AQA GCSE Physics | 8463

SPECIFICATION POINT 4.4.4.2

Nuclear fusion

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**12**
Available paper years	**2006–2025**

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.

4.4.4.2 Nuclear fusion

Answer 01 · Mark scheme

November 2006 | PHY1A | Original Q1 | Legacy

One	**A**	electrical	**1**
	B	heat	**4**
	C	light	**3**
	D	sound	**2**

4.4.4.2 Nuclear fusion

Answer 02 · Mark scheme January 2010 | PHY2H | Original Q2 | Legacy

Question 2

question	answers	extra information	mark
2(a)(i)	(two) nuclei (of light elements) join forming a larger / heavier nucleus / one	accept hydrogen atoms for nuclei accept comparative term equivalent to larger accept forms a helium (nucleus / atom) this mark only scores if fusion is in terms of hydrogen atoms	1 1
2(a)(ii)	stars	accept a named star e.g. the Sun accept nebula mention of planets negates answer	1
2(b)(i)	any **one** from: • (currently) only experimental • reaction does not last long enough • use more energy than they produce	allow difficult to control do **not** allow inefficient on its own	1
2(b)(ii)	any **one** from: • will give another source of energy • unlimited fuel supplies / energy • would not produce any radioactive waste • want to show that it can be done	do **not** accept answers only in terms of fossil fuels or carbon dioxide accept unlimited hydrogen accept less radioactive waste accept nuclear for radioactive do **not** accept toxic waste accept any sensible suggestion	1

Question 2 continues on the next page . . .

PHY2H

Question 2 continued . . .

question	answers	extra information	mark
2(c)(i)	any **one** from: • repeating did not produce the same results / data • experiments were not / may not be reproducible • data / experiments were not valid	accept could not be repeated accept has not been repeated do **not** accept answers in terms of scientists being biased	1
2(c)(ii)	any **one** from: • cannot trust journalists • newspaper journalist may not have a science background • newspaper may publish what people want to read • newspaper may simplify ideas • people believe / trust the scientists writing the journal • people have heard of the scientists writing in the journal • scientists writing in the journal are famous • journal only publishes the work of respected / famous scientists • data is checked by other scientists before published in the journal	bias is insufficient on its own accept any sensible suggestion, these are examples they do not constitute a full list	1
Total			**7**

4.4.4.2 Nuclear fusion

Answer 02 · Mark scheme

January 2010 | PHY2H | Original Q2 | Legacy

PHY2H

4.4.4.2 Nuclear fusion

Answer 03 · Mark scheme

June 2011 | PHY3H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	(forces due to) gravity and radiation pressure correct direction of forces (forces) are balanced / equilibrium / equal	accept for **3** marks an answer in terms of sufficient hydrogen (1) to keep fusion reaction (1) reference to burn / burning negates this mark going at a continuous /steady rate (1) if fuel is used instead of hydrogen maximum of **2** marks	1 1 1
6(b)	the Sun will remain stable (for several billion years) based on evidence	 accept a specific example of evidence eg that the Sun has remained stable during the life of our planet / for 4.5 billion years **or** still contains more than 50 % hydrogen **or** by comparison with the lifecycle of (similar) stars allow a refutation eg not based on prejudice / whim / hearsay / folk law / historical or religious authority	1 1
Total			**5**

4.4.4.2 Nuclear fusion

Answer 03 · Mark scheme June 2011 | PHY3H | Original Q6 | Legacy

PHY3H

4.4.4.2 Nuclear fusion

Answer 04 · Mark scheme

January 2013 | PH2HP | Original Q3 | Legacy

Question 3

question	answers	extra information	mark
3(a)	forces (within the star) are balanced	if specific forces are mentioned they must be appropriate	1
3(b)(i)	bigger the mass (of the star) the shorter the 'main sequence' period	accept bigger the star the shorter the time	1
3(b)(ii)	any **one** from: • insufficient evidence • do not know (exact) amount of hydrogen in star • time too long (to measure directly) • may be other factors (not yet known) that determine length of 'main sequence' period • values are based on theory / calculation	accept do not know (exact) mass of star	1
3(b)(iii)	faster than		1
	larger stars have a shorter 'main sequence' period so they must have the faster (rate of) nuclear fusion	there must be a link between shorter 'main sequence' and nuclear fusion, this may be implied from the first marking point	1
	the end of 'main sequence' happens as the hydrogen in (the core of) a star is used up **or** (since) they use up hydrogen at a faster (rate)	accept more massive stars (are brighter so) release energy faster	1

Question 3 continues on the next page . . .

4.4.4.2 Nuclear fusion

Answer 04 · Mark scheme

question	answers	extra information	mark
3(c)	Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.		6

0 marks	Level 1 (1–2 marks)	Level 2 (3–4 marks)	Level 3 (5–6 marks)
No relevant content.	There is a basic description of what happens to a star much larger than the Sun after the 'main sequence' period. **OR** Two stages are correctly named and are in the correct sequence.	There is a clear description of what happens to a star much larger than the Sun after the 'main sequence' period. **AND** At least two stages are correctly named and are in the correct sequence.	There is a detailed description of what happens to a star much larger than the Sun after the 'main sequence' period. **AND** At least three stages are named, in the correct sequence. There are no additional incorrect stages given.

Examples of the points made in the response:	extra information
• (the core of the) star runs out of hydrogen • (the star) expands (to form) • (the star) cools (to form)	• the core shrinks • helium starts to fuse to form other elements
• a red supergiant	accept super red giant do **not** accept red giant
• (outer layers) explode	• fusion of lighter elements to form heavier elements (up to iron)
• as a supernova	
• elements heavier than iron are formed • core shrinks	accept heaviest elements are formed
• becoming a neutron star	
• if mass large enough (core collapses)	
• (to form) a black hole	if a correct description and sequence for a star the same size as the Sun and much bigger than the Sun given without clearly indicating which is which is limited to Level 2

Total			12

4.4.4.2 Nuclear fusion

Answer 04 · Mark scheme

January 2013 | PH2HP | Original Q3 | Legacy

PH2HP

4.4.4.2 Nuclear fusion

Answer 05 · Mark scheme June 2015 | PH2HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. ref.	ID
3(a)(i)	splitting of a(n atomic) nucleus	do not accept splitting an atom	1	AO1 2.6.1b	**E**
3(a)(ii)	Neutron		1	AO1 2.6.1c	**E**
3(b)(i)	nuclei have the same charge **or** nuclei are positive	accept protons have the same charge	1	AO1 2.3.1d	**E**
3(b)(ii)	(main sequence) star	accept Sun or any correctly named star accept red (super) giant	1	AO1 2.6.2b	**E**
3(c)(i)	any **two** from: • easy to obtain / extract • available in (very) large amounts • releases more energy (per kg) • produces little/no radioactive waste	do **not** accept figures *only* naturally occurring is insufficient seawater is renewable is insufficient less cost is insufficient	2	AO2/3 2.6	**E**
3(c)(ii)	any **one** from: • makes another source of energy available • increases supply of electricity • able to meet global demand • less environmental damage • reduces amount of other fuels used	accept any sensible suggestion accept a specific example accept a specific example	1	AO3 2.6	**E**
3(d)	12	allow **1** mark for obtaining 3 half-lives	2	AO2 2.5.2h	**E**

4.4.4.2 Nuclear fusion

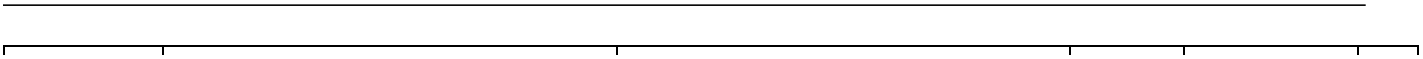
Answer 05 · Mark scheme

Total			**9**

4.4.4.2 Nuclear fusion

Answer 05 · Mark scheme

June 2015 | PH2HP | Original Q3 | Legacy



4.4.4.2 Nuclear fusion

Answer 06 · Mark scheme June 2016 | PH2HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)(i)	(enough) dust and gas (from space) is pulled together by: gravitational attraction **or** gravitational forces **or** gravity	accept nebula for dust and gas accept hydrogen for gas accept gas on its own dust on its own is insufficient mention of air negates this mark ignore any (correct) stages beyond this	1 1	AO1 2.6.2c
6(a)(ii)	joining of two (atomic) nuclei (to form a larger one)	do not accept atoms for nuclei	1	AO1 2.6.2a
6(a)(iii)	more sensitive astronomical instruments / telescopes **or** infrared telescopes developed	accept better technology more knowledge is insufficient	1	AO3 2.6
6(b)(i)	(other) planets / solar systems	do not accept galaxy moons is insufficient	1	AO3 2.6
6(b)(ii)	provided evidence to support theory	accept proves the theory	1	AO1 2.6
6(c)	elements heavier than iron are formed only when a (massive) star explodes	accept materials for elements accept supernova for star explodes accept stars can only fuse elements up to (and including) iron	1	AO1 2.6.2f
Total			**7**	

4.4.4.2 Nuclear fusion

Answer 06 · Mark scheme

June 2016 | PH2HP | Original Q6 | Legacy



4.4.4.2 Nuclear fusion

Answer 07 · Mark scheme

June 2019 | 8463/1H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
8.1	Initial temperature was a control variable		1	WS3.7 4.3.2.2 AO3
8.2	copper greater change in mass (than the other metals)	 this mark is dependent on scoring the first mark allow more ice melted (than the other metals) allow the ice melted faster (than the other metals)	1 1	4.1.2.1 AO3
8.3	variation in initial mass of ice cube **or** surface area of the ice cube touching the metal	allow variation in initial volume of ice cube allow melting of ice while handling allow variation in room temperature allow initial temperature of metal block	1	WS3.7 4.1.2.1 AO3

4.4.4.2 Nuclear fusion

Answer 07 · Mark scheme

8.4	$E = m \times 2100 \times 15$ $E = m \times 334\,000$ $5848 = 31\,500\ m + 334\,000\ m$ **or** $5848 = 365\,500\ m$ $m = \frac{5848}{(31\,500 + 334\,000)}$ **or** $m = \frac{5848}{(365\,500)}$ $m = 0.016$ (kg)	an answer of 0.016 (kg) scores **5** marks allow **2** marks for an answer that rounds to 0.186 or 0.0175 if no other mark scored allow **1** mark for either $5848 = m \times 2100 \times 15$ **or** $5848 = m \times 334\,000$	1 1 1 1 1	4.3.2.2 4.3.2.3 AO2
Total			**9**	

4.4.4.2 Nuclear fusion

Answer 08 · Mark scheme

November 2020 | 8463/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	Any **one** from: • (medical) x-rays • radiotherapy • nuclear weapons (testing) • named nuclear disaster eg Chernobyl / Fukushima / Three Mile Island.	allow CT scans allow nuclear fallout ignore radioactive / nuclear waste	1	AO1 4.4.3.1
05.2	uranium / plutonium	ignore any number given allow thorium	1	AO1 4.4.4.1
05.3	neutron absorbed by a uranium nucleus nucleus splits into two parts and (2 / 3) neutrons (are released) and gamma rays (are emitted)	 allow an atom splits into two parts if 1st marking point doesn't score 	1 1 1 1	AO1 4.4.4.1
05.4	lighter nuclei join to form heavier nuclei some of the mass (of the nuclei) is converted to energy (of radiation)	allow specific examples	1 1	AO1 4.4.4.2
05.5	activity decreases quickly risk of harm decreases quickly	allow nuclei / waste will decay at a greater rate ignore waste is radioactive for less time allow burial site doesn't need to be monitored for as long **or** doesn't need to be buried underground for as long **or** may not need to be buried underground	1 1	AO3 4.4.2.3
Total			**10**	

4.4.4.2 Nuclear fusion

Answer 09 · Mark scheme

November 2021 | 8463/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	nuclei decreases	do not accept atoms	1 1	AO1 4.4.4.2
02.2	m = 0.004 (kg) E = 0.004 × 5200 × 50 000 000 E = 1.04 × 10^9 (J) **or** E = 1 040 000 000 (J)	 allow a correct substitution of an incorrectly/not converted value of m allow a correct calculation using an incorrectly/not converted value of m	1 1 1	AO2 4.3.2.2 4.1.1.3
02.3	any **two** from: • to make sure the fusion process is possible • to develop an understanding of the process • to make adaptations to the process • to assess the efficiency of the process • to make predictions • assess safety risks • to assess environmental impact • set-up cost is lower (for small scale experiments)		2	AO3 4.1.3

4.4.4.2 Nuclear fusion

02.4	releases carbon dioxide which causes global warming **OR** releases particulates which causes global dimming **or** which causes breathing problems **OR** releases sulfur dioxide which causes acid rain **OR** releases nitrogen oxides which causes breathing problems **or** which causes acid rain	allow releases greenhouse gases allow which causes climate change	1 1	AO1 4.1.3
Total			**9**	

4.4.4.2 Nuclear fusion

Answer 10 · Mark scheme

November 2021 | 8463/1H | Original Q11

Question 11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
11.1	the gradient for ice is steeper than the gradient for water (liquid) which means that less energy is needed to increase the temperature by a fixed amount	allow the temperature of the ice increased faster than the temperature of the water	1 1	AO3 4.3.2.2
11.2	water took more time to vaporise than the ice took to melt which means that less energy is needed to change the state from solid to liquid (than from liquid to vapour)		1 1	AO3 4.3.2.3
11.3	any **two** from: • ice/water would take more time to increase in temperature • ice/water would take more time to change state • the change in temperature with time would not be linear	allow gradients would be less steep allow horizontal lines would be longer	2	AO3 4.3.2.2 4.3.2.3 RPA1

4.4.4.2 Nuclear fusion

Answer 10 · Mark scheme

November 2021 | 8463/1H | Original Q11

11.4	E = 69 000 (J)		1	AO2 4.3.2.3
	69 000 = 0.030 × L	allow a correct substitution of an incorrectly/not converted value of E	1	
	$L = \frac{69\,000}{0.030}$	allow a correct rearrangement using an incorrectly/not converted value of E	1	
	L = 2 300 000 **or** L = 2.3×10^6	allow a correct calculation using an incorrectly/not converted value of E	1	
	J/kg	allow a unit consistent with their numerical answer eg 2300 kJ/kg	1	

Total			**11**

4.4.4.2 Nuclear fusion

Answer 11 · Mark scheme

June 2023 | 8463/1H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	polarity of the potential difference doesn't change	allow direction of the potential difference doesn't change	1	AO1 4.2.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	$E = QV$		1	AO1 4.2.4.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	$5010 = Q \times 12$ $Q = \frac{5010}{12}$ $Q = 417.5$ (C)	 allow 418 (C)	1 1 1	AO2 4.2.4.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	$5010 = 0.015 \times L$ $L = \frac{5010}{0.015}$ $L = 334\,000$ (J/kg)		1 1 1	AO2 4.3.2.3

4.4.4.2 Nuclear fusion

Answer 11 · Mark scheme

June 2023 | 8463/1H | Original Q3

Question	Answers	Mark	AO / Spec. Ref.
03.5	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.3.1.1 4.3.2.1
	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 • particles in a solid are in a regular pattern • particles in a liquid are in a random arrangement • particles in a solid are vibrating about fixed positions • particles in a liquid are moving freely • as the ice changes to water the temperature remains constant • because as the ice changes to water the potential energy of the particles increases • as the water warms the particles move faster • so the kinetic energy of the particles increases • internal energy is the total kinetic and potential energy of all the particles ignore any references to density of ice vs liquid water ignore any references to spacing of particles		

Total Question 3	14

4.4.4.2 Nuclear fusion

Answer 12 · Mark scheme

June 2025 | 8463/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	(atoms of an element with) the same number of protons but a different number of neutrons	ignore number of electrons allow same atomic number allow different mass number	1 1	AO1 4.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	light(er) nuclei fuse to form heavier nuclei / elements some of the mass (of the nuclei) is converted into energy (of radiation)	allow hydrogen nuclei fuse ignore bonding / colliding allow to form helium nuclei	1 1 1	AO1 4.4.4.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	(a large amount of energy transferred) causes a small temperature increase of the walls / material (therefore) the walls of the reactor should not reach melting point	 allow (therefore) the walls of the reactor should not melt	1 1	AO3 4.1.1.3 4.3.2.2 4.3.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	any **one** from: • a nuclear explosion • a (nuclear) meltdown • a nuclear bomb	allow atomic for nuclear allow Chernobyl / Fukushima (disaster)	1	AO1 4.4.4.1

Total Question 5	8

4.4.4.2 Nuclear fusion

Answer 08 · Examiner comments

November 2020 | 8463/1H | Original Q5

Question 5 (Standard/High demand)

05.1 40% of student scored a mark on this question. Electronics, microwaves, phones and food and drink were common incorrect responses. Man-made doesn't mean 'made by man' in this context it refers to the radiation source being artificial rather than naturally occurring. Incorrect answers commonly seen included things which are not man-made, eg sunlight, cosmic rays, other types of radiation which do not contribute to background radiation like microwaves or infrared.

05.2 74% of students could name a nuclear fuel. The most popular answer being 'uranium'. Commonly seen incorrect answers included coal, oil, gas and petrol.

05.3 Only 6% of students scored all 4 marks. To score the first marking point, students needed to indicate that the neutron becomes part of the U-235 nucleus, it was insufficient to only say that the neutron collides with the nucleus. Very few students scored the 4th marking point. Many students hadn't revised the process, evidenced by their meandering discussion of different radiation types and gold sheets. Whilst many students had some idea of the nuclear fission process, they often failed to gain marks because their answers lacked detail or were imprecise, eg neutrons being absorbed by 'atoms' rather than 'nuclei', a nucleus 'splitting' without the detail of two daughter nuclei being produced. A number of students went on to describe the chain reaction and / or the process of electricity generation which was unnecessary.

05.4 Only 8% of students scored both marks, with 29% of students scoring 1 mark. Elements fuse or atoms fuse was insufficient. Nuclei fuse was insufficient unless they said to form a larger / heavier nucleus. Very few knew that some of the mass of the nuclei was converted into energy. Some students fell back on their knowledge of chemical reactions and mentioned breaking bonds and exothermic reactions.

05.5 Only 8% of students scored 2 marks, 39% of students scored 1 mark. Very few students linked the short half-life to how the activity of the waste would change with time. Most students who scored the first marking point did so for saying the radioactive waste would decay quicker. Students tended to score the second marking point rather than the first, although vague statements like less harm/damage to the environment were insufficient.

4.4.4.2 Nuclear fusion

Answer 09 · Examiner comments November 2021 | 8463/1H | Original Q2

Question 2 (Common Question)
Question **02.1** was not very well answered, around half the students scored the first marking point, but very few scored the second. The calculation was well answered, the most common mistake was not converting the mass from g to kg. Questions **02.3** and **02.4** were generally well answered due to the numerous options allowed in the mark scheme.

4.4.4.2 Nuclear fusion

Answer 10 · Examiner comments

November 2021 | 8463/1H | Original Q11

Question 11

Question **11.1** was answered poorly, with many students mixing up specific heat capacity and specific latent heat in their answers, and referring to incorrect parts of the graph. Around a third of students scored a mark on **11.2** and **11.3**. Question **11.4** discriminated well with a good spread of marks. The unit conversion was often performed incorrectly, which led to a 'power of ten' error and prevented students gaining a mark. Few students gave the correct unit, even though the equation needed is on the equations sheet.

Concluding Remarks

This paper was broadly similar to papers from previous series. The errors that students made in calculations were common errors, usually involving incorrect unit conversions or failing to convert units.

An area of the specification that stood out as being particularly poorly answered was section 4.2 which was tested in the Required Practical Activity in question 3 and again in question 10.

Most of the students understand the importance of showing clear working out when completing a calculation. This is crucial in the more complex calculations.

Similar to previous series, a significant number of the students were unable to read values from graphs accurately and failed to realise when numerical values were not given in standard SI units.

4.4.4.2 Nuclear fusion

Mark Ranges and Award of Grades

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

4.4.4.2 Nuclear fusion

Answer 11 · Examiner comments

June 2023 | 8463/1H | Original Q3

Question 3 (Standard Demand)

03.1 Very few correct answers, only 11 % of students scored a mark. Many students gave answers in terms of charge flow and current which were insufficient. The specification does not mention alternating or direct current, only alternating or direct p.d. Answers like ‘ the potential difference flows in one direction’ were insufficient to score.
. Saying the potential difference only travels/goes in one direction was insufficient, as this suggested charge flow. Saying that ‘the potential difference is always positive’ or ‘the potential difference doesn’t go negative’ were creditworthy. ‘The potential difference is in one direction’ was creditworthy. ‘The potential difference isn’t alternating’ was insufficient.

03.2 Almost all students answered correctly. In this exam series, students were provided with all the equations on an Equations Sheet.

03.3 98% of students scored 3 marks on this calculation question

03.4 95% of students scored 3 marks. A small minority of students scored 2 marks, usually due to a spurious conversion of mass from kg to g.

03.5 To score in Level 2, students needed to make comparisons of the movement and arrangement of particles in ice and liquid water. In addition to this, for students to score a Level 3 mark they needed to discuss either the change of state at constant temperature increasing the potential energy of the particles or how the warming of liquid water increased the kinetic energy of the particles. For 6 marks, both these aspects needed discussion. Students found this question difficult with only 9 % scoring 5 or 6 marks and48 % scoring 3 or 4 marks. The mean mark was 3.

4.4.4.2 Nuclear fusion

Answer 12 · Examiner comments June 2025 | 8463/1H | Original Q5

05.1

Just over 80 % of the students scored 2 marks for correctly describing what is meant by an isotope of an element. The number of electrons was ignored as this does not define an isotope.

05.2

Students needed to say light / lighter / small nuclei to demonstrate they understood that it is only lighter nuclei which fuse. The word fuse could have been substituted for other words like 'join', or 'combine' but 'collide' was insufficient. Some students demonstrated an excellent understanding of the fusion process and fusion in stars was accurately described. Fusion on earth where an extra neutron is released was ignored, as the process as stated in the specification was being tested. Just fewer than 20 % of the students scored 3 marks, while nearly 30 % of the students scored 2 marks and approximately 15 % of the students scored 1 mark.

05.3

Most students who scored a mark did so for stating that the reactor walls should not melt. Few students scored the first marking point. Most students were vague and used phrases like the walls need to 'withstand the high temperatures' which did not score a mark. Many students confused specific heat capacity with thermal conductivity and thermal insulation. Containing the fusion energy or products was another common insufficient response. Only

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Answer 12 · Examiner comments June 2025 | 8463/1H | Original Q5

about 4 % of the students scored 2 marks, while approximately 40 % of the students scored 1 mark.

05.4

Just over 30 % of the students scored the mark for the consequence of an uncontrolled chain reaction. 'Explosion' unqualified was insufficient to score the mark.