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Examiners' Report
June 2018

IAL Physics WPH02 01

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Introduction

The mean mark on this paper was almost identical to that achieved in the WPH02 paper of Summer 2017. However, the multiple choice questions were not answered as well overall, Question 7 and 10 both being correctly chosen by less than half of the students taking the exam. In spite of this, all of the questions allowed access to students across the ability range.

On Question 7 of the multiple choice, it was generally answer B that was chosen instead of the correct answer A. This shows that most students were aware that the drift velocity would be less in a wider wire/bar, but might also demonstrate that students are not as well prepared for situations with squared cross sections.

On Question 10, most of the incorrect answers were either B or C, suggesting that students were confusing this situation with filament lamps where such factors would be more significant.

Question 11 (a)

This is a standard calculation question, the style of which has appeared on many previous papers. However, there are a number of common errors that are made by students answering such questions, which were once again seen during the course of this examination series.

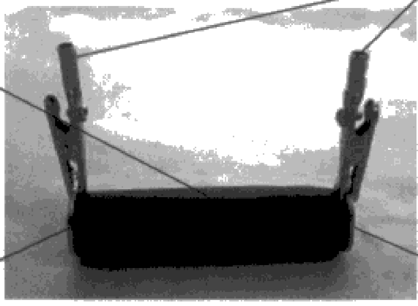
One of the most common mistakes was a failure to realise that the diameter, rather than radius, had been given in the question. A number of the students who scored 1 mark on this question had calculated πd^2 rather than πr^2 to establish a cross sectional area. Those students who did this could score MP2 as the value they were inserting into the resistivity equation was something that was measured in m^2. This made it a dimensionally-correct term in the equation.

Another mistake which was made was confusing resistance with resistivity. However, this was not seen as often as in previous series.

The majority of students scored 3 marks on this question.

11 A student carried out an investigation using conducting putty. Conducting putty is a material that is a good conductor and can be made into different shapes.

The student formed the conducting putty into cylinders of different sizes. Coins were pushed into the conducting putty at either end so that crocodile clips could be attached to connect the conducting putty into a circuit.



(a) The student made a cylinder of conducting putty of length 0.075 m and diameter 9.0 mm.

Calculate the resistance of the cylinder of conducting putty.

(3)

resistivity of conducting putty = $4.2 \times 10^{-2}\ \Omega\text{m}$

$R = \rho\frac{l}{A} = 4.2\times10^{-2}\Omega m \times 0.075m \div (\pi\times(9\times10^{-3})^2)$

$= 12.4\Omega$

Resistance = 12.4Ω

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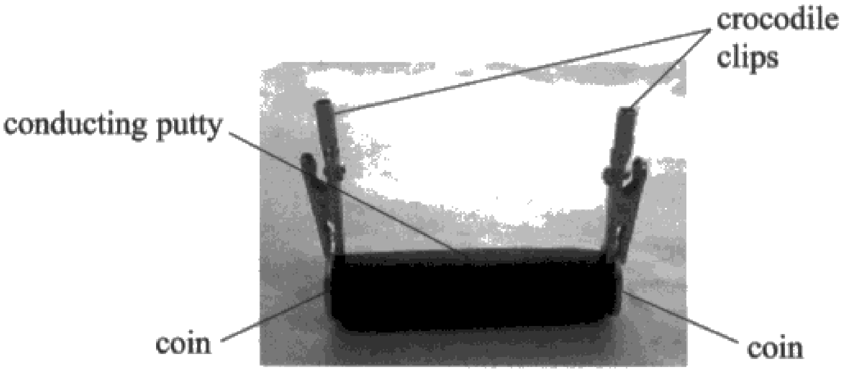
Examiner Comments

This student has not halved the diameter to use in πr^2, so does not achieve MP1. The substitution into the resistivity equation uses a dimensionally-correct cross sectional area, so scores MP2. The answer is incorrect due to the use of diameter instead of radius, so MP3 is not achieved.

11 A student carried out an investigation using conducting putty. Conducting putty is a material that is a good conductor and can be made into different shapes.

The student formed the conducting putty into cylinders of different sizes. Coins were pushed into the conducting putty at either end so that crocodile clips could be attached to connect the conducting putty into a circuit.



(a) The student made a cylinder of conducting putty of length 0.075 m and diameter 9.0 mm.

Calculate the resistance of the cylinder of conducting putty.

(3)

resistivity of conducting putty = $4.2 \times 10^{-2}\ \Omega\,m$

$R = \frac{\rho L}{A} = \frac{4.2\times10^{-2} \cdot 0.075}{\frac{\pi}{4}(9.0\times10^{-3})^2} = 49.5\,\Omega$ ~~0.050 Ω~~

Resistance = ~~0.050 Ω~~ 50 Ω.

ResultsPlus
Examiner Comments

This is a good 3 mark response. All the values used in the equation are clearly substituted correctly, and the answer is correct, with an appropriate unit.

The student had initially calculated an answer that had a power of 10 error but then crossed this out and wrote the correctly calculated value.

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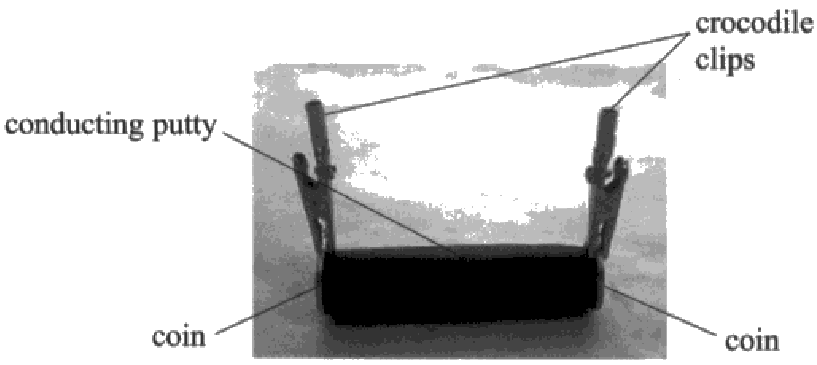
Examiner Tip

If a student answers a question and then crosses out the answer, credit can be awarded to crossed out work if a new answer has not been written. This means that it is important to cross out any work neatly so that the original working/answer can be seen. If the student has scribbled out the work so that it is no longer easy to decipher what is written, no credit can be gained from this work.

If a new answer is written after work has been crossed out, examiners will only mark the work that has not been crossed out.

11 A student carried out an investigation using conducting putty. Conducting putty is a material that is a good conductor and can be made into different shapes.

The student formed the conducting putty into cylinders of different sizes. Coins were pushed into the conducting putty at either end so that crocodile clips could be attached to connect the conducting putty into a circuit.



(a) The student made a cylinder of conducting putty of length 0.075 m and diameter 9.0 mm.

Calculate the resistance of the cylinder of conducting putty.

(3)

resistivity of conducting putty = $4.2 \times 10^{-2}\ \Omega\text{m}$

$\rho = \frac{RA}{l}$ $\quad R = \frac{\rho l}{A} = \frac{4.2 \times 10^{-2} \times 0.075}{4.5 \times 10^{-3}} = 0.7\ \Omega$

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Examiner Comments

This student has halved the diameter to determine a value for radius, but has just inserted this directly in as an area into the resistivity equation.

Clearly this does not achieve MP1 as they have made no attempt at calculating cross sectional area. They can also not gain MP2 as the substitution for area is not dimensionally-correct i.e. it would be measured in metres rather than metres squared.

Question 11 (b)

Unfortunately many of the students taking this examination did not access the two last marking points on this question via any of the alternatives. As a consequence, the majority of the cohort scored either 0 or 1 marks out of the possible 3. The most common score was 1 mark, as most of the students mentioned either a correct change of resistance or current for the situation given.

(b) Two cylinders of conducting putty are connected in parallel across a battery. The cylinders have the same length but different cross-sectional areas.

Explain why the cylinder with the larger cross-sectional area will reach a higher temperature than the other cylinder.

(3)

Two cylinders are in parallel. the voltage of two cylinders are the same. $R = \frac{\rho l}{A}$. A large cross-sectional area means the cylinder has a small resistance. $P = \frac{V^2}{R}$. A small resistance cause a large power. So the ~~temp~~ temperature of ~~A face~~ the cylinder with the larger cross-sectional area is higher.

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Examiner Comments

This is a good, clear response that scores all 3 marks via the first alternative on the mark scheme. MP2 is achieved in lines 1-2, MP1 is in lines 2-3 and MP3 is in lines 3-4.

As the students were being asked to compare just two cylinders, the examiners accepted certain answers that were not full comparisons e.g. large area so small resistance (for MP1).

(b) Two cylinders of conducting putty are connected in parallel across a battery. The cylinders have the same length but different cross-sectional areas.

Explain why the cylinder with the larger cross-sectional area will reach a higher temperature than the other cylinder.

(3)

$I = nqvA$

n, q, and v doesn't change. The cylinder with larger cross-sectional area will has larger current. When the current is high, there are more collision between nucleus and electron creating heat energy.

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Examiner Comments

This student has given an answer which is more in line with alternative 3 on the mark scheme. They clearly state near the beginning that the larger cross sectional area leads to a larger current, so score MP1.

There is a reference to more collisions, but two key features are missing with the response. Firstly, the collision needs to be between electrons and either ions or atoms. In addition, there needs to be an idea of the rate rather than just number. As such, this student does not achieve MP2 and there is no reference to MP3 so scores 1 mark in total.

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Examiner Tip

When answering questions with the command word "Explain", try to consider whether the explanation is enhanced by the use of an equation.

If an equation is used within the answer, clearly state what each term in the equation is, and whether each term increases, decreases or stays the same in the situation being described.

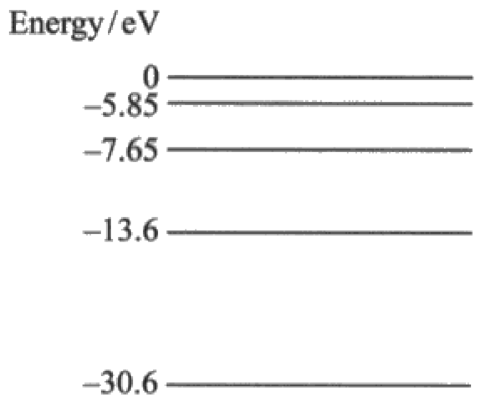
Question 12 (a)

This calculation included a number of steps, but will be one that is familiar to students who have seen previous papers. As a result, more than half of the students achieved all 3 marks here. There were fairly similar numbers of students scoring 0, 1 or 2 on this question.

12 Chemists use flame tests to identify the presence of metals in a substance.

The substance is heated in a flame and the resulting colour of the flame is an indication of the metal present.

(a) Some of the energy levels for an atom of a particular metal are shown.



An electron in the atom is excited to the –5.85 eV energy level. The electron then makes the transition to the –7.65 eV energy level.

Calculate the wavelength of the radiation that would be emitted as a result of this transition.

(3)

$=(-5.85)-(-7.65) = 1.8\,eV$ $1.8 \times 1.6\times10^{-19} = 2.88\times10^{-19}\,J.$

$E = hf.$ $E = h\frac{v}{\lambda}$ $\frac{2.88\times10^{-19}}{6.63\times10^{-34}} = \frac{v}{\lambda}$

$\frac{v}{\lambda} = 4.34\times10^{14}$ $\lambda = 6.9\times10^{-7}$

Wavelength = 6.9×10^{-7} m

ResultsPlus
Examiner Comments

This is a clearly laid out answer which scores all 3 marks. The student has worked out the difference between the energy levels in eV and then converted this into Joules. They have then used both of the equations required for MP2 to establish a correct answer with units.

ResultsPlus
Examiner Tip

MP1 on this question was for an understanding of the conversion between eV and J, so as long as the value in eV chosen was something that could be seen within the question, then MP1 could be achieved.

12 Chemists use flame tests to identify the presence of metals in a substance.

The substance is heated in a flame and the resulting colour of the flame is an indication of the metal present.

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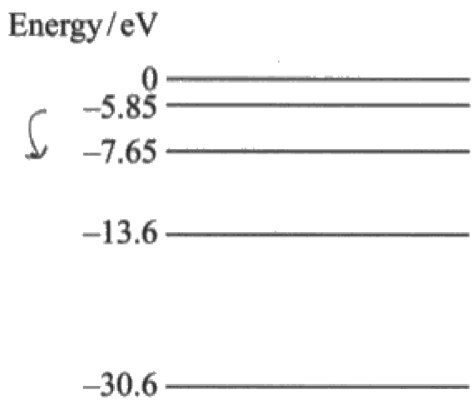


An electron in the atom is excited to the –5.85 eV energy level. The electron then makes the transition to the –7.65 eV energy level.

Calculate the wavelength of the radiation that would be emitted as a result of this transition.

(3)

$E = hf$ $\quad f = \frac{1}{t}$ $\therefore t = 3.683 \times 10^{-34}$.

$E = E_1 + E_2$

$= 1.8 eV$

$\therefore 1.8 = hf$

$1.8 = 6.63 \times 10^{-34} \times f$

$f = 2.714932127 \times 10^{33}$

$v = f\lambda$

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

$\lambda = \frac{3.0 \times 10^8}{2.7149.. \times 10^{33}}$

$\lambda = 1.105 \times 10^{-25}$ m

Wavelength = 1.105×10^{-25} m.

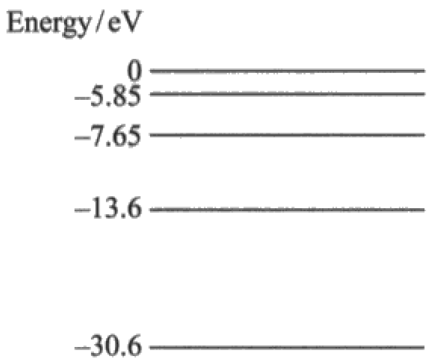
ResultsPlus
Examiner Comments

This student scores MP2 only. There is no evidence that the eV energy level difference has been converted from eV to J, so MP1 cannot be achieved. Clearly, this leads to an incorrect answer so MP3 cannot be achieved either.

12 Chemists use flame tests to identify the presence of metals in a substance.

The substance is heated in a flame and the resulting colour of the flame is an indication of the metal present.

(a) Some of the energy levels for an atom of a particular metal are shown.



An electron in the atom is excited to the –5.85 eV energy level. The electron then makes the transition to the –7.65 eV energy level.

Calculate the wavelength of the radiation that would be emitted as a result of this transition.

(3)

Electron volts = –7.65 ev

Energy = 7.65 × (1.6 × 10⁻¹⁹) = 1.224 × 10⁻¹⁸ J

$E = \frac{hc}{\lambda}$ $\quad 1.224 \times 10^{-18} = \frac{(6.63 \times 10^{-34}) \times (3 \times 10^{8})}{\lambda}$

$\lambda = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{1.224 \times 10^{-18}}$ $\quad \lambda = 1.625 \times 10^{-7}$

Wavelength = 1.63×10^{-7} m

ResultsPlus
Examiner Comments

This student has not calculated an energy difference between the two energy levels described in the question. However, calculating this difference is not an individual marking point in its own right. As a result, this script can potentially score both MP1 and MP2.

At the top of the answer they have clearly shown that they are converting (-)7.65eV into Joules. Clearly this is one of the energy levels shown on the diagram so MP1 is awarded. This energy value is then correctly inserted into a combined equation covering MP2, so scores that mark as well.

As the student had chosen a single energy level rather than a difference, they cannot achieve MP3, so score 2 marks in total.

Question 12 (b)

This question initially looks very similar to other questions from previous papers, where students were asked to explain why atoms only emit radiation with specific frequencies. However, the question on this paper was asking why different metals give rise to different frequencies of radiation. As a result, a significant number of students answering by stating that atoms have discrete energy levels were not going to pick up a mark for this, as they had not told us explicitly that these energy levels were different for different metals. Many of the students scored 0 out of 2 on this question, with very few scoring both marks.

(b) Explain why substances containing different metals will produce different colours of flames.

(2)

Different metals have different discrete energy levels. So the difference in energy level is different. Hence frequency is different. Therefore different metals will produce different colours of flames.

ResultsPlus
Examiner Comments

This student has clearly understood that different metals have different energy levels. They have also included the word "discrete" which is correct, but would not have achieved MP1 had it not been for the inclusion of the word "different".

They also have the idea of different differences in energy levels so score MP2 as well.

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Examiner Tip

Read questions carefully. When a question seems to be very similar to one that has appeared on a previous examination, check the wording to see if something different is being asked.

Question 13 (a)

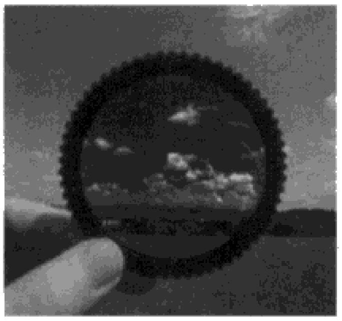
This is a standard 2 mark definition question that has been on several examinations over the last few years. However, it remains one where students often find it difficult to use the correct wording to achieve both marking points.

With MP2 being dependent upon the awarding of MP1, a number of students fail to achieve a mark as they do not mention oscillations or vibrations anywhere in their answer. In addition, the two versions of the mark scheme are not possible to be mixed and matched i.e. if a student starts their answer in terms of oscillations being only in one plane, they need to add "including the direction of wave travel", "including the direction of energy transfer" or "including the direction of propagation" in order to get the second marking point.

In spite of being a fairly standard definition question, the marks of 0, 1 and 2 were scored almost equally across the students that took the paper.

13 Polarising filters are often used when taking photographs outdoors.

Light from the sky is partially plane-polarised. A polarising filter can be placed in front of a camera lens to make the sky appear darker. The intensity of the light transmitted through the polarising filter is reduced, compared to the intensity without the polarising filter, as shown.



(a) Explain what is meant by plane-polarised light.

(2)

Plane polarised light is when all the vibrations of the wave is confined to a single plane perpendicular to the direction of travel of wave.

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Examiner Comments

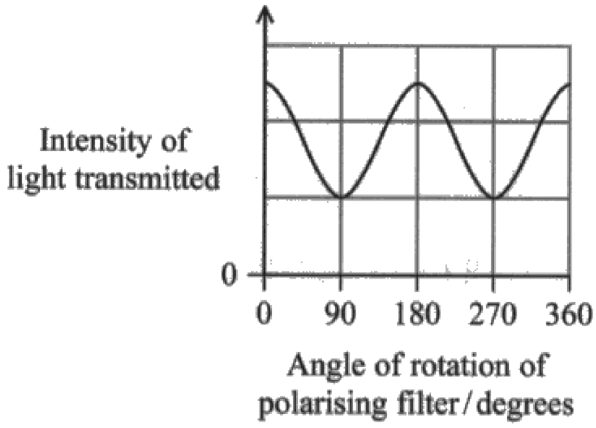
This student has a commonly-seen answer, where they state that all of the vibrations are in one plane (scoring MP1). However, the statement that this is perpendicular to the direction of travel of the wave does not score MP2, as this can only gain MP2 if linked to vibrations being in one direction only.

Question 13 (b)

For a 4 mark question, it was unfortunate that the vast majority of students scored either 0 or 2 marks. A very small number of students scored above 2 marks.

The main reason for students generally not scoring more than 2 marks very often was two-fold. Firstly, many students focussed solely on the situation at the extremes of intensity such as 0° and 90°, rather than looking at what was taking place in between. Secondly, many did not consider why the intensity never reached zero. As a result, the main marking points being achieved were MP1 and MP3.

*(b) The light from the sky is transmitted through the polarising filter into the camera. As the polarising filter is rotated, the intensity of the light transmitted through the polarising filter varies as shown.



Explain why the intensity of the light transmitted through the polarising filter varies as shown.

(4)

When the angle of rotation ~~of~~ the polarising filter is rotated to 90° and 270° the intensity of light transmitted is ~~very~~ lower then when it is rotated by 0°, 180°, 360°. This is because of the polarising filter being perpendicular to the the light from sky and therefore absorbing some light thus reducing the intensity. While at 0°, 180°, and 360° the polarising filter is parallel to the light from sky, allowing ~~all~~ light to pass through the filter without a loss in the intensity.

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Examiner Comments

This is a typical example of a 2 mark response, where the student has only really addressed the extremes of intensity and not considered what happens between and why the intensity never reaches zero.

The wording is quite clear for MP1 and MP3, but there is nothing else of merit.

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Examiner Tip

When explaining a graph, students need to consider all aspects of the graph, not just the highest and lowest values.

Question 13 (c)

A large number of students answering this question seemed to have forgotten by this point in the question that the light from the sky discussed earlier in the question was partially plane polarised. As a consequence, a lot of the answers given did not refer to polarisation at all. For those who did mention polarisation, there was also sometimes confusion about the effect described in the question, as a number wrote about the clouds producing light that was totally plane polarised, rather than being less plane polarised than the light from the sky.

plane of polarisation of the polarising filter

(c) Suggest why the clouds don't appear to darken as much as the sky when viewed through the polarising filter.

(1)

light from ~~clouds~~ clouds is unpolarised

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Examiner Comments

A straightforward way of answering this question, by stating that the light from the clouds is unpolarised.

(c) Suggest why the clouds don't appear to darken as much as the sky when viewed through the polarising filter.

(1)

Intensity of light ~~from~~ of the clouds does not change as much as the sky, as light transmitted through clouds is partially polarised. Light from the sky is not polarised.

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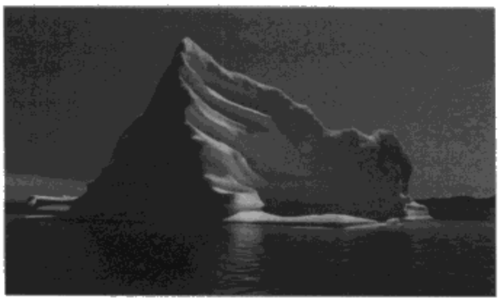
Examiner Comments

This student has the answer the wrong way round, saying that the light from the sky is not polarised yet the light from the clouds is partially polarised. This clearly scores 0 marks, but might demonstrate that some students did not distinguish clearly between the sky and clouds as being different things.

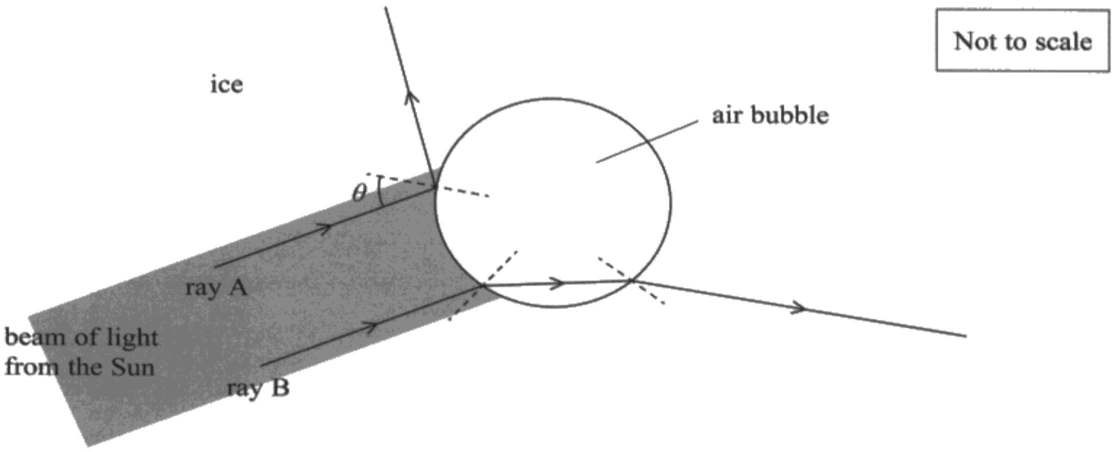
Question 14 (a)

A straightforward calculation question that students generally answered well. Those who scored 0 mainly did not realise that they should incorporate the speed of light in a vacuum/air into their calculation.

14 The photograph shows an iceberg.



A beam of light from the Sun travels through the top layer of ice and is incident on an air bubble. The diagram shows the path of two rays of light within the beam, ray A and ray B.



The refractive index of ice is 1.31

(a) Calculate the speed of light in ice.

(2)

$_1\mu_2 = \frac{v_1}{v_2}$ $\quad 1.31 = \frac{(3\times10^8)}{v_2}$

$v_2 = \frac{(3\times10^8)}{1.31}$

$v_2 = 2.3\times10^8\ ms^{-1}$

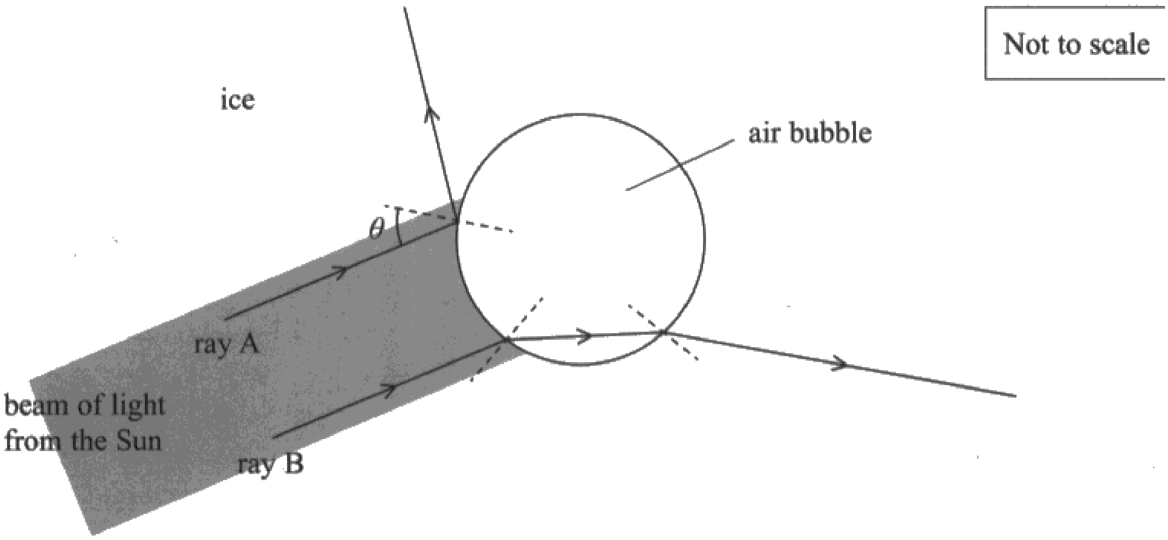
Speed of light in ice = $2.3\times10^8\ ms^{-1}$

ResultsPlus
Examiner Comments

An ideal 2 mark answer with the correct answer and units clearly seen.

14 The photograph shows an iceberg.

A beam of light from the Sun travels through the top layer of ice and is incident on an air bubble. The diagram shows the path of two rays of light within the beam, ray A and ray B.



The refractive index of ice is 1.31

(a) Calculate the speed of light in ice.

(2)

$1.31 = \frac{v_1}{3.00 \times 10^8}$

$v_1 = 3.93 \times 10^8$

Speed of light in ice = 3.93×10^8 ms^{-1}

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Examiner Comments

This is one of the commonest type of responses that scored 1 mark. Although the student has got their equation the wrong way up, they have inserted appropriate numbers to get a speed.

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Examiner Tip

Although a full understanding of why speeds cannot be greater than the speed of light is not expected until A2, students should be wary if any calculated speed is determined to have a value greater than the speed of light in a vacuum.

Question 14 (b)

Marking point 1 was for a description of what happens during the refraction at the chosen boundary, whilst marking point 2 was for explaining why this happened. For each marking point there were various alternatives possible which were all commonly seen.

Although options were available where the word refraction did not need to be mentioned, no credit was given to students simply talking about the ray "bending" away from the normal.

(b) Explain why ray B follows the path shown as it enters the air bubble.

(2)

Angle of incidence of ray B is smaller than critical angle, so the light is refracted.

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Examiner Comments

This student has clearly gained MP1 at the start but has given no explanation about why the refraction has taken place so does not score MP2.

(b) Explain why ray B follows the path shown as it enters the air bubble.

(2)

As ray B Enters the bubble it is refracted away from the normal as it is travelling to a more optically dense medium to a less optically less dence medium. And is then refracted towards the normal as its travelling from less optically dense medium to a more optically dense medium

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Examiner Comments

This student has gained both of the marking points initially by their discussion of the ray entering the air bubble.

The discussion that follows is assumed to be about what happens when the ray leaves the bubble although this is not entirely clear.

It was felt that this student was describing the whole process of entering and leaving the bubble, so both marks were awarded.

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Examiner Tip

This student might have ended up having issues with completing the examination paper, as they wrote a lot more for a 2 mark answer than was ideally required. If a question is simply asking for what happens when the ray enters the bubble, that is all that needs to be discussed.

Question 14 (c)

The wording of this question clearly caused a level of confusion for some students, as a number of scripts where all the work was evident to score the 2 marks failed to achieve them due to further, unnecessary processing. By asking for a "minimum" angle, a number of students clearly felt that when they had calculated an answer that they needed to give a value that was "a little more" than this. For some this was simply to round up 49.8º to 50º (scoring both marks). For others, 49.8º was calculated, and then the minimum value was quoted as 51º, resulting in MP2 not being awarded.

(c) Ray A is totally internally reflected at the surface of the air bubble.

Determine the minimum size of the angle θ.

(2)

$\sin C = \frac{1}{1.31}$ → $\theta = 90 - 50$

$= 40°$

$C = 50°$

Minimum size of angle θ = 40°

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Examiner Comments

This student has calculated the correct answer of 50º and would achieve both marks if they left their answer as this. However, they have decided that the minimum angle must be 90º minus their calculated value, so their given answer is incorrect. This scores MP1 only.

(c) Ray A is totally internally reflected at the surface of the air bubble.

Determine the minimum size of the angle θ.

(2)

$M = \frac{1}{\sin C} \Rightarrow \sin C = \frac{1}{M}$

$M = \frac{\sin i}{\sin r}$

$C = \sin^{-1}\left(\frac{1}{M}\right)$

$C = \sin^{-1}\left(\frac{1}{1.31}\right)$

$C = 49.8°$

$\therefore$ min angle $= 50°$

Minimum size of angle θ = ...

ResultsPlus
Examiner Comments

A good, 2 mark response. The answer and unit are both clearly written. Both 49.8º and 50º are perfectly acceptable answers.

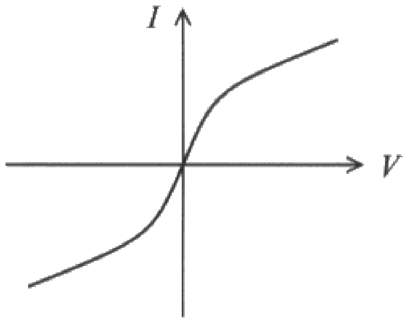
Question 15 (a)

This question proved to be very difficult for some students, with more than half of the cohort scoring either a mark of 0 or 1 out of 5.

Explaining the shape of a V-I graph for a filament lamp is a higher order skill, and many students failed to access MP5 as they wrote about the current decreasing at some point in their answer. These students were allowed to gain MP1 as the discussion about current decreasing usually came into student arguments as being something that happened "late" in the graph, after the resistance of the lamp had increased.

As a question assessing quality of written communication, the answer needed to be in a logical order, and a number of students did not make clear links from one point to the next.

15 The graph shows how the current *I* through a filament lamp varies with the potential difference *V* applied across it.



*(a) Explain the shape of the graph in terms of particle behaviour.

(5)

When ~~- As~~ Voltage increases Current increases.

- Rate of increase of current decreases as resistance increasing ~~as~~ as voltage increasing, shown by decreasing gradient.

- This is as when current increases ~~the~~ temperature increases so there are more frequent collisions ~~what~~ with lattice ions thus drift velocity decreases. ~~Cur~~ Current I = nAve, so as drift velocity decreases rate of increase of current decreases so resistance increases as $R = \frac{V}{I}$.

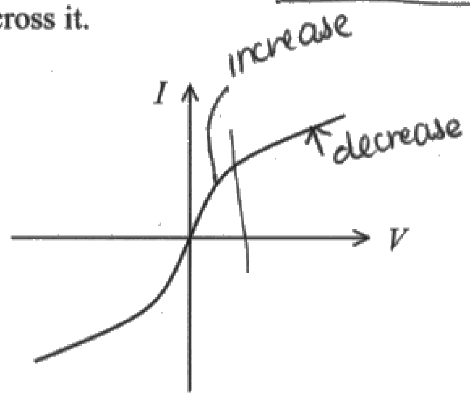
- Resistance is inverse of gradient, gradient is decreasing thus ~~voltage~~ resistance increasing.

ResultsPlus
Examiner Comments

This student scores MP1 in the first line of their answer. They then score MP5 in lines 2 and 3, and MP3 in line 4.

Unfortunately, they have not written down what the more frequent collisions are between as they only mention lattice ions (not electrons). This means that they cannot score MP4. There is no mention of temperature increase so no MP2. Overall the response scores 3 marks.

15 The graph shows how the current *I* through a filament lamp varies with the potential difference *V* applied across it.



*(a) Explain the shape of the graph in terms of particle behaviour.

(5)

~~Bc~~ As the voltage increase there is a increase in current at first, then the current begins to reduce. As ~~p.d~~ voltage increases in the ~~metal~~ filament lamp ~~metal ions~~, there is an increase in temprature of the metal setting more electrons free at first, but then as voltage increases more the temprature increases further of the filament lamp, causing vibration of the lattice metal ions so the electrons collide with them, there is ~~an~~ an increase in resistance, as because more opposition of current flow by ~~a~~ vibrations. Resistance increases current reduces, there is more energy dissipated at this stage.

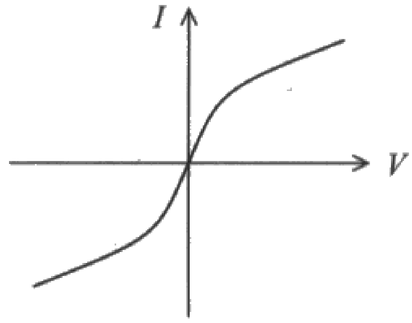
ResultsPlus
Examiner Comments

Line 1 of this response scores MP1, and line 3 has MP2 for temperature increase.

Unfortunately, the mention of current reducing in line 2 means that MP5 cannot be awarded, as the current never drops for the graph as p.d. increases.

Line 6 almost scores MP3 but there is no sign from the answer that the lattice vibrations increase. There is also no idea of the frequency of electron-ion collisions increasing, so MP4 cannot be awarded either.

15 The graph shows how the current I through a filament lamp varies with the potential difference V applied across it.



*(a) Explain the shape of the graph in terms of particle behaviour.

(5)

As the potential difference is increased, current increases as V = I x R and this is proportional in the start. However, current has a heating effect so increase in current increases temperature. Increase in temperature causes the lattice atoms to vibrate faster with greater amplitude due to more kinetic energy. The electrons flowing therefore has a (more frequent) greater collision with lattice atoms impending flow of electrons. This increases resistance to flow of electrons and as resistance increases, the rate of increase of current with V decreases causing the graph to curve as V = I x R.

ResultsPlus
Examiner Comments

A very rare 5 mark response.

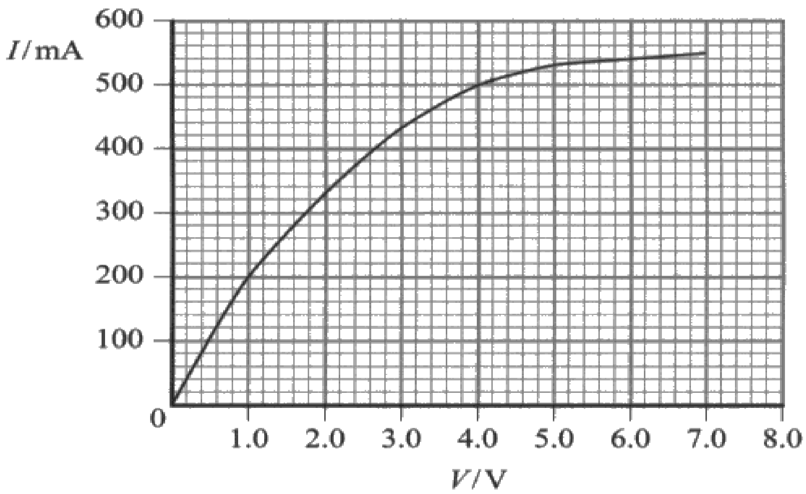
All of the marking points are seen in the order shown on the mark scheme, with MP1 in line 1, MP2 in line 3, MP3 in lines 4&5, MP4 in lines 6&7 and MP5 in line 9.

Question 15 (b)

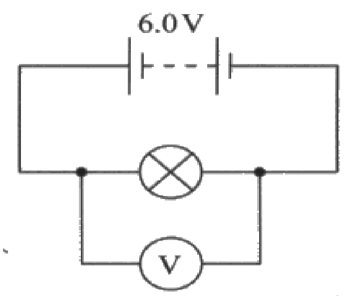
This calculation required students to read a value from a graph before using ideas of conservation of energy to establish a value for internal resistance. More than half of the students managed to score all 3 marks, with the majority of the rest scoring just 1 mark.

The most common mistake was to read off a value for current when the p.d. was 6.0V, rather than the 4.2V given. This would lead to a current value outside of the expected range for MP1 and then an incorrect answer, so no MP3.

(b) The current-potential difference graph for a particular filament lamp is shown below.



This filament lamp is connected across a battery of e.m.f. 6.0 V as shown below.



The voltmeter reading is 4.2 V.

Determine the internal resistance of the battery.

(3)

At 4.2V, current = 505×10^{-3} A

$\mathcal{E} = V + Ir$

$6 = 4.2 + 0.505 \times r$

$r = 3.56\ \Omega$

Internal resistance = $3.56\ \Omega$

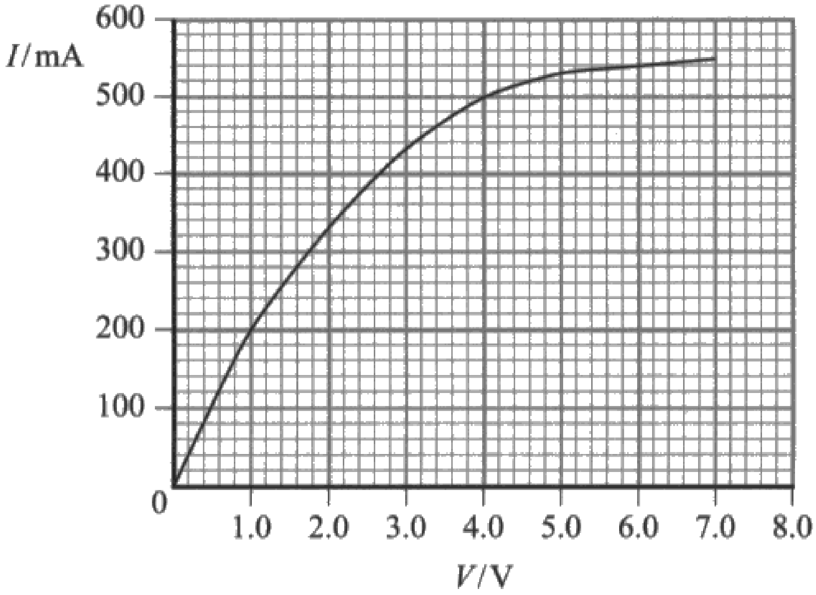
ResultsPlus
Examiner Comments

An ideal answer, very clearly laid out for 3 marks. The equation for e.m.f. used is not a given equation in the examination, but many students have been taught this so it is accepted as an alternative to the idea that the sum of the e.m.f.s is equal to the sum of the p.d.s in any loop of a circuit.

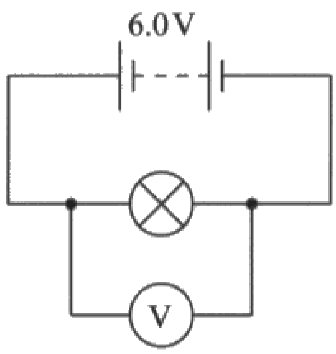
ResultsPlus
Examiner Tip

When reading values from a graph, it is a good idea to show clearly what value has been read off, as this student has done.

(b) The current-potential difference graph for a particular filament lamp is shown below.



This filament lamp is connected across a battery of e.m.f. 6.0 V as shown below.



The voltmeter reading is 4.2 V.

Determine the internal resistance of the battery.

(3)

6 / (500 x10^{-3}) = 12 Ω

4.2 / (500 x10^{-3}) = 8.4 Ω

12 - 8.4 = 3.6 Ω

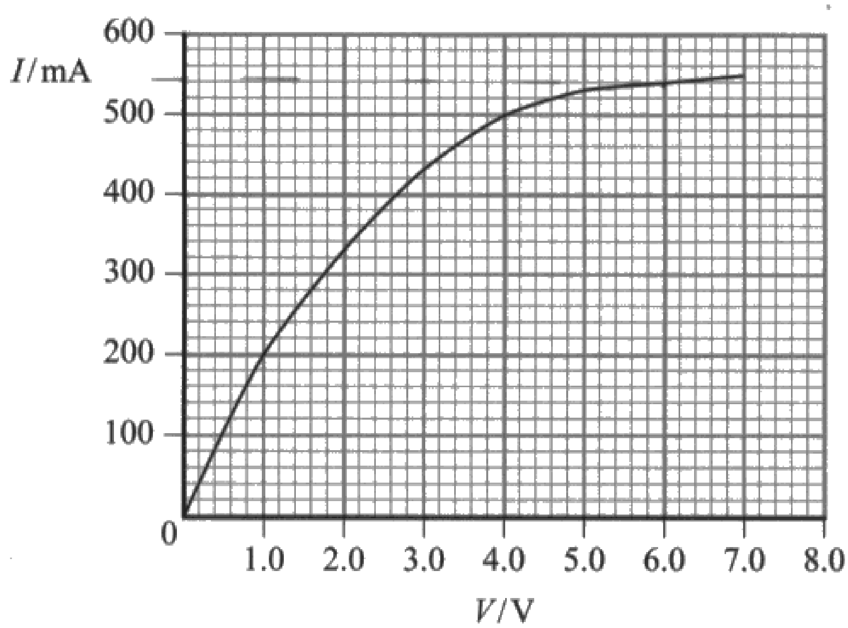
Internal resistance = 3.6 Ω

ResultsPlus
Examiner Comments

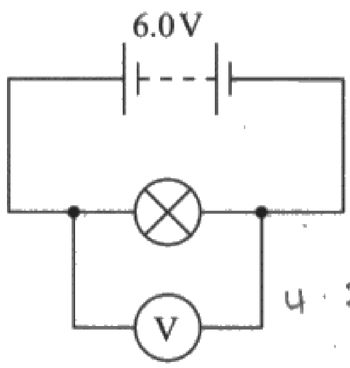
Another 3 mark response, but done in a quite different way (the second alternative shown on the mark scheme).

This student has calculated the total resistance of the circuit, then subtracted the resistance of the lamp to work out the internal resistance.

(b) The current-potential difference graph for a particular filament lamp is shown below.



This filament lamp is connected across a battery of e.m.f. 6.0 V as shown below.



$\varepsilon = V + Ir$

The voltmeter reading is 4.2 V.

Determine the internal resistance of the battery.

(3)

At 6 V the current = 540×10^{-3} A

$\varepsilon = V + Ir$

$6 = 4.2 + (540 \times 10^{-3} \times r)$

$r = 3.3\ \Omega$

Internal resistance = $3.3\ \Omega$

ResultsPlus
Examiner Comments

This student has clearly read off the current value at 6.0V, rather than 4.2V, so cannot score MP1. However, they have used this current correctly in the equation for e.m.f. and have calculated an internal resistance (scoring MP2). The answer is obviously out of range for MP3 so this script scores 1 mark in total.

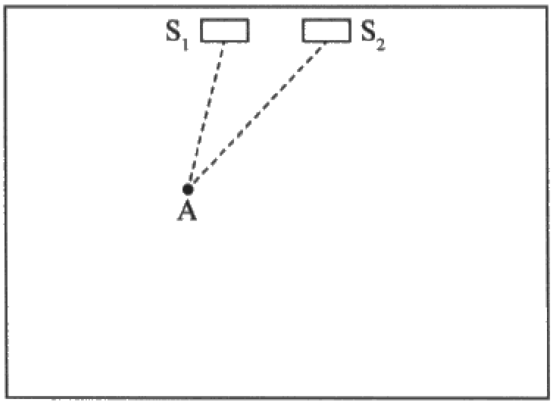
Question 16 (a)

There were many aspects to this question, including a calculation of wavelength for MP1. Both this and the mention of destructive superposition for MP3 were the most commonly awarded marking points.

MP2 and MP4 were not as commonly awarded, mainly due to the fact that quite often students did not describe path difference correctly (MP2), and did not mention amplitude (MP4)

16 The quality of the sound heard by listeners at a concert depends on the design of the concert hall.

(a) Two loudspeakers, S_1 and S_2, are connected to the same source. They are placed a small distance apart in a concert hall. The loudness of the sound heard from the speakers varies throughout the concert hall.



Point A is 3.10 m from S_1 and 4.00 m from S_2.

S_1 and S_2 emit a sound of frequency 567 Hz.

Explain why the sound heard at A will be quiet. Your answer should include a calculation.

(4)

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

Wavelength = $\frac{v}{f}$ = $\frac{340}{567}$ = 0.60 m

Wave from S_1 = $\frac{3.10}{0.60}$ = 5.17 λ

Wave from S_2 = $\frac{4.0}{0.60}$ = 6.67 λ

6.67 λ - 5.17 λ = 1.5 λ = $(1 + \frac{1}{2})\lambda$

$(n + \frac{1}{2})\lambda$ path difference, therefore phase difference of waves at A is π, so the waves are in antiphase and undergo destructive interference to give a minimum amplitude of sound.

↓ (volume)

ResultsPlus
Examiner Comments

This is an ideal answer scoring all 4 marks.

There is a clear calculation of wavelength at the start, scoring MP1.

The student then calculates each of the path lengths in terms of wavelength, and clearly shows that the difference is 1.5λ. On the next line they call this path difference so score MP2.

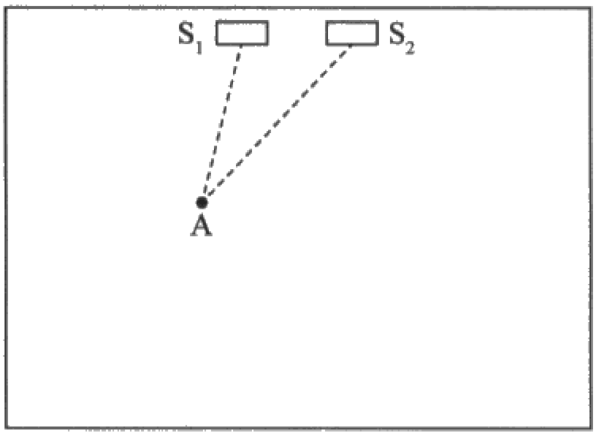
They then state that the waves are in antiphase and cause destructive interference (either of these would have scored MP3) and there is a minimum amplitude (MP4).

ResultsPlus
Examiner Tip

A statement that the path difference is (n+1/2)λ would not be sufficient on its own for MP2 here as students have been asked specifically what is happening at point A. Thus, the value of n in the equation has to be 1.

16 The quality of the sound heard by listeners at a concert depends on the design of the concert hall.

(a) Two loudspeakers, S_1 and S_2, are connected to the same source. They are placed a small distance apart in a concert hall. The loudness of the sound heard from the speakers varies throughout the concert hall.



Point A is 3.10 m from S_1 and 4.00 m from S_2.

S_1 and S_2 emit a sound of frequency 567 Hz.

Explain why the sound heard at A will be quiet. Your answer should include a calculation.

(4)

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

λ of sound : 340 = 567 ~~...~~ × λ

λ = 0.599 m ≈ 0.6

~~...~~ phase at S_1 = $\frac{3.1}{0.6}$ = $\frac{31}{6}$ = $5\frac{1}{6}$

AM = 4.6

phase at S_2 = $\frac{20}{3}$ = $6\frac{2}{3}$ Δ phase = 7.7

because of an odd ~~...~~ fraction of λ as the phase difference then destructive interference will occur and the amplitude will decrease.

ResultsPlus Examiner Comments

This candidate has calculated the wavelength so scores MP1. Unfortunately, all of their subsequent discussions refer to phase difference rather than path difference so does not score MP2. They have clearly said that there will be destructive interference so score MP3, but the idea of the amplitude decreasing is not good enough for MP4. It needs to be a minimum amplitude.

Question 16 (b)

When a question clearly discusses two different methods of reducing the formation of stationary waves, it is important for students answering the question to describe which outcome matches with which method. Some students discussed it too generally and did not refer to either soft fabrics or tiles at varying angles.

(b) The formation of standing waves within the concert hall may also create points where the sound heard is loud or quiet. Two methods used to prevent the formation of standing waves are using soft fabrics on the walls or using tiles placed on the walls at varying angles.

Suggest how each of these two methods reduces the formation of standing waves.

(3)

Placing fabrics on the walls will allow for an incident wave to be absorbed by the fabrice and prevent it from reflecting back towards the source and superposing with the incident wave

Placing tiles on the walls at varying angles will reflect the incident wave in a different direction hence it will not be reflected back towards the source and will not superpose with the incident wave

(Total for Question 16 = 7 marks)

ResultsPlus
Examiner Comments

This is a really good 3 mark response which makes it clear which method leads to which result.

Question 17 (a)

This type of calculation has appeared on a number of examinations in the past, and perhaps this is one of the reasons why students scored highly on it this time.

The students who scored 0 were mainly those who did not realise that they should use the speed of light (similar questions in the past have been about ultrasound, thus requiring the speed of sound to be used). There were also some students who clearly used the wave equation rather than speed = distance/time.

For the students who scored 1 mark, this was most likely due to forgetting to incorporate a factor of 2 into their answer, ending up with 78m.

The very small number of students who scored 2 marks out of 3 were almost all due to either a failure to include a suitable unit on the answer, or for having a power of 10 error in their calculation.

17 The photograph shows a new design of car that can travel with minimal operation from the driver compared to a conventional car.

The new car contains systems to detect other vehicles. One system uses a pulse-echo technique with laser light and another system uses the Doppler effect with microwaves.

(a) One of these new cars travels behind a truck. Both vehicles are travelling at the same speed.

Pulses of laser light are transmitted from the new car and the time taken for each reflected pulse to return is measured.

The time between a pulse being transmitted and returning is measured to be 2.6×10^{-7} s.

Calculate the distance between the new car and the truck.

(3)

~~$v = f\lambda$~~ speed = distance / Time

$v = \frac{\lambda}{T}$ ~~λ~~

(speed of laser light) = distance / $2 \cdot 6 \times 10^{-7}$ s

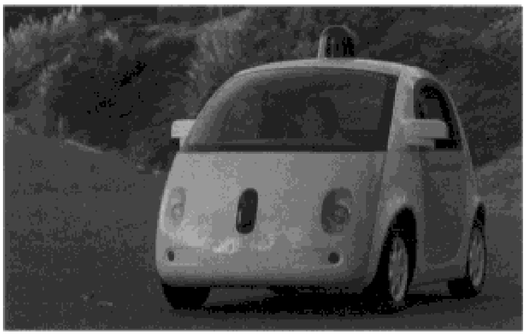
Actual Distance = Distance / 2

Distance = ...

ResultsPlus
Examiner Comments

This student clearly knows the majority of the theory required in order to answer this question, including the involvement of the factor of 2. However, the speed of light is never shown in their equation so their score is 0.

17 The photograph shows a new design of car that can travel with minimal operation from the driver compared to a conventional car.



The new car contains systems to detect other vehicles. One system uses a pulse-echo technique with laser light and another system uses the Doppler effect with microwaves.

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Pulses of laser light are transmitted from the new car and the time taken for each reflected pulse to return is measured.

The time between a pulse being transmitted and returning is measured to be 2.6×10^{-7} s.

Calculate the distance between the new car and the truck.

(3)

speed = c

time of one trip = $\frac{2.6\times10^{-7}}{2}$ = 1.3×10^{-7} s

distance = speed × time

= $3.00\times10^{8} \times 1.3\times10^{-7}$

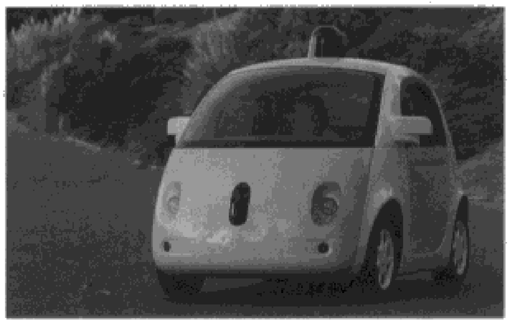
= 39m

Distance = 39m

ResultsPlus
Examiner Comments

This is a model 3 mark answer with all of the working clearly shown and an answer with units at the end.

17 The photograph shows a new design of car that can travel with minimal operation from the driver compared to a conventional car.



$v = f\lambda$

$f = \frac{2\lambda}{v}$ $\quad f = \frac{1}{t}$

$\frac{\lambda}{2}$ $\quad v = \frac{1}{t} \times 2\lambda$

The new car contains systems to detect other vehicles. One system uses a pulse-echo technique with laser light and another system uses the Doppler effect with microwaves.

(a) One of these new cars travels behind a truck. Both vehicles are travelling at the same speed.

Pulses of laser light are transmitted from the new car and the time taken for each reflected pulse to return is measured.

The time between a pulse being transmitted and returning is measured to be 2.6×10^{-7} s.

Calculate the distance between the new car and the truck.

(3)

$v = f\lambda$ $\quad$ ~~$v = \frac{2\lambda}{t}$~~ $\quad v = \frac{2\lambda}{t}$

$f = \frac{1}{t}$

$v =$ $\quad v = \frac{2\lambda}{2.6 \times 10^{-7}}$

$f = \frac{1}{2.6 \times 10^{-7}}$ = ~~3846153.85~~

$= 38 \times 10^{5}$ Hz $\quad = 76 \times 10^{5}$

ResultsPlus
Examiner Comments

This student has used the wave equation. Some students using this method actually managed to achieve the correct answer of 39m, but all responses like this end up scoring 0. This is because the time given is not a time period, so calculating f = 1/T is not an appropriate calculation for this question.

Question 17 (b) (i)

The majority of students scored 1 mark on this question, primarily as there was rarely an indication that the motion between the car and the truck was active i.e. the distance between the car and truck was decreasING rather than the distance between the car and truck had decreasED. The Doppler effect is about relative motion not whether things are closer than they were or further than they were.

Although such a distinction might seem difficult to decipher, it was clear that some students felt that the frequency or wavelength had changed simply because the pulse was returning in a quicker time as the two vehicles were now closer.

(b) The speed of the truck decreases.

(i) Explain how the new car uses the Doppler effect with microwaves to detect that the speed of the truck has decreased.

(3)

Because the truck and car are ~~go~~ getting ~~et~~ closer to each other, it means that the wavelength of the reflected pulses off the truck and sensed by the car become smaller, ∴ ~~we~~ also ~~the time taken for the pulse to from travel to the truck and back to the car is reducing ∴ $s = \frac{d}{t}$ and s is decreasing if d (wav~~ the frequency is constant ∴ $v = f\lambda$ if λ decreases then the ~~value~~ value of v decreases ~~sin~~.

ResultsPlus
Examiner Comments

This script scores just 1 mark. If their answer had simply been what they wrote on the first 3 lines, they would have scored all 3 marks, as they have a correct change of wavelength for two vehicles actively getting closer to each other.

Unfortunately, they then continue towards the end by saying that the frequency stays the same. Although there was only an expectation for students to write about either frequency or wavelength changing, if there is any indication that one stayed the same then neither MP1 nor MP3 could be achieved.

(b) The speed of the truck decreases.

(i) Explain how the new car uses the Doppler effect with microwaves to detect that the speed of the truck has decreased.

(3)

When the speed of the truck decreases or in other words, the truck is approaching relative to the new car, the emitted microwaves will change in frequency when reflected off the truck. Since the truck is approaching, the wavelengths will be shortened and hence the frequency increases. The car can now detect the the blue-shifting of the microwave and knows they are getting closer.

ResultsPlus
Examiner Comments

A good 3 mark answer. The reference to blue shift is ignored as it does not contribute any detail required for the marks.

Question 17 (b) (ii)

For this question, there was a subtle difference between what was expected for MP1 and MP2.

MP1 was all about the speed of response of the system, whereas MP2 was all about the time of response. MP3 was clearly a separate issue in terms of the result of the automated braking system.

Clearly, some students felt that the word "automated" implied a quick response, but this is not the case and could not gain any credit as it was given in the question. Almost half of students scored 0 out of 3, largely due to answers being too vaguely centred on general road safety.

(ii) The new car automatically applies the brakes when it detects that the speed of the truck has decreased.

Explain why the introduction of the new car may reduce road traffic accidents.

(3)

It may reduce road traffic accidents because human error will be avoided as car automaticaly will appy brakes as it detects a hazard (which would be a truck decreasing speed in front). It doesn't require reaction time, therefore the brakes applied are quicker to avoid an accident.

ResultsPlus
Examiner Comments

This student scores both MP1 and MP2 in the last two lines of their answer.

ResultsPlus
Examiner Tip

"Human error" is not a phrase that will score marks on physics exams, as students need to be more specific about what that "error" is, in this case the reaction time.

(ii) The new car automatically applies the brakes when it detects that the speed of the truck has decreased.

Explain why the introduction of the new car may reduce road traffic accidents.

(3)

It can apply brakes faster as it does not have reaction time before applying breaks. This means the car will stop in a shorter distance.

ResultsPlus
Examiner Comments

A really good response scoring all 3 marks in a very clear way.

ResultsPlus
Examiner Tip

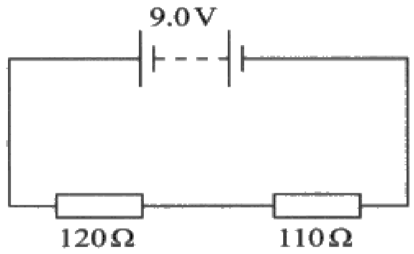
Some students suggested in their answers that the new car would reduce the braking distance. The speed of response of the system only affects thinking distance (and as a result, total stopping distance).

Question 18 (a)

This question was split into parts (i) and (ii) with part (i) clearly scoring much more highly than part (ii). Over half of all the students taking the examination scored 2 marks out of 4, usually by achieving both marks in part (i).

Part (ii) was more challenging for some students who were not clear about how to use such resistance ratios. This part often scored 0, although a fair number did score all 4 marks on the whole of part (a).

18 (a) A 9.0 V battery of negligible internal resistance is connected as shown.



(i) Calculate the potential difference (p.d.) across the 120 Ω resistor.

(2)

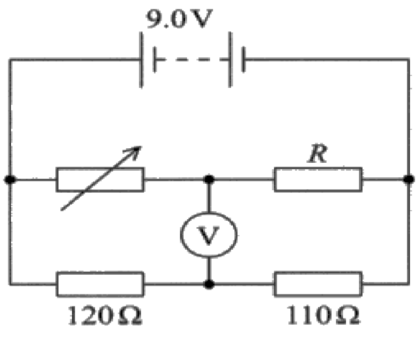
$\frac{V_1}{V_2} = \frac{R_1}{R_2}$

$\frac{V_1}{9V - V_1} = \frac{120\Omega}{110\Omega}$

$V_1 = 4.7V$

p.d. = 4.7V

(ii) A student added to the circuit, as shown below, in order to determine the resistance *R* of a resistor.



As the student adjusted the variable resistor, the reading on the voltmeter changed. When the variable resistor had a resistance of 295 Ω, the reading on the voltmeter was 0 V. This happened because the p.d. across the variable resistor was equal to the p.d. across the 120 Ω resistor.

Show that the value of *R* is about 300 Ω.

(2)

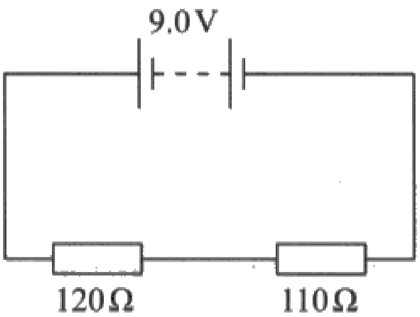
$\frac{120\Omega}{110\Omega} = \frac{295\Omega}{R}$

$R = 270\ \Omega \approx 302\Omega$

ResultsPlus
Examiner Comments

This is an example of a student who completed both parts successfully to score a total of 4 marks. The working is clear and not at all difficult to follow.

18 (a) A 9.0 V battery of negligible internal resistance is connected as shown.



(i) Calculate the potential difference (p.d.) across the 120 Ω resistor.

(2)

V = IR

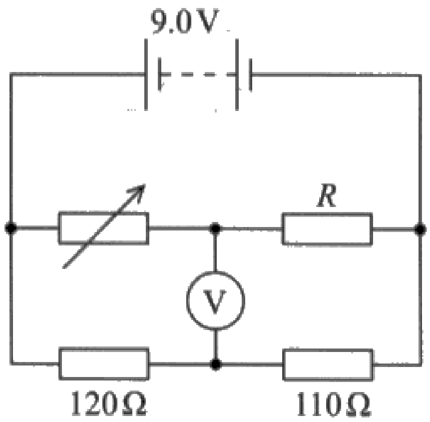
R_T = 120 + 110 = 230 Ω

$\frac{120}{230} \times 9.0$ = 4.6956...

↳ 4.7V

p.d. = 4.7V

(ii) A student added to the circuit, as shown below, in order to determine the resistance *R* of a resistor.



As the student adjusted the variable resistor, the reading on the voltmeter changed. When the variable resistor had a resistance of 295 Ω, the reading on the voltmeter was 0 V. This happened because the p.d. across the variable resistor was equal to the p.d. across the 120 Ω resistor.

Show that the value of *R* is about 300 Ω.

(2)

~~120 + 110 = 230~~ 120 + 110 = 230 Ω

$\frac{1}{295} + \frac{1}{120}$ = 85 Ω 230 + 85 = 315 Ω

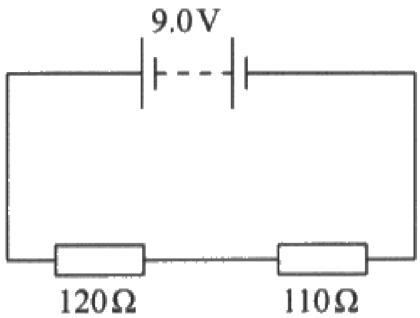
ResultsPlus
Examiner Comments

This is a typical example of a student who achieves both marks on part (i) but has difficulty establishing how to answer part (ii). Seeing as the question asks students to show that the value of R is about 300Ω, there were lots of attempts such as this where an answer in the right sort of range seems to have been engineered from incorrect physics. As a result, this attempt at part (ii) gained no credit.

ResultsPlus
Examiner Tip

With "show that" questions, the answer needs to be shown to at least one more significant figure than the value given. This means that for this question, as the "show that" value is 300Ω, the calculated value should be somewhere between 250 and 349 Ω. If doing such a calculation, an answer is produced which is outside of this range, it is advisable (if required later in the question) to use the "show that" value rather than the calculated value.

18 (a) A 9.0 V battery of negligible internal resistance is connected as shown.



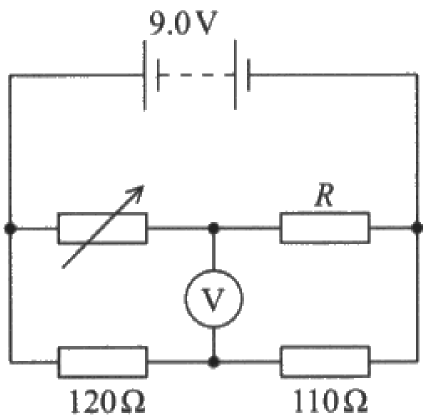
(i) Calculate the potential difference (p.d.) across the 120 Ω resistor.

(2)

$\frac{120}{120+110} \times 9.0 = 4.696$ V ≈ 4.7 V

p.d. = 4.7 V

(ii) A student added to the circuit, as shown below, in order to determine the resistance *R* of a resistor.



As the student adjusted the variable resistor, the reading on the voltmeter changed. When the variable resistor had a resistance of 295 Ω, the reading on the voltmeter was 0 V. This happened because the p.d. across the variable resistor was equal to the p.d. across the 120 Ω resistor.

Show that the value of *R* is about 300 Ω.

(2)

$\frac{R}{295+R} = \frac{120}{120+110}$

$\Rightarrow 230R = 35400 + 120r$

$\Rightarrow R = \frac{35400}{110} = 321.8 \approx 300$ ohm

ResultsPlus
Examiner Comments

This student has once again worked out a perfectly correct answer to part (i). However in part (ii) they have used a ratio of resistances that is inverted, leading to an answer of 322Ω. This can score MP1 on part (ii), but not MP2 as the answer is incorrect.

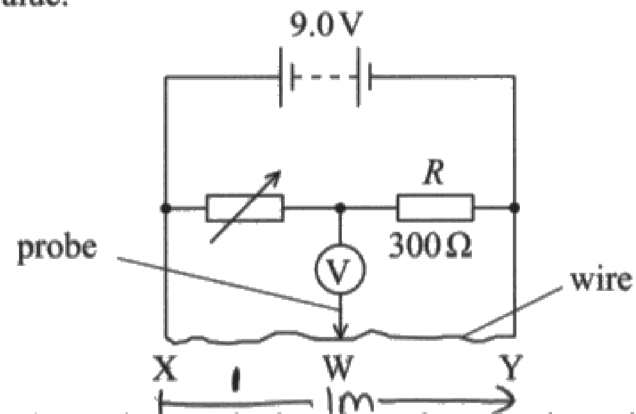
ResultsPlus
Examiner Tip

On "show that" questions, the units are shown in brackets in the mark scheme. This is because the units have already been given in the question so a candidate giving an answer of 270 on this question (provided that the working was correct) could score both marks on part (ii).

Question 18 (b) (i)

For a large number of students, this part of the question became far too tough. Out of all the questions on the paper, this was the one that was most often left with an entirely blank answer space. It was surprising to see so many students, having been told that the 120Ω and 110Ω resistors from earlier in the question had now been replaced with a wire, still did calculations clearly involving 120, 110 or 230 Ω.

(b) A different form of the circuit is shown below. The 120 Ω and 110 Ω resistors were replaced with a wire XY of length 1.000 m. *R* is 300 Ω and the variable resistor was altered to a different value.



(i) The student moved the probe attached to the voltmeter along the wire until, at W, the reading on the voltmeter was 0 V. This occurred when the length XW was 33.0 cm.

Calculate the resistance of the variable resistor, assuming that the wire XY has a uniform cross-sectional area.

(2)

300Ω ~~meters~~ 1m

x — 0.33m

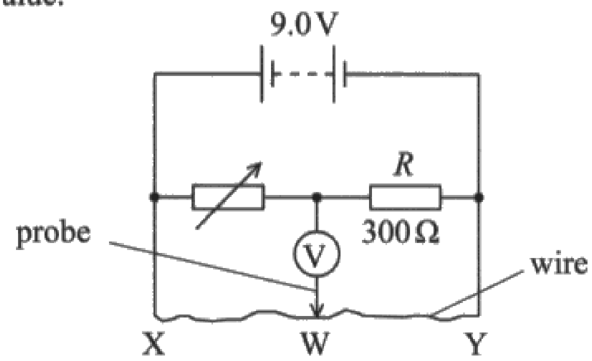
Resistance of the variable resistor = 99 Ω.

ResultsPlus
Examiner Comments

This student has shown limited working for the examiner to see, but it was deemed clear enough that the student was attempting to do a ratio of lengths to resistances using the 300Ω and two lengths of relevance from the question.

Although this was enough to enable MP1 to be achieved, MP2 was not accessible as the student had chosen the whole length of the wire rather than 0.67m for the section "in parallel" to the 300Ω resistor.

(b) A different form of the circuit is shown below. The 120 Ω and 110 Ω resistors were replaced with a wire XY of length 1.000 m. R is 300 Ω and the variable resistor was altered to a different value.



(i) The student moved the probe attached to the voltmeter along the wire until, at W, the reading on the voltmeter was 0 V. This occurred when the length XW was 33.0 cm.

Calculate the resistance of the variable resistor, assuming that the wire XY has a uniform cross-sectional area.

(2)

$\frac{R}{33} = \frac{300}{67}$ ⇒ R = 148 Ω

Resistance of the variable resistor = 148 Ω

ResultsPlus
Examiner Comments

A very good answer, with a clear ratio of two lengths to resistances, giving the correct value and unit at the end.

ResultsPlus
Examiner Tip

If it is clear from a calculation such as this one, it is not always necessary to convert given values into the correct SI units for ratio calculations. Although one would normally expect lengths to be portrayed in metres, this student clearly understood that the ratio would be the same as long as the units chosen (in this case, cm) were the same for the two distances.

Question 18 (b) (ii)

This question required two separate resistances to be described (that of the wire between XW, and of the variable resistor), but many students failed to make it clear which one they were talking about in their answers. As a result, only a very small number of the students achieved both marks here.

Quite a few students suggested that making the section of wire XW thinner would make its resistance higher than that of the section of wire WY. This is not a good description as the section of wire WY was longer, and so would be very likely to have a higher resistance due to its length.

There were very few direct comments regarding how the actual or measured resistance of the variable resistor would be incorrect.

(ii) The student discovered that the wire was thinner between X and W than it was between W and Y.

Explain why this results in an error in the calculated value of the resistance of the variable resistor.

(2)

The resistance of XW is larger, so the potential difference is larger.
so the ~~d~~ resistance of variable resistor ~~is~~ measured is smaller than the true value.

ResultsPlus
Examiner Comments

This is a rare 2 mark response, clearly making the distinction between the resistance of XW and that of the variable resistor.

(ii) The student discovered that the wire was thinner between X and W than it was between W and Y.

Explain why this results in an error in the calculated value of the resistance of the variable resistor.

(2)

The cross-sectional area is no longer uniform, as the diameter is not uniform.
$R = \frac{\rho l}{A}$ ∴ 'A' will change so 'R' will change

ResultsPlus
Examiner Comments

This is an answer that fails to describe just how the resistance might change, so scores no marks.

(ii) The student discovered that the wire was thinner between X and W than it was between W and Y.

Explain why this results in an error in the calculated value of the resistance of the variable resistor.

(2)

The calculated value of the varible resistor is different because the thinner the wire more resistance will be there which will give a different reading of resistance.

ResultsPlus
Examiner Comments

The section in the middle of this answer about the thinner wire having more resistance scores MP1. However, there is no link to how the variable resistor resistance would change as a result. Thus there is no MP2 here.

Question 18 (b) (iii)

Although this was a generally well-answered question, many students appeared to be unaware that the question was not just asking how to measure the diameter of a wire accurately. The final marking point required an explanation of how the wire could be proved to be uniform in diameter.

A sign of good preparation for the WPH03 paper was the number of students who correctly identified the micrometer as the piece of apparatus to use in this situation (although digital calipers were also accepted).

(iii) Describe how the student could check that the diameter of the wire is uniform.

(3)

By using a micrometer screw guage. He should measure the diameter of the wire at different positions and orientation and then get the mean value of the diameter.

ResultsPlus
Examiner Comments

A typical 2 mark response, scoring MP1 and MP2. There is no reference to whether the wire is uniform or not, so no access to MP3.

ResultsPlus
Examiner Tip

If quoting potential apparatus that can be used to measure something, avoid listing more than one piece of apparatus. If a student had said that the diameter could be measured using a micrometer or a metre rule, then they would not have achieved MP1 as only one of the pieces of apparatus quoted would be acceptable.

(iii) Describe how the student could check that the diameter of the wire is uniform.

(3)

use the micrometer to get the diameter of the wire for ~~two~~ a lot of values and then get the mean ~~of the~~ value of the diameter to get the the accurate cross area, and then choose other some value to compare with the value.

ResultsPlus
Examiner Comments

This student only scored MP1 for the apparatus chosen (micrometer). Although there is mention of taking "a lot of values" there is no indication that these would be from different places or orientations of the wire, so MP2 could not be gained. There is no reference to uniformity either, so MP3 could not be scored.

(iii) Describe how the student could check that the diameter of the wire is uniform.

(3)

Measure the diameter of the wire at 4 different places along the wire using a micrometer. ~~If the~~ Calculate the average diameter. If the average diameter is same as the 4 diameters measured, then the wire is uniform.

ResultsPlus
Examiner Comments

A good 3 mark response, clearly stating MP1 and MP2 in the first sentence. The approach to discussing uniformity is a bit more convoluted, but by suggesting that the individual diameter readings are all identical to the average value, that suggests uniformity (so gains MP3).

ResultsPlus
Examiner Tip

On some questions, it is perfectly acceptable to give a converse argument for a particular marking point. On this question for example, MP3 could equally-well be achieved if a student had said "if the 4 readings taken are all different, then the wire is not uniform".

Question 19 (a) (i)

It was pleasing to see so many students following the instruction to include a calculation in their answer. On this occasion, there were three potential routes to answer the question, although the answer they gave for MP3 had to match the calculation they had performed.

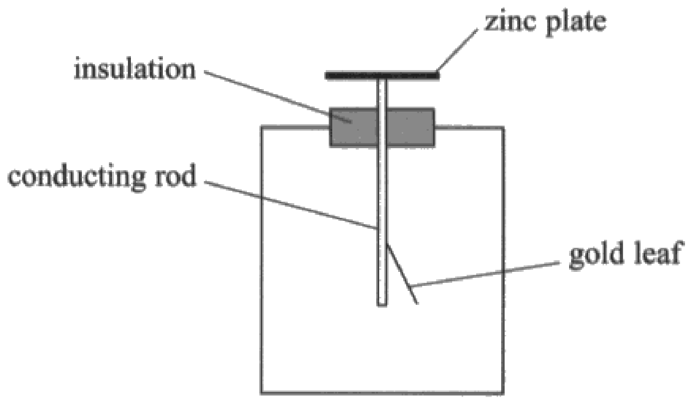
The majority of those seen chose to calculate the photon energy, and explain their answer in terms of how it related to the work function. Although this was a perfectly acceptable route to take in answering the question, many failed to mention "photon" when talking about the energy of the light being greater than the work function.

Very few of those students calculating the kinetic energy made it clear that the reason for electron release was that the kinetic energy value was positive.

A significant number of students described the effect of electron release to be to make the gold leaf positively charged so that it now attracted the negatively charged conducting rod.

Both MP3 and MP4 proved difficult to achieve, so only a small number of students achieved all 4 marks.

19 A gold leaf electroscope is a device that can be used to detect charge. The deflection of the gold leaf depends on the amount of charge on the zinc plate and the conducting rod.



In a demonstration of the photoelectric effect, a teacher charged the zinc plate with a negative charge and the gold leaf was deflected.

When ultraviolet radiation of frequency 2.0×10^{15} Hz was shone onto the zinc plate, the deflection of the gold leaf reduced.

(a) (i) Explain why the deflection of the gold leaf reduced. Your answer should include a calculation.

(4)

work function for zinc = 6.9×10^{-19} J

$hf = \phi + \frac{1}{2}mv^2$ $E = hf = 1.326 \times 10^{-18}$

$1.328 \times 10^{-13} - 6.9 \times 10^{-19} = \frac{1}{2}mv^2$

$KE = 6.36 \times 10^{-19}$ as energy of photon is higher than work function electrons are emitted from the zinc plate reducing its negative charge

ResultsPlus
Examiner Comments

This student has worked out both the photon energy and the kinetic energy of the released electrons. Either of these scores MP1 and MP2 with the answers gained.

The answer following this is in terms of photon energy being greater than the work function, so this scores MP3. The student then describes both electron emission and reducing negative charge so also scores MP4.

ResultsPlus
Examiner Tip

Even if asked to do a calculation as part of a question, it is not usually expected for this calculation to end with units on the values given. On this script neither the photon energy nor kinetic energy have Joules written at the end, but the units for MP2 are in brackets on the mark scheme, so are not necessary.

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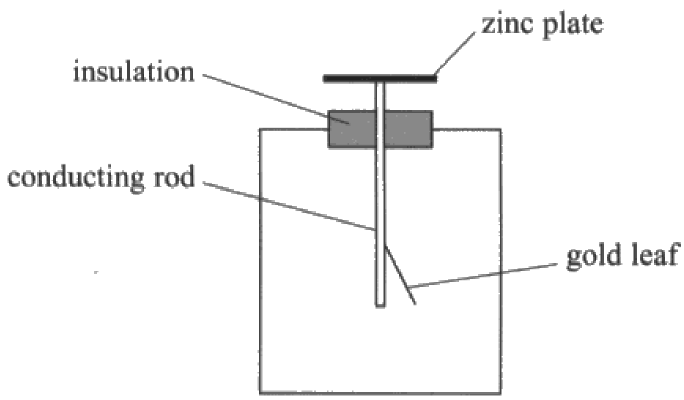

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(a) (i) Explain why the deflection of the gold leaf reduced. Your answer should include a calculation.

(4)

work function for zinc = 6.9×10^{-19} J

$\phi = 6.9 \times 10^{-19}$.

The zinc plate was negative, so deflection

But when U.V. radiation shone, it cause photo-electric emission, due to which it became less charged.

$E = hf$ | $6.9 \times 10^{-19} = h \times f$ | $f = \frac{6.9 \times 10^{-19}}{6.63 \times 10^{-34}} = 1.04 \times 10^{15}$ Hz

Frequency used here is more than the threshold frequency, due to which photo-electric emission occurs, and the zinc plate gets less charged as electrons emit from its surface.

ResultsPlus
Examiner Comments

This is another good 4 mark answer, although this time in terms of threshold frequency. The student has calculated the threshold frequency to get MP1 and MP2, then stated that this is less than the frequency of the UV being used (scoring MP3). They state twice about electron emission leading to a reduction in charge so score MP4 as well.

Question 19 (a) (ii)

Almost half of the students answering this question scored 0 marks out of 4, in spite of the fact that most of the marking points were awarded on a fairly regular basis. The unfortunate nature of such a description is that it requires a significant amount of technical wording, which was not quite detailed enough from a large number of students.

For example, on MP2 there was a need to talk about the energy of the UV being the same in this situation. Quite a few students made statements such as "as the frequency of the light is the same, the photon energy is still greater than the work function". This has not told us that the (photon) energy remains constant. Likewise, for MP3 there were often references to "less photons emitted" and "less electrons released" but no concept of them being at a slower rate when the intensity was lower. The most commonly awarded marking point was MP1.

(ii) Explain what would be observed with the gold leaf electroscope if ultraviolet radiation of the same frequency but with a lower intensity was used.

(4)

-> The deflection will be reduced as decreasing intensity will decrease number of electrons emitted from zinc plate. ~~according~~

ResultsPlus
Examiner Comments

A typical example of a response scoring 0 marks but coming reasonably close to both MP3 and MP4. The decreased number of electrons emitted would have scored MP3 if there had been a reference to rate. The deflection was reduced in the first experiment, so to score MP4 there would need to once again be a reference to the rate at which this occurred.

(ii) Explain what would be observed with the gold leaf electroscope if ultraviolet radiation of the same frequency but with a lower intensity was used.

(4)

The lower the intensity means the rate of electrons being emitted would decrease, so the gold leaf would still deflect because the frequency of the ultraviolet radiation is the same to excite and emit the electron, but everything would happen slower.

ResultsPlus
Examiner Comments

MP3 is gained in lines 1-3 of this response, but the reference to "everything would happen slower" is not sufficient for MP3, so this student scores just 1 mark in total.

(ii) Explain what would be observed with the gold leaf electroscope if ultraviolet radiation of the same frequency but with a lower intensity was used.

(4)

The frequency of the photons and thus its energy, remains unchanged, so photoelectric emission still occurs and the leaf falls. However the number of photons incident per unit time decreases, so the rate of photoelectric emission decreases. This is because each photon can only transfer energy to one electron. As a result, the leaf falls slower.

ResultsPlus
Examiner Comments

A perfect 4 mark answer.

Question 19 (b)

This question could be approached in two alternative ways. As such, the mark scheme is divided so that for each marking point, the first alternative is a description of what is really observed during the photoelectric effect, whilst the second alternative has the observation expected from the wave model. It was possible for an individual student to gain marks for both describing the wave model and the particle model. However, an answer such as "in the wave model, any frequency would be capable of releasing electrons, whereas in the photoelectric effect there is a minimum frequency to release electrons" might have given students the impression that they had scored 2 separate marking points. However, such an answer would only score 1.

MP1 and MP2 were clearly the most commonly scored marking points, with very few students making arguments in terms of kinetic energy of electrons.

Many students answered purely in terms of general statements such as "the photoelectric effect only occurs above a particular frequency". For all of the marking points available, there needed to be reference to the emission of electrons (this word is underlined in the mark scheme).

(b) In the early 20th century, the wave model was generally accepted as an explanation of the nature of light.

Explain why the wave model cannot explain the photoelectric effect.

(3)

→ There is an immediate removal of electron from the surface of metal

→ Increasing intensity doesn't increase kinetic energy of electron.

→ only a specific frequency of radiation causes emission of electrons.

ResultsPlus
Examiner Comments

This student has answered in bullet points and the first statement has scored MP1. The second bullet point also scores MP3. However, the final bullet point is not quite good enough for MP2 as there is no indication that the "specific" frequency is actually a "minimum".

(b) In the early 20th century, the wave model was generally accepted as an explanation of the nature of light.

Explain why the wave model cannot explain the photoelectric effect.

(3)

For wave theory: the energy ~~could build~~ could build up with time.

And it says that any frequency can ~~emit~~ ~~emite~~ release electron.

But photoelectric effect need above the threshold frequency and the energy could not be built up.

ResultsPlus
Examiner Comments

The middle paragraph for this student gains MP2. Although they are close to MP1 in the first paragraph, there is no indication of a time delay and no indication of it being linked to electron emission.

(b) In the early 20th century, the wave model was generally accepted as an explanation of the nature of light.

Explain why the wave model cannot explain the photoelectric effect.

(3)

- In wave theory, energy can be built up so electrons ~~are emitted~~ take time before they are emitted and can be emitted at any frequency which is not correct because there a threshold frequency which electrons ~~are~~ will not be emitted if frequency of light is less than this threshold frequency

- ~~Wave theory, Also it's said~~

- Also wave theory states that as intensity of light increases, ~~energy of~~ kinetic energy gained of electrons increases which is also wrong, the effect of increasing intensity of light is rate of emittion of electrons will increase since 1 photon is absorbed by 1 electron

(Total for Question 19 = 11 marks)

ResultsPlus
Examiner Comments

This is a rare 3 mark response. In lines 1 & 2 the student scores both MP1 and MP2, whilst MP3 is scored at the start of their second paragraph on lines 6 & 7.

Paper Summary

Based on their performance on this paper, students are offered the following advice:

- students should not attempt to learn mark schemes for previous papers and assume that they are directly applicable to different applications
- on calculation questions, all of the working out should be shown clearly, including which numbers have been inserted into the equation. "Use of" marks on the mark scheme require the insertion of correct numbers into the formulae
- if asked to explain the shape of a graph (as with Questions 13(b) and 15(a)), make sure that all aspects of the graph are considered, rather than the extremes
- when answering questions about the nature of light, ensure that there is significant discussion of the role of photons, as this is a key word that should appear in answers on such questions.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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