Pearson Edexcel

Mark Scheme (Results)

January 2020

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 path difference of λ would cause constructive interference A is not the correct answer as this path difference would cause destructive interference C is not the correct answer as this phase difference would cause neither constructive nor destructive interference D is not the correct answer as this phase difference would cause destructive interference	**(1)**
2	**D is the correct answer** (Polarised waves have oscillations in one direction and perpendicular to the direction of wave travel) A is not the correct answer as the single plane of polarisation includes the direction of wave travel and is not perpendicular to it B is not the correct answer as polarised waves do not contain many plames C is not the correct answer as polarised waves do not contain many directions	**(1)**
3	**D is the correct answer** (Total resistance in series is 10Ω and 2.5Ω in parallel) A is not the correct answer as the two resistances are the wrong way around B is not the correct answer as this assumes the formulae for series and parallel resistors are the same C is not the correct answer as this assumes the formulae for series and parallel resistors are the same	**(1)**
4	**A is the correct answer** (Both points X and Y represent positions on the graph where there is infinite resistance as the current is zero) B is not the correct answer as there is a non-infinite resistance at Z C is not the correct answer as there is also infinite resistance at Y D is not the correct answer as there is a non-infinite resistance at Z	**(1)**
5	**D is the correct answer** (Drift velocity is I/nqA) A is not the correct answer as drift velocity is not I/nA B is not the correct answer as drift velocity is not nqA/I C is not the correct answer as drift velocity is not nA/I	**(1)**
6	**B is the correct answer** ($hf = \Phi + KE_{max}$ so increasing f increases KE_{max}) A is not the correct answer as electrons are released instantaneously C is not the correct answer as increasing intensity only increases the number of electrons released and each electron still has the same kinetic energy D is not the correct answer as it is higher frequency, not wavelength, that eventually passes a threshold value to release electrons	**(1)**
7	**A is the correct answer** (Reading on V_1 decreases, readings on V_2 and A increase) B is not the correct answer as the decreased resistance of the thermistor will lead to a greater share of the p.d. across the fixed resistor C is not the correct answer as the meter readings show what would happen if the temperature decreased D is not the correct answer as none of the three meter readings would change in the ways stated	**(1)**

8	**C is the correct answer** (Both transverse and longitudinal waves can be refracted) A is not the correct answer as it is only electromagnetic waves that travel at the same speed in a vacuum – there are other transverse waves which travel at different speeds B is not the correct answer as transverse waves have vibrations that are perpendicular to the direction of wave travel D is not the correct answer as light is a transverse wave that can travel through liquids	**(1)**
9	**C is the correct answer** (The diffraction grating is set up so that it is parallel to the screen) A is not the correct answer as θ is calculated by taking measurements of diffraction grating to screen distance and the distance between bright dots then using trigonometry B is not the correct answer as the diffraction grating should be perpendicular to the laser light beam D is not the correct answer as the distance between the bright dots is best measured using a metre rule	**(1)**
10	**A is the correct answer** (Evidence for the wave nature of electrons came from experiments involving diffraction) B is not the correct answer C is not the correct answer D is not the correct answer	**(1)**

Question Number	Answer	Mark
11a	Recognises that node to node distance = $\lambda/2$ **Or** $\lambda = L/2$ stated (1) Wavelength = 0.85m (1) <u>Example of calculation</u> Node to node distance = $\lambda/2$. String has 4 loops so total length of string is 2λ λ = 1.70 m / 2 = 0.85 m.	**(2)**
11b	Use of $v = \sqrt{(T/\mu)}$ (1) Use of $T = mg$ (1) v = 21 m s^{-1} (1) <u>Example of calculation</u> $T = mg$ = 0.20 kg × 9.81 N kg^{-1} = 1.96 N $v = \sqrt{(T/\mu)} = \sqrt{(1.96\text{ N} / 4.5 \times 10^{-3}\text{ kg m}^{-1})}$ = 20.9 m s^{-1}	**(3)**
11c	T and μ are the same **Or** (As f decreases,) λ *in*creases (1) Speed would be the same **Or** There is no effect (on the speed) (1)	**(2)**
	Total for question 11	**7**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>12ai</td><td>Use of $I = P/A$ (1)
Maximum energy received in one hour = 3.6×10^{19} J (1)

<u>Example of calculation</u>
$P = I \times A = (1100\ \text{Wm}^{-2}) \times (9.2 \times 10^{12}\ \text{m}^2) = 1.0 \times 10^{16}$ W
$E = P \times t = (1.0 \times 10^{16}\ \text{W}) \times (60 \times 60) = 3.6 \times 10^{19}$ J</td><td>(2)</td></tr>
<tr><td>12aii</td><td>Calculates total energy usage in 2014
Or Calculates total energy received by solar panels in 1 year (1)

Comparison of energies (hours with hours or years with years) to come to a correct conclusion. (1)

Allow e.c.f. from values in (a)(i)

Possible comparisons:
<table>
<tr><th>Total energy worldwide in 2014</th><th>Total energy received by solar panels</th></tr>
<tr><td>23800 TWh (in a year)</td><td>87,600,000 TWh (if using 24 hours)</td></tr>
<tr><td>23800 TWh (in a year)</td><td>43,800,000 TWh (if using 12 hours)</td></tr>
<tr><td>8.6×10^{19} J (in a year)</td><td>3.2×10^{23} J (if using 24 hrs)</td></tr>
<tr><td>8.6×10^{19} J (in a year)</td><td>1.6×10^{23} J (if using 12 hrs)</td></tr>
<tr><td>9.8×10^{15} J (in an hour)</td><td>3.6×10^{19} J (in an hour)</td></tr>
</table>
<u>Example of calculation</u>
Total E worldwide in 1 year = $23{,}800 \times (3.6 \times 10^{15}\ \text{J}) = 8.6 \times 10^{19}$ J
$8.6 \times 10^{19}\ \text{J} / 3.6 \times 10^{19}\ \text{J} = 2.4$ (hours), so worldwide electrical energy consumption for 2014 would be produced in less than 3 hours</td><td>(2)</td></tr>
<tr><td>12b</td><td>MAX 2 from:

Sand(storms) reduce amount/intensity/energy/power of light (1)

Fewer electrons released in the (solar) panel (1)

Sand(storms) absorbs/blocks/reflects some light (1)

Sand(storms) reduces area of panel/desert (1)</td><td>(2)</td></tr>
<tr><td></td><td>Total for question 12</td><td>6</td></tr>
</table>

<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.

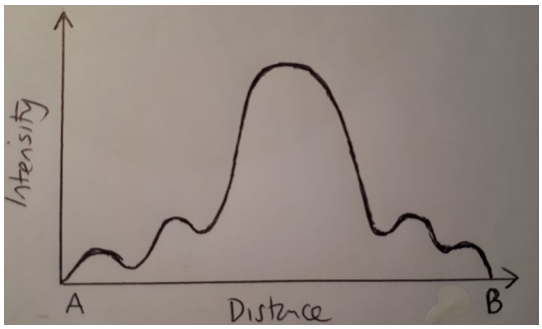
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</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

• Ultrasound is reflected from boundaries/baby
• (This reflection is caused by) change in density
• Time taken between pulse being sent and received measured
• Speed of ultrasound is known
• Speed = distance/time can be used (to calculate the distance to boundary)
• Clear indication that this calculation includes ½ time or ½ distance

(Candidates can potentially achieve 1 linkage mark if they have scored both IC1 and IC2. They can potentially achieve 1 linkage mark if they have scored 3 of IC3-6)
</td><td>(6)</td></tr>
<tr><td></td><td>Total for question 13</td><td>6</td></tr>
</table>

Question Number	Answer	Mark
14a	Minimum energy required to release/emit a (photo)electron (from the surface of the metal) (1)	**(1)**
14b	Ultraviolet has a higher (photon) energy (than visible light) (1) Ultraviolet (photons) have an energy greater than the work function **Or** Visible light (photons) have an energy less than the work function (1) **OR** Ultraviolet has a higher frequency (than visible light) (1) Ultraviolet has a frequency greater than the threshold frequency **Or** Visible light has a frequency less than the threshold frequency (1) (Allow converse statements for MP1)	**(2)**
14ci	(Increased intensity means) more <u>photons</u> per second (1) (More photons leads to) more electrons emitted (per second) (1) Reading on ammeter is increased **Or** Current is increased (1) (For MP1 there needs to be an indication of rate e.g. "per unit time")	**(3)**
14cii	Use of $E = hf$ (1) Use of $V = W/Q$ (1) Use of $hf = \Phi + \frac{1}{2} mv^2_{max}$ (1) Work function = 7.6×10^{-19} (J) (1) **<u>Example of Calculation</u>** $hf = \Phi + \frac{1}{2} mv^2_{max} = hf = \Phi + QV$ $hf = (6.63 \times 10^{-34}\ \text{Js})\ (2.00 \times 10^{15}\ \text{Hz}) = 1.33 \times 10^{-18}\ \text{J}$ $QV/eV = (1.60 \times 10^{-19}\ \text{C})\ (3.59\ \text{V}) = 5.74 \times 10^{-19}\ \text{J}$ $hf - eV = 7.56 \times 10^{-19}\ \text{J}$	**(4)**
	Total for question 14	**10**

Question Number	Answer	Mark
15a	There is a decrease in speed/velocity (1) Part of the wavefront meets the boundary before the rest (1) (Ignore references to density and refractive index) (Allow MP2 for correct addition to the diagram by eye for wavefronts both before and after the boundary)	**(2)**
15bi	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find speed in deep water (1) Use of $v = \sqrt{(gd)}$ to find speed in shallow water (1) Calculates ratio of speeds (1) Correctly equates ratio of speeds to ratio of sine of each angle (1) $r = 17°$ (1) Example of calculation $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ms}^{-2} \times 15 \text{ m})}{2\pi}} = 4.8 \text{ ms}^{-1}$ (deep water) $v = \sqrt{(gd)} = \sqrt{(9.81 \text{ ms}^{-2} \times 0.50 \text{ m})} = 2.2 \text{ ms}^{-1}$ (shallow water) ratio of speeds = (4.8 ms^{-1}) / (2.2 ms^{-1}) = 2.2 sin r = sin (40) / 2.2 = 0.29 $r = 17°$	**(5)**
15bii	Use of $f = 1/T$ and $v = f\lambda$ to find speed of wave (1) Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find same speed in deep water, confirming that deep water equation is the correct equation for this wave (1) Deep water equation only works if $d > 342 / 2$ so d must be > 171m (1) Example of calculation $f = 1 / 14.8 \text{ s} = 0.0676 \text{ Hz}$ $v = 0.0676 \text{ Hz} \times 342 \text{ m} = 23.1 \text{ ms}^{-1}$ $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ms}^{-2} \times 342 \text{ m})}{2\pi}} = 23.1 \text{ ms}^{-1}$ (deep water)	**(3)**
	Total for question 15	**10**

Question Number	Answer	Mark
16a	Waves spread out (as they pass through the gap) (1) Each point on the wave(front) acts as a source of new/secondary wave(let)s (1)	**(2)**
16b	Maximum intensity halfway between A and B (by eye) (1) Central maximum broader than other maxima (by eye) (1) Central maximum greater than twice the height from zero intensity (by eye) of other maxima (1) 	**(3)**
	Total for question 16	**5**

Question Number	Answer	Mark
17a	Energy (supplied) to/per unit charge **Or** Work done (supplied) to/per unit charge **Or** The work done moving unit charge around the whole circuit (1)	**(1)**
17bi	Use of sum of e.m.f. = sum of p.d. **Or** see $\mathcal{E} = V + Ir$ with correct substitutions (1) $r = 1.9 \times 10^{-2}\ \Omega$ (1) Example of calculation $\mathcal{E} = V + Ir$, 12.0 V = 11.81 V + (9.83 A) r. so $r = 0.0193\ \Omega$	**(2)**
17bii	Plot V against I (1) Determine the gradient (1) Gradient is $-r$ (1) **OR** Plot I against V (1) Determine the gradient (1) Gradient is $-(1/r)$ (1) **OR** Plot $(\mathcal{E} - V)$ against I (1) Determine the gradient (1) Gradient is r (1)	**(3)**

17c	Calculates circuit current using $I = \varepsilon$ / Total R **Or** Calculates p.d. across fixed resistor using potential divider equation (1) Use of a power equation (to calculate Power dissipated in fixed resistor) (1) Divides final power by initial power **Or** Divides difference in power by initial power **Or** Calculates 70% of initial power (1) Calculated value for final power/initial power is greater than 70% of initial power so student incorrect **Or** Calculated value for difference between initial and final power is less than 30% so student incorrect **Or** Calculated value for 70% of initial power is less than the final power so student incorrect (1) (Candidates who use incorrect values of I, V or R in either power calculation for MP2 cannot be awarded MP3 or MP4) <u>Example of calculation</u> Initially $I = \varepsilon$ / Total R = 9.0 V / (5.0 + 0.10 Ω) = 1.76 A Power of external resistor = $I^2 R$ = (1.76 A)^2 (5.0 Ω) = 15.5 W When r = 0.50 Ω, $I = \varepsilon$ / Total R = 9.0 V / (5.0 + 0.50 Ω) = 1.64 A Power of external resistor = $I^2 R$ = (1.64 A)^2 (5.0 Ω) = 13.4 W Percentage of original value = (13.4 W) / (15.5 W) = 0.86 (or 86%)	**(4)**
	Total for question 17	**10**

Question Number	Answer	Mark
18a	Use of speed = distance / time (1) Calculates distance travelled by sound in 3s = 1020 (m) **Or** calculates time taken for sound to travel 1 km = 2.94 (s) **Or** calculates speed to travel 1000m in 3 seconds = 333 (ms^{-1}) (1) Time taken by light to reach 1 km is almost instantaneous / 3.3×10^{-6} s so teacher is (approximately) correct. (1) <u>Example of calculation</u> For light, $t = d/v$ = 1000 m / 3.00×10^{8} ms^{-1} = 3.33×10^{-6} s For sound, $t = d/v$ = 1000 m / 340 ms^{-1} = 2.94 s Difference in arrival time = 2.94 s ≈ 3 s	**(3)**
18bi	Use of $Q = It$ (1) Q = 0.75 C (1) <u>Example of calculation</u> $Q = It$ = 25,000 A × (30×10^{-6} s) = 0.75C	**(2)**
18bii	Use of $P = VI$ (1) $P = 3.0 \times 10^{13}$ W (1) <u>Example of calculation</u> $P = VI$ = (1.2×10^{9} V) × 25,000 A = 3.0×10^{13} W	**(2)**
18biii	Use of $A = \pi r^2$ (1) Use of $R = \rho l/A$ (1) ρ = 0.24 (Ω m) (1) <u>Example of calculation</u> Cross sectional area of wire = $\pi r^2 = \pi (2.5 \times 10^{-2})^2 = 1.96 \times 10^{-3}$ m^2 $R = V/I$ = (1.2×10^{9} V) / 25,000 A = 48,000 Ω ρ = RA/l = (48,000 Ω) (1.96×10^{-3} m^2) / 400 m = 0.235 Ωm	**(3)**
18biv	Air in the lightning channel has been ionised **Or** Lightning channel unlikely to have a uniform diameter / CSA (1)	**(1)**

18ci	Energy levels (in atoms) are discrete/specific (1) (Energy makes) electrons move up energy levels **Or** Electrons are excited (1) (Electrons) move back down energy levels, releasing photons **Or** (Electrons) are de-excited, releasing photons (1) Energy difference (between levels) is proportional to frequency of photon (resulting in line spectrum being produced) **Or** Photon energy is proportional to frequency (resulting in line spectrum being produced) (1)	**(4)**
18cii	Different atoms/elements have different (differences in) energy levels (1)	**(1)**
	Total for question 18	**16**