OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH04

Unit 4 Energy and Energy resources

Mark scheme

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2 5 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 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.

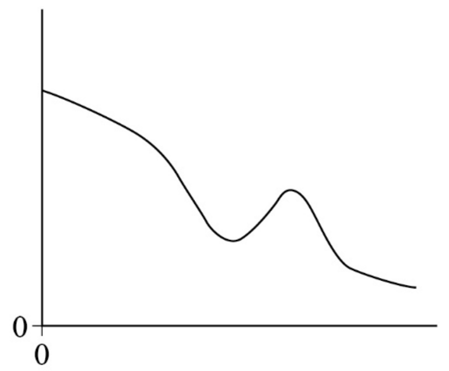
Step 2 Determine a mark

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	Graph showing central maximum, non-zero first minimum and further reduction to a non-zero level. ✓	 Accept the correct presence of further minima.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Uses $\lambda = \frac{h}{p}$ to attempt to find the de Broglie wavelength of the electrons. ✓ The idea that, (for diffraction,) the (de Broglie) wavelength should be comparable to the size of the nucleus. ✓ Gets an answer of 3.0×10^{-15} (m) ✓	Condone – they are about the same size so suitable Max 2 if no indication about whether it is or is not suitable.	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	The idea that Pb-208 has a greater/different nuclear diameter than Pb-204 (as $R = R_0 A^{\frac{1}{3}}$) (and that since the technique actually measures diameter), the measured value will be greater/different for Pb-208 than for Pb-204 ✓	Accept statement that difference will be very small because not much difference in nuclear diameter.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Any TWO from: ✓✓ Converts alpha particle energy to J $E = \frac{Q_1 Q_2}{4\pi\epsilon_0 r}$ seen Selects $2 \times 1.6 \times 10^{-19}$ and $82 \times 1.6 \times 10^{-19}$ as Q_1 and Q_2 Then: answer that rounds to 2.8×10^{-14} (m) ✓	Expect 1.344×10^{-12} J	3	2 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Idea that the distance of closest approach is the same because it depends on the proton/charge number (and not the nucleon number). ✓		1	AO2

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	The idea that molecules/particles collides with the walls of the container and experience a change in momentum when they do. ✓ The walls exert a force equal to the rate of change of momentum on the molecules. ✓ The molecules exert an equal and opposite force on the walls **and** reference to Newton 3. ✓ Relates pressure to force per unit area. ✓	Condone gas collide with wall… Accept $F = \frac{mv-mu}{t}$ or equivalent for mp2	4	2 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Attempts use of $\frac{1}{2}mc_{\mathrm{rms}}{}^2 = \frac{3}{2}kT$ (with T the same for both gases). OR Recognises that (mean) molecular energy is the same for both (as they have the same temperature). ✓ Attempts to find the ratio of c_{Ar} to c_{Xe} ✓ Manipulates to get 1.8 ✓	Allow valid use of any equation e.g. $pV = \frac{1}{3}Nm(c_{\mathrm{rms}})^2$ that leads to equating ratio of rms speeds to a ratio of masses. Expect to see $\frac{c_{\mathrm{Ar}}^2}{c_{\mathrm{Xe}}^2} = \frac{0.132}{0.040} = 3.3$ calculator value 1.817	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Uses $P = \frac{NkT}{V}$ OR $P = \frac{nRT}{V}$ OR $p = \frac{2NE_K}{3V}$ (from $pV = \frac{1}{3}Nm(c_{\mathrm{rms}})^2$ and $E_K = \frac{3}{2}kT$) OR use of $pV = \frac{1}{3}Nm(c_{\mathrm{rms}})^2$ with their answer to **02.2** ✓ States that both contribute the same pressure as N, (k), T and V are the same for both (or n, (R), T and V). ✓	Allow attempts to calculate P in terms of N and V, substituting for k (or R) and T for MP1. They can then access MP2. **Alternatives for 1 mark max** Idea that xenon has more momentum change per collision but argon has more collisions per second. ✓ OR Accept calculation of both pressures using half of the total volume for each. ✓	2	1 × AO2 1 × AO4

Total			**9**

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>03.1</td><td>This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.
<table><tr><th>Mark</th><th>Criteria</th></tr><tr><td>6</td><td>All three areas covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr><tr><td>5</td><td>All three areas covered, at least two in detail.
Whilst there will be gaps, there should only be an occasional error.</td></tr><tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.</td></tr><tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr><tr><td>2</td><td>Only one area discussed, or makes a partial attempt at two areas.</td></tr><tr><td>1</td><td>None of the three areas covered without significant error.</td></tr><tr><td>0</td><td>No relevant analysis.</td></tr></table></td><td>Nuclear changes
In fusion:
2 small nuclei (LHS of graph) combine (to make a larger nucleus).
In fission:
Splitting of a large nucleus (RHS of graph) to form 2 smaller nuclei.
How each process can begin
Fusion – High temperature/high KE/high pressure so that nuclei get close enough to fuse / overcome repulsion or potential energy.
Fission is initiated when nucleus absorbs a (thermal) neutron and (becomes unstable). Accept reference to spontaneous fission.
Confinement to parts of diagram
• Fusion
BE (per nucleon) increases.
(Large change in BE per nucleon in fusion.)
Occurs on LHS with possible reference to 56.
• Fission
Increase in BE per nucleon.
(Large release of energy because (although change in BE per nucleon is smaller) there are a lot of nucleons involved.)
Occurs on RHS with possible reference to 56</td><td>6</td><td>2 × AO1
2 × AO2
1 × AO3
1 × AO4</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Strong magnetic fields are required (to confine plasma) ✓ Idea that if electromagnets were not superconducting, the power dissipated in the magnets would be very great, (leading to damage or too much energy cost for reactor to be a net provider of power.) ✓ Particles constrained to move at high speed in circular paths (reference to $BQv = m\frac{v^2}{r}$) so very strong magnetic fields needed. OR Idea that the plasma is too hot for physical confinement / would cool the plasma on contact with the container ✓	Allow (plasma) looses energy for cools down	3	1 × AO1 2 × AO2

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Extracts a correct pair of values for p and V from **Figure 4**. ✓ Calculates two values of pV correctly for their data. ✓ Explains that pV is only constant if temperature is constant (with reference to $pV = nRT$ or $pV = NkT$) ✓	Expect $(1.5, 2.45)$ and $(0.70 – 0.75, 5.0)$ Condone omission of or errors in powers of ten in mp1 and mp2. Expect to see a product of $35 – 37.5$ (J) no unit penalty. Accept checking that, if one halves, the other doubles. MP3 still required as separate statement. Accept any correct alternative comparison.	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Attempts to find the area under the graph. ✓ Counts $20–22$ squares OR calculates that one square is equivalent to 1.25 (J) ✓ Adds in 14 squares or 17.5 J from below the graph (due to the false origin) to give 43 to 45 J ✓ OR use of integration ✓ substitution limits ✓ answer in range 43 to 45J ✓		3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Idea that work is done on the gas / $W > 0$ so either: energy must be transferred to the surroundings / $Q < 0$ (because $\Delta U = 0$) **or** the internal energy must increase / $\Delta U > 0$ (because $Q = 0$). ✓ Any **one** from: ✓ • $\Delta U = Q + W$ with terms defined • Idea that heat cannot be transferred to the surroundings unless there is a temperature difference. **or** Idea that an increase in internal energy is an increase in temperature		2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Compression performed slowly (to give time for heat transfer). ✓ Material of the cylinder should be a good thermal conductor and/or the cylinder should have thin walls (to permit heat transfer). ✓		2	1 × AO2 1 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Uses $pV = nRT$ ✓ 0.015 (mol) ✓	Condone missing powers of ten in MP1 Accept rearrangement and incorrect data in mp1	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Uses $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$ ✓ Extracts both pairs of data correctly. ✓ Uses absolute temperature and subtracts to find the temperature change. ✓ **OR** Uses $pV = nRT$ ✓ Uses $(5.0 \times 10^{-4}, 0.75 \times 10^{5})$ together with candidate's value from **04.5 ecf** ✓ Uses absolute temperature and subtracts to find the temperature change. ✓	Condone missing powers of ten. Expect to see $(1.5, 4.0)$ and $(5.0, 0.74)$. Expect to see 190 (K) (186-195) mp3 – independent Allow use of $(1.5 \times 10^{-4}, 4.0 \times 10^{5})$ if other end was used in **04.5**	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.7	Plot a graph of $\ln p$ (y–axis) against $\ln V$ (x–axis) ✓ b = negative of the gradient. ✓	Allow use of log with any base. 2nd mark is dependent on the 1st **Alternative:** Plot a graph of $\ln V$ (y–axis) against $\ln p$ (x–axis) $b = \frac{1}{-\text{gradient}}$	2	1 × AO2 1 × AO3

Total			**17**

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Use of $T = Fr$ e.g. $F \times 0.2 = 4.5$ ✓ Use of $F_s = k\Delta l$ ✓ Use of both equations leading to 0.015 (m) ✓	Expect to see $F = 22.5$ N Condone use of $F \times 0.4 = 4.5$ Expect to see $F_s = 36.3$ N Accept other units if correct and stated.	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	95 (W) ✓	condone 93.6 – 95.4	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	46 (J) **ecf** for incorrect read-off in **05.2** ✓	Look for 0.00518(candidate's **05.2**)^2	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Determines α as $\frac{21\ (\text{rad s}^{-1})}{2.3\ (\text{s})}$ ✓ Use of resultant torque $= I\alpha + 4.5 = 0.21\alpha + 4.5$ ✓ Torque applied by rider $= \frac{280}{80} \times$ candidate's resultant torque ✓ 22.4 – 22.5 (N m) ✓	Expect 9.13 rad s^{-2} Expect 6.42 N Allow $\frac{140}{40}$ for $\frac{280}{80}$ Expect 3.5×6.42 Allow 22 or 23 (from correct rounding) Allow alternative route using forces.	4	1 × AO1 3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Idea that Torque is constant for 2.3 s ✓ Idea that Torque is constant and has a smaller value after 2.3 s ✓		2	1 × AO1 1 × AO2

Total			**11**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	States that there must be 4 (parallel arms) of 30 cells in (series)... ✓ calculates maximum terminal pd of $16.2\ \mathrm{V}$ **OR** the number of cells in each arm and then rounds up to integer values **AND** calculates a maximum current of $12.8\ \mathrm{A}$ **OR** the number of arms and then rounds up to integer values ✓	Max 1 if no mention of series or parallel. Look for numerical justification	2	1 × AO1 1 × AO2

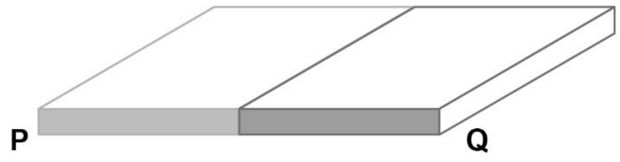
Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Idea that 0.63 (V) is the emf of the cell / the pd with zero current. ✓ Idea that 3.5 (A) is the current (through the internal resistance) when all of the emf is dropped across the internal resistance. ✓	Allow open circuit voltage / pd Allow short circuit current. Allow current when resistance / circuit or terminal pd is zero.	2	1 × AO2 1 × AO3

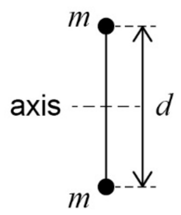
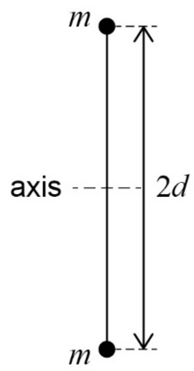
Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Uses $P = VI$ to find the power from one cell and gets $1.70–1.76\ \mathrm{W}$ ✓ Multiplies by 60 to get $102 – 105$ (W) ✓	Allow use of $P = IV$ for 1 branch $= 20.7 - 21.1\ \mathrm{W}$ Condone 2sf	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Uses series resistance formulae for 12 cells. OR Uses parallel resistance formulae for 5 arms. ✓ Uses $r = 0.18$ (Ω) to give 0.43 (Ω) ✓	Expect 2.16 Allow anything that rounds to 0.43	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	Uses $I = \frac{P}{4\pi r^2}$ ✓ Together with EITHER $I_{\text{surface}} = \frac{1350 \times 4\pi(1.5 \times 10^{11})^2}{4\pi(1.5 \times 10^{11} + 10^5)^2}$ leading to an answer indistinguishable from 1350 ($\mathrm{W\ m^{-2}}$) OR A justification based on the magnitude of the distance change compared with the number of sf of the data provided. ✓	Candidates using $I_1 r_1^2 = I_2 r_2^2$ get MP1 and MP2. Allow any valid comparison.	2	AO2

Total			**10**	

Question	Key	Answer	AO
7	D	increases stays the same	AO1
8	C	$m^2\ s^{-2}$	AO1
9	C	60 ºC	AO3
10	B		AO3
11	D	$\frac{V_0}{273}$	AO3
12	D	e^c $\frac{1}{3}$	AO3
13	A	${}^2_1H + {}^3_1H \rightarrow {}^4_2He + n$	AO3
14	B	low nucleon number high specific heat capacity good neutron absorber	AO1
15	A	increasing the ratio $\frac{\text{number of uranium-235 atoms}}{\text{number of uranium-238 atoms}}$ for the sphere	AO2

16	**B**	 	AO3
17	**A**	130 J	AO2
18	**B**	temperature and mass of gas	AO3
19	**A**	the maximum power that the turbine can extract from the wind passing through the turbine	AO2
20	**C**	$T_1 < T_S < T_2$	AO4
21	**B**	3.6 MW	AO2