AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.6.2.3

Properties of electromagnetic waves 2

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**8**
Available paper years	**2018–2024**

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.

6.6.2.3 Properties of electromagnetic waves 2

Answer 01 · Mark scheme

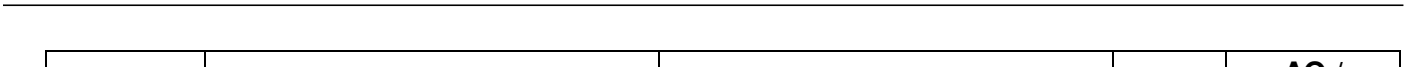
June 2018 | 8464/P/1F | Original Q5

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	**isotope** / **number of neutrons** / **number of protons** uranium-238 / 146 / **92** thorium-234 / **144** / 90		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**	

6.6.2.3 Properties of electromagnetic waves 2

Answer 01 · Mark scheme

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



6.6.2.3 Properties of electromagnetic waves 2

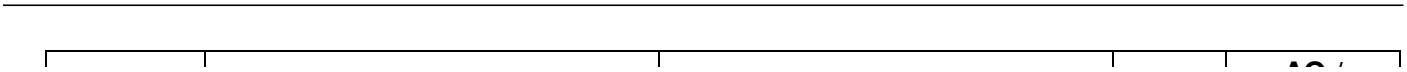
Answer 02 · Mark scheme June 2018 | 8464/P/2F | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	R		1	AO1 6.6.2.1
04.2	they have the same wave speed as visible light they have a lower frequency than gamma rays		1 1	AO1 6.6.2.1
04.3	any **two** from: • ageing of the skin • skin cancer • eye damage	 allow sunburn burn unqualified is insufficient cancer is insufficient allow mutation of genes in skin cells allow blindness	2	AO1 6.6.2.3
04.4	any **two** from: • gamma (rays) • X-rays • ultraviolet		2	AO1 6.6.2.4
Total			**7**	

6.6.2.3 Properties of electromagnetic waves 2

Answer 02 · Mark scheme

June 2018 | 8464/P/2F | Original Q4



6.6.2.3 Properties of electromagnetic waves 2

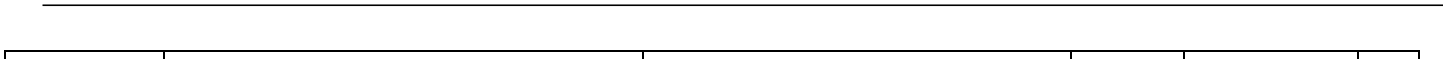
Answer 03 · Mark scheme June 2019 | 8464/P/2F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
05.1	velocity frequency wavelength		1 1 1	AO1 6.6.2.3	G
05.2	so people are not exposed to (as much) gamma radiation because gamma radiation can damage human tissue	allow less gamma radiation reaches the Earth's surface allow increases the risk of cancer or (cell) mutation allow gamma rays are ionising ignore any reference to temperature / heating of the atmosphere	1 1	AO1 6.6.2.3	E
05.3	(microwaves) are used in (satellite) communications	ignore any reference to temperature / heating of the atmosphere	1	AO2 6.6.2.4	E
05.4	can cause skin cancer / premature ageing	allow sunburn allow eye / skin damage cancer on its own is insufficient	1	AO1 6.6.2.3	E
05.5	risk from UV radiation is highest in July / summer two correct readings from the bar chart which support their comparison	allow any sensible comparison of named months / seasons if no other mark scored, two correct readings from the graph scores **1** mark	1 1	AO3 6.6.2.3	E
Total			**9**		

6.6.2.3 Properties of electromagnetic waves 2

Answer 03 · Mark scheme

June 2019 | 8464/P/2F | Original Q5



6.6.2.3 Properties of electromagnetic waves 2

Answer 04 · Mark scheme

November 2020 | 8464/P/2F | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	skin		1	AO1 6.6.2.4
03.2	dose is much lower than even slight increased risk of cancer dose	allow much less than 100 mSv	1	AO3 6.6.2.3
03.3	to reduce the dose of radiation (they are exposed to)	allow reduce the risk	1	AO3 6.6.2.3
03.4	sterilising medical equipment		1	AO1 6.6.2.3
03.5	they are ionising		1	AO1 6.6.2.3
03.6	**microwaves** data is transmitted / detected by (mobile) phone / WiFi / satellite **visible light** example of device / system description of how light is used	 allow signal / information for data allow bluetooth e.g. the internet transfers information via visible light in fibre optics e.g. image produced / seen on a TV / mobile phone	 1 1 1 1	AO1 6.6.2.4

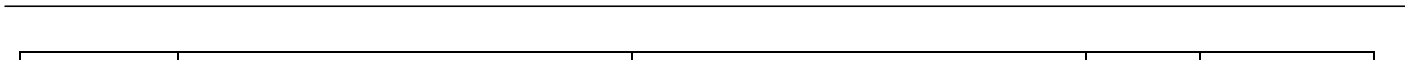
6.6.2.3 Properties of electromagnetic waves 2

		allow any sensible suggestion for visible light, but the two marks must be linked		
Total			**9**	

6.6.2.3 Properties of electromagnetic waves 2

Answer 04 · Mark scheme

November 2020 | 8464/P/2F | Original Q3



6.6.2.3 Properties of electromagnetic waves 2

Answer 05 · 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

6.6.2.3 Properties of electromagnetic waves 2

Answer 05 · Mark scheme

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

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**	

6.6.2.3 Properties of electromagnetic waves 2

Answer 06 · Mark scheme November 2021 | 8464/P/2F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	(air resistance) increases		1	AO1 6.5.4.1.5
05.2	less than		1	AO3 6.5.4.1.5
05.3	s = 35 × 14 s = 490 (m)		1 1	AO2 6.5.4.1.2
05.4	work done = force × distance **or** W = Fs		1	AO1 6.5.2
05.5	54 000 000 = F × 270 $F = \frac{54\,000\,000}{270}$ F = 200 000 (N)		1 1 1	AO2 6.5.2

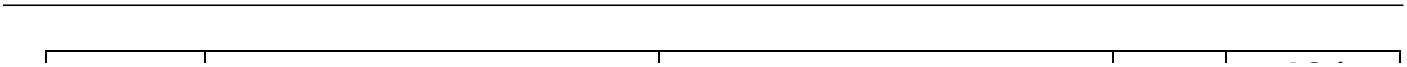
6.6.2.3 Properties of electromagnetic waves 2

Question	Answers	Mark	AO / Spec. Ref.
05.6	**Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	4–6	AO3 6.5.4.1.2
	Level 1: Relevant features are identified and differences noted.	1–3	
	No relevant content	0	
	Indicative content • distance travelled is the same for each aeroplane • time in the air is much greater for jet aeroplane • speed of rocket plane is much greater • speed of rocket plane is 32 times greater • radiation dose each hour greater for rocket aeroplane • radiation dose each hour is 2 times greater for rocket aeroplane • overall radiation dose is less for rocket plane • dose in jet aeroplane is 16 times greater overall • much higher risk in jet aeroplane • increased risk of skin cancer • increased risk of gene mutation and cancer To access level 2, there must be a relevant calculation.		
Total			**14**

6.6.2.3 Properties of electromagnetic waves 2

Answer 06 · Mark scheme

November 2021 | 8464/P/2F | Original Q5



6.6.2.3 Properties of electromagnetic waves 2

Answer 07 · 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

6.6.2.3 Properties of electromagnetic waves 2

Answer 07 · 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

6.6.2.3 Properties of electromagnetic waves 2

Answer 08 · 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

6.6.2.3 Properties of electromagnetic waves 2

Answer 08 · Mark scheme

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**

6.6.2.3 Properties of electromagnetic waves 2

Answer 05 · 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.

6.6.2.3 Properties of electromagnetic waves 2

Answer 05 · 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.

Mark Ranges and Award of Grades

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

6.6.2.3 Properties of electromagnetic waves 2

Answer 06 · Examiner comments November 2021 | 8464/P/2F | Original Q5

Question 5 (Low demand and standard demand)

05.1 Over 50% of students correctly stated that the air resistance would increase. Of those that didn't, many of them failed to answer the question, and wrote answers such as 'the acceleration will overcome the air resistance'.

05.2 Only 15% of students correctly identified that the lift force on the wings will be the same as the weight of the rocket aeroplane.

05.3 This low demand calculation was very well answered, with the vast majority of students scoring 2 marks.

05.4 Over 50% of students correctly recalled the equation.

05.5 This standard demand calculation was reasonably well answered. Nearly 75% were able to substitute into the correctly rearranged equation, and the vast majority of those went on to correctly evaluate the answer and score full marks.

05.6 This question was an extended response question that was marked with a level of response mark scheme. Over 10% of students did not attempt the question. Of those that did 35% did not write any relevant content. Nearly all these students failed to include any

Answer 06 · Examiner comments November 2021 | 8464/P/2F | Original Q5

information from the question. Where students are given an additional instruction such as 'Use values from Table 2', they must do so. Of the 35% of students that did score mark the majority made simple statements that the radiation dose for the rocket aeroplane was greater. Very few appreciated that because the rocket aeroplane was much faster, it spent much less time in the air. Only a handful of students wrote level 2 answers.

6.6.2.3 Properties of electromagnetic waves 2

Answer 07 · 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 07 · 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 08 · Examiner comments

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

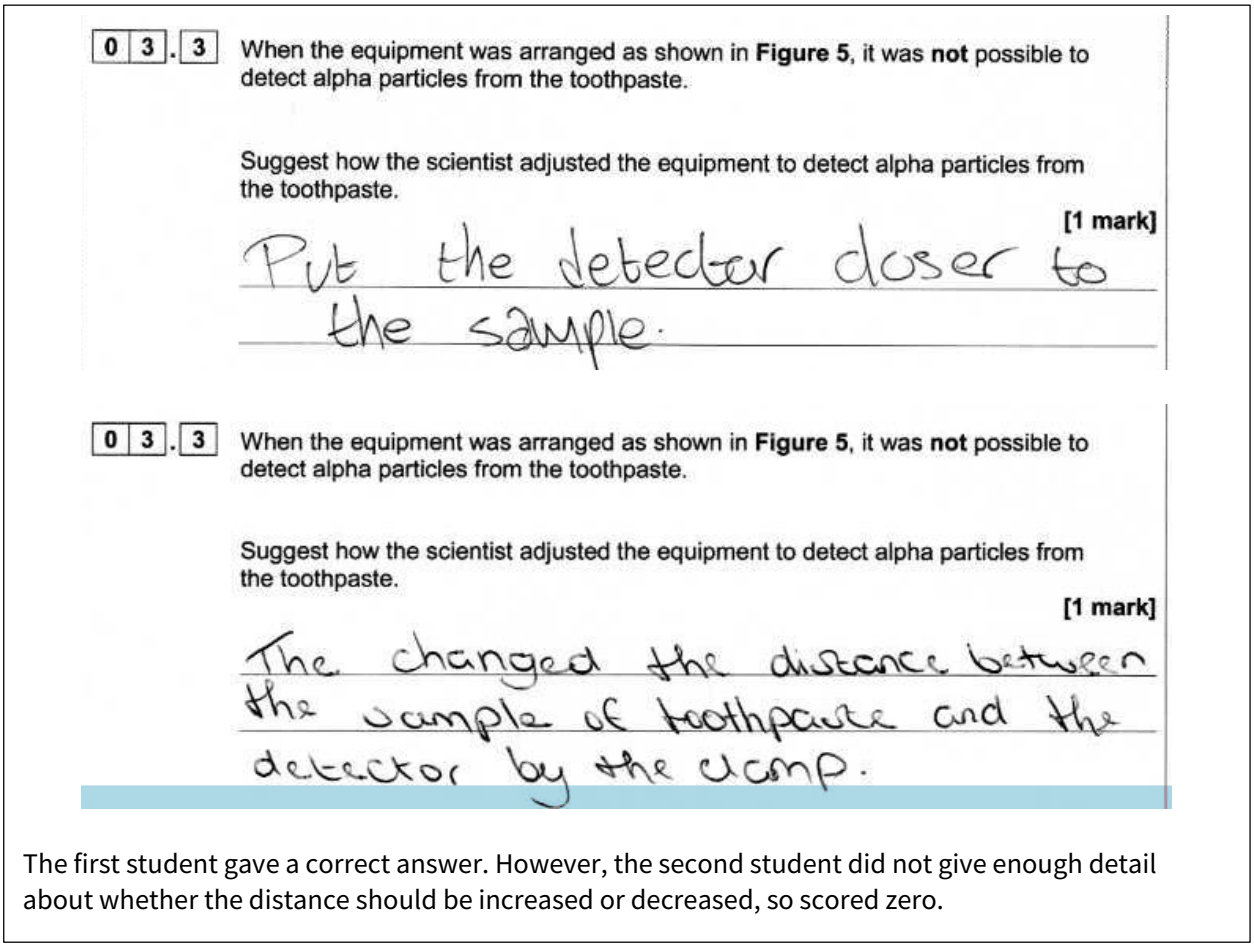
Question 3 (low demand)

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.

© 2024 AQA and its licensors. All rights reserved.

6.6.2.3 Properties of electromagnetic waves 2

Answer 08 · 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.