AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.2.3

Half-lives and the random nature of radioactive decay

Past-paper questions

Tier	**Foundation**
Question groups	**4**
Available paper years	**2019–2025**

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.

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 01

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

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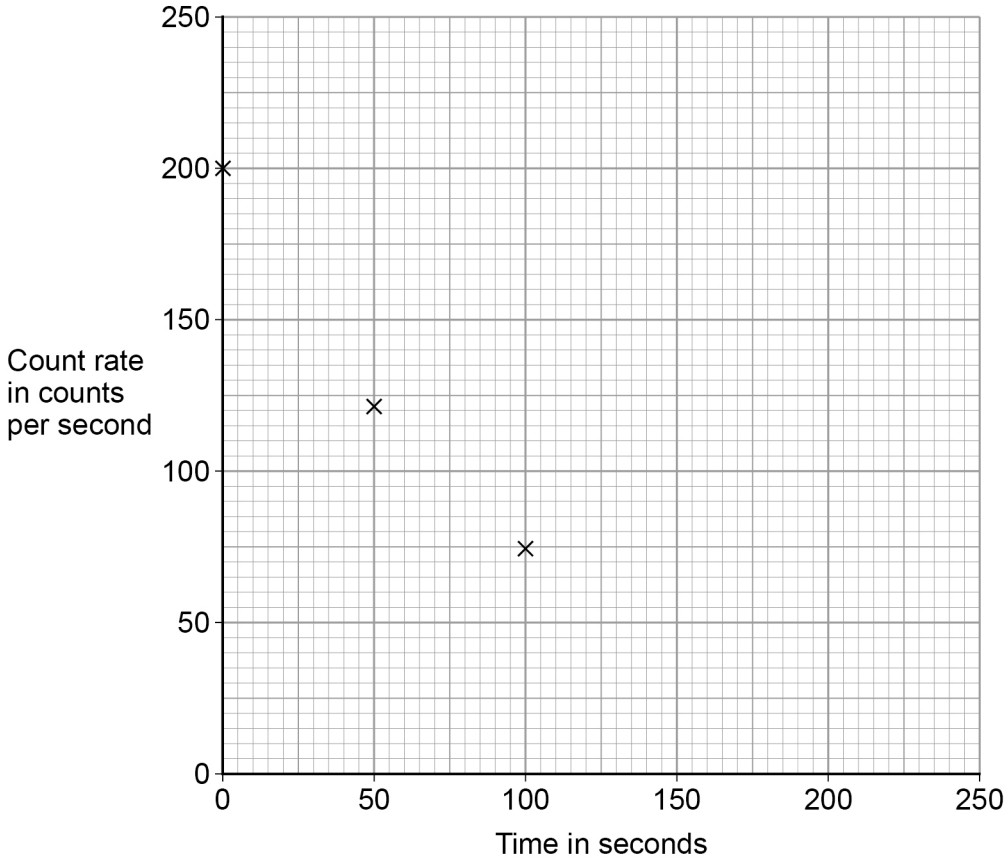
Question 01 · continued

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

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Question 01 · continued

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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6.4.2.3 Half-lives and the random nature of radioactive decay

Question 02

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]

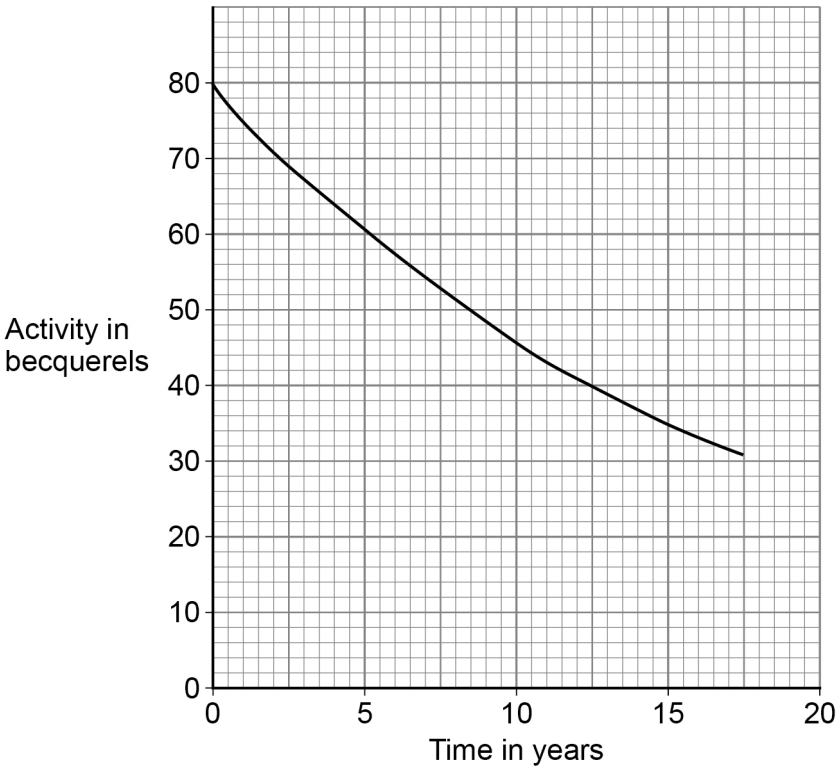
contamination	**irradiation**	**ionisation**	**decay**

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



6.4.2.3 Half-lives and the random nature of radioactive decay

Question 02 · 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 02 · 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. ☐

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 02 · 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 ☐

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Turn over for the next question

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 03

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.

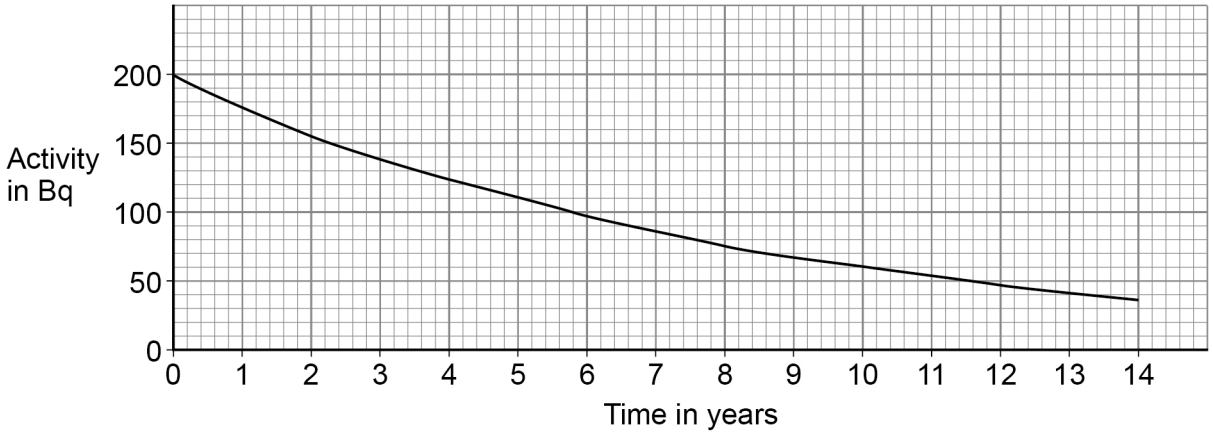
- Radium-228 atoms have one more neutron and one more proton. ☐
- Radium-228 atoms have two more neutrons and two more protons. ☐
- Radium-228 atoms have two more neutrons. ☐
- Radium-228 atoms have two more protons. ☐

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 03 · 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 ☐

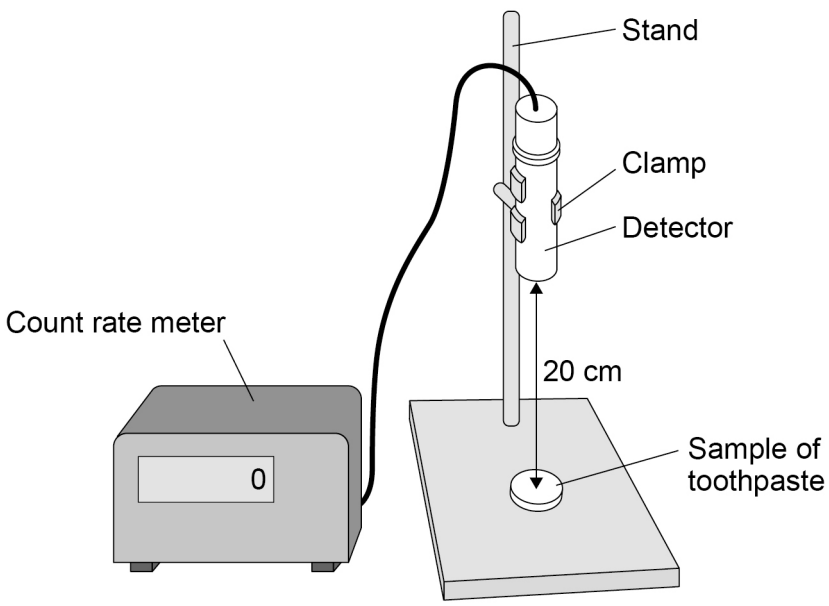
100 years ☐

Question 3 continues on the next page

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

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 03 · 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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6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04

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. ☐

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · 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

6.4.2.3 Half-lives and the random nature of radioactive decay

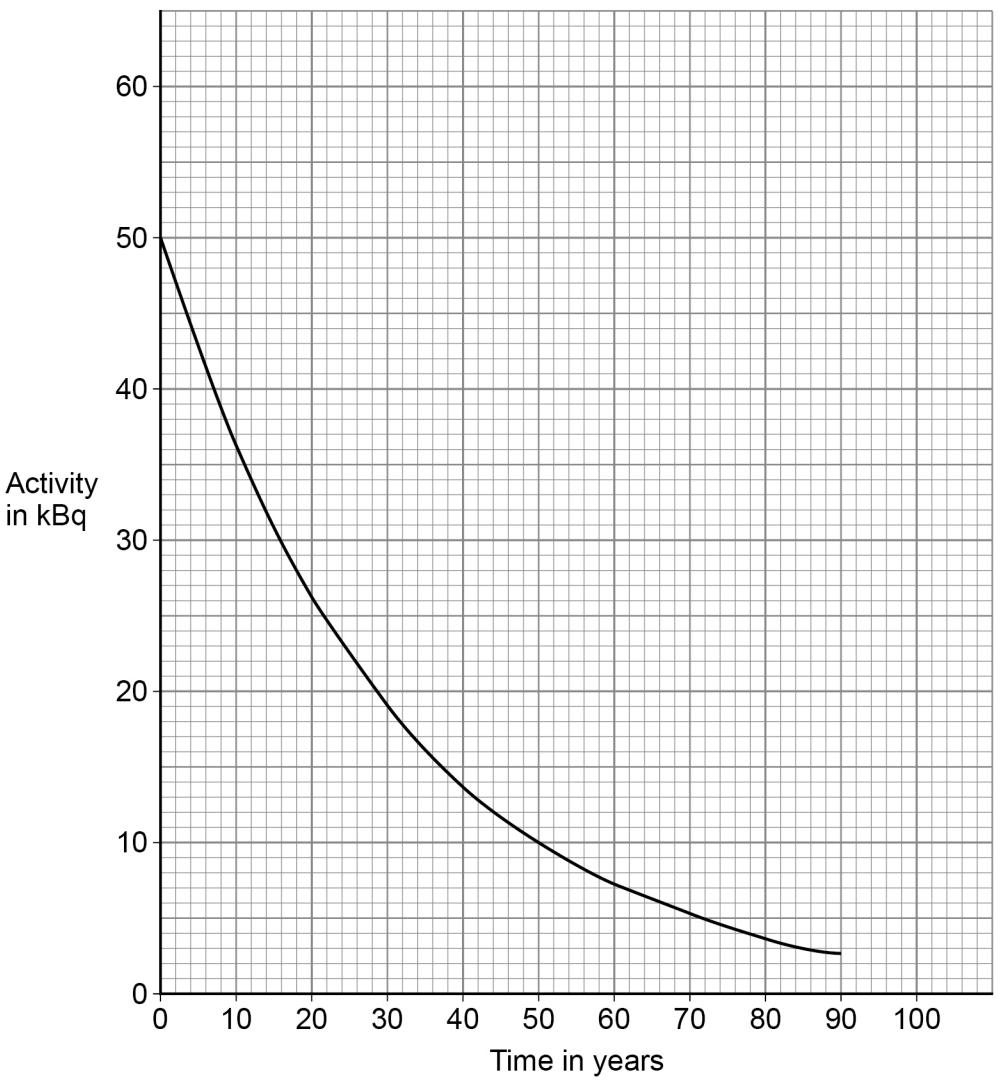
Question 04 · continued

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

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · 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 ☐

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · 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 _____.

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