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Examiners' Report
June 2025

Int Advanced Level Physics WPH12 01

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Introduction

WPH12 is a unit paper on the Pearson Edexcel International AS level course which covers the topics of Waves and Electricity. As usual, the paper for this series contained 10 marks of multiple choice questions in Section A. Section B had 8 longer answer questions which consisted of short open responses, calculations and some extended written answers. Question 15) was related to Core Practical activities that candidates undertake as part of the IAL course. This unit always contains one 6 mark linkage question, which on this occasion was about how standing waves were produced in an open ended tube. On the whole, candidate performance on the paper during this series was broadly in line with previous series, although there are always going to be particular questions that candidates find more challenging. In this series the questions found to be the most difficult were Q12, Q14(b), Q16(a), Q16(c), Q17(b)(ii), Q18(a) Q18(b) and Q18(d). Candidates continue to show evidence of good preparation for the test but there are some aspects that need more focus. As is often the case marks were lost for failing to add units to calculations and some responses were too general and not linked to the context in the question. The standard in this paper was similar to previous series although there were several contexts within this paper that may have been less familiar than previous series, for example questions 13a and 14b.

Section A: Multiple Choice. Section A was generally completed very well by most candidates and there were no particular questions that appeared to be more challenging than others.

Question 11

This is a question that has been commonly asked over many series. However, it is normally the case that a resistance and diameter is given to calculate a resistivity or a resistivity and diameter is given to calculate a resistance. This time both resistance and resistivity were given in order to determine a diameter. The first marking point was for the use of the resistivity equation to calculate an area. This area was then used to calculate a diameter using ∏r2 for the calculation of a radius and the third marking point was for a correct answer.

11. A wire has a resistance of 65 mΩ. The length of the wire is 0.25 m.

The wire has a circular cross-sectional area.

Calculate the diameter of the wire.

resistivity of the metal of the wire = $5.6 \times 10^{-8}\,\Omega\text{m}$

$R = \frac{V}{I}$ $\quad 65 \div 0.25 = 260\ \Omega$

$R = \frac{\rho l}{A} = \frac{5.6\times10^{-8}\ \cancel{\Omega m} \div 65}{(0.25)^2\,\pi} =$

ResultsPlus
Examiner Comments

This candidate appears to be confused by what the question is asking and seems to be attempting to use Ohm's Law to determine something. It was then realised that the resistivity equation was required but the values were substituted incorrectly.

ResultsPlus
Examiner Tip

It is common to confuse resistance with resistivity and the terms must be substituted correctly into the correct equation.

11: A wire has a resistance of 65 mΩ. The length of the wire is 0.25 m.

The wire has a circular cross-sectional area.

Calculate the diameter of the wire.

resistivity of the metal of the wire = $5.6 \times 10^{-8}\,\Omega\text{m}$

$R = \frac{\rho l}{A}$, $\quad 5.6 \times 10^{-8} = \rho$,

So $65 \times 10^{-3} = \frac{5.6 \times 10^{-8} \times 0.25}{A}$

$65 \times 10^{-3} = \frac{1.4 \times 10^{-8}}{A}$

$65 \times 10^{-3} A = 1.4 \times 10^{-8}$

$A = 1.4 \times 10^{-8} / 65 \times 10^{-3}$

$= 2.154 \times 10^{-7}\,m^2$, $r = \sqrt{\frac{2.154 \times 10^{-7}}{\pi}} = 2.62 \times 10^{-4}\,m$

Diameter = $2.62 \times 10^{-4}\,m$

ResultsPlus
Examiner Comments

This candidate carried out all of the necessary steps to calculate a radius but needed to double this to arrive at a diameter so only scored the first two marking points.

ResultsPlus
Examiner Tip

Be clear about the quantity you have been asked to calculate.

Answer ALL questions in the spaces provided.

11 A wire has a resistance of 65 mΩ. The length of the wire is 0.25 m.

The wire has a circular cross-sectional area.

Calculate the diameter of the wire.

resistivity of the metal of the wire = $5.6 \times 10^{-8}\,\Omega\text{m}$

65×10^{-3}

$R = 0.065$

$\cancel{R = 65\,m\Omega}$

$\rho = 5.6 \times 10^{-8}$

$R = \frac{\rho L}{A}$

$L = 0.25$

$A =$

$\cancel{B\ 65 = 5.6 \times 10^{-8}}$

$0.065 = \frac{5.6 \times 10^{-8}(0.25)}{A}$

Diameter = ...

ResultsPlus Examiner Comments

This candidate substituted all values into the resistivity equation correctly and went no further so only the first marking point was awarded.

ResultsPlus Examiner Tip

Even if you are unsure that you have used the correct equation it is always worthwhile to solve it.

11 A wire has a resistance of 65 mΩ. The length of the wire is 0.25 m.

The wire has a circular cross-sectional area.

Calculate the diameter of the wire.

resistivity of the metal of the wire = $5.6 \times 10^{-8}\,\Omega\text{m}$

$R = \frac{\rho L}{A}$ $\qquad R = \frac{\rho L}{\pi r^2}$ $\qquad \sqrt{\frac{\rho L}{R \times \pi}} = r$

$R\pi r^2 = \rho L$ $\qquad \sqrt{\frac{5.6\times10^{-8} \times 0.25}{\pi \times 65\times10^{-3}}} = r$

$r = 2.62 \times 10^{-4}$

$2 \times 2.62\times10^{-4}$ $\qquad d = 2r$

5.24×10^{-4} m

Diameter = 5.24×10^{-4}

ResultsPlus
Examiner Comments

This candidate completed all the steps correctly and calculated the correct value for diameter. Although the unit was not provided in the answer line it was provided in the calculation so the third marking point was awarded.

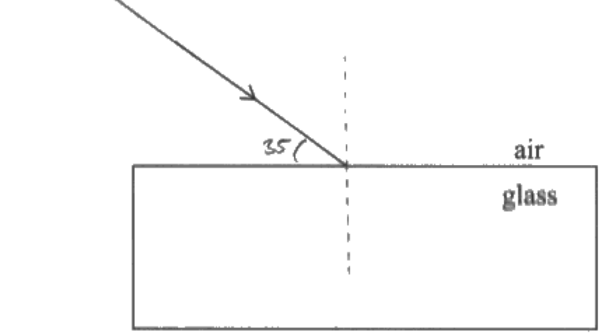
ResultsPlus
Examiner Tip

If no unit is provided in the answer line then you must remember to include a unit with your answer unless it is a "show that" question.

Question 12(a)

This question was in two parts. The first part required the determination of an angle of incidence from a diagram. To do this a normal needed to be drawn and the angle between the normal and the ray measured with a protractor. The second part required the use of this angle in the Snell's Law equation to calculate the angle of refraction in the glass block.

12 A student uses a ray box to direct a narrow ray of light onto the surface of a glass block, as shown.



(a) (i) Determine the angle of incidence.

(1)

Angle of incidence = ~~40°~~ 35°

(ii) Calculate the angle of refraction in the glass block.

refractive index of glass block = 1.5

(2)

$n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightarrow \cancel{n_1 \times \sin 40 = 1.5 \times \sin\theta}$ 35

$\cancel{n = \frac{c}{v}}$ $\quad 1.5 \times \sin 35 \quad A \text{ of } r = \sin^{-1}(0.860...)$

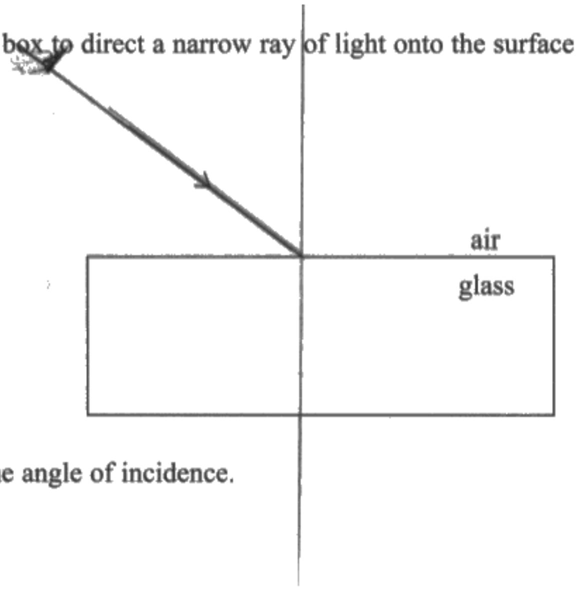
$\cancel{n = 3\times10^8}$ $\quad = 0.860... \quad = 59.3°$

Angle of refraction = 59.3°

ResultsPlus
Examiner Comments

This candidate made the mistake of not using the angle between the normal and the incident ray so the marking point was not awarded. However, we allowed an error carried forward for the second part which meant that had 35 0 been used in the Snell's Law equation and the calculation performed correctly then both marks were awarded. However, this candidate wrote down the correct equation to be used but did not substitute the values correctly.

12 A student uses a ray box to direct a narrow ray of light onto the surface of a glass block, as shown.



(a) (i) Determine the angle of incidence.

(1)

Angle of incidence = 54°

(ii) Calculate the angle of refraction in the glass block.

refractive index of glass block = 1.5

(2)

$1.5 = \frac{\sin i}{\sin r}$ $\quad \sin r = \frac{\sin(54)}{1.5}$

$= \sin^{-1}(0.53934)$

$32.693...$

Angle of refraction = 32.7°

ResultsPlus
Examiner Comments

For part i we accepted a value between 53 and 55 degrees and for part ii we accepted a value between 32 and 33 degrees. This candidate measured an angle within range and correctly calculated an angle of refraction in range, so achieved full marks.

ResultsPlus
Examiner Tip

Even if the measured angle is wrong full credit can be given for the correct use of the measured angle in subsequent parts.

(a) (i) Determine the angle of incidence.

(1)

Angle of incidence = 36°

(ii) Calculate the angle of refraction in the glass block.

refractive index of glass block = 1.5

(2)

$1 \cdot \sin 36° = 1.5 \sin\theta$

$\theta = 23.07°$

Angle of refraction = 23.07°.

ResultsPlus
Examiner Comments

This candidate used the wrong angle for part i but correctly used this angle in the second part so full credit was given.

ResultsPlus
Examiner Tip

Credit can often be given for the substitution of incorrect values into equations.

(a) (i) Determine the angle of incidence.

(1)

Angle of incidence = $55°$

(ii) Calculate the angle of refraction in the glass block.

refractive index of glass block = 1.5

(2)

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$1 \times \sin 55 = 1.5 \times \sin \theta_2$

$\theta = \sin^{-1} \left(\frac{1 \times \sin 55}{1.5} \right) = 33.1$

Angle of refraction = 33.1

ResultsPlus
Examiner Comments

This candidate measured the angle of incidence correctly and used it to calculate a correct angle of refraction. Unfortunately the unit was missing from the final answer.

ResultsPlus
Examiner Tip

Always remember to include units in answers and that degrees are units.

(a) (i) Determine the angle of incidence.

(1)

Angle of incidence = 38°

(ii) Calculate the angle of refraction in the glass block.

refractive index of glass block = 1.5

(2)

~~1.5×~~ 1×Sin 38 ~~×~~ = 1.5 × Sin(x)

ResultsPlus
Examiner Comments

This candidate was not awarded the marking point for part i. However, the incorrect value was correctly substituted into the Snell's Law equation for the first marking point of part ii. The candidate did not complete the calculation.

ResultsPlus
Examiner Tip

Always complete a calculation even if you think that your substituted values are incorrect.

Question 12(b)i

This is a question that has been asked in many previous papers and there are two alternative marking schemes. The first marking scheme relates to planes and the second relates to directions. Responses cannot be given credit for mixing both parts and the marks are given for the alternative with the highest score. The question asks for the difference between polarised and unpolarised light.

(b) The light from the ray box is unpolarised. When reflected by glass, some of this light will become polarised.

(i) Explain the difference between unpolarised light and polarised light.

(3)

~~unplo~~ unpolarised light vibrate in all directions perpendicular to the direction of the energy transfer it is the electric field of the em wave that vibrate. and in polarised light the electric field only vibrate in one direction perpendicular to the direction of energy tran[illegible]

ResultsPlus
Examiner Comments

This is a response using directions and scores all three marks. We ignore the comment about unpolarised light vibrating in directions perpendicular to the directions of energy transfer. The third marking point is dependent upon the second being awarded.

ResultsPlus
Examiner Tip

The word "direction" must be seen for the third marking point to be awarded.

(b) The light from the ray box is unpolarised. When reflected by glass, some of this light will become polarised.

(i) Explain the difference between unpolarised light and polarised light.

(3)

upolarized light oscillates in all directions while polarized light oscillates only parallel to direction of plane light.
Unpolarized light has varying Intensity while polarised light intensity is the intensity of the plane light only

ResultsPlus
Examiner Comments

This script was awarded the first marking point and the remaining comments were irrelevant. No credit is given for discussions related to intensity.

(b) The light from the ray box is unpolarised. When reflected by glass, some of this light will become polarised.

(i) Explain the difference between unpolarised light and polarised light.

(3)

unpolarised light particals moves in all direction perdendecular to the wave travel

polarised light particals moves in one direction perpendeculor to the wave travel

ResultsPlus
Examiner Comments

This candidate did not discuss oscillations or vibrations of the wave and scored no marks as a consequence.

ResultsPlus
Examiner Tip

Descriptions of polarisation must include oscillations/vibrations.

(b) The light from the ray box is unpolarised. When reflected by glass, some of this light will become polarised.

(i) Explain the difference between unpolarised light and polarised light.

(3)

unpolarised light particle vibrate at all direction (call plane) that prependicular to light travell, polarised light particle vibrate at one plane that prependicular to light travell

ResultsPlus
Examiner Comments

This candidate used both planes and directions in their response. As we could award the first marking point and the first alternative or the first two marking points of the second alternative we awarded the best score.

ResultsPlus
Examiner Tip

In descriptions of polarisation do not mix planes and directions.

Question 12(b)ii

In this question candidates were asked to describe what would happen if light reflected form the glass was viewed through a rotated polarising filter. Candidates were told in part i that some of the light reflected from the glass was polarised. The first marking point required the idea that the intensity of the light would change. The second marking point was for an indication that the light went from maximum to minimum as the filter was rotated through 90 degrees. The third marking point was for describing the conditions for maximum or minimum intensity in relation to the alignment of the filters. There were two alternatives for the last marking point and candidates who correctly described both of these were awarded all three marks for the question.

Question 13(a)

This type of question has been fairly common but this had a slight variation in that the pulse duration was provided to candidates. We were also told that the pulse must return before another pulse was emitted or the transducer would not be able to detect the crack. Candidates were told the temperature of the concrete and a graph of velocity vs temperature was provided. To score the first marking point candidates needed to determine a speed value of between 4110 and 4120 m/s from the graph. The second marking point was for the use of velocity = s/v and the third was for understanding that the pulse travelled out and back and that there needed to be a factor of 2 for time or distance. The final marking point was for a correct comparison of time distance or speed and the correct conclusion that the crack would not be detected. <<< image::images/WPH12_01_Q13a_405524_01.png[Screenshot of candidate work,role=DWtemplate-screenshot]

ResultsPlus
Examiner Comments

This candidate correctly read 4115 m/s from the graph and used this to calculate a time. The time was then doubled and compared to 200 micro seconds. As the time was smaller than 200 micro seconds the pulses would overlap and as a consequence the crack would not be detected.

ResultsPlus
Examiner Tip

When dealing with pulse echo calculations it is important to use a factor of 2 for distance or time.

A pulse of ultrasound is incident on a crack in this piece of concrete. The crack is a distance of 4.0 cm from the transducer.

The temperature of the concrete is 23 °C.

Deduce whether the transducer can detect ultrasound reflected from this crack.

duration of ultrasound pulse = 200 μs

(4)

$v/ms^{-1} = 4115\ m/s$ $\qquad \frac{200}{10^6} = 2\times10^{-4}\ s$

$\frac{4}{100} = 0.04m$

$s = \frac{v}{t}$ $\qquad 4115 \times \frac{2\times10^{-4}}{2} = 0.4115m$

$4\ \cancel{115 \times 2\times10^{-4}}$

$\frac{0.04}{4115} = 9.72\times10^{-6}$ $\cancel{\times 0.04} =$ $\qquad \frac{0.04\times2}{4115} = 1.944\times10^{-5}\ s$

$1.944\times10^{-5} \neq 2\times10^{-4}$

$0.4115m \neq 0.04m$

∴ Ultrasound will go beyond

ResultsPlus Examiner Comments

All calculations were correct and a valid comparison of distance was made. Unfortunately the conclusion was incorrect so this candidate was awarded the first three marking points.

A pulse of ultrasound is incident on a crack in this piece of concrete. The crack is a distance of 4.0 cm from the transducer.

The temperature of the concrete is 23 °C.

Deduce whether the transducer can detect ultrasound reflected from this crack.

duration of ultrasound pulse = 200 µs

(4)

When temperature = 23°C, $V = 4150\ \text{ms}^{-1}$

$2S = V \times T$

$V = \cancel{\frac{T}{2S} = \frac{200 \times 10^{-6}}{2 \times 4 \times 10^{-2}}} = \frac{2S}{T}$

$V = \frac{2 \times 4 \times 10^{-2}}{200 \times 10^{-6}} = 400\ \text{ms}^{-1}$

Therefore they will overlap as the velocity is much different

ResultsPlus Examiner Comments

This candidate read the speed value from the graph incorrectly and was not awarded the first marking point. However, the calculations were correct and used a factor of 2 correctly so the second and third marking points were awarded. The conclusion was incorrect so the fourth marking point was not given.

ResultsPlus Examiner Tip

Take care when reading values from graphs.

A pulse of ultrasound is incident on a crack in this piece of concrete. The crack is a distance of 4.0 cm from the transducer.

The temperature of the concrete is 23 °C.

Deduce whether the transducer can detect ultrasound reflected from this crack.

duration of ultrasound pulse = 200 μs

(4)

Yes the transducer can detect ultrasound reflected from this crack, but only when it doesn't overlap with the pulse emitted by the transducer.

ResultsPlus
Examiner Comments

This candidate is only repeating information from the question and no credit is given for this.

ResultsPlus
Examiner Tip

No marks will be awarded for stating information provided in the stem of the question.

Question 13(b)

This question has been asked in previous papers and candidates are asked to explain why increasing the frequency of the pulse would enable the detection of smaller cracks. The first marking point was for an indication that the wavelength would be smaller and the second was a statement that this led to greater resolution or less diffraction.

(b) Pulses of ultrasound with a higher frequency can be used to find cracks of shorter length.

Explain why a higher frequency is used.

(2)

Higher frequency is used becuse the thickness of the cocrete

~~sh~~

ResultsPlus
Examiner Comments

This candidate starts a discussion but does not finish it.

(b) Pulses of ultrasound with a higher frequency can be used to find cracks of shorter length.

Explain why a higher frequency is used.

(2)

higher frequency means shorter wavelength, this increases resolution and helps find small details (small cracks)

ResultsPlus
Examiner Comments

A textbook response.

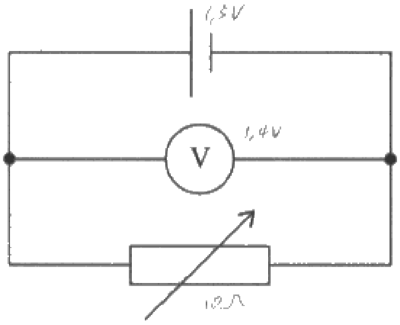
ResultsPlus
Examiner Tip

When making comparisons of wavelength or resolution we need to see larger/smaller and not just large/small.

Question 14(a)

Candidates were given a circuit diagram of a cell in series with a variable resistor. There was a voltmeter across the cell. The question asked for a calculation of internal resistance of the cell. The first marking point was for calculation of the current in the circuit as the terminal potential difference and resistance of the variable resistor were provided. The second marking point was for the use of Ohm's Law to calculate the internal resistance, and the final marking point was for a correct answer.

(a) One cell is removed from the battery and connected in the circuit shown.



When the resistance of the variable resistor is 10 Ω, the reading on the voltmeter is 1.4 V.

Calculate the internal resistance of the cell.

(3)

voltmeter reading $= 1.4V = V_{terminal} = \mathcal{E} - Ir = V_{resistor}$

$I = I_{resistor} = \frac{V_{resistor}}{R_{resistor}} = \frac{1.4}{10} = 0.14A$

$Ir = \mathcal{E} - V_{terminal} = 1.5 - 1.4 = 0.1V$

$r = \frac{0.1}{0.14} = 0.714\,\Omega$

Internal resistance = $0.714\,\Omega$

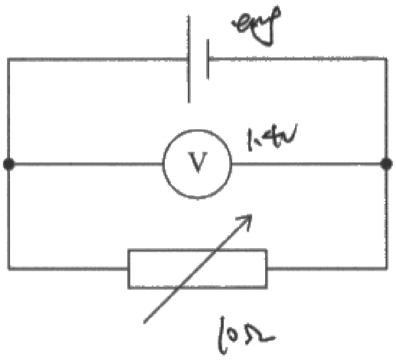
ResultsPlus
Examiner Comments

This candidate carried out all steps correctly and calculated the correct resistance with unit. Ideally the response should have been to 2 significant figures but too many significant figures is not penalised.

ResultsPlus
Examiner Tip

Use the correct number of significant figures.

(a) One cell is removed from the battery and connected in the circuit shown.



When the resistance of the variable resistor is 10 Ω, the reading on the voltmeter is 1.4 V.

Calculate the internal resistance of the cell.

(3)

$emf = 1.5\,V$ $\qquad emf = IR_1 + Ir$

$I = \frac{V}{R} = \frac{1.4}{10} = \frac{7}{50}$ $\qquad \cancel{1.5 = \frac{1.4}{10} \cdot 1.4 + \frac{1.4}{10} r}$

$\cancel{\frac{1.63}{125} = \frac{1.4}{10} r}$ $\qquad \cancel{r = \frac{326}{35}}$

$1.5 = \frac{7}{50} \times 10 + \frac{7}{50} \times r$

$\frac{1}{10} \div \frac{7}{50} = \frac{5}{7}$

Internal resistance = $\cancel{9.31\Omega}$ $\frac{5}{7}$

ResultsPlus Examiner Comments

This candidate used a different approach to the mark scheme as the emf formula was used. We do not include this calculation in the mark scheme as this formula is not provided on the question paper. However, full credit will be given for its use. This candidate carried out the calculation correctly but left the response as a fraction and as a consequence the third marking point was not awarded.

ResultsPlus Examiner Tip

Do not provide an answer to calculations in fractions.

Calculate the internal resistance of the cell.

(3)

$V = IR$

$E = I(R + r)$

$r = \frac{E}{I} - R$

$r = \frac{(1.5 - 1.4) \times 10}{1.5} - 10$

$r = 3.33$

Internal resistance = 3.33

ResultsPlus
Examiner Comments

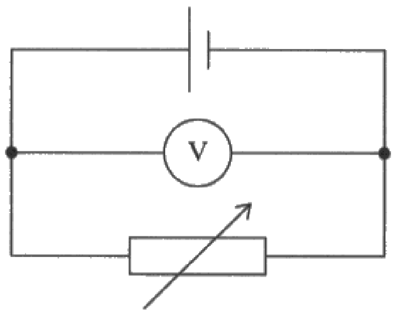
This candidate attempted to use the emf formula but became confused and although an answer was provided the calculation was incorrect.

ResultsPlus
Examiner Tip

Be careful using formulae that are not provided as mistakes will often result in no marks being awarded.

The battery contains several identical cells connected in series. Each cell has an e.m.f. of 1.5 V.

(a) One cell is removed from the battery and connected in the circuit shown.



When the resistance of the variable resistor is 10 Ω, the reading on the voltmeter is 1.4 V.

Calculate the internal resistance of the cell.

(3)

$I = \frac{V}{R} = \frac{1.5}{10} = 0.15\text{ A} \quad R = \frac{V}{I} = \frac{1.4}{0.15} = 9.33\,\Omega$

Internal resistance = 9.33 Ω

ResultsPlus Examiner Comments

This candidate used the emf of the cell rather than the terminal potential difference but was awarded the first marking point for the calculation of a current.

ResultsPlus Examiner Tip

It is important to distinguish between emf and terminal potential difference.

Question 14(b)

Candidates were told here that as the battery in an electric bicycle is used it will become warm but that it would become hot if the bicycle was going up a steep hill. An explanation for this was required. The first marking point was for the idea that the battery or the motor would need to do more work or that more power was needed. The second marking point was awarded for an understanding that to provide more power then more current would be needed and this had to be linked to a relevant power equations. The third marking point was for an understanding that more current in the circuit would mean more current through the internal resistance so the p.d. across it would increase. The final marking point was for the idea that the additional heat produced was due to the thermal energy transfer from the internal resistance. Unfortunately, coherent responses were not often seen.

(b) The battery in an electric bicycle gets warm when the battery supplies power to the motor in the bicycle.

Explain why the battery gets hot when the bicycle is going up a steep hill.

(4)

(more work DONE to go, up, more energy is transferred)

AS battery supplies more power to the motor, current increases ~~due~~ according to P=VI, while Emf of the battery is constant. According to Emf = I(R+r), as current increases the p.d. across the internal resistance increases as well. Thus, it means more energy is dissipated as a heat in the battery, causing the battery to get hot.

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Examiner Comments

This candidate provided a three mark response in which they had a clear understanding of what was causing the battery to become hot. The final marking point was not awarded as there was no relevant discussion about the heat coming from the internal resistance.

ResultsPlus
Examiner Tip

The emf of a cell is fixed so the emf of a battery will never increase.

(b) The battery in an electric bicycle gets warm when the battery supplies power to the motor in the bicycle.

Explain why the battery gets hot when the bicycle is going up a steep hill.

(4)

When the battery supplies power to the motor in the bicycle, the current becomes large, so that will produce heat generation. Also the battery from electric energy transfer kinetic energy, there will some energy transfer to heat energy ~~or~~, when the bicycle is going up a steep hill, the K.E transfer to G.P.E, there also will be some energy becomes heat energy.

ResultsPlus
Examiner Comments

This candidate started well as an understanding that more current was needed was demonstrated. However, there was no link between current and power equation and no indication of why the current would increase and the response then lost its way.

(b) The battery in an electric bicycle gets warm when the battery supplies power to the motor in the bicycle.

Explain why the battery gets hot when the bicycle is going up a steep hill.

(4)

The energy of the battery that going up a steep hill greater. so the power greater.
Due to $P = VI$. the volt constant. the current of the battery increase. so the heat energy greater. the battery has more waste energy. so the battery gets hot.

ResultsPlus
Examiner Comments

The first two marking points were awarded but the candidate failed to expand on the consequences of greater current across the internal resistance.

(b) The battery in an electric bicycle gets warm when the battery supplies power to the motor in the bicycle.

Explain why the battery gets hot when the bicycle is going up a steep hill.

(4)

when the ~~battery is~~ bicycle is moving up it is moving against gravity more ~~power~~ energy will be needed from the bicycle to be able to move $P = \frac{E}{t}$
so more power will be needed
from the battery and it will become hotter

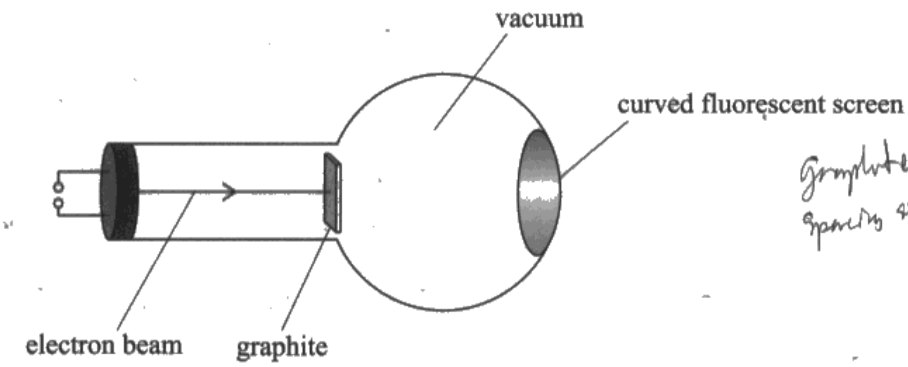
ResultsPlus
Examiner Comments

A very common response where only the first marking point could be awarded.

Question 15(a)

This question asked for the definition of diffraction and the first marking point was for the idea that the waves spread out. The second marking point was for the idea that the waves spread out when passing through a gap or going around an object.

15 The diagram shows apparatus used to demonstrate the diffraction of an electron beam in a school laboratory.



Graphite regular spacing similar atom

A beam of electrons is accelerated by a high potential difference towards a piece of graphite. The graphite diffracts the electron beam, producing a diffraction pattern on the fluorescent screen.

(a) State what is meant by diffraction.

(2)

Diffraction is the spreading of waves as it entered through a gap.
The gap has to be similar to the size of an electron

ResultsPlus
Examiner Comments

The first sentence was sufficient for both marks.

A beam of electrons is accelerated by a high potential difference towards a piece of graphite. The graphite diffracts the electron beam, producing a diffraction pattern on the fluorescent screen.

(a) State what is meant by diffraction.

(2)

Diffraction is the waves pass through a gap and will be obseration.

ResultsPlus Examiner Comments

Second marking point only as there is no indication of waves spreading.

A beam of electrons is accelerated by a high potential difference towards a piece of graphite. The graphite diffracts the electron beam, producing a diffraction pattern on the fluorescent screen.

(a) State what is meant by diffraction.

(2)

Diffraction is when particles change thier direction as they act as waves.

ResultsPlus Examiner Comments

No marks here as there was no mention of waves.

ResultsPlus Examiner Tip

Some candidates described the wave as bending rather than spreading out and this is insufficient.

Question 15(b)

In part i candidates have been presented with a diagram of equipment used in schools to demonstrate diffraction. They are told that the electron in the tube is accelerated through a high potential difference and asked to show that the de Broglie wavelength of the electrons was a certain value. The first marking point was for calculating the energy of an electron using the equation V = W/Q. This value was then substituted into the kinetic energy equation to calculate the velocity of the electron for the second marking point. The third marking point was for the calculation of wavelength using the de Broglie equation and the fourth marking point was for the correct answer.

In part ii the candidates were asked to comment on the validity of a statement from a student. This required a calculation of a diffraction angle and a statement that the diffraction pattern would not be seen.

(b) An electron is accelerated through a potential difference of 4.9 kV.

(i) Show that the de Broglie wavelength for the electron is about 1.8×10^{-11} m.

(4)

$\cancel{\lambda = \frac{h}{p}}$ $h = 6.6 \times 10^{-34}$ nm → m = 1.23×10^{-9}

$\lambda = \frac{1.23}{\sqrt{V}}$ nm $= \frac{1.23 \times 10^{-9}}{\sqrt{4.9 \times 10^{3}}}$

$= 1.75 \times 10^{-11}$ m

Deduce whether a second order maximum would be clearly visible on a screen. The screen is placed about a metre away from the grating.

$\lambda = 1.8 \times 10^{-11}$ m

(3)

$\frac{3\pi}{2}$ $\lambda = 1.8 \times 10^{-11}$

ResultsPlus Examiner Comments

For part i this response was more common than we would have liked to have seen. The candidate arrived at the correct answer but with no indication of how this was calculated. It was likely that because it was a "show" question that the candidate chose a value close to the one required in the hope that marks would be given. There is no evidence of any sensible calculations. For part ii no attempt was made at a calculation.

ResultsPlus Examiner Tip

In the mark scheme the use of an equation requires substitution of correct values as working needs to be seen.

In part i there were no correct calculations.

In part ii there was an attempt to calculate d using 500 and this was correctly substituted into the diffraction equation for the second marking point.

(b) An electron is accelerated through a potential difference of 4.9 kV.

(i) Show that the de Broglie wavelength for the electron is about 1.8×10^{-11} m.

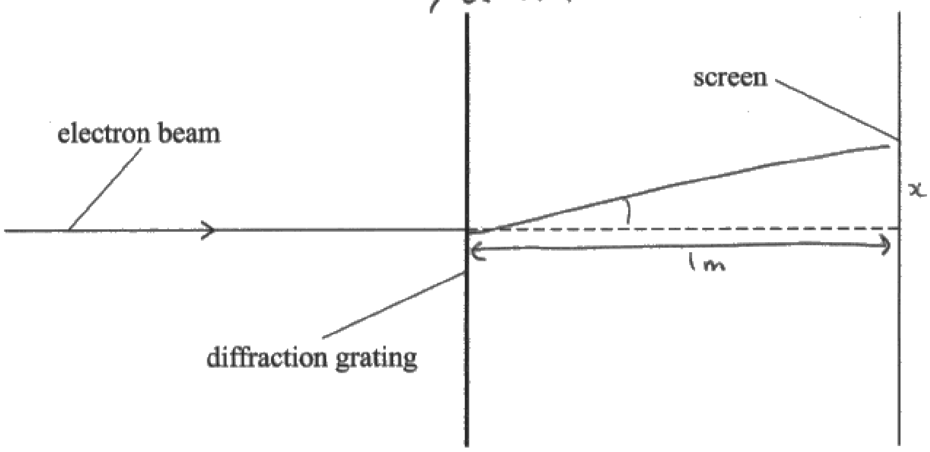
(4)

$\frac{h}{mv}$ $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times v}$

$v = \frac{hc}{\lambda}$

4900 V $\lambda = 1.8 \times 10^{-11}$

(ii) A student suggests that the beam of electrons would produce a diffraction pattern if a diffraction grating with 5000 lines per cm was used. / 0.01 m



Deduce whether a second order maximum would be clearly visible on a screen. The screen is placed about a metre away from the grating.

$\lambda = 1.8 \times 10^{-11}$ m

(3)

$2n\lambda$

$d \sin\theta = n\lambda$

$\frac{0.01}{5000} \sin(\theta) = 2(1.8 \times 10^{-11})$

$\therefore$ it would be visible on the screen

ResultsPlus
Examiner Comments

See above.

(b) An electron is accelerated through a potential difference of 4.9 kV.

(i) Show that the de Broglie wavelength for the electron is about 1.8×10^{-11} m.

$v = f\lambda$

(4)

$p.d = 4.9 \times 10^{3}$ V

$V = \frac{W}{Q}$

$VQ = W$

$4.9 \times 10^{3} \times 1.6 \times 10^{-19} = W$

Energy $= 7.84 \times 10^{-16}$

$E = hf$ $f = \frac{E}{h}$ $f = \frac{7.84 \times 10^{-16}}{6.63 \times 10^{-34}}$ $f = 1.18 \times 10^{18}$

Deduce whether a second order maximum would be clearly visible on a screen.
The screen is placed about a metre away from the grating.

$\lambda = 1.8 \times 10^{-11}$ m

(3)

$n\lambda = d \sin\theta$

$\lambda = 1.8 \times 10^{-11}$

$d = 1/5000$

$\theta =$

(Total for Question 15 = 9 marks)

$n\lambda = d\sin\theta$

$n = \frac{d\sin\theta}{\lambda}$

ResultsPlus
Examiner Comments

This candidate was able to calculate the energy of the electron in part i but was unclear how to proceed from there. There was an attempt to use the photon energy equation but this was not relevant to this context. In part ii there was an attempt to calculate the slit separation and although this was incorrect it was sufficient for the first marking point.

In part i the correct value for energy of the electron has been calculated but the candidate thought that this was momentum and scored no further marks.

In part ii the correct angle was calculated but no statement made about the validity of the student's comment, so the third marking point was not awarded.

(b) An electron is accelerated through a potential difference of 4.9 kV.

(i) Show that the de Broglie wavelength for the electron is about 1.8×10^{-11} m.

(4)

$V = 4.9 \times 10^3\ V$

$\lambda = \frac{h}{p}$

$= \frac{6.63 \times 10^{-34}}{7.84 \times 10^{-16}}$

$= 8.46 \times 10^{-19}$

$\cancel{p =}$ $p = VI$

$I = \frac{\Delta Q}{\Delta t}$

$= 1.6 \times 10^{-19}$

$p = 1.6 \times 10^{-19} \times 4.9 \times 10^3$

$= 7.84 \times 10^{-16}$

Deduce whether a second order maximum would be clearly visible on a screen.
The screen is placed about a metre away from the grating.

$\lambda = 1.8 \times 10^{-11}$ m

(3)

$d = \frac{\cancel{1m}\ 1cm}{5000} = 2\times10^{-4}$ m.

$n\lambda = d\sin\theta$.

$2\times1.8\times10^{-11} = 2\times10^{-4}\sin\theta$.

$\sin\theta = 1.8\times10^{-7}$.

$\theta = \sin^{-1}(1.8\times10^{-7}) = 1.03\times10^{-5}$ °.

No.

(Total for Question 15 = 9 marks)

ResultsPlus
Examiner Comments

See above

A model answer for both parts.

(b) An electron is accelerated through a potential difference of 4.9 kV.

(i) Show that the de Broglie wavelength for the electron is about 1.8×10^{-11} m.

(4)

$W = QV = \frac{1}{2}mv^2$.

$1.6\times10^{-19}\times4.9\times10^{3} = \frac{1}{2}\times9.11\times10^{-31}\times v^2$

$v = 4.15\times10^{7}$ m/s.

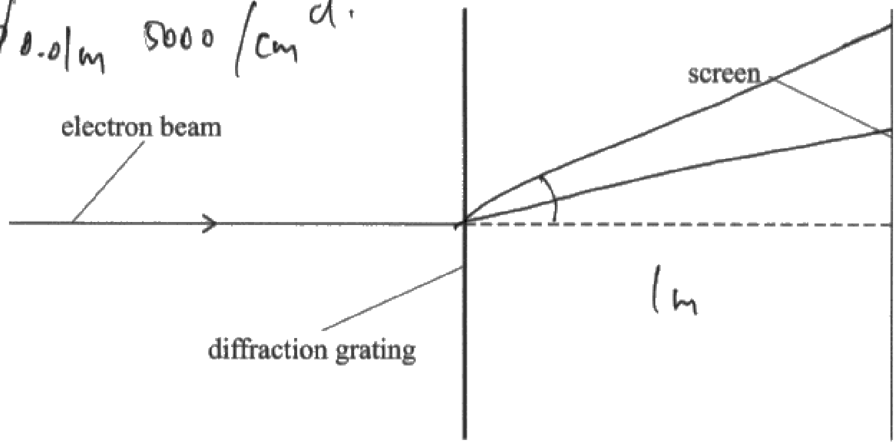
$\lambda = \frac{h}{p}$

$= \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times4.15\times10^{7}}$

$= 1.75\times10^{-11}$ m

(ii) A student suggests that the beam of electrons would produce a diffraction pattern if a diffraction grating with 5000 lines per cm was used.

5000 / 0.01 m   5000 / cm   d.



Deduce whether a second order maximum would be clearly visible on a screen. The screen is placed about a metre away from the grating.

$\lambda = 1.8 \times 10^{-11}$ m

(3)

$n\lambda = d \sin\theta$.

$2 \times 1.8 \times 10^{-11} = \cancel{\frac{1}{5000} \times \sin\theta}\ \frac{1}{500000} \times \sin\theta$.

$\theta = 1.03 \times 10^{-3}$.

$\tan\theta = \frac{x}{1}$

$x = 0.000018\,m = 1.8 \times 10^{-5}\,m$.

It would not be clearly

(Total for Question 15 = 9 marks)

ResultsPlus Examiner Comments

See above.

(b) An electron is accelerated through a potential difference of 4.9 kV.

(i) Show that the de Broglie wavelength for the electron is about 1.8×10^{-11} m.

(4)

$\lambda = \frac{h}{p}$ $\quad \lambda = \frac{h}{mv}$ $\quad V = \frac{W}{Q}$

$4.9 \times 10^{3} = \frac{W}{1.6 \times 10^{-19}}$ $\quad W = 7.84 \times 10^{-16}$

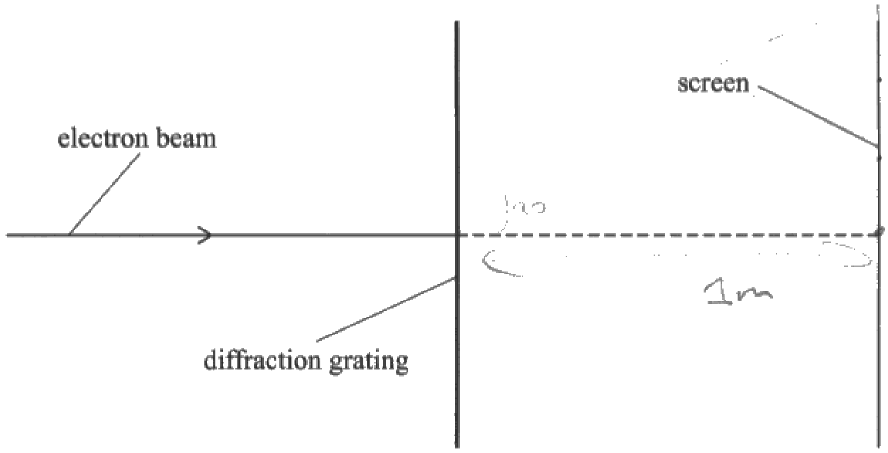
$7.84 \times 10^{-16} = \frac{1}{2} mv^2$ $\quad \cancel{mv = 3.96 \times 10^{-8}}$

$\cancel{\lambda = \frac{6.63 \times 10^{-34}}{3.96 \times 10^{-8}}}$ $\quad \cancel{\lambda = 1.7 \times 10^{-26}}$

$v = 4.15 \times 10^{7}\ \text{ms}^{-1}$ $\quad \lambda = \frac{6.63 \times 10^{-34}}{4.15 \times 10^{7} \times 9.11 \times 10^{-31}}$

$\lambda = 1.75 \times 10^{-11}$ m $\simeq 1.8 \times 10^{-11}$ m

(ii) A student suggests that the beam of electrons would produce a diffraction pattern if a diffraction grating with 5000 lines per cm was used.



Deduce whether a second order maximum would be clearly visible on a screen. The screen is placed about a metre away from the grating.

$\lambda = 1.8 \times 10^{-11}$ m

(3)

$n\lambda = d\sin\theta$ $\quad \cancel{n=} \quad N = \frac{1}{d}$

$d = 0.02$

$\cancel{1.8 \times 10^{-11} n = 2.7 \times 10^{-7} \sin\theta}$ $\quad 1.8 \times 10^{-11} n = 0.02 \sin 90$

$\cancel{1.8 \times 10^{-11} n = 2.7 \times 10^{-7} \sin 90}$ $\quad n = 1.1 \times 10^{9}$

$\cancel{n = 1.1 \times 10^{9}}$ hence second order maximum will not be visible

(Total for Question 15 = 9 marks)

ResultsPlus
Examiner Comments

A model answer for part i. In part ii there was an attempt to calculate n using a diffraction angle of 90 degrees which was a perfectly acceptable method. However, there was a power of ten error in the calculation so the final mark could not be awarded.

Question 16(a)

This was a slight variation on the usual question of asking for a definition of emf. In this case candidates were asked for a specific definition of what an emf of 6V meant and this proved to be more of a challenge than was expected.

(a) State what is meant by an e.m.f. of 6.00 V.

(1)

The amount of chemical energy converted to electrical per unit charge when charge passes

ResultsPlus Examiner Comments

This response started well but tried to give a generic explanation without mentioning the significance of 6.

A common response where the suggestion is that 6V is the work done per coloumb. However 1 V is 1 Joules per coloumb so the work done per coloumb here is 6 joules.

(a) State what is meant by an e.m.f. of 6.00 V.

(1)

Work done per unit charge of 6.00 V for transferring other forms of energy into ~~x~~ electrical energy.

ResultsPlus Examiner Comments

Remember to answer in terms of the context of the question.

(a) State what is meant by an e.m.f. of 6.00 V.

(1)

6V means 6J energy needed to drive 1C charge pass through the circuit.

ResultsPlus Examiner Comments

A perfect response.

Question 16(b)

In this question candidates were presented with a circuit and asked a number of questions divided into three parts.

Part i was a "show" question which required the calculation of a c current to verify the value on the ammeter. The first marking point was for calculating the p.d. across a 200 Ω resistor and using this in the Ohms Law equation to calculate the current for the second mark. The final mark was for a correct current.

This part was generally well answered but some candidates used the emf value from the battery and were limited to the second marking point.

Part ii required the resistance of an unknown resistor in the parallel section of the circuit to be determined. The first marking point was for a calculation of resistance using Ohm's Law to determine the resistance of the parallel section. The second marking point was for the calculation of the resistance using the parallel resistance formula and the final mark was for the correct answer. This was again well answered but many candidates struggled with arranging the parallel resistor formula correctly.

Part iii was for the calculation of a power but many candidates used the wrong p.d. value.

(b) The reading on the voltmeter is 1.64 V.

(i) Show that the reading on the ammeter is about 20 mA. 20×10^{-3} A

(3)

$V = IR$

1.64 = I R

(ii) Determine the resistance of resistor X.

(3)

$R = \frac{V}{I} \Rightarrow R = \frac{1.64}{20\times10^{-3}} = 82$

$\frac{1}{82} = \frac{1}{100} + \frac{1}{x}$

$\frac{1}{82} - \frac{1}{100} = \frac{9}{4100} \Rightarrow x = 455.55\Omega$

Resistance of resistor X = 455.6Ω

(iii) Determine the power dissipated in the 100 Ω resistor.

(2)

$P = I^2R$

$P = (20\times10^{-3})^2\times100 = 0.04W$

Power = $0.04W$

ResultsPlus
Examiner Comments

Part i: There was no attempt to calculate a potential difference or to use Ohm's Law. Part ii: This was a successful calculation, showing the value of current from part i and this is perfectly acceptable for full marks. Part ii: The first marking point was awarded for the correct use of a power equation but 20 mA was not the current across the 100Ω resistor.

ResultsPlus
Examiner Tip

If you are unable to calculate a correct value in a "show" question then always show that value in any subsequent calculations.

(b) The reading on the voltmeter is 1.64 V.

(i) Show that the reading on the ammeter is about 20 mA.

(3)

$\mathcal{E} = V_V + V_{R_3}$ $\quad R_T \cancel{I} = R_{1+2} \cancel{I} + R_3 \cancel{I}$ $\quad \frac{1}{R_{1+2}} = \frac{1}{R_1} + \frac{1}{R_2}$

$V = IR$ $\quad \frac{\mathcal{E}}{I} = R_{1+2} + R_3 = \frac{\mathcal{E}}{\frac{V_3}{R_3}}$ $\quad \mathcal{E} = V_V + V_{R_3}$

$R_1 = 100$

$R_2 = X$ $\quad \cancel{R_{1+2} = \frac{\mathcal{E} R_3}{V_3} - R_3 = 78.2336}$ $\quad V_{R_3} = \mathcal{E} - V_V = 4{,}36\,V$

$R_3 = 200$

$V_{R_3} = I R_3 \Rightarrow I = 0.0218\,A \cong 21.8\,mA$

(ii) Determine the resistance of resistor X.

(3)

$\frac{\mathcal{E}}{I} = R_{1+2} + R_3 = \frac{\mathcal{E}}{\frac{V_3}{R_3}}$ $\quad R_{1+2} = \frac{\mathcal{E}R_3}{V_3} - R_3 = 75.22936$

$\frac{1}{R_{1+2}} = \frac{1}{R_1} + \frac{1}{R_2}$ $\quad \frac{1}{R_2} = \frac{1}{R_{1+2}} - \frac{1}{R_2}$ $\quad R_2 = \frac{1}{\frac{1}{R_{1+2}} - \frac{1}{R_2}} = 303.704 \simeq 304\,\Omega$

$R_1 = 100$

Resistance of resistor X = ~~304~~ $300\,\Omega$

(iii) Determine the power dissipated in the $100\,\Omega$ resistor.

(2)

$P = VI$ $\quad$ ~~$\frac{I_{R_1}}{I} = \frac{R_{R_{31}}}{R_{R_{1+2}}}$~~ $\quad \frac{I_{R_1}}{I} = 1 - \frac{R_{R_1}}{R_p}$

$P_{R_1} = V_{R_1} I_{R_1}$ $\quad R_p = 100 + 304 = 400$

$I_{R_1} = 0.01635$

$V_{R_1} = V_V = V_{R_2}$ $\quad P = 0.026814\,W \simeq 26.8\,mW$

Power = ~~26.8~~ $27\,mW$

ResultsPlus
Examiner Comments

A full response to all parts and all marks were awarded. There was a little confusion in part i to confirm the steps taken but all working was shown. The emf formula can be used in this paper although it is not provided on the formula sheet.

ResultsPlus
Examiner Tip

If using a formula not provided then all steps must be correct for any marks to be awarded.

(b) The reading on the voltmeter is 1.64 V.

(i) Show that the reading on the ammeter is about 20 mA.

(3)

$6 - 1.64 = 4.4\ V$

$I = \frac{V}{R}$

$I = \frac{4.4}{200}$

$I = 0.022\ A = 22mA \approx 20mA$

(ii) Determine the resistance of resistor X.

(3)

$R = \frac{V}{I} \quad \frac{1.64}{0.022} = 74.5\ \Omega \approx 75\Omega$

$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{75} = \frac{1}{100} + \frac{1}{x}$

$x = 300$

$\frac{1}{75} - \frac{1}{100} = \frac{1}{x} \qquad \frac{1}{x} = \frac{1}{300}$

Resistance of resistor X = 300

(iii) Determine the power dissipated in the 100 Ω resistor.

(2)

$P = I^2R = 0.022^2 \times 100 = 0.0484\ W$

Power = 0.0484 W

ResultsPlus
Examiner Comments

Part i was clearly done correctly Part ii: The calculation was correct and the resistance rounded to 300 Ω which is correct. We do require a unit which this candidate failed to add to the answer. However, as the unit was used in the resistance calculation on the first line then this was accepted as the unit for the final answer and all marks were awarded. Part ii: The wrong current was used but a correct power equation meant that the first marking point could be awarded.

ResultsPlus
Examiner Tip

If in doubt always provide a unit for any quantity calculated.

(b) The reading on the voltmeter is 1.64 V.

(i) Show that the reading on the ammeter is about 20 mA. $\div 1000$

(3)

$6.00 - 1.64 = 4.36$

$V = IR \quad I = \frac{V}{R} = \frac{4.36}{200} = 0.0218 \times 1000$

$= 21.8\,mA$

(ii) Determine the resistance of resistor X.

(3)

$V_{out} = V_{in} \times \frac{R_2}{(R_1+R_2)}$ $\qquad 1.64 = 6.00 \times \frac{100}{(x+100)}$

$1.64 = \frac{600}{x+100}$

$x+100 = \frac{600}{1.64}$

$x = \frac{600}{1.64} - 100 = 265.8$

Resistance of resistor X = 265.9 Ω

(iii) Determine the power dissipated in the 100 Ω resistor.

(2)

$P = \frac{V^2}{R} = \frac{1.64^2}{100} = 0.027\ \text{W}$

Power = 0.027 W

ResultsPlus
Examiner Comments

Part i and part ii were both correct. In part ii this candidate attempted to use the ratio of resistances to the ratio of p.d. but was unclear about what values to use or how to use the ratio correctly.

ResultsPlus
Examiner Tip

This ratio would be acceptable as an alternative method if correct values were used and the calculation performed correctly.

Question 16(c)

This question required a comment on what would happen if two of the resistors in the circuit were swapped. The first marking point was for an indication that the resistance of the parallel section would increase and the second for suggesting that this would mean the parallel combination would receive a greater share of the p.d. The first marking point was usually awarded but the second very much less so.

Discuss the scientist's prediction.

You do not need to include calculations in your answer.

(2)

When resistors are switched then total resistance in ~~the~~ two parallel resistor will increase so p.d. for it will increase, so reading will increase so it is correct

ResultsPlus
Examiner Comments

A common response for the first marking point. Simply stating that the voltmeter reading would increase was not sufficient for the second marking point.

(c) The student makes the following prediction.

> If I switch the positions of the 100 Ω resistor and the 200 Ω resistor, then the reading on the voltmeter will increase.

Discuss the student's prediction.

You do not need to include calculations in your answer.

(2)

the ~~res~~ total resistance of ~~par~~ circuit will decrease, ~~so by V=IR, current in circuit~~ and the ~~par~~ resistance of parallel section of circuit will increase so it will share larger proportion of voltage so voltage accross parallel section will increase so voltmeter ~~rede~~ reading increases, therefore student is correct.

ResultsPlus
Examiner Comments

The first marking point is clear and the second almost there but not quite enough. There needed to be an indication that the share of parallel combination resistance to other resistance increased.

Discuss the student's prediction.

You do not need to include calculations in your answer.

(2)

In a Series circuit, the voltage will be divided according to the resistance ratio. as such. changing the positions of the ~~resti~~ resistors will not change the reading in the voltmeter.

ResultsPlus
Examiner Comments

This was a general comment that was not worthy of any credit.

Discuss the student's prediction.

You do not need to include calculations in your answer.

(2)

If the student switches the positions of 100 and 200 Ω resistors the total resistance of the resistors in parallel will increase. As the parallel resistors will now claim a greater contribution to total resistance of the circuit they will also have a higher potential running across it. Therefore the student prediction: voltmetre reading will increase is correct

ResultsPlus
Examiner Comments

A textbook response.

Question 17(a)

This was the indicative content question. The first indicative content (IC) mark was for stating that the tuning fork generated a wave. The second was for suggesting that this wave reflected off the end of the tube and the third for stating that this reflected wave interfered with the incoming wave. The fourth IC mark was for correctly linking amplitude with phase and the fifth for linking amplitude with node or antinode. The final IC mark was for a statement that there would be a node at the closed end or an antinode at the open end.

This was a very good response for 5 marks and missed the final IC mark. There was a lot of information provided and this answer contained a lot of irrelevant material. IC marks can be awarded for concise response.

*(a) Describe how a stationary wave is formed inside the tube.

(6)

Waves from the tuning fork travel along the open-ended tube and reflect off of the end of the tube. This reflected wave, will interfere with the emmitted wave from the tuning fork and they will interfere constructivly or destructively forming nodes and Antinodes. Moreover, if the waves are in phase and have a path difference of $n\lambda$ and a phase difference of 2π, they will interfere constructively. (Amplitude of the wave is the sum of the two waves combined) It's amplitude is at a maximum. This, ~~[illegible]~~ will lead to the formation of an antinode (maximum amount of displacement. On the other hand, if the waves are antiphase, π out of phase with a path difference of $(\frac{1}{2}+n)\lambda$ they will undergo destructive inteference. This is when the waves amplitudes add up to cancel out forming areas of no displacement or movement (nodes). In a stationary wave, the phase difference in between the node to node area is out of phase and closer to the antinode its 0° out of phase.

ResultsPlus
Examiner Comments

Remember to link relevant comments to the context. There is no need to overemphasise points already made.

*(a) Describe how a stationary wave is formed inside the tube.

(6)

① the vibration of tuning fork will emit a ~~sound~~ wave to ~~the~~ the open-ended tube.

② when the wave travel through the tube it will reflect ~~an~~ at the end of the tube

③ the forward wave and the reflected wave superposed and form the stationary wave. which have node and antinode.

④ as ~~the~~ two end of the tube is open, the wave will spread, it will form two antinode at two end and node in the tube.

ResultsPlus
Examiner Comments

This is an example of a concise answer which scored IC 1 2 3 and 6. No comments were made about amplitude or phase.

ResultsPlus
Examiner Tip

For standing waves phase is important so try to include references to it in your responses.

*(a) Describe how a stationary wave is formed inside the tube.

(6)

The tuning fork produces a wave. The wave produced by tuning fork reflects from the close end of the tube. The waves produced by tuning fork and the waves reflected from close end interfere. It interferes constructively and destructively. At the points where destructive interference occurs, the waves meet in antiphase [phase difference = π radians]. Here, points of zero ~~θ~~ displacement or amplitude called ~~or~~ nodes are formed. The nodes ~~are~~ always ~~remain~~ have zero displacement. At points where constructive interference occurs, waves meet in phase [phase difference = 0 radians]. Here points of maximum displacement or amplitude called antinodes are formed. The close end always forms a node and the open end forms an antinode.

ResultsPlus
Examiner Comments

A perfect response which used all but no more of the space provided.

Question 17(b)i

To answer this part correctly it was important to understand that the simplest wave formed in an open ended tube will produce an antinode at the open end so a quarter of a complete wave is produced. The wavelength could then be calculated and used in the wave equation.

(b) When the length of the tube was 20.4 cm, the simplest possible stationary wave was formed inside the tube.

(i) Calculate the frequency of the sound produced by the tube.

speed of sound in air = $340\,\mathrm{m\,s^{-1}}$

(3)

$\cancel{\lambda = f}$ $v = \lambda f$; simplest, (one node, one antinode)

then $\frac{1}{4}\lambda = 20.4 \times 10^{-2}\,\mathrm{m}$

$\Rightarrow \lambda = 0.816\,\mathrm{m}$

$\Rightarrow f = \frac{v}{\lambda} = \frac{340}{0.816}$

$\Rightarrow f \approx 416.6\,\mathrm{Hz} \approx$ 420 Hz

Frequency = 420 Hz

ResultsPlus Examiner Comments

This candidate provided a textbook response and rounded the answer to 420 Hz.

ResultsPlus Examiner Tip

Remember to include units in the answer.

(b) When the length of the tube was 20.4 cm, the simplest possible stationary wave was formed inside the tube.

(i) Calculate the frequency of the sound produced by the tube.

speed of sound in air = $340\,\text{m}\,\text{s}^{-1}$

(3)

$l = \frac{3}{4}\lambda$ or $l = \frac{1}{4}\lambda$

$\lambda = 0.204\,\text{m} \times \frac{4}{3} = 0.272\,\text{m}$ $\lambda = 0.204 \times 4 = 0.816$

$f = \frac{v}{\lambda} = \frac{340\,\text{ms}^{-1}}{0.272\,\text{m}} = 1250\,\text{Hz}$ $f = \frac{v}{\lambda} = 416.7\,\text{Hz}$

Frequency = 1250 Hz

ResultsPlus
Examiner Comments

A common error where the incorrect wavelength was calculated. This meant that only the first marking point could be scored.

This candidate rearranged the wave equation incorrectly.

(b) When the length of the tube was 20.4 cm, the simplest possible stationary wave was formed inside the tube.

fundamental

(i) Calculate the frequency of the sound produced by the tube.

speed of sound in air = 340 m s^{-1}

(3)

$f = \frac{v}{\lambda}$, $f = \frac{v}{\frac{1}{\lambda}}$ $\lambda = 2L$ ⟶ $f = \frac{1}{2L} \div v$

↳ $f = v \div \frac{1}{2L}$ $= 340 \div \frac{1}{2 \times 0.204}$

↳ $f = 69.36$ ≃ $f = 69$ Hz

Frequency = 69 Hz

ResultsPlus
Examiner Comments

Make sure to check rearrangement of equations.

(b) When the length of the tube was 20.4 cm, the simplest possible stationary wave was formed inside the tube.

(i) Calculate the frequency of the sound produced by the tube.

speed of sound in air = $340\,\mathrm{m\,s^{-1}}$

(3)

$\cancel{f =}$ $\cancel{\lambda = 4}$ $\lambda = 4L$, $L = 0.2m$. $\lambda = 0.8m$.

$f = v/\lambda = \frac{340}{0.8} = 425Hz$

Frequency = 425HZ

ResultsPlus
Examiner Comments

This candidate rounded the lengths of the pipe which resulted in the wrong answer so did not score the last marking point.

Question 17(b)ii

This question required some lateral thinking. This is related to end correction which is not in this specification but was not required to score the marks. It should have been obvious that if the frequency was smaller then the wavelength was greater for the first marking point. The second was for some indication that the wave would therefore not fit in the tube.

(ii) The actual frequency of the sound produced by the tube is slightly less than the calculated value.

Suggest why.

(2)

The ~~ant~~ antinode at the open end may be slightly further from the open end, ~~thus~~ thus ~~increasing~~ increasing the wavelength.

ResultsPlus
Examiner Comments

A very clear response that did not require any knowledge of the concept of end correction.

(ii) The actual frequency of the sound produced by the tube is slightly less than the calculated value.

Suggest why.

(2)

~~The speed of sound in air is not the~~
The given speed of sound in air value is not the most accurate value which is smaller than 340 m/s.

ResultsPlus
Examiner Comments

Some candidates attempted to answer in terms of the speed of the wave but this would not change in this experiment.

(ii) The actual frequency of the sound produced by the tube is slightly less than the calculated value.

Suggest why.

(2)

~~The Part of wave stationary wave produced is slightly outside th~~

Same part of stationary wave is outside the tube so length of the total Stationary Wave is more So the ~~fre~~ wavelength is also longer

(Total for Question 17 = 11 marks)

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Examiner Comments

No mention of antinode so the second marking point only.

Question 18(a)

Variations of this question are common in this paper. The marks were awarded for the idea that electrons will move up energy levels if they receive a correct amount of energy and will emit this energy as photons when they return to their original energy level.

Explain why the mercury atoms emit photons.

(2)

when the electrons are accelerated in the UV lamp, they collide with mercury atoms, These collisions, exiting their electrons to higher energy levels, then when they're energy gets low they realese energy as photons of uv light

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Examiner Comments

This candidate understood that the electron would jump an energy level but did not describe the return of the electron to its original level correctly.

the tube.
These mercury atoms then emit photons.

Explain why the mercury atoms emit photons. **(2)**

Mercury atoms contain ~~delocalised electrons~~ positive ions, and trapped light which absorb the electrons from the circuit absorb their energy, which is above mercuries' work function, which alows its photons to be

![ResultsPlus Examiner Comments]

Many attempted to answer this question in terms of work function but that has not relevance in this context.

(2)

The ~~fre~~ energy of the UV waves ~~is greater than the work function~~ of mercury, this leads to e
The electrons collide with the atoms and transfer energy to the mercury atom, leading to electrons being excited to higher energy

ResultsPlus Examiner Comments

This candidate scored both marks but the answer was outside the answer space. This is not a problem for examiners but it best to keep within the answer space or indicate that there is more of the response elsewhere.

Question 18(b)

This question required that candidates show the value for the energy incident on a phone screen. This value was then used in part ii to calculate the number of photons released from an ultraviolet light.

For part i the area of the screen was calculated for the first marking point. For the second marking point the power of the lamp had to be calculated. This power was used to calculate a value for energy for the third marking point and the final mark was for the correct answer.

In part ii the first marking point was for the use of the wave equation and the second was for the calculation of photon energy and the final two marks were for the correct calculation of the number of photons released.

(i) Show that the total energy incident on the glass screen during this time is about 130 J.

(4)

$I = \frac{P}{A}$ $P = I \times V$

$Q = It$

$5.0\times10^{-3}\ Wm^{-2} = \frac{P}{105.105}$ $W = IVt$

$P = 5.28528\ W$ $W = Pt$

$\cancel{Q = I \times t}$ $\cancel{KE = \frac{1}{2}mv^2}$

$W = 5.25 \times 25 = 131.4\ J$

$\approx 130\ J$

(ii) Determine the number of photons incident on the glass screen in this time.

wavelength of UV light = 395 nm 395×10^{-9}

(4)

$I = nqvA$ $v = f\lambda$

$I = n \times 1.6\times10^{-19} \times v \times \cancel{A}\ 105.105$

$\lambda = \frac{h}{p}$

$p = 1.678\times10^{-27}$

$p = mv$

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Examiner Comments

For part i this candidate provided a textbook answer but was very confused about photon energy in the second part and attempted to use an equation related to current in a wire which had no relevance here.

(i) Show that the total energy incident on the glass screen during this time is about 130 J.

(4)

$I = \frac{P}{A}$ $\qquad 50 \times 10^{-3} = \frac{P}{7.15 \times 14.7}$

$A = 7.15 \times 14.7$ $\qquad P = 50 \times 10^{-3} \times 105.105$

$P = 5.25525$

$P = \frac{E}{t}$ $\qquad E = 130\,J$

$t = \frac{130}{5.25525} = 24.7371\ldots\ s$

$\approx 25\,s$

(ii) Determine the number of photons incident on the glass screen in this time.

wavelength of UV light = 395 nm

(4)

$v = f\lambda$ $\qquad f = \frac{3 \times 10^{8}}{395 \times 10^{-9}}$

$= 7.594936\ldots \times 10^{14}\ Hz$

$E = hf$ $\qquad E = h \times 7.594\ldots \times 10^{14}$

$= 5.0324 \times 10^{-19}$

charge of an electron = 1.6×10^{-19}

ResultsPlus
Examiner Comments

This candidate completed all of the correct steps in part i but gave the final answer as 130J which is the "show that" value. This does not score the final marking point as at least one more significant figure is required in a "show that" question. In part ii only the first two marking point were awarded as the candidate was unsure as to what to do with the photon energy value.

ResultsPlus
Examiner Tip

Provide at least one more significant figure to "show that" calculations.

(i) Show that the total energy incident on the glass screen during this time is about 130 J.

(4)

$I = \frac{P}{A}$, $P = IA = 50 \times 10^{-3} \times 10^{4} \times 0.0715 \times 0.147 = 5.26\,W$,

$\cancel{I}$

$\because E = pt \quad \therefore E = 5.26 \times 25 = 131\,J$.

(ii) Determine the number of photons incident on the glass screen in this time.

wavelength of UV light = 395 nm

$E = hf = \phi + E_{k\,max}$.

$h \cdot \frac{c}{\lambda}$. $I = \frac{NQ}{t}$.

(4)

$\cancel{E = VQ \quad \therefore V = \frac{131}{1.6 \times 10^{-19}} \quad V = 8.2 \times 10^{20}\,V}$.

$E = hf = h\frac{c}{\lambda} = 6.63 \times 10^{-34} \times \frac{3 \times 10^{8}}{395 \times 10^{-9}} = 5.04 \times 10^{-19}\,J$.

$\because E = VQ \quad \therefore V = \frac{5.04 \times 10^{-19}}{1.6 \times 10^{-19}} = 3.15\,V$. $I = \frac{NQ}{t}$,

$\because E = IVt \quad \therefore I = \frac{131}{3.15 \times 25} = 1.67\,A$, $1.67 = \frac{1.6 \times 10^{-19} \cdot N}{25}$

$\Downarrow$

$\because \cancel{I = nAev}$ $\cancel{\frac{1}{2}mv^2 = 5.04 \times 10^{-19}}$, $\cancel{v = 1.05 \times 10^{6}\,m/s}$

$N = 2.6 \times 10^{20}$

$\cancel{\because I = nAev, \quad n = \frac{1.67}{0.0715 \times 0.147 \times 1.6 \times 10^{-19} \times 1.05 \times 10^{6}}}$

$\cancel{= 9.4 \times 10^{14}}$ $\cancel{I = \frac{NQ}{t}}$, $\cancel{1.67 = \frac{1.6 \times 10^{-19} \times N}{25}}$

$\cancel{N = 2.6 \times 10^{20}}$

Number of photons = 2.6×10^{20}

ResultsPlus Examiner Comments

A textbook response to part i but another example of a candidate who calculated photon energy but did no know what to do with it.

(i) Show that the total energy incident on the glass screen during this time is about 130 J.

(4)

$I = \frac{P}{A}$

$P = 50 \times 10^{-3} \times 7.15 \times \cancel{\ } \times 14.7 \times \cancel{\ }$

$= 5.26 \cancel{\times} \ W$

$E = Pt$

$= 5.26 \cancel{\ } \times 25$

$= 132 J$

(ii) Determine the number of photons incident on the glass screen in this time.

wavelength of UV light = 395 nm

(4)

$v = f\lambda$

$f = \frac{3 \times 10^{8}}{395 \times 10^{-9}}$

$= 7.59 \times 10^{14} Hz$

$E = hf$

$= 6.63 \times 10^{-34} \times 7.59 \times 10^{14}$

$= 5.03 \times 10^{-19} J$

Number of photons = ...

$n = \frac{132}{5.03 \times 10^{-19}} = 2.62 \times 10^{20}$

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Examiner Comments

A perfect response to both parts.

Question 18(c)

This question required candidates to have an understanding that energy levels in atoms are discrete and that only specific wavelengths of photons could be emitted by the mercury atoms. There were two possible answers to this question because not enough information was provided in the question to allow for an answer that was more definitive than the other. The idea was that either the electrons had already reached their maximum energy level and could not emit higher frequency photons or that the electrons could be excited further so could release higher frequency photons.

(c) The potential difference applied between the electrodes in the UV lamp is increased.

Explain the effect this would have on the frequency of the UV light produced by the lamp.

(2)

Increasing the potential difference increases the speed of electrons, so increases the frequency of collisions between electrons and mercury, so increases the number of photons emitted. More photons means greater intensity, so greater power, greater energy (E=hf), so greater

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Examiner Comments

This response contained nothing about energy levels so was not awarded any marks.

(c) The potential difference applied between the electrodes in the UV lamp is increased.

Explain the effect this would have on the frequency of the UV light produced by the lamp.

(2)

The electrons will have more energy if p.d is increased $(V = \frac{W}{Q})$. Therefore the electrons in the mercury atoms can go to higher energy levels. This means that there is a greater energy difference between discrete energy levels. When the electron deexcites, it emits photons, with energy equal to the now greater difference in energy. As photon energy = hf, the frequency of light will be

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Examiner Comments

A perfect response for the second alternative of the mark scheme.

(c) The potential difference applied between the electrodes in the UV lamp is increased.

Explain the effect this would have on the frequency of the UV light produced by the lamp.

(2)

Mercury has fixed energy level, photon energy equals to energy level difference, so may not change.

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Examiner Comments

This candidate was awarded the first marking point for the first alternative of the mark scheme. However, the second part could not be awarded and the candidate said the frequency might stay the same. Had the candidate said the frequency would stay the same both marks would have been awarded.

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Examiner Tip

Stating that something may or may not happen is not credit worthy. The answer must be specific.

Question 18(d)

Moving the lamp closer does not increase the intensity of the light emitted from the lamp but it does increase the intensity of the light received by the phone screen and this subtle difference was important for the first marking point to be awarded. For the second marking point the idea of a rate of photons arriving on the screen was needed.

Nothing of any relevance to this context.

(d) Suggest why the hardening time of the glue is reduced if the UV lamp is moved closer to the mobile phone screen.

(2)

wavelength will decrease so frequency will increase so more energy per photon so the uv light will dry the phone faster.

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Examiner Comments

See above.

(d) Suggest why the hardening time of the glue is reduced if the UV lamp is moved closer to the mobile phone screen.

(2)

distance between phone and UV is reduced. Intensity Recived is greater

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Examiner Comments

It was clear that the intensity referred to the light received by the phone and not emitted by the lamp. No reference to photons so the second mark was not awarded.

(d) Suggest why the hardening time of the glue is reduced if the UV lamp is moved closer to the mobile phone screen.

(2)

This increasing intensity. ~~This increases~~ ~~Power~~ ~~which reduces~~ of uv light. Because area coverage will be less. Power is ~~reduced~~ increased. $P = \frac{E}{t}$ so time is reduced.

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Examiner Comments

The power received increase was an acceptable alternative to rate of photons received.

Paper Summary

Based on their performance on this paper, candidates should:

- Always remember to include relevant units in calculation questions.
- Make sure that in 'show that' questions, one more significant figure is added.
- When making asked for a deduction use phrases such as "is" or "will" rather than "may" or "maybe".
- Always show the numbers you are substituting into calculations as these could gain credit where a wrong answer is provided.
- When answering indicative content questions try to form a logical structure to your answers before writing anything down. Also remember that it is not always necessary to write long descriptions of physics.
- When using equations to help explain concepts always define the terms of the equation.

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