

GCSE Combined Science: Trilogy

Worksheet: Half-lives and the random nature of radioactive decay

TIME 30 min	TOTAL 30 marks	CALCULATOR Allowed	DIFFICULTY Easy, Medium
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Topics: Half-lives and the random nature of radioactive decay

NAME _____	CLASS _____	DATE _____
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- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Answer all questions in the spaces provided.
- In all calculations, show clearly how you work out your answer.
- The marks for questions are shown in brackets.

0 1

A sample of a tracer used to study how plants take up fertiliser has an activity of 480 kBq. Its half-life is 8 days.

0 1 . 1 Calculate its activity after 8 days.

.....

.....

.....

.....

Activity = kBq

[2 marks]

0 2

0 2 . 1

What is meant by the half-life of a radioactive isotope?

Tick (✓) **one** box.

The time it takes for the number of unstable nuclei in a sample to halve

☐

Half of the time it takes for all the nuclei in a sample to decay

☐

The time it takes for the mass number of a nucleus to halve

☐

The time it takes for a nucleus to lose half of its protons

☐

[1 mark]

0 2 . 2

A sample of a radioactive isotope has an activity of 800 Bq. The half-life of the isotope is 2 days.

What is the activity of the sample after 2 days?

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.....

.....

Activity = Bq

[1 mark]

0 2 . 3

What is the activity of the sample after 6 days?

.....

.....

.....

Activity = Bq

[1 mark]

0 2 . 4

Radioactive decay is random. What does this mean?

.....

.....

[1 mark]

0 3

0 3 . 1

State **two** quantities, other than activity, that halve after one half-life.

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.....

.....

[2 marks]

0 4

A dose of a medical tracer has an activity of 640 MBq. Its half-life is 3 hours.

0 4 . 1

Calculate its activity after 9 hours.

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.....

.....

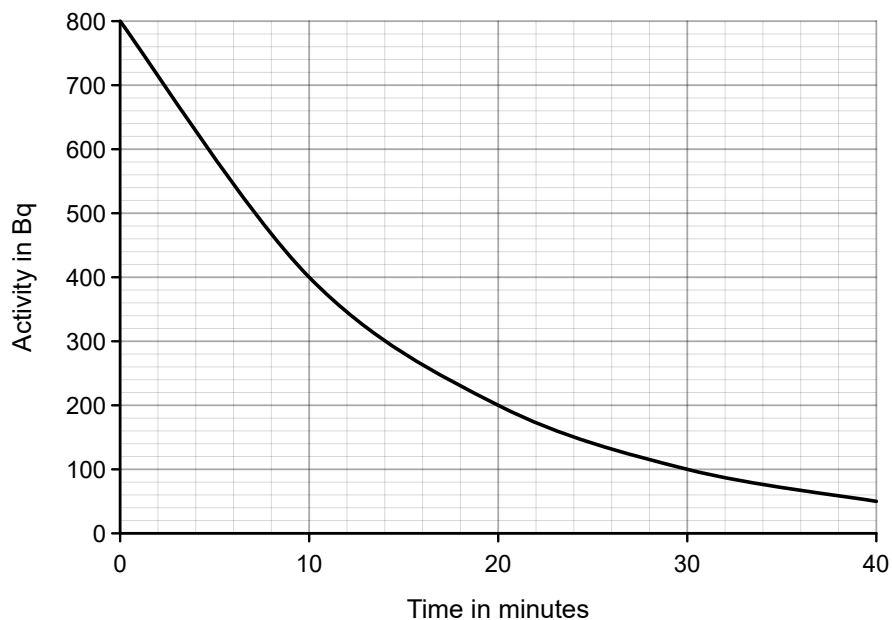
Activity = MBq

[2 marks]

0 5

Figure 1 shows a decay curve for a sample of a radioactive isotope, starting with an activity of 800 Bq.

Figure 1



0 5 . 1

Use Figure 1 to find the half-life of the isotope. Draw suitable construction lines on the graph to show your method.

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.....

Half-life = minutes

[3 marks]

0 6

A student used a Geiger–Müller tube to measure the count rate from a radioactive source every 10 minutes. The background count rate was 30 counts per minute. Table 1 shows the results.

Table 1

Time in minutes	Count rate in counts per minute	Count rate corrected for background in counts per minute
0	830	800
10	608	A
20	423	393
30	319	289
40	227	197

0 6 . 1

Calculate the value of A in Table 1.

.....

.....

.....

A = counts per minute

[1 mark]

0 6 . 2

Use Table 1 to determine the half-life of the source. Explain how you used the data.

.....

.....

.....

.....

[2 marks]

0 6 . 3

Explain why the student subtracted the background count rate before finding the half-life.

.....

.....

.....

.....

[2 marks]

0 6 . 4

The corrected count rates in Table 1 do not lie exactly on a smooth curve. Suggest why.

.....

.....

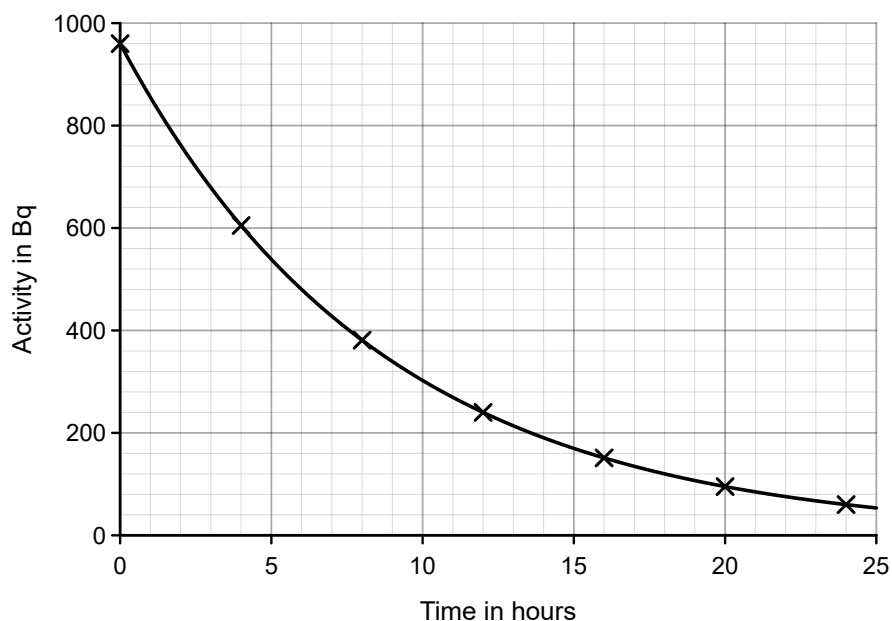
[1 mark]

.....

0 7

Figure 2 shows how the activity of a sample of a radioactive isotope changes with time.

Figure 2



0 7 . 1

Use Figure 2 to determine the half-life of the isotope.

.....

.....

.....

.....

Half-life = hours

[2 marks]

0 7 . 2

Predict the activity of the sample after 30 hours.

.....

.....

.....

.....

Activity = Bq

[2 marks]

0 7 . 3

Explain why the activity of the sample decreases with time.

.....

.....

[1 mark]

0 8

0 8 . 1

After 3 half-lives, the activity of a radioactive sample is 15 Bq.
Calculate its initial activity.

.....

.....

.....

.....

Initial activity = Bq

[3 marks]

0 9

A sample of radioactive waste from a hospital has a half-life of 4 days. After 12 days, its activity is 40 MBq.

0 9 . 1

Calculate the initial activity.

.....

.....

.....

.....

Initial activity = MBq

[3 marks]

END OF QUESTIONS

Mark scheme

GCSE Combined Science: Trilogy · Worksheet: Half-lives and the random nature of radioactive decay · 30 marks

Question 1 (2 marks)

01.1 [2 marks]

Answer: 240 kBq

- 8 days = 1 half-life (1)
 - activity = $480 \div 2 = 240$ (kBq) (1)
-

Question 2 (4 marks)

02.1 [1 mark]

Correct: The time it takes for the number of unstable nuclei in a sample to halve

02.2 [1 mark]

Answer: 400 Bq

- 400 (Bq) (1)
-

02.3 [1 mark]

Answer: 100 Bq

- 100 (Bq) (1)
-

02.4 [1 mark]

Answer: You cannot predict when a particular nucleus will decay.

- it is not possible to predict which nucleus will decay next / when a particular nucleus will decay (1)
-

Question 3 (2 marks)

03.1 [2 marks]

Answer: Any two of: the number of undecayed nuclei, the count rate from the sample, the mass of the radioactive isotope remaining.

- the number of undecayed (unstable) nuclei of the isotope in the sample (1)
- the count rate from the sample (after subtracting background) (1)
- the mass of the radioactive isotope remaining (1)

Any 2 of the points above.

Question 4 (2 marks)

04.1 [2 marks]

Answer: 80 MBq

- 9 hours = 3 half-lives (1)
 - activity = $640 \div 8 = 80$ (MBq) (1)
-

Question 5 (3 marks)

05.1 [3 marks]

Answer: 10 minutes

- half of the initial activity = 400 (Bq) (1)
- construction lines drawn from 400 Bq across to the curve and then down to the time axis (1)
- half-life = 10 (minutes) (allow 9–11) (1)

Notes: Allow any other correct pair of values, e.g. 200 Bq to 100 Bq.

Question 6 (6 marks)

06.1 [1 mark]

Answer: 578

- $608 - 30 = 578$ (1)

06.2 [2 marks]

Answer: About 20 minutes: the corrected count rate roughly halves every 20 minutes ($800 \rightarrow 393$, $578 \rightarrow 289$, $393 \rightarrow 197$).

- the corrected count rate (about) halves in 20 minutes, e.g. from 800 to 393, from 578 to 289 or from 393 to 197 counts per minute (1)
- half-life = 20 minutes (allow 19–21) (1)

06.3 [2 marks]

Answer: Background does not decay with the source, so without subtracting it the count rate would not halve in one half-life and the half-life would come out too long.

- the background count rate does not come from the source / does not decrease with time (1)
- if it is not subtracted, the count rate does not halve in one half-life, so the half-life found would be too long (1)

06.4 [1 mark]

Answer: Radioactive decay is random.

- radioactive decay is random (1)
-

Question 7 (5 marks)

07.1 [2 marks]

Answer: 6 hours

- correct use of the graph, e.g. the activity falls from 960 Bq to 480 Bq (1)
- 6 (hours) (allow 5.7–6.3) (1)

07.2 [2 marks]

Answer: 30 Bq

- 30 hours = 5 half-lives (1)
- $960 \div 2^5 = 30$ (Bq) (1)

Notes: Allow ECF from the half-life found.

07.3 [1 mark]

Answer: There are fewer and fewer unstable nuclei left to decay.

- the number of unstable nuclei (left to decay) decreases (1)

Question 8 (3 marks)

08.1 [3 marks]

Answer: 120 Bq

- after 3 half-lives, activity = initial activity $\div 8$ (1)
- initial activity = 15×8 (1)
- 120 (Bq) (1)

Question 9 (3 marks)

09.1 [3 marks]

Answer: 320 MBq

- $12 \div 4 = 3$ half-lives (1)
 - initial activity = $40 \times 2^3 = 40 \times 8$ (1)
 - 320 (MBq) (1)
-