

INTERNATIONAL AS PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

June 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

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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	$\text{kg m}^2 \text{A}^{-1} \text{s}^{-3} \checkmark$	Units in any order	1	AO1
Total			1	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	8.3 (m s ⁻¹) ✓	Calculator value: 8.275862069. Penalise rounding errors	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	(4 × amplitude =) 12 (m) ✓		1	AO2

Total			2	
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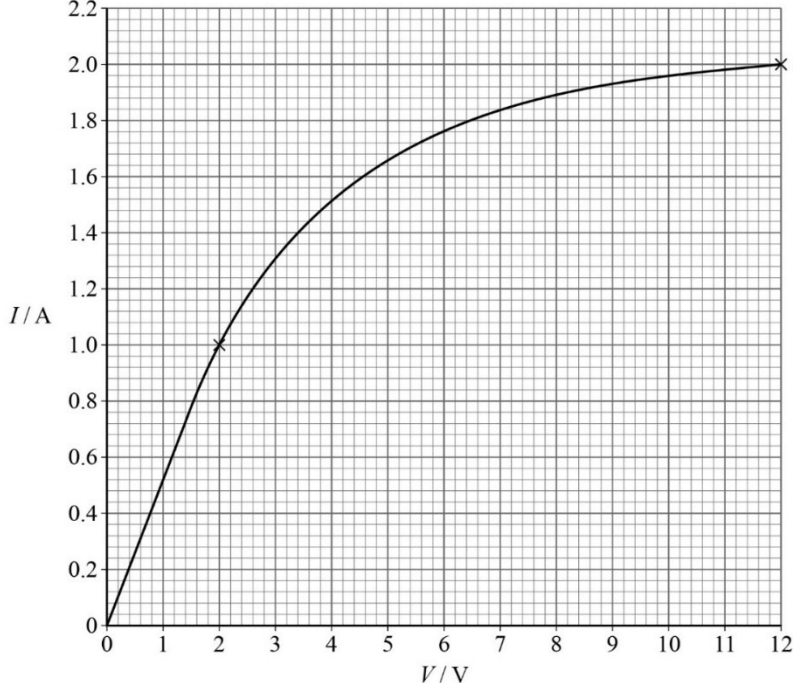
Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Resistance decreases as temperature increases OR Resistance increases as temperature decreases ✓	Do not allow simply 'at high temperature there is low resistance' – Condone a comparison of resistances between two temperatures Ignore idea that resistance is inversely proportional to temperature	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Idea that the resistivity is zero (at and) below critical temperature ✓ Idea of sharp increase in resistivity at critical temperature (-266°C) ✓ Idea that resistivity increases with temperature above the critical temperature ✓	All marks can be awarded from a graph sketch; candidate may use false origins If MP2 is given from the graph, the increase must appear close to vertical If no other marks given, allow 1 mark only for resistivity increases with temperature with no reference to critical temperature Allow resistance for resistivity If the graph and words do not match, it is a 'talk-out'	3	AO1

Total			4	
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Question	Answers	Additional comments/Guidelines	Mark	AO
04	<p>Any two from: ✓✓</p> <ul style="list-style-type: none"> • use of trigonometry to determine θ_1 (8.1°) • use of their θ_1 and $n\lambda = d \sin \theta$ to find d • use of their d and $n\lambda = d \sin \theta$ to find θ_3 <p>25° ✓</p>	<p>allow use of $\sin \theta$ or $\tan \theta$ for BP1 and BP2 only</p> <p>bp2 and bp3 may be combined in one equation eg $\sin \theta_3 = 3 \sin \theta_1$ for 2 marks</p> <p>do not allow MP3 if double slit equation used</p>	3	<p>1 × AO1</p> <p>2 × AO2</p>
Total			3	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Idea that voltage is proportional to current ✓ at constant temperature / under constant physical conditions ✓	If algebra used, terms must be defined Ignore references to resistance being constant	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	<p>Line passes through:</p> <ul style="list-style-type: none"> • (2.0 V, 1.0 A) ✓ • (12 V, 2.0 A,) ✓ <p>Smooth line through origin with (constant then) decreasing gradient ✓</p>	<p>Expect to see:</p>  <p>Do not allow zero or negative gradient for MP3</p> <p>If no line drawn, MP1 and MP2 can still be awarded for correctly plotted points</p> <p>Apply list rule if more than 2 points are plotted</p>	3	3 × AO3
Total			5	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Any one from: ✓ <ul style="list-style-type: none"> • converts eV to J correctly • use of $hf = \phi + E_{k(\max)}$ 9.8×10^{14} (Hz) ✓	For BP2, condone mixed units	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Use of $KE = \frac{1}{2}mv^2$ to find v OR Use of $\lambda = \frac{h}{mv}$ ✓ 9.3×10^{-10} (m) ✓	OR use of $p = \sqrt{2mE_k}$ ($= 7.1 \times 10^{-25}$ kg m s ⁻¹)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	<p>Any three from: ✓✓✓</p> <ul style="list-style-type: none">• idea that there is a one to one interaction between a <u>photon</u> and an electron• f_B is below the <u>threshold frequency</u>• link energy of <u>photon</u> to light frequency eg $E = hf$• photons with f_B have <u>photon</u> energy lower than the <u>work function</u> OR define work function		3	AO1
Total			7	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	(Use of $F = kx$ and $F = mg$ to give) 0.20 (kg) ✓	Do not allow 1sf	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Determines extension with m OR subtracts their extension from 0.055 ✓ 0.034 (m) ✓	(0.021 m) Alternative method for MP1: calculates extension due to M alone = $\frac{Mg}{k}$	2	1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Use of $T = 2\pi\sqrt{\frac{m}{k}}$ OR use of $f = \frac{1}{T}$ ✓ 3.5 (Hz) ✓		2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	<p>Any three from: ✓✓✓</p> <ul style="list-style-type: none"> • amplitude will be larger • idea that the difference in equilibrium points before and after cutting will be larger (than with a smaller M) • frequency will be the same • states equation or proportionality and idea that this does not depend on M / this only depends on k and m 	<p>For BP2, allow idea that the difference in potential energies before and after cutting is larger (than with a smaller M)</p> <p>For BP2, allow the idea that the amplitude is equal to the contribution to the extension from M</p>	3	AO2
Total			8	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	1.5 J of work is done by the cell per 1 C of charge OR 1.5 J of energy is used in passing 1 C of charge through the cell and the circuit ✓	Candidate's explanation must clearly be about emf not terminal pd or lost volts Allow energy transferred for work done Allow the cell transfers 1.5 J of energy per 1 C of charge from chemical energy (to other forms)	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Connect a high-resistance voltmeter (across the cell) ✓ when no/negligible current is flowing OR idea of disconnecting from the rest of the circuit ✓	Condone 'infinite resistance' for high resistance	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	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.		6	2 × AO2 4 × AO3
	Mark	Criteria		
	6	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.		
	5	A fair attempt to analyse all three areas. If there are several errors or missing parts then 5 marks should be awarded.		
	4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.		
	3	One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.		
	2	Only one area discussed or makes a partial attempt at two areas.		
	1	A partial attempt at one area.		
	0	None of the three areas covered without significant error.		
		<p><i>Examples of relevant explanation – candidate may use different wording</i></p> <p>A₁</p> <ul style="list-style-type: none"> • A₁ reading increases • the (total) resistance of the circuit decreases <p>V</p> <ul style="list-style-type: none"> • V decreases • V measures the potential difference across the whole parallel section • potential divider argument (to explain why V reading decreases) with circuit resistance and internal resistance <p>OR</p> <ul style="list-style-type: none"> • lost volts increase since current is larger (same r) and V reading = emf – lost volts <p>A₂</p> <ul style="list-style-type: none"> • A₂ reading decreases • $V = IR$ with R constant and V decreasing <p><i>A statement with no explanation partially addresses each area</i> <i>A statement with relevant explanation fully addresses each area</i></p>		
Total			9	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Absorption (by the glass) OR Light refracting out of fibre ✓	Allow attenuation, scattering Do not allow material dispersion	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Longest path = $\frac{D}{\sin \theta_c}$ OR $\Delta t = \frac{\Delta D}{v}$ seen in some form ✓ Both combined with convincing rearrangement ✓	Alternative mp1: correct use of $v \sin \theta_c$	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	<p>Any two from: ✓✓</p> <ul style="list-style-type: none"> • use of $v = \frac{c}{n}$ to get v • calculates θ_c OR use of $\sin \theta_c = \frac{n_2}{n_1}$ (with $n_2 = 1$) • rearrangement to $D = v \Delta t \left(\frac{1}{\sin \theta_c} - 1 \right)^{-1}$ <p>710 (m) ✓</p>	<p>Expect $v = 2.05 \times 10^8 \text{ ms}^{-1}$,</p> <p>Eg $\Delta t = \frac{D}{v} (n - 1)$ is sufficient for BP2. Expect $\theta_c = 43^\circ$</p> <p>Allow answers that round to 710m or 715m. Do not allow 720m.</p>	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	<p>Any two from: ✓✓</p> <ul style="list-style-type: none"> • cladding increases the critical angle • more of the (paths of) light are refracted out of the fibre • idea of fewer possible paths of light in the fibre. <p>Any one from: ✓</p> <ul style="list-style-type: none"> • less pulse broadening • reduces chance of pulses overlapping • increased rate of data transmission possible. 	<p>Ignore any reference to cladding protecting the fibre from damage</p> <p>Ignore 'reduces modal dispersion'</p> <p>Ignore reference to cross-talk between fibres</p> <p>Max 1 mark in total if candidate suggests that cladding keeps more light in the fibre</p>	3	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
09.5	Pulse is less broadened than grey curves, not narrower than $1\ \mu\text{s}$ and same period as before ✓ Pulse has lower amplitude than grey curves ✓	The breadth of the base of each pulse is being compared	2	AO3
Total			11	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Finds mean of 5 values with anomaly removed OR divides their mean by 9 ✓ $w = 4.32 \text{ (mm)}$ ✓	Expect 38.9 mm 3sf only for MP2	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Finds uncertainty using half range OR percentage uncertainty calculated from their uncertainty and their mean x ✓ both correct ✓	Do not penalise use of anomaly 0.6 without anomaly or 2.4 with anomaly Allow alternative: Finds uncertainty using half range/9 AND Percentage uncertainty calculated from this uncertainty and their w Condone: Finds uncertainty using difference between upper or lower bound and mean for MP1 option 1 Expect to see 2% Allow 1.5% or 6.1% with anomaly Do not allow > 2sf in MP2	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Use of $\lambda = \frac{ws}{D}$ with candidate's value of w to give correct λ ✓	Expect 549 nm (or 559 nm with anomaly)	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	% uncertainty in $D = 0.3\%$ OR 100/315 OR 1/315 OR Attempts to add their value in 10.2 + their % uncertainty in $D + 5\%$ ✓ Both and max 2sf ✓	Condone method using upper and/or lower bounds, evaluated correctly for 2 marks Expect to see: 7% if 2% is used in Question 10.2 6.8% if 1.5% is used in Question 10.2	2	2 × AO3

Total			7	
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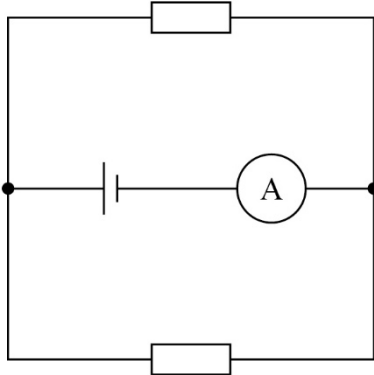
Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Idea that intensity is maximum when (the polarisation directions of) the filters are parallel and minimum when (the polarisation directions of) the filters are perpendicular ✓	<p>Condone explanation of just one of maximum or minimum</p> <p>It must be clear that the angle is between (the polarisation directions of) the filters (not the angle on the x-axis of the graph)</p> <p>Allow a reference to Malus's Law if the angle is defined (not on specification)</p>	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	<p>As light level increases, resistance (of the LDR) decreases ✓</p> <p>Idea that resistors in series share voltage in the ratio of resistances ✓</p>	<p>Alternative for mp2: current increases and $V = IR$</p>	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	<p>Any two of: ✓✓</p> <ul style="list-style-type: none"> Read-off from graph 3000 Ω Use of $I = \frac{12}{\text{their read-off} + 8000}$ use of $V = I \times 8000$ with their I <p>8.7 (V) ✓</p>	<p>Allow use of potential divider equation for BP2 and BP3</p> <p>Allow for BP3: $V = 12 - (\text{their } I \times \text{their read-off})$ two marks (BP2 and BP3) for use of minimum light intensity leading to 4.7 (V)</p>	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	<p>Circuit 1: idea that (since they are in parallel) the voltmeter reading is constant / 12 V (regardless of light intensity) ✓</p> <p>Circuit 2: (since the resistor has too low resistance), the ratio of R to LDR is too low ✓</p> <p>Idea that the variation of voltmeter readings is negligible ✓</p>	<p>For MP2, allow a comparison between the resistor and the LDR</p>	3	AO4

Total			9	
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Question	Key	Answer	AO
12	C	$\sqrt{2}d$	AO1
13	B	36%	AO2
14	C		AO2
15	C	The amplitude decreases to a smaller non-zero value.	AO1
16	C	It is in the same direction as the velocity.	AO1
17	A	16μ	AO1
18	D	π rad	AO2
19	B	There is non-zero amplitude at the nodes.	AO2
20	C	13	AO3
21	D	The frequency is inversely proportional to the wavelength.	AO1
22	B	0.99 m	AO3

23	C	An orbital electron falls to a lower energy level to replace an emitted electron.	AO1
24	B	$\frac{1}{2}$	AO2
25	B	decreasing the accelerating pd	AO4

Total marks = 14