Pearson
Edexcel

Examiners' Report
June 2022

IAL Physics WPH12 01

ResultsPlus

Introduction

This is the ninth sitting of this paper. Candidates appear to be becoming more familiar with the different style of particular types of question on this specification, so some questions performed much better than similar question in previous series.

Q13(b)(ii) and Q17(b) were both questions where a calculation needed to be followed with making a decision (in Q13(b)(ii) this was about the temperature of a filament, in Q17(b) it was about the type of UV light emitted by a light source). Candidates seem to have become much better at including their decision at the end of their calculations as this specification has progressed.

Q15(a) was a 6 mark question requiring the ability to structure an answer logically, showing how the points made related or followed on from each other. These types of question have generally not been answered well since the first WPH12 paper in 2019, and unfortunately this series was no exception. Candidates found it difficult to relate charge conservation with current, and energy conservation with voltage.

Q16 was related to Core Practical 5: Investigate the effects of length, tension and mass per unit length on the frequency of a vibrating string or wire. Although the part of the question involving a calculation was answered very well, the more descriptive aspects of stationary waves are still proving difficult for candidates to answer.

Overall, however, the paper was answered very well, showing significant improvements on previous series in some key areas.

On average, candidates scored between 5 and 6 out of 10 on the multiple choice section A part of the paper. By far the best answered question was Q06 (a simple $Q=It$ calculation), although Q04 and Q08 were both answered correctly by only around one third of the candidates. Q04 highlighted a common difficulty with polarisation questions, whereas Q08 was more likely to have been lower scoring due to the circuit diagram having a different style to that commonly seen on such questions.

Question 11 (a)

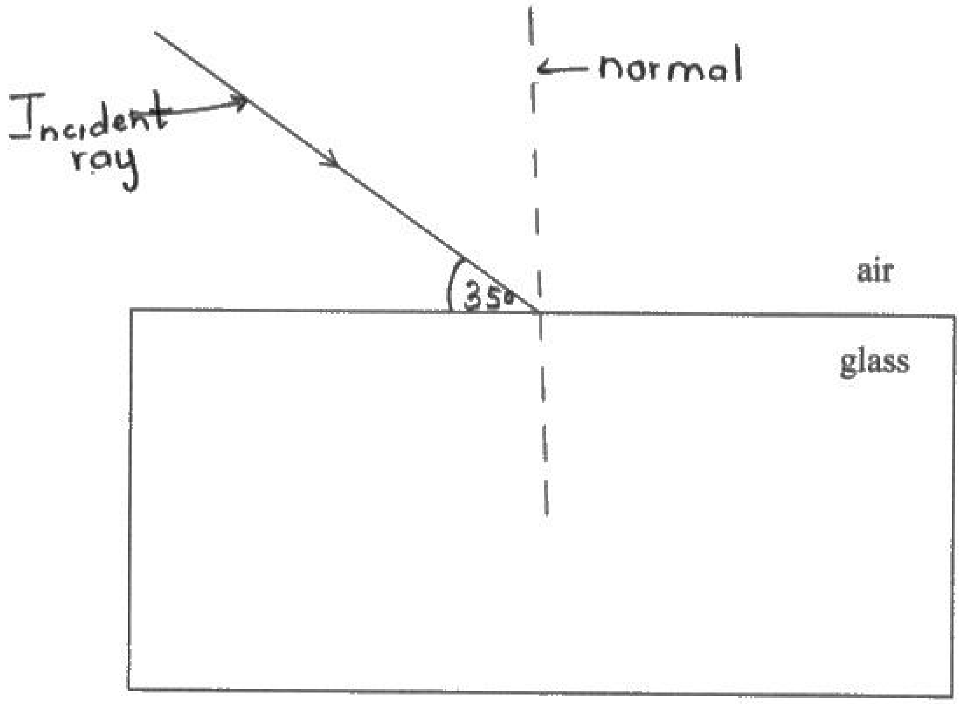
This was a rather straightforward question, requiring candidates to complete a refraction diagram, following a measurement of the angle of incidence and a subsequent calculation. As candidates were measuring angles from a diagram, there was a small, allowed tolerance on the angles of incidence and refraction.

Those candidates who correctly measured the angle of incidence commonly ended up scoring all 5 marks. However, some candidates clearly did not realise that the diagram had been drawn to scale, so the angle could be measured directly from the diagram. Most of these candidates ended up scoring 1 mark at best for the normal line being drawn correctly.

An issue with a significant number of candidates was either measuring the incorrect angle and calling it the angle of incidence (usually between the ray drawn and the edge of the glass block) or using the protractor incorrectly and measuring what should have been 55° as 35°. Either of these alternatives usually resulted in the candidate failing to achieve both marking points 1 and 3, as both of these needed to be within the given range.

A number of candidates also failed to recognise that, once the angle of refraction had been calculated, it needed to be drawn at the correct angle on the diagram.

11 The diagram shows a ray of light incident on a glass block.



(a) Complete the diagram to show the path of the ray as it enters the block. Use the space below for any calculations.

refractive index of glass = 1.58

(5)

$n_1 \sin\theta = n_2 \sin\theta$

$1.\text{~~58~~}0 \sin 35^\circ = 1.58 \times \sin\theta$

$1.\text{~~58~~}0 \times 0.5735 = 1.58 \times \sin\theta$

$\sin\theta = \text{~~Max~~} \dfrac{1.00 \times 0.5735}{1.58}$

$\sin\theta = 0.3629.$

$\theta = \sin^{-1}(0.3629)$

$\theta = 21.27^\circ$

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Examiner Comments

This candidate has not measured the correct angle of incidence, as they have measured from the edge of the glass block to the incident ray, rather than from the incident ray to the normal line. This means that they do not score the first marking point. However, they have taken their angle and used it in the correct equation to score marking point 2. They do not score marking point 3 as their value for the angle of refraction is out of the range given. They do draw a normal line, scoring marking point 4. Considering that the candidates were asked to complete the diagram to show the path of the ray as it enters the block, this one does not score marking point 5 as there is no refracted ray drawn.

So, this scores marking points 2 and 4.

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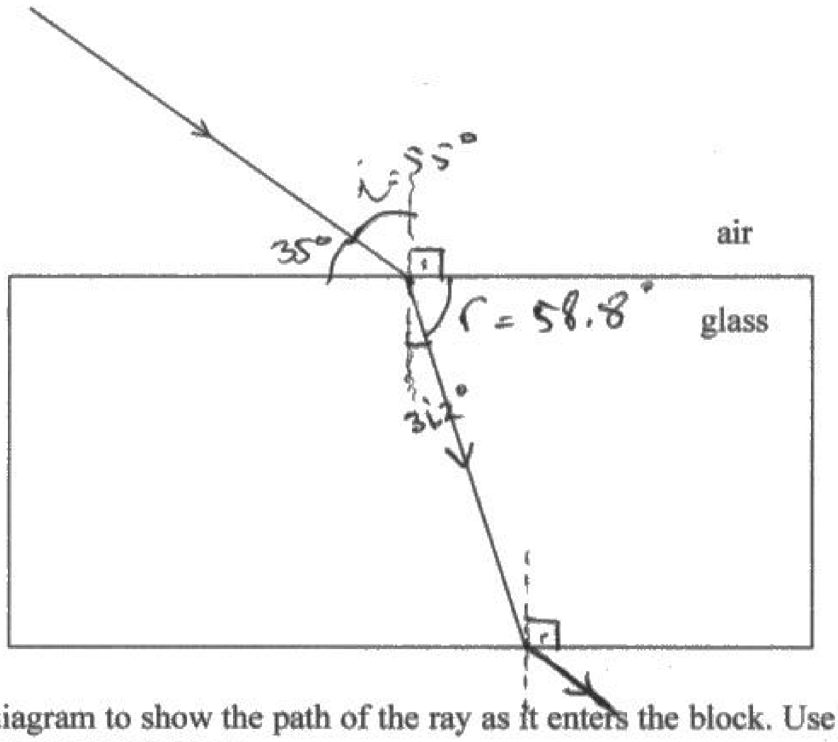
Examiner Tip

Remember that when measuring angles of incidence and refraction, these are to be measured from the normal line.

11 The diagram shows a ray of light incident on a glass block.



(a) Complete the diagram to show the path of the ray as it enters the block. Use the space below for any calculations.

refractive index of glass = 1.58

(5)

$n_a = 1$ $\qquad n_1 \sin\theta = n_2 \sin\theta$

$n_g = 1.58$ $\qquad 1.\sin 55 = 1.58 . \sin\theta$

$\theta_g = \sin^{-1}\left(\frac{\sin 55}{1.58}\right)$

$\theta_g = 31.2$

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Examiner Comments

This candidate has performed all the correct calculations, with the correct angles inserted, so scores all of the first 3 marking points with their calculation and result. They have also scored marking point 4 for their normal line. However, their drawn refracted ray is not close enough to the angle they have calculated, suggesting that they have not used a protractor to make sure that the angle is correct. This does not score marking point 5.

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Examiner Tip

When asked to complete a diagram as part of an answer, ensure that any drawn rays are at the correct angle as calculated.

Question 11 (b)

This part was generally answered very well, with the majority of candidates scoring all 3 marks. The majority of incorrect answers were either those where candidates used the refractive index from the previous part of the question to calculate the critical angle, or candidates who just calculated the refractive index using the ratio of speeds (and nothing else). Both of these answers usually ended up scoring 1 mark only.

(b) The speed of light in a different type of glass is $1.96 \times 10^8 \text{ m s}^{-1}$.

Calculate the value of the critical angle at a boundary between this type of glass and air.

(3)

~~$\sin C = \frac{v}{n}$~~ $\quad n = \frac{c}{v}$

~~$= \frac{1.96 \times 10^8}{1.58}$~~ $\quad c = nv$

$= 1.58 \times 1.96 \times 10^8$

$C = \sin^{-1}\left(\frac{1}{1.58}\right) = 39.3°$ $\quad = 3.09 \times 10^8$

Critical angle = 39.3°

ResultsPlus Examiner Comments

This is a typical 1 mark response, where the candidate has not clearly understood that this part of the question is about a different type of glass than that used in part (a). As a result, they have used the same refractive index they were given in part (a) to calculate the critical angle. This was allowed for marking point 2, which this candidate achieves. However, they do not score marking point 1 as they have not used the speed of light given. They also do not score marking point 3 as their answer is not correct.

ResultsPlus Examiner Tip

Try to consider how data given in the question can be used to calculate an answer.

(b) The speed of light in a different type of glass is $1.96 \times 10^8\,\text{m}\,\text{s}^{-1}$.

Calculate the value of the critical angle at a boundary between this type of glass and air.

(3)

$n = \frac{c}{V}$

$= \frac{3 \times 10^8}{1.96 \times 10^8}$

$= 1.5306$

$\sin C = \frac{1}{n}$

$\sin C = 1 \div \frac{3 \times 10^8}{1.96 \times 10^8}$

$C = 40.8°$

Critical angle = 40.8°

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Examiner Comments

This is a fully-correct answer for all 3 marks. The refractive index value has been calculated correctly using the relative speed of light for each substance, and then the critical angle calculated correctly, with correct units too.

(b) The speed of light in a different type of glass is $1.96 \times 10^8\,\mathrm{m\,s^{-1}}$.

Calculate the value of the critical angle at a boundary between this type of glass and air.

(3)

$n = \frac{1}{\sin C}$ $\quad n = \frac{c}{v}$ $\quad \frac{3 \times 10^8}{1.96 \times 10^8} = 1.53$

$1.53 = \frac{1}{\sin C}$ $\quad \sin^{-1}\left(\frac{1}{1.53}\right)$ $\quad C = 40.8°$

Critical angle = 40.8

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Examiner Comments

Another fully-correct answer for all 3 marks. Although the units are missing from the answer line, they can be seen in the working above.

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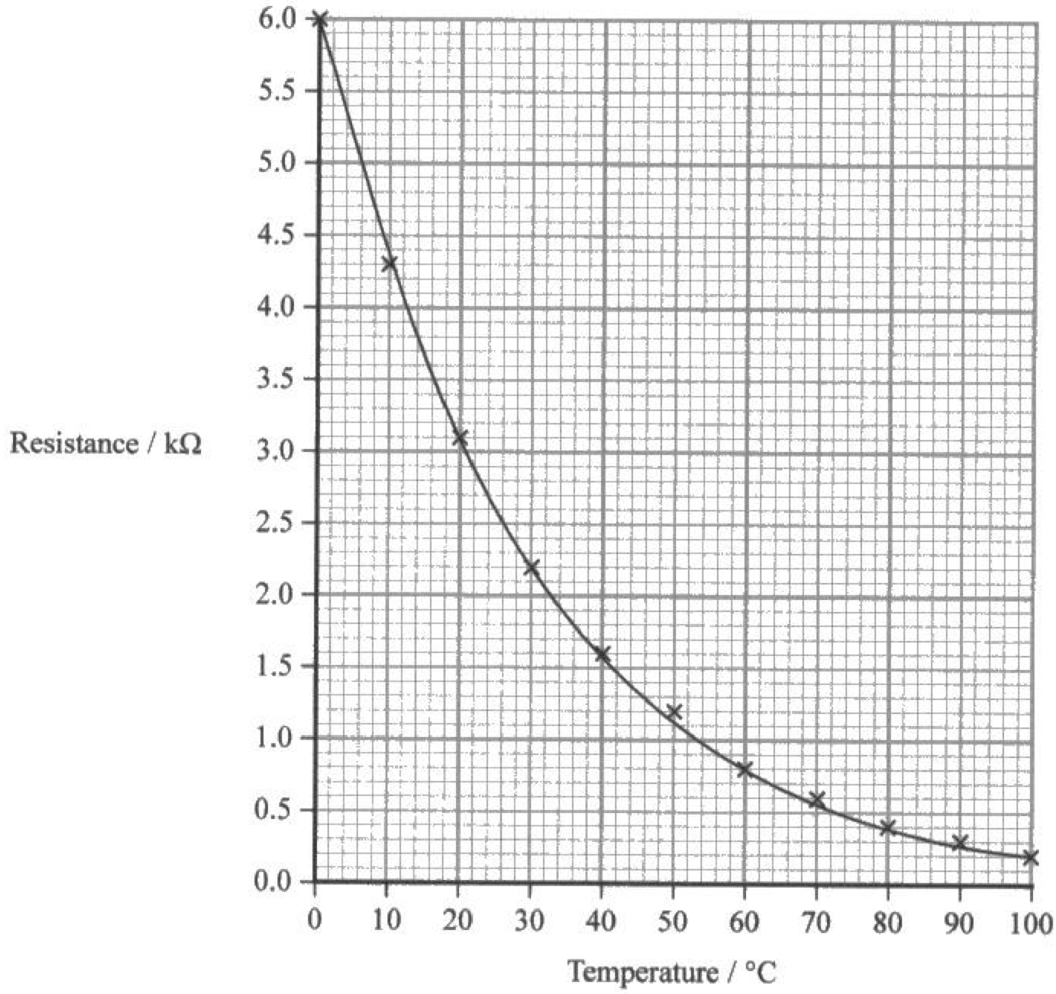
Examiner Tip

Remember that all answers to calculations require appropriate units to be added in order to achieve the final marking point.

Question 12 (a)

This was a multi-step calculation that was answered incredibly well on the whole. The most common mark awarded was 4 out of 4, and more than three quarters of candidates scored at least 2 marks. Most candidates were able to read off the correct resistance value at the given temperature, although a number then failed to correctly work out the resistance of the whole combination correctly. In spite of this, marking point 3 could have been achieved by dividing the given 12V by a recognised value of resistance, so those scoring 2 marks were usually achieving marking points 1 and 3.

The resistance of the thermistor varies with temperature, as shown by the graph.



(a) Determine the milliammeter reading when the temperature of the thermistor is 54 °C.

(4)

$V = IR_{total}$

$\frac{1}{R_{total}} = \frac{1}{2000} + \frac{1}{3000+1000}$

$R_{total} = \frac{4000}{3}$

$V = IR_{total}$

$12 = I \times \frac{4000}{3}$

$I = 9 \times 10^{-3}$ A

$= 9$ mA

Milliammeter reading = 9 mA

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Examiner Comments

A good answer, scoring all 4 marks.
Although we cannot see a clear statement that the resistance of the thermistor at the given temperature is 1000 ohms, this value is used in the resistors in parallel formula when added to the 3000 ohm resistance.
All of the subsequent calculations lead to a correct answer.

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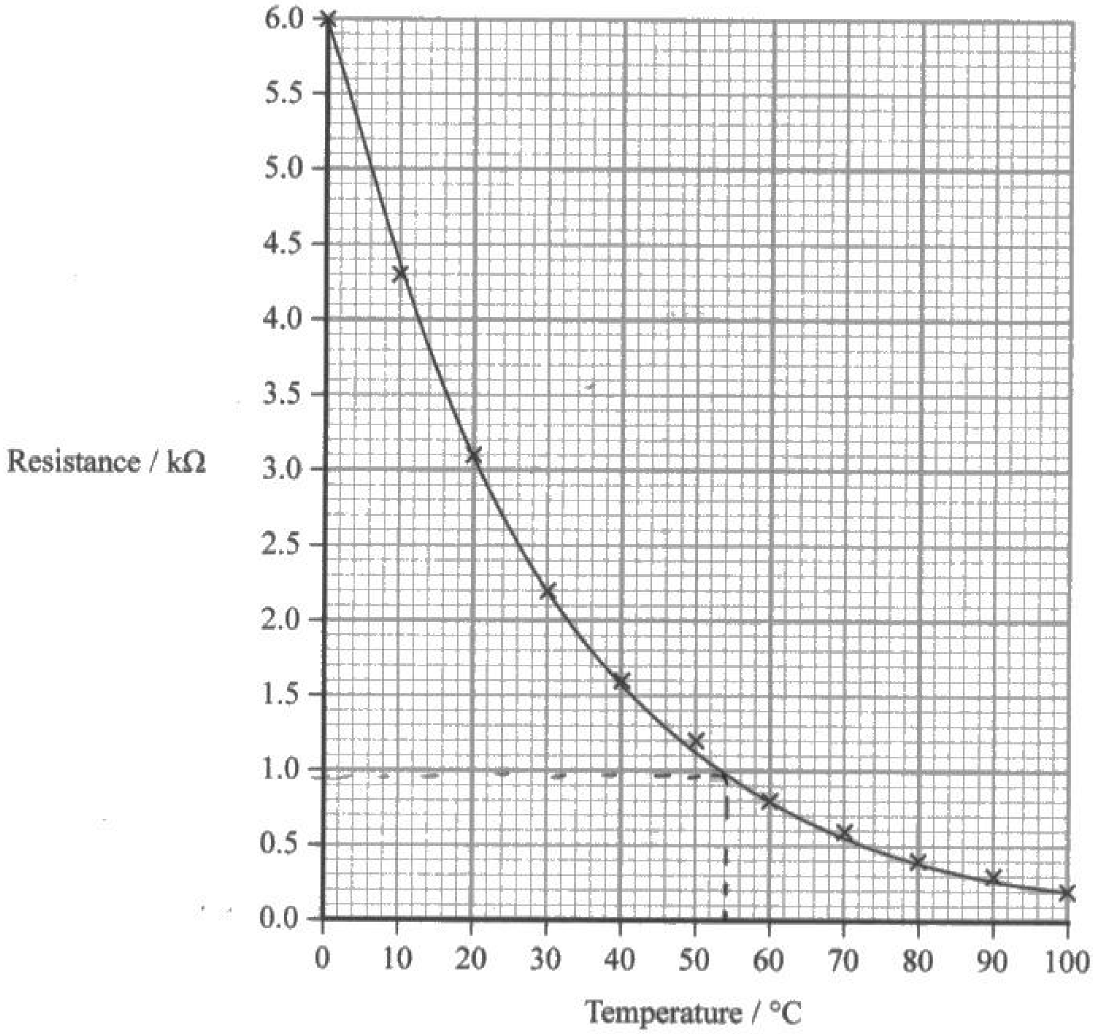
Examiner Tip

When reading a value from a graph, it is always useful to clearly write somewhere what the value has been read off as. In this case it is quite clear where the 1000 has come from, but that is not always the case.

The resistance of the thermistor varies with temperature, as shown by the graph.



mA

(a) Determine the milliammeter reading when the temperature of the thermistor is 54 °C.

(4)

R = 0.9 kΩ = 900 Ω

V = 12 V

V = IR

$I = \frac{V}{R} = \frac{12}{900} = 0.0133\ A$

= 13.3 mA

Milliammeter reading = 13.3 mA

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Examiner Comments

This candidate has slightly misread the graph and has read off the resistance as 900 ohms. This is not within the range for marking point 1, so that marking point is not awarded. They also fail to use the resistors in parallel formula, perhaps assuming that the given 12V is entirely across the thermistor. This means that they also do not score marking point 2. However, they score marking point 3 as they have clearly divided the 12V given by a resistance value from the question. The answer is incorrect, so no marking point 4 awarded.

Question 12 (b)(i)

Another question where the most common score was to achieve full marks. Candidates generally remembered the way that the resistance of a thermistor varies with temperature. However, as many candidates learn this description in terms of what happens when the temperature increases, there were a few who did not achieve both marks as they did not describe the situation in this question, where temperature decreases. Those candidates who simply discussed in terms of temperature increase could still score marking point 1, but they could only achieve marking point 2 if they were describing a temperature decrease and had correctly identified the change in resistance caused.

(b) (i) Explain how decreasing the temperature of the thermistor affects the voltmeter reading. Do not include calculations in your answer.

(2)

Decreasing the temperdture of the thermistor will increase the resistance of the thermistor, [illegible] The voltmeter reading will increase.

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Examiner Comments

A nice and clear 2 mark response, relating the reduction in temperature with the increase of resistance and the voltmeter reading increasing.

(b) (i) Explain how decreasing the temperature of the thermistor affects the voltmeter reading. Do not include calculations in your answer.

(2)

As temperature ~~Increases~~ Decreases the voltage reading across thermistor ~~decreases~~ Increases as $V = IR$ $I = V/R$ as the resistance ~~Increases~~ Decreases while current is ~~constant~~ ~~Decreases~~ constant ~~Dc~~ $V = \frac{E}{Q}$ $I = \frac{Q}{t}$

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Examiner Comments

This candidate clearly changed their mind about their answer on a couple of occasions, leading to them unfortunately not scoring either of the 2 marking points. Although they start off correctly stating that as temperature decreases, the voltage reading increases, marking point 2 is dependent on marking point 1, so there needs to be a correct statement about how the resistance changes. The statement about resistance is incorrect, so no marks are scored.

Bear in mind that current does not stay constant in this circuit, so marking point 2 was not awarded if candidates made an incorrect statement about current (increasing or staying the same).

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Examiner Tip

It is often useful in electricity questions to use equations to back up your argument. However, do check to see if the argument works. This candidate has stated that voltage increases, then uses V = IR (with constant current) to state that the resistance must decrease.

Question 12 (b)(ii)

This was a question that proved to be difficult for the majority of the candidates, a significant number of whom appeared to answer it as if the question was referring to the power of the thermistor. Although many candidates used a relevant equation for power, they were generally used to explain why the power increased or decreased when in reality (for the resistor at least) the power remained the same.

(ii) Explain how decreasing the temperature of the thermistor affects the power dissipated by the 2.0 kΩ resistor. Do not include calculations in your answer.

(2)

~~It increases the power~~ It doesn't affect the power dissipated by 2.0 kΩ resistor as the circuit is parallel and therefore voltage across it is still 12V and as $P=\frac{V^2}{R}$ Power is the same

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Examiner Comments

A really clear 2 mark response, using the correct equation to relate to the variables they have discussed in their answer. If this candidate had attempted to use the two other power equations stated in the mark scheme, they would have been required to explain what happened to the current in order to gain access to both marks.

(ii) Explain how decreasing the temperature of the thermistor affects the power dissipated by the 2.0 kΩ resistor. Do not include calculations in your answer.

(2)

Holding the 2.0k Ω resistor's resistance constant, decreasing the temperature of thermistor increase the resistance of thermistor and thus increase the total resistance of circuit. The passing current to the 2.0 kΩ resistor increases and increase the power dissipated by the 2.0 kΩ resistor.

(Total for Question 12 = 8 marks)

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Examiner Comments

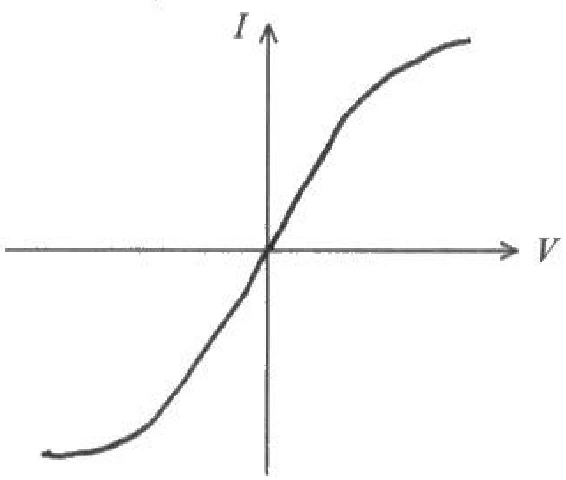
Although it is clear that this candidate is answering the question in terms of the specified resistor, they have focussed their answer on whole circuit changes, rather than the changes (if any) for the resistor. Any mention of there being a changing current or voltage for the resistor resulted in a failure to achieve marking point 2. This candidate also does not suggest that either voltage or current would stay the same so also does not achieve marking point 1.

Question 13 (a)

A standard IV graph question. Some candidates failed to draw the correct shape in the positive quadrant, and some failed to create a symmetrical pattern in the negative quadrant. As has been the case in previous examinations, some candidates "hooked" their graphs, implying that as V continued to increase, I started to decrease beyond a certain point. In spite of these occasional slips, the most commonly awarded mark was 2.

(a) Complete the sketch graph to show how current varies with potential difference for a filament bulb.

(2)



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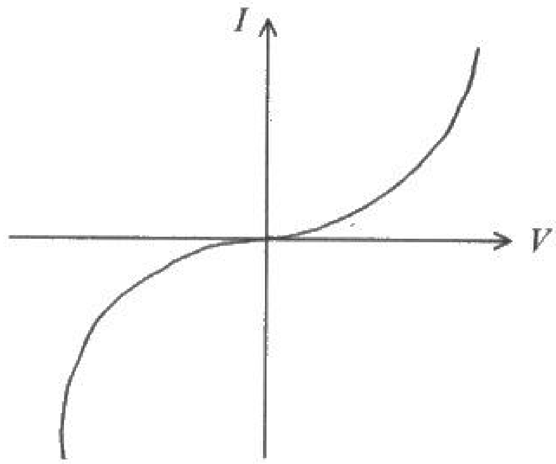
Examiner Comments

A graph which has been well drawn in the positive quadrant. The graph is just about symmetrical enough in the negative quadrant so scores both marks. The drawn section in the negative quadrant does tend to plateau somewhat but was considered to be just about acceptable.

(a) Complete the sketch graph to show how current varies with potential difference for a filament bulb.

(2)



ResultsPlus
Examiner Comments

The graph has been drawn incorrectly in the positive quadrant. This would have been correct if the axes had been drawn the other way round. The negative quadrant was deemed to be just about symmetrical enough to warrant the award of marking point 2, although it was just about on the limits of acceptability.

Question 13 (b)(i-ii)

These two parts of Q13 were linked together as both required the use of the cross-sectional area of the wire in the filament. Once again, there was a consistently high score achieved on this, with both parts having full marks as the most commonly achieved score. By a very small margin, part (ii) was answered better than (i).

In order to establish the drift velocity in Q13(b)(i), candidates needed to calculate the cross-sectional area of the wire. However, some of them performed calculations that were more complicated than was required, usually involving including the length of the wire to calculate volume. There were also a significant number of candidates who did not substitute correct values, such as the charge of an electron, into the drift velocity equation. The majority of candidates scoring 2 marks failed to include the units on their answer.

In Q13(b)(ii) the idea was that candidates could achieve a partial error carried forward for an incorrect cross-sectional area from (i) into (ii). However, many candidates appeared to start the whole area calculation again, resulting in many who did not get full marks on (i) scoring full marks on (ii). There were a very small number of candidates who had a power of 10 error in their calculation who then struggled to ensure that their calculated resistivity value was to the same order of magnitude (-7) as all of those shown in the table from which they were choosing. In spite of the complications, and the need to make a decision at the end, more than half of the candidates scored full marks on this part.

(b) The tungsten wire has a diameter of 0.046 mm and a length of 580 mm. When emitting light, there is a current of 0.44 A in the filament and a potential difference of 140 V across the filament.

(i) Calculate the drift velocity v of the electrons in the tungsten wire.

number of charge carriers per m^3 in tungsten = 1.26×10^{29}

(3)

$I = nqvA$

$v = \frac{I}{nqA}$

$v = \frac{0.44}{1.26\times10^{29} \times 140 \times 1.66\times10^{-3}}$ 1.66×10^{-9}

$v = 1.50\times10^{-29}$ $v = 8.11\times10^{-3}$

$A = \pi r^2$

$A = \pi \times 0.023^2$

$A = 1.66\times10^{-3}$

$A = \pi r^2$

$A = \pi \times (2.3\times10^{-5})^2$

$A = 1.66\times10^{-9}$

v = 1.50×10^{-29} 8.11×10^{-3}

(ii) When the potential difference across the tungsten filament is 140 V the current in the filament is 0.44 A.

The table shows typical resistivity values for tungsten at different temperatures.

Temperature / °C	20	700	1700	2700	3200
Resistivity / Ωm	0.55×10^{-7}	2.43×10^{-7}	5.57×10^{-7}	9.04×10^{-7}	10.85×10^{-7}

Deduce the temperature of the filament.

(3)

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

$R = \frac{140}{0.44}$

$R = 318$

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

* when the temperature increases the resistivity also increases,

$R = \frac{140 \times 580}{1.66\times10^{-3}}$

1 m = 1000 mm

x = 580

1000 x = 580

x = 580/1000

x = 0.58

(48919.91)

$\rho = \frac{140\times0.58}{1.66\times10^{-9}}$

$\rho = 4.79\times10^{-7}$

Temperature = 1700 °C

(Total for Question 13 = 8 marks)

4.6×0^{-5}

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Examiner Comments

In part (i), this candidate has clearly worked out a correct cross-sectional area at the right hand side of their working, so they achieve marking point 1. Marking point 2 was not awarded as they have substituted 140 V as the value for q, which clearly results in an incorrect answer, so no marking point 3.

In part (ii), they have calculated the resistance at the top left of their working but have scribbled it out. This means they cannot score marking point 1. Their use of the resistivity equation then appears to have resistance and resistivity the wrong way round, and thus the substitutions are incorrect (no marking point 2 or 3 awarded).

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Examiner Tip

If a candidate deems their calculation to be incorrect, it should be crossed out carefully. If this working is not replaced by any other calculations, then examiners can award marks for work that has been crossed out. However, if the original calculation has been crossed out too heavily, examiners will not be able to decipher the crossed out work.

(b) The tungsten wire has a diameter of 0.046 mm and a length of 580 mm. When emitting light, there is a current of 0.44 A in the filament and a potential difference of 140 V across the filament.

(i) Calculate the drift velocity v of the electrons in the tungsten wire.

number of charge carriers per m^3 in tungsten = 1.26×10^{29}

(3)

$I = nqvA$ $I = 0.44$ $n = 1.26 \times 10^{29}$ $q = 1.6 \times 10^{-19}$ $v = ?$ $A = \pi r^2$

$A = \pi \times \left(\frac{0.046 \times 10^{-3}}{2}\right)^2 = 1.66 \times 10^{-9}$

$0.44 = 1.26 \times 10^{29} \times 1.6 \times 10^{-19} \times 1.66 \times 10^{-9} \times v$

$v = 0.013$

v = $0.013\ ms^{-1}$

(ii) When the potential difference across the tungsten filament is 140 V the current in the filament is 0.44 A.

The table shows typical resistivity values for tungsten at different temperatures.

Temperature / °C	20	700	1700	2700	3200
Resistivity / Ωm	0.55×10^{-7}	2.43×10^{-7}	5.57×10^{-7}	9.04×10^{-7}	10.85×10^{-7}

Deduce the temperature of the filament.

(3)

$R = \frac{\rho l}{A}$ $V = IR$ $R = 140 \div 0.44 = 318.2$

$318.2 = \frac{\rho \times 580 \times 10^{-3}}{1.66 \times 10^{-9}}$ ~~En qnh~~ $\rho = 9.1 \times 10^{-7}$

↓ $T = 2700$

$T = 2700\ °C$

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Examiner Comments

A very good answer scoring all 3 marks on both sections.

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Examiner Tip

Although calculations require the correct units to appear on the answer, interim values calculated do not require units. As a result, there is no penalty for this candidate not having the units for cross-sectional area in part (i) or on resistance in part (ii).

Question 14 (a)(i)

A relatively straightforward start to Q14, with a couple of calculations using given formulae and data. Generally, it was very well answered with almost two thirds of all candidates scoring the full 4 marks. The next most common score was 3 marks, usually as a result of either not including units on the speeds or due to forgetting to square root one of the calculations.

14 When an earthquake occurs, two types of wave travel through the Earth. The two types of wave are P-waves (longitudinal) and S-waves (transverse).

(a) The velocities of P-waves and S-waves as they travel through the Earth are related to the density ρ of the material they are travelling through.

The velocity v_p of P-waves and the velocity v_s of S-waves are given by the following equations:

$$v_p = \sqrt{\frac{K + \frac{4}{3}G}{\rho}} \qquad v_s = \sqrt{\frac{G}{\rho}}$$

where K and G are constants for a particular material below the Earth's surface.

(i) The density of one material is $2700\,\text{kg m}^{-3}$.

Calculate v_p and v_s in this material.

$K = 7.55 \times 10^{10}\,\text{Pa}$
$G = 2.61 \times 10^{10}\,\text{Pa}$

(4)

$$V_p = \sqrt{\frac{7.55\times10^{10} + \frac{4}{3}\times 2.61\times10^{10}}{2700}} = 4.1\times10^{7}\,\text{ms}^{-1}$$

$$V_s = \sqrt{\frac{2.61\times10^{10}}{2700}} = 3109\,\text{ms}^{-1}$$

$v_p = 4.1\times10^{7}\,\text{ms}^{-1}$

$v_s = 3109\,\text{ms}^{-1}$

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Examiner Comments

This candidate has correctly worked out the speed of the S-waves with an appropriate unit, so scores marking points 1 and 3 for that calculation. The substitution into the other equation is correct, but the candidate has failed to square root to get the answer. Although they score marking point 2 for the substitution, this scores 3 marks in total.

ResultsPlus
Examiner Tip

Check calculations thoroughly. Although the scenario of this question is perhaps a little unusual for some candidates, it is worth considering whether earthquake waves travelling through the Earth would be likely to travel at almost 14% of the speed of light.

14 When an earthquake occurs, two types of wave travel through the Earth. The two types of wave are P-waves (longitudinal) and S-waves (transverse).

(a) The velocities of P-waves and S-waves as they travel through the Earth are related to the density ρ of the material they are travelling through.

The velocity v_p of P-waves and the velocity v_s of S-waves are given by the following equations:

$$v_p = \sqrt{\frac{K + \frac{4}{3}G}{\rho}} \qquad v_s = \sqrt{\frac{G}{\rho}}$$

where K and G are constants for a particular material below the Earth's surface.

(i) The density of one material is $2700\,\mathrm{kg\,m^{-3}}$.

Calculate v_p and v_s in this material.

$K = 7.55 \times 10^{10}\,\mathrm{Pa}$
$G = 2.61 \times 10^{10}\,\mathrm{Pa}$

(4)

$V_p = \sqrt{\frac{7.55 \times 10^{10} + \frac{4}{3} \times 2.61 \times 10^{10}}{2700}}$

$V_p = 6400$

$V_s = \sqrt{\frac{2.61 \times 10^{10}}{2700}}$

$V_s = 3109$

$v_p =$ 6400

$v_s =$ 3100

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Examiner Comments

This candidate has correctly worked out the two values for speed but has missed off the units from both. As it is the same unit that is missing from both, it was decided to only penalise the missing unit once on this question, so this candidate scores 3 marks in total.

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Examiner Tip

Always look at calculated answers to determine whether there should be a unit. There are very few numerical values that would be calculated on this paper that do not have a unit (eg refractive index).

Question 14 (a)(ii)

Another generally well-answered question, although the fact that marking point 2 was dependent on marking point 1 meant that the vast majority of candidates scored either 0 or 2 (with 2 being the most commonly awarded).
Although the question stated that the value of G was 0 for liquids, a number of candidates chose to discuss it purely in terms of properties of transverse waves, often resulting in no marks being scored. Candidates will find it hard to explain such answers in terms of the properties of the waves, as light waves (which are also transverse) can travel through liquids.

(ii) The Earth contains layers of liquid. The value of G for liquids is 0.

Explain whether S-waves can travel through liquids.

(2)

$v_s = \sqrt{\frac{0}{\rho}} = 0$ ∴ S-waves cannot travel through liquids as $v_s = 0$ when $G = 0$ given $v_s = \sqrt{\frac{G}{\rho}}$

ResultsPlus
Examiner Comments

A commonly-seen 2 mark response.

(ii) The Earth contains layers of liquid. The value of G for liquids is 0.

Explain whether S-waves can travel through liquids.

(2)

Yes they could travel through liquids because S-waves are transverse waves which could travel through any medium and without a meduim

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Examiner Comments

This is a candidate who does not refer to the value of G given in the question and the effect it has on wave velocity, resulting in no marks being awarded.

Question 14 (b)(i)

A standard definition of coherence, although candidates often find marking point 2 difficult to articulate. Those who tend to refer to phase often discuss it in terms of a need for the waves to be "in phase" rather than just having a constant phase difference. Marking point 1 was commonly scored, although some candidates failed to achieve this due to some vagueness in wording, such as "the frequency is similar".

(b) During a single earthquake, S-waves can be produced by more than one source. If two coherent S-waves meet, interference can take place.

(i) Explain what is meant by coherent.

(2)

Coherent wave's meet in Phase with a parth difference of nλ they produc constructive interferance.

ResultsPlus
Examiner Comments

"In phase" is not sufficient for marking point 2. No reference to frequency or wavelength so no marking point 1 awarded either.

(b) During a single earthquake, S-waves can be produced by more than one source. If two coherent S-waves meet, interference can take place.

(i) Explain what is meant by coherent.

(2)

Same direction of travel, same frequency, same wavelength. Amplitude can be different

ResultsPlus
Examiner Comments

Both "same frequency" and "same wavelength" are acceptable for marking point 1, so this candidate scores that mark. However, there is no reference to phase so no marking point 2.

(b) During a single earthquake, S-waves can be produced by more than one source. If two coherent S-waves meet, interference can take place.

(i) Explain what is meant by coherent.

(2)

coherent means have the same frequency with a constant phase relationship

ResultsPlus
Examiner Comments

A good 2 mark response with both aspects clearly stated.

Question 14 (b)(ii)

The different context for this question perhaps made it more difficult for candidates than expected. Most recognised that when the amplitude was 0 there was destructive interference taking place. Many candidates also recognised that the waves would be in antiphase. The least commonly awarded marking point was the discussion of path difference. Although the two sources were stated in the question to be coherent, it was not necessary to assume that they started off being in phase, so any path difference would have been accepted. However, for marking point 2 the waves needed to be in antiphase at A.

A small number of candidates were discussing stationary waves, often getting confused with the terminology and describing A as being at a node.

(ii) A scientist created a model to predict the effect of two coherent S-waves at different distances from the source. The model predicted the amplitude of the S-waves at positions A and B shown on the diagram.

The amplitude of the waves at position A was zero. The amplitude of the waves at position B was greater than zero.

Explain why the amplitude of the waves at position A was zero.

(3)

At position A, there is a path difference of $\frac{1}{2}\lambda$ between the waves, making them in antiphase meaning they destructively interfere and cancel each other out; the peaks of one are at the trough of another and thus add to result in 0 amplitude.

ResultsPlus
Examiner Comments

This scores all 3 marking points in the first 3 lines of the answer. A good, clear description of the situation. Although we do not know whether the path difference in this situation would be half a wavelength, the fact that the candidate has recognised that there is a path difference is enough for marking point 1.

(ii) A scientist created a model to predict the effect of two coherent S-waves at different distances from the source. The model predicted the amplitude of the S-waves at positions A and B shown on the diagram.

The amplitude of the waves at position A was zero. The amplitude of the waves at position B was greater than zero.

Explain why the amplitude of the waves at position A was zero.

(3)

two coherent waves travelling in opposite directions meet & superpose & cancel each other out due to being in antiphase (180°) so the amplitude will be 0

ResultsPlus
Examiner Comments

A very clear description of a stationary wave, as the waves in this question are not moving in opposite directions. However, there is mention of the waves being in antiphase, so we can credit marking point 2. Although superposition is mentioned, we are not told whether this is constructive or destructive, so no marking point 3 awarded.

Although this candidate does not mention position A in their answer, it is perfectly acceptable here as position A is the subject of the question.

(ii) A scientist created a model to predict the effect of two coherent S-waves at different distances from the source. The model predicted the amplitude of the S-waves at positions A and B shown on the diagram.

The amplitude of the waves at position A was zero. The amplitude of the waves at position B was greater than zero.

Explain why the amplitude of the waves at position A was zero.

(3)

The two waves when they superpose at position A were out of phase which resulted in destructive interference. This leads to node being formed at A which is a region of zero displacement.

ResultsPlus
Examiner Comments

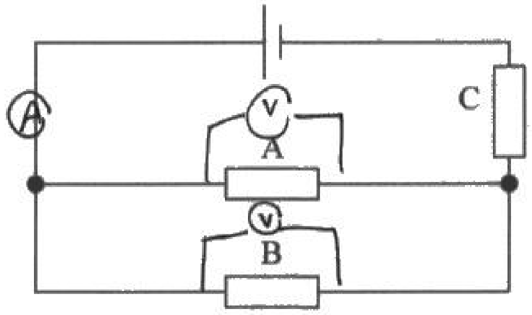
As in previous series, "out of phase" is not considered to be equivalent to "antiphase", so this candidate does not score marking point 2. However, they do mention destructive interference, so score marking point 3.

Question 15 (a)

Specification point 67 refers to the conservation of charge and energy in circuits, specifically relating them to current and voltage, respectively. This is clearly an area that is poorly understood by a significant proportion of the candidates who took this paper. The question was not answered very well and, unfortunately, many of the candidates who scored no marks had left the answer space entirely blank.

The question had intended to help candidates by linking the quantities being conserved with the quantities being measured. However, some candidates started off incorrectly by assuming that the current and potential difference measurements should be used to calculate either resistance (V/I) or power (V x I). As a consequence, only a very small percentage of the candidates scored all 6 marks.

15 The diagram shows a circuit containing three identical resistors, A, B and C. The cell has negligible internal resistance.



*(a) Explain how measurements of current and potential difference could be used to demonstrate that charge and energy are both conserved in this circuit. Your answer should refer to resistors A, B and C.

(6)

$I = \frac{Q}{t}$ $V = \frac{E}{Q}$ $V = IR$ $V_A = V_B$ and $V_A + V_C = V_T = EMF$

If the P.D. is measured across A, B and C then the combind P.D will be equal to EMF or the P.D of the cell. And if current is measured next to each resistor then we would see that the current at next to B and A is equal to that of C. We can then use the equation V = IR meaning the total Volatage would be equal to Voltage of $V_T = V_B + V_A + V_C$ (as V_A and V_B is equal

$\mathcal{E} = IR_B + IR_A + IR_C$

so if the over all voltage and current is the same, then the charge is the same and so does the energy

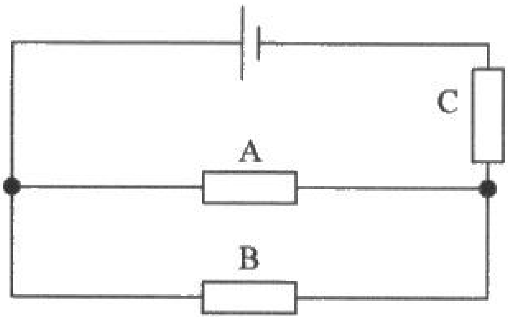
$(V = \frac{E}{Q}$ and $I = \frac{Q}{t})$

ResultsPlus
Examiner Comments

This candidate scores 4 of the 6 IC marks in the first line of their answer. Although all of them are in terms of symbols or algebra, they match the IC points well. IC1 is in the first equation at the start of the answer, IC4 in the next equation. In the box at the end of that first line, they score IC5 and IC6 for their equations. Around 5 lines below they also score IC3. So, it is only IC2 that is not awarded.

The total of 5 IC marks leads to 3 physics marks. It was felt that there was enough of a link between the points to award both linkage marks, so a total of 5 marks was scored.

15 The diagram shows a circuit containing three identical resistors, A, B and C. The cell has negligible internal resistance.



*(a) Explain how measurements of current and potential difference could be used to demonstrate that charge and energy are both conserved in this circuit. Your answer should refer to resistors A, B and C.

(6)

~~A~~ ~~current is equal,~~ voltage is the same for path resistor A and path resistor B. The energy is conserved as $V = \frac{W}{Q}$ and charge is conserved as resistor A plus resistor B's current equals resistor C's current.

ResultsPlus
Examiner Comments

The first two lines gain IC6. The equation on line 3 scores IC4. The last couple of lines score IC3. Although the answer is only 5 lines long, they have achieved 3 of the IC points, scoring 2 physics marks. The addition of a linkage mark gives this 3 marks in total.

Question 15 (b)(i-ii)

Part (i) was generally answered well, with a significant majority of candidates scoring all 3 marks. The most common mistakes were for candidates to mix up the formulae for series and parallel circuits, or to fail to invert to obtain the parallel resistance from its formula.

Part (ii) was less well answered, perhaps partly due to a misunderstanding on the part of the candidates. Although many were able to identify a suitable position for the single ammeter, a significant number of candidates clearly did not realise that using a single ammeter reading meant that the terminal potential difference could not be measured directly and had to be calculated instead. As a result, the most commonly achieved score was 1 out of 3 marks, with the other possible scores (0, 2 and 3 marks) being achieved in roughly equal numbers.

(b) (i) Calculate the total resistance of the circuit.

resistance of each resistor = 12.5 Ω

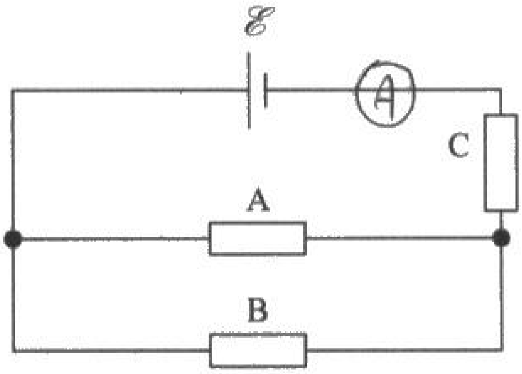
(3)

total resistance $= 12.5 + \frac{1}{\frac{1}{12.5} + \frac{1}{12.5}}$

$= 18.75\ \Omega$

Total resistance = 18.75 Ω

(ii) The resistors are connected to a different cell, with e.m.f. $\mathscr{E}$, as shown. The cell has an internal resistance.



Describe how a single ammeter reading can be used to determine the internal resistance of the cell. You should add to the diagram to show the position of this ammeter.

(3)

The internal resistance can be found with $\varepsilon = Ir + IR$

ResultsPlus
Examiner Comments

The answer to part (i) is fully correct. The candidate has combined the series and parallel equations in one larger equation, but this is perfectly clear to see how the correct answer is achieved.

This candidate also answers part (ii) very well. The position of the ammeter is acceptable for marking point 3, and the equation given is acceptable for marking point 1, as it does not include V, which cannot be measured directly using this circuit. The only step missing is the rearrangement to show how the internal resistance can be calculated from the given formula.

ResultsPlus
Examiner Tip

If a question asks how to calculate internal resistance, the formula given should have the internal resistance as the subject of the formula.

(b) (i) Calculate the total resistance of the circuit.

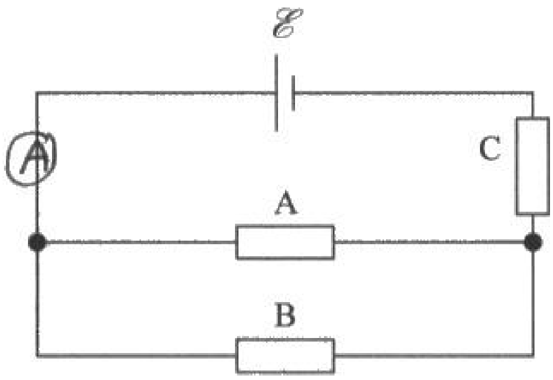
resistance of each resistor = 12.5 Ω

(3)

$\frac{1}{12.5} + \frac{1}{12.5} = \frac{1}{Rt}$ ~~th~~ $Rt = 6.25\ \Omega$ $6.25 + 12.5 = 18.75 = R_t$

Total resistance = 18.75

(ii) The resistors are connected to a different cell, with e.m.f. $\mathscr{E}$, as shown. The cell has an internal resistance.



Describe how a single ammeter reading can be used to determine the internal resistance of the cell. You should add to the diagram to show the position of this ammeter.

(3)

$\mathcal{E} = V + IR$ This (A) shows current arriving at the cell. This current should equal the current leaving the cell and I at C since it's shared in series.

ResultsPlus
Examiner Comments

This candidate starts part (i) with a correct calculation for the parallel resistance, and then adds it to the series resistance correctly. However, they forget to include the unit for resistance, so end up with 2 marks in total for this part.

On part (ii) the ammeter is located correctly so scores marking point 3. However, the equation given has terminal potential difference included, with no suggestion as to how this can be determined using the reading from a single ammeter. So, this did not score marking points 1 or 2.

(b) (i) Calculate the total resistance of the circuit.

resistance of each resistor = 12.5 Ω

(3)

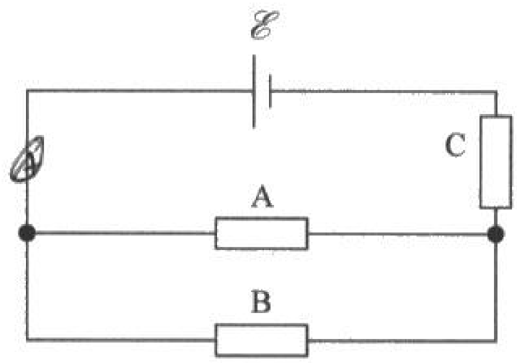
12.5+12.5 = 25

$\frac{1}{25} + \frac{1}{12.5} = \frac{3}{25} \rightarrow \left(\frac{3}{25}\right)^{-1} \rightarrow \frac{25}{3}$

$\rightarrow 8.3\ \Omega$

Total resistance = 8.3 Ω

(ii) The resistors are connected to a different cell, with e.m.f. ℰ, as shown. The cell has an internal resistance.



Describe how a single ammeter reading can be used to determine the internal resistance of the cell. You should add to the diagram to show the position of this ammeter.

(3)

- Current in series is same, the total resistance is known from (b)(i) which is 8.3 Ω, $\varepsilon = I(R+r)$ 'r' = internal resistance, $\frac{\varepsilon}{I} - R = r$

ResultsPlus
Examiner Comments

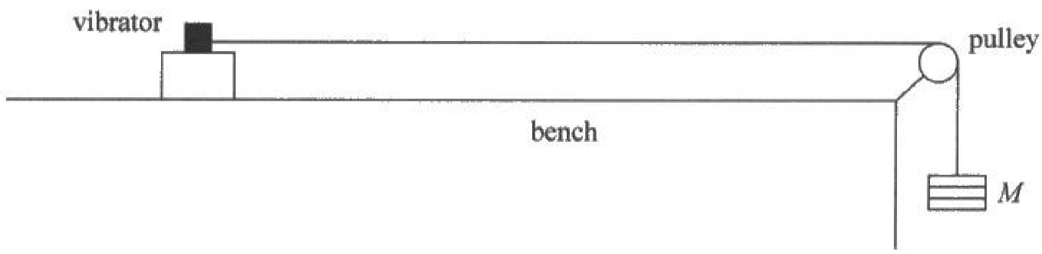
Unfortunately, on part (i) the candidate has the series and parallel resistor formulae the wrong way round, so ended up scoring no marks.

On part (ii), however, they locate the ammeter correctly (so get marking point 3). They then score the other two marking points by quoting $E = I(R+r)$ and then rearranging it so that the internal resistance is the subject of the formula.

Question 16 (a)

Considering that this practical is a core practical, it was surprising to see so many candidates unable to explain how the stationary wave formed on the string using what is a pretty standard setup. Far too many candidates just gave a standard description about how a stationary wave forms in any situation and did not address the question as to "how a stationary wave forms on the string". As such, marking points 1 and 2 were quite commonly missed out, with a tendency for candidates to talk simply of "two waves travelling in opposite directions at the same speed". Even then, some candidates failed to mention superposition, and focussed answers on nodes and antinodes, which are not really relevant to "how a stationary wave forms".

16 A student investigated stationary waves on a stretched string. The string was attached to a vibrator and a mass *M*, as shown.



(a) Explain how a stationary wave forms on the string.

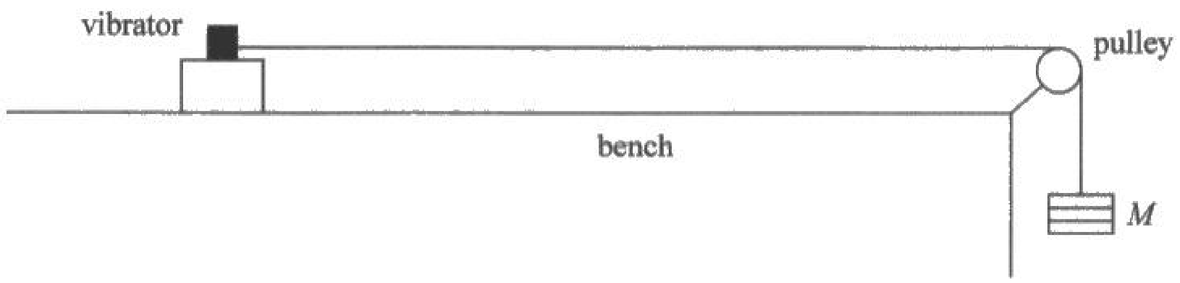
(3)

waves travelling in opposites directions meet and interfere, superposition occurs. ~~They create points where~~ creating points where they are in phase and points where they are in antiphase. If they are in phase, there is an antinode, an antinode means maximum amplitude.

ResultsPlus
Examiner Comments

This is a typical example of a candidate scoring marking point 3 only, as there is no mention of how the two waves travelled in opposite directions on this string.

16 A student investigated stationary waves on a stretched string. The string was attached to a vibrator and a mass M, as shown.



(a) Explain how a stationary wave forms on the string.

(3)

the waves travel from the vibrator and a reflected back by the pulley. when the two waves travelling in opposite direction superimpose. constructive interference and destructive interference occurs. Constructive interference ~~produced~~ produces antinodes with maximum amplitude while destructive interference produces nodes of minimal ~~displacement~~ amplitude.

ResultsPlus
Examiner Comments

This candidate has applied their understanding very well to give a response incorporating all 3 marking points within the first 3 lines of their answer.

ResultsPlus
Examiner Tip

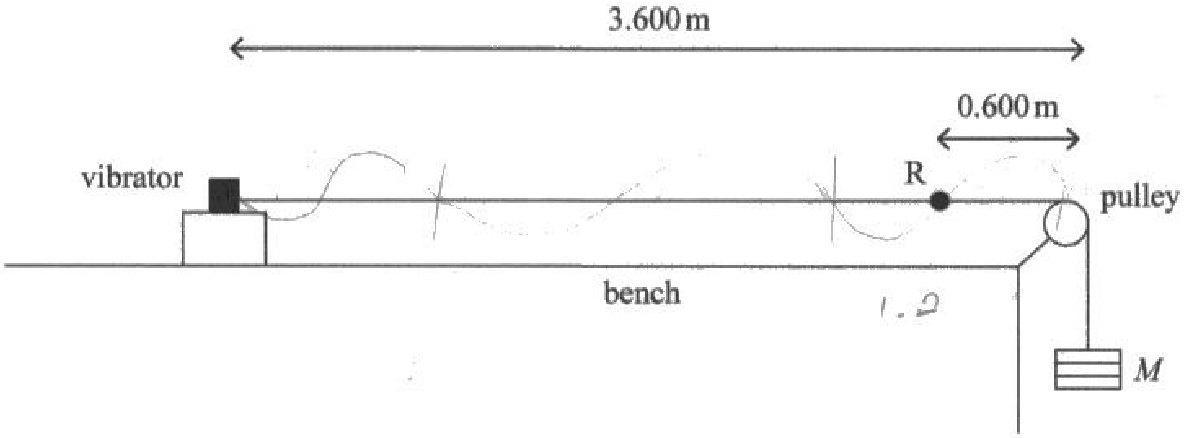
The word "Superimpose" is not accepted as a replacement for the word "Superpose". This candidate would not have scored marking point 3 if it had not been for them going on to discuss interference, an alternative word for marking point 3.

Question 16 (b)

The two most commonly achieved scores on this 5 mark question were 0 and 5. This shows quite clearly that significant numbers of candidates found this multi-step calculation too difficult to access, although those who did know what to do often scored full marks. The next most common mark scored was 4, and this was almost always due to the fact that candidates found it difficult to conclude about whether point R would be a node or not.

(b) The frequency of the stationary wave was 30.0 Hz. The distance between the vibrator and the pulley was 3.600 m. Point R is 0.600 m from the pulley, as shown.

Diagram **NOT** to scale



Determine whether there was a node at point R.

$M = 0.300\,\text{kg}$
mass per unit length of string $= 2.27 \times 10^{-3}\,\text{kg m}^{-1}$

(5)

$\lambda = ?$ $v = f\lambda$ $v = ?$ $v = \sqrt{\frac{T}{\mu}}$ $\mu = 2.27\times10^{-3}$ $M = 0.3\,\text{kg}$ so $W = Mg$

$W = 0.3 \times 9.81 = 2.943$

$v = \sqrt{\frac{2.943}{2.27\times10^{-3}}} = 36$

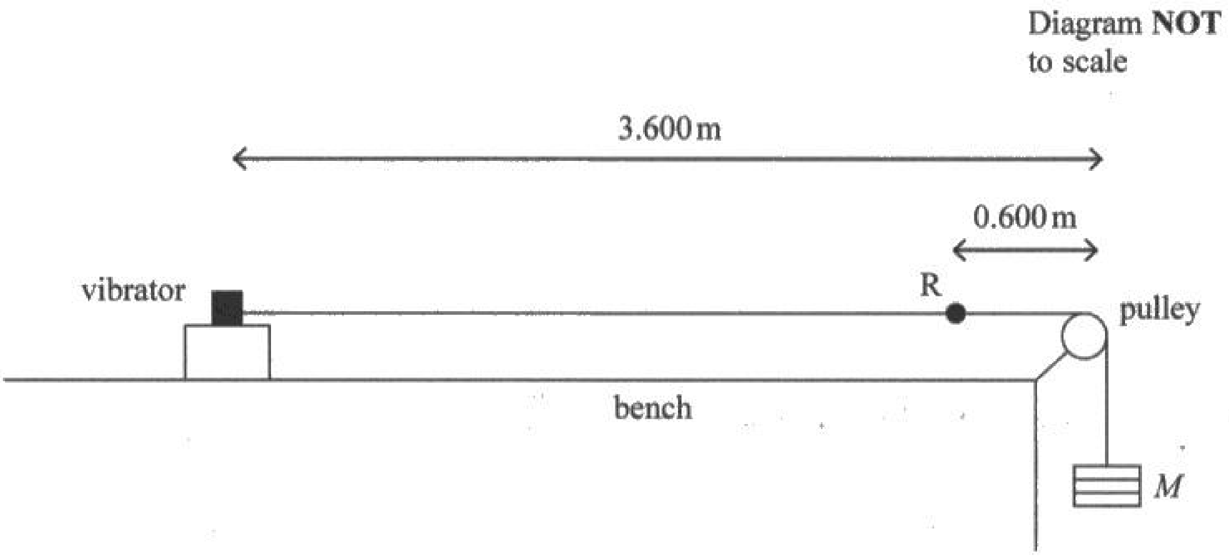
$36 = 30 \times \lambda$ $\lambda = 1.2$

At R there is a node, because the $\lambda = 1.2$, and since 0.6 is half of 1.2, there will be a node.

ResultsPlus
Examiner Comments

The calculation leading to the wavelength of 1.2(m) scores all of the first 4 marking points. Although they don't explicitly state that the node to node distance is half a wavelength, it was felt that this candidate had given a sufficient enough answer to allow marking point 5 to be awarded too.

(b) The frequency of the stationary wave was 30.0 Hz. The distance between the vibrator and the pulley was 3.600 m. Point R is 0.600 m from the pulley, as shown.



Determine whether there was a node at point R.

$M = 0.300$ kg
mass per unit length of string = 2.27×10^{-3} kg m^{-1}

(5)

M = 300 g

T = mg = 300 × 9.81 = 2943 N

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{2943}{2.27 \times 10^{-3}}} = 1138.6$ m s^{-1}

$\lambda = \frac{v}{f} = \frac{1138.6}{30} = 37.95$ m

$\Delta x = \frac{\lambda}{2\pi}\phi$

$3 = \frac{37.95}{2\pi}\phi$

$\phi = 0.49669 \approx \frac{1}{6}\pi \rightarrow$ ~~odd~~ even integer

No there is an antinode

ResultsPlus
Examiner Comments

The mistake that this candidate has made with their calculation is to assume that masses used in physics equations are in grams, rather than kilograms. As a result, they have calculated the tension to be 2943 N rather than 2.943 N. In "Use of" marks, power of 10 errors are not penalised so, as this candidate consequently completes all of the calculations correctly, they score marking points 1, 2 and 3. However, the value for marking point 4 needed to be 1.2(m), so they do not achieve this mark. There is also no internal error carried forward within the same part of a question, so whether or not their conclusion about node / antinode is correct, they cannot achieve marking point 5.

ResultsPlus
Examiner Tip

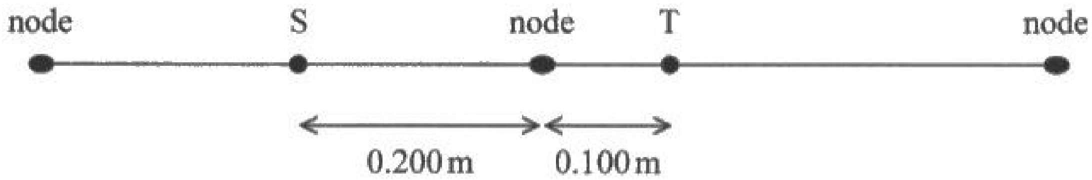
Although equations are given to candidates in the formula sheets, remember that the correct units for each equation also need to be remembered.

Question 16 (c)(i)

Since this specification started in 2019, the graphical interpretation of phase differences in stationary waves has been assessed on 3 occasions. On each of those occasions, the questions have not been answered well, primarily as candidates appear to be answering it as if it were a diagram of a progressive wave. It was quite common to see phase differences of 135 degrees being mentioned, which is the value it would be if it were a progressive wave. A number of candidates also stated that the phase difference between the two points was 3/8ths of lambda. Even the small number of candidates who were aware that the two points were in antiphase commonly found it too difficult to articulate an explanation for it.

Candidates should be aware that all points in adjacent node to node sections of a stationary wave will be in antiphase with each other.

(c) The mass *M* was changed and the frequency of the vibrator was adjusted, so that a different stationary wave formed on the string. Adjacent nodes were separated by 0.400 m. The diagram shows two points, S and T, on the string at an instant when the string was straight.



(i) Explain the phase relationship between points S and T.

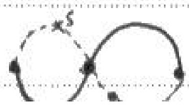
(2)

λ = 0.8 m. Distance between adjacent nodes = 0.4 m.

The points S and T are on either side of a node.

This means that points S and T are π radians

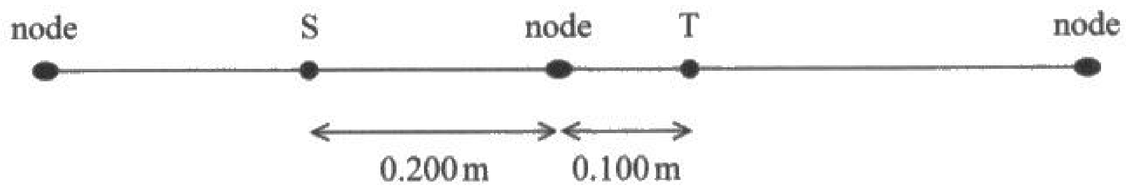
out of phase (antiphase).



ResultsPlus Examiner Comments

This was a rare candidate who scored both marking points. At the end they have stated that S and T are in antiphase, which picks up marking point 1. The statement "points S and T are on either side of a node" was allowed for marking point 2, as they are talking about a singular (assumed to be the same) node.

(c) The mass M was changed and the frequency of the vibrator was adjusted, so that a different stationary wave formed on the string. Adjacent nodes were separated by 0.400 m. The diagram shows two points, S and T, on the string at an instant when the string was straight.



(i) Explain the phase relationship between points S and T.

(2)

They are in antiphase as T and S are between two different nodes

ResultsPlus
Examiner Comments

Although this candidate scores marking point 1 in the first line, it is not really clear enough about the adjacency of the node to node sections to enable marking point 2 to be awarded here.

Question 16 (c)(ii)

Candidates generally had a much better grasp of this part of the question than they did with Q16(c)(i). The most common mark achieved on this question was 1 out of 2, for the statement that S had a greater amplitude than T. Although not strictly correct, candidates who stated that S had double the amplitude of T were awarded marking point 1 as they had implied that it was greater. Unfortunately, many candidates failed to score marking point 2 as they did not make a comparison between S and T.

(ii) Explain how the amplitude of vibration of the string at point S compares with the amplitude of vibration of the string at point T.

(2)

Point S has ~~the~~ a double amplitude of vibration compare ~~to~~ with point T since it has a double distance ~~b~~ from ~~node~~ the closest node.

ResultsPlus Examiner Comments

As mentioned previously, although S does not have double the amplitude of T, this was an acceptable statement for marking point 1, which this candidate scores in the first line and a bit. They also score marking point 2 as they clearly state that S is further from the closest node (this is the third version of marking point 2 on the mark scheme).

(ii) Explain how the amplitude of vibration of the string at point S compares with the amplitude of vibration of the string at point T.

(2)

S is ~~[illegible]~~ lower than T because T is closer to a node than S is

ResultsPlus Examiner Comments

Although marking point 2 is stated very clearly in this answer, it is dependent on the awarding of marking point 1. However, this candidate has stated that S has a lower amplitude than T, so does not score either marking point.

Question 17 (a)

A standard definition question which comes up regularly on this unit. The difference in this series is that the candidates have been told in the question that this is about the release of electrons, hence the reason why the main answer required is simply "minimum energy...".

This question was answered correctly more often than not, with the vast majority of candidates who failed to achieve the mark forgetting to use a word such as "minimum", "least", "lowest" or other suitable equivalents.

Although "required to release electrons from the surface of a metal" was not required in the answer (hence why it is in brackets), there were a small number of candidates who failed to achieve the mark as they made statements such as "the minimum energy required to emit a photon".

17 Ultraviolet light is incident on a zinc plate. If the photon energy is greater than the work function of the zinc, electrons are released.

(a) State what is meant by work function.

(1)

The amount of energy required for an electron/ photon to be emitted / move up energy level

ResultsPlus
Examiner Comments

This answer is both lacking any suggestion of "minimum" before the word energy and is not sure about whether it is electrons or photons. Also, the answer is given in terms of energy levels, which is not relevant to the photoelectric effect.

ResultsPlus
Examiner Tip

When words appear in brackets on a mark scheme, it means that we do not need to see the words in brackets stated. However, they are always included in the mark scheme as it makes a more complete answer, not just the minimum required.

17 Ultraviolet light is incident on a zinc plate. If the photon energy is greater than the work function of the zinc, electrons are released.

(a) State what is meant by work function.

(1)

Work function is the minimum ~~frequency~~ energy needed to release a photoelectron.

ResultsPlus
Examiner Comments

A perfect answer for the mark.

Question 17 (b)

A multi-step calculation, which required a decision to be made at the end. Candidates generally found this quite difficult, although there were still a significant number of full mark responses.

One of the main issues for some candidates was caused by the fact that there were two separate equations that required a velocity to be substituted, and an incorrect velocity substitution was often seen. Answers that started with an attempt to find a frequency using the speed of light and the de Broglie wavelength often did not score many marks.

A quite common mistake was to simply calculate the work function in Joules, then use this as the energy of the photon to get an answer of 289 nm. This often resulted in the candidate scoring 2 marks.

(b) The ultraviolet (UV) section of the electromagnetic spectrum can be split into three parts, known as UVA, UVB and UVC. The range of wavelengths of these parts is given in the table.

	UVC	UVB	UVA
Range of wavelength / nm	200–280	280–320	320–400

The minimum de Broglie wavelength of the released electrons is 1.50×10^{-9} m.

Deduce whether the ultraviolet light incident upon the zinc plate is UVA, UVB or UVC.

work function of zinc = 4.30 eV

(6)

$4.30\ eV \rightarrow 6.88 \times 10^{-19}\ J$

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

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

$v = \frac{h}{m\lambda}$

$= \frac{6.63 \times 10^{-34}}{(9.11 \times 10^{-31}) \times (1.50 \times 10^{-9}\ m)}$

$= 4.85 \times 10^{5}\ m s^{-1}$

$v = f\lambda$

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

$\frac{4.85 \times 10^{5}\ m s^{-1}}{1.50 \times 10^{-9}\ m}$

$f = 3.23 \times 10^{14}\ Hz$

$E = hf$

$= (6.63 \times 10^{-34}) \times (3.23 \times 10^{14}\ Hz)$

$= 2.14 \times 10^{-19}\ J$

$E = h \frac{v}{\lambda}$

$E_{UVC} = \frac{(6.63 \times 10^{-34}\ Js) \times 4.85 \times 10^{5}\ m s^{-1}}{240 \times 10^{-9}\ m}$

$= 1.34 \times 10^{-21}\ J$

ResultsPlus
Examiner Comments

This candidate scores marking points 1 and 2 over on the left hand side of their answer section, with the calculation of the speed of the electrons. They also scores marking point 3 with the conversion of the work function into joules. However, there is no evidence of the equation required for marking point 4, and so the use of the wave equation is with the electron speed rather than the speed of light, so no marking point 5. As with other calculation questions, there is no internal error carried forward within the same part of a question, so even if this candidate had calculated a wavelength and concluded the type of UV, this would not score marking point 6.

(b) The ultraviolet (UV) section of the electromagnetic spectrum can be split into three parts, known as UVA, UVB and UVC. The range of wavelengths of these parts is given in the table.

	UVC	UVB	UVA
Range of wavelength / nm	200–280	280–320	320–400

The minimum de Broglie wavelength of the released electrons is 1.50×10^{-9} m.

Deduce whether the ultraviolet light incident upon the zinc plate is UVA, UVB or UVC.

work function of zinc = 4.30 eV

(6)

$\frac{6.63 \times 10^{-34}}{1.5 \times 10^{-9} \times 9.11 \times 10^{-31}} = 9.85 \times 10^{5} = v$

$\lambda = \frac{h}{m \times v}$

$m = 9.11 \times 10^{-31}$

$\frac{1}{2}mv^2 = hf - \phi$ $\quad \phi = 4.3 \times 1.6 \times 10^{-19}$

$\lambda = 1.50 \times 10^{-9}$

$\frac{1}{2} 9.11 \times 10^{-31} \times (9.85 \times 10^5)^2$ $\quad \phi = 6.88 \times 10^{-19}$

$h = 6.63 \times 10^{-34}$

$= (6.63 \times 10^{-34}) f - 6.88 \times 10^{-19}$

$v = \frac{h}{m \times \lambda}$

$f = 1.2 \times 10^{15}$

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

$\frac{3 \times 10^8}{1.2 \times 10^{15}} = \lambda$

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

$\lambda = 2.5 \times 10^{-7}$

$= 250 \times 10^{-9}$

$= 250$ nm which is UVC

ResultsPlus
Examiner Comments

A fully-correct answer for all 6 marks.

At the top left, the candidate has calculated the speed of the electrons, so scores marking points 1 and 2. Just below this they have converted the work function into joules, so score marking point 3. Below that they have rearranged the equation for marking point 4 and substituted all of the numbers correctly to find the frequency. They then use this with the speed of light in the wave equation (marking point 5) to find the wavelength of UV. They then deduce that it is UVC to get the final marking point.

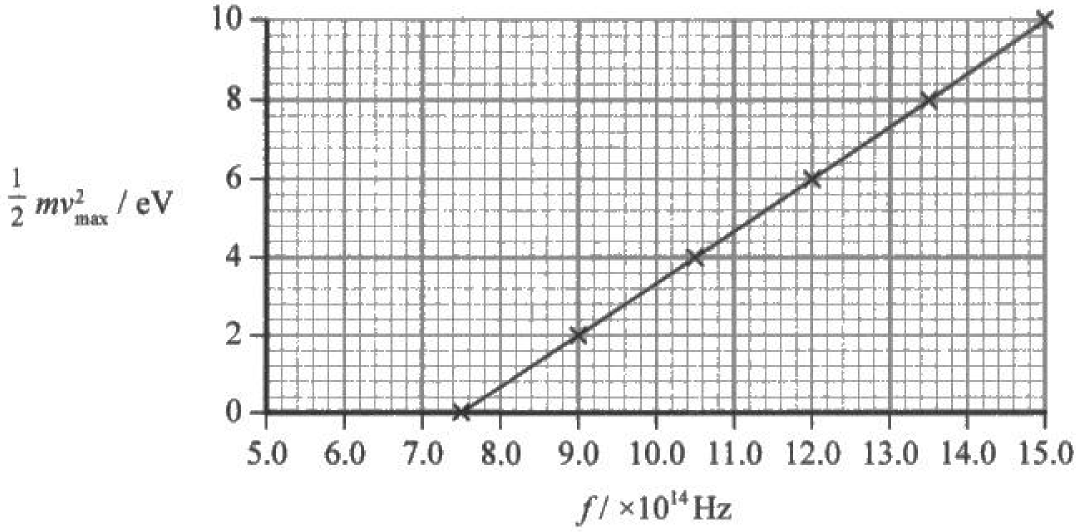
Question 17 (c)

The final question on a paper is commonly not answered as well as it might be had it appeared earlier in the paper. Although it was a difficult question, meaning that the majority of candidates scored 0 marks, there were significant numbers of candidates who achieved the other possible scores.

Candidates were asked to describe two ways that the graph is not consistent with the values known for a zinc plate. Although reference was made to the zinc plate in the question (which suggested that answers should have been in terms of the threshold frequency or the work function), answers relating to whether the gradient was the Planck constant were also accepted.

Those candidates who attempted to show whether the gradient was correct, often failed to convert values or made power of 10 errors. Those who attempted to show that the y-intercept was in the wrong place often failed to recognise that the x-axis did not start at 0. The most successful attempts to score marks came from candidates who used the work function of zinc to work out what the threshold frequency should be, then comparing it to the x-intercept of the graph.

(c) A student used a zinc plate and UV light of different frequencies in an experiment. The student's graph of maximum kinetic energy of the released electrons against the frequency of the incident UV light is shown.



Einstein's photoelectric equation applies to this situation.

$$hf = \phi + \frac{1}{2}mv^2_{max}$$

Describe two ways that the graph is **not** consistent with the values known for a zinc plate. Your answer should include calculations.

work function of zinc = 4.30 eV

(4)

$\phi = 4.3 \cdot 1.6 \cdot 10^{-19}$

threshold frequency $= \frac{4.3 \cdot 1.6 \cdot 10^{-19}}{6.63 \cdot 10^{-34}} = 1.03 \cdot 10^{15}$ Hz

Threshold frequency on the graph, i.e., the x intercept should be at ~~1.03·10^15~~ 10 · 10^14 Hz.

~~$13 \cdot 10^{14} \cdot 6.63 \cdot 10^{-34} \neq (4.3 + 6.5)(1.6 \cdot 10^{-19})$~~

The gradient of the graph should be planck's constant, but it's not.

(Total for Question 17 = 11 marks)

$\frac{10 \cdot 1.6 \cdot 10^{-19}}{7.5 \cdot 10^{14}} = 2.13 \cdot 10^{-33}$

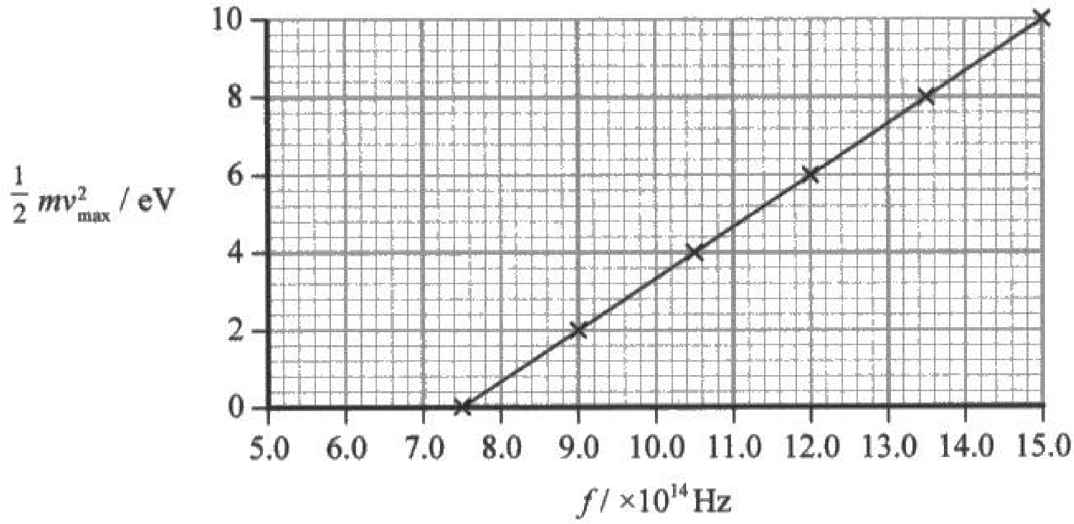
TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

$2.13 \cdot 10^{-33} \neq 6.63 \cdot 10^{-34}$

ResultsPlus
Examiner Comments

A good 4 mark answer in which the candidate performs two correct calculations to work out the expected threshold frequency and the actual gradient of the graph. Both are fully correct.

(c) A student used a zinc plate and UV light of different frequencies in an experiment. The student's graph of maximum kinetic energy of the released electrons against the frequency of the incident UV light is shown.



Einstein's photoelectric equation applies to this situation.

$$hf = \phi + \frac{1}{2}mv^2_{max}$$

Describe two ways that the graph is **not** consistent with the values known for a zinc plate. Your answer should include calculations.

work function of zinc = 4.30 eV

(4)

E=hf , when $\frac{1}{2}mv^2_{max}=0$ hf should be equals to work function

In the student's graph, $E = 6.63\times10^{-34} \times 7.5\times10^{14} = 4.97\times10^{-19}$ J = 3.11 eV

The work function of zinc is 4.30 eV but not 3.11 eV, so

the graph is not consistent. $\frac{1}{2}mv^2_{max}$ cannot be 0 as ~~there will~~

~~be~~ ~~velocity~~ both mass and velocity could not hit

0. So the graph is not consistent.

ResultsPlus
Examiner Comments

This candidate scores 2 marks for their calculation of work function as 3.11eV and comparing it with the known value of work function (4.3eV). This is the alternative stated at the end of the mark scheme.

The discussion of kinetic energy not being possible to equal zero is not relevant to this question, so gained no further credit.

Paper Summary

Some areas of real strength seen during this examination are:

- performance in multi-step calculations, particularly Q12(a) and Q16(b).
- use of equations to back up explanations, most notably in Q12(b)(ii) and Q15(a).

Based on their performance in this paper, candidates should:

- consider how to adapt their understanding to unusual situations. In particular, Q14 and Q17 contained some aspects that were not presented in a standard way. Although Q16(a) referred to the formation of a stationary wave in a core practical, many candidates gave generic descriptions rather than one for this unique situation.
- practice more with using protractors and drawing scale diagrams.
- answer more questions relating to how stationary waves can be drawn graphically (and interpreted).
- allocate time to the 6 mark linkage questions. In this series the answer space for Q15(a) was commonly left completely blank.