Pearson Edexcel

Mark Scheme (Results)

Summer 2023

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH12)
Paper 01
Unit 2: Waves and Electricity

Summer 2023
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Answer	Mark
1	**A is the correct answer as diffraction is the spreading of waves as they pass an object** B is not the correct answer as interference is not the spreading of waves C is not the correct answer as reflection is not the spreading of waves D is not the correct answer as refraction is not the spreading of waves	**(1)**
2	**B is the correct answer as decreasing the time period increases the frequency (f = 1/T)** A is not the correct answer as amplitude is unaffected by time period C is not the correct answer as speed is affected by both time period and wavelength D is not the correct answer as wavelength is affected by both time period and speed	**(1)**
3	**A is the correct answer as frequency is unchanged when travelling into a different medium** B is not the correct answer as some of the light intensity becomes the reflected light. C is not the correct answer as the speed decreases when travelling into a more optically-dense substance D is not the correct answer as the wavelength decreases when travelling into a more optically-dense substance	**(1)**
4	**C is the correct answer as the p.d. across a uniform wire is directly proportional to its length** A is not the correct answer as this does not show a directly proportional relationship B is not the correct answer as this does not show a directly proportional relationship D is not the correct answer as this does not show a directly proportional relationship	**(1)**
5	**D is the correct answer as $v = \frac{h}{\lambda m}$** A is not the correct answer as v is not equal to $\frac{m}{h\lambda}$ B is not the correct answer as v is not equal to $\frac{\lambda m}{h}$ C is not the correct answer as v is not equal to $\frac{h\lambda}{m}$	**(1)**
6	**C is the correct answer as the path difference of 1.5λ is equivalent to a phase difference of π radians** A is not the correct answer as 0 radians would mean that the path difference was 0, λ, 2λ etc. B is not the correct answer as π/2 radians would mean that the path difference was 0.25λ, 1.25λ etc. D is not the correct answer as 3π/2 radians would mean that the path difference was 0.75λ, 1.75λ etc.	**(1)**

7	**D is the correct answer as coherence can only occur if the waves have the same frequency** A is not the correct answer as coherence does not require waves to be in antiphase, they just need a constant phase difference B is not the correct answer as coherence does not require waves to be in phase, they just need a constant phase difference C is not the correct answer as waves can still be coherent, even if their amplitudes are different.	**(1)**
8	**D is the correct answer as decreasing the distance between the central maximum and the first order maximum would require sinθ to be reduced (presuming that the distance from the diffraction grating to the screen is unchanged), and $\lambda = \frac{d \sin\theta}{n}$** A is not the correct answer as this does not affect sinθ B is not the correct answer as this would increase the distance between the central maximum and first order maximum C is not the correct answer as more lines per mm would make d smaller, so as $d = \frac{n\lambda}{\sin\theta}$, which would make sinθ increas	**(1)**
9	**A is the correct answer. The power of the Sun is constant, so *IA* is constant for all the planets. I_E x 4π (1.49 × 10^{11} m)^2 = I_J × 4π (7.78 × 10^{11}m)^2** B is not the correct answer as 4π cancels in the equation C is not the correct answer as the radius of orbit has not been squared D is not the correct answer as 4π cancels in the equation and the radius of the orbit has not been squared	**(1)**
10	**A is the correct answer as decreased temperature results in a decrease in lattice vibrations** B is not the correct answer as this would only happen if the temperature increased C is not the correct answer as a filament is not a semiconductor D is not the correct answer as a filament is not a semiconductor	**(1)**

Question Number	Answer	Mark
11(a)	Calculates total charge **(1)** Use of $I = \Delta Q/\Delta t$ **(1)** $I = 1.28$ (A) **(1)** (MP3 – allow minus sign on answer) Example of calculation Total charge = $4.80 \times 10^{20} \times 1.60 \times 10^{-19}$ C = 76.8 C $Q = It$, so $I = 76.8$ C / 60 s = 1.28 A	**3**
11(b)	Use of $V = W/Q$ **or** $W = VIt$ **(1)** Potential difference = 0.31 V (e.c.f. from (a)) **(1)** OR Use of $P = W/t$ and $P = VI$ **(1)** Potential difference = 0.31 V (e.c.f. from (a)) **(1)** ("show that" value also gives 0.31 V) (allow answer of 0.3V) (e.c.f. can be for *I* or *Q* value from (a)) Example of calculation $V = W / It = 24$ J / (1.28 A × 60 s) = 0.31 V	**2**
	Total for question 11	**5**

Question Number	Answer	Mark
12(a)	$\varepsilon = 1.50$ V (accept answers in the range 1.48 V to 1.52 V) **(1)** Attempt to calculate gradient of graph to find *r* **(1)** $r = 0.75\ \Omega$ (accept answers in the range 0.72 Ω to 0.78 Ω) **(1)**	**3**
12(b)	Gradient is doubled **(1)** y-intercept is doubled **(1)** (If no other marks scored, allow "new graph has steeper gradient **and** y-intercept has a greater value" for 1 mark) (If no other marks scored, allow new values for ε and *r*, consistent with their answers to (a))	**2**
	Total for question 12	**5**

Question Number	**Answer**	**Mark**
13(a)	Angles as 43° **and** 65° (+/− 1°) **(1)** Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ (allow use of $n = \frac{\sin i}{\sin r}$) **(1)** Refractive index in range 1.29 to 1.37 **(1)** (MP3 dependent on MP1) <u>Example of calculation</u> $n_1\sin\theta_1 = n_2\sin\theta_2$ $n_1 \times \sin(43°) = 1.00 \times \sin(65°)$ $n_1 = 1.33$	3
13(b)(i)	Unpolarised light has vibrations/oscillations in many/all planes **(1)** Plane polarised light has vibrations/oscillations in one plane only **(1)** Including the direction of wave travel **(1)** **OR** Unpolarised light has vibrations/oscillations in many/all directions **(1)** Plane polarised light has vibrations/oscillations in one direction only **(1)** Perpendicular to the direction of wave travel **(1)** (MP3 dependent on either MP1 or MP2) (MP3 – for “direction of wave travel” allow “direction of energy transfer” or “direction of propagation”)	3
13(b)(ii)	(Polarising) filter is rotated **(1)** Filter not aligned with plane of reflected light, so less light transmitted **(1)** **OR** (Polarising) filter positioned at 90° **(1)** to the plane of the reflected light, so no light transmitted **(1)** **OR** Place (polarising) filter so that it its plane of polarisation is vertical **(1)** Horizontally polarised (reflected light) is not transmitted **(1)** (Maximum 1 mark if using two filters)	2
	Total for question 13	**8**

<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>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

- Resistance of LDR decreases
- Due to increase in number of (conduction) electrons
- So the resistance of circuit decreases
Or This results in greater current in circuit/LDR/resistor
- e.m.f. of the circuit is the same
- And due to $P = VI$ **Or** $P = I^2R$ **Or** $P = V^2/R$ (for whole circuit)
- The power dissipated by the circuit increases

(IC2 – allow “number of charge carriers” or “charge carrier density”)
(IC4 – allow “total circuit voltage/p.d.” for “e.m.f.”)
(IC6 – needs to be related to correct V,I,R for **whole** circuit)
</td><td>6</td></tr>
<tr><td></td><td>Total for question 14</td><td>6</td></tr>
</table>

Question Number	Answer	Mark
15(a)	Some of the pulse passes/refracts through crack A **(1)** (Some of the pulse) reflects from crack (B) **(1)** Because the density/material/medium of the crack will be different (to the metal) **(1)**	**3**
15(b)	Use of speed = distance / time **(1)** Correct factor of 2 in converting time or distance **(1)** Depth = 4.1 cm / 0.041 m, hence crack A **(1)** Example of calculation Distance = speed × time = 5900 m s^{-1} × $\frac{1.4 \times 10^{-5} s}{2}$ = 0.041 m	**3**
15(c)	Higher frequency means lower wavelength **(1)** Therefore greater level of detail possible **(1)** (MP1 – allow converse statement i.e. "lower frequency means greater wavelength") (MP2 - allow reference to greater resolution or that smaller objects can be seen)	**2**
	Total for question 15	**8**

Question Number	Answer	Mark
16(a)	Corresponding values from best fit line **(1)** Use of $P = VI$ **(1)** Minimum potential difference = 9.0 V **(1)** <u>Example of calculation</u> $P = VI$ At 9.0 V, $P = 9.0\ \text{V} \times 3.9\ \text{A} = 35.1\ \text{W}$	3
16(b)(i)	In parallel, each headlight receives 12 V **Or** In series, each headlight receives 6 V **(1)** In parallel, headlights will have higher power/brightness **Or** In series, headlights will have lower power/brightness **(1)** In parallel, if one headlight breaks/fails, the other one remains on **Or** In series, if one headlight breaks/fails, the other one goes out **(1)**	3
16(b)(ii)	Use of $R = V/I$ **(1)** Use of resistors in parallel formula to calculate R_T in parallel **(1)** Rseries is not 4 × Rparallel, so student not correct **(1)** <u>Example of calculation</u> (Using data from the graph): R of single headlight in parallel = $\frac{V}{I} = \frac{12.0\ \text{V}}{4.6\ \text{A}} = 2.61\Omega$ (for parallel headlights), $\frac{1}{R_T} = \frac{1}{2.61\ \Omega} + \frac{1}{2.61\ \Omega}$, so $R_T = 1.30\ \Omega$ R of single headlight in series = $\frac{V}{I} = \frac{6.0\ \text{V}}{3.2\ \text{A}} = 1.88\ \Omega$ (for series headlights), $R_T = 1.88\ \Omega + 1.88\ \Omega = 3.76\ \Omega$ 3.76 / 1.30 = 2.9, so is 2.9 × less in parallel, not 4 × less	3
16(c)	Use of $R = \rho l/A$ **(1)** Use of $I = nqvA$ **(1)** Drift velocity = $3.4 \times 10^{-4}\ \text{m s}^{-1}$ **(1)** <u>Example of calculation</u> $R = \rho l/A$, so $A = \frac{\rho l}{R} = \frac{1.72 \times 10^{-8}\ \Omega\ \text{m}}{0.0175\ \Omega\ \text{m}^{-1}} = 9.83 \times 10^{-7}\ \text{m}^2$ $v = \frac{4.60\ \text{A}}{8.49 \times 10^{28}\text{m}^{-3} \times 1.60 \times 10^{-19}\text{C} \times 9.83 \times 10^{-7}\text{m}^2} = 3.4 \times 10^{-4}\ \text{m s}^{-1}$	3
	Total for question 16	**12**

Question Number	**Answer**	**Mark**
17(a)	Electron moves to a higher energy level **(1)** Then drops back (down, releasing a photon) **(1)** (MP1 allow electron is excited. MP2 allow electron is de-excited) (MP2 allow returns to ground state)	**2**
17(b)(i)	Use of $v = f\lambda$ with $v = 3.00 \times 10^8$ m s^{-1} **(1)** Use of $E = hf$ **(1)** Conversion from J to eV **(1)** Photon energy = 5.7 eV **(1)** <u>Example of calculation</u> $v = f\lambda$, f = 3.00×10^8 m s^{-1} / 218×10^{-9} m = 1.38×10^{15} Hz $E = hf = 6.63 \times 10^{-34}$ Js × 1.38×10^{15} Hz = 9.12×10^{-19} J E (in eV) = 9.12×10^{-19} J / 1.60×10^{-19} J eV^{-1} = 5.70 eV	**4**
17(b)(ii)	(Differences between) energy levels are discrete **Or** only certain jumps/transitions are possible **(1)** No difference of 5.7 eV, so not possible (for this photon to be produced) **(1)** (MP2 – allow comment consistent with their calculated value from b(i))	**2**
17(c)(i)	Use of $hf = \Phi + \frac{1}{2} mv^2_{\text{max}}$ **(1)** Use of $E_k = \frac{1}{2} mv^2$ with $m = 9.11 \times 10^{-31}$ kg **(1)** Maximum possible speed = 1.5×10^6 m s^{-1} **(1)** <u>Example of calculation</u> $E_k = hf - \Phi = 1.63 \times 10^{-18}$ J – 5.89×10^{-19} J = 1.04×10^{-18} J $E_k = \frac{1}{2} mv^2$, $v = \sqrt{\frac{1.04 \times 10^{-18}\ \text{J}}{0.5 \times 9.11 \times 10^{-31}\text{kg}}}$ = 1.5×10^6 m s^{-1}	**3**
17(c)(ii)	**MAX 2** from: • There is a minimum/threshold frequency for electron release **(1)** • Electrons are released instantaneously **(1)** • (Changing) intensity does not affect KE/speed/release of an electron **(1)** **MAX 2** from: • The energy of a photon increases as frequency increases **(1)** • Photon energy has to be greater than the work function **(1)** • Each photon only interacts with one electron **(1)**	**3**
	Total for question 17	**14**

Question Number	Answer		Mark
18(a)	Wave (on string) is <u>reflect</u>ed	**(1)**	
	At the end/peg/bridge	**(1)**	
	Superposition/interference takes place	**(1)**	**3**
18(b)	Use of $v = \sqrt{\frac{T}{\mu}}$	**(1)**	
	Use of $v = f\lambda$	**(1)**	
	And $\lambda = 2L$	**(1)**	
	f = 293 (Hz, which is closest to) String 2	**(1)**	**4**
	<u>Example of calculation</u> $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{71.5\text{ N}}{2.03 \times 10^{-3}\text{ kg m}^{-1}}} = 187.7\text{ m s}^{-1}$ $v = f\lambda$, so $f = 187.7\text{ m s}^{-1} / (2 \times 0.32\text{ m}) = 293\text{ Hz}$		
18(c)	Waves have the same frequency/period	**(1)**	
	Waves have different speeds/wavelengths	**(1)**	
	Sound wave has same amplitude for all points **and** stationary wave does not	**(1)**	
	Sound waves transfer energy **and** stationary waves do not	**(1)**	
	Waves on string are transverse **and** sound waves are longitudinal	**(1)**	**5**
	(MP2 – do not allow contradictions e.g. “they have different speeds but the same wavelength”)		
	Total for question 18		**12**

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