OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL AS
PHYSICS
PH02

Unit 2 Electricity, waves and particles

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 mark

Question	Answers	Additional comments/Guidelines	Mark	AO
01	Correct expression for d in m **OR** use of $n\lambda = d \sin\theta$ ✓ 16 (°) ✓	Condone incorrect d in MP1 option 2	2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	C ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	1.6×10^4 ✓	Ignore unit	1	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Any **two** from: ✓✓ • use of $\lambda = \frac{h}{mv}$ OR $\lambda = \frac{h}{p}$ • use of $E = \frac{1}{2}mv^2$ • use of $E = eV$ 0.67 (V) ✓	Both mp1 and mp2 can be awarded for the use of a combination of two equations listed on the left-hand side, eg use of one of: • $V = \frac{h^2}{2me\lambda^2}$ • $v = \frac{p^2}{2me}$ Expect to see $v = 4.85 \times 10^5$ m s^{-1} Accept POT error for mp1, mp2	3	AO2
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	1.32 ✓	Condone 2sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Any **two** from: ✓✓ • more (directions of paths of) light refracted out of the fibre / fewer paths available / smaller range of angles / fewer lengths of path available / fewer (total internal) reflections • reduces **modal** dispersion • reduces pulse broadening • increases rate of data transmission / reduces (chance of) data loss	Ignore references to 'efficiency' Ignore references to speed of light down fibre Apply list rule Condone 'prevents' for 'reduces' throughout	2	AO1
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Any **two** from: ✓✓ • use of $V = IR$ to find I • reads off V for their I • adds their V to 2.6 V $= 3.8$ to 4.0 (V) ✓	 expect 0.055 A expect 1.2 to 1.4 V	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	A tangent is drawn at the origin and the voltage where the curve leaves the tangent is read off ✓ $V_1 = 0$ (V), $V_2 = 0.80$ to 0.95 (V) ✓	 Allow 1sf Do **not** allow 1V for MP2	2	AO3
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	At least **two** from: ✓ • metal bar has larger **cross-sectional** area than the wire • metal bar has shorter length than the wire • metal bar is made of a lower resistivity metal than the wire reference to resistivity equation OR both corresponding proportionalities from the equation ✓	For MP2, must be standard symbols from data booklet or symbols defined	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Correct expression for length of wire $(= \pi \times 0.045 \times 16 \times 10 = 22.6\ \text{m})$ ✓ Correct expression for cross-sectional area of wire = $\frac{\pi}{4} \times (0.91 \times 10^{-3})^2$ (= 6.5 × 10^{-7} m^2) ✓ Use of resistivity equation $\rho = \frac{RA}{l}$ (with their A and their *l*) ✓ 5.3×10^{-7} (Ω m) ✓	mp1 and mp2 and mp3 can be combined Allow POT error for MP2 and MP3 only Allow 3 marks total for final answer with only POT error	4	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Idea that the other components in the ohmmeter circuit have resistance or contact resistance ✓	Accept idea that even when the slider is at **B**, some of the long wire is in the circuit Ignore reference to ohmmeter having its own resistance	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Use of potential divider method **OR** Expression for current using total resistance then use of $V = IR$ with 18.3 ohm✓ $= 1.5(2)$ (V) ✓	Expect to see 0.083 A	2	AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Idea that the (electrons in the) atoms are in a bound state / energy is required to ionise the atoms / reference to (electrostatic) attraction between the nucleus and the electron ✓ Idea that the ionisation level is defined as zero energy ✓	Allow idea that energy is released when atom moves to a lower energy level Condone that (potential) energy is lower when the electrons are closer to the nucleus Condone electron for atom Condone 'at infinity' for ionisation	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Downward arrow from highest to lowest level		1	AO3

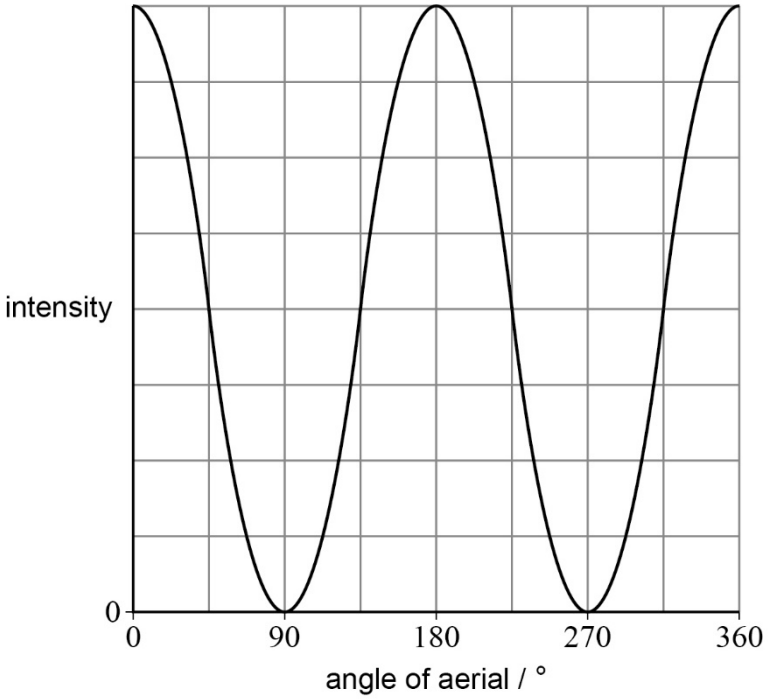
Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Any **two** from: ✓✓ • correct read-offs of the lines for their transition (to half a small square) OR correct read-off of ΔE for their transition eg -2.5 eV, -10.4 eV OR eg $\Delta E = 0.2$ eV • use of $\Delta E = \frac{hc}{\lambda}$ **OR** $\Delta E = hf$ and $c = f\lambda$ • any correct conversion from eV to J wavelength corresponding to their chosen transition ✓	Eg if correct transition chosen, 1.6×10^{-7} (m) If shortest transition chosen, 6.2×10^{-6} (m)	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Any two of: ✓✓ • (Free) electrons (emitted by electrode) are accelerated by pd (in the tube) • (Free) electrons collide with mercury atoms • (Free) Electrons transfer (some of) their (kinetic) energy to the mercury atoms	Do not allow (for any marking point) confusing the free electrons with the mercury atomic electrons Condone electrons in mercury atoms for mercury atoms	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	Any **three** from: ✓✓✓ • mercury atoms de-excite **AND** emit ultraviolet photons • the (UV) **photons are absorbed** by the powder coating atoms • idea that powder coating atoms cascade/de-excite in smaller steps/de-excite emitting photons in the visible spectrum or with less energy than UV • idea of lots of visible wavelengths being emitted to combine to form white light	BP1 and BP2 require 'photons' 'powder coating atoms' can be expressed via different phrases	3	AO1
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Use of $c = f\lambda$ to find λ **OR** Use of $w = \frac{\lambda \times 0.75}{0.095}$ with their wavelength ✓ 0.22 (m) ✓		2	1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Idea that this equation requires the distance to the screen to be large (compared with w or s or λ) **OR** small angles ✓	Ignore reference to the width of each slit	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Sketch: two peaks and two troughs of zero intensity per 360 degrees (labelled A) ✓	Ignore shape apart from number of peaks. Ignore phase. Condone troughs that do not go to zero intensity Expect to see:  	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Idea that the aerial must be aligned with (the oscillations of) the wave ✓ Idea of (the aerial and the wave) being parallel leading to high intensity and being perpendicular leading to zero intensity ✓	Condone 'vibrations' for oscillations Condone references to the gap orientation for the wave oscillation orientation for MP2	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.5	Flat line (labelled B) ✓ at approximately half height of line **A**'s maximum ✓		2	AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Any **one** from: ✓ • the oscillation is damped • energy is removed from the system • air resistance OR friction at the point of suspension		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	**X** drawn vertically below the bob at equilibrium position ✓ Idea that the speed is greatest at this point OR shortest transit time ✓	Condone **X** drawn at least halfway down the string	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	Reduces the percentage uncertainty (in T) ✓ for the same absolute uncertainty over a longer time ✓	Allow relative, fractional for percentage Allow eg reaction time for absolute uncertainty	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	Idea that each calculated value of T is actually $0.9T$ OR g becomes $\frac{g}{0.9^2}$ ✓ $= 12.1$ (m s^{-2}) ✓	mp1 can be awarded for seeing $0.9T$	2	AO3
Total			**7**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>10.1</td><td>Correct values in Table 1 to 3 sf ✓

Their values correctly plotted ✓

<table>
<tr><th>R / Ω</th><th>I / A</th><th>$\frac{1}{I}$ / A^{-1}</th></tr>
<tr><td>4.0</td><td>0.991</td><td>1.01</td></tr>
<tr><td>5.0</td><td>0.872</td><td>1.15</td></tr>
<tr><td>6.0</td><td>0.781</td><td>1.28</td></tr>
<tr><td>7.0</td><td>0.680</td><td>1.47</td></tr>
<tr><td>8.0</td><td>0.611</td><td>1.64</td></tr>
<tr><td>9.0</td><td>0.560</td><td>1.79</td></tr>
</table>
</td><td></td><td>2</td><td>1 × AO2
1 × AO3</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>10.2</td><td>Line of best fit, extended to the y-axis ✓</td><td></td><td>1</td><td>AO3</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Rearranges $\varepsilon = I(R + r)$ to make *R* the subject ✓ and links to $y = mx + c$ ✓	Expect to see $R = \varepsilon \times \frac{1}{I} - r$ Eg by aligning each term vertically	2	AO2

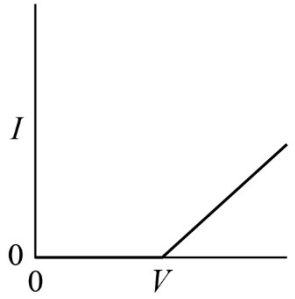
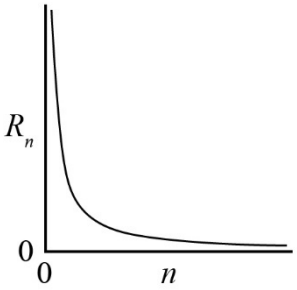
Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Determines gradient from large triangle ✓ $\varepsilon =$ between 6.0 and 6.4 (V) ✓ $r =$ between 2.0 and 2.6 (Ω) ✓	Two read-offs must be at least half the line apart. One can be y-intercept MP2 and MP3 are quality marks	3	AO2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Two waves travelling in opposite directions **superpose** ✓ Waves meet in phase / with zero phase difference ✓ Constructively interfere / produce maximum amplitude ✓	Maximum 2 marks if waves are described as 'coherent' If neither MP2 nor MP3 awarded, condone 1 mark for BOTH: Waves meet in antiphase / with π rad phase difference AND Destructively interfere / produce minimum amplitude Do not allow 'maximum displacement' for maximum amplitude in mp3	3	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	Use of $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ **OR** $\mu = 0.0015\ \text{kg m}^{-1}$ ✓ 73 (N) ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	($\frac{L}{4}$ leading to) 0.21 (m) **OR** ($\frac{3L}{4}$ leading to) 0.63 (m) ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	Tension increases **AND** reference to $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ ✓ Tension increases by a (much) larger factor than the length ✓	Allow correct statement of proportionality between frequency and tension Allow ratio of (root) tension to (root) length increases For 'factor', allow words such as ratio, proportion etc	2	AO2
Total			**8**	

Question	Key	Answer	AO
12	**A**	cool the superconducting wires.	AO1
13	**B**		AO3
14	**D**		AO3
15	**D**	decreases increases	AO1
16	**D**	$\frac{3\varepsilon R}{3R+r}$	AO1
17	**C**	$0.91f$	A01

18	**B**	$0.80\ \text{m}$	AO2
19	**B**	directing the lasers so that patterns are produced at eye level	AO4
20	**C**	be coherent with each other.	AO2
21	**A**	$\varphi \qquad g$	AO3
22	**B**	Photoelectrons are emitted.	AO2
23	**A**	fast-moving electrons	AO1
24	**A**	$f \qquad 2P$	AO2
25	**B**	The photoelectric effect demonstrates the particle-like behaviour of light.	AO1