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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

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251XPH02/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	Makes m the subject of the de Broglie equation **OR** substitutes for λ and v into de Broglie equation ✓ 1.9×10^{-28} (kg) ✓	MP1: condone POT error for λ Calculator value is 1.87925×10^{-28} kg	2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02	Max ✓✓ Uses area of graph **OR** states that area = Q Determines total area (in A h) Converts A h to C 7.8×10^{3} (C) ✓	Total area = 2.172 A h Max 2 for counting squares method: accept 22 ± 0.5 squares of 0.1 A h. Calculator value is 7819.2 C	3	1 × AO1 2 × AO3
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	0.027 (m) ✓	Calculator value is 0.02727 m	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Links observed effects to polarisation ✓	MP1: e.g. "the grille acts as a polariser" Any reference to grille causing polarising must refer to orientation of detector for further marks.	3	1 × AO1 1 × AO2 1 × AO3
	Comments on effects for the two orientations of grille ✓	MP2: e.g. "in Fig. 3 microwaves are blocked by grille; in Fig. 4 microwaves pass through grille" MP2: Condone incorrect correlation between orientation of grille and polarisation direction.		
	Links polarisation as a property of only transverse waves, so microwaves are transverse waves ✓	MP3: Condone absence of word "only".		
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Uses equation for A or determines A **OR** reads off ρ as 0.97×10^{-7} Ω m ✓ Uses $\rho = \frac{RA}{l}$ ✓ 0.26 (m) ✓	MP1: $A = 2.545 \times 10^{-10}$ m². Condone power of ten (POT) error in A. MP2: Allow POT for ρ. Allow their incorrect A e.g. 1.02×10^{-10} m² (from using 1.8×10^{-5} as r) MP3: Calculator value = 0.2597 m Allow 2 marks for 1.04 m (from 1.02×10^{-10} m²)	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Evidence of relevant method (may be seen on Fig. 5) ✓ 1.8×10^{-7} (Ω m) ✓	Accept for MP1: • determines gradient: allow 4.1×10^{-10} or 4.2×10^{-10}. Condone POT error. • uses $y = mx + c$ • use of similar triangles • use of $y - y_1 = m(x - x_1)$	2	AO4
Total			**5**	

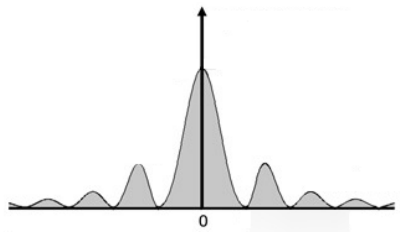
Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Potential divider argument given **OR** calculates current as 0.0136 A ✓ 660 (Ω) from some relevant working ✓	MP1: e.g. ratio of pds (at max R) is $3{:}9$, so ratio of resistances is $1{:}3$ MP2: 0.0136 A gives $662\ \Omega$	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	There will now be a pd across internal resistance $_{1a}$✓ Idea that emf is now shared across internal resistance and load resistance/**R**/$220\ \Omega$ $_{2a}$✓ **OR** Current in circuit will reduce $_{1b}$✓ Uses $220\ \Omega$ in $V=IR$ to conclude that reading will be <12 V $_{2b}$✓	MP1a: Condone 'lost volts' MP2a: May see "terminal pd = emf – lost volts" used. Allow potential divider arguments.	2	AO1
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Makes k the subject of period of mass–spring system **OR** calculates $T = 0.56$ (s) ✓ Allow a value that rounds 25 or 26 (N m^{-1}) ✓	MP1: Expect $T = 0.5555$ s MP2: Allow 1 mark for 2.4 N m^{-1} (from correct rearrangement for k but using 1.8 as T)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Maximum amplitude occurs because resonance occurs (at 1.8 Hz) ✓ Maximum amplitude occurs when: frequency of forced oscillation equals frequency of free oscillation **OR** driving frequency equals natural/resonant frequency ✓	MP1 is for an explanation of why the amplitude has a maximum value MP2 is for an explanation of why the maximum amplitude occurs at 1.8 Hz MP2: Condone "applied" frequency.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Max 2: ✓✓ Amplitude of oscillations will be smaller at all frequencies or at resonance frequency/$1.8\ \mathrm{Hz}$ or maximum amplitude will be smaller (with water/Fig. 9 compared to without water/Fig. 8) Maximum amplitude oscillation/resonance still occurs at $1.8\ \mathrm{Hz}$ or natural frequency is still $1.8\ \mathrm{Hz}$ Increased (rate of) energy dissipation (for the same amplitude/speed)	MP1: “there are smaller amplitude oscillations” is insufficient MP2: allow natural/resonant frequency may be (slightly) less than $1.8\ \mathrm{Hz}$ (due to damping)	2	AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Basic description of pattern: central bright maximum with second maxima either side ✓ Detail of central maximum e.g. brighter than secondary maxima; width is twice that of any secondary maximum ✓	Max 1 for marks awarded from an unlabelled diagram of visible pattern. A sketch of the visible pattern should have central maximum labelled.  A sketch of the intensity variation must have y-axis labelled as intensity  Reject any reference to white light or a continuous spectrum occurring.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Idea that pattern is broader ✓ Brightness/intensity (of maxima) decreases ✓	MP1: accept a specific reference e.g. width of central maximum widens MP1: Reject reasoning based on double-slit interference or diffraction grating.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Calculates d (2.5×10^{-6} m) **OR** substitutes values into diffraction equation ✓ Max $n = 4$ ✓	Allow a POT in error in d or λ but not both. ($n = 4.72$)	2	AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Same frequency / wavelength ✓ Constant phase difference / relationship ✓	MP2: "In phase" is insufficient.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Waves (from the loudspeakers) in anti-phase / $180°$ out of phase / pi (rad) out of phase (at minimum) ✓ Path difference (at minimum) $= \frac{\lambda}{2}$ ✓ Reference to superposition or destructive interference occurring ✓	If no other mark given, allow 'wavelength is 20 cm' for 1 mark. Treat reference to "node" as neutral.	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	0.10 (m) with some relevant explanation ✓ Explanation in terms of interference and path difference **OR** in terms of stationary waves ✓	Allow 'wavelength is 20 cm' for 1 mark if not already credited in **08.2** MP1: Condone 1 sf MP2: e.g. minimum-to-minimum spacing is half wavelength; maximum-to-minimum is quarter wavelength Accept "node" for minimum, and "antinode" for maximum.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Amplitude of wave from **B** > amplitude of wave from **A** ✓ Idea that superposition of the two unequal amplitudes produces a larger resultant amplitude (than previous minimum) ✓	MP2: Allow idea that, due to superposition, resultant amplitude cannot be zero or that a node cannot be produced. MP2: Allow idea that (magnitude of) destructive interference is reduced.	2	AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Electron transfers energy to a mercury atom by collision ✓ Collision excites/ionises the atom **OR** moves electron to higher (energy) level or ejects electron from atom ✓ (mercury) Atom/ion de-excites, emitting (UV) photon ✓	Accept “Hg” for “mercury”. A reference to “collision” is needed only once if both MP1 and MP2 are awarded.	3	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Substitution into $E = hf$ ✓ Divides 42×10^{-3} by their E ✓ 8.3×10^{16} or 8.4×10^{16} ✓	MP1: Expect 5.039×10^{-19} (J) MP2: Condone POT error in power MP3: Calculator value = 8.3353×10^{16}	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	Uses $P = VI$ with 3.4 V **OR** reads off I as 19 mA ✓ 0.65 ✓	MP1: Expect P = 64.6 mW MP2: Allow 0.63 to 0.67, or 63% to 67%.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	Uses $V = IR$ to get pd across fixed R $_{1a}$✓	MP1a: Expect 1.161 V. Condone POT error for current.	3	AO3
	Reads off, and adds, pds for LEDs $_{2a}$✓	MP2a: Expect V_{red} = 2.05 V; V_{green} = 2.70 V; V_{blue} = 3.05 V. Condone 1 misreading beyond ±0.05 V of expected value.		
	Determines resistance of each LED $_{1b}$✓	MP1b: Expect R_{red} = 47.7 Ω; V_{green} = 62.8 Ω; V_{blue} = 70.9 Ω. Condone 1 miscalculation.		
	Finds total resistance (with $V = IR$) $_{2b}$✓	MP2b: Expect 181.4 + 27 = 208.4 Ω		
	Value that rounds to 9.0 (V) $_{3}$✓	MP3: Reject a 1 sf answer.		
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	0.85 (s) ✓	2 sf only	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Determines half of the range in Table 1 $= 0.095$ s ✓ 11 ✓	MP1: condone using full range divided by mean MP2: Accept 11%. Accept 10 (or 10%) from a correct method. 1 or 2 sf only.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	$\frac{1.63}{0.83}$ to get 1.96 m s^{-1} ✓ Uses their percentage uncertainty with their speed ✓	MP2: 1 or 2 sf only. Expect 0.2 m s^{-1}. Allow ecf from **10.2**	2	AO3

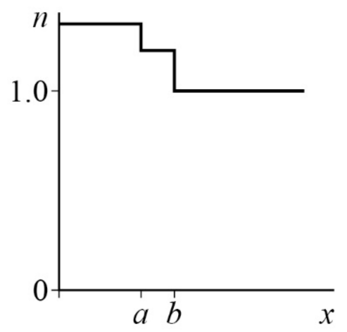
Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Idea that parallax error will result in a larger measured time $_{1a}$✓ Larger measured time leads to: smaller calculated (mean) terminal speed (for same height/1.63 m) or smaller percentage uncertainty in (the incorrect) time $_{2a}$✓ **OR** Idea that terminal speed is not be reached by 1.63 m $_{1b}$✓ (so) overall terminal speed will be lower or measured time would be larger $_{2b}$✓	MP1: Accept a description of parallax error e.g. “line is below student A’s eyes” Accept idea that results are unaffected if student A crouches to remove parallax error. Reject idea that measurement of height is affected. Accept comments about redrawing the line on the wall to remove parallax error.	2	AO4
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Determines speed of light in glass as 1.97×10^8 (m s^{-1}) ✓ 1.03×10^8 (m s^{-1}) ✓	MP1: Allow 2 sf value in working out.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	Angle of refraction = 61° ✓ Uses Snell's law with either angle associated with the correct refractive index ✓ 1.2 ✓	MP2: e.g. $n_1\sin\theta_1 = n_2\sin61$ **OR** $1.52\sin45 = n_2\sin\theta_2$ Alternative MP2: Calculates ${}_{m}n_{g} = 0.809$ Expect 1.23	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	1.1 ✓	Must be correctly rounded. Calculator value = 1.0748	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	If n < n_{min} the critical angle would be < $45°$ ✓ Total internal reflection will occur (at first glass–material boundary) ✓ Idea that light will not pass into the material or that the angle of deviation (from horizontal) cannot be measured ✓	MP1 may be a calculated example or a reference to critical angle equation. MP1: Allow “critical angle < incident angle”	3	AO4
Total			**9**	

Question	Key	Answer	AO
12	B	down up	AO3
13	C	$\frac{1}{\text{gradient}}$ | $\frac{f \text{ intercept}}{\text{gradient}}$	AO3
14	C	$30\ \Omega$	AO3
15	A	remove an electron from the atom.	AO1
16	B	$\frac{2\lambda D}{s}$	AO2
17	C	$\frac{4\pi^2}{S}$	AO2
18	A	decreases remains the same	AO1
19	D	unchanged unchanged doubled	AO3
20	B		AO3

21	D	$\frac{9T}{4}$	AO2
22	A	$32°$	AO1
23	B	41 kJ	AO3
24	D	$5I_1 = 3I_2 + 2I_3$	AO3
25	A	4.8×10^{-20} J	AO3