Pearson Edexcel

Mark Scheme (Results)

January 2025

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

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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.

Mark scheme notes

Underlying principle
The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. **It is not a set of model answers.**

1. Mark scheme format
1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the MS has specified specific words that must be present. Such words will be indicated by underlining e.g. '<u>resonance</u>'

1.2 Bold lower case will be used for emphasis e.g. '**and**' when two pieces of information are needed for 1 mark.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties
2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a unit e.g the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.5 The mark scheme will indicate if no unit error is to be applied by placing brackets around the unit.

3. Significant figures
3.1 Use of too many significant figures in the theory questions will not prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

4. Calculations

4.1 **use of** the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.2 If a 'show that' question is worth 2 marks, then both marks will be available for a reverse working. If the question is worth 3 marks then only 2 marks will be available.

4.3 The mark scheme will show a correctly worked answer for illustration only.

5. Quality of Written Expression

5.1 Questions that asses the ability to show a coherent and logically structured answer are marked with an asterisk.

5.2 Marks are awarded for indicative content and for how the answer is structured.

5.3 Linkage between ideas, and fully-sustained reasoning is expected.

Question Number	Answer	Mark
1	**The only correct answer is B - total number of conduction electrons in 1 m^3 of a material** **A** is not correct because *n* refers to the number of charge carriers per unit volume, not per unit length. **C** is not correct because the total number of electrons is not the same as the number of charge carriers, and *n* refers to the number of charge carriers per unit volume, not per unit length. **D** is not correct because the total number of electrons is not the same as the number of charge carriers.	1
2	**The only correct answer is D -** $\frac{It}{e}$ **A** is not correct because the charge passing in time *t* should be divided by the charge on an electron. **B** is not correct because the charge passing in time *t* should be current divided by time. **C** is not correct because the charge passing in time *t* should be current multiplied by time and should be divided by the charge on an electron.	1
3	**The only correct answer is C - 0.5*vt*** **A** is not correct because the pulse has to travel to the object and back, so the distance should be halved. **B** is not correct because distance should be velocity × time and the pulse has to travel to the object and back, so the distance should be halved. **D** is not correct because distance should be velocity × time.	1
4	**The only correct answer is B -**  **A** is not correct because this pattern would form after the waves move a quarter of a wavelength. **C** is not correct because the waves would completely destructively interfere after moving three quarters of a wavelength. **D** is not correct because this pattern would form after the waves move 1 wavelength.	1
5	**The only correct answer is A - the number of conduction electrons decreases so the ammeter reading decreases.** **B** is not correct because the current would decrease. **C** is not correct because the number of conduction electrons would decrease. **D** is not correct because the number of conduction electrons would decrease, and the current would decrease.	1
6	**The only correct answer is C -** $\frac{2\varepsilon}{3}$ **A** is not correct because the two resistors in parallel have half the resistance of the resistor connected across the voltmeter **B** is not correct because the resistors do not share the potential difference equally **D** is not correct because the p.d. cannot be greater than the emf	1

7	**The only correct answer is B – phase difference between P and Q is 0° and amplitude of oscillation of P and Q is less than *A*** **A** is not correct because the amplitude of oscillation of P and Q is less than *A* **C** is not correct because P and Q are in phase and the amplitude of oscillation of P and Q is less than *A* **D** is not correct because P and Q are in phase	**1**
8	**The only correct answer is D -** $\frac{L}{d} \times R$ **A** is not correct because the resistance of the wire should be proportional to R and proportional to the length of the wire. **B** is not correct because the resistance of the wire should be proportional to the length of the wire. **C** the resistance of the wire should be proportional to R.	**1**
9	**The only correct answer is B - 3** **A** is not correct because the energy transferred to the electron is not 4.91 eV **C** is not correct because the energy transferred to the electron is not 6.70 eV **D** is not correct because the energy transferred to the electron is not 7.73 eV	**1**
10	**The only correct answer is A -** $\frac{10 \times (9 - 6)}{6}$ **B** is not correct because this is a potential difference squared divided by a resistance **C** is not correct because this gives a resistance divided by potential difference squared **D** is not correct because the answer is inverted	**1**

Question Number	Answer	Mark
11	Use of $p = mv$ **(1)** Use of $\lambda = \frac{h}{p}$ **(1)** $\lambda = 2.0 \times 10^{-11}$ m **(1)** <u>Example calculation</u> $p = 9.11 \times 10^{-31}$ kg $\times 3.6 \times 10^{7}$ m s^{-1} $= 3.28 \times 10^{-23}$ kg m s^{-1} $\lambda = \frac{6.63 \times 10^{-34} \text{ J s}}{3.28 \times 10^{-23} \text{ kg m s}^{-1}} = 2.02 \times 10^{-11}$ m	3
	Total for question 11	**3**

Question Number	Answer		Mark
12	Use of $I = \frac{P}{A}$	**(1)**	
	$P = 0.48$(W) **Or** A = 10.7 (cm^2) **Or** I = 1250 (W m^{-2})	**(1)**	
	Comparison with a value from the question and conclusion consistent with answer	**(1)**	**3**
	Example calculation $P = 750 \text{ W m}^{-2} \times 6.4 \times 10^{-4} \text{ m}^2 = 0.48 \text{ W}$ $0.48 \text{ W} < 0.80 \text{ W}$ so the battery will not charge		
	Total for question 12		**3**

Question Number	Answer		Mark
13(a)	(As temperature increases) the metal lattice vibrations increase There is an increase in the frequency of collisions of electrons with the lattice So the resistance increases MP3 dependent on MP2 or MP1	**(1)** **(1)** **(1)**	**3**
13(b)	Calculates cross-sectional area of wire Use of $R = \frac{\rho l}{A}$ $\rho = 9.8 \times 10^{-7} \Omega$ m <u>Example calculation</u> $A = \frac{\pi \times (0.51 \times 10^{-3}\text{ m})^2}{4} = 2.04 \times 10^{-7}\text{ m}^2$ $\rho = \frac{0.67\ \Omega \times 2.04 \times 10^{-7}\text{ m}^2}{0.14\text{ m}} = 9.76 \times 10^{-7}\ \Omega\text{ m}$	**(1)** **(1)** **(1)**	**3**
	Total for question 13		**6**

Question Number	Answer	Mark
14(a)	Oscillations / vibrations are perpendicular to the <u>direction</u> of energy transfer **Or** Oscillations / vibrations are perpendicular to the <u>direction</u> of wave travel (allow propagation for wave travel) **(1)**	1
14(b)(i)	Uses appropriate trigonometry to determine θ **(1)** Use of $n\lambda = d\sin\theta$ to calculate d **(1)** Calculate $\frac{1}{d}$ **(1)** Number of lines per mm = 260 **(1)** <u>Example calculation</u> $\theta = \tan^{-1}\left(\frac{0.22\text{ m}}{1.30\text{ m}}\right) = 9.61°$ $1 \times 650 \times 10^{-9}\text{ m} = d\sin(9.61°)$ $d = \frac{650 \times 10^{-9}\text{ m}}{\sin(9.61)} = 3.89 \times 10^{-6}\text{ m}$ No. of lines per mm = $\frac{10^{-3}}{3.89 \times 10^{-6}\text{ m}} = 257$	4
14(b)(ii)	The path difference (for light from different slits travelling to the screen) is one wavelength **(1)** (So) the waves are in phase at the screen **(1)** (So) constructive interference occurs (causing a maximum) **(1)**	3
	Total for question 14	**8**

Question Number	Answer		Mark
15(a)	Current in lamp is 0.46 A to 0.48 A Use of $R = \frac{V}{I}$ Use of $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ to calculate R_{tot} $R_T = 5.1\ \Omega$ (allow $R_T = 5.0\ \Omega$ if current = 0.48 A) <u>Example calculation</u> $R_{\text{lamp}} = \frac{3.6\text{ V}}{0.47\text{ A}} = 7.66\ \Omega$ $\frac{1}{R_T} = \frac{1}{15\ \Omega} + \frac{1}{7.66\ \Omega} = 0.197\ \Omega^{-1}$ $R_T = \frac{1}{0.197\ \Omega^{-1}} = 5.08\ \Omega$	(1) (1) (1) (1)	4
15(b)	Use of $R = \frac{V}{I}$ to determine current Use of $P = VI$ **Or** $P = \frac{V^2}{R}$ **Or** $P = I^2\text{R}$ P = 3.2 W [allow e.c.f. from 15(a)] **Or** Use of ratio of p.d. = ratio of resistance to find resistance across variable resistor Use of $P = VI$ **Or** $P = \frac{V^2}{R}$ **Or** $P = I^2\text{R}$ P = 3.2 W [allow e.c.f. from 15(a)] <u>Example calculation</u> $I = \frac{3.6\text{ V}}{5.08\ \Omega} = 0.709\text{ A}$ $P = 4.5\text{ V} \times 0.709\text{ A} = 3.19\text{ W}$ (show that value gives 3.24 W) $R_{variable} = \frac{5.07\ \Omega \times 0.9\text{ V}}{3.6\text{V}} = 1.27\ \Omega$ $P = \frac{4.5^2}{6.34\ \Omega} = 3.2\text{ W}$	(1) (1) (1)	3
	Total for question 15		**7**

Question Number	Answer		Mark
16(a)	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**

***16(b)**

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.

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content

IC1 Increasing the intensity of light increases the number of photons (per second) incident on the LDR

IC2 This causes the number of (conduction) electrons in the LDR to increase

IC3 The resistance of the LDR decreases

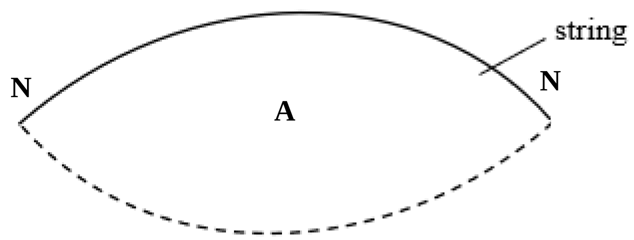
IC4 The internal resistance (of the cell) is constant

IC5 (As the current increases) the potential difference across the internal resistance increases

IC6 The terminal p.d. decreases so the voltmeter reading decrease
Or p.d across LDR decreases so the voltmeter reading decrease

Mark: **6**

	Total for question 16	**7**

Question Number	Answer		Mark
17(a)	Nodes labelled at both ends **and** Antinode labelled in the middle of the string  	**(1)**	**1**
17(b)	Waves / vibrations <u>reflect</u> from the end(s) of the string superposition / interference occurs	**(1)** **(1)** **(1)**	**3**
17(c)(i)	Equates $f\lambda$ with $\sqrt{\frac{T}{\mu}}$ Equates λ to 2l $f^2 = \frac{1}{4l^2\mu} \cdot T$ compares with $y = mx\ (+\ c)$	**(1)** **(1)** **(1)**	**3**
17(c)(ii)	Determines $\frac{\Delta f^2}{\Delta T}$ Uses gradient = $\frac{1}{4l^2\mu}$ $\mu = 6.4 \times 10^{-4}$ kg m^{-1} to 6.7×10^{-4} kg m^{-1} <u>Example calculation</u> Gradient = $\frac{2500}{4.7}$ = 532 $532\ \text{Hz}^2\ \text{N}^{-1} = \frac{1}{4 \times (0.85\ \text{m})^2 \times \mu}$ $\mu = \frac{1}{4 \times (0.85\ \text{m})^2 \times 532\ \text{Hz}^2\ \text{N}^{-1}} = 6.50 \times 10^{-4}\ \text{kg m}^{-1}$	**(1)** **(1)** **(1)**	**3**
	Total for question 17		**10**

Question Number	Answer		Mark
18(a)	Angle of incidence = 40°	(1)	
	Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$	(1)	
	Angle of refraction = 25°	(1)	3
	<u>Example calculation</u> $1 \times \sin 40° = 1.5 \times \sin\ \theta_2$ $\theta_2 = \sin^{-1}\left(\frac{\sin(40°)}{1.5}\right) = 25.4°$		
18(b)	**Either** Use of $\sin(C) = \frac{1}{n}$ $C = 42(°)$ comparison of C with 45(°) and consistent conclusion	(1) (1) (1)	3
	Or Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ with $n_2 = 1$ $\sin\theta_2 = 1.06$ $As\ sin\theta_2 > 1$ so the ray will be totally internally reflected		
	<u>Example calculation</u> $\sin(C) = \frac{1}{1.5}$ $C = \sin^{-1}\left(\frac{1}{1.5}\right) = 41.8(°)$ 45° > 41.8° so the ray will be totally internally reflected		
18(c)	Rays of light have different (path) lengths / distances	(1)	
	So different rays take different times (to travel to the other end of the optical fibre)	(1)	
	So the duration of the (emerging) pulse is longer / greater	(1)	
	And some rays refract out of the fibre	(1)	
	So the intensity of the emerging pulse / light is lower	(1)	5
18(d)	There is a smaller difference in refractive index **Or** There is a smaller difference in speed of light between the two materials **Or** cladding has a greater refractive index than air **Or** cladding has a refractive index greater than 1	(1) (1)	2
	(So) the critical angle is increased MP2 dependent on MP1		
	Total for question 18		**13**

Question Number	Answer	Mark
19(a)	Each photon (absorbed transfers all of its energy) to one electron **(1)** The energy shared between the kinetic energy of the electron and the energy to break free **(1)** Electrons need different amounts of energy to escape the surface (so kinetic energy of photoelectrons varies.) **(1)**	**3**
19(b)	In the wave model, more intense light has greater amplitude waves **Or** In the wave model, more intense light means each wave transfers more energy **(1)** (So) in the wave model light of any intensity would release (photo)<u>electrons</u> **(1)** (In the particle model) intensity affects the number of <u>photons</u> (per second) **Or (**In the particle model) intensity does not affect the energy of each <u>photon</u> **(1)** (But) ultraviolet photons / light have more energy than a visible light so ultraviolet would cause the release of (photo)<u>electrons</u> **(1)** (So) this demonstrates the particle nature of light **(1)**	**5**

19(c)	Use of $c = f\lambda$ with with c = 3 x 10^8 ms^{-1} Use of E = hf Use of $hf = \varphi + E_{\text{k max}}$ Converts from J to eV or Use of $V = \frac{W}{Q}$ $E_{\text{k max}} = 0.66$ (e)V < 1.5 (e)V so no current is detected **Or** $E_{k\ max}$ = 1.1×10^{-19} J < 2.4×10^{-19} J so no current is detected **Or** photon energy required = 9.30 x 10^{-19} J > 7.96 x 10^{-19} J so no current is detected <u>Example calculation</u> $f = \frac{3.00 \times 10^8 \text{ m s}^{-1}}{250 \times 10^{-9} \text{ m}} = 1.2 \times 10^{15} \text{ Hz}$ $6.63 \times 10^{-34} \text{ J s} \times 1.2 \times 10^{15} \text{ Hz} = 6.9 \times 10^{-19} \text{ J} + E_{\text{k max}}$ $E_{\text{k max}} = 7.96 \times 10^{-19} \text{ J} - 6.9 \times 10^{-19} \text{ J} = 1.06 \times 10^{-19} \text{ J}$ $E_{\text{k max}} = \frac{1.06 \times 10^{-19} \text{ J}}{1.6 \times 10^{-19} \text{ J eV}^{-1}} = 0.663 \text{ eV}$ $0.663 \text{ eV} < 1.5 \text{ eV}$ so no current is detected	**(1)** **(1)** **(1)** **(1)** **(1)**	5
	Total for question 19		**13**

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with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom