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INTERNATIONAL QUALIFICATIONS

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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

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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.

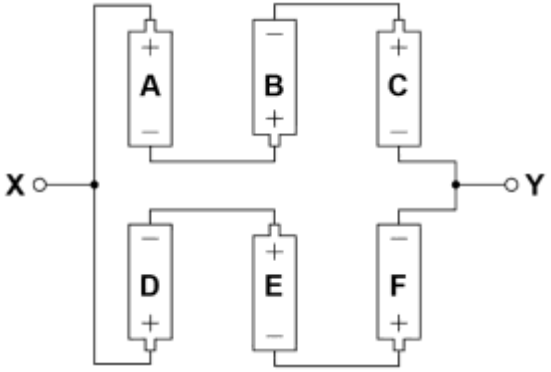
An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01	$T = \frac{60}{39}$ OR f = 39/60 **OR** use of $T = 2\pi\sqrt{\frac{l}{g}}$ or equivalent with their T ✓ 0.59 (m) ✓	39/60 must clearly be a frequency Accept answers that round to 0.588 or 0.589 Reject 0.60	2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02	Any correct energy conversion from eV to J or vice versa ✓ 1.7 (eV) ✓	Expect to see 2.81 eV **OR** 1.76×10^{-19} J	2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Idea that (each) term is a work done per unit charge Idea that the LHS is energy input (per unit charge) by the cell and RHS is work done (per unit charge) in the cell + work done (per unit charge) in the rest of the circuit		2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04	read-off voltage = 0.144 V (correct to half small square) ✓ Use of $R = \frac{V}{I}$ leading to $R = 180$ (Ω) ✓	Do not allow 0.142 V Allow 1 mark total for full calculation done from incorrect V (outside the tolerance)	2	AO3 AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	correct connections drawn ✓	expect:  	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Max 2: ✓✓ • Idea that the three cells D,E,F will run down more quickly or heat up more OR the current **in DEF** will increase • The total emf remains the same • The total **internal** resistance will double (because no current flows in A,B,C) • The current (drawn by the toy/between X and Y) will decrease OR the terminal pd will decrease	For MP2 and MP3, a simple calculation is insufficient. The internal resistance or emf must be compared to the previous one. Eg condone 'r is 0.75 ohm which is larger than before' For MP4, ignore any attempt to quantify Ignore any conclusions about whether the toy will stop 'working'	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Any two of: ✓✓ • total emf (= 4.5 V) • total resistance (= 0.375 Ω) • use of $I = \frac{V}{R}$ 12 (A) ✓		3	AO1 AO2 AO3
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Any two of: ✓✓ • idea that (free) electrons collide with the atoms • (free) electrons transfer energy to the atoms • The atoms go to higher energy levels	Condone throughout for sodium atoms eg 'sodium (orbital) electrons'	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	MP1 Photon energy corresponds to difference between energy levels ✓ Max 2 of: ✓✓ • MP2 Energy levels (within sodium atom) are discrete/fixed/specific/quantised • MP3 Sodium atoms de-excite emitting a photon • MP4 Wavelength is specific/discrete etc since energies are specific and $E = \frac{hc}{\lambda}$	Reject MP2 if candidate implies that photons have energy levels Accept also: idea that the whole spectrum might not be available if limited by the energy/voltage	3	AO2 AO1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Read off largest wavelength = 589.6 nm ✓ Use of $E = \frac{hc}{\lambda}$ ✓ 3.37×10^{-19} (J) ✓	award MP2 for any wavelength in the diagram, condone POT must be at least 3sf for MP3	3	AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	the natural/harmonic frequency of (the air in) the cylinder matches this (driving) frequency (of the loudspeaker) ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Stationary at P, maximum amplitude at Q ✓ Vertical (or parallel to PQ) oscillations at Q ✓	Ignore references to random motion of particles Condone vibrate for oscillate	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	$\lambda = 4(L + x)$ AND $v = f\lambda$ combined without errors in manipulation ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Correct read off from large triangle ✓ Gradient calculated and use of gradient $= \frac{4}{v}$ ✓ leading to 310–320 (m s^{-1}) ✓	Some annotation on the graph must be seen for MP1 Condone POT error for MP1 and MP2 MP2 may be combined into one step do not credit MP3 without any working 2sf or 3sf for MP3	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	Idea that it is the *x*-intercept OR idea that it is the *y*-intercept multiplied by $\frac{v}{4}$ ✓ description of how to determine the x- or *y*-intercept mathematically eg using similar triangles ✓ **Alternative:** Idea of one data point AND gradient/previously-calculated *v* being used ✓ and substituted into the equation $\frac{1}{f} = \frac{4L}{v} + \frac{4x}{v}$ ✓	Reject MP2 for a graphical extrapolation or just simply the word 'extrapolate'	2	AO4
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Spreading of pulse / parts of a pulse take different times to travel through the fibre / pulse broadening ✓ Due to different paths through the optical fibre / due to entering the optical fibre at different angles ✓	MP1 must refer to pulse/signal/information etc. Eg 'different rays take different times' is insufficient for MP1 Zero marks for a description that includes material dispersion or references to different colours	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	use of $v = \frac{c}{n}$ leading to 1.52 ✓	Condone 2sf here	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Use of $\Delta x = v\Delta t$ to find the maximum path difference ✓ Path difference evaluated to at least 3sf, then adds $10\ \text{km}$ to find the longest path to get $12.7\ (\text{km})$ ✓	MP1 requires words or algebra or subject of equation Alternative: Calculates total time ✓ Evaluates total time and then calculates distance of longest path ✓ MP2 depends on MP1	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	(Use of $\cos^{-1}\left(\frac{10.0}{12.7}\right)$ leading to) 38° ✓ ecf from **08.3**		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.5	Correct read-off for the time period (0.8×10^{-4} s) (reject POT error here) **OR** use of $f = \frac{1}{T}$ (condone a read-off for an incorrect time period, eg pulse duration, interval between pulses) ✓ Both correct leading to 1.25×10^{4} (Hz) ✓		2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.6	Read off pulse duration = 0.24×10^{-4} s (reject POT error) OR Add the time delay (13.7×10^{-6} s) to a value of time ✓ 3.8×10^{-5} (s) ✓		2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.7	Idea of broadened pulses overlapping ✓		1	AO2
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Angle is defined as $\frac{\text{arc length}}{\text{radius}}$ ✓	Alternative: (sin θ or tan θ = n $\frac{w}{D}$ and) angle is small so sin θ (or tan θ) is approximately θ	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Direct measurement of separation of at least 5 (angular) fringes with evidence seen on figure ✓ Use of measurement of scale line to determine (angular) fringe width(s) ✓ Use of $\theta_n = \frac{n\lambda}{s}$ ✓ 1.05×10^{-11} to 1.25×10^{-11} (m) (at least 2 sf) ✓	MP1 only awarded when annotation shows measurements taken to centre of fringe. Expect angular fringe separation to be around 2.2×10^{-5} rad Do not allow diffraction grating equation MP3 is rejected if candidate attempts to evaluate a length for either w or D MP4 reliant on MP2 AND 3	4	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	Use of $mv = \frac{h}{\lambda}$ (to find v) ✓ Use of $\frac{1}{2}mv^2 = eV$ ✓ 1.5×10^4 (V) ecf on **09.2** ✓	MP1 and MP2 can be combined Expect to see $V = \frac{h^2}{2\lambda^2 me}$ Expect $1.2\text{-}1.3 \times 10^4$ (V) if prev answer was in range	3	AO2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	(Use of $P = \frac{V^2}{R}$ leading to) 2900 (W) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Power/energy/heat dissipated in nichrome/in the water must be much greater (than power/energy/heat dissipated in copper wires) ✓1 (in series) the voltage is shared in the ratio of resistances ✓2 Voltage must be much higher across the nichrome (than the copper) since $P = IV$ ✓3 **OR** the current is the same in the copper and the nichrome ✓2 $P = I^2R$ so resistance of nichrome must be higher ✓3	Allow 2 marks max for: compares local mains voltage with quoted voltage across nichrome wire ✓ current must be the same in nichrome and cable ✓ If no other mark awarded, allow one mark for to avoid energy/power loss in cable or to reduce overheating in copper cable	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Use of $R = \frac{\rho L}{A}$ **OR** evaluation or correct expression of A ✓ 1.3 (m) ✓ (1.29 m to 3sf)	$A = 8.0 \times 10^{-8}$ m^2 Allow POT error in MP1 Do not allow 1.30m (rounding error)	2	AO2

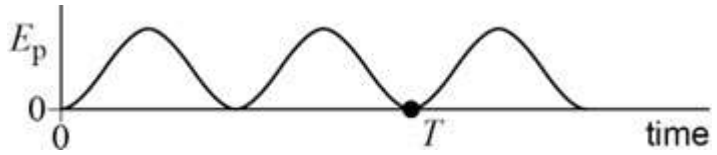
Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Power consumption decreases (for the first $5\ \text{ms}$) then is constant thereafter ✓ Because: R increases as T increases (for the first $5\ \text{ms}$) ✓ V stays the same AND statement of $P = \frac{V^2}{R}$ or equiv ✓	Full marks can be awarded for a correct discussion that takes into account voltage varying slightly due to nichrome:copper potential divider	3	AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	x = 52.3 cm ✓	Accept equivalent answer in m or mm Must be 3sf only	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	1 mm uncertainty leading to 0.2(%) $\frac{0.1\ (\text{cm})}{\text{answer to } \mathbf{11.1}} \times 100$ ✓	Condone 0.19(%) 1 or 2 sf only	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	Any two of: ✓✓ • Use of tanθ = $\frac{x}{2D}$ to determine θ • Use of $d\sin\theta = n\lambda$ with their (sin)θ and their d • Correct expression of d (reject POT error) λ = 648 nm ✓	Ecf on their x For bullet point 1 only, condone sinθ in place of tanθ only if the candidate comments on small angle approximation in words or algebraically Expect 7.45° d = 1.0 x 10^{-5} m	3	AO2 × 2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	Idea that the *x*/angle between bright maxima will increase ✓ Decreases percentage uncertainty in x or θ AND decreases percentage uncertainty in wavelength ✓	Ignore references to grating spacing	2	AO4
Total			**7**	

Question	Key	Answer	AO
12	**D**	$\text{kg m}^3\ \text{s}^{-3}\ \text{A}^{-2}$	AO1
13	**C**	8 V	AO2
14	**C**	0.78 A	AO2
15	**B**	increase | decrease	AO2
16	**A**	2.7%	AO4
17	**B**	1.4%	AO4
18	**B**		AO3
19	**D**	$2K$ | $\frac{1}{H}$	AO1
20	**A**	4.5λ | longitudinal	AO1

21	**B**	457 Hz	AO1
22	**C**	68°	AO1
23	**C**	28°	AO2
24	**A**	$N_X < N_Y$ | $E_X > E_Y$	AO1
25	**D**	$\frac{1}{hc}$	AO1

Total 14 marks