Pearson Edexcel

Mark Scheme (Results)

October 2020

Pearson Edexcel International Advanced Subsidiary/Advanced Level
In Physics (WPH012)
Paper 1: 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] ✓ **1**
[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.]

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	**C is the correct answer** as to calculate speed, the wavelength is determined from the displacement-distance graph and multiplied by the frequency which is determined from the displacement-time graph. A is not the correct answer as this can be determined from either graph B is not the correct answer as this can be determined from the displacement-time graph only D is not the correct answer as this can be determined from the displacement-distance graph only	**(1)**
2	**C is the correct answer** as a path difference of λ is equivalent to a phase difference of 360°, so $3\lambda/8$ is equivalent to 3/8ths of 360° which = 135° A is not the correct answer as 34° is 3/8ths of 90° B is not the correct answer as 68° is 3/8ths of 180° D is not the correct answer as 270° is 3/8ths of 720°	**(1)**
3	**D is the correct answer** as $n\lambda = d\sin\theta$ where $n = 1$ and $d = 1/300$. $\tan\theta$ = 0.40m / 2.00m. A is not the correct answer as the wavelength is not $300\sin\theta$ B is not the correct answer as the wavelength is not $300\sin\theta$ C is not the correct answer as θ is not $\sin^{-1}$ (0.40/2.00)	**(1)**
4	**B is the correct answer** as power is a derived quantity A is not the correct answer as current is a base quantity C is not the correct answer as the coulomb is a derived unit D is not the correct answer as the volt is a derived unit	**(1)**
5	**A is the correct answer** as a large change in density causes most of the ultrasound to reflect, so the ultrasound does not penetrate deeper into the body. B is not the correct answer as this does not affect whether ultrasound can enter the lungs C is not the correct answer as this does not affect whether ultrasound can enter the lungs D is not the correct answer as ultrasound is not considered to cause damage to the body.	**(1)**
6	**D is the correct answer** as it is the graph for a thermistor A is not the correct answer as it is not a graph for a diode B is not the correct answer as it is not a graph for a filament lamp C is not the correct answer as it is not a graph for a resistor	**(1)**
7	**A is the correct answer** as $\rho = VA / Il$, where $A = x^2$ and $l = x$ B is not the correct answer C is not the correct answer D is not the correct answer	**(1)**
8	**D is the correct answer** as only transverse waves can be polarised A is not the correct answer as only transverse waves can be polarised B is not the correct answer as only transverse waves can be polarised C is not the correct answer as only transverse waves can be polarised	**(1)**

9	**B is the correct answer** as v α $1/A$ when I, n and q are the same. A is not the correct answer as both wires have the same charge carrier density as they are both made from copper. C is not the correct answer as both wires have the same current as they are in series D is not the correct answer as the length of the wire is not related to drift velocity	**(1)**
10	**D is the correct answer** as the sum of the e.m.f.s is equal to the sum of the p.d.s in the circuit. A is not the correct answer as if the resistance of the LDR halved the voltmeter reading would increase. B is not the correct answer as increasing the light intensity would increase the voltmeter reading (as the LDR would have a lower resistance) C is not the correct answer as increasing the light intensity would increase the voltmeter reading (as the LDR would have a lower resistance)	**(1)**

Question Number	Answer	Mark
11a	Use of $n_1\sin\theta_1 = n_2\sin\theta_2$ with both 1.33 and 1.52 seen (1) angle of refraction = 37° (1) **<u>Example of calculation</u>** $n_1\sin\theta_1 = n_2\sin\theta_2$ 1.33 sin (43°) = 1.52 sin r r = 36.6°	**2**
11b	Use of sin $C = 1/n$ (1) critical angle = 61° (1) **OR** Use of sin C = 1 / 1.14 (if ratio calculated in (a)) (1) critical angle = 61° (1) (Allow an ecf of n_1/ n_2 ratio from (a)) **<u>Example of calculation</u>** sin $C = 1/n$ $C = \sin^{-1}$ (1.33/1.52) = 61.0°	**2**
	Total for question 11	**4**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>12(a)</td><td>Uses ratio of resistances to p.d.s
V = 1.2 V

OR
Use of $R = V/I$
V = 1.2 V

<u>Example of calculation</u>
$V = \left(\frac{55\ \text{k}\Omega}{12\ \text{k}\Omega + 55\ \text{k}\Omega}\right) \times 1.5\ \text{V} = 1.23\ \text{V}$</td><td>(1)
(1)

(1)
(1)</td><td>2</td></tr>
<tr><td>12(b)</td><td>1 mark for each correct reason
1 mark for each explanation

<table><tr><th>Reason</th><th>Explanation</th></tr><tr><td>Cell has (internal) resistance</td><td>Terminal/cell p.d. is lower
Or lost volts</td></tr><tr><td>Resistance in wires/connections</td><td>Wires/connections have p.d. across them too.</td></tr><tr><td>Voltmeter has a “low” resistance
Or voltmeter draws current</td><td>Resistance of parallel combination would be less than 55 kΩ (so p.d. would be lower)</td></tr></table></td><td>(1)(1)
(1)(1)</td><td>4</td></tr>
<tr><td></td><td>Total for question 12</td><td></td><td>6</td></tr>
</table>

Question Number	Answer	Mark
13a	Use of $v = f\lambda$ (1) $\lambda = 0.40$ (m) (1) Wave is suitable (1) **OR** Use of $v = f\lambda$ (1) $f = 850$ (Hz) / 0.85 (kHz) (1) Wave is suitable (1) **OR** Use of $v = f\lambda$ (1) $v = 340$ (m/s) (1) Wave is suitable (1) (MP3 by any method is dependent upon awarding both MP1 and MP2) **<u>Example of calculation</u>** $v = f\lambda$ $340\ \text{m s}^{-1} = 850\ \text{Hz} \times \lambda$ $\lambda = 0.40$ m	**3**

Question	Answer	Mark
*13b	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

- Sound (from ANR) has to diffract to reach the furthest/right ear
- (Sound) cancelled when destructive interference takes place
- (Sound) louder when constructive interference takes place
- Destructive interference is where waves are in antiphase
- Constructive interference is where waves are in phase
- When distance between the ears is half a wavelength
  Or distance between the ears is approximately 20cm.

(For IC1, do not allow "noise from engine diffracts to reach the right ear")
(For IC2 to IC5, interference or superposition are accepted)
(For IC2 and IC3 accept correct reference to minimum/maximum amplitude)
(For IC4 and IC5, accept answers in terms of path difference. However, path difference must be in terms of λ and phase difference in terms of π or °)

Linkage mark 1 – needs at least 2 from IC1-IC3 to consider this.
Linkage mark 2 – needs at least 2 from IC4-IC6 to consider this.

6

	Total for question 13	**9**

Question Number	Answer	Mark
14a	Minimum energy required to release a(n) (photo)electron (from the surface of a metal) (1)	**1**
14b	Use of $E = hf$ (1) Use of $hf = \Phi + \frac{1}{2} mv^2_{max}$ (1) $\Phi = 5.90 \times 10^{-19}$ (J) so metal is magnesium (1) **<u>Example of calculation</u>** $E = hf = (6.63 \times 10^{-34}\ \text{Js}) \times (6.32 \times 10^{15}\ \text{Hz}) = 4.19 \times 10^{-18}\ \text{J}$ $hf - \frac{1}{2} mv^2_{max} = 4.19 \times 10^{-18}\ \text{J} - 3.60 \times 10^{-18}\ \text{J} = 5.90 \times 10^{-19}\ \text{J}$ so metal used is magnesium.	**3**
14ci	Use of $I = P/A$ (1) Use of $P = W/t$ with $W = 3.62 \times 10^{-19}$ (J) (1) $t = 118$ s (1) **<u>Example of calculation</u>** $I = P/A$, $(38.0 \times 10^{-3}\ \text{Wm}^{-2}) \times (8.10 \times 10^{-20}\ \text{m}^2) = 3.08 \times 10^{-21}$ W. $t = W/P$, $(3.62 \times 10^{-19}\ \text{J}) / (3.08 \times 10^{-21}\ \text{W}) = 118$ seconds.	**3**
14cii	One photon releases one electron (1) Photons transfer all of their energy to the electrons **Or** Photons are packets/quanta of energy (1)	**2**
	Total for question 14	**9**

Question Number	Answer		Mark
15a	Substitutes values into $E = (\frac{e^2}{kh})^2 (\frac{m}{8})$	(1)	
	Converts J into eV	(1)	
	13.5eV or 13.6 eV	(1)	**3**
	(MP3 is dependent upon correct working being shown)		
	<u>Example of calculation</u> $E = = \frac{(1.60 \times 10^{-19} \text{C})^4 \ (9.11 \times 10^{-31} \text{ kg})}{(8.85 \times 10^{-12} \text{ Fm}^{-1})^2 \ (6.63 \times 10^{-34} \text{ Js})^2 \times 8}$ $E = 2.17 \times 10^{-18}$ J $(2.17 \times 10^{-18}$ J) / $(1.60 \times 10^{-19}$ J eV^{-1}) = 13.56eV		
15b	Substitutes values into $r = \frac{h^2 k}{\pi m e^2}$	(1)	
	$r = 5.3 \times 10^{-11}$ (m)	(1)	
	Use of $\lambda = h/p$	(1)	
	$\lambda = 2.8 \times 10^{-14}$ (m) (for neutron)	(1)	
	neutron wavelength not similar to size of atom radius, so student is incorrect	(1)	**5**
	(MP5 is dependent upon awarding all of MP1-4 and there needs to be some comparison of the two values)		
	(allow MP1 and/or MP3 for candidates who substitute the incorrect mass into the equation e.g. mass of neutron where it should be mass of electron in MP1)		
	<u>Example of calculation</u> $r = \frac{h^2 k}{\pi m e^2} = \frac{(6.63 \times 10{-}34 \text{ Js})^2 (8.85 \times 10{-}12)}{\pi \ (9.11 \times 10{-}31 \text{ kg})(1.60 \times 10{-}19 \text{ C})^2}$ r = 5.31×10^{-11} m For neutron, $\lambda = h/p = (6.63 \times 10^{-34}$ Js) / $(1.67 \times 10^{-27}$ kg) $(1.4 \times 10^{7}$ m s^{-1}) = 2.84×10^{-14} m		
	Total for question 15		**8**

Question Number	Answer		Mark
16a	Idea that when waves rise from 900 m depth they speed up **Or** indication that speed at 700m is greater than at 900m	(1)	
	Curving is due to the change in speed being gradual **Or** not a sudden change in direction as there is no sudden change in speed.	(1)	
	Waves are refracted away from the normal	(1)	
	Angle of incidence reaches/exceeds the critical angle (at 700m) **Or** angle of refraction becomes 90° (at 700m)	(1)	
	(At 700 m, total internal) reflection takes place (allow TIR)	(1)	**5**
16b	Path in diagram B is a longer (distance) **Or** straight line path is a shorter (distance)	(1)	
	Sound waves travel faster on path in diagram B **Or** sound waves travel slower on straight line path **Or** sound waves travel faster at 700m than at 900m	(1)	**2**
16c	Any **two** from:		
	(Change in) temperature in the sea (Change in) pressure in the sea (Change in) density/salinity of the sea	(1) (1) (1)	**2**
	Total for question 16		**9**

Question Number	Answer		Mark
17a	(Two) waves travelling in opposite directions **Or** wave meeting its reflection Nodes are points of zero/minimum amplitude **and** antinodes are points of maximum amplitude Nodes linked to destructive interference **and** antinodes linked to constructive interference	(1) (1) (1)	**3**
17b	Equates $v = f\lambda$ and $v = \sqrt{(T/\mu)}$ Rearranges to give $f^2 = \frac{T}{\mu\lambda^2}$ **Or** $f^2 = \frac{T}{\mu(2L)^2}$ Replaces T with W in equation Where μ and λ are constants **Or** where μ and L are constants $f^2 \alpha W$ **Or** no "c" in "$y=mx+c$" **Or** y-intercept is 0 **Or** in the format $y = mx$ (MP5 is dependent on some correct working leading to an equation) (Award MP4 if stated that $\frac{1}{\mu\lambda^2}$ = constant or equivalent in terms of l)	(1) (1) (1) (1) (1)	**5**
17c	(Connect signal generator to) cathode ray oscilloscope **Or** record movement of the string with a video camera (Measure time period T and) calculate $f = 1/T$	(1) (1)	**2**
17d	Use of $v = \sqrt{(T/\mu)}$ Identifies that $\lambda = 2L$ $\mu = 4.3 \times 10^{-4}$ kg m^{-1} **<u>Example of calculation</u>** $f\lambda = \sqrt{(T/\mu)}$, 659 Hz × (2 × 0.328 m) = $\sqrt{(80.0 \text{ N} / \mu)}$, $\mu = 4.3 \times 10^{-4}$ kg m^{-1}	(1) (1) (1)	**3**
	Total for question 17		**13**

Question Number	Answer		Mark
18a	Use of resistors in parallel formula Resistance of parallel section of circuit calculated as 1.33Ω Total circuit resistance = 2Ω + their parallel resistance **Or** Use of ratio of resistance:p.d. Use of $I = V/R$ to calculate total circuit current (3A) **Or** Use of $I = V/R$ to calculate p.d. across resistor A (6V) Use of $P = VI$, $P = V^2/R$ or $P = I^2R$ A = 18W, B = 2W, C = 2W, D = 8W **<u>Example of calculation</u>** $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ (for parallel combination) $\frac{1}{Rp} = \frac{1}{2} + \frac{1}{4}$ $R_p = 1.33\ \Omega$ Total resistance in circuit = (1.33 + 2.00) = 3.33 Ω $I = V/R$ (for whole circuit) = 10.0 V / 3.33 Ω = 3.00 A For resistor A, $P = I^2R$ = $(3.00\text{ A})^2 \times 2.00\ \Omega$ = 18 W Current through D = $\frac{2}{3}$ (3.00 A) = 2.00 A For D, $P = I^2R$ = $(2.00\text{ A})^2 \times 2.00\ \Omega$ = 8 W For B and C, $P = I^2R$ = $(1.00\text{ A})^2 \times 2.00\ \Omega$ = 2 W	(1) (1) (1) (1) (1) (1)	**6**
18b	(With resistor D removed there is) lower circuit current **Or** (with resistor D removed there is) lower p.d. across A Seeing an appropriate power equation to support the conclusion that power would be less in A	(1) (1)	**2**
18c	As p.d increases, current increases (As current increases,) temperature increases (allow "heats up") Atoms/ions/lattice have greater vibrations/KE Increased rate of collisions between electrons and atoms/ions	(1) (1) (1) (1)	**4**
	Total for question 18		**12**

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