Mark Scheme (Results)

October 2024

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

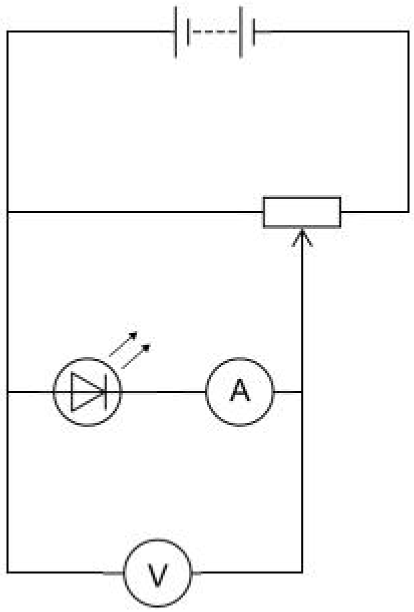
Question Number	**Answer**	**Mark**
1	**B is the correct answer** A is not correct because intensity is power per unit area C is not correct because intensity should be power per unit area on a surface D is not correct because intensity should be power per unit area on a surface	**1**
2	**D is the correct answer** A is not correct because the electrons need to move to lower energy levels and emit photons. B is not correct because the electrons need to move to lower energy levels. C is not correct because the electrons need to emit photons.	**1**
3	**A is the correct answer** B is not correct because the distance should be doubled. C is not correct because the time should be halved. D is not correct because the time should be halved and the expression is inverted.	**1**
4	**B is the correct answer** A is not correct because the 0.7s is not the time period of the wave C is not correct because the 0.4s is not the time period of the wave D is not correct because 0.4 s – 0.1 s is only half the time period of the wave	**1**
5	**D is the correct answer** A is not correct because both the resistance and lattice vibrations should increase. B is not correct because the resistance should increase. C is not correct because the lattice vibrations should increase.	**1**
6	**D is the correct answer** A is not correct because the current should increase and the potential difference should increase. B is not correct because the current should increase. C is not correct because the potential difference should increase.	**1**
7	**B is the correct answer** A is not correct because the de Broglie wavelength would be 4λ. C is not correct because the de Broglie wavelength would be 0.5λ. D is not correct because the de Broglie wavelength would be 0.125λ.	**1**
8	**C is the correct answer** A is not correct because the resistance of the 7 Ω and 18 Ω resistors in parallel is not correct. B is not correct because the resistance of the 7 Ω and 18 Ω resistors in parallel is not correct and there is a short circuit around the 4 Ω resistor. D is not correct because there is a short circuit around the 4 Ω resistor.	**1**

9	**C is the correct answer** A is not correct because this would describe the motion if it was a stationary wave. B is not correct because in a complete time period F and G would then reverse direction again. D is not correct because the wave is travelling to the right, not to the left.	**1**
10	**C is the correct answer** A is not correct because this gives the current. B is not correct because this gives the potential difference across the 20 Ω resistor. D is not correct because this gives 1/power.	**1**

Question Number	Answer	Mark
11	Electrons can behave as waves **(1)** Because the rings show diffraction / interference **(1)**	**2**
	Total for question 11	**2**

Question Number	Answer	Mark
12	The current in each wire is the same **(1)** The (cross-sectional) area of each wire is the same **(1)** Because $I = nqvA$ the (average) velocity of electrons (in the copper wires) is less (than that in the nichrome wire) **(1)**	**3**
	Total for question 12	**3**

Question Number	Answer	Mark
13(a)	Oscillations / vibrations are perpendicular to the <u>direction</u> of energy transfer of the wave **(1)** **Or** Oscillations / vibrations are perpendicular to the <u>direction</u> of wave travel / propagation	**1**
13(b)	The paths are different lengths / distances **(1)** **Or** There is a path difference If the path difference is a whole number of wavelengths **(1)** **Or** path difference = nλ where n is an integer Waves are in phase (so constructive interference occurs) **(1)** **Or** there is a phase difference of 0 (so constructive interference occurs) **Or** there is a phase difference of 2πn where n is an integer	**3**
	Total for question 13	**4**

Question Number	Answer	Mark
14(a)	LED, power supply and ammeter, in series **(1)** (allow diode for LED) Method to vary the potential difference across the LED **(1)** LED connected in forward bias **and** voltmeter connected in parallel with LED **(1)** <u>Example circuit</u> 	**3**
14(b)	Current = 37 (mA) read from graph **(1)** (allow range 36 to 38 mA) Use of $P = VI$ **(1)** Power of LED = 0.0814 W (allow range 0.079 to 0.084 W) **(1)** <u>Example calculation</u> $P = 2.2 \text{ V} \times 37 \times 10^{-3} \text{ A} = 0.0814 \text{ W}$	**3**
14(c)	Between 0 V and 1.6 V the resistance of the LED was (almost) infinite **(1)** (As p.d. increased) above 1.6 V, the resistance of the LED decreased **(1)** Max 1 mark for statement that resistance is initially (almost) infinite and then decreases	**2**
	Total for question 14	**8**

Question Number	Answer		Mark
15(a)	Use of cross-sectional area = width × thickness	**(1)**	
	Use of factor of 6 to determine total length of metal strips **Or** Use a factor of 6 to determine the resistance of one strip	**(1)**	
	Use of $R = \frac{\rho l}{A}$	**(1)**	
	$\rho = 4.8 \times 10^{-7} \Omega \text{ m}$	**(1)**	**4**
	<u>Example calculation</u> $A = 1.40 \times 10^{-3} \text{ m} \times 0.23 \times 10^{-3} \text{ m} = 3.22 \times 10^{-7} \text{ m}^2$ $l_{\text{total}} = 6 \times 18 \times 10^{-3} \text{ m} = 0.108 \text{ m}$ $\rho = \frac{0.16\ \Omega \times 3.22 \times 10^{-7} \text{ m}^2}{0.108 \text{ m}} = 4.77 \times 10^{-7} \Omega \text{ m}$		
15(b)	The cross-sectional area of each metal strip is $\frac{\text{volume}}{l}$	**(1)**	
	So the resistance of each strip is $\frac{\rho l^2}{\text{volume}}$	**(1)**	
	So resistance is proportional to l^2 (which gives a straight line through the origin)	**(1)**	**3**
	Total for question 15		**7**

Question Number	Answer	Mark
16(a)	Direct the laser away from people's eyes Stand behind the laser Avoid directing the laser at reflective surfaces **(1)**	**1**
16(b)	The distance from the central maximum to any other maximum **(1)** **or** the distance between two maxima of the same order The (perpendicular) distance between the diffraction grating and the screen **(1)**	**2**
16(c)(i)	$\theta = 9°$ **(1)** Calculates d **(1)** Use of $n\lambda = d \sin\theta$ **(1)** $\lambda = 630$ (nm) **(1)** Example calculation $\theta = \frac{18°}{2} = 9°$ $d = \frac{10^{-3}\text{ m}}{250} = 4 \times 10^{-6}$ m $\lambda = 4 \times 10^{-6}$ m $\times \sin(9°) = 626$ nm	**4**
16(c)(ii)	Use of $n\lambda = d \sin\theta$ with $\theta = 90°$ **(1)** $n_{\text{max}} = 6$ **(1)** (ecf from (c)(i)) Example calculation $n_{\text{max}} = \frac{4 \times 10^{-6}}{630 \times 10^{-9}} = 6.3$	**2**
	Total for question 16	**9**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>17(a)</td><td>Use of $n = \frac{c}{v}$ (1)

$v = 2.26 \times 10^8 \text{ m s}^{-1}$ (1)

<u>Example calculation</u>
$v = \frac{3.00 \times 10^8 \text{ m s}^{-1}}{1.33} = 2.256 \times 10^8 \text{ m s}^{-1}$</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 The speed of light is less in water (than air)
Or The refractive index of water is greater than the refractive index of air
Or Water is more (optically) dense than air
IC2 So ray A refracts towards the normal (and is incident on the person’s eyes)
IC3 The angle (of incidence) of ray B at the water surface is greater than the critical angle
IC4 So ray B is totally internally reflected (and is incident on the person’s eyes)
IC5 The angle (of incidence) of ray C at the water surface is less than the critical angle
IC6 So (most) light from ray C is transmitted / refracted (into the air so is not incident on the person’s eyes)</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)	Oscillations / waves <u>reflect</u> from (each) end of the cable **(1)** The (reflected) waves interfere / superpose **(1)** A node forms where there is destructive interference **Or** An antinode forms where there is constructive interference **(1)**	**3**
18(b)	Point X has a large / maximum amplitude **(1)** At point X the displacement varies (between maximum displacement and zero displacement) **(1)** At point Y the cable always has zero displacement **(1)** **Or** At point Y the cable is stationary	**3**

18(c)(i)	Calculates mass per unit length	**(1)**	**2**
	μ = 24.1 (kg m^{-1})	**(1)**	
	<u>Example calculation</u> $\mu = \frac{2.10 \times 10^3 \text{ kg}}{87.0 \text{ m}}$ μ = 24.14 kg m^{-1}		
18(c)(ii)	Use of $W = mg$	**(1)**	**6**
	Use of $T = \frac{W}{\text{number of cables}}$	**(1)**	
	Use of $v = \sqrt{\frac{T}{\mu}}$	**(1)**	
	Use of $v = f\lambda$ with λ = 320 m **or** λ = 7 m **Or** Use of $v = f\lambda$ with f = 280 Hz	**(1)**	
	Lowest possible frequency produced by standing wave on longest cable = 1.1 Hz **Or** Lowest possible frequency produced by standing wave on shortest cable = 48 Hz **Or** Length of cable needed to give lowest frequency of 280 Hz = 0.60 m	**(1)**	
	Lowest frequency waves produced < 280 Hz so humming is not produced by standing waves on the suspending cables **Or** length of cable is not within range 3.5 to 160 m so humming is not produced by standing waves on the suspending cables	**(1)**	
	<u>Example calculation</u> $W = 140 \times 10^6 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 1.37 \times 10^9 \text{ N}$ $T = \frac{1.37 \times 10^9 \text{N}}{500} = 2.74 \times 10^6 \text{ N}$ $v = \sqrt{\frac{2.74 \times 10^6 \text{ N}}{24 \text{ kg m}^{-1}}} = 338 \text{ m s}^{-1}$ $f = \frac{338 \text{ m s}^{-1}}{320} = 1.06 \text{ Hz}$ **or** $f = \frac{338 \text{ m s}^{-1}}{7} = 48.3 \text{ Hz}$ Lowest frequency waves produced < 280 Hz so humming is not produced by standing waves on the suspending cables		
	Total for question 18		**14**

Question Number	Answer		Mark
19(a)	A photon (incident on a surface) is absorbed by an atom / electron **Or** A photon (incident on a surface) collides with an atom / electron An electron gains energy and is emitted (from the surface)	(1) (1)	**2**
19(b)	(To cause the photoelectric effect) the energy (of a photon) must be greater than the work function (of the photocathode) **Or** (to cause the photoelectric effect) the frequency (of a photon) must be greater than the threshold frequency (of the photocathode) Photon energy is proportional to frequency, so photons below a certain frequency / energy cannot cause the photoelectric effect	(1) (1)	**2**
19(c)	Use of 1 eV = 1.6×10^{-19} J Use of $E = hf$ Use of $v = f\lambda$ Comparison of 840 nm with 700 nm and conclusion all wavelengths of visible light can be detected **Or** Comparison of 2.85×10^{-19} J with 2.37×10^{-19} J and conclusion all wavelengths of visible light can be detected **Or** Comparison of 1.78 eV with 1.48 eV and conclusion all wavelengths of visible light can be detected **Or** Comparison of 3.57×10^{14} Hz with 4.29×10^{14} Hz Example calculation $E = 1.48 \text{ eV} \times 1.6 \times 10^{-19} \text{ J eV}^{-1} = 2.37 \times 10^{-19}$ J $f_{\text{threshold}} = \frac{2.37 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ Js}} = 3.57 \times 10^{14}$ Hz $\lambda_{\text{threshold}} = \frac{3 \times 10^{8} \text{ m s}^{-1}}{3.57 \times 10^{14} \text{ Hz}} = 840 \times 10^{-9}$ m 700 nm < 840 nm so all wavelengths of visible light can be detected	(1) (1) (1) (1)	**4**

19(d)	Use of $E_k = \frac{1}{2} mv^2$ **(1)** Use of $V = \frac{W}{Q}$ **(1)** Final kinetic energy = 1.81×10^{-17} (J) **(1)** Example calculation Initial $E_k = 0.5 \times 9.11 \times 10^{-31}\ \text{kg} \times (1.35 \times 10^{6}\ \text{m s}^{-1})^2 = 8.30 \times 10^{-19}\ \text{J}$ $W = 108\ \text{V} \times 1.6 \times 10^{-19}\ \text{C} = 1.73 \times 10^{-17}\ \text{J}$ Final kinetic energy (= 1.73×10^{-17} J + 8.30×10^{-19} J) = 1.81×10^{-17} J	**3**
19(e)	**EITHER** Use of $V = IR$ to calculate current in circuit **(1)** Calculates total p.d across resistors A to D **(1)** Use of sum of e.m.f. = sum of p.d **(1)** Internal resistance = 1.20 MΩ **(1)** **OR** Calculates total p.d. across resistors A to D **(1)** Uses ratio of resistance = ratio of p.d. **(1)** Correct values substituted into ratio equation **(1)** Internal resistance = 1.20 MΩ **(1)** Example calculation $I = \frac{108\ \text{V}}{85 \times 10^{3}\ \Omega} = 1.27 \times 10^{-3}\ \text{A}$ $V = 1960 - 4 \times 108 = 1530\ \text{V}$ $r = \frac{1530\ \text{V}}{1.27 \times 10^{-3}\text{A}} = 1.20 \times 10^{6}\ \Omega$	**4**
	Total for question 19	**15**