables are continuous or discrete.

3D To fix the problem, workmen were asked to dig a hole down to the pipe.

The best place for the workmen to dig the hole is . . .

1 3 m from the inspection pit.

2 5 m from the inspection pit.

3 7 m from the inspection pit.

4 9 m from the inspection pit.

4.4.2.1 Radioactive decay and nuclear radiation

Question 77

March 2010 | PHY1BP | Original Q5 | Legacy

QUESTION FIVE

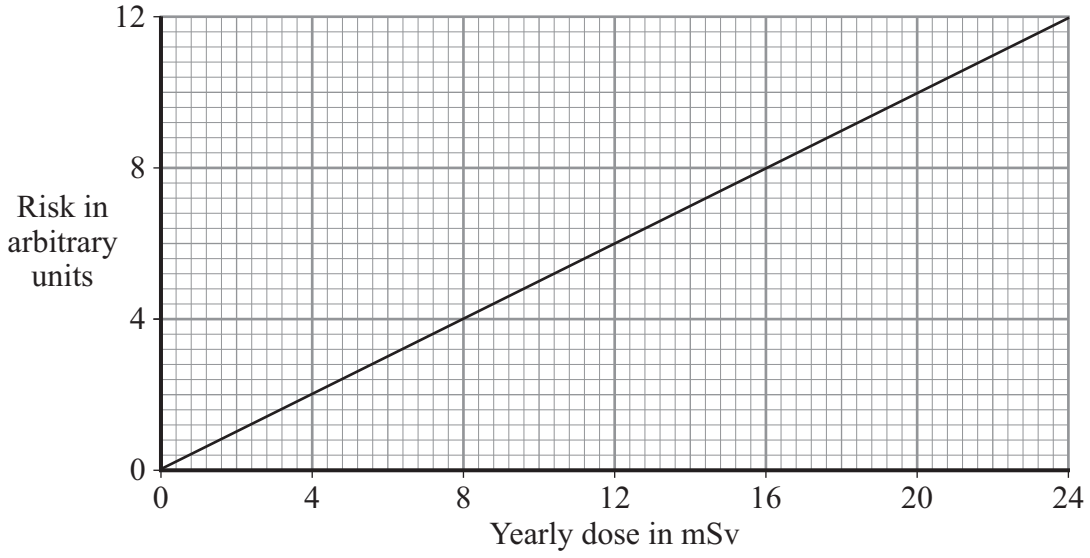
Workers in industries that use radioactive materials have the amount of radiation they receive carefully monitored. The amount of radiation received is called the dose. The industries set dose limits.

The table shows the maximum yearly dose that is allowed for three groups of people. The higher the dose of radiation received, the greater the risk of developing cancer.

Description	Yearly dose limit in millisieverts (mSv)
Member of the public	1
Worker under 18 years	6
Pregnant adult worker	4

A millisievert is a unit of radiation dose.

5A The graph shows how the risk changes with the yearly dose.



The graph shows that the risk . . .

1 does not depend on the yearly dose.

2 is 2 arbitrary units for a member of the public.

3 is inversely proportional to the yearly dose.

4 is directly proportional to the yearly dose.

4.4.2.1 Radioactive decay and nuclear radiation

Question 77 · continued March 2010 | PHY1BP | Original Q5 | Legacy

5B The yearly dose limit for an adult worker is five times that of a pregnant adult worker.

What is the risk (in arbitrary units) for an adult worker?

1 3

2 10

3 15

4 20

5C Nuclear power stations produce radiation.

Which one of the following does **not** reduce the risk to power station workers?

1 building power stations far from centres of population

2 giving the workers protective clothing

3 monitoring the dose each worker receives to ensure that radiation limits are not exceeded

4 shielding the workers from the source of radiation

5D Workers may be subjected to alpha, beta or gamma radiation.

Outside the body, alpha is less dangerous to workers than beta because alpha radiation . . .

1 cannot penetrate the skin.

2 is deflected by electric fields.

3 is much less strongly ionising.

4 has a much longer range.

4.4.2.1 Radioactive decay and nuclear radiation

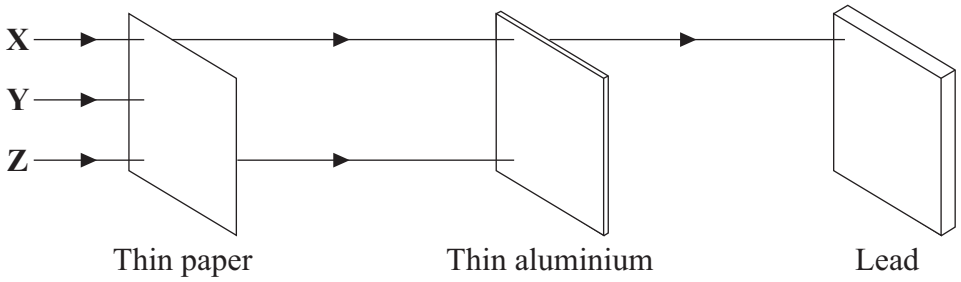
Question 78

March 2010 | PHY1BP | Original Q6 | Legacy

QUESTION SIX

This question is about radioactive substances and the radiation they emit.

The diagram shows how each type of radiation, **X**, **Y** and **Z**, is absorbed by different materials.



6A Which row in **Table 1** shows the correct radiation types?

Table 1

	X	Y	Z
1	beta	alpha	gamma
2	gamma	alpha	beta
3	beta	gamma	alpha
4	gamma	beta	alpha

6B When gamma radiation is absorbed, . . .

1 the absorber increases in mass.

2 the absorber shows a rise in temperature.

3 the radiation will become helium gas.

4 the radiation will transform into light.

4.4.2.1 Radioactive decay and nuclear radiation

Question 78 · continued

6C Which row in **Table 2** correctly describes the three types of radiation?

Table 2

	Alpha	Beta	Gamma
1	an electron from outside the nucleus	a helium nucleus	a short wavelength electromagnetic wave
2	a short wavelength electromagnetic wave	an electron from outside the nucleus	a helium nucleus
3	a helium nucleus	an electron from inside the nucleus	a high frequency electromagnetic wave
4	a helium nucleus	a short wavelength electromagnetic wave	an electron from inside the nucleus

6D The radioactive gas thoron, which has a half-life of 50 seconds, is used in an experiment. At the end of the experiment, the count rate had fallen to $\frac{1}{32}$ of the count rate at the beginning.

The time taken to carry out the experiment was . . .

1 200 seconds.

2 250 seconds.

3 300 seconds.

4 1600 seconds.

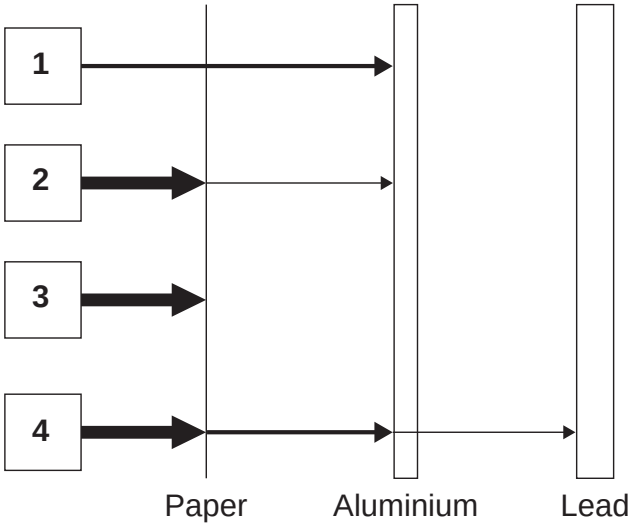
4.4.2.1 Radioactive decay and nuclear radiation

Question 79

QUESTION TWO

Three absorbers are placed in front of four sources of radiation, **1**, **2**, **3** and **4**.

The amount of radiation is represented by the thickness of the horizontal arrows.



Match statements, **A**, **B**, **C** and **D**, with the labels **1–4** on the diagram.

A Source gives off alpha radiation only.

B Source gives off alpha and beta radiation only.

C Source gives off alpha, beta and gamma radiation.

D Source gives off beta radiation only.

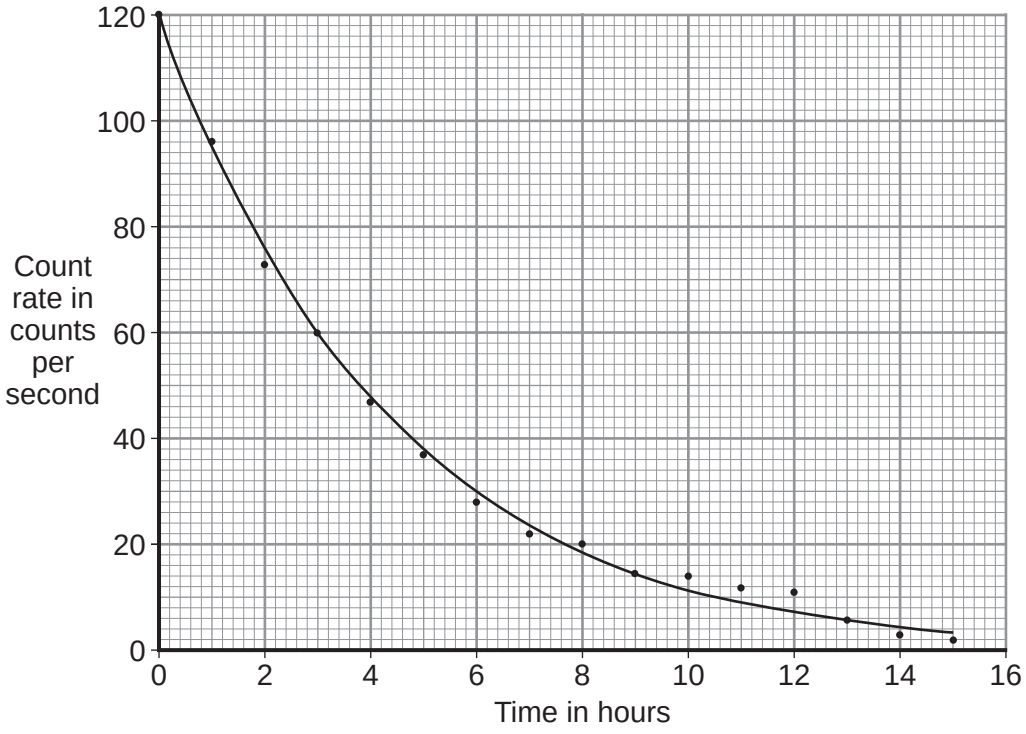
4.4.2.1 Radioactive decay and nuclear radiation

Question 80

June 2010 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

The graph shows the count rate of a radioactive isotope over 15 hours.



4A Which row in the table describes correctly the types of variable?

	Count rate	Time
1	categoric	categoric
2	categoric	continuous
3	continuous	categoric
4	continuous	continuous

4B Not all the points of the graph lie on the drawn curve.

The line drawn is called . . .

1 a discrete line.

2 a line of best fit.

3 a line of least resistance.

4 an error line.

4.4.2.1 Radioactive decay and nuclear radiation

Question 80 · continued June 2010 | PHY1BP | Original Q4 | Legacy

4C The half-life of the radioactive isotope is . . .

1 2 hours.

2 3 hours.

3 5 hours.

4 7 hours.

4D A different radioactive isotope has a half-life of 10 hours.

What fraction of the original mass of isotope will be left after 30 hours?

1 $\frac{1}{3}$

2 $\frac{1}{8}$

3 $\frac{1}{30}$

4 $\frac{7}{8}$

4.4.2.1 Radioactive decay and nuclear radiation

Question 81

June 2010 | PHY1BP | Original Q5 | Legacy

QUESTION FIVE

Some radioactive isotopes emit alpha particles. Other radioactive isotopes emit beta particles.

5A What is an alpha particle?

1 a helium nucleus

2 an electron from outside the nucleus

3 an electron from inside the nucleus

4 one proton and one neutron

5B What is a beta particle?

1 a helium nucleus

2 an electron from outside the nucleus

3 an electron from inside the nucleus

4 two protons and two neutrons

5C The half-life of a radioactive isotope is 1 second.

This means that after 2 seconds . . .

1 the count rate will have fallen to zero.

2 the count rate will have halved.

3 the number of nuclei of this isotope will have halved.

4 three-quarters of the nuclei of this isotope will have decayed.

5D Two scientists measured the half-life of another radioactive isotope. One obtained a value of 3.8 hours. The second scientist obtained a value of 4.65 hours.

What conclusion could you make?

1 The second scientist is correct because his answer shows greater precision.

2 You cannot tell which scientist is correct.

3 This isotope has a variable half-life.

4 The half-life is too short to measure accurately.

4.4.2.1 Radioactive decay and nuclear radiation

Question 82

June 2010 | PHY1BP | Original Q7 | Legacy

QUESTION SEVEN

In 1896, Henri Becquerel was doing an experiment with uranium. He first thought that uranium absorbed energy from the Sun and then re-emitted the energy as X-rays. Then, on a cloudy day, he found that the uranium emitted radiation even when the uranium sample was wrapped in black paper.

7A This suggests that . . .

1 his original theory was wrong and further investigation was needed.

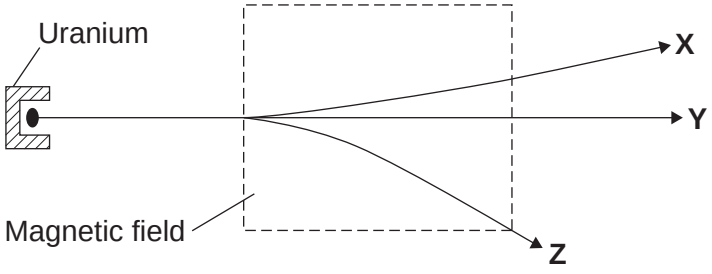
2 his test was fair but more variables needed to be controlled.

3 his original theory was correct and further investigation was needed.

4 his test was not fair and more variables needed to be controlled.

7B Becquerel passed the radiation emitted by uranium through a magnetic field. He found that there were three different types of radiation.

The diagram shows the paths of the three types of radiation, **X**, **Y** and **Z**, in the magnetic field.



Later, Ernest Rutherford called the three types of radiation alpha, beta and gamma.

Which is the correct row in the table?

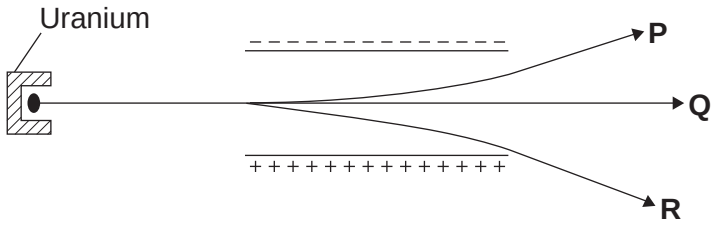
	X	Y	Z
1	alpha	beta	gamma
2	alpha	gamma	beta
3	beta	alpha	gamma
4	beta	gamma	alpha

4.4.2.1 Radioactive decay and nuclear radiation

Question 82 · continued

7C The radiation emitted by uranium can also be deflected in an electric field between two charged plates.

The diagram shows the paths taken by the three types of radiation, **P**, **Q** and **R**, in an electric field.



The explanation for the different paths is that . . .

1 **P** and **R** have the same electric charge and **Q** is uncharged.

2 **P** and **R** are oppositely charged and **P** has a larger mass than **R**.

3 **P** and **R** are oppositely charged and **R** has a larger charge than **P**.

4 **Q** is uncharged and has a larger mass than both **P** and **R**.

7D Rutherford measured the range in air of the three types of radiation.

Which row of the table gives the correct order of range?

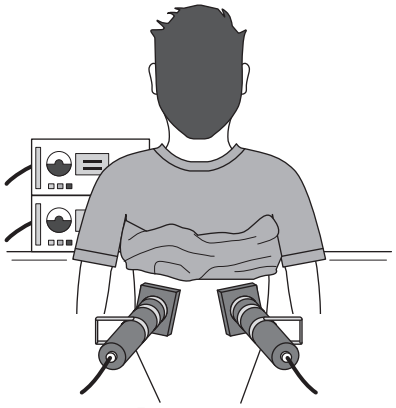
	Shortest range ⟶ **Longest range**		
1	alpha	beta	gamma
2	alpha	gamma	beta
3	beta	alpha	gamma
4	beta	gamma	alpha

4.4.2.1 Radioactive decay and nuclear radiation

Question 83

June 2010 | PHY1H | Original Q2 | Legacy

2 (a) A doctor uses the radioactive isotope technetium-99 to find out if a patient's kidneys are working correctly.



The doctor injects a small amount of technetium-99 into the patient's bloodstream.

Technetium-99 emits *gamma radiation*.

Give **two** reasons why an isotope that emits gamma radiation is injected into the patient rather than an isotope that emits alpha radiation.

1 .....

.....

2 .....

.....

(2 marks)

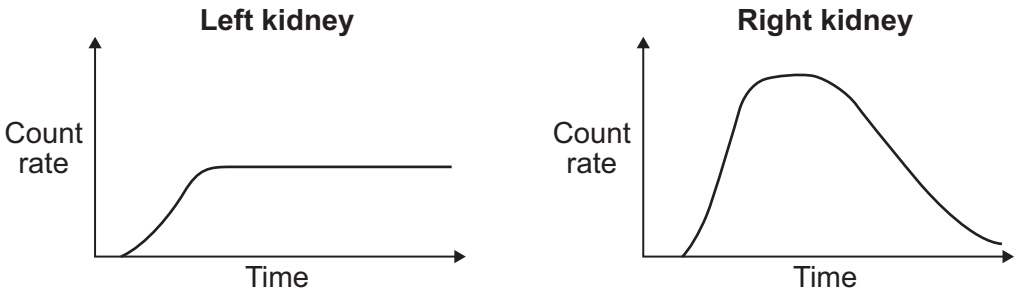
4.4.2.1 Radioactive decay and nuclear radiation

Question 83 · continued

2 (b) If the patient's kidneys are working correctly, the technetium-99 will pass from the bloodstream into the kidneys and then into the patient's urine.

Detectors are used to measure the radiation emitted from the kidneys.

The level of radiation emitted from each kidney is recorded on a graph.



2 (b) (i) How do the graphs show that technetium-99 is passing from the bloodstream into each kidney?

.....

.....

(1 mark)

2 (b) (ii) By looking at the graphs, the doctor is able to tell if there is a problem with the patient's kidneys.

Which **one** of the following statements is correct?

Put a tick (✓) in the box next to your answer.

Only the right kidney is working correctly. ☐

Only the left kidney is working correctly. ☐

Both kidneys are working correctly. ☐

Explain the reason for your answer.

.....

.....

.....

.....

(3 marks)

Question 2 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 83 · continued

2 (c) The patient was worried about having a radioactive isotope injected into their body. The doctor explained that the risk to the patient's health was very small as technetium-99 has a short *half-life*.

2 (c) (i) What does the term *half-life* mean?

.....

.....

(1 mark)

2 (c) (ii) Explain why it is important that the doctor uses an isotope with a short half-life rather than an isotope with a long half-life.

.....

.....

.....

.....

(2 marks)

9

4.4.2.1 Radioactive decay and nuclear radiation

Question 84

June 2010 | PHY2H | Original Q4 | Legacy

4 (a) Uranium atoms do not always have the same number of neutrons.
What are atoms of the same element that have different numbers of neutrons called?

.....

(1 mark)

4 (b) By emitting an alpha particle, an atom of uranium-235 decays into an atom of thorium.

An alpha particle, which is the same as a helium nucleus, is represented by the symbol $^{4}_{2}He$.

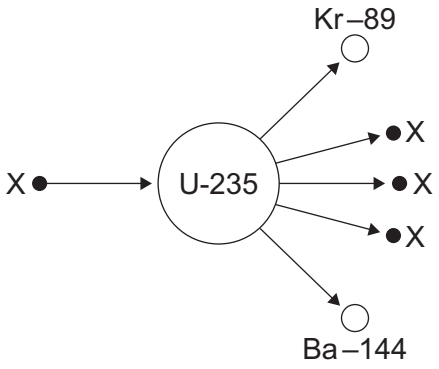
The decay can be represented by the equation below.

Complete the equation by writing the correct number in each of the two boxes.

$$^{235}_{92}U \longrightarrow \square \; Th \; + \; ^{4}_{2}He$$

(2 marks)

4 (c) The diagram shows an atom of uranium-235 being split into several pieces.



4 (c) (i) Name the process shown in the diagram.

.....

(1 mark)

4 (c) (ii) Name the particles labelled X.

.....

(1 mark)

4 (d) Uranium-235 is used as a fuel in some nuclear reactors.
Name another substance used as a fuel in some nuclear reactors.

.....

(1 mark)

6

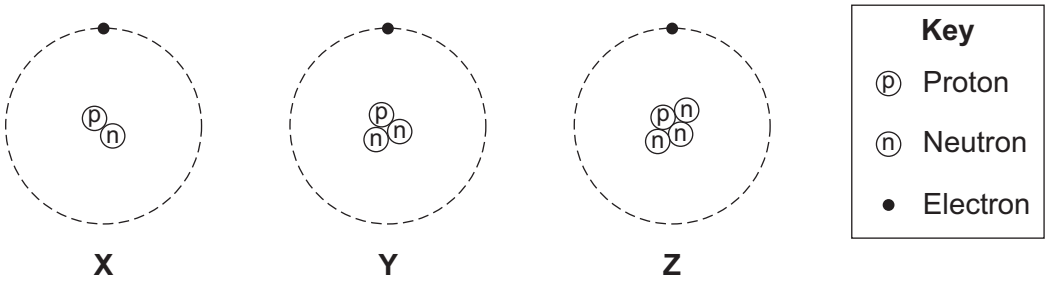
4.4.2.1 Radioactive decay and nuclear radiation

Question 85

November 2010 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

The diagram shows three atoms, **X**, **Y** and **Z**.



3A Which of these atoms are isotopes of the same element?

1 **X**, **Y** and **Z**

2 **X** and **Y** only

3 **X** and **Z** only

4 **Y** and **Z** only

3B Some substances are radioactive.

What does this mean?

1 Radio signals make these substances emit radiation.

2 These substances can take part in chemical reactions.

3 These substances emit radiation from the nuclei of their atoms.

4 These substances glow in the dark.

4.4.2.1 Radioactive decay and nuclear radiation

Question 85 · continued

3C Some substances emit beta radiation.

What is beta radiation?

1 a helium nucleus

2 an electron from outside the nucleus

3 an electron from inside the nucleus

4 an electromagnetic wave

3D The warning label is from a smoke detector.

Warning!
This device contains a source that emits alpha radiation.
Do not take this device apart.

What is the reason for this warning?

1 Alpha radiation is very dangerous if the source gets inside the body.

2 Alpha radiation can travel very long distances in the air.

3 Alpha radiation has the longest half-life.

4 Alpha radiation is the most penetrating of all radiations.

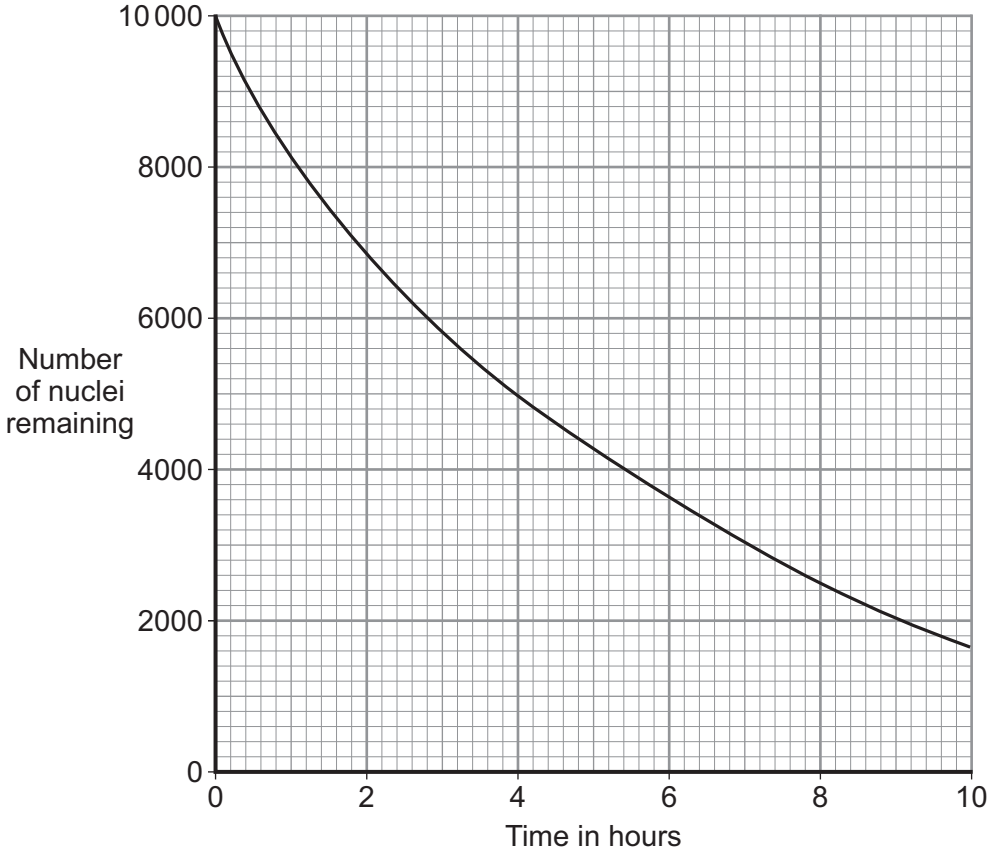
4.4.2.1 Radioactive decay and nuclear radiation

Question 86

November 2010 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

The graph shows the decay of a small sample of radioactive isotope. At the start, the sample contains 10 000 nuclei.



4A What is the half-life of the isotope shown in the graph?

1 2 hours

2 4 hours

3 6 hours

4 8 hours

4B How many of the original nuclei would remain after three half-lives?

1 1250

2 2500

3 3333

4 none

4.4.2.1 Radioactive decay and nuclear radiation

Question 86 · continued November 2010 | PHY1BP | Original Q4 | Legacy

4C This radioactive isotope may be suitable . . .

1 as a source of radiation in a smoke alarm.

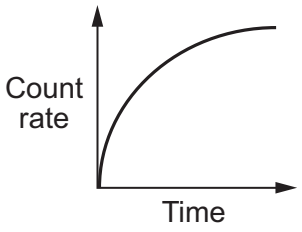
2 as a source of radiation to monitor the thickness of paper in a paper mill.

3 as a medical tracer in the human body.

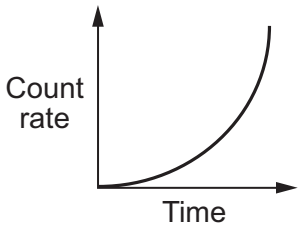
4 to use in finding the age of an ancient bone.

4D Which one of the following graphs would show how the count rate for this isotope changes with time?

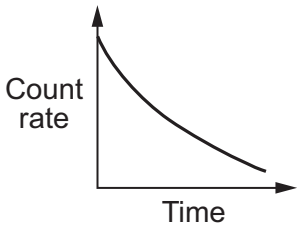
1



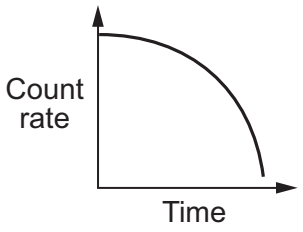
2



3



4



4.4.2.1 Radioactive decay and nuclear radiation

Question 87

November 2010 | PHY1BP | Original Q8 | Legacy

QUESTION EIGHT

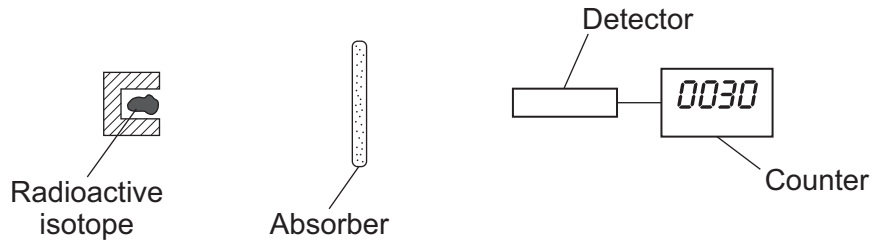
Radioactive isotopes may emit alpha, beta or gamma radiation.

A sixth-form student carried out experiments on different radioactive isotopes, **S**, **T** and **V**.

She was told that:

- all three types of radiation are emitted
- the experiments must be done in a vacuum.

In the first experiment, she put different absorbers in turn between each of the isotopes and a detector. She measured the count rate from each isotope.



The results are shown in **Table 1**.

Table 1

Isotope	Count rate in counts per second			
	No absorber	Sheet of paper	10 mm of aluminium	100 mm of lead
S	40	40	40	2
T	60	20	18	4
V	75	74	0	0

8A From these results, it can be concluded that isotope **V** emits . . .

1 alpha radiation only.

2 beta radiation only.

3 gamma radiation only.

4 alpha and gamma radiation.

8B Which source emits more than one type of radiation?

1 **S**

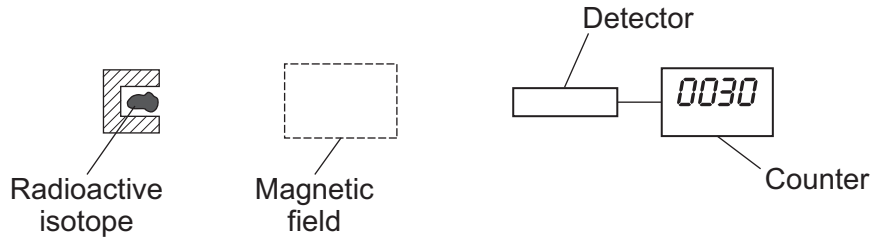
2 **T**

3 **V**

4 none of them

Question 87 · continued

8C In a second experiment, the absorber was replaced by a magnetic field.



The results are shown in **Table 2**.

Table 2

Isotope	Count rate in counts per second	
	Without magnetic field	With magnetic field
S	40	40
T	60	20
V	75	0

Which one of the following conclusions from the experiment is correct?

1 **V** could be a gamma emitter and a beta emitter.

2 **V** and **T** both emit gamma radiation.

3 **S** is either an alpha emitter or a beta emitter.

4 **T** could be an alpha emitter and a gamma emitter.

8D Some types of radiation are deflected by a magnetic field.

This is because the radiation . . .

1 is like a wave.

2 has a positive charge or a negative charge.

3 has north poles and south poles.

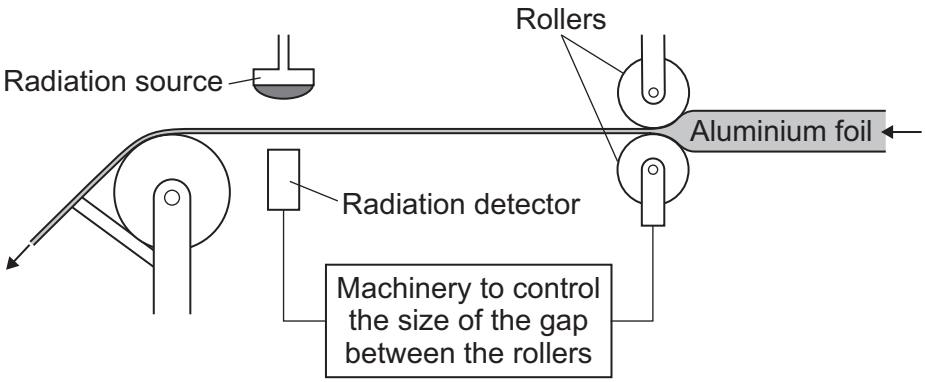
4 has no mass.

4.4.2.1 Radioactive decay and nuclear radiation

Question 88

January 2011 | PHY1H | Original Q7 | Legacy

7 The diagram shows a system used to control the thickness of aluminium foil as it is being rolled. A radiation source and detector are used to monitor the thickness of the foil.



7 (a) Which type of source, alpha, beta or gamma, should be used in this control system?

.....

Explain why each of the other two types of source would **not** be suitable.

.....

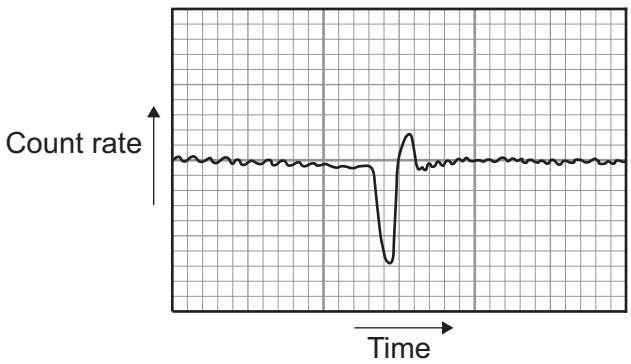
.....

.....

.....

(3 marks)

7 (b) The chart shows how the count rate recorded by the detector varies over a short period of time.



4.4.2.1 Radioactive decay and nuclear radiation

Question 88 · continued

Use the graph to explain how the thickness of the foil changes, and how the control system responds to this change.

.....

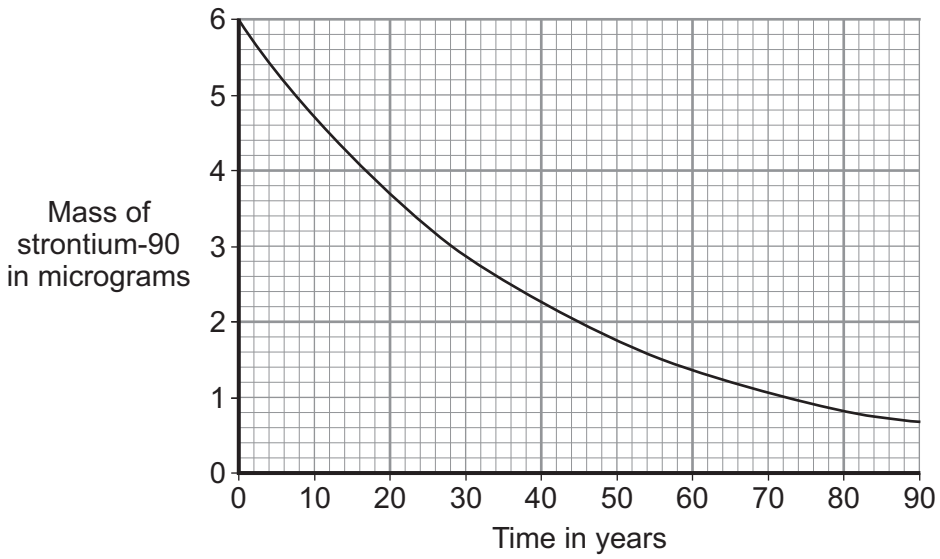
.....

.....

.....

(2 marks)

7 (c) When first used, the radiation source contains 6 micrograms of strontium-90.
The graph shows how the mass of the strontium-90 will decrease as the nuclei decay.



The control system will continue to work with the same source until 75% of the original strontium-90 nuclei have decayed.

After how many years will the source need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

.....

.....

.....

Number of years = ...

(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 89

3 (a) Background radiation is all around us all the time.

3 (a) (i) Radon is a natural source of background radiation.

Name another natural source of background radiation.

.....

(1 mark)

3 (a) (ii) X-rays are an artificial source of background radiation.

Name another artificial source of background radiation.

.....

(1 mark)

3 (a) (iii) An atom of radon-222 decays by emitting an alpha particle.
The equation representing the decay is shown below.

$$^{222}_{86}\text{Rn} \longrightarrow {}^{218}_{84}\text{X} + \text{alpha particle}$$

How can you tell from the equation that 'X' is not an atom of radon?

.....

.....

(1 mark)

Question 3 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 89 · continued

3 (b) Having an X-ray taken increases your exposure to radiation.

The table gives:

- the radiation doses received for 6 different medical X-rays;
- the number of days' of exposure to natural background radiation each dose is equivalent to.

Medical X-ray	Radiation dose received (in arbitrary units)	Equivalent number of days of exposure to natural background radiation
Chest	2	2.4
Skull	7	8.4
Pelvis	22	26.4
Hip	44	52.8
Spine	140	
CT head scan	200	240

A hospital patient has an X-ray of the spine taken.
Calculate the number of days of exposure to natural background radiation that an X-ray of the spine is equivalent to.

Show how you work out your answer.

.....

.....

.....

Equivalent number of days = ...

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 89 · continued

3 (c) Scientists have shown that X-rays increase the risk of developing cancer.
The scientists came to this conclusion by studying the medical history of people placed in one of two groups, **A** or **B**.
The group into which people were put depended on their X-ray record.

3 (c) (i) Person **J** has been placed into group **A**.
Place each of the people, **K**, **L**, **M**, **N** and **O**, into the appropriate group, **A** or **B**.

Person	J 	K 	L 	M 	N 	O 
Medical X-ray record	3 arm	None	None	2 skull	None	4 leg

Group A	Group B
J	

(1 mark)

3 (c) (ii) To be able to make a fair comparison, what is important about the number of people in each of the two groups studied by the scientists?

.....

.....

(1 mark)

3 (c) (iii) What data would the scientists have compared in order to come to the conclusion that X-rays increase the risk of developing cancer?

.....

.....

(1 mark)

Question 3 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 89 · continued

3 (c) (iv) The chance of developing cancer due to a CT head scan is about 1 in 10 000.
The chance of developing cancer naturally is about 1 in 4.

A hospital patient is advised by a doctor that she needs to have a CT head scan.
The doctor explains to the patient the risks involved.

Do you think that the patient should give her permission for the CT scan to be taken?

Draw a ring around your answer.

Yes **No**

Give a reason for your answer.

.....

.....

(1 mark)

9

4.4.2.1 Radioactive decay and nuclear radiation

Question 90

March 2011 | PHY1BP | Original Q2 | Legacy

QUESTION TWO

Radioactive isotopes have many uses.

The table gives the types of radiation emitted and the half-lives of four radioactive isotopes, **A**, **B**, **C** and **D**.

Isotope	Radiation emitted	Half-life
A	alpha	432 years
B	beta	29 years
C	gamma	6 hours
D	gamma	5 years

Match isotopes, **A**, **B**, **C** and **D**, with the most appropriate uses **1**–**4** in the table below.

	Use
1	controlling the thickness of aluminium foil as it is produced
2	sterilising medical instruments used in an operating theatre
3	injecting into a patient as a medical tracer
4	used inside a smoke detector

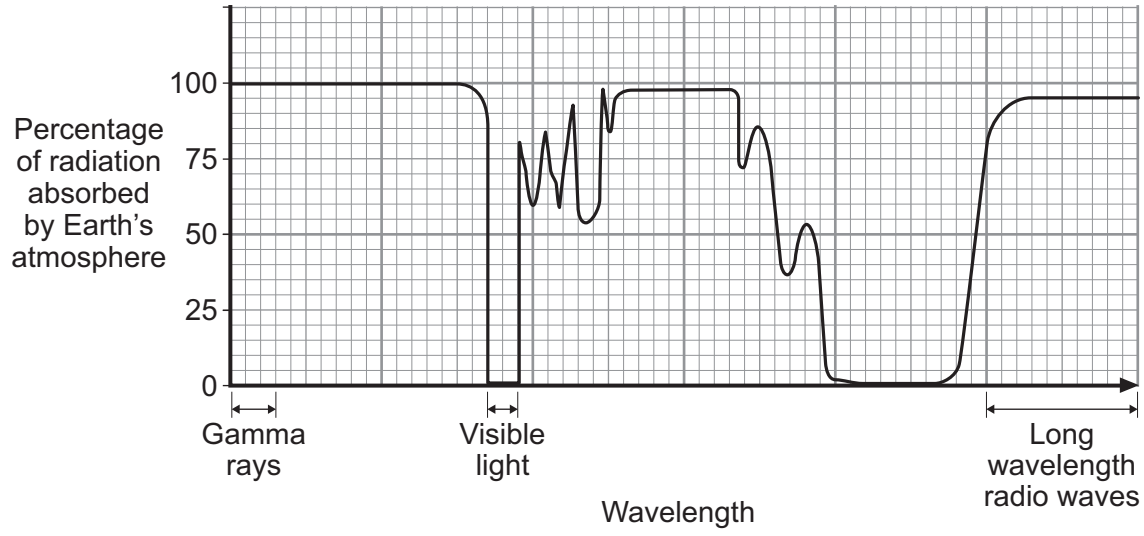
4.4.2.1 Radioactive decay and nuclear radiation

Question 91

March 2011 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

The diagram shows the absorption of electromagnetic radiation by the Earth's atmosphere.



4A The diagram shows that . . .

1 all wavelengths of gamma radiation reach the Earth's surface.

2 all wavelengths of radio waves reach the Earth's surface.

3 all wavelengths of ultraviolet radiation reach the Earth's surface.

4 all wavelengths of visible light reach the Earth's surface.

4B Some objects in space emit X-rays.

Where would you put a telescope to detect these X-rays?

1 above the Earth's atmosphere

2 at the top of a hill

3 at ground level in a hot desert

4 at ground level in the Antarctic

4.4.2.1 Radioactive decay and nuclear radiation

Question 91 · continued

The table gives information about some space telescopes.

Name	Hubble	Compton	Chandra	Spitzer
Launched in	1990	1991	1999	2003
Detects	infra red rays ultraviolet rays visible light	gamma rays	X-rays	infra red rays

4C Which statement about these space telescopes can be deduced from the information in the table?

1 They all collect data using mirrors.

2 They all detect electromagnetic radiation.

3 They are all in space at present.

4 They were all used to study the Earth.

4D From the information in the table, which one of the following emissions could be detected by one of these space telescopes?

1 alpha particles

2 nuclear radiation

3 radio waves

4 sound waves

4.4.2.1 Radioactive decay and nuclear radiation

Question 92

March 2011 | PHY1BP | Original Q6 | Legacy

QUESTION SIX

Some radioactive substances emit beta particles.

6A What is a beta particle?

1 an electron from outside the nucleus

2 an electron from inside the nucleus

3 a neutron from inside the nucleus

4 a proton from inside the nucleus

6B Which row in the table correctly describes the properties of beta particles?

	Range in air	Penetration through materials
1	a few centimetres	stopped by thin paper
2	about a metre	stopped by thin paper
3	about a metre	stopped by thin aluminium
4	several kilometres	stopped by thick lead

6C Beta particles cause ionisation.

What does this mean?

1 They make non-radioactive sources become radioactive.

2 They produce charged particles when they collide with atoms.

3 They remove charged particles from the air.

4 They stop other radioactive sources from emitting radiation.

6D How is a beta particle different from an alpha particle?

1 Alpha particles do not cause ionisation but beta particles do.

2 Alpha particles are deflected by magnetic fields and beta particles are not.

3 Beta particles are deflected by electric fields and alpha particles are not.

4 Beta particles have a much smaller mass than alpha particles.

4.4.2.1 Radioactive decay and nuclear radiation

Question 93

March 2011 | PHY1BP | Original Q8 | Legacy

QUESTION EIGHT

An isotope, **X**, is radioactive and decays into isotope **Y**, which is not radioactive.

Rocks such as granite contain both of these isotopes.

The half-life of isotope **X** is 4 million years.

8A A sample of granite is found to contain one atom of **Y** for each atom of **X**.

The age of the rock is about . . .

1 1 million years.

2 2 million years.

3 4 million years.

4 6 million years.

8B Another sample of rock is known to be 8 million years old.

The ratio of the number of atoms of **X** to the number of atoms of **Y** would be . . .

1 1 : 2

2 1 : 3

3 1 : 4

4 2 : 1

8C A sample of rock contains atoms of isotope **X**, but no atoms of isotope **Y**.

This is because . . .

1 all the atoms of **Y** have decayed.

2 the atoms of **X** in this sample are not radioactive.

3 the half-life of atoms of **X** in this sample is greater than 4 million years.

4 the rock has only recently been formed.

8D Isotope **X** decays by emitting alpha particles.

An alpha particle consists of . . .

1 2 electrons only.

2 2 protons and 2 neutrons.

3 2 neutrons only.

4 2 protons and 2 electrons.

Turn over for the next question

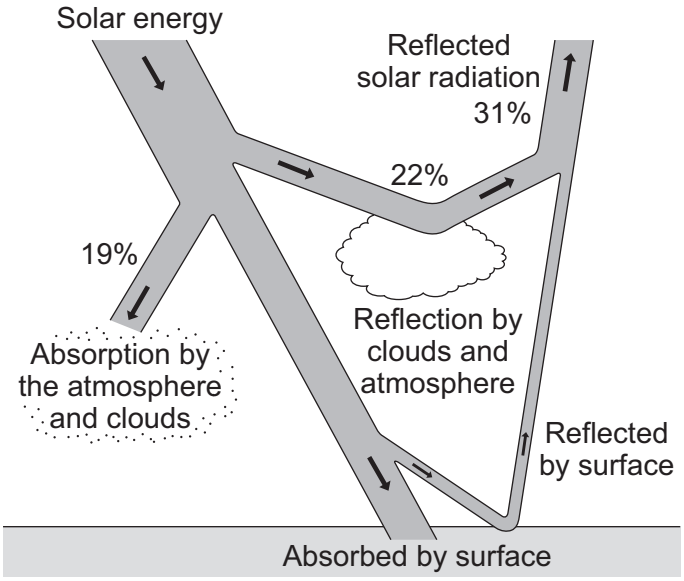
4.4.2.1 Radioactive decay and nuclear radiation

Question 94

March 2011 | PHY1BP | Original Q9 | Legacy

QUESTION NINE

The diagram shows what happens to solar energy as it enters the Earth's atmosphere on one day.



9A What percentage of the energy is absorbed by the Earth's surface?

1 28 %

2 50%

3 72 %

4 78 %

9B Solar radiation consists of different groups from the electromagnetic spectrum. In the ultraviolet region there are three main types, as shown in the diagram below.

Gamma	X-ray	Ultraviolet **UVC UVB UVA**	Visible	Infra red	Microwave	Radio

Which of the following statements is correct?

1 UVA rays have the same frequency, longer wavelength and travel at a faster speed than UVB rays.

2 UVB rays have a lower frequency, the same wavelength and travel at the same speed as UVC rays.

3 UVB rays have a lower frequency, a longer wavelength and travel at the same speed as UVC rays.

4 UVB rays have a higher frequency, a shorter wavelength and travel at a slower speed than UVC rays.

4.4.2.1 Radioactive decay and nuclear radiation

Question 94 · continued

March 2011 | PHY1BP | Original Q9 | Legacy

A measure of the ability of a surface to reflect sunlight is called the 'albedo' of the surface.

The *albedo* has a range of values from 0 (no reflection) to 1 (total reflection).

The table below gives the *albedo* values for some surfaces on the Earth.

Surface	Albedo
forest	0.06 – 0.14
crops	0.15 – 0.25
dry soil	0.24 – 0.35
ice	0.33 – 0.38
dry sand	0.36 – 0.44
old snow	0.42 – 0.60
new concrete	0.50 – 0.60
fresh snow	0.80 – 0.90

9C From the table, which of the following surfaces has the biggest range of *albedo* values?

1 crops

2 dry sand

3 dry soil

4 old snow

9D The average *albedo* of the Earth – atmosphere system is currently about 0.30. Scientists think that this value may rise over the next 50 years.

Which one of the following statements supports their idea?

1 More crops are being produced.

2 The Earth is getting further away from the Sun.

3 There is a decrease in forest area and an increase in urban areas.

4 Less fresh snow is being deposited because of climate change.

END OF TEST

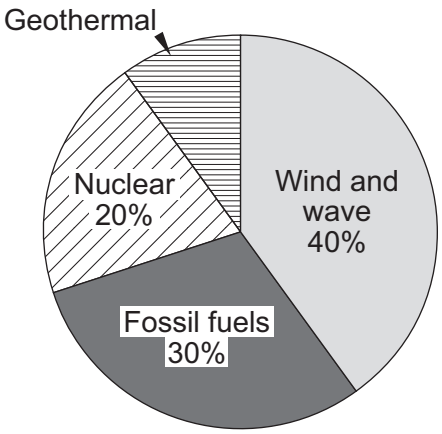
4.4.2.1 Radioactive decay and nuclear radiation

Question 95

June 2011 | PHY1AP | Original Q1 | Legacy

QUESTION ONE

The pie chart shows how a country's electricity demands are met using different energy sources.



Match percentages, **A**, **B**, **C** and **D**, with the numbers **1**–**4** in the sentences.

A 10 %

B 20 %

C 40 %

D 50 %

The percentage of electricity generated from non-renewable sources is . . . **1** . . . .

The percentage of electricity generated from geothermal sources is . . . **2** . . . .

The percentage of electricity generated using a source that produces radioactive waste is . . . **3** . . . .

The percentage of electricity generated using the kinetic energy of the source directly is . . . **4** . . . .

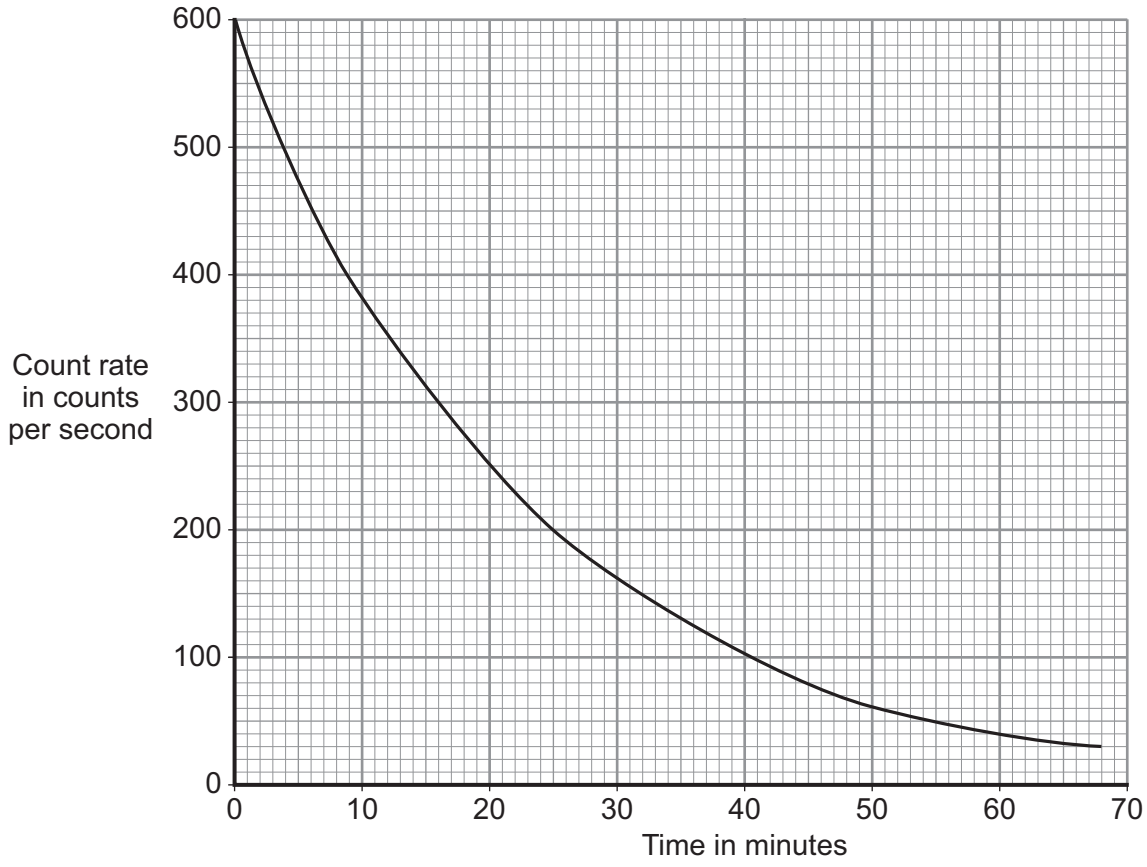
4.4.2.1 Radioactive decay and nuclear radiation

Question 96

June 2011 | PHY1BP | Original Q2 | Legacy

QUESTION TWO

The graph shows how the count rate of a radioactive isotope changes with time.



Match figures, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A 16

B 25

C 150

D 600

The initial count rate was . . . **1** . . . counts per second.

The time taken for the count rate to fall to 200 counts per second is . . . **2** . . . minutes.

The half-life of the radioactive isotope is . . . **3** . . . minutes.

The count rate after two half-lives was . . . **4** . . . counts per second.

4.4.2.1 Radioactive decay and nuclear radiation

Question 97

June 2011 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

The following article appeared in a newspaper.

Radioactive Fruit!

Some supermarkets sell fresh fruit that has been exposed to radiation.

A spokesperson for the supermarkets explained: "The radiation kills bacteria on the surface and inside the fruit. This means that the fruit stays fresh for longer. Scientists have done tests on the treated fruit and are sure that it is safe to eat."

He added: "Fruit that has been treated in this way will be clearly labelled."

A consumer group has said: "We do not believe that fruit treated with radioactivity is safe. We are trying to stop supermarkets from selling it."

3A To reassure customers that the treated fruit is safe to eat, the supermarket should . . .

1 explain that the treated fruit will stay fresh for longer.

2 sell the treated fruit at a lower price than the untreated fruit.

3 show that the scientists who did the tests were not biased.

4 tell customers that the taste of the fruit has not changed.

3B The government has said that all fruit should be clearly labelled to show if it has been treated with radiation.

This is because . . .

1 people can then decide whether or not they want to eat fruit treated with radiation.

2 the government knows that treated fruit is dangerous to eat.

3 the government wants to encourage people to eat more fruit.

4 the labels can make the fruit more attractive.

4.4.2.1 Radioactive decay and nuclear radiation

Question 97 · continued

3C The headline of the newspaper says that the fruit is radioactive.

What should scientists do to test if this is true?

1 measure the time it takes for the fruit to go rotten

2 put the fruit close to a radiation detector and see if the count rate goes up

3 put the fruit close to a radiation detector and see if the count rate goes down

4 see if the fruit glows when placed in a dark room

3D The radiation used to treat the fruit kills bacteria both on the surface and inside the fruit.

The radioactive isotope used must emit the right type of radiation. It must also have a suitable half-life.

Which row in the table describes the most suitable radioactive isotope to use?

Isotope	Radiation emitted	Half-life
1	alpha	6 hours
2	alpha	60 years
3	gamma	5 hours
4	gamma	5 years

4.4.2.1 Radioactive decay and nuclear radiation

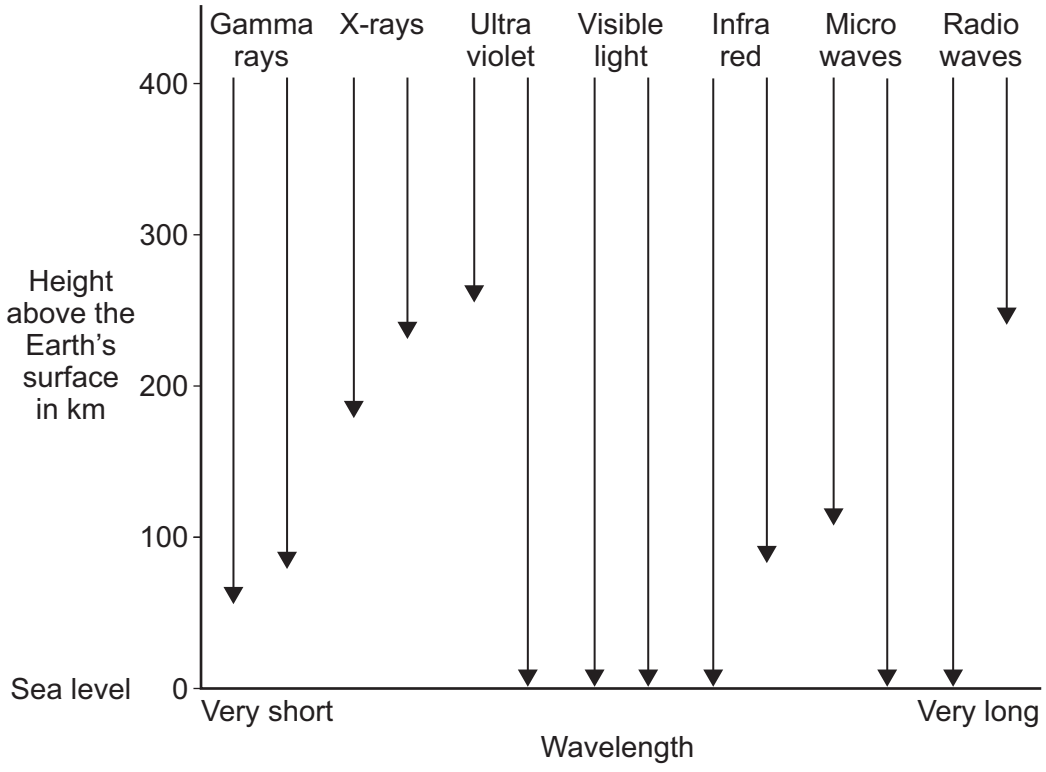
Question 98

June 2011 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

Telescopes can be based on the Earth's surface or put into orbit in space.

The diagram shows how far electromagnetic waves penetrate the Earth's atmosphere. For some types of electromagnetic radiation, longer and shorter waves penetrate the atmosphere to different depths.



4A Telescopes on Earth detect **all** wavelengths of . . .

1 radio waves only.

2 visible light only.

3 radio waves and visible light.

4 visible light and X-rays.

4B Which of the following statements about the use of telescopes in space is true?

1 The atmosphere distorts the image produced by the telescope.

2 The telescopes are affected by light pollution from the Earth.

3 The telescopes can detect electromagnetic waves that cannot reach the Earth's surface.

4 The telescopes are easy to repair and maintain.

4.4.2.1 Radioactive decay and nuclear radiation

Question 98 · continued

The table gives information about some space telescopes. Each telescope detects a different type of electromagnetic radiation.

Telescope	Wavelength detected in nanometres
INTEGRAL	less than 0.01
Chandra	0.01 – 20
FUSE	20 – 400
Hubble	400 – 700
Spitzer	1000 – 1 000 000

4C The Hubble telescope detects visible light.

Which telescope detects infra red radiation?

1 Chandra

2 FUSE

3 INTEGRAL

4 Spitzer

4D Which telescope detects X-rays?

1 Chandra

2 FUSE

3 INTEGRAL

4 Spitzer

4.4.2.1 Radioactive decay and nuclear radiation

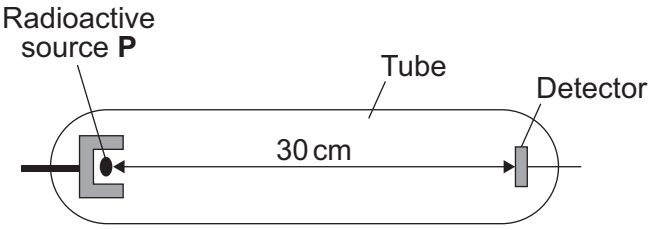
Question 99

June 2011 | PHY1BP | Original Q6 | Legacy

QUESTION SIX

Ernest Rutherford did many experiments in studying the properties of radioactive sources. He gave names to the three types of radiation emitted by radioactive sources.

One experiment used apparatus similar to that shown.



6A Rutherford found that when the air in the tube was removed, the radiation from **P** was detected. When the air was returned to the tube, no radiation was detected.

The radioactive source **P** emitted . . .

1 alpha particles.

2 beta particles.

3 gamma rays.

4 X-rays.

6B Another radioactive source, **Q**, was used. When a magnetic field was applied across the tube with no air inside, it made no difference to the radiation detected.

This shows that **Q** emits . . .

1 alpha and beta particles.

2 alpha particles and gamma rays.

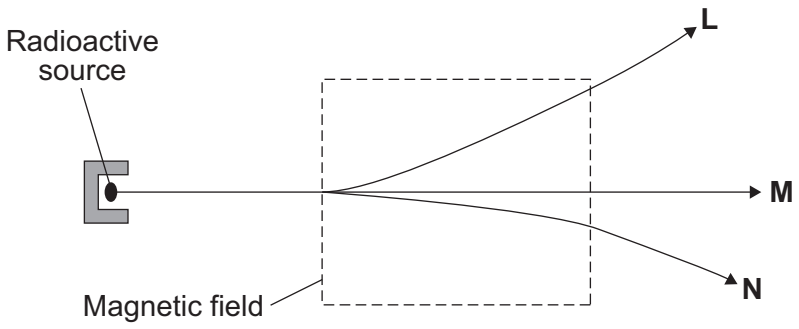
3 beta particles only.

4 gamma rays only.

4.4.2.1 Radioactive decay and nuclear radiation

Question 99 · continued

6C The diagram shows three types of radiation, **L**, **M** and **N**, from a radioactive source. They are passing through a magnetic field.



Radiation **N** is deflected less than radiation **L** and in the opposite direction.

This is because radiation **N** consists of particles which . . .

1 have a smaller mass than **L** and the same charge.

2 have a bigger mass than **L** and the same charge.

3 have a smaller mass than **L** and the opposite charge.

4 have a bigger mass than **L** and the opposite charge.

6D Which row in the table correctly identifies the three types of radiation emitted by radioactive materials?

	Alpha	Beta	Gamma
1	an electron	a helium nucleus	an electromagnetic wave
2	a helium nucleus	an electromagnetic wave	an electron
3	a helium nucleus	an electron	an electromagnetic wave
4	an electron	an electromagnetic wave	an electron

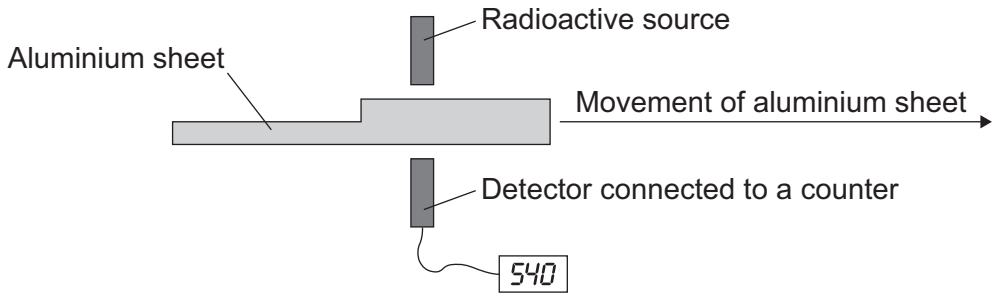
4.4.2.1 Radioactive decay and nuclear radiation

Question 100

June 2011 | PHY1BP | Original Q7 | Legacy

QUESTION SEVEN

A teacher demonstrates how radiation can be used in industry to monitor the thickness of aluminium sheets.



7A Which type of radioactive source should she choose?

1 an alpha emitter

2 a beta emitter

3 a gamma emitter

4 it does not matter

7B The teacher chose the isotope strontium-90 as the radioactive source. The most common isotope of strontium, strontium-88, contains 38 protons and 50 neutrons in its nucleus.

What particles are in the strontium-90 nucleus?

1 38 protons and 50 neutrons

2 38 protons and 52 neutrons

3 40 protons and 50 neutrons

4 42 protons and 48 neutrons

7C What happens to the count rate shown by the counter when a thinner part of the aluminium sheet passes the detector?

1 It increases.

2 It decreases.

3 It stays the same.

4 It falls to zero.

4.4.2.1 Radioactive decay and nuclear radiation

Question 100 · continued

7D Strontium-90 has a half-life of 28 years. The source contains 100 mg of strontium-90.

How long will it be before 75 mg of strontium-90 has decayed?

1 7 years

2 14 years

3 56 years

4 84 years

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 101

June 2011 | PHY1H | Original Q2 | Legacy

2 (a) By 2023, nearly all of the existing nuclear power stations in the UK will be closed down.

2 (a) (i) Before a nuclear power station can be demolished, the remaining nuclear fuel, radioactive waste materials and reactor must be carefully removed.

What is this process called?

Put a tick (✓) in the box next to your answer.

decommissioning ☐

decontaminating ☐

dismantling ☐

(1 mark)

2 (a) (ii) The workers are exposed to radiation as they remove the reactor. One of the biggest risks is from the isotope cobalt-60, which has a half-life of 5.3 years.

Explain the advantage of waiting 11 years after a nuclear power station has closed down before starting to remove the reactor.

.....

.....

.....

.....

(2 marks)

4.4.2.1 Radioactive decay and nuclear radiation

Question 101 · continued

2 (b) It is almost certain that new nuclear power stations will be built in the UK.

The table shows the results of surveys asking people in the UK whether they were in favour of, or against, the building of new nuclear power stations.

	2001	2005	2007
Percentage (%) in favour	20	41	65
Percentage (%) against	60	28	20
Percentage (%) not sure	20	31	15

2 (b) (i) From these surveys, how did public opinion on the building of new nuclear power stations change between 2001 and 2007?

.....

.....

(1 mark)

2 (b) (ii) Suggest a reason why some people may think that the results from these surveys are unreliable.

.....

.....

(1 mark)

2 (b) (iii) Give **one** reason in favour of building new nuclear power stations.

.....

.....

(1 mark)

Question 2 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 101 · continued

2 (c) The government of one Middle Eastern country has decided to build its first nuclear power station. The oil that would have been used to generate electricity can then be sold to other countries.

On what is this decision based?

Put a tick (✓) in the box next to your answer.

economic issues ☐

ethical issues ☐

social issues ☐

(1 mark)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 102

June 2011 | PHY1H | Original Q6 | Legacy

6 (a) Carbon has three naturally occurring isotopes. The isotope, carbon-14, is radioactive. An atom of carbon-14 decays by emitting a beta particle.

6 (a) (i) Complete the following sentences.

The atoms of the three carbon isotopes are the same as each other because

..... .

The atoms of the three carbon isotopes are different from each other because

..... .

(2 marks)

6 (a) (ii) What is a beta particle and from what part of an atom is it emitted?

.....

.....

(1 mark)

6 (b) Carbon-14 is constantly being made in the atmosphere, yet for most of the last million years, the amount of carbon-14 in the atmosphere has not changed.

How is this possible?

.....

.....

(1 mark)

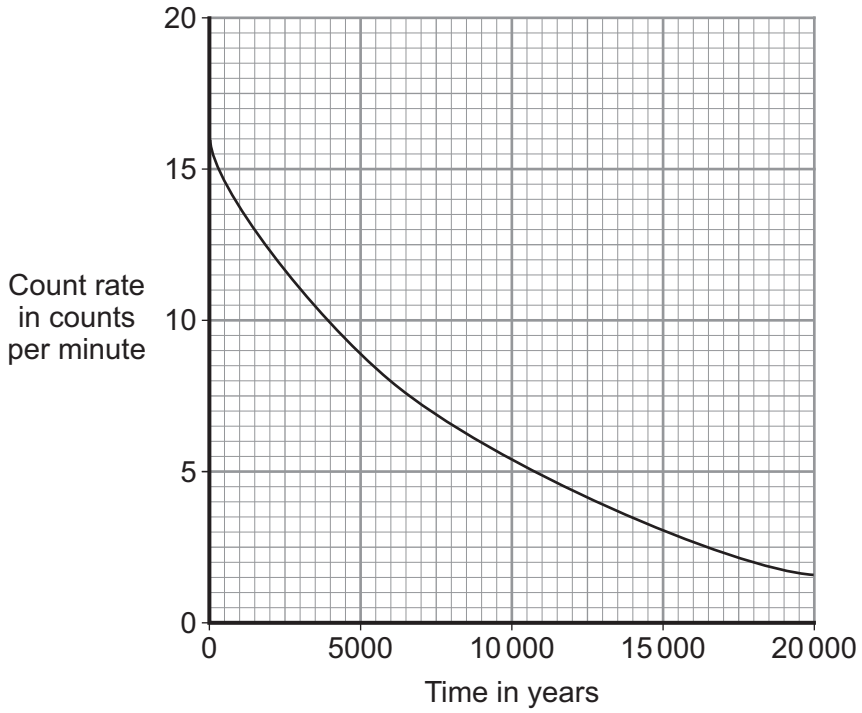
4.4.2.1 Radioactive decay and nuclear radiation

Question 102 · continued

6 (c) Trees take in carbon-12 and carbon-14 from the atmosphere. After the tree dies, the proportion of carbon-14 that the tree contains decreases.

Graph **A** shows the decay curve for carbon-14.

Graph **A**



6 (c) (i) Lake Cuicocha in Ecuador was formed after a volcanic eruption.
Carbon taken from a tree killed by the eruption was found to have a count rate of 10.5 counts per minute.
At the time of the eruption, the count rate would have been 16 counts per minute.

Use graph **A** to find the age of Lake Cuicocha.

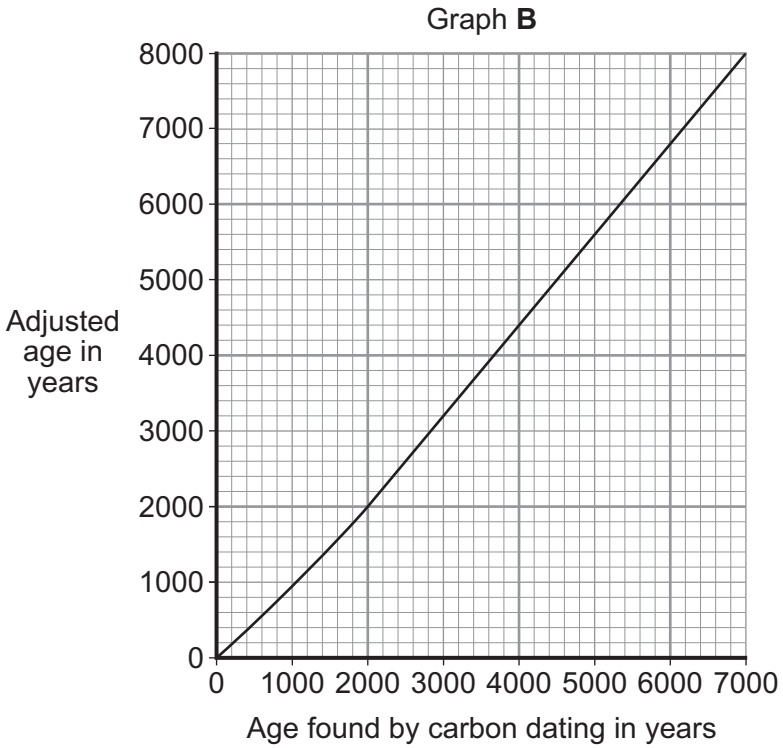
Age of Lake Cuicocha = ... years
(1 mark)

Question 6 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 102 · continued

6 (c) (ii) Finding the age of organic matter by measuring the proportion of carbon-14 that it contains is called carbon dating. This technique relies on the ratio of carbon-14 to carbon-12 in the atmosphere remaining constant. However, this ratio is not constant so the age found by carbon dating needs to be adjusted.



Graph **B** is used to adjust the age of an object found by carbon dating.
The value obtained from graph **B** will be no more than 50 years different to the true age of the object.

Use graph **B** and the information above to find the maximum age that Lake Cuicocha could be.

Show clearly how you obtain your answer.

.....

.....

Maximum age of Lake Cuicocha = ... years
(2 marks)

7

4.4.2.1 Radioactive decay and nuclear radiation

Question 103

June 2011 | PHY2H | Original Q4 | Legacy

4 When the nucleus of a radium-225 atom decays, it changes into a nucleus of actinium-225.

$$^{225}_{88}\text{Ra} \longrightarrow {}^{225}_{89}\text{Ac} + \boxed{\text{Radiation}}$$

What type of radiation is emitted by radium-225?

Draw a ring around your answer.

alpha **beta** **gamma**

Explain the reason for your answer.

.....

.....

.....

.....

.....

.....

(3 marks)

3

4.4.2.1 Radioactive decay and nuclear radiation

Question 104

November 2011 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

The frequencies of the waves in the electromagnetic spectrum can be grouped into types.

Match types, **A**, **B**, **C** and **D**, with the descriptions **1**–**4** in the table.

A gamma rays

B infra red rays

C radio waves

D ultraviolet rays

1	They have a higher frequency than X-rays.
2	They have a lower frequency than microwaves.
3	They have a lower frequency than visible light but a higher frequency than microwaves.
4	They have a lower frequency than X-rays but a higher frequency than visible light.

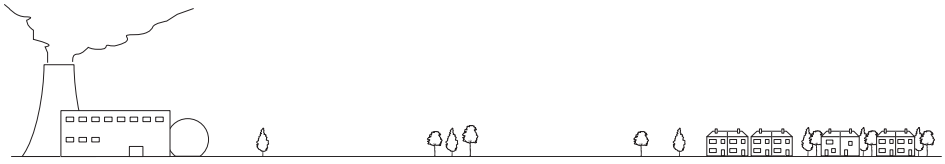
4.4.2.1 Radioactive decay and nuclear radiation

Question 105

November 2011 | PHY1BP | Original Q4 | Legacy

QUESTION FOUR

A nuclear power station is built a few miles away from a village.



The nuclear power station uses radioactive uranium as its fuel. After a few years, there are more cases of cancer than usual occurring in the village. The villagers think that this is because of radiation from the power station.

4A Any radiation reaching the village directly from the power station will be . . .

1 alpha radiation only.

2 beta radiation only.

3 gamma radiation only.

4 alpha, beta and gamma radiation.

4B The increased number of cancer cases near the power station . . .

1 proves that the power station is the only cause of these cancers.

2 proves that the power station is one possible cause of these cancers.

3 suggests that the power station is the only cause of these cancers.

4 suggests that the power station is one possible cause of these cancers.

4C Checks are to be made for any link between the power station and the increased number of cancer cases in the village.

This is most likely to be done by . . .

1 shutting down the power station to see if the number of cases decreases.

2 re-housing the villagers away from the power station to see if the number of cancer cases decreases.

3 re-housing the villagers closer to the power station to see if the number of cancer cases increases.

4 comparing the villagers' health records with those of people who do not live near nuclear power stations.

4.4.2.1 Radioactive decay and nuclear radiation

Question 105 · continued

November 2011 | PHY1BP | Original Q4 | Legacy

4D Exposure to radiation from radioactive sources used in schools must be kept to a minimum.

The best way to do this is to store the source in a box lined with . . .

1 aluminium.

2 glass.

3 lead.

4 wood.

Turn over for the next question

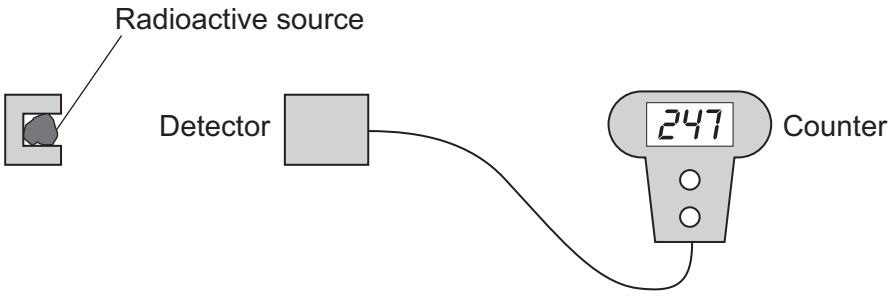
4.4.2.1 Radioactive decay and nuclear radiation

Question 106

November 2011 | PHY1BP | Original Q5 | Legacy

QUESTION FIVE

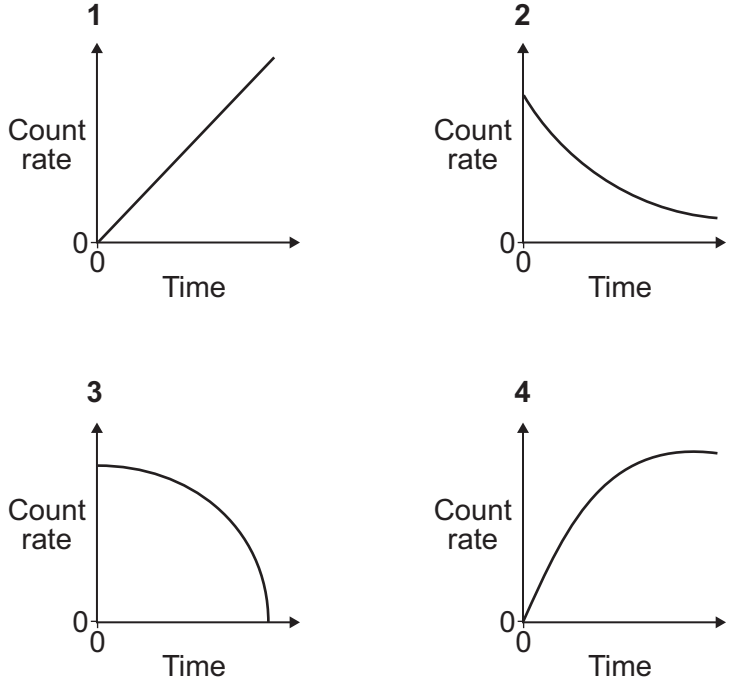
A teacher used the apparatus shown in the diagram to measure the count from a radioactive source.



She put the radioactive source near the detector. She measured the number of counts in 20 seconds. She reset the counter to zero and measured the number of counts in the next 20 seconds. She continued this for 10 minutes.

5A The teacher asked the students to plot a graph of the count rate against time.

Which of the following could be the expected shape of the graph?



4.4.2.1 Radioactive decay and nuclear radiation

Question 106 · continued

5B The students can use their graphs to find the half-life of the radioactive source.

What is meant by *half-life*?

1 half the time it takes for the count rate to fall to zero

2 half the time it takes for the number of nuclei in the sample to halve

3 the time it takes for the count rate to halve

4 the time it takes for the number of nuclei in the sample to fall to zero

5C Which of the following will affect the initial count rate in the sample?

1 the pressure in the room

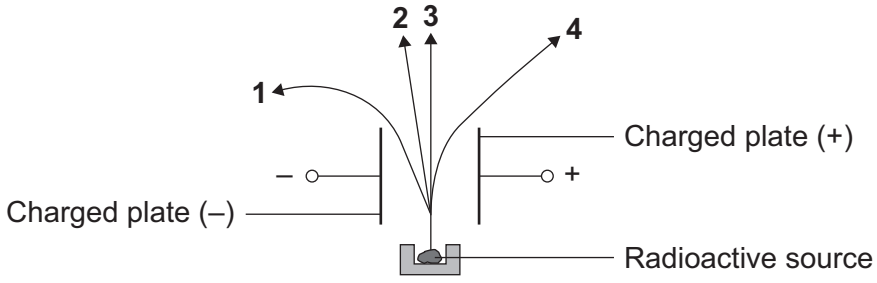
2 the original number of nuclei in the sample

3 the temperature of the room

4 the temperature of the sample

5D A radioactive source is placed close to a pair of charged parallel plates with an electric field between them.

Which of the lines, **1**, **2**, **3** or **4**, on the diagram shows the path of the beta particles emitted by the source?



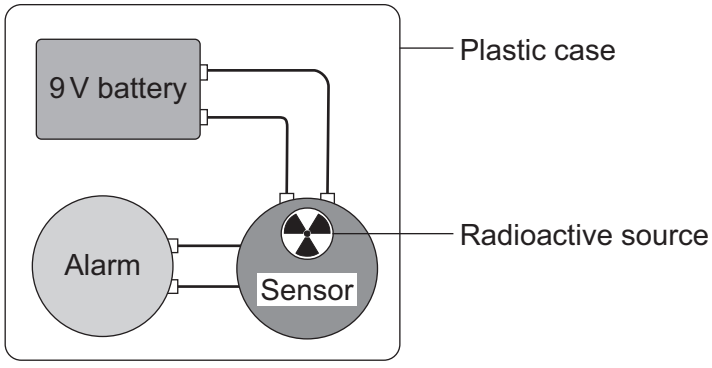
4.4.2.1 Radioactive decay and nuclear radiation

Question 107

November 2011 | PHY1BP | Original Q7 | Legacy

QUESTION SEVEN

The diagram shows the parts of a smoke detector. The radioactive source emits alpha particles.



The alpha particles ionise the air inside the sensor, which causes a small electric current. Any smoke getting into the sensor will absorb alpha particles. This reduces the current. The change in current sets off the alarm.

7A A source that emits alpha particles will not harm people in the same room as the detector.

This is because alpha particles . . .

1 do not damage human cells.

2 are highly ionising.

3 will not pass through the plastic case.

4 are deflected by the Earth's magnetic field.

7B The smoke detector would **not** work if a radioactive source that emitted only gamma rays was used.

This is because gamma rays . . .

1 would pass through the plastic case.

2 would not ionise the air inside the sensor sufficiently.

3 travel through the air at the same speed as light.

4 would be affected by the battery.

4.4.2.1 Radioactive decay and nuclear radiation

Question 107 · continued

7C An alpha particle consists of . . .

1 2 electrons and 2 neutrons.

2 2 electrons and 2 protons.

3 2 neutrons and 2 protons.

4 2 neutrons only.

7D The radioactive source has a half-life of about 400 years.

What fraction of the nuclei in the source will have decayed in 1200 years?

1 $\frac{1}{8}$

2 $\frac{1}{3}$

3 $\frac{2}{3}$

4 $\frac{7}{8}$

4.4.2.1 Radioactive decay and nuclear radiation

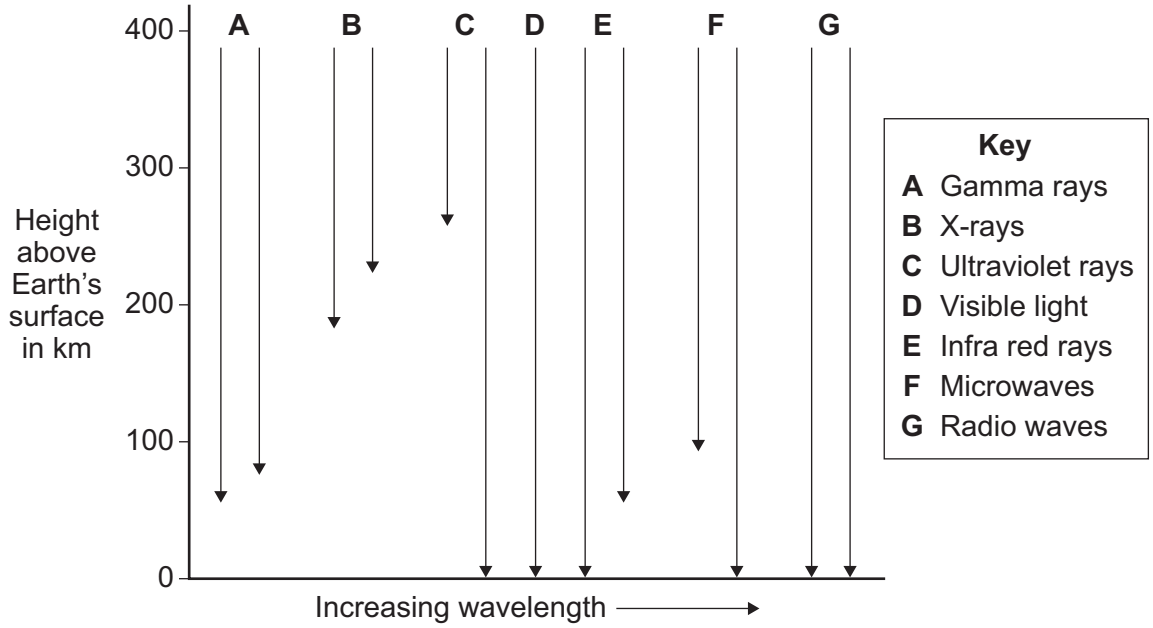
Question 108

November 2011 | PHY1BP | Original Q9 | Legacy

QUESTION NINE

The diagram shows how far electromagnetic waves can penetrate the Earth's atmosphere.

Where two arrows are shown for a particular type of electromagnetic radiation, longer and shorter waves penetrate the atmosphere to different depths.



9A Which one of the following statements is true?

1 Gamma rays penetrate the atmosphere further than all other types of electromagnetic radiation.

2 All frequencies of ultraviolet radiation reach the Earth's surface.

3 No frequencies of radio waves reach the Earth's surface.

4 Higher frequencies of microwaves are completely absorbed by the atmosphere.

9B What would be the minimum height above the Earth for a satellite carrying telescopes designed to detect gamma rays, X-rays and ultraviolet radiation of all wavelengths?

1 50 km

2 70 km

3 180 km

4 260 km

4.4.2.1 Radioactive decay and nuclear radiation

Question 108 · continued

9C Optical telescopes used to observe objects in space are limited because they can be used only . . .

1 as ground-based telescopes.

2 at night.

3 to observe a small region of the electromagnetic spectrum.

4 to observe one region of the sky.

9D Electromagnetic radiation from distant galaxies is very weak and is therefore very difficult to detect.

Some space telescopes use liquid helium to keep scientific instruments at a very low temperature.

Which type of weak electromagnetic radiation would best be detected by instruments kept at a very low temperature?

1 gamma rays

2 X-rays

3 infra red rays

4 ultraviolet rays

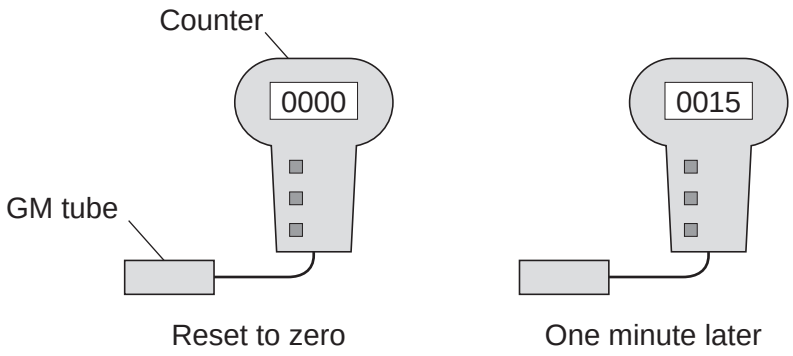
END OF TEST

4.4.2.1 Radioactive decay and nuclear radiation

Question 109

2 (a) A teacher used a Geiger-Műller (GM) tube and counter to measure the *background radiation* in her laboratory.

The teacher reset the counter to zero, waited one minute and then took the count reading. The teacher repeated the procedure two more times.



2 (a) (i) Background radiation can be either from natural sources or from man-made sources.

Name **one man-made** source of background radiation.

.....

(1 mark)

2 (a) (ii) The three readings taken by the teacher are given in the table.

Count after one minute
15
24
18

The readings given in the table are correct.

Why are the readings different?

.....

.....

(1 mark)

4.4.2.1 Radioactive decay and nuclear radiation

Question 109 · continued

January 2013 | PH2HP | Original Q2 | Legacy

2 (b) Some scientists say they have found evidence to show that people living in areas of high natural background radiation are less likely to develop cancer than people living in similar areas with lower background radiation.

The evidence these scientists found does not definitely mean that the level of background radiation determines whether a person will develop cancer.

Suggest a reason why.

.....

.....

(1 mark)

2 (c) An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

An alpha particle is the same as a helium nucleus. The symbol below represents an alpha particle.

$$^{4}_{2}He$$

2 (c) (i) How many protons and how many neutrons are there in an alpha particle?

Number of protons = ...

Number of neutrons = ...

(2 marks)

2 (c) (ii) The decay of radon-222 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.

$$^{222}_{86}Rn \longrightarrow \boxed{}\ \boxed{}\ Po + \text{alpha particle}$$

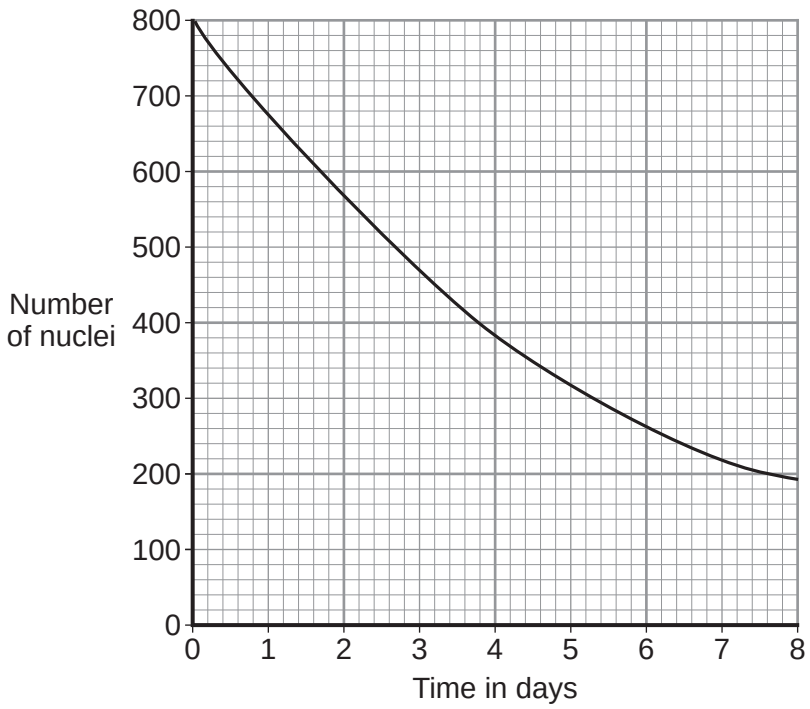
(2 marks)

Question 2 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 109 · continued

2 (d) The graph shows how, in a sample of air, the number of radon-222 nuclei changes with time.



Use the graph to find the half-life of radon-222.

Show clearly on the graph how you obtain your answer.

Half-life = ... days
(2 marks)

9

4.4.2.1 Radioactive decay and nuclear radiation

Question 110

June 2013 | PH2HP | Original Q5 | Legacy

5 In 2011 an earthquake caused severe damage to a nuclear power station in Japan. The damage led to the release of large amounts of radioactive iodine-131($^{131}_{53}I$) into the atmosphere.

5 (a) The table gives some information about an atom of iodine-131($^{131}_{53}I$).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1 mark)

5 (b) Complete the sentence.

The number of protons in an atom is called the proton number or

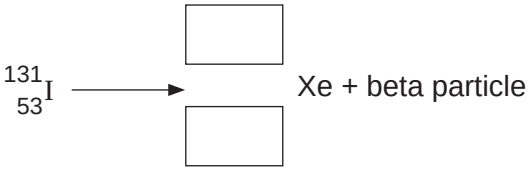
the ..... number.

(1 mark)

5 (c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

5 (c) (i) The decay of iodine-131 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.



(2 marks)

Question 5 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 110 · continued

5 (c) (ii) A sample of rainwater contaminated with iodine-131 gives a count rate of 1200 counts per second.

Calculate how many days it will take for the count rate from the sample of rainwater to fall to 75 counts per second.

Half-life of iodine-131 = 8 days

Show clearly how you work out your answer.

.....

.....

..... days
(2 marks)

5 (c) (iii) If people drink water contaminated with iodine-131, the iodine-131 builds up in the thyroid gland. This continues until the thyroid is saturated with iodine-131 and cannot absorb any more. The radiation emitted from the iodine-131 could cause cancer of the thyroid.

In Japan, people likely to be drinking water contaminated with iodine-131 were advised to take tablets containing a non-radioactive isotope of iodine.

Suggest why this advice was given.

.....

.....

.....

.....
(2 marks)

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 111

June 2014 | PH2HP | Original Q6 | Legacy

6 (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

[1 mark]

.....

6 (b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

6 (b) (i) What happens during the process of nuclear fission?

[1 mark]

.....

.....

6 (b) (ii) Inside which part of a nuclear power station would molybdenum be produced?

[1 mark]

.....

6 (c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \longrightarrow {}^{99}_{43}\text{Tc} + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

[2 marks]

.....

Give a reason for your answer.

.....

.....

Question 6 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 111 · continued

6 (d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term 'half-life'?

[1 mark]

.....

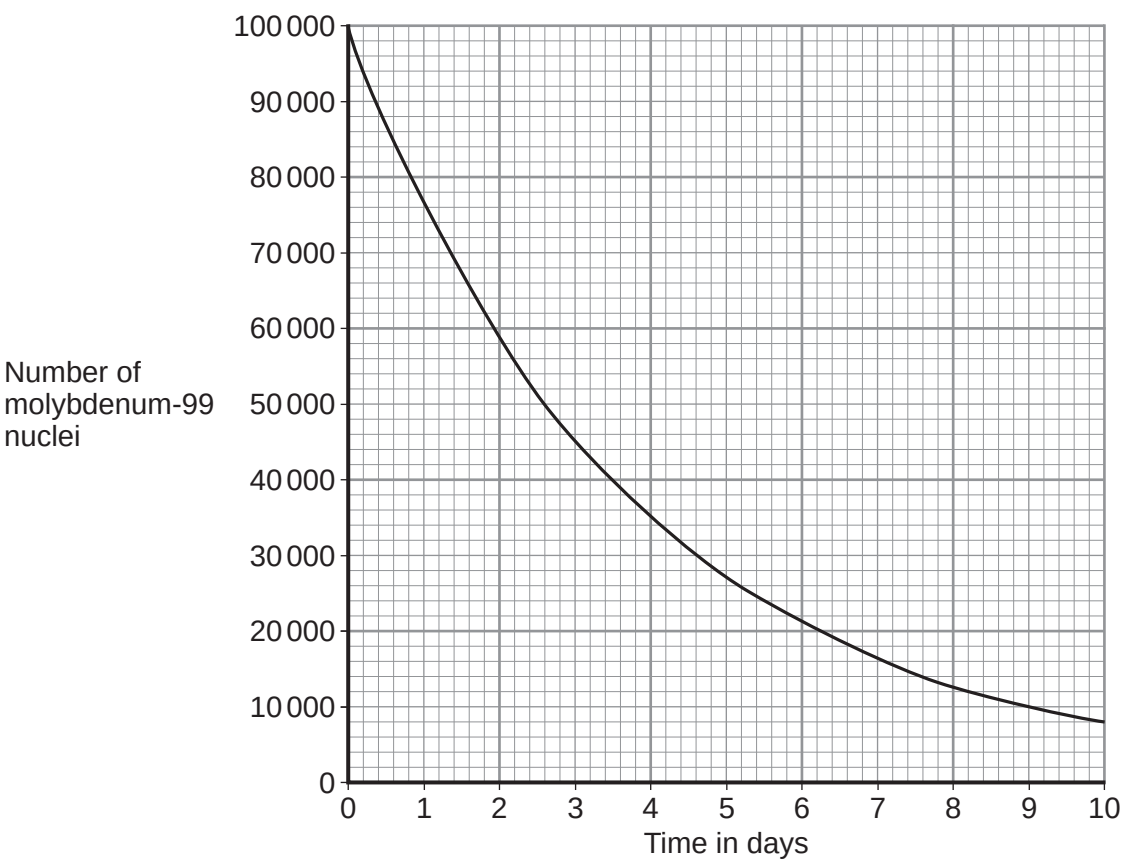
.....

.....

6 (e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

6 (e) (i) **Figure 7** shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.

Figure 7



4.4.2.1 Radioactive decay and nuclear radiation

Question 111 · continued

A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

[2 marks]

.....

.....

.....

Number of days = ...

6 (e) (ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

[2 marks]

.....

.....

.....

.....

6 (e) (iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

[1 mark]

.....

.....

11

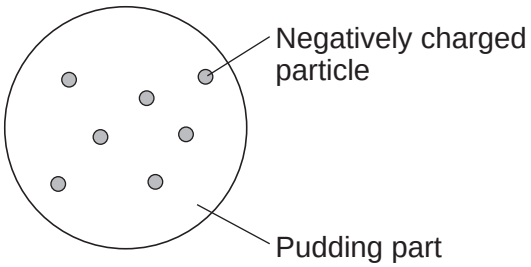
4.4.2.1 Radioactive decay and nuclear radiation

Question 112

June 2015 | PH2HP | Original Q2 | Legacy

2 (a) Over 100 years ago, scientists thought the atom was like a 'plum pudding'.
Figure 3 shows the plum pudding model of the atom.

Figure 3



The scientists knew that an atom has negatively charged particles. They also knew that an atom has no overall charge.

What did the scientists conclude about the **charge** on the 'pudding part' of the atom?
[1 mark]

.....

.....

Question 2 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 112 · continued

2 (b) Two scientists named Rutherford and Marsden devised an experiment to investigate the plum pudding model of the atom. The experiment involved firing alpha particles at a thin sheet of gold. The scientists measured how many of the alpha particles were scattered.

Using the plum pudding model, the scientists predicted that only a few of the alpha particles would be scattered by more than 4°.

Over several months, more than 100 000 measurements were made.

2 (b) (i) The results from this experiment caused the plum pudding model to be replaced by a new model of the atom.

Explain why.

[2 marks]

.....

.....

.....

.....

.....

.....

2 (b) (ii) Suggest **one** reason why other scientists thought this experiment provided valid evidence for a new model of the atom.

[1 mark]

.....

.....

.....

4.4.2.1 Radioactive decay and nuclear radiation

Question 112 · continued

2 (c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe the model now used for the structure of an atom.

In your answer you should:
- give details of the individual particles that make up an atom
- include the relative masses and relative charges of these particles.

Do **not** include a diagram in your answer.

[6 marks]

.....

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Extra space .....

.....

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10

4.4.2.1 Radioactive decay and nuclear radiation

Question 113

June 2015 | PH2HP | Original Q3 | Legacy

3 Many countries use nuclear power stations to generate electricity.
Nuclear power stations use the process of nuclear fission to release energy.

3 (a) (i) What is nuclear fission?

[1 mark]

.....

.....

3 (a) (ii) Plutonium-239 is one substance used as a fuel in a nuclear reactor. For nuclear fission to happen, the nucleus must absorb a particle.

What type of particle must be absorbed?

[1 mark]

.....

3 (b) Nuclear **fusion** also releases energy.
Nuclear fusion happens at very high temperatures. A high temperature is needed to overcome the repulsion force between the nuclei.

3 (b) (i) Why is there a repulsion force between the nuclei of atoms?

[1 mark]

.....

.....

3 (b) (ii) Where does nuclear fusion happen naturally?

[1 mark]

.....

Question 113 · continued

3 (c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

Table 2 gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Table 2

Type of fuel	Energy released from 1 kg of fuel in joules
Fusion fuel	3.4×10^{14}
Fission fuel	8.8×10^{13}

3 (c) (i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

[2 marks]

1 .....

.....

.....

2 .....

.....

.....

3 (c) (ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

[1 mark]

.....

.....

.....

Question 3 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 113 · continued

3 (d) Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

[2 marks]

.....

.....

Half-life = ... years

9

4.4.2.1 Radioactive decay and nuclear radiation

Question 114

June 2016 | PH2HP | Original Q2 | Legacy

2 Alpha particles, beta particles and gamma rays are types of nuclear radiation.

2 (a) Describe the structure of an alpha particle.

[1 mark]

_____

_____

2 (b) Nuclear radiation can change atoms into ions by the process of ionisation.

2 (b) (i) Which type of nuclear radiation is the least ionising?

[1 mark]

Tick (✓) **one** box.

alpha particles ☐ beta particles ☐ gamma rays ☐

2 (b) (ii) What happens to the structure of an atom when the atom is ionised?

[1 mark]

_____

_____

2 (c) People working with sources of nuclear radiation risk damaging their health.

State **one** precaution these people should take to reduce the risk to their health.

[1 mark]

_____

_____

4.4.2.1 Radioactive decay and nuclear radiation

Question 114 · continued

2 (d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The type of radiation emitted from a radioactive source can be identified by comparing the properties of the radiation to the properties of alpha, beta and gamma radiation.

Describe the properties of alpha, beta and gamma radiation in terms of their:

- penetration through materials
- range in air
- deflection in a magnetic field.

[6 marks]

Extra space

10

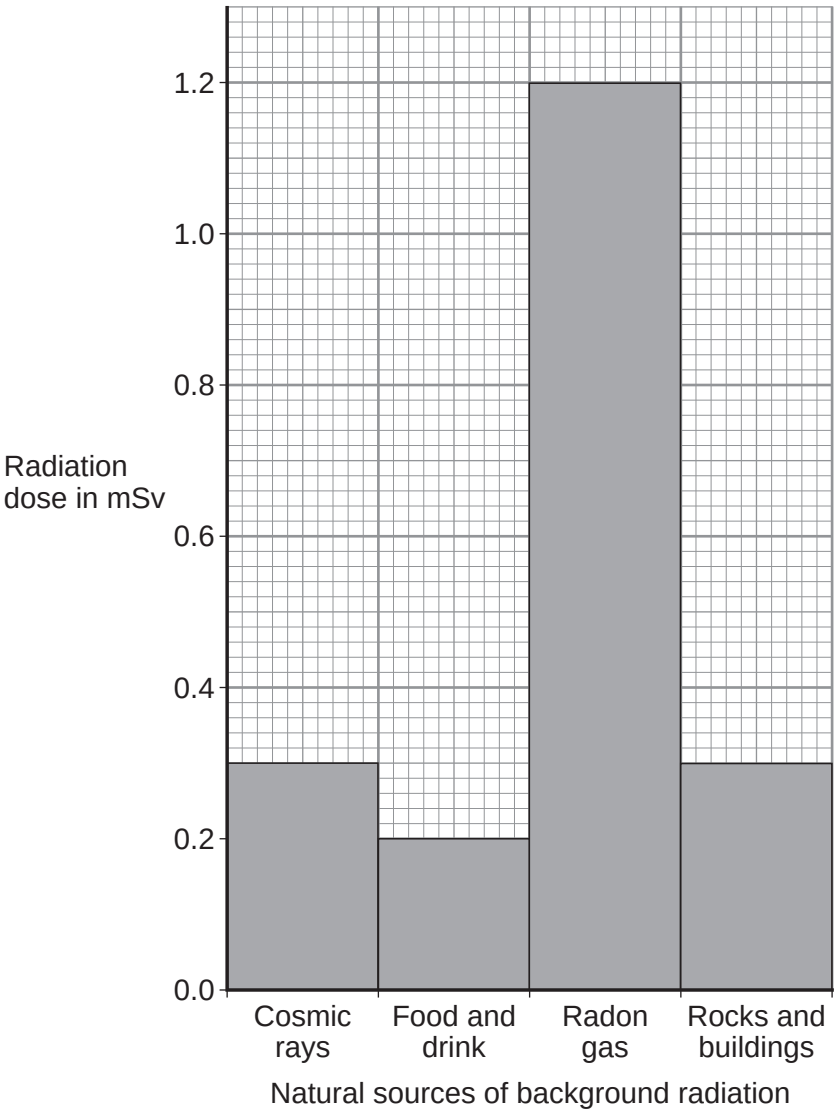
4.4.2.1 Radioactive decay and nuclear radiation

Question 115

June 2017 | PH2HP | Original Q2 | Legacy

2 **Figure 1** shows the total radiation dose that the average person in the UK gets from natural background radiation sources in one year.

Figure 1



2 (a) (i) Calculate the percentage of the total radiation dose the average person in the UK receives from cosmic rays.

[2 marks]

Percentage radiation dose from cosmic rays = _____ %

4.4.2.1 Radioactive decay and nuclear radiation

Question 115 · continued

2 (a) (ii) Over one year, a person may get a higher than average dose of radiation from cosmic rays.

Suggest **one** reason why.

[1 mark]

_____

_____

2 (a) (iii) Some sources of background radiation are man-made.

Name **one** man-made source of background radiation.

[1 mark]

_____

_____

2 (b) Before using a radioactive source a teacher measured the background radiation in her laboratory. She did this three times. The measurements were taken correctly but the three measurements were different.

Why were the three background measurements different?

[1 mark]

_____

_____

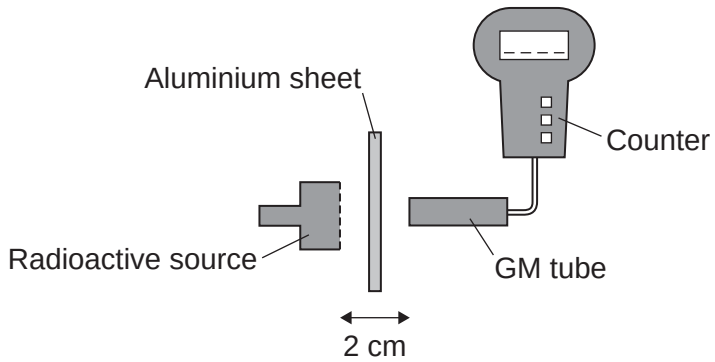
Question 2 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 115 · continued

2 (c) **Figure 2** shows the apparatus the teacher used to investigate the radiation emitted by a source.

Figure 2



The teacher changed the thickness of the aluminium between the source and the Geiger-Müller (GM) tube.

The number of counts recorded for each thickness is given in **Table 1**.
The mean background measurement was 20 counts in one minute.

Table 1

Thickness of aluminium in millimetres	Counts in one minute
2	350
4	68
6	20

2 (c) (i) A student concluded that the radioactive source emits beta radiation.

Explain how the information in **Table 1** supports this conclusion.

[2 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 115 · continued

2 (c) (ii) The teacher said that the source also emits alpha radiation.

Describe how the investigation could be changed in order to show that the source emits alpha radiation.

[2 marks]

_____

_____

_____

_____

_____

_____

9

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

Question 116

June 2018 | 8463/1H | Original Q2

0 2 A teacher used a Geiger-Muller tube and counter to measure the number of counts in 60 seconds for a radioactive rock.

0 2 . 1 The counter recorded 819 counts in 60 seconds. The background radiation count rate was 0.30 counts per second.

Calculate the count rate for the rock.

[3 marks]

Count rate = _____ per second

0 2 . 2 A householder is worried about the radiation emitted by the granite worktop in his kitchen.

1 kg of granite has an activity of 1250 Bq. The kitchen worktop has a mass of 180 kg.

Calculate the activity of the kitchen worktop in Bq.

[2 marks]

Activity = _____ Bq

Question 2 continues on the next page

Question 116 · continued

0 2 . 3 The average total radiation dose per year in the UK is 2.0 millisieverts.

Table 1 shows the effects of radiation dose on the human body.

Table 1

Radiation dose in millisieverts	Effects
10 000	Immediate illness; death within a few weeks
1000	Radiation sickness; unlikely to cause death
100	Lowest dose with evidence of causing cancer

The average radiation dose from the granite worktop is 0.003 millisieverts per day.

Explain why the householder should **not** be concerned about his yearly radiation dose from the granite worktop.

One year is 365 days.

[2 marks]

0 2 . 4 Bananas are a source of background radiation. Some people think that the unit of radiation dose should be changed from sieverts to Banana Equivalent Dose.

Suggest **one** reason why the Banana Equivalent Dose may help the public be more aware of radiation risks.

[1 mark]

8

4.4.2.1 Radioactive decay and nuclear radiation

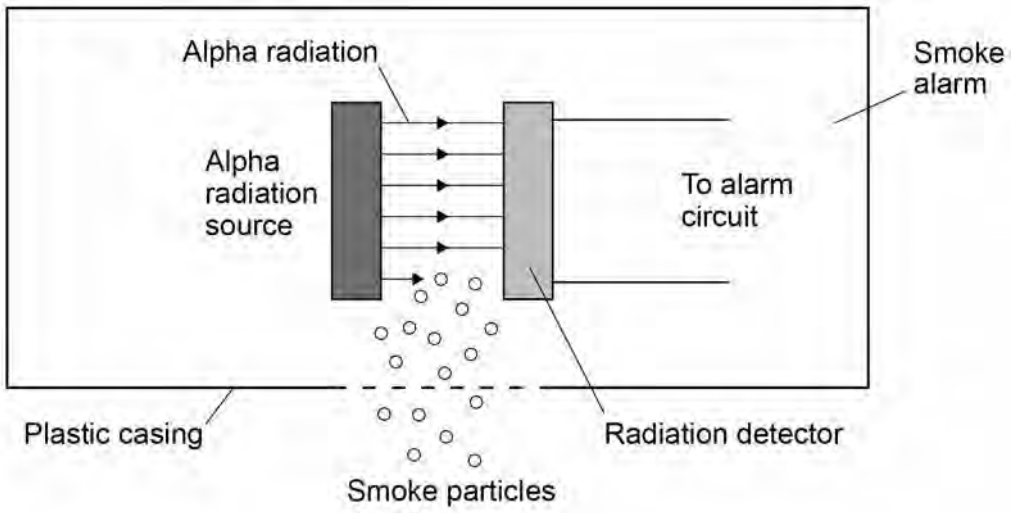
Question 117

June 2018 | 8463/1H | Original Q6

0 6 Smoke alarms contain an alpha radiation source and a radiation detector.

Figure 9 shows part of the inside of a smoke alarm.

Figure 9



0 6 . 1 The smoke alarm stays off while alpha radiation reaches the detector.

Why does the alarm switch on when smoke particles enter the plastic casing?

[1 mark]

0 6 . 2 Why is it safe to use a source of alpha radiation in a house?

[1 mark]

4.4.2.1 Radioactive decay and nuclear radiation

Question 117 · continued

0 6 . 3 The smoke alarm would not work with a radiation source that emits beta or gamma radiation.

Explain why.

[2 marks]

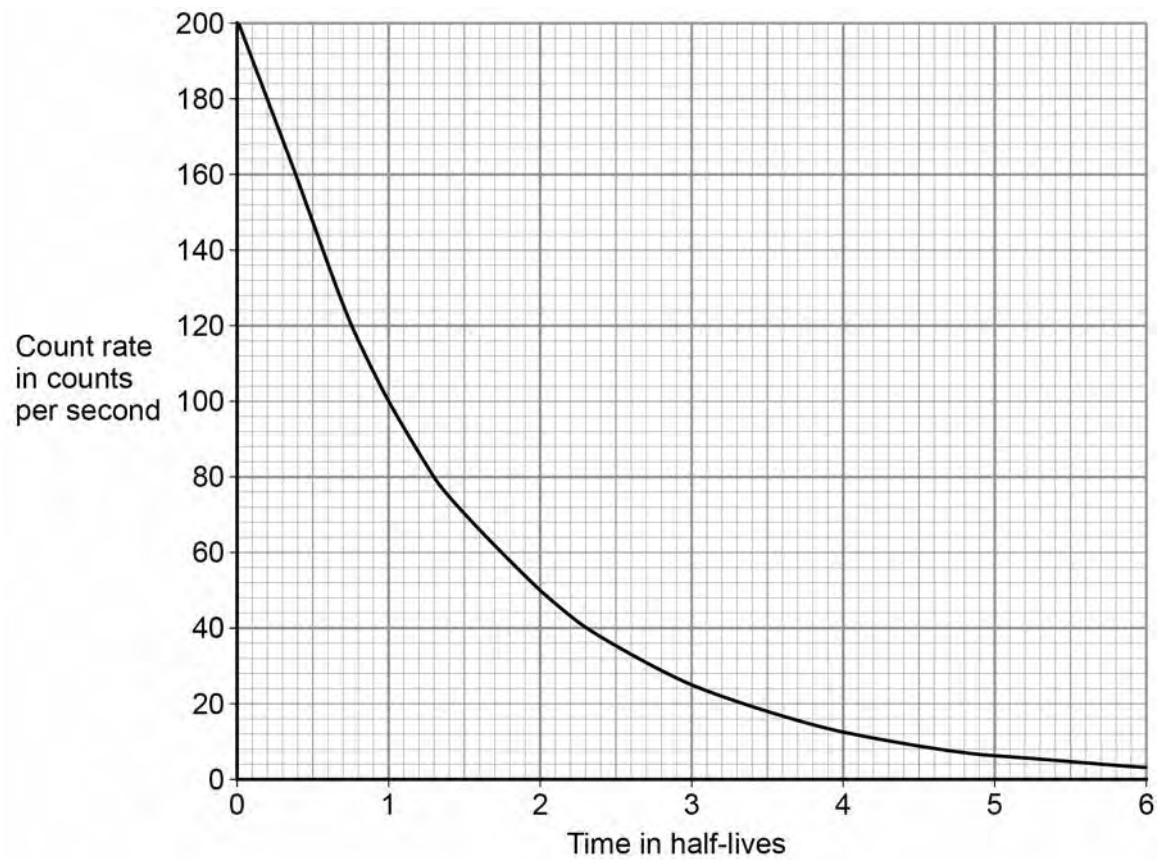
Question 6 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 117 · continued

0 6 . 4 **Figure 10** shows how the count rate detected from the radiation source in the smoke alarm changes with time.

Figure 10



The smoke alarm switches on when the count rate falls to 80 counts per second.

Explain why the radiation source inside the smoke alarm should have a long half-life.

[2 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 117 · continued

0 6 . 5 **Figure 11** shows a patient who has been injected with a radioactive source for medical diagnosis.

Figure 11



Explain the ideal properties of a radioactive source for use in medical diagnosis.

[4 marks]

10

4.4.2.1 Radioactive decay and nuclear radiation

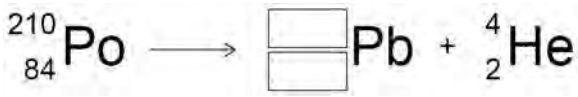
Question 118

June 2019 | 8463/1H | Original Q5

0 5 Polonium-210 $\left({}^{210}_{84}\mathrm{Po}\right)$ is a radioactive isotope that decays by emitting alpha radiation.

0 5 . 1 Complete the decay equation for polonium-210

[2 marks]



0 5 . 2 Explain why contamination of the inside of the human body by a radioactive material that emits alpha radiation is highly dangerous.

[3 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 118 · continued

0 5 . 3 A sample of polonium-210 was left for 414 days.

After this time it had a mass of 1.45×10^{-4} g

The half-life of polonium-210 is 138 days.

Calculate the initial mass of the sample.

[3 marks]

Initial mass = _____ g

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 119

November 2020 | 8463/1H | Original Q5

0 5 Radioactive waste from nuclear power stations is a man-made source of background radiation.

0 5 . 1 Give **one** other man-made source of background radiation.

[1 mark]

Nuclear power stations use the energy released by nuclear fission to generate electricity.

0 5 . 2 Give the name of **one** nuclear fuel.

[1 mark]

0 5 . 3 Nuclear fission releases energy.

Describe the process of nuclear fission inside a nuclear reactor.

[4 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 119 · continued

0 5 . 4 A new type of power station is being developed that will generate electricity using nuclear fusion.

Explain how the process of nuclear fusion leads to the release of energy.

[2 marks]

0 5 . 5 Nuclear fusion power stations will produce radioactive waste. This waste will have a much shorter half-life than the radioactive waste from a nuclear fission power station.

Explain the advantage of the radioactive waste having a shorter half-life.

[2 marks]

10

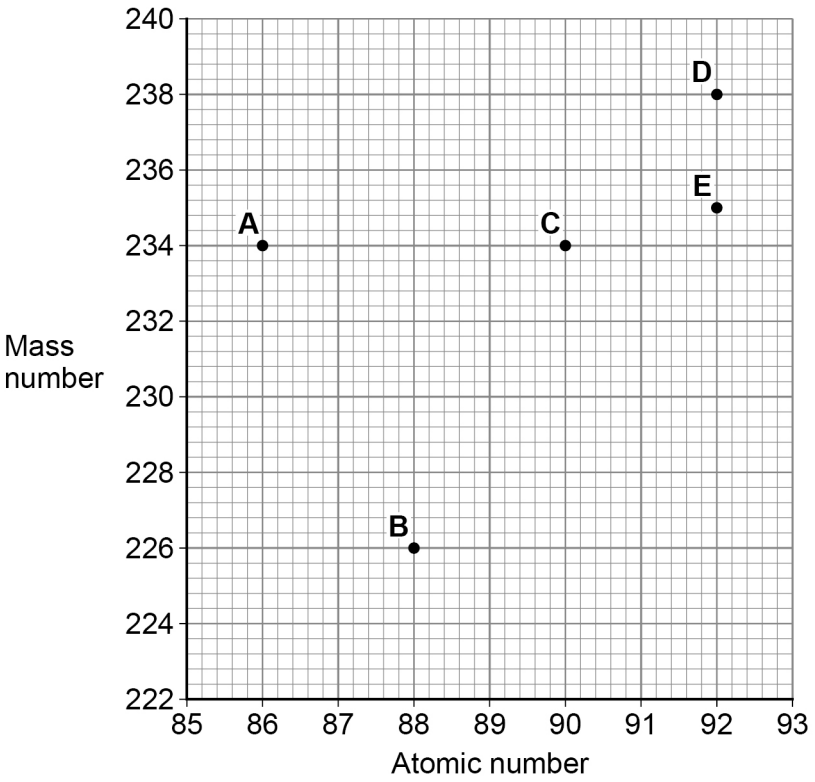
4.4.2.1 Radioactive decay and nuclear radiation

Question 120

November 2021 | 8463/1H | Original Q6

0 6 **Figure 6** shows the mass number and the atomic number for the nuclei of five different atoms.

Figure 6



0 6 . 1 How many neutrons are there in a nucleus of atom **A**?

[1 mark]

4.4.2.1 Radioactive decay and nuclear radiation

Question 120 · continued

0 6 . 2 Which **two** atoms in **Figure 6** are the same element?

[1 mark]

Tick (✓) **one** box.

A and **B** ☐

A and **C** ☐

C and **D** ☐

D and **E** ☐

Question 6 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

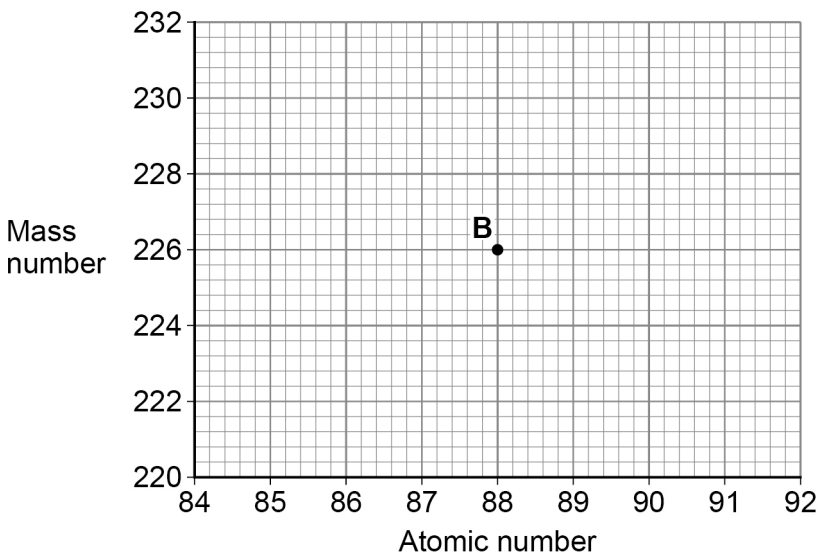
Question 120 · continued

0 6 . 3 Nucleus **B** decays by emitting an alpha particle.

Draw an arrow on **Figure 7** to represent the alpha decay.

[2 marks]

Figure 7



0 6 . 4 What is meant by the 'random nature of radioactive decay'?

[1 mark]

4.4.2.1 Radioactive decay and nuclear radiation

Question 120 · continued

0 6 . 5 A polonium (Po) nucleus decays by emitting an alpha particle and forming a lead (Pb) nucleus.

$$Po \rightarrow Pb + \alpha$$

The lead (Pb) nucleus then decays by emitting a beta particle and forms a bismuth (Bi) nucleus.

$$Pb \rightarrow Bi + \beta$$

The bismuth (Bi) nucleus then decays by emitting a beta particle and forms a polonium (Po) nucleus.

$$Bi \rightarrow Po + \beta$$

Explain how these three decays result in a nucleus of the original element, polonium.

[3 marks]

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 121

June 2022 | 8463/1H | Original Q7

0 7 Alpha particles, beta particles and gamma rays are types of nuclear radiation.

0 7 . 1 What does an alpha particle consist of?

[1 mark]

0 7 . 2 A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

Complete the nuclear equation for this decay by writing the missing number in each box.

[2 marks]

$$\square_{36}\mathrm{Kr} \longrightarrow \square^{85}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e}$$

0 7 . 3 Internal contamination of the human body means radioactive material is inside the human body.

Explain how the risk from internal contamination is different to the risk from external irradiation by a source of alpha radiation.

[5 marks]

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 122

June 2023 | 8463/1H | Original Q5

0 5 Some isotopes emit nuclear radiation.

0 5 . 1 Carbon-14 and carbon-12 are isotopes of carbon.

Compare the structure of an atom of carbon-14 with the structure of an atom of carbon-12.

[3 marks]

0 5 . 2 Carbon-14 is a radioactive isotope.

Carbon-14 has a half-life of 5700 years.

What does 'a half-life of 5700 years' mean?

[1 mark]

Question 5 continues on the next page

Question 122 · continued

Table 1 gives the half-life of some other radioactive isotopes.

Table 1

Isotope	Half-life in seconds
Nitrogen-18	0.62
Nitrogen-17	4.17
Fluorine-17	64.37
Fluorine-18	6584.34

0 5 . 3 A sample of fluorine-17 has an activity that is one quarter of its original activity.

Calculate the age of the sample of fluorine-17.

[2 marks]

Age = _____ s

0 5 . 4 All of the isotopes in **Table 1** emit beta radiation.

Explain which isotope would cause the biggest risk to a person's health based only on the half-life of each isotope.

[3 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 122 · continued

0 5 . 5 People who work in the nuclear power industry need to be aware of irradiation and contamination.

Describe the difference between irradiation and contamination.

[2 marks]

0 5 . 6 Give **one** health risk to a person working close to a source of nuclear radiation.

[1 mark]

0 5 . 7 Workers in nuclear power stations are monitored to check the radiation they emit.

A worker stands 1 cm away from a radiation detector.

The amount of radiation the worker emits is recorded.

Explain why the worker needs to stand close to the radiation detector.

[2 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 122 · continued

0 5 . 8 Workers in the nuclear power industry are exposed to nuclear radiation.

Pilots on aircraft are exposed to cosmic radiation from space.

daily dose caused by working in a nuclear power station = 0.00050 mSv

hourly dose from cosmic rays to a pilot while flying = 0.0030 mSv

Calculate the number of days it takes for a nuclear power station worker to receive the same dose as a pilot flying for 24 hours.

[3 marks]

Number of days = _____

17

4.4.2.1 Radioactive decay and nuclear radiation

Question 123

June 2023 | 8463/1H | Original Q8

0 8 Scientists developed new models of the atom as new particles were discovered.

0 8 . 1 Draw **one** line from each particle to the year it was discovered.

[2 marks]

Particle	Year of discovery
Electron	1897
Neutron	1911
Nucleus	1920
Proton	1932

Question 8 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

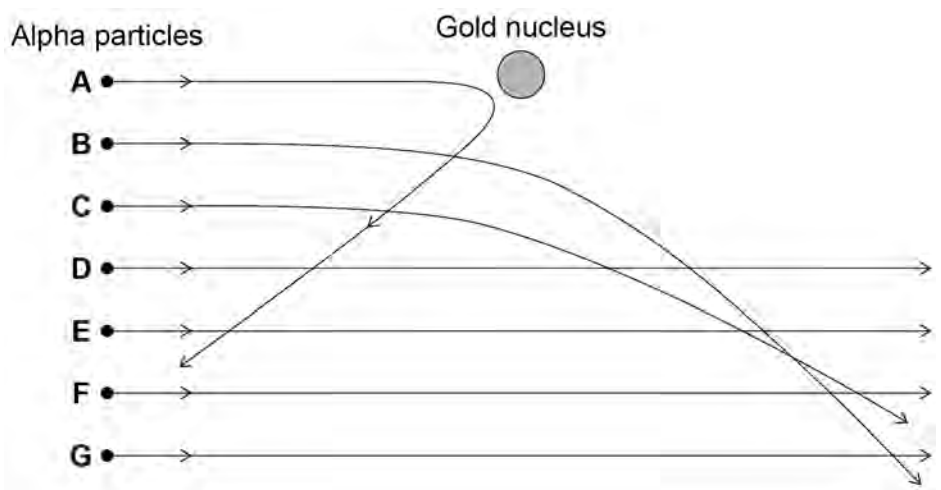
Question 123 · continued

The nucleus was discovered using an alpha particle scattering experiment.

Alpha particles were directed at a sheet of gold foil.

Figure 8 shows the paths taken by seven alpha particles, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

Figure 8



0 8 . 2 Explain why alpha particle **A** takes the path shown in **Figure 8**.

[2 marks]

0 8 . 3 Explain why the path of alpha particle **B** is more tightly curved than the path of alpha particle **C**.

[2 marks]

4.4.2.1 Radioactive decay and nuclear radiation

Question 123 · continued

0 8 . 4 What can be deduced about the atom from the paths taken by alpha particles **D**, **E**, **F** and **G** in **Figure 8**?

[1 mark]

Tick (✓) **one** box.

The atom contains a nucleus. ☐

The atom contains protons, neutrons and electrons. ☐

The atom is mostly empty space. ☐

0 8 . 5 How is the Bohr model of the atom different from the nuclear model of the atom?

[1 mark]

0 8 . 6 Explain how an electron can move up and down between energy levels in an atom.

[2 marks]

10

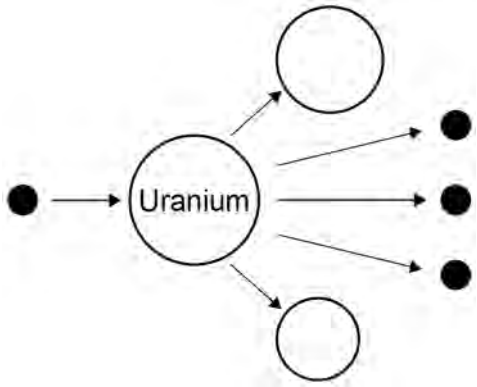
4.4.2.1 Radioactive decay and nuclear radiation

Question 124

0 2 The process of nuclear fission is used in nuclear power stations.

Figure 2 shows the process of nuclear fission.

Figure 2



0 2 . 1 Complete the sentences.

Choose answers from the box.

[3 marks]

electrons	**gamma rays**	**neutrons**	**nuclei**	**protons**

In nuclear power stations, energy is released from

uranium _____.

The uranium in **Figure 2** splits into two parts and

releases three _____.

The process of nuclear fission releases electromagnetic radiation in the

form of _____.

4.4.2.1 Radioactive decay and nuclear radiation

Question 124 · continued

Use the Physics Equations Sheet to answer questions **02.2** and **02.3**.

0 2 . 2 Write down the equation which links energy (*E*), power (*P*) and time (*t*).

[1 mark]

0 2 . 3 A nuclear power station has a power output of 500 MW.

Calculate the energy output in 3600 s.

Give your answer in J.

[3 marks]

Energy output = _____ J

0 2 . 4 Radioactive waste produced by nuclear power stations has a long half-life.

Suggest **one** precaution taken to reduce the hazard caused by radioactive waste from power stations.

[1 mark]

4.4.2.1 Radioactive decay and nuclear radiation

Question 124 · continued

0 2 . 5 Nuclear power stations do **not** generate electricity every day of the year.

One nuclear power station generated electricity for 92% of a year.

one year = 365 days

Calculate the number of days during the year that the nuclear power station generated electricity.

[2 marks]

Number of days = _____

10

Turn over for the next question

4.4.2.1 Radioactive decay and nuclear radiation

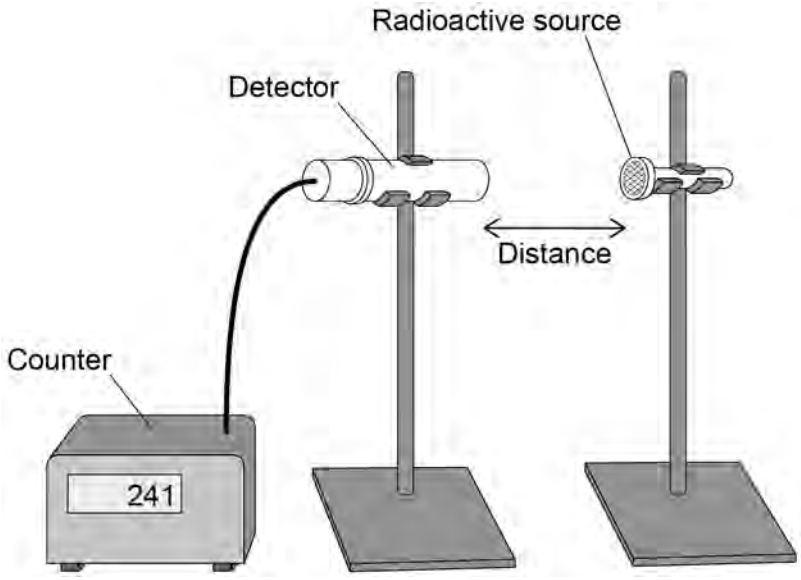
Question 125

June 2024 | 8463/1H | Original Q9

0 9 A teacher investigated the radiation emitted by two different radioactive sources, **A** and **B**.

Figure 14 shows a radiation detector positioned near one of the radioactive sources.

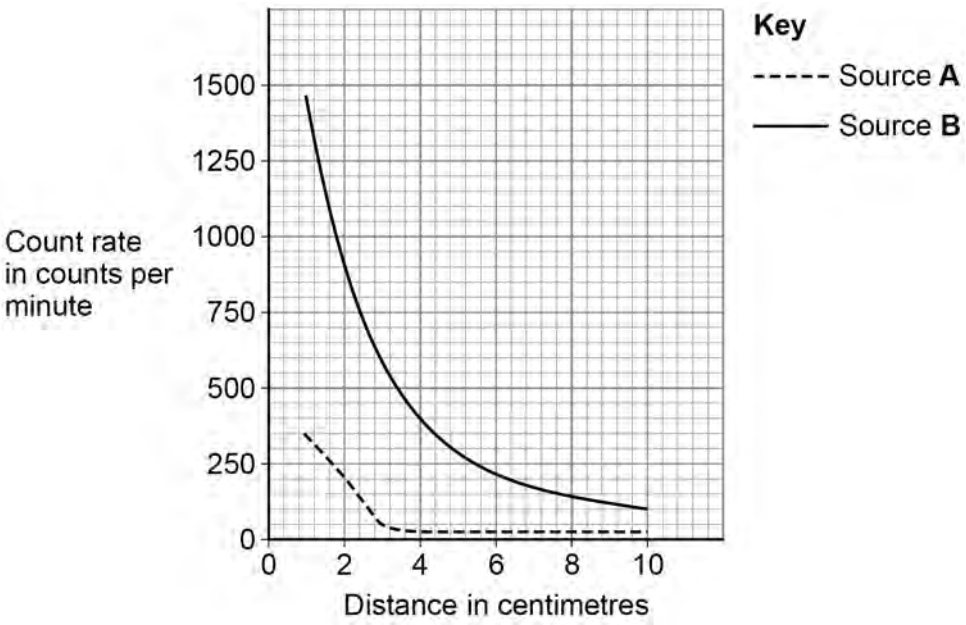
Figure 14



The teacher measured the count rate at different distances for each radioactive source.

Figure 15 shows the results.

Figure 15



4.4.2.1 Radioactive decay and nuclear radiation

Question 125 · continued

0 9 . 1 Explain how **Figure 15** shows that Source **A** only emits alpha radiation.

[3 marks]

0 9 . 2 **Figure 15** can **not** be used to determine if Source **B** emits beta radiation or gamma radiation.

Explain how an absorbing material could be used to show which type of radiation is emitted by Source **B**.

[2 marks]

Question 9 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

Question 125 · continued

The teacher took safety precautions during the experiment.

0 9 . 3 Suggest **one** safety precaution the teacher would have taken to reduce the radiation dose the teacher received.

[1 mark]

0 9 . 4 Suggest **one** safety precaution that the teacher would have taken to avoid becoming contaminated.

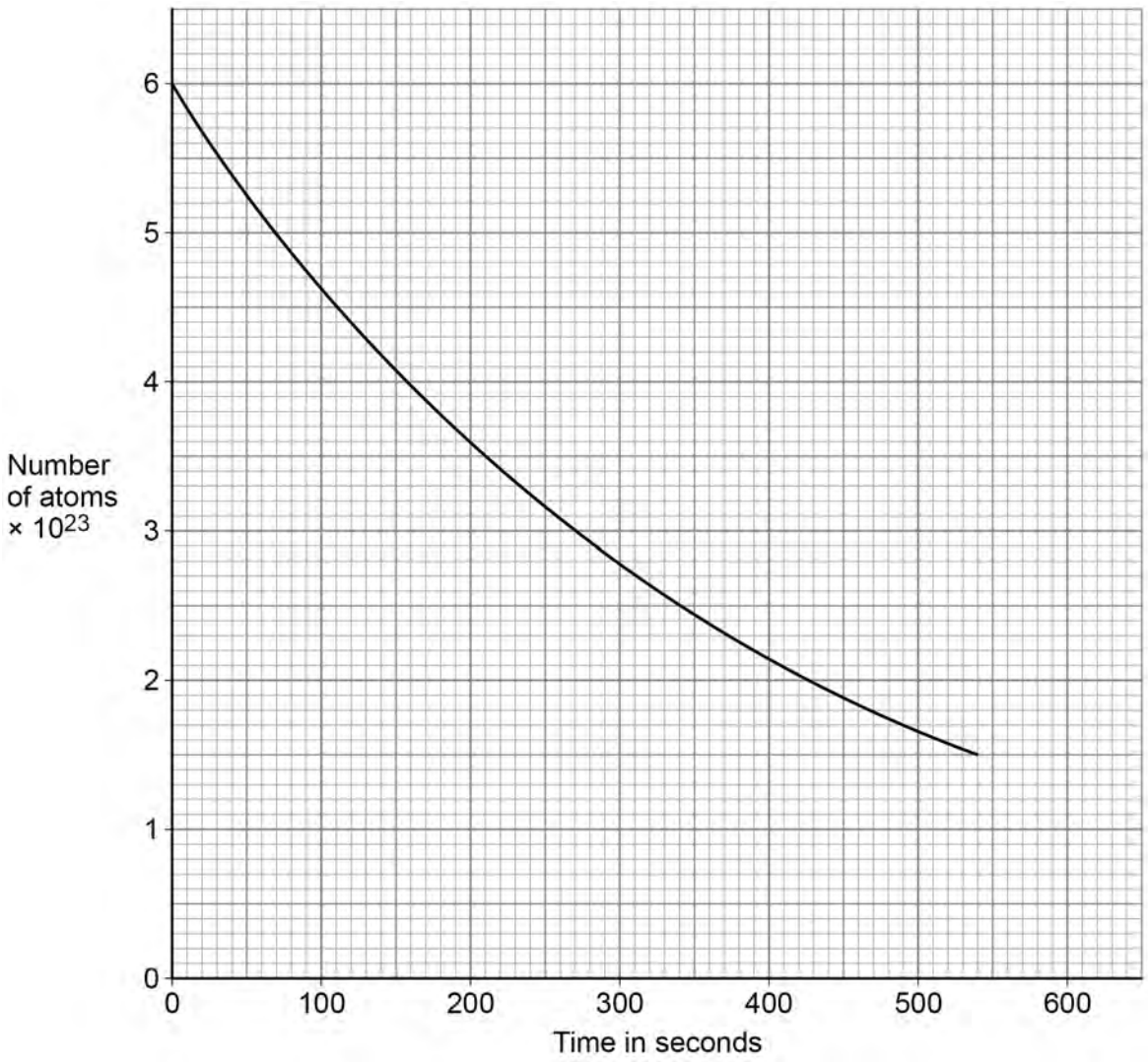
[1 mark]

4.4.2.1 Radioactive decay and nuclear radiation

Question 125 · continued

0 9 . 5 **Figure 16** shows how the number of atoms of a radioactive element in a sample varied with time.

Figure 16



Activity is the rate at which a source of unstable nuclei decays.

Determine the activity of the radioactive sample at 300 seconds.

Give the unit.

[4 marks]

Activity = _____ Unit _____

11

4.4.2.1 Radioactive decay and nuclear radiation

Question 126

June 2024 | 8463/2H | Original Q6

0 6 Radio waves and gamma rays both transfer energy.

0 6 . 1 Give **three** other similarities between radio waves and gamma rays.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

4.4.2.1 Radioactive decay and nuclear radiation

Question 126 · continued

Both radio waves and gamma rays are used in medicine.

0 6 . 2 Give **one** medical use of gamma rays.

[1 mark]

0 6 . 3 Explain why exposure to gamma rays can be harmful but exposure to radio waves is **not** harmful.

[2 marks]

0 6 . 4 Some medical scanners produce radio waves at a specific frequency.

Explain how radio waves are produced at a specific frequency.

[2 marks]

8

4.4.2.1 Radioactive decay and nuclear radiation

Question 127

June 2025 | 8463/1H | Original Q7

0 7 Some atoms emit radiation.

0 7 . 1 Why do scientists sometimes change the model used to describe the structure of the atom?

[1 mark]

Tick (✓) **one** box.

- Existing models use ideas that are old fashioned. ☐
- New evidence is discovered that existing models cannot explain. ☐
- Scientists need to develop new models every 100 years. ☐
- The public do not understand old models so new ones are created. ☐

0 7 . 2 When radioactivity was discovered, the dangers of radiation were not known.

Some scientists were irradiated and contaminated while working with the radioactive materials.

Describe the difference between irradiation and radioactive contamination.

[2 marks]

Question 7 continues on the next page

4.4.2.1 Radioactive decay and nuclear radiation

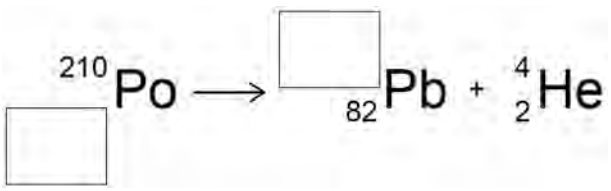
Question 127 · continued

0 7 . 3 Polonium-210 was one of the first radioactive elements to be discovered.

Polonium-210 (Po) decays into lead (Pb).

Complete the nuclear equation for polonium-210.

[2 marks]



0 7 . 4 Polonium-210 has a half-life of 138 days.

A sample of polonium contains 256 000 atoms.

Calculate the time taken for the number of polonium-210 atoms to reach 16 000.

[3 marks]

Time taken = _____ days

4.4.2.1 Radioactive decay and nuclear radiation

Question 127 · continued

0 7 . 5 A sample of polonium contains equal numbers of polonium-209 atoms and polonium-210 atoms.

Polonium-209 has a half-life of 125 **years**.

Polonium-210 has a half-life of 138 **days**.

Explain how the activity of polonium-209 compares with the activity of polonium-210 in this sample.

[2 marks]

10

Turn over for the next question