OXFORD
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INTERNATIONAL A-LEVEL
PHYSICS
PH04
Unit 4 Energy and Energy resources

Mark scheme

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2 1 1 X P H 0 4 / M S

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	Two from: ✓ ✓ negligible forces between particles (except during collisions) volume of particles is negligible (compared to volume of container) particles collide elastically collision duration is negligible compared to time between collisions	 Accept "point particles/molecules" Accept particles move randomly	2	AO1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Converts T to kelvin $(285.5\ \mathrm{K})$ ✓ Uses $\frac{1}{2}m(c_{\mathrm{rms}})^2 = \frac{3}{2}kT$ ✓ $423\ (\mathrm{m\ s^{-1}})$ ✓ Any 2 sf answer from some appropriate working ✓	 Allow other formulae involving $(c_{\mathrm{rms}})^2$ Using $12.5\ °\mathrm{C}$ for T gives $88.5\ (\mathrm{m\ s^{-1}})$	4	AO1 AO2 AO2 AO4
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	154 (neutrons) seen ✓ Attempts to calculate a mass defect (expect 2.02 u) **OR** attempts to convert a mass in u to kg ✓ 3.4×10^{-27} (kg) ✓	May be seen as (252 – 98) (154 n + 98 p) = 254.04862 u = 4.219×10^{-25} kg $m_{Cf} = 4.186\times10^{-25}$ kg Allow 3.3×10^{-27} (kg)	3	AO1 AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Calculates difference in mass, including 4 neutrons ✓ Converts mass difference to energy (u to eV, or kg to J) ✓ 210 (MeV) ✓	Expect 0.22532 u or 3.7×10^{-28} kg	3	AO2 AO2 AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Acceptable method to obtain V and I values for maximum power ✓ (Uses $P = VI$ to get) 0.50 to 0.52 (W) ✓	Award zero marks for any attempt to get area	2	AO3 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	5 cells in series give 3.6 V ✓ Evidence of combining cell resistances in series ✓ Evidence of combining cell resistances in parallel ✓ (so array needed is) two parallel sets of 5 cells ✓	Accept a circuit diagram. (Condone incorrect symbol for solar cell.)	4	AO1 AO1 AO2 AO2
Total			6	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Evidence of use of $\rho = \frac{m}{V}$ ✓ Substitution of values into $pV = NkT$ **OR** $pV = nRT$ ✓ 8.8×10^{27} ✓	Allow 9.03×10^{27} if 1.5×10^{4} moles used to multiply by N_A	3	AO2 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Uses $\frac{m}{N}$ to get molecular mass **OR** $\frac{N}{N_A}$ to get number of moles (1.5×10^{4}) ✓ Uses $M = mN_A$ **OR** $M = \frac{m}{n}$ ✓ $4.0\ \text{g mol}^{-1}$ **OR** $4.1\ \text{g mol}^{-1}$ ✓	Award MP1 or 2 if seen in **04.1** Allow any consistent value and unit of molar mass	3	AO1 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Uses $Q = mc\Delta\theta$ **OR** $\frac{Q}{t} = \frac{m}{t}c\Delta\theta$ ✓ $\Delta\theta = 255\ (\text{K})$ ✓ Adds their $\Delta\theta$ to 860 ✓	Condone power of ten error Expect $1100\ (\text{K})$	3	AO3 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Work done by gas (so W is negative) ✓ Heat transfers from gas (initially so Q is negative) ✓ Use of 1st law ($\Delta U = Q + W$) to demonstrate that U decreases ✓		3	AO2 AO2 AO2
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Substitutes into $\theta = \frac{1}{2}\alpha t^2$ ✓ Uses θ for 3 rotations (expect to see 6π) ✓ 7.8 (rad s^{-2}) ✓	**Alternative method** Identifies mean omega $6\pi/2.2$ ✓ Identifies max omega (2 × mean omega) **OR** uses $\alpha = \frac{\Delta\omega}{t}$ ✓ 7.8 (rad s^{-2}) ✓	3	AO2 AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Use of $mg - tension = mA$ or equivalent **OR** Use of torque $= tension \times r$ ✓ Two equations combined with correct manipulation ✓		2	AO3 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Calculates torque ✓ Uses torque $= I\alpha$ ✓ 2.4×10^{-3} or 2.5×10^{-3} (kg m^2) ✓	torque $= 0.0193$ N m Allow 1 sf. Allow 8.6 for α, which gives 2.2×10^{-3} kg m^2	3	AO3 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	(Friction) provides opposing/resistive torque **OR** reduces the resultant torque (on disc) ✓ Reduces the (angular or linear) acceleration **OR** increases time to fall ✓ Experimental value of I would be larger than actual I ✓	Accept energy/work done argument. MP3 must be consistent with their argument.	3	AO4 AO4 AO4
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Use of $mgh = 30 \times 10^{12}$ with h = 120, 130, or 140 m ✓ 2.4×10^{10} (kg) ✓	Condone power of ten error for energy	2	AO3 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Uses efficiency to get input power or useful energy output ✓ Uses energy = power × time ✓ 3.8 (hours) ✓	Condone one power of ten error for MP1 and MP2. Allow 2 marks for 5.65 (hours).	3	AO1 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Idea that water needs to be pumped back to upper reservoir ✓ Idea that pumping process is less than 100% efficient ✓	Credit sensible reference to 67% (from 0.82^2)	2	AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Used to meet surges in demand ✓ Short start-up time ✓ Store energy (from base load) at times of low demand ✓		3	AO3 AO3 AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	nuclei must come within few femtometres to fuse ✓ high kinetic energy needed to overcome (electrostatic) repulsion by nuclei ✓	Accept idea that strong nuclear force needs to dominate	2	AO1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	2.5×10^{-14} (J) ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Same value/2.5×10^{-14} (J) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Idea that combined kinetic energy is available ✓ Idea of kinetic energy (completely) transfers to electric potential energy (in a head on collision) ✓ Refers to $V = \frac{Q}{4\pi\epsilon_0 r}$ **AND** $\Delta W = Q\Delta V$ **OR** $E = \frac{Q_1 Q_2}{4\pi\epsilon_0 r}$ ✓	MP1 or MP3 may be evident in a worked example. Only award MP3 if equations are used correctly.	3	AO3 AO3 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	Calculates two binding energies ✓ Attempt to calculate difference in energy ✓ Converts to J to give 1.4×10^{-12} (J) ✓	Expect 2.2246 MeV and 28.2956 MeV Expect 8.4819 MeV	3	AO2 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.6	$m_{\mathrm{He}} = 4m_{\mathrm{n}}$ so $v_{\mathrm{n}} = 4v_{\mathrm{He}}$ (from conservation of momentum) ✓ Argues for dependence of $\mathrm{E_k}$ on velocity eg $v_{\mathrm{n}} = 4v_{\mathrm{He}}$, so $E_{k,\mathrm{n}} = 16E_{k,\mathrm{He}}$ **OR** mass eg $m_{\mathrm{He}} = 4m_{\mathrm{n}}$ so $E_{k,\mathrm{He}} = 4E_{k,\mathrm{n}}$ ✓ Shows that both effects lead to $E_{k,\mathrm{n}} = 4E_{k,\mathrm{He}}$ ✓		3	AO3 AO3 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.7	One from: ✓ Damage to reactor structural materials (on atomic level) Damage to human tissue/cell/DNA due to radiation effects Production of radioactive nuclides		1	AO3
Total			**14**	

Question	Key
8	B
9	A
10	C
11	C
12	A
13	D
14	B
15	B
16	C
17	B
18	A
19	B
20	D
21	C
22	B