Mark Scheme (Results)

October 2022

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH12)
Paper 01 Waves and Electricity

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

October 2022
Question Paper Log Number P71879A
Publications Code WPH12_01_2210_MS

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.

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. '<u>resonance</u>'

1.2 Bold lower case will be used for emphasis e.g. '**and**' when two pieces of information are needed for 1 mark.

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 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in ePen.

2.4 Occasionally, it may be decided not to insist on a 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.

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

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 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 mean that one mark will not be awarded (but not more than once per clip). Accept $9.8\ m\ s^{-2}$ or $9.8\ N\ kg^{-1}$

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers may score full marks.

4.2 Some working is expected for full marks to be scored in a 'show that' question or an extended calculation question.

4.3 If a 'show that' question is worth 2 marks, then both marks will be available for a reverse working. If the question is worth 3 marks then only 2 marks will be available.

4.4 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.

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

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.

Question Number	Answer	Mark
1	**D is the correct answer** A is not the correct answer as the speed of a wave is independent of its amplitude. B is not the correct answer as the speed of a wave is independent of its amplitude. C is not the correct answer as period and frequency are both related to time. To calculate speed, a quantity involving distance is also required.	**(1)**
2	**A is the correct answer** B is not the correct answer as this transition would result in the emission of a photon with the shortest wavelength. C is not the correct answer as the arrow direction indicates absorption rather than emission. D is not the correct answer as the arrow direction indicates absorption rather than emission.	**(1)**
3	**D is the correct answer** A is not the correct answer as increasing temperature causes an increase in current for this circuit. B is not the correct answer as increasing temperature causes an increase in current for this circuit. C is not the correct answer as increasing temperature decreases the p.d. across the thermistor, but increases the p.d. across the fixed resistor.	**(1)**
4	**A is the correct answer** B is not the correct answer as both compressions and rarefactions have zero displacement of molecules at their centre. C is not the correct answer as both compressions and rarefactions have zero displacement of molecules at their centre. D is not the correct answer as both compressions and rarefactions have zero displacement of molecules at their centre.	**(1)**
5	**C is the correct answer** A is not the correct answer as the graph on the right is that of a diode. B is not the correct answer as the graph in the middle is that of a filament bulb. D is not the correct answer as the graph on the left is that of an ohmic conductor.	**(1)**

6	**B is the correct answer** A is not the correct answer as increasing the temperature of a metal wire causes an increase in the amplitude of lattice vibrations. C is not the correct answer as a change in the number of conduction electrons is normally related to semiconductors. D is not the correct answer as a change in the number of conduction electrons is normally related to semiconductors.	**(1)**
7	**A is the correct answer** B is not the correct answer as the total charge (1.25×45 C) is divided by e to establish the number of electrons passing in 45 seconds. C is not the correct answer as the total charge (1.25×45 C) is divided by e to establish the number of electrons passing in 45 seconds. D is not the correct answer as the total charge (1.25×45 C) is divided by e to establish the number of electrons passing in 45 seconds.	**(1)**
8	**A is the correct answer** B is not the correct answer as the light reflected is polarised. C is not the correct answer as some of the light is reflected. D is not the correct answer as the rest of the light is refracted.	**(1)**
9	**B is the correct answer** A is not the correct answer as the number of pulses detected is not related to the amount of interference that takes place. C is not the correct answer as the number of pulses detected is not related to the frequency of the waves. D is not the correct answer as the number of pulses detected is not related to the wavelength of the waves.	**(1)**
10	**C is the correct answer** A is not the correct answer as these are units of charge. B is not the correct answer as these are units of power. D is not the correct answer as these are units of the Planck constant, which is not equivalent to a volt.	**(1)**

Question Number	Answer		Mark
11	(The pattern shows that) diffraction is taking place (The pattern shows that) interference/superposition is taking place Bright/Maxima related to Constructive (interference) **Or** Dark/Minima related to Destructive (interference)	(1) (1) (1)	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12a	Ammeter in series with cell and an external component with resistance Voltmeter parallel with cell Variable resistor included in circuit	(1) (1) (1)	**3**
12b	(Uses conservation of energy to) obtain the equation $\varepsilon = V + Ir$ Compares $\varepsilon = V + Ir$ with $y = mx + c$ e.m.f. is the y-intercept of the graph Internal resistance is the negative of the gradient	(1) (1) (1) (1)	**4**
	Total for question 12		**7**

Question Number	Answer		Mark
13a	Use of $R = V/I$ (to find resistance of whole circuit) Subtracts 9 Ω from 11 Ω (to get 2 Ω) Use of resistors in parallel formula $R = 6.0\ \Omega$ (MP3 - Allow $2 = \frac{3R}{3+R}$) **OR** Use of $R = V/I$ (to find V across 9.0 Ω resistor) Subtracts 1.26V from 1.54V (to get 0.28V) Conservation of charge used to establish current in R (0.467 A) $R = 6.0\ \Omega$ <u>Example of calculation</u> $R = V/I$ for whole circuit = 1.54 V / 0.14 A = 11 Ω Resistance of parallel section = 11 Ω − 9 Ω = 2 Ω $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$, so $\frac{1}{R} = \frac{1}{2} - \frac{1}{3} = \frac{1}{6}$ So $R = 6\ \Omega$ **OR** $V = IR$ for 9.0 Ω resistor = 0.14 A × 9.0 Ω = 1.26 V p.d. across 3.0 Ω resistor and resistor R = 1.54 V – 1.26 V = 0.28 V (for 3.0 Ω resistor) $I = V / R$ = 0.28 V / 3.0 Ω = 0.0933 A Current in resistor R = 0.14 A – 0.0933 A = 0.0467 A $R = V / I$ = 0.28 V / 0.0467 A = 6.0 Ω	(1) (1) (1) (1) (1) (1) (1) (1)	**4**

13bi	Use of cross-sectional area = πr^2 (1) Cross-sectional area = 1.8×10^{-8} (m^2) (1) ("Show that" so units not required) (MP1 – not awarded if diameter is used) <u>Example of calculation</u> cross-sectional area = $\pi r^2 = \pi \left(\frac{0.15 \times 10^{-3}\,\text{m}}{2}\right)^2 = 1.77 \times 10^{-8}\ \text{m}^2$	**2**
13bii	Use of $R = \rho l/A$ (1) Length of copper wire = 9.5 m (1) (e.c.f. from (b)(i)) (Answer using "show that" value = 10.7 m) <u>Example of calculation</u> $l = \frac{RA}{\rho} = \frac{(9.0\ \Omega)(1.77 \times 10^{-8} m^2)}{(1.68 \times 10^{-8}\Omega\text{m})} = 9.48$ m	**2**
13biii	Use of $I = nqvA$ (1) $v = 5.8 \times 10^{-4}$ m s^{-1} (1) (e.c.f. from b(i)) (Answer using "show that" value = 5.2×10^{-4} m s^{-1}) (ignore minus sign on answer) <u>Example of calculation</u> $v = \frac{I}{nqA} = \frac{(0.14\ \text{A})}{(8.49 \times 10^{28} m^{-3})(1.60 \times 10^{-19} C)(1.77 \times 10^{-8} m^2)} = 5.8 \times 10^{-4}$ m s^{-1}	**2**
	Total for question 13	**10**

Question Number	Answer	Mark
14a	The electron only receives energy from one photon **Or** there is a one to one interaction between photons and electrons (1) Some of the photon energy is needed to overcome the work function **Or** There is a minimum energy required to release electrons from the (surface of the) plate (1) Remaining photon energy is transferred to kinetic energy of electron (and is therefore lower than photon energy) **Or** Photon energy is shared between the work function and kinetic energy of electron (so kinetic energy less than photon energy) (1)	3
14b	Use of $E_k = ½ mv^2$ (1) Use of $hf = \Phi + ½ mv^2{}_{max}$ (1) Conversion of work function from eV into J (1) $f = 1.1 \times 10^{15}$ (Hz), so source A (1) <u>Example of calculation</u> $E_k = ½ mv^2 = ½ \times 9.11 \times 10^{-31}$ kg $\times (5.70 \times 10^5$ m s$^{-1})^2 = 1.48 \times 10^{-19}$ J $\Phi = 3.68$ eV $\times 1.60 \times 10^{-19}$ J eV$^{-1} = 5.89 \times 10^{-19}$ J $hf = 1.48 \times 10^{-19}$ J $+ 5.89 \times 10^{-19}$ J $= 7.37 \times 10^{-19}$ J $f = \frac{7.37 \times 10^{-19}\text{ J}}{6.63 \times 10^{-34}\text{Js}} = 1.11 \times 10^{15}$ Hz, so source A	4
	Total for question 14	**7**

Question Number	Answer	Mark
15ai	Divides 2Hz by 880 or 881Hz or 882Hz (1) 0.23% / 0.2% is less than 0.3% (so heard as same frequency) (1) **OR** Calculates 0.3% of 880 Hz or 882Hz (1) 879.4 Hz is less than 880 Hz (so heard as same frequency) **Or** 882.6 Hz is greater than 882 Hz (so heard as same frequency) **Or** 2.6 Hz is greater than 2 Hz (so heard as the same frequency) (1) Example of calculation $\frac{(882-880)\text{ Hz}}{882\text{ Hz}} \times 100 = 0.23\%$	**2**

***15aii**

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

- The two sound waves are not coherent (as they have a different frequency)
- As they do not have a constant phase relationship/difference
  Or the phase difference changes
- Loud sounds related to constructive interference/superposition
- Quiet sounds related to destructive interference/superposition
- Constructive/loud sounds when in phase
- Destructive/quiet sounds when out of phase

(IC5 – allow phase difference of 2nπ radians / 0°)
(IC6 – allow antiphase or phase difference of π radians / 180°)
(Do not accept answers in terms of path differences or λ)

6

15b	Use of $v = f\lambda$ (1) $\lambda = 2L$ used (1) Use of $v = \sqrt{(\frac{T}{\mu})}$ (1) Decrease in tension = 2.5 N (1) <u>Example of calculation</u> $(f\lambda)^2 = T/\mu$ $\lambda = 2L = 2 \times 0.187 = 0.374$ m for 882 Hz, $(882 \text{ Hz} \times 0.374 \text{ m})^2 = T / 5.08 \times 10^{-3}$ kg m^{-1} $T = 552.8$ N for 880 Hz, $(880 \text{ Hz} \times 0.374 \text{ m})^2 = T / 5.08 \times 10^{-3}$ kg m^{-1} $T = 550.3$ N decrease in $T = 2.5$ N	**4**
	Total for question 15	**12**

Question Number	Answer	Mark
16ai	Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ (1) with $\sin \theta_2$ as 1 (1) critical angle = 75.1(°) (1) **Or** calculates ratio $n_2 : n_1$ (1) Use of $\sin C = 1/n$ (1) critical angle = 75.1(°) (1) <u>Example of calculation</u> $n_1 \sin \theta_1 = n_2 \sin \theta_2$ $1.48 \times \sin C = 1.43 \times \sin 90°$ $C = 75.1°$	**3**
16aii	Angle of incidence measured/stated in range 79-81° (1) This is greater than the critical angle (1) <u>Total internal</u> <u>reflect</u>ion takes place (1) (MP1 can be awarded for seeing angle correctly marked on diagram) (If no angle of incidence measured, score 0) (MP3 dependent upon awarding MP2) (MP2 and MP3 can be awarded if angle of incidence is measured to be between 76° and 85°) (e.c.f. from (i))	**3**
16bi	Use of $n = c/v$ with $n = 1.48$ (1) Use of speed = distance / time (1) Time = 3.4×10^{-4} s (1) (Allow MP2 if using speed of light in a vacuum) <u>Example of calculation</u> $v = c/n = 3.00 \times 10^{8}\ \text{ms}^{-1} / 1.48 = 2.03 \times 10^{8}\ \text{ms}^{-1}$ time = distance / speed = 70,000 m / $2.03 \times 10^{8}\ \text{ms}^{-1} = 3.45 \times 10^{-4}$ s	**3**
16bii	(Lower RI leads to) lower critical angle (1) More light (totally internally) reflected **Or** less light refracted **Or** more of the incident light will hit the boundary at an angle greater than the critical angle (1) (MP2 dependent on awarding MP1)	**2**
	Total for question 16	**11**

Question Number	Answer	Mark
17ai	Use of $P = VI$ (1) $P = 0.11$ (W) (1) (MP1 - Allow methods where R is calculated and then either $P = I^2R$ or $P = V^2/R$ is used to calculate P) <u>Example of calculation</u> $P = VI = 12.0 \text{ V} \times 9.2 \times 10^{-3} \text{ A} = 0.11 \text{ W}$	**2**
17aii	Use of $E = Pt$ to calculate energy of LED (1) Use of $v = f\lambda$ **and** $E = hf$ to calculate photon energy (1) Divides total energy in one minute by energy of a photon (1) Number of photons in one minute = 2.1×10^{19} (1) (candidates who do not convert minutes into seconds can score a maximum of 2 marks – MP2 and MP3) ("show that" value leads to 1.9×10^{19}) (allow full e.c.f. from (i)) <u>Example of calculation</u> $E = Pt = 0.11\text{W} \times 60 \text{ s} = 6.6 \text{ J}$ $f = \frac{v}{\lambda} = \frac{3.00 \times 10^{8} \text{ms}^{-1}}{627 \times 10^{-9} \text{m}} = 4.78 \times 10^{14} \text{ Hz}$ $E = hf = 6.63 \times 10^{-34} \text{ Js} \times 4.78 \times 10^{14} \text{ Hz} = 3.17 \times 10^{-19} \text{ J}$ Number of photons in one minute = $\frac{6.6 \text{ J}}{3.17 \times 10^{-19} \text{J}} = 2.1 \times 10^{19}$	**4**
17b	(Lower wavelength leads to) greater (photon) energy (1) Therefore fewer photons (in one minute) (1) (MP1 – accept hc/λ increases or hf increases) (MP2 dependent on awarding of MP1)	**2**
17c	Use of $A = 4\pi r^2$ (1) Use of $I = P/A$ (1) $I = 2200$ (W m^{-2}, which is greater than 1100 W m^{-2}) so student is correct (1) (MP2 – allow if use $A = 0.69/1100$) <u>Example of calculation</u> $A = 4\pi (0.005)^2 = 3.14 \times 10^{-4} \text{ m}^2$ $I = \frac{0.69 \text{ W}}{3.14 \times 10^{-4} \text{m}^2} = 2196 \text{ W m}^{-2}$	**3**
	Total for question 17	**11**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>18a</td><td>Use of $n\lambda = d \sin \theta$
$\theta_2 = 29°$

(For MP1, allow calculation of $d/\lambda = 4.13$ or $\lambda/d = 0.242$)

<u>Example of calculation</u>
$\sin 14.0° = 0.242$ (when $n = 1$)
$n = \frac{d}{\lambda} \sin \theta$, so if d and λ are the same, when $n = 2$, $\sin \theta$ is doubled
so $\sin \theta_2 = 0.242 \times 2 = 0.484$
$\sin^{-1} 0.484 = 28.9°$</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>18b</td><td>Suitable graph suggested (see table below)
Calculate/determine gradient
Correct method for determining λ from gradient of graph

(MP2 do not award without any suggestion of the graph to be plotted)
(MP2 do not award if either of the axes involves λ)

<table>
<tr><th colspan="2">MP1</th><th colspan="2">MP3</th></tr>
<tr><th>y-axis</th><th>x-axis</th><th>gradient =</th><th>or λ =</th></tr>
<tr><td>n</td><td>$d \sin \theta$</td><td>$1/\lambda$</td><td>1/gradient</td></tr>
<tr><td>$d \sin \theta$</td><td>n</td><td>λ</td><td>gradient</td></tr>
<tr><td>n</td><td>$\sin \theta$</td><td>d/λ</td><td>d/gradient</td></tr>
<tr><td>$\sin \theta$</td><td>n</td><td>λ/d</td><td>gradient × d</td></tr>
<tr><td>$\sin \theta$</td><td>n/d</td><td>λ</td><td>gradient</td></tr>
<tr><td>n/d</td><td>$\sin \theta$</td><td>$1/\lambda$</td><td>1/gradient</td></tr>
</table></td><td>(1)
(1)
(1)</td><td>3</td></tr>
<tr><td>18c</td><td>Use of tan to calculate θ_2 (allow Pythagoras to find hypotenuse and then using sin or cos)

Use of $n\lambda = d\sin\theta$ with $n = 2$

Use number of lines per m(m) = 1 / d

Number of lines per mm = 149, so labelling incorrect
Or $d = 3.33 \times 10^{-6}$ m, not 6.69×10^{-6} m, so labelling incorrect

<u>Example of calculation</u>
$\tan \theta = 0.397 \text{ m} / 2.00 \text{ m} = 0.199$, $\theta = 11.2°$
$n\lambda = d\sin\theta$, so $d = n\lambda / \sin \theta = 2 \times 650 \times 10^{-9} \text{ m} / \sin (11.2°)$
$d = 6.69 \times 10^{-6}$ m
number of lines per metre = $1/d = 1 / 6.69 \times 10^{-6} \text{ m} = 149{,}000 \text{ m}^{-1}$
$= 149 \text{ mm}^{-1}$</td><td>(1)

(1)

(1)

(1)</td><td>4</td></tr>
<tr><td></td><td>Total for question 18</td><td></td><td>9</td></tr>
</table>

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom