Pearson Edexcel

Mark Scheme (Results)

January 2024

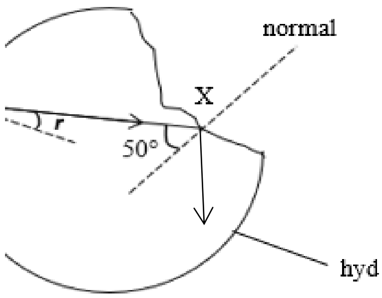
Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH12)
Paper 01: Waves and Electricity

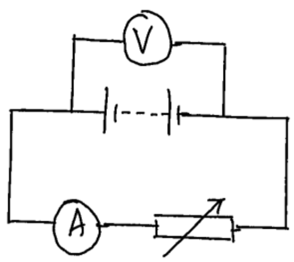
Question Number	Answer
1	**A is the correct answer** B is not correct because the light would refract towards the normal C is not correct because the light moves into a material with a greater refractive index D is not correct because the light would not be transmitted along the normal
2	**C is the correct answer** A is not correct because the number of conduction electrons should increase B is not correct because the number of conduction electrons should increase and the resistance should decrease D is not correct because the resistance should decrease
3	**A is the correct answer** B is not correct because this would give the momentum of the electron C is not correct because this gives $\frac{1}{\text{velocity}}$ D is not correct because this would give $\frac{1}{\text{momentum}}$ for the electron
4	**C is the correct answer** A is not correct because this describes an energy of 1 J B is not correct because this describes a current of 1 A D is not correct because this describes a charge of 1 C
5	**D is the correct answer** A is not correct because 0.15 (A) is the current in the 10 Ω resistor. B is not correct because 0.50 V is the potential difference across the 5 Ω resistor when the switch is open. C is not correct because 1.00 V is the potential difference across the 10 Ω resistor when the switch is open.
6	**C is the correct answer** A is not correct because the line should start at the origin. B is not correct because the line should start at the origin and should not cross the x-axis D is not correct because the gradient should be positive
7	**D is the correct answer** A is not correct because this gives the time period of the wave. B is not correct because this gives half the time period of the wave. C is not correct because the denominator is half the time period.

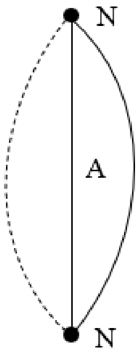
8	**B is the correct answer** A is not correct because doubling *d* causes the area over which the light is spread out to quadruple C is not correct because doubling *d* causes the area to quadruple and *I* already takes into account the area of the sphere over which the light is spread out D is not correct because *I* already takes into account the area of the sphere over which the light is spread out	1
9	**C is the correct answer** A is not correct because 180° - 90° is 90° B is not correct because 270° - 180° is 90° D is not correct because 270° - 360° is -90°	1
10	**B is the correct answer** A is not correct because E_1 should be added to the energy of the photon. C is not correct because the speed of light should be part of the numerator and wavelength should be the denominator and E_1 should be added to the energy of the photon. D is not correct because the speed of light should be part of the numerator and wavelength should be the denominator.	1

Question Number	Answer		Mark
11(a)	There is a constant phase relationship/difference	**(1)**	1
11(b)	(Reflected light) interferes / superposes (with the light from the laser)	**(1)**	1
	Total for question 11		**2**

Question Number	Answer		Mark
12	Use of $R = \frac{V}{I}$ Use of $I = \frac{\Delta Q}{\Delta t}$ Time taken = 4.2 s **Or** Use of $P = \frac{V^2}{R}$ Use of $P = \frac{W}{t}$ **and** $V = \frac{W}{Q}$ Time taken = 4.2 s <u>Example calculation</u> $I = \frac{8.9\text{ V}}{7.5\ \Omega} = 1.19\text{ A}$ $\Delta t = \frac{5.0\text{ C}}{1.19\text{ A}} = 4.20\text{ s}$	(1) (1) (1) (1) (1) (1)	3
	Total for question 12		**3**

Question Number	Answer		Mark
13(a)	There is little /no refraction **Or** There will be little/no change in direction (of light) **Or** Incident angle ≈ refracted angle **Or** Light (from observers side) is (transmitted and) not reflected Because there is only a small change in the speed/no change in speed of light (at the boundary between water and the hydro-beads)	(1) (1)	2
13(b)(i)	Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ $r = 29°$ <u>Example of calculation</u> $1 \times \sin(42°) = 1.38 \sin(r)$ $r = \sin^{-1}\left(\frac{\sin(42°)}{1.38}\right) = 29°$	(1) (1)	2
13(b)(ii)	**EITHER** Use of $\sin C = \frac{1}{n}$ $C = 46(°)$ Total internal reflection shown on diagram (dependent on MP2) **OR** Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\sin\theta = 1.06$ (which is > 1) Total internal reflection shown on diagram (dependent on MP2) <u>Example of calculation</u> $\sin(C) = \frac{1}{1.38}$ $C = \sin^{-1}\left(\frac{1}{1.38}\right) = 46.4°$  	(1) (1) (1) (1) (1) (1)	3

	Total for question 13	7
Question Number	**Answer**	**Mark**
14(a)	There was no current (in the battery) **(1)** So there was no potential difference across the internal resistance **(1)**	**2**
14(b)	Voltmeter connected across battery **and** ammeter in series with battery **(1)** Variable resistor in series with battery **Or** potential divider **(1)** <u>Example of circuit</u> 	**2**
14(c)(i)	e.m.f. = 8.8 V **(1)** Calculates gradient of graph **(1)** Internal resistance = 2.2 to 2.4 Ω **(1)** <u>Example of calculation</u> $r = \frac{(8.8-0)\text{ V}}{(3.8-0)\text{ A}} = 2.3\ \Omega$	**3**
14(c)(ii)	As the current (in the battery) increases, the potential difference across the internal resistance increases **(1)** Until the p.d. across the internal resistance equals the e.m.f. (and current can no longer increase) **(1)**	**2**
	Total for question 14	**9**

Question Number	Answer		Mark
15(a)	Oscillations / vibrations are perpendicular to the direction of energy transfer **Or** Oscillations / vibrations are perpendicular to the direction of wave travel (allow propagation for wave travel)	**(1)**	**1**
15(b)	Shape of wave correct Node labelled at each end and antinode labelled in the middle (MP2 dependent on MP1) Example of diagram  	**(1)** **(1)**	**2**
15(c)	Use of $v = f\lambda$ Use of $v = \sqrt{\frac{T}{\mu}}$ Use of $\mu = \frac{m}{l}$ [with l = 1.5 m] Mass of string = 3.1 (g), so string B [Allow reverse working for full marks] Example of calculation v = 196 Hz × 0.72 m = 141 m s^{-1} $\mu = \frac{41\text{ N}}{(141\text{ m s}^{-1})^2} = 2.06 \times 10^{-3}\text{ kg m}^{-1}$ m = 1.5 m × 2.06×10^{-3} kg m^{-1} = 3.09×10^{-3} kg	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 15		**7**

Question Number	Answer		Mark
16(a)	Use of $A = \pi r^2$	**(1)**	
	Use of $R = \frac{\rho l}{A}$	**(1)**	
	l = 63 m	**(1)**	**3**
	<u>Example calculation</u> $A = \pi \times \left(\frac{12 \times 10^{-3}\ \text{m}}{2}\right)^2 = 1.13 \times 10^{-4}\ \text{m}^2$ $l = \frac{0.078\ \Omega \times 1.13 \times 10^{-4}\ \text{m}^2}{1.4 \times 10^{-7}\ \Omega\ \text{m}} = 63.0\ \text{m}$		
16(b)	Use of $W = VIt$	**(1)**	
	$W = 1.3 \times 10^8$ J	**(1)**	
	Or **c** Use of $I = \frac{\Delta Q}{\Delta t}$ **and** $V = \frac{W}{Q}$	**(1)**	
	$W = 1.3 \times 10^8$ J	**(1)**	
	Or Use of $P = VI$ **and** $P = \frac{W}{t}$	**(1)**	
	$W = 1.3 \times 10^8$ J	**(1)**	**2**
	<u>Example calculation</u> $W = 1.5 \times 10^8\ \text{V} \times 1.2 \times 10^4\text{A} \times 70 \times 10^{-6}\text{s} = 1.26 \times 10^8\ \text{J}$		
16(c)	The copper cable has a lower resistance (because length and diameter are the same but copper has a lower resistivity)	**(1)**	
	(With the same p.d.) there is a greater current in the copper cable	**(1)**	
	Since $I = nqvA$, it is not possible to say whether the student is correct **Or** Since $I = nqvA$, the student might be correct	**(1)**	**3**
	Total for question 16		**8**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>17(a)</td><td>Each point on a wavefront is (treated as) a source of (secondary) wavelets (1)

these further wave (let)s interfere / superpose (and the resulting waves predict the shape) (1)</td><td>2</td></tr>
<tr><td>*17(b)</td><td>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
Indicative content
IC1 Waves (from each gap) interfere / superpose

IC2 At position A there is no path / phase difference

IC3 So, there is constructive interference (leading to large amplitude oscillations)

IC4 At position B, the phase difference varies with wavelength

IC5 If there is an odd number of half wavelengths path difference, there is destructive interference leading to small oscillations
Or If the waves are in antiphase there is destructive interference leading to small oscillations

IC6 And if there is a whole number of wavelengths path difference there is constructive interference leading to large oscillations
Or If the waves are in phase there is constructive interference leading to large oscillations</td><td>6</td></tr>
<tr><td></td><td>Total for question 17</td><td>8</td></tr>
</table>

Question Number	Answer	Mark
18(a)(i)	Use of $P = VI$ and $V = IR$ **Or** Use of $P = I^2 R$ and $V = IR$ **(1)** Appropriate algebra to derive $P = \frac{V^2}{R}$ **(1)**	2
18(a)(ii)	**EITHER** Their resistance from graph divided by 4 **(1)** Use of $P = \frac{V^2}{R}$ **(1)** Use of p.d. across battery = 5 × p.d. across R **(1)** p.d. across battery = 9.0 – 9.2 V **(1)** **OR** Their resistance from graph divided by 4 **(1)** Use of $P = I^2 R$ **(1)** Use of $V = I(R + R_t)$ **(1)** p.d. across battery = 9.0 – 9.2 V **(1)** <u>Example calculation</u> Resistance of $R = \frac{35\ \Omega}{4} = 8.75\ \Omega$ $0.38\ \text{W} = \frac{V_\text{R}^2}{8.75\ \Omega}$ $V_\text{R} = \sqrt{0.38\ \text{W} \times 8.75\ \Omega} = 1.82\ \text{V}$ $V_B = 5 \times 1.82\ \text{V} = 9.1\ \text{V}$	4
18(b)(i)	Number of conduction electrons (per unit volume) increases **(1)** So current increases (for the same potential difference and $R = V/I$) **(1)**	2
18(b)(ii)	(Increased temperature caused) increased lattice/atom/ion vibrations (in the thermistor and the wire resistor) **(1)** This caused an increase in collisions between electrons and the lattice/ions/atoms (in the thermistor and the wire resistor) **(1)** So the resistance of the wire resistor increased **(1)** (Because current decreases) total resistance of the circuit must increase **(1)** So the increase in the resistance of the wire resistor must be greater than the decrease in the resistance of the thermistor **(1)**	5
	Total for question 17	**13**

Question Number	Answer		Mark
19(a)	Substitution into $hf = \phi$	**(1)**	
	Use of 1eV = 1.6×10^{-19} J	**(1)**	
	Threshold frequency = 4.5×10^{14} Hz	**(1)**	**3**
	<u>Example calculation</u> $E = 1.86 \text{ eV} \times 1.6 \times 10^{-19} \text{ J eV}^{-1} = 2.98 \times 10^{-19} \text{ J}$ $f = \dfrac{2.98 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ J s}} = 4.49 \times 10^{14} \text{ Hz}$		
19(b)	The number of photons (arriving) each second on the cell is the same	**(1)**	
	(Initially) layer 1 absorbs photons with the greater frequency (of those emitted by the Sun)	**(1)**	
	Photons reaching layer 2 have an energy greater than the work function (of layer 2) **Or** Photons reaching layer 2 have a frequency greater than the threshold frequency (of layer 2)	**(1)**	
	One photon interacts with one electron	**(1)**	
	so, the rate at which electrons are released remains the same	**(1)**	**5**
19(c)	Use of $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$	**(1)**	
	$R_T = 0.40$ (Ω)	**(1)**	
	Use of potential divider equation (to determine p.d. across resistor) **Or** Use of $\varepsilon = I(R+r)$ (to determine current in resistor)	**(1)**	
	Use of power equation to find power (dissipated in resistor)	**(1)**	
	$P = 5.2$ (W) which is less than half of 13 (W) so the suggestion is correct	**(1)**	**5**
	<u>Example calculation</u> $R_{\text{internal}} = \dfrac{1}{\dfrac{1}{0.80\ \Omega} + \dfrac{1}{0.8\ \Omega}} = 0.40\ \Omega$ $V = \dfrac{5.0 \text{ V} \times 4.0\ \Omega}{4.0\ \Omega + 0.4\ \Omega} = 4.55 \text{ V}$ $I = \dfrac{5.0 \text{ V}}{4.0\ \Omega + 0.40\ \Omega} = 1.14 \text{ A}$ $P = 4.55 \text{ V} \times 1.14 \text{ A} = 5.19 \text{ W}$		
	Total for question 19		**13**