OXFORD AQA
INTERNATIONAL QUALIFICATIONS

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

Mark scheme

January 2026

Version: 1.0 Final

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	Any **two** from: ✓✓ • evidence of correct calculation of volume of container (= 1.79×10^{-3} m^3) • evidence of calculation of volume of one sweet (= (their container volume – 1.15×10^{-3}) ÷ 595) • calculates mass of one sweet (= their volume of one sweet × 1180) 1.3×10^{-3} (kg) ✓	Condone power of ten error in MP1 and MP2 ($6.39 \times 10^{-4} \div 595$ =) 1.07×10^{-6} m^3 Alternative BP2 and BP3 • evidence of calculation of mass of sweets = (their container volume – 1.15×10^{-3}) × 1180 (≈ 0.75) • calculates mass of one sweet (= their mass of sweets ÷ 595) Do not condone missing subtraction in BP2.	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Any **one** from: • calculates their number of moles using $pV = nRT$ • multiplies their number of moles by molar mass of nitrogen **OR** ✓ Any **one** from: • calculates their number of particles using $pV = NkT$ • divides their number of particles by Avogadro's number and multiplies by molar mass of nitrogen 1.5 (g) ✓	number of moles $= 5.2 \times 10^{-2}$ number of particles $= 3.15 \times 10^{22}$ Accept 3 sf or more answers that round to 1.46 or 1.47	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Idea that $p \div T$(in kelvin) is constant with their converted T OR Evidence of conversion to K e.g. 273 -15 OR 258 seen ✓ 9.8×10^{4} (Pa) ✓	Allow use of $pV = nRT$ OR $pV = NkT$ using their n and V OR their N and V from 1.2 allow ecf for these routes in MP2 allow 9.7×10^{4}	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Any **two** from: ✓✓ • (at lower temperature) gas particles inside container move more slowly • gas particles hit inside of container less often (per second) AND at lower mean speed/ lower mean change in momentum on collision • idea that the smaller (average change in) momentum/impulse means that a smaller force is exerted on lid/container (when cold than when warm) Force from gas outside > force from gas inside (so lid is harder to take off) ✓	Allow reverse argument based on warmer gas outside Allow missing reference to "mean" in BP2 if some relevant idea of average or mean seen elsewhere eg.reference to average KE If no other mark awarded allow one mark for argument based on the pressure being less when cold	3	AO2

Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Kinetic energy does not change ✓ Potential energy increases ✓		2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Any **two** from: ✓✓ • uses $mc\Delta\theta$ for either copper or water • relates 36 kJ to sum of their $mc\Delta\theta$ • finds their $\Delta\theta$ and subtracts from 45 °C 15 (°C) ✓	Calculator value = 14.61384258	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Uses $mc\Delta\theta$ for 0.015 kg of water with $\Delta\theta = 55$ °C **OR** Relates 36 kJ to sum of their $mc\Delta\theta$ and mL ✓ 2.2×10^{6} (J kg^{-1}) ✓	If no other mark given, allow 1 mark for equating 36 kJ to 0.015 × L	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	**Two** suitable changes eg Use a lid on the can with reason eg Reduces heat loss (to the surroundings)✓ Use more water Reduces percentage uncertainty✓	Change and reason needed for a mark. Alternatives: • lid to prevent evaporative losses • deeper water to ensure none of the steam escapes • wait until water is boiling strongly to ensure steam is dry • insulate the tube/tube with lower heat capacity to ensure steam stays dry • stir the water before reading temp to ensure all water is at this temp • use a temperature range such that the initial temperature is the same number of degrees below and above the room temperature to ensure that energy transfers to and from the surroundings are equal.	2	AO4

Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Evidence of attempt at suitable graph inidicated by quantities on axes✓ Suitable scales ✓ Suitable labels of graph axis quantities, with relevant units ✓ MP1 and MP2 and points give a straight line ✓ Analysis to show equation is consistent with the graph ✓	eg R against $A^{\frac{1}{3}}$ **OR** R^{3} against A **OR** log (R) against log (A) For MP2 assume missing origin label is “0”. For MP3 do not allow In(R) for In (R/fm) For MP4 non-log graph should be shown to go through the (0,0) either on the graph or by analysis Eg for MP5 Comparison with y = mx + c or justification in terms of (direct) proportionality OR, if log-log graph used, gradient $= 3$ or 0.33	5	2 × AO4 1 × AO3 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	<u>Uses graph</u> to determine correct value of R or R_0 (≈ 1.06 fm) **OR** Uses their R_0 or R reading to determine their $A^{\frac{1}{3}}$ ✓ 102 based on correct method ✓	Allow alternative MP1 for correct use of R^3 vs A graph or log-log graph. Allow 90 to 120	2	1 × AO3 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Any **two** from: ✓✓ • evidence of determination of charge for either alpha or sodium • correct conversion of femto to metres • evidence of use potential energy equation 2.0×10^{-13} J based on correct working✓	Do not penalise POT error in BP1 3.2 x 10-19 or 1.76 x 10-18 In BP1 if no value used for e, allow the mark if 2e AND 11e seen For BP3 do not credit use of coulomb force x r.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Idea that answer depends on the alpha particle kinetic energy ✓	Allow idea that alpha particle approach only depends on protons Allow idea that alpha particles lose all their KE before reaching the nucleus	1	AO1

Total			**11**

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	The energy required to separate (to infinity) the nucleons in the nucleus **OR** The energy required to separate a nucleus into its constituent nucleons ✓	Allow work done for energy required Allow energy released when nucleus is formed from constituent nucleons Allow (mass of constituent nucleons – mass of nucleus) $\times c^2$ Condone idea that it is the minimum energy required to remove all of the nucleons from a nucleus	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Steep positive gradient left-hand side leading to peak at about $A = 60$ and binding energy per nucleon between 8 and 9 ✓ Less steep right-hand side passing through $A = 240$ and BEPN between 7 and 8 with negative gradient ✓	Max 1 if graph does not go to at least 240 Allow one grid square either side when checking nucleon number values.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Idea that the binding energy per nucleon of the larger nucleus must be less than the BEPN of the two smaller nuclei ✓ Idea that an increase in binding energy is associated with energy release ✓		2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	(As nucleus only contains one proton), the mass of nucleons and nucleus are the same ✓	Allow idea that: nothing is separated **OR** only one nucleon, so there is nothing to bind to, hence no binding energy Condone idea that there is only one constituent nucleon or there are no consistuent proton**s** and neutrons.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Any **three** from: ✓✓✓ • converts either binding energy per nucleon to a binding energy • converts an energy in MeV into J • subtracts (2×) their binding energy for He-3 from their binding energy for He-4 • multiplies their change in BE by 9.2×10^{37} 1.9×10^{26} (W) ✓	7.71 or 28.28 Expect to see 1.2, 4.5 or 2.1 ($\times 10^{-12}$) In BP3: for 'their binding energy' condone use of BEPN values OR use of 2 x BEPN values	4	1 × AO1 2 × AO2 1 × AO3

Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Evidence of use of $\frac{1}{2}I\omega^2$ **OR** $T = \frac{2\pi}{\omega}$ ✓ 0.86 (s) ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Any **four** from: ✓✓✓✓ • $947 - 933$ (= 14) to find change in KE • Evidence of correct conversion of 17° to rad (0.297) • uses $T\theta$ = change in KE with their angle to find T • adds 18 N m to their T to find applied torque • uses $0.68 \times F$ = their applied torque 96 (N) ✓	Alternative BP1, and BP3 • Work out final speed (7.4) • Use rotational suvat to find acceleration (1.35) AND uses $T = I\alpha$ with their α Allow 95 (N)	5	1 × AO3 4 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Evidence of use of conservation of angular momentum ✓ 6.7 (rad s^{-1}) ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Evidence of use of **two** from: ✓✓ • $T = I\,a$ with correct T and I • angular suvat • angular impulse • work equation 11 (s) **AND** 28 (rad) ✓	In BP1 condone use of 35 for I	3	AO2

Total			**12**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	0.040 (A) **AND** 0.64 (V) ✓	Allow 0.039 to 0.041 and 0.639 to 0.641	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Use of $I = p/4\pi r^2$ ✓ 2.0×10^{11} (m) ✓	Allow 2.1×10^{11}	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Any **three** from: ✓✓✓ • uses 25% correctly • uses 45% correctly • uses 650 divided by their effective incident power OR required input power divided by 720 (to calculate area) • correct use of area of cell 4012 (cells) ✓	720 x (1-0.75) x 0.45 x 20×10^{-4} x n = 650	4	2 × AO3 2 × AO2

Total			**7**

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>07</td><td>

The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

<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 several 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>
</table>

</td><td>

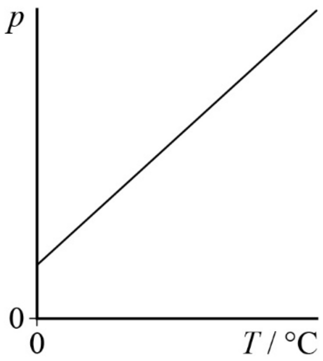
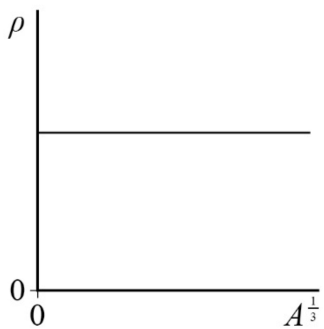
In each area a complete answer is more than half of the bullet points, a partial answer is one bullet point.

A: Principles of operation
- High and low reservoirs
- Generator/turbine acts as motor/pumps
- Water downward at times of high demand
- Water upwards at times of low demand

B: Why pumped storage system is used
- Allows base-load generators to be on all of the time
- When demand exceeds supply, energy produced (from the generator)
- When supply exceeds demand, energy used (to drive motor/pump)
- Idea that system more efficient / reduces cost
- Quick start-up time allows quick response when demand surges

C: Max power
- Reference to $E = \frac{1}{2}\pi r^2 p v^3$ with symbols defined
- Dependence of v on vertical separation of reservoirs and why
- Radius of turbine
- Reference to other inefficiencies eg resistive heating

</td><td>6</td><td>5 × AO1
1 × AO2</td></tr>
</table>

Question	Key	Answer	AO
8	A	The rms speed of the molecules of **X** is greater than the rms speed of the molecules of **Y**.	AO2
9	C		AO3
10	A	**S** and **T**	AO3
11	D	$149\ \text{m s}^{-1}$	AO2
12	B	by the system. from the system.	AO1
13	B		AO3
14	D	2.0 20 0.05	AO3

15	**C**	2.0 30 0.04	AO3
16	**C**	$2E$	AO2
17	**A**	$\frac{1}{2}P_{A}$	AO3
18	**A**	0.22 clockwise	AO2
19	**B**	low similar	AO1
20	**B**	cools the fuel rods that still generate heat.	AO1
21	**D**	The back-up power stations can be brought on line quickly.	AO3
22	**C**	10^{16} J	AO3

Total = 15 marks