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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

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196XPH02/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 Assessment Writer.

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

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	Marking guidance	Mark	Comments
01	Use of $\lambda = \frac{h}{p}$ **or** $\lambda = \frac{h}{mv}$ ✓ 5.64×10^{-10} (m) ✓	2	When substituting into $\lambda = \frac{h}{p}$ do not accept v instead of p Accept 5.6×10^{-10} (m)
02	d calculated (= 4 μm) **or** appropriate use of $\frac{1}{250 \text{ x } 10^3}$ ✓ use of $n\lambda = d \sin\theta$ (= 6.5×10^{-7} m) ✓ use of $c = f\lambda$ ✓ $f = 4.6(4) \times 10^{14}$(Hz)✓	4	Condone power of 10 for MP1. MP2 and MP3
03	rotate the filter ✓ correct set-up described **or** idea that it is necessary to measure, monitor or observe (the variation in) intensity during rotation ✓ if the intensity varies it is polarised and/or if the intensity does not vary, it is not polarised **or** if it is polarised, when rotated, a minimum is observed ✓	3	Correct setup could be on a diagram For correct setup, must be clear that the filter is between the lamp and the meter ignore any reference to the filter reducing the intensity of the light as it would do this in either case do not award MP3 for answers involving discrete measurements only

Question	Marking guidance	Mark	Comments
04.1	any mention of resonance ✓ the idea that there is a periodic driving force or a forcing oscillation ✓ (Max amplitude or resonance when) the frequency of the forcing oscillation matches the resonant/natural frequency of vibration (of the machine) ✓	3	Look for the idea that there is a force causing the oscillation and that the applied force is periodic or oscillating Not just the rotation of the drum for MP2
04.2	smooth curve with a single peak ✓	1	
04.3	damping reduces the amplitude **or** peak is lowered ✓ idea that damping removes energy from the system ✓	1 1	Ignore reference to the width of the peak or its position on the graph

Question	Marking guidance	Mark	Comments
05.1	not a straight line (through the origin) **or** V not proportional to I **or** resistance is increasing or changing **or** gradient not constant✓	1	
05.2	MAX 3: electrons collide with lattice / ions / atoms ✓ idea that there is a transfer of energy between electron and lattice ion ✓ vibration of ions/atoms increases ✓ resistance / temperature increases ✓	3	Accept frequency or amplitude or just vibration
05.3	Two correct read-offs V_{lamp} = 2.65 to 2.75 V; V_{diode} = 0.63 to 0.64 V ✓ both values added ✓	2	Expect 3.28 to 3.39 correct answer (without working) gets both marks

Question	Marking guidance	Mark	Comments
06.1	(free) electrons collide with the (mercury) atoms (and transfer energy) ✓	1	Accept atoms collide with electrons Ignore the idea that atoms collide with each other
06.2	mercury atoms de-excite **or** emit photons of UV / $7.2\ \mathrm{eV}$ light ✓ (UV) photons are absorbed by atoms (of powder coating) ✓	2	Not just collide Accept photons transfer (all of) their energy to the atoms (of the powder)
06.3	de-excitation occurs via other levels the idea that smaller energy drops result in lower energy/ lower frequency/ longer wavelength / visible light emitted	2	Accept in steps
06.4	From 3 to 2, and downwards with only one arrow drawn	1	
06.5	Conversion of eV to J seen or implied ✓ Use of $E = \frac{hc}{\lambda}$ ✓ $5.18 \times 10^{-6}\ \mathrm{m}$ ecf from 06.4 ✓	3	other possible answers $5.36 \times 10^{-7}\ \mathrm{m}$ $2.68 \times 10^{-7}\ \mathrm{m}$ $2.54 \times 10^{-7}\ \mathrm{m}$ $1.78 \times 10^{-7}\ \mathrm{m}$ $1.73 \times 10^{-7}\ \mathrm{m}$

Question	Marking guidance	Mark	Comments
07.1	(as the current increases,) the voltage across the internal resistance increases ✓ so less of the total voltage is available to the external resistance **or** correct equation discussed eg terminal pd $= E - Ir$ ✓ **Alternative** R decreased ✓ R has a smaller share of the voltage wtte ✓	2	allow 'lost volts increase' for MP1 must be clear which resistor is being discussed For MP2, allow 'terminal pd decreases' Must include that E is fixed but condone omission of statement that r is fixed must be clear which resistor is being discussed
07.2	line of best fit drawn <u>and</u> intercept used ✓ 5.7–5.9 V ✓	2	Expect to see an additional line for **07.4**

07.3	attempt to take the gradient ✓ correct readings, with evidence seen on the graph defining 2 points at least 2.5 A apart✓ 1.15–1.27 (Ω) ✓ Alternative: use of their value of E and a point on the line of I greater than 2.5 A. ✓ Use of $V = E - Ir$ ✓ 1.15–1.27 (Ω) ✓	3	Must be from the line and not from two data points for both MP1 and MP2 Accept use of both intercepts without annotation of graph reject a negative number for MP3 Expect to see triangle with greater than half size of graph.

07.4	straight line with negative gradient and V intercept of 2.7 to 3.0 ✓ straight line with negative gradient and half the gradient of the original ✓	2	MP1 and MP2 can be given even when no best fit line has been drawn for 07.1/07.2. Line can be extrapolated to judge intercept Gradients judged by eye note: it will have the same I intercept if both marks are correct

Question	Marking guidance	Mark	Comments
08.1	Any **two** from: stationary waves have nodes/ antinodes, progressive waves do not ✓ in a progressive wave, the phase varies continuously across all points (along one wavelength), whereas in a stationary wave, all points between adjacent nodes are in phase ✓ in a stationary wave, different points have different amplitudes whereas all points in a progressive wave (can) have the same amplitude ✓	2	Must be a comparison
08.2	Use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ ✓ Use of $\mu = \frac{m}{l}$ ✓ tripling f is seen ✓ 509 or 510(Hz) ✓	4	condone power of ten errors for MP1 MP2 and MP3 expect to see $\mu = 1.60 \times 10^{-3}$ kg/m
08.3	correct expression for λ or calculation of λ (= 0.408 m or $\frac{2}{3} \times 0.612$) ✓ use of $c = f\lambda$ with any of the values of frequency or wavelength ✓ 208 or 210 (m s^{-1}) **ecf** from 08.2 ✓	3	condone the use of <u>both</u> the frequency and wavelength of the fundamental, ie λ = 1.224 m <u>and</u> f = 170 Hz, for both marks if correctly calculated as it will legitimately lead to the same answer for ecf look for 0.41 x candidate's 08.2
08.4	motionless (because it is at a node) ✓	1	Accept oscillating with minimum amplitude, or fixed or stationary

08.5	3.14 (rad) ✓	1	accept π

Question	Marking guidance	Mark	Comments
09.1	Use of $\sin\theta_c = \frac{1}{n_1}$ (leading to n_f= 1.45) ✓ use of $v = \frac{c}{n}$ leading to 2.07×10^8 m s^{-1} ✓	2	must be at least 3 sf accept use of $\sin\theta = \frac{v}{c}$ for 2 marks at least one of the equations must be seen in a correct form
09.2	**Method 1** use of $\Delta t = \frac{\Delta D}{v}$ ✓ some form of $D = \frac{320}{\cos\theta}$ seen ✓ ΔD found (= 92 m) ✓ $4.4(4) \times 10^{-7}$ (s) ✓ **Method 2** Use of $\Delta t = \frac{D}{v_1} - \frac{D}{v_2}$ ✓ $v_H = v\cos\theta$ or $v_H = 1.61 \times 10^8$ (m s^{-1}) ✓ Either t_x or t_y calculated correctly ✓ $4.4(4) \times 10^{-7}$ (s) ✓	4	i.e. $\frac{320}{\cos 39}$ or $\frac{320}{0.777}$ or 412 (m) seen 4.37×10^{-7}(s) if 2.1×10^8 m s^{-1} rather than 2.07×10^8 m s^{-1} i.e. 1.55×10^{-6} (s) or 1.99×10^{-6} (s) 4.37×10^{-7}(s) if 2.1×10^8 m s^{-1} rather than 2.07×10^8 m s^{-1} Correct answer gets full marks.

09.3	Cladding increases the critical angle (at the core-cladding boundary) ✓ So a smaller range of paths is available / more light is incident below the critical angle and hence removed ✓	2	Accept reference to time difference (between different paths)provided it is related to path difference Do not award MP2 if argument is about core narrowing alone

Question	Marking guidance	Mark	Comments
10.1	1.27 s ✓	1	3 or 4 sf only and unit required
10.2	0.8 ✓	1	No sf penalty
10.3	9.8 ecf from 10.1✓	1	2 or 3 sf If $10T$ used, expect to see 0.098
10.4	Clear attempt to use $\Delta k\% = 2\Delta T\ \% + \Delta m\%$ **or** $\Delta m\%= 2$ ✓ 3.6 **ecf from 10.2** ✓	2	Accept $\Delta m\%= \frac{0.008}{0.4}\ x\ 100\%$ No sf penalty

10.5	Clear evidence of one determination from the graph ✓ Two or more values of half life averaged ✓ Answer in the range 23to 26 s ✓	3	Expect to see construction lines on the graph for MP1 MP3 dependent on MP2 No sf penalty

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