OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH04

Unit 4 Energy and Energy resources

Mark scheme

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236XPH04/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 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.

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>01</td><td>Max 4 from:
<table><tr><th>Property✓✓</th><th>Observation. ✓✓</th></tr><tr><td>move in random directions/randomly</td><td>the smoke particles are ‘jiggling’ randomly</td></tr><tr><td>very small/negligible volume</td><td>only the (smoke) particles can be seen/ (smoke) particles only jiggle about one position</td></tr><tr><td>move very fast</td><td>momentum of (bigger smoke) particles changes</td></tr><tr><td>Random speeds/ range of KE</td><td>(smoke) particles ‘jiggle’ different amounts/ move with different speeds.</td></tr></table></td><td>Mark as a list. Mark the answer space as a whole: ignore the ‘1’ and ‘2’
Max 2 from each column.
The ‘property’ is about the gas molecules, the ‘observation’ is about the smoke particles.
Accept alternatives for ‘random’ such as ‘unpredictable’, ‘no preferred direction’, ‘various directions’, ‘irregular’ etc.
Allow ‘jiggle’ for ‘move randomly’.
An unqualified reference to ‘particles’ is taken to mean the smoke particles. An unqualified ‘they’ refers to the gas molecules.</td><td>4</td><td>2 × AO1
2 × AO3</td></tr>
</table>

Total			**4**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Two from ✓✓ Converts temperature to kelvin Evidence of attempt to use $pV = nRT$ Evidence of attempt to use $(V =)\ \pi r^2 h$ $r = 0.12$ (m) ✓	accept 0.13 (m)	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	(Read off and subtraction =) 95 **–** 25 **OR** 70 (mol) seen **OR** Evidence of use of mass = their amount (mol) × 0.029 (kg mol^{-1}) OR mass = their amount (mol) × 29 (g mol^{-1}) ✓ mass = 2.0(3) kg ✓	Accept 71 to 69 Expect 70 × 0.029 = 2.0(3) kg Reject 1 sf answer Accept answers between 2.0 and 2.1 (kg)	2	1 × AO3 1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Calculates $\frac{\Delta p}{\Delta \text{n}}$ or $\frac{p}{\text{n}}$ for at least two points and shows that it is constant ₁✓ Uses data from **Figure 3** to show that the intercept is zero. ₂✓ Refers to $pV = nRT$, with R and V constant (and therefore T is constant). ₃✓	MP1 and MP2 can be awarded for calculating $\frac{p}{\text{n}}$ (expect 4×10^4 Pa/mol) OR T (expect 290 (K)) and showing it is constant for at least two points. In MP3 accept 'V/R constant' for 'R and V constant' Alternative: Relates $pV = nRT$ to $y = mx + c$ to show that gradient is $\frac{RT}{V}$ ₁✓ Uses data from **Figure 3** to show that $c = 0$ ₂✓ R and V constant (therefore T constant) ₃✓	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Internal energy = sum of kinetic energies (and potential energies) of molecules ✓ PE zero (as gas ideal) ✓ Average KE constant as T is constant ✓ Therefore internal energy increases as n increases ✓	Accept (internal) energy = $\frac{3}{2}nRT$ OR $\frac{3}{2}NkT$. Condone missing reference to molecules No reference to potential energy gets **Max 3** In MP3 condone "average speed" for "average KE". Condone 'total' for 'internal'	4	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	Steeper <u>straight</u> line ✓ Higher starting pressure ✓		2	AO2
Total			**14**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Evidence of determination of area of floor OR determines difference in temperature ✓ Evidence of substitution into thermal conductivity equation ✓ 0.17 ✓ $\text{W m}^{-1}\text{ K}^{-1}$ ✓	Expect to see ($A = 2.5 \times 4.2$) = 10.5 (m^2) Expect to see ($\Delta\theta$ = 45 - 22 =) 23 (K) Condone missing or incorrect units in MP1 and MP2 E.g. for MP3: $1200 = \dfrac{k \times their\ A \times their\ \Delta\theta}{3.5(\times 10^{-2})}$ Allow POT error in substitution Allow substitution of incorrect thickness (4.2 or 2.5) An answer where the substitution of Boltzmann's constant for k is seen can only access MP1. Condone $\text{kg m s}^{-3}\text{ K}^{-1}$ but do not allow k for K.	4	3 × AO2 1 × AO3

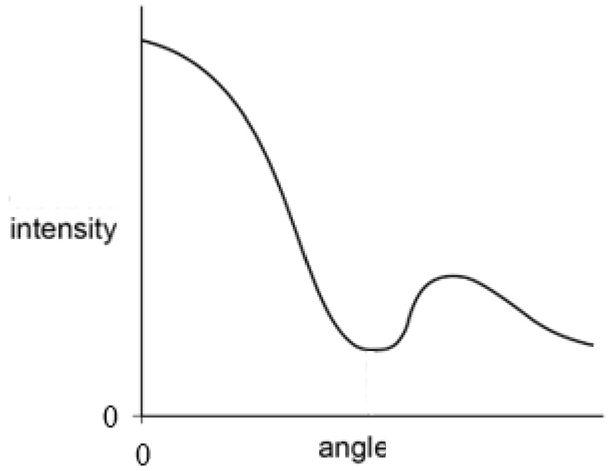
Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Substitution into U-value equation With correct temperature difference ✓ 76 (ºC)✓	Rate of energy transfer = $UA\Delta\theta$ Expect to see (θ_c - 22) Calculator value is 76.4217687	2	1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Idea that the (rate of) energy transfer depends on the temperature (of the heating system) ₁✓ With carpet, the temperature (of the heating system) is greater therefore rate of (wasted) energy transfer (to ground etc.) is greater ₁✓₂✓	Allow ecf for their **03.2** (compare with 45 ºC) The first statement only gets MP1. MP1 and MP2 can be given for the second statement.	2	2 × AO4
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Evidence of determination of charge on silicon OR charge on alpha ✓ Convert MeV to J (to find E_k)✓ Substitution into EPE equation ✓ 6.2×10^{-15} (m) ✓	$Q_{Si} = 14 \times 1.6 \times 10^{-19}$ or 2.24×10^{-18}(C) $Q_\alpha = 2 \times 1.6 \times 10^{-19}$ or 3.2×10^{-19} (C) $E_k = 6.5 \times 1.6 \times 10^{-13}$ or 1.04×10^{-12} (J) E.g. for MP3: $their\ E_k = \frac{their\ Q_{Si} \times their\ Q_\alpha}{4\pi\varepsilon_0 r}$ Allow POT error in MP1, MP2 and MP3	4	2 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Idea that before reaching the nucleus: the alpha particle is stopped OR all the KE (of the alpha particle) is transferred in EPE ✓	Allow alternative answer suggesting that: value does not take into account radius of alpha particle. OR calculation assumes collision is head-on.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Idea that the (change in) EPE is the same (in both situations). ✓ Charge on Y greater (than charge on X) ✓ Therefore, estimated value for Y is greater (than value for X) ✓	Accept formula for EPE. Allow reverse arguments MP3 can be given on its own provided there is some support, e.g. 'Y has more protons (than X).'	3	2 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Curve correct With central max, one min inflection point and no points of zero intensity Second peak less than half height of central max above min. ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Idea that electron diffraction depends on diameter/size of nucleus OR electron diffraction does not depend on proton number/charge (on nucleus) ✓ Radius the same as nucleon number the same (40) ✓	In MP1 do not accept 'number of nucleons' for diameter. Allow 'mass (number)' for 'nucleon number'.	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Best-fit line drawn ✓ Point on line read ✓ $\ln R = \frac{1}{3}\ln A + \ln R_0$ seen OR Correct use of e^x for their point ✓ Answer between 1.04 fm and 1.07 fm ✓	Equal scatter of points on either side of line. Expect a line going through (2.7, 0.95) and (3, 1.05). Reject multiple or thick lines. Only allow a plotted point if on the line. Ignore POT error. Only MP1 and MP3 can accessed for using intercept on y-axis = $\ln R_0$. Note $\ln (1.04) = 0.039221$ $\ln (1.07) = 0.06759$	4	AO3
Total			**15**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Makes a judgement about average power ✓ Determines 7 days in seconds (604800) ✓ Multiplies their power in W × their time in s and converts to an order of magnitude ✓	Expect to see value between 34000 (MW) and 40000 (MW). Allow sum of estimates based for each day × number of seconds in one day. Allow order of magnitude estimations. Expect to see 10^{16} (J) Condone 16 and 1 x 10^{16} (J) Alternative: Counts squares (expect to see approximately 14 large squares or 56 small squares) ✓ Finds value of 1 square (1 large square is equivalent to 20 000 × 10^{6} × 24 × 3600 (J)) ✓ Multiplies their number of squares x their value of 1 square (expect to see an answer around 2.4 × 10^{16}) and converts to an order of magnitude. ✓	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	2(.2) × 10^{10} (W) ✓	Accept 2 × 10^{10} to 3 × 10^{10} (W) Accept 1 sf answer.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	**Similarity** ✓ Width shows length of time Sun is up and that does not change (much). OR Max of each peak at noon shows brightest time of day. **Difference** ✓ Different heights show that some days cloudier than others. OR Different shapes show that cloud cover varies from day to day.	If no other mark given, award **Max 1** for a similarity and a difference stated. Allow alternatives for 'brightest time of day' e.g. 'that is when the sun is direct', 'at 90^{o}' etc. "Differences in weather" is not enough for the explanation.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Base-power stations same on both days, AND back-up on day 4 greater (than on day 2) ✓ Base-power: idea that base power stations are on all of the time/solar not available throughout the whole day ✓ Back-up: idea that on day 4 more needed from back-up as less is supplied by solar ✓	Evidence for MP1 may be seen in MP2 and MP3. In MP2 allow idea that base power stations (often) have a long start up time or that their power output is constant.	3	AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Evidence of use of Mr^2 ✓ $r = 6.8 \times 10^{-2}$ (m) ✓	Can be by re-arrangement or substitution Condone use of one mass in MP1 Calculator value is 6.770032×10^{-2} (m)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Evidence of use of a rotational KE equation ✓ 7.3(2) (rad s^{-1}) ✓	Calculator value is 7.3236851	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Idea that r decreases so I decreases ✓ Uses $T = I\,\alpha$ to make conclusion about change in α consistent with their change in I from MP1. ✓	Both marks can be given for a full algebraic approach. Expect 'α increases' for their conclusion.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Idea that some energy is transferred from GPE of the spheres (as they fall). ✓ Idea that work done (by frictional torque) = change in KE / $59\ \mathrm{mJ}$ + change in GPE ✓	In MP1 allow idea that the GPE (of the spheres) decreases.	2	AO2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Idea that only a small amount of the rest energy of the nucleons is lost when the nucleus is formed. OR The rest energy of the nucleons and rest energy of the nucleus are very similar and the binding energy is (only) the difference between them. OR binding energy = mass defect x c^2 AND rest energy = rest mass/mass of nucleus/nucleons x c^2 AND mass defect << rest mass/mass of nucleus/nucleons OR Binding energy = rest energy of (individual) nucleons – rest energy of nucleus AND rest energy of nucleons ≈ rest energy of nucleus. ✓	Allow reverse in terms of splitting up the nucleus into nucleons Alternative : (binding energy =) Δmc^2 $= m_{nucleons}c^2 - m_{nucleus}c^2$ AND $m_{nucleons}c^2 \approx m_{nucleus}c^2$ Condone some confusion between rest energies. Condone < for <<	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Identifies X as neutron ✓ Converts mass of neutron to MeV to give answer that rounds to 940 to 3sf (MeV) ✓	Identification can be by mass used in MP2. Expect to see 1.00867 (u) x 931.5 ($MeV\ u^{-1}$) = 939.6 (MeV) Allow use of mass of neutron in kg (1.675×10^{-27} to give 942(.2 MeV)) Allow use of 1.67×10^{-27} kg (to give 939.4 (MeV)) only if neutron identified.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Q subtracted from binding energy of He-3 ✓ Divided by 2 to get 2.2(2) (MeV) ✓	Allow 1 mark for an answer of 5.5 MeV from adding Q and binding energy of He-3 and halving.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	energy released per (fusion) reaction ✓ pressure / temperature required (for optimum rate of fusion reaction) ✓	'energy released' is insufficient for MP1 For MP2 allow idea of amount of energy required OR strength of magnetic field required	2	AO1
Total			**7**	

Question	Key	Answer	AO
8	**C**	16 kJ kg^{-1}	AO3
9	**B**	200 J	AO1
10	**A**	the number of molecules in the gas $\frac{R}{N_A}$	AO1
11	**B**	They have negligible mass.	AO1
12	**D**	161 MeV	AO2
13	**C**	$Am_n + Z(m_p - m_n) - M$	AO1
14	**B**	boron graphite	AO1
15	**A**	7 15	AO2
16	**D**	3.2%	AO2
17	**C**	1.23 W	AO3
18	**D**	6.6×10^{19}	AO2
19	**D**	340 MW	AO2
20	**B**	The determination of the critical mass assumes that the fuel is spherical.	AO1
21	**D**	2.6 rad s^{-1}	AO3
22	**A**	8	AO2