OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH04

Unit 4 Energy and Energy resources

Mark scheme

June 2025

Version: 1.0 Final

256XPH04/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	Idea that it allows for long duration of (close together) recordings✓	Do not allow idea of convenience of placing sensor in test tube Ignore references to errors or accuracy Condone the idea that: It allows rapid changes of temperature to be recorded It allows the time and temperature to be recorded at the same time. It allows many/ more readings in a short time.	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Idea that at this temperature latent heat is transferred (to the surroundings as the liquid changes to solid) ✓ Idea energy 'released' (by liquid) during phase change is equal to energy lost to surroundings so temperature is constant ✓	In MP1 allow idea that energy is transferred as bonds are **formed**. Alternative for MP2: discussion around kinetic energy (of particles) being constant as potential energy changes	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Any **three** from: ✓✓✓ • calculation of a $\Delta\theta$ • use of $Q = mc\Delta\theta$ with any $\Delta\theta$ and either c • use of $Q = mL$ • their ΔQ for liquid cooling added to their mL and their ΔQ for solid cooling Answer that rounds to 2.61×10^4 (J) ✓	eg $80\ ^\circ\text{C} - 58\ ^\circ\text{C}$ **OR** $22\ ^\circ\text{C}$ seen	4	2 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Evidence of a tangent drawn on **Figure 1** at 300 s ✓ Answer in the range 0.15 to 0.17 (K s^{-1}) ✓	Judge tangent by eye. Condone minus sign on answer line.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Any **two** from: ✓✓ • determines rate of energy transfer from **S** $P = mc \times 0.055$ • uses their rate of energy transfer $= \frac{kA\Delta\theta}{L}$ to determine their $\Delta\theta$ • uses their reading at 400 s – their $\Delta\theta$ All three bullets correct and answer = 29 (°C) ✓	Condone POT error in MP1 and MP2. In bullet 2 condone for rate of energy transfer: use of 0.055 use of an energy ÷ a time (e.g. $2.61 \times 10^4 \div 800$) Allow 29.5 to 30.5 for their reading at 400 s.	3	AO2

Total			12

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Uses $\frac{3}{2}kT$ ✓ 3.5×10^{-22} (J) ✓	Accept ΔT in MP1 Condone T in $^{o}\mathrm{C}$ in MP1.	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Use of $p\Delta V$ ✓ 30 (J) ✓	Condone POT error in MP1 Calculator value is 30.25	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Any **two** from: ✓✓ • converts temperature to K • $N = \frac{pV}{kT}$ **OR** $N = \frac{N_A pV}{RT}$ seen or used in some form • subtracts their N_{up} from their N_{down} **OR** subtracts V_{up} from V_{down} 7.2×10^{21} ✓	Allow use of their $p\Delta V$ from **02.2** in bullet 2. A correct use gets bullet 2 and bullet 3; allow ecf in MP3.	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Idea that: external pressure is lower so moving air out of the balloons requires less energy/ less work done ✓ more energy needed in heating the air as the air starts colder/the temperature difference is greater ✓ the total work done on the air as it leaves the balloon is the same (as ΔN is the same and T is the same) and work done $= \Delta N\, kT$ ✓	In MP3 allow discussion in words without the equation where the relationship is implied. E.g. "As the temperature is the same and the same number of particles leave the balloon, the work done (on the air) is the same" Allow discussion in terms of moles. If no other mark given, allow **1 MAX** for all three correct without explanation.	3	AO2

Total			**10**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Any **two** from: ✓✓ evidence of • calculation of volume of nucleus • calculation of mass of nucleus • use of their mass and their volume to calculate a density 2.7×10^{17} (kg m^{-3}) ✓	**MP1** condone use of half the radius **MP3** cannot be awarded if there are two or more errors in the determination of the volume Allow mass determination using 54 u OR $54 \times 1.67 \times 10^{-27}$ OR $26\ m_p + 28\ m_n$	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Any **two** from: ✓✓ • determines R_0 using data from **03.1** • uses $R = R_0 A^{1/3}$ to determine their A • uses their $A - 26$ to determine their number of neutrons 32 ✓	Alternatives bullet 1 and bullet 2: Use of ratios: bullet 1 correct ratio equation in symbols or substitution bullet 2 correct A determined OR Use of density (from 3.1) bullet 1 determines mass (= $\frac{4}{3}\pi r^3 \rho$ or from ratios) bullet 2 their mass ÷ mass of nucleon to get their A **OR** subtracts mass of 26 protons then divides their mass by the mass of neutron (to get answer)	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Any **three** from: ✓✓✓ • determines charge on iron nucleus **OR** charge on alpha particle • uses (change in) electric potential energy • sets their (change in) electric potential energy equal to initial kinetic energy in some form • uses the mass of an alpha particle 8.5×10^{6} (m s^{-1}) ✓	eg for bullet point 3: $\frac{Qq}{4\pi\varepsilon_0 r} = \frac{1}{2}\ mv^2$ seen Look for (change in) electric $E_p = 2.4 \times 10^{-13}$ (J) Mass of alpha = 6.6×10^{-27}(kg)	4	1 × AO1 3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	$5(.0) \times 10^{-14}$ m **AND** idea that closest approach depends on the charge on the (target) nucleus (not the mass) **OR** the charge on both nuclei is the same **OR** number of protons is the same✓	Do not accept 'they are isotopes' on its own.	1	AO1
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Any two from ✓✓ • Identification of areas for fission and fusion • Description of fission and fusion • Idea that there is an **increase** in binding energy (per nucleon) **OR description** of mass defect (to release energy) Idea that change in binding energy per nucleon is greater for fusion ✓ Consideration of the impact of the difference in number of nucleons involved, leading to idea that fission releases more energy ✓	e.g. Fusion on LHS and fission on RHS Fission: (energy released when) nucleus splits into smaller nuclei Fusion: (energy released when) small nuclei combine into larger nuclei Accept reverse argument (Very many) more nucleons on RHS/fission side so energy released greater Evidence for MP3 and MP4 may be seen in suitable calculations	4	2 × AO1 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Any **two** from: ✓✓ Evidence of • determines binding energy for one nucleus • determines their energy released from their binding energy calculations and not including neutrons • converts their energy to J 2.6×10^{-11} (J) ✓	Look for: U binding energy = 1790.414 (MeV) La binding energy = 1203.04 (MeV) Br binding energy = 748.7133 (MeV) 161.34 (MeV) In bullet 3 do **not** condone POT error	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Any **two** from: ✓✓ Evidence of • calculation of the mass of 26 protons in u or kg • calculation of the mass of 30 neutrons in u or kg • subtracting mass of iron nucleus (in u or kg) from their total mass • converting their **difference** into MeV 471 (MeV) ✓	26 protons = 26 × 1.00728 u = 26 × 1.673 x 10^{-27} kg 30 neutrons = 30 × 1.00867 u = 30 × 1.675 × 10^{-27} kg Difference = 0.51438u = 8.40 × 10^{-28} kg In bullet 3 do not allow 56u as their total mass. Accept use of alternative units Accept range 470 to 480	3	AO3

Total			10

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Any **two** from: ✓✓ Evidence of • converts 481 revolutions to radian • calculates their work done by frictional torque **OR** deceleration a of wheel • equates their work done to change in kinetic energy using kinetic energy $= \frac{1}{2} Iw^2$ **OR** uses $T = Ia$ 0.049 (kg m^2) ✓	Expect to see 3022 (rad) Expect to see 10.9 (N m) Expect to see 0.073 (rad s^{-2})	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Max three from✓✓✓ Evidence of • calculation of weight of **P** • determination of angular displacement (175°) • Converts either 5 degrees or their angular displacement into radian • uses $T \times$*their* $\theta = mg\Delta h$ 2.6×10^{-3} (N m) ✓	Expect to see Weight = 0.17 (N) 0.087 (rad) or 3.05 (rad) Condone 1 sf answer	4	1 × AO3 3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Any **four** from: ✓✓✓✓ • (take repeat readings and) reject anomalous results • (several repeats and) find half-range and use for absolute uncertainty (in angle or height) • how to use the uncertainty to determine the percentage uncertainty • combine percentage uncertainties in h and θ • use percentage uncertainty to determine absolute uncertainty	In BP2 condone use of half the range of the torque (T) Condone missing reference to mean once only. Allow consistent use of fractional uncertainties for percentage uncertainties. Alternative: Any **four** from: ✓✓✓✓ • Reject anomalous results • Use h_{max} and θ_{min} to determine T_{max} • Use h_{min} and θ_{max} to determine T_{min} • Determines T_{mean} • Use (T_{max} - T_{min}) divided by 2 OR T_{max} - T_{mean} OR T_{mean} -T_{min}.	4	3 × AO3 1 × AO4
Total			**11**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>06.1</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>A fair attempt to analyse all three areas. If there are several errors or missing parts then 5 marks should be awarded.</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>
</table>
</td>
<td>
A full analysis requires more than half the bullet points in any one area. One bullet point is sufficient for a partial answer.

Maximum power output
• wind speed
• radius of blades/area swept by blades
• importance of location and reliability/strength of wind
• reasons not all energy can be used eg friction in bearings, wind speed does not decrease to zero etc

Number and arrangement
• size/spacing of turbines related to available space
• idea of wind shadows
• consideration of size of turbine related to power output and how close together they can be due to wind shadow

Environmental factors
• noise
• harmful to birds/damage to habitats in construction
• means land can’t be used for anything else
• example of aesthetic impact
• light shadow flicker/ strobing
</td>
<td>6</td>
<td>AO1</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Determines area of sphere at Earth's orbit **OR** Multiplies $1.3\ (\times 10^3)$ by their **area** of sphere ✓ 3.8×10^{26} (W) ✓	Condone POT errors in **MP1**	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Idea that: sunlight absorbed/reflected/scattered from clouds/atmosphere ✓ angle of Sun changes throughout the day/year OR assumes panels are at right angles to light (from the Sun)✓ not all power from Sun can be used by solar panel / there is a maximum efficiency (of about 20%) ✓	In **MP1** allow idea that albeido of Earth is not zero	3	AO3

Total			**11**

Question	Key	Answer	AO
7	**A**	0.20	AO3
8	**D**	contain atoms with a small nucleon number.	AO1
9	**A**	to decrease the number of thermal neutrons	AO1
10	**D**	4.5×10^{-9} kg s^{-1}	AO2
11	**D**	The volume of an individual particle is negligible.	AO1
12	**B**	$U_1 + Q - U_0$	AO1
13	**B**	increase decrease	AO4
14	**C**	kg s^{-3} K^{-1}	AO1
15	**D**	84 kg m^2	AO3
16	**C**	12 V to 18 V	AO4
17	**C**	7.8×10^4 s	AO2
18	**A**	3.1×10^{-4}	AO3
19	**B**	4 cm^3	AO2
20	**D**	Back-up power stations can be started up quickly.	AO1
21	**A**	0.50 rad s^{-2} clockwise	AO2

Total marks = 15