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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

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221XPH02/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 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	Answers	Additional comments/Guidelines	Mark	AO
01.1	7.67×10^{-4} (s) **OR** 7.7×10^{-4} (s) ✓	Penalise 1 sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	6.8×10^{7} (V) ✓	Penalise 1 sf	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Use of $E = Pt$ leading to 1.2(3) (s) ✓	Penalise 1 sf	1	AO2
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02	Use of $d \sin\theta = n\lambda$ ✓ $d = 3.5 \times 10^{-6}$ (m) **OR** $\frac{42 \times 10^{-3}}{12000}$ ✓ uses $n = 2$ **OR** $\theta = 20.7^{o}$ ✓ 6.2×10^{-7} (m) OR 6.19×10^{-7} ✓	Condone pot error in MP2 Answer of 1.16×10^{-6} m from $\theta = 41.4^{o}$ gets max 3.	4	2 × AO1 2 × AO2
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Max 3 Lamps too far apart (to produce fringes that are observable to the naked eye) ✓ Not coherent... ✓ ...because they don't have a constant phase relationship ✓ Idea that a pair of wavefronts or photons coinciding are not likely to have the same frequency ✓	For MP4, accept the idea that filament lamps emit light of many frequencies	3	1 × AO1 2 × AO2
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04	Physical evidence for the existence of energy levels✓ Explanation of how energy levels give rise to photons/quanta of particular energies/frequencies✓ Discussion of why the energy levels must be discrete ✓	E.g. for MP1: line (emission and/or absorption) spectra Allow 'not continuous' for line ✓ e.g. for MP3 why spectra have a limited number of frequencies or wavelengths Accept similar argument for characteristic spectrum of X-rays	3	3 × AO1
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Uses $c = f\lambda$ to get 3.95×10^{-10} (m) to at least 3 sf ✓	Must have convincing use of POT	1	AO1

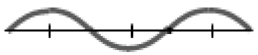
Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Uses $\lambda = \frac{h}{mv}$ to get 1.78×10^{-10} (m) to at least 3 sf ✓	Must have convincing use of POT	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Chooses electron as (de Broglie) wavelength is closer to atomic separation… ✓ … so the diffraction angle will be greater ✓	 Allow wider diffraction	2	1 × AO2 1 × AO4
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Mercury atoms emit UV photon as they de-excite ✓ Absorbed by (phosphor) coating of tube ✓ Idea that phosphor atoms de-excite in smaller stages, so emit lower energy (visible) photons ✓	Condone 'relax' for de-excite	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	More charge carriers available ✓ Links increase in potential difference with either increase in rate of collisions or increase in energy available per collision ✓	Condone ions/electrons for charge carriers Condone 'number' for 'rate' Treat references to temperature as neutral	2	2 × AO2
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	0 or zero ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	One mark for the wave correctly drawn ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	States that there are nodes and antinodes ✓ Idea that the stationary wave is formed by the superposition of the two waves ✓ Amplitude (at antinodes) of 2 A **OR** amplitude at P is zero✓ Explanation of how superposition produces a node or an antinode ✓	MP1 and MP3 and MP4 could be on a diagram Condone superimposition, but not interference for superposition.	4	2 × AO1 2 × AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	R_L in the range 3100 to 3400 (Ω) ✓ R_T in the range 7000 to 8000 (Ω) ✓ Candidate adds the two values and uses $I = \frac{V}{R}$ ✓ 5.3×10^{-4} (A) to 5.9×10^{-4} (A) ✓	Need to see equation or subject of an equation for MP3 Do not award MP4 if both MP1 and MP2 are incorrect.	4	2 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	$R_L = 100\ \Omega$ ✓ Correct potential divider equation seen **OR** Calculates new current = 1.1×10^{-3} A✓ 5.9 (V) ✓	Expect to see $\frac{100}{5600} \times 6$ **OR** $\frac{5500}{5600} \times 6$ Must see equation or subject of an equation for MP2	3	1 × AO2 2 × AO3
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Measures h with a metre ruler **AND** uses stopwatch or other suitable timing device… ✓ At least 5 sets of values of h and T ✓ Time at least 5 oscillations or for a period of at least 20 s **OR** use of fiduciary marker **OR** means of checking metre ruler is vertical ✓		3	3 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Plots T^2 against h ✓ gradient is $(-)\frac{4\pi^2}{g}$ ✓ Intercept is $\frac{4\pi^2}{g}H$ ✓	Expect to see $T^2 = \frac{4\pi^2}{g}H - \frac{4\pi^2}{g}h$ but accept MP1 without full rearrangement seen Allow alternative straight line graphs Marks can be awarded from a diagram. Expect line to have a negative gradient for MP2 and positive intercept for MP3.	3	2 × AO3 1 × AO4
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Idea that a small force from the spring acts on (large mass) M implying reference to a Newton's law of motion ✓	Accept statement that M has a high inertia	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Counts 10 to 12 cycles, seen or correctly used✓ Interprets scale correctly – eg 1 square is equivalent to 2 second ✓ 2.5 to 3.0 (Hz) ✓	Condone 1 sf answer	3	1 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Uses $s = vt$ or notes delay is equivalent to 2 mm travel of graph paper ✓ 4 s delay ✓ 28 000 (m) ✓	Allow ecf for their time in 10.2	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Amplitude is lower … ✓ ... as it is attenuated by travelling a greater distance through the medium ✓	For MP2 accept an inverse square law argument **OR** that energy is absorbed as the vibrations pass through the Earth	2	1 × AO1 1 × AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Uses 1 mm as the uncertainty to give $\frac{1}{625}\times 100 = 0.16\,(\%)$ ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	Calculates the resistance per unit length as $8.48\ (\Omega\ \mathrm{m}^{-1})$ ✓ Calculates percentage uncertainty of resistance as $\frac{0.3}{5.3}\times 100 = 5.7$ or 6 **AND** Adds their percentage uncertainty of resistance to their answer from **11.1** ✓ Answer in the range $(\pm)\ 0.49$ to $0.52\ (\Omega\ \mathrm{m}^{-1})$ ✓	Allow 8.5 The number of decimal places should be consistent with the answer to 'resistance per unit length' e.g. if 8.5 is used only accept 0.5	3	2 × AO1 1 × AO2

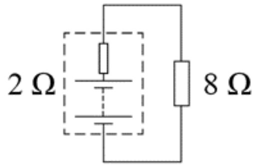
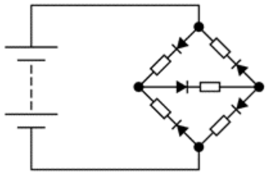
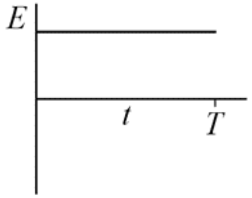
Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	Large triangle used to collect correct data ✓ Answer in the range 8.1 to 8.3 $(\Omega\ \mathrm{m}^{-1})$ ✓		2	2 × AO3

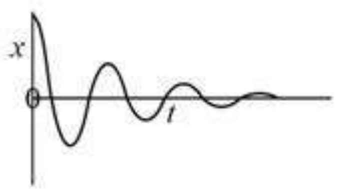
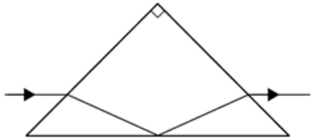
Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	ANY TWO from: ✓✓ The idea that finding the gradient is an averaging process (and reduces random errors) Systematic errors can be avoided (such as the intercept – contact resistance in this case) Idea that single set of measurements may be anomalous	Allow systematic errors can be corrected, once identified	2	2 × AO4
Total			**8**	

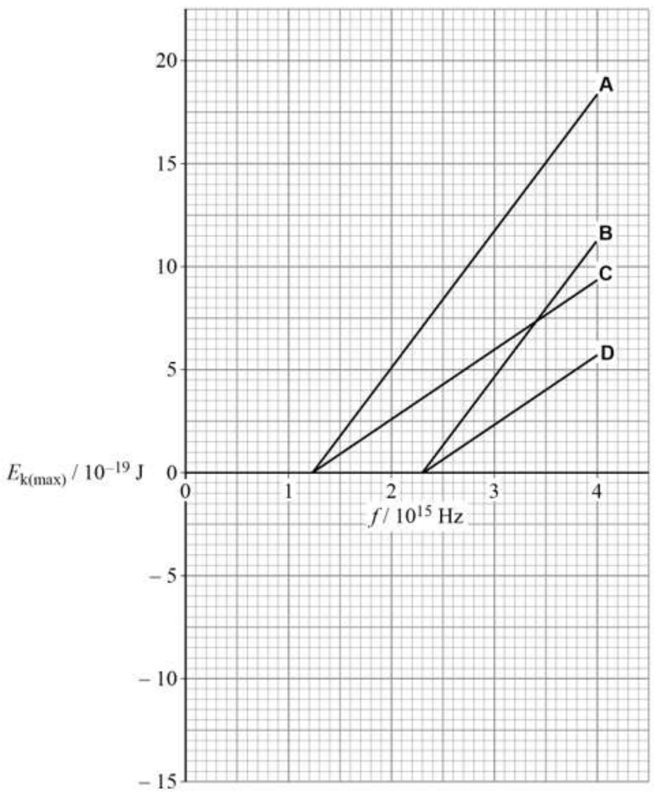
Question	Answers	Additional comments/Guidelines	Mark	AO
12.1	Use of $P = \frac{V^2}{R}$ ✓ 52.9 (Ω) to at least 3 sf ✓	Need to see equation or subject of equation Accept use of $P = VI$ and $I = \frac{V}{R}$	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
12.2	Use of $\rho = \frac{RA}{L}$ **OR** finding the correct area = 5.9×10^{-8} (m^2) ✓ 6.37 or 6.4 (m) ✓	Accept answer in mm if unit given If R = 53 (Ω) used answer is 6.38 (m) Do not allow more than 3sf	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
12.3	**maximum** elements shown in parallel (with lamp in parallel too) ✓ 2000 (W) ✓ **minimum** elements shown in series (with lamp in parallel with the series combination of heating elements) ✓ 500 (W) ✓	For MP1 and MP3 both to be awarded, the lamp must be seen correctly connected in at least one diagram Do not condone 1 sf answers	4	1 × AO1 2 × AO2 1 × AO3
Total			**8**	

Question	Key	Answer	AO
13	**C**	600 Hz	AO2
14	**D**		AO3
15	**C**		AO3
16	**A**	0–5 0–1	AO3
17	**D**		AO3
18	**D**	π	AO3
19	**B**	2.3 minimum	AO3

20	**A**		AO3
21	**C**		AO3
22	**B**	Material dispersion is minimised by using a narrow fibre.	AO1
23	**D**	Positrons exhibit the same wave-like properties as electrons that have the same velocity.	AO1
24	**B**	increasing the potential difference across the tube.	AO2

25	**A**		AO3
26	**C**	increasing the frequency of the incident radiation	AO1