Pearson
Edexcel

Mark Scheme (Results)

October 2019

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

Question Number	Answer	Mark
1	**C is the correct answer as the resistance of both listed components decreases as the applied potential difference increases.** A is not the correct answer as the resistance of an ohmic conductor remains constant when the applied potential difference increases. B is not the correct answer as the resistance of a filament lamp increases when the applied potential difference increases. D is not the correct answer as the resistance of a filament lamp increases when the applied potential difference increases.	**(1)**
2	**A is the correct answer as this represents the current in the internal resistance multiplied by the p.d. across the internal resistance.** B is not the correct answer as this is the power dissipated by the external resistance C is not the correct answer as this is the power dissipated by the whole circuit. D is not the correct answer as this equation combines the p.d. across the external resistance with the value for the internal resistance – as a result, it does not represent the power of any of the components in the circuit	**(1)**
3	**B is the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$** A is not the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$ C is not the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$ D is not the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$	**(1)**
4	**B is the correct answer as increasing light intensity increases the number of electrons released per second (N), but does not affect the maximum kinetic energy of each released electron (E_k)** A is not the correct answer as the graphs show no effect on N and an effect on E_k C is not the correct answer as the graphs show an effect on E_k D is not the correct answer as the graphs show no effect on N	**(1)**
5	**A is the correct answer $v = I/nAq$ – doubling d quadruples A, and with n doubling also, the denominator is 8 times larger** B is not the correct answer as A is quadrupled and n is doubled (factor of 8 overall) C is not the correct answer as A is quadrupled and n is doubled (factor of 8 overall) D is not the correct answer as A is quadrupled and n is doubled (factor of 8 overall)	**(1)**
6	**B is the correct answer as polarisation only occurs in transverse waves** A is not the correct answer as diffraction can be demonstrated for all waves C is not the correct answer as refraction can be demonstrated for all waves D is not the correct answer as superposition can be demonstrated for all waves	**(1)**
7	**D is the correct answer as efficiency is the useful power output (250W) divided by the total power input (Intensity x Area).** A is not the correct answer as this is (Power × Area) / Intensity B is not the correct answer as this is Intensity / (Power × Area) C is not the correct answer as this is the reciprocal of the efficiency equation	**(1)**
8	**D is the correct answer as $P = V^2/R$, so for a constant resistance, doubling V results in P quadrupling.** A is not the correct answer as this suggests that P is constant regardless of V B is not the correct answer as this suggests that P is directly proportional to V C is not the correct answer as this suggests that doubling P quadruples V	**(1)**

9	**B is the correct answer as 7*λ*/4 represents 3.5 radians, which is 1.5π radians out of phase.** A is not the correct answer as 3*λ*/2 represents 3π radians which is antiphase C is not the correct answer as 3λ represents 6π radians which is in phase D is not the correct answer as 7λ/2 represents 7π radians, which is antiphase	**(1)**
10	**B is the correct answer as $n\lambda = d\sin\theta$, and reducing *d* would increase $\sin\theta$ if *n* and *λ* remain the same.** A is not the correct answer as this would result in the maxima being closer together C is not the correct answer as this would have no effect on the distance D is not the correct answer as this would result in the maxima being closer together	**(1)**

Question Number	Answer	Mark
11	Use of $E = hf$ (1) Converts J to eV (1) Transition from (–) 0.54eV to (–) 0.85eV (1) **<u>Example of calculation</u>** $E = hf = (6.63 \times 10^{-34}\ \text{Js}) \times (7.48 \times 10^{13}\ \text{Hz}) = 4.96 \times 10^{-20}\ \text{J}$ $4.96 \times 10^{-20}\ \text{J} / (1.60 \times 10^{-19}\ \text{J eV}^{-1}) = 0.31\ \text{eV}$	**(3)**
	Total for question 11	**3**

Question Number	Answer	Mark
12a	Use of $p = mv$ for electron ($m = 9.11 \times 10^{-31}$ kg used) (1) Use of $\lambda = h/p$ (1) Speed of car = 1.5×10^{-26} (m s^{-1} which is very small) so student suggestion is correct. (1) **<u>Example of calculation</u>** p for electron = $(9.11 \times 10^{-31}\ \text{kg})\ (1.5 \times 10^{7}\ \text{m s}^{-1}) = 1.37 \times 10^{-23}\ \text{kgms}^{-1}$ λ for electron = $(6.63 \times 10^{-34}\ \text{Js}) / (1.37 \times 10^{-23}\ \text{m})$ $= 4.8 \times 10^{-11}$ m. For the car, $4.8 \times 10^{-11}\ \text{m} = (6.63 \times 10^{-34}\ \text{Js}) / (900\ \text{kg})\ v$ $v = 1.5 \times 10^{-26}\ \text{m s}^{-1}$	**(3)**
12b	The car is not a single particle **Or** The car does not behave like a wave/particle **Or** de Broglie equation has only been demonstrated for microscopic particles (1)	**(1)**
	Total for question 12	**4**

Question Number	Answer		Mark
13a	Use of $V=W/Q$ $W = 7.92 \times 10^5$ J **Example of calculation** $W = V \times Q$ = 22 x 36,000 = 792,000 J	(1) (1)	**(2)**
13bi	Use of speed = distance/time Time = 0.45 s (Accept 7.5×10^{-3} minutes or 1.25×10^{-4} hours) **Example of calculation** 16 km hr^{-1} = 16,000 m/ 3,600 s= 4.4 m s^{-1} Time = distance / speed = 2.0 m / 4.4 m s^{-1} = 0.45 seconds.	(1) (1)	**(2)**
13bii	Use of $I = Q / t$ Calculates total charge used in 2.00 m Number of electrons = 4.2×10^{19} (e.c.f. from (i)) **OR** Use of speed = distance / time Calculates total charge used in 2.00m Number of electrons = 4.2×10^{19} (no e.c.f. required from (i) for this method) **Example of calculation** $I = Q / t$ = 36,000 C / (40 x 60) s = 15 A Total charge used in 2.00m = I × t = 15 A x 0.45 s = 6.75 C number of electrons = 6.75 C / 1.6×10^{-19} C = 4.2×10^{19}	(1) (1) (1) (1) (1) (1)	**(3)**
	Total for question 13		**7**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*14a</td><td>
<p>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p>
<p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p>
<p>The following table shows how the marks should be awarded for indicative content.</p>
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
<p>The following table shows how the marks should be awarded for structure and lines of reasoning.</p>
<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>
<p>Indicative content</p>

When temperature is higher, greater energy to electrons (in thermistor)
When temperature is higher, more conduction/free electrons
When temperature is higher, lower resistance in thermistor
Decreased p.d. across thermistor / YZ
Or current in circuit/thermistor increases
Increased p.d. across fixed resistor Or increased p.d. across XY
So for the air conditioning application, secondary circuit should be across XY

<p>(Allow converse statements for IC 1,2, 3 and 4)
(Do not allow contradicting statements for IC4 e.g. lower V so lower I)</p>
</td><td>(6)</td></tr>
</table>

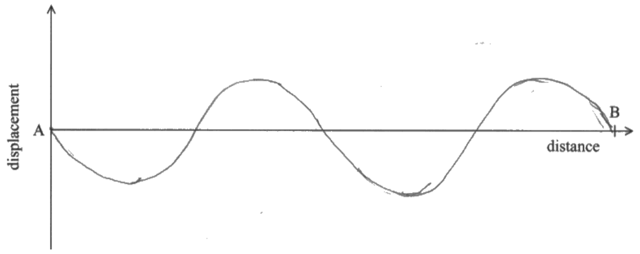
14b	Ratio of p.d.s to resistances	(1)	
	See either 775 Ω **or** 263 Ω for light dependent resistor	(1)	
	Difference = (−) 512 Ω	(1)	
	Or		
	Use of $R = V/I$ to calculate current	(1)	
	See either 775 Ω **or** 263 Ω for light dependent resistor	(1)	
	Difference = (−) 512 Ω	(1)	**(3)**
	Example of calculation $\frac{7.29\ \text{V}}{4.71\ \text{V}} = \frac{1200\ \Omega}{R}$ so $R = 775\ \Omega$ $\frac{9.84\ \text{V}}{2.16\ \text{V}} = \frac{1200\ \Omega}{R}$ so $R = 263\ \Omega$ Difference in resistance = 263 Ω - 775 Ω = (−) 512 Ω		
	Total for question 14		**9**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>15a</td><td><u>Diameter</u> of wire with a micrometer or digital calliper (1)
<u>Length</u> of wire using a metre rule (1)
Potential difference (in parallel with the wire) with a voltmeter and current (in series with the wire) with an ammeter
Or resistance, using an ohmmeter (in parallel with the wire) (1)</td><td>(3)</td></tr>
<tr><td>15b</td><td>Use of πr^2 or $\pi d^2/4$ (1)
Suitable axes (1)
Corresponding gradient to give resistivity
(MP3 dependent on MP2) (1)
Some examples of appropriate axes
<table>
<tr><th>y-axis</th><th>x-axis</th><th>gradient</th></tr>
<tr><td>R</td><td>l</td><td>ρ / A</td></tr>
<tr><td>R</td><td>l/A</td><td>ρ</td></tr>
<tr><td>RA</td><td>l</td><td>ρ</td></tr>
<tr><td>l</td><td>R</td><td>A / ρ</td></tr>
<tr><td>l</td><td>RA</td><td>$1 / \rho$</td></tr>
<tr><td>l/A</td><td>R</td><td>$1 / \rho$</td></tr>
<tr><td>V</td><td>Il</td><td>ρ / A</td></tr>
</table></td><td>(3)</td></tr>
<tr><td></td><td>Total for question 15</td><td>6</td></tr>
</table>

Question Number	Answer	Mark
16a	(Two) waves travelling in opposite directions **Or** Wave reflected back on itself (1) Superposition / interference occurs (1)	**(2)**
16bi	Units of u are ms^{-1} and units of d are m (1) Units of f are s^{-1} (1)	**(2)**
16bii	Use of $v = \sqrt{(T/\mu)}$ (1) Recognises that $\lambda = 2L/3$ **Or** states that $\lambda = 0.22$ m (1) Uses their calculated v and their λ in $v = f\lambda$ to establish f (1) Use of $f = Ku/d$ with their f to establish u (1) $u = 1.1\ ms^{-1}$ (1) **Example of calculation** $v = \sqrt{(T/\mu)} = \sqrt{(63N / 0.58 \times 10^{-3}\ kgm^{-1})} = 330\ ms^{-1}$ $\lambda = 2L/3 = (2 \times 0.33 / 3) = 0.22$ m $f = v/\lambda = 330\ ms^{-1} / 0.22\ m = 1500$ Hz $u = fd/K = [1500\ Hz \times (0.15 \times 10^{-3}\ m)] / 0.2 = 1.125\ ms^{-1}$	**(5)**
	Total for question 16	**9**

Question Number	Answer	Mark
17a	(Pulse reflects at) a boundary between different materials/media/densities (1) (allow "between steel and air" for "between different materials") (allow "speed of ultrasound in air is different to that of steel")	**(1)**
17b	**Method 1** (Calculating distance to crack) Reads time difference of 24.5 - 25 μs from graph (1) Use of speed = distance/time to calculate distance (1) Uses half time or half distance in calculation (1) Depth = 7.1 - 7.3 cm < 15cm, so reflection is from a crack **Or** Depth = 7.1 - 7.3 cm < 15cm, so cannot be from bottom of rail (1) **OR Method 2** (Calculating time to bottom of rail and back) Use of speed = distance/time to calculate time (1) Uses 30cm in calculation (1) Reads time difference of 24.5 - 25 μs from graph (1) Time = 52μs > 24.5 – 25 μs , so reflection is from a crack **Or** Time = 52μs > 24.5 – 25 μs , so cannot be from the bottom of rail (1) **<u>Example of calculation</u>** Time between transmitting and receiving = 24.75μs So time taken to get to point of reflection = 12.375μs Distance = speed × time = 5800 m s^{-1} × (12.375 × 10^{-6}) = 0.072 m.	**(4)**
17c	Most/all of the ultrasound is reflected by the first crack **Or** Pulse does not reach second crack **Or** None of the pulse is transmitted after the crack **Or** Ultrasound signal from deeper cracks is too weak to be detected (1)	**(1)**
17d	The idea that there is a time delay before reflected/received signals return (1) The idea that the train will no longer be in the same position if it is moving too fast. **Or** the idea that the train will be in the same/similar position of it is moving slowly (1)	**(2)**
	Total for question 17	**8**

Question Number	Answer	Mark
18a	Vibrations/oscillations in one plane (1) which includes the direction of wave travel (1) **Or** Vibrations/oscillations in one direction (1) perpendicular to the direction of wave travel (1)	**(2)**
18b	The refracted ray lacks the planes of oscillation in the reflected light. **Or** the refracted ray has a plane of polarisation perpendicular to the plane of polarisation of the reflected light (1) So, the refracted ray must also be partially plane polarised (1) (MP2 conditional on awarding MP1)	**(2)**
18ci	See $n_a\sin\theta_a = n_g\sin\theta_g$ **Or** $n_a\sin\theta_B = n_g\sin r$ (1) $n_a\sin(\theta_B) = n_g\sin(90 - \theta_B)$ **Or** $n_a\sin(\theta_B) = n_g\cos(\theta_B)$ **Or** $\sin r = \cos\theta_B$ (1) $\sin(\theta_B)$ divided by $\cos(\theta_B)$ to give $\tan(\theta_B)$ leading to answer (1)	**(3)**
18cii	Substitution of values into tan(θ_B) = $\frac{n_g}{n_a}$ (1) $\theta_B = 56°$ (1) **<u>Example of calculation</u>** $\tan(\theta_B) = \frac{n_g}{n_a}$ $\theta_B = \tan^{-1}(1.50 / 1.00) = 56°$	**(2)**
18ciii	Refractive index (of glass) is greater for violet **Or** $\frac{n_g}{n_a}$ is greater for violet **Or** $\tan\theta_B$ / $\sin\theta_B$ / θ_B is greater for violet (1) Clearly links one of the above to the student being incorrect. (1)	**(2)**
	Total for question 18	**11**

Question Number	Answer	Mark
19ai	Minimum labelled at either rarefaction (1)	**(1)**
19aii	Zero displacement at all compressions and/or all rarefactions. (1) Two complete wave cycles shown. (1)  (Allow graph inverted in relation to the one shown above)	**(2)**
19bi	Describes an initial situation where the two traces are in antiphase / phase (1) Record the position of the microphone (from the metre rule) **Or** Measure the distance from the loudspeaker to the microphone (1) Move microphone (gradually) until the two traces are next in antiphase / phase (1) Record the new position of the microphone and calculate the distance moved by the microphone **Or** Measure the new distance from the loudspeaker to the microphone and calculate the distance moved by the microphone (1) Multiply calculated/measured wavelength by frequency to determine the speed **Or** Describes a suitable graph to determine the speed (1) (MP5 - examples of suitable graphs are λ against $1/f$ or f against $1/\lambda$. Both would give a gradient of v which needs to be stated to achieve the mark)	**(5)**
19bii	Time period read off oscilloscope (from one point to the next in phase point) **Or** number of waves per second read off oscilloscope (1) Time period (for both traces) is the same (1)	**(2)**
19biii	Use of $v = f\lambda$ (1) Calculates λ of 8.5 cm (for 4.0 kHz) **and** 2.3 cm (for 15.0 kHz) (1) Percentage uncertainty greater for 2.3cm than 8.5cm (so student correct) **Or** Percentage uncertainty greater for 15.0kHz than 4.0kHz (so student correct) **Or** Percentage uncertainty is reduced if measurements taken across several wavelengths (so student not necessarily correct) (1) (Do not allow “uncertainty” for “percentage uncertainty”) **<u>Example of calculation</u>** $\lambda = v/f = (340\ \text{ms}^{-1}) / (4000\ \text{Hz}) = 0.085\ \text{m}$ $\lambda = v/f = (340\ \text{ms}^{-1}) / (15000\ \text{Hz}) = 0.023\ \text{m}$	**(3)**
	Total for question 19	**13**