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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

January 2021

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2 1 1 X P H 0 2 / M S

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

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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.

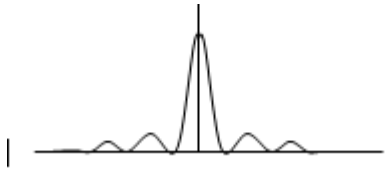
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

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

Question	Answers	Additional comments/Guidelines	Mark	ID details
01.1	The resistance between opposite faces of a unit cube (of the material) ✓	Accept resistance x cross-sectional area divided by length. Do not accept equation in symbols only.	1	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
01.2	Use of $R = \frac{\rho l}{A}$ ✓ 0.63 (m) ✓	Substitution or rearrangement If diameter used for radius, give 1 mark max provided answer given (2.5 m) Look for 4.52×10^{-8} for area Do not accept 0.62 (m)	2	E
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
02	(Idea that reflection at ends produces) two waves (travelling) in opposite directions ✓ Waves have the same frequency/wavelength (and similar amplitude) ✓ Idea that the amplitude of the stationary wave is the (algebraic) sum of the original wave and its reflection ✓	If there is a suggestion that the waves are in phase or coherent allow MAX 2 Accept mention of superposition of the two waves for MP3 Condone superimpose for superpose	3	E
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
03.1	Correct general shape with correct curvature of lines, minima at zero or constant value above and symmetrical AND each maximum lower than the previous one ✓ Width of central maximum approximately 2 × width of subsequent maxima and central maximum much higher than the 1st max on both sides ✓	Must be 5 maxima for MP2  For MP2 look for central maximum at least 3 times as high as the 1st max on both sides	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
03.2	M marked on the abscissa between the 1st maximum from Question 03.1 and the origin ✓		1	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
03.3	Brighter maxima ✓	Allow increase (intensity) Condone 'stronger' Treat comments about position and clarity as neutral	1	E
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
04.1	Use of $I = \frac{V}{R}$ or total resistance is $0.015 + 0.0076\ (\Omega)$ ✓ $540\ (\text{A})$ ✓	Alternative for MP1: determination of V across the external resistance (8.1 V) Allow 530 A	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
04.2	Use of $P = I^2R$ ✓ 4370 **or** $4400\ (\text{W})$ ecf ✓	Allow ecf for candidate's $04.1^2 \times 0.015$ Credit alternative routes Calculation of heat in external resistor (2220 W) gets 1 MAX	2	E
Total			**4**	

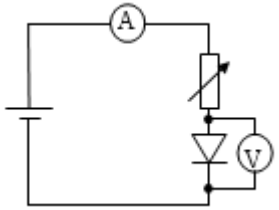
Question	Answers	Additional comments/Guidelines	Mark	ID details
05.1	Multiplies by 1.6×10^{-19} to give $5.47(2) \times 10^{-19}$ (J) to at least 3 sf ✓	must show some working do not allow 5.48×10^{-19} (J) do not allow route with non-zero current	1	

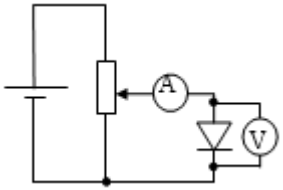
Question	Answers	Additional comments/Guidelines	Mark	ID details
05.2	Uses $hf = \phi + E_{k(max)}$ ✓ Uses $c = f\lambda$ or $E = \frac{hc}{\lambda}$ ✓ 2.15×10^{-7} (m) ✓	Need consistent units in MP1 Look for $hf = 9.248 \times 10^{-19}$ J or 5.56 eV Accept 2.2 and $2.1(4)$	3	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
05.3	Gradient for both (new) lines the same as that for sodium ✓ Magnesium line lower than sodium AND Caesium line higher than sodium line. ✓	Condone lack of labels in MP1 caesium line must have a negative intercept on ordinate Condone Ca for Caesium Ignore any lines drawn below horizontal axis Do not award MP2 if MP1 incorrect	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
05.4	V_s reduced because (photo)electrons collide with atoms in the air✓ Reducing their KE / their velocity/ KE_{max}✓	accept argument that V becomes zero because <u>all</u> photoelectrons are stopped Allow idea that KE is absorbed or used up Do not condone 'energy' Do not give MP2 if process is confused with work function	2	E
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
06.1	 Correct shape with threshold between 0.5 V and 0.8 V and the maximum voltage < 1.0 V ✓	Line must extend above half of y-axis Line must curve when leaving X-axis	1	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
06.2	 All circuit symbols present and correct ✓ Circuit correct including polarity ✓	Ignore switch if drawn or 'protective' resistor in series with diode Accept diode with circle, continuous line through the triangle If LDR or thermistor used for variable resistor, allow MAX 1 Condone use of middle and end terminals on potential divider for variable resistor.	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
06.3	 Correct circuit ✓	Penalise incorrect diode symbol and/or polarity only once in 06.2 and 06.3 Accept equivalent circuit	1	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
06.4	Allows P.d. across diode to go down to 0V OR Full range of potential differences available ✓	If more than one answer given, mark as a list. E.g 'protects circuit' loses mark if given as an extra statement.	1	E
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
07.1	Takes datum from Figure 7A – thermistor resistance is 11 to $11.5\ \Omega$ ✓ Finds resistance of lamp from Figure 7B $(3.0 / 0.85) = 3.5(3)\ \Omega$ **or** $(3 / 0.8)$ ✓ $= 3.75\ \Omega$ uses $\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ 2.67 to $2.83\ \Omega$ ✓	For MP2 allow alternatives e.g. calculation of currents (0.27 to 0.26 + 0.85 to 0.8) to give 1.12 to 1.06 A Substitution or rearrangement at least 3 sf	4	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
07.2	Uses a potential divider equation or uses 3 × their 07.1 ✓ 3 × their 07.1 ✓	Allow alternatives e.g. Calculates circuit current (1.12 A to 1.06 A)✓ Uses $R = V/I$ to give 3 × their 07.1 ✓ Expect to see around $8.1\ \Omega$	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
07.3	Use of $P = VI$ to give 2.4 to 2.7 (W) ✓	Allow use of alternative power equations Allow ecf	1	E

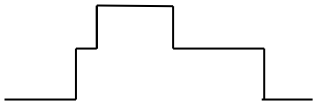
Question	Answers	Additional comments/Guidelines	Mark	ID details
07.4	Resistance of lamp increases (as it heats up) OR Resistance of thermistor falls (as it heats up) ✓ Other statement from MP1 AND sensible comment about the resistance of the combination ✓	In MP1 condone statement that both increase or both decrease. Comment about one or other component dominating **or** resistance is likely to fall since resistance of combination is less than that of either component **or** impossible to say as we do not know which dominates	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
07.5	Initial rate of temperature (increase) will be lower ✓ Because pd across lamp reduces **or** power in lamp reduces ✓	Do not award any marks if answer suggests rate increases or stays the same. Condone suggestion that the lamp resistance is (initially) constant Do not condone 'thermistor' or 'combination' for 'lamp'	2	E
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
08.1	coherence requires the two sources to have • the same frequency/ wavelength AND • constant phase relationship/difference ✓ The idea that the above must be true as the light comes from the same source ✓	Ignore references to amplitude Allow the light (for both) comes from the laser	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
08.2	When light from both paths arrive in phase a bright fringe is produced **OR** When light from both paths arrive in anti-phase a dark fringe is produced ✓ Idea that moving the mirror causes a path difference ✓	Condone discussion in terms of path difference in MP1 E.g. for MP2 '… changes the path length of the light from M2	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
08.3	¼ wavelength = $162.5\ \text{nm}$ with reference to d or distance moved by M2 ✓ explanation of how moving the mirror by ¼ λ produces a phase difference of π or ½ cycle✓	For MP2 allow idea that moving mirror d changes path length by $2d$ Accept argument in either 08.2 or 08.3	2	

Question	Answers	Additional comments/Guidelines	Mark	ID details
08.4	Height changes correspond to changing brightness ✓ All 4 height changes are equal ✓ Scale so that height change (from dark to light or vice versa) approximately 1.6×10^{-7} m ✓	Condone MP1 for attempt to line up – e.g. dotted lines seen. Example:  Accept if 'central' peak is another dip down to the zero level etc. Accept shoulders rounded within two horizontal squares	3	

Question	Answers	Additional comments/Guidelines	Mark	ID details
08.5	(Smaller wavelength) improves resolution **or** allows smaller difference in height to be detected wtte ✓	Allow increases or higher for improves Allow description of improvement that doesn't mention resolution Treat references to frequency as neutral	1	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
08.6	Idea that modal dispersion is caused by many different pathways OR different length paths✓ (The uneven face will cause) light entering the fibre to be at a variety of angles (to the axis) ✓	Allow 'emitted through different angles' Marks can be credited in a labelled diagram	2	E
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
09.1	Clear evidence of extrapolation of the rays on the diagram ✓ Answer in the range 40 to 42 degrees ✓	Only award MP2 if MP1 awarded	2	

Question	Answers	Additional comments/Guidelines	Mark	ID details
09.2	Answer in the range $\pm(1.0 \text{ to } 2.0)^{\circ}$ ✓		1	

Question	Answers	Additional comments/Guidelines	Mark	ID details
09.3	Measurement involves 2 readings✓	Answer should be consistent with the answer to 09.2	1	

Question	Answers	Additional comments/Guidelines	Mark	ID details
09.4	$\frac{(a+d)}{2}$ correctly calculated ✓ Consistent % uncertainty calculated ✓	Expect an answer of 2 to 4% and accept 1 or 2 sf only Do not condone adding of absolute uncertainties unless d = 50 Expect to see (100 x their 9.2 divided by their 9.1) + 1%	2	

Question	Answers	Additional comments/Guidelines	Mark	ID details
09.5	Refractive index in the range 1.65 to 1.75 ✓ % uncertainty 1% greater than the answer given in 09.4 ✓	2 or 3 sf only No sf penalty	2	
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	ID details
10.1	Finds actual number of oscillations in $24\ \text{h} = 61626$ ✓ Finds the necessary number of oscillations in $24\ \text{h} = 61714$ ✓ $88 \times 1.4 = 123\ (\text{s})$ ✓	Alternative $24 \times 60 \times 60/1.4$✓ $\times\ 0.002$✓ $= 123\ \text{s}$✓	3	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
10.2	Uses $T = 2\pi\sqrt{\frac{l}{g}}$ ✓ $0.49\ \text{m}$ to at least 2 sf ✓	Substitution or manipulation Must show some working	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
10.3	Additional mass should be placed above the existing centre of mass (wtte) ✓ Idea that the new centre of mass will be nearer to the point of suspension or that the effective length of the pendulum is less. ✓	Allow ref to rigid base Only allow MP2 if MP1 awarded	2	E

Question	Answers	Additional comments/Guidelines	Mark	ID details
10.4	Additional mass needs to be placed higher so that C of M is higher OR (Effective) length is shorter ✓		1	E
Total			**8**	

Question	Answer
11	C
12	D
13	B
14	D
15	A
16	C
17	D
18	A
19	B
20	C
21	C
22	C
23	B
24	B