AQA

A-LEVEL
Physics

PHA5/2D – Turning Points in Physics
Mark scheme

2450
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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 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.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1 (a)	(at terminal velocity v), weight of droplet (or mg) = viscous drag (or $6\pi\eta r v$) ✓ $(4\pi r^3/3) \times \rho g = 6\pi\eta r v$ or $r (= (9\eta v / 2\rho g)^{-1/2}$ ✓ $r = \left(\frac{9 \times 1.8 \times 10^{-5} \times 2.1 \times 10^{-4}}{2 \times 860 \times 9.8}\right)^{\frac{1}{2}}$ ✓ $= 1.42(1.41) \times 10^{-6}$ m ✓ **Reverse calculation max 3** viscous force = $6\pi\eta r v = 6 \times 3.24 \times 1.8 \times 10^{-5} \times 1.4 \times 10^{-6} \times 2.1 \times 10^{-4}$ $= 1.0 \times 10^{-13}$(N)✓ weight = $\frac{4}{3}\pi r^3 \rho g = \frac{4}{3} \times 3.14 \times (1.4 \times 10^{-6})^3 \times 860 \times 9.8 = 9.7 \times 10^{-14}$ ✓ so (to 1 sf) weight of droplet (or mg) viscous drag (or $6\pi\eta r v$) (as required for terminal speed) ✓	Note: some evidence of calculation needed to give final mark	4	

Question	Answers	Additional Comments/Guidance	Mark	ID details
1 (b) (i)	electric force (or QV/d) = droplet weight (or *mg*) **OR** correct equation with values✓ $Q = 9.7\times10^{-14} \times \frac{5.5\times10^{-3}}{850}$ ✓ = 6.3 × 10^{-19} C✓ **OR** $Q = \frac{4}{3} \times 3.14 \times (1.42\times10^{-6})^3 \times 860 \times 9.8 \times \frac{5.5\times10^{-3}}{850}$ ✓ = 6.5 x 10^{-19} C✓ [or Q = viscous force × *d* / *V*] 6π × 1.8 × 10^{-5}× 1.4 × 10^{-6}× 2.1 × 10^{-4} × 5.5 × 10^{-3} / 850 ✓ Or 1.0 x 10^{-13} x 5.5 × 10^{-3} / 850 (ecf for viscous force calculated in 1(a)) Q = 6.5 × 10^{-19}C ✓	***Use of e instead of Q or = 2 marks max*** For the 2nd mark, allow use of viscous force calculation. Use of viscous force method does not get 1st mark. If both methods are given and only one method gives Q = ne (where n = integer >1), ignore other method for 2nd mark and 3rd mark. For the final mark, Q must be within *ne* ± 0.2 × 10^{-19} from a correct calculation.	3	
1 (b) (ii)	4 or answer consistent with 1(b)(i) ✓		1	
Total			**8**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2 (a) (i)	Newton's other theories were successful (or Newton was more eminent scientist so Newton's view was accepted) ✓ **alternatives**, Huygens' theory was based on longitudinal waves which cannot explain polarisation **OR** Huygens' theory could not explain sharp shadows	Not just that he was 'well known'	1	
2 (a) (ii)	**EITHER** Newton predicted that light travels faster in glass than in air, Huygens predicted the opposite ✓ the speed of light in water (or glass) was (eventually) found to be less than the speed of light in air ✓ ✓		2	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2 (b)	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear**. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive, coherent and logical explanation which recognises that the pattern is due to interference of light which is a wave property. They should know that at a bright fringe, the waves from the two slits are in phase and therefore reinforce each other and this can happen at positions where the path difference is zero or a whole number of wavelengths. They may not refer to the need for the waves to be coherent. Their answer should be well-presented in terms of spelling, punctuation and grammar. **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides a logical explanation which recognises that interference of light is a wave property. They should know either a bright fringe is where the waves from the two slits are in phase or a dark fringe is where they are out of phase by 180° and be aware there are different positions where these conditions apply. They may know the general condition for the path difference for a bright fringe or a dark fringe although they may not recognise that this condition explains why there are more than two bright fringes. Their answer should be adequately or well-presented in terms of spelling, punctuation and grammar. **Low Level (Poor to limited): 1 or 2 marks**		Max 6	

	The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate recognises that interference of light is a wave property and that the waves from the two slits reinforce at a bright fringe or cancel at a dark fringe. They may confuse path difference and phase difference and their explanation of why there are more than two bright fringes may be vague or absent. Their answer may lack coherence and may contain a significant number of errors in terms of spelling and punctuation. **Incorrect, inappropriate or no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics. **Statements expected in a competent answer should include some of the following marking points.** the pattern is due to interference of light from the two slits interference is a wave property light from the two slits is in phase at a bright fringe and therefore reinforces the path difference (from the central bright fringe to the two slits) is zero **EITHER** bright fringes are formed away from the centre wherever the path difference is a whole number of wavelengths **OR** dark fringes are formed away from the centre wherever the path difference is a whole number of wavelengths + a half wavelength the path difference for the n^{th} bright fringe from the centre is *m* wavelengths where n is any whole number since n is any whole number, more than two bright fringes are observed		

Total		**9**

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3 (a) (i)	work done = eV ✓ E_{Kmax} = work done due to stopping potential = (1.6 × 10^{-19} × 0.38) = 6.1 × 10^{-20} J ✓		1	
3 (a) (ii)	photon energy = $hf = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{560\times10^{-9}}$) ✓ = 3.55 × 10^{-19} J ✓ $\phi = hf - E_{K(max\_)}$ = 3.55 × 10^{-19} – 6.1 × 10^{-20} = 2.9(4) × 10^{-19} J ✓	Sub^{n} condone powers of 10 Allow their photon energy – their 3(a)(i)	3	
3 (b) (i)	work function of Y is greater than that of X PLUS 2 from photons (in each experiment) have the same energy (as in a) ✓ OR energy given to an electron is same Photon energy is insufficient to liberate an electron from Y✓ work function (of Y) is the minimum energy needed by an electron to escape ✓ OR energy to liberate an electron in greater for Y than for X when a (conduction) electron in the metal absorbs a photon, it gains all the energy of the photon ✓		Max 3	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3 (b) (ii)	wave theory predicts that incident light (of any frequency) would cause photoelectric emission (from any metal) ✓ and any **one** of the following points wave theory could not explain why light below a certain frequency (or below a threshold frequency) could not cause photoelectric emission ✓ **OR** this (threshold) frequency is characteristic of the metal (or depends on the metal) ✓ **OR** wave theory could not explain the instantaneous emission of photoelectrons ✓		2	
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4 (a) (i)	inertial frame is stationary or moving at constant velocity ✓ which Newton's law(s) of motion obeyed in inertial reference frames✓ **OR** Same laws of physics are obeyed in all inertial frames of reference.		2	
4 (a) (ii)	speed of light in free space is invarient/independent of motion of source and motion of observer ✓		1	
4 (b) (i)	Attempt to use $m\ (= m_0\ (1 - v^2/c^2)^{-1/2})\ = 9.1 \times 10^{-31} \times (1 - 0.993^2)^{-1/2}$ (kg) ✓ $= 7.7 \times 10^{-30}$ kg ✓	Response implying that m_0 is required answer = 0	2	
4 (b) (ii)	$E\ (= mc^2)\ = 7.7 \times 10^{-30} \times (3.0 \times 10^8)^2$ ✓ $= 6.9 \times 10^{-13}$ J ✓		2	
4 (b) (iii)	$E_K\ (= E - m_0c^2)\ =\ 6.9 \times 10^{-13} - (9.1 \times 10^{-31} \times (3.0 \times 10^8)^2)$ ✓ $= 6.1 \times 10^{-13}$ J✓		2	
Total			**9**	