A-level

PHYSICS
7408/2

Paper 2

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the ‘extra information’ column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of ‘it’

Answers using the word ‘it’ should be given credit only if it is clear that the ‘it’ refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

‘Ignore’ or ‘insufficient’ is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

‘Do **not** allow’ means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word ‘Show that…’, the answer should be quoted to **one more** sf than the sf quoted in the question eg ‘Show that X is equal to about 2.1 cm’ –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer'. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

Level of response mark schemes are broken down into three levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are two marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level. i.e. if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

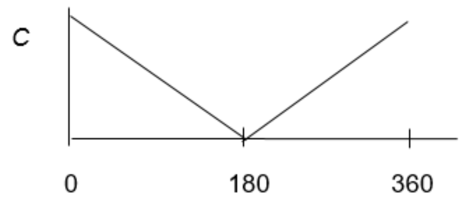
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	(Dielectric constant is) $\frac{\text{permittivity of medium}}{\text{permittivity of free space}}$ and is equal to 6 ✓ OR The permittivity of the dielectric is 6 times the permittivity of free space	Allow: $\frac{C\text{ with dielectric (between plates)}}{C\text{ in a vacuum}} = 6$. Its not enough to quote relative permittivity = 6	1	AO1 1a

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	(Electric field exists between plates) Polar molecules align with their positive side facing the negative plate (owtte) ✓$_1$ producing a counter electric field/reducing the field between the plates ✓$_2$ The pd V reduces between the capacitor plates but charge Q remains the same so capacitance Q/V increases. ✓$_3$	✓$_1$ or vice versa. ✓$_3$ This mark may be approached from the idea that more charge would be required to maintain pd hence C increases by referencing $C = Q/V$	3	AO1 1a ×3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Q remains the same ✓1 New C is $6 \times$ previous C ✓2 Energy difference = 3.8×10^{-9} J ✓3	✓2 May be seen in the substitution in the energy difference calculation ✓3 Calculates change in energy using $E = ½Q^2\left(\frac{1}{C_2} - \frac{1}{C_1}\right)$ = 4.58x10^{-9} – 7.64x10^{-10} Where $Q = 7.6 \times 10^{-10}$ C : $c_1 = 63 \times 10^{-12}$ F and $c_2 = 6 \times 63 \times 10^{-12}$ $E = 378 \times 10^{-12}$ J Condone a negative final answer If no marks given award single mark for the initial energy stored = $4.58\text{x}10^{-9}$ J	3	AO2 1h ×3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	showing a linear decrease and increase ✓ points correct at 0, 180 and 360 degrees ✓	 Ignore graph beyond 360 degrees	2	AO2 1h × 1 AO3 1b × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Insert dielectric between plates/attach dielectric to one plate OR reduce air gap explained ✓ Dielectric has $\varepsilon_r = 4$ ✓ air gap reduced to ¼ ✓	1st mark for quantitative answer for air gap or dielectric or both. (Allow: more plates when explained) 2nd and 3rd marks for numerical analysis for air gap **and** dielectric change. Do not allow incorrect physics.	3	AO3 1a × 3

Total			**12**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Relating the gravitational force to mass × acceleration with the acceleration being centripetal in any form ✓1 show the working leading to answer $\omega = \sqrt{\frac{GM}{(R+h)^3}}$ ✓2	✓1 $\frac{GMm}{r^2} = (ma) = \frac{mv^2}{r}$ or $mr\omega^2$ or $mv\omega$ and r can be replaced by $R + h$	2	3.7.2.4 AO2 1e ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	$\left(\omega = \sqrt{\frac{GM}{(R+h)^3}} = \sqrt{\frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{\left(2.02 \times 10^{7} + 6.37 \times 10^{6}\right)^3}}\right)$ $= 1.45 \times 10^{-4}$ (rad s^{-1}) ✓1 $T = \frac{2\pi}{\omega} = \frac{2\pi}{1.45 \times 10^{-4}} = 4.3(1) \times 10^{4}$ (s) ✓2	✓1 A full substitution in the equation can gain this mark even if ω is incorrectly calculated A final correct answer for *T* gains both marks	2	3.7.2.4 AO2 1b ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Launch from **Z** with some speed or energy argument ✓1 At this position the satellite has the largest initial speed/kinetic energy from the Earth's rotation. ✓2	✓1 Condone ref. to equator rather than Z Consider answer Y only if extremely well explained in terms of different potentials and fuel use.	2	3.7.2.4 AO1 1b AO3 1b

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	gravitational potential energy $= (-)\frac{GMm}{r}$ OR $(-)\frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 1630}{2.66 \times 10^{7}}$ ✓1 gravitational potential energy = -2.44×10^{10} (J) ✓2	✓1 for the equation or substitution without the need for the negative sign only allow ecf for $r = 6.37 \times 10^{6}$ giving gpe = -1.02×10^{11} J ✓2 the minus is necessary for the mark Correct answer gains both marks	2	3.7.2.3 AO1 1b ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	In a higher orbit the linear speed is smaller using $v = \sqrt{\frac{GM}{r}}$ or $v \propto \frac{1}{\sqrt{r}}$ ✓₁ Suitable justification of $v \propto \frac{1}{\sqrt{r}}$ ✓₂	✓₂ example $v = r\omega = r\sqrt{\frac{GM}{(R+h)^3}} = r\sqrt{\frac{GM}{(r)^3}} = \sqrt{\frac{GM}{r}}$ Or derivation from basics	2	3.7.2.4 AO2 1e ×2

Total			**10**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	(If not in a vacuum) gas atoms will collide with air atoms, changing their direction or speed distribution. ✓	There must be some indication of a change of the oven gas molecules associated with collisions If temperature change is mentioned this must be related to speed distribution for the mark	1	AO1.1a ×1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Finds time taken for one rev AND/OR time for $1/8$ rev ✓ (Uses speed = distance/time to get) $= 0.500 / 1.04 \times 10^{-3} = 480\ \text{m s}^{-1}$ ✓ (so about $500\ \text{m s}^{-1}$)	1 rev in $1/120\ \text{s}$ or $0.00833\ \text{s}$ Time for $45°$ or $1/8$ rev $= 1.04 \times 10^{-3}\ \text{s}$ Must have 2 or more sf answer but $500\ \text{m s}^{-1}$ is acceptable as a final answer provided the calculated time for $45°$ or $1/8$ rev is shown and rounded down to 2 sf	2	AO2.1h ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Mass of one atom $= m = 0.209/N_A = 3.47 \times 10^{-25}\ \text{kg}$ ✓1 Substitutes m and answer **03.2** in $½m(c_{rms})^2 = \frac{3}{2}kT$ and rearranges ✓2 $T = 1930\ \text{K}$ ✓3	✓1 May be seen in the substitution of the equation that follows ✓2 $T = \frac{m}{3k}$(answer **03.2**)^2 ✓3 Accept $2095\ \text{K}$ or $2100\ \text{K}$ if $500\ \text{m s}^{-1}$ used A correct answer also gains the second mark	3	AO1.1b ×1 AO2.1c ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	(Pressure is due to collisions of atoms with oven walls) With fewer atoms fewer collisions <u>per second</u> ✓$_{1a}$ but average momentum change per collision stays the same or therefore the total momentum change per second falls (so pressure drops) ✓$_{2a}$ OR Reference to $pV = \frac{1}{3}Nm(c_{rms})^2$ ✓$_{1b}$ c_{rms} is constant as T is constant hence $p \propto N$ (so pressure drops) ✓$_{2b}$	✓$_{1a}$ There must be a reference to frequency or rate of collision ✓$_{1b}$ The equation may be in any equivalent kinetic theory form $pV=nRT$ is not acceptable unless a connection is made between T and c_{rms}	2	AO1.1b ×1 AO2.1c ×1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	$(pV = nRT)$ leaked $n = \frac{V((p_1 - p_2)}{RT}$ ✓ $= 8.42 \times 10^{-3}$ mol	ecf for T from **03.3**	1	AO2.1h ×1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.6	At higher temp atoms will be faster (so drum will not have turned as far) ✓$_{1a}$ Darkest area will be closer to A ✓$_{2a}$	✓$_1$ Accept drawing but allow any degree of maximum darkness. The drawing may be flat or curved.  Allow more atoms will pass through S as it passes the oven, for the first mark making the dark patch darker, for the second mark. This must be linked to the more atoms	2	AO3.1a ×2
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Magnetic flux density at $0.070\ \text{m} = 0.07 \pm 0.005\ \ \text{T}$ ✓ (use of flux linkage $N\Phi = BAN$ $= 0.07 \times 3.5 \times 10^{-5} \times 200$) Flux linkage = $4.9 \pm 0.2 \times 10^{-4}$ (Wb-turns) ✓	shown calculated to at least 2 sig figs	2	3.7.5.3 AO2 1d ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	(As the coil moves) there is a rate of change of flux through the coil ✓$_1$ (owtte) The induced emf is proportional to the rate of change of flux (linkage) so the (magnitude) of the emf decreases ✓$_2$ (owtte)	✓$_1$ The first part ie the induced emf is proportional to the rate of change of flux linkage may be given in a number of ways eg emf $= N\frac{\Delta\Phi}{\Delta t}$ or $N\frac{\Delta(BA)}{\Delta t}$ or simply saying ‘because of Faraday’s law’. Ignore the sign of the emf ✓$_2$ It’s not enough to say the emf decreases Connection between rate of change of flux and change of flux with distance must be made	2	3.7.5.4 AO1 1b AO2 1c

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Finding a gradient from a tangent ✓1 Attempting to use Faraday's law emf = $N\frac{\Delta(BA)}{\Delta t}$ OR incorporating velocity into Faraday's law $NA\left(\frac{\Delta B}{\Delta x}\right)v$ ✓2 emf = $\left(200 \times 3.5 \times 10^{-5}(0.693) \times 0.80\right)$ emf = 3.6 to 4.2×10^{-3} (V) ✓3 The maximum emf (in the range considered) is the greatest at $x = 0.10$ m (as the gradient is the greatest) So No ✓4 owtte	✓1 This can be calculated at any x eg at $x = 0.10$ m gives $\frac{\Delta B}{\Delta x} = \left(\frac{0.095}{0.137}\right) = 0.69(3)$ (T m^{-1}) ✓2 The mark is given for an attempt to use Faraday's law. Allow errors provided the form of the equation remains correct. ✓3 The expected value is $3.8(8) \times 10^{-3}$ V {range to be decided at standardisation} ✓4 No and an indication that the emf at $x = 0.10$ m is the maximum available. This could come earlier in the answer and can be inferred by a reference to the maximum gradient in the range considered. No ecf. If no marks are awarded allow 1 mark if candidate states that the largest emf is expected at $x = 0.10$ m If only the second mark is awarded allow a mark for finding $\frac{\Delta B}{\Delta t}$ or $N\frac{\Delta \phi}{\Delta t}$ between x = 0.07 and 0.10 m (e.g. $\frac{200 \times 3.5 \times 10^{-5}(0.07 - 0.024)}{0.0375}$)	4	3.7.5.4 AO2 1d ×2 AO3 1a ×2

Total			**8**

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Force due to uniform <u>magnetic</u> field (is constant and always) at 90^{o} to direction of travel ✓ Identifies this force as the centripetal force for circular/semicircular motion ✓	Reference to velocity will be taken as the velocity of the proton	2	AO1 1a ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	(1 electron through 10 kV = 10000 eV 14 MeV by 10000 eV) = 1400 (times) ✓		1	AO2 1f × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	$F = Bev$ AND $F = m_p v^2/R$ ✓ Equates forces giving $v = eBR/m_p$ ✓ $E_k = ½m_p v^2 = ½m_p(eBR/m_p)^2$ ✓ $E_k = e^2B^2R^2 / 2m_p$	1st mark for either or both 2nd mark for expression for v 3rd mark for substituting in $½m_p v^2$ Condone use of *Q or q* for *e*	3	AO2 1d ×3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Uses $= \dfrac{e^2B^2R^2}{2m_p}$ to calculate E_k for any one cyclotron in J or eV ✓ Calculates E_k for 3 cyclotrons or argues that as **X** is just OK, **Y** will be greater and **Z** will be less than 11 MeV ✓ So reasoned choice of **X** ✓ cost/$11.7^{1.5}$ = £2.3 million/$10^{1.5}$ cost = £2.9 million ✓	For **X** $E_k = \dfrac{(1.6 \times 10^{-19})^2 \times 1.3^2 \times 0.38^2}{2 \times 1.67 \times 10^{-27}}$ $= 1.87 \times 10^{-12}$ J or 11.7 MeV For **Y** $E_k = 2.32 \times 10^{-12}$ J or 14.5 MeV **or Y** must have higher energy because BR and hence B^2R^2 must be greater For **Z** $E_k = 6.89 \times 10^{-13}$ J 4.3 MeV **or** by inspection B^2R^2 will be too low to give 11 MeV Or other appropriate method	4	AO2 1h ×1 AO3 1a ×3

Total			**10**

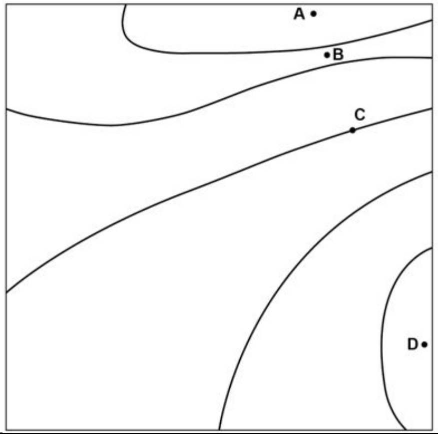
Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Total Mass of nuclei is more than the mass of the fusion product ✓1 Binding energy or Binding energy per nucleon increases when a nucleus is formed by fusion ✓2	✓1 Alternatively the B/A of the fusion product is greater than B/A of both the starting nuclei. ✓2 In order to release energy, the total binding energy of the two nuclei must be less than the binding energy of the nuclide formed	2	3.8.1.6 AO1 1b ×2

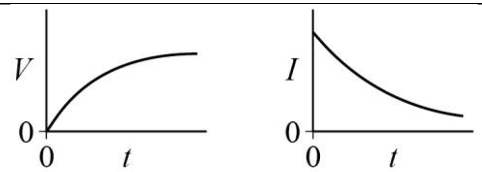
Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	($\Delta m = \left(\text{mass } {}^{3}_{2}\text{He} + \text{mass } {}^{17}_{8}\text{O}\right) - \text{mass } {}^{20}_{10}\text{Ne}$) $\Delta m = 0.02272$ (u) ✓1 Energy released = 3.38 to 3.40×10^{-12} J ✓2 (allow an ecf for the conversion of units)	✓1 $\Delta m = (3.01603 + 16.99913) - 19.99244) = 0.02272$ u (must have at least 3 sig fig) ✓2 $\Delta m = 0.02272 \times 1.661\ 10^{-27}$ kg $= 0.02272 \times 1.661\ 10^{-27} \times (3.00 \times 10^{8})^{2}$ J $= 3.39 \times 10^{-12}$ J OR $\Delta m = 0.02272 \times 931.5$ MeV $= 21.16 \times 1.60 \times 10^{-13}$ J $= 3.39 \times 10^{-12}$ J	2	3.8.1.6 AO2 1f ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Mark for use of potential energy formula and identifying the 2(e) and the 8(e) ✓1 $\left(V = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r} = \frac{2 \times 8 \times \left(1.60 \times 10^{-19}\right)^2}{4\pi \times 8.85 \times 10^{-12} \times 5.1 \times 10^{-15}}\right)$ $V = 7.2(2) \times 10^{-13}$ (J) ✓2 (correct answer only)	✓1 condone other numerical errors ✓2 correct final answer gains both marks	2	3.8.1.5 AO2 1f ×2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Making reference to the doubling charge which increases the gain in potential energy or force needed (to bring nuclei together) ✓1 (owtte) (So) the larger charge (of $^{34}_{16}\mathrm{S}$) requires greater kinetic energy or pressure for fusion and decreases the rate of fusion ✓2 (owtte) Making reference to the larger radius/size of the sulphur nucleus compared to the oxygen nucleus (So) the larger radius (of $^{34}_{16}\mathrm{S}$) (requires smaller kinetic energy or pressure for fusion) and the separation can be larger for fusion to take place so increases the rate of fusion ✓3 (owtte)	✓1 no computation is expected Condone increase instead of doubling ✓3 A full calculation is not expected, such as $\frac{R_S}{R_O} = \sqrt[3]{\frac{A_S}{A_O}} = \sqrt[3]{\frac{34}{17}} = \sqrt[3]{2}$ If no marks are awarded accept number of protons for charge in mp1.	3	3.8.1.5 AO2 1b AO3 1b ×2

Total			**9**

Question	Key	Answer
7	A	$0.10\ \mathrm{kg\ s^{-1}}$.
8	B	u
9	B	temperature in ºC pressure in Pa
10	A	$4.3\ \mathrm{m\ s^{-1}}$
11	B	
12	B	$4g$
13	A	7.2 J
14	D	a repulsive force of $\frac{3}{4}F$
15	C	10^{36}
16	C	$\frac{QV}{d}$
17	D	72 mm
18	D	$\frac{E}{9}$ $\frac{V}{3}$
19	C	No work is done moving an electron from **M** to **N.**

20	D	
21	A	lift upwards away from the wires.
22	A	one
23	D	The peak-to-peak voltage is 650 V.
24	B	$\frac{9}{2}P$
25	B	200 0.45
26	A	Its rate of change of momentum is at a minimum.
27	C	10
28	B	$16N$
29	C	to decrease neutron speeds
30	A	2.3×10^{8} W
31	C	2.55×10^{-13} J