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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

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191XPH02/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	description of longitudinal wave ✓ description of polarisation **OR** only transverse waves can be polarised ✓	2	eg oscillations/vibrations occur parallel to direction of energy/wave eg restriction of oscillations/vibrations to one plane/direction
02	Two from: ✓ ✓ use of W=Pt use of W=QV converting t to seconds 1100 (C) ✓ **OR** Two from: ✓ ✓ use of P=IV use of Q=It converting t to seconds 1100 (C) ✓	3	Condone time in minutes for 1st MP only. Condone time in minutes in 2nd MP only.
03.1	MRI scanners / particle accelerators / MAGLEV trains / SQUIDs / electrical power transmission ✓	1	Allow other examples not listed here Not electromagnet or power magnet

03.2	high magnetic fields / low or no heating effect / increased efficiency for power transmission ✓	1	Reason must match application given in 03.1

Question	Marking guidance	Mark	Comments
04.1	$\frac{f^2}{T} = \frac{1}{4\mu l^2}$ seen in this form or re-arranged ✓ gradient = $\frac{f^2}{T}$ plus appropriate manipulation ✓	2	
04.2	evidence of obtaining gradient (expect 45) ✓ μ calculated using their gradient ✓ use of μ = m/L ✓ 4.4×10^{-3} (kg) ✓	4	Penalise 1 sf answer
05	<u>mercury</u> atoms are excited/ionised ✓ by electron collisions ✓ atoms/ions de-excite/relax (emitting UV photons) ✓	3	Allow descriptions of electrons moving between energy levels for 1st and 3rd MP

Question	Marking guidance	Mark	Comments
06.1	Three from: ✓ ✓ ✓ reading from graph: 3.2 ± 0.2 (kΩ) their R_T + 10 × 10^3 (Ω) use of I = 18/R Unit consistent with power of 10 used for R 1.34 to 1.38 × 10^{-3} (A) or 1.34 to 1.38 (mA) ✓	4	Full marks for correct answer. Allow alternative method using pot divider equation. Condone power of ten omission for 1st MP Allow C s^{-1} and V Ω^{-1} Accept answers rounded to 2sf from correct graph reading
06.2	use of P = I^2R eg (their 06.1)^2 × 10 × 10^3 ✓ 0.018 or 0.019 or 0.020 (W) ✓	2	Condone power of ten error for current and/or resistance for 1st MP only. Allow 1st MP for calculation of power of circuit: P = 18^2/total R or P = 18 × their 0.61), or use of V=IR Allow ecf from 06.1

Question	Marking guidance	Mark	Comments
07.1	work done when accelerating an electron through a pd of 1 V ✓	1	Accept "energy gained when an electron accelerates through a pd of 1 V" OWTTE
07.2	Use of W=VQ (or VIt if t=1s) and $E_k = ½ mv^2$ **OR** $v = \sqrt{\frac{2VQ}{m}}$ seen ✓ Substitution of values of electron charge or mass leading to $5.93x10^5\sqrt{V}$ ✓	2	Accept "e" for "Q". Allow 1.76×10^{11} if clearly used for $\frac{e}{m_e}$
07.3	use of $\lambda = \frac{h}{mv}$ **OR** $v = 4.17 \times 10^7$ (m s^{-1}) seen ✓ 1.7×10^{-11} (m) or 1.74×10^{-11} (m) ✓	2	$v = 4.19 \times 10^7$ if exact values used Allow 1.8×10^{-11} (m)
07.4	Max 2 from: ✓ ✓ electrons (previously) considered to be particles electrons/particles not expected to diffract only waves (previously) observed to diffract diffraction is a wave property (shows) electron can behave like a wave	2	

07.5	Max 2 from: ✓ ✓	2	
	smaller electron momentum/speed/velocity/energy larger de Broglie wavelength larger diffraction angle		Accept double slit argument

Question	Marking guidance	Mark	Comments
08.1	use of Snell's Law with correct values eg $n=\frac{\sin 30}{\sin 22}$ seen ✓ 1.335 or 1.33 ✓	2	Must see n as subject Accept 1.34. Value required to at least 3 sf.
08.2	refractive index of water is less than refractive index of glass ✓	1	Accept optical density for refractive index
08.3	angle of incidence = $90 - 22$ **OR** $68°$ seen ✓ use of Snell's Law eg $1.3\sin 68 = 1.55\sin\theta$ ✓ angle of refraction (into glass) = $51.0°$ ✓	3	Allow use of their 08.1 (1.335 gives 53.0°)
08.4	critical angle (glass–air) = $\sin^{-1}\left(\frac{1.00}{1.55}\right)$ ✓ critical angle = 40.2 (degrees) ✓ laser beam totally internally reflects, from some relevant rationale ✓	3	ecf from 08.3
08.5	sensible safety suggestion eg beam aimed away from students; reflections from water/glass ✓	1	Don't allow "wear goggles"

Question	Marking guidance	Mark	Comments
09.1	Max 3 from: ✓ ✓ ✓ all oscillate with same amplitude X and Y oscillate with same phase/time period/frequency Z oscillates with longer time period/lower frequency (than X and/or Y) $T_Z = \sqrt{2}T_X$ (or $\sqrt{2}T_Y$) **OR** calculations of T_Z, and T_X or T_Y	3	Ignore reference to damping 4th marking point implies 3rd marking point ie 2 marks for $T_Z = \sqrt{2}T_X$ (or $\sqrt{2}T_Y$) **OR** correct calculations of T_Z, and T_X or T_Y. (Allow equivalent versions for f.) Reference to all three pendulums required for 3 marks
09.2	Max 2 from: ✓ ✓ fewer oscillations (before it stops moving) oscillations at same frequency/time period (as undamped pendulum) height/energy/amplitude reduced (more rapidly)	2	
09.3	use of $T = 2\pi\sqrt{\frac{l}{g}}$ **OR** $f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$ **OR** 1.343 (s) seen ✓ 0.745 (Hz) ✓	2	
09.4	decrease the length of the pendulum ✓ by 0.004 m OR to 0.446 m ✓	2	

Question	Marking guidance	Mark	Comments
10.1	to limit the current in the circuit/to protect the battery / to prevent short circuit ✓	1	OWTTE
10.2	both points accurately plotted ✓ error bars correctly shown on all points ✓	2	
10.3	well drawn straight line of best fit ✓	1	
10.4	large triangle drawn or implied and values taken from the line of best fit - more than 8 cm or ΔI $> or = 2$ ✓ answer in the range −0.16 to −0.18 $(\mathrm{V\ A^{-1}})$ ✓	2	 2 or 3 sf with negative sign
10.5	reads their y-intercept (expect within range 7.20 to 7.28) or uses values from line of best fit ✓ answer equal to the <u>magnitude</u> of the gradient found in 10.4 ✓	2	3 sf only. ecf from 10.4. Penalise negative sign.

Question	Marking guidance	Mark	Comments
11.1	conversion of time from microseconds ✓ use of f=1/T ✓ 2.5×10^6 (Hz) ✓	3	Condone power of ten error for 2nd mark
11.2	single pulse drawn at $12.6\ \mu s$ ✓ same frequency **OR** reduced amplitude ✓	2	Allow between 11.8 μs and 13.4 μs Ignore phase. Condone only one cycle drawn.
11.3	reading from graph = $160\ \mu s$ ✓ use of s = vt eg $1540 \times 160 \times 10^{-6}$ **OR** $\frac{s}{2} = vt$ **OR** 0.246 m seen ✓ 0.12 (m) ✓	3	Allow full marks for 156 or $158\ \mu s$

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