GradeMax



Mark Scheme (Results)

October 2021

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:

'Show that' calculation of weight

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]

Example of answer: **3**

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 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.

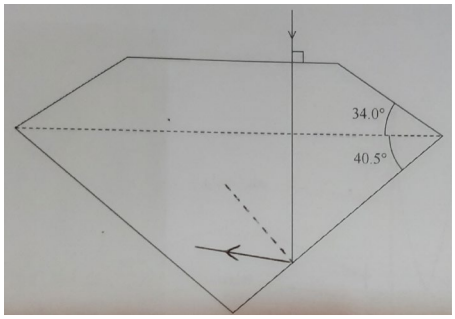
6.4 Points should be plotted to within 1 mm.

- 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	**B is the correct answer as it is a *V-I* graph for a filament lamp** A is not the correct answer as it is not a *V-I* graph for a diode C is not the correct answer as it is not a *V-I* graph for an ohmic conductor D is not the correct answer as it is not a *V-I* graph for a thermistor	**(1)**
2	**C is the correct answer as the distance between the laser and diffraction grating is not required in the equation $n\lambda = d\sin\theta$** A is not the correct answer as the distance from the diffraction grating to the screen is used to calculate θ in the equation $n\lambda = d\sin\theta$ B is not the correct answer as the distance from the central maximum to the first order maximum is used to calculate θ in the equation $n\lambda = d\sin\theta$ D is not the correct answer as the distance between the slits in the diffraction grating is used to calculate d in the equation $n\lambda = d\sin\theta$	**(1)**
3	**C is the correct answer as *v* represents the drift velocity of the charge carriers.** A is not the correct answer as n is the number of charge carriers per m^3 B is not the correct answer as q is the charge per charge carrier D is not the correct answer as A is the cross-sectional area	**(1)**
4	**A is the correct answer as a higher temperature both increases the number of conduction electrons released by a thermistor and increases the amplitude of the lattice vibrations.** B is not the correct answer as the number of conduction electrons does not decrease C is not the correct answer as the amplitude of lattice vibrations does not stay the same D is not the correct answer as neither the number of conduction electrons decrease nor the amplitude of lattice vibrations stay the same.	**(1)**
5	**A is the correct answer as $R = V/I$, and V is measured in JC^{-1} and I is measured in Cs^{-1}.** B is not the correct answer as the units of resistance are not JC^2s^{-1} C is not the correct answer as the units of resistance are not $JC^{-1}\ s^{-1}$ D is not the correct answer as the units of resistance are not JCs	**(1)**
6	**A is the correct answer as $v = \sqrt{(T/\mu)}$, where $T = Mg$ and μ = mass m per unit length, where length = $4L/3$** B is not the correct answer as this suggests the overall length of the string is $2L/3$ C is not the correct answer as this suggests the overall length of the string is L D is not the correct answer as this suggests the overall length of the string is $L/3$	**(1)**

7	**C is the correct answer as the path difference of 12cm is half the wavelength, causing destructive interference (no heating).** A is not the correct answer as the path difference of 12cm would only cause maximum heating if it was a multiple of the wavelength B is not the correct answer as the path difference of 12cm would only cause maximum heating if it was a multiple of the wavelength. D is not the correct answer as the path difference of 12cm would only cause no heating if it was an odd half multiple of the wavelength.	**(1)**
8	**B is the correct answer as, for a uniform wire, the ratio of distances AS:SB is the same as the ratio R_1:R_2, and distance AS = y, distance SB = $x-y$** A is not the correct answer as x is not the distance SB C is not the correct answer as y is not the distance SB D is not the correct answer as the ratio x/y is equivalent to the ratio $(R_1+R_2)/R_1$	**(1)**
9	**B is the correct answer as λ is much smaller than the gap size** A is not the correct answer as λ matches the gap size C is not the correct answer as λ is larger than the gap size D is not the correct answer as λ matches the gap size	**(1)**
10	**D is the correct answer as Z is a full cycle from V, and compressions are separated by one full wave cycle.** A is not the correct answer as W is neither a compression nor a rarefaction B is not the correct answer as X is a rarefaction C is not the correct answer as Y is neither a compression nor a rarefaction	**(1)**

Question Number	Answer	Mark
11a	Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ (1) Use of $n = c/v$ with $c = 3.00 \times 10^8$ (m s^{-1}) (1) $v = 1.4 \times 10^8$ (m s^{-1}) so material is cubic zirconia (1) (For MP1, allow use of n = sin i / sin r) (All marks can be achieved if candidate calculates n for all of the gemstones and compares to value calculated in MP1) <u>Example of calculation</u> $n_1\sin\theta_1 = n_2\sin\theta_2$, 1.00 sin (50°) = n_2 sin (21°), n_2 = 2.14 $n = c/v$, so v = (3.00 × 10^8 m s^{-1}) / 2.14 = 1.4 × 10^8 m s^{-1}	**3**
11bi	Use of sin C = 1/ n where $n = c/v$ (1) Critical angle for diamond is 24° (1) (40.5° > 24°) so diagram shows reflection at the boundary (1) Ray completed showing TIR in correct direction by eye (1) **OR** Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ (1) $n_1\sin\theta_1$ = 1.57 (1) (sin θ_2 > 1) so diagram shows reflection at the boundary (1) Ray completed showing TIR in correct direction by eye (1) (Only allow MP3 if TIR is drawn on the diagram, not just stated)  <u>Example of calculation</u> sin C = 1/ n = (1.24 × 10^8 ms^{-1}) / (3.00 × 10^8 ms^{-1}) = 0.41. C = sin^{-1} (0.41) = 24°	**4**
11bii	Silicon carbide has a greater refractive index (than diamond) **Or** silicon carbide has a smaller critical angle (than diamond) **Or** critical angle for silicon carbide is 23° **Or** critical angle is still less than the angle of incidence **Or** sin θ_2 is still > 1 (1) So total internal reflection (TIR) would (still) take place (MP2 dependent on MP1) (1) (Calculation of n for silicon carbide not good enough for MP1)	**2**
	Total for question 11	**9**

Question Number	Answer	Mark
12(a)	Waves have been reflected by the water surface (1) Transmitted wave and reflected wave interfere **Or** waves travelling in opposite directions interfere (1) (For MP2, allow 'superpose' for 'interfere') (For MP2, do not allow 'opposite waves')	**2**
12(b)(i)	Use of $v = f\lambda$ (1) With λ = 4 × length of column (or see 0.772m) (1) v = 340 ms^{-1} (1) Example of calculation λ = 4 × length of column = 4 × 0.193 m = 0.772 m $v = f\lambda$ = 440 Hz × 0.772 m = 339.7 ms^{-1}	**3**
12(b)(ii)	(Wave)length would be longer **Or** node to antinode distance would be longer (1) This would cause the value (for the speed of sound) to be higher (than calculated value, which is therefore less accurate) (1) (MP2 dependent on MP1) (Answer can be written in the converse e.g. the wavelength used in the calculation is shorter, so the calculated speed is lower).	**2**
	Total for Question 12	**7**

Question Number	Answer		Mark
13a	Use of $P = V^2 / R$ **Or** Use of $P = VI$ **and** $R = V/I$	(1)	
	Use of $R = \rho l / A$	(1)	
	Use of $A = \pi r^2$ or $\pi d^2 / 4$	(1)	
	Length of wire = 2.1 m	(1)	**4**
	<u>Example of calculation</u> $R = V^2 / P = (12V)^2 / 60\ W = 2.4\ \Omega$. $A = \pi r^2 = \pi \times (0.125 \times 10^{-3}\ m)^2 = 4.9 \times 10^{-8}\ m^2$ $l = RA / \rho = (2.4\ \Omega)(4.9 \times 10^{-8}\ m^2) / (5.6 \times 10^{-8}\ \Omega\ m) = 2.1m$		
13b	A has a lower resistance than B **Or** (at 12V) $R_A = 2.4\Omega$. $R_B = 4.8\Omega$	(1)	
	p.d. will not be shared equally between them **Or** B requires/has greater p.d. than A	(1)	
	A will have less than 12V so will not operate normally (so the student is incorrect) **Or** B will have more than 12V so will not operate normally (so the student is incorrect)	(1)	
	OR		
	(at 12V) $I_A = 5A$, $I_B = 2.5A$	(1)	
	(Circuit is series so) current should be the same for both	(1)	
	Either A will have too little current, so will not operate normally (so student is incorrect) **Or** B will have too much current, so will not operate normally (so student is incorrect)	(1)	**3**
	(For MP2 in second alternative, do not allow a calculation of total circuit current = 3.3 A, as this would not be the current in this circuit)		
	Total for question 13		**7**

Question Number	Answer	Mark
14a	(In the wave model) <u>energy</u> is built up over time **Or** (in the wave model) the <u>energy</u> is spread across the wave (1) So (photo)<u>electron</u>s would not be released immediately/instantaneously (1) **Or** so (photo)<u>electron</u>s would be released after a time delay (MP1 – allow any wording indicating a time delay e.g. 'slowly') (MP2 – do not allow "photoelectric emission" unless it is directly linked to <u>electron</u> release)	**2**
14bi	Use of $hf = \Phi + \frac{1}{2}mv^2_{max}$ (1) Converts from eV to J (1) Use of $E_k = \frac{1}{2}mv^2$ (with m = 9.11×10^{-31}) (1) Maximum speed of electrons = 7.3×10^5 ms^{-1} (1) <u>Example of calculation</u> Φ (in J) = 4.3 eV × (1.6×10^{-19} J eV^{-1}) = 6.9×10^{-19} J $hf - \Phi = \frac{1}{2}mv^2$ = (9.3×10^{-19} J) – (6.9×10^{-19} J) = 2.4×10^{-19} J 2.4×10^{-19} J = ½ (9.11×10^{-31} kg) v^2 $v = 7.3 \times 10^5$ ms^{-1}	**4**
14bii	Lower work function (than zinc) would result in greater (maximum) speed (of electrons) (1) Greater wavelength (of ultraviolet light) would result in smaller (maximum) speed (of electrons) **Or** to achieve greater (maximum) speed (of electrons), a smaller wavelength would be required (1) The relative sizes of these changes are not known so no conclusion could be reached **Or** the first suggestion is correct, the second is incorrect (1) (MP1/MP2 – ignore references to KE)	**3**
	Total for question 14	**9**

Question Number	Answer	Mark
15a	See $I_T = I_1 + I_2$ (1) See $V/R_T = V/R_1 + V/R_2$ (1) Divides both sides by V to give $1/R_T = 1/R_1 + 1/R_2$ **Or** V is the same in parallel, so $1/R_T = 1/R_1 + 1/R_2$ (1) (MP3 cannot be awarded for just seeing the equation as this is given on the formula sheet).	**3**
15bi	Use of resistors in parallel formula for N, P and Q (or see 3.3 Ω from relevant working) (1) Adds total to resistance of O (or see 8.3 Ω) (1) Total resistance = 3.1 (Ω) (1) (No unit penalty as is a "show that") (Each step in calculation could be achieved with product/sum calculations, but need to see bracketed values for MP1 and MP2) <u>Example of calculation</u> Resistor N = 5.0 Ω, P + Q = 5.0 Ω + 5.0 Ω = 10.0 Ω $1/R_T$ for N parallel with (P+Q) = (1/5.0 Ω) + (1/10.0 Ω). R_T = 10/3 = 3.3 Ω. O in series with this 3.3Ω, so total for N,O,P,Q section = 25/3 = 8.3 Ω. $1/R_T$ (for whole combination) = (1 / 8.3 Ω) + (1 / 5.0 Ω) R_T = 3.1 Ω	**3**
15bii	Replace resistor M (1) The resistance of a parallel combination is always less than a single resistor in parallel with the others. (1) (MP2 dependent on MP1)_	**2**
	Total for question 15	**8**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*16a</td><td>This question assesses a student's ability to show a coherent and logically structur
answer with linkages and fully sustained reasoning. Marks are awarded for indicat
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
• Atoms/electrons absorb energy/photons
• Electrons move to higher energy levels
• Then drop down energy levels, releasing <u>photons</u>
• Energy levels are discrete
• For hydrogen atoms, there are only a small number of possible energy level differences (that can occur to produce visible light)
• Since $E = hf$ and $v = f\lambda$, only certain wavelengths are emitted

(For IC1, do not allow 'gain energy')
(For IC2 and IC3, allow electrons excited and de-excited)
(IC4, allow 'atoms only have certain/specific energy levels')</td><td>6</td></tr>
<tr><td>16b</td><td>Air contains different gases/molecules/elements/atoms (1)

Each (different) gas has its own energy levels (so light with a large number of wavelengths/frequencies are released) (1)

(MP1 – do not accept 'air is a mixture of different particles')</td><td>2</td></tr>
<tr><td></td><td>Total for question 16</td><td>8</td></tr>
</table>

Question Number	Answer	Mark
17a	Use of $V = W / Q$ or $W = VIt$ (1) ε = 1.56 (V) (1) Use of $V = IR$ (1) Sum of e.m.f.s = Sum of p.d.s **Or** see $\varepsilon = V + Ir$ r = 2.6 Ω (1) (1) **OR** Use of $W = Pt$ With $P = I^2R$ (1) with $R = r + 12$ (1) All other data correctly substituted ($50 = (0.107)^2 (r + 12) 300$) (1) r = 2.6 Ω (1) <u>Example of calculation</u> $\varepsilon = W / Q$ = (50 J) / (0.107 A)(300 s) = 1.56 V $\varepsilon = IR + Ir$, 1.56 V = (0.107 A) (12 Ω) + (0.107 A) r, r = 2.56 Ω	**5**
17b	(Increasing R) decreases I **Or (**Increasing R) gives R a greater share of the total resistance in the circuit (1) Less p.d. across internal resistance **Or** Ir becomes less (Accept decrease in 'lost volts') (1)	**2**
17c	Take readings for p.d. and current (1) Change resistance / R (1) Plot a graph of V against I (1) Gradient is $-r$. (1) (MP4 conditional on MP3) (Allow MP3/4 for graph of I-V with gradient $-1/r$) (A sketch graph of V-I with the gradient labelled $-r$ can achieve MP3/4)	**4**
	Total for question 17	**11**

Question Number	Answer	Mark
18(a)	Use of $I = P / A$ (1) $A = 4\pi r^2$ with $r = 1.50 \times 10^{11}$ (m) (1) Solar intensity at the solar panel = 1350 W m^{-2} (1) <u>Example of calculation</u> For intensity of sunlight at the panel: $I = P / A = (3.83 \times 10^{26}\ W) / 4\pi (1.50 \times 10^{11}\ m)^2 = 1355\ W\ m^{-2}$	**3**
18(b)	Use of $v = f\lambda$ with $v = 3.00 \times 10^8\ m\ s^{-1}$ (1) Use of $E = hf$ (1) Energy of photon = 3.7×10^{-19} (J) (1) (Correct substitution into E = hc/λ can score both MP1 & MP2) <u>Example of calculation</u> $v = f\lambda$, $(3.00 \times 10^8\ m\ s^{-1}) = f \times (532 \times 10^{-9}\ m)$, $f = 5.64 \times 10^{14}$ Hz $E = hf = (6.63 \times 10^{-34}\ J\ s) \times (5.64 \times 10^{14}\ Hz) = 3.74 \times 10^{-19}$ J	**3**
18(c)(i)	Use of speed = distance / time with $v = 3.00 \times 10^8\ m\ s^{-1}$ (1) Height of orbit = 4.8×10^5 m (1) (Allow MP1 for candidates who fail to halve the time) <u>Example of calculation</u> Distance = speed × time = $(3.00 \times 10^8\ m\ s^{-1}) \times (3.20 \times 10^{-3}\ s / 2)$ Height of orbit = 480 km	**2**
18(c)(ii)	Photons from other/unknown sources also arrive at the satellite **Or** only photons emitted (by the laser) should be recorded **Or** other (wavelengths of) photons are not emitted (by the laser) (1) (Allow 'light' or 'waves' for 'photons')	**1**
18(d)	(For a flat surface) measurements give the same time/distance (1) (Higher elevation means that) photons/light will return in less time **Or** $s = vt/2$ gives smaller distance to the ice (1)	**2**
	Total for question 18	**11**

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