Mark Scheme (Results)

January 2023

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.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**1**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

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. 'resonance'

1.2 Bold lower case will be used for emphasis.

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 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.

2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).

2.5 Occasionally, it may be decided not to penalise a missing or incorrect 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.

2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

3.2 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 $9.8\ N\ kg^{-1}$

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

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

4.3 **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.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

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

4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

$80\ cm \times 50\ cm \times 1.8\ cm = 7200\ cm^3$
$7200\ cm^3 \times 0.70\ g\ cm^{-3} = 5040\ g$
$5040 \times 10^{-3}\ kg \times 9.81\ N/kg$
$= 49.4\ N$

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

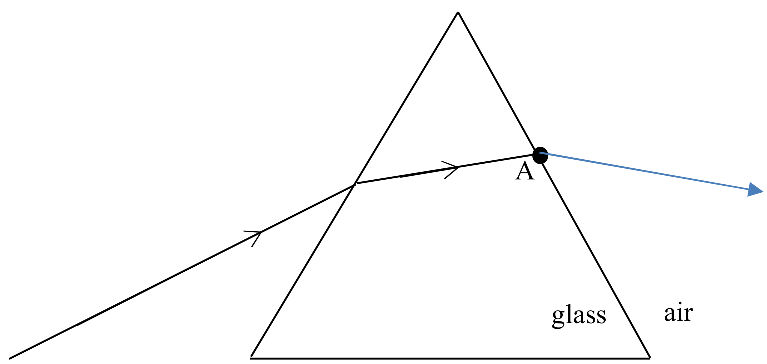
- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	**C is the correct answer** A is not the correct answer as the *I*-*V* graph for a diode is not a straight line through the origin. B is not the correct answer as the *I*-*V* graph for a filament lamp is not a straight line through the origin. D is not the correct answer as the *I*-*V* graph for a thermistor is not a straight line through the origin.	**(1)**
2	**B is the correct answer** A is not the correct answer as the amplitude decreases C is not the correct answer as the speed decreases D is not the correct answer as the wavelength decreases	**(1)**
3	**A is the correct answer** B is not the correct answer as TIR can only take place when light is travelling from a more optically dense medium to a less optically dense medium. C is not the correct answer as TIR can only take place when light is travelling from a more optically dense medium to a less optically dense medium. D is not the correct answer as TIR can only take place when light is travelling from a more optically dense medium to a less optically dense medium.	**(1)**
4	**A is the correct answer** B is not the correct answer as the distance between the diffraction grating and the screen is not represented by any letter in this equation. C is not the correct answer as this is $1/d$ D is not the correct answer as this is n	**(1)**
5	**C is the correct answer** A is not the correct answer as the time has not been converted from ms to s. B is not the correct answer as the time has not been converted from ms to s, and the given time has not been halved. D is not the correct answer as the given time has not been halved.	**(1)**
6	**A is the correct answer** B is not the correct answer as both the ammeter and voltmeter readings decrease. C is not the correct answer as the voltmeter reading decreases. D is not the correct answer as the ammeter reading decreases.	**(1)**
7	**C is the correct answer as the possible jumps in energy levels are from n=3 to n=-2, n=3 to n=1 and n=2 to n=1.** A is not the correct answer as there is more than one possible energy level jump. B is not the correct answer as there are more than two possible energy level jumps. D is not the correct answer as there are less than four possible energy level jumps.	**(1)**

8	**D is the correct answer as rarefactions are points where the pressure is a minimum.** A is not the correct answer as there is no displacement of the particles at a compression. B is not the correct answer as the pressure is a maximum at a compression. C is not the correct answer as there is no displacement of the particles at a rarefaction.	**(1)**
9	**B is the correct answer as energy transferred = VQ** A is not the correct answer as energy transferred does not = VQt C is not the correct answer as energy transferred does not = VQ/t D is not the correct answer as energy transferred does not = v/Qt	**(1)**
10	**C is the correct answer as the distance between adjacent nodes is half a wavelength** A is not the correct answer as all points between two adjacent nodes are in phase. B is not the correct answer as antinodes are points of maximum amplitude. D is not the correct answer as stationary waves have no net transfer of energy.	**(1)**

Question Number	Answer	Mark
11	Use of $\lambda = h/p$ (1) Use of $p = mv$ (1) $m = 9.1 \times 10^{-31}$ (kg), so mass is that of an electron **Or** $m = 9.1 \times 10^{-31}$ (kg), so equals m_e **Or** $m = 9.1 \times 10^{-31}$ (kg), so yes it is (1) (MP3 – Do not allow answers that suggest the calculated mass is less than that of an electron, but allow "similar", "about the same") <u>Example of calculation</u> $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}\ \mathrm{J\ s}}{7.37 \times 10^{-10}\ \mathrm{m}} = 9.00 \times 10^{-25}\ \mathrm{kg\ m\ s^{-1}}$ $m = \frac{p}{v} = \frac{9.00 \times 10^{-25}\ \mathrm{kg\ m\ s^{-1}}}{9.89 \times 10^{5}\ \mathrm{m\ s^{-1}}} = 9.10 \times 10^{-31}\ \mathrm{kg}$	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
12ai	Angle of incidence = 58° **and** angle of refraction = 40° (1) Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ (1) Refractive index of glass = 1.3 (1) (Allow MP2 if angles of 32° and 50° are used) <u>Example of calculation</u> $n_1\sin\theta_1 = n_2\sin\theta_2$ $1.00 \times \sin 58° = n_2 \times \sin 40°$ $n_2 = 1.32$	**3**
12aii	Ray drawn refracting away from the normal (1) (Normal line does not need to be drawn on diagram)  	**1**
12b	Use of $n = c/v$ with $c = 3.00 \times 10^8$ ms^{-1} and $n = 1.63$ (1) Speed of light in glass = 1.8×10^8 m s^{-1} (1) <u>Example of calculation</u> $v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m s}^{-1}}{1.63} = 1.84 \times 10^8 \text{ m s}^{-1}$	**2**
	Total for question 12	**6**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>13a</td><td>Z has greater (cross sectional) area than W (1)

So Z has smaller resistance than W (1)

Z has greater current than W (1)

Since $I = nAve$, with both A and I 4 × greater in Z, (drift velocity is the same) (1)</td><td>4</td></tr>
<tr><td>13b</td><td>
<table>
<tr><th>Quantity</th><th>Same value for W and Z</th><th>Larger value in W</th><th>Larger value in Z</th><th></th></tr>
<tr><td>Current in the wires</td><td>×</td><td></td><td></td><td>(1)</td></tr>
<tr><td>Resistance of the wires</td><td></td><td>×</td><td></td><td>(1)</td></tr>
<tr><td>Potential difference across the wires</td><td></td><td>×</td><td></td><td>(1)</td></tr>
<tr><td>Drift velocity of the charge carriers in the wires</td><td></td><td>×</td><td></td><td>(1)</td></tr>
</table>
</td><td>4</td></tr>
<tr><td></td><td>Total for question 13</td><td>8</td></tr>
</table>

Question Number	Answer		Mark
14ai	Use of $\frac{1}{R} = \frac{1}{500\ \Omega} + \frac{1}{600\ \Omega}$ Use of $V = IR$ Voltmeter reading = 6.3 (V) <u>Example of calculation</u> $\frac{1}{R_{\text{parallel}}} = \frac{1}{500\ \Omega} + \frac{1}{600\ \Omega}$, so $R_{\text{parallel}} = 273\ \Omega$ $V = IR = 23.0 \times 10^{-3}\ \text{A} \times 273\ \Omega = 6.28\ \text{V}$	(1) (1) (1)	**3**
14aii	p.d. across thermistor = 12 V – 6.3 V (allow ecf from ai) Use of $P = VI$ (allow use of $P = I^2R$ or $P = V^2 / R$) $P = 0.13$ W <u>Example of calculation</u> p.d. across thermistor = 12.0 V – 6.3 V = 5.7 V $P = VI = 5.7\ \text{V} \times 23 \times 10^{-3}\ \text{A}$ $P = 0.13$ W	(1) (1) (1)	**3**
14b	Resistance (of circuit/thermistor) increases Ammeter reading decreases (dependent on MP1) **Or** Current decreases (dependent on MP1) p.d. across thermistor increases **Or** V=IR for fixed/parallel resistors, and I decreases Reading on voltmeter decreases (dependent on MP3) **Or** p.d. across fixed/parallel resistors decreases (dependent on MP3) (Allow 1 mark maximum if stated that both ammeter and voltmeter readings decrease, and no other marks have been awarded)	(1) (1) (1) (1)	**4**
	Total for question 14		**10**

Question Number	Answer	Mark
*15a	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

- Waves diffract (as they pass through the gaps)
  Or Waves spread out (as they pass through the gaps)
- At X/loud the waves are in phase
  Or at X/loud the path/phase difference is 0
- Constructive interference/superposition at X
  Or constructive interference/superposition when loud
- When moving away (from X), path/phase difference changes
- Destructive interference/superposition when no sound is heard
- This is where the waves are in antiphase
  Or This is where the waves have a path difference of $\lambda/2$

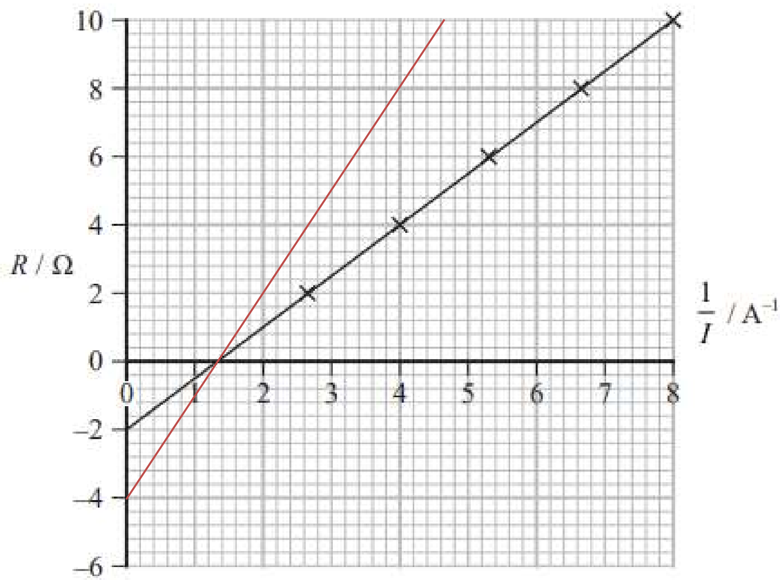
(IC2 – **do not** accept phase difference of 2nπ or path difference of nλ)
(IC6 – allow phase difference of 180° or π radians)
(IC6 – **do not** accept path difference of (n + ½) λ)

Mark: **6**

15b	Light from two lamps is not coherent (1) as the phase relationship/difference is not constant **Or** coherence requires waves to have a constant phase difference (1) (MP2 **-** Allow as wavelength/frequency is not the same **Or** the light is not monochromatic)	**2**
	Total for question 15	**8**

Question Number	Answer	Mark
16ai	Use of area = 1.20 (m) × 0.80 (m) (1) Use of $I = P/A$ (needs to be a dimensionally-correct area) (1) Use of efficiency = useful power output / total power input (1) Efficiency = 14 % (1) <u>Example of calculation</u> P of Sun at solar cell = $I \times A$ = 1040 W m^{-2} × 1.20 m × 0.80 m = 998 W Efficiency = $\frac{140\ \text{W}}{998\ \text{W}}$ = 0.14 (14 %)	**4**
16aii	Any two from: Light from the sun may not be incident on the solar panel at 90° (1) Intensity might be lower due to clouds/rain/fog (1) Light may be reflected at the solar panel (1) Pump may not be 100% efficient (1) Friction between the water and the pipe **Or** Energy transferred to thermal energy (1)	**2**
16bi	Unpolarised has oscillations/vibrations in all/many planes (1) Plane polarised has oscillations/vibrations in one plane (1) which includes the direction of (wave) travel (1) (MP3 dependent on MP1 or MP2 being awarded) **Or** Unpolarised has oscillations/vibrations in all/many directions (1) Plane polarised has oscillations/vibrations in one direction (1) which is perpendicular to the direction of (wave) travel (1) (MP3 dependent on MP1 or MP2 being awarded)	**3**
16bii	(Light directed through a) polarising filter (1) No change in intensity as filter is rotated **Or** if it was polarised, the intensity would change as the filter is rotated (1)	**2**
	Total for question 16	**11**

Question Number	Answer		Mark
17a	Use of sum of e.m.f. = sum of p.d. Correct rearrangement leading to given equation **Or** Total resistance of circuit = $R + r$ Correct rearrangement with total resistance replaced by $\frac{\varepsilon}{I}$ <u>Example of rearrangement</u> $\varepsilon = I\,(R + r)$, so $\frac{\varepsilon}{I} = R + r$, so $R = \frac{\varepsilon}{I} - r$	(1) (1) (1) (1)	**2**
17b	Gradient calculation (to calculate ε) $\varepsilon = 1.5$ V $r = 2\ \Omega$ **OR** $r = 2\ \Omega$ (read from y-intercept) Use of co-ordinates from the graph with the formula $\varepsilon = 1.5$ V	(1) (1) (1) (1) (1) (1)	**3**
17c	Current (in r/R/circuit) decreases Reference to $P = I^2 r$ (Do not allow if R used instead of r) P decreases, so student is correct (MP3 dependent on MP2) **OR** V across r decreases Reference to $P = V^2/r$ (Do not allow if R used instead of r) P decreases, so student is correct (MP3 dependent on MP2) **OR** V across r decreases $P = VI$ **and** current (in r/R/circuit) decreases P decreases, so student is correct (MP3 dependent on MP2) **OR** Current (in r/R/circuit) decreases $P = VI$ **and** p.d. across r decreases P decreases, so student is correct (MP3 dependent on MP2)	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	**3**

17d	Graph is steeper than initial graph and is a straight line (1) Exactly 2 × original gradient (1) y-intercept at −4 Ω (1) 		**3**
	Total for question 17		**11**

Question Number	Answer	Mark
18ai	Use of $E_k = ½ mv^2$ with $m = 9.11 \times 10^{-31}$ kg (1) Conversion of J to eV (1) Energy = 0.35 eV (1) <u>Example of calculation</u> $E_k = ½ \times 9.11 \times 10^{-31}\ \text{kg} \times (3.51 \times 10^5\ \text{m s}^{-1})^2 = 5.60 \times 10^{-20}$ J $E_k = \frac{5.60 \times 10^{-20}\ \text{J}}{1.6 \times 10^{-19}\ \text{J eV}^{-1}} = 0.35$ eV	**3**
18aii	Use of $v = f\lambda$ with $v = 3.00 \times 10^8$ m s^{-1} (1) Use of $E = hf$ (1) Use of $hf = \Phi + ½ mv^2_{max}$ (1) $\Phi = 5.86 \times 10^{-19}$ (J), so the metal is magnesium (1) <u>Example of calculation</u> $E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34}\ \text{J s} \times 3.00 \times 10^8\ \text{m s}^{-1}}{310 \times 10^{-9}\ \text{m}} = 6.42 \times 10^{-19}$ J $\Phi = hf - ½ mv^2_{max} = 6.42 \times 10^{-19}\ \text{J} - 5.60 \times 10^{-20}\ \text{J} = 5.86 \times 10^{-19}$ J $\Phi = 5.86 \times 10^{-19}$ J	**4**
18b	Each photon only interacts with one electron (1) Electrons absorb energy from photons **Or** photons transfer energy to electrons (1) Minimum energy required for an electron to be emitted (1) Higher (photon) energy related to higher frequency(, so frequency of radiation has to be above a particular value) (1) (MP3 – allow correct reference to work function) (MP4 – allow reference to E = hf)	**4**
18c	Any two from: Intensity is related to the number of photons (per second) (1) Intensity is related to the number of (photo)electrons (per second) (1) Intensity does not affect the energy (of the photons/photoelectrons) (1)	**2**
	Total for question 18	**13**

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