AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.1.2

Mass number, atomic number and isotopes

Past-paper questions

Tier	**Foundation**
Question groups	**7**
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.

6.4.1.2 Mass number, atomic number and isotopes

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

Question 01 · continued

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

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6.4.1.2 Mass number, atomic number and isotopes

Question 02

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

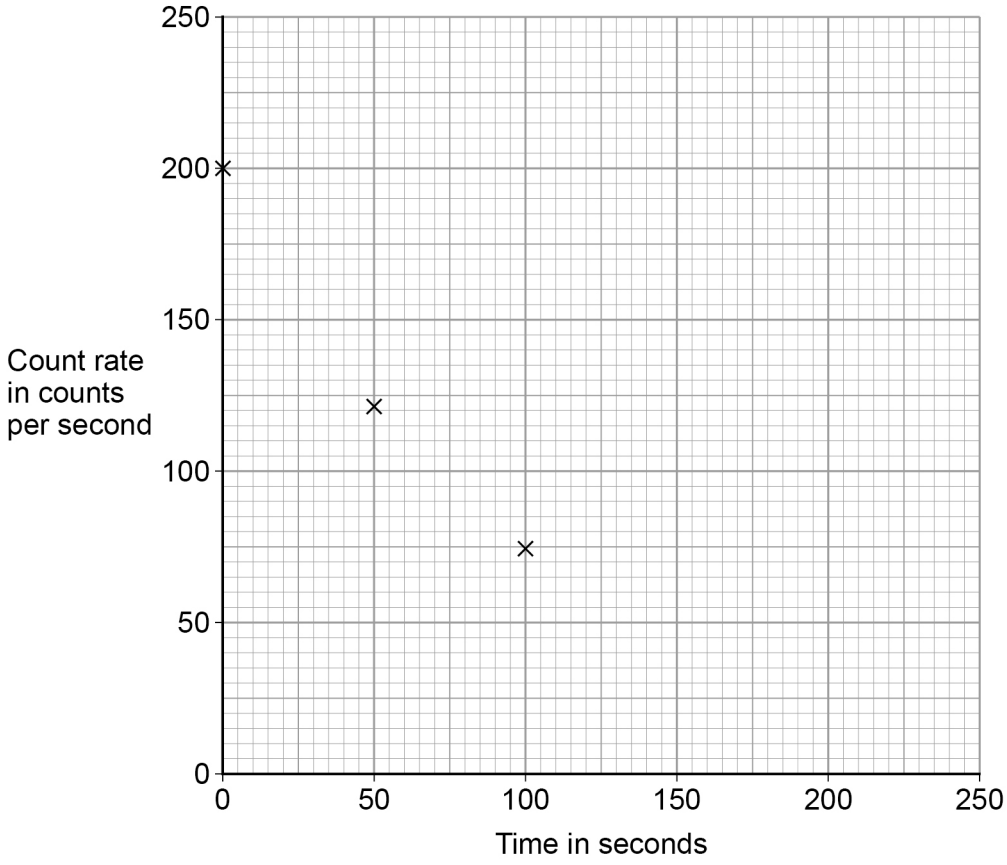
Time in seconds	Count rate in counts per second
0	200
50	122
100	74
150	45
200	27

6.4.1.2 Mass number, atomic number and isotopes

Question 02 · 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

6.4.1.2 Mass number, atomic number and isotopes

Question 02 · 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]

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6.4.1.2 Mass number, atomic number and isotopes

Question 03

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

6.4.1.2 Mass number, atomic number and isotopes

Question 03 · continued

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 ☐

6.4.1.2 Mass number, atomic number and isotopes

Question 03 · continued

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

[6 marks]

11

6.4.1.2 Mass number, atomic number and isotopes

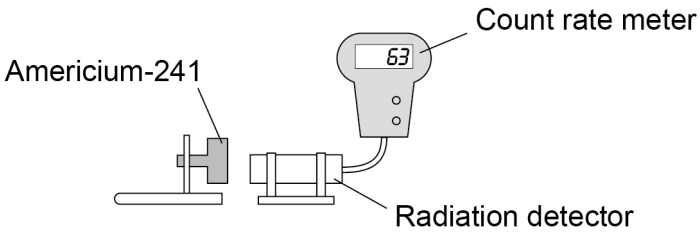
Question 04

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 ☐

Question 04 · 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

Question 04 · 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]

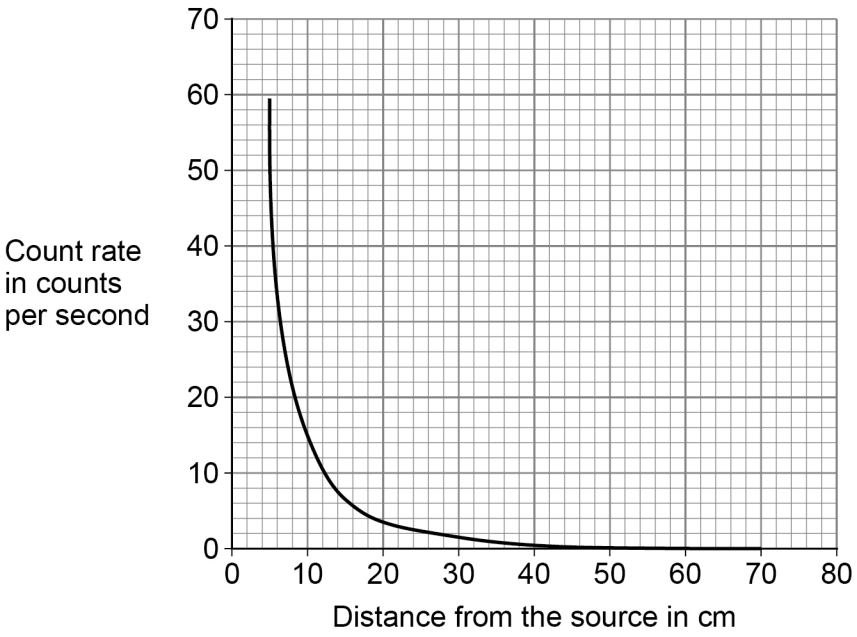
Type of variable	Description
	Count rate
Control variable	
	Distance between the source and detector
Dependent variable	
	Radioactive source
Independent variable	
	Time

6.4.1.2 Mass number, atomic number and isotopes

Question 04 · 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

6.4.1.2 Mass number, atomic number and isotopes

Question 05

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 ☐

6.4.1.2 Mass number, atomic number and isotopes

Question 05 · continued

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.

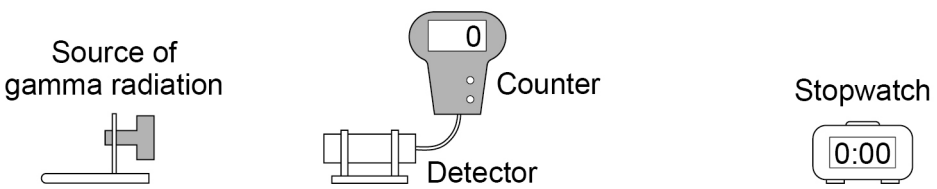
Question 1 continues on the next page

Question 05 · 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

6.4.1.2 Mass number, atomic number and isotopes

Question 05 · 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

Question 05 · 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]

_____

_____

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6.4.1.2 Mass number, atomic number and isotopes

Question 06

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.

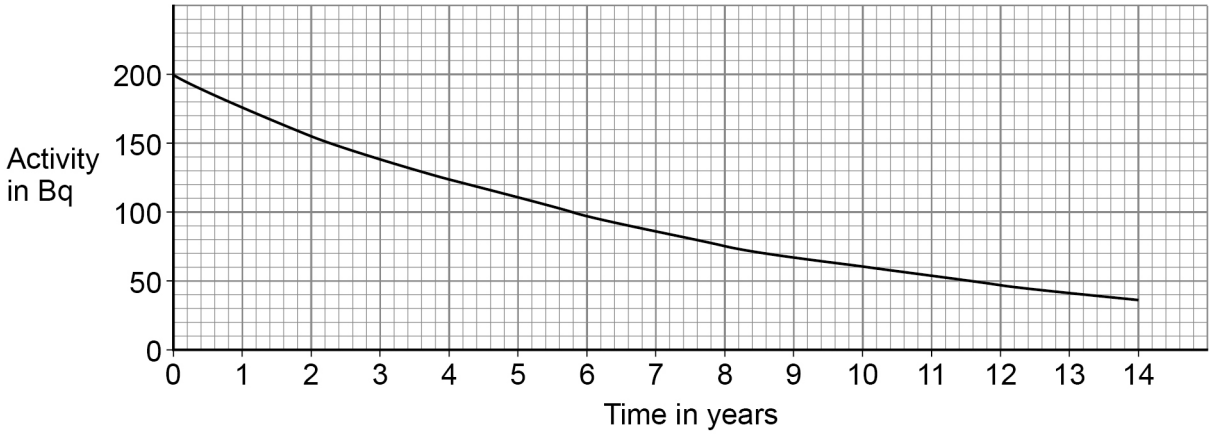
- Radium-228 atoms have one more neutron and one more proton. ☐
- Radium-228 atoms have two more neutrons and two more protons. ☐
- Radium-228 atoms have two more neutrons. ☐
- Radium-228 atoms have two more protons. ☐

6.4.1.2 Mass number, atomic number and isotopes

Question 06 · 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

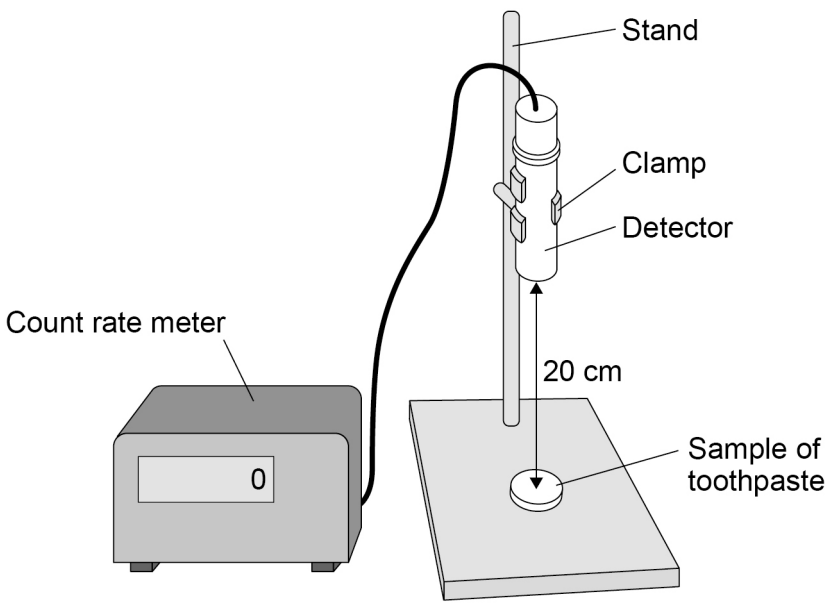
6.4.1.2 Mass number, atomic number and isotopes

Question 06 · 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

6.4.1.2 Mass number, atomic number and isotopes

Question 06 · 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. ☐

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6.4.1.2 Mass number, atomic number and isotopes

Question 07

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. ☐

6.4.1.2 Mass number, atomic number and isotopes

Question 07 · continued

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

6.4.1.2 Mass number, atomic number and isotopes

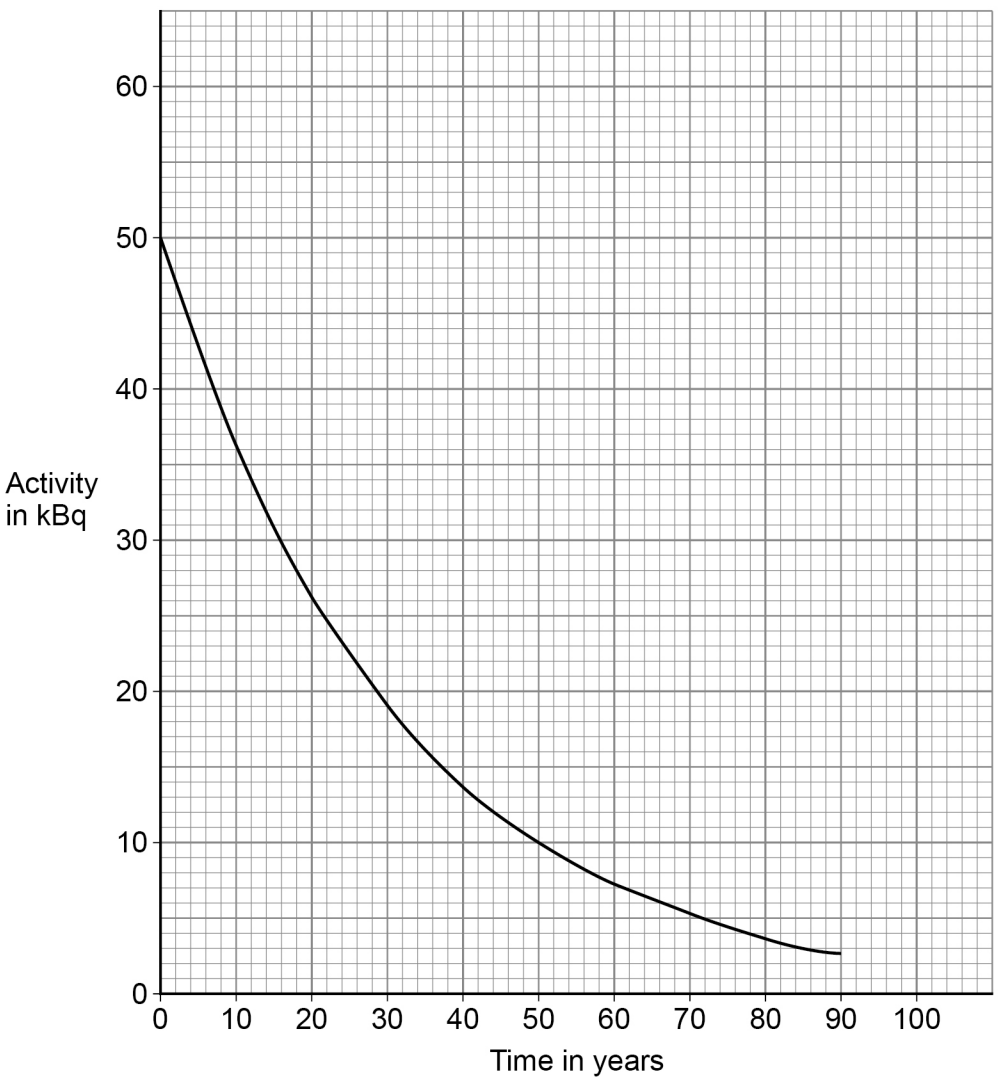
Question 07 · continued

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

Question 07 · 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 ☐

6.4.1.2 Mass number, atomic number and isotopes

Question 07 · 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