OXFORD INTERNATIONAL AQA EXAMINATIONS

# INTERNATIONAL A-LEVEL
# PHYSICS
# PH04

Unit 4 Energy and Energy resources

Mark scheme

June 2019

Version: 1.0 Final

*196XPH04/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 Assessment Writer.

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.

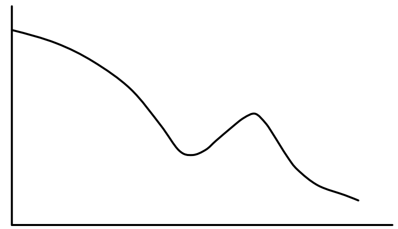
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

| Question | Marking guidance | Mark | Comments |
|---|---|---|---|
| **01.1** | Gas: only kinetic energy (since particles have zero potential energy) ✓<br>Solid: kinetic <u>and</u> potential energies ✓<br>OR<br>Internal energy is the sum of individual particle kinetic and potential energies ✓<br>Potential energy of particles is zero in a gas ✓ | 2 | |
| **01.2** | Use of $pV = nRT$ or $pV = NkT$ ✓<br>$273 + 23$ (K) OR 296 K seen OR 1.79 (1.8) (mol) ✓<br>1.1 **or** $1.08 \times 10^{24}$ | 3 | Either correct substitution or correct rearrangement.<br>Accept 1.83 mol based on $v = 4.5 \times 10^{-2}$ |
| **01.3** | Uses the area under the graph ✓<br>18 to 20 squares **or** each square is equivalent to 250 J ✓<br>4500 to 5000 (J) | 3 | Accept small square equivalent to 10 J |

| **01.4** | | 4 | Max 2 marks for re-calculating the temperature at **Y** |
|---|---|---|---|
| | Work is done on the gas (*W* is positive) ✓<br>There is no heat transfer (since the compression is rapid) ✓<br>… so internal energy of gas increases or correct application of 1st law equation✓<br>Temperature increases as internal energy or molecular kinetic energy increases ✓ | | MP4 must be accompanied by some explanation |

| Question | Marking guidance | Mark | Comments |
|---|---|---|---|
| **02.1** | Substitutes into equation correctly, condoning omission of powers of ten ✓<br>Correctly calculates 2 values of $k$ including correct powers of ten ✓<br>Calculates all 3 values correctly and finds the mean of $1.49 \times 10^{-45}$ ($m^3$) ✓ | 3 | $1.57 \times 10^{-45}$ ; $1.47 \times 10^{-45}$ ; $1.42 \times 10^{-45}$ |
| **02.2** | Finds the percentage uncertainty using the half range of candidate's values from 02.1 **ecf** ✓ | 1 | Expect to see 5%<br>Accept $\frac{Max-mean}{mean} x100$ or $\frac{Mean-min}{mean} x100$ |
| **02.3** | Calculation approach – calculates 2 densities correctly ✓<br>Calculates all 3 densities correctly and concludes that they are sufficiently similar ✓<br><br>Algebraic approach: uses $m = 1.67 \times 10^{-27}$ A and $V = \frac{4}{3}\pi r^3$ to shown that density is a function of $\frac{A}{R^3}$ ✓<br>$\frac{A}{R^3} = \frac{1}{k}$ which is a constant✓ | 2 | Values of density: $2.5(4) \times 10^{17}$ ; $2.7(1) \times 10^{17}$ ; $2.8(1) \times 10^{17}$ ;<br><br>Ignoring powers of ten: MAX 1<br><br>Expect to see $\rho = \frac{3\ x\ 1.67\ x\ 10^{-27}}{4\pi}.\frac{1}{k}$. |

| Question | Marking guidance | Mark | Comments |
|---|---|---|---|
| **02.4** | MAX 3<br><br>Top path: Little or no deviation ✓<br><br>Middle path: Reflected back along own path ✓<br><br>Deviation >> deviation of top path ✓<br><br>Distance of closest approach is on middle alpha particle path ✓ | 3 | Accept deviation of up to $60^{o}$ by eye<br><br>Accept parallel to original path if gap is less than $2\ \mathrm{mm}$<br><br>Expect between $20^{\circ}$ and $160^{\circ}$ (by eye) but compared with deviation of top path<br><br>Must not touch nucleus<br><br>No marks awarded for paths with sharp angle turns (apart from head on) |
| **02.5** | Correct general shape ✓<br><br>… with non-zero first minimum labeled $\theta$ ✓ | 2 | Allow subsequent, maxima and minima<br>MP2 dependant on MP1<br> |

| Question | Marking guidance | Mark | Comments |
|---|---|---|---|
| **03.1** | Uses $T = I\alpha$ ✓<br>applied torque = 440 x 0.090 OR 39.6 (N m) ✓<br>52 or 51.6 rad ($s^{-2}$) ✓ | 3 | Either correct substitution or rearrangement<br>Award MP2 if (net torque =) 35.6 seen |
| **03.2** | 31 (rad $s^{-1}$) ecf ✓ | 1 | Ecf from 03.1 (0.6 × answer to 03.1) |
| **03.3** | Use of $w = \frac{v}{r}$ leading to 117 to at least 3 sf ✓ | 1 | Not 116 (rounding error) |
| **03.4** | Use of $E_k = \frac{1}{2}mv^2$ or $E_k = \frac{1}{2}I\omega^2$ ✓<br>Correct kinetic energy for bike ($1.14 \times 10^5$) or for one wheel (4968) or for both wheels (9936) ✓<br>Finds rotational $E_k$ as a percentage of translational $E_k$ or total $E_k$ ✓<br>Total kinetic energy = $1.23 \times 10^5$ (J) ✓<br>8.0(3)% based on $\omega$=120 OR 7.6% based on $\omega$=117 ✓ | 4 | Accept 4696 (1 wheel) or 9392 (2 wheels) based on $\omega$=117 for MP2<br>Condone use of only 1 wheel for MP3<br><br>Accept reasonable rounding error in final answer |
| **03.5** | reduces moment of inertia or mass ✓<br>Linked argument to show that acceleration and / or deceleration will be greater (for same torque) ✓<br>Uses $t = I\alpha$ or uses F = ma to link to acceleration ✓ | 3 | Or less torque needed to produce same acceleration (MP2) |

| Question | Marking guidance | Mark | Comments |
|---|---|---|---|
| **04.1** | (very) high temperature ✓<br>(Fully) ionized **or** has (all of) electrons removed from atoms ✓<br>Either ionised state allows nuclei to "touch" **or** high temperature means that nuclei have sufficient KE to enable them to overcome electrostatic repulsion WTTE ✓ | 3 | |
| **04.2** | (Mass difference =) $8 \times 10^{-31}$ (kg) seen ✓<br>Uses $E = mc^2$ ✓<br>$7.2 \times 10^{-14}$ (J) | 3 | Allow other unit if correct and unit stated |
| **04.3** | ${}^{2}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + \gamma$<br>**or** deuterium and hydrogen fuse to form helium−3<br>${}^{3}_{2}\mathrm{He} + {}^{3}_{2}\mathrm{He} \rightarrow {}^{4}_{2}\mathrm{He} + 2\,{}^{1}_{1}\mathrm{H}$<br>**or** 2 × helium−3 fuse to produce helium−4 and hydrogen✓ | 2 | Condone additional incorrect particles in the equations<br>Condone confusion of H and He for MAX 1<br>Reactions can be in the form of a description or an equation. Accept lack of perfect detail in descriptive answers. |

| Question | Marking guidance | Mark | Comments |
|---|---|---|---|
| 05.1 | Use of $I = \frac{P}{4\pi r^2}$ ✓<br>Leading to 207 to at least 3 sf ✓ | 2 | Correct substitution with or without the 15%<br><br>Not 206 |
| 05.2 | $5.8 \times 10^6$ **or** $\times 6.0 \times 10^6$ ✓ cao | 1 | 207 W $m^{-2}$ gives 5.8<br>200 W $m^{-2}$ gives 6.0 accept 1 sf here |
| 05.3 | Idea that (constantly) adjusting the angle of the panels so that they are always at 90° to the solar radiation ✓ | 1 | Accept making them track the Sun |
| 05.4 | Neither emit carbon dioxide ✓<br>Risk of leak of radioactive products from a fission power station ✓<br>Need for long term storage of radioactive waste ✓<br>Mining of uranium is damaging to the environment ✓<br>Solar panels use toxic or scarce resources ✓<br>Large areas of habitat affected **or** can use areas that would otherwise be used for food production ✓<br>MAX 3 | 3 | For full marks, account must include valid comments on both nuclear and solar<br><br>For 3 marks answers must make valid comments about both solar and nuclear |

| Question | Key |
|---|---|
| 06 | D |
| 07 | D |
| 08 | C |
| 09 | C |
| 10 | B |
| 11 | B |
| 12 | C |
| 13 | A |
| 14 | B |
| 15 | C |
| 16 | D |
| 17 | B |
| 18 | D |
| 19 | B |

| Question | Key |
|---|---|
| 20 | C |
| 21 | C |
| 22 | D |
| 23 | C |
| 24 | B |
| 25 | C |
| 26 | B |
| 27 | C |
| 28 | A |
| 29 | C |
| 30 | C |
| 31 | B |
| 32 | D |
| 33 | C |

| Question | Key |
|---|---|
| 34 | A |
| 35 | B |