Mark Scheme (Results)

Summer 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:

<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] ✓

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 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.

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	**D is the correct answer as the base units of the watt are kgm^2s^{-3}.** A is not the correct answer as the base units of the coulomb are As B is not the correct answer as the base units of the joule are kgm^2s^{-2} C is not the correct answer as the base units of the volt are $kgm^2s^{-3}A^{-1}$	**(1)**
2	**D is the correct answer as speed = $f\lambda$ and $f = 1/T$** A is not the correct answer as the speed of a wave is not related to amplitude B is not the correct answer as the speed of a wave is not related to amplitude C is not the correct answer as this would mean speed = λ / f which is incorrect	**(1)**
3	**B is the correct answer as 0.12 $P = I \times A$** A is not the correct answer (incorrect rearrangement of the equation) C is not the correct answer (incorrect rearrangement of the equation) D is not the correct answer as the surface area of a sphere is not πr^2	**(1)**
4	**D is the correct answer as $v = \sqrt{(T/\mu)}$ and increasing T increases v** A is not the correct answer as this would only alter the wavelength of the wave B is not the correct answer as this does not affect the speed of the wave C is not the correct answer as this would decrease the speed of the wave	**(1)**
5	**A is the correct answer as the correct rearrangement of the de Broglie equation is $v = h / \lambda m$** B is not the correct answer as this is an incorrect rearrangement of the equation C is not the correct answer as this is an incorrect rearrangement of the equation D is not the correct answer as this is an incorrect rearrangement of the equation	**(1)**
6	**D is the correct answer as this is the graph for a thermistor** A is not the correct answer as this is not the graph for a diode B is not the correct answer as this is not the graph for a filament lamp C is not the correct answer as this is not the graph for an ohmic conductor	**(1)**
7	**C is the correct answer there is minimum displacement of particles at both compressions and rarefactions** A is not the correct answer as rarefactions also have minimum displacement B is not the correct answer as compressions also have minimum displacement D is not the correct answer as both compressions and rarefactions have minimum displacement of particles.	**(1)**
8	**B is the correct answer as there is no downwards jump of energy levels equivalent to 0.54eV when falling from the −0.54eV level** A is not the correct answer as this difference in energy levels is produced when an electron falls from the −0.54 eV level to the −0.85 eV level C is not the correct answer as this difference in energy levels is produced when an electron falls from the −1.51eV level to the −13.60 eV level D is not the correct answer as this difference in energy levels is produced when an electron falls from the −0.54 eV level to the −13.60 eV level	**(1)**

9	**C is the correct answer as speed = distance/time and *t* is the time taken for the ultrasound to travel a distance of 2*d*** A is not the correct answer as this does not take into account the fact that the time *t* for the ultrasound travel a distance of 2*d*. B is not the correct answer as the time taken for the ultrasound to return to the boat is unrelated to the frequency of the ultrasound used. D is not the correct answer as the time taken for the ultrasound to return to the boat is unrelated to the frequency of the ultrasound used.	**(1)**
10	**A is the correct answer as 16cm = 2λ (whole number of wavelengths path difference)** B is not the correct answer as this would result in the waves meeting in antiphase (destructive interference) C is not the correct answer as this would result in the waves meeting in antiphase (destructive interference) D is not the correct answer as this would result in the waves meeting in antiphase (destructive interference)	**(1)**

Question Number	Answer	Mark
11(a)	To limit the current (in the circuit) **Or** To avoid overheating/melting (in the circuit) (1)	**1**
11(b)	$\frac{I_W}{I_Z} = 1$ (1) as current is the same around a series circuit. (1) $\frac{v_W}{v_Z} = 0.25$ (or 1:4) (1) as the (cross-sectional) area / A is 4 times less for Z **Or** as the (cross-sectional) area / A is 4 times greater for W (1) (for MP3, allow an answer “<1”) (Do not award MP2 if value for MP1 is incorrect) (Do not award MP4 if value for MP3 is incorrect)	**4**
	Total for question 11	**5**

Question Number	Answer	Mark
12(a)	Potential difference is the energy transfer per unit charge (1)(1) Energy is dissipated in the battery (1) Energy transferred to circuit is less than energy transferred in battery **OR** Potential difference is the energy transfer per unit charge (1) Voltage is dropped across the internal resistance (1) Less voltage is dropped across the rest of the circuit (1) (MP3 via either method is conditional upon awarding MP2) (Allow "lost volts in the internal resistance" for MP2 via 2nd method) (Allow "terminal p.d. is lower" for MP3 via 2nd method)	**3**
12(b)	Use of $I = \frac{V}{R}$ for the whole circuit (1) Use of $V = IR$ for one of the resistors (1) V = 8.5 V (voltmeter reading) (1) (Award 1 mark for candidates using V = IR with any values given in the question) **OR** See ratio of p.d.s compared to ratio of resistances (1) With correct values substituted (1) V = 8.5 V (voltmeter reading) (1) (Award 1 mark for candidates using potential divider formula with any values given in the question). <u>Example of calculation</u> $I = \frac{9.0\text{ V}}{(270+15)\Omega} = 0.0316\text{ A}$ $V = 0.0316\text{ A} \times 270\ \Omega = 8.53\text{ V}$	**3**
12(c)	Use of $V = \frac{W}{Q}$ (1) W = 110 J (1) (Can award MP1 if candidate multiplies any value of V (of 9.0V or less) by the given charge) <u>Example of calculation</u> $W = 9.0\text{ V} \times 12\text{ C} = 108\text{ J}$	**2**
	Total for Question 12	8

Question Number	Answer	Mark
13(a)	Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ (1) r for violet light = 31.9° **or** r for red light = 32.3° (1) Use of trigonometry to calculate horizontal distances whilst in block (1) For violet, distance = 3.98 cm **or** for red, distance = 4.05 cm (1) Distance between points = 0.070 cm / 0.70 mm (1) (If working is only shown to 2 significant figures, the distances will come out to be the same. This can score MP1-4 only if all the working is clearly shown) (For MP1, allow use of $n = \sin i / \sin r$) (If candidate has the n values the wrong way round, MP1 can still be awarded if equation used correctly otherwise) <u>Example of calculation</u> $n_1\sin\theta_1 = n_2\sin\theta_2$. In air, $n_1 = 1.000$ and $\theta_1 = 54.00°$ so, for violet light, $\sin r = \sin(54.00°) / 1.532$, so $r = 31.88°$ For red light, $\sin r = \sin(54.0°) / 1.513$, so $r = 32.32°$ For violet light, $\tan(31.88°) = x / 6.400$ cm, so $x = 3.981$ cm For red light, $\tan(32.32°) = x / 6.40$ cm, so $x = 4.049$ cm Distance between points = 4.049 cm − 3.981 cm = 0.068 cm	**5**
13(b)	Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ (1) Calculates $n\sin\theta$ as 0.99 for red **Or** 1.01 for violet (1) Red light refracts out of the glass as $n\sin\theta < 1$ (1) Violet light undergoes total internal reflection as $n\sin\theta > 1$ (1) (If candidate has the n values the wrong way round, MP1 can still be awarded if equation used correctly otherwise) **OR** Use of $\sin C = 1/n$ (1) Critical angle for violet = 40.7° **Or** critical angle for red = 41.4° (1) Red light refracts out of the glass as $C > i$ (1) Violet light undergoes total internal reflection as $C < i$ (1) <u>Example of calculation</u> $n\sin\theta$ for violet light = 1.532 sin (41.00°) = 1.005. $n\sin\theta$ for red light = 1.513 sin (41.00°) = 0.993.	**4**
	Total for question 13	**9**

Question Number	Answer	Mark
14(a)	Uses $R = V/I$ for resistor (1) **Or** uses potential divider Uses $R = V/I$ for thermistor (1) R for thermistor = 19 Ω (1) Temperature = 32 - 36°C (1) <u>Example of calculation</u> $R = V/I$, $I = V/R$ (for resistor), I = (3.42 V) / (11.5 Ω) = 0.297 A $R = V/I$ (for thermistor) = (9.00 – 3.42 V) / (0.297 A) = 18.8 Ω	**4**
14(b)	Increased e.m.f. leads to greater current (1) (Increased current leads to) greater temperature (1) Resistance of thermistor would decrease (1) (The proportion of the total p.d. across thermistor would decrease so) voltmeter reading would more than double so student incorrect (1) (For MP4 there needs to be a clear conclusion that the student is incorrect)	**4**
	Total for question 14	**8**

Question Number	Answer		Mark
15(a)	Use of $v = f\lambda$ using $v = 3.00 \times 10^8$ (ms^{-1}) Use of $E = hf$ Converts from J to eV Photon energy of source B = 4.43 (eV) (Can achieve MP1 and MP2 together if correctly using $E = hc/\lambda$) (Units are in brackets, as this is a "show that" question, where the units have already been given in the question) (For a "show that" question, the answer needs to be given to at least one more significant figure than that given in the question, so an answer of 4.4eV would not score MP4 unless it is shown to a greater number of significant figures beforehand) (A fully correct reverse calculation, showing that with a 4.4eV energy, the radiation would have a wavelength of 283nm can score a maximum of 3 marks) Example of calculation $v = f\lambda$ so $f = (3.00 \times 10^8\ ms^{-1}) / (280 \times 10^{-9}\ m) = 1.07 \times 10^{15}$ Hz $E = hf$, so $E = (6.63 \times 10^{-34}$ Js$) \times (1.07 \times 10^{15}$ Hz$) = 7.09 \times 10^{-19}$ J in eV, this is $(7.09 \times 10^{-19}$ J$) / (1.60 \times 10^{-19}$ J $eV^{-1}) = 4.43$ eV	(1) (1) (1) (1)	4

***15(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

- Frequency of source A is less than the threshold frequency for either metal.
  Or frequency of source B is less than the threshold frequency for copper but is greater than the threshold frequency for zinc.
- (Photon) energy of source A is less than the work function for either metal
- (Photon) energy of source B is less than the work function for copper but is greater than the work function for zinc.
- Work function of zinc must be between 2.0 eV and 4.4 eV
  Or work function of copper must be greater than 4.4 eV
- Intensity is (linked to) the number of photons per second
- Each photon releases one electron (so greater intensity leads to greater number of electrons per second)

6

Total for question 15	**10**

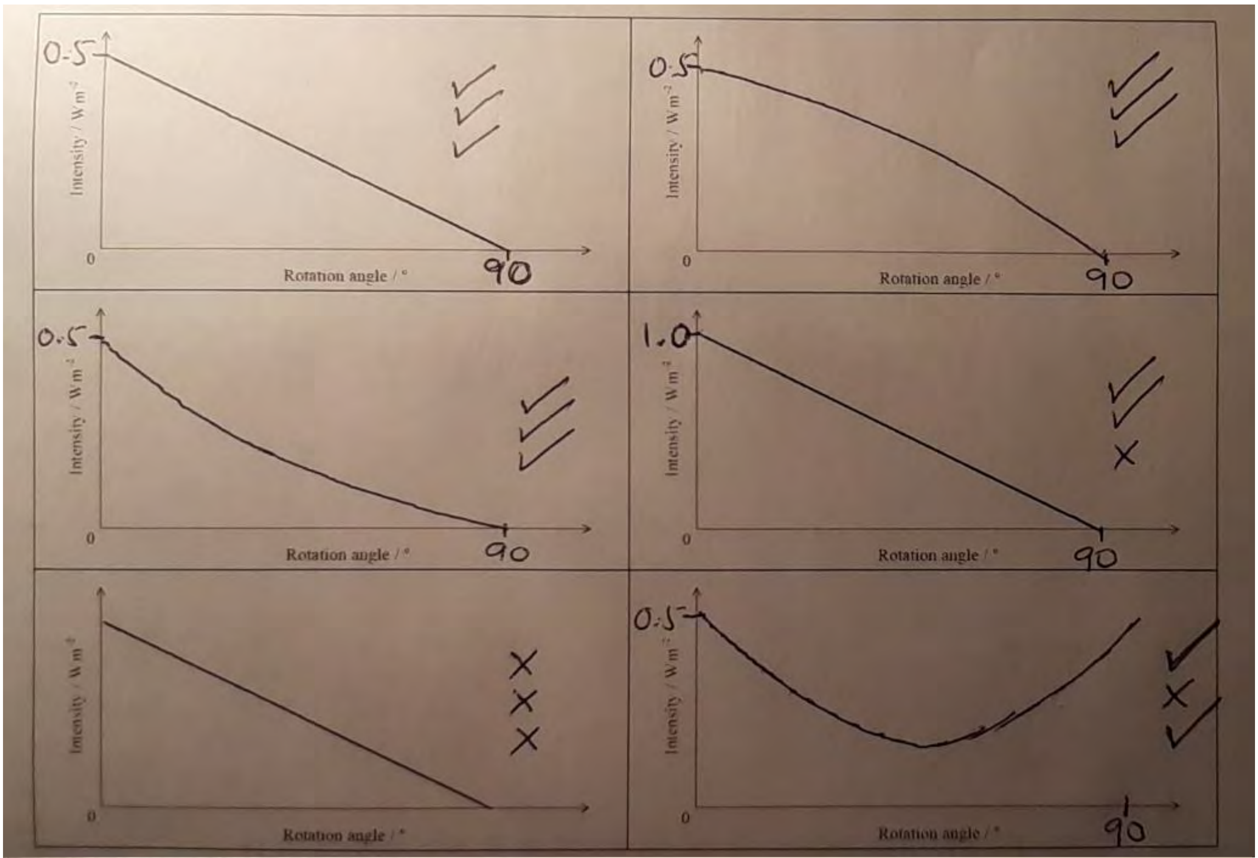
Question Number	Answer		Mark
16(a)	Unpolarised light vibrates/oscillates in all planes Plane polarised light vibrates/oscillates in one plane Including the direction of wave travel **OR** Unpolarised light vibrates/oscillates in all directions Plane polarised light vibrates/oscillates in one direction Perpendicular to the direction of wave travel	(1) (1) (1) (1) (1) (1)	**3**
16(b)	Number(s) added to both axes Single maximum at 0° **and** single minimum at 90° Intensity at 0° $\leq 0.5\ \mathrm{W\,m^{-2}}$ (but not 0) (MP3 cannot be awarded if the graph has a positive gradient) <u>Examples of graphs</u> (These appear at the end of the mark scheme)	(1) (1) (1)	**3**
16(c)	(Polarising) filters at 90° to each other do not allow light to pass through Rotation of plane of polarisation (due to stress) allows light to pass Darker areas represent less stress **Or** brighter areas represent greater stress	(1) (1) (1)	**3**
	Total for question 16		**9**

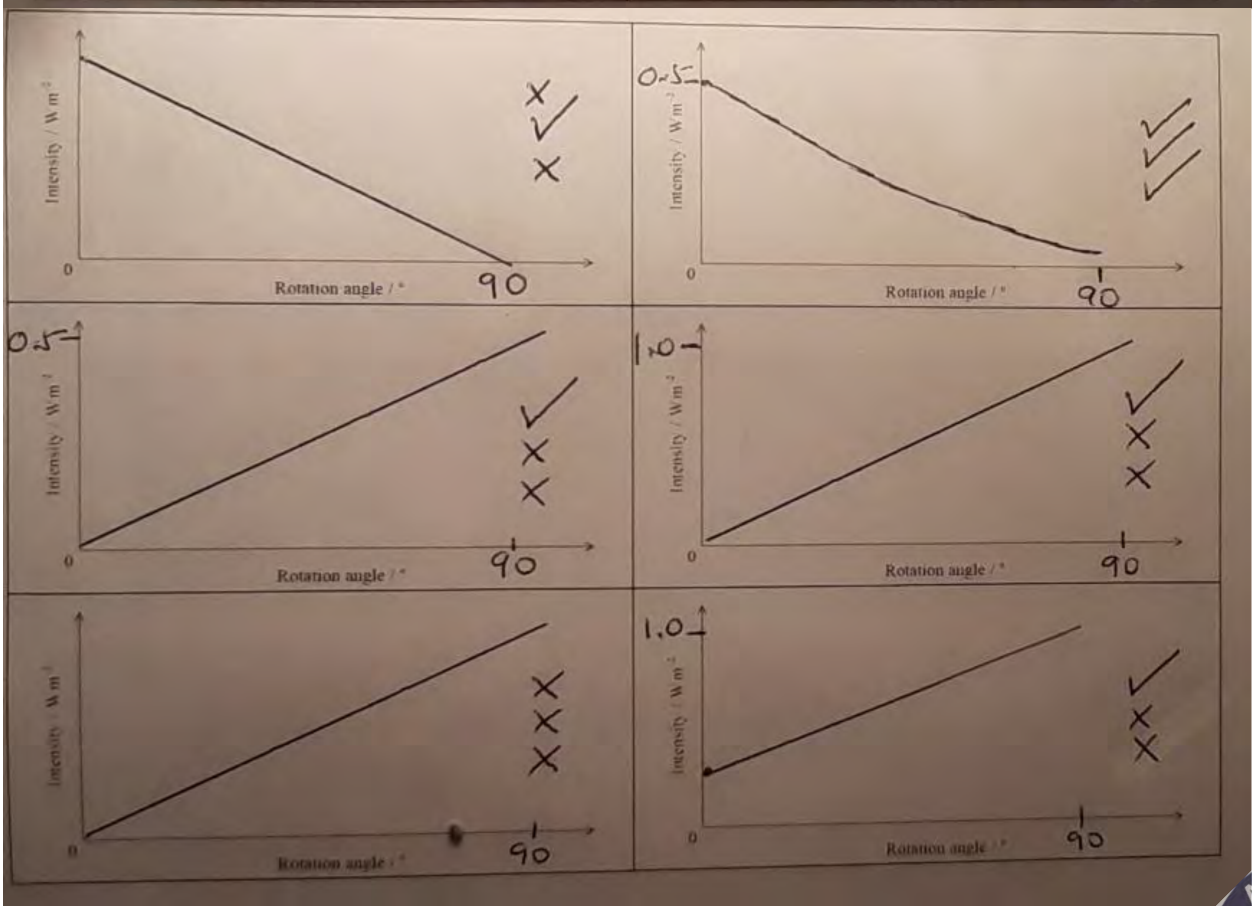
Question Number	Answer		Mark
17(a)	Measure the position of the microphone **Or** measure the distance of the microphone from the speaker	(1)	
	Move microphone gradually until crest on the lower trace lines up with the trough of the top trace and measure the position **Or** move microphone until traces are next in antiphase	(1)	
	(Calculate the) distance moved by the microphone (which) is the wavelength	(1)	
	A method to determine the time period T from the oscilloscope [e.g. time period is approx. 5 x the timebase of the oscilloscope]	(1)	
	Multiply wavelength by $1/T$	(1)	**5**
	(Do not award MP5 for "use $v = f\lambda$")		
17(b)	Amplitude of the upper trace has increased **Or** trough of one trace is (again) aligned to top of the other trace.	(1)	
	Photograph 3 had the microphone closer to the loudspeaker **Or** Microphone has been moved a whole number of wavelengths.	(1)	
	(Sound) intensity varies with distance from loudspeaker	(1)	**3**
	(For "amplitude", allow "height" or "vertical displacement" but not "size" or "displacement")		
	(To award both MP1 and MP2, the statements need to be linked i.e. first alternative in MP1 linked to first alternative in MP2) (MP2 via second alternative can be awarded if candidate states that the microphone has been moved one wavelength)		
	Total for question 17		**8**

Question Number	Answer		Mark
18(a)	Use of $A = \pi r^2$ Use of $R = \rho l / A$ $R = 23.5$ (Ω) (Units are in brackets, as this is a "show that" question, where the units have already been given in the question) (For a "show that" question, the answer needs to be given to at least one more significant figure than that given in the question, so an answer of 24 Ω would not score MP3 unless it is shown to a greater number of significant figures beforehand) (If a candidate uses diameter instead of radius, MP2 can still be awarded if the substituted value for *A* is dimensionally-correct) <u>Example of calculation</u> $A = \pi r^2 = \pi \times (0.0905 \times 10^{-3}\text{ m})^2 = 2.57 \times 10^{-8}\text{ m}^2$ $R = \rho l / A = (1.10 \times 10^{-6}\ \Omega\text{m}) \times (0.550\text{ m}) / (2.57 \times 10^{-8}\text{ m}^2)$ $= 23.5\ \Omega$	(1) (1) (1)	**3**
18(b)	Maximum power when total resistance of circuit is the lowest Calculation of total resistance when X and Y are closed Use of $P = V^2/R$ Maximum power = 9W, which is less than 12 W, so student incorrect (allow full e.c.f. from (a), including situations where power is calculated to be more than 12W so student is correct) (MP1 and MP2 can be awarded if candidate clearly calculates the power when switches X and Y are closed with no explanation). (MP3 can be awarded when candidate has only switch X or switch Y closed) (For MP4 there needs to be a clear conclusion of whether the student is correct or incorrect) (Some students might calculate the power of each individual resistor when both switches X and Y are closed – this is an acceptable method that can gain full credit – look for 6W, 1.5W and 1.5W added to give 9W) <u>Example of calculation</u> When X is closed, $R_{tot} = 23.5\ \Omega + 23.5\ \Omega = 47\ \Omega$ When Y is closed, $R_{tot} = 23.5\ \Omega$ When X and Y are closed, $R_{tot} = \left(\frac{1}{47\ \Omega} + \frac{1}{23.5\ \Omega}\right)^{-1} = 15.7\ \Omega$ $P = V^2 / R$, so greatest power when resistance is lowest, $= (12.0\text{ V})^2 / (15.7\ \Omega) = 9.2\text{ W}$ (If using the "show that" value from (a), power = 9W)	(1) (1) (1) (1)	**4**

18(c)(i)	Use of $R = V / I$ to calculate I Use of $I = Q / t$ **and** number of electrons = Q / e Number of electrons = 3.2×10^{18} (no units) (allow full e.c.f. from (a)) <u>Example of calculation</u> $I = V / R = 12.0\ \text{V} / 23.5\ \Omega = 0.511$ A. $Q = It$ (for 1 second) = 0.511A × 1.0 s = 0.511 C Number of electrons = 0.511 C / (1.60×10^{-19} C) = 3.2×10^{18} electrons (if using the "show that" value from (a), answer = 3.1×10^{18})	(1) (1) (1)	**3**
18(c)(ii)	Temperature of resistor increases Resistance of resistor increases Use of $P = V^2 / R$ to explain that power output falls (For MP3, allow use of $P = VI$ as long as it is clear that I decreases)	(1) (1) (1)	**3**
	Total for question 18		**13**

Example graphs for Q16b





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