Mark Scheme (Results)

June 2019

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

Question Number	Answer	Mark
1	**D is the correct answer** A is not the correct answer as these are the units of charge B is not the correct answer as these are the units of energy C is not the correct answer as these are the units of force	**(1)**
2	**C is the correct answer** A is not the correct answer as the intensity does not vary as the filter is rotated B is not the correct answer as the intensity does not vary as the filter is rotated D is not the correct answer as one filter will allow some oscillations to pass	**(1)**
3	**D is the correct answer** A is not the correct answer as waves on a string are transverse B is not the correct answer as waves on a string are transverse C is not the correct answer as waves on a vibrating string are not progressive	**(1)**
4	**A is the correct answer (de Broglie wavelength = 2.43 x 10^{-9} m)** B is not the correct answer as the de Broglie wavelength = 1.82 x 10^{-9} m C is not the correct answer as the de Broglie wavelength = 1.13 x 10^{-12} m D is not the correct answer as the de Broglie wavelength = 9.93 x 10^{-13} m	**(1)**
5	**C is the correct answer** A is not the correct answer as this is the graph for a fixed resistor B is not the correct answer as this is the graph for a filament lamp D is not the correct answer as this graph does not match any component	**(1)**
6	**A is the correct answer** B is not the correct answer as it can be altered to change frequency (CP 5) C is not the correct answer as it can be altered to change frequency (CP 5) D is not the correct answer as it can be altered to change frequency (CP 5)	**(1)**
7	**B is the correct answer** A is not the correct answer as distance has not been doubled C is not the correct answer as time has been doubled, instead of halved D is not the correct answer as distance has been doubled and time halved	**(1)**
8	**D is the correct answer** A is not the correct answer as the two wires are both of the same material B is not the correct answer as the current is the same in parallel C is not the correct answer as the *v* is the same (if *I, n, q* and *A* are constant)	**(1)**
9	**A is the correct answer** B is not the correct answer as it appears in neither of the definitions C is not the correct answer as it only appears in the definition for current D is not the correct answer as it only appears in the definition for p.d.	**(1)**
10	**B is the correct answer** A is not the correct answer as X and Z are in antiphase C is not the correct answer as Y and Z have the same frequency D is not the correct answer as point Z is an antinode	**(1)**

Question Number	Answer	Mark
11	Use of $A = \pi r^2$ (1) Use of $R = \rho l/A$ (1) Resistivity = 2.5×10^{-8} (Ω m) so aluminium (1) (If candidates calculate A as 1.02×10^{-7} m^2 they get 2.6×10^{-8} Ω m) <u>Example of calculation</u> $A = \pi (0.18 \times 10^{-3})^2 = 1.0 \times 10^{-7}$ m^2. $\rho = RA/l = (50 \times 10^{-3}\ \Omega)\ (1.0 \times 10^{-7}\ \text{m}^2) / (0.200\ \text{m}) = 2.5 \times 10^{-8}\ \Omega\ \text{m}$	3
	Total for question 11	**3**

Question Number	Answer	Mark
12a	The average/mean velocity of the (free) electrons (1) (allow "speed" for "velocity", and "charge carriers" for "electrons").	**1**
12b	Use of $I = nqvA$ with e = (−)1.60×10^{-19} (C) (1) v = (−) 3.65×10^{-4} m s^{-1} (1) <u>Example of calculation</u> $v = I/nqA = \frac{1.31\ \text{A}}{(8.49 \times 10^{28}\ \text{m}^{-3})(1.60 \times 10^{-19}\ \text{C})(2.64 \times 10^{-7}\ \text{m}^2)}$ $v = 3.65 \times 10^{-4}$ m s^{-1}	**2**
	Total for question 12	**3**

Question Number	Answer		Mark
13a	Use of $I = P/A$	(1)	
	Use of $A = 4\pi r^2$	(1)	
	$r = 1.47 \times 10^{11}$ m	(1)	**3**
	(MP3 can only be awarded if 1410 W m^{-2} has been used)		
	Example of calculation $4\pi r^2 = (3.83 \times 10^{26}$ W) / 1410 W m^{-2}		
	r = 1.47×10^{11}m.		
13b	Mars orbits at a greater distance from the Sun than the Earth as the intensity is lower	(1)	
	Mars has a more elliptical orbit than the Earth	(1)	
	The (relative) difference between the maximum and minimum intensity for Mars is greater.	(1)	**3**
	(All 3 marking points need to be comparisons)		
	Total for question 13		**6**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*14</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>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>
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

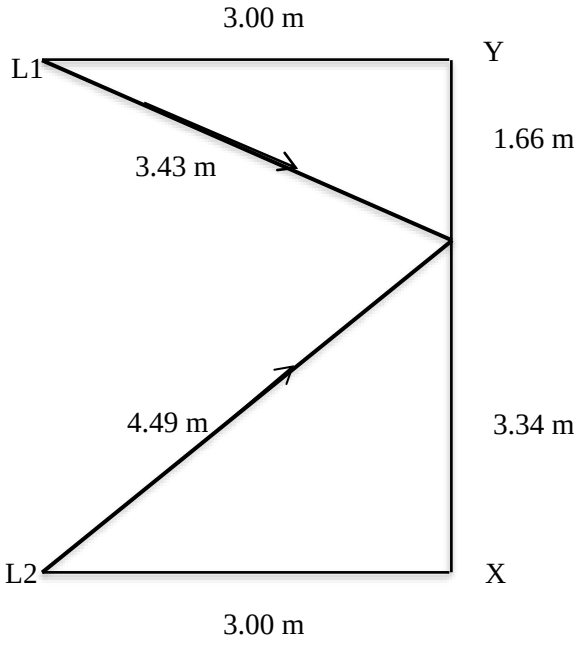
Minimum / threshold frequency required to release electrons.
For waves, any frequency would be able to release electrons.
Release of electrons is instantaneous.
If the wave model were correct, (energy) would take time to build up before electrons were released.
(Kinetic) energy of released electrons dependent on frequency.
If the wave model were correct, the (kinetic) energy of the released electrons would be dependent on the intensity.

</td><td>6</td></tr>
<tr><td></td><td>Total for question 14</td><td>6</td></tr>
</table>

Question Number	Answer		Mark
15a	See $V_T = V_1 + V_2$ See $IR_T = IR_1 + IR_2$ (Divides by I to give) $R_T = R_1 + R_2$	(1) (1) (1)	**3**
15b	Use of $V = IR$ with 7.0V and 0.5A Use of $\frac{1}{Rtot} = \frac{1}{R1} + \frac{1}{R2}$ $R = 12\Omega$ **Or** Use of $V = IR$ with 6Ω and 0.5A (to get 3V across 6Ω resistor) Second use of $V = IR$ with $V = 4$V R = 12Ω <u>Example of calculation</u> R for whole circuit = (7.0V/0.5A) = 14Ω So R for parallel section = 14 – 6 = 8Ω $1/8 = 1/24 + 1/R_2$ $R_2 = 12\Omega$	(1) (1) (1) (1) (1) (1)	**3**
15ci	Use of $V = IR$ to determine circuit current Use of $P = I^2R$ or $P = V^2/R$ or $P = VI$ $P = 1.5 \times 10^{-2}$ W **Or** Ratio of resistances used to calculate p.d. across R Use of $P = V^2/R$ $P = 1.5 \times 10^{-2}$ W <u>Example of calculation</u> I = 12.0 V / (8000 + 670 Ω) = 1.38×10^{-3} A P = $(1.38 \times 10^{-3}$ A$)^2 \times 8000 = 0.015$ W	(1) (1) (1) (1) (1) (1)	**3**
15cii	Decrease in the number of conduction/ free electrons Greater resistance of LDR Less p.d. across the fixed resistor (allow "voltage" for "p.d.") Use of a suitable power equation to conclude that less power dissipated in the fixed resistor. (Converse argument not allowed for MP1 & MP2) (For MP4, do not accept an answer that includes an incorrect statement about one of the variables)	(1) (1) (1) (1)	**4**
	Total for question 15		**13**

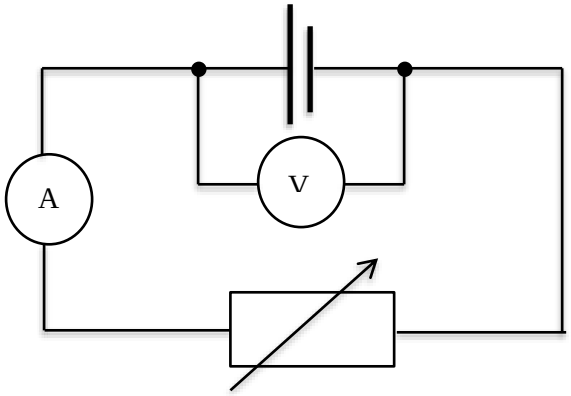
Question Number	Answer		Mark
16a	(Sodium) electrons/atoms gain/absorb energy And electrons move to higher energy levels (Sodium) electrons drop to lower energy levels, releasing <u>photons</u> (For MP2 & MP3, allow excited and de-excited) (For MP2 & MP3, do not allow "atoms" for "electrons") (For "levels" accept shells, orbitals, states)	(1) (1) (1)	**3**
16b	Use of $c = f\lambda$ **and** Use of $E=hf$ Converts J to eV Energy = 2.11eV <u>Example of calculation</u> $f = (3.00 \times 10^{8}\ \text{m s}^{-1}) / (589 \times 10^{-9}\ \text{m}) = 5.09 \times 10^{14}\ \text{Hz}$ $E = (6.63 \times 10^{-34}\ \text{Js}) \times (5.09 \times 10^{14}\ \text{Hz}) = 3.38 \times 10^{-19}\ \text{J}$ E (in eV) $= (3.38 \times 10^{-19}\ \text{J}) / (1.60 \times 10^{-19}\ \text{J eV}^{-1}) = 2.11\text{eV}$	(1) (1) (1)	**3**
16c	Uses $\tan\theta = s / D$ Use of $n\lambda = d\sin\theta$ with $n = 1$ Grating has 301 lines / mm, so the label is correct. **OR** Uses $sin\theta = \frac{s}{\sqrt{(s^2+D^2}}$ Use of $n\lambda = d\sin\theta$ with $n = 1$ Grating has 301 lines / mm, so the label is correct. (Use of double slit or single slit equations does not gain any credit) (Allow reverse calculation to show that 300 lines per mm leads to a value of λ that is close to the given value or that 300 lines per mm leads to a value of d or θ that is close to a value calculated). <u>Example of calculation</u> $\tan\theta = 0.234\ \text{m} / 1.30\ \text{m} = 0.18$ $\theta = 10.2°$ $n\lambda = d\sin\theta$, so $d = 589 \times 10^{-9}\ \text{m} / \sin 10.2° = 3.33 \times 10^{-6}\ \text{m}$ lines per mm $= 1 / 3.33 \times 10^{-3}\ \text{m} = 301$.	(1) (1) (1) (1) (1) (1)	**3**
	Total for question 16		**9**

Question Number	Answer		Mark
17a	Path difference is zero **Or** both waves have travelled the same distance from the speakers to O	(1)	
	Waves are in phase	(1)	
	Constructive interference/superposition takes place	(1)	**3**
17bi	Use of Pythagoras with 1.66m and 3.00m **Or** Use of Pythagoras with 3.34m and 3.00m	(1)	
	Path difference calculated	(1)	
	Uses wavelength = 2 × their path difference	(1)	
	Use of $v = f\lambda$	(1)	
	Speed of sound = 340 ms^{-1} (dependent on correct calculation)	(1)	**5**
	<u>Example of calculation</u> Path length of waves from Speaker 1 = $\sqrt{((3.00\ m)^2 + (1.66\ m)^2)}$ = 3.43m Path length of waves from Speaker 2 = $\sqrt{((3.00\ m)^2 + (3.34\ m)^2)}$ = 4.49m Path difference = 1.06m, so λ = 2.12m. $v = f\lambda$ = 160 Hz × 2.12 m = 339ms^{-1}		



17bii	Hard for a person to judge when sound is quietest/loudest As the amplitude on the oscilloscope can be measured more accurately (For "amplitude" allow "maximum", "minimum", "displacement", "loudness" or "quietness") **Or** Distance between ears is greater than the size of the microphone receiver Less percentage uncertainty in distance measurement taken **Or** Microphone at same level as tape measure whereas ears are higher Distances measured will be different from true distance to ears	(1) (1) (1) (1) (1) (1)	**2**
17c	Reflections/echoes from walls/ceiling (in the classroom) would occur Idea that more than two waves meet and interfere/superpose (at any point so maxima/minima less pronounced)	(1) (1)	**2**
	Total for question 17		**12**

Question Number	Answer	Mark
18a	For light travelling in a more (optically) dense substance and meeting a less (optically) dense substance **Or** for light travelling a material with higher RI and meeting one with a lower RI (1) Angle of incidence is greater than (or equal to) the <u>critical angle</u> (1)	**2**
18b	Wave slows down as it enters the glass (1) Part of the wave(front) meets the glass first, so wave direction changes (1) **OR** Refractive index of glass is greater than that of air Or Density of glass is greater than that of air (1) So angle of incidence is greater than the angle of refraction (accept "bends towards the normal") (1)	**2**
18c	Use of sin $C = 1/n$ for glass-air boundary (1) Subtracts calculated critical angle from 90° (1) Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ for glass-water boundary (1) $\theta = 59°$ (1) (For MP3, both 1.50 and 1.30 need to be seen in the calculation). <u>Example of calculation</u> Critical angle for glass-air boundary = $\sin^{-1}(1.00 / 1.50) = 41.8°$ Angle of incidence for glass-water boundary = 90° - 41.8° = 48.2° $1.50 \times \sin(48.2°) = 1.30 \times (\sin\theta)$ $\theta = 59.3°$	**4**
	Total for question 18	**8**

Question Number	Answer		Mark
19a	Ammeter in series with cell, voltmeter in parallel with cell Variable resistor  (Voltmeter can be drawn in parallel with the (variable) resistor for MP1,as long as there are no other components with resistance in the circuit).	(1) (1)	**2**
19b	Line of best fit drawn ε = 0.28 – 0.29 V (Magnitude of) gradient calculated using a best fit line r = 400 – 430 **Ω** (If no best fit line has been drawn, only MP2 and MP4 are available) <u>Example of calculation</u> Gradient = ΔV / ΔI = −0.18 V / (0.44 x 10^{-3} A) = −409 **Ω** so r = 409 **Ω**	(1) (1) (1) (1)	**4**

19c	In series/A there is a greater (combined) resistance than in parallel/B **Or** Resistance in series/A is 2R, resistance in parallel/B is R/2. (1) So greater current in parallel/B **Or** so less current in series/A (1) As $\mathcal{E}$ and r the same **Or** since $\mathcal{E} = V + Ir$ **Or** more lost volts in parallel/B (1) Terminal potential difference is greater in series/A (1) **OR** In series/A there is a greater (combined) resistance than in parallel/B **Or** Resistance in series/A is 2R, resistance in parallel/B is R/2. (1) as $\mathcal{E}$ and r the same (1) $V = \frac{\varepsilon R}{R+r}$ (1) Terminal potential difference is greater in series/A (1)	**4**
	Total for question 19	**10**