OXFORD AQA
INTERNATIONAL QUALIFICATIONS

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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

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241XPH02/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 mark

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	converts E to 8.32×10^{-19} J **OR** uses 5.2 and a value for h in $E = \frac{hc}{\lambda}$ or $E = hf$ ✓ 2.4×10^{-7} (m) ✓	Expect $f = 1.25 \times 10^{15}$ Hz Calculator value is 2.3906×10^{-7} (m)	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	idea that UV photon is absorbed by atom in the powder coating and is excited ✓ idea that atom (in the powder coating) de-excites and emits photons ✓ links de-excitation to emission of photons that have less energy (than UV and are visible) ✓	MP1: Condone photon "collides" with atom Allow 1 mark (for MP1 and MP2) for a description of excitation and de-excitation without reference to atoms. Condone "in smaller energy steps". Accept longer wavelengths or smaller frequencies.	3	AO1
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ ✓ $\mu = 2.1 \times 10^{-4}$ (kg m^{-1}) ✓ $2.5 \times$ their μ ✓	MP1: Full substitution or algebraic rearrangement with μ as subject. Condone substitution into incorrect algebraic rearrangement. MP2 Calculator value: 2.0828×10^{-4} (kg m^{-1}) Calculator value: 5.2071×10^{-4} (kg)	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	330 (Hz) ✓	Expect to see 325 (Hz)	1	AO3
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Max 3 from: ✓ ✓ ✓ idea that (atomic) energy levels are quantised (so) transitions between energy levels have discrete values of ΔE idea that wavelengths/frequencies (of spectral lines) correspond to ΔE **OR** photon energy equals ΔE idea that lines are “characteristic” for a particular element idea that lines are X-rays due to (very) large ΔE	MP1 and MP2 relate to the quantisation of atomic energy levels. MP3 relates emission of radiation/photon to deexcitation process. MP4 relates to why different elements have different spectral lines. e.g. atoms of different elements have unique energy levels MP5: why the lines are X-rays (rather than e.g. visible light)	3	AO1
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	amplitude is 1.8 mm ✓ 7.2 (mm) ✓	Allow MP1 for 3.6 mm	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	1.60×10^{-3} (s) ✓	Allow 2 sf answer	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	answer in range of -1.0 to -1.1 (mm) ✓	negative sign must be present	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	630 **OR** $\frac{1}{\text{their } \mathbf{04.2}}$ ✓	expect 625 (Hz)	1	AO1
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	ratio of potential difference across **R** to current in **R** OWTTE ✓	Allow $R = \frac{V}{I}$ where V is pd across **R** and I is current in/through **R**. Condone "voltage" for pd. Reject any reference to pd per unit current.	1	AO1

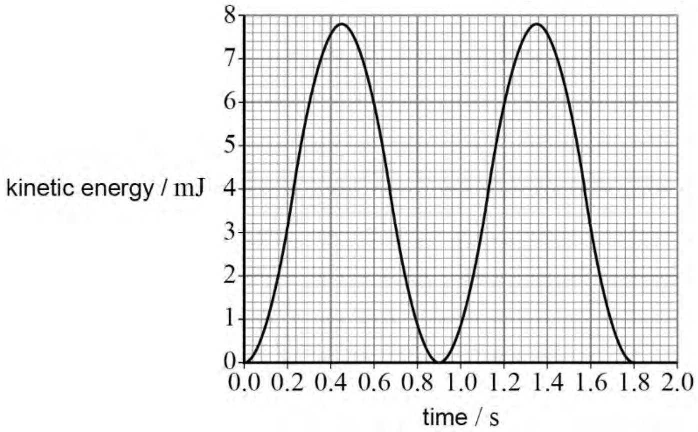
Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	(non-ideal) ammeter has some resistance ✓$_1$ so: current in **R**/circuit is reduced ✓$_{2a}$ use of $V = IR$ to explain V_2 less than V_1 ✓$_{3a}$ **OR** pd occurs across ammeter ✓$_{2b}$ potential divider argument for why V_2 is less than V_1 ✓$_{3b}$ **OR** V_1 = emf ✓$_{2c}$ V_2 = emf – pd across ammeter ✓$_{3c}$	Any reference to "internal resistance" must clearly relate to the ammeter. e.g. for ✓$_{3a}$: as R is constant, if I decreases, V_2 decreases according to $V=IR$ e.g. ✓$_{3b}$: emf is now shared between ammeter and **R**, so V_2 is less than V_1	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Yes because: no current occurs in the ideal voltmeter, or ammeter gives an accurate measurement for I in **R** **OR** voltmeter only measures pd across **R**, or V_2 is the accurate pd of **R** ✓	Condone idea that V_2 and I are a consistent pair of readings for **R**, or that adding ammeter leads to a (proportionate) decrease in V and in I	1	AO4
Total			**5**	

<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>correct general shape (2 peaks) ✓

both axes labelled e.g. “E_k / mJ” and “time / s”✓

scales on each axis: E_k values from 0 to 7.8 and time values from 0 to 1.8 ✓</td><td>MP3: sketch must take up at least half of grid on each axis; sketch should not extend beyond 7.8 on their E_k axis or beyond 1.8 on their time axis; sketch should not correspond to negative value of E_k

</td><td>3</td><td>AO2</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	halves 1.80 to get 0.90 ✓ subtracts 0.90 or their half period from 1.61 ✓ doubles $(1.61 - 0.9)$ to get 1.42 s ✓ **OR** $\frac{T_1}{2} + \frac{T_2}{2} = 1.61$ ✓ $T_1 + T_2 = 3.22$ ✓ $T_2 = 3.22 - 1.80 = 1.42$ s ✓	Candidate may use alternatives to T_1 and T_2	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	uses 1.4 in $T = 2\pi\sqrt{\frac{l}{g}}$ ✓ $l = 0.487$ m ✓ $x = 0.32$ (m) ✓	MP1: Substitutes into equation or rearranges algebraically for l. Condone use of "x" for "l" in MP1 but not in MP2. Use of 1.42 s gives $l = 0.501$ m and $x = 0.304$ m.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	rate of energy transfer is greater between **O** and **R** because: amount of energy transfer is same (for **Q** to **O** as **O** to **R**) ✓ but duration of transfer is less ✓	Allow reverse arguments.	2	AO2
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	idea that oscillations occur parallel (to energy transfer) ✓ correct reference to oscillations and direction of energy transfer ✓	Condone “vibrations” for “oscillations”.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	uses $v = \frac{x}{t}$ with a relevant time in seconds ✓ takes into account that their Δt is for multiples of $2d$ ✓ answer in range 5.8×10^{-3} to 6.1×10^{-3} (m) ✓	Relevant time should be between 2.2×10^{-6} s and 2.6×10^{-6} s, or multiples of these.	3	1 × AO4 1 × AO3 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	time for ultrasound to travel through paint will be longer (than for equivalent thickness of metal) ✓ so will appear as a thicker piece of metal ✓	If no other mark accept there is an extra distance.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	distance for reflection **R** is $2(y + d)$ **OR** distance for reflection **S** is $2(y + d) + 2y$ or $(4y + 2d)$ ✓ shows difference is $2y$ ✓	MP1: Expressions must be accompanied by reference to path **R** or **S**	2	AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	uses parallel resistor formula or divides 2.40 by 2 with reason to show equivalent R of lamps is 1.20 ✓ adds 0.061 to 1.20 to get 1.26 ✓	MP2: internal resistance must be in Ω	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	determines total current using Ohm's law **OR** attempts to use relevant resistances in a potential divider equation ✓ 12 (V) ✓	MP1: Expect 10.151 A for $1.26\ \Omega$; and 9.846 A for $1.3\ \Omega$ MP1: may see $\frac{1.2}{1.261}$ or $\frac{0.061}{1.261}$, with rounded values of 1.261 Expect to see 11.8, 12.18 or 12.20 V	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	external/total R will increase so total current will decrease ✓ leading to fewer 'lost volts', so terminal pd increases ✓ **OR** load R will increase, so ratio of load R:internal r or load R:total R increases ✓ leading to larger proportion of emf across load, so terminal pd increases ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Power in **Fig. 12** is greater than in **Fig. 11** because: current in **X** increases ✓$_{1a}$ and refers to $P = I^2R$ ✓$_{2a}$ **OR** V increases ✓$_{1b}$ and refers to $P = \frac{V^2}{R}$ ✓$_{2b}$ **OR** V <u>and</u> I increase ✓$_{1c}$ and refers to $P = VI$ ✓$_{2c}$	MP2 is contingent on MP1.	2	AO2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	0.03 (V) ✓	condone 2 sf answer	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	steepest line and shallowest line drawn ✓	1.67 and 1.60 on RHS of **Fig. 14** 4.45 and 4.65 on bottom of **Fig. 14** Min line through top of 1st plot and bottom of last Max line through bottom of 3rd plot and top of last	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	evidence of using shallowest line ✓ uses $\Delta f \geq 1.0 \times 10^{14}$ to determine gradient **OR** correct read offs for a pair of data points ✓ method to determine *h*: uses $h = e \times$ gradient **OR** use of simultaneous equations ✓ answer that rounds to 4.7×10^{-34} (J s) ✓	If only 1 line is drawn on **Fig. 14**, MP2 and MP3 can still be accessed. Expect gradient around 2.9×10^{-15} (N.B. Gradient of steepest line ~3.6×10^{-15}) Allow for MP3: Rearranges equation $V = \frac{hf}{e} - \frac{\phi}{e}$ with comparison to $y = mx + c$ Max 2 or 3 sf. Allow answer that rounds to 4.8×10^{-34} (J s).	4	1 × AO3 1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	Max 2 from: ✓ ✓ determine gradient of steepest line **OR** of line of best fit uses gradients of two lines to determine an absolute uncertainty use their absolute uncertainty/mean × 100	Condone taking gradient to be equal to *h*. MP2: e.g. ½ [m(steepest)–m(shallowest)]	2	AO4
Total			**8**	

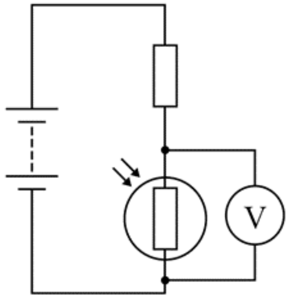
Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	idea that only the weight of m_A compresses spring **OR** weight of m_B doesn't contribute to compressive force on spring ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	uses $W = mg$ **AND** $F = k\Delta L$ ✓ uses ¼ of mass/weight **OR** correct attempt to deal with 30% of their ΔL ✓ 0.25 (m) ✓	MP1: Expect to see total weight = 18 639 N; ¼ of total weight = 4660 N MP1: Expect to see ΔL = 7.6 cm.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	uses $T = 2\pi\sqrt{\frac{m}{k}}$ ✓ 7.2 (Hz) ✓	MP1: Substitutes correct m and k in equation. Expect $T = 0.139$ s Allow 1 mark for evaluating $\frac{1}{T}$ from an incorrect mass. Allow 7.14 Hz from 0.14 s.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	MP1: comment about damping eg dissipation of energy from oscillating system; reduction of time/number of oscillations ✓ MP2: detail about reason eg ride comfort, maintaining tyre contact ✓	Allow “reduce amplitude of oscillation”. MP2 is contingent on MP1.	2	AO2
Total			**8**	

<table>
<tr><th>Question</th><th>Key</th><th>Answer</th><th>AO</th></tr>
<tr><td>11</td><td>C</td><td>A^{-2} kg m^3 s^{-3}</td><td></td></tr>
<tr><td>12</td><td>D</td><td>16R</td><td></td></tr>
<tr><td>13</td><td>C</td><td>2.6×10^{21}</td><td></td></tr>
<tr><td>14</td><td>B</td><td>480 nm</td><td></td></tr>
<tr><td>15</td><td>B</td><td>The frequency of the light does not change.</td><td></td></tr>
<tr><td>16</td><td>B</td><td>30 Ω</td><td></td></tr>
<tr><td>17</td><td>D</td><td><table><tr><td>2.4</td><td>2.2</td></tr></table></td><td></td></tr>
<tr><td>18</td><td>A</td><td><table><tr><td>J</td><td>K</td><td>J</td></tr></table></td><td></td></tr>
<tr><td>19</td><td>C</td><td>1.4×10^{-21} J</td><td></td></tr>
<tr><td>20</td><td>B</td><td>23 V</td><td></td></tr>
</table>

21	**A**		
22	**B**	$n_X > n_Y$; $n_Y < n_Z$	
23	**D**	The light from the grating must be polarised.	
24	**D**	3.2 m	