AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.1.1

The structure of an atom

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**15**
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.

6.4.1.1 The structure of an atom

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

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>05.1</td><td>gamma</td><td></td><td>1</td><td>AO1
6.4.2.1</td></tr>
<tr><td>05.2</td><td>alpha</td><td></td><td>1</td><td>AO1
6.4.2.1</td></tr>
<tr><td>05.3</td><td>gamma</td><td></td><td>1</td><td>AO1
6.4.2.1</td></tr>
<tr><td>05.4</td><td><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></td><td></td><td>1
1</td><td>AO2
6.4.1.2</td></tr>
<tr><td>05.5</td><td>$\Delta\theta = 80\ ^\circ C$
$E = 150 \times 4200 \times 80$
$E = 50\ 400\ 000$ (J)</td><td>an answer of 50 400 000 scores 3 marks

allow 50 000 000 (J)

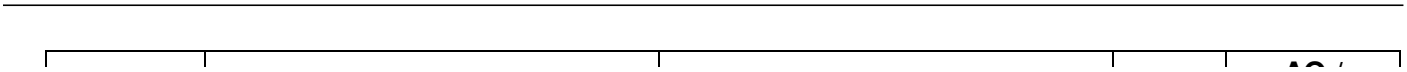
allow max 2 marks for correct calculation using incorrect value of $\Delta\theta$

allow 1 mark for correct calculation using $\theta = 20$ or $\theta = 100$</td><td>
1
1
1</td><td>AO2
6.3.2.2</td></tr>
<tr><td>Total</td><td></td><td></td><td>8</td><td></td></tr>
</table>

6.4.1.1 The structure of an atom

Answer 01 · Mark scheme

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



6.4.1.1 The structure of an atom

Answer 02 · Mark scheme

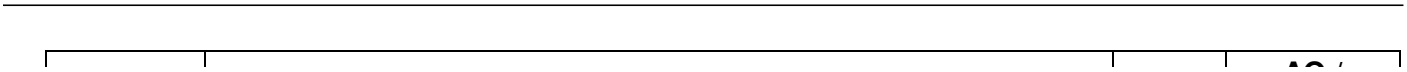
June 2018 | 8464/P/1F | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	electron atom nucleus orbit		1 1 1 1	AO1 6.4.1.3 5.1.1.3
06.2	positive charge is provided by protons (every atom of the same element contain the) same number of protons	 do **not** accept same number of protons and neutrons ignore reference to electrons	1 1	AO1 6.4.1.2 6.4.1.3
06.3	 $v = 300\ 00\ 000 \times \left(\frac{7}{100}\right)$ v = 21 000 000 (m/s)	an answer of 21 000 000 scores **2** marks allow any correct method of determining 7% of 300 000 000 allow 2.1×10^7 (m/s)	 1 1	AO2 6.4.1.3
06.4	 $r = 6 \times 2.5 \times 10^{-11}$ $r = 1.5 \times 10^{-10}$ (m)	an answer in the range 1.4×10^{-10} to 1.6×10^{-10} scores **2** marks allow a ratio in the range of 5.7–6.3 or measurements that would give this range, correctly substituted allow 1.4×10^{-10} to 1.6×10^{-10} their ratio $\times 2.5 \times 10^{-11}$ correctly calculated scores **1** mark	 1 1	AO2 6.4.1.1
Total			**10**	

6.4.1.1 The structure of an atom

Answer 02 · Mark scheme

June 2018 | 8464/P/1F | Original Q6



6.4.1.1 The structure of an atom

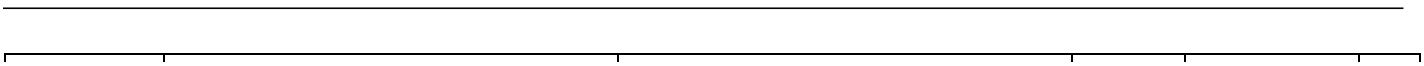
Answer 03 · Mark scheme June 2019 | 8464/P/1F | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
03.1	they changed direction	allow deflected/reflected/repelled	1	AO 1/1 6.4.1.3	E
03.2	diameter = $\frac{0.18}{6000}$ = 0.000 030 (nm)	an answer of 0.000 03 (nm) or 3.0×10^{-5} (nm) scores **2** marks allow 3.0×10^{-5} (nm)	1 1	AO2/2 6.4.1.1	E
03.3	A		1	AO 1/1 6.4.1.1	A
03.4	1100 (°C)		1	AO3/2b 6.3.2.3	G
03.5	8 (minutes)	allow 12 (minutes)	1	AO3/2b 6.3.2.3	G
03.6	the rate of change of temperature of the gold		1	AO3/1a 6.1.1.3, 6.3.2.2	A
Total			**7**		

6.4.1.1 The structure of an atom

Answer 03 · Mark scheme

June 2019 | 8464/P/1F | Original Q3



6.4.1.1 The structure of an atom

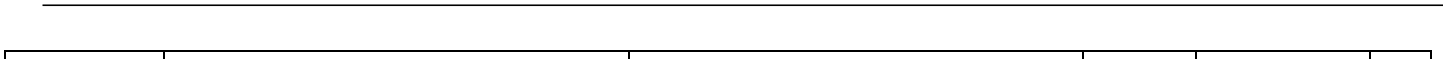
Answer 04 · Mark scheme June 2019 | 8464/P/1F | Original Q4

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**		

6.4.1.1 The structure of an atom

Answer 04 · Mark scheme

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



6.4.1.1 The structure of an atom

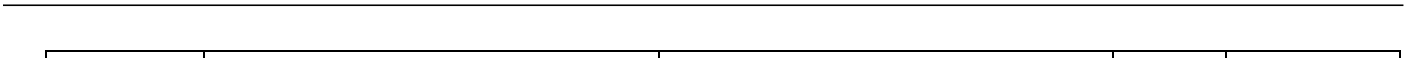
Answer 05 · Mark scheme November 2020 | 8464/P/1F | Original Q2

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**	

6.4.1.1 The structure of an atom

Answer 05 · Mark scheme

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



6.4.1.1 The structure of an atom

Answer 06 · 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

6.4.1.1 The structure of an atom

Answer 06 · 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

6.4.1.1 The structure of an atom

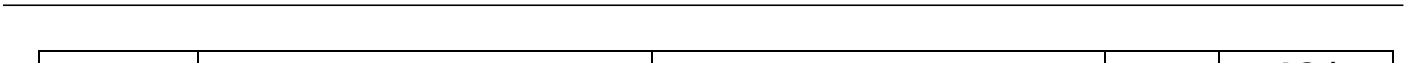
Answer 07 · Mark scheme November 2021 | 8464/P/1F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	$V = I\ R$		1	AO1 6.2.1.3
05.2	3.9 = 0.12 × R $R = \frac{3.9}{0.12}$ R = 32.5 (Ω)	 allow R = 33 (Ω)	1 1 1	AO2 6.2.1.3
05.3	energy = power × time **or** E = P t		1	AO1 6.2.4.2
05.4	time = 150 000s energy = 0.46 × 150 000 energy = 69 000 (J)	 allow a substitution using an incorrectly/not converted value of time allow a correct calculation using an incorrectly/not converted value of time	1 1 1	AO2 6.2.4.2
05.5	thermistor		1	AO1 6.2.1.1
05.6	the current will increase (because) the resistance decreases		1 1	AO1 6.2.1.4
Total			**11**	

6.4.1.1 The structure of an atom

Answer 07 · Mark scheme

November 2021 | 8464/P/1F | Original Q5



6.4.1.1 The structure of an atom

Answer 08 · Mark scheme

November 2021 | 8464/P/1F | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	more than 10 000 times bigger		1	AO1 6.4.1.1
06.2	the atom becomes a positive ion the atom loses an electron		1 1	AO1 6.4.1.2
06.3	beta radiation is only weakly ionising		1	AO3 6.4.2.1

Question	Answers	Mark	AO / Spec. Ref.
06.4	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3 6.4.2.1
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • move the detector very close to the source • record the count rate • position the paper between the source and the detector • record the new count rate • alpha radiation will not penetrate through paper • if the count rate with the paper is (significantly) less than without then the source emits alpha radiation • remove the paper and position the aluminium between the source and the detector • record the new count rate • (alpha and) beta radiation will not penetrate through the aluminium • if the count rate has (significantly) reduced compared with using paper then beta radiation is present • if radiation penetrates through the aluminium then gamma radiation is present • the experiment should be repeated and mean results calculated because radioactivity is a random process To access level 3, the candidate must use the paper sheet, the aluminium sheet and no sheet, and describe how the results would indicate the presence of alpha, beta or gamma radiation.		
Total		**10**	

6.4.1.1 The structure of an atom

Answer 09 · 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

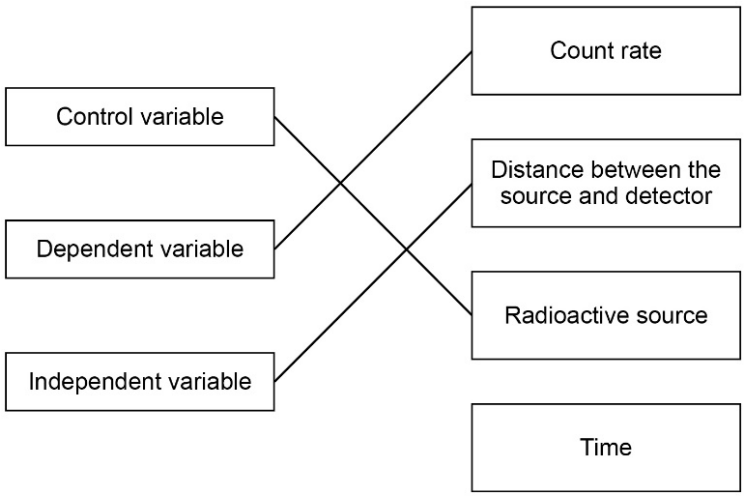
Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	$^{0}_{-1}e$		1	AO1 6.4.2.2

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

6.4.1.1 The structure of an atom

Answer 09 · Mark scheme

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

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

6.4.1.1 The structure of an atom

Answer 10 · 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

6.4.1.1 The structure of an atom

Answer 10 · 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

6.4.1.1 The structure of an atom

Answer 11 · 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

6.4.1.1 The structure of an atom

Answer 11 · 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**

6.4.1.1 The structure of an atom

Answer 12 · Mark scheme

June 2024 | 8464/P/1F | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	2 protons and 2 neutrons	ignore helium nucleus	1	AO1 6.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	118		1	AO1 6.4.1.2

Question	Answers	Mark	AO / Spec. Ref.
07.3	**Level 2:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	4–6	AO1 AO3 6.4.1.3
	Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1–3	
	No relevant content	0	
	Indicative content Plum pudding model • the atom is a ball of positive charge • electrons are embedded in the ball Reasons why the plum pudding model was replaced • the results were not correctly predicted by the plum pudding model • the plum pudding model did not predict that some particles would be deflected • the large angle deflections suggest that the atom contains a nucleus • all deflections suggest that the nucleus is charged • most alpha particles were not deflected suggesting that atoms are mostly empty space Nuclear model • mass is concentrated in the nucleus • the nucleus is charged • the atom is mostly empty space • electrons orbit the nucleus in the nuclear model		

6.4.1.1 The structure of an atom

Answer 12 · Mark scheme

June 2024 | 8464/P/1F | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	James Chadwick		1	AO1 6.4.1.3

Total Question 7	**9**

6.4.1.1 The structure of an atom

Answer 13 · Mark scheme

June 2024 | 8464/P/2F | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	energy		1	AO1 6.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	330 m/s		1	AO1 6.5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	frequency amplitude		1 1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	4000 Hz		1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	$T = \frac{1}{4000}$ 0.00025 (s)	allow ecf from question **03.4**	1 1	AO1 6.6.1.2

6.4.1.1 The structure of an atom

Answer 13 · Mark scheme

June 2024 | 8464/P/2F | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	compression rarefaction	either order	1 1	AO1 6.6.1.1

Total Question 3	**9**

6.4.1.1 The structure of an atom

Answer 14 · 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

6.4.1.1 The structure of an atom

Answer 14 · 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**

6.4.1.1 The structure of an atom

Answer 15 · Mark scheme

June 2025 | 8464/P/2F | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	pole X south **and** pole Y north opposite poles attract **or** a north pole and a south pole attract	allow X is S allow Y is N MP2 dependent on MP1	1 1	AO3 AO1 6.7.1.1

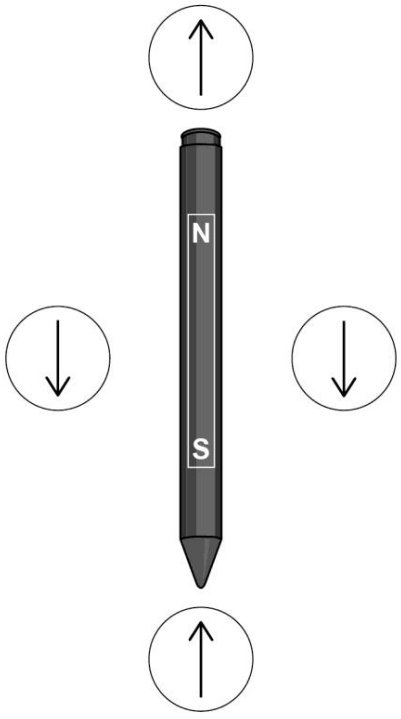
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	from 3.5 to 4.5 cm	either order	1	AO3 6.7.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	$\frac{4.0 + 3.5 + 4.0 + 3.5 + 4.5}{5}$ 3.9 (cm)	allow $\frac{19.5}{5}$	1 1	AO2 6.7.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	random errors		1	AO1 6.7.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	(the magnetic force) decreased		1	AO1 6.7.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	steel		1	AO1 6.7.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	arrow in circle next to south pole pointing upwards arrows in circles next to the middle of pen pointing downwards  		1 1	AO3 6.7.1.2

Total Question 4	10

6.4.1.1 The structure of an atom

Answer 03 · Examiner comments — June 2019 | 8464/P/1F | Original Q3

Question 3

03.1 Only about 30% of students could describe alpha particles as deflecting or rebounding from the gold atom. Many described the alpha particles as not going through, which was insufficient as it was given in the question. Some students thought alpha particles would be absorbed or destroyed.

03.2 A good attempt at this question to calculate the size of a nucleus using the ratio to the size of the atom was made by around 40% of students, with approximately 30% gaining both marks. A common mistake was to divide instead of multiplying. Some students tried to do the correct sum, but instead calculated 0.18 ÷ (1/6000) instead of calculating 0.18/6000. Nearly 10% of students made no attempt at this question. Using ratios is a mathematical skill in the specification.

03.3 This question testing knowledge of electron energy levels was correctly answered by just over 30% of students.

03.4 This question required students to identify that the temperature remains constant while a substance melts, and then read this temperature from the graph. 45% of students were able to do this correctly. Some student did not associate the constant temperature with the change of state, but more commonly they failed to correctly determine the scale on the temperature axis.

Answer 03 · Examiner comments — June 2019 | 8464/P/1F | Original Q3

03.5 About 35% of students could determine the time for the change of state from the graph. Reading values from graphs and using those values are required mathematical skills.

03.6 Nearly 60% of students correctly identified the gradient of the graph as the rate of change of temperature.

6.4.1.1 The structure of an atom

Answer 04 · 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.

Answer 07 · Examiner comments — November 2021 | 8464/P/1F | Original Q5

Question 05 (Standard demand)

05.1 Slightly over a third of students selected the correct equation.

05.2 Full marks were gained by approximately a third of the students, with more than 50% failing to gain any credit.

05.3 This equation was correctly recalled by slightly less than half of students.

05.4 Most students did not attempt to convert 2500 minutes into seconds. Very few students gained all 3 marks, although over 60 % gained at least 2 marks.

05.5 Only a very small proportion of foundation tier students were able to correctly identify the symbol for a thermistor.

05.6 Most students failed to recognise that the resistance of the thermistor would decrease as temperature increased, with many students stating that because the potential different across the thermistor was constant, the current in the thermistor must also be constant. Another misconception demonstrated in a number of responses was that the current would increase because the increased temperature gives the current more energy. Nearly one in five students did not attempt the question.

6.4.1.1 The structure of an atom

Answer 08 · Examiner comments November 2021 | 8464/P/1F | Original Q6

Question 06 (Standard demand)

06.1 This question was answered correctly by roughly one in three students.

06.2 Around 15% of students gained both marks, with slightly over half gaining just one mark.

06.3 Many students gave answers which were too vague, such as “beta radiation is not strong enough”, or stated that beta radiation is not ionising, which is incorrect. Very few students answered correctly.

6.4.1.1 The structure of an atom

Answer 08 · Examiner comments November 2021 | 8464/P/1F | Original Q6

06.4 Most students struggled to answer this question, with many unable to write answers containing any relevant content. Many answers suggested placing the piece of paper or aluminium into the radioactive source holder, for example. A fair proportion of students did not read the question carefully, and suggested changing the radioactive source to test the equipment using one source of just alpha radiation, one of just beta, and one that emits just gamma radiation, although it was still possible to gain full credit if they did this.

Some students recalled that paper stops alpha radiation, that aluminium stops beta radiation, and that gamma would penetrate both, but didn't describe how to set up the equipment. Others described how to set up the equipment, but not how to use any measurements to draw conclusions.

Nearly a quarter of students did not attempt to answer the question.

6.4.1.1 The structure of an atom

Answer 08 · Examiner comments

November 2021 | 8464/P/1F | Original Q6

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

6.4.1.1 The structure of an atom

Answer 09 · 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.

6.4.1.1 The structure of an atom

Answer 10 · 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 10 · 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 11 · Examiner comments

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

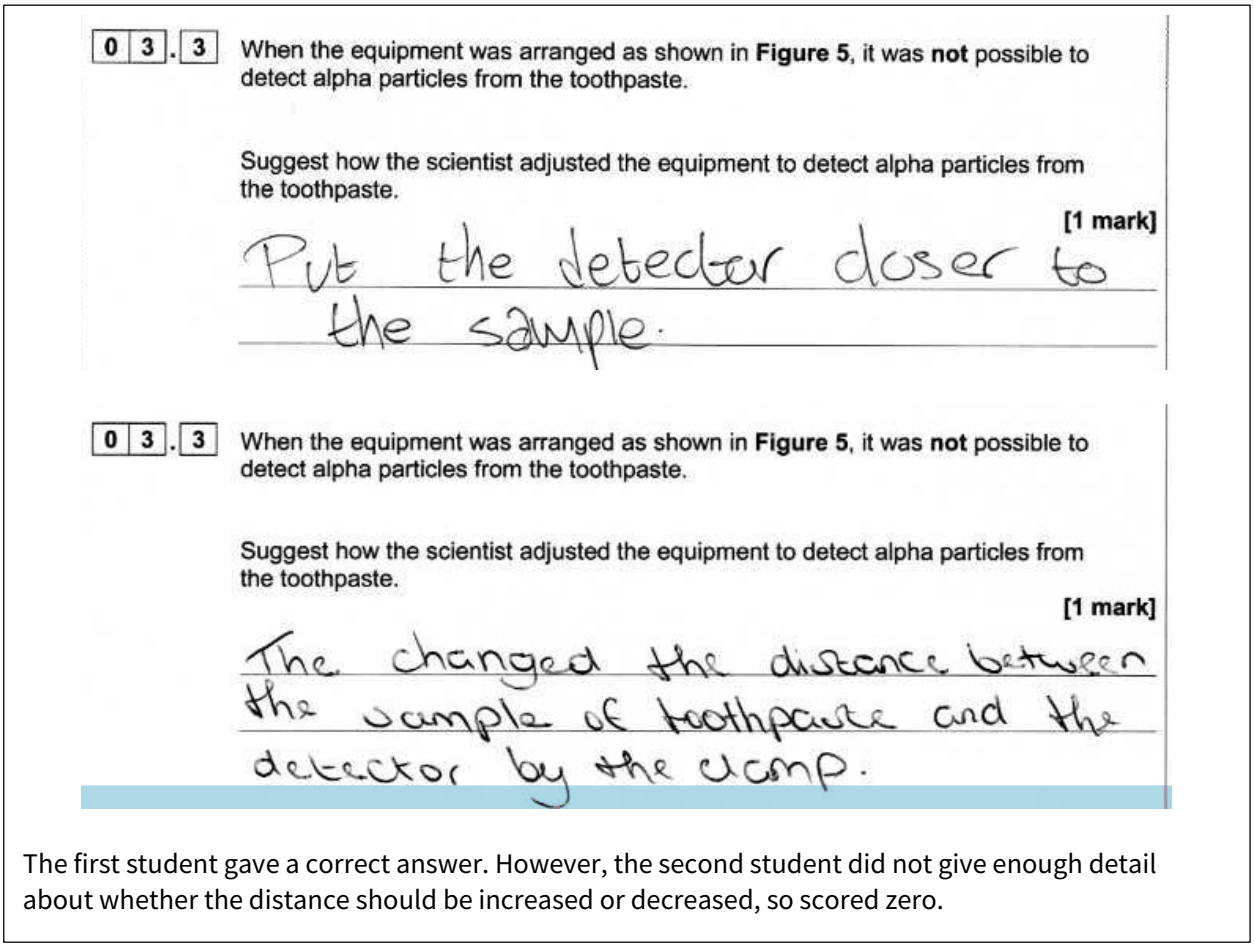
Question 3 (low demand)

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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6.4.1.1 The structure of an atom

Answer 11 · 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 12 · Examiner comments

June 2024 | 8464/P/1F | Original Q7

Question 7 (standard demand)

07.1 Most students were unable to accurately recall the structure of an alpha particle, with less than one in 10 students giving a full description.

07.2 The number of neutrons was correctly determined by just under half the students.

07.3 Foundation tier students tended to struggle with this question. Most were unable to describe details of either the plum pudding model or the nuclear model of the atom, and so made very little progress with their answers. The question was not attempted by about a fifth of students, and about a third gained any credit.

Some students used diagrams of the two models as part of their answers. Clearly labelled diagrams could help students to gain credit, but many diagrams were not labelled at all. However, many answers which included unlabelled diagrams had then gone on to describe features of each model, and the diagrams may have helped these students to recall the relevant details and to structure their answers.

There were a few misconceptions, which were demonstrated by a number of students. Descriptions of the plum pudding model as a proton with embedded electrons was common. A small proportion of answers alluded to positive electrons and negative electrons being present in atoms. A similar proportion referred to atoms being neutral because they contain neutrons.

It was relatively common for students to be unable to distinguish between the predicted results and the actual results, with many answers treating both of these as results gained by experiment.

A significant minority of students stated that the nuclear model was so called because it contains neutrons. Such statements may have been caused by students looking ahead at question 07.4 and incorrectly guessing that neutrons were discovered by conducting alpha particle scattering experiments.

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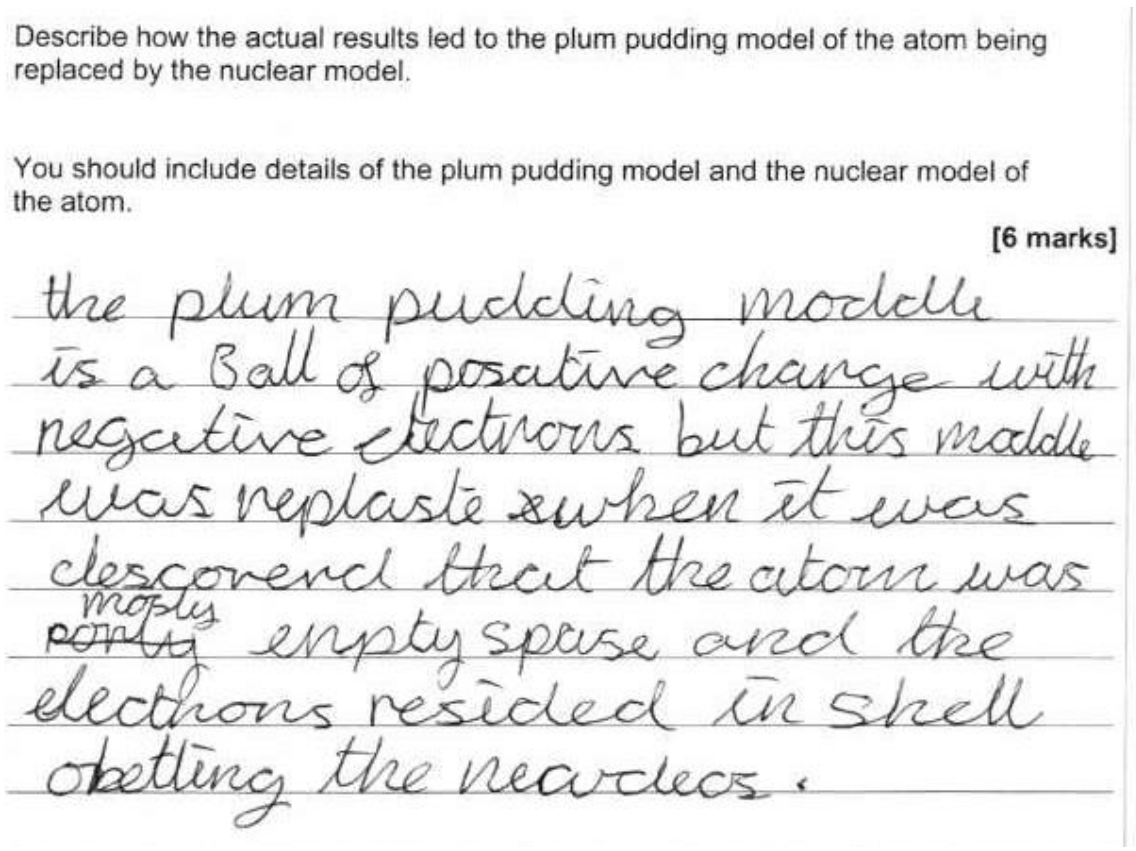
6.4.1.1 The structure of an atom

Answer 12 · Examiner comments June 2024 | 8464/P/1F | Original Q7

Describe how the actual results led to the plum pudding model of the atom being replaced by the nuclear model.

You should include details of the plum pudding model and the nuclear model of the atom.

[6 marks]



This response is at the top of Level 1, gaining 3 marks. There is a description of the plum pudding model, but the description of the nuclear model lacks any detail about the massive and charged nature of the nucleus. Had the answer also included some detail about the nucleus or referred to how the actual results led to the rejection of the plum pudding model, the answer would have been in Level 2.

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6.4.1.1 The structure of an atom

Answer 12 · Examiner comments June 2024 | 8464/P/1F | Original Q7

Describe how the actual results led to the plum pudding model of the atom being replaced by the nuclear model.

You should include details of the plum pudding model and the nuclear model of the atom.

[6 marks]

- The ~~pudd~~ plum pudding model was a solid sphere of positive charge, with negatively charged electrons throughout.
- Some alpha particles passed straight through, showing it is mainly empty space, not a solid ball.
- Some were slightly deflected showing there are the electrons circling the positive charge in the middle.
- Some completely ~~deflected~~ deflected back as they were repelled by the positive charge at the centre of the atom.
- The nuclear model was made to show these findings. It had a positive nucleus in the centre, a cloud of electrons orbitting it and the rest is mainly empty space.

In order to achieve the top mark on 'extended response' type questions, answers do not have to be completely correct, and neither do they need to address every single point in the indicative content on the mark scheme.

This response (from a Higher tier paper) gives a complete description of the plum pudding model. It describes how the evidence led to an understanding both that the atom is mostly empty space and that the nucleus is positively charged. However the statement that some alpha particles were deflected by electrons is incorrect, and there is no mention of the nucleus being massive.

However, taken as a whole, there is a reasonably detailed description of the plum pudding model, relevant points made about how the evidence led to the nuclear model, and a reasonably detailed description of the nuclear model, which was enough to allow this student to gain the maximum mark of 6 on this question.

07.4 About 40% of students correctly identified the scientist who provided evidence for the existence of neutrons.

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6.4.1.1 The structure of an atom

Answer 12 · Examiner comments

June 2024 | 8464/P/1F | Original Q7

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6.4.1.1 The structure of an atom

Answer 13 · Examiner comments

June 2024 | 8464/P/2F | Original Q3

Question 3 (low demand)

03.1 Over 90% of students knew that waves transfer energy.

03.2 A little over 30% of students knew the speed of sound in air.

03.3 This question required students to compare two different waves. 80% of students gained at least 1 mark and 45% gained both marks. The majority of students that only gained 1 mark correctly stated that wave A had a greater frequency but did not identify that both waves had the same amplitude.

03.4 About three-quarters of students correctly selected 4000 Hz as the same as 4 kHz.

03.5 Just over half of students correctly calculated the period using the equation given. Students who correctly used their incorrect answer from question 03.4 were still able to gain full marks for this question.

03.6 About 80% of students scored at least 1 mark on this question, and 25% of students scored 2 marks. There was approximately an even number of 1-mark answers that selected either compression or rarefaction.

Answer 14 · 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.

6.4.1.1 The structure of an atom

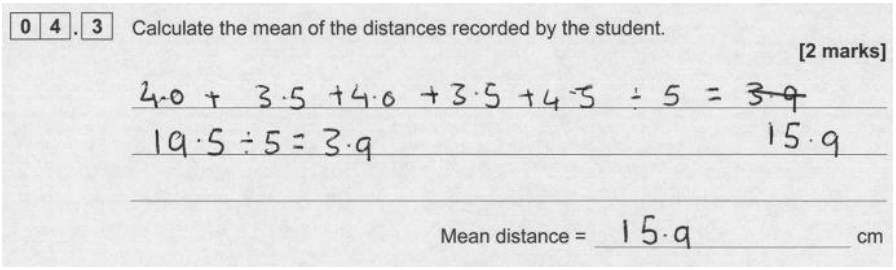
Answer 15 · Examiner comments June 2025 | 8464/P/2F | Original Q4

Question 4 (Low and standard demand)

04.1 Just over half scored at least one mark for correctly identifying the poles, with around 40% being able to give a correct reason for their answer.
Many students had misconceptions about the poles of magnets, with common answers including east and west poles, or positive and negative poles.

04.2 About four in five students were able to correctly identify the range of the values given.

04.3 Slightly less than three quarters of the students correctly calculated the mean value. Some students just added up all the values. Others apparently did not read the question carefully, with some students building on their answer to the previous question by calculating the size of the range, or by determining the uncertainty in the mean value.


0 4 . 3 Calculate the mean of the distances recorded by the student.

[2 marks]

4·0 + 3·5 + 4·0 + 3·5 + 4·5 ÷ 5 = ~~3·9~~

19·5 ÷ 5 = 3·9 15·9

Mean distance = 15·9 cm

When calculating a mean, students would be well advised to use brackets appropriately, or to break the calculation down into an addition, and then a division.
This student incorrectly added the first four numbers to one-fifth of the final number, arriving at the incorrect answer, so gained no credit.
They also demonstrated that they could calculate the answer correctly, but by putting the answer of 15.9 on the answer line, they had chosen the incorrect line of working.

04.4 Approximately half the students recognised that repeating and calculating a mean reduces the effect of random errors.

04.5 Nearly two thirds recognised that increasing the distance between two magnets causes the magnetic forces between them to decrease.

04.6 Only about 40% knew that steel is magnetic.

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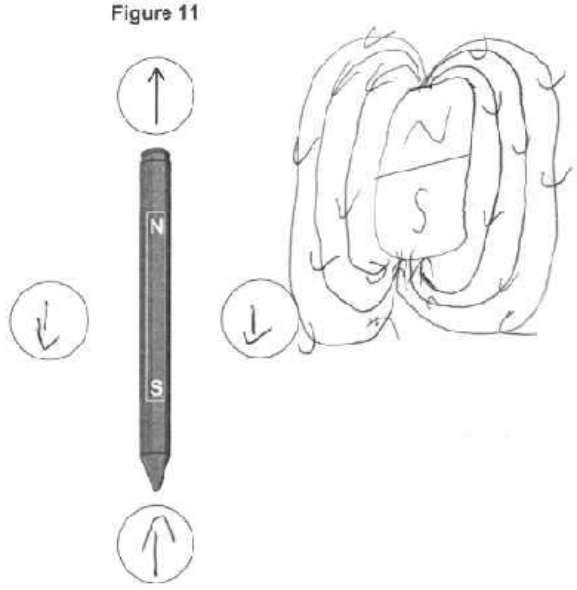
6.4.1.1 The structure of an atom

Answer 15 · Examiner comments

June 2025 | 8464/P/2F | Original Q4

04.7 This question proved to be difficult for the majority of students, with only about a fifth gaining any credit, and less than one in ten students gaining both marks. The most common answer by far was to have all of the arrows pointing away from the magnet in the pen.

Figure 11



This student draws a diagram of the field pattern that they had clearly learned. This helped them to add the arrows to the plotting compasses in the diagram and gain both marks. In physics questions, whether completing diagrams or writing descriptions or explanations, it can often help students to draw a quick sketch of a situation to help them gather their thoughts.