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Examiners' Report
June 2017

IAL Physics WPH02 01

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Introduction

The mean mark on this paper was 5 marks higher than that for the equivalent unit paper in summer 2016. The majority of this was due to the fact that the multiple-choice questions were answered much more successfully.

Question 7 was the only multiple-choice question that less than 70% of the candidates achieved the mark for.

Most of the marks in the section beyond the multiple choice were accessible, although some candidates were finding it difficult to apply their understanding to scenarios that were different to those that they had seen in previous papers. In particular, Questions 15 and 17 saw students giving answers that were reminiscent of acceptable responses to questions on other exams.

Question 11 (a)

72% of the candidates achieved this mark, calculating the wavelength of a standing wave from a diagram with three loops shown. Although the data given was in centimetres, students commonly gave their answers in terms of metres. The common mistakes tended to be multiples or standard divisions of the given 96cm, such as 48cm, 72cm and 144cm.

(a) Determine the wavelength of the wave.

(1)

96÷3×2 = 64 cm

= 0.64m

Wavelength = 0.64 m

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Examiner Comments

This candidate has converted the answer into metres, which is perfectly acceptable. This is a useful practice, as if the value had been required for a later calculation, metres would have been the preferable unit for it to be converted to.

Question 11 (b)

This question proved to be much more demanding, as it required candidates to recognise how standing waves differ from progressive waves in terms of phase difference. If this had been a progressive wave, the phase difference would have been somewhere in the region of 270° or 3π/2 radians, and this is by far the most common answer seen. However, for a standing wave, any point between two adjacent nodes is always in antiphase with any point between the adjacent node-to-node distance, so they are 180° or π radians out of phase here (antiphase).

Many candidates chose to give more than one answer, and some decided to also give the path difference. However, there was only ever a requirement for one answer to be given.

(b) W and X are points on the string.

State the phase difference between W and X.

(1)

180° / 2π

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Examiner Comments

This candidate has given two different answers. Unfortunately, one of them is correct and the other is incorrect, so the mark cannot be awarded.

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Examiner Tip

If a question asks for the phase difference between two points on a wave, it is best to present a single answer. If more than one answer is provided, all of those given need to be correct in order to score the mark.

Question 11 (c)

The question was asking how a standing wave is formed. It did not state specifically that this had to be the standing wave described earlier in the question, but many candidates took this to be the case, so there were two alternatives to the first marking point as a result. In general, the definition would discuss two waves travelling in opposite directions and meeting. As the example earlier in the question had a wave being emitted and then reflected back on itself, this was also accepted.

Whichever alternative, there needed to be some idea of superposition or interference taking place in order to achieve the second mark, whilst the mention of how nodes and antinodes are formed gained the third mark. Many candidates did not use the terms node and antinode, and quite a few who did were confused as to which one represented a maximum, and which represented a minimum.

(c) Describe how a standing wave is formed.

(3)

wave travels from one end of the string to the other and is reflected. The incident and reflected wave are travelling in opposite direction and they superpose. At points where they superpose in phase, constructive interference takes place and antinodes form and at points they superpose in antiphase, destructive interference takes place and nodes form.

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Examiner Comments

A model 3-mark answer, clearly describing all necessary aspects.

Standing wave is not transfer energy and time.

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Examiner Comments

This candidate describes what a standing wave does in terms of energy transfer, rather than telling us how the standing wave formed in the first place. It gained no credit for this.

Question 12 (a)

Similar questions have come up on previous examinations. However, although the mark scheme was very similar to those used in the past, many candidates did not make their answer clear enough. Some of the answers just repeated information given in the question whilst a significant number of those failing to achieve the mark mentioned the need to avoid interference taking place. Some candidates presented incomplete answers or some that were incorrectly ordered e.g. "One wave is sent before the previous one returns".

(a) State why it is necessary to emit the ultrasound in pulses.

(1)

The next pulse must be sent after receiving the previous one, a continuous wave isn't able to do this.

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Examiner Comments

A correct answer, using the first alternative on the mark scheme.

because if it was emitted in rays, the reflected one could interfere with the incident wave

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Examiner Comments

The common incorrect answer, discussing the possibility of interference. This is not the reason why ultrasound is sent in pulses.

Question 12 (b)

Although a different scenario, this question is similar to many that have been asked in previous series. Unfortunately, there were still a significant number who failed to recognise that half of the time would be taken to reach the object that the signal was being reflected from, and half the time would be taken to make the return journey. As a result, almost a quarter of the candidates scored 1 mark, which was most typically scored by those who used speed = distance/time, but failed to account for the factor of 2. The 9% of students who scored 2 marks most commonly failed to include units on the answer. However, over 50% of the candidates achieved all 3 marks.

(b) A car manufacturer claims that the sensors are able to detect objects from a distance of 0.10 m from the car.

Calculate the maximum duration of each pulse.

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

(3)

~~$V \neq f\lambda$~~

~~$V =$~~

$V = f\lambda$

$f\lambda = V$

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

$= \frac{340}{0.10}$

$= 3400\,Hz$

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

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

$= \frac{1}{3400} = 2.94 \times 10^{-4}\,s$

Maximum duration = ~~3.9~~ $2.94 \times 10^{-4}\,s$

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Examiner Comments

This candidate appears to be attempting to use the wave equation, which is obviously incorrect physics. The distance provided in the question is not a wavelength, so it is inappropriate to use this equation to answer it. These approaches scored 0.

$s = \frac{2d}{t}$

~~0.10 = ~~ $340 = \frac{2 \times 0.10}{t}$

$340t = 0.2$

$t = \frac{0.2}{340}$

$t = 5.88 \times 10^{-4}$ s

Maximum duration = 5.9×10^{-4} s

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Examiner Comments

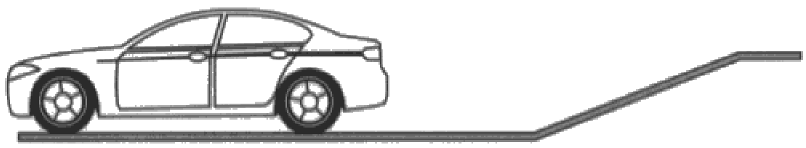
A perfect 3-mark answer.

Question 12 (c)

This question was split into two parts: both concerned suggestions about why ultrasound pulses might not return to a car from which they were sent. Generally, candidates coped fairly well with the first part, about why the signal would return from an ascending ramp. Some candidates added to the given diagram to show the direction that the ultrasound pulse would head off in (away from the car) and this was perfectly acceptable. On part (ii) quite a few candidates seemed to be more concerned with possible diffraction that would take place around the post, without making it clear that the emitted signal would not return. References to diffraction were treated as neutral, but many candidates failed to link it to a lack of reflection from the post.

(c) (i) Suggest why the sensors may not help the driver when reversing towards an ascending ramp.

(1)



The waves of ultrasound will be reflected upwards and will not return to the sensors.

(ii) Suggest why the sensors may not help the driver when reversing towards a thin post.

(1)

The ultrasound wave will just diffract around the post and not get reflected back.

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Examiner Comments

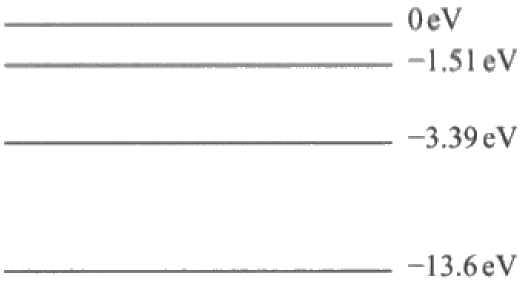
A good answer, scoring the mark in both parts. The reference to diffraction was ignored in part (ii) as the candidate mentions clearly that the signal is not reflected back.

Question 13 (a–b)

Taking parts (a) and (b) together, there was a good spread of marks scored from 0 to 5, with an average of 2.96/5. 20% of the students gained all 5 marks here. Out of the 5 marks, the most common marks not to award were for the definition in part (a) and the final answer mark on (b), where candidates often had the two levels the wrong way round.

In part (a), many of the candidates mimicked the question by referring to states rather than levels, This was the main reason for students missing out on this mark.

13 The diagram shows some of the energy levels for hydrogen.



(a) State what is meant by the ground state of an atom.

(1)

the lowest energy level occupied by an electron.

(b) Identify the transition which would result in the emission of light of wavelength 660 nm.

(4)

$f = \dfrac{3\times10^{8}}{660\times10^{-9}}$

$= 4.54\times10^{14}$

$hf = 4.54\times10^{14}\times6.63\times10^{-34}$

$= 3.0136\times10^{-19}$

$eV = \dfrac{3.0136\times10^{-19}}{1.6\times10^{-19}}$

$= 1.8835 \approx 1.88$

$-1.51 - -3.39$

$eV = 1.88$

Transition −1.51 eV to −3.39 eV

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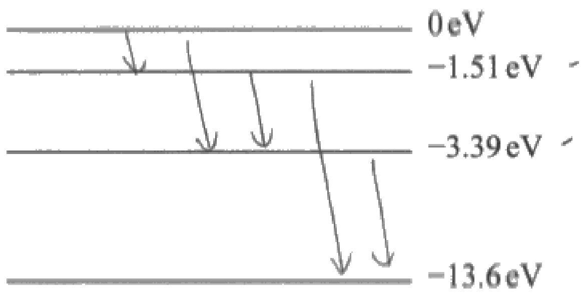
Examiner Comments

This answer is fully correct on both parts. In part (b), although the energy levels have minus signs on them, it was decided that candidates who wrote the levels without the minus signs could still gain full credit on this question, as only a limited number of levels had been given in the question, and there was no +1.51eV or +3.39eV level on the diagram.

13 The diagram shows some of the energy levels for hydrogen.



(a) State what is meant by the ground state of an atom.

(1)

The lowest energy level than an electron of the atom can possess

(b) Identify the transition which would result in the emission of light of wavelength 660 nm.

(4)

660nm = $6 \cdot 6 \times 10^{-7}$ m

$1 \cdot 51 - 0 = 1 \cdot 51$ eV

$1 \cdot 51$ eV $\times 1 \cdot 6 \times 10^{-19} = 2 \cdot 416 \times 10^{-19}$ J

$E = hf$

$2 \cdot 416 \times 10^{-19} \div (6 \cdot 63 \times 10^{-34}) = 3 \cdot 64 \times 10^{14}$ Hz

$v = f\lambda$

$(3 \times 10^{8}) \div (3 \cdot 64 \times 10^{14}) = 8 \cdot 23 \times 10^{-7}$

$3 \cdot 39 - 1 \cdot 51 = 1 \cdot 88$ eV

$1 \cdot 88$ eV $\times (1 \cdot 6 \times 10^{-19}) = 3 \cdot 008 \times 10^{-19}$

$f = E \div h$

$3 \cdot 008 \times 10^{-19} \div (6 \cdot 63 \times 10^{-34}) = 4 \cdot 54 \times 10^{14}$

$\lambda = v \div f$

$(3 \times 10^{8}) \div (4 \cdot 54 \times 10^{14}) = 6 \cdot 6 \times 10^{-7}$ m

$\approx$ 660nm

Transition $-3 \cdot 39$ eV to $-1 \cdot 51$ eV

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Examiner Comments

This script also scores the mark for part (a). However, the approach to part (b) was quite a common one. This was a reverse argument.There were only a limited number of energy transitions that could take place, so some students adopted the approach where they selected a transition and worked backwards to find the wavelength that it would be associated with. This candidate took two attempts before finding the correct transition, but unfortunately wrote them in the answer boxes the wrong way round, failing to achieve the final marking point as a result.

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Examiner Tip

When answering questions about transitions between energy levels, candidates should remember that any movement up the energy levels represents absorption. Movement down the energy levels represents emission.

Question 13 (c)

Almost half of the candidates on this question scored just 1 mark. This was a result of assuming that the photon energy was equal to the kinetic energy of the released electron. These candidates had failed to recognise that the photon energy partly went towards providing the energy for ionisation. Only 30% of the candidates managed to take the photon energy and subtract the ionisation energy to achieve the correct answer. Many achieved the correct answer by clearly using the photoelectric effect equation, which is not applicable to this situation.

Calculate the kinetic energy, in J, of the released electron.

(3)

$E = hf = 3.58 \times 10^{-18}$ J

$= 22.38$ eV

$22.38 - 13.6 = 8.78$ eV $= 1.4 \times 10^{-18}$ J

Kinetic energy = 1.4×10^{-18} J

ResultsPlus

Examiner Comments

A fully correct answer, clearly presented.

Calculate the kinetic energy, in J, of the released electron.

(3)

$E = Hf$ ~~$E = 13.6 \times 1.6 \times 10^{-19}$~~ ~~$Hf = 5.4 \times 10^{15}$~~

$Hf = \phi + \frac{mv^2}{2}$ ~~$= 2.176 \times 10^{-18}$~~ $Hf = 5.4 \times 10^{15} \times 6.63 \times 10^{-34}$

$13.6 \times 1.6 \times 10^{-19}$ $= 3.58 \times 10^{-18}$ J

$= 2.176 \times 10^{-18}$

Kinetic energy = ... J

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Examiner Comments

This candidate has calculated both the photon energy and the ionisation energy, but then failed to recognise that one must be subtracted from the other. As a result, this candidate scores just the first mark.

$E = h \cdot f$

$= 5.4 \times 10^{15} \times 6.63 \times 10^{-34}$

$= 3.58 \times 10^{-18}$ J

Question 13c_98783_01.png

Kinetic energy = 3.58×10^{-18} J

ResultsPlus

Examiner Comments

This was by far the most common answer seen to this question. Photon energy is calculated, and no further processing takes place beyond that point. It scores 1 mark only.

Question 13 (d)

This question was poorly answered, partly due to the different nature of the question, partly due to candidates failing to recognise that significantly more detail was required in their answer than had already been given in the whole of question 13. Although the question was about absorption spectra, most candidates answered it as if it were a question about emission spectra. These candidates could pick up the first marking point, but not the second, which clearly had to be related to absorption rather than emission. From the information at the start of question 13, it was clear that electrons are only found in certain energy levels, and that movement between these energy levels could be related to the frequency/wavelength of photons. So for marking point 1, candidates needed to go beyond that to say that there were only certain differences between energy levels possible. Vague answers such as "only certain wavelengths are missing from the emerging light as they are absorbed by the gas" gained no credit, as this information had been given in the question.

Explain why certain wavelengths are missing from the emerging light.

(2)

electrons are found ~~is~~ in specific energy levels, so thier is specific energy differences which means certain wavelengths will be emitted

ResultsPlus

Examiner Comments

This is a typical candidate answer limiting their response to emission only. However, their answer does score the first mark for the specific energy level differences idea.

When words are underlined in a mark scheme, it means that the candidate answer has to include those exact words. For question 13d, the words "photon" and "absorbed" are underlined, meaning that they both have to appear. However, in marking point 1, the candidates needed to express the idea of there being only certain "differences" between energy levels. The word "differences" is not underlined, as alternatives such as "changes", "transitions" and "jumps" would be equally accepted.

Explain why certain wavelengths are missing from the emerging light.

(2)

electrons have discrete energy levels
one electron absorbs the energy of one photon
and moves to a higher energy level. ~~only~~.
~~the~~ the energy of photon equals the energy difference
between the two energy levels. Only certain energy differences

(Total for Question 13 = 10 marks)

~~only~~ are possible, ~~so~~ due to $E = hf = \frac{hc}{\lambda}$, only
Certain wavelengths of photons are absorbed

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Examiner Comments

This is a rare 2-mark answer. In the context of what was quite a tricky question for students, the link between photon energy and frequency was accepted in the form of the equation E=hf.

Question 14 (a)

This is another question that was weakly answered. Some of the definition questions on the paper were not straightforward, and 67% of the students scored 0/2. The first marking point is a key part of any definition for a property that is measured in Volts. The second mark specifically makes it an e.m.f.

(a) State what is meant by the e.m.f. $\mathcal{E}$ of the battery.

(2)

It is total energy supplied ~~add~~ by transferring all the chemical energy ~~in the battery~~ into electric energy. $V = \frac{E}{Q}$
And e.m.f is the energy transfered per unit of coloumb.

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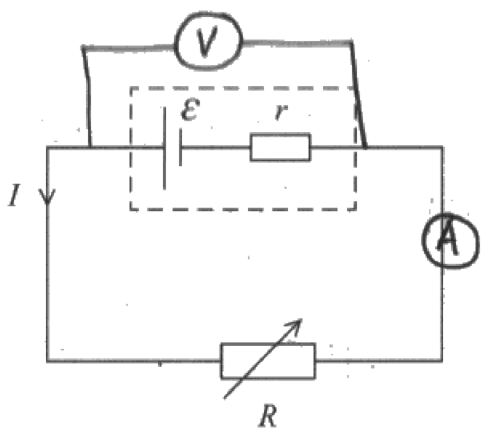
Examiner Comments

This answer scored both marks.
The first marking point is gained as work done is analogous to energy transferred. The second marking point is seen at the start. It is not ideally worded, as the candidate suggests that e.m.f. is an energy rather than energy transferred per unit charge.

Question 14 (b)(i)

This question was generally very well done, with 85% of candidates scoring the mark. The voltmeter could be positioned around the variable resistor or across the whole battery (including the internal resistance). The ammeter just had to be anywhere in the series part of the circuit.



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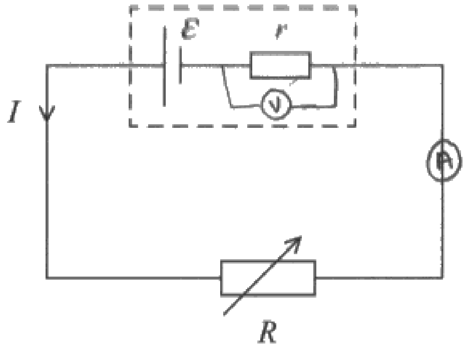
Examiner Comments

An acceptable answer for the mark.



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Examiner Comments

This candidate has drawn the voltmeter around the internal resistance alone. This would not be possible with a real voltmeter as candidates are expected to know that the internal resistance is not simply a small resistor within the power supply that leads could be placed in parallel across.

Question 14 (b)(ii)

Another question not scoring highly, with only 20% achieving the mark. Most candidates had part of the answer, but most of these failed to add in the problem that this would cause (as requested in the question). Most of the candidates who achieved the mark scored it via the first method shown on the mark scheme.

Suggest why this could be a problem if the battery has a low internal resistance.

(1)

Too much current will flow through the circuit.

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Examiner Comments

This candidate has the idea of a large current, but fails to link it to heating.

low internal resistance, more current, so could cause heating of the battery.

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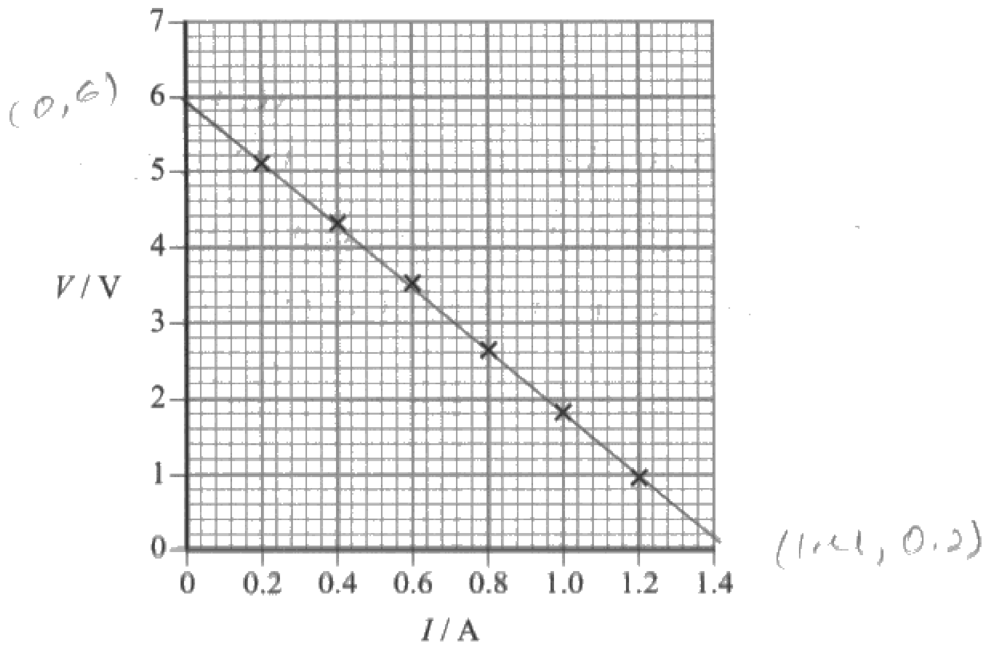
Examiner Comments

This candidate clearly states why the greater current will cause a problem, so scores the mark.

Question 14 (c)

This question has two parts. In part (c)(i), candidates were expected to draw a best fit line, and to determine the values for the e.m.f. and internal resistance from the graph. Students are expected to know that the e.m.f. is established from looking at the y-intercept and that the internal resistance is the gradient of the graph. As a result, it was felt that there was no need to instruct candidates within the question to draw a line of best fit. Many candidates did not. In part (c)(ii), candidates were expected to take their values from part (i) and use them with a relevant power equation to calculate the power dissipated in R. It seems that the majority of the candidates did not realise the importance of being told to do this when the value of R was equal to r. Effectively, this either meant that the total resistance in the circuit was 2r OR that the e.m.f. of the battery was shared equally between R and r.

(c) The student plotted the results on a graph.



(i) Determine values for $\mathcal{E}$ and r.

(4)

$\mathcal{E}$ = y intercept

$\mathcal{E}$ = 6V.

r = − gradient

$r = -\left(\frac{6-0.2}{0-1.4}\right)$

$= -(-4.14)$

$= 4.14\ \Omega$.

$\mathcal{E}$ = 6V.

r = 4.14Ω.

(ii) The power transferred from the battery to the load resistance is a maximum when $R = r$.

Calculate the maximum power dissipated in R.

(3)

$P = V^2/R$ $0.72^2 \times$ $V \text{ in } R = \frac{4.14}{4.14 \times 2} \times 6$

$= 3^2/4.14$

$= 2.17$ W. $= 3$ V.

Maximum power = ...

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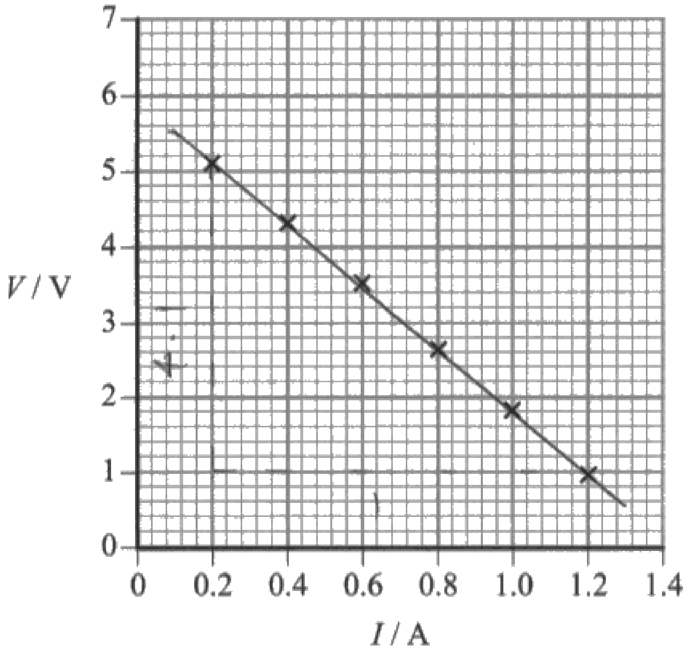
Examiner Comments

A perfect answer scoring full marks on both parts. Only 12% of the candidates sitting this paper achieved this score.

(c) The student plotted the results on a graph.



(i) Determine values for $\mathcal{E}$ and r.

(4)

$\mathcal{E} = V - Ir$ $\quad$ $\mathcal{E} = 5.1 - (0.2 \times 4.1)$

$r =$ gradient.

$\frac{4.1}{1} = 4.1$

$\mathcal{E} =$ 4.28 V

$r =$ 4.1 Ω

(ii) The power transferred from the battery to the load resistance is a maximum when $R = r$.

Calculate the maximum power dissipated in R.

(3)

$P = \frac{V^2}{R}$

$\frac{4.28^2}{4.1} \rightarrow 4.47$

4.47 W

Maximum power = [crossed out]

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Examiner Comments

Although this candidate has drawn a best fit line, it has not been extended to the intercept with the y-axis, and the answer for the e.m.f. clearly shows that they have not attempted to use this intercept to achieve the value. However, they have clearly worked out the gradient to establish a within-range answer for r. This scores 2 marks for part (i). The candidate then uses their values from (i) in a relevant power equation for part (ii) to score 1 mark. There is no idea of the resistance being doubled or the e.m.f. from (i) being halved so there are no more marks.

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Examiner Tip

The gradient of this graph should be -r. For this examination, a failure to see the gradient quoted as a negative value did not incur a penalty. However, it is worth noting that depending on the style of the question, there will be examinations where such penalties might be incurred by students. If this had been one of those occasions, this candidate might have only scored 1 mark in (i).

Question 15 (a)

This standard definition question has been asked on a number of previous examination series, usually with a degree of variation in terms of the medium through which the wave is travelling. In this examination, the air is mentioned in the question, so there was no insistence for marking point 2 on the candidates mentioning air, but we needed to see some idea of the substances through which the sound wave was travelling. As a result, marking point 2 was the most common mark not to award on this question.

Words in brackets on mark schemes are those that are not essential for the candidate to achieve the marking point. However, they are included in the mark scheme as a full explanation would ideally include those words.

(a) Explain how sound travels through the air.

(3)

Sound travels with the to and fro vibrations of the air molecules through successive compressions and rarefaction. The air molecules vibrate parallel to the ~~E~~ travel of energy.

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Examiner Comments

A pretty good response gaining all 3 marks. For marking point 3, apart from "wave travel", we also accepted "energy travel" and "propagation".

Sound travels by oscillations parallel to the direction of travel via a series of compressions and rarefactions.

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Examiner Comments

A generally good answer for 2 marks, but there is no idea of molecules, particles or atoms for marking point 2.

Question 15 (b)(i)

Many candidates tended to treat this as a standard "what is meant by diffraction?" question. However, this question was deliberately applied to the given scenario, within which discussion of gaps was not expected. In spite of this, many responses simply spoke about it as being the spreading of waves as they pass through a gap or around an obstacle. If they did not specify which one was happening in this case, they did not score marking point 2. Rather worryingly, a number of candidates who only seemed to know the definition of diffraction through gaps decided that the sound was travelling into one ear and out of the other.

(i) Describe how the sound reaches the right ear by diffraction.

(2)

waves travel to gaps It is the bending of waves along a gap. When gap is as same size as wavelength, diffraction is most.

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Examiner Comments

This candidate discusses the bending of light, rather than spreading, which gives the suggestion that the candidate is talking about refraction. In addition, they only discuss this in relation to gaps, so no marks are scored here. Marking point 2 was dependent upon the awarding of marking point 1, so no mentioning of spreading of waves resulted in no marks being achieved.

the sound waves spread out around the (obstacle) listener's head to reach the ear

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Examiner Comments

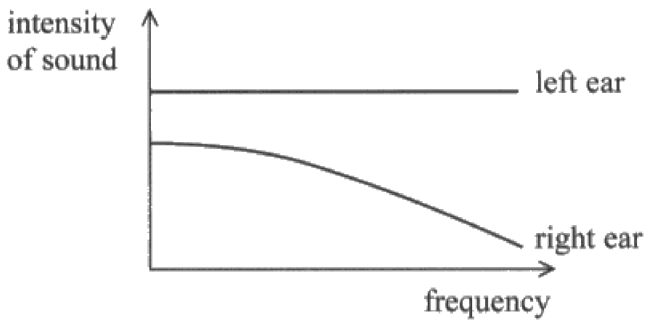
This candidate has clearly understood the context of the question and talks about spreading and does not refer to gaps whatsoever. A good 2-mark answer.

Question 15 (b)(ii)

It was difficult to achieve all 5 marks on this question, as there were a number of aspects to discuss in relation to the graphs drawn. Three of the marks were simply for stating clearly what the graphs showed, although many candidates failed to make it clear when they described it. For example, candidates often wrote sentences such as "For the left ear the intensity remains constant, whilst for the right ear the intensity decreases". Neither part of this statement clearly related it to "as the frequency increases". A number of candidates were also confused about the way to read the graph as there were quite a few who made statements such as "for the right ear, the frequency decreases". On top of this, even for those candidates who correctly described the graphs, it appeared that they were confused about the process by which the sound was reaching the right ear. Some felt that more sound would reach the right ear if there was less diffraction rather than more. It was assumed that candidates writing about sound diffracting as it passed through the gap of the left ear had already failed to achieve a mark in 15bi, so there was no loss of marks on this part if they wrote about gaps.

*(ii) The intensity of a sound heard by the ear is the power per unit area reaching the ear.

A particular source of sound is placed to the left of the listener. The graph shows how the intensity of the sound reaching each ear varies over a range of frequencies.



Explain the differences in the intensity of the sound reaching the left ear and the right ear.

(5)

- The intensity of the sound is constant for the left ear because the speed of the sound is constant.
- As the frequency increases, the wavelength decreases since speed of the sound is constant.
- Sound reaches the right ear by diffraction.
- So ~~the~~ as the frequency is increased, the wavelength decreases and ~~i~~ is no longer similar to the size of the left ear hole.
- Therefore the sound spreads out less causing lower sound to be heard and causing the intensity of sound to fall.

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Examiner Comments

This candidate scored marking points 1,4 and 5, giving a total score of 3 marks. There is clear discussion of earholes so the student thinks that the sound is passing into the left ear and coming out at the right ear. However, this was ignored for this part of the question. Also, although the reasoning for why the intensity of sound is constant for the left ear is incorrect, marking point 1 was simply for the observation of what the graph demonstrated, rather than an explanation.

Sound reaching the left ear has a constant ~~frequency and~~ intensity because the sound waves are directly moving into the listener's ear without diffracting through any gap or obstacle. However, the sound reaching the right ear must first diffract along the person's head before reaching his right ear. Therefore, ~~so~~ the waves will spread out and the sound's intensity will decrease as the frequency increases (the sound waves are moving towards the listener; Doppler effect → frequency increases as the sound waves come close to each other). The intensity is the power per unit area, meaning ~~as the area of the obstacle increases,~~ that the area is inversely proportional to the intensity. The person's head has a large area and therefore a ~~small~~ low intensity of sound is heard.

(Total for Question 15 = 10 marks)

ResultsPlus
Examiner Comments

This candidate scores only marking points 1 and 4. They have talked about diffraction, but not related the increase in frequency to decreased diffraction, so cannot access marking point 5.

The left ear recieves all sound, no matter the frequency, without it diffracting, so ~~energy~~ intensity remains higher than ~~of~~ the right ear and it remains constant. The right ear recieves the sound after it has diffracted, decreasing the intensity. Diffraction decreases the intensity as the sound wave spreads out, also spreading out the energy. The graph also shows that as frequency increases the intensity decreases. This is because as frequency increases wavelength decreases. When wavelength decreases, the sound wave diffracts less and less sound reaches the ear decreasing the intensity. Also the right ear recieves less intensity than the left ear because the wave has to travel more distance to reach the right ear, dissopating more energy

(Total for Question 15 = 10 marks)

ResultsPlus

Examiner Comments

A rare 5-mark response, although all of it needs to be read before all of the marking points are seen. Marking points 1,2 and 4 represented the observations that could be made from the graph. Marking points 3 and 5 were for the explanations. Unlike some other questions, there was no necessity to approach these in any particular order, as they did not logically follow each other. As a result, the fact that the candidate picks up marking points 2 and 3 right at the end does not provide any issue with awarding all 5 marks (this question assesses quality of written communication, so the answer needs to be logical and clear in order to be able to award all 5 marks).

Question 16 (a)(i)

This is another question where candidates quite often wrote an answer that was simply paraphrasing the question. Only 6% of the candidates scored both marking points. The definition for drift velocity as a mean velocity was given, and candidates needed to explain why it was a mean velocity. However, many just wrote the same statement in a slightly different way e.g. "the drift velocity is the average velocity of all the electrons".

(i) Explain why drift velocity is defined as a mean velocity.

(2)

because the actual velocity of the electrons vary as they ~~bump into~~ collide with a other ~~atoms~~ ions of the metal they are in so a mean value is calculated to avoid complication.

ResultsPlus

Examiner Comments

A rare two-mark answer. This candidate has talked about the electrons colliding with "other" ions, but this was considered acceptable.

Because not all electrons are travelling at the same speed, since they travel randomly in different directions and bump into eachother.

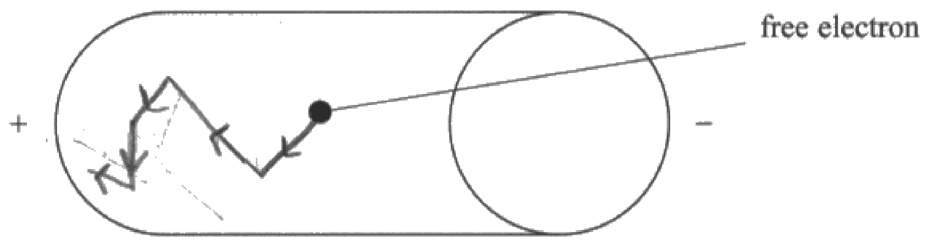
ResultsPlus

Examiner Comments

A common answer, where the candidate scored marking point 1 early in the answer, but then went on to suggest that it is due to electrons colliding with other electrons. As a result, marking point 2 was not awarded here.

Question 16 (a)(ii)

More than 60% of the candidates scored 1 mark on this question. Most of those answering knew that the direction of electron movement would be towards the left on the diagram. The idea was that the candidates should start from the dot drawn in the middle of the diagram, but others started from different points. Those starting from different points had to have a clear arrow, whilst those starting from the drawn dot were assumed to start from there and whichever direction they headed from there was their direction of electron movement. Quite a few candidates failed to visualise the diagram, and drew lines that seemed to be reflecting only from the edges of the wire (somewhat like a diagram of total internal reflection). This was not demonstrating collisions with ions within the wire, so did not gain full credit. Most tended to draw a single straight arrow to the left, scoring just 1 mark.



Draw on the diagram to show a possible path of the electron as it moves through the tungsten filament.

(2)

ResultsPlus
Examiner Comments

This was an ideal answer, with sharp changes of direction throughout the drawn line.

Question 16 (b)(i)

For most candidates this was a relatively straightforward calculation. Only 15% of the cohort failed to achieve at least 2 of the 3 marks on offer for this question. The majority of this 15% were candidates who had confused resistance and resistivity in the equation.

(i) Calculate the resistivity of tungsten at room temperature.

(3)

$\rho = \frac{RA}{L}$

$= \frac{\left(\frac{12}{1.2}\right) \times 7.9\times10^{-11}}{1.3\times10^{-3}}$

$\frac{10 \times 7.9\times10^{-11}}{1.3\times10^{-3}}$

$\frac{7.9\times10^{-10}}{1.3\times10^{-3}}$

6.0769×10^{-7}

Resistivity = 6.08×10^{-7}

ResultsPlus
Examiner Comments

In this candidate's work, there is a clear sign of a resistance calculation of 12 divided by 1.2. This scores marking point 1. Marking point 2 is gained by the use of a correctly-rearranged equation for resistivity. The candidate has the wrong power of 10 conversion for the value of length, but this is not penalised for a substitution into an equation. However, this power of 10 error leads to an incorrect power of 10 on the answer so marking point 3 is not accessible. In addition, the candidate has not given any units in their answer, so a power of 10 error or a unit error would both result in marking point 3 not being awarded.

ResultsPlus
Examiner Tip

On most questions, power of 10 errors and unit errors are only ever applied to the final marking point. Although these are two separate errors, it only leads to the failure to achieve one of the marks.

Question 16 (b)(ii)

This proved to be a difficult question for most of the students, even those achieving the top grades. The average mark on the question was below 1 out of 4. This can be explained by these typical mistakes on each marking point:

Marking point 1 - Often not achieved because candidates failed to write about atoms or ions vibrating "more". Some answers described ions starting to vibrate which was not good enough.

Marking point 2 - Often not achieved because candidates failed to write about increasing the "rate" of collisions. Some answers stated that there were more collisions between electrons and ions, which had no aspect of rate.

Marking points 3 & 4 - Candidates often failed to refer to any equations in order to back up their argument. Both of these marking points relied on using an equation.

With reference to the lattice of the metal, explain why the resistivity has increased.

(4)

As the temperature increases, the lattice electrons gain energy and start vibrating faster. This increases collisions and drift velocity decreases. According to $I=nAqv$, current also decreases, so the ~~sese~~ resistance of the filament increases. and $R \propto \rho$ so resistivity also increases.

ResultsPlus

Examiner Comments

This response scored marking point 3 only. In an attempt at marking point 1, the candidate talks about electrons vibrating faster, rather than ions or atoms. The reference to increasing collisions is not clear enough as it contains no information about what is colliding with what, and also no reference to rate. Marking point 3 is seen on lines 3 and 4, but the following statement about resistance increasing is not related to an equation or the fact that p.d. would have to remain constant in order for this to happen.

As temperature increases, lattice ions vibrates more.
So electrons collides more frequently with lattice ions and ~~its velocity~~ their drift velocity decrease.
As $I = nqAv$ and $R = \frac{V}{I}$, the increase in temperature will cause the decrease in current and the increase in resistance when the p.d. is constant.
Since $R = \rho \frac{l}{A}$ ~~and~~ and length and cross-sectional area won't change, the increase in temperature will cause the increase in resistivity.

ResultsPlus
Examiner Comments

A rare 4-mark answer. All of the points have been clearly made and explained. Apart from question 15(b)(ii), this is the other quality of written communication question so, when considering whether to award all 4 marks, an assessment needs to be made as to whether the work is clear and logical. There is no doubt of that in this case.

Question 16 (b)(iii)

Most candidates answering this question seemed to get either the idea that at lower temperatures there would be a low resistance/resistivity, or that there would be a high initial current. However, few tended to link these aspects together in a logical way. Only 12% of all the candidates achieved this mark.

(iii) Suggest why a tungsten filament is more likely to break when first switched on and not after it has been switched on for some time.

(1)

When first switched on, the filament has lowest resistance and so the current is largest. After switched on, the resistance increases and current decreases.

ResultsPlus
Examiner Comments

This script was awarded the mark for the first alternative on the mark scheme. Although at first it does not seem to be comparative, the whole thing read together clearly answers the question.

A sudden current can over heat the filament too quickly.

ResultsPlus
Examiner Comments

This script was a rare example of a candidate who achieved the mark via alternative 2 from the mark scheme. Many had the idea of a sudden increase in current, but few related it to a very rapid heating effect.

Question 17 (a)

This has been asked in a number of examinations in the past few years, and candidates are starting to get a bit more familiar with it now. However, the average mark for the question was still only 0.92/2, which was largely down to candidates writing an answer which had aspects of both mark scheme alternatives, without being correctly linked. The second mark for each of the alternatives was dependent upon the awarding of the first marking point on that alternative.

(a) Describe what is meant by a polarised wave.

(2)

a wave having only one plane of particle oscillation which is perpendicular to propagation of the wave.

ResultsPlus

Examiner Comments

This candidate starts by writing about there being only one plane of oscillation. Candidates talking about planes should then follow this with "including the diretion of wave travel" in order to score marking point 2. However, this candidate continues by stating that this is perpendicular to the propagation of the wave. This is only an acceptable statement if it is paired with "polarised waves have oscillations in one direction only". As a result, this candidate scores 1 mark only.

Question 17 (b)

Polarisation is a topic where there are a number of different applications, which can make it difficult for candidates to adapt to. In this question, candidates were asked to explain why the fish looked darker when viewed through the polarising sunglasses. However, a number of candidates wrote about how the sunglasses reduced glare from the light reflected from the surface of the water. This was what was meant to be written for the answer to part (c), but candidates failed to realise that they were just being asked in general about why the amount of light coming in to polarising sunglasses is reduced in its intensity in the process.

(b) Explain why the fish look darker when viewed through polarising sunglasses.

(2)

Polarising sunglasses have filters alignments of molecules that are parallel to the direction of travel of light rays. ~~when the of~~ This polarises light and reduces the number of its planes of oscillation. As it only allow a plane ~~parallel~~ along it to pass. This reduces the intensity of the light waves, as some light ~~the~~ waves perpendicular to the alignment will not pass.

ResultsPlus

Examiner Comments

The first four lines of this answer do not really contribute an enormous amount to achieving the marks. However, what is written in the last couple of lines scores both marking points. The mark scheme for this question was not very strict on this part of question 17, as filters were not mentioned until part (c). Even though this candidate talks about filters near the start, if they had just said that the light waves perpendicular to the sunglasses would not pass, that would have been acceptable for marking point 1.

As only light reflected by the fish passes through the polarising sunglasses but the light reflected off the water is perpendicular to the plane of the polaroid and ∴ do not pass through the sun glasses & ∴ glare is reduced.

ResultsPlus

Examiner Comments

This is a typical answer from a student who thinks that they are meant to be describing why the glare has been reduced. Unfortunately, such answers did not gain any credit for this part.

Question 17 (c)

The candidate answers for this question suggest quite heavily that a significant proportion felt that the light that the fisherman was attempting to look at was indeed the light reflected from the water. Many of those suggested filter B did so as it would allow the light reflected from the water to pass through. Perhaps partially as a result of this confusion, very few candidates felt it necessary to say what would happen to the light that came from the fish so did not say anything relevant to marking point 2.

(c) The diagrams show two polarising filters, A and B, which could be used in sunglasses. The arrows represent the plane of polarisation of light transmitted by the filter.

A B

A fisherman is viewing fish, that are under the water, through polarising sunglasses. Light reflected from the surface of the water is partially polarised in a plane parallel to the surface of the water.

Explain which filter, A or B, the fisherman should have in the sunglasses in order to see the fish clearly.

(2)

filter B. The plane of polarisation is in same orientation as light orientation which is ~~perpendi~~ parallel to surface. The filter A is perpendicular orientation and blocks light.

ResultsPlus

Examiner Comments

This is a typical answer from a student who has selected filter B and then explains perfectly why filter A would be the best for the fisherman to use. Unfortunately, it scored no marks.

(c) The diagrams show two polarising filters, A and B, which could be used in sunglasses. The arrows represent the plane of polarisation of light transmitted by the filter.

A fisherman is viewing fish, that are under the water, through polarising sunglasses. Light reflected from the surface of the water is partially polarised in a plane parallel to the surface of the water.

Explain which filter, A or B, the fisherman should have in the sunglasses in order to see the fish clearly.

(2)

A, so the plane of polarisation of light reflected off the water surface is perpendicular to the plane of polarisation of sunglasses, light is blocked reducing glare, while light reflected off fish is unpolarised

ResultsPlus

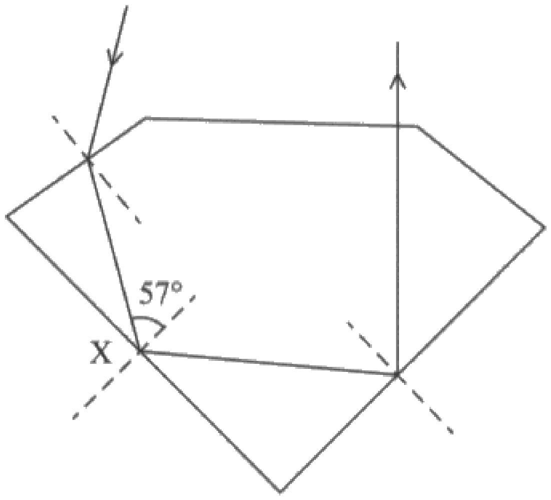
Examiner Comments

A rare 2-mark response, explaining exactly what is required. Unfortunately, only 1% of the candidates scored both marks on this question.

Question 18 (a)

This was generally a very accessible question for most candidates, with some good scores. 46% of the candidates scored all 4 marks, and the fact that the marking points were pretty independent of each other meant that many other candidates scored marks.

(a) The diagram shows the path of one ray of light as it passes through a cut diamond.



Not to scale

Explain the path taken by the ray of light when it is incident at the diamond-air interface at X. Your answer should include a calculation.

refractive index of diamond = 2.4

(4)

The ray of light is totally internally reflected as 57° is greater than the critical angle.

$n = \frac{1}{\sin C}$ $2.4 = \frac{1}{\sin C}$ $\sin C = \frac{1}{2.4}$

The critical angle of diamond is 24.6°, the incidence angle at X, is greater than the critical angle therefore total internal reflection occurs, Critical angle is the angle of incidence for which the angle of refraction is 90°.

$C = \sin^{-1}\left(\frac{1}{2.4}\right)$

$C = 24.62431835°$

$C = 24.6°$

$57° > 24.6°$

ResultsPlus

Examiner Comments

A very good 4-mark answer, with clear working out for the two calculation marks.

Question 18 (b)(i)

This part of the question was less successful than part (a). Seeing as earlier in the question candidates had been told that sparkling is caused by reflections of light inside the diamond, it was not possible to give an independent mark for stating that in diamond there were a greater number of reflections. As this marking point (3) was dependent upon the award of either marking point 1 or marking point 2, the vast majority of candidates scored either 2 or 0 on this question. In addition, the majority of candidates achieving 2 marks scored marking points 1 and 3. Marking point 2 was very rarely achieved, and was usually accompanied by the other two marking points as well.

(b) Zircon is a popular, cheaper alternative to diamond.

refractive index of diamond = 2.4
refractive index of zircon = 2.0

(i) Explain how a higher refractive index causes diamond to sparkle more than zircon.

(3)

Higher refractive index means, the critical ~~angle for~~ angle for the medium is lower, therefore more incident light has an angle greater than the critical angle meaning more total internal reflection occurs at the boundary causing more sparkle.

For zircon $n = \frac{1}{\sin C}$ $\sin C = \frac{1}{2}$

$C = \sin^{-1}(\frac{1}{2})$

$C = 30°$

~~The~~ The critical angle for zircon is greater than that for Diamond by $(30 - 24.6 = 5.4°)$ therefore less incident light is totally internally reflected.

ResultsPlus

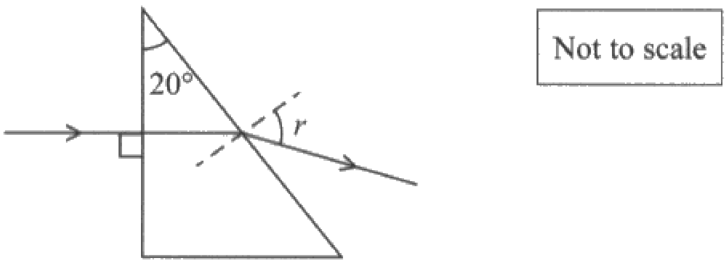
Examiner Comments

This candidate scores marking points 1 and 3, and is not far from achieving marking point 2 as well. It is just not clear enough that they are talking about a wider range of angles being greater than the critical angle.

Question 18 (b)(ii)

A combination of this being a difficult question, and that it arrived at the end of the paper, made this a very low scoring question. Over 70% of the candidates scored 0/3, with less than 3% scoring 3/3. There were two main reasons for this. Firstly, a number of candidates were attempting to do the calculation for light refracting the other way from that shown in the diagram. This resulted in angles of 9.8 and 8.2 degrees, which scored 1 mark only. Secondly, a number of candidates did not read the question carefully, and decided to use a protractor to read the angle as drawn in the diagram. Unfortunately, as this was in the region of 35 to 40 degrees, and the critical angles of diamond /zircon were 25/30 degrees, this would have resulted in total internal reflection. This resulted in a number of students stating that there was a Math Error on their calculator.

(ii) The refractive index of a transparent material can be measured using a 20° prism of the material.



A ray of light is incident perpendicularly to one face and passes straight into the prism. The angle of refraction r, as it leaves the prism, can be measured and the refractive index of the material calculated.

By making suitable calculations suggest whether it is possible to distinguish between diamond and zircon using a protractor to measure the angles.

(3)

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

Diamond: $2.4 = \frac{\sin 20}{\sin r}$

$r = \sin^{-1}\left(\frac{\sin 20}{2.4}\right)$

$r = 8.19°$, Yes possible the least count of protractor is 1°, and the difference is 1.66°.

Zircon:

$2 = \frac{\sin 20}{\sin r}$

$r = \sin^{-1}\left(\frac{\sin 20}{2}\right)$ $r = 9.85°$,

(Total for Question 18 = 10 marks)

ResultsPlus
Examiner Comments

This is a typical 1-mark response where the candidate has assumed that the light ray is refracting in the opposite direction to the way it really is. Unfortunately, as marking point 3 was dependent upon the awarding of marking point 2, this candidate could not score marking point 3 (just marking point 1).

Angle of incidence = 90 − [180 − (20+90)] = 20°

For diamond :

~~r = sin^-1 (sin 20 / 1÷2.4)~~ r = $\sin^{-1}\left(\frac{\sin 20}{1 \div 2.4}\right) \approx 55.2°$

For zircon :

r = $\sin^{-1}\left(\frac{\sin 20}{1 \div 2}\right) \approx 43.2°$

Protractor measures to nearest 1°. Difference in angles of diamond and zircon is much larger than uncertainty.

ResultsPlus
Examiner Comments

A rare good 3-mark answer.

Paper Summary

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

- Learn key definitions well. Some of the definitions on this paper have appeared in several previous examination series, and the definitions have remained the same during this time.
- When a question is clearly related to a particular application, ensure that you are answering the question posed. On question 15, too many people answered part (b)(i) in terms of gaps when it should have been quite clear that the diffraction was being caused by the sound having to pass around the head of the person.
- In electricity questions where an explanation is required, it is often useful to use equations in your answer, particularly noting which terms in the equation stay the same, and which change.
- When provided with a graph which includes already plotted data, any discussion of the graph should be preceded by the drawing of a best fit line. The questions will rarely ask you to do this, but it will be expected.

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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