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	**Higher**
Question groups	**6**
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.

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 01

June 2018 | 8464/P/1H | Original Q4

0 4 The Chernobyl disaster was a nuclear accident that happened in 1986

Radioactive isotopes were released into the environment.

The radioactive isotopes emitted alpha, beta and gamma radiation.

0 4 . 1 What is an alpha particle?

[1 mark]

Tick **one** box.

- 2 charged particles and 2 neutral particles. ☐
- 2 charged particles and 4 neutral particles. ☐
- 4 charged particles and 2 neutral particles. ☐
- 4 charged particles and 4 neutral particles. ☐

0 4 . 2 Which statement about beta radiation is true?

[1 mark]

Tick **one** box.

- It is the fastest moving type of radiation. ☐
- It is the type of radiation with a negative charge. ☐
- It is the type of radiation with the greatest mass. ☐
- It is the type of radiation with the greatest range in air. ☐

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 01 · continued

0 4 . 3 Which statement about gamma radiation is true?

[1 mark]

Tick **one** box.

It is a low frequency electromagnetic wave. ☐

It causes the charge of the nucleus to change. ☐

It causes the mass of the nucleus to change. ☐

It has a very long range in air. ☐

Question 4 continues on the next page

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 01 · continued

Table 3 shows the half-lives of two of the radioactive isotopes that contaminated the environment.

Table 3

Isotope	Half-life
Caesium–137	30 years
Iodine–131	8 days

0 4 . 4 A soil sample was taken from the area around Chernobyl in 1986

The soil sample was contaminated with equal amounts of caesium–137 and iodine–131

Explain how the risk linked to each isotope has changed between 1986 and 2018

Both isotopes emit the same type of radiation.

[4 marks]

0 4 . 5 Determine the year when the activity of the caesium–137 in the soil sample will be 1/32 of its original value.

[3 marks]

Year = _____

10

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 02

June 2019 | 8464/P/1H | Original Q6

0 6 Lanthanum-140 is a radioactive isotope.

0 6 . 1 A nucleus of lanthanum-140 emits gamma radiation.

What happens to the mass number and the charge of the nucleus when gamma radiation is emitted?

[1 mark]

Tick (✓) **one** box.

Mass number	Charge	
Decreases	Decreases	☐
Decreases	Stays the same	☐
Stays the same	Decreases	☐
Stays the same	Stays the same	☐

0 6 . 2 Why is it difficult to detect gamma radiation?

[1 mark]

Question 6 continues on the next page

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 02 · continued

0 6 . 3 Activity is the rate at which a radioactive source decays.

A teacher measured the count-rate from a sample of lanthanum-140 using a Geiger-Muller (G-M) tube.

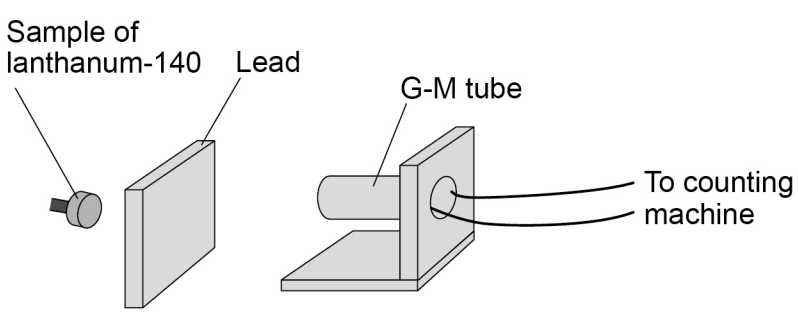
Explain why the count rate was less than the activity of the sample of lanthanum-140

[2 marks]

The teacher investigated how the thickness of lead affected the amount of gamma radiation that could pass through it.

Figure 6 shows the apparatus.

Figure 6



0 6 . 4 Explain why the teacher stood as far away from the apparatus as possible.

[2 marks]

Question 02 · continued

Table 1 shows the results.

Table 1

Thickness of lead in cm	Count rate in counts per second
0.5	110
1.0	60
1.5	33
2.0	18
2.5	10

0 6 . 5 The teacher concluded that the count rate was **not** inversely proportional to the thickness of lead.

Explain why the teacher was correct.

Use the data in **Table 1**.

[3 marks]

0 6 . 6 Lanthanum-140 can also emit beta radiation and change into cerium.

Complete the equation showing the decay of lanthanum (La) 140 into cerium (Ce).

[2 marks]

$$^{140}_{57}\mathrm{La} \longrightarrow {}^{\quad}_{\quad}\mathrm{e} + {}^{\quad}_{\quad}\mathrm{Ce}$$

Question 02 · continued

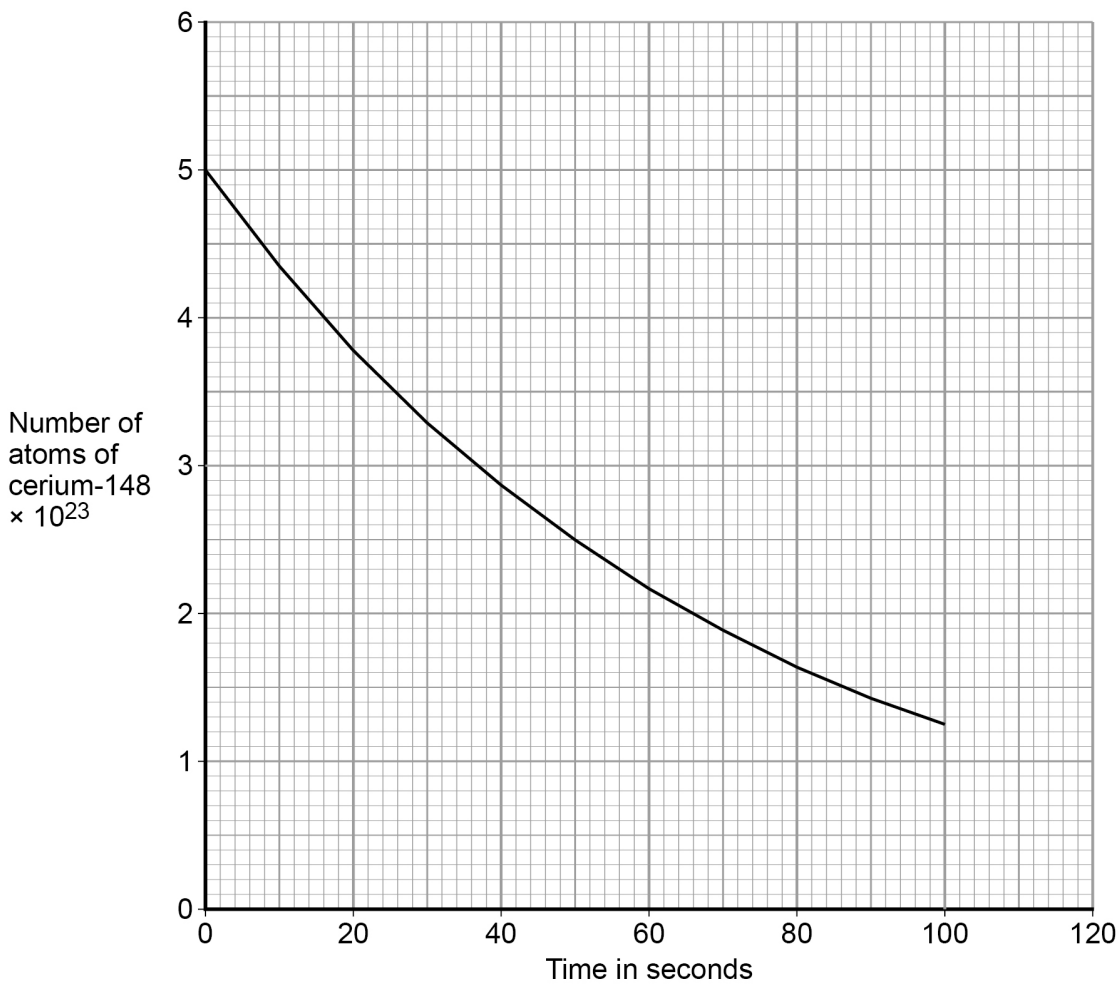
There are other isotopes of cerium which are radioactive.

Different isotopes of cerium have different half-lives.

The half-life of an isotope can be found by studying how the number of atoms changes over time.

Figure 7 shows how the number of atoms of cerium-148 in a 120 g sample changes over time.

Figure 7



6.4.2.3 Half-lives and the random nature of radioactive decay

Question 02 · continued

0 6 . 7 Determine the ratio of the number of cerium atoms in the sample when it was 100 seconds old compared with when the sample was 350 seconds old.

Use data from **Figure 7**.

[4 marks]

Ratio = _____

0 6 . 8 Determine the activity of the sample of cerium when the sample was 20 seconds old.

Use **Figure 7**.

[3 marks]

Activity = _____ Bq

18

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 03

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

0 6 A student modelled radioactive decay by rolling some dice in a tray.

Dice that landed on the number six were removed from the tray.

The removed dice represent nuclei that have decayed.

0 6 . 1 Why is rolling dice a suitable model for radioactive decay?

[1 mark]

0 6 . 2 The student rolled 144 dice and removed all those that landed on the number six.

The student rolled the remaining dice and again removed all those that landed on the number six.

When the student had rolled the dice 20 times there were 9 dice left.

Calculate the most likely number of times that the student had rolled the dice before the number of dice had halved.

You should show how you work out your answer.

[3 marks]

Answer = _____ rolls of the dice

Question 03 · continued

0 6 . 3 The number of times the dice have to be rolled to halve the original number of dice in the tray represents the half-life.

Figure 7 shows an eight-sided dice and a six-sided dice.

Figure 7



The student now used eight-sided dice to model radioactive decay. Dice that landed on the number six were again removed from the tray.

The half-life represented by rolling eight-sided dice is likely to be different from the half-life represented by rolling six-sided dice.

Explain how.

[2 marks]

0 6 . 4 A teacher has two radioactive sources, **A** and **B**.

Source **A** has a longer half-life than source **B**.

What can be deduced about the nuclei in source **A** compared with the nuclei in source **B**?

Do **not** refer to isotopes in your answer.

[1 mark]

7

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04

June 2023 | 8464/P/1H | Original Q4

0 4 A scientist investigated a sample of a radioactive material to determine if it would be suitable for medical use.

0 4 . 1 The method, results and conclusions of the scientist will need to be checked by other scientists before the results of the investigation are published.

What name is given to this checking process?

[1 mark]

0 4 . 2 There is an increased risk of cancer if the scientist is irradiated by nuclear radiation.

What property of nuclear radiation causes the increased risk of cancer?

[1 mark]

0 4 . 3 The activity of a radioactive source is the rate at which the nuclei of the source decay.

What is the unit for the activity of a radioactive source?

[1 mark]

0 4 . 4 The scientist placed a radiation detector near the sample and measured the count-rate.

Explain why the count-rate is less than the activity of the sample.

[2 marks]

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · continued

0 4 . 5 The scientist recorded the count-rate from the sample with the radiation detector at different distances from the sample.

Table 2 shows the results.

Table 2

Distance between the sample and the detector in centimetres	Count-rate in counts/second
2.0	300
5.0	24
10.0	0

Explain which type of radiation was emitted by the sample.

[2 marks]

Question 4 continues on the next page

Question 04 · continued

0 4 . 6 The scientist moved the detector closer to the sample and started a stopwatch.

The scientist measured the count-rate from the sample at different times.

Table 3 shows some of the results.

Table 3

Time in minutes	Count-rate in counts/second
0	1568
30	**X**
60	98

The scientist realised that 30 minutes is a whole number of half-lives.

Calculate the value of **X** in **Table 3**.

[3 marks]

X = _____ counts/second

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 04 · continued

0 4 . 7 The scientist had a second sample of the radioactive material.

The scientist made appropriate measurements, then calculated the half-life of each sample.

Why was the half-life calculated from the second sample slightly different from the half-life calculated from the first sample?

[1 mark]

Tick (✓) **one** box.

Radioactive decay is a random process. ☐

The count-rate from a radioactive sample is predictable. ☐

The samples were at different temperatures. ☐

The size of each sample was different. ☐

11

Turn over for the next question

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 05

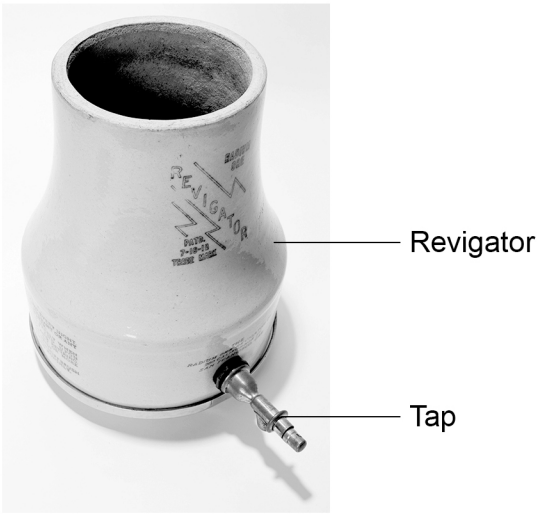
0 5 Some people used to think that radioactive substances had health benefits.

In the 1920s, a water container called a revigator was sold.

The walls of a revigator contain radioactive isotopes.

Figure 6 shows a revigator.

Figure 6



The revigator was filled with water and left overnight.

People then drank the water from the revigator.

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 05 · continued

0 5 . 1 The water was irradiated and contaminated by the radioactive isotopes in the walls of the revigator.

Explain how irradiating and contaminating the water affected the hazard caused by drinking the water.

[4 marks]

Irradiating _____

_____

_____

_____

Contaminating _____

_____

_____

_____

Question 5 continues on the next page

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 05 · continued

A scientist tested some water that had been left in a revigator.

The water contained radon-222 and vanadium-52.

0 5 . 2 Vanadium-52 (V) decays by emitting beta particles.

What is the correct nuclear equation for this process?

[1 mark]

Tick (✓) **one** box.

$^{52}_{23}V - {}^{0}_{-1}\beta \rightarrow {}^{52}_{22}Ti$ ☐

$^{52}_{23}V - {}^{0}_{-1}\beta \rightarrow {}^{52}_{24}Cr$ ☐

$^{52}_{23}V \rightarrow {}^{52}_{22}Ti + {}^{0}_{-1}\beta$ ☐

$^{52}_{23}V \rightarrow {}^{52}_{24}Cr + {}^{0}_{-1}\beta$ ☐

Question 05 · continued

0 5 . 3 **Table 2** shows the half-lives of radon-222 and vanadium-52.

Table 2

Isotope	Half-life
Radon-222	3.8 days
Vanadium-52	3.7 minutes

The scientist measured the radiation emitted by a sample of radon-222 and the radiation emitted by a sample of vanadium-52.

The scientist repeated the measurements 7.4 minutes later.

Explain how the activity of the radon-222 and vanadium-52 had changed after 7.4 minutes.

[4 marks]

Radon-222 _____

_____

_____

_____

Vanadium-52 _____

_____

_____

_____

0 5 . 4 Scientists monitored the effects of drinking the water from a revigator.

Their methods and results were checked by other scientists.

What name is given to the process of other scientists checking work before it is published?

[1 mark]

_____

10

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 06

June 2025 | 8464/P/1H | Original Q4

0 4 Three types of radiation emitted by unstable nuclei are:

- alpha particle
- beta particle
- gamma ray.

0 4 . 1 Describe each type of radiation.

[3 marks]

Alpha particle _____

_____

Beta particle _____

_____

Gamma ray _____

_____

0 4 . 2 The radioactive isotope gold-198 (Au) decays to mercury (Hg) by emitting beta radiation.

Complete the nuclear equation for the decay of gold-198.

[2 marks]

$$^{198}_{79}\text{Au} \rightarrow \ ^{\quad}_{\quad}\text{Hg} + \ ^{\quad}_{\quad}\beta$$

Question 4 continues on the next page

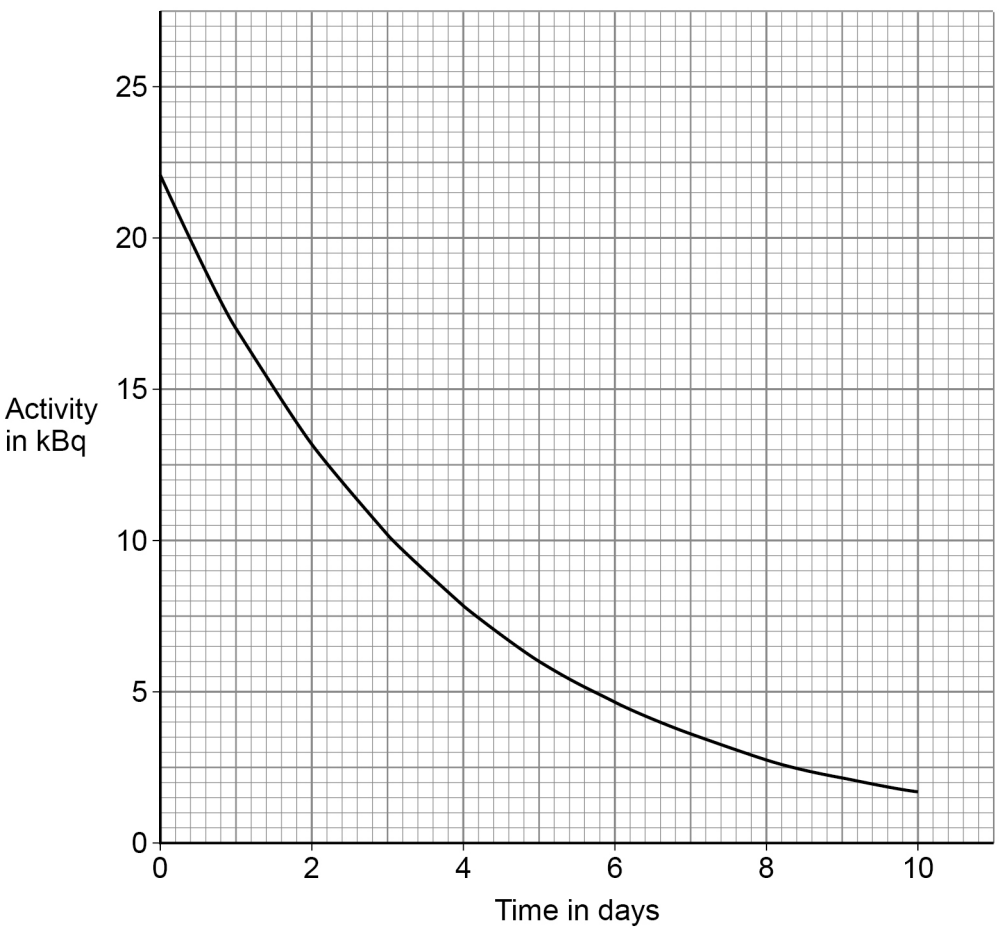
Question 06 · continued

Gold-198 is used in the treatment of cancer.

A small sample containing gold-198 is surgically implanted into a patient, very near to the cancer cells.

Figure 4 shows how the activity of the sample changes after it has been implanted.

Figure 4



0 4 . 3 Determine the half-life of gold-198.

[2 marks]

Half-life = _____ days

6.4.2.3 Half-lives and the random nature of radioactive decay

Question 06 · continued

0 4 . 4 Determine the percentage decrease in the activity at 5 days.

Give your answer to 2 significant figures.

[4 marks]

Percentage decrease (2 significant figures) = _____ %

0 4 . 5 The sample containing gold-198 is implanted very near to the cancer cells.

Give **two** reasons why.

[2 marks]

1 _____

2 _____

0 4 . 6 After treatment, the sample containing gold-198 is **not** removed from the patient.

Suggest why the sample is left in the patient and **not** removed.

[1 mark]

_____

14