AQA GCSE Physics | 8463

SPECIFICATION POINT 4.4.2.3

Half-lives and the random nature of radioactive decay

Past-paper questions

Tier	**Higher**
Question groups	**54**
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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 01

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?

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Explain the reasons for your choice.

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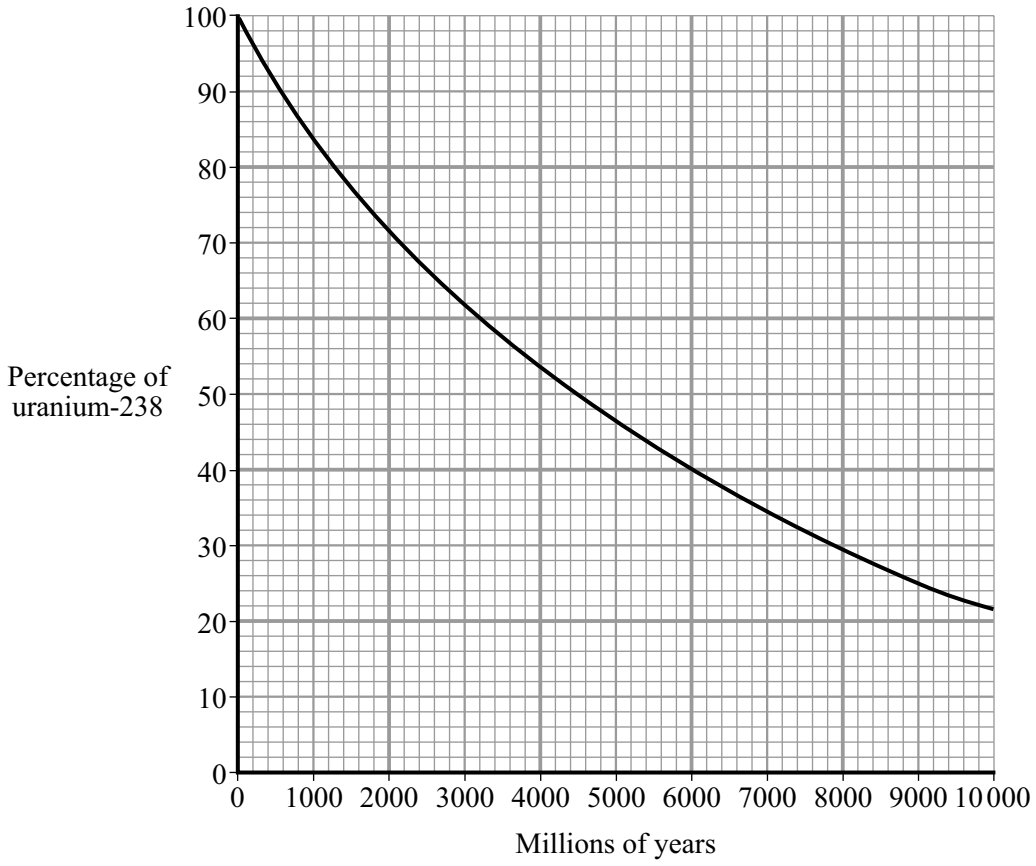
(3 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 01 · continued

MARGIN BLANK

(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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 02

June 2003 | 3462H3 | Original Q12 | Legacy

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Explain the reasons for your choice.

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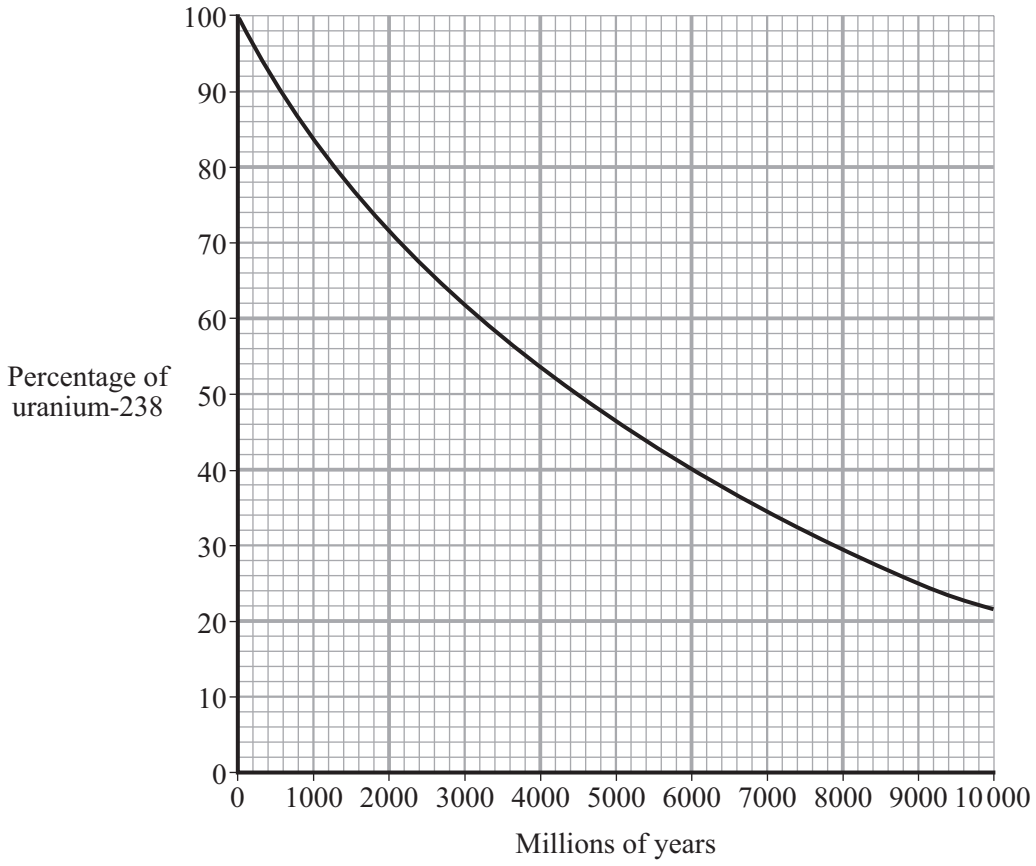
(3 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 02 · continued

MARGIN BLANK

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.....

.....

Age of rock = ...million years

(2 marks)

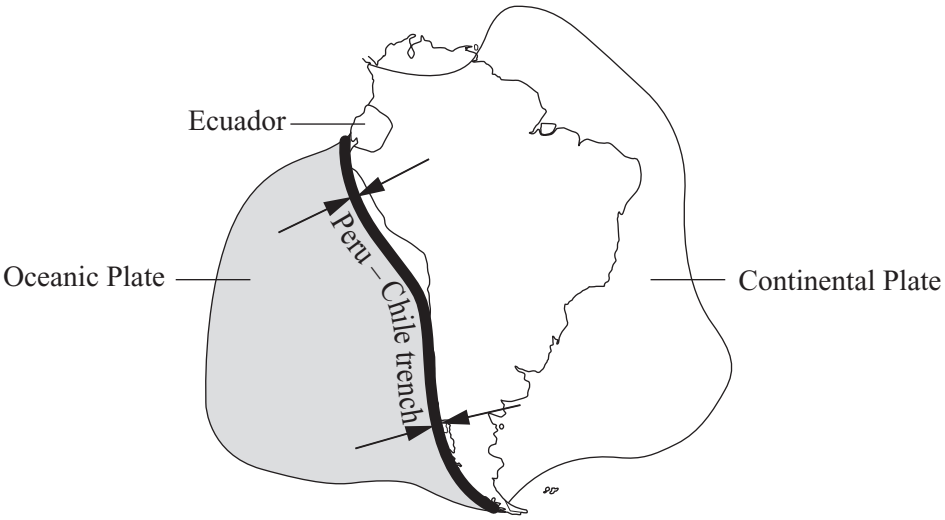
7

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 03

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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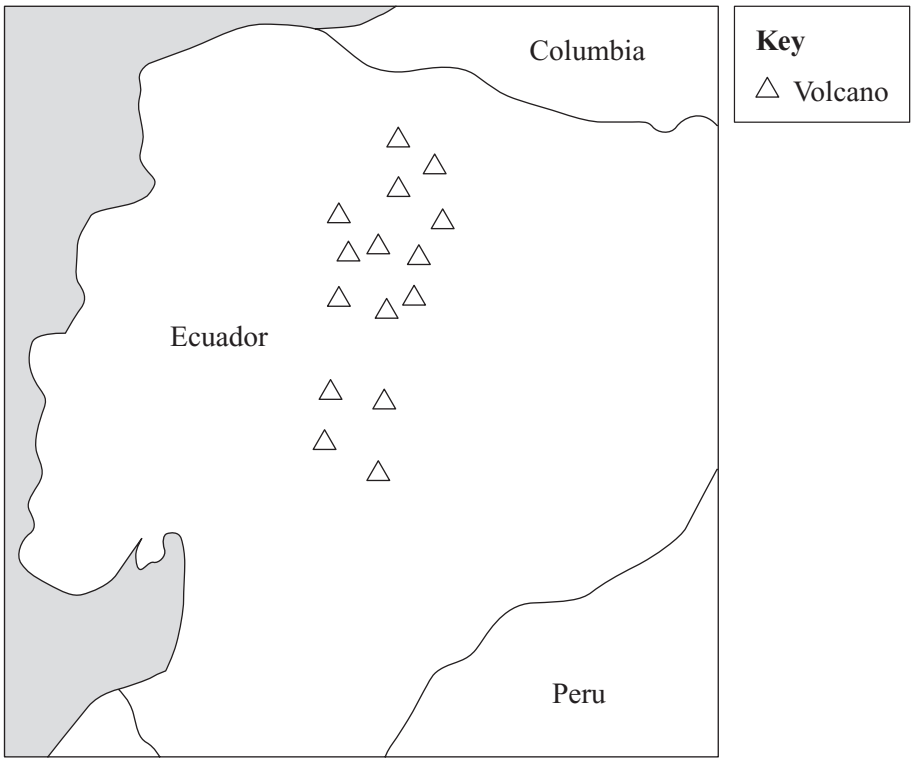
(2 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 03 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 03 · 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)

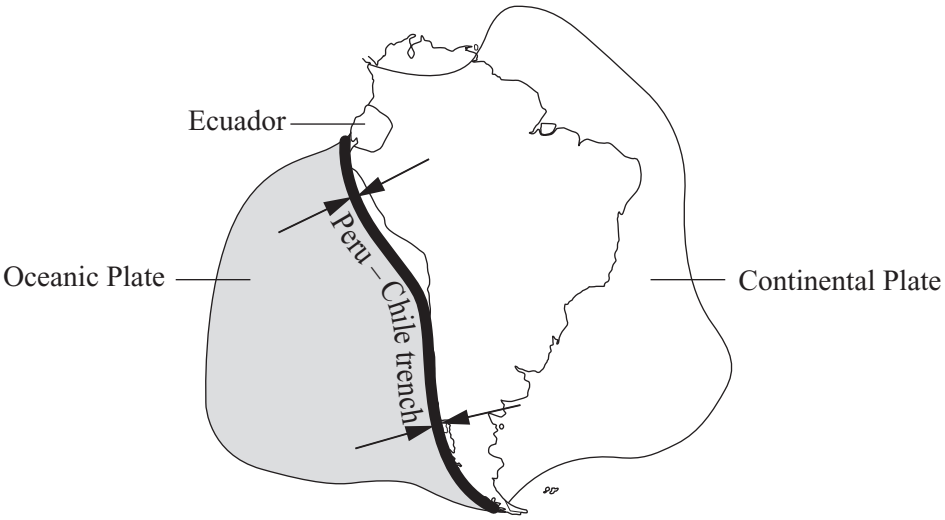
12

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 04

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.

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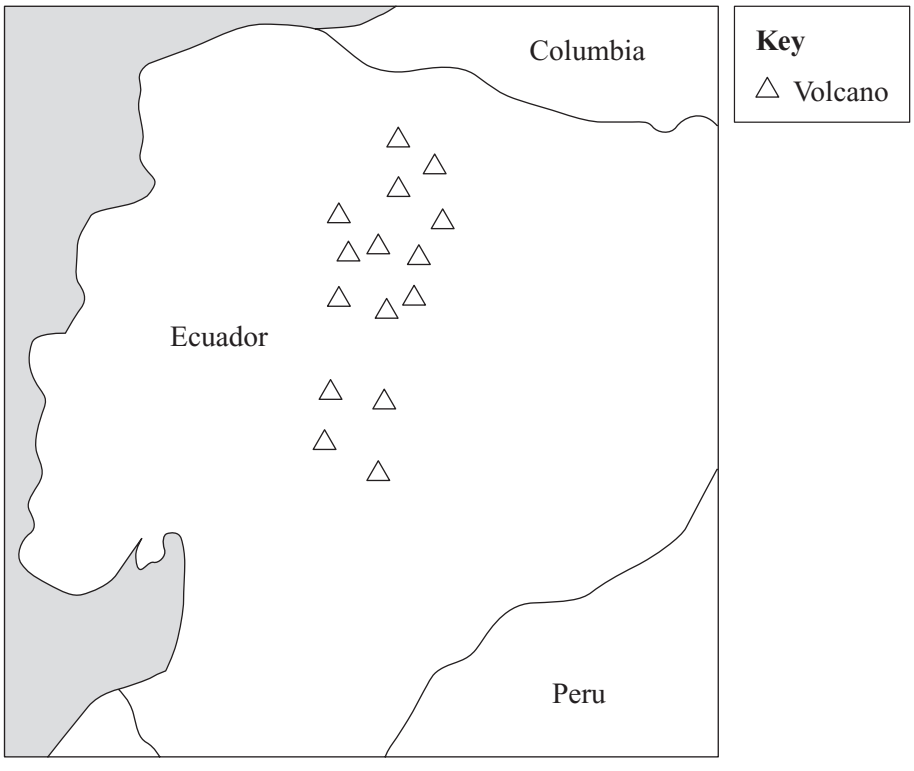
(2 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · 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)

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

.....

(1 mark)

QUESTION 11 CONTINUES ON THE NEXT PAGE

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · 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.

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> 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 05

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 05 · continued

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

These particles . . .

1 add electrons to the air.

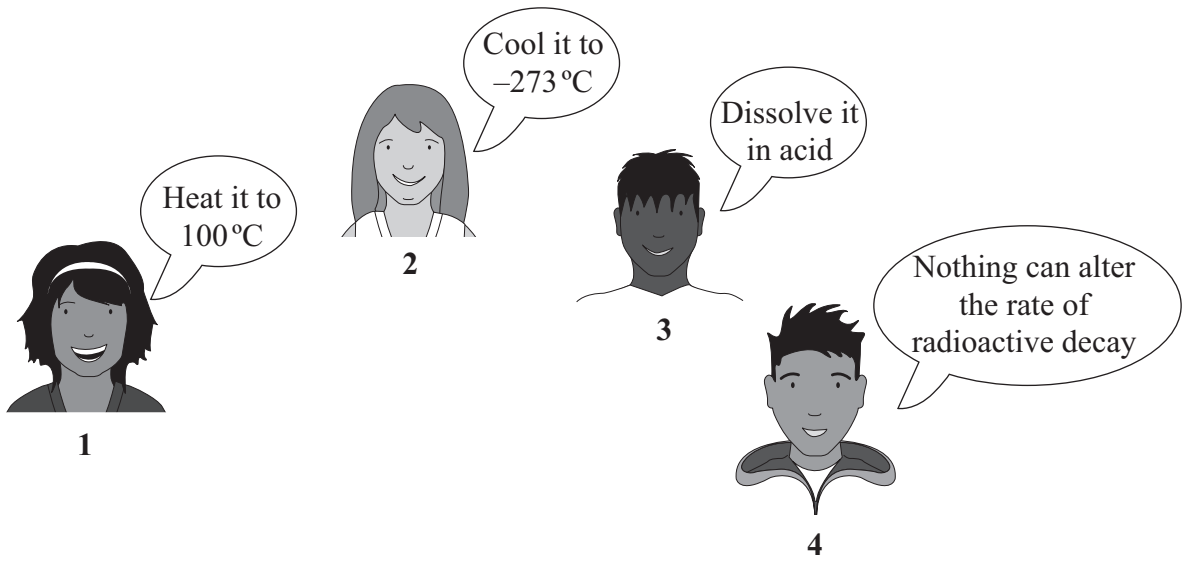
2 add neutrons to the air.

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?



4.4.2.3 Half-lives and the random nature of radioactive decay

Question 06

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?

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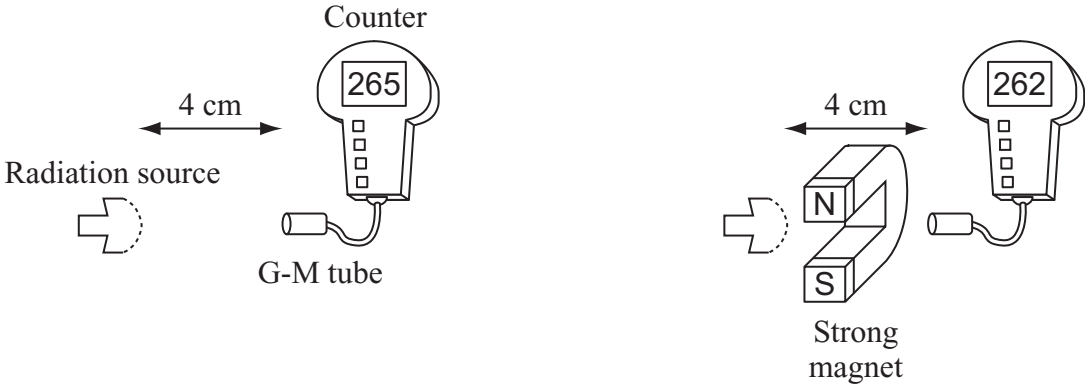
(1 mark)

(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.

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(2 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 06 · continued

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(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.

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(2 marks)

7

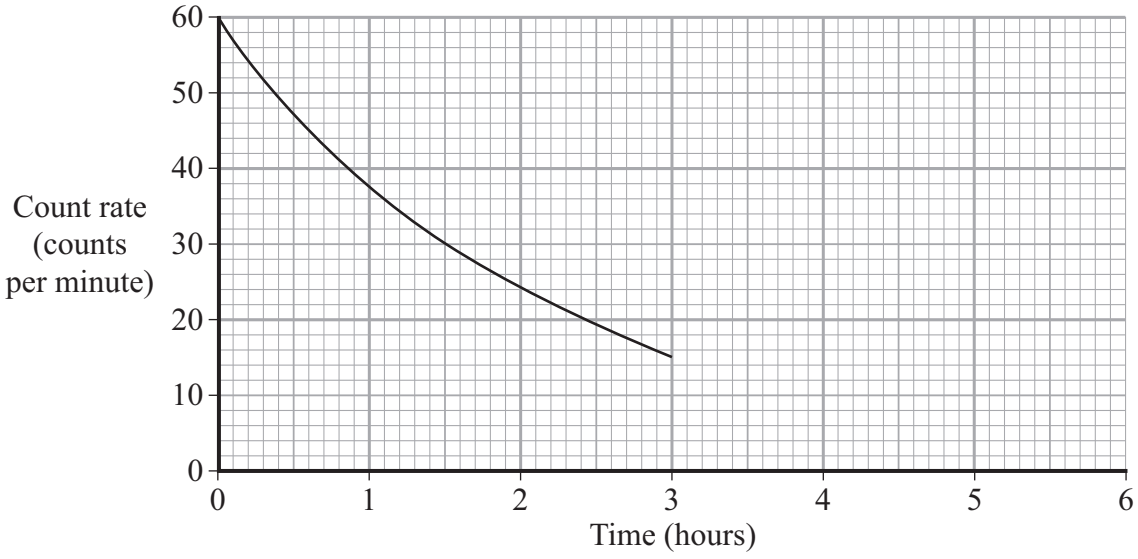
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 07

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 $\frac{x}{16}$

4.4.2.3 Half-lives and the random nature of radioactive decay

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 08

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 08 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 09

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 09 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 10

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 . . .

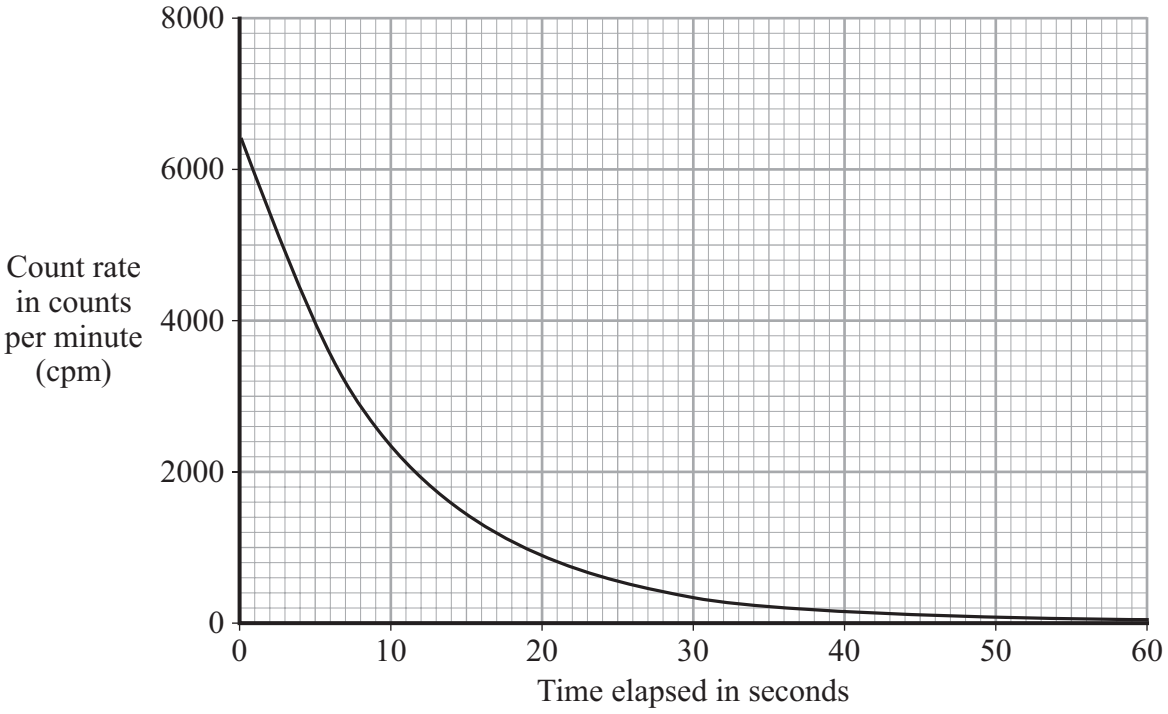
1 be increased by increasing its temperature.

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.



4.4.2.3 Half-lives and the random nature of radioactive decay

Question 10 · 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

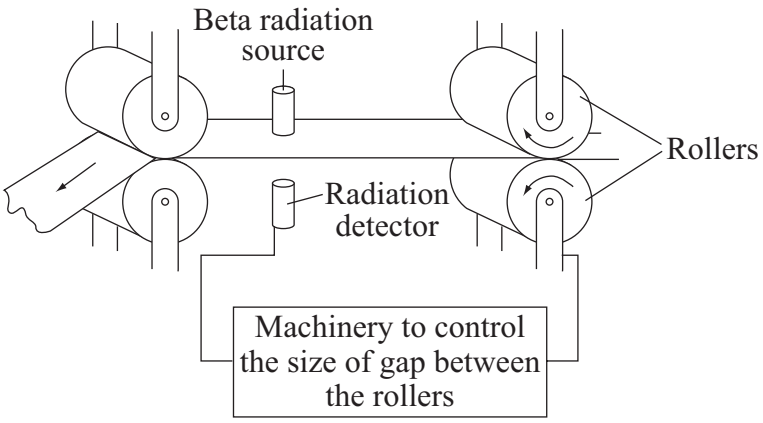
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 11

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 11 · continued

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 12

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

Question 12 · continued

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

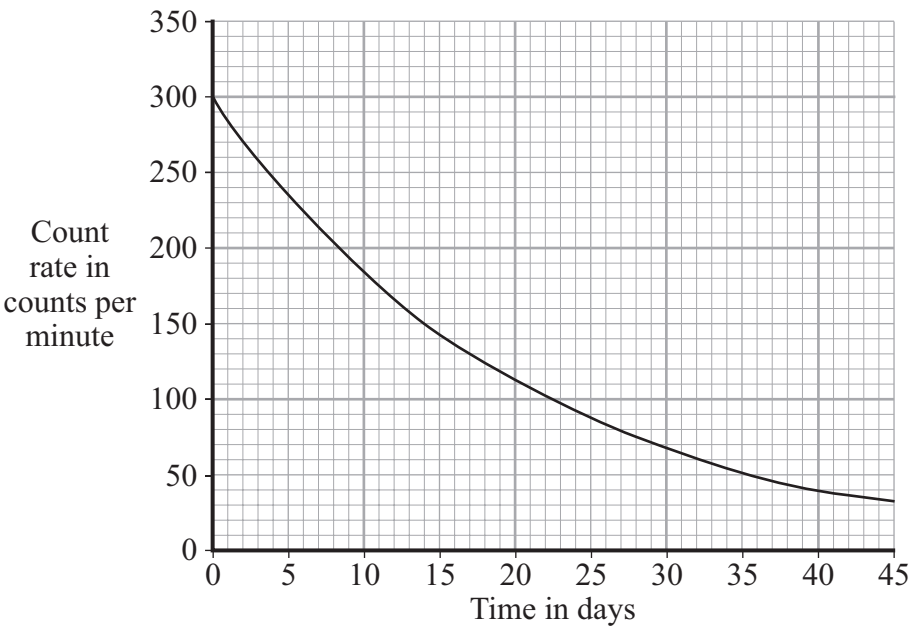
(i) How is an atom of phosphorus-32 different from an atom of the stable isotope phosphorus-31?

.....

.....

(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

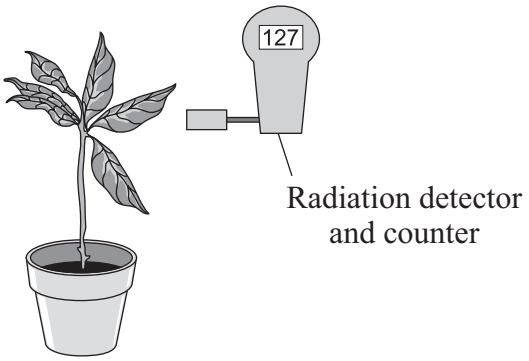
(2 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 12 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 13

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 14

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 14 · continued

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 15

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**

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 15 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 16

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 17

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)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 17 · 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)

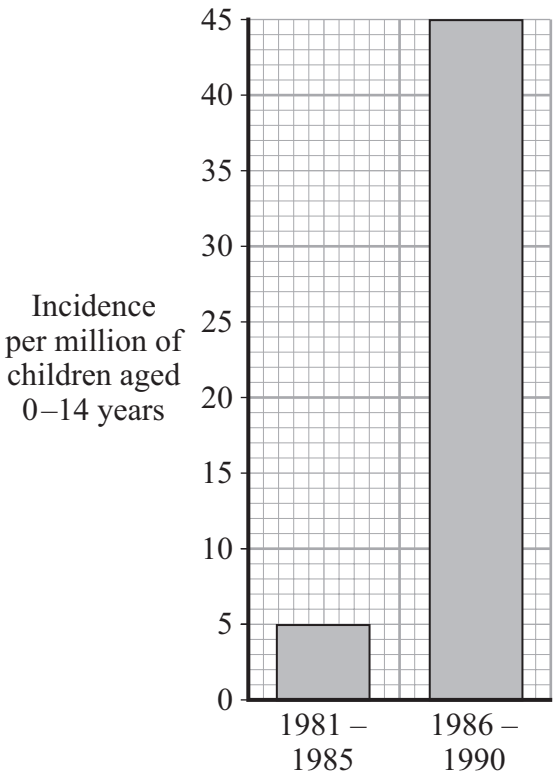
Question 6 continues on the next page

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 17 · 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)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 17 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

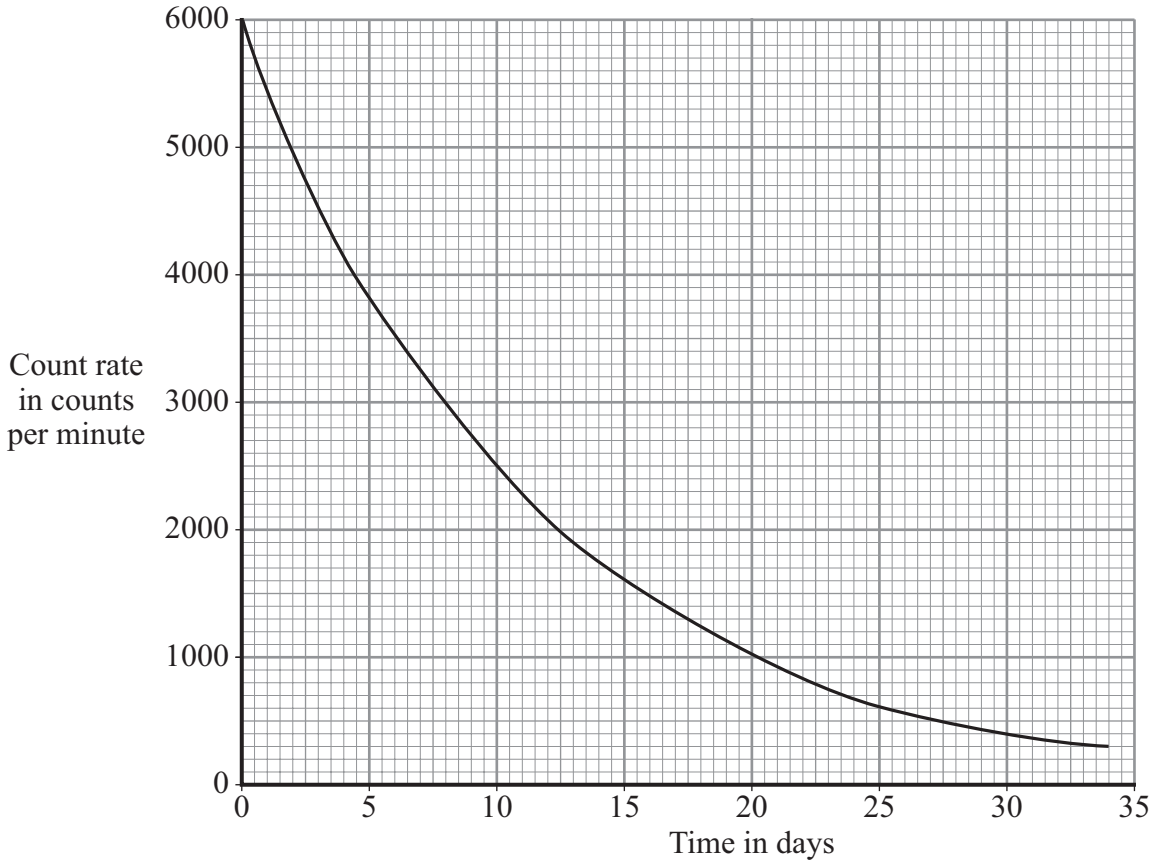
Question 18

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 19

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?

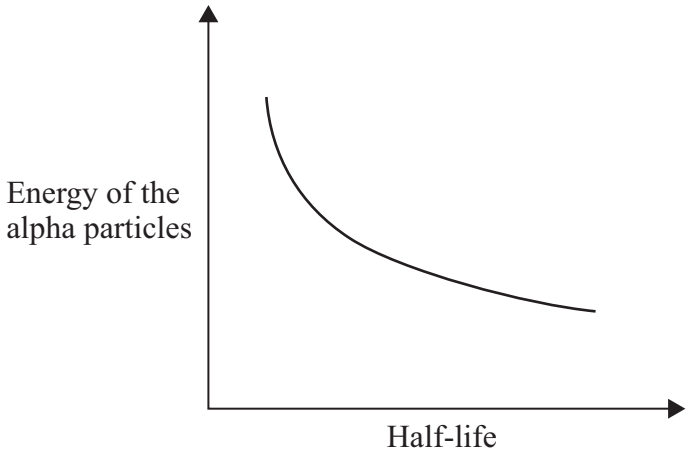
1 by changing the temperature of the nucleus

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.



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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 20

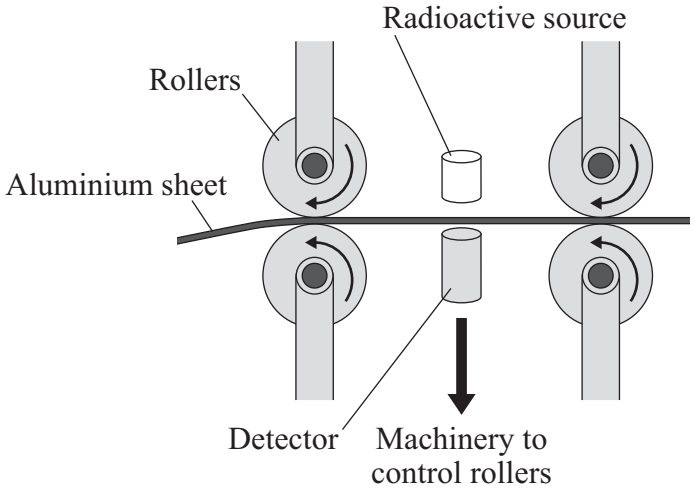
November 2008 | PHY1BP | Original Q7 | Legacy

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**

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 20 · 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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 21

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)

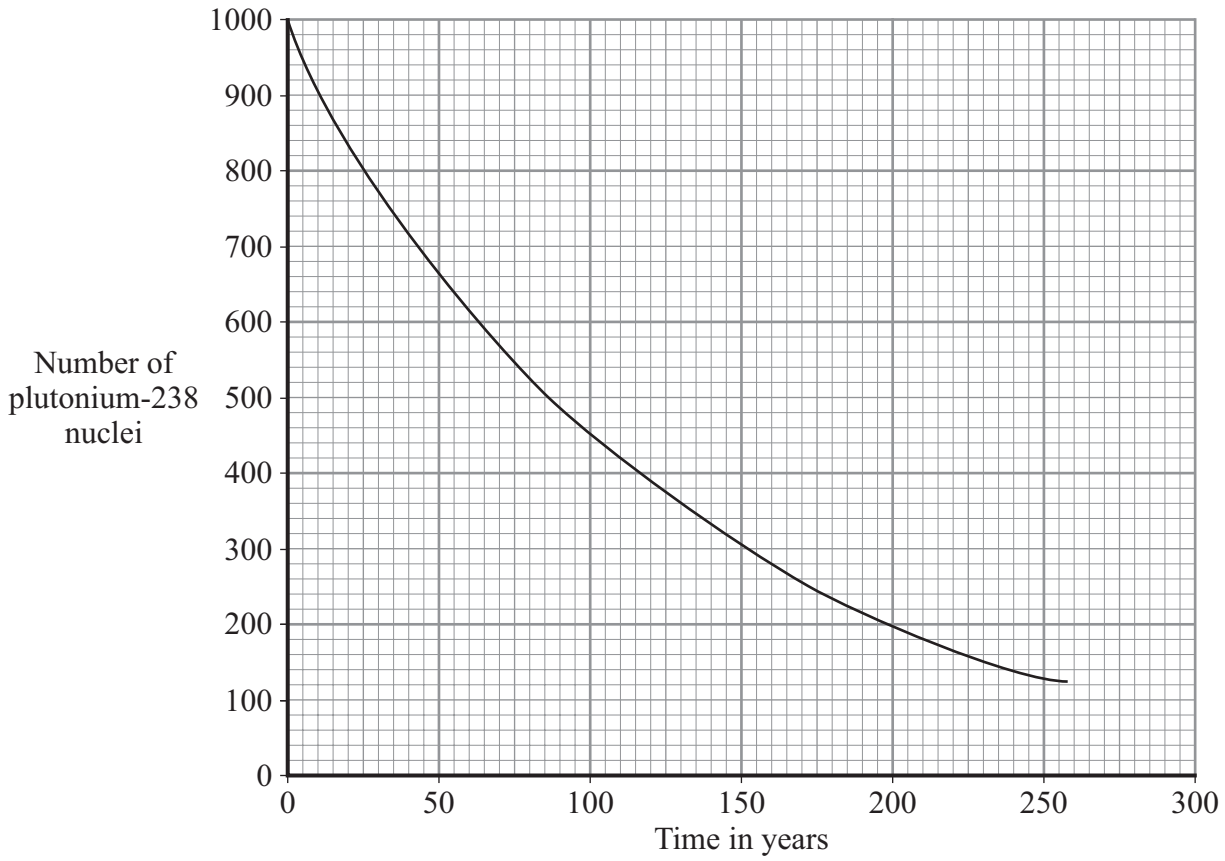
Question 4 continues on the next page

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 21 · 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)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 21 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 22

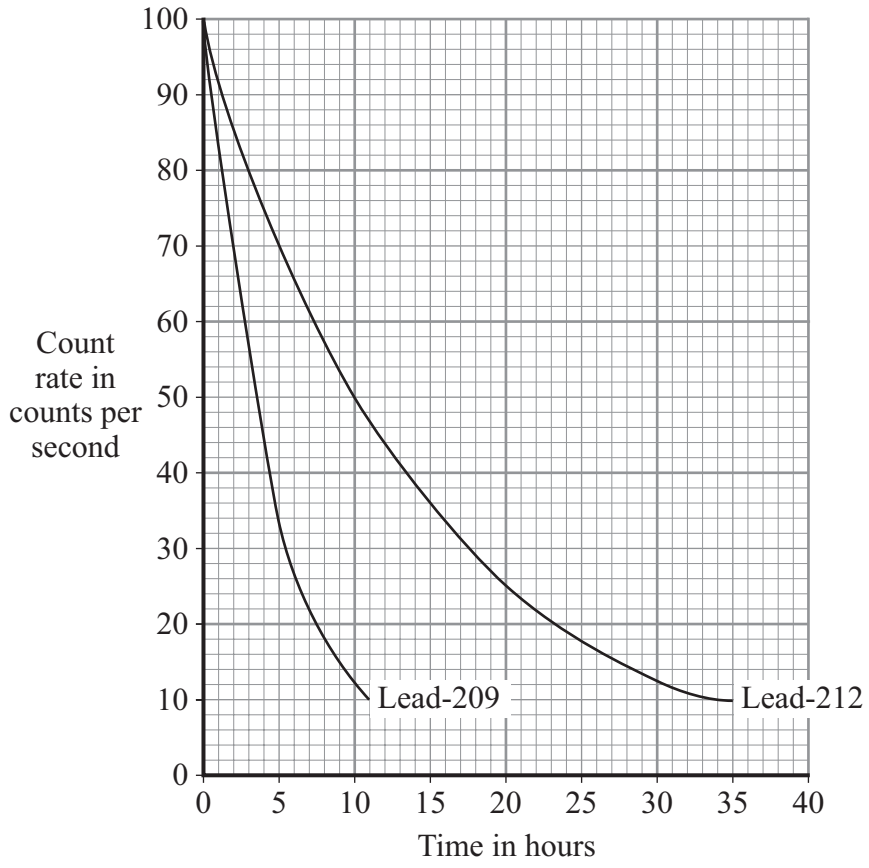
March 2009 | PHY1BP | Original Q1 | Legacy

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.



4.4.2.3 Half-lives and the random nature of radioactive decay

Question 22 · 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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 23

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 23 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 24

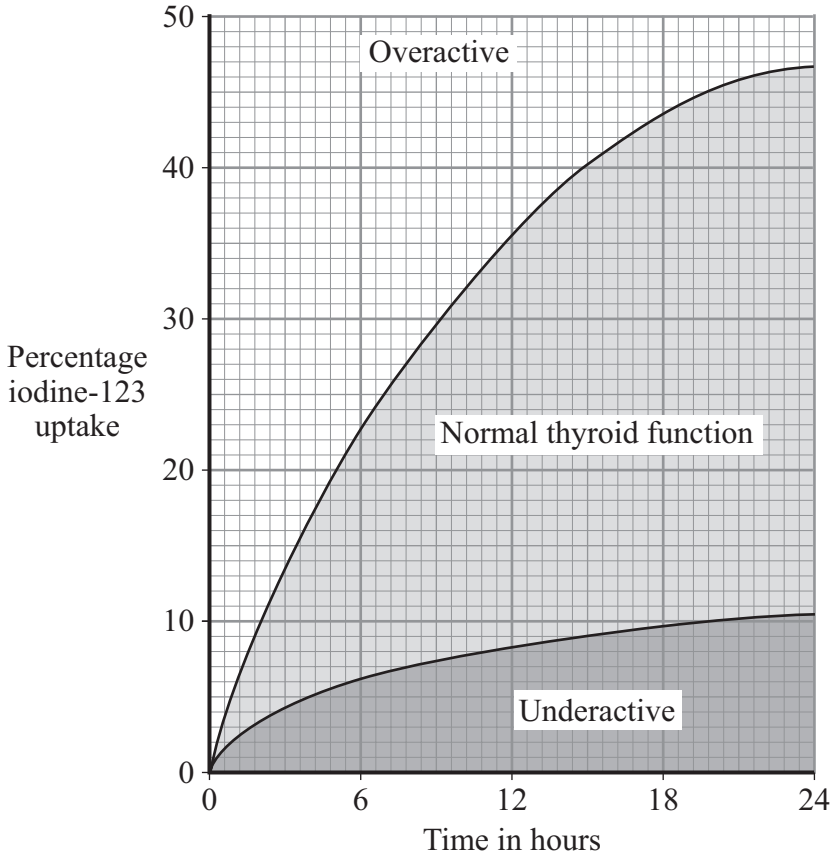
June 2009 | PHY1BP | Original Q5 | Legacy

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 24 · 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

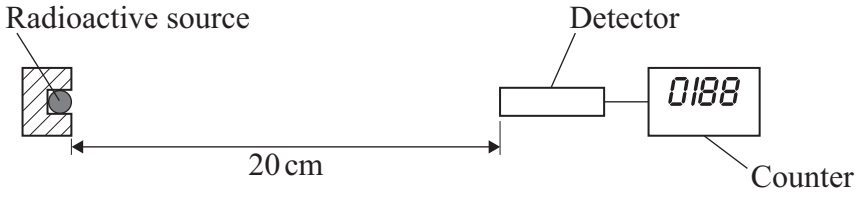
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 25

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.

Question 25 · continued

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

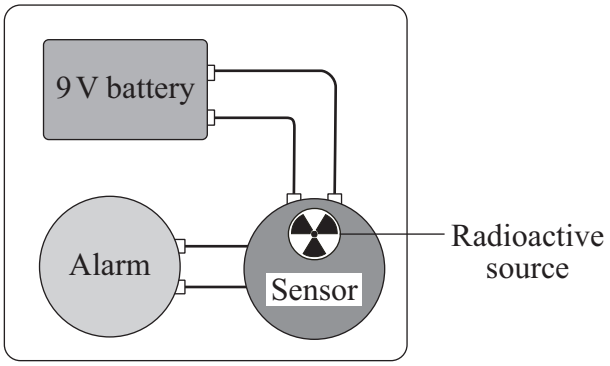
END OF TEST

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 26

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?

.....

.....

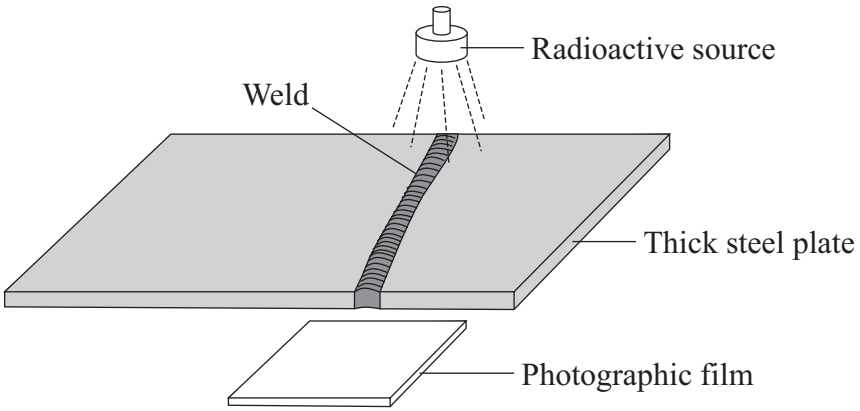
(1 mark)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 26 · 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

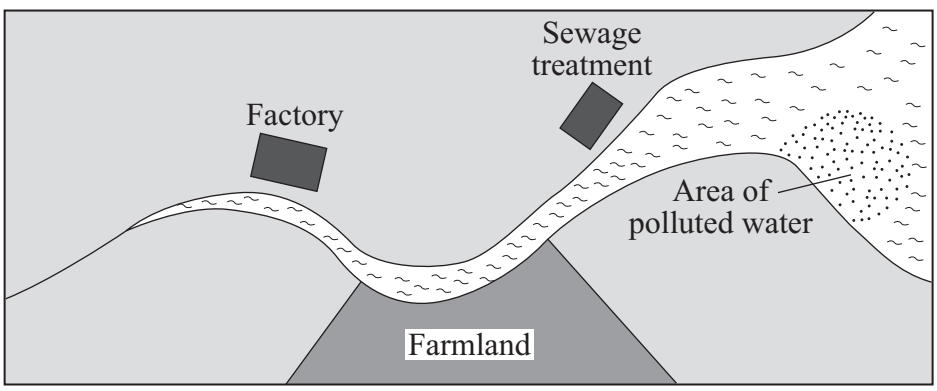
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 26 · 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.

.....

.....

.....

.....

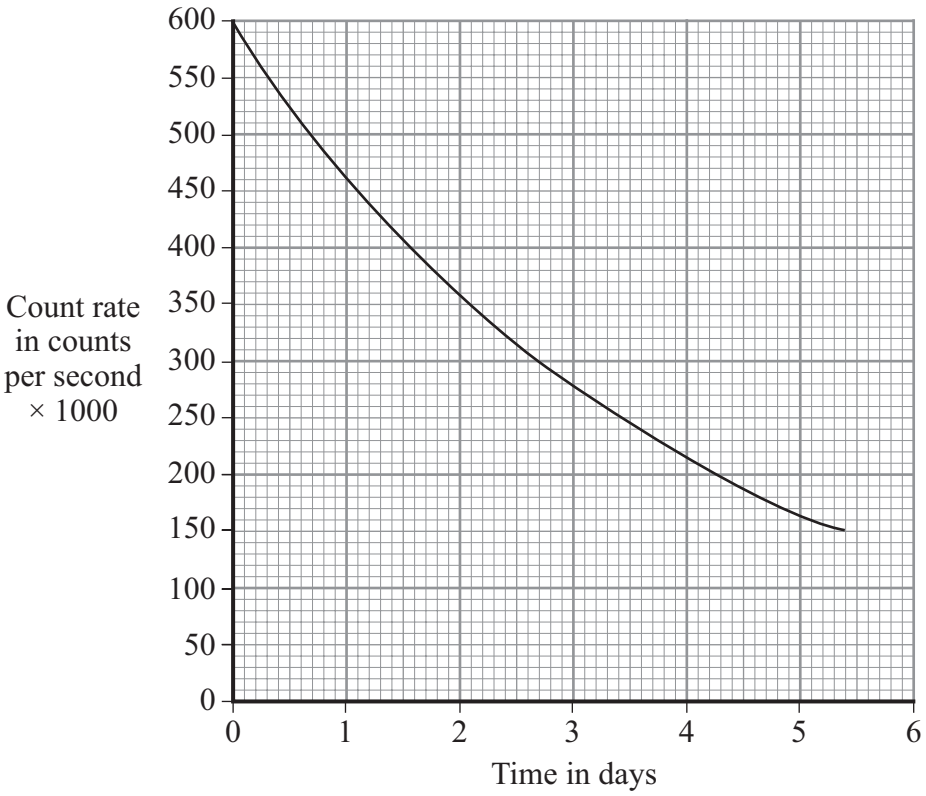
(2 marks)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 26 · 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

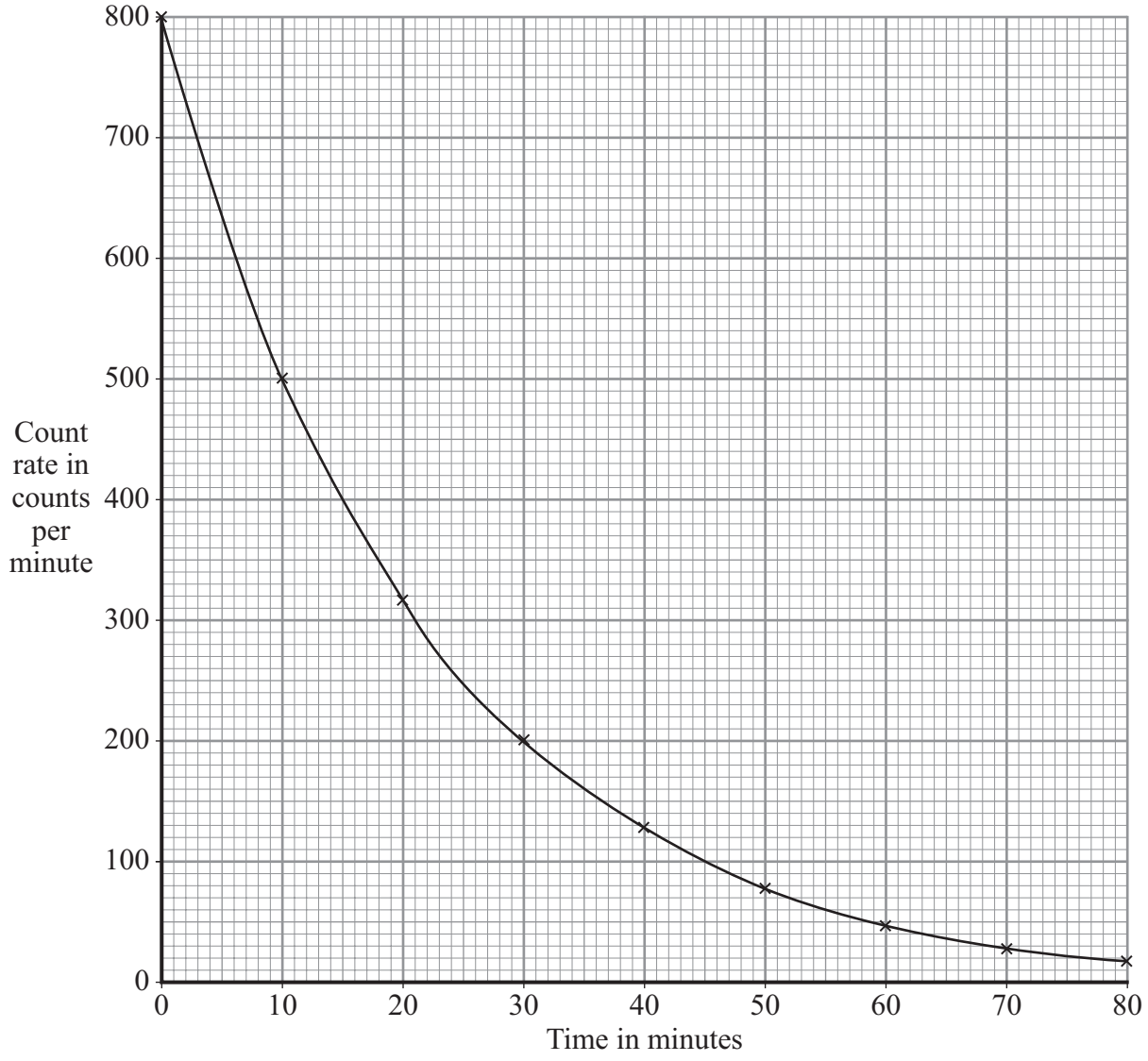
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 27

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 27 · continued November 2009 | PHY1BP | Original Q4 | Legacy

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.

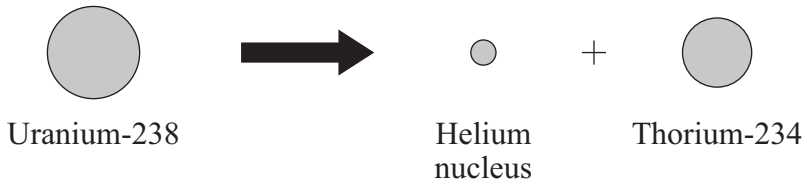
3 The half-life of the technetium-99 isotope is relatively short.

4 There is no risk in using radioactive materials.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 28

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?

.....

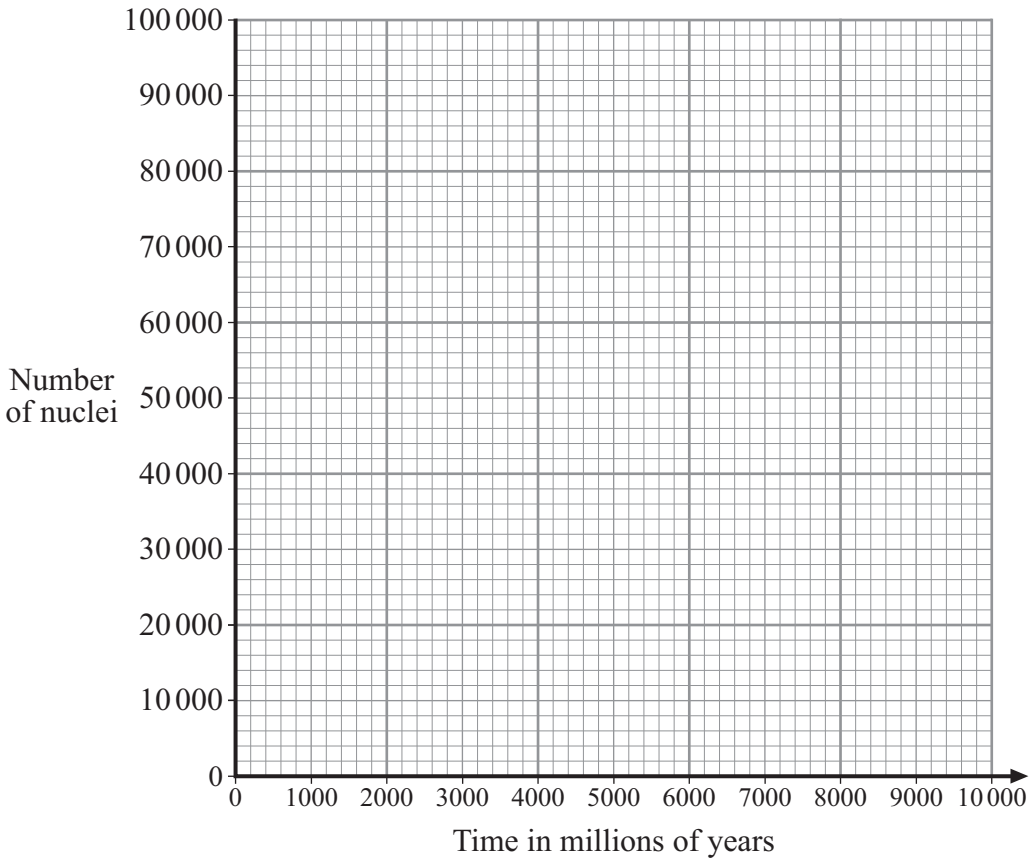
(1 mark)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 28 · 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

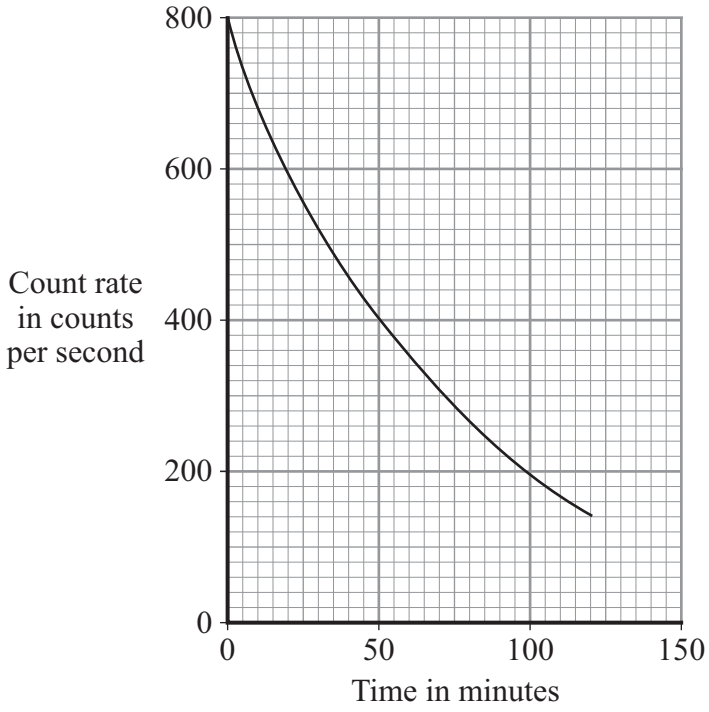
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 29

March 2010 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

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



4.4.2.3 Half-lives and the random nature of radioactive decay

Question 29 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 30

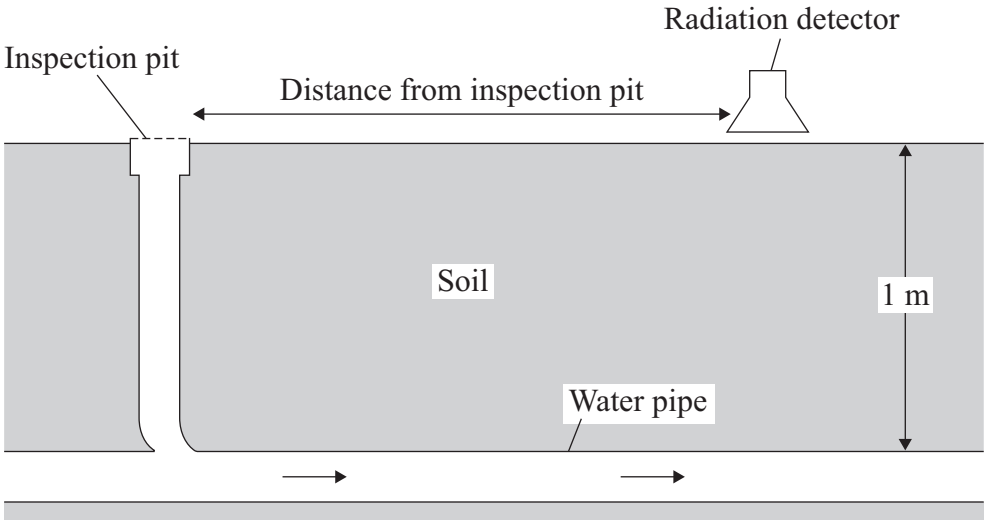
March 2010 | PHY1BP | Original Q3 | Legacy

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 30 · 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.

4.4.2.3 Half-lives and the random nature of radioactive decay

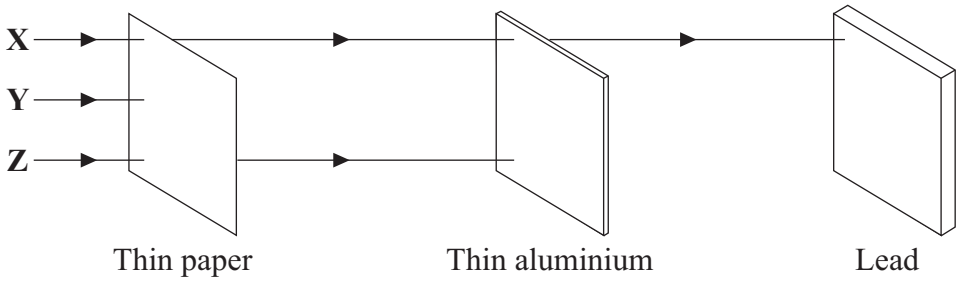
Question 31

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 31 · continued March 2010 | PHY1BP | Original Q6 | Legacy

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.

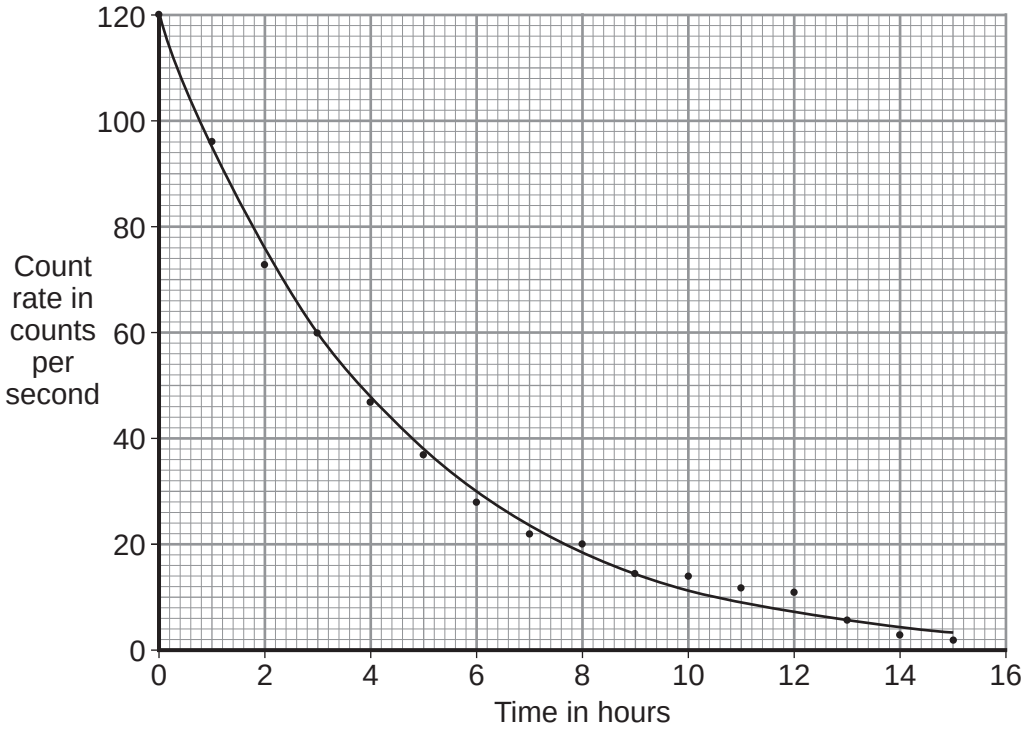
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 32

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 32 · 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 $\frac{7}{8}$

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 33

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.

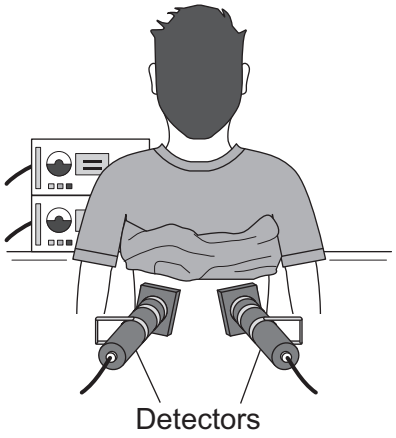
4 The half-life is too short to measure accurately.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 34

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)

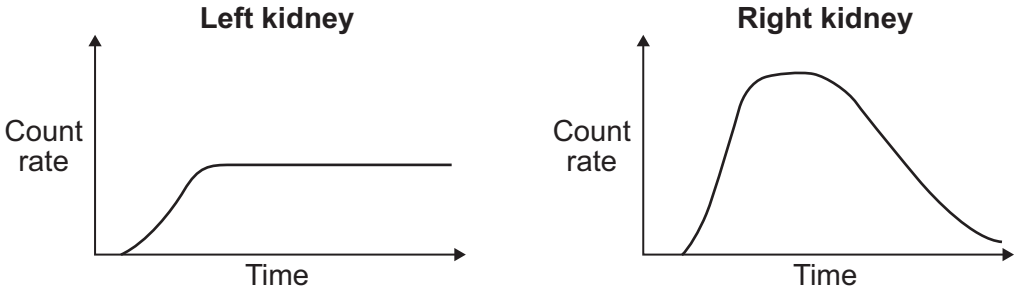
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 34 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 34 · 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

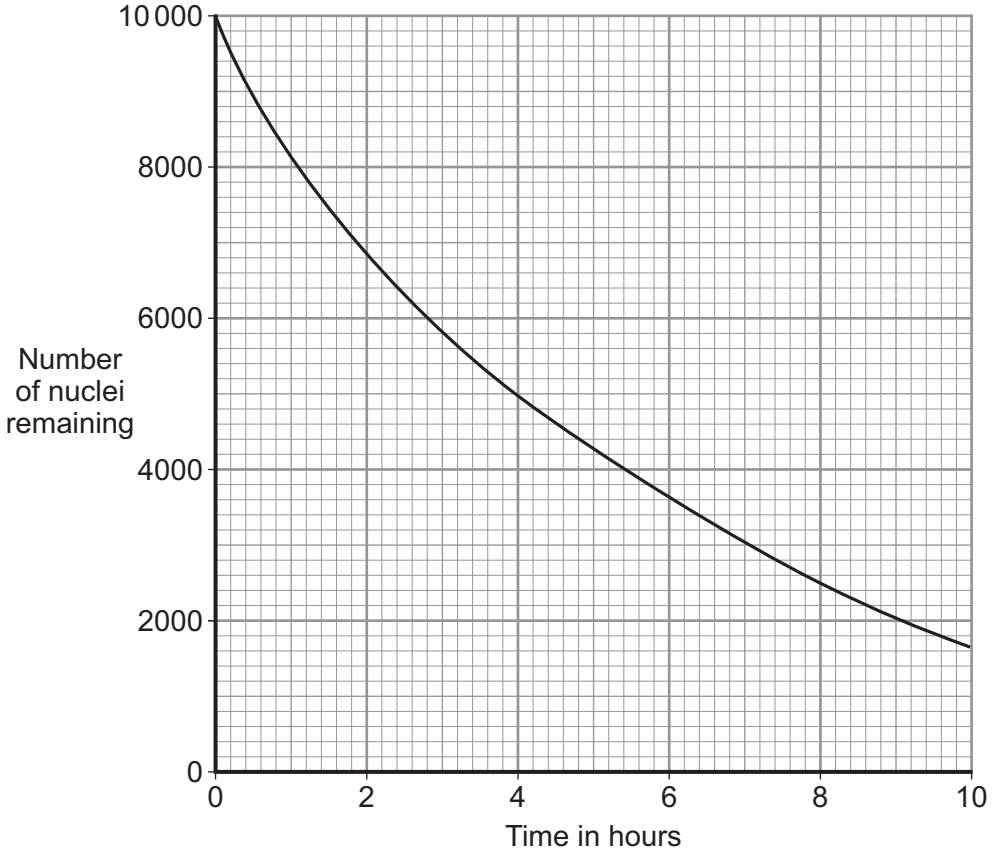
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 35

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 35 · continued November 2010 | PHY1BP | Original Q4 | Legacy

4C This radioactive isotope may be suitable . . .

1 as a source of radiation in a smoke alarm.

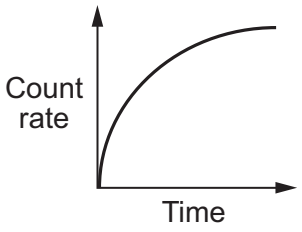
2 as a source of radiation to monitor the thickness of paper in a paper mill.

3 as a medical tracer in the human body.

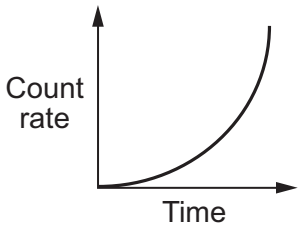
4 to use in finding the age of an ancient bone.

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

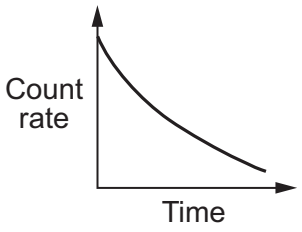
1



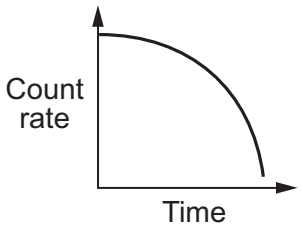
2



3



4



4.4.2.3 Half-lives and the random nature of radioactive decay

Question 36

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 37

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 37 · continued

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

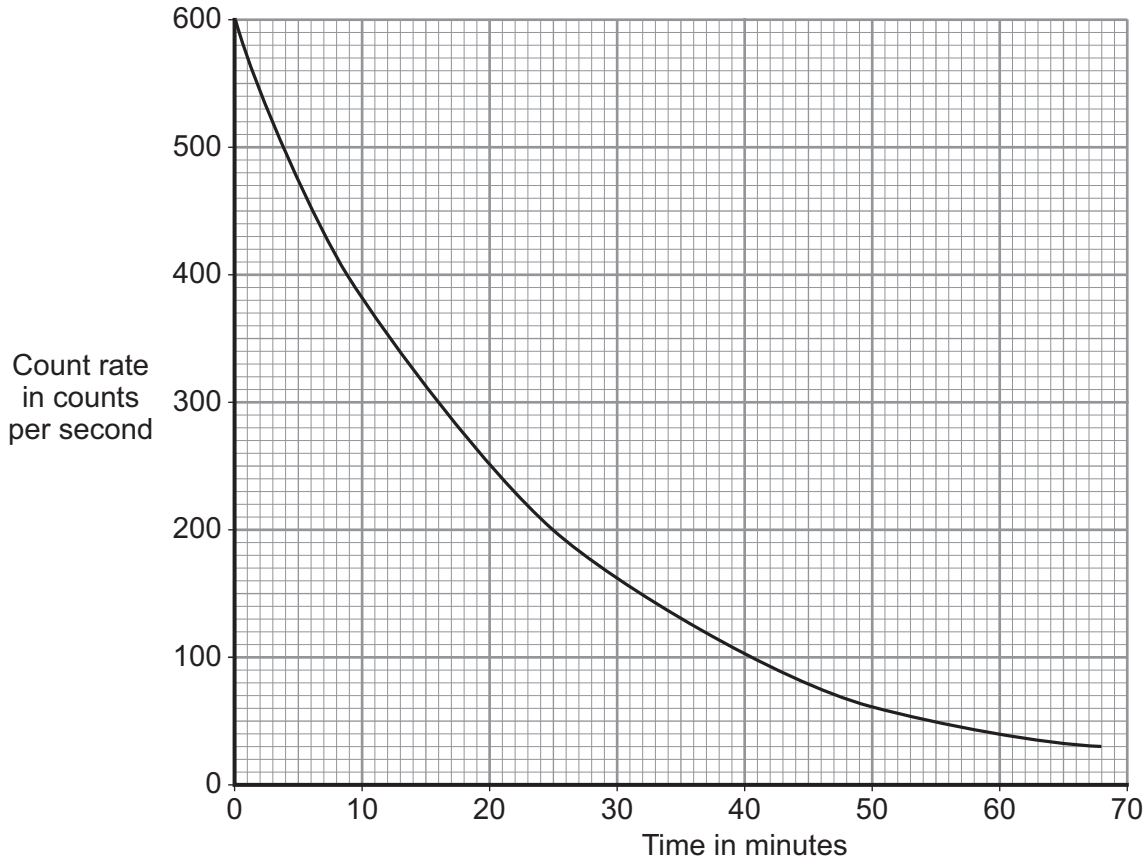
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 38

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 39

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 39 · 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

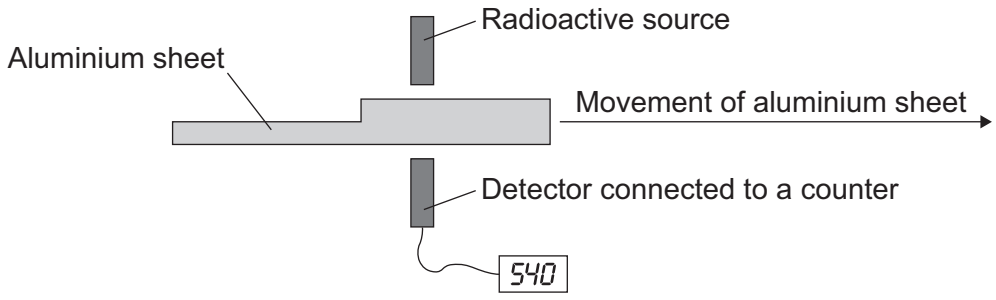
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 40

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 40 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 41

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)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 41 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 41 · 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

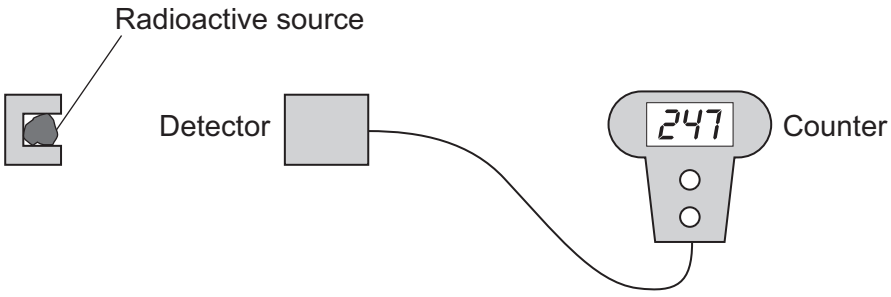
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 42

November 2011 | PHY1BP | Original Q5 | Legacy

QUESTION FIVE

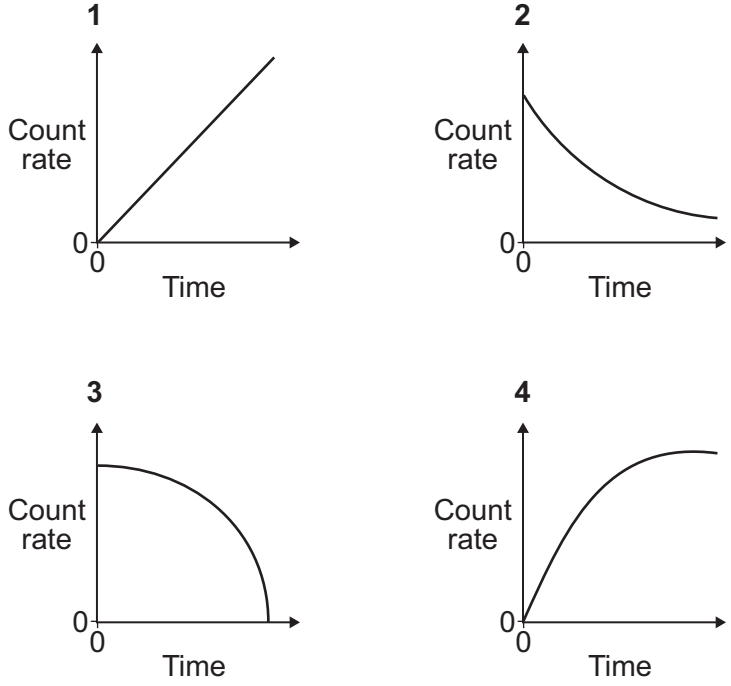
A teacher used the apparatus shown in the diagram to measure the count from a radioactive source.



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?



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

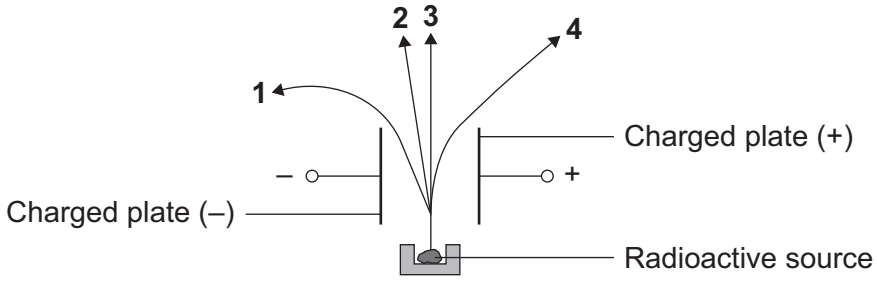
2 the original number of nuclei in the sample

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?



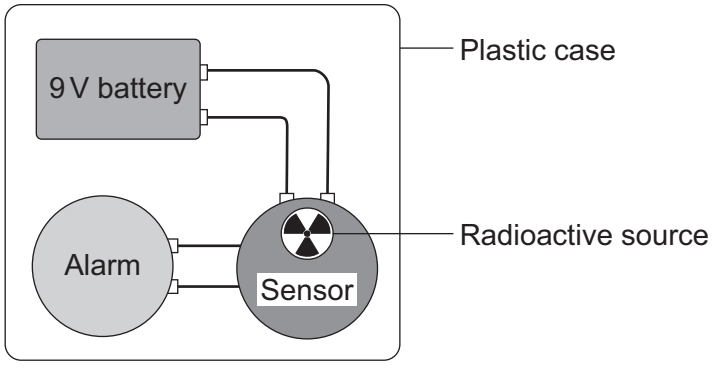
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 43

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.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 43 · 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 $\frac{7}{8}$

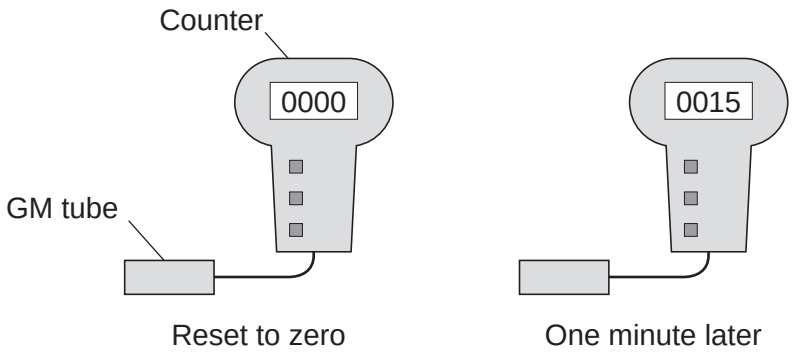
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 44

January 2013 | PH2HP | Original Q2 | Legacy

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)

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 44 · continued

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.

$$^{4}_{2}\text{He}$$

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.

$$^{222}_{86}\text{Rn} \longrightarrow \square\ \square + \text{Po} + \text{alpha particle}$$

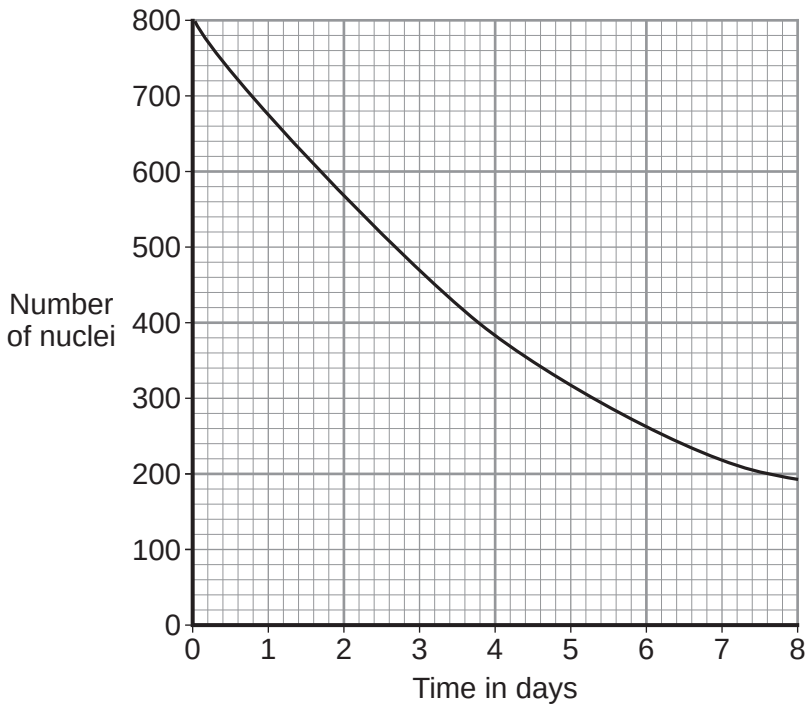
(2 marks)

Question 2 continues on the next page

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 44 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 45

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

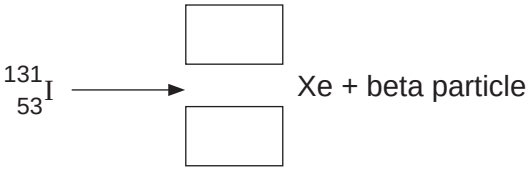
the ..... number.

(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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 45 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 46

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 46 · continued

6 (d) Technetium-99 has a short half-life and emits gamma radiation.

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

[1 mark]

.....

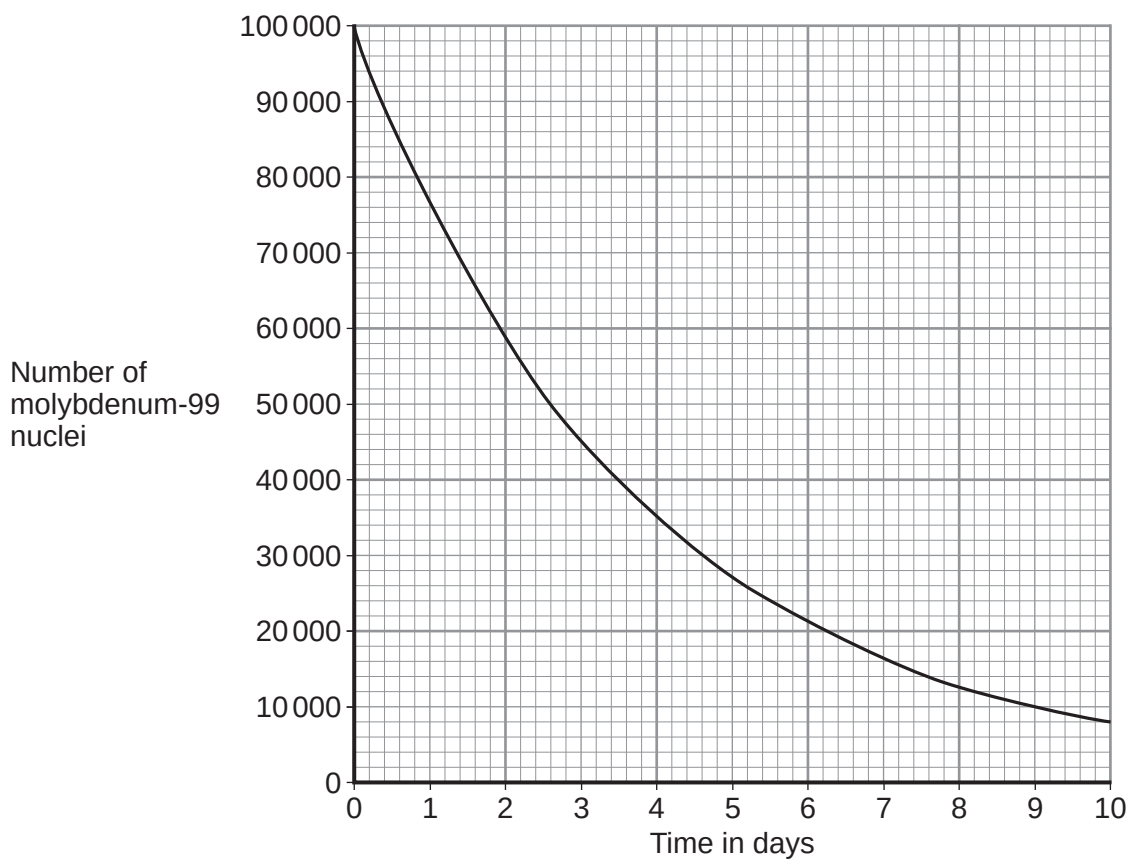
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.....

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



4.4.2.3 Half-lives and the random nature of radioactive decay

Question 46 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 47

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]

.....

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 47 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 47 · 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

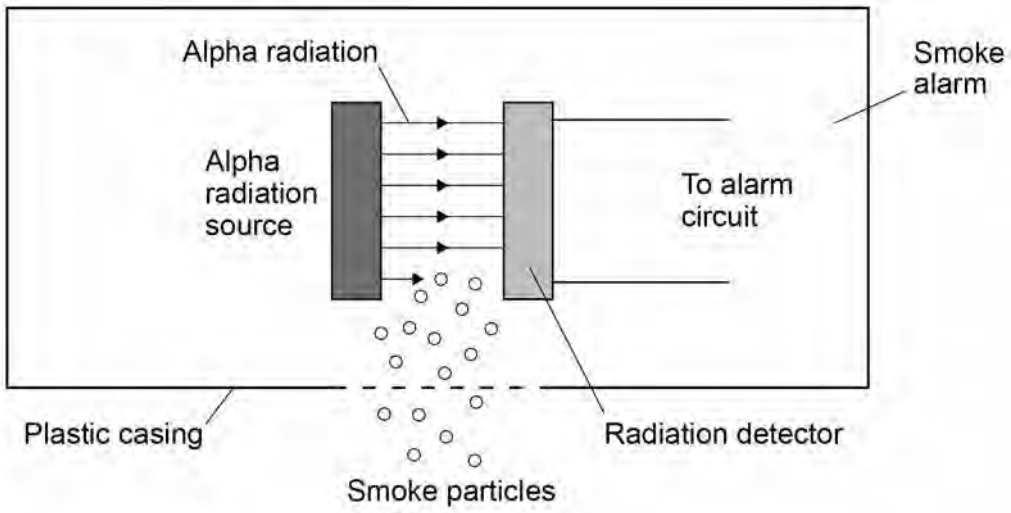
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 48

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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 48 · continued

0 6 . 3 The smoke alarm would not work with a radiation source that emits beta or gamma radiation.

Explain why.

[2 marks]

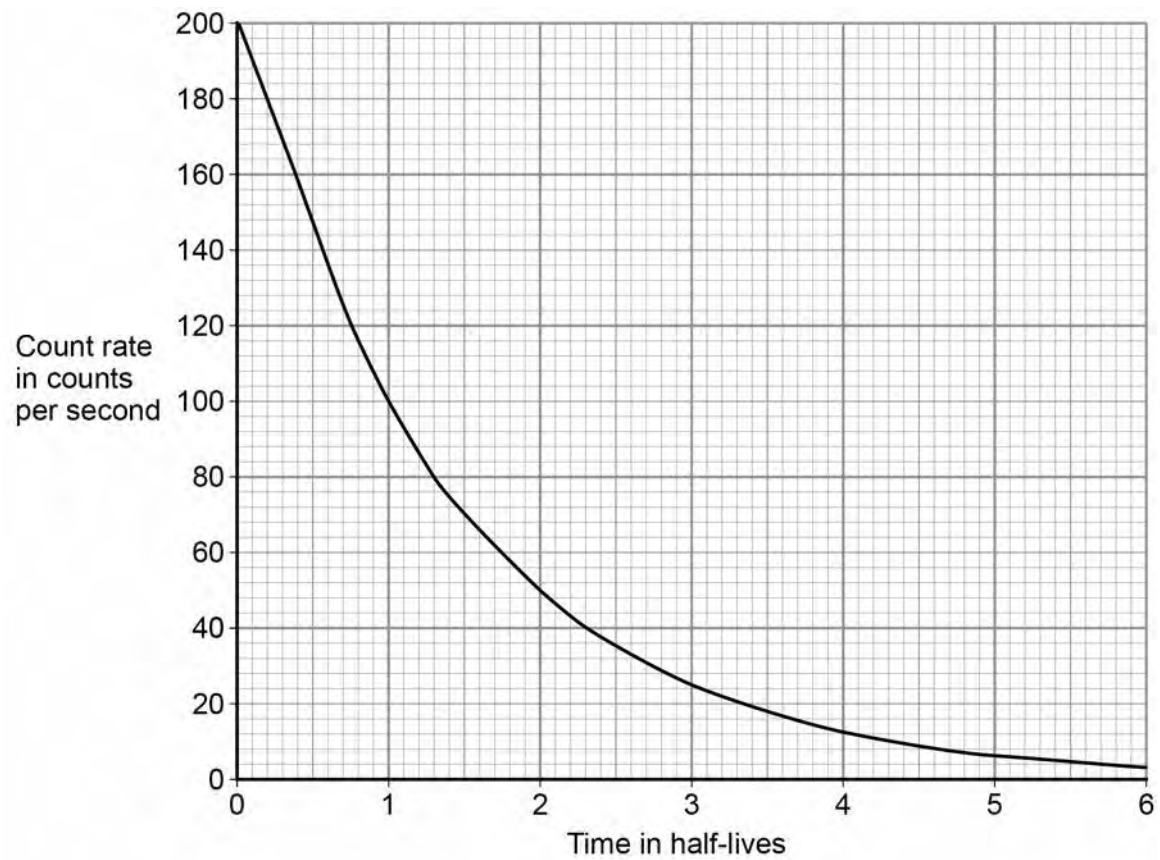
Question 6 continues on the next page

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 48 · 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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 48 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

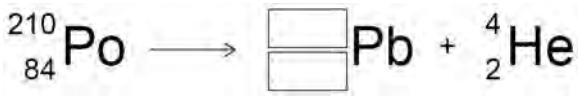
Question 49

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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 49 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 50

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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 50 · 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

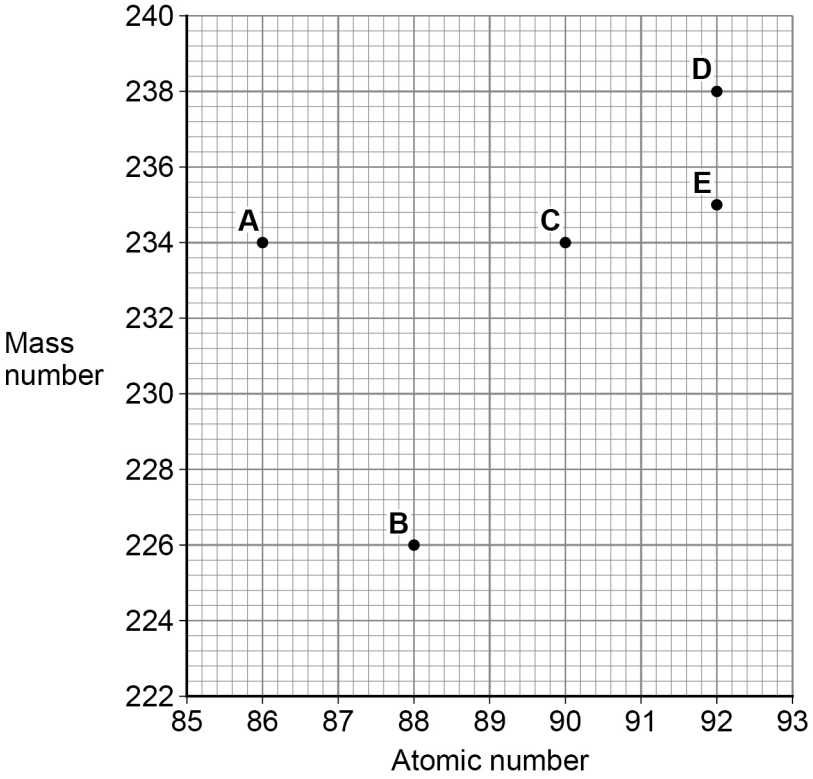
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 51

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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 51 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

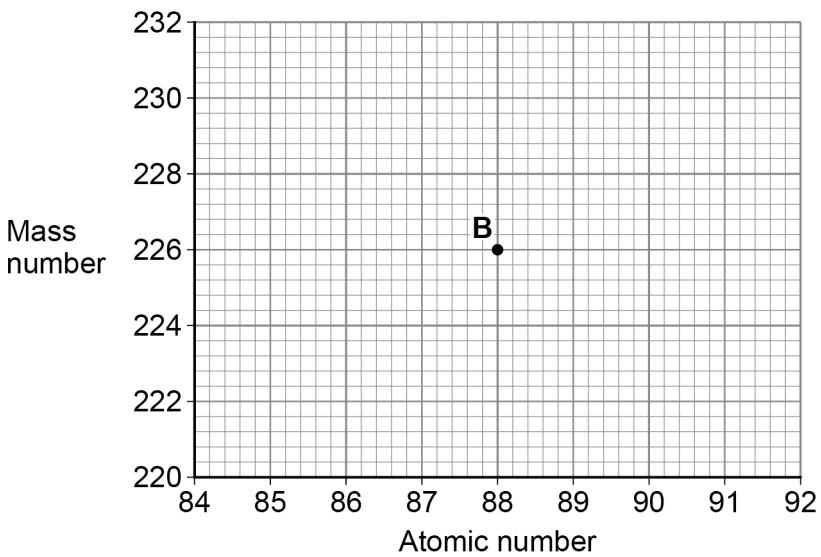
Question 51 · continued

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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 51 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 52

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 52 · 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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 52 · 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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 52 · 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

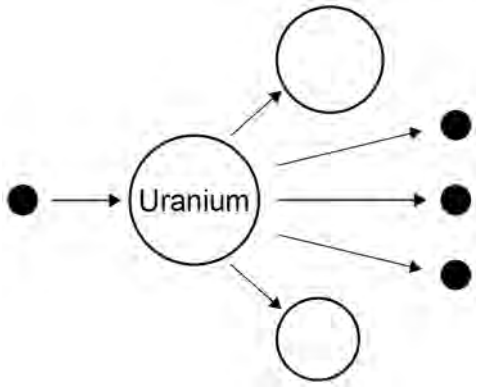
4.4.2.3 Half-lives and the random nature of radioactive decay

Question 53

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 _____.

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 53 · 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]

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 53 · 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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 54

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

4.4.2.3 Half-lives and the random nature of radioactive decay

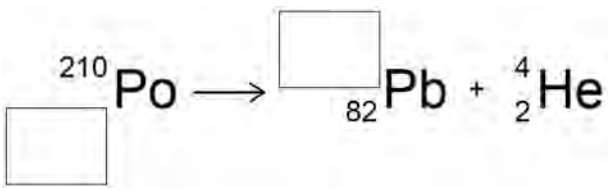
Question 54 · continued

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

4.4.2.3 Half-lives and the random nature of radioactive decay

Question 54 · 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