Mark Scheme (Results)

June 2019

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 × 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	**D is the correct answer** A is not the correct answer as these are the units of charge B is not the correct answer as these are the units of energy C is not the correct answer as these are the units of force	**(1)**
2	**C is the correct answer** A is not the correct answer as the intensity does not vary as the filter is rotated B is not the correct answer as the intensity does not vary as the filter is rotated D is not the correct answer as one filter will allow some oscillations to pass	**(1)**
3	**D is the correct answer** A is not the correct answer as waves on a string are transverse B is not the correct answer as waves on a string are transverse C is not the correct answer as waves on a vibrating string are not progressive	**(1)**
4	**A is the correct answer (de Broglie wavelength = 2.43×10^{-9} m)** B is not the correct answer as the de Broglie wavelength = 1.82×10^{-9} m C is not the correct answer as the de Broglie wavelength = 1.13×10^{-12} m D is not the correct answer as the de Broglie wavelength = 9.93×10^{-13} m	**(1)**
5	**C is the correct answer** A is not the correct answer as this is the graph for a fixed resistor B is not the correct answer as this is the graph for a filament lamp D is not the correct answer as this graph does not match any component	**(1)**
6	**A is the correct answer** B is not the correct answer as it can be altered to change frequency (CP 5) C is not the correct answer as it can be altered to change frequency (CP 5) D is not the correct answer as it can be altered to change frequency (CP 5)	**(1)**
7	**B is the correct answer** A is not the correct answer as distance has not been doubled C is not the correct answer as time has been doubled, instead of halved D is not the correct answer as distance has been doubled and time halved	**(1)**
8	**D is the correct answer** A is not the correct answer as the two wires are both of the same material B is not the correct answer as the current is the same in parallel C is not the correct answer as the v is the same (if I, n, q and A are constant)	**(1)**
9	**A is the correct answer** B is not the correct answer as it appears in neither of the definitions C is not the correct answer as it only appears in the definition for current D is not the correct answer as it only appears in the definition for p.d.	**(1)**
10	**B is the correct answer** A is not the correct answer as X and Z are in antiphase C is not the correct answer as Y and Z have the same frequency D is not the correct answer as point Z is an antinode	**(1)**

Question Number	Answer	Mark
11	Use of $A = \pi r^2$ (1) Use of $R = \rho l/A$ (1) Resistivity = 2.5×10^{-8} (Ω m) so aluminium (1) (If candidates calculate A as 1.02×10^{-7} m^2 they get 2.6×10^{-8} Ω m) <u>Example of calculation</u> $A = \pi\ (0.18 \times 10^{-3})^2 = 1.0 \times 10^{-7}$ m^2. $\rho = RA/l = (50 \times 10^{-3}\ \Omega)\ (1.0 \times 10^{-7}\ \text{m}^2) / (0.200\ \text{m}) = 2.5 \times 10^{-8}\ \Omega$ m	3
	Total for question 11	**3**

Question Number	Answer	Mark
12a	The average/mean velocity of the (free) electrons (1) (allow "speed" for "velocity", and "charge carriers" for "electrons").	**1**
12b	Use of $I = nqvA$ with e = (−)1.60×10^{-19} (C) (1) v = (−) 3.65×10^{-4} m s^{-1} (1) <u>Example of calculation</u> $v = I/nqA = \frac{1.31\ \text{A}}{(8.49 \times 10^{28}\ \text{m}^{-3})(1.60 \times 10^{-19}\ \text{C})(2.64 \times 10^{-7}\ \text{m}^2)}$ $v = 3.65 \times 10^{-4}$ m s^{-1}	**2**
	Total for question 12	**3**

Question Number	Answer		Mark
13a	Use of $I = P/A$ Use of $A = 4\pi r^2$ $r = 1.47 \times 10^{11}$ m (MP3 can only be awarded if 1410 W m^{-2} has been used) <u>Example of calculation</u> $4\pi r^2 = (3.83 \times 10^{26}\ \text{W}) / 1410\ \text{W m}^{-2}$ r = 1.47×10^{11}m.	(1) (1) (1)	**3**
13b	Mars orbits at a greater distance from the Sun than the Earth as the intensity is lower Mars has a more elliptical orbit than the Earth The (relative) difference between the maximum and minimum intensity for Mars is greater. (All 3 marking points need to be comparisons)	(1) (1) (1)	**3**
	Total for question 13		**6**

Question Number	Answer	Mark
***14**	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.	

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
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

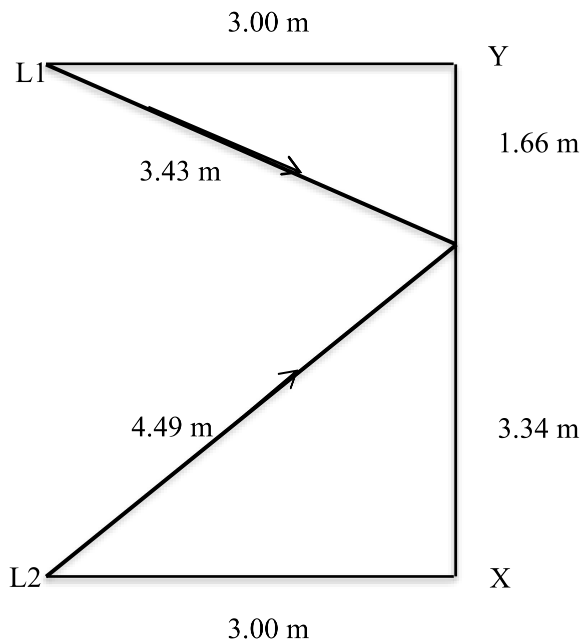
- Minimum / threshold frequency required to release electrons.
- For waves, any frequency would be able to release electrons.
- Release of electrons is instantaneous.
- If the wave model were correct, (energy) would take time to build up before electrons were released.
- (Kinetic) energy of released electrons dependent on frequency.
- If the wave model were correct, the (kinetic) energy of the released electrons would be dependent on the intensity.

6

	Total for question 14	**6**

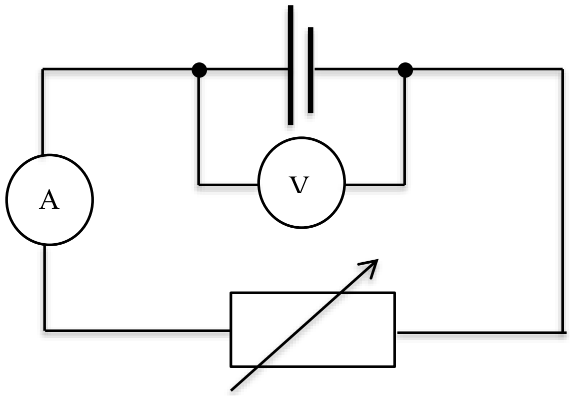
Question Number	Answer		Mark
15a	See $V_T = V_1 + V_2$ See $IR_T = IR_1 + IR_2$ (Divides by I to give) $R_T = R_1 + R_2$	(1) (1) (1)	**3**
15b	Use of $V = IR$ with 7.0V and 0.5A Use of $\frac{1}{Rtot} = \frac{1}{R1} + \frac{1}{R2}$ $R = 12\Omega$ **Or** Use of $V = IR$ with 6Ω and 0.5A (to get 3V across 6Ω resistor) Second use of $V = IR$ with $V = 4$V R = 12Ω <u>Example of calculation</u> R for whole circuit = (7.0V/0.5A) = 14Ω So R for parallel section = 14 – 6 = 8Ω $1/8 = 1/24 + 1/R_2$ $R_2 = 12\Omega$	(1) (1) (1) (1) (1) (1)	**3**
15ci	Use of $V = IR$ to determine circuit current Use of $P = I^2R$ or $P = V^2/R$ or $P = VI$ $P = 1.5 \times 10^{-2}$ W **Or** Ratio of resistances used to calculate p.d. across R Use of $P = V^2/R$ $P = 1.5 \times 10^{-2}$ W <u>Example of calculation</u> $I = 12.0 \text{ V} / (8000 + 670\ \Omega) = 1.38 \times 10^{-3}$ A $P = (1.38 \times 10^{-3} \text{ A})^2 \times 8000 = 0.015$ W	(1) (1) (1) (1) (1) (1)	**3**
15cii	Decrease in the number of conduction/ free electrons Greater resistance of LDR Less p.d. across the fixed resistor (allow "voltage" for "p.d.") Use of a suitable power equation to conclude that less power dissipated in the fixed resistor. (Converse argument not allowed for MP1 & MP2) (For MP4, do not accept an answer that includes an incorrect statement about one of the variables)	(1) (1) (1) (1)	**4**
	Total for question 15		**13**

Question Number	Answer		Mark
16a	(Sodium) electrons/atoms gain/absorb energy And electrons move to higher energy levels (Sodium) electrons drop to lower energy levels, releasing <u>photons</u> (For MP2 & MP3, allow excited and de-excited) (For MP2 & MP3, do not allow “atoms” for “electrons”) (For “levels” accept shells, orbitals, states)	(1) (1) (1)	**3**
16b	Use of $c = f\lambda$ **and** Use of $E=hf$ Converts J to eV Energy = 2.11eV <u>Example of calculation</u> $f = (3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}) / (589 \times 10^{-9}\ \mathrm{m}) = 5.09 \times 10^{14}$ Hz $E = (6.63 \times 10^{-34}\ \mathrm{Js}) \times (5.09 \times 10^{14}\ \mathrm{Hz}) = 3.38 \times 10^{-19}$ J E (in eV) = $(3.38 \times 10^{-19}\ \mathrm{J}) / (1.60 \times 10^{-19}\ \mathrm{J\ eV^{-1}}) = 2.11$eV	(1) (1) (1)	**3**
16c	Uses $\tan\theta = s / D$ Use of $n\lambda = d\sin\theta$ with $n = 1$ Grating has 301 lines / mm, so the label is correct. **OR** Uses $sin\theta = \frac{s}{\sqrt{(s^2+D^2}}$ Use of $n\lambda = d\sin\theta$ with $n = 1$ Grating has 301 lines / mm, so the label is correct. (Use of double slit or single slit equations does not gain any credit) (Allow reverse calculation to show that 300 lines per mm leads to a value of λ that is close to the given value or that 300 lines per mm leads to a value of d or θ that is close to a value calculated). <u>Example of calculation</u> $\tan\theta = 0.234\ \mathrm{m} / 1.30\ \mathrm{m} = 0.18$ $\theta = 10.2°$ $n\lambda = d\sin\theta$, so d = 589×10^{-9} m / sin 10.2° = 3.33×10^{-6} m lines per mm = 1 / 3.33×10^{-3} m = 301.	(1) (1) (1) (1) (1) (1)	**3**
	Total for question 16		**9**

Question Number	Answer		Mark
17a	Path difference is zero **Or** both waves have travelled the same distance from the speakers to O Waves are in phase Constructive interference/superposition takes place	(1) (1) (1)	3
17bi	Use of Pythagoras with 1.66m and 3.00m **Or** Use of Pythagoras with 3.34m and 3.00m Path difference calculated Uses wavelength = 2 × their path difference Use of $v = f\lambda$ Speed of sound = 340 ms^{-1} (dependent on correct calculation) <u>Example of calculation</u> Path length of waves from Speaker 1 = $\sqrt{((3.00\text{ m})^2 + (1.66\text{ m})^2)}$ = 3.43m Path length of waves from Speaker 2 = $\sqrt{((3.00\text{ m})^2 + (3.34\text{ m})^2)}$ = 4.49m Path difference = 1.06m, so λ = 2.12m. $v = f\lambda$ = 160 Hz × 2.12 m = 339ms^{-1} 	(1) (1) (1) (1) (1)	5

17bii	Hard for a person to judge when sound is quietest/loudest (1) As the amplitude on the oscilloscope can be measured more accurately (1) (For “amplitude” allow “maximum”, “minimum”, “displacement”, “loudness” or “quietness”) **Or** Distance between ears is greater than the size of the microphone receiver (1) Less percentage uncertainty in distance measurement taken (1) **Or** Microphone at same level as tape measure whereas ears are higher (1) Distances measured will be different from true distance to ears (1)	**2**
17c	Reflections/echoes from walls/ceiling (in the classroom) would occur (1) Idea that more than two waves meet and interfere/superpose (at any point so maxima/minima less pronounced) (1)	**2**
	Total for question 17	**12**

Question Number	Answer		Mark
18a	For light travelling in a more (optically) dense substance and meeting a less (optically) dense substance **Or** for light travelling a material with higher RI and meeting one with a lower RI Angle of incidence is greater than (or equal to) the <u>critical angle</u>	(1) (1)	**2**
18b	Wave slows down as it enters the glass Part of the wave(front) meets the glass first, so wave direction changes **OR** Refractive index of glass is greater than that of air Or Density of glass is greater than that of air So angle of incidence is greater than the angle of refraction (accept "bends towards the normal")	(1) (1) (1) (1)	**2**
18c	Use of $\sin C = 1/n$ for glass-air boundary Subtracts calculated critical angle from 90° Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ for glass-water boundary $\theta = 59°$ (For MP3, both 1.50 and 1.30 need to be seen in the calculation). <u>Example of calculation</u> Critical angle for glass-air boundary = $\sin^{-1}$(1.00 / 1.50) = 41.8° Angle of incidence for glass-water boundary = 90° - 41.8° = 48.2° 1.50 × sin (48.2°) = 1.30 × (sin θ) $\theta = 59.3°$	(1) (1) (1) (1)	**4**
	Total for question 18		**8**

Question Number	Answer	Mark
19a	Ammeter in series with cell, voltmeter in parallel with cell (1) Variable resistor (1)  (Voltmeter can be drawn in parallel with the (variable) resistor for MP1,as long as there are no other components with resistance in the circuit).	**2**
19b	Line of best fit drawn (1) ε = 0.28 – 0.29 V (1) (Magnitude of) gradient calculated using a best fit line (1) r = 400 – 430 Ω (1) (If no best fit line has been drawn, only MP2 and MP4 are available) Example of calculation Gradient = $\Delta V / \Delta I = -0.18 \text{ V} / (0.44 \times 10^{-3} \text{ A}) = -409\ \Omega$ so r = 409 Ω	**4**

19c	In series/A there is a greater (combined) resistance than in parallel/B **Or** Resistance in series/A is 2R, resistance in parallel/B is R/2. (1) So greater current in parallel/B **Or** so less current in series/A (1) As $\mathcal{E}$ and r the same **Or** since $\mathcal{E} = V + Ir$ **Or** more lost volts in parallel/B (1) Terminal potential difference is greater in series/A (1) **OR** In series/A there is a greater (combined) resistance than in parallel/B **Or** Resistance in series/A is 2R, resistance in parallel/B is R/2. (1) as $\mathcal{E}$ and r the same (1) $V = \frac{\varepsilon R}{R+r}$ (1) Terminal potential difference is greater in series/A (1)	**4**
	Total for question 19	**10**