Pearson Edexcel

Mark Scheme (Results)

June 2024

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

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question Number	Answer	Mark
1	**B is the correct answer** A is not correct the resistance of a metal increases with temperature C is not correct because resistance of a thermistor decreases with temperature and resistance of a metal increases with temperature D is not correct because resistance of a thermistor decreases with temperature	**1**
2	**D is the correct answer** A is not correct because the potential difference should not be halved and 3.3 V should be subtracted from 10 V B is not correct because the potential difference across R_1 is not the same as that across the voltmeter C is not correct because the potential difference should not be halved	**1**
3	**B is the correct answer** A is not correct because 1.33 should multiply the sin of the refracted angle in water C is not correct because the equation is inverted D is not correct because the equation is inverted and 1.33 should multiply the sin of the refracted angle in water	**1**
4	**C is the correct answer** A is not correct because attraction between opposite charges is not evidence of wave behaviour B is not correct because the electrons are behaving as particles D is not correct because the electrons are behaving as particles	**1**
5	**C is the correct answer** A is not correct because the p.d. across r should be added to the p.d. across the 6 Ω resistor B is not correct because there is a potential difference across r D is not correct because the current in r is $\frac{1.2}{6}$ A	**1**
6	**C is the correct answer** A is not correct because photoelectrons would have no kinetic energy at threshold frequency. B is not correct because this describes light emitted in an emission spectrum rather than light absorbed in the photoelectric effect. D is not correct because the frequency is not a maximum, and the electron should leave the surface rather than becoming excited.	**1**
7	**D is the correct answer** A is not correct because 6 Ω is not connected in parallel B is not correct because the resistance of the parallel section is inverted C is not correct because the 2 Ω and 3 Ω resistors are in series	**1**

8	**C is the correct answer** A is not correct because mass per unit length should not change so the denominator should be 1 B is not correct because mass per unit length should not change so the denominator should be 1 D is not correct because velocity should be proportional to the square root of tension	1
9	**A is the correct answer** B is not correct because current in R = current in 4.7 Ω resistor – 0.13 C is not correct because current in 4.7 Ω resistor $= \frac{1.4\text{ V}}{4.7\ \Omega}$ D is not correct because current in 4.7 Ω resistor $= \frac{1.4\text{ V}}{4.7\ \Omega}$ and current in R = current in 4.7 Ω resistor – 0.13	1
10	**B is the correct answer** A is not correct because gradient $= \frac{1}{hc}$ C is not correct because gradient $= \frac{1}{hc}$ D is not correct because gradient $= \frac{1}{hc}$	1

Question Number	Answer	Mark
11	Light emitted from the mobile phone screen is polarised **(1)** When the phone is rotated, the plane of polarisation of the light and the plane of polarisation of the polarising (filter in the) sunglasses are perpendicular **(1)** (when the phone is rotated) the sunglasses / polarising filter absorb the light **(1)**	3
	Total for question 11	**3**

Question Number	Answer	Mark
12(a)	Violet light has the shortest wavelength (in the visible spectrum) **Or** Violet light has a shorter wavelength than red light **(1)** So needs a shorter path difference to give constructive interference **Or** So $d\sin(\theta)$ for violet light takes a smaller value, and therefore θ must be smaller **(1)** **Or** $\lambda = d\sin(\theta)$ so $\sin(\theta)$ is smaller	**2**
12(b)	Use of $n\lambda = d\sin(\theta)$ **(1)** $\lambda = 3.9 \times 10^{-7}$ m **(1)** <u>Example of calculation</u> $\lambda = 1.62 \times 10^{-6}\,\mathrm{m} \times \sin(14°) = 3.919 \times 10^{-7}\mathrm{m}$	**2**
	Total for question 12	**4**

Question Number	Answer	Mark
13(a)	Use of $v = \frac{s}{t}$ **(1)** Halves distance or doubles time **(1)** Distance = 28 m **(1)** <u>Example of calculation</u> $s = 1500\ \text{m s}^{-1} \times 37 \times 10^{-3}\ \text{s} = 55.5\ \text{m}$ $\frac{55.5\ \text{m}}{2} = 27.8\ \text{m}$	**3**
13(b)	An echo must return to the transducer before the next pulse is transmitted **Or** T (should be) > time for the echo to return **(1)** So if *T* increases, the maximum distance increases **(1)**	**2**
13(c)	Higher frequency sound waves lead to smaller wavelength **(1)** This gives better resolution (dependent on MP1) **(1)** **Or** Higher frequency sound waves will diffract less	**2**
	Total for question 13	**7**

Question Number	Answer		Mark
14(a)(i)	The resistance of a sample of the material of unit cross sectional area and unit length **Or** $\rho = \frac{RA}{l}$ with terms defined	**(1)**	**1**
14(a)(ii)	Measure the L using a metre rule	**(1)**	
	Measure the thickness of the material using a micrometer **Or** Measure the thickness of the material using vernier callipers	**(1)**	
	Use an ammeter and voltmeter to determine the resistance using $R = \frac{V}{I}$ **Or** Use an ohmmeter to measure the resistance of the sample	**(1)**	
	Use $\rho = \frac{RA}{l}$ to determine the resistivity **Or** valid description of a graph and gradient calculation to determine the resistivity	**(1)**	**4**
14(b)	Copper has a high concentration of charge carriers	**(1)**	
	$I = nAvq$ so (for a given current) drift velocity is small	**(1)**	**2**
14(c)	The same potential difference is applied across each additional panel	**(1)**	
	So each panel dissipates the same power, and power output of the system increases	**(1)**	
	OR		
	As more panels are connected, the resistance (of the system) decreases (and potential difference remains the same)	**(1)**	
	And $P = \frac{V^2}{R}$ so power output of the system increases	**(1)**	
	OR		
	As more panels are connected, the current in the power supply increases (and potential difference across each panel is the same)	**(1)**	
	And $P = VI$ so power output of the system increases	**(1)**	
	OR		
	As more panels are connected, the current in the power supply increases and the resistance of the system decreases by the same factor	**(1)**	
	And $P = I^2R$ so power output of the system increases	**(1)**	**2**

14(d)	Use of A = length × thickness **(1)** Use of $\rho = \frac{RA}{l}$ **(1)** Use of $R_{\text{total}} = \frac{R_{1\text{ panel}}}{5}$ **(1)** Use of $P = \frac{V^2}{R}$ **(1)** 680 W is greater than 350 W so the system is not safe **(1)** **OR** Use of A = length × thickness **(1)** Use of $\rho = \frac{RA}{l}$ **(1)** Use of $P = \frac{V^2}{R}$ **(1)** Use of $P_{\text{total}} = 5 \times P_{1\text{ panel}}$ **(1)** 680 W is greater than 350 W so the system is not safe **(1)** <u>Example of calculation</u> $A = 1.60\text{ m} \times 0.48 \times 10^{-3}\text{ m} = 7.68 \times 10^{-4}\text{ m}^2$ $R = \frac{6.4 \times 10^{-3}\ \Omega\text{ m} \times 0.51\text{ m}}{7.68 \times 10^{-4}\text{ m}^2} = 4.25\ \Omega$ $R_{\text{total}} = \frac{4.25\ \Omega}{5} = 0.85\ \Omega$ $P = \frac{(24\text{ V})^2}{0.85\ \Omega} = 678\text{ W}$	**5**
	Total for question 14	**14**

Question Number	Answer	Mark
15(a)	Uses at least 3 waves to determine *T* **(1)** Use of *f* = 1/*T* **(1)** *f* = in range 375 to 425 Hz **(1)** Example of calculation $T = \frac{5 \times 1.5 \times 10^{-3}\ \text{s}}{3} = 2.5 \times 10^{-3}\ \text{s}$ $f = \frac{1}{2.5 \times 10^{-3}\ \text{s}} = 400\ \text{Hz}$	**3**
15(b)	Wavelength of wave 1 is three times the wavelength of wave 2 **(1)** **or** Wavelength of 4λ seen for wave 1 and $\frac{4}{3}\lambda$ seen for wave 2 So frequency of wave 1 is a third the frequency of wave 2 **(1)** Because the speed of sound is constant and $v = f\lambda$ **(1)**	**3**
15(c)	Draws line of best fit and calculates gradient **(1)** *v* = in the range $320\ to\ 345$ m s^{-1} **(1)** Example of calculation $v = \frac{0.48\ \text{m} - 0.33\ \text{m}}{1.5 \times 10^{-3}\text{Hz}^{-1} - 1.05 \times 10^{-3}\text{Hz}^{-1}} = 333\ \text{m s}^{-1}$	**2**
15(d)	Use of $v = f\lambda$ **(1)** Use of $\lambda = 4 \times L$ **(1)** *f* = 300 Hz **(1)** Example of calculation $\lambda = 4 \times 0.282\ \text{m} = 1.13\ \text{m}$ $f = \frac{340\ \text{m s}^{-1}}{1.13\ \text{m}} = 301\ \text{Hz}$	**3**
	Total for question 15	**11**

Question Number	Answer	Mark
16(a)	The resistance of the LDR increases,(so the current decreases) **Or** The resistance of the LDR increases, so the LDR has a greater p.d. **(1)** So the p.d. across the fixed resistor decreases (dependent on MP1) **(1)**	**2**
16(b)	Use of $V = IR$ **(1)** Use of $R_{\mathrm{LDR}}: R_{\mathrm{resistor}} = 3:2$ **(1)** $R_{\mathrm{LDR}} = 33\ \Omega$ **(1)** **OR** Use of $V_{\mathrm{LDR}}: V_{\mathrm{resistor}} = 3:2$ **(1)** Use of $V = IR$ **(1)** $R_{\mathrm{LDR}} = 33\ \Omega$ **(1)** <u>Example of calculation</u> $R_{\mathrm{resistor}} = \frac{0.62\ \mathrm{V}}{28 \times 10^{-3}\ \mathrm{A}} = 22.1\ \Omega$ $R_{\mathrm{LDR}} = 22.1\ \Omega \times \frac{3}{2} = 33.2\ \Omega$ **OR** $0.62\ \mathrm{V} \times \frac{3}{2} = 0.93\ \mathrm{V}$ $R_{\mathrm{LDR}} = \frac{0.93\ \mathrm{V}}{28 \times 10^{-3}\ \mathrm{A}} = 33\ \Omega$	**3**
	Total for question 16	**5**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>17(a)(i)</td><td>
Use of $E = hf$ (1)
$f = 5.19 \times 10^{14}$ Hz (1)
<u>Example of calculation</u>
$$f = \frac{3.44 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J s}} = 5.189 \times 10^{14}\ \text{Hz}$$
</td><td>2</td></tr>
<tr><td>*17(a)(ii)</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>
IC1 The potential difference causes a current in the gas / tube
IC2 So energy is transferred to the gas atoms
IC3 Electron/atom gains (sufficient) energy to move up energy levels
IC4 An (excited) electron (is unstable and) falls back down emitting a photon
IC5 With a wavelength/frequency corresponding to the difference in the energy levels Or reference to $E = hf$ or $E \propto f$
IC6 Electrons/atoms exist in discrete/fixed/certain energy levels so only certain frequencies / wavelengths are emitted
</td><td>6</td></tr>
</table>

17(b)(i)	Use of 1 eV = 1.6×10^{-19} J **(1)** Use of $hf = \phi + \frac{1}{2}mv_{\text{max}}^2$ **(1)** $v_{\text{max}} = 5.34 \times 10^5$ m s^{-1} **(1)** <u>Example of calculation</u> $4.75 \text{ eV} \times 1.6 \times 10^{-19} \text{ J eV}^{-1} = 7.6 \times 10^{-19} \text{ J}$ $7.6 \times 10^{-19}\text{J} = 6.3 \times 10^{-19}\text{J} + \frac{1}{2} \times 9.11 \times 10^{-31}\text{kg} \times v_{\text{max}}^2$ $v_{\text{max}} = 534\,000 \text{ m s}^{-1}$	3
17(b)(ii)	Use of $p = mv$ and $\lambda = \frac{h}{p}$ **(1)** $\lambda = 1.4 \times 10^{-9}$ m **(1)** <u>Example of calculation</u> $\lambda = \frac{6.63 \times 10^{-34} \text{ J s}}{9.11 \times 10^{-31}\text{kg} \times 5.3 \times 10^5 \text{ m s}^{-1}} = 1.37 \times 10^{-9}\text{m}$	2
	Total for question 17	**13**

Question Number	Answer		Mark
18(a)	Light slows down when it enters the glass This is because light has a greater density / refractive index than air	**(1)** **(1)**	**2**
18(b)	Angle of incidence = 37° Use of $\sin C = \frac{1}{n}$ C = 41° 37° < 41(°) so total internal reflection will not take place and the surface must be silvered <u>Example of calculation</u> Angle of incidence = 90° – 53° = 37° $C = \sin^{-1}\left(\frac{1}{1.52}\right) = 41.1°$	**(1)** **(1)** **(1)** **(1)**	**4**
18(c)(i)	Intensity is the energy per second per metre squared **Or** Intensity is the power per metre squared **Or** $I = \frac{P}{A}$ with terms defined The energy of each photon is not known	**(1)** **(1)**	**2**
18(c)(ii)	Use of $v = f\lambda$ Use of $E = hf$ Determines number of photons per second arriving at sensor Determines number of electrons passing a point each second in the circuit 83 - 88% of photons detected <u>Example of calculation</u> $E = \frac{6.63 \times 10^{-34}\text{ J s} \times 3 \times 10^{8}\text{m s}^{-1}}{600 \times 10^{-9}\text{ m}} = 3.3 \times 10^{-19}\text{ J}$ $\text{no. of photons incident on sensor} = \frac{1.0\text{ W}}{3.3 \times 10^{-19}\text{ J}} = 3.0 \times 10^{18}\text{ s}^{-1}$ $\text{no. of electrons} = \frac{0.41\text{ A}}{1.6 \times 10^{-19}\text{ C}} = 2.6 \times 10^{18}\text{ s}^{-1}$ $\frac{2.6 \times 10^{18}\text{ s}^{-1}}{3.0 \times 10^{18}\text{ s}^{-1}} \times 100\% = 87\%$	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 18		**13**

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