Mark Scheme (Results)

January 2022

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

Question Number	Answer	Mark
1	**C is the correct answer as $V = W/Q$** A is not the correct answer as volts are not equivalent to energy/time B is not the correct answer as volts are not equivalent to power/time D is not the correct answer as volts are not equivalent to power/charge	**(1)**
2	**A is the correct answer as $v = h/m\lambda$** B is not the correct answer as v is not = $h/q\lambda$ C is not the correct answer as v is not = $m\lambda/h$ D is not the correct answer as v is not = $q\lambda/h$	**(1)**
3	**D is the correct answer as the sum of e.m.f. = the sum of p.d.** A is not the correct answer as this does not include the p.d. across R_2 B is not the correct answer as this does not include the p.d..across R_2 C is not the correct answer as this does not include the p.d. across R_1	**(1)**
4	**B is the correct answer as a thermistor is a semiconductor** A is not the correct answer as this would occur when temperature decreases C is not the correct answer as this would occur when temperature decreases D is not the correct answer as this, although it does occur, has a lesser effect than the release of more conduction electrons	**(1)**
5	**B is the correct answer as the light bends towards the normal when travelling from L to M (so $v_L > v_M$) but bends away from the normal when travelling from M to N, but there is not as much of a change of direction as there was from L to M.** A is not the correct answer as light bends away from the normal travelling from M to N so v_N must be greater than v_M C is not the correct answer as light bends towards the normal travelling from L to M so v_L must be greater than v_M D is not the correct answer as light bends away from the normal travelling from M to N, so v_N must be greater than v_M	**(1)**
6	**C is the correct answer as light travels faster in L than in M** A is not the correct answer as light travels faster in L than in M B is not the correct answer as light travels faster in L than in N D is not the correct answer as light travels faster in N than in M	**(1)**
7	**D is the correct answer as X and Z are in two adjacent node to node sections, which will always be in antiphase with each other** A is not the correct answer as W and X are between the same pair of nodes, between which all points are in phase B is not the correct answer as W and Y are in two adjacent node to node sections, which will always be in antiphase with each other C is not the correct answer as X and Y are in two adjacent node to node sections, which will always be in antiphase with each other	**(1)**
8	**A is the correct answer as the graph shown is a V-I graph for a diode** B is not the correct answer as the graph is not that for a filament lamp C is not the correct answer as the graph is not that for an ohmic conductor D is not the correct answer as the graph is not that for a thermistor	**(1)**

9	**B is the correct answer as λ/8 is one eighth of a full wave cycle, and so is π/4 radians** A is not the correct answer as this is equivalent to a path difference of λ/4 C is not the correct answer as this is equivalent to a path difference of λ/16 D is not the correct answer as this is equivalent to a path difference of λ/32	**(1)**
10	**C is the correct answer as power for the whole circuit = $\varepsilon \times I$ and I increases whilst e.m.f. remains the same** A is not the correct answer as increased intensity increases the number of conduction electrons released by the LDR B is not the correct answer as the potential difference across the LDR will decrease, causing the potential difference across the resistor to increase D is not the correct answer as the resistance of an LDR decreases as light intensity increases	**(1)**

Question Number	Answer		Mark
11a	Use of $R = \rho l/A$ $\rho = 1.1 \times 10^{-6}\ \Omega\text{m}$ <u>Example of calculation</u> $\rho = \dfrac{RA}{l} = \dfrac{(2.0\ \Omega)\ (2.5 \times 10^{-7}\text{m}^2)}{0.45\ \text{m}} = 1.11 \times 10^{-6}\ \Omega\text{m}$	(1) (1)	**2**
11b	Use of $R = V/I$ Use of $I = nqvA$ $v = 4.2 \times 10^{-4}\ \text{m s}^{-1}$ <u>Example of calculation</u> $I = V/R = (3.0\ \text{V}) / 2.0\ \Omega) = 1.5\text{A}$ $v = \dfrac{I}{nqA} = \dfrac{1.5\ \text{A}}{(9.0 \times 10^{28}\ \text{m}^{-3})(1.60 \times 10^{-19}\ \text{C})\ (2.5 \times 10^{-7}\text{m}^2)}$ $= 4.17 \times 10^{-4}\ \text{m s}^{-1}$	(1) (1) (1)	**3**
11c	Halving length halves resistance Which doubles the current I = nqvA related to drift velocity doubling (so suggestion is correct)	(1) (1) (1)	**3**
	Total for question 11		**8**

Question Number	Answer	Mark
12a	**Either** Ultrasound is (partially) reflected (from boundaries) (1) (Measure) the time taken or time delay (for signal to return) (1) Calculate expected time for pulse to return (if no air gap) **Or** Compare to known time for pulse to return (1) If time for pulse to return < time calculated, air gap is present (1) **Or** Ultrasound is (partially) reflected (from boundaries) (1) (Measure) the time taken or time delay (for signal to return) (1) Calculate distance for pulse to travel (1) If distance pulse returns from < thickness of RSJ, air gap is present **Or** If distance pulse returns from = thickness of RSJ, no air gap (1)	**4**
12b	(Higher frequency) gives smaller wavelength (1) (Smaller wavelength leads to) high level of detail/resolution (1) (Smaller wavelength) can detect small(er) objects/gaps **Or** (With 20kHz) the detail would not be sufficient to identify air gaps **Or** (With 20kHz,) air gaps might be smaller than the wavelength (1)	**3**
	Total for question 12	**7**

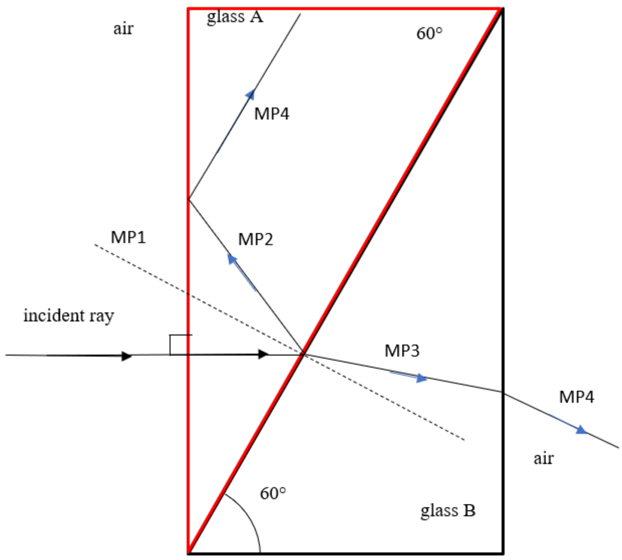
<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*13</td><td>
This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured 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

Photon energy is related to frequency
One to one interaction between photons and electrons
A minimum energy/frequency is required (for electron release)
Release of electrons is instantaneous
Frequency affects the kinetic energy of the (released) electrons
Intensity affects the number of electrons (per second)

</td><td>6</td></tr>
<tr><td></td><td>Total for question 13</td><td>6</td></tr>
</table>

Question Number	Answer		Mark
14a	Calculates θ (using tan)	(1)	
	Calculates d using $\frac{1}{\text{number of lines per m}}$	(1)	
	Use of $n\lambda = d\sin\theta$	(1)	
	$\lambda = 6.3 \times 10^{-7}$ m	(1)	**4**
	<u>Example of calculation</u> $\tan\theta = \frac{0.500\text{ m}}{1.690\text{ m}}$, therefore $\theta = 16.5°$ $d = \frac{1}{450{,}000} = 2.22 \times 10^{-6}$ m. $\lambda = \frac{d\sin\theta}{n} = \frac{(2.22 \times 10^{-6}\text{m})(\sin 16.5°)}{(1)} = 6.31 \times 10^{-7}$ m		
14b	(Waves from the different slits meet and) superposition/interference takes place	(1)	
	(Bright dots are where) waves are in phase	(1)	
	(Superposition/interference) is constructive	(1)	**3**
14c	White dot at O	(1)	
	Spectra seen (either side of O)	(1)	**2**
	Total for question 14		**9**

Question Number	Answer	Mark
15a	Difficult to judge/measure the exact position of node **Or** Ruler is not close to the string (so there might be parallax error) (1)	**1**
15bi	Calculates gradient by best fit or plotted points from graph (1) Recognises distance between adjacent nodes = $\lambda/2$ **Or** Recognises that speed of waves on the string = 2 × gradient (1) Use of $v = \sqrt{\frac{T}{\mu}}$ to find T (1) Use of $T = mg$ with g = 9.81 N kg^{-1} (accept $W = mg$) (1) m = 0.21 kg (1) <u>Example of calculation</u> Gradient = $\frac{2.7\ m}{0.080\ s}$ = 33.75 m s^{-1} Speed = 2 × gradient = 67.5 m s^{-1} $v = \sqrt{T/\mu}$, 67.5 $\text{m s}^{-1} = \sqrt{\frac{T}{4.5 \times 10^{-4}\ \text{kg m}^{-1}}}$ T = 2.05 N $m = \frac{W}{g} = \frac{T}{g} = \frac{2.05\text{N}}{9.81\ \text{N kg}^{-1}}$ = 0.209 kg	**5**
15bii	Straight line with shallower gradient drawn, starting from origin (1) Line has a gradient of around 0.7 × line drawn (1) (Graph line if continued to the last value for $1/f$ should be between 1.8 and 2.0m for d).	**2**
	Total for question 15	**8**

Question Number	Answer		Mark
16a	Transverse: vibrations/oscillations are perpendicular to the direction of (wave) travel Longitudinal: vibrations/oscillations are parallel to the direction of (wave) travel	(1) (1)	**2**
16bi	The light is (incident on the boundary) along the normal **Or** The angle of incidence is 0° **Or** The light hits (prism A) at right angles	(1)	**1**
16bii	Normal line correctly drawn at right angles to boundary (by eye) Reflected ray in correct direction from boundary (by eye) Refracted ray in correct direction from boundary (by eye) Correct refraction at the right hand side of the glass block (by eye) **and** either TIR or correct direction refraction at the left hand side (by eye) 	(1) (1) (1) (1)	**4**
16biii	Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ with 30°, 1.40 and 1.55 substituted correctly Angle of refraction = 27° <u>Example of calculation</u> $n_1 \sin \theta_1 = n_2 \sin \theta_2$, so 1.40 (sin 30°) = 1.55 (sin r), r = 26.8°	(1) (1) (1)	**3**
16c	Light (emerging) is polarised Only transverse waves can be polarised	(1) (1)	**2**
	Total for question 16		**12**

Question Number	Answer	Mark
17a	**Either** Uses resistors in parallel formula correctly (1) Adds series resistance (1) Use of $V = IR$ to find whole circuit current (1) Current in the 6.0 Ω resistor = 0.67(A) (1) Use of $Q = It$ (1) 4.2×10^{18} (electrons) (1) **Or** Uses resistors in parallel formula correctly (1) Uses potential divider to calculate V across parallel section (1) Use of $V = IR$ to find current in 6.0 Ω resistor (1) Current in the 6.0 Ω resistor = 0.67(A) (1) Use of $Q = It$ (1) 4.2×10^{18} (electrons) (1) <u>Example of calculation</u> $\frac{1}{Rp} = \frac{1}{3.0\Omega} + \frac{1}{6.0\Omega}$, so $R_{parallel} = 2.0\ \Omega$ Total circuit resistance = 4.0 Ω + 2.0 Ω = 6.0 Ω $I = V / R$ = 12 V / 6.0 Ω = 2.0 A Current in 6.0 Ω resistor is 1/3 of 2.0A = 0.67 A No. of electrons per second = $\frac{\text{current}}{\text{charge per electron}} = \frac{0.67\text{ A}}{1.60 \times 10^{-19}\text{C}}$ $= 4.2 \times 10^{18}$ electrons per second	**6**
17b	(Student is correct that) resistance in circuit/parallel is greater (1) V is the same (1) So if student uses $P = V^2/R$ (1) Power in whole circuit would be less, so student incorrect (1) **Or** (Student is correct that) resistance in circuit/parallel is greater (1) This leads to current being lower (1) So if student used $P = VI$ with same V (1) Power in whole circuit would be less, so student incorrect (1) **Or** (Student is correct that) resistance in circuit/parallel is greater (1) This leads to current being lower (1) Effect of decreasing current > the effect of increasing resistance (1) Power in whole circuit would be less, so student incorrect (1) (MP4 via any method is dependent on awarding MP2 & MP3)	**4**
	Total for question 17	**10**

Question Number	Answer		Mark
18a	Conversion of eV into J Use of $E = hf$ Use of $v = f\lambda$ with $v = 3.00 \times 10^{8}$ ms^{-1} λ = 654 (nm), so light (for this transition) is red <u>Example of calculation</u> 1.9 eV × (1.60 × 10^{-19} JeV^{-1}) = 3.04 × 10^{-19} J $f = \frac{E}{h} = \frac{3.04 \times 10^{-19}\text{ J}}{6.63 \times 10^{-34}\text{Js}} = 4.59 \times 10^{14}$ Hz $\lambda = \frac{v}{f} = \frac{3.00 \times 10^{8}\text{ ms}^{-1}}{4.59 \times 10^{14}\text{ Hz}} = 6.54 \times 10^{-7}$ m	(1) (1) (1) (1)	**4**
18b	Converts 8.60 light years into metres Use of $I = P/A$ Use of $A = 4\pi r^2$ Power of Sirius A = 9.73 × 10^{27} W <u>Example of calculation</u> 8.60 × 365 × 24 × 60 × 60 × (3.00 × 10^{8} ms^{-1}) = 8.14 × 10^{16} m $P = I \times A$ = (1.17 × 10^{-7} Wm^{-2}) (4π) (8.14 × 10^{16} m)^2 = 9.73 × 10^{27} W	(1) (1) (1) (1)	**4**
18c	Atoms have fixed/certain/discrete energy levels **Or** Emitted photons have discrete energy Only certain transitions are possible (in a hydrogen atom) **Or** Some transitions are not possible (in a hydrogen atom) (For MP2, allow "differences in energy (levels)" for "transitions")	(1) (1)	**2**
	Total for question 18		**10**