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Examiners' Report
June 2015

GCE Physics 6PH02 01

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June 2015

Publications Code US042373

Introduction

This is the seventh summer series in which Unit 2, Physics at Work, has been examined. The assessment structure is the same as that of Unit 1, Physics on the Go, consisting of Section A with ten multiple choice questions, and Section B with a number of short answer questions followed by some longer, structured questions based on contexts of varying familiarity.

The paper allowed candidates of all abilities to demonstrate their knowledge and understanding of Physics.

Candidates at the lower end of the range could complete straightforward calculations involving simple substitution and limited rearrangement, including structured series of calculations, but could not always tackle calculations involving several steps, a choice of variables or extra factors, such as the factor of 2 for echo-location. They also knew in outline standard definitions, but often omitted key technical terms, and similarly knew some significant points in explanations linked to standard situations, such as interference, but missed important details and did not always set out their ideas in a logical sequence, sometimes just quoting as many key points as they could remember without particular reference to the context.

Steady improvement was demonstrated in all of these areas through the range of increasing ability and at the higher end all calculations were completed faultlessly, most definitions were given with all the required details and most points were included in ordered explanations of the situations in the questions.

Section A

The multiple choice questions discriminated well, with performance improving across the ability range for all items. Candidates around the E grade boundary typically scored about 5 and A grade candidates usually got 7 or more correct.

For some lower scoring questions the frequency of incorrect choices indicates common errors.

Question 3: Candidates getting the wrong answer nearly always chose response C, suggesting that they focused on $E = hf$ and ignored the rest.

Question 5: The incorrect answer of choice was B, which is the correct shape with axes reversed.

Question 8: There was a difference between more successful candidates, who tended to choose A, and less successful candidates, who were more likely to opt for C. A is correct in terms of units based on joule per coulomb, but C is not a base unit. The choice of C involves at least two errors, but does include only base units.

Question 11 (a)

A majority of candidates were able to define threshold frequency, with those who did not generally omitting to state that it was the 'minimum' frequency. A significant minority referred to energy instead of frequency.

11 When electromagnetic radiation is incident on a metal plate, electrons may be emitted.

(a) State what is meant by threshold frequency.

(1)

Threshold frequency is the frequency required to give an electron enough energy to be emitted as a photoelectron

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Examiner Comments

'The frequency required' is not sufficient to get the mark for minimum frequency, so this scores zero.

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Examiner Tip

Identify all of the standard technical terms in the specification that could require definition and learn them, focusing on key details, like 'minimum' and 'surface' in this case.

11 When electromagnetic radiation is incident on a metal plate, electrons may be emitted.

(a) State what is meant by threshold frequency.

(1)

The minimum energy required to free one electron from the surface of the metal.

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Examiner Comments

The question asks for threshold frequency, but this answer is in terms of energy. This is a reference to work function rather than threshold frequency.

ResultsPlus
Examiner Tip

Read the question and write what it asks for specifically and not just something remembered from the topic.

11 When electromagnetic radiation is incident on a metal plate, electrons may be emitted.

(a) State what is meant by threshold frequency.

(1)

The threshold frequency is the minimum frequency required for the photoelectric effect to take place.

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Examiner Comments

This has the required reference to minimum frequency, but referring to the photoelectric effect is not sufficient. There must be a statement about the emission of electrons.

11 When electromagnetic radiation is incident on a metal plate, electrons may be emitted.

(a) State what is meant by threshold frequency.

(1)

~~The frequency which m~~ The highest frequency that will not emit any electrons from the metal.

ResultsPlus

Examiner Comments

This might seem to be saying the same thing as the required answer, but photoemission will occur at the threshold frequency and this explicitly identifies a frequency for which emission does not take place.

Question 11 (b)

This was a straightforward calculation for the majority, although some neglected either the conversion from eV to joule or did not apply the Planck constant. Occasionally candidates attempted to use the whole photoelectric equation, including the maximum kinetic energy, which should be zero at the threshold frequency. These candidates used ½ mv^2, substituting for the mass of an electron and the speed of light.

(b) Calculate the threshold frequency for a metal with a work function of 2.28 eV.

(3)

$E = hf$ $2.28 \times 1.6 \times 10^{-19} = 3.65 \times 10^{-19}$

$3.65 \times 10^{-19} = (6.63 \times 10^{-34}) \times f$

$\frac{E}{h} = f = 5.50 \times 10^{14}$

Threshold frequency = 5.50×10^{14}

(Total for Question 11 = 4 marks)

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Examiner Comments

The calculation in this example has been completed successfully, with each step clearly shown. The candidate has omitted the unit and therefore does not get the final mark for the answer because magnitude cannot be expressed correctly without the unit.

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Examiner Tip

Numerical answers must include a unit to be awarded the answer mark.

Exceptions to this are quantities expressed as ratios, such as efficiency, refractive index and sine.

(b) Calculate the threshold frequency for a metal with a work function of 2.28 eV.

(3)

$E = hf$

$2.28 = 6.63 \times 10^{-34} \times f$

$\frac{2.28}{6.63 \times 10^{-34}} = f$

Threshold frequency = 3.44×10^{33}

(Total for Question 11 = 4 marks)

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Examiner Comments

This candidate has gained a mark for use of the expression $E = hf$ but did not convert the work function from eV to J. Candidates might be reminded of the need to do this by noticing the unit of the Planck constant, J s.

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Examiner Tip

Calculations for the photoelectric effect and atomic spectra may involve energy in eV or J and you need to check carefully whether a conversion is required.

(b) Calculate the threshold frequency for a metal with a work function of 2.28 eV.

(3)

$2.28 \times 1.6 \times 10^{-19} = 3.648 \times 10^{-19}$ Hz

Threshold frequency = 3.648×10^{-19} Hz

(Total for Question 11 = 4 marks)

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Examiner Comments

This candidate has converted the work function from eV to J for one mark but has not used $E = hf$.

With reference to the earlier examples, this candidate has not written out the relevant equation and that may be part of the reason why they are able to conclude that an energy is a frequency.

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Examiner Tip

Write equations out before completing calculations. This will help to avoid omissions that could cost marks.

Question 12 (a)

About two thirds of the entry successfully explained the need for pulses. Many gave answers that simply outlined the idea of the pulse-echo technique, e.g. "so that you can record how long it takes for the sent signal to return".

12 An ultrasonic distance estimator can be used to measure the length of a room.

The estimator is held against one wall. It emits pulses of ultrasound and detects them when they return after reflection by the opposite wall.

(a) Explain why the ultrasound must be emitted in pulses.

(1)

So that it has finished emitting by the time the ultrasound returns

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Examiner Comments

This response has some resemblance to the required answer, suggesting that the candidate has been told the required answer, but it isn't saying the same thing and does not get the mark.

(a) Explain why the ultrasound must be emitted in pulses.

(1)

So that you can identify the reflected wave

ResultsPlus
Examiner Comments

This response also has some resemblance to the required answer, this time the first of the alternatives on the mark scheme. Again, it is not making the required statement. In this example there is not likely to be another wave that could be identified in the place of the reflected ultrasound.

(a) Explain why the ultrasound must be emitted in pulses.

(1)

So a ~~p~~ wave can return before the next is sent, enable us to to see which reflected waves corresponds with which wave that was sent out

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Examiner Comments

This is a nice example including both of the suggested answers on the mark scheme.

Question 12 (b)

Ninety percent of candidates were able to apply the speed equation to calculate time, but only half of them arrived at the correct answer because many did not correctly apply the factor of 2. A minority had a problem using centimetres and the final unit was occasionally omitted.

(b) The shortest distance the estimator can measure is 40 cm.
Calculate the longest pulse duration that would allow this distance to be measured.

speed of ultrasound in air = 330 m s^{-1}

(3)

$S = \frac{D}{T}$

$\text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{0.4\,m}{330\,ms^{-1}} = 1.21 \times 10^{-3}\,s$

Pulse duration = 1.21×10^{-3} s

ResultsPlus
Examiner Comments

This is a typical example of a response where the factor of 2 has been omitted, so there is one mark for time = distance/speed being used.

ResultsPlus
Examiner Tip

Remember that pulse-echo questions will nearly always involve a factor of 2 because distance travelled by the pulse is twice the distance from the emitter to the object.

(b) The shortest distance the estimator can measure is 40 cm.

Calculate the longest pulse duration that would allow this distance to be measured.

speed of ultrasound in air = 330 m s^{-1}

(3)

80 cm ~~dist~~ ~~[illegible]~~

$s = \frac{d}{t}$ $\frac{d}{s} = t$ $\frac{80}{330} = 0.24$ s

Pulse duration = 0.24 s

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Examiner Comments

This candidate has successfully applied the factor of 2 but has not stated the distance in metres, so only two marks have been awarded.

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Examiner Tip

When quantities are stated in prefixed multiples of the base unit they should be converted to the standard unit before substitution into equations, for example 80 cm should be substituted as 0.8 m.

Question 12 (c)

A clear majority got this mark, some aided in reaching the answer by drawing a simple diagram or adding lines to the photograph. Unlabelled diagrams do not gain credit, but in this case some of them clarified the written answer. Answers were sometimes a bit too vague to gain credit, such as 'it reflects so that it doesn't reach the detector', which could suggest an attenuation effect rather than a different direction. Some candidates invoked the effects of refraction or diffraction and others suggested that the estimator was measuring too many different distances due to the slope.

(c) When the estimator is pointed at a sloping wall, as shown in the photograph, it is unable to measure this distance.

Suggest why the estimator is unable to measure the distance to the sloping wall.

(1)

Diffraction occurs and the pulse is spread out to a different area, not where the reader is.

(Total for Question 12 = 5 marks)

ResultsPlus

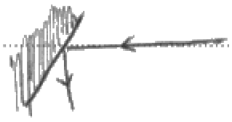
Examiner Comments

This answer has been linked to diffraction, despite the mention of reflection at the start of the question, so there is no mark.

Suggest why the estimator is unable to measure the distance to the sloping wall.

(1)

Due to the slope in the wall, the waves reflect at an angle and cannot return to the estimator.



(Total for Question 12 = 5 marks)

ResultsPlus
Examiner Comments

This gets the mark as a correct answer. The diagram alone would not have gained the mark, but it supports the text in this case. Even when a diagram does not get marks it may help a candidate to clarify their thinking.

ResultsPlus
Examiner Tip

Diagrams may be helpful in understanding a situation but they will not generally gain marks on their own without labelling equivalent to the required answer.

Question 13 (a)

Although nearly all candidates linked drift velocity to the speed of electrons, they rarely mentioned 'average' or identified free electrons, and only about one in ten mentioned both to get the mark.

13 (a) State what is meant by drift velocity when applied to a metal conductor.

(1)

The average velocity the electrons move at through the metal conductor.

ResultsPlus
Examiner Comments

This answer includes the required detail in terms of average velocity, but just refers to electrons in general rather than the delocalised electrons.

13 (a) State what is meant by drift velocity when applied to a metal conductor.

(1)

The velocity of the charge carriers :=> e.g. the electrons

ResultsPlus
Examiner Comments

This response refers to charge carriers rather than electrons in general, but does not refer to average velocity and therefore lacks the required detail for the mark.

Question 13 (b) (i-ii)

(i) Most candidates were able to select the equation $I = nqvA$ but they did not often state that n and q are the same for both resistors in order to justify their comparison of the drift velocities. As the ratio of cross-sectional areas was given, a numerical relationship for the drift velocities was expected and not just a statement that Y had a greater drift velocity. Candidates not giving the ratio did not gain credit.

(ii) The most common mark awarded was for stating that Y had a greater resistance, even if the answer to part (i) was incorrect, but this was rarely explained satisfactorily in terms of drift velocity. Collisions were mentioned frequently, but quite often these were collisions between electrons. The third mark was very rarely awarded.

Although stated in the question that the current was the same for both conductors, answers often assumed a constant potential difference and referred to changes in the current, e.g. because of increased amplitude of vibrations due to collisions between conduction electrons and lattice ions. This was answering the wrong question and candidates may indeed have been thinking of a previous question about resistance of a filament lamp.

Some used $R = \rho l/A$, getting the correct answer for the first mark, but the question specifically required reference to drift velocity so no more marks were available.

(b) Two conductors of the same material and length carry the same current. Conductor X has twice the cross-sectional area of conductor Y.

(i) By referring to an appropriate equation, compare the drift velocities for conductor X and conductor Y.

(2)

$I = nqvA$

Same current so for 2A in X, the drift velocity in X would be half that of Y.

*(ii) Explain the difference in resistance of conductor X and conductor Y in terms of the difference in drift velocity.

(3)

As the drift velocity ~~decreases~~ increases the resistance of the conductor ~~increases~~ increases, as there are more collisions between electrons and ion cores which are vibrating so there is higher resistance in the metal. The temperature will increase which will further increase the resistance as the ion cores vibrate with greater amplitude

(Total for Question 13 = 6 marks)

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Examiner Comments

(i) The answer is correct, but the reference to the appropriate equation is not sufficient to be awarded both marks. Candidates needed to make the link between the equation and the conclusion clear.

(ii) The reasoning is fine in terms of the collisions, but the specific link to resistance via $R = V/I$ is not made. The first mark is not awarded because the candidate has not stated clearly which resistor has the higher resistance. It may be inferred by looking at part (i), but the examiners mark each section as it is written, with the exception of arithmetic errors carried forward, and it is the candidate's responsibility to make their answers clear.

(b) Two conductors of the same material and length carry the same current. Conductor X has twice the cross-sectional area of conductor Y.

(i) By referring to an appropriate equation, compare the drift velocities for conductor X and conductor Y.

(2)

velocity = current / (area x no of charge carriers x charge of carries)

since it is the same material & has the same current, only area changes. ~~Xls~~ Therefore X will have a lower drift velocity than Y

*(ii) Explain the difference in resistance of conductor X and conductor Y in terms of the difference in drift velocity.

(3)

conductor Y has a higher resistance than X because it's drift velocity is faster. If electrons in the material are moving faster they are more likely to collide within the material, so the number of collisions within a certain time will increase, which increases it's resistance.

(Total for Question 13 = 6 marks)

ResultsPlus
Examiner Comments

(i) The reference to the equation is satisfactory, but the answer only says that one resistance is greater and does not give a numerical comparison.

(ii) The first two parts are very clear, but this just goes from more collisions to greater resistance without saying why.

Question 14 (a)

About half of candidates were credited for the answer to this question, most of these for quoting direct proportionality. A large minority just made a statement like 'as area increases, length increases', which was true but is not a relationship as such.

14 The instruction booklet for an electric garden shredder includes the following advice.

When using an extension cable, the following dimensions should be observed:

Cross-sectional area of conductor / mm^2	Maximum cable length / m
1.00	40
1.50	60
2.50	100

(a) Describe the relationship between area and length in the table.

(1)

The greater the length of the cable the greater the cross sectional area must be

ResultsPlus

Examiner Comments

This is just a very general statement that as one quantity increases so does the other. Candidates are expected to be able to identify direct proportionality.

14 The instruction booklet for an electric garden shredder includes the following advice.

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Cross-sectional area of conductor / mm^2	Maximum cable length / m
1.00	40
1.50	60
2.50	100

(a) Describe the relationship between area and length in the table.

(1)

~~length~~ ~~[illegible]~~ length ~~divied~~ divided by 4 ~~and~~ and then divided by 1000 would be area.

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Examiner Comments

In this question, credit was given to answers establishing the relationship between the quantities in terms such as length (in m) = 40 x area (in mm^2), but this answer involves too many steps.

Question 14 (b) (i-iii)

The majority of candidates achieved at least five marks for this six mark section.

(i) The most common error in this part was using the wrong power of ten for the area in m^2, starting with 1.0×10^{-3}. As this was a 'show that' question, most could see that this gave them the wrong answer so they could go back to their working and identify their mistake.

(ii) There was not generally a problem with this calculation, although it was apparent that some candidates did not realise that rate of energy transfer required a power equation. A significant minority applied a length of 40 m for this part, even though they used 80 m in part (i), so they recalculated resistance or halved the value from part (i).

(iii) This part was tackled very well using one of the three available methods, although some candidates again worked with a length of 40 m.

(b) The cable for the shredder contains two conductors in series, the live wire and the neutral wire. A cable of length 40 m has a total conductor length of 80 m.

(i) Show that the resistance of a copper conductor of length 80 m and cross-sectional area 1.00 mm^2 is about 1.3 Ω.

resistivity of copper = 1.68×10^{-8} Ω m

(2)

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

$R = \frac{1.68 \times 10^{-8} \times 80}{1 \times 10^{-3}}$

$= 1.344 \times 10^{-3}$ Ω

(ii) When in use the current for the shredder is 11 A.
Calculate the rate of energy dissipation by the 40 m, 1.00 mm² cable when it is used with the shredder.

(2)

~~$P = I^2 R$~~ ~~$R = \frac{\rho L}{A} = \frac{1.68\times10^{-8} \times 40}{1} = 6.72\times10^{-4}$~~

~~$P =$~~ ~~$P = I^2 R$~~ $P = I^2 R$

~~$= 11^2 \times 6.72\times10^{-4}$~~ $P = 11^2 \times 1.3$

~~$= 0.0813$ W (3sf)~~ $P = 157.3$ W

Rate of energy dissipation = ~~0.0813 W~~ 157 W

(iii) Calculate the total potential difference across the conductors in the 40 m cable when it is used with the shredder.

(2)

$P = IV$

$V = \frac{P}{I}$ $= \frac{157.3}{11}$

~~$= \frac{0.0813}{11}$~~

~~$= 0.00739$ V (3sf)~~ $= 14.3$ V

Potential difference = ~~0.00739 V~~ 14.3 V

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Examiner Comments

(i) The method is correct, for one mark, but there has been an error in converting the units of area. The question states that the value should be about 1.3 Ω, so a candidate would be expected to try to identify the error when the answer is not as expected.(ii) Correct answer. Note that the quoted 'show that' value of resistance has sensibly been used instead of the incorrect answer from part (i). (iii) Correct answer.

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Examiner Tip

Remember that 1 m² is (1000 mm)², i.e. 1 x 10⁶ mm².

Also, when an answer does not mention the 'show that' value, go over the working to identify the error.

(b) The cable for the shredder contains two conductors in series, the live wire and the neutral wire. A cable of length 40 m has a total conductor length of 80 m.

(i) Show that the resistance of a copper conductor of length 80 m and cross-sectional area 1.00 mm^2 is about 1.3 Ω.

resistivity of copper = 1.68×10^{-8} Ω m

(2)

$R = \frac{\rho l}{A}$ $l = 80$

$\rho = 1.68 \times 10^{-8}$

$A = 1 \times 10^{-6}$ m^2

$R = \frac{1.68 \times 10^{-8} \times 80}{1 \times 10^{-6}} = \frac{168}{125}$ Ω

$= 1.344$ Ω approx 1.3 Ω

0.01

0.01

1

0.1

0.1

$1\ cm^2 = 1 \times 10^{-4}\ m^2$

$1\ mm^2 = 10^{-2}\ cm^2$

0.01

0.1 cm

0.001

0.001 mm

1.000 m

100.00 cm

1.00 cm

0.1 cm

1.0 mm

0.1

(ii) When in use the current for the shredder is 11 A.
Calculate the rate of energy dissipation by the 40 m, 1.00 mm² cable when it is used with the shredder.

(2)

ATF from

$R = 0.672\ \Omega$

$P = I^2 R.$

$= 11^2 \times R.$

$= 121 \times 0.672$

$= 81.312$

Rate of energy dissipation = 81.312 W

(iii) Calculate the total potential difference across the conductors in the 40 m cable when it is used with the shredder.

(2)

$P = \frac{V^2}{R}$ $P = 81.312 = \frac{V^2}{R}.$ $R = 0.672.$

$81.312 \times 0.672 = V^2$

$V = \sqrt{81.312 \times 0.672} = \sqrt{54.641664}$

$= 7.392$

Potential difference = 7.392 V.

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Examiner Comments

(i) Correct answer.

(ii) The candidate has recalculated the resistance using a length of only 40 m, so the answer is only half what it should be.

(iii) The power from the previous part has been used here and processed correctly so the answer, although incorrect, is awarded both marks applying 'error carried forward'.

Question 14 (c)

Only a fifth of the entry gained any credit here, usually for suggesting that the resistance would be too large. Candidates most commonly stated that the cable would overheat in this case, sometimes adding that this was because a larger current would be needed to provide the shredder with a high enough potential difference. They did not think of the fixed mains supply or about the current required by the shredder remaining at 11 A.

(c) Suggest why the advice in the instruction booklet is included.

(2)

More heat will be generated the longer the cable is because a larger current will be required to allow the voltage to travel along the wire. A thicker wire allows better dissipation of heat meaning the wire is less likely to melt!

(Total for Question 14 = 9 marks)

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Examiner Comments

This includes an odd reference to voltage travelling along a wire. There is a suggestion that a greater current would be required but it doesn't make it clear that this couldn't happen because the potential difference from the supply couldn't be increased.

(c) Suggest why the advice in the instruction booklet is included.

(2)

If a cable is used that is greater than the maximum length suggested this could cause a very large resistance in the cable. This could cause the ~~wi~~ cable to heat up a lot when in use.

(Total for Question 14 = 9 marks)

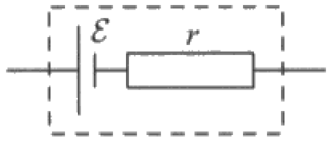
ResultsPlus
Examiner Comments

This response gets a mark for stating that a longer cable would have a very large resistance, but, when it refers to heating, does not take into account the fixed potential difference which would mean a reduced current.

Question 15 (a)

This was poorly done for such a simple circuit. About four fifths gained a generous mark for showing an ammeter and voltmeter connected to the cell and not in series with each other, but many of them had nothing else at all in their circuit and others had fixed resistors, light bulbs and thermistors rather than a standard variable resistor as the load resistance.

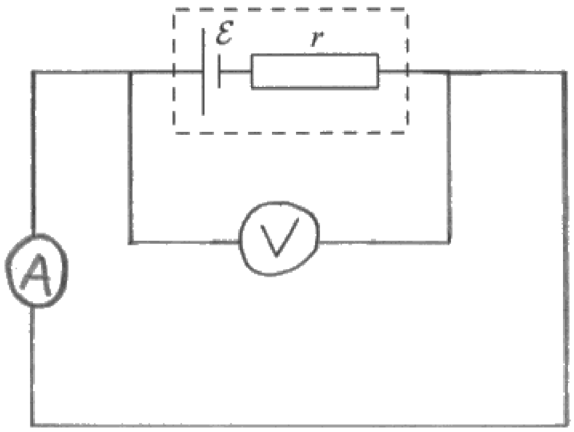
15 A cell may be represented as an e.m.f. $\mathcal{E}$ in series with an internal resistance r.



A student used the relationship $V = \mathcal{E} - Ir$ and a graphical method to determine $\mathcal{E}$ and r. She connected a cell in a circuit and took a series of measurements of the current I in the cell and the potential difference V across the terminals of the cell.

(a) Complete a circuit diagram of a circuit she could have used.

(2)



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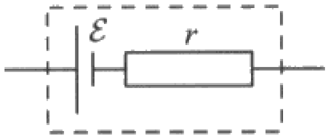
Examiner Comments

This is a very common response with no load resistance. This would short circuit the cell and allows no means of varying potential difference or current, even though the table and graph in the question show that this is necessary.

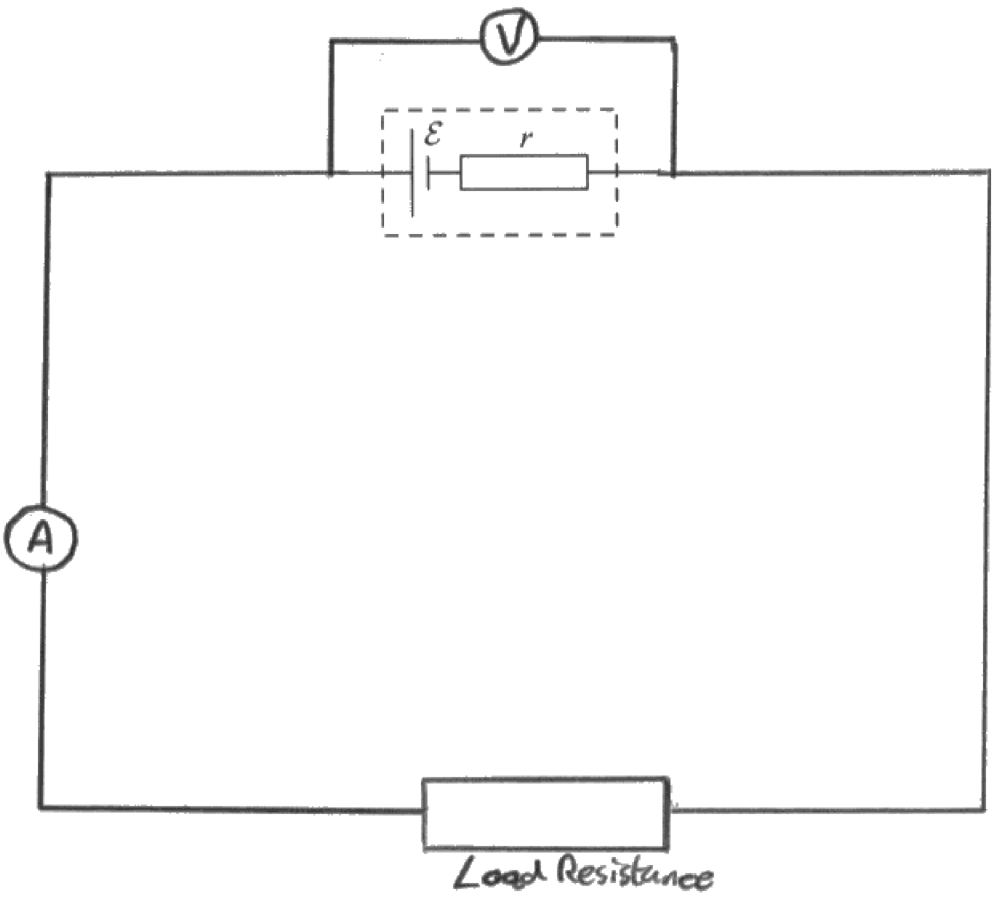
15 A cell may be represented as an e.m.f. $\mathcal{E}$ in series with an internal resistance r.



A student used the relationship $V = \mathcal{E} - Ir$ and a graphical method to determine $\mathcal{E}$ and r. She connected a cell in a circuit and took a series of measurements of the current I in the cell and the potential difference V across the terminals of the cell.

(a) Complete a circuit diagram of a circuit she could have used.

(2)



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Examiner Comments

This is an improvement in that there is a load resistance, but it cannot be varied and would not provide data for the table and graph.

Question 15 (b)

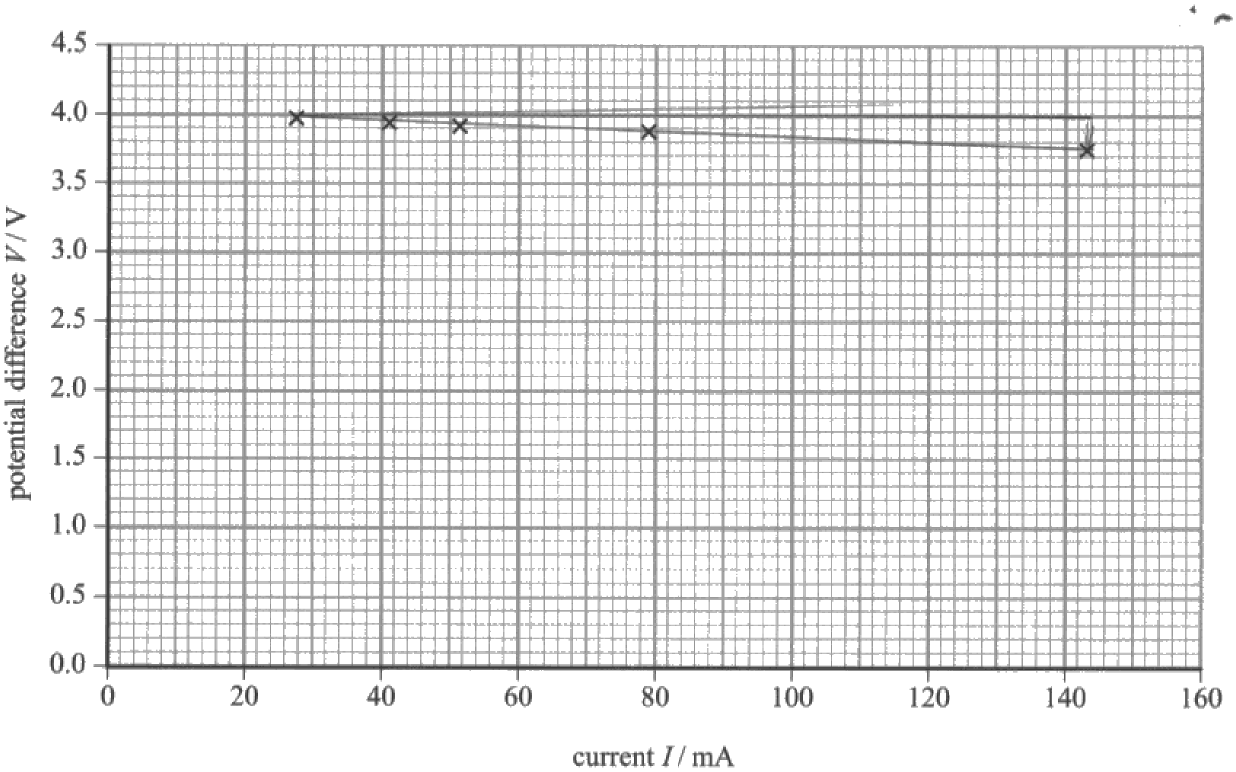
While the majority gained at least two marks, most commonly for the line and the intercept, only about a quarter were awarded all four marks because of a range of errors and omissions.

The number of candidates who did not even draw a line was surprisingly large. The question required use of the graph so calculations based on the table values alone by these candidates were not credited, although they were allowed a mark for the e.m.f., if they stated it, on the principle that they could have used a ruler placed along the line of the points to read off the axis.

Many candidates, having drawn a line, still took values from the table for the calculation. This was only credited if the values were well spaced and actually on the line they had drawn. Some candidates did not convert mA to A. An unfortunately large minority omitted units.

(b) The student's measurements are shown in the table and plotted on the graph.

I / mA	V / V
27.5	3.97
41.0	3.94
51.6	3.90
78.6	3.88
143.0	3.75



E - 3.94 = 41 R
E - 3.97 = 27.5 R
0.03 = 13.5 R
R = 0.002

E - 3.88 = 78.6 R
E - 3.9 = 51.6 R
0.02 = 27 R

Determine values for $\mathcal{E}$ and r from the graph and show how you obtained your answers.

(4)

$V = -Ir + \mathcal{E}$

$\frac{dV}{dI} = \frac{3.75 - 3.97}{143 - 27.5} = \frac{-0.22}{115.5} = -0.0019 = r$

$3.9 = -(51.6 \times -0.00019) + \mathcal{E}$

$3.9 = 9.804 \times 10^{-3} + \mathcal{E}$

$\mathcal{E} = 3.8902$

$\mathcal{E}$ = 3.8902

r = 0.00019

ResultsPlus

Examiner Comments

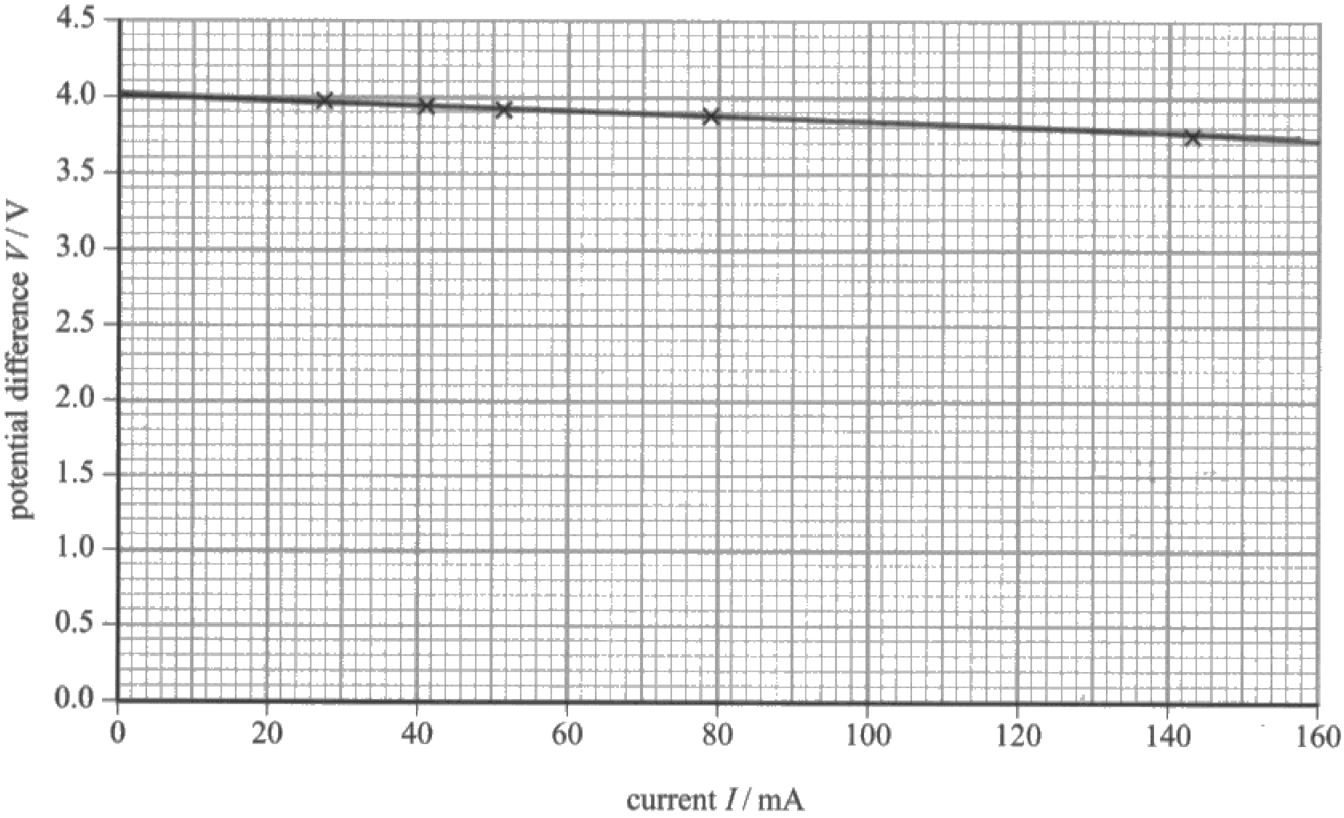
While this candidate shows a general understanding of the relationship between terminal p.d., e.m.f. and internal resistance, there are a number of errors limiting this to two marks.

The line has not been extrapolated to the y-axis, so the e.m.f. has not been determined in the most straightforward way - from the intercept. It is just outside the accepted range and has been given without a unit.

The line is sufficient to allow a calculation of the gradient over the required range, and therefore internal resistance, but the result has also been given without the unit.

(b) The student's measurements are shown in the table and plotted on the graph.

I / mA	V / V
27.5	3.97
41.0	3.94
51.6	3.90
78.6	3.88
143.0	3.75



$V = \varepsilon - Ir$

$y = mx + c$

$-r$ = gradient

ε y intercept

Determine values for $\mathcal{E}$ and r from the graph and show how you obtained your answers.

(4)

$\mathcal{E}$ is the y intercept => 4 V

$V = \mathcal{E} - Ir$

r is the gradient × -1 =>

gradient $\frac{3.75 - 3.97}{143 - 27.5} \approx -1.9 \times 10^{-3}$

$-1.9 \times 10^{-3} \times -1 = 1.9 \times 10^{-3}$

$\mathcal{E}$ = 4V

r = 1.9×10^{-3}

ResultsPlus

Examiner Comments

The graph and intercept are fine and so is the use of the graph to calculate the internal resistance. There is a problem because mA have not been converted to A and this hasn't been taken into account in the final answer. In addition, the units of resistance have been omitted.

Question 15 (c)

While a larger number of candidates may well have had a good idea of what was required, poor expression and confusion about technical terms such as accuracy and precision meant that only about one in six gained a mark for their response. A statement such as 'use a larger scale' was not sufficient as it could be interpreted in different ways and would not be possible on this graph in the desired way without the additional step of starting the y-axis at a higher value, which was not stated. Others suggested 'using mV instead of V', but this could just apply to axis labels and also did not include the starting point.

(c) Explain how the graph could be constructed to obtain better values for $\mathcal{E}$ and r.

(2)

Increase the scale of the y axis. This could spread the data out more, allowing allowing to draw a a a better line and find the gradient more accurately.

(Total for Question 15 = 8 marks)

ResultsPlus
Examiner Comments

Increasing the scale would help, but it would not be possible on this graph without starting at a higher value and that has not been stated.

The comment about a better line is not specific and the statement about a more accurate gradient is not supported.

(c) Explain how the graph could be constructed to obtain better values for $\mathcal{E}$ and r.

(2)

Starting the y-axis from 3·5 would mean you can plot and read off the graph more easily making the values for $\mathcal{E}$ and r more accurate.

(Total for Question 15 = 8 marks)

ResultsPlus
Examiner Comments

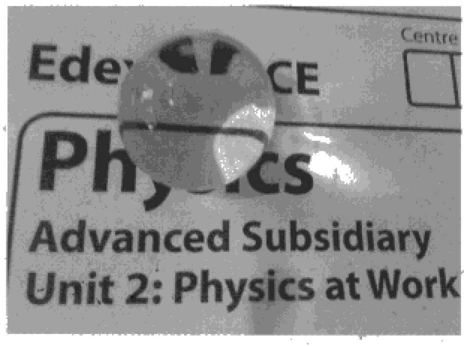
This has the required scale change for one mark, but it isn't sufficient to say that something is easier. There is an assertion that the values of e.m.f. and internal resistance would be more accurate, but these still depend on a hand drawn line and the link isn't established.

Question 16 (a)

While few candidates did not get either mark, only about half got both. Some missed a mark because they said the light bends, which could be a curved path, rather than stating that there would be a change in direction. Others did not mention the change in medium.

16 Flower arrangers sometimes use gel balls instead of water to fill vases.

The photograph below shows some writing seen through one of these gel balls. The writing is distorted because the gel ball refracts light.



(a) Explain what is meant by refraction.

(2)

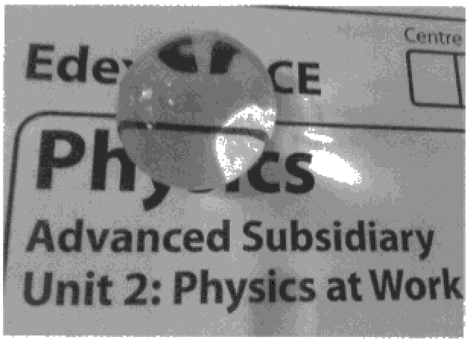
when the speed and wavelength of light changes as it passes through the boundary of two mediums with different refractive index's.

ResultsPlus
Examiner Comments

This answer refers correctly to changes in speed and wavelength for one mark, but does not mention their effect which is a change in direction.

16 Flower arrangers sometimes use gel balls instead of water to fill vases.

The photograph below shows some writing seen through one of these gel balls. The writing is distorted because the gel ball refracts light.



(a) Explain what is meant by refraction.

(2)

Refraction is the apparent bending of light as it passes into a material of different density due to a different speed in that density of material. i.e. It bends as it changes speed because the speed of light in that material is different to outside.

ResultsPlus
Examiner Comments

This gets a mark for the change in speed, but not for change in direction because it refers to bending. This is not accepted because it could mean there is a curved path for the light.

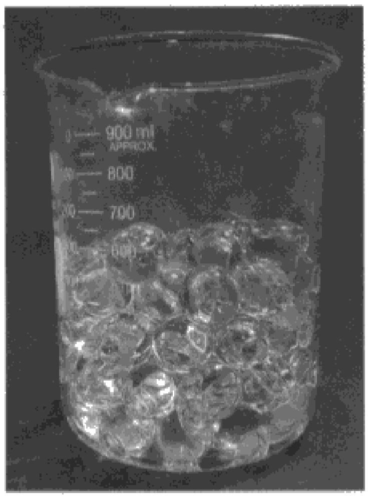
ResultsPlus
Examiner Tip

Avoid the use of the word 'bend' when describing refraction and refer to a change in direction instead.

Question 16 (b)

A clear majority gained some credit for this part, but only about one in six got the full answer. Candidates most frequently suggested that there would be no refraction but did not link this to the wave speed being constant throughout.

(b) The photographs below show a beaker containing gel balls. When water is added to the beaker, the gel balls below the water surface are no longer visible.



Explain how this shows that the gel has the same refractive index as water.

(2)

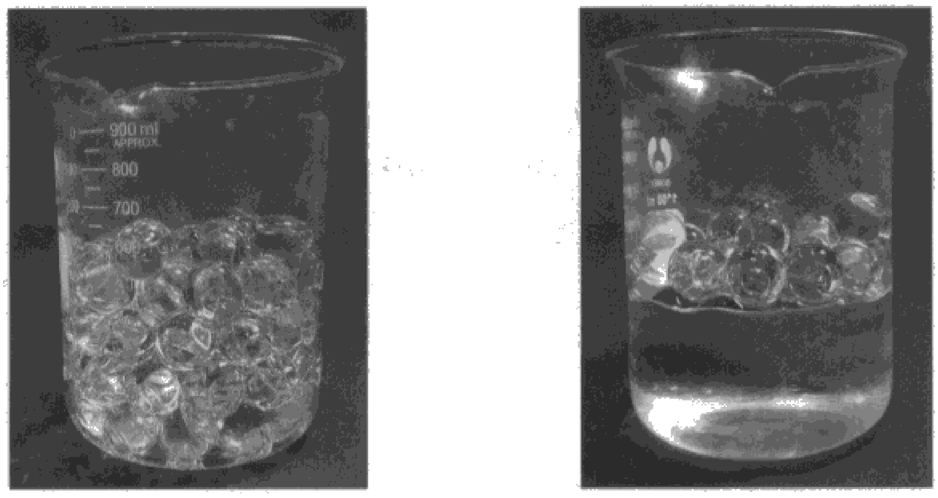
The light passing through the beaker is refracted by the water, and it would then be refracted again by the gel balls if their refractive index was different. This would make the balls visible because the surface of them would change the direction of the light. However, we can't see them so the light hasn't been refracted further and the gel has the same refractive index as the water.

ResultsPlus

Examiner Comments

This answer is credited for identifying that refraction does not take place, but it is not linked to wave speed or density.

(b) The photographs below show a beaker containing gel balls. When water is added to the beaker, the gel balls below the water surface are no longer visible.



Explain how this shows that the gel has the same refractive index as water.

(2)

when the light passes through the water into the balls the light does not ~~slow~~ change ~~speed~~ velocity and will continue travelling through at the same refractive index that of the water.

ResultsPlus

Examiner Comments

This answer is correct in the reference to no change of velocity, but it does not go on to link this to no change in direction.

Question 16 (c)

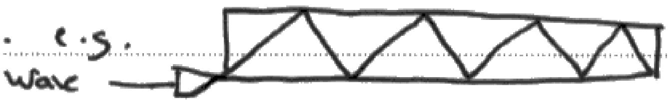
This was another standard definition but only about a third got both marks. Candidates clearly had a good idea of what was required but ether omitted any mention of incidence, just referring to the angle the wave arrives at or similar, or did not make it clear that light was all reflected and none was refracted at this angle.

(c) A student decides to use a gel ball to model the formation of a rainbow by raindrops. He wants to see if total internal reflection occurs.

Explain what is meant by total internal reflection.

(2)

When the angle of incidence is greater than the critical angle. This results in the ~~refracted wave being refracted further~~ reflected wave ~~undergoe~~ undergoing further reflection within the object. e.g.



ResultsPlus
Examiner Comments

This answer identifies the angle of incidence greater than the critical angle but doesn't make it clear that there is only reflection and no refraction. The diagram might support this, but the labelling is insufficient as it does not make lack of refraction explicit.

(c) A student decides to use a gel ball to model the formation of a rainbow by raindrops. He wants to see if total internal reflection occurs.

Explain what is meant by total internal reflection.

(2)

Total Internal Reflection is when the angle of incidence passes the critical angle of a material, the wave is no longer refracted but reflected.

ResultsPlus
Examiner Comments

This gets a mark for stating that the wave is no longer refracted but reflected.'Passes the critical angle' is not sufficient as it could refer to a steady increase or a steady decrease in angle until that point is reached.

Question 16 (d) (i-iii)

A good majority gained at least four marks for this three part section and nearly half got five or more marks and a quarter got all six. The calculations were relatively straightforward and provided the majority of the marks.

In part (iii), some candidates didn't use information about angles but just assumed that total internal reflection would occur. Some candidates clearly thought that there is only reflection or refraction in any situation and were not aware of partial internal reflection. Some correctly stated that angle y was smaller than the critical angle but drew the wrong conclusion.

(i) Show that the angle *x* is about 40°.

refractive index of gel = 1.33

(2)

refractive index = $\frac{\sin i}{\sin r}$

~~1.33 / sin r~~ $\frac{\sin 60}{1.33} = \sin r$

$\sin^{-1}\left(\frac{\sin 60}{1.33}\right) = 40°$ ish

(ii) Show that the critical angle for light striking the boundary of gel with air is about 50°.

(2)

~~$\sin^{-1}(1.33) = 43°$~~

~~$43° \approx 50$~~

$\sin^{-1}\left(\frac{1}{1.33}\right) = 48 \simeq 50$

(iii) Angle *x* has the same value as angle *y*.
Explain whether light from the laser will be observed on screen 1.

(2)

no as the angle y is less than the critical angle so it reflect the light ~~back~~

ResultsPlus
Examiner Comments

In parts (i) and (ii) the equations are used correctly for one mark each, but the answers are not awarded a mark in either case. In (i) the answer is not given to an extra decimal place to the suggested answer of 40° and in (ii) the rounding to 48° is incorrect.

In (ii), y has been identified as smaller than the critical angle, but the effect has been misinterpreted.

(i) Show that the angle x is about 40°.

refractive index of gel = 1.33

(2)

$\mu = \frac{\sin i}{\sin r} = \frac{\sin 60}{\sin r} = 1.33$.

$\sin r = \frac{\sin 60}{1.33}$

$r = \sin^{-1}\left(\frac{\sin 60}{1.33}\right)$.

$= 40.63°$ approx $40°$

(ii) Show that the critical angle for light striking the boundary of gel with air is about 50°.

(2)

$\mu = \frac{1}{\sin C}$ $\quad \frac{1}{\sin C} = 1.33$ ~~$\frac{C}{1.33} =$~~

$\frac{1}{1.33} = \sin C$

$C = \sin^{-1}\left(\frac{1}{1.33}\right)$.

$= 48.75°$ ≈ approx $50°$.

(iii) Angle x has the same value as angle y.
Explain whether light from the laser will be observed on screen 1.

(2)

light will be observed on screen 1 as the critical angle of the boundry of gell and air is greater than the value of y therefore light cannot be reflected internally.

ResultsPlus
Examiner Comments

The calculations are correct in (i) and (ii). The last part has a slight error in that it says light cannot be internally reflected. At such angles there is some internal reflection and some refraction. The diagram shows the reflection.

Question 17 (a)

While the mark for waves meeting was straightforward and usually awarded, the following part about adding displacement was only seen about a sixth of the time. There were often descriptions, sometimes with diagrams, of peaks and troughs meeting, showing that candidates had an understanding in outline, but they could not give this standard definition. Many candidates referred to adding amplitudes or mixed amplitude and displacement in their answers.

17 (a) State what is meant by the principle of superposition of waves.

(2)

The amplitude of 2 waves or more are added together. They can either cancel out, become of a higher amplitude or a lower amplitude. For example

ResultsPlus
Examiner Comments

No marks were awarded. The reference is to amplitude rather than displacement. The diagrams are not sufficient without labelling, which would, in this case, need to be as much as the written answer would require anyway.

ResultsPlus
Examiner Tip

Remember that when describing superposition reference to adding the displacements is required rather than adding the amplitudes.

17 (a) State what is meant by the principle of superposition of waves.

(2)

When two or more waves meet, travelling in opposite directions and ~~same frequency~~ they overlap, the sum of the displacements/ amplitudes is equal to the total displacement /amplitude.

ResultsPlus
Examiner Comments

This offers the examiner the choice between displacement and amplitude and so does not get the mark. If a candidate isn't sure, they can't expect the examiner to choose for them. The exception would be when multiple answers are all acceptable individually.

ResultsPlus
Examiner Tip

If you leave a choice of answers and one is incorrect, you will not be given the mark.

Question 17 (b)

Few candidates failed to score at least one mark here, the most common being for 'perpendicular' in the first sentence, and over half scored two, usually by changing rotated to blocked or similar. Far fewer made the other changes. Some candidates made the required change to a sentence but made other changes so that it was no longer correct, for example in the second sentence where they could end up saying that parallel oscillations were blocked. A noticeable minority changed transverse to longitudinal for electromagnetic waves.

(b) Electromagnetic waves involve oscillating electric fields.

A student made the following notes about the polarisation of electromagnetic waves. The notes contain a number of errors.

> Electromagnetic waves are transverse, with oscillations ~~parallel~~ Perpendicular to the direction of motion.
>
> When they pass through a polarising filter all the components of the oscillations ~~perpendicular~~ Parallel to the filter's plane of polarisation are rotated.
>
> The oscillations of the polarised wave are all in the same plane which is perpendicular to the direction of energy transfer.

Copy the passage, correcting the errors.

(4)

Electromagnetic waves are longitudinal, with oscillations perpendicular to the direction of motion.
When they pass through a polarising filter all the components of the oscillations parallel to the filter's plane of polarisation are stopped.
The oscillations of the polarised wave are all in the same plane which is parallel to the direction of energy transfer.

ResultsPlus
Examiner Comments

This answer has been awarded no marks. The correct change to perpendicular was made in the first sentence, but the waves have been changed to longitudinal so the sentence is not a correct statement.

Similarly, a correct change was made at the end of the second sentence but it has been made incorrect by the change to the direction.

(b) Electromagnetic waves involve oscillating electric fields.

A student made the following notes about the polarisation of electromagnetic waves. The notes contain a number of errors.

> *Electromagnetic waves are transverse, with oscillations parallel to the direction of motion.*
>
> *When they pass through a polarising filter all the components of the oscillations perpendicular to the filter's plane of polarisation are rotated.*
>
> *The oscillations of the polarised wave are all in the same plane which is perpendicular to the direction of energy transfer.*

Copy the passage, correcting the errors.

(4)

Electromagnetic waves are transverse, with oscillations ~~perpendicular~~ to the direction of propogation. When they pass through a polarising filter ~~all~~ all of the components of the oscillations perpendicular to ~~the~~ the filters's plane of polarisation are ~~the~~ absorbed. The oscillations of the polarised wave are all in the same plane which is perpendicular to the direction of energy transfer.

ResultsPlus

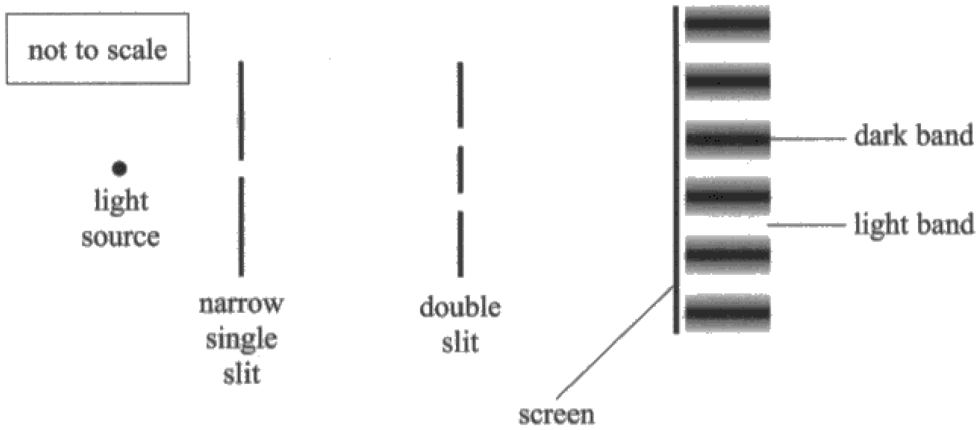
Examiner Comments

The changes are all correct except the last one where it should be stated that the plane includes the direction of propagation.

Question 17 (c) (i)

About three quarters gained at least one mark, most commonly for linking constructive and destructive interference to light and dark areas respectively, but only about half of them got any more than this. The lack of clarity and precision seen in part (a) was also seen here with many describing interference somewhat vaguely in terms of peaks and troughs rather than phase or path difference. Some got phase and path difference mixed up, for example referring to a phase difference of λ. For those who did describe interference well, the difference between scoring three marks and two marks was often due to writing 'out of phase' instead of 'antiphase'.

(c) The arrangement in the diagram demonstrates the effect of superposition. When a monochromatic light source is used, a series of dark and light bands is formed on the screen.



*(i) Explain how the dark and light bands are formed by light reaching the screen from the two slits of the double slit.

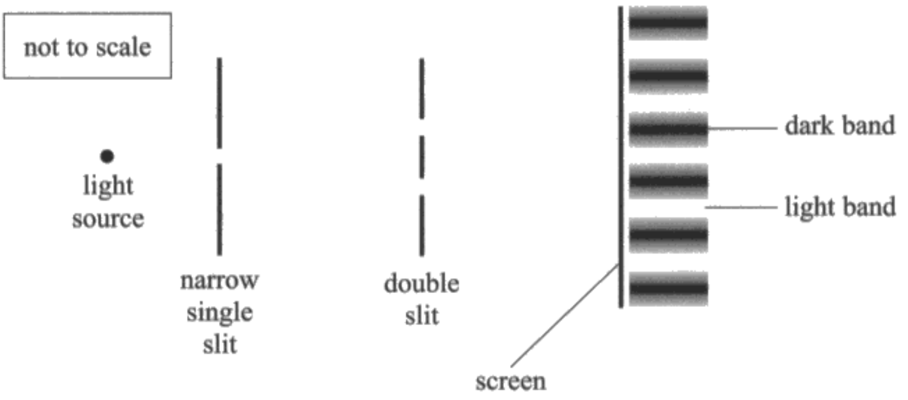
(3)

Light is diffracted from the narrow slit, and again through the double slit. The waves are coherent as they are from the same source and therefore produce constructive and destructive interference as a constant phase relationship. Where a peak meets a trough, destructive interference occurs, leaving 0 amplitude and a dark band. At 2 peaks, constructive interference occurs producing max amplitude and a light band.

ResultsPlus
Examiner Comments

This links dark and light to destructive and constructive interference correctly, but the rest of the explanation lacks detail as it does not refer to either phase change or path difference. Answers based on peak meets trough alone did not get the superposition marks.

(c) The arrangement in the diagram demonstrates the effect of superposition. When a monochromatic light source is used, a series of dark and light bands is formed on the screen.



*(i) Explain how the dark and light bands are formed by light reaching the screen from the two slits of the double slit.

(3)

The light is diffracted as it passes through the slits, so the waves spread out and move in different directions. The light bands are formed when these diffracted ~~moves~~ waves meet each other in phase, so that they interfere constructively and reinforce one another. The ~~band~~ dark bands occur where the light waves have destructively interfered because they're out of phase and cancel out each other's amplitudes.

The light bands have a high intensity of light due to the large amplitudes of the reinforced waves.

ResultsPlus
Examiner Comments

This gets two marks, the only error being a reference to 'out of phase' for destructive interference instead of 'antiphase'.

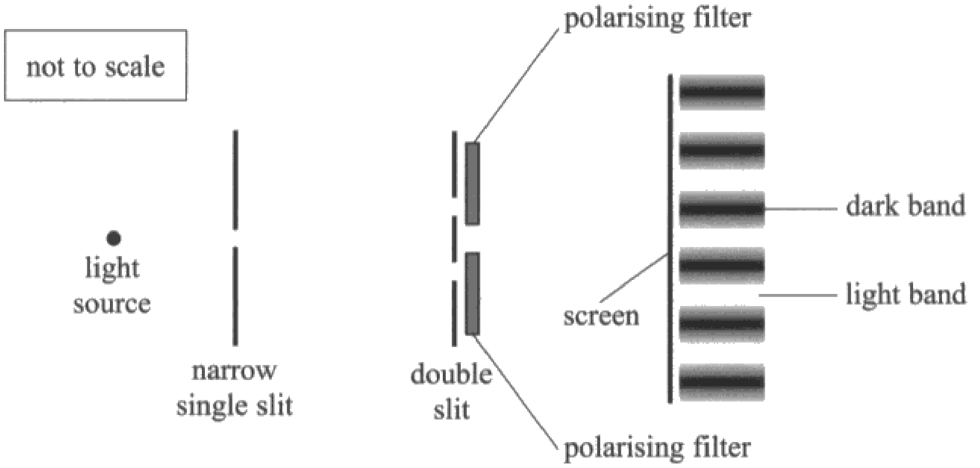
ResultsPlus
Examiner Tip

'Out of phase' simply means not in phase. The situation for destructive interference should be described as 'antiphase'.

Question 17 (c) (ii)

About half of the entry got at least one mark by suggesting that interference would not occur, but a very small minority got all three. A mark was commonly missed by candidates just saying that waves were perpendicular or in perpendicular directions without mentioning oscillation.

(ii) Polarising filters are placed behind the slits as shown. When the planes of polarisation are parallel, the pattern of light and dark bands is still seen.



If one polarising filter is rotated through 90° there are no dark bands and the screen is illuminated evenly.

Explain why there are no dark bands when one filter has a plane of polarisation at 90° to that of the other filter.

(3)

because the peaks & troughs of one polarised wave are in a different plane to the ~~light~~ waves that travelled through the other filter. Therefore there is no constructive of destructive interference* so the wall is evenly illuminated.
* As you can only cancel out peaks & troughs that work in the same plane.

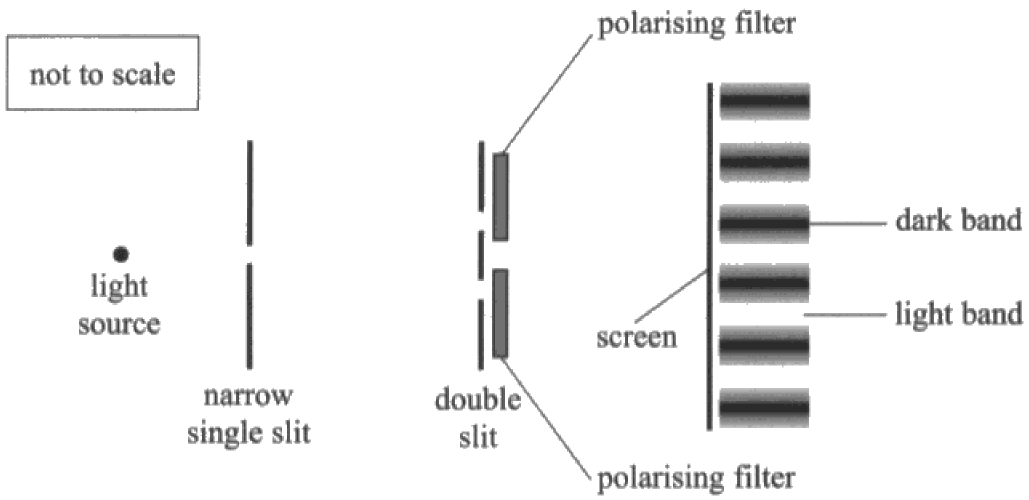
ResultsPlus
Examiner Comments

This answer gets the mark for no interference, but no more. The reference to different planes is not sufficient. They needed to be perpendicular, because there would be interfering components for other angles. It also should have referred to oscillations in the perpendicular planes or directions.

ResultsPlus
Examiner Tip

When considering polarisation, remember that oscillations have components in all planes except that perpendicular to their own plane.

(ii) Polarising filters are placed behind the slits as shown. When the planes of polarisation are parallel, the pattern of light and dark bands is still seen.



If one polarising filter is rotated through 90° there are no dark bands and the screen is illuminated evenly.

Explain why there are no dark bands when one filter has a plane of polarisation at 90° to that of the other filter.

(3)

~~the~~ If one of the filters has a ~~rotated~~ plane of polarisation at 90° to that of the other, the light ~~[illegible]~~ coming out of the filters will we oscillating in different planes perpendicular to eachother, therefore the planes of light will not superpose so no destructive superposition will take place and the screen will be illuminated evenly.

ResultsPlus

Examiner Comments

This correctly identifies the perpendicular planes and consequent lack of superposition, but does not address the lack of dark bands specifically by reference to the lack of points of zero amplitude.

Question 18 (a)

The great majority, nearly 9 out of 10, scored a straightforward four marks. The most common error was to add 69 000 J and 29 000 J for total energy.

18 When food is cooked in a microwave oven, microwave radiation is absorbed by water molecules, increasing the internal energy of the food.

(a) A student heats water in a microwave oven for 1 minute to determine the efficiency of the oven at transferring energy to the water. The current in the microwave oven is 5.0 A and the potential difference is 230 V. The increase in internal energy of the water is 29 000 J.

Calculate the efficiency of the microwave oven at heating the water.

(4)

$$Eff = \frac{\text{total energy output}}{\text{total energy input}} \times 100 = \frac{29{,}000}{(69{,}000 + 29{,}000)} \times 100$$

$$= \frac{29{,}000}{98{,}000} \times 100 = 29.6\%$$

$$W = Itv$$

$$= 5 \times 60 \times 230 = 69000\ J$$

Efficiency = ...

ResultsPlus

Examiner Comments

The total energy has been calculated correctly, but it has then been misapplied by having the energy output added, so this was awarded two marks.

18 When food is cooked in a microwave oven, microwave radiation is absorbed by water molecules, increasing the internal energy of the food.

(a) A student heats water in a microwave oven for 1 minute to determine the efficiency of the oven at transferring energy to the water. The current in the microwave oven is 5.0 A and the potential difference is 230 V. The increase in internal energy of the water is 29 000 J.

Calculate the efficiency of the microwave oven at heating the water.

(4)

$W = VIt$ $\quad W = 230 \times 5 \times 60$

$= 6900$

$\frac{6900}{29000} \times 100 = 23.8\%$

ResultsPlus

Examiner Comments

This gets a mark for the use of $W = IVt$ only, but there is a mistake in the calculation. The candidate has calculated efficiency with the smaller value as the numerator to ensure the value is less than 100%, but it is incorrect because of the wrong answer for total energy.

Question 18 (b)

Only about a third scored here, many candidates misidentifying microwaves as ionising radiation which would result in cancer. While a large number identified water as an absorber of microwaves, many did not mention water in the body or make a clear link to the effect on tissues in the body or else they made statements like 'the body will be cooked'.

(b) The photograph shows a microwave leakage detector.

The detector is held next to the microwave oven to see if any microwave radiation is leaking to the surroundings.

Suggest why microwave radiation leaking to the surroundings could be dangerous to people.

(2)

Although they are long wavelengths, they have high amplitude and therefore high energy. This energy is ionising and can ~~be~~ cause cancerous cells.

ResultsPlus
Examiner Comments

This incorrectly identifies microwaves as ionising radiation.

(b) The photograph shows a microwave leakage detector.

The detector is held next to the microwave oven to see if any microwave radiation is leaking to the surroundings.

Suggest why microwave radiation leaking to the surroundings could be dangerous to people.

(2)

Microwave radiation transfers energy to water molecules and humans are largely composed of water so it could heat up the water molecules in us and cause damage.

ResultsPlus

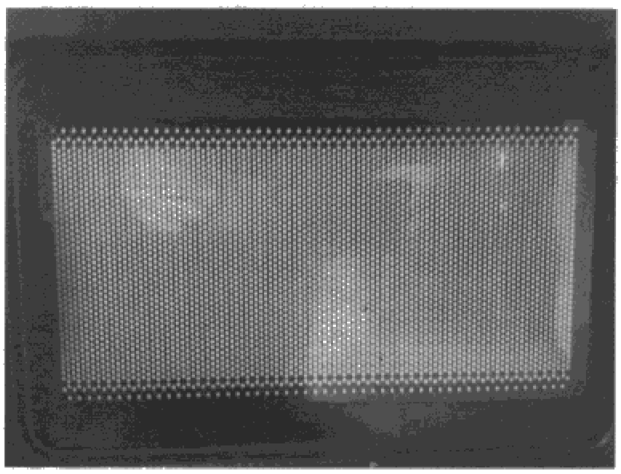
Examiner Comments

This correctly identifies water as a good absorber of some microwave radiation and states that human bodies contain a lot of water, but does not identify possible harm in enough detail.

Question 18 (c) (i)

A large majority got at least one part of this question correct and nearly two thirds got two marks, so this is one of the better remembered definitions. A mark was sometimes lost by reference to bending.

(c) The internal walls of the microwave oven are solid metal. The photograph shows the door of a microwave oven.



The door consists of two sheets of glass with a layer of metal between. The layer of metal has many small holes in it, so that food inside the microwave oven may be seen while it is being heated without exposing the user to dangerous levels of microwave radiation. It has been suggested that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(i) Explain what is meant by diffraction.

(2)

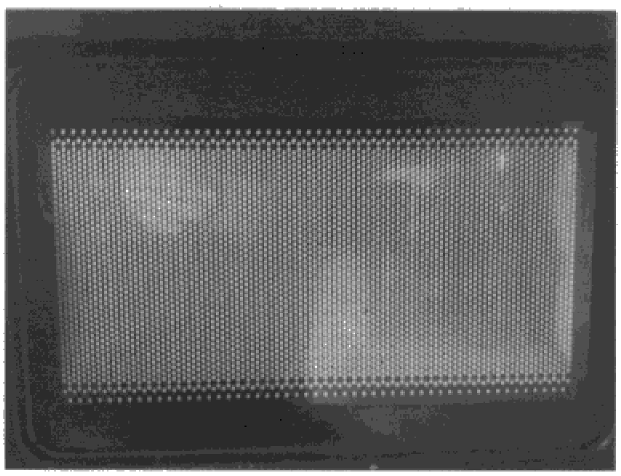
Diffraction is when sound or light passes through a slit ~~a~~ which spreads out the source. The smaller the slit the bigger the diffraction.

ResultsPlus

Examiner Comments

This identifies waves passing through a slit as an example, but refers to spreading the source instead of spreading of the waves.

(c) The internal walls of the microwave oven are solid metal. The photograph shows the door of a microwave oven.



The door consists of two sheets of glass with a layer of metal between. The layer of metal has many small holes in it, so that food inside the microwave oven may be seen while it is being heated without exposing the user to dangerous levels of microwave radiation. It has been suggested that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(i) Explain what is meant by diffraction.

(2)

Diffraction is the spreading out of waves as it passes through an obstacle or around a gap.

ResultsPlus
Examiner Comments

This is nearly correct but has been poorly expressed as it refers to waves passing through an obstacle or around a gap rather than vice versa.

Question 18 (c) (ii)

Although most candidates were able to apply the wave equation, about a third did not get the final answer, usually through a power of ten error for Giga. Answers were sometimes so large or small one might have expected candidates to notice and try again, but they usually just accept what they see on the calculator display.

(ii) Calculate the wavelength of the microwave radiation used in the oven.

microwave frequency = 2.5 GHz.

k 1000
M 1000×1000
G 1000×1000×1000

(2)

$v = \lambda f$ $\qquad 3\times10^8 \div 2.5,000,000,000$

$3\times10^8 \div 2.5\times10^{10} = 0.014$

Wavelength = 0.014m

ResultsPlus
Examiner Comments

This gets a mark for use of the wave equation as power of ten errors are allowed for this mark.

Giga has been incorrectly applied as 10^{10} and the calculation is incorrect.

ResultsPlus
Examiner Tip

Be sure to know the required SI prefixes.

(ii) Calculate the wavelength of the microwave radiation used in the oven.

microwave frequency = 2.5 GHz. 2.5×10^{-9}

(2)

$v = f\lambda$

$\lambda = v/f$

$\lambda = \dfrac{3\times10^{8}}{2.5\times10^{-9}}$

$\lambda = 1.2\times10^{17}$ m

Wavelength = 1.2×10^{17} m

ResultsPlus

Examiner Comments

This has been set out correctly but there is a mistake in the calculation. Candidates would generally be expected to realise that an answer like this is highly unlikely and check their calculations.

ResultsPlus

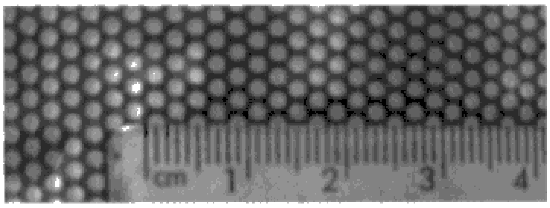
Examiner Tip

When an answer is clearly far too large or too small, check your calculations.

Question 18 (c) (iii)

About one in six didn't get the mark. Some misread the scale, e.g. 0.2 mm, some may have wrongly converted when they wanted to give the answer in m, e.g. 0.2 m, some halved their measurement, some calculated the area and a few just got it wrong, e.g. 3 mm.

(iii) The photograph shows a section of the microwave oven door. Use the photograph to determine the diameter of the holes.



(1)

$0.2\,mm = 0.2 \times 10^{-3}\,m$

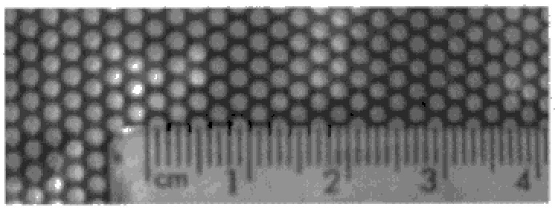
Diameter = $0.2 \times 10^{-3}\,m$

ResultsPlus

Examiner Comments

An example of a candidate misreading the scale units.

(iii) The photograph shows a section of the microwave oven door. Use the photograph to determine the diameter of the holes.



(1)

$2\,mm = 0.2\,cm = 0.002\,m$

Diameter = ~~2mm~~ $0.002\,m$

ResultsPlus

Examiner Comments

Many candidates gave the answer in a range of units, like in this response.

On the whole it is better to give just one answer in case one of the different versions is incorrect as this could jeopardise the mark.

Question 18 (c) (iv)

Only about one in five scored on this question. Many made it clear that they think that diffraction only occurs when the wavelength is about the same as the gap size. Many more have apparently only considered diffraction when gap size is equal to or greater than wavelenght and not investigated smaller gaps where there is still diffraction through a very large angle but a decreasing intensity.

*(iv) Discuss the suggestion that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(3)

The holes must be a similar size to the wavelength in order for diffraction to occur. The wavelength of the microwaves is far too large to diffract through the holes. The wavelength of visible light is smaller than that of microwaves so can diffract and pass through the holes.

(Total for Question 18 = 14 marks)

ResultsPlus
Examiner Comments

This incorrectly suggests that diffraction only occurs when the size of the gap is the same as the wavelength.

It also compares the wavelength of light to microwaves but not the gap size.

ResultsPlus
Examiner Tip

You must be able to describe the effects of diffraction when the gap is much smaller than the wavelength as well as when it is much larger.

*(iv) Discuss the suggestion that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(3)

- Wavelength of microwave radiation is far greater than the diameter of the holes...
- ... preventing microwaves from passing ~~the~~ through.
- Visible light would have a wavelength far smaller than the diameter of the holes...
- and so could pass through (and not be diffracted).

ResultsPlus

Examiner Comments

This correctly identifies the size of microwaves and light waves relative to the gap size and links this to little diffraction for light to get two marks. There is no general comment about gap size linked to diffraction.

Paper Summary

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

- learn definitions in detail so they can be quoted fully, using the required terminology
- check that quantitative answers represent sensible values and to check calculations when they do not
- learn standard descriptions of physical processes, such as polarisation and interference, and be able to apply them to specific situations, identifying the parts of the general explanation required to answer the particular question.

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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