AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.2.1

Radioactive decay and nuclear radiation

Past-paper questions

Tier	**Foundation**
Question groups	**17**
Available paper years	**2018–2025**

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.

6.4.2.1 Radioactive decay and nuclear radiation

Question 01

June 2018 | 8464/P/1F | Original Q5

0 5 Radioactive nuclei can emit alpha, beta or gamma radiation.

0 5 . 1 Which type of radiation is the most penetrating?

[1 mark]

Tick **one** box.

Alpha (α) ☐

Beta (β) ☐

Gamma (γ) ☐

0 5 . 2 Which type of radiation is the most ionising?

[1 mark]

Tick **one** box.

Alpha (α) ☐

Beta (β) ☐

Gamma (γ) ☐

0 5 . 3 Which type of radiation has the longest range in air?

[1 mark]

Tick **one** box.

Alpha (α) ☐

Beta (β) ☐

Gamma (γ) ☐

Question 5 continues on the next page

When radioactive isotopes in the Earth's crust decay they release energy.

The decay causes the heating of rocks in the crust.

0 5 . 4 **Figure 8** shows the decay of uranium–238 (U–238) into thorium–234 (Th–234).

Figure 8

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Complete **Table 2** to show the number of neutrons and protons in the nuclei.

[2 marks]

Table 2

Isotope	Number of neutrons	Number of protons
uranium–238	146	
thorium–234		90

0 5 . 5 Geothermal power stations pump water through heated rocks.

The temperature of the water increases from 20 °C to its boiling point of 100 °C

Calculate the change in thermal energy when the mass of water heated is 150 kg

Specific heat capacity = 4 200 J/kg °C

Use the Physics Equations Sheet.

[3 marks]

Change in thermal energy = _____ J

8

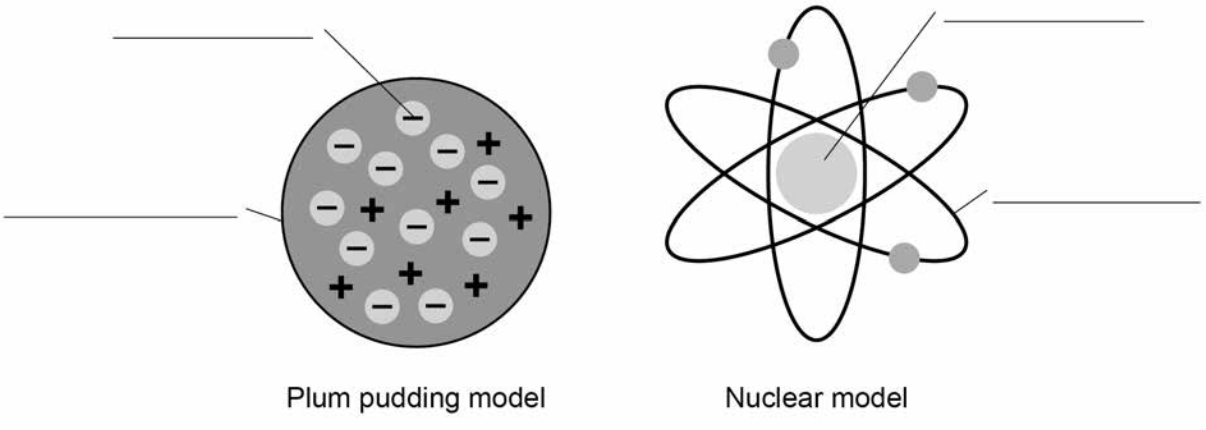
6.4.2.1 Radioactive decay and nuclear radiation

Question 02

June 2018 | 8464/P/1F | Original Q6

0 6 **Figure 9** shows two models of the atom.

Figure 9



0 6 . 1 Write the labels on **Figure 9**

Choose the answers from the box.

[4 marks]

atom	**electron**	**nucleus**
neutron	**orbit**	**proton**

0 6 . 2 Explain why the total positive charge in every atom of an element is always the same.

[2 marks]

Question 6 continues on the next page

Question 02 · continued

0 6 . 3 The results from the alpha particle scattering experiment led to the nuclear model.

Alpha particles were fired at a thin film of gold at a speed of 7% of the speed of light.

Determine the speed of the alpha particles.

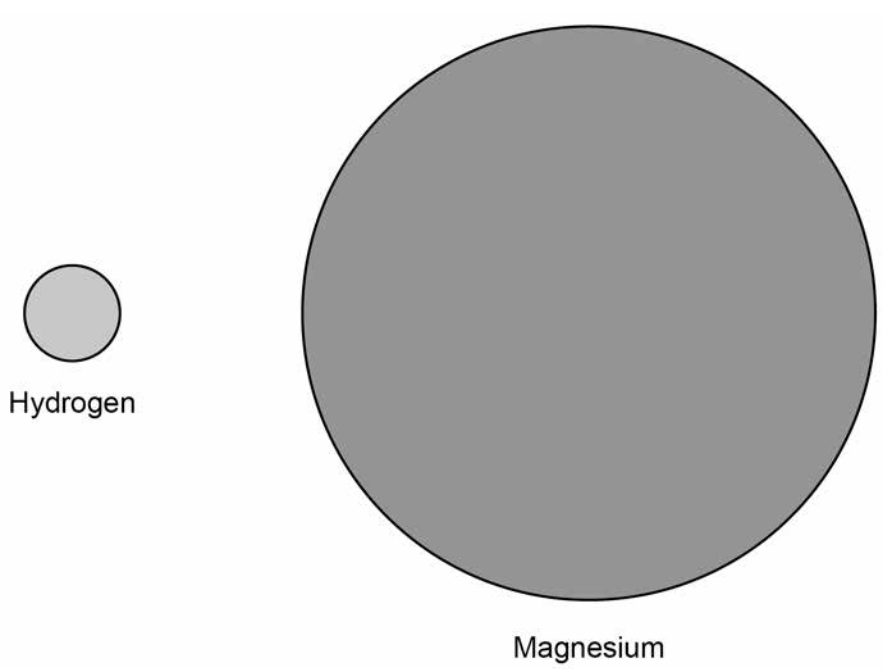
Speed of light = 300 000 000 m/s

[2 marks]

Speed = _____ m/s

0 6 . 4 **Figure 10** shows two atoms represented as solid spheres.

Figure 10



A hydrogen atom has a radius of 2.5×10^{-11} m

Determine the radius of a magnesium atom.

Use measurements from **Figure 10**

[2 marks]

Radius = _____ m

10

6.4.2.1 Radioactive decay and nuclear radiation

Question 03

0 4 **Figure 5** shows types of waves within the electromagnetic spectrum.

Some of the types of waves are represented by letters.

Figure 5

P	**microwaves**	**Q**	**visible light**	**R**		**S**	**gamma rays**

0 4 . 1 Which letter shows the position of ultraviolet (UV) radiation within the electromagnetic spectrum?

[1 mark]

Tick **one** box.

P ☐ **Q** ☐ **R** ☐ **S** ☐

0 4 . 2 A special lamp can produce UV radiation.

Which **two** statements describe the electromagnetic waves emitted by a UV lamp?

[2 marks]

Tick **two** boxes.

They have a higher frequency than X-rays. ☐

They have the same wave speed as visible light. ☐

They have a longer wavelength than microwaves. ☐

They have a lower frequency than gamma rays. ☐

They have a greater wave speed than radio waves. ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 03 · continued

0 4 . 3 UV radiation is used to treat a vitamin D deficiency.

People should **not** use a UV lamp for long periods of time.

State **two** risks of exposure to high levels of UV radiation.

[2 marks]

1 _____

_____

2 _____

_____

0 4 . 4 Ionising radiation is used for some medical imaging.

Name **two** types of electromagnetic waves that are used.

[2 marks]

1 _____

2 _____

7

6.4.2.1 Radioactive decay and nuclear radiation

Question 04

June 2019 | 8464/P/1F | Original Q3

0 3 In an experiment, a beam of alpha particles was directed at a thin sheet of gold foil.

0 3 . 1 Most of the alpha particles passed straight through the gold foil.

Alpha particles which passed close to the nucleus of a gold atom did **not** pass straight through.

What happened to the alpha particles which passed close to the nucleus of a gold atom?

[1 mark]

0 3 . 2 The results suggested that the diameter of the nucleus of a gold atom is $\frac{1}{6000}$ of the diameter of the atom.

The diameter of a gold atom is 0.18 nm

Calculate the diameter of a gold nucleus in nm

[2 marks]

Diameter = _____ nm

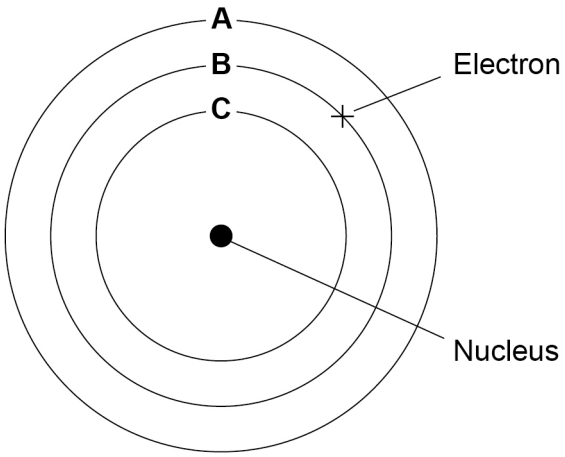
6.4.2.1 Radioactive decay and nuclear radiation

Question 04 · continued

0 3 . 3 Further experiments showed that gold nuclei are surrounded by electrons in different energy levels.

Figure 4 shows three of the energy levels around the nucleus of a gold atom.

Figure 4



The electron in energy level **B** absorbs electromagnetic radiation.

Which energy level will the electron be in after it has absorbed the electromagnetic radiation?

[1 mark]

Tick (✓) **one** box.

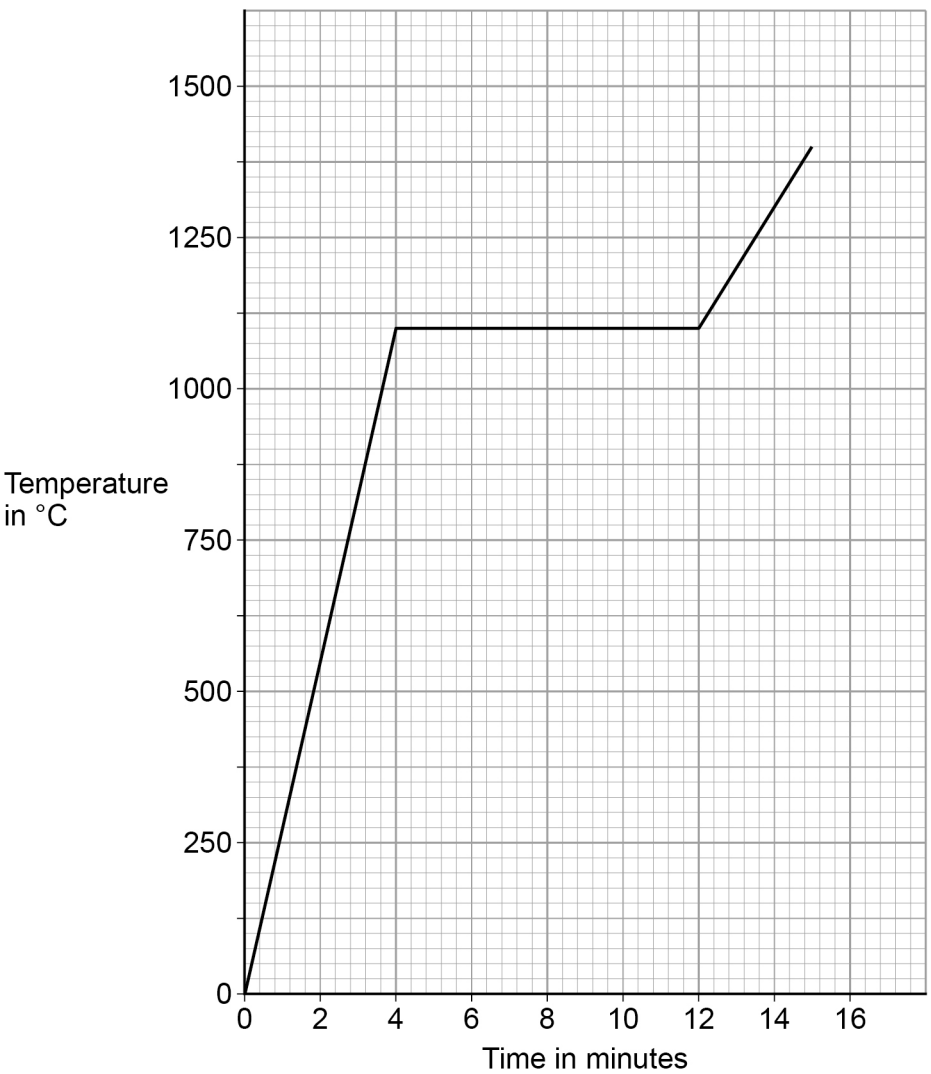
A ☐ **B** ☐ **C** ☐

Question 3 continues on the next page

Question 04 · continued

Figure 5 shows how the temperature of a small sample of gold changes as it is heated from a solid to a liquid.

Figure 5



0 3 . 4 What is the melting point of the gold?

[1 mark]

Melting point = _____ °C

0 3 . 5 How many minutes did it take for all of the gold in the sample to change from solid to liquid?

[1 mark]

Time taken = _____ minutes

6.4.2.1 Radioactive decay and nuclear radiation

Question 04 · continued

0 3 . 6 What does the gradient of the graph in **Figure 5** represent?

[1 mark]

Tick (✓) **one** box.

- The internal energy of the gold ☐
- The rate of change of temperature of the gold ☐
- The specific heat capacity of the gold ☐

7

Turn over for the next question

6.4.2.1 Radioactive decay and nuclear radiation

Question 05

June 2019 | 8464/P/1F | Original Q4

0 4 Protactinium (Pa) is radioactive.

0 4 . 1 An atom of one isotope of protactinium contains 91 protons and 143 neutrons.

What is the correct symbol for this atom?

[1 mark]

Tick (✓) **one** box.

$^{143}_{91}Pa$ ☐ $^{234}_{91}Pa$ ☐ $^{234}_{143}Pa$ ☐ $^{91}_{52}Pa$ ☐

A teacher investigated how the count rate from a sample of protactinium changed over time.

Table 2 shows the results.

Table 2

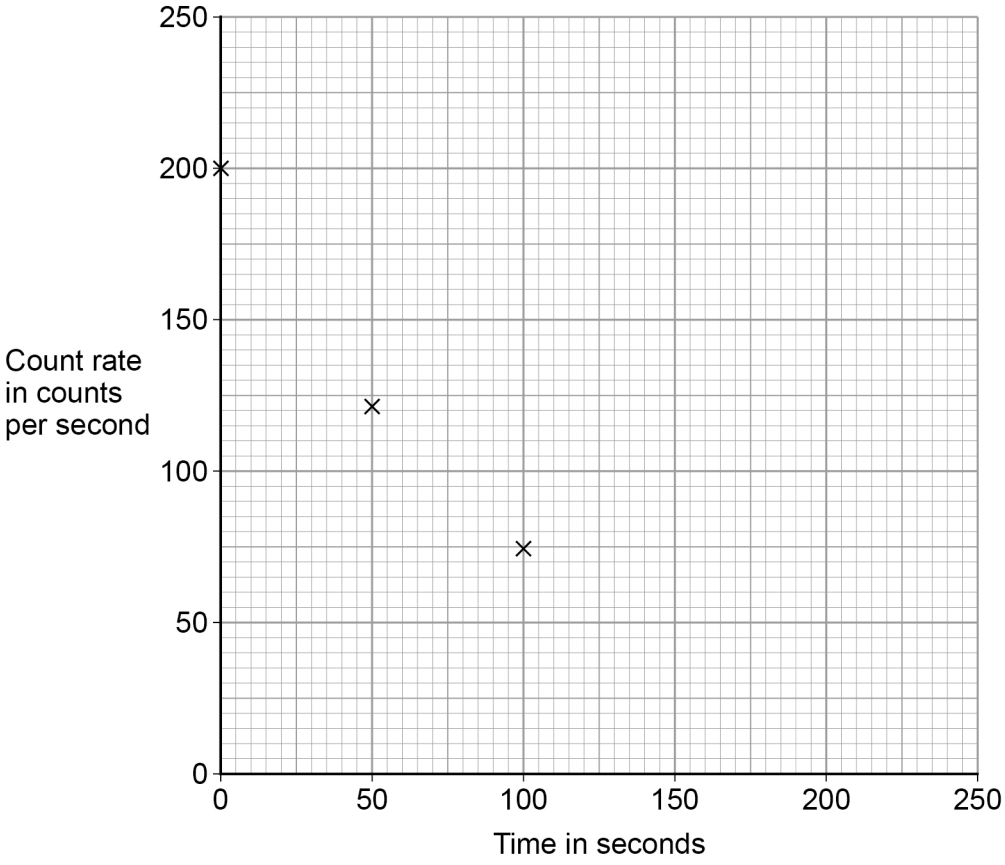
Time in seconds	Count rate in counts per second
0	200
50	122
100	74
150	45
200	27

6.4.2.1 Radioactive decay and nuclear radiation

Question 05 · continued

Figure 6 shows some of the teacher's results.

Figure 6



0 4 . 2 Complete the graph in **Figure 6**.

Use data from **Table 2**.

Draw the line of best fit.

[2 marks]

0 4 . 3 How much time did it take for the count rate to change from 200 counts per second to 100 counts per second?

[1 mark]

Time taken = _____ s

0 4 . 4 What is the half-life of protactinium?

[1 mark]

Half-life = _____ s

6.4.2.1 Radioactive decay and nuclear radiation

Question 05 · continued June 2019 | 8464/P/1F | Original Q4

0 4 . 5 The nuclear radiation from the protactinium can pass through paper.

This radiation can only be detected up to 1 metre away from the protactinium.

What type of radiation is emitted by the protactinium?

[1 mark]

Tick (✓) **one** box.

Alpha ☐

Beta ☐

Gamma ☐

Neutron ☐

0 4 . 6 The teacher read an article about the effects of radiation on the human body.

Why are articles in scientific journals generally more trustworthy than articles in newspapers?

[1 mark]

7

6.4.2.1 Radioactive decay and nuclear radiation

Question 06

June 2019 | 8464/P/2F | Original Q5

0 5 The Sun emits all types of electromagnetic waves.

Figure 7 shows the electromagnetic spectrum.

Figure 7

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

0 5 . 1 Complete the sentences.

Choose answers from the box.

[3 marks]

frequency	**mass**	**power**
velocity		**wavelength**

In a vacuum, all electromagnetic waves travel at the same _____ .

Gamma waves have the greatest _____ .

Radio waves have the greatest _____ .

0 5 . 2 Explain why it is important that the Earth's atmosphere absorbs gamma rays emitted by the Sun.

[2 marks]

_____

_____

_____

_____

0 5 . 3 Some microwaves are **not** absorbed by the Earth's atmosphere.

Why is this useful?

[1 mark]

_____

6.4.2.1 Radioactive decay and nuclear radiation

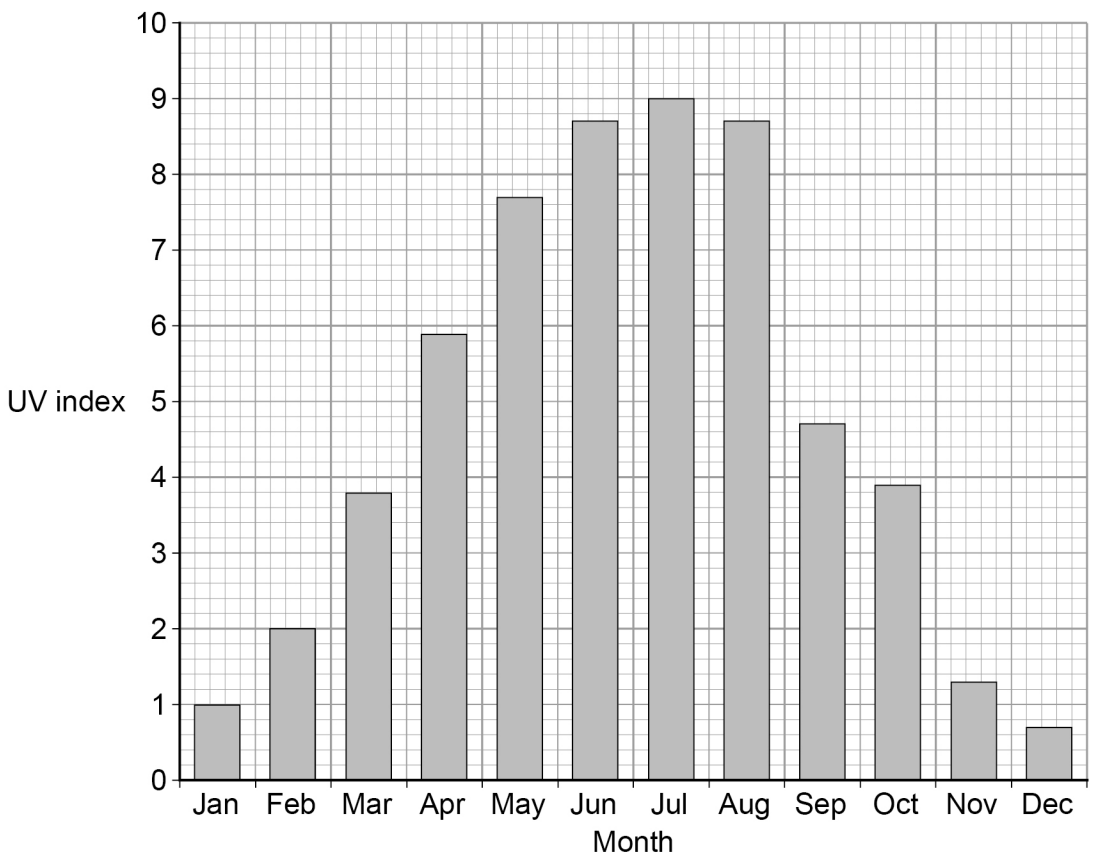
Question 06 · continued

Some ultraviolet (UV) radiation from the Sun passes through the atmosphere and reaches the surface of the Earth.

The amount of UV radiation that reaches the surface of the Earth can be measured on a scale called the UV index.

Figure 8 shows the average midday UV index in the UK for 1 year.

Figure 8



0 5 . 4 Why is exposure to UV radiation harmful to humans?

[1 mark]

6.4.2.1 Radioactive decay and nuclear radiation

Question 06 · continued

0 5 . 5 Compare the risk from UV radiation at different times of year in the UK.

Use data from **Figure 8**.

[2 marks]

9

Turn over for the next question

6.4.2.1 Radioactive decay and nuclear radiation

Question 07

0 2 Between 1951 and 1992 the USA tested nuclear weapons in a desert.

0 2 . 1 Complete the sentence.

Choose the answer from the box.

[1 mark]

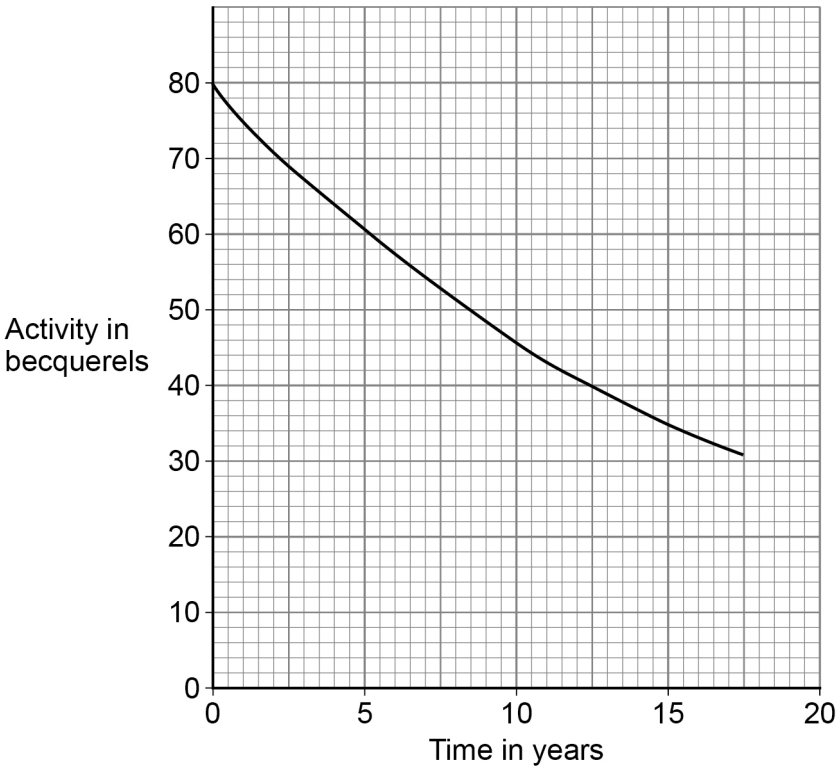
contamination	**irradiation**	**ionisation**	**decay**

Radioactive dust from the nuclear weapons testing settled on the desert. This is called radioactive _____ .

The desert now contains radioactive tritium.

Figure 3 shows how the activity of the tritium in a sample taken from the desert changed with time.

Figure 3



6.4.2.1 Radioactive decay and nuclear radiation

Question 07 · continued

0 2 . 2 The sample was collected from the desert in 1992.

Determine the activity of the tritium in the sample in 2007.

[2 marks]

Activity = _____ Bq

0 2 . 3 How much time did it take for the activity of the tritium in the sample to decrease from 80 Bq to 40 Bq?

[1 mark]

Time = _____ years

0 2 . 4 What is the half-life of tritium?

[1 mark]

Half-life = _____ years

0 2 . 5 The sample started with 45 billion atoms of tritium.

After 4 years the sample had 36 billion atoms of tritium.

Calculate the percentage of the tritium in the sample that remained after 4 years.

[2 marks]

Percentage of tritium remaining = _____ %

Question 07 · continued

0 2 . 6 A scientist determined the activity of a sample of tritium every minute for 3 minutes.

Table 1 shows the results.

Table 1

Time in minutes	Activity in Bq
0	149
1	151
2	148
3	152

Why do the activity readings in **Table 1** vary?

[1 mark]

Tick (✓) **one** box.

Radioactive decay is a random process. ☐

Temperature changes affect the radioactive decay. ☐

The number of radioactive nuclei keeps increasing and decreasing. ☐

0 2 . 7 What safety precaution should scientists take when working with radioactive materials in a laboratory?

[1 mark]

Tick (✓) **one** box.

Tie long hair back before handling the materials. ☐

Use long tongs to handle the materials. ☐

Wear safety goggles when handling the materials. ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 07 · continued

0 2 . 8 Studies show that children born near the area of the desert containing tritium were more likely to develop cancer.

It is important that the results from these studies are checked by other scientists.

What is this process called?

[1 mark]

Tick (✓) **one** box.

- Experiment review ☐
- Peer review ☐
- Results review ☐
- Test review ☐

10

Turn over for the next question

6.4.2.1 Radioactive decay and nuclear radiation

Question 08

November 2020 | 8464/P/1F | Original Q6

0 6 Different radioactive isotopes emit different types of nuclear radiation.

A polonium-210 (Po) nucleus emits an alpha particle (α) and turns into a lead (Pb) nucleus.

This can be represented by the equation:

$$^{210}_{84}Po \longrightarrow {}^{A}_{Z}Pb + \alpha$$

0 6 . 1 What is the value of A in the equation?

[1 mark]

Tick (✓) **one** box.

A = 206 ☐ A = 208 ☐ A = 210 ☐ A = 211 ☐

0 6 . 2 What is the value of Z in the equation?

[1 mark]

Tick (✓) **one** box.

Z = 80 ☐ Z = 82 ☐ Z = 85 ☐ Z = 86 ☐

Question 6 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 08 · continued November 2020 | 8464/P/1F | Original Q6

0 6 . 3 A strontium-89 nucleus (Sr) emits a beta particle (β) and turns into an yttrium nucleus (Y).

This can be represented by the equation:

$$^{89}_{38}\text{Sr} \longrightarrow {}^{A}_{Z}\text{Y} + \beta$$

What are the values of A and Z in the equation?

[2 marks]

A = _____

Z = _____

0 6 . 4 Gamma radiation is another type of nuclear radiation.

What does gamma radiation consist of?

[1 mark]

Tick (✓) **one** box.

- High energy neutrons ☐
- Electromagnetic waves ☐
- Particles with no charge ☐
- Positively charged ions ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 08 · continued

0 6 . 5 Explain the differences between the properties of alpha, beta and gamma radiations.

[6 marks]

11

6.4.2.1 Radioactive decay and nuclear radiation

Question 09

November 2020 | 8464/P/2F | Original Q3

0 3 X-rays and gamma rays are types of electromagnetic waves.

X-rays are used for medical imaging.

0 3 . 1 Which substance will **not** absorb X-rays?

[1 mark]

Tick (✓) **one** box.

Bone ☐ Metal ☐ Skin ☐

Table 1 shows the effect of exposure to different doses of radiation.

Table 1

Dose in mSv	Effect on the human body
100	slightly increased risk of cancer
1000	5% increased risk of cancer
5000	high risk of death

0 3 . 2 During one X-ray a person receives a dose of 0.100 mSv

Why is this dose unlikely to harm the person?

[1 mark]

0 3 . 3 A doctor takes an X-ray photograph of a person.

When taking the X-ray photograph, the doctor stands behind a screen.

Suggest why.

[1 mark]

6.4.2.1 Radioactive decay and nuclear radiation

Question 09 · continued

0 3 . 4 Which of the following are gamma rays used for?

[1 mark]

Tick (✓) **one** box.

Cooking food ☐

Energy-efficient lamps ☐

Sterilising medical equipment ☐

0 3 . 5 Why are gamma rays and X-rays harmful to humans?

[1 mark]

Tick (✓) **one** box.

They are ionising ☐

They are radioactive ☐

They travel at the speed of light ☐

0 3 . 6 Electromagnetic waves are also used in communications.

Describe how microwaves and visible light are used in communications.

[4 marks]

Microwaves _____

_____

_____

_____

Visible light _____

_____

_____

_____

9

6.4.2.1 Radioactive decay and nuclear radiation

Question 10

November 2021 | 8464/P/1F | Original Q6

0 6 A radioactive source emits alpha, beta and gamma radiation.

0 6 . 1 An alpha particle is the same as a helium nucleus.

How many times bigger is the radius of a helium atom than the radius of an alpha particle?

[1 mark]

Tick (✓) **one** box.

- Less than 100 times bigger ☐
- Exactly 5000 times bigger ☐
- More than 10 000 times bigger ☐

0 6 . 2 Alpha particles can ionise atoms in the air.

What happens to an atom when it is ionised by an alpha particle?

[2 marks]

Tick (✓) **two** boxes.

- A neutron in the atom becomes a proton. ☐
- The atom becomes a positive ion. ☐
- The atom gains a neutron. ☐
- The atom gains a proton. ☐
- The atom loses an electron. ☐

Question 6 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 10 · continued

November 2021 | 8464/P/1F | Original Q6

0 6 . 3 A spark detector is a device that can be used to detect alpha radiation.

A spark detector works by alpha particles ionising atoms in the air near a wire mesh.

A large potential difference creates a spark when the air near the wire mesh is ionised.

Suggest why a spark detector **cannot** detect beta radiation.

[1 mark]

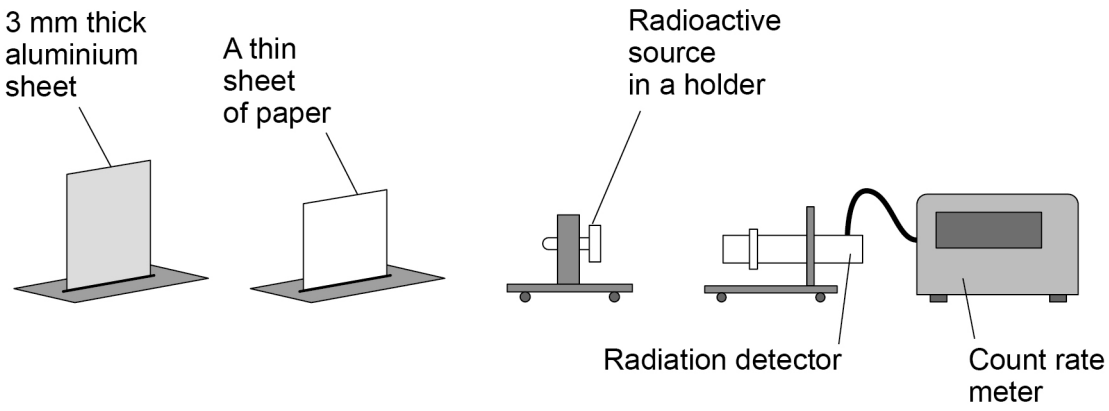
6.4.2.1 Radioactive decay and nuclear radiation

Question 10 · continued

0 6 . 4 A teacher wants to demonstrate that the radioactive source emits alpha, beta and gamma radiation.

Figure 11 shows the equipment the teacher has.

Figure 11



Describe a method the teacher could use.

[6 marks]

10

6.4.2.1 Radioactive decay and nuclear radiation

Question 11

November 2021 | 8464/P/2F | Original Q5

0 5 Scientists are developing a rocket aeroplane designed to travel much faster than jet aeroplanes.

0 5 . 1 The rocket aeroplane must accelerate along a runway to take off.

What would happen to the air resistance acting on the rocket aeroplane as it accelerates?

[1 mark]

0 5 . 2 An upward force called lift will act on the wings of the rocket aeroplane when it moves.

Complete the sentence.

Choose the answer from the box.

[1 mark]

less than	**the same as**	**greater than**

As the rocket aeroplane starts to accelerate along the runway, the lift force on the wings will be _____ the weight of the rocket aeroplane.

Question 5 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 11 · continued November 2021 | 8464/P/2F | Original Q5

0 5 . 3 During the first 14 seconds the average speed of the rocket aeroplane on the runway will be 35 m/s.

Calculate the distance that the rocket aeroplane will travel during the first 14 seconds.

Use the equation:

distance travelled = average speed × time

[2 marks]

Distance travelled = _____ m

0 5 . 4 Write down the equation which links distance (*s*), force (*F*) and work done (*W*).

[1 mark]

0 5 . 5 When the rocket aeroplane travels a distance of 270 m on the runway the engines will do 54 000 000 J of work.

Calculate the average force exerted by the engines.

[3 marks]

Average force = _____ N

6.4.2.1 Radioactive decay and nuclear radiation

Question 11 · continued

0 5 . 6 The rocket aeroplane will fly at a greater height than a jet aeroplane.

The height that an aeroplane flies at affects the radiation dose a passenger will receive each hour.

Table 2 shows the speed of each aeroplane and the radiation dose a passenger will receive each hour.

Table 2

Aeroplane	Speed in metres per second	Radiation dose each hour in millisieverts
Rocket aeroplane	8000	0.006
Jet aeroplane	250	0.003

Exposure to ionising radiation has risks and possible consequences.

Evaluate the risks and possible consequences of flying in a rocket aeroplane and in a jet aeroplane.

Assume the same journey is made in each aeroplane.

Use values from **Table 2**.

[6 marks]

14

6.4.2.1 Radioactive decay and nuclear radiation

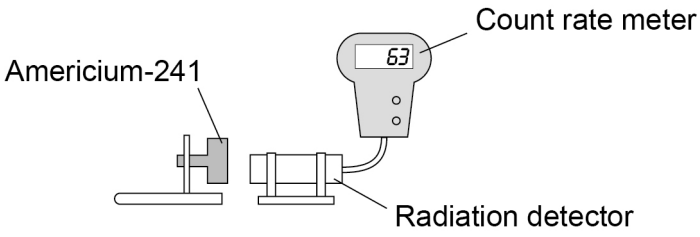
Question 12

June 2022 | 8464/P/1F | Original Q3

0 3 A teacher demonstrated that the radioactive isotope americium-241 emits alpha particles.

Figure 4 shows the equipment used.

Figure 4



0 3 . 1 An americium-241 nucleus (Am) emits an alpha particle and turns into a neptunium nucleus (Np).

Which is the correct nuclear equation for this decay?

Tick (✓) **one** box.

[1 mark]

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

$^{241}_{95}Am \longrightarrow {}^{245}_{93}Np + {}^{4}_{2}He$ ☐

$^{241}_{95}Am \longrightarrow {}^{237}_{97}Np + {}^{4}_{2}He$ ☐

0 3 . 2 What is the furthest distance that alpha radiation can travel in air?

Tick (✓) **one** box.

[1 mark]

A few millimetres ☐

A few centimetres ☐

A few metres ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 12 · continued

0 3 . 3 The teacher placed a piece of paper between the americium-241 and the radiation detector.

The reading on the count rate meter decreased by a large amount.

Why does the decreased reading show that americium-241 emits alpha radiation?

Tick (✓) **one** box.

[1 mark]

Paper stops alpha radiation. ☐

Paper stops all types of radiation. ☐

Paper stops beta and gamma radiation. ☐

The teacher replaced the americium-241 with a source of beta radiation.

0 3 . 4 Which symbol represents a beta particle?

[1 mark]

Tick (✓) **one** box.

$^{0}_{-1}e$ ☐

$^{0}_{0}e$ ☐

$^{-1}_{-1}e$ ☐

$^{-1}_{0}e$ ☐

Question 3 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 12 · continued

0 3 . 5 The count rate from the source was 119 ± 7 counts per second.

Calculate the smallest count rate this could have been.

[1 mark]

Smallest count rate = _____ counts per second

A teacher investigated how the distance between a different radioactive source and the detector affects the count rate.

0 3 . 6 Draw **one** line from each type of variable to the description.

[3 marks]

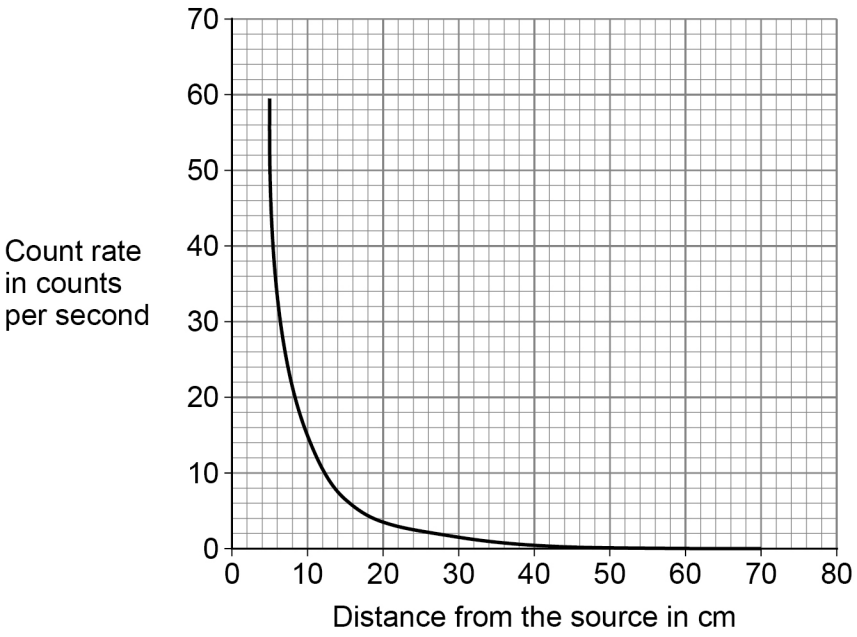
Type of variable	Description
	Count rate
Control variable	
	Distance between the source and detector
Dependent variable	
	Radioactive source
Independent variable	
	Time

6.4.2.1 Radioactive decay and nuclear radiation

Question 12 · continued

0 3 . 7 **Figure 5** shows how the count rate from the different radioactive source changed with the distance from the source.

Figure 5



Describe the relationship between the distance from the source and the count rate.

[2 marks]

10

6.4.2.1 Radioactive decay and nuclear radiation

Question 13

June 2023 | 8464/P/1F | Original Q1

0 1 A scientist investigated the radiation emitted by different radioactive isotopes.

The scientist had a sample of polonium-210.

The radiation emitted by polonium-210 can be represented by the symbol $^{4}_{2}\text{He}$.

0 1 . 1 Which type of radiation can be represented by the symbol $^{4}_{2}\text{He}$?

[1 mark]

Tick (✓) **one** box.

Alpha ☐

Beta ☐

Gamma ☐

0 1 . 2 How many protons are there in a particle of radiation represented by $^{4}_{2}\text{He}$?

[1 mark]

Tick (✓) **one** box.

2 ☐ 4 ☐ 6 ☐ 8 ☐

0 1 . 3 A polonium-210 (Po) nucleus changes into a lead (Pb) nucleus by emitting a $^{4}_{2}\text{He}$ particle. This is shown by the following nuclear equation.

$$^{210}_{84}\text{Po} \rightarrow {}^{206}_{\mathbf{X}}\text{Pb} + {}^{4}_{2}\text{He}$$

What is the value of **X**?

[1 mark]

Tick (✓) **one** box.

80 ☐ 82 ☐ 84 ☐ 86 ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 13 · continued

June 2023 | 8464/P/1F | Original Q1

0 1 . 4 The sample of polonium-210 had an activity of 100 Bq.

Complete the sentence.

Choose the answer from the box.

[1 mark]

25	**50**	**100**	**200**

After one half-life, the activity of polonium-210 in the sample

was _____ Bq.

Question 1 continues on the next page

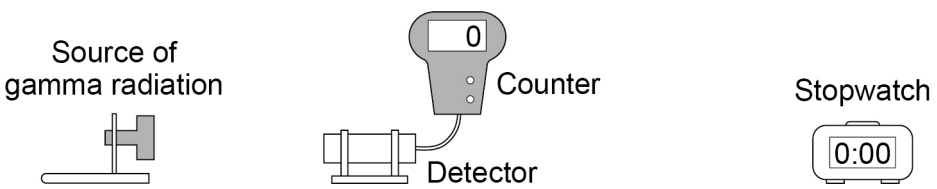
6.4.2.1 Radioactive decay and nuclear radiation

Question 13 · continued

The scientist investigated another radioactive isotope that is a source of gamma radiation.

Figure 1 shows the equipment used.

Figure 1



0 1 . 5 The count-rate is the number of counts detected each second.

In 30 seconds the number of counts detected was 1500.

Calculate the count-rate.

[2 marks]

Count-rate = _____ counts per second

6.4.2.1 Radioactive decay and nuclear radiation

Question 13 · continued

The scientist placed a thick sheet of lead between the source of gamma radiation and the detector.

0 1 . 6 What was the effect of the sheet of lead on the count-rate?

Give a reason for your answer.

[2 marks]

Effect _____

_____

Reason _____

_____

0 1 . 7 The lead was irradiated by the gamma radiation.

What happened to the lead when it was irradiated by the gamma radiation?

[1 mark]

Tick (✓) **one** box.

The lead atoms became radioactive. ☐

The lead gained atoms from the radioactive source. ☐

The lead was exposed to gamma radiation. ☐

Question 1 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 13 · continued

0 1 . 8 Gamma radiation is emitted from the nucleus of an atom.

Complete the sentence.

Choose the answer from the box.

[1 mark]

electromagnetic waves	**high speed electrons**
neutrons	**positively charged ions**

Gamma radiation consists of _____.

0 1 . 9 **Figure 2** shows the scientist holding the radioactive source using tongs.

Figure 2



Suggest **one** reason why using long tongs rather than short tongs was safer for the scientist.

[1 mark]

_____

_____

11

6.4.2.1 Radioactive decay and nuclear radiation

Question 14

June 2023 | 8464/P/2F | Original Q6

0 6 The Sun emits a continuous spectrum of electromagnetic waves.

Figure 14 names some of the groups of waves in the electromagnetic spectrum.

Figure 14

A	**B**	Infrared	Visible light	Ultraviolet	**C**	Gamma rays

0 6 . 1 Name groups **A**, **B** and **C** in **Figure 14**.

[2 marks]

A _____

B _____

C _____

0 6 . 2 Give **one** similarity and **one** difference between the properties of ultraviolet waves and gamma rays.

[2 marks]

Similarity _____

_____

Difference _____

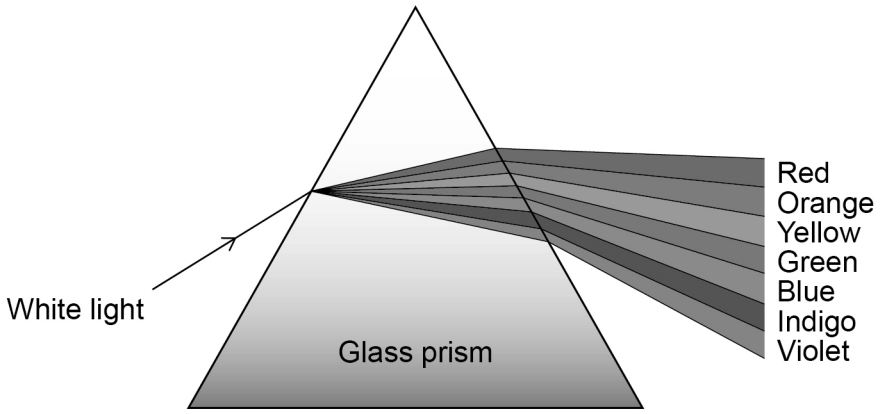
_____

6.4.2.1 Radioactive decay and nuclear radiation

Question 14 · continued

Figure 15 shows white light split into a spectrum of different colours by a glass prism.

Figure 15



0 6 . 3 Light changes direction when it enters the glass prism.

What name is given to this process?

[1 mark]

Question 6 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 14 · continued

Use the Physics Equations Sheet to answer questions **06.4** and **06.5**.

0 6 . 4 Write down the equation that links frequency (f), wavelength (λ) and wave speed (v).

[1 mark]

0 6 . 5 The wave in the middle of the spectrum has a wavelength of 5.0×10^{-7} m.

wave speed of light = 3.0×10^{8} m/s

Calculate the frequency of the wave.

[3 marks]

Frequency = _____ Hz

9

6.4.2.1 Radioactive decay and nuclear radiation

Question 15

June 2024 | 8464/P/1F | Original Q3

0 3 Some people used to think that radioactive substances had health benefits.

100 years ago, a company made toothpaste containing the radioactive isotopes radium-228 and radium-226.

Figure 3 shows the symbols for these isotopes.

Figure 3

$^{228}_{88}Ra$ $^{226}_{88}Ra$

0 3 . 1 How are atoms of radium-228 different from atoms of radium-226?

[1 mark]

Tick (✓) **one** box.

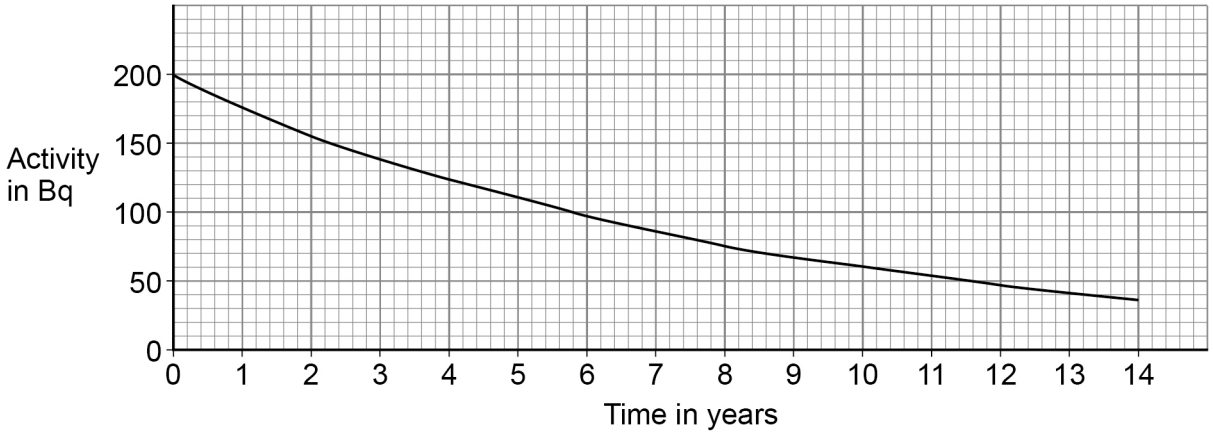
- Radium-228 atoms have one more neutron and one more proton. ☐
- Radium-228 atoms have two more neutrons and two more protons. ☐
- Radium-228 atoms have two more neutrons. ☐
- Radium-228 atoms have two more protons. ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 15 · continued

0 3 . 2 **Figure 4** shows how the activity of a sample of radium-228 changed over time.

Figure 4



What is the approximate half-life of radium-228?

[1 mark]

Tick (✓) **one** box.

- 6 years ☐
- 7 years ☐
- 14 years ☐
- 100 years ☐

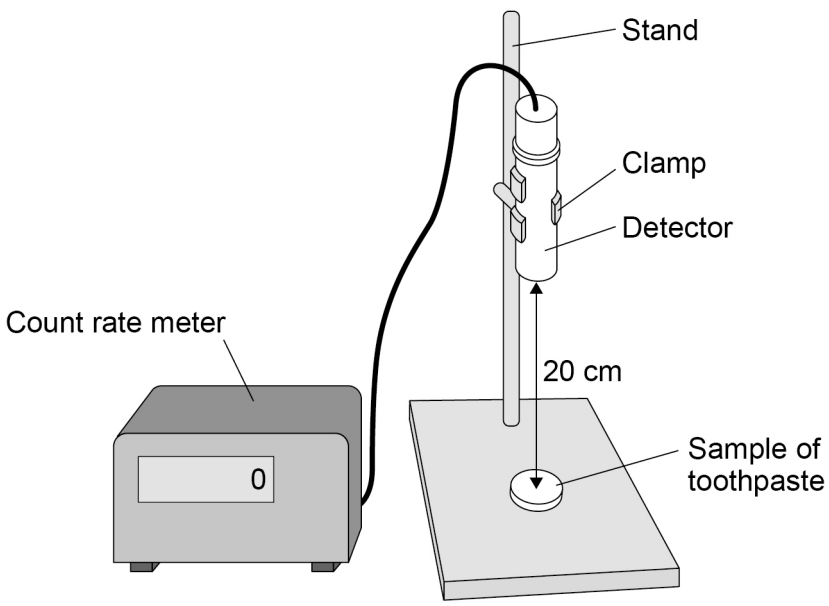
Question 3 continues on the next page

Question 15 · continued

A scientist investigated whether the toothpaste in four tubes of the 100-year-old toothpaste is equally radioactive.

Figure 5 shows the equipment used.

Figure 5



0 3 . 3 When the equipment was arranged as shown in **Figure 5**, it was **not** possible to detect alpha particles from the toothpaste.

Suggest how the scientist adjusted the equipment to detect alpha particles from the toothpaste.

[1 mark]

0 3 . 4 The scientist adjusted the equipment and determined the activity of the toothpaste from each tube.

Table 1 shows the results.

Table 1

Tube	Activity in Bq
A	3150
B	2940
C	3180
D	3050

What was the range of activities shown in **Table 1**?

[1 mark]

From _____ Bq to _____ Bq

0 3 . 5 What was the independent variable in the investigation?

[1 mark]

Tick (✓) **one** box.

The activity of the toothpaste ☐

The mass of toothpaste used ☐

The temperature of the toothpaste ☐

The tube of toothpaste used ☐

Question 3 continues on the next page

Question 15 · continued

0 3 . 6 What was the dependent variable in the investigation?

[1 mark]

Tick (✓) **one** box.

- The activity of the toothpaste ☐
- The mass of toothpaste used ☐
- The temperature of the toothpaste ☐
- The tube of toothpaste used ☐

0 3 . 7 When the toothpaste was new, it caused a risk to health because of the nuclear radiation emitted.

What happened to the risk to health from the toothpaste after 100 years?

[1 mark]

0 3 . 8 Which property makes nuclear radiation hazardous?

[1 mark]

Tick (✓) **one** box.

- Nuclear radiation is ionising. ☐
- Nuclear radiation is penetrating. ☐
- Nuclear radiation is too small to see. ☐
- Nuclear radiation makes objects radioactive. ☐

8

6.4.2.1 Radioactive decay and nuclear radiation

Question 16

June 2024 | 8464/P/1F | Original Q7

0 7 Last century, scientists used evidence from the alpha particle scattering experiment to develop a new model of the atom.

In the experiment, alpha particles were directed towards a piece of gold foil.

0 7 . 1 What does an alpha particle consist of?

[1 mark]

0 7 . 2 A gold atom has the symbol $^{197}_{79}Au$.

How many neutrons are there in this gold atom?

[1 mark]

Number of neutrons = _____

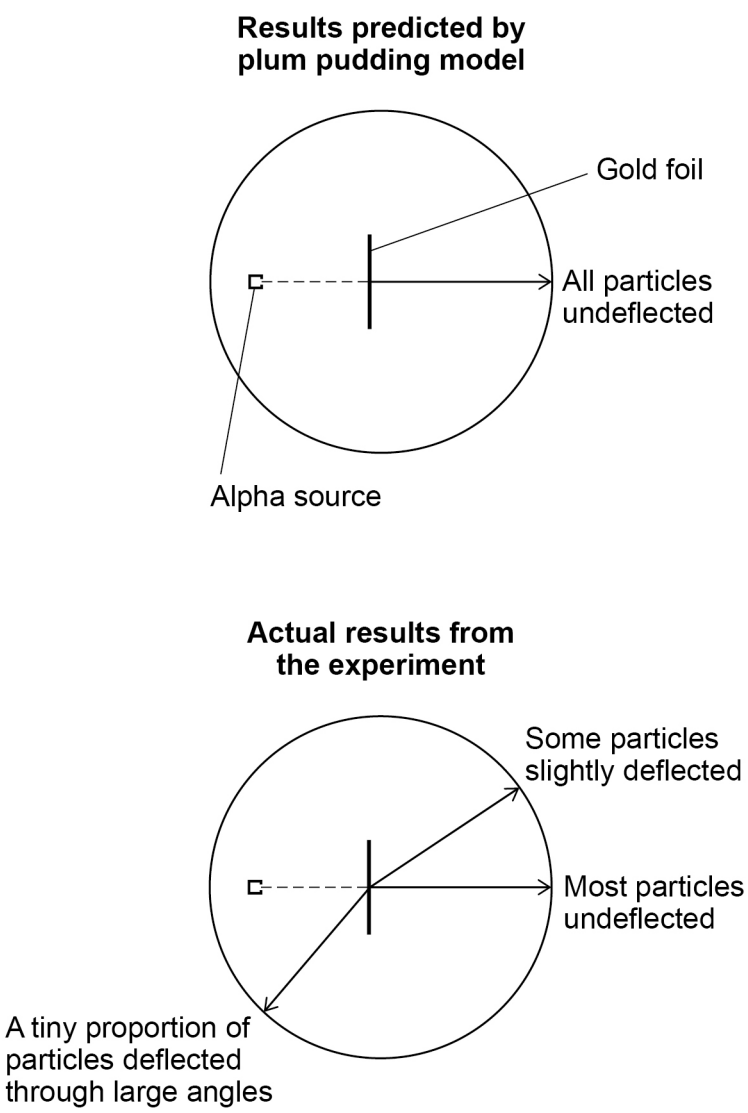
Question 7 continues on the next page

Question 16 · continued

0 7 . 3 The alpha particle scattering experiment led to the plum pudding model of the atom being replaced by the nuclear model.

Figure 11 shows the results predicted by the plum pudding model and the actual results from the alpha particle scattering experiment.

Figure 11



6.4.2.1 Radioactive decay and nuclear radiation

Question 16 · continued

Describe how the actual results led to the plum pudding model of the atom being replaced by the nuclear model.

You should include details of the plum pudding model and the nuclear model of the atom.

[6 marks]

0 7 . 4 Scientists did not know that neutrons existed when they first did alpha particle scattering experiments.

Which scientist did the experiments that provided evidence that neutrons exist?

[1 mark]

Tick (✓) **one** box.

Isaac Newton ☐

James Chadwick ☐

Niels Bohr ☐

9

6.4.2.1 Radioactive decay and nuclear radiation

Question 17

June 2025 | 8464/P/1F | Original Q1

0 1 There are different isotopes of the element lead.

0 1 . 1 What is the difference between the atoms of different isotopes of lead?

[1 mark]

Tick (✓) **one** box.

- The number of electrons ☐
- The number of neutrons ☐
- The number of protons ☐

0 1 . 2 The isotope lead-210 is radioactive.

What is meant by 'lead-210 is radioactive'?

[1 mark]

Tick (✓) **one** box.

- Lead-210 forms many different compounds. ☐
- Lead-210 has unstable nuclei. ☐
- Lead-210 melts at a low temperature. ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 17 · continued

June 2025 | 8464/P/1F | Original Q1

0 1 . 3 The isotope lead-210 emits beta radiation.

What is beta radiation?

[1 mark]

Tick (✓) **one** box.

- Electromagnetic radiation emitted from nuclei ☐
- High speed electrons ejected from nuclei ☐
- Particles that consist of two neutrons and two protons ☐

Question 1 continues on the next page

6.4.2.1 Radioactive decay and nuclear radiation

Question 17 · continued

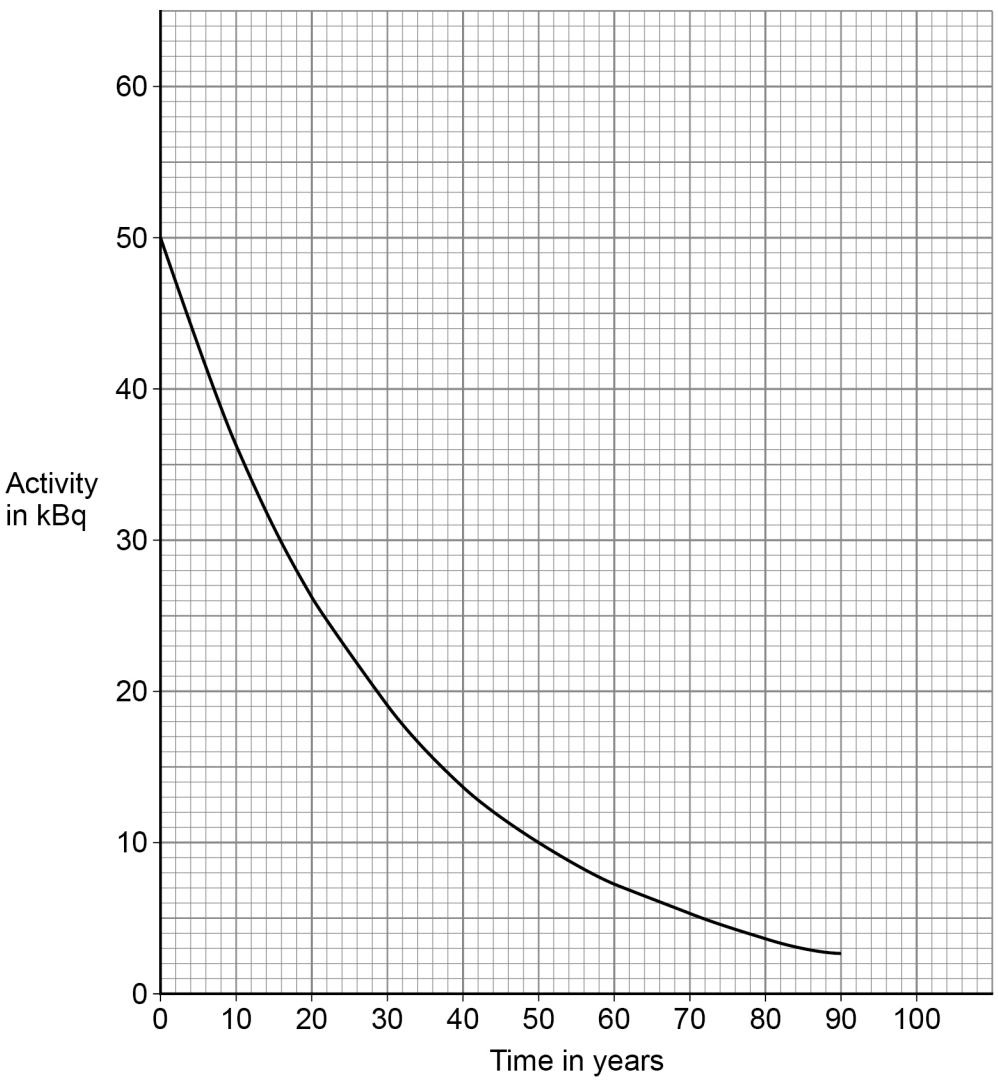
June 2025 | 8464/P/1F | Original Q1

The paint in an old painting contains the isotope lead-210.

The lead-210 in the paint can be used to estimate the age of the painting.

Figure 1 shows how the activity of the lead-210 in the paint changes with time.

Figure 1



0 1 . 4 What was the initial activity of the lead-210 in the paint?

Use **Figure 1**.

[1 mark]

Activity = _____ kBq

6.4.2.1 Radioactive decay and nuclear radiation

Question 17 · continued

0 1 . 5 Calculate the activity of the lead-210 in the paint after one half-life.

[1 mark]

Activity = _____ kBq

0 1 . 6 What was the estimated age of the painting when the activity was 10 kBq?

Use **Figure 1**.

[1 mark]

Age = _____ years

The paint also contains other radioactive substances.

0 1 . 7 A scientist removed the other radioactive substances before measuring the activity.

The activity would be greater if the other radioactive substances were **not** removed.

How would the estimate of the age of the painting be different if the activity was greater?

Use **Figure 1**.

[1 mark]

Tick (✓) **one** box.

The estimated age would be lower ☐

The estimated age would be the same ☐

The estimated age would be greater ☐

6.4.2.1 Radioactive decay and nuclear radiation

Question 17 · continued

The other radioactive substances in the paint emit different types of radiation.

0 1 . 8 Complete the sentence.

Choose the answer from the box.

[1 mark]

alpha	**beta**	**gamma**

The type of radiation with the greatest range in air is _____.

0 1 . 9 Complete the sentence.

Choose the answer from the box.

[1 mark]

alpha	**beta**	**gamma**

The type of radiation that is the least penetrating is _____.

9