AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.2.3

Half-lives and the random nature of radioactive decay

Mark schemes and examiner comments

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

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

6.4.2.3 Half-lives and the random nature of radioactive decay

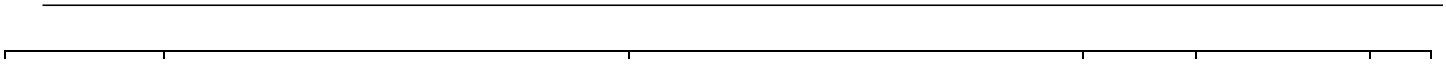
Answer 01 · Mark scheme June 2019 | 8464/P/1F | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
04.1	$^{234}_{91}Pa$		1	AO1/1 6.4.1.2	A
04.2	points correctly plotted to within 1 mm a curved line of best fit passing within 1 mm of all 5 points	 ignore any line beyond 200 seconds	1 1	AO2.2 6.4.2.3 WS 3.2	E
04.3	70 (s)	allow an answer between 65 and 75 (s) allow an answer consistent with their drawn line	1	AO2/2 6.4.2.3 WS 3.5	E
04.4	70 (s)	allow an answer between 65 and 75 (s) allow their answer to question **04.3**	1	AO3/2b 6.4.2.3	E
04.5	beta		1	AO1.1 6.4.2.1	A
04.6	articles in scientific journals are peer reviewed	allow articles in scientific journals are based on evidence/data allow newspaper articles may be oversimplified/inaccurate/biased	1	AO1.1 6.4.2.4 WS 1.6	E
Total			**7**		

6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 01 · Mark scheme

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



6.4.2.3 Half-lives and the random nature of radioactive decay

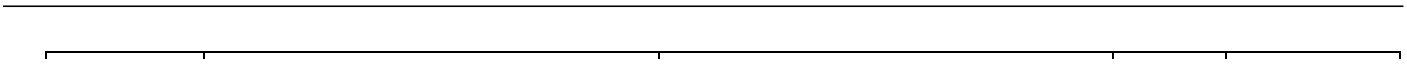
Answer 02 · Mark scheme November 2020 | 8464/P/1F | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	contamination		1	AO1 6.4.2.4
02.2	2007-1992 = 15 35 (Bq)	allow an indication of the student reading from 15 years on the graph allow an answer between 34 and 36 (Bq)	1 1	AO2 6.4.2.3
02.3	12.5 (years)		1	AO2 6.4.2.3
02.4	12.5 (years)	allow the same value as their answer to 02.3	1	AO1 6.4.2.3
02.5	$\frac{36\ 000\ 000\ 000}{45\ 000\ 000\ 000}$ (× 100) 80 (%)	allow $\frac{36}{45}$ (× 100)	1 1	AO2 6.4.2.3
02.6	radioactive decay is a random process		1	AO1 6.4.2.3
02.7	use long tongs to handle the materials		1	AO1 6.4.2.4
02.8	peer review		1	AO1 6.4.2.4
Total			**10**	

6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 02 · Mark scheme

November 2020 | 8464/P/1F | Original Q2



6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 03 · Mark scheme

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

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	radium-228 atoms have two more neutrons		1	AO1 6.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	6 years		1	AO2 6.4.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	decrease the distance between the toothpaste and the detector		1	AO3 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	2940 3180	answers may be in either order	1	AO3 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	the tube of toothpaste used		1	AO3 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	the activity of the toothpaste		1	AO3 6.4.2.1

6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.7	there is less risk		1	AO3 6.4.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.8	nuclear radiation is ionising		1	AO1 6.4.2.1 6.4.2.4

Total Question 3	**8**

6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 04 · Mark scheme June 2025 | 8464/P/1F | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	the number of neutrons		1	AO1 6.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	lead-210 has unstable nuclei		1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	high speed electrons ejected from nuclei		1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	50 (kBq)	allow an answer in the range 49 (kBq) to 50 (kBq)	1	AO2 6.4.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	25 (kBq)	allow ecf from question **01.4**	1	AO2 6.4.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	age = 50 (years)		1	AO3 6.4.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.7	the estimated age would be lower		1	AO3 6.4.2.1 6.4.2.3

6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.8	gamma		1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.9	alpha		1	AO1 6.4.2.1

Total Question 1	**9**

6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 01 · Examiner comments June 2019 | 8464/P/1F | Original Q4

Question 4

04.1 The content of this question is shared with the chemistry specification and was answered correctly by just over 35% of the students.

04.2 Almost 70% of students gained at least 1 mark and about a third of gained both marks. Points were often plotted within acceptable tolerances but the line – which should have been a smooth curve – was often drawn dot-to-dot or as a straight line.

04.3 Almost half of the students were able to read the time value correctly from their graphs. A value consistent with their line, or with a correct line of best fit, was acceptable.

04.4 Fewer than one in four students were able to associate the answer to the previous question with the half-life of the isotope.

04.5 Just under 40% of students knew that beta particles have a range of up to a metre.

04.6 This question produced a wide range of responses but only about 30% of students scored the mark. Students were expected to describe peer review but this was rarely seen. Acceptable alternatives about data or evidence in scientific journals, and newspaper articles being inaccurate or biased enabled more students to gain the mark. Many students simply stated that articles in scientific journals are written by scientists and articles in newspapers are not, that scientists know what they are talking about, or scientists are more reputable than journalists, but these responses were not sufficient for credit. There was also a misconception, which was less common, in which students appeared to misunderstand what a scientific journal is.

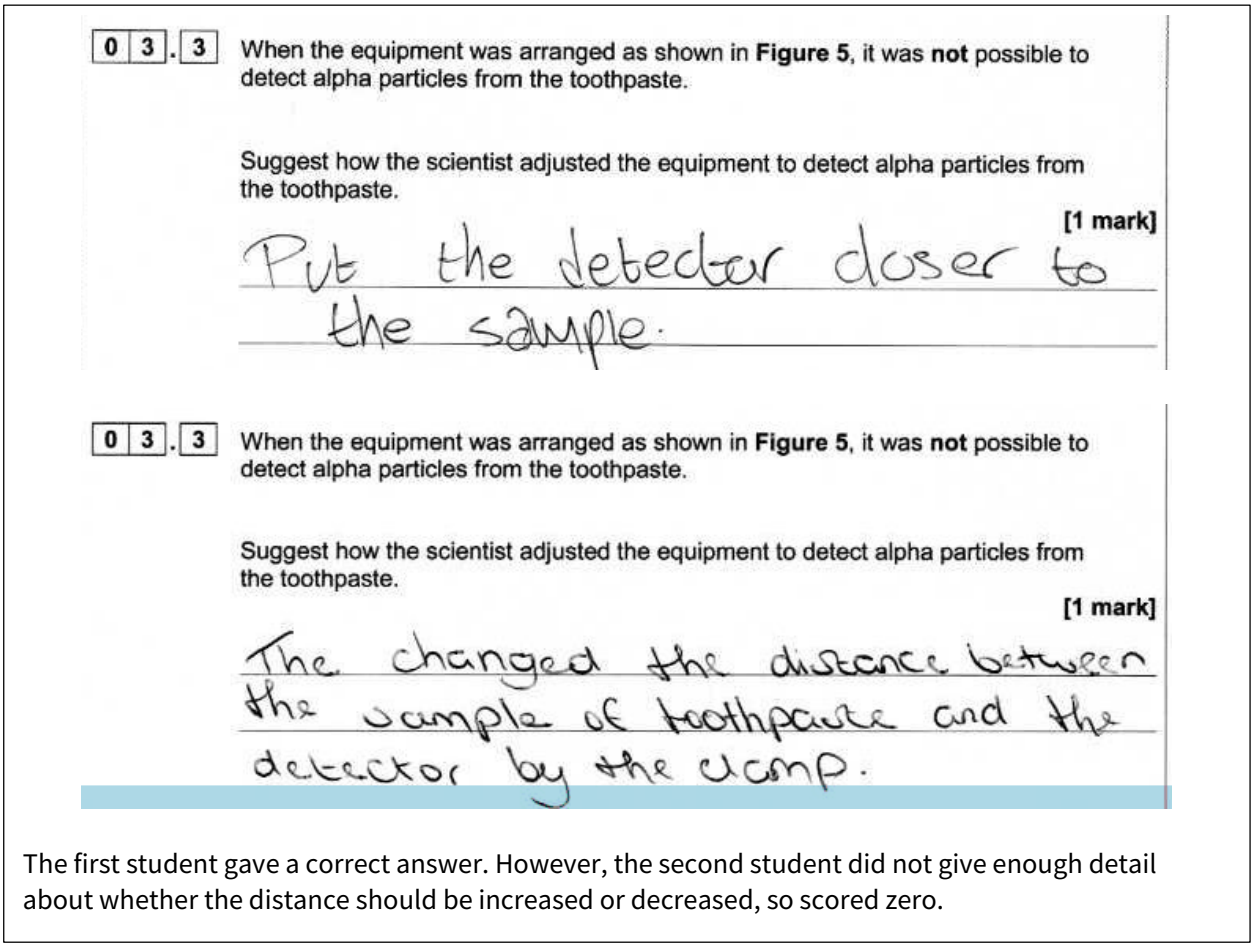
Question 3 (low demand)

03.1 The most common answer to this question was from students who incorrectly selected the second option (radium-228 atoms have two more protons than radium-226 atoms). Slightly over a third of students identified that the difference is only in the number of neutrons.

03.2 Only about 30% of students were able to identify the half-life from the graph. Over half of all students selected 7 years, half the maximum time shown on the *x*-axis of the graph.

03.3 This question was answered correctly by nearly 60% of students.

Incorrect answers that were relatively common included suggestions to use more toothpaste or to use a more sensitive detector. Some students showed a lack of familiarity with a Geiger-Muller tube, mistaking the detector for a microscope and leading to incorrect answers.



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]

Put the detector closer to the sample.

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]

The changed the distance between the sample of toothpaste and the detector by the clamp.

The first student gave a correct answer. However, the second student did not give enough detail about whether the distance should be increased or decreased, so scored zero.

03.4 Nearly three-quarters of all students gave the correct range.

03.5 Just over a third of students correctly identified the independent variable.

03.6 Slightly less than 40% of students correctly identified the dependent variable.

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6.4.2.3 Half-lives and the random nature of radioactive decay

Answer 03 · Examiner comments June 2024 | 8464/P/1F | Original Q3

03.7 Just under half of all students could identify how the level of risk changed.

It was reasonably common for students to describe what happened to the activity of the toothpaste rather than the risk. It was also common to state that there would be no risk, but this contradicted the results from the scientist's investigation so did not score. Descriptions of a reduction in the rate of emission of radiation were not enough to score a mark.

Some students misinterpreted the question and, instead of referring to the risk from the radioactive toothpaste, described the risk from toothpaste generally. Statements that referred to modern toothpaste being safer did not answer the question.

03.8 Nearly 40% of students correctly identified that the ionising nature of nuclear radiation makes it hazardous. About a third of students showed the misconception that nuclear radiation makes objects radioactive.

Answer 04 · Examiner comments June 2025 | 8464/P/1F | Original Q1

Question 1 (Low demand)

01.1 Approximately one third of students knew the difference between the atoms of different isotopes of lead.

01.2 Approximately two thirds of students knew what is meant by 'lead-210 is radioactive'.

01.3 Approximately one third of students knew what beta radiation is.

01.4 80% of students were able to read the initial activity correctly from the graph.

01.5 Just under 20% of students answered this question correctly. There was a very wide range of incorrect answers indicating that many students struggled to understand how to answer the question.

01.6 This question was well answered with a little over 50% giving the correct age of the painting.

01.7 Half of the students knew that the estimated age would be lower if the other radioactive substances were not removed.

01.8 60% of students correctly selected gamma as the type of radiation with the greatest range in air.

01.9 80% of students correctly selected alpha as the type of radiation that is the least penetrating.