Pearson Edexcel

Mark Scheme (Results)

October 2023

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH12)
Paper 01
Unit 2: 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.

Question Number	Answer	Mark
1	**A is the correct answer** B is not the correct answer as wavelength is a distance C is not the correct answer as d is a distance D is not the correct answer as θ is an angle	**(1)**
2	**C is the correct answer** A is not the correct answer as there is a small current In the reverse direction correct answer as there is a small current In the reverse direction D is not the correct answer as there is a small current when the p.d. $<$ 0.7 V	**(1)**
3	**B is the correct answer** A is not the correct answer as this would reduce the detail C is not the correct answer as this would have no effect on detail D is not the correct answer as this would reduce the detail	**(1)**
4	**D is the correct answer** A is not the correct answer as a larger charge would decrease drift velocity B is not the correct answer as a larger diameter would decrease drift velocity C is not the correct answer as a larger current would increase drift velocity	**(1)**
5	**B is the correct answer** A is not the correct answer as the time period can be determined from the graph C is not the correct answer as the wave could be transverse or longitudinal D is not the correct answer as the wave could be transverse or longitudinal	**(1)**
6	**B is the correct answer** A is not the correct answer as the wavelength is 2/3 of the length VY C is not the correct answer as the wavelength is 2/3 of the length VY D is not the correct answer as the wavelength is 2/3 of the length VY	**(1)**
7	**C is the correct answer** A is not the correct answer as these would be in antiphase B is not the correct answer as these would be in antiphase D is not the correct answer as this is incorrect	**(1)**
8	**C is the correct answer** A is not the correct answer as $T = \mu v^2$ or $T \propto {}^{m}/_{l}$ so $2l$ is $T/2$ B is not the correct answer as $T = \mu v^2$ or $T \propto {}^{m}/_{l}$ so $2l$ is $T/2$ D is not the correct answer as $T = \mu v^2$ or $T \propto {}^{m}/_{l}$ so $2l$ is $T/2$	**(1)**
9	**D is the correct answer** A is not the correct answer as this corresponds to the smallest energy change B is not the correct answer as this corresponds to the smallest energy change C is not the correct answer as this corresponds to the smallest energy change	**(1)**
10	**C is the correct answer** A is not the correct answer as light transmitted Is unpolarised as this is unchanged B is not the correct answer as light reflected must be polarised as it Is absorbed by the filter D is not the correct answer as light reflected must be polarised as it Is absorbed by the filter	**(1)**

Question Number	Answer	Mark
11	Waves <u>reflect</u> off surrounding objects / surfaces **(1)** Time to return is detected **(1)** This time can be used to determine the distance/position of an object **(1)**	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
12	Use of conservation of charge **(1)** Use of conservation of energy **(1)** Algebra leading to given expression **(1)** <u>Example of derivation</u> (conservation of charge) $I = I_1 + I_2$ $\frac{V_{tot}}{R_{tot}} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$ (conservation of energy) $V_{tot} = V_1 = V_2$ $\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_{tot}} = \frac{R_1+R_2}{R_1R_2}$ $R_{tot} = \frac{R_1R_2}{R_1 + R_2}$	**3**
	Total for question 12	**3**

Question Number	Answer	Mark
13(a)	Use of $R = \frac{\rho l}{A}$ **(1)** Use of cross-sectional area = width × thickness **(1)** Thickness of layer of carbon $= 1.2 \times 10^{-5}$m **(1)** <u>Example of calculation</u> $8.8\ \Omega = \frac{3.7 \times 10^{-5}\Omega\ \mathrm{m} \times 0.12\ \mathrm{m}}{0.042\ \mathrm{m} \times t}$ $t = 1.2 \times 10^{-5}$m	**3**
13(b)(i)	Use of $R = V/I$ to calculate I **Or** ratio of resistances = ratio of p.d.s **(1)** Calculate p.d. across the internal resistance (see 0.1V) **Or** calculate whole circuit resistance (see 9.4 Ω) **(1)** r = 0.63 Ω **(1)** <u>Example of calculation</u> $I = \frac{1.4}{8.8} = 0.16\ \mathrm{A}$ $r = \frac{0.1\ \mathrm{V}}{0.16\ \mathrm{A}} = 0.63\ \Omega$	**3**
13(b)(ii)	Reading on voltmeter = 0.35 V **(1)** <u>Example of calculation</u> $\frac{V}{1.4\ \mathrm{V}} = \frac{3.0\ \mathrm{cm}}{12.0\ \mathrm{cm}}$ $V = 0.35\ \mathrm{V}$	**1**
	Total for question 13	**7**

Question Number	Answer	Mark
14(a)	10^{o}C corresponds to 2.0 Ω **(1)** Use of ratio of resistances **(1)** Use of corresponding ratio of p.d.s **(1)** To a p.d. of 0.7(06) V **(1)** If temperature goes below this level then resistance of thermistor increases **(1)** So p.d. to heater (switch) increases and so heater switch does perform as required **(1)** <u>Example of calculation</u> $\frac{V}{6.0} = \frac{2.0}{15 + 2.0}$ V = 0.706 V **Or** 10^{o}C corresponds to 2.0 Ω **(1)** Use of $I = V/R$ for whole circuit **(1)** Use of $V = IR$ for thermistor **(1)** To a p.d. of 0.7(06) V **(1)** If temperature goes below this level then resistance of thermistor increases **(1)** So p.d. to heater (switch) increases and so heater switch does perform as required **(1)** <u>Example of calculation</u> I = 6.0 V / (2 + 15) Ω = 0.353 A V = 0.353 A × 2.0 Ω = 0.706 V	**6**
14(b)	Increase in temperature results in more electrons released **Or** Increase in temperature results in more electrons moving into conduction band **(1)** So resistance decreases (dependent on MP1) **(1)** [allow converse argument]	**2**
	Total for question 14	**8**

Question Number	Answer		Mark
15(a)	Electrons can exhibit wave behaviour Electrons diffract as they pass through the graphite **Or** graphite acts as a diffraction grating Structure of graphite must be ordered/ regular / layered The (de Broglie) wavelength of the electrons is similar to the spacing of gaps between atoms	**(1)** **(1)** **(1)** **(1)**	**4**
15(b)(i)	Use of $V = W/Q$ $W = 3.8 \times 10^{-16}$ (J) <u>Example of calculation</u> $W = 1.6 \times 10^{-19}\text{C} \times 2400\text{ V} = 3.84 \times 10^{-16}\text{ J}$	**(1)** **(1)**	**2**
15(b)(ii)	Use of $E_k = \frac{1}{2}mv^2$ $v = 2.9 \times 10^{7}\text{ m s}^{-1}$ (allow ecf from (b)(i)) <u>Example of calculation</u> $E_k = 3.8 \times 10^{-16}\text{ J} = \frac{1}{2}9.11 \times 10^{-31}\text{kg} \times v^2$ $v = 2.90 \times 10^{7}\text{ m s}^{-1}$	**(1)** **(1)**	**2**
15(b)(iii)	(Increasing the accelerating p.d.) would increase the (maximum) momentum of the electrons **Or (**Increasing the accelerating p.d.) would increase the (maximum) velocity of the electrons Use of $\lambda = \frac{h}{p}$ so (de Broglie) wavelength of the electrons decreases So the diameter of the circles would decrease **Or** Distance between maxima decreases	**(1)** **(1)** **(1)**	**3**
	Total for question 15		**11**

Question Number	Answer	Mark
16(a)	Interference/superposition takes place **(1)** Destructive (interference) occurs when (the two reflective) waves meet in antiphase (and these wavelengths are missing) **(1)** If the path difference is equal to (n + 1/2) λ [Allow If 2d = (n + 1/2) λ] **(1)**	**3**
16(b)	Use of path difference = 2d **(1)** Use of minimum occurs when path difference = λ / 2 **(1)** Use of $n = c/v$ (with $v = f\lambda$) **(1)** wavelength in air = 6.0 ×10^{-7} m **(1)** <u>Example of calculation</u> Path difference = 2 × 6.5 × 10^{-8} m = 1.3 × 10^{-7} m wavelength in coating = 2 × 1.3 × 10^{-7} m = 2.6 × 10^{-7} m wavelength in air = 2.6 × 10^{-7} m × 2.3 = 5.98 × 10^{-7} m = 598 nm	**4**
16(c)	Use of $I = P/A$ **(1)** Use of $P = E/t$ **(1)** Use of Efficiency = useful power output/power input **(1)** Efficiency = 0.31 **Or** 31% **(1)** <u>Example of calculation</u> Power incident on solar array = 1.1 kW m^{-2} × 8.7 m^2 × cos 60 = 4.785 kW Power output from solar array = 5.4 × 10^6 J ÷ 3600 s = 1.5 kW Efficiency = 1.5 kW ÷ 4.785 kW = 0.313	**4**
	Total for question 16	**11**

Question Number	Answer	Mark

***17(a)**

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 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 throughc	2
Answer is partially structured with some linkages and lines c reasoning	1
Answer has no linkages between points and is unstructured	0

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

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

Indicative content

IC1 <u>Photons</u> (of ultraviolet light)

IC2 cause (photo)electrons to be emitted

IC3 from (the surface of) the magnesium / ribbon

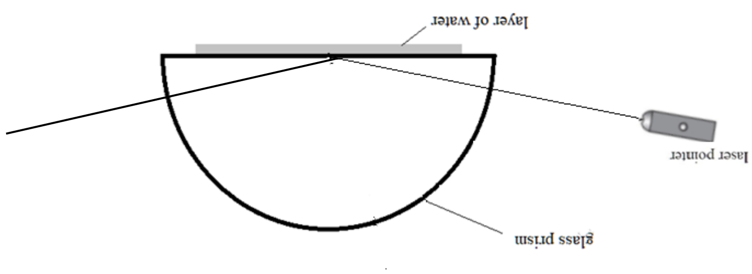
IC4 as the (photon) energy is greater than the work function of magnesium
Or as the frequency of the ultraviolet light is greater than the threshold frequency of magnesium

IC5 The electrons are attracted to the positively charged gauze (and create the current).

IC6 When the polarity is reversed the current is zero because the electrons no longer have enough kinetic energy to move across the gap
Or When the polarity is reversed the current is zero because the work function of copper is larger than the photon energy
Or When the polarity is reversed the current is zero because the threshold frequency of copper is larger than the frequency of ultraviolet light

Mark: **6**

17(b)(i)	Greater intensity increases the rate of photons emission from the lamp This leads to an increased (emission) rate of (photo)electrons (crossing the airgap) So greater rate of flow of charge **Or** increase in current	**(1)** **(1)** **(1)**	**3**
17(b)(ii)	Use of $c = f\lambda$ Use of $E = hf$ Converts work function and photon energy to the same unit E = 2.0 (eV)= which is less than φ so photoelectric effect will not take place **Or** $E = 3.1 \times 10^{-19}$ (J) which is less than 5.9×10^{-19} (J) so photoelectric effect will not take place **Or** threshold frequency (f_0) = 8.9 x10^{14} (Hz) which is greater than 4.7 x 10^{14} (Hz) so photoelectric effect will not take place <u>Example of calculation</u> Frequency of light = 3.0×10^{8} m s^{-1} / 6.33×10^{-7}m = 4.74×10^{14} Hz $E = 6.63 \times 10^{-34}$ J s $\times 4.74 \times 10^{14}$ s^{-1} = 3.14×10^{-19} J $\varphi = 3.7$ V $\times 1.6 \times 10^{-19}$ J V^{-1} = 5.92×10^{-19} J	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**13**

Question Number	Answer	Mark
18(a)	**MAX 4** A wavefront is a line on which all points are in phase **(1)** The wavefronts are parallel to the boundary (between air and glass) **Or** The wavefronts are perpendicular to the normal **Or** Light is (travelling) along the normal **Or** Light is (travelling) perpendicular to the (surface of the) glass block **(1)** So all of the (points on the) wavefront enter the glass at the same time **(1)** The wave slows down (as it enters the glass block) **(1)** But the whole wavefront travels the same distance in the same time (so the ray does not change direction) **(1)**	4
18(b)	Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ **(1)** Substitution of θ_2 = 90° **(1)** c = 62 (°) **(1)** <u>Example of calculation</u> $1.51 \times \sin c = 1.33 \times \sin 90^0$ c = 61.7°	3
18(c)	Ray reflects off glass / water interface with no refracted ray **(1)** Angle of reflection = Angle of incidence (by eye) **(1)** Ray is undeviated at glass / air interface **(1)** <u>Example</u> 	3

18(d)	(Some of) the light (travelling from the glass) is refracted/transmitted into the fingers/ridges/skin **(1)** Dark areas where fingers/ridges/skin is in contact with glass **(1)** (Some of) the light (travelling from the glass) is reflected from the air/valley **(1)** Light areas where air is in contact with glass. **(1)**	**4**
	Total for question 18	**14**

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