OXFORD AQA

INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH04

Unit 4 Energy and Energy resources

Mark scheme

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241XPH04/MS

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 www.oxfordaqa.com

Level of response marking instructions

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

Step 1 Determine 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, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. 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	The sum of the (randomly distributed) kinetic energies ✓ and potential energies ✓ (of the particles in the system)		2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Uses $\Delta U = Q + W$ with $W = (-)\ 350$ J and $Q = (+)\ 20$ J ✓ $\Delta U = -330$ (J) ✓	Negative sign needed for MP2 Note: answer of 330, 370 or -370 (J) get one mark.	2	AO2
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Use of $pV = \frac{1}{3}Nm(c_{rms})^2$ OR Mass of one molecule $= 6.3 \times 10^{-4} \div 1.3 \times 10^{22}$ $= 4.9 \times 10^{-26}$ uses $\frac{3}{2}kT = \frac{1}{2}m(c_{rms})^2$ to find T (=296 K) uses number of moles = $1.3 \times 10^{22} \div 6.02 \times 10^{23}$ (=0.022) Uses $pV = NRT$ (to determine V) ✓ Evidence of $V = \frac{4}{3}\pi r^3$ used to give a consistent value of r ✓ $r = 5.0 \times 10^{-2}$ (m) ✓	Condone POT error in MP1 and MP2 Expect to see $1.02 \times 10^5 V = \frac{1}{3} \times 6.3 \times 10^{-4} \times 2.53 \times 10^5$ In MP1 condone **one** error e.g. use of either $Nm = 1.3 \times 10^{22} \times 6.3 \times 10^{-4}$ (look for $V = 6.8 \times 10^{18}$ and $r = 1.2 \times 10^6$) OR $c_{rms} = 2.53 \times 10^5$ (look for $V = 1.32 \times 10^2$ and $r = 3.16$) Expect to see $V = 5.2 \times 10^{-4}$ (m^3) Note $V = 1.7$ ($\times 10^{24}$) or $r = 7.4$ ($\times 10^7$) indicates two errors and only MP2 can be awarded.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Use of $m = \frac{\text{mass of gas}}{N}$ ✓$_1$ Use of average kinetic energy $= \frac{1}{2}\,their\,m(c_{\text{rms}})^2$ ✓$_2$ 6.1×10^{-21} (J) ✓$_3$	Expect to see $m = 4.846\ (\times 10^{-26}\ \text{kg})$ In MP2 allow use of c_{rms} = 2.53 ×10^5 (to give $1.55\ (\times 10^{-15}\ \text{J})$) Alternative for MP1 and MP2: kinetic energy $= \frac{3pV}{2N}$ OR kinetic energy $= \frac{3kT}{2}$ seen ✓$_1$ Correct substitutions with their V or their T ✓$_2$ Allow ecf from **02.1**	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Max 2 from: ✓✓ • Idea that pressure on/of the gas in the sphere increases • Idea that there must be an increase in the rate of change of momentum of molecules of gas (hitting liquid) • Idea that the speed of the molecules does not change (as the temperature does not change) OR average force per molecular collision is unchanged Idea that the reduced volume increases the rate of collisions✓	If no other mark given, allow 1 mark for identifying relationship between volume and pressure at constant temperature for a fixed mass of gas	3	2 × AO1 1 × AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Determines mass melted by heater in 5 minutes OR Determines energy provided by heater in 5 minutes ✓ Evidence of use of $Q = mL$ ✓ 2.86×10^5 ✓ J kg^{-1} ✓	Mass = 41.6 – (16 ÷ 2) = 33.6 g Energy = 32 × 5 × 60 = 9600 J Credit answers based on 1 minute Allow unit consistent with their value	4	2 × AO3 1 × AO2 1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Use of rate of heat transfer $= \frac{kA\Delta\theta}{L}$ ✓ 4.7 ✓	Look for $\frac{0.12 \times 1.75 \times 10^{-2} \times 5.5}{1.7 \times 10^{-3}}$ In MP1 condone POT errors Expect to see 6.8 (W) Condone answer expressed as ratio eg 4.7:1	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Evidence of attempt to determine ratio of mass of ice melted due to heater divided by mass melted with heater switched off ✓1 Ratio is 4.2 which is not equal to answer to **03.2** (so student is incorrect) ✓2	Expect to see $(41.6 - (16 \div 2)) \div (16 \div 2)$ In MP1 condone missing subtraction or use of different times Allow **max 1** for use of their specific latent heat from **03.1** as it is not the accepted value. Allow alternative comparing masses: Attempt to calculate masses✓1 Compares masses with valid conclusion✓2	2	1 × AO2 1 × AO4

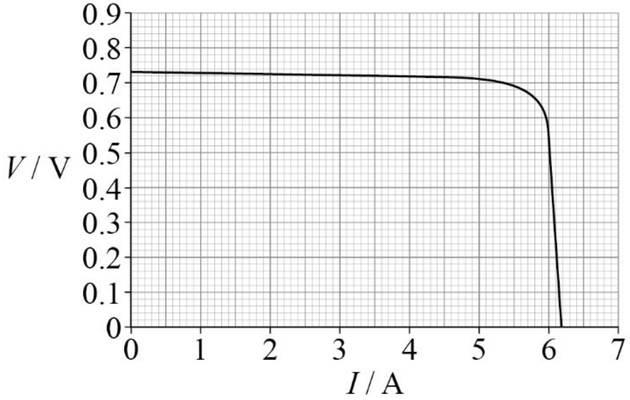
Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Two from eg: ✓✓ Conduct experiment in cooler surroundings therefore less heating from surroundings Increase the power output of the heater therefore makes heating from surroundings less significant Dry the ice to remove water already melted Cover top of ice to reduce heating from room Conduct the experiment for longer so that the (percentage) uncertainty in mass is reduced	Answers should be consistent with either their measured power being too small or their measured mass too big Accept a statement of two appropriate changes for 1 mark Must give two explanations for full marks Treat as neutral any changes to material or dimensions of the funnel.	2	2 × AO4
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Use of Mr^2 for 7.2 m or 5.6 m in an equation with total moment of inertia and I_{jib} ✓ Calculation of difference in moment of inertia ✓ 6.3×10^4 kg ✓	Expect to see $3.75 \times 10^7 = I_{\text{jib}} + M \times 7.2^2$ OR $3.62 \times 10^7 = I_{\text{jib}} + M \times 5.6^2$ Calculator value is 63476.56	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Max 3 from ✓✓✓ • Reads off (20, 0.9) from graph • Uses constant angular acceleration equation with their read-off • Uses $T = I\alpha$ with their α • Adds 3.5×10^4 to their T 1.98×10^5 (N m) ✓	Allow 0.85 to 0.92 for θ Expect to see $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ or 4.5×10^{-3} rad s^{-2} (range is 4.25 to 4.6) Expect to see $3.62 \times 10^7 \times 4.5 \times 10^{-3}$ Expect to see $1.63 \times 10^5 + 3.5 \times 10^4$ (N m) 1.89×10^5 to 2.02×10^5	4	1 × AO3 3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Maximum angular speed identified as steepest part of graph ✓ Calculation of angular speed leading to an answer of 0.08 to 0.09 rad s^{-1} ✓ Compares their gradient with 0.10 with a relevant statement ✓	Either from gradient of line or from use of acceleration from **04.2** Expect idea that max speed is less than speed limit and therefore no	3	2 × AO3 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Increasing d increases moment of inertia $_1$✓ (initial) KE of jib is greater $_2$✓ Frictional torque does more work and work done $= T\theta$ and therefore $\theta_2 > \theta_1$ $_3$✓ OR Reference to: resistive torque $= I\alpha$ and therefore $a_2 < a_1$ $_2$✓ $\theta = \frac{\omega^2}{2\alpha}$ and therefore $\theta_2 > \theta_1$ $_3$✓		3	AO2
Total			**13**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Axes labelled with suitable scales ✓ Line starting from $(0, 0.73)$ ✓ Curve passing through $(5.89, 0.63)$ ✓ Smooth line down to $(6.18, 0)$ ✓	If no other mark given, allow 1 mark for correct general shape 	4	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Use of efficiency to calculate input power ✓ Use of intensity = power divided by area ✓ 970 ✓	Condone use of output power in MP2 Condone POT error for area in MP2	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Two from✓ • calculates number of cells from total power divided by power from one cell • calculates number across the array from total voltage divided by voltage from one cell • Calculation of number down the array from calculated total current divided by current from one cell 8 cells $\times$ 13 cells ✓	Expect to see 104 Expect to see 8 Expect to see 13	3	2 × AO3 1 × AO2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Moderator ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	eg graphite, (heavy) water ✓	Do not accept hydrogen, heavy hydrogen or deuterium	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Idea that there is a higher probability of thermal neutrons being absorbed (by U-235 nucleus) (than fast-moving neutrons) ✓ Idea that (on average) requires one decay to lead to (at least) one further decay ✓	Allow reverse argument. Allow idea that absorption is more likely or more achievable	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Determination of fraction of energy left after one collision ✓ 0.76 MeV ✓	Expect to see 0.75, ¾ or 75% Allow MP1 for determination of fraction of energy lost	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	Idea that the mass of a nucleus of X is closer to the mass of a neutron ✓ Idea that (in each collision) a greater percentage of the neutron kinetic energy transferred/ energy transfer is more efficient (so fewer collisions would be needed) ✓	In MP2 allow reverse idea for heavier nuclei	2	AO2

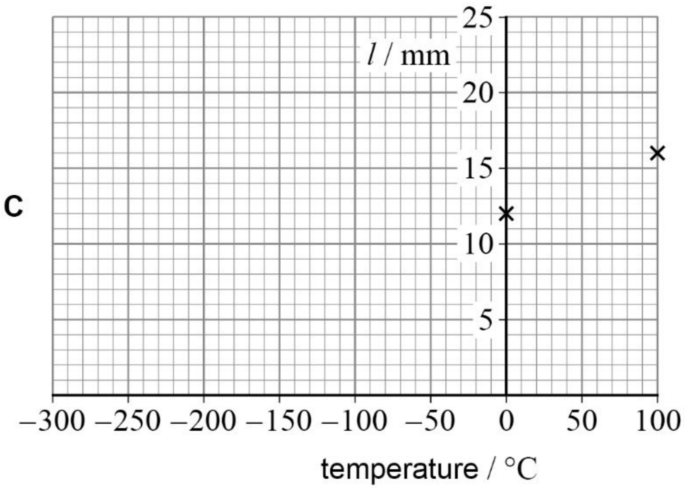
Question	Answers	Additional comments/Guidelines	Mark	AO
06.6	Attempt to determine mass difference in u 235.0439 – 136.9256 – 96.911– 1.00867 ✓ = 0.1986 u ✓ Evidence of correct method to convert their u to MeV. 185 or 186 (MeV) ✓	Expect to see 185 MeV	4	1 × AO1 3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.7	Appropriate risk ✓ Appropriate benefit ✓	eg for MP1 environmental damage from leak or waste, security issues eg for MP2 reduced dependence on fossil fuels, allows local generation	2	AO1
Total			**14**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	A and mass are proportional AND R^3 and volume are proportional ✓ (R_0 is a constant and therefore) A divided by R^3 is constant AND Density = mass ÷ volume Therefore density constant ✓	Alternative: Use of mass = Au Use of $V = \frac{4}{3}\pi R^3$ Substitutes into $R = R_0 A^{\frac{1}{3}}$ ✓ Density = mass ÷ volume u, R_0 (and π) are all constant and therefore density is constant. ✓	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Attempt to determine R_0 from helium nucleus data ✓ $A = 197$ substituted into $R = R_0 A^{\frac{1}{3}}$ ✓ 6.16 fm ✓	Expect to see 1.06 fm	3	1 × AO3 2 × AO2
Total			**5**	

Question	Key	Answer	AO
8	**B**	12 K	AO2
9	**D**	$3P$ | $\frac{V}{2}$	AO1
10	**C**	1.3×10^{-12} J	AO2
11	**B**	**P** and **R**	AO3
12	**D**	${}^{3}_{2}\text{He} + {}^{3}_{2}\text{He} \rightarrow {}^{4}_{2}\text{He} + 2{}^{1}_{1}\text{H}$	AO1
13	**B**	$\frac{v}{\sqrt{2}}$	AO2
14	**A**	1.1 kW	AO2
15	**A**	**X** | **Y**	AO1
16	**D**	Over a cycle, the electrical energy input to the PSS is greater than the electrical energy output.	AO1
17	**B**	It can be switched on quickly in periods of high demand.	AO1
18	**C**	$\text{m}^2\ \text{s}^{-2}\ \text{K}^{-1}$	AO1
19	**C**	6.25×10^4 W	AO2

20	**C**	Experiment **C** 	AO3
21	**B**	2.2%	AO4
22	**C**	processing radioactive products of the reactions	AO1