AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.1.2

Mass number, atomic number and isotopes

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**7**
Available paper years	**2018–2025**

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.

6.4.1.2 Mass number, atomic number and isotopes

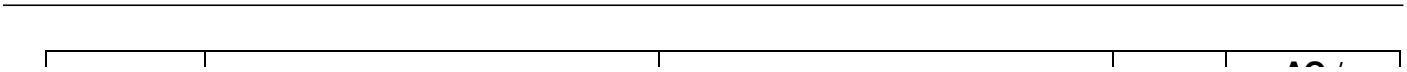
Answer 01 · Mark scheme June 2018 | 8464/P/1F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	gamma		1	AO1 6.4.2.1
05.2	alpha		1	AO1 6.4.2.1
05.3	gamma		1	AO1 6.4.2.1
05.4	<table><tr><th>isotope</th><th>number of neutrons</th><th>number of protons</th></tr><tr><td>uranium-238</td><td>146</td><td>**92**</td></tr><tr><td>thorium-234</td><td>**144**</td><td>90</td></tr></table>		1 1	AO2 6.4.1.2
05.5	$\Delta\theta = 80\ ^\circ C$ $E = 150 \times 4200 \times 80$ $E = 50\ 400\ 000$ (J)	an answer of 50 400 000 scores **3** marks allow 50 000 000 (J) allow **max 2** marks for correct calculation using incorrect value of $\Delta\theta$ allow **1** mark for correct calculation using $\theta = 20$ **or** $\theta = 100$	1 1 1	AO2 6.3.2.2
Total			**8**	

6.4.1.2 Mass number, atomic number and isotopes

Answer 01 · Mark scheme

June 2018 | 8464/P/1F | Original Q5



6.4.1.2 Mass number, atomic number and isotopes

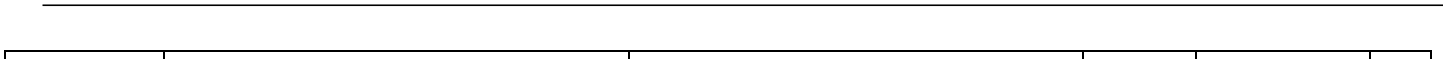
Answer 02 · Mark scheme June 2019 | 8464/P/1F | Original Q4

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**		

6.4.1.2 Mass number, atomic number and isotopes

Answer 02 · Mark scheme

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



6.4.1.2 Mass number, atomic number and isotopes

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	A = 206		1	AO2 6.4.2.2
06.2	Z = 82		1	AO2 6.4.2.2
06.3	89 39	numbers must be in this order	1 1	AO2 6.4.2.2
06.4	electromagnetic waves		1	AO1 6.4.2.1

6.4.1.2 Mass number, atomic number and isotopes

Answer 03 · Mark scheme

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

Question	Answers	Mark	AO / Spec. Ref.
06.5	**Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 6.4.1.2 6.4.2.1 6.4.2.2
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content <u>alpha radiation</u> • an alpha particle is the same as a helium nucleus • alpha is the least penetrating • alpha is stopped by paper or skin • alpha has the shortest range in air • alpha will travel a few cm in air • because alpha is most ionising • because alpha has a charge of +2 <u>beta radiation</u> • a beta particle is an electron (emitted from the nucleus) • beta penetrates less than gamma and more than alpha • beta is stopped by a thin sheet of aluminium • beta has a shorter range than gamma • beta will travel up to 1m in air • because beta is more ionising that gamma and less ionising than alpha • because beta has a charge of -1 <u>gamma radiation</u> • gamma radiation is an electromagnetic wave • gamma is the most penetrating • gamma is reduced/stopped by several cm of lead or thick concrete • gamma has the largest range in air • gamma will travel very large distances in air • because gamma is least ionising • because is uncharged to access level 3 the answer should compare alpha, beta and gamma radiation and provide some explanation of their properties		

Total			11

6.4.1.2 Mass number, atomic number and isotopes

Answer 04 · Mark scheme

June 2022 | 8464/P/1F | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	$^{241}_{95}Am \longrightarrow {}^{237}_{93}Np + {}^{4}_{2}He$	first box ticked	1	AO2 6.4.2.2

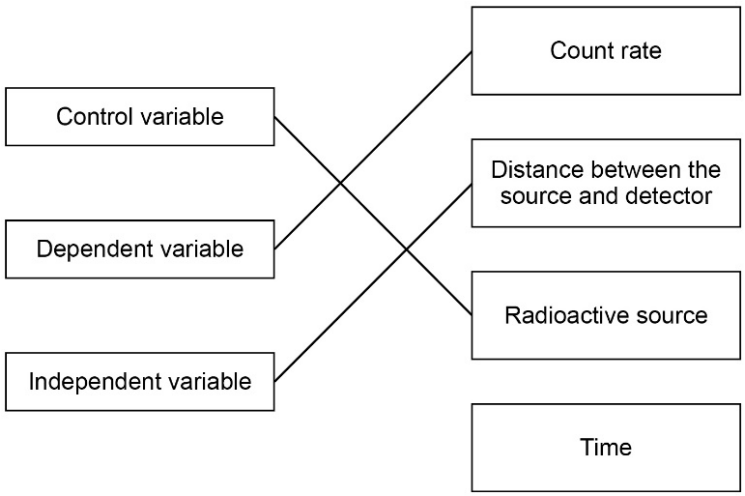
Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	a few centimetres		1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	paper stops alpha radiation		1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	$^{0}_{-1}e$		1	AO1 6.4.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	112		1	AO2 6.4.2.1

6.4.1.2 Mass number, atomic number and isotopes

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	 do **not** accept more than one line from a box on the left		1 1 1	AO3 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.7	as distance increases the count rate decreases (between 40 cm and 50 cm) the count rate becomes zero		1 1	AO3 6.4.2.1

Total Question 3		10

6.4.1.2 Mass number, atomic number and isotopes

Answer 05 · Mark scheme June 2023 | 8464/P/1F | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	alpha		1	AO1 6.4.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	2		1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	82		1	AO2 6.4.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	50		1	AO1 6.4.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	$\frac{1500}{30}$ 50 (counts per second)		1 1	AO2 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	the count-rate decreased because (gamma) radiation is absorbed by lead	allow decreased to (almost) zero allow (gamma) radiation cannot penetrate (thick) lead	1 1	AO1 6.4.2.1

6.4.1.2 Mass number, atomic number and isotopes

Answer 05 · Mark scheme

June 2023 | 8464/P/1F | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.7	the lead was exposed to gamma radiation		1	AO1 6.4.2.4

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.9	any one from: • (longer tongs give) a greater distance between the scientist and the radioactive source • (longer tongs) reduce the amount of radiation the scientist is exposed to • (longer tongs) reduce the risk of cell mutation	allow (longer tongs) reduce the risk of cancer	1	AO1 6.4.2.4

Total Question 1	11

6.4.1.2 Mass number, atomic number and isotopes

Answer 06 · 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

6.4.1.2 Mass number, atomic number and isotopes

Answer 06 · 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**

6.4.1.2 Mass number, atomic number and isotopes

Answer 07 · 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

6.4.1.2 Mass number, atomic number and isotopes

Answer 07 · 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**

6.4.1.2 Mass number, atomic number and isotopes

Answer 02 · 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.

6.4.1.2 Mass number, atomic number and isotopes

Answer 04 · Examiner comments

June 2022 | 8464/P/1F | Original Q3

Question 03 (Low demand and standard demand)

03.1 Just under half of all students were able to identify the correct nuclear equation.

03.2 Slightly less than 45% of students recalled that alpha radiation can travel a few centimetres in air.

03.3 Nearly three quarters of the students knew that paper stops alpha radiation.

03.4 Only about 40% of students identified the symbol for a beta particle.

03.5 Approximately a quarter of students gained the mark for this calculation.

Many students added 7 to 119, while a large number of students appeared not to understand the symbol ±, and divided or multiplied the two numbers.

03.6 Only about 5% of students correctly identified all three variables, with about 10% giving two correct answers. Approximately 55% of students gained at least one mark.

03.7 Nearly 60% of students gained at least one mark on this question, with the vast majority of these describing the decreasing count rate with increased distance from the source.

Some students incorrectly identified this as an inversely proportional relationship. The range in air of nuclear radiation helps to distinguish between alpha, beta, and gamma radiation, but very few students commented on the maximum distance travelled.

6.4.1.2 Mass number, atomic number and isotopes

Answer 05 · Examiner comments — June 2023 | 8464/P/1F | Original Q1

Question 01 (Low demand)

01.1 Approximately half of all students identified the type of radiation.

01.2 Slightly more than 40% of students recognised that an alpha particle has 2 protons.

01.3 About two-thirds of students chose the correct value for X.

01.4 Just under two thirds of students chose the correct activity.

01.5 Nearly 80% of students scored full marks in this simple calculation, with the majority of the remaining students gaining no credit. Common mistakes were losing a zero somewhere in the working, multiplying the two numbers together rather than dividing.

01.6 Nearly 50% of students gained some credit on this question, although only about a fifth of students scored both marks.

Many students did not state the effect of the lead on the count-rate, with a fair proportion writing that there were fewer counts and making no reference to rate or a time-frame. A small minority of students stated that the lead stopped the gamma from being emitted by the source, which is incorrect and gained no credit.

It appeared that some students misread the question and described the effect of the radiation on the lead, giving a description of the lead being irradiated rather than describing the effect on the count-rate.

01.7 Around 40% of students knew that the lead was exposed to gamma radiation, with the remaining students being split more or less equally between the other two options.

01.8 Just over 40% of students identified that gamma radiation consists of electromagnetic waves.

Answer 05 · Examiner comments — June 2023 | 8464/P/1F | Original Q1

01.9 Roughly a third of students gave a correct answer. It was very common for students to state that using the long tongs made it less likely for the radioactive source to touch the skin. Many students stated that the radioactivity could travel through the tongs. It was reasonably common for students to think that it was being held by tongs so that it could be safely held above a bunsen burner. A small, but noticeable, proportion of students gave statements indicating that they thought the radioactive source was hot, or could electrocute you, or could explode, which was why the tongs were needed.
There was some confusion from a small proportion of students about the difference between radiation and radioactivity. These students tended to give answers describing longer tongs reducing the exposure of the scientist to radioactivity, rather than to radiation, which was not creditworthy.

Answer 06 · Examiner comments

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

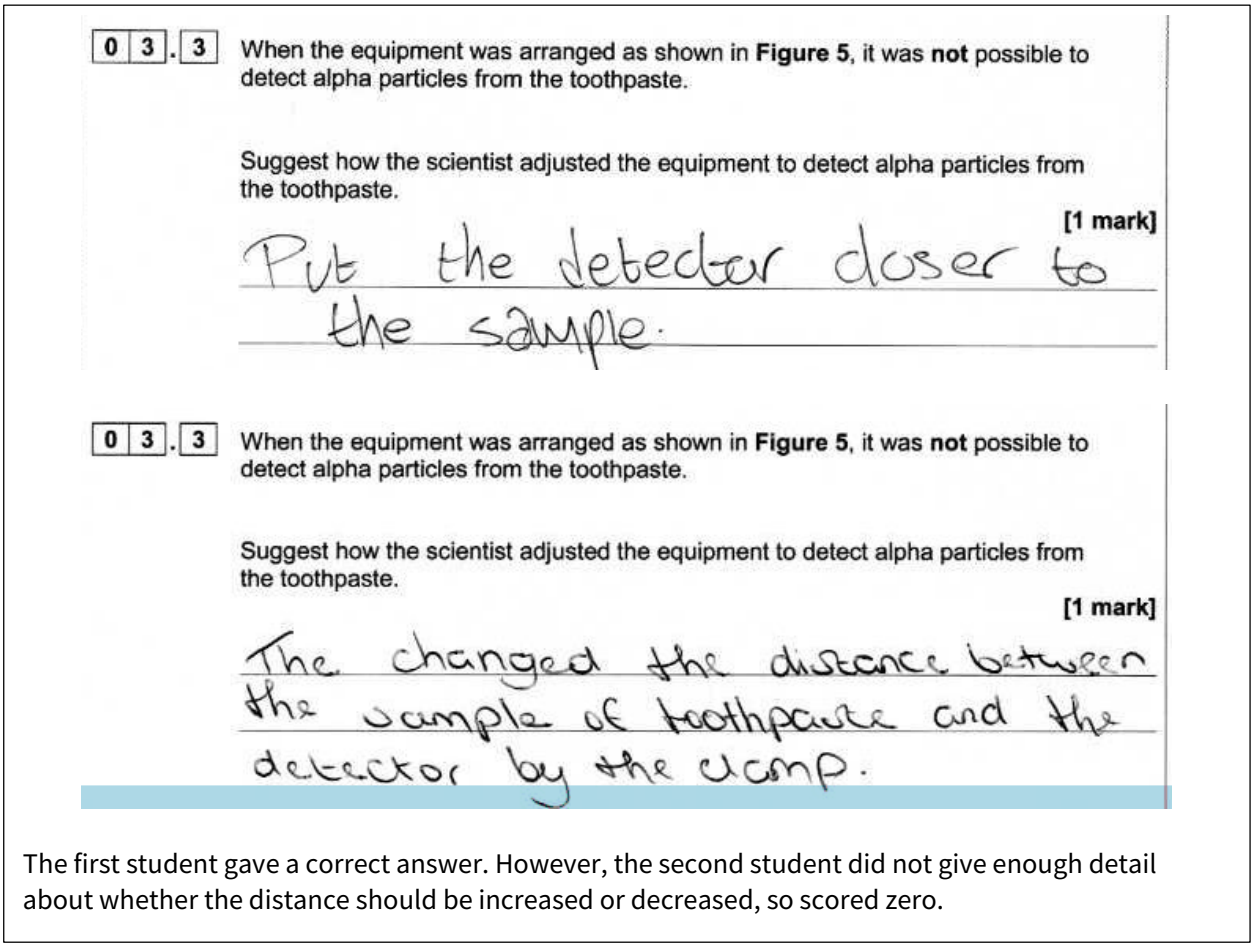
Question 3 (low demand)

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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6.4.1.2 Mass number, atomic number and isotopes

Answer 06 · 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 07 · 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.