Mark Scheme (Results)

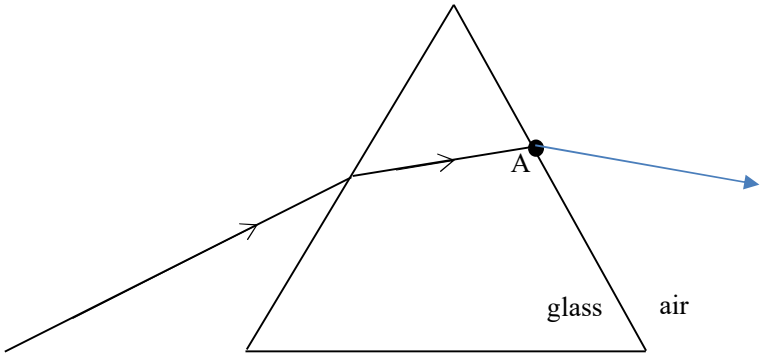
January 2023

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

Question Number	Answer	Mark
1	**C is the correct answer** A is not the correct answer as the *I-V* graph for a diode is not a straight line through the origin. B is not the correct answer as the *I-V* graph for a filament lamp is not a straight line through the origin. D is not the correct answer as the *I-V* graph for a thermistor is not a straight line through the origin.	**(1)**
2	**B is the correct answer** A is not the correct answer as the amplitude decreases C is not the correct answer as the speed decreases D is not the correct answer as the wavelength decreases	**(1)**
3	**A is the correct answer** B is not the correct answer as TIR can only take place when light is travelling from a more optically dense medium to a less optically dense medium. C is not the correct answer as TIR can only take place when light is travelling from a more optically dense medium to a less optically dense medium. D is not the correct answer as TIR can only take place when light is travelling from a more optically dense medium to a less optically dense medium.	**(1)**
4	**A is the correct answer** B is not the correct answer as the distance between the diffraction grating and the screen is not represented by any letter in this equation. C is not the correct answer as this is $1/d$ D is not the correct answer as this is n	**(1)**
5	**C is the correct answer** A is not the correct answer as the time has not been converted from ms to s. B is not the correct answer as the time has not been converted from ms to s, and the given time has not been halved. D is not the correct answer as the given time has not been halved.	**(1)**
6	**A is the correct answer** B is not the correct answer as both the ammeter and voltmeter readings decrease. C is not the correct answer as the voltmeter reading decreases. D is not the correct answer as the ammeter reading decreases.	**(1)**
7	**C is the correct answer as the possible jumps in energy levels are from n=3 to n=-2, n=3 to n=1 and n=2 to n=1.** A is not the correct answer as there is more than one possible energy level jump. B is not the correct answer as there are more than two possible energy level jumps. D is not the correct answer as there are less than four possible energy level jumps.	**(1)**

8	**D is the correct answer as rarefactions are points where the pressure is a minimum.** A is not the correct answer as there is no displacement of the particles at a compression. B is not the correct answer as the pressure is a maximum at a compression. C is not the correct answer as there is no displacement of the particles at a rarefaction.	**(1)**
9	**B is the correct answer as energy transferred = *VQ*** A is not the correct answer as energy transferred does not = *VQt* C is not the correct answer as energy transferred does not = *VQ/t* D is not the correct answer as energy transferred does not = *v/Qt*	**(1)**
10	**C is the correct answer as the distance between adjacent nodes is half a wavelength** A is not the correct answer as all points between two adjacent nodes are in phase. B is not the correct answer as antinodes are points of maximum amplitude. D is not the correct answer as stationary waves have no net transfer of energy.	**(1)**

Question Number	Answer	Mark
11	Use of $\lambda = h/p$ (1) Use of $p = mv$ (1) $m = 9.1 \times 10^{-31}$ (kg), so mass is that of an electron **Or** $m = 9.1 \times 10^{-31}$ (kg), so equals m_e **Or** $m = 9.1 \times 10^{-31}$ (kg), so yes it is (1) (MP3 – Do not allow answers that suggest the calculated mass is less than that of an electron, but allow "similar", "about the same") <u>Example of calculation</u> $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}\ \text{J s}}{7.37 \times 10^{-10}\ \text{m}} = 9.00 \times 10^{-25}\ \text{kg m s}^{-1}$ $m = \frac{p}{v} = \frac{9.00 \times 10^{-25}\ \text{kg m s}^{-1}}{9.89 \times 10^{5}\ \text{m s}^{-1}} = 9.10 \times 10^{-31}\ \text{kg}$	**3**
	Total for question 11	**3**

Question Number	Answer		Mark
12ai	Angle of incidence = 58° **and** angle of refraction = 40° Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ Refractive index of glass = 1.3 (Allow MP2 if angles of 32° and 50° are used) <u>Example of calculation</u> $n_1\sin\theta_1 = n_2\sin\theta_2$ $1.00 \times \sin 58° = n_2 \times \sin 40°$ $n_2 = 1.32$	(1) (1) (1)	**3**
12aii	Ray drawn refracting away from the normal (Normal line does not need to be drawn on diagram)  	(1)	**1**
12b	Use of $n = c/v$ with $c = 3.00 \times 10^8$ ms^{-1} and $n = 1.63$ Speed of light in glass = 1.8×10^8 m s^{-1} <u>Example of calculation</u> $v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m s}^{-1}}{1.63} = 1.84 \times 10^8$ m s^{-1}	(1) (1)	**2**
	Total for question 12		**6**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>13a</td><td>Z has greater (cross sectional) area than W (1)

So Z has smaller resistance than W (1)

Z has greater current than W (1)

Since $I = nAve$, with both A and I 4 × greater in Z, (drift velocity is the same) (1)</td><td>4</td></tr>
<tr><td>13b</td><td>
<table>
<tr><th>Quantity</th><th>Same value for W and Z</th><th>Larger value in W</th><th>Larger value in Z</th></tr>
<tr><td>Current in the wires</td><td>×</td><td></td><td></td></tr>
<tr><td>Resistance of the wires</td><td></td><td>×</td><td></td></tr>
<tr><td>Potential difference across the wires</td><td></td><td>×</td><td></td></tr>
<tr><td>Drift velocity of the charge carriers in the wires</td><td></td><td>×</td><td></td></tr>
</table>
(1)
(1)
(1)
(1)
</td><td>4</td></tr>
<tr><td></td><td>Total for question 13</td><td>8</td></tr>
</table>

Question Number	Answer		Mark
14ai	Use of $\frac{1}{R} = \frac{1}{500\ \Omega} + \frac{1}{600\ \Omega}$ Use of $V = IR$ Voltmeter reading = 6.3 (V) Example of calculation $\frac{1}{R_{\text{parallel}}} = \frac{1}{500\ \Omega} + \frac{1}{600\ \Omega}$, so $R_{\text{parallel}} = 273\ \Omega$ $V = IR = 23.0 \times 10^{-3}\ \text{A} \times 273\ \Omega = 6.28\ \text{V}$	(1) (1) (1)	**3**
14aii	p.d. across thermistor = 12 V – 6.3 V (allow ecf from ai) Use of $P = VI$ (allow use of $P = I^2R$ or $P = V^2 / R$) $P = 0.13$ W Example of calculation p.d. across thermistor = 12.0 V – 6.3 V = 5.7 V $P = VI = 5.7\ \text{V} \times 23 \times 10^{-3}\ \text{A}$ $P = 0.13$ W	(1) (1) (1)	**3**
14b	Resistance (of circuit/thermistor) increases Ammeter reading decreases (dependent on MP1) **Or** Current decreases (dependent on MP1) p.d. across thermistor increases **Or** $V=IR$ for fixed/parallel resistors, and I decreases Reading on voltmeter decreases (dependent on MP3) **Or** p.d. across fixed/parallel resistors decreases (dependent on MP3) (Allow 1 mark maximum if stated that both ammeter and voltmeter readings decrease, and no other marks have been awarded)	(1) (1) (1) (1)	**4**
	Total for question 14		**10**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*15a</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><td>IC points</td><td>IC mark</td><td>Max linkage mark</td><td>Max final mark</td></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><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></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

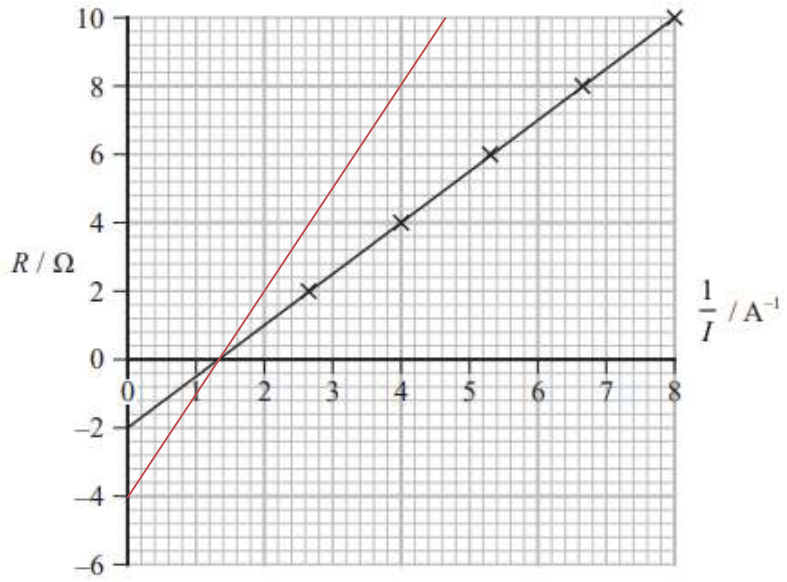
Waves diffract (as they pass through the gaps)
Or Waves spread out (as they pass through the gaps)
At X/loud the waves are in phase
Or at X/loud the path/phase difference is 0
Constructive interference/superposition at X
Or constructive interference/superposition when loud
When moving away (from X), path/phase difference changes
Destructive interference/superposition when no sound is heard
This is where the waves are in antiphase
Or This is where the waves have a path difference of $\lambda/2$

(IC2 – do not accept phase difference of $2n\pi$ or path difference of $n\lambda$)
(IC6 – allow phase difference of 180° or π radians)
(IC6 – do not accept path difference of $(n + ½)\lambda$)
</td><td>6</td></tr>
</table>

15b	Light from two lamps is not coherent (1) as the phase relationship/difference is not constant **Or** coherence requires waves to have a constant phase difference (1) **(**MP2 **-** Allow as wavelength/frequency is not the same **Or** the light is not monochromatic**)**	**2**
	Total for question 15	**8**

Question Number	Answer		Mark
16ai	Use of area = 1.20 (m) × 0.80 (m) Use of $I = P/A$ (needs to be a dimensionally-correct area) Use of efficiency = useful power output / total power input Efficiency = 14 % Example of calculation P of Sun at solar cell = $I \times A$ = 1040 W m^{-2} × 1.20 m × 0.80 m = 998 W Efficiency = $\frac{140\ \text{W}}{998\ \text{W}}$ = 0.14 (14 %)	(1) (1) (1) (1)	**4**
16aii	Any two from: Light from the sun may not be incident on the solar panel at 90° Intensity might be lower due to clouds/rain/fog Light may be reflected at the solar panel Pump may not be 100% efficient Friction between the water and the pipe **Or** Energy transferred to thermal energy	(1) (1) (1) (1)	**2**
16bi	Unpolarised has oscillations/vibrations in all/many planes Plane polarised has oscillations/vibrations in one plane which includes the direction of (wave) travel (MP3 dependent on MP1 or MP2 being awarded) **Or** Unpolarised has oscillations/vibrations in all/many directions Plane polarised has oscillations/vibrations in one direction which is perpendicular to the direction of (wave) travel (MP3 dependent on MP1 or MP2 being awarded)	(1) (1) (1) (1) (1) (1)	**3**
16bii	(Light directed through a) polarising filter No change in intensity as filter is rotated **Or** if it was polarised, the intensity would change as the filter is rotated	(1) (1)	**2**
	Total for question 16		**11**

Question Number	Answer		Mark
17a	Use of sum of e.m.f. = sum of p.d. Correct rearrangement leading to given equation **Or** Total resistance of circuit = $R + r$ Correct rearrangement with total resistance replaced by $\frac{\varepsilon}{I}$ <u>Example of rearrangement</u> $\varepsilon = I(R + r)$, so $\frac{\varepsilon}{I} = R + r$, so $R = \frac{\varepsilon}{I} - r$	(1) (1) (1) (1)	**2**
17b	Gradient calculation (to calculate ε) $\varepsilon = 1.5$ V $r = 2\ \Omega$ **OR** $r = 2\ \Omega$ (read from y-intercept) Use of co-ordinates from the graph with the formula $\varepsilon = 1.5$ V	(1) (1) (1) (1) (1) (1)	**3**
17c	Current (in r/R/circuit) decreases Reference to $P = I^2r$ (Do not allow if R used instead of r) P decreases, so student is correct (MP3 dependent on MP2) **OR** V across r decreases Reference to $P = V^2/r$ (Do not allow if R used instead of r) P decreases, so student is correct (MP3 dependent on MP2) **OR** V across r decreases $P = VI$ **and** current (in r/R/circuit) decreases P decreases, so student is correct (MP3 dependent on MP2) **OR** Current (in r/R/circuit) decreases $P = VI$ **and** p.d. across r decreases P decreases, so student is correct (MP3 dependent on MP2)	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	**3**

17d	Graph is steeper than initial graph and is a straight line (1) Exactly 2 × original gradient (1) y-intercept at −4 Ω (1)  	**3**
	Total for question 17	**11**

Question Number	Answer		Mark
18ai	Use of $E_k = ½ mv^2$ with $m = 9.11 \times 10^{-31}$ kg Conversion of J to eV Energy = 0.35 eV <u>Example of calculation</u> $E_k = ½ \times 9.11 \times 10^{-31}$ kg $\times (3.51 \times 10^5$ m s$^{-1})^2 = 5.60 \times 10^{-20}$ J $E_k = \frac{5.60 \times 10^{-20} \text{ J}}{1.6 \times 10^{-19} \text{ J eV}^{-1}} = 0.35$ eV	(1) (1) (1)	**3**
18aii	Use of $v = f\lambda$ with $v = 3.00 \times 10^8$ m s^{-1} Use of $E = hf$ Use of $hf = \Phi + ½ mv^2_{max}$ $\Phi = 5.86 \times 10^{-19}$ (J), so the metal is magnesium <u>Example of calculation</u> $E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \text{ J s} \times 3.00 \times 10^8 \text{ m s}^{-1}}{310 \times 10^{-9} \text{ m}} = 6.42 \times 10^{-19}$ J $\Phi = hf - ½ mv^2_{max} = 6.42 \times 10^{-19}$ J $- 5.60 \times 10^{-20}$ J $= 5.86 \times 10^{-19}$ J $\Phi = 5.86 \times 10^{-19}$ J	(1) (1) (1) (1)	**4**
18b	Each photon only interacts with one electron Electrons absorb energy from photons **Or** photons transfer energy to electrons Minimum energy required for an electron to be emitted Higher (photon) energy related to higher frequency(, so frequency of radiation has to be above a particular value) (MP3 – allow correct reference to work function) (MP4 – allow reference to E = hf)	(1) (1) (1) (1)	**4**
18c	Any two from: Intensity is related to the number of photons (per second) Intensity is related to the number of (photo)electrons (per second) Intensity does not affect the energy (of the photons/photoelectrons)	 (1) (1) (1)	**2**
	Total for question 18		**13**