AQA GCSE Physics | 8463

SPECIFICATION POINT 4.4.1.2

Mass number, atomic number and isotopes

Past-paper questions

Tier	**Higher**
Question groups	**52**
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.

4.4.1.2 Mass number, atomic number and isotopes

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?

.....

Explain the reasons for your choice.

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.....

.....

.....

(3 marks)

4.4.1.2 Mass number, atomic number and isotopes

Question 01 · continued

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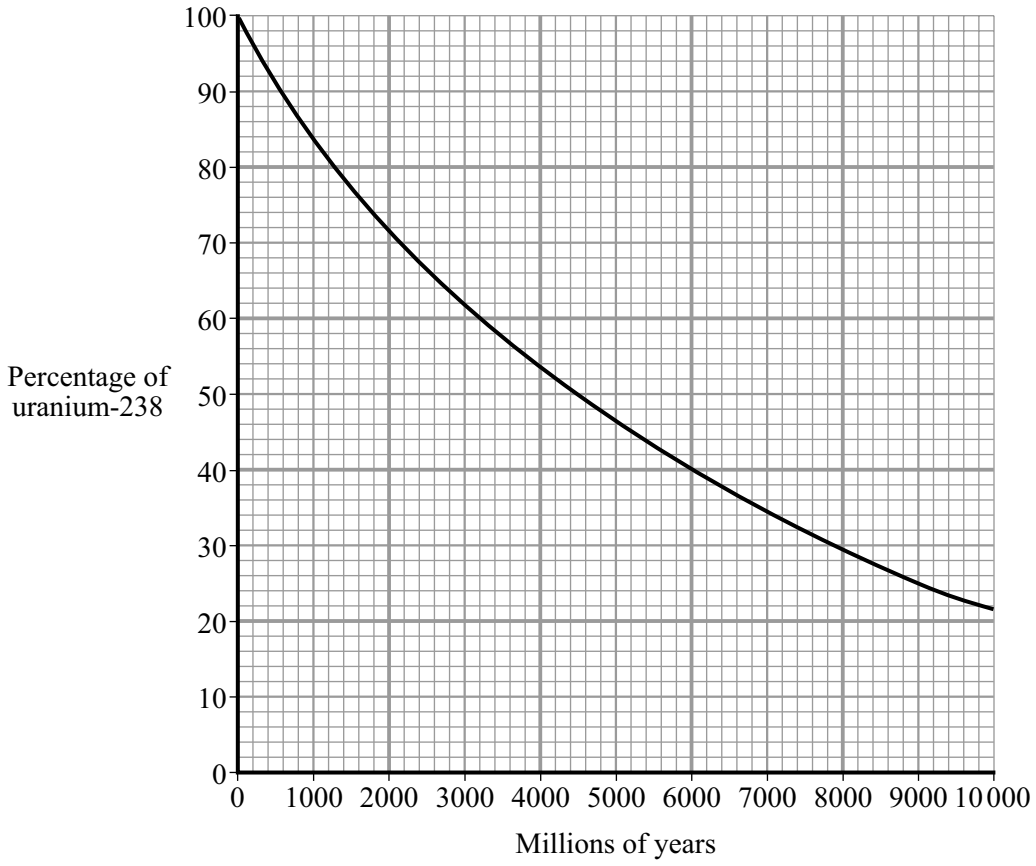
(b) Igneous rock contains uranium-238 which eventually changes to the stable isotope lead-206. The graph shows how the percentage of uranium-238 nuclei present in an igneous rock changes with time.



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

.....

.....

Age of rock = ...million years

(2 marks)

7

4.4.1.2 Mass number, atomic number and isotopes

Question 02

June 2003 | 3462H3 | Original Q12 | Legacy

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

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

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(1 mark)

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

.....

Explain the reasons for your choice.

.....

.....

.....

.....

(3 marks)

4.4.1.2 Mass number, atomic number and isotopes

Question 02 · continued

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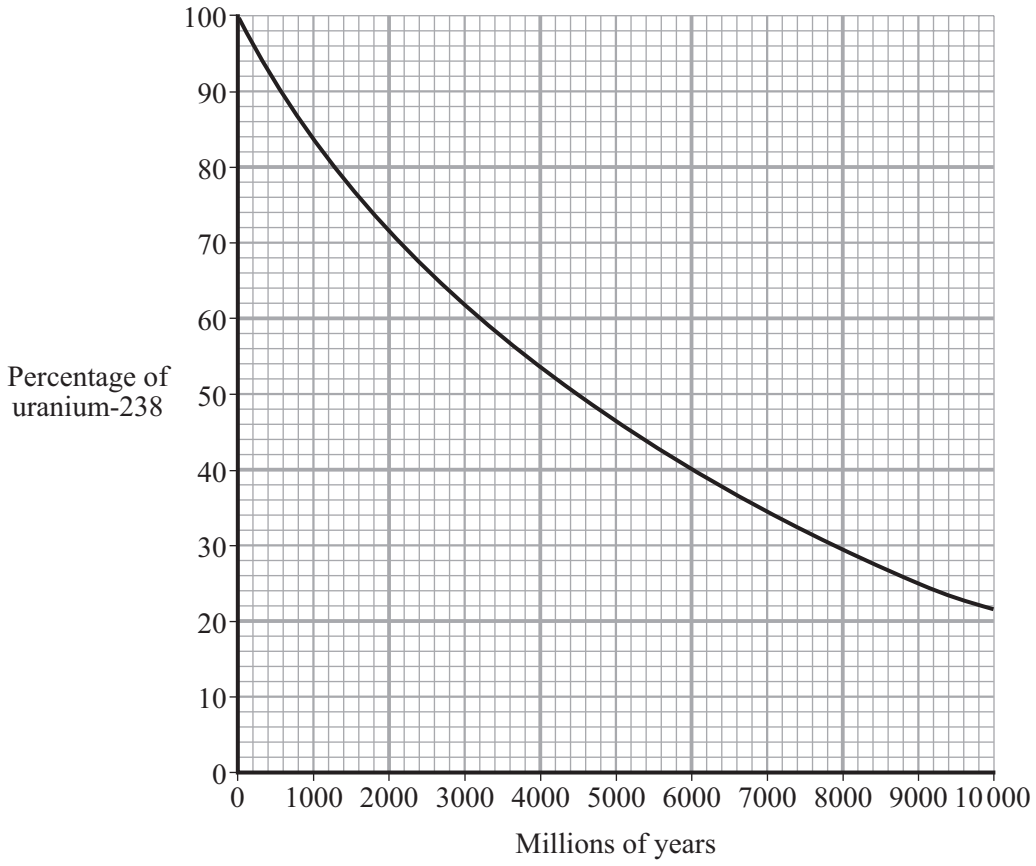
(b) Igneous rock contains uranium-238 which eventually changes to the stable isotope lead-206. The graph shows how the percentage of uranium-238 nuclei present in an igneous rock changes with time.



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

.....

.....

Age of rock = ...million years

(2 marks)

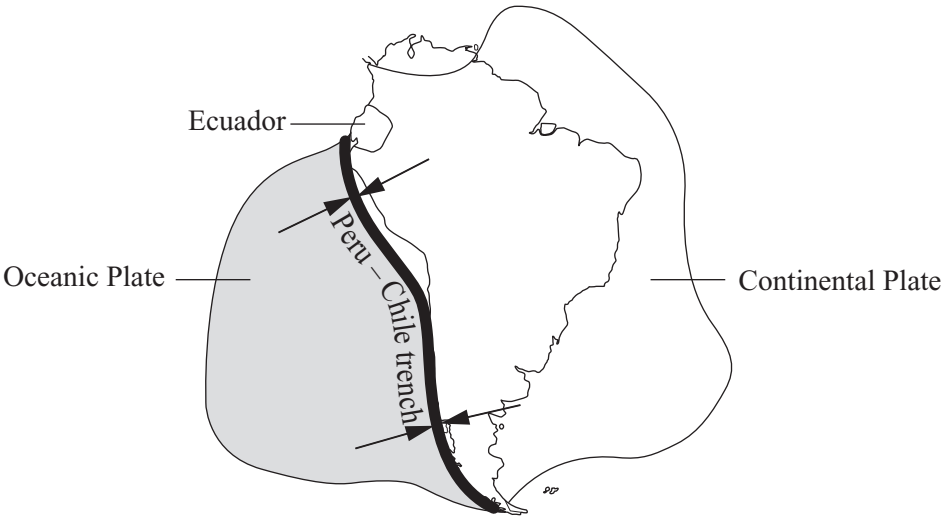
7

4.4.1.2 Mass number, atomic number and isotopes

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.

.....

.....

.....

.....

(2 marks)

4.4.1.2 Mass number, atomic number and isotopes

Question 03 · continued

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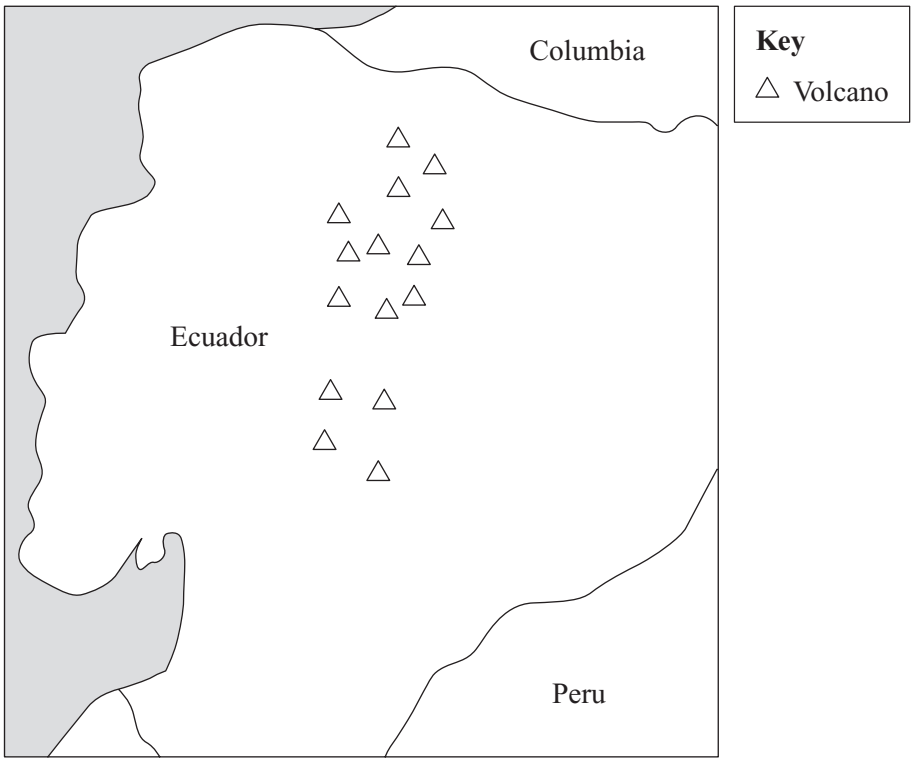
(b) The map shows the location of some of the volcanoes in Ecuador. The volcanoes are all close to the Peru–Chile trench.



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

4.4.1.2 Mass number, atomic number and isotopes

Question 03 · continued

MARGIN BLANK

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

.....

.....

.....

.....

(2 marks)

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

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

.....

(1 mark)

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

.....

.....

Kinetic energy = ... joules
(1 mark)

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

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

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

.....

(1 mark)

(ii) Calculate the age of the rock.

.....

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

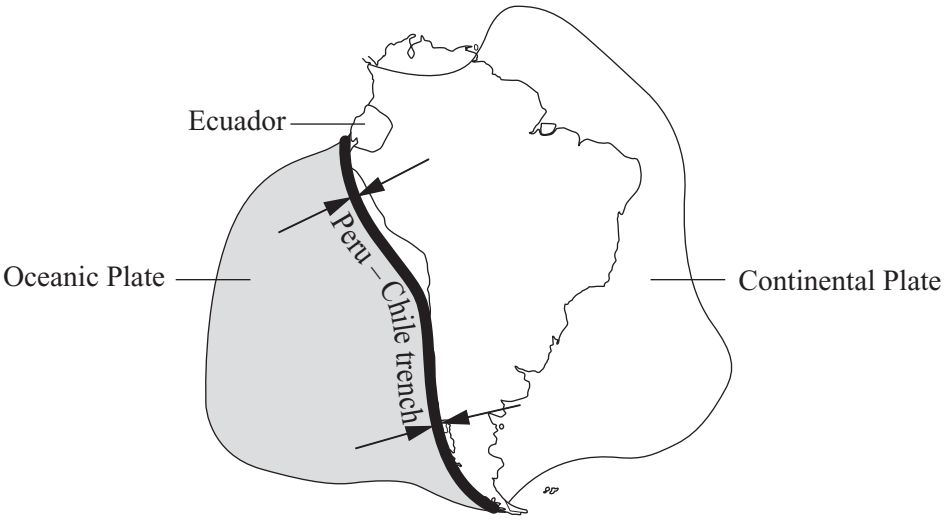
12

4.4.1.2 Mass number, atomic number and isotopes

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.

.....

.....

.....

.....

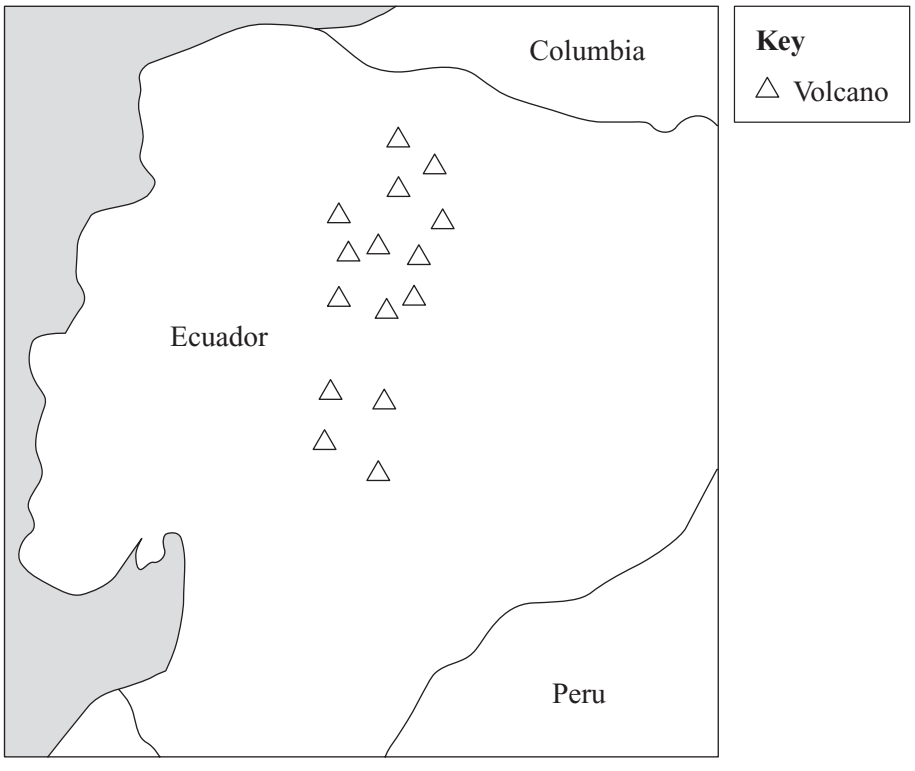
(2 marks)

4.4.1.2 Mass number, atomic number and isotopes

Question 04 · continued

MARGIN BLANK

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



Explain how the volcanoes were formed.

.....

.....

.....

.....

.....

.....

(3 marks)

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

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

.....

(1 mark)

QUESTION 11 CONTINUES ON THE NEXT PAGE

4.4.1.2 Mass number, atomic number and isotopes

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.

> Igneous rocks contain potassium-40. This is a radioactive isotope. It has a half-life of 1300 million years.
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> Potassium-40 decays into argon-40 which is stable.
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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

4.4.1.2 Mass number, atomic number and isotopes

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

4.4.1.2 Mass number, atomic number and isotopes

Question 05 · continued

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

These particles . . .

1 add electrons to the air.

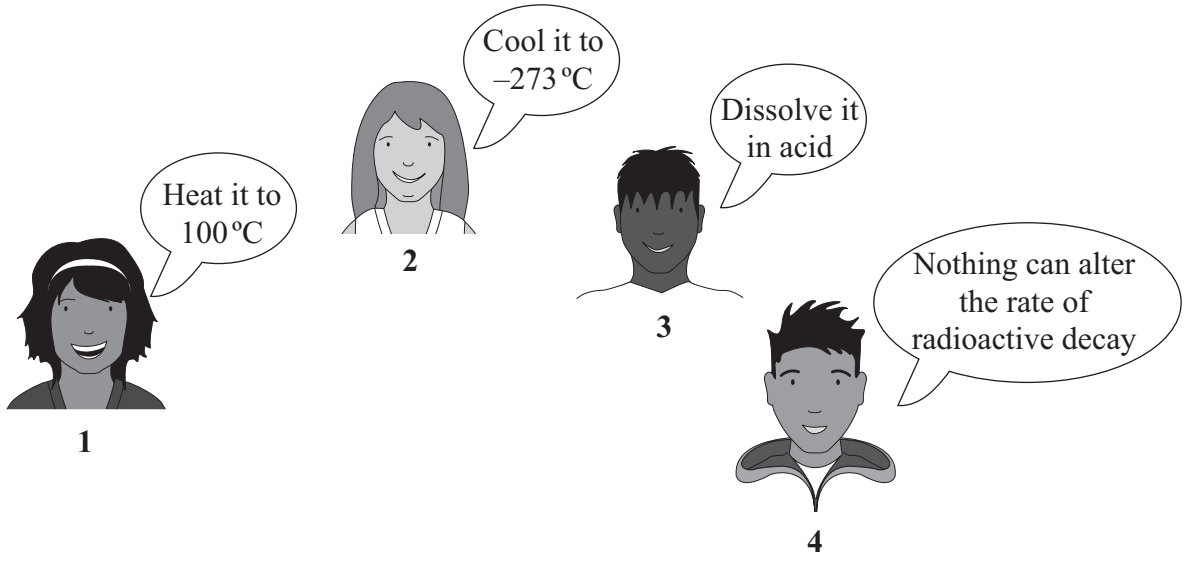
2 add neutrons to the air.

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?



4.4.1.2 Mass number, atomic number and isotopes

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?

.....

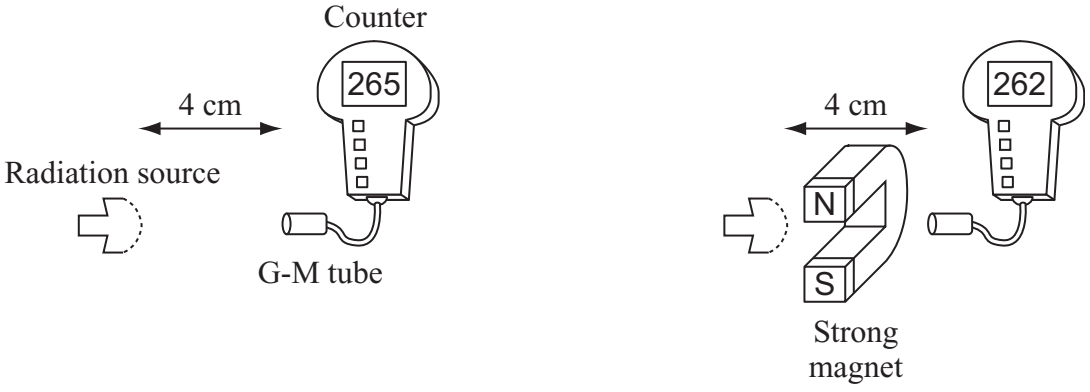
(1 mark)

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

.....

(1 mark)

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



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

.....

.....

.....

.....

(2 marks)

4.4.1.2 Mass number, atomic number and isotopes

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.

.....

.....

.....

.....

(2 marks)

7

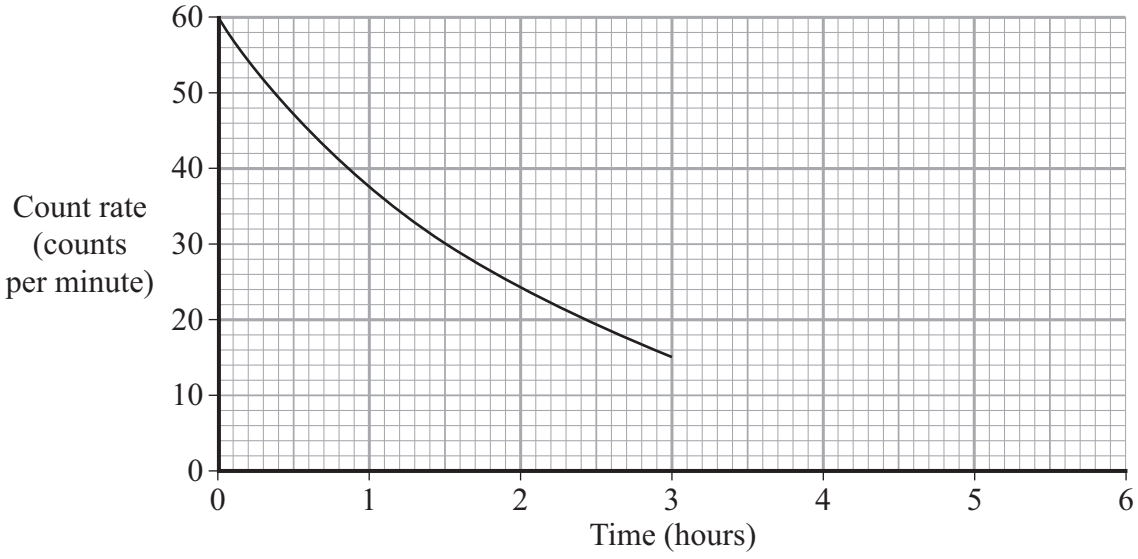
4.4.1.2 Mass number, atomic number and isotopes

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 $\frac{x}{16}$

4.4.1.2 Mass number, atomic number and isotopes

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

4.4.1.2 Mass number, atomic number and isotopes

Question 08

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.

4.4.1.2 Mass number, atomic number and isotopes

Question 08 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 09

June 2007 | PHY1H | Original Q1 | Legacy

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

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

.....

(1 mark)

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

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

.....

.....

(1 mark)

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

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

electrons	**neutrons**	**protons**

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

(1 mark)

Question 1 continues on the next page

Question 09 · continued

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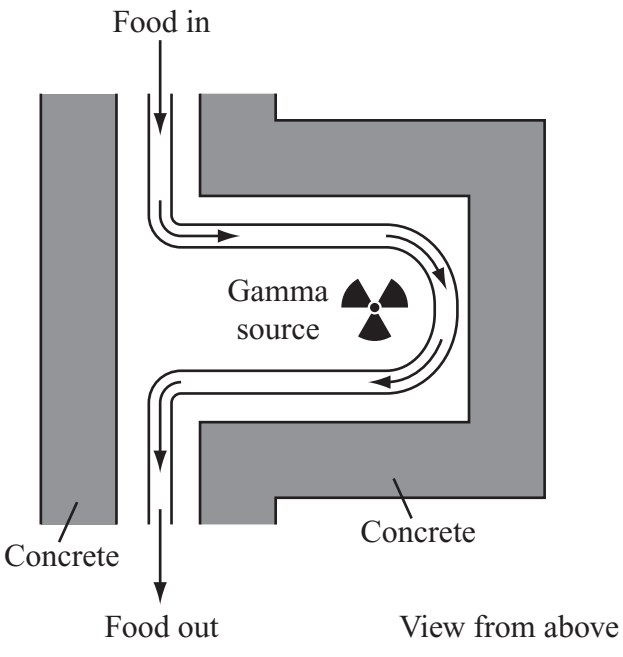
(b) The diagram shows how a conveyor belt can be used to move food past the radioactive source.



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

.....

.....

(1 mark)

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

.....

.....

(1 mark)

4.4.1.2 Mass number, atomic number and isotopes

Question 09 · continued

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

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

.....

.....

.....

.....

(2 marks)

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



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

.....

.....

(1 mark)

8

4.4.1.2 Mass number, atomic number and isotopes

Question 10

November 2007 | PHY1B | Original Q5 | Legacy

QUESTION FIVE

There are different types of electromagnetic radiation and nuclear radiation.

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

1 infra red radiation

2 microwaves

3 visible light

4 X-rays

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

1 infra red radiation

2 microwaves

3 visible light

4 X-rays

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

1 They can be seen by the human eye.

2 They are members of the electromagnetic spectrum.

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

4 They travel at the same speed in a vacuum.

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

1 gamma radiation

2 X-rays

3 microwave radiation

4 ultraviolet radiation

4.4.1.2 Mass number, atomic number and isotopes

Question 11

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 . . .

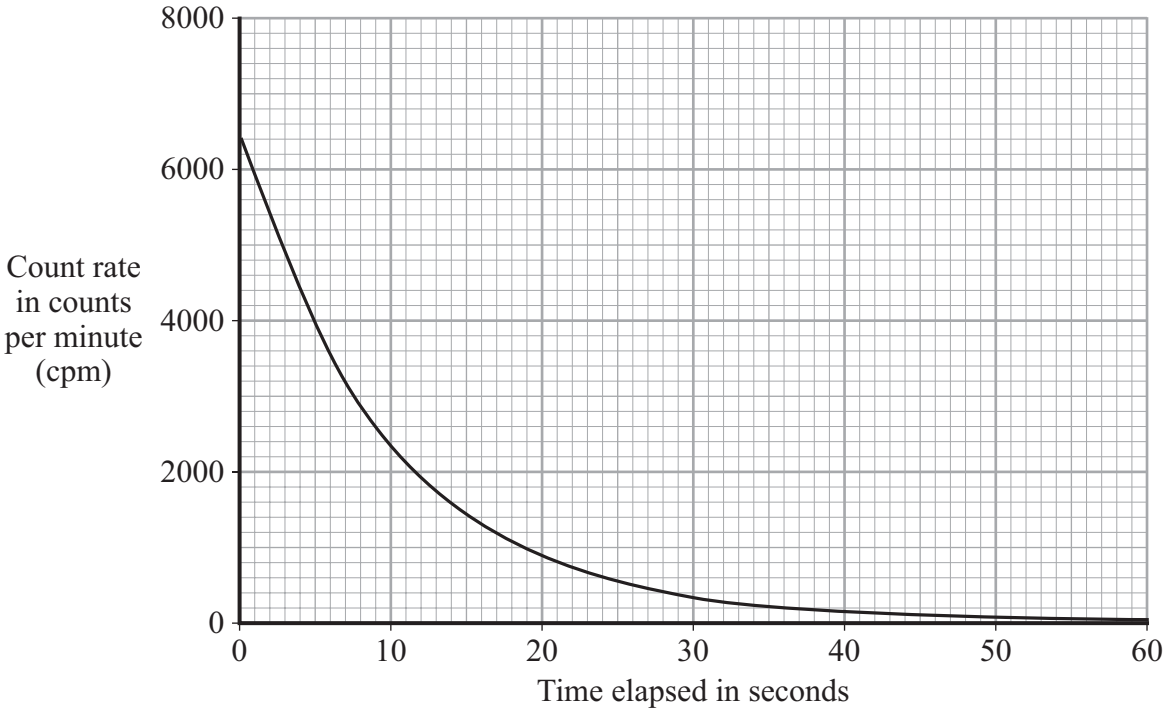
1 be increased by increasing its temperature.

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.



4.4.1.2 Mass number, atomic number and isotopes

Question 11 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 12

November 2007 | PHY1B | Original Q8 | Legacy

QUESTION EIGHT

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

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

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

1 alpha particles.

2 beta particles.

3 gamma rays.

4 X-rays.

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

1 high penetrating power.

2 a long range in air.

3 low ionising power.

4 low penetrating power.

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

Which one of the following statements is true?

1 The particles emitted by polonium-210 are radioactive.

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

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

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

4.4.1.2 Mass number, atomic number and isotopes

8D Another isotope of polonium is polonium-208.

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

1 more neutrons.

2 fewer neutrons.

3 more protons.

4 fewer protons.

Turn over for the next question

4.4.1.2 Mass number, atomic number and isotopes

Question 13

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 13 · continued

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

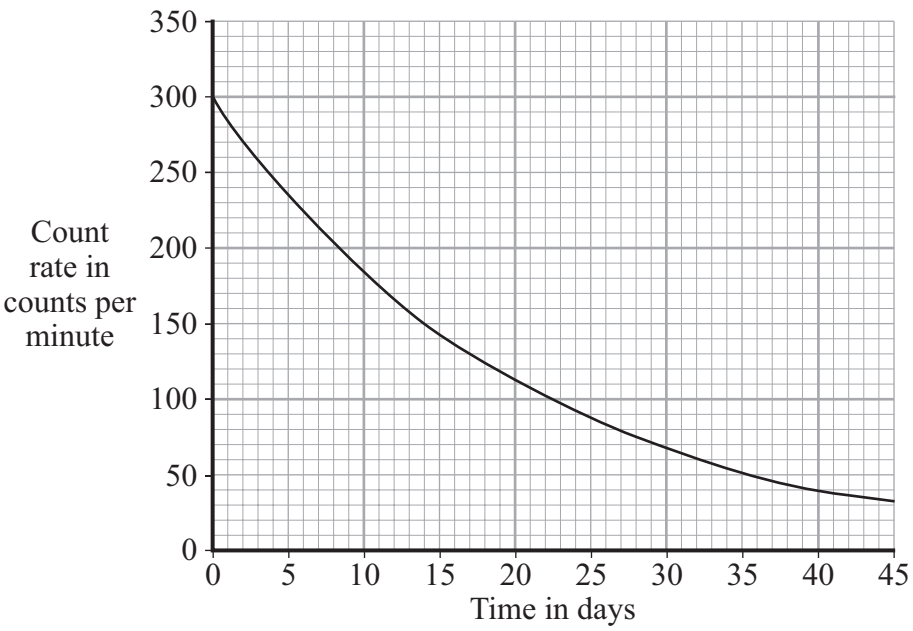
(i) How is an atom of phosphorus-32 different from an atom of the stable isotope phosphorus-31?

.....

.....

(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)

4.4.1.2 Mass number, atomic number and isotopes

Question 13 · continued

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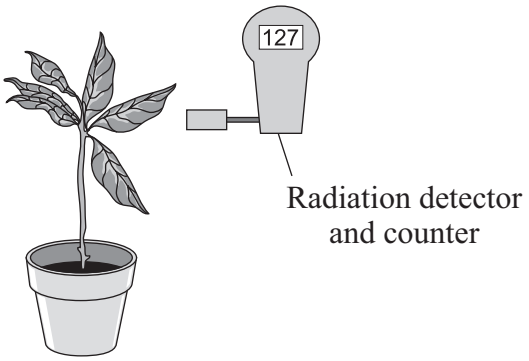
(iii) Plants use phosphorus compounds to grow. Watering the root system of a plant with a solution containing a phosphorus-32 compound can help scientists to understand the growth process.



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

.....

.....

.....

.....

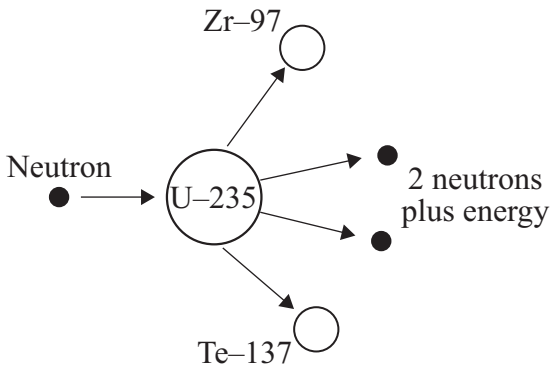
(2 marks)

9

4.4.1.2 Mass number, atomic number and isotopes

Question 14

4 (a) The diagram shows what can happen when the nucleus of a uranium atom absorbs a neutron.



(i) What name is given to the process shown in the diagram?

.....

(1 mark)

(ii) Explain how this process could lead to a chain reaction.

You may wish to add further detail to the diagram to help your answer.

.....

.....

.....

.....

(2 marks)

(iii) How does the mass number of an atom change when its nucleus absorbs a neutron?

.....

(1 mark)

4.4.1.2 Mass number, atomic number and isotopes

Question 14 · continued

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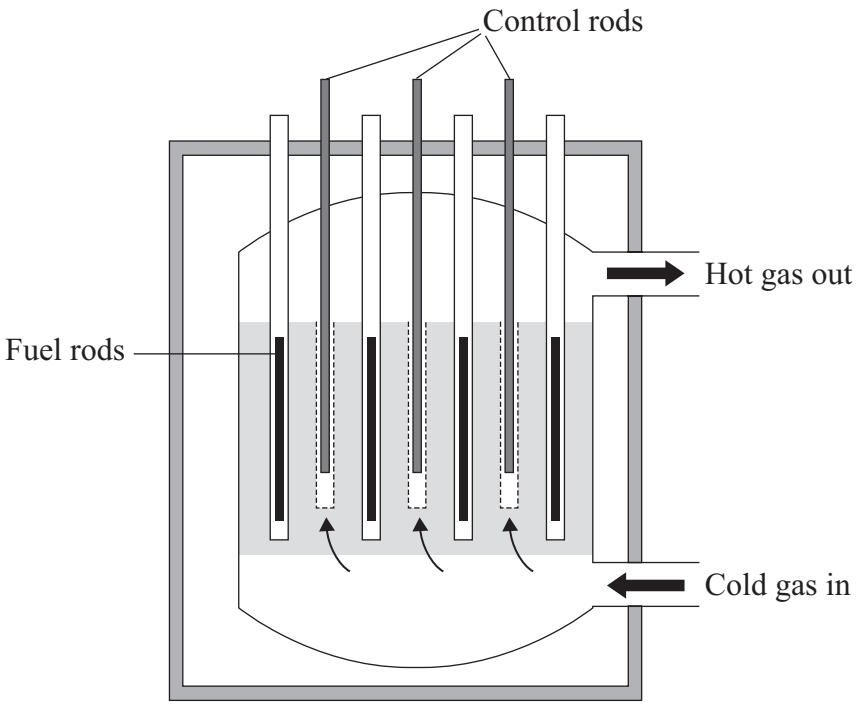
(b) Uranium-235 is used as a fuel in some nuclear reactors.



The reactor contains control rods used to absorb neutrons.

Suggest what happens when the control rods are lowered into the reactor.

.....

.....

.....

.....

(2 marks)

6

4.4.1.2 Mass number, atomic number and isotopes

Question 15

March 2008 | PHY1BP | Original Q8 | Legacy

QUESTION EIGHT

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

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

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

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

1 2

2 3

3 4

4 5

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

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

1 4 billion

2 7 billion

3 15 billion

4 30 billion

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

This is because . . .

1 all the carbon-14 will have decayed away.

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

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

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

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

1 a cotton cloak.

2 a gold plate.

3 a paper scroll.

4 a wooden mast.

Turn over for the next question

4.4.1.2 Mass number, atomic number and isotopes

Question 16

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**

4.4.1.2 Mass number, atomic number and isotopes

Question 16 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 17

June 2008 | PHY2H | Original Q2 | Legacy

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

mass number	222
atomic number	86
radiation emitted	alpha particle

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

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

..... inside an atom.

(2 marks)

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

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

..... *(1 mark)*

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

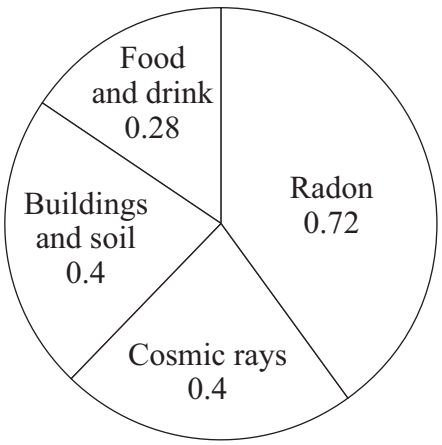
An alpha particle consists of 2 protons and 2 neutrons.

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

.....

(1 mark)

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



Question 17 · continued

for mark

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

.....

.....

Proportion of radon = ...

(2 marks)

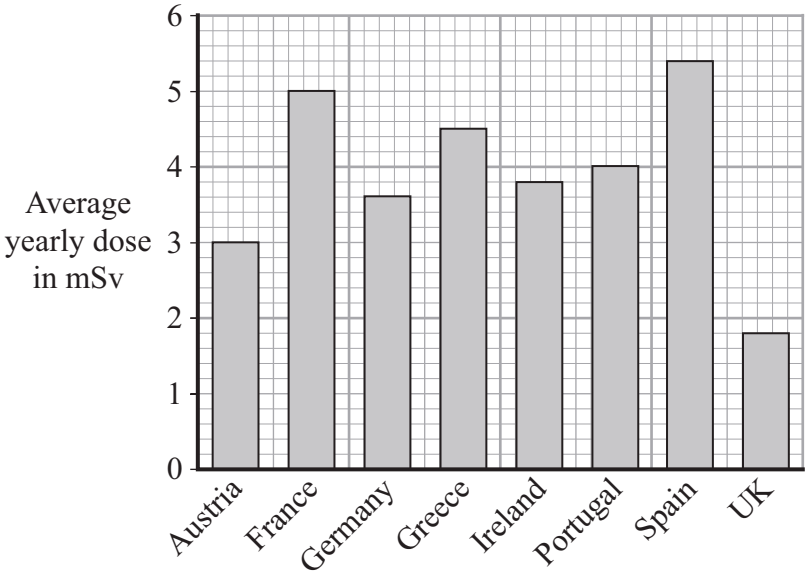
2 (b) (ii) Not all background radiation is from natural sources.

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

.....

(1 mark)

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



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

.....

(1 mark)

Question 2 continues on the next page

4.4.1.2 Mass number, atomic number and isotopes

Question 17 · continued

for mark

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

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

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

Draw a ring around your answer.

Yes **No**

Explain your answer.

.....

.....

.....

.....

(2 marks)

10

4.4.1.2 Mass number, atomic number and isotopes

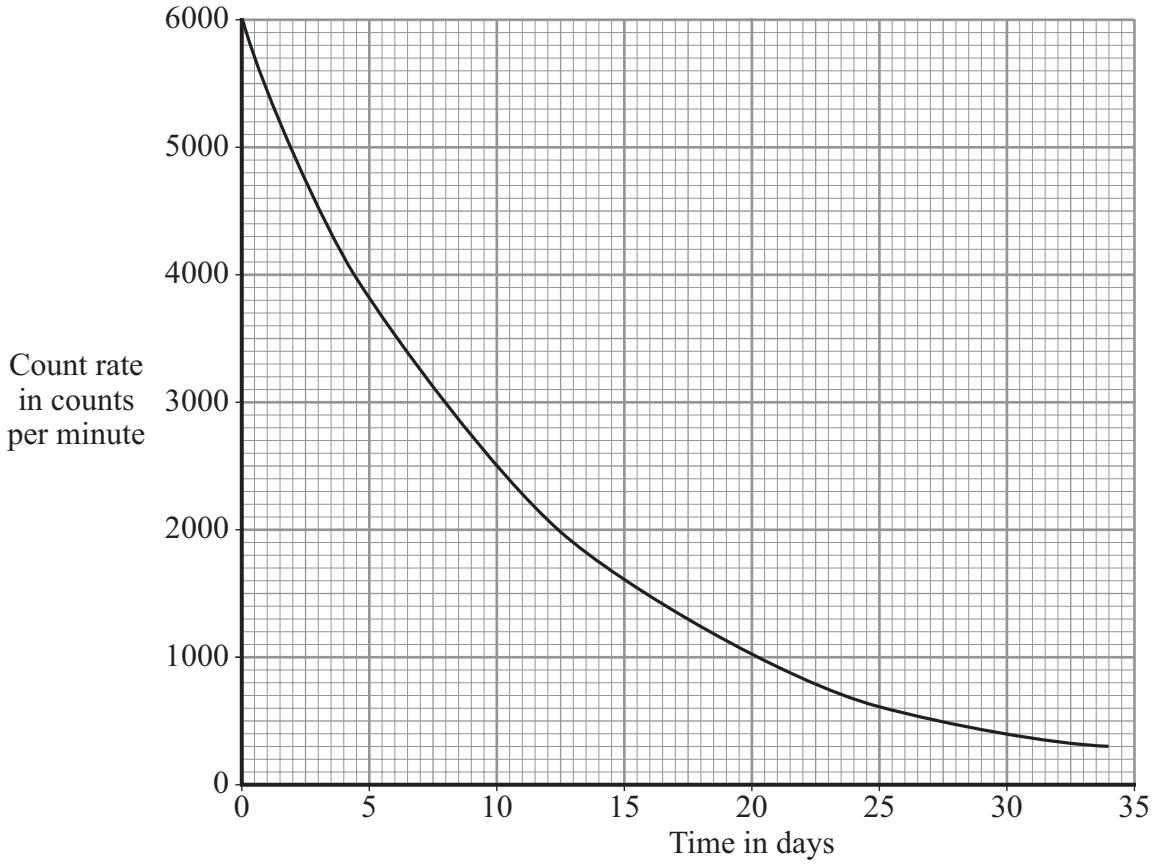
Question 18

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.

4.4.1.2 Mass number, atomic number and isotopes

Question 19

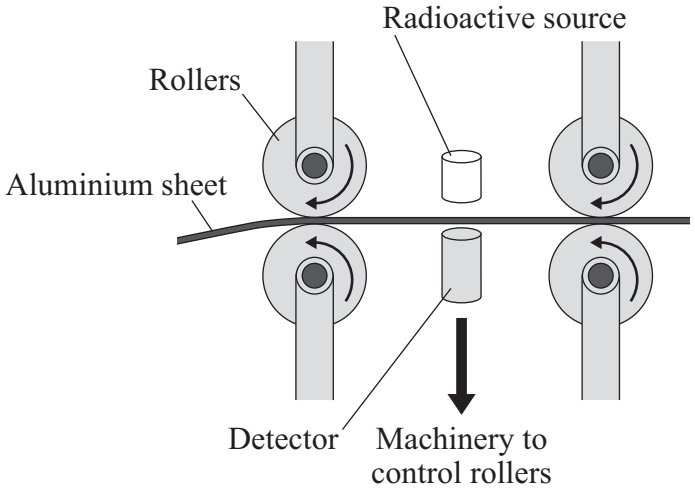
November 2008 | PHY1BP | Original Q7 | Legacy

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**

Question 19 · continued

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.

4.4.1.2 Mass number, atomic number and isotopes

Question 20

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)

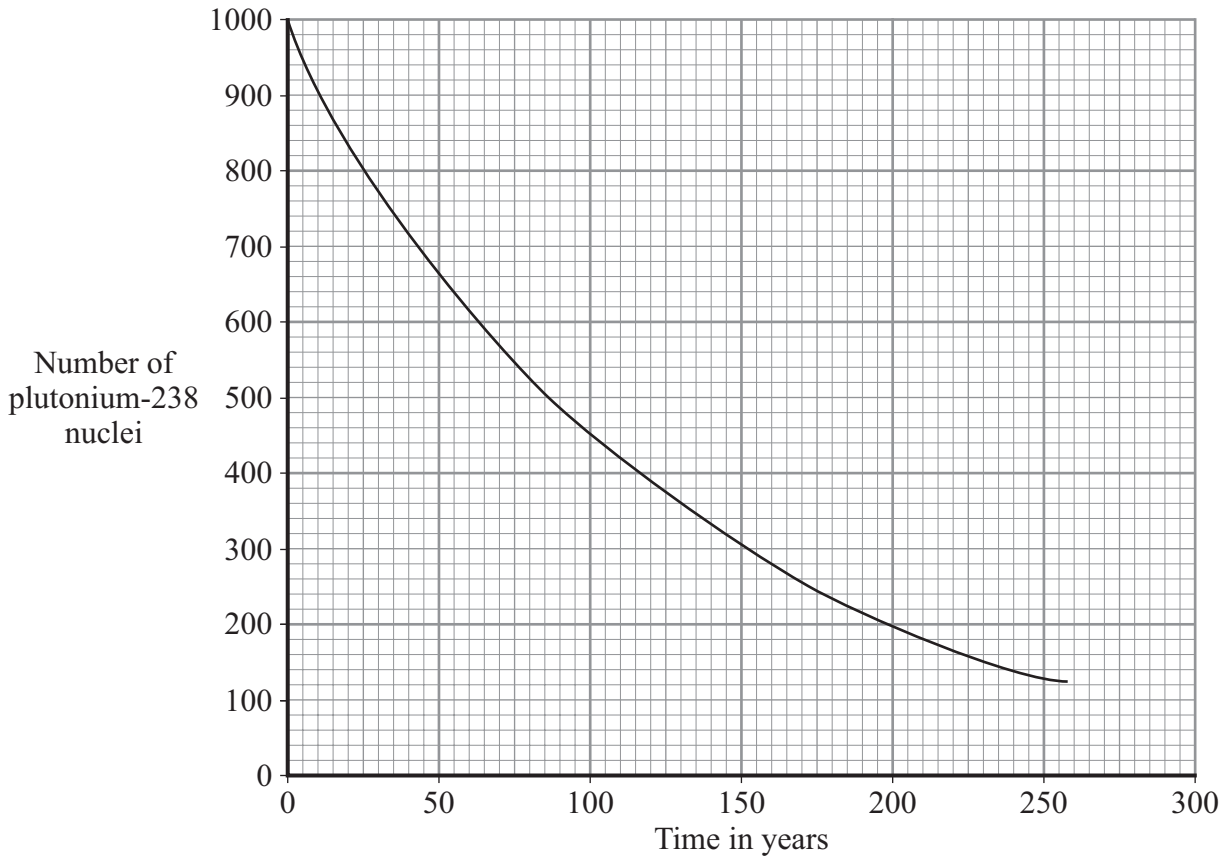
Question 4 continues on the next page

4.4.1.2 Mass number, atomic number and isotopes

Question 20 · 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)

4.4.1.2 Mass number, atomic number and isotopes

Question 20 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 21

January 2009 | PHY2H | Original Q6 | Legacy

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

mass number	238
number of protons	92
number of neutrons	

(1 mark)

6 (b) Complete the following sentence.

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

..... .

(1 mark)

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

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

.....

(1 mark)

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

.....

.....

(1 mark)

4

4.4.1.2 Mass number, atomic number and isotopes

Question 22

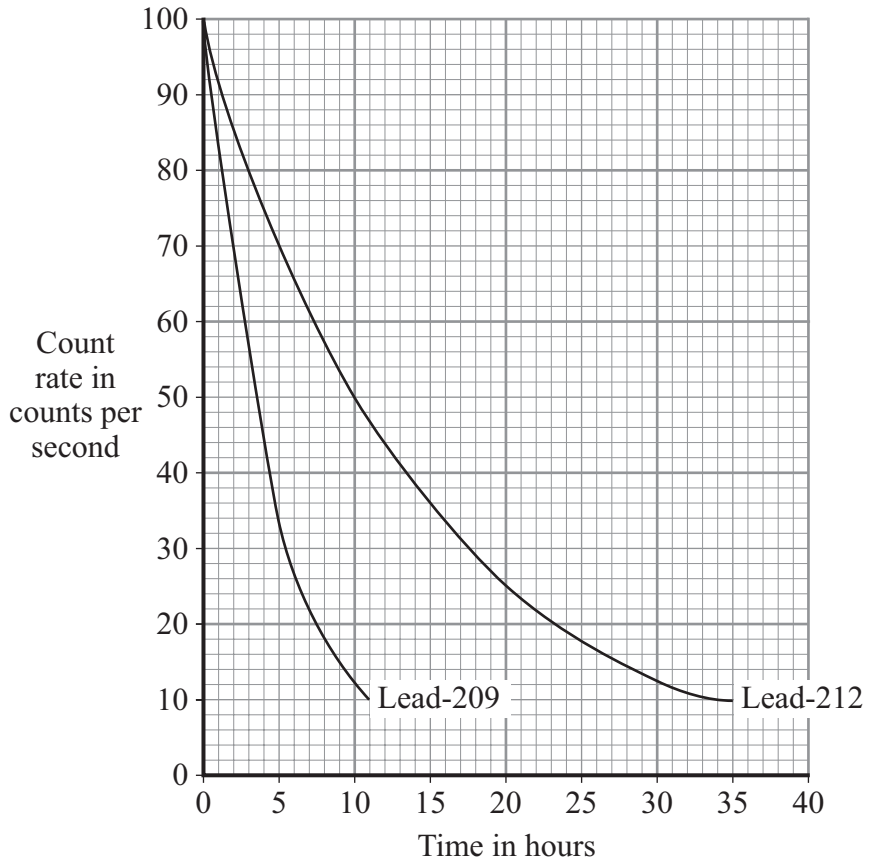
March 2009 | PHY1BP | Original Q1 | Legacy

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.



4.4.1.2 Mass number, atomic number and isotopes

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.

4.4.1.2 Mass number, atomic number and isotopes

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.

4.4.1.2 Mass number, atomic number and isotopes

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

4.4.1.2 Mass number, atomic number and isotopes

Question 24

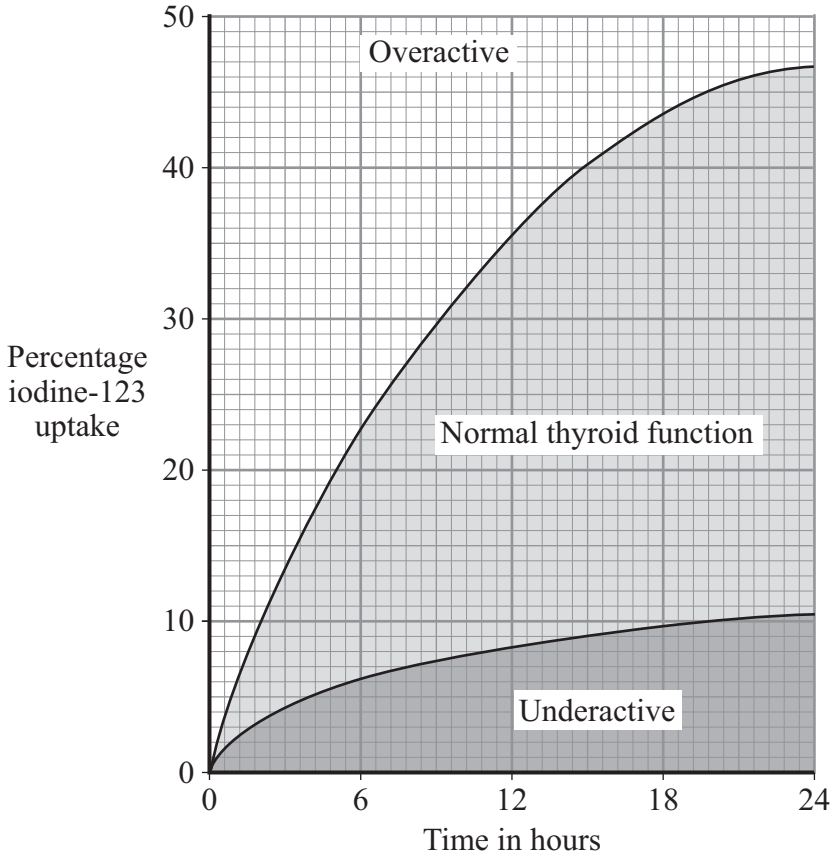
June 2009 | PHY1BP | Original Q5 | Legacy

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?

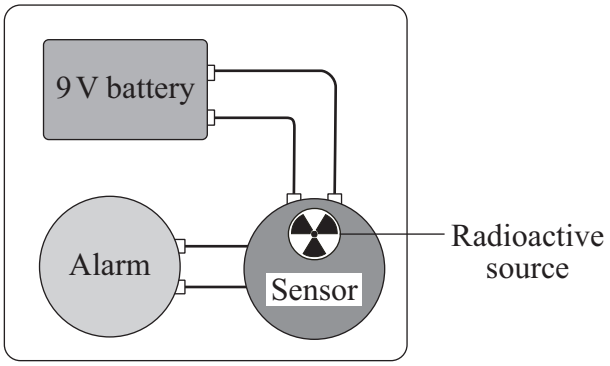
Student	Factor affecting rate of gamma emission
1	body temperature
2	age and sex of patient
3	length of time after the drink is taken
4	chemical composition of sodium iodide

4.4.1.2 Mass number, atomic number and isotopes

Question 25

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?

.....

.....

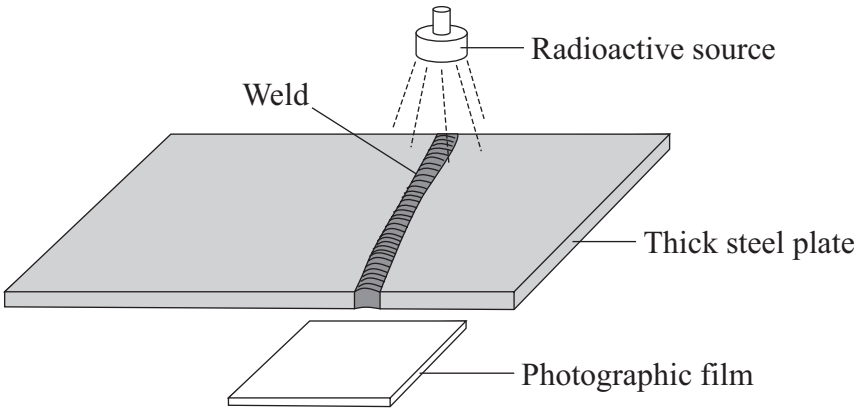
(1 mark)

4.4.1.2 Mass number, atomic number and isotopes

Question 25 · 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

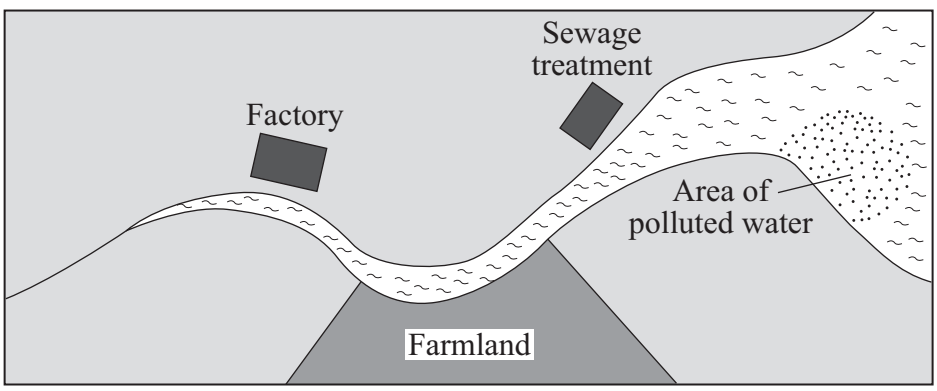
4.4.1.2 Mass number, atomic number and isotopes

Question 25 · 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.

.....

.....

.....

.....

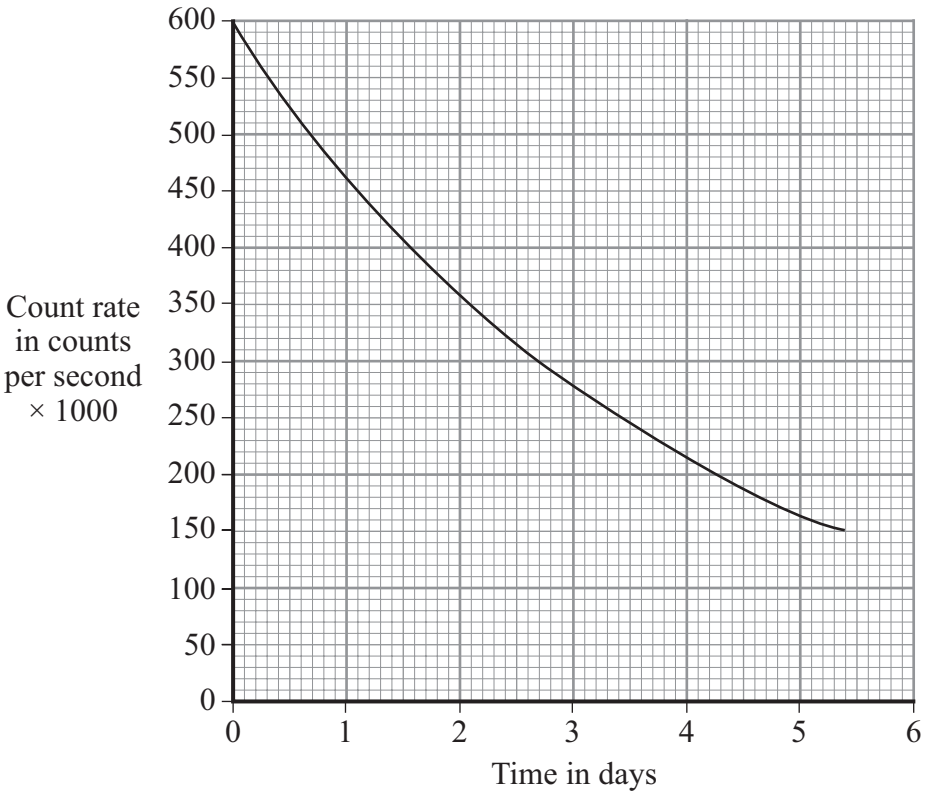
(2 marks)

4.4.1.2 Mass number, atomic number and isotopes

Question 25 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 26

June 2009 | PHY2H | Original Q1 | Legacy

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

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

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

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

.....

.....

.....

.....

(2 marks)

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

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

.....

.....

(1 mark)

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

What type of particle is absorbed?

.....

(1 mark)

4.4.1.2 Mass number, atomic number and isotopes

Question 26 · continued

for mark

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

What name is given to this process?

.....

(1 mark)

7

Turn over for the next question

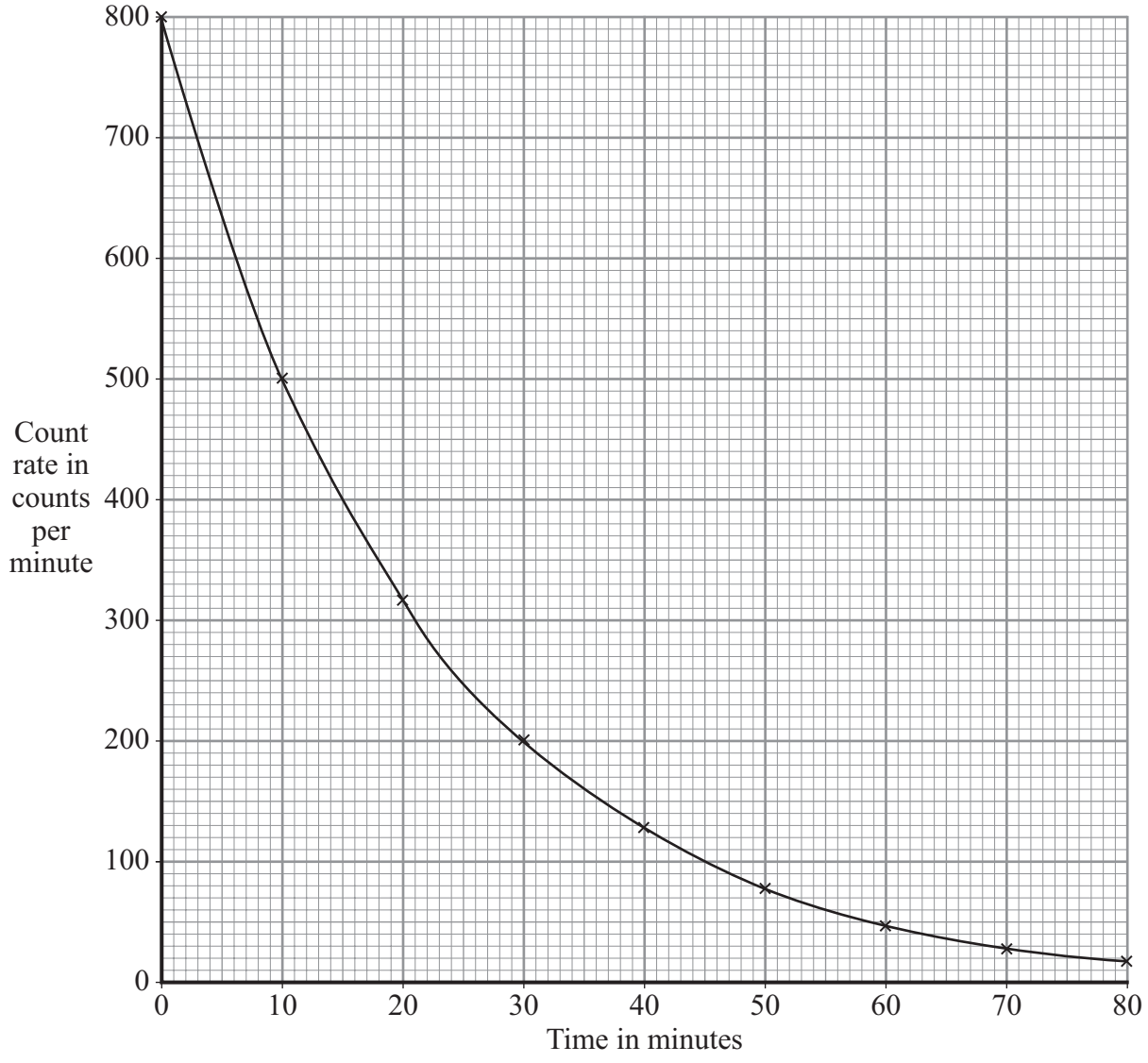
4.4.1.2 Mass number, atomic number and isotopes

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

4.4.1.2 Mass number, atomic number and isotopes

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.

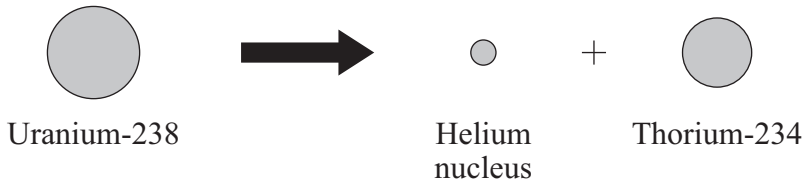
4 There is no risk in using radioactive materials.

4.4.1.2 Mass number, atomic number and isotopes

Question 28

January 2010 | PHY1H | Original Q4 | Legacy

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?

.....

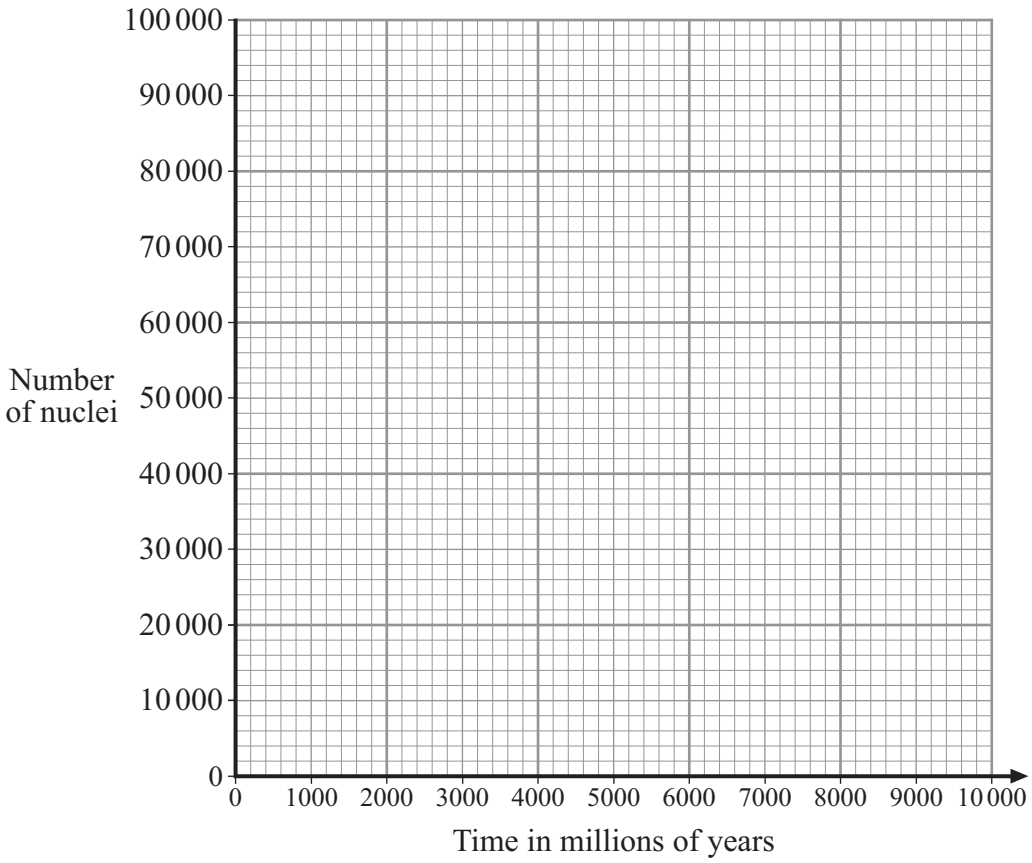
(1 mark)

4.4.1.2 Mass number, atomic number and isotopes

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)

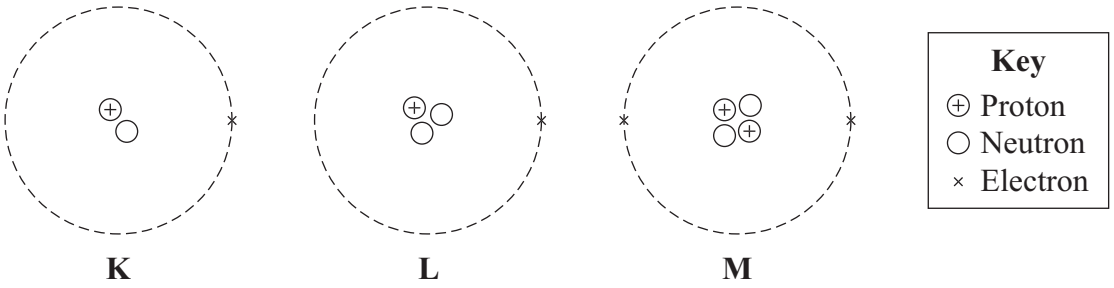
6

4.4.1.2 Mass number, atomic number and isotopes

Question 29

January 2010 | PHY2H | Original Q3 | Legacy

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



K **L** **M**

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

..... and .....

(1 mark)

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

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

.....

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

.....

.....

(2 marks)

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

mass number	230
atomic number	90

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

.....

(1 mark)

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

.....

(1 mark)

4.4.1.2 Mass number, atomic number and isotopes

Question 29 · continued

for mark

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

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

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

.....

Explain the reason for your answer.

.....

.....

.....

.....

.....

(3 marks)

8

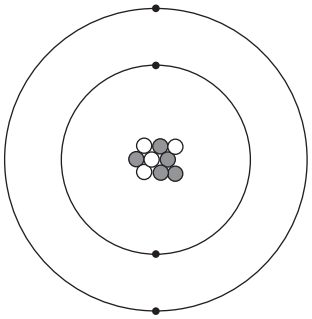
4.4.1.2 Mass number, atomic number and isotopes

Question 30

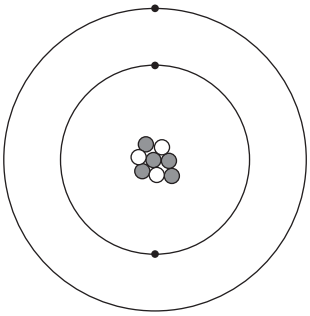
June 2010 | PHY1BP | Original Q1 | Legacy

QUESTION ONE

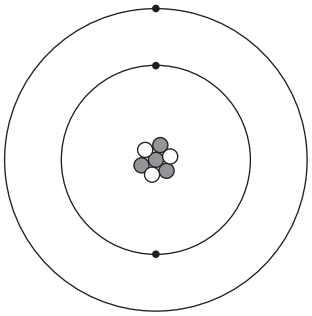
The diagram shows four atoms, **W**, **X**, **Y** and **Z**.



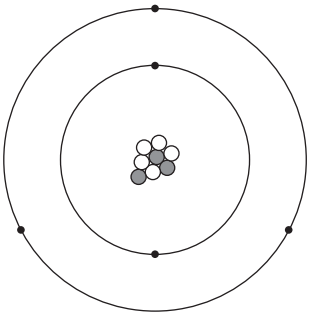
Atom **W**



Atom **X**



Atom **Y**



Atom **Z**

4.4.1.2 Mass number, atomic number and isotopes

Question 30 · continued

Atoms **X** and **Y** are isotopes of the same element.

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

A three

B four

C five

D eight

Atom **W** contains . . . **1** . . . electrons.

Atom **X** contains . . . **2** . . . neutrons.

Atom **Y** contains . . . **3** . . . protons.

Atom **Z**'s nucleus contains . . . **4** . . . particles.

Turn over for the next question

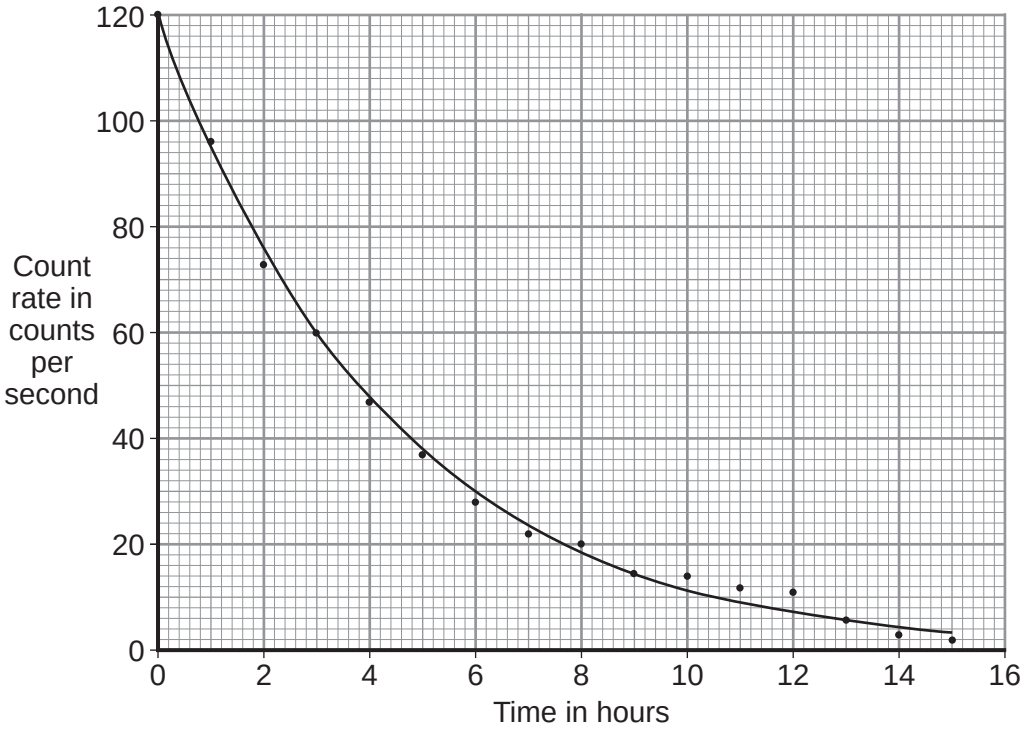
4.4.1.2 Mass number, atomic number and isotopes

Question 31

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.

4.4.1.2 Mass number, atomic number and isotopes

Question 31 · 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 $\frac{7}{8}$

4.4.1.2 Mass number, atomic number and isotopes

Question 32

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.

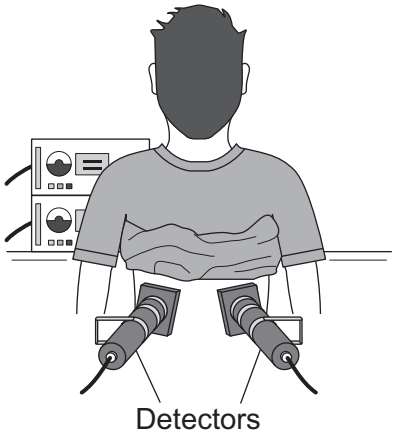
4 The half-life is too short to measure accurately.

4.4.1.2 Mass number, atomic number and isotopes

Question 33

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)

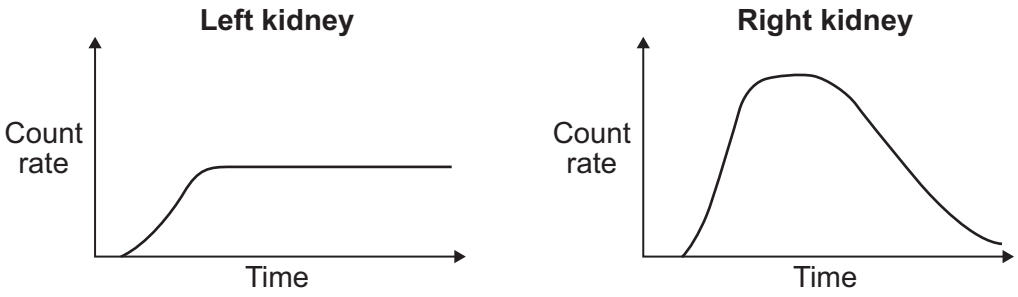
4.4.1.2 Mass number, atomic number and isotopes

Question 33 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 33 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 34 June 2010 | PHY2H | Original Q4 | Legacy

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

.....
(1 mark)

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

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

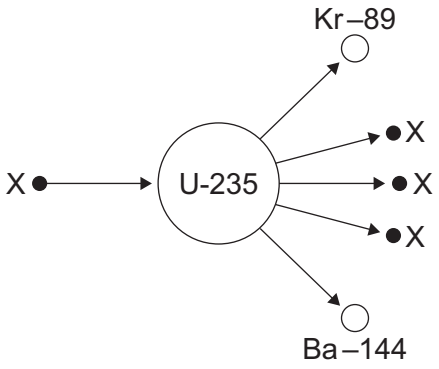
The decay can be represented by the equation below.

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

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

(2 marks)

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



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

.....
(1 mark)

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

.....
(1 mark)

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

.....
(1 mark)

6

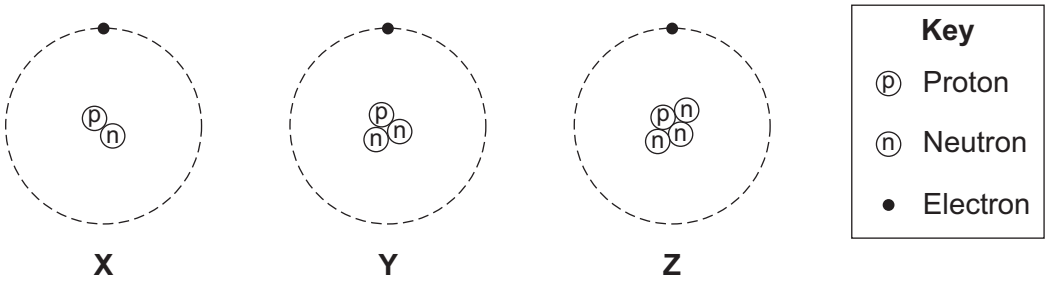
4.4.1.2 Mass number, atomic number and isotopes

Question 35

November 2010 | PHY1BP | Original Q3 | Legacy

QUESTION THREE

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



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

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

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

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

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

3B Some substances are radioactive.

What does this mean?

1 Radio signals make these substances emit radiation.

2 These substances can take part in chemical reactions.

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

4 These substances glow in the dark.

3C Some substances emit beta radiation.

What is beta radiation?

1 a helium nucleus

2 an electron from outside the nucleus

3 an electron from inside the nucleus

4 an electromagnetic wave

3D The warning label is from a smoke detector.

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

What is the reason for this warning?

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

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

3 Alpha radiation has the longest half-life.

4 Alpha radiation is the most penetrating of all radiations.

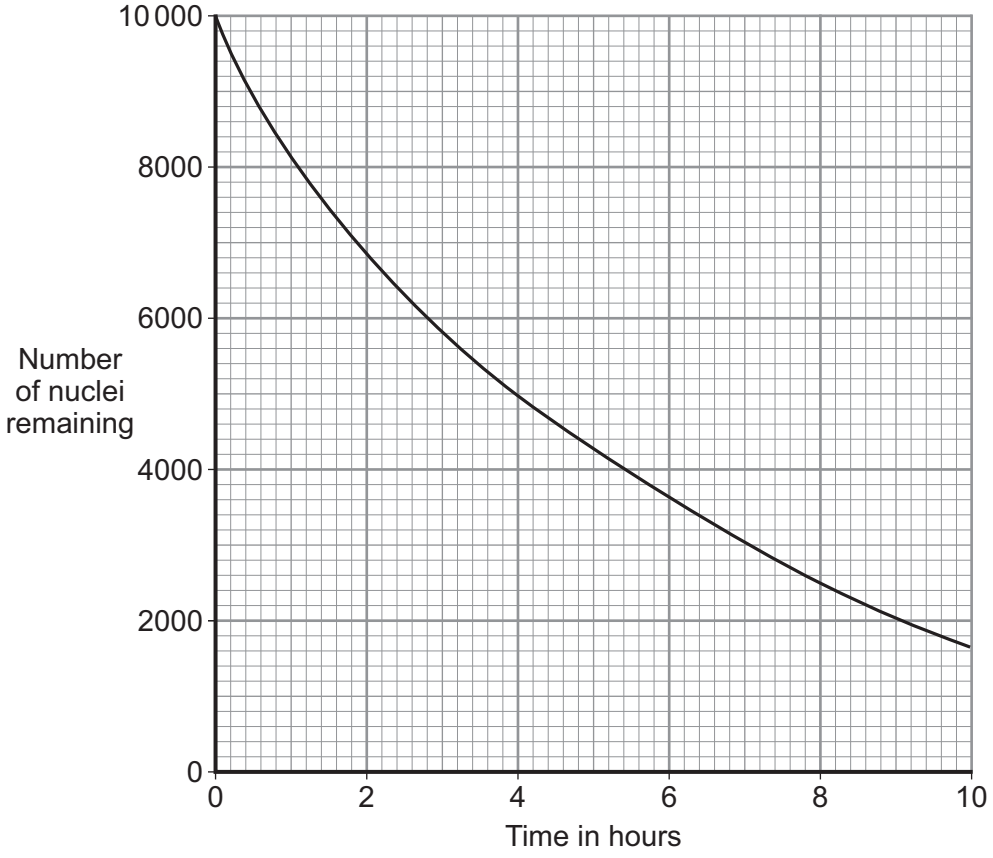
4.4.1.2 Mass number, atomic number and isotopes

Question 36

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

4.4.1.2 Mass number, atomic number and isotopes

Question 36 · continued November 2010 | PHY1BP | Original Q4 | Legacy

4C This radioactive isotope may be suitable . . .

1 as a source of radiation in a smoke alarm.

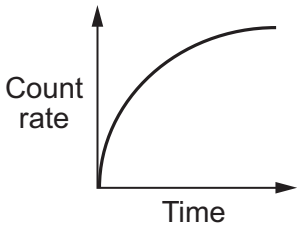
2 as a source of radiation to monitor the thickness of paper in a paper mill.

3 as a medical tracer in the human body.

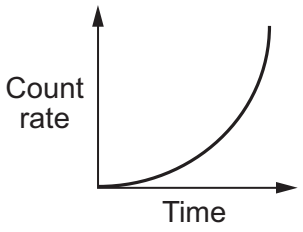
4 to use in finding the age of an ancient bone.

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

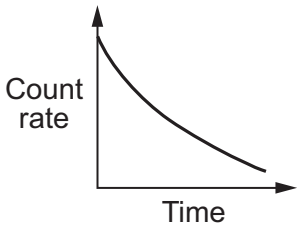
1



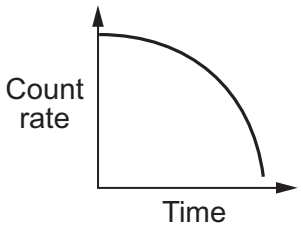
2



3



4



4.4.1.2 Mass number, atomic number and isotopes

Question 37

November 2010 | PHY1BP | Original Q8 | Legacy

QUESTION EIGHT

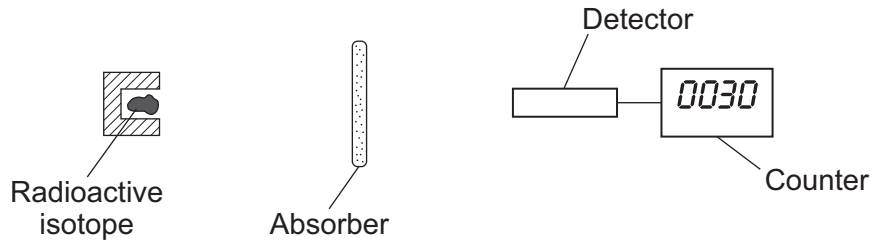
Radioactive isotopes may emit alpha, beta or gamma radiation.

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

She was told that:

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

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



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

Table 1

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

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

1 alpha radiation only.

2 beta radiation only.

3 gamma radiation only.

4 alpha and gamma radiation.

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

1 **S**

2 **T**

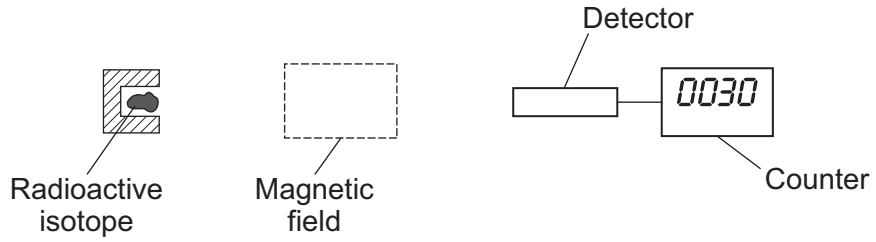
3 **V**

4 none of them

4.4.1.2 Mass number, atomic number and isotopes

Question 37 · continued

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



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

Table 2

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

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

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

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

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

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

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

This is because the radiation . . .

1 is like a wave.

2 has a positive charge or a negative charge.

3 has north poles and south poles.

4 has no mass.

4.4.1.2 Mass number, atomic number and isotopes

Question 38

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

4.4.1.2 Mass number, atomic number and isotopes

Question 39

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.

4.4.1.2 Mass number, atomic number and isotopes

Question 39 · 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

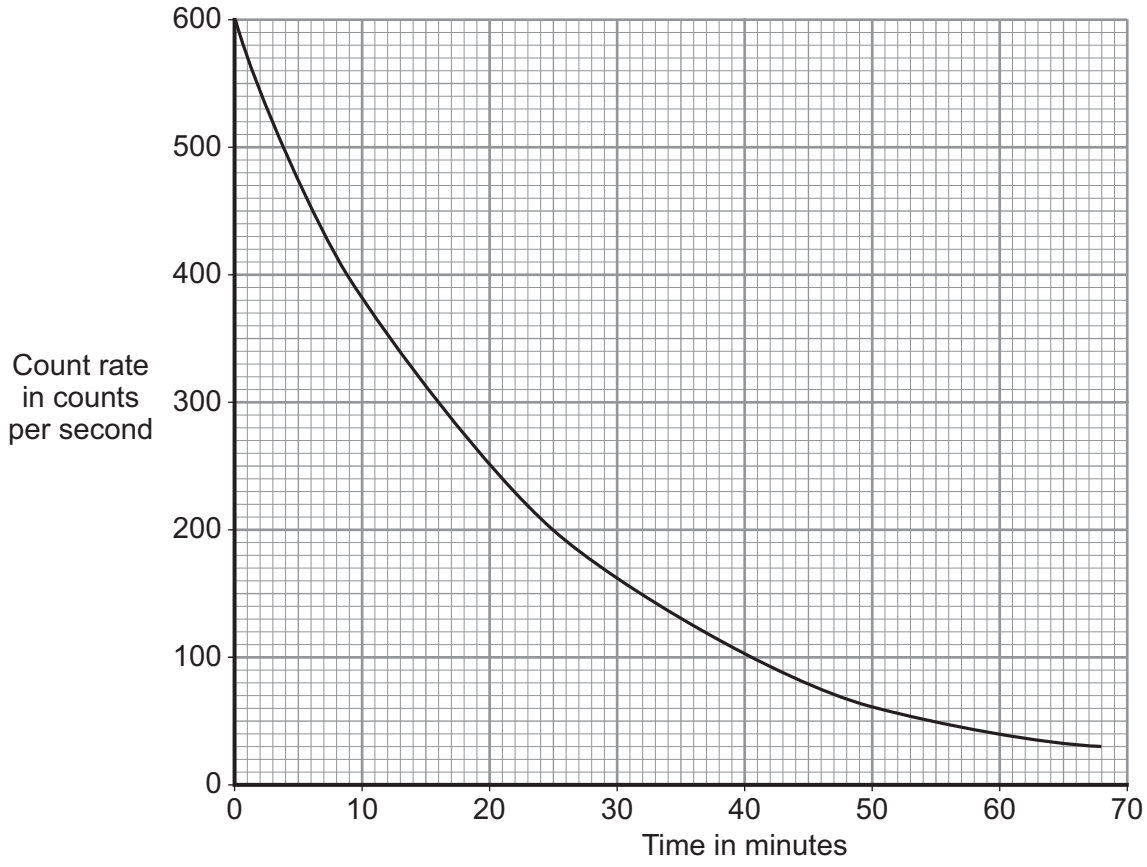
4.4.1.2 Mass number, atomic number and isotopes

Question 40

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.

4.4.1.2 Mass number, atomic number and isotopes

Question 41 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.

4.4.1.2 Mass number, atomic number and isotopes

Question 41 · 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?

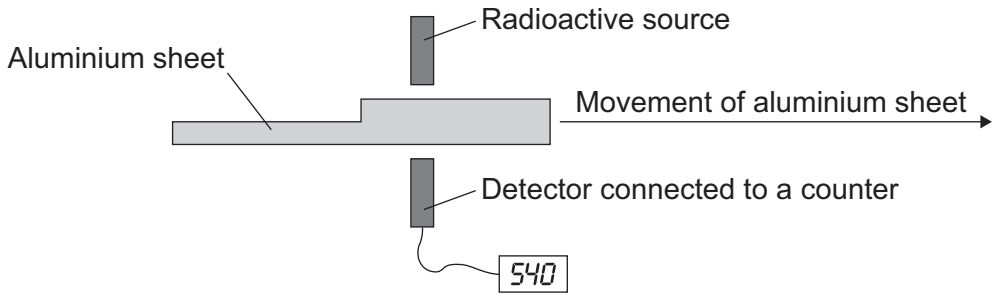
Isotope	Radiation emitted	Half-life
1	alpha	6 hours
2	alpha	60 years
3	gamma	5 hours
4	gamma	5 years

4.4.1.2 Mass number, atomic number and isotopes

Question 42 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.

4.4.1.2 Mass number, atomic number and isotopes

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

4.4.1.2 Mass number, atomic number and isotopes

Question 43

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)

4.4.1.2 Mass number, atomic number and isotopes

Question 43 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 43 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 44

June 2011 | PHY1H | Original Q6 | Legacy

6 (a) Carbon has three naturally occurring isotopes. The isotope, carbon-14, is radioactive. An atom of carbon-14 decays by emitting a beta particle.

6 (a) (i) Complete the following sentences.

The atoms of the three carbon isotopes are the same as each other because

..... .

The atoms of the three carbon isotopes are different from each other because

..... .

(2 marks)

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

.....

.....

(1 mark)

6 (b) Carbon-14 is constantly being made in the atmosphere, yet for most of the last million years, the amount of carbon-14 in the atmosphere has not changed.

How is this possible?

.....

.....

(1 mark)

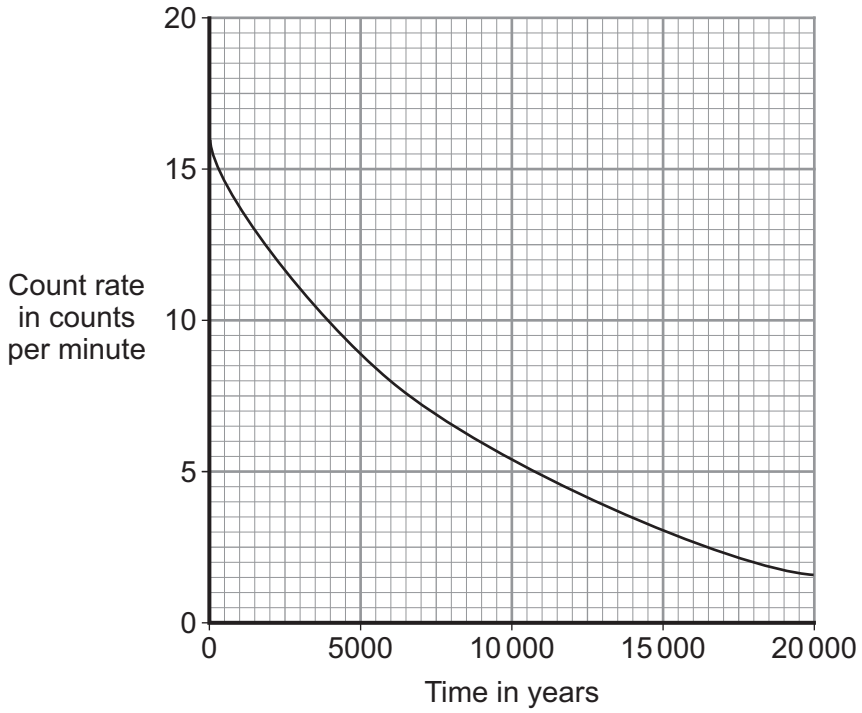
4.4.1.2 Mass number, atomic number and isotopes

Question 44 · continued

6 (c) Trees take in carbon-12 and carbon-14 from the atmosphere. After the tree dies, the proportion of carbon-14 that the tree contains decreases.

Graph **A** shows the decay curve for carbon-14.

Graph **A**



6 (c) (i) Lake Cuicocha in Ecuador was formed after a volcanic eruption.
Carbon taken from a tree killed by the eruption was found to have a count rate of 10.5 counts per minute.
At the time of the eruption, the count rate would have been 16 counts per minute.

Use graph **A** to find the age of Lake Cuicocha.

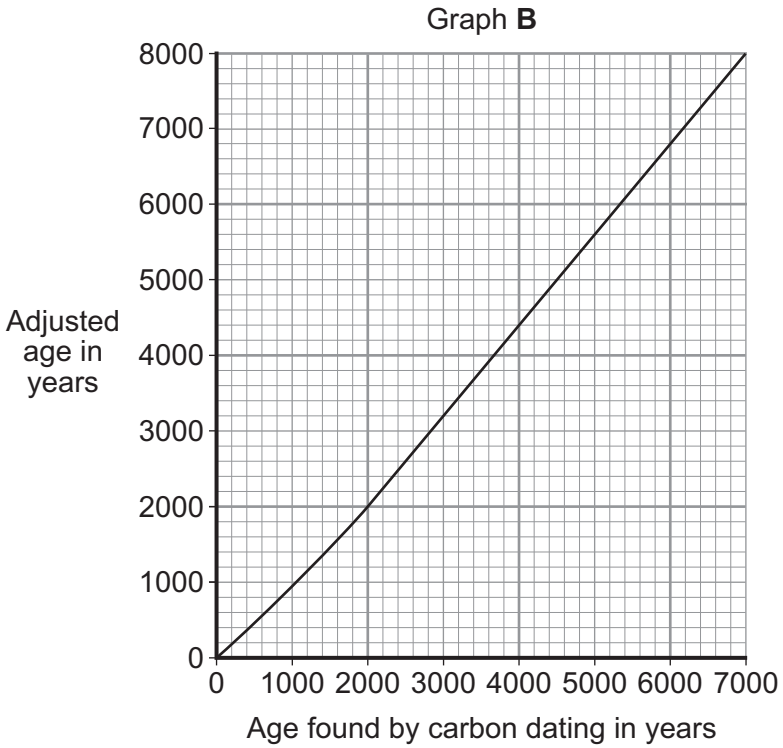
Age of Lake Cuicocha = ... years
(1 mark)

Question 6 continues on the next page

4.4.1.2 Mass number, atomic number and isotopes

Question 44 · continued

6 (c) (ii) Finding the age of organic matter by measuring the proportion of carbon-14 that it contains is called carbon dating. This technique relies on the ratio of carbon-14 to carbon-12 in the atmosphere remaining constant. However, this ratio is not constant so the age found by carbon dating needs to be adjusted.



Graph **B** is used to adjust the age of an object found by carbon dating.
The value obtained from graph **B** will be no more than 50 years different to the true age of the object.

Use graph **B** and the information above to find the maximum age that Lake Cuicocha could be.

Show clearly how you obtain your answer.

.....

.....

Maximum age of Lake Cuicocha = ... years
(2 marks)

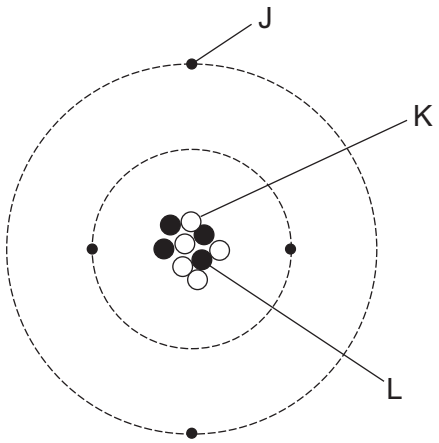
7

4.4.1.2 Mass number, atomic number and isotopes

Question 45

June 2011 | PHY2H | Original Q3 | Legacy

3 The diagram represents an atom of beryllium.



3 (a) Complete the following statements by writing one of the letters, **J**, **K** or **L**, in each box.

Each letter should be used only **once**.

The particle with a positive charge is ☐

The particle with the smallest mass is ☐

The particle with no charge is ☐

(2 marks)

3 (b) Give the reason why all atoms have a total charge of zero.

.....

.....

(1 mark)

3 (c) Complete the following sentence.

There are several isotopes of beryllium. Atoms of different beryllium isotopes will have different numbers of ..... .

(1 mark)

3 (d) What happens to the structure of an atom to change it into an ion?

.....

.....

(1 mark)

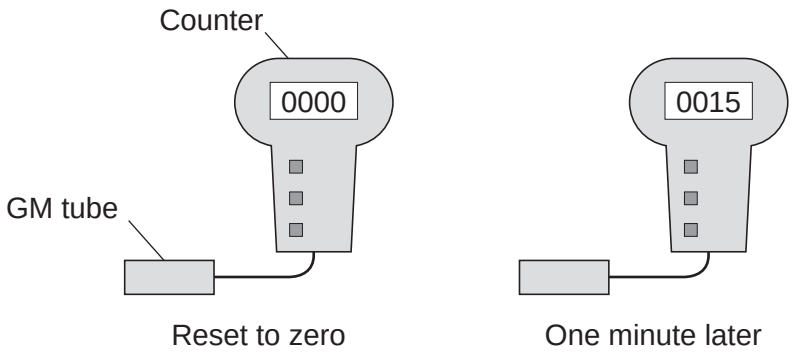
5

4.4.1.2 Mass number, atomic number and isotopes

Question 46

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)

4.4.1.2 Mass number, atomic number and isotopes

Question 46 · continued

January 2013 | PH2HP | Original Q2 | Legacy

2 (b) Some scientists say they have found evidence to show that people living in areas of high natural background radiation are less likely to develop cancer than people living in similar areas with lower background radiation.

The evidence these scientists found does not definitely mean that the level of background radiation determines whether a person will develop cancer.

Suggest a reason why.

.....

.....

(1 mark)

2 (c) An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

An alpha particle is the same as a helium nucleus. The symbol below represents an alpha particle.

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

2 (c) (i) How many protons and how many neutrons are there in an alpha particle?

Number of protons = ...

Number of neutrons = ...

(2 marks)

2 (c) (ii) The decay of radon-222 can be represented by the equation below.

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

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

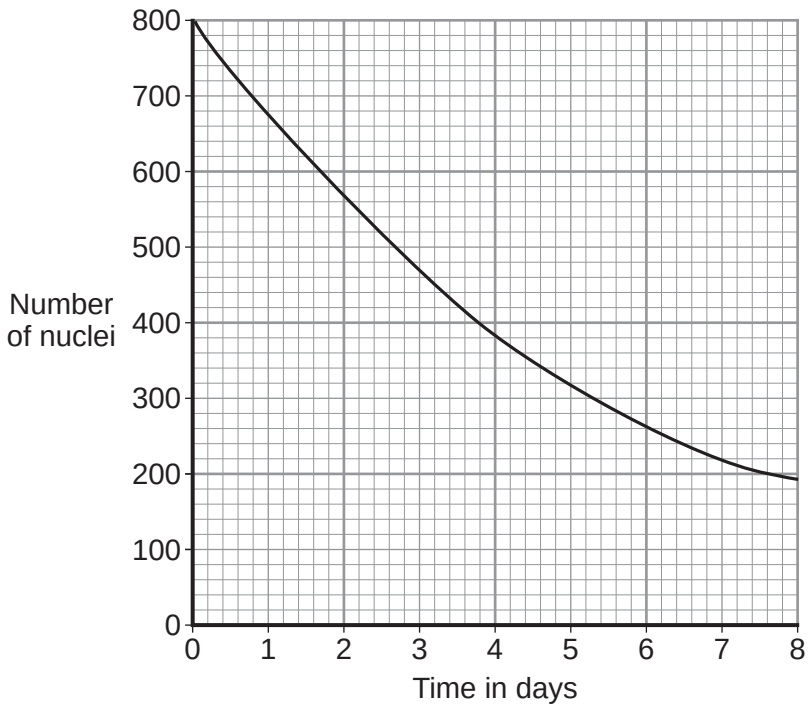
(2 marks)

Question 2 continues on the next page

4.4.1.2 Mass number, atomic number and isotopes

Question 46 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 47

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

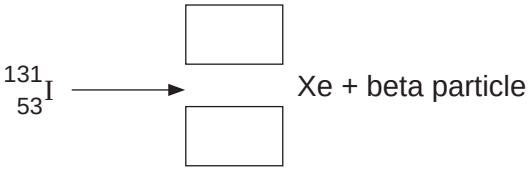
the ..... number.

(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

4.4.1.2 Mass number, atomic number and isotopes

Question 47 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 48

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

4.4.1.2 Mass number, atomic number and isotopes

Question 48 · continued

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

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

[1 mark]

.....

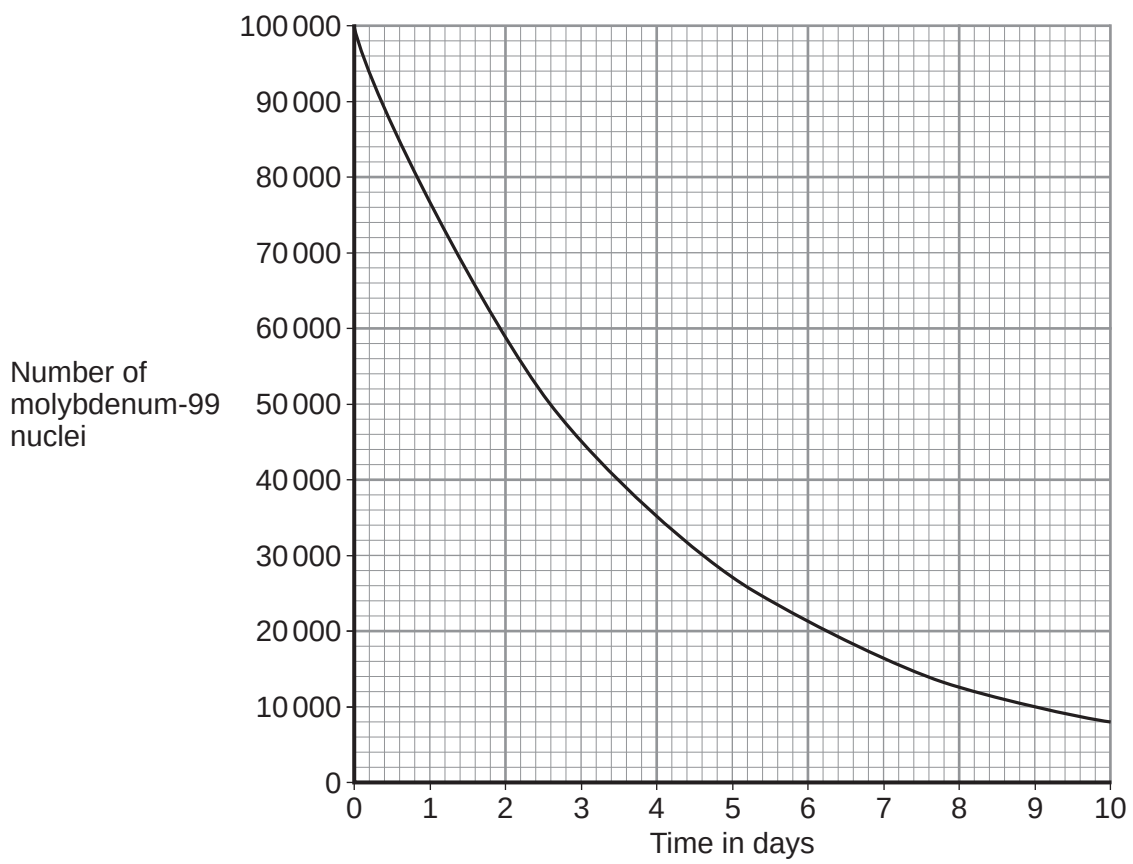
.....

.....

6 (e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

6 (e) (i) **Figure 7** shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.

Figure 7



4.4.1.2 Mass number, atomic number and isotopes

Question 48 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 49

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]

.....

4.4.1.2 Mass number, atomic number and isotopes

Question 49 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 49 · 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

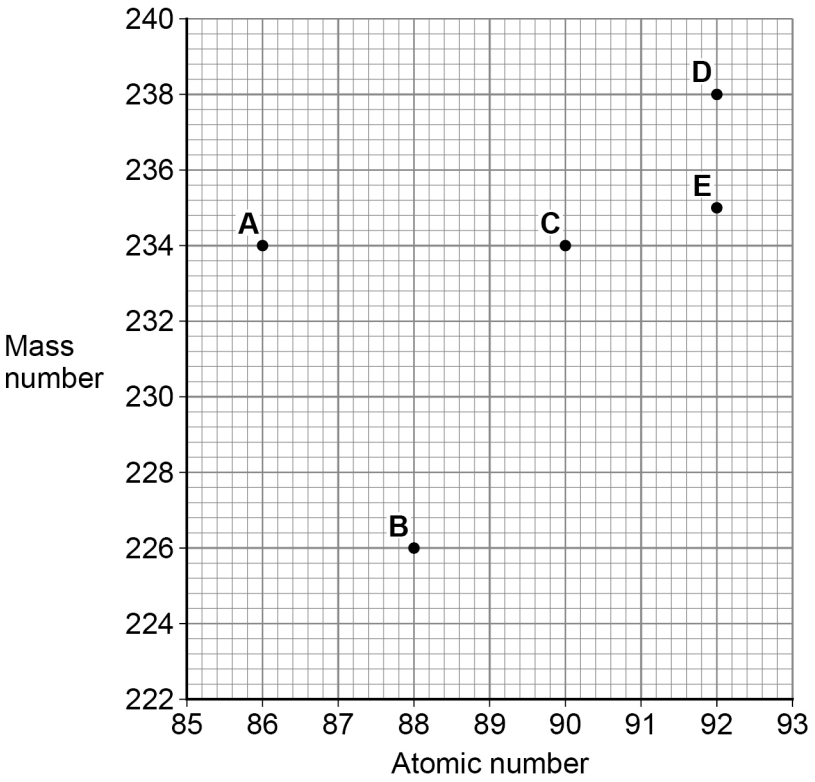
4.4.1.2 Mass number, atomic number and isotopes

Question 50

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]

4.4.1.2 Mass number, atomic number and isotopes

Question 50 · 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

4.4.1.2 Mass number, atomic number and isotopes

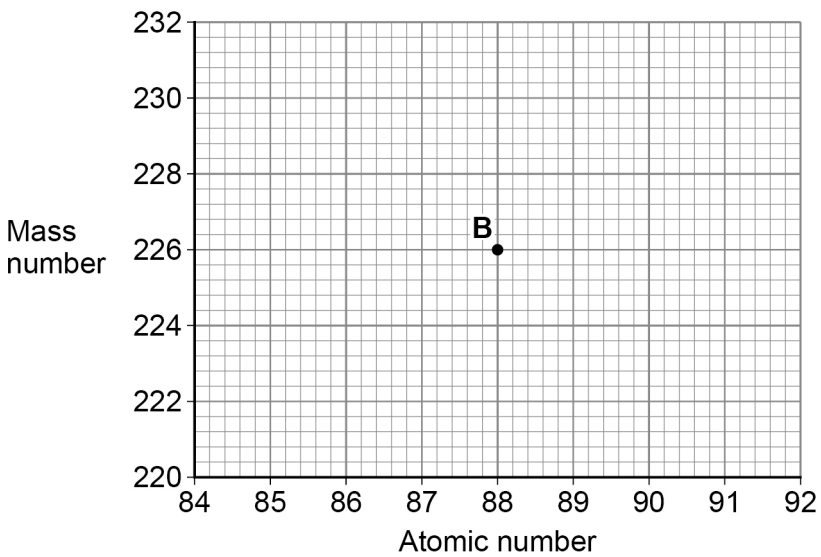
Question 50 · continued

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]

4.4.1.2 Mass number, atomic number and isotopes

Question 50 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 51

June 2023 | 8463/1H | Original Q5

0 5 Some isotopes emit nuclear radiation.

0 5 . 1 Carbon-14 and carbon-12 are isotopes of carbon.

Compare the structure of an atom of carbon-14 with the structure of an atom of carbon-12.

[3 marks]

0 5 . 2 Carbon-14 is a radioactive isotope.

Carbon-14 has a half-life of 5700 years.

What does 'a half-life of 5700 years' mean?

[1 mark]

Question 5 continues on the next page

Question 51 · 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]

4.4.1.2 Mass number, atomic number and isotopes

Question 51 · 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]

4.4.1.2 Mass number, atomic number and isotopes

Question 51 · 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

4.4.1.2 Mass number, atomic number and isotopes

Question 52

June 2025 | 8463/1H | Original Q5

0 5 Scientists have used lasers to start a nuclear **fusion** reaction.

The scientists used the lasers to heat a small amount of an isotope of hydrogen.

0 5 . 1 Describe what is meant by 'isotopes' of an element.

[2 marks]

0 5 . 2 Explain how nuclear **fusion** releases energy.

[3 marks]

4.4.1.2 Mass number, atomic number and isotopes

Question 52 · continued

0 5 . 3 The fusion reaction releases large amounts of energy.

The fusion reaction takes place in a reactor.

Explain why the walls of the reactor should be made from a material with a very high specific heat capacity.

[2 marks]

0 5 . 4 Nuclear fusion is safer than nuclear fission.

Nuclear **fission** can lead to an uncontrolled chain reaction.

Give **one** consequence of an uncontrolled chain reaction.

[1 mark]

8