OXFORD
INTERNATIONAL
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INTERNATIONAL A-LEVEL
PHYSICS
PH04

Unit 4 Energy and Energy resources

Mark scheme

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221XPH04/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 oxfordaqaexams.org.uk

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	Use of $pV = NkT$ ✓ $(N =)\ 3.73 \times 10^{23}$ to at least 3 sf ✓	Alternative 1st mark $pV = nRT$ and $N = nN_A$ Allow one mark for n = 0.62 if no other mark awarded	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Use of (total) mass = N × mass of one particle AND density = mass / volume ✓ density = 0.18 (kg m^{-3}) ✓	allow POT error for MP1 0.17 (kg m^{-3}) if Show value used	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Statement of 1st law with at least two terms defined (in the context of the gas in the container) ✓ Gas does work while expanding (against atmospheric pressure and the balloon's elastic) (W <0) ✓ Little or no heat transfer into the balloon (Q ~0) ✓ Internal energy decreases and links this directly to temperature (ΔU< 0)✓	expect statement of 1st law in symbols or words, given with context accept for MP3: less heat is transferred into the gas than work done MP2-4 must refer to gas in the balloon for MP4, link must refer to KE or an equation	4	1 × AO1 3 × AO2

Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Use of angular deceleration = change in angular velocity / time AND Use of $\tau = I\alpha$ **OR** Use of $\tau t = I\Delta\omega$ ✓ $t = 2.5$ (s) ✓	Condone one error in manipulation or substitution for MP1	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Finds the difference in moment of inertia = $8.1 \times 10^{-5} - 3.5 \times 10^{-5}$ ✓ Use of $I = 3mr^2$ ✓ (m =) 7.2×10^{-3} kg ✓	7.2, 7.25, 7.246 **not** 7.3	3	3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Use of $\tau = I\alpha$ ✓ Use of $\alpha = \frac{\Delta\omega}{t}$ ✓ Adds resultant torque and frictional torque OR use of $\tau = Fr$ ✓ (F =) 0.044 (N) ✓	alternative for MP1 and MP2: use of $\tau = \frac{\Delta J}{t}$ ✓✓ For MP3, full substitution and manipulation needed	4	4 × AO3

Total			9

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	$P = \Delta mgh/\Delta t$ AND $\Delta m = \rho \Delta V$ seen and combined ✓	condone m for Δm alternative: P = work done/time = $F\Delta d/\Delta t$ AND $F = (h\rho g)A$ AND $\Delta V = A\Delta d$ seen and combined ✓	1	1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	140 ($m^3\ s^{-1}$) ✓ cao		1	1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Max two: Water still has kinetic energy/KE after passing through turbine ✓ Losses in the generator (eg ohmic heating)✓ Friction in bearings of turbine/generator ✓ reference to fluid friction when passing through the pipes or turbine ✓		2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Counts and combines squares (16 below axis, 10 above axis) ✓ Determines the area of one square = 200 MWh OR 7.2×10^{11} J ✓ Net energy = -4.3×10^{12} (J) ✓	For MP1, area below axis must be negative or subtracted POT must be correct for MP2 minus sign required for MP3	3	3 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	Idea that more energy is required raising water back to the upper reservoir than is generated (over 24 hours) ✓	reject ideas of heat loss in a particular part of the process etc	1	1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.6	Stores energy in times of low demand ✓ Quick start up time (during peak demand) ✓		2	2 × AO1
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Use of $I = L/4\pi r^2$ (= 1360 W) ✓ Use of $I = P/A$ (= 400 W) ✓ 0.29 ✓		3	3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Use of $E(/t) = m(/t)\ c\ \Delta\theta$ ✓ 24 (°C) ✓		2	2 × AO2
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Volume is proportional to temperature OR reference to Charles' Law OR statement of ideal gas law with N/n, p constant ✓ Length is proportional to volume as cross-sectional area is constant ✓	alternative: the KE/speed of the gas particles increases ✓ collisions between particles and container walls/liquid column remains the same (so length increases) ✓	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	extrapolation to the x-intercept leading to –250 to –270 (°C) ✓	allow mathematical extrapolation no more than 3sf	1	1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Read off l for chosen T (not l=0)✓ Conversion of °C to K ✓ Use of $pV = nRT$ **and** $V = l\,A$✓ 0.75 to 0.80 (mm^2) ✓	alternative: two read-offs (in order to calculate gradient) OR uses gradient calculated in **5.2** if applicable✓ conversion of °C to K ✓ calculates gradient AND $A = nR/(P \times$ gradient) ✓ 0.75 to 0.80 (mm^2) ✓ allow POT errors for MP1,3	4	4 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	MAX 2: Uncertainty due to extrapolation from a narrow range ✓ Large percentage uncertainty in measuring the length of the air column because the length is small ✓ Difficulty in measuring length of air column described (eg parallax, ruler in the water bath)✓	Accept idea that the air column and the water bath are at different temperatures when temperature is measured (eg slow heat transfer through glass) ✓ Accept idea of meniscus (affecting *l*) Condone the pressure in the laboratory varies Condone evaporation of liquid	2	2 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Greater gradient AND greater y-intercept OR (line would extrapolate to) same x-intercept ✓ double gradient AND double y-intercept ✓	line must extend into the positive x- region	2	2 × AO4
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Idea that the distance depends on the alpha's (initial) energy ✓ Idea that alpha approach is a calculation but electron diffraction is a measurement✓ Idea that alpha puts an upper limit on nuclear radius but electron diffraction measures actual radius✓		Max 3	3 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	MP1*:* at least two of: ✓ total mass of nucleus $= Au$ equation for volume of a sphere density = mass/volume MP2*:* all of the above combined AND reasonably clear rearrangement ✓		2	2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO

06.3	Reads off correctly from large triangle ✓ Determines the gradient ✓ Use of $R = \left(\frac{3u}{4\pi\rho}\right)^{\frac{1}{3}} A^{\frac{1}{3}}$ ✓ to get 2.3×10^{17} ✓	expect to see gradient = 1.2×10^{-15} (m) accept 2.4×10^{17}	4	4 × AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	The work that must be done to separate the nucleus into its constituent neutrons and protons OR The energy released when a nucleus is formed from its constituent neutrons and protons		1	1 × AO1

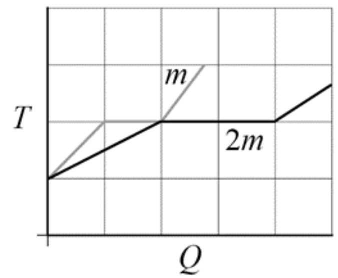
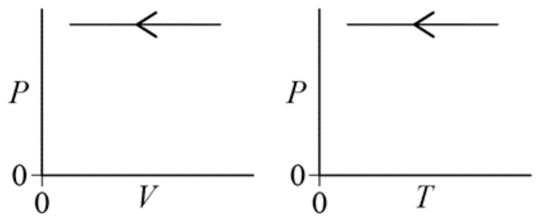
Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Determines the binding energy of U-235 / Cs-136 / Rb-97 ✓ Determines the binding energy difference (169.48 MeV) ✓ Converts MeV to J to get 2.71×10^{-11} (J) ✓	1783.8709 MeV, 1141.01416 MeV, 812.3362 MeV Penalise minus sign in the final answer	3	3 × AO2

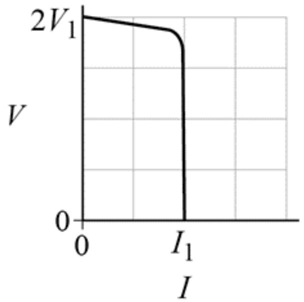
Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Divides power/energy released per reaction ✓ Converts number of nuclei into mass ✓ $= 1.83(2) \times 10^{-5}$ (kg s^{-1}) ✓	expect to see 4.7×10^{19} nuclei/s allow POT error for MP1 and MP2	3	3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Use of $\frac{1}{2}m\,(c_{\text{rms}})^2 = \frac{3}{2}kT$ ✓ Mass of neutron used ✓ $= 4.6 \times 10^3$ (m s^{-1}) ✓		3	3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	MP1 – control rods absorb neutrons AND the depth/length of the control rods in the reactor can be adjusted MP2 – idea that constant rate of fission requires that an average of one neutron per fission goes on to induce another fission MP3: relates constant rate of fission with constant power output	MP2: number of free neutrons in the core must be constant	3	3 × AO1
Total			**13**	

Section B – Multiple Choice

Question	Key	Answer	AO
8	B	zero positive positive	AO2
9	A	$kg\ m\ s^{-3}\ K^{-1}$	AO1
10	C	$2R$	AO2
11	C		AO3
12	B		AO3
13	B	$422\ m\ s^{-1}$	AO3
14	A	small nucleon number poor neutron absorber	AO1
15	B	**V** and **W** **Y** only	AO3
16	D	6.17 MeV	AO2

17	**C**	effective confinement of the plasma in the reactor	AO1
18	**C**	$\sqrt{\frac{m(2gh - v^2)}{I}}$	AO2
19	**B**		AO2
20	**A**	photovoltaic solar panels / greenhouse gases not emitted during power generation / toxic materials used in manufacture of panels	AO1
21	**D**	295 K	AO2
22	**B**	3.1P	AO2