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Examiners' Report
June 2014

GCE Physics 6PH02 01

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Introduction

This is the sixth 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.

This paper allowed candidates to demonstrate their knowledge of content across the whole specification for this unit, showing progression from GCSE and answering questions to the depth appropriate to their level of understanding.

There was some evidence of candidates quoting answers from mark schemes to previous papers when they were not entirely relevant to the questions in this paper, such as the roar of a tiger in question 11 and 'reference to $E = hf$' in 13(b). While past papers and mark schemes are useful preparation, candidates could use them to help them to learn the physics rather than learn the actual mark schemes.

A number of responses were seen where candidates recognised the situations and had some recall of techniques, explanations and terminology, but imprecise detail and failure to express themselves clearly prevented the award of marks.

SECTION A - Multiple choice

Question	**Percentage of correct responses**
1	87
2	78
3	71
4	92
5	76
6	39
7	87
8	84
9	48
10	72

In the following questions a large majority of candidates with incorrect answers made the same choice.

Q1. Most of those choosing incorrectly identified period, suggesting that they read it a bit too quickly and focused on 'one oscillation'.

Q2.The favoured incorrect response was D, so the correct equation was applied but the p.d. used was 3.0 V from e.m.f. of the two cells.

Q4.The few who didn't identify polarisation generally chose refraction. While they are less likely to have observed this, they should know that it applies to all waves.

Q7. Although incorrect answers were rare, they were most frequently ultraviolet, suggesting that the parts of the electromagnetic spectrum had not been learned in order because ultraviolet and X-rays would both appear on one side so one could not be chosen without the other.

Q8. The favoured incorrect response was 'electrons behave as particles' – essentially the opposite of the correct answer. 'Electrons have negative charge' was chosen extremely rarely.

Other incorrect choices were more evenly spread – especially question 6 where the correct answer was given 39% of the time and the others about 20% each, suggesting that this was not at all well understood.

SECTION B

Question 11

Apart from a few candidates referring to transverse waves, the great majority scored one mark by stating that infrasound travels as a longitudinal wave, usually mentioning compressions and rarefactions as well.

Only about half went on to achieve a second mark, because of imprecise expression and ambiguous terminology. There was wide appreciation of the relative directions of the oscillations and propagation, but the mark was often not awarded because these were not sufficiently well described. For example, 'movement', 'moves' and 'motion' in this context could apply to the oscillations or the propagation of the wave. 'The movement is in the same direction as the wave' is a typical example.

The question specifically asked about infrasound in air, but relatively few candidates mentioned molecules of air oscillating. Poor expression resulted in a few describing air molecules being compressed individually when they should have been describing regions of compression. Occasionally the answer that 'the wave travels in the direction of energy transfer' is seen.

Describe how infrasound travels through the air.

(3)

Infrasound travels by mechanical longditudinal wave. They traverse by causing particles of air to compress and rarefract along the plain of motion thereby passing on the wave through the air.

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Examiner Comments

This gets a mark for stating that the infrasound travels as a longitudinal wave. There is an idea of compression and rarefaction, but it appears to say that individual particles are compressed. 'Along the plain of motion' may be an attempt to describe the direction of oscillation.

Describe how infrasound travels through the air.

(3)

It travels as a longitudinal wave by vibrating particles forming nodes, areas of compression and antinodes, area of rarefraction. It moves parallel to its direction of travel and only moves on one plane.

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Examiner Comments

2 marks are awarded, for longitudinal wave and for saying that particles vibrate.

Areas of compression and rarefaction (spelled here as rarefraction) are misidentified with nodes and antinodes, suggesting some confusion with a picture of a longitudinal standing wave.

The description says 'it moves parallel to its direction of travel'. While 'direction of travel' is clear, 'moves' could refer to the wave, in which case the sentence says little, or to the motion of the individual particles. This ambiguity is always introduced into descriptions of waves when words like 'move', 'motion' and 'movement' are used instead of vibration, oscillation, propagation etc.

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Examiner Tip

Avoid using words like 'move', 'motion' and 'movement' when describing longitudinal and transverse waves.

Question 12

With only about half of the candidates getting a single mark for mentioning a very small current through the voltmeter, this question demonstrated a generally poor understanding of current and potential difference applied to circuits.

Candidates who suggested the current through the voltmeter should be small usually failed to appreciate the significance of this. A common answer was that the current should pass through the component rather than the voltmeter, as if there was a fixed current in the circuit. In the context of their answers, these candidates did not appreciate that the potential difference across the voltmeter would be the same as that across the component and that the current through the component would therefore be unaffected. In this question's context, determining resistance, it is the ratio of potential difference to current that matters and not the particular values anyway. The key point was that the current through the ammeter should be the same as the current through the component.

As the question mentioned the voltmeter and not the ammeter, many discussed the effect on potential difference, quite a few mentioning 'voltage through the component'.

A few candidates discussed total resistance but could rarely express their answers clearly enough to gain credit, usually saying little more than that $1/R$ would be very small.

Some candidates failed to score a mark through lack of detail, such as stating that the ammeter reading would not be accurate without saying why or just saying the voltmeter current should be low rather than very small.

Explain why the voltmeter should have a very high resistance.

(2)

the voltmeter should have a very high resistance, so that it does not disrupt how the circuit works when it is connected in parrallel with a component. If the voltmeter had a low resistance, the entire resistance of the circuit would be changed as parralel resistances add using $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$, and if both R_1 and R_2 are similar, the total R will be half of those values.

(Total for Question 12 = 2 marks)

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Examiner Comments

This response is awarded 1 mark for describing the possible effect on the resistance of the parallel section of the circuit, but it does not say how this would affect the measurement of the resistance of the component, i.e. by causing a greater current in the ammeter than the current in the component.

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Examiner Tip

You need to be able to describe the reasons for the resistance of meters in terms of current and potential difference in series and parallel circuits.

Explain why the voltmeter should have a very high resistance.

(2)

If the voltmeter has a high resistance this will stop any current from passing through the voltmeter. this ensures all current passes through the component its in parallel with and theres only a neglible amount through voltmeter.

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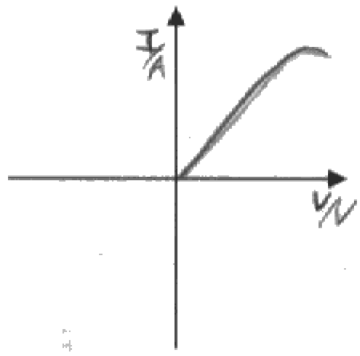
Examiner Comments

This candidate achieves one mark for saying (twice) that the current in the voltmeter is negligible. In an explanation this needs to be linked to the final outcome, which is a correct determination of the resistance of the component. The response says that all current passes through the component, but the key missing effect of the negligible voltmeter current here is that the current measured by the ammeter is the same as the current in the component.

Question 13 (a)

A large number failed to label the axes, so they could not get the mark for the correct curve. A large number who committed themselves to labelled axes drew the curve the wrong way. Quite a few with labelled axes and the correct curve did not take sufficient care with their drawing and added a 'hook' showing decreasing current at the end. Most candidates gained a mark for symmetry, but only a third scored full marks.

13 (a) Sketch a graph to show how current varies with potential difference for a filament lamp.



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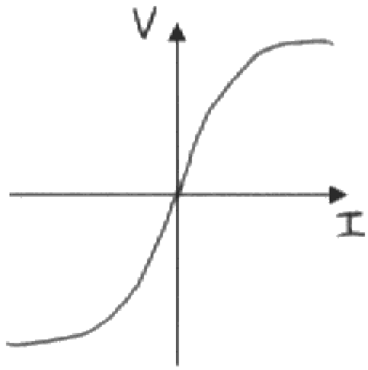
Examiner Comments

This sketch has the general trend for the change in current and p.d., but goes too far in showing a decrease in current. The line is not drawn for negative values.

13 (a) Sketch a graph to show how current varies with potential difference for a filament lamp.



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Examiner Comments

The curve doesn't match the axes, as this sketch indicates decreasing resistance at higher currents.

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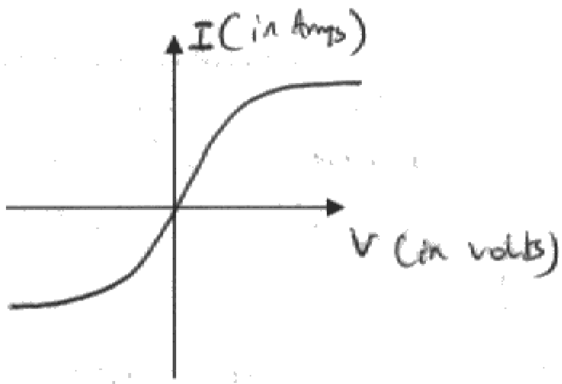
Examiner Tip

You should be able to sketch and interpret I-V graphs for components with either orientation of axes.

13 (a) Sketch a graph to show how current varies with potential difference for a filament lamp.



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Examiner Comments

A correct version.

Question 13 (b)

The majority of candidates applied the correct model but answered the wrong question here, commonly writing in detail about the effect of temperature on resistance and often concluding with a statement that current is reduced, directly contradicting the question. These candidates were still able to gain credit for establishing a link between energy dissipation and collisions of electrons with lattice ions.

Most candidates who started with reference to $I = nAvq$ realised that only v could increase and made a better start, although a few thought n would increase.

Candidates giving the correct explanation sometimes failed to score the second mark through a lack of detail, such as describing increased collisions but not saying what was colliding with what, or failing to refer to an increase, for example just stating that there are collisions of electrons with lattice ions. Some candidates only referred to collisions between electrons.

(b) The temperature of a filament lamp increases as the current through it increases.

Explain this in terms of the structure of a metal.

(3)

As temperature increases in the filament, it causes to ions in the lattice to vibrate due to them heating up. Because the ions are vibrating, there is a much greater chance of them getting in the way of the ~~electrons~~ charge-carrying electrons moving through the component. ~~And as this is more~~ And as this makes it more difficult for electrons to move through, there is an increase in resistance

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Examiner Comments

This candidate is not answering the question asked. The candidate is required to explain the increase in temperature but instead starts with an increase in temperature and describes its effect. Even there it should refer to increasing lattice ion vibration and not just lattice ion vibration.

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Examiner Tip

It is valuable to revise using past paper questions, but read questions carefully to be sure they aren't just similar at first glance to previous questions.

(b) The temperature of a filament lamp increases as the current through it increases.

Explain this in terms of the structure of a metal.

(3)

Current is the number of electrons that past in one second. Increasing the current cause more electrons to pass through in a second. However the thickness of the wire hasn't change therefore a higher amount of electrons are trying to past the space this increases friction and causes the filament to heat up.

ResultsPlus
Examiner Comments

The increasing rate for flow of electrons is identified, but there is not sufficient detail in the rest of the answer. Interactions with the lattice ions need to be included.

(b) The temperature of a filament lamp increases as the current through it increases.

Explain this in terms of the structure of a metal.

(3)

- A metal consists of positive ions that are surrounded by a sea of delocalised electrons. (free floating or mobile electrons).
- As the current increases, the electrons carrying the charge would move faster, and so would collide more often with the ions in the metal causing the metal atoms to vibrate and heating the metal (causing the metal to heat up)

(Total for Question 13 = 5 marks)

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Examiner Comments

This is a good answer overall which scored two marks. A reference to the metal ions vibrating more is required for the final mark because it is describing an increase in temperature.

Question 14 (a)

While a majority of candidates had an appreciation of the basic difference between polarised and unpolarised light, lack of detail restricted the awarding of the first 2 marks to a little over half and a fundamental misunderstanding of the geometry of the situation meant only a fifth of candidates got full marks.

Candidates usually quoted a single plane or direction for polarised light, but they did not all mention oscillations, many referring to light travelling in a single plane or direction.

Unpolarised light was similar, but a few more missed the mark through referring to ‘any direction’ or ‘more than one plane’ which were not sufficient for ‘many’.

A number of candidates described directions of oscillations in one part and planes containing the direction of oscillations in the next, so their marks were restricted.

Some may be losing the third mark because they are thinking of the definition of transverse waves. They commonly say ‘polarised light has oscillations in a single plane which is perpendicular to the direction of propagation of the wave’ (although even here some repeat the error in question 11 and talk about the direction of movement of the wave). The direction of the oscillation at a point is perpendicular to the direction of wave propagation, but along the length of the wave the directions all align in the same plane which contains the direction of wave propagation.

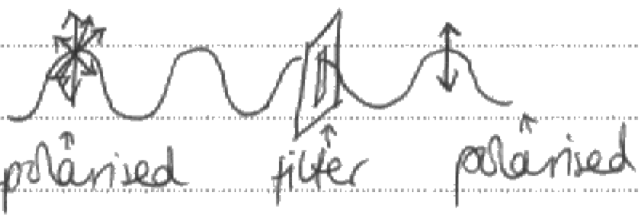
Candidates occasionally drew fairly detailed diagrams. These may help to clarify the situation for the candidates concerned, but without detailed labelling they do not gain marks.

14 Iceland spar is a crystalline form of calcite. An incident ray of unpolarised light is separated into two plane polarised rays by a sample of Iceland spar. The two rays of polarised light follow different paths.

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

(3)

unpolarised light is when light travels in many different planes, at right angles to the direction of travel. Polarised light only travels in one plane.



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Examiner Comments

The answer here refers to travel in many planes when it should be oscillations in many planes. The planes are also described as being at right angles to the direction of travel.

The diagram gains no credit because the arrows are not labelled. Labels of 'oscillations in all directions (or planes)' and 'oscillations in one direction (or plane)' for unpolarised and polarised light respectively would have been awarded marks.

ResultsPlus
Examiner Tip

Diagrams will only gain marks if they are fully labelled.

14 Iceland spar is a crystalline form of calcite. An incident ray of unpolarised light is separated into two plane polarised rays by a sample of Iceland spar. The two rays of polarised light follow different paths.

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

(3)

Unpolarised light vibrates in many planes. When ~~[illegible]~~ unpolarised light is passed through a polarising filter; all but one plane of which the light is travelling in are filtered out; polarising light only vibrates in one plane.

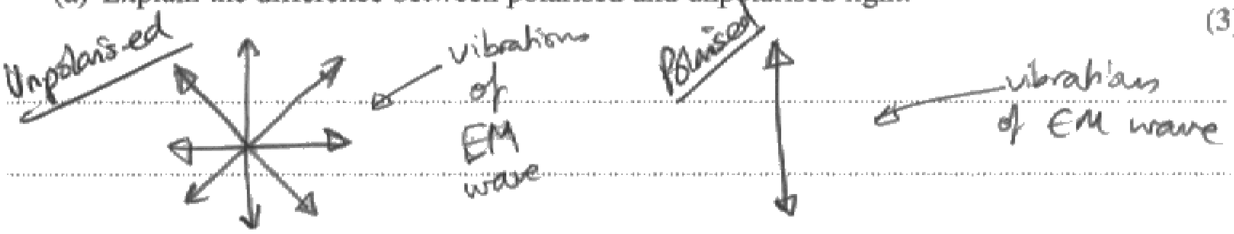
ResultsPlus
Examiner Comments

The first and last parts of this question gain a mark each. The rest is describing the process of polarisation, which is not what this question is asking for.

14 Iceland spar is a crystalline form of calcite. An incident ray of unpolarised light is separated into two plane polarised rays by a sample of Iceland spar. The two rays of polarised light follow different paths.

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

(3)



~~Fig~~ (diagrams showing the end of a wave).

Unpolarised light → the oscillations of the electromagnetic field are in all planes perpendicular to the direction of travel of the wave.

Polarised light → the oscillations are restricted to one plane perpendicular to the direction of travel of the wave and this plane contains the direction of energy transfer.

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Examiner Comments

This response would get 3 marks without the references to 'perpendicular to the direction of travel', but this phrase contradicts the correct reference to 'this plane contains the direction of energy transfer' at the end.

Question 14 (b)

This was marked as a QWC question and said 'explain', so candidates were expected to set out an answer that stated some points and linked them logically to provide an explanation of the observation described.

Many candidates appeared to have forgotten the introduction to the question on page 8, where they were told twice that a single incident ray results in two rays of polarised light, by the time they start part (b) on page 9. There was rarely reference to this, although it was necessary to include it in an adequate explanation, and in many answers it was stated that there is polarised light and unpolarised light.

Candidates generally had some idea of what was happening when the filter was used, but did not always describe it in sufficient detail. They often just said that a filter only allowed rays from one image through, without saying why or that 'polaroid filters only allow light in one orientation to pass through' without linking the orientation of the light and the filter specifically for either transmitted or absorbed light.

Most candidates achieved a mark by describing a basic change in the appearance of the images as the filter is rotated, but rarely gave sufficient correct detail for the last mark. They frequently only considered the one image seen in the original orientation, and often said it would 'become polarised and fade away' as the angle approached 90°, as if 'polarised' is synonymous with 'absorbed'. Others were able to describe single images at the correct multiples of 90°, but said nothing at all would be seen in between these angles. Components were mentioned extremely rarely, and lack of this understanding matched the descriptions of the in between angles.

Overall, about three quarters got at least 1 mark and nearly half got 2 or more.

Explain why only one image is seen and describe what would be seen as the filter is rotated through 360°.

(4)

Normal light is unpolarised and travels in many different planes. When it passes through a polarising filter and is polarised, it only travels in one plane. There is only one image seen because the light passing through the filter is only traveling in one plane. When the filter is rotated 360°, the image seen is the same, because the filter has been rotated back to its original position.

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Examiner Comments

The references to 'travels' in various planes don't help in this answer, but a comparison with what the filter allows could still have been made. The question asks about what happens through the whole rotation, but there is only a clear reference to the end point.

Explain why only one image is seen and describe what would be seen as the filter is rotated through 360°.

(4)

the two images produced by the sample are polarised into different plane, when the filter is placed over the top of the sample it only allows one plane of polarised light through. If it lines up with the direction of the polarised light beneath you can see it.

when the filter is turned ~~45°~~ between 0° and 45° the image seen originally will fade slightly and the other image will begin to be seen more. Between 45° and 90° the original image will fade to nothing and the new image will become as clear as the original was. Between 90° and 180° the same pattern will occur but the other way round. and between 180° and 360° the first 180° will repeat itself.

(Total for Question 14 = 7 marks)

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Examiner Comments

This answer is structured in a logical sequence, addressing all points, and is awarded all 4 marks.

Question 15 (a)

While a unit of eV or joule was often given, the quantity was usually 'energy' or 'kinetic energy' only. The unit mark was still allowed for an incomplete version of 'maximum kinetic energy of photoelectrons' as the quantity, so over half of candidates gained the unit mark, but a very small proportion got the quantity mark as well.

Some candidates gave a number as the quantity, sometimes using the threshold frequency on the graph to calculate the work function energy.

(a) State a quantity, and its unit, which could have been plotted on the Y-axis to produce this graph.

(2)

kinetic energy of emitted photoelectron $Kg\,m^2 s^{-4}$

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Examiner Comments

This doesn't mention maximum and the unit is attempted in base units, although there is no indication in the question that this is required. The unit would be kg m^2 s^{-2}.

(a) State a quantity, and its unit, which could have been plotted on the Y-axis to produce this graph.

(2)

Energy emitted (J) as KE of electron.

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Examiner Comments

A correct unit, but again no reference to maximum.

Question 15 (b)

A large majority of candidates appreciated that a certain minimum energy is required for photoemission and that this is significant to explaining threshold frequency, but the level of detail in the answers varied widely. Many answers did not mention photons at all, and quite a few did not even mention electrons, referring simply to the minimum frequency for the photoelectric effect to occur. Some got photons and electrons reversed in their answers. Sometimes this may have been because of the term 'photoelectron' having some similarity to 'photon', but in other cases there was overlap with descriptions of atomic spectra where photons are emitted.

A common statement was 'the threshold frequency is the minimum energy required for electron emission, conflating work function and threshold frequency'.

Although candidates often list a set of facts when answering questions about the photoelectric effect, and, indeed, a number stated unnecessarily that the intensity only affected the number of electrons emitted, the specific question was sufficiently different that many did not make the usual statement that one photon is absorbed by one electron. $E = hf$ was often mentioned, but it was not generally used to link threshold frequency and the minimum energy required, particularly when it was not identified as the photon energy.

Candidates sometimes lost out by not being clear about 'minimum', perhaps just referring to 'a certain energy'.

(b) The threshold frequency is shown on the graph.

Explain why there is a threshold frequency.

(4)

$E = \Phi + \frac{1}{2}mv^2_{max}$

$E = hf \quad hf = \Phi + \frac{1}{2}mv^2_{max}$

h is a constant so frequency causes the change. The threshold frequency ~~ø~~ is the frequency of light needed for the photoelectric effect to occur - this is different for each metal. From the equation a large enough frequency is needed to overcome the work function of a metal.

(Total for Question 15 = 6 marks)

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Examiner Comments

This response gets close to most of the points but lacks the required detail. Photons and electrons are not mentioned. The prerequisites 'for the photoelectric effect to occur' are mentioned, but the precise nature of the photoelectric effect is not established. 'The frequency of light needed' is not sufficient to convey the idea of minimum frequency and 'to overcome the work function' is not sufficient for minimum energy. $E = hf$ appears, but it is not explained.

(b) The threshold frequency is shown on the graph.

Explain why there is a threshold frequency.

(4)

The threshold frequency is the minimum frequency required to ~~[illegible]~~ release one electron from the surface of a metal. The frequency tells us how much energy a photon has

$E_{photon} = hf$ ← frequency (h → plancks constant). A photon passes this energy to an electron when they collide and ∴ for an electron to break it's bonds it needs a certain amount of energy, so the photon needs a certain frequency, the minimum being the threshold frequency.

(Total for Question 15 = 6 marks)

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Examiner Comments

A good, full mark response for comparison. The ideas are expressed correctly and linked logically to give an explanation, as required.

Question 16 (a)

The great majority completed this question correctly, scoring six marks, with the most common error made by a small minority being a unit error for W or J.

16 An electric kettle is used to heat water from room temperature to boiling point.

(a) (i) Calculate the electrical power used by the kettle.

potential difference = 230 V

current = 12.5 A

(2)

P = VI

Electrical power = 2875

(ii) The kettle is switched on for 140 s.

Calculate the total energy supplied to the kettle.

(2)

W = VIt   2875 × 140 = 402500

Total energy supplied = 402500

(iii) The amount of thermal energy transferred to the water is calculated to be 351 000 J.

Calculate the efficiency of the kettle at heating the water.

(2)

$\frac{351000}{402500} \times 100 = 87.2\%$

Efficiency = 87.2%

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Examiner Comments

Units have been emitted, so the final mark for the answers are not awarded.

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Examiner Tip

A quantity must have a magnitude and unit and the mark will generally not be awarded for a magnitude without a unit unless the unit has been indicated already, such as in a 'show that' question.

16 An electric kettle is used to heat water from room temperature to boiling point.

(a) (i) Calculate the electrical power used by the kettle.

potential difference = 230 V

current = 12.5 A

(2)

P = VI   230 × 12.5 = 2875

Electrical power = 2875

(ii) The kettle is switched on for 140 s.

Calculate the total energy supplied to the kettle.

(2)

W = VIt   230 × 12.5 × 140 = 402500

Total energy supplied = 402500 W

(iii) The amount of thermal energy transferred to the water is calculated to be 351 000 J.

Calculate the efficiency of the kettle at heating the water.

(2)

$\frac{351000}{402500} \times 100 = 87.2049689...$

Efficiency = 87.2%

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Examiner Comments

The units for the first two parts were sometimes reversed, as in this example.

Question 16 (b)

Most candidates scored a mark for identifying something other than the required useful energy output, frequently the production of sound or the heating effect on the surroundings, although some just stated that energy was wasted as heat without being more specific.

Only about one in three went on to qualify this by describing the useful energy output in some way, although it was more commonly correct when the first mark was gained by describing heating of something other than the water in the kettle.

(b) A student suggests that the useful energy required is thermal and the kettle only produces thermal energy, so it should be 100 % efficient.

Discuss this suggestion.

(2)

Some thermal energy is lost to its surrounding so the kettle is not 100% efficient because it doesn't use all of the energy supplied

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Examiner Comments

This response gets one mark for the idea of heating the surroundings, but it does not include enough detail on how the kettle 'doesn't use all of the energy supplied' by describing what would be considered useful in this context.

(b) A student suggests that the useful energy required is thermal and the kettle only produces thermal energy, so it should be 100 % efficient.

Discuss this suggestion.

(2)

It may be true that the kettle only produces thermal energy, but not all of that energy is useful: only the energy given to the water is useful. Some of the thermal energy is lost into the kettle itself, and its surroundings.

(Total for Question 16 = 8 marks)

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Examiner Comments

This is a full mark response for comparison. Useful energy is defined and heating of the kettle and surroundings is described.

Question 17 (a)

This is a standard definition, but it does not always appear to have been learned as such, with only a quarter of the candidates getting both marks. Most were able to identify a packet of energy or similar, but many seem to think it only applies to light and did not refer to electromagnetic radiation in general.

(a) Explain what is meant by a photon.

(2)

A photon is a packet of energy containing a fixed amount of it.

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Examiner Comments

This gets a mark for packet of energy, but does not refer to 'electromagnetic'.

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Examiner Tip

Standard definitions, such as this, of the photon, should be learned in the correct detail.

(a) Explain what is meant by a photon.

(2)

a photon is a single, discrete packet of electromagnetic energy.

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Examiner Comments

A correct answer which is awarded 2 marks.

Question 17 (b)

The great majority applied $E = hf$, but about a third of those did not convert from eV to J first. A number of candidates omitted the unit Hz. A few did not calculate a difference in energy levels.

(b) Calculate the frequency of the photons produced as the neon atoms drop from level E_3 to level E_2.

(3)

20.66 - 18.70 = 1.96

Frequency = 1.96 Hz

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Examiner Comments

The energy level difference has been calculated, but no further calculations have been carried out. Even though the energy values are clearly in eV, the difference has been quoted in Hz as the final answer. The operation of subtraction would net result in a different unit being applied, a possible exception being between K and °C.

(b) Calculate the frequency of the photons produced as the neon atoms drop from level E_3 to level E_2.

(3)

20.66 - 18.70 = 1.96 E=hf f= E/h

1.96 / 6.63×10⁻³⁴ = 2.96×10³³

Frequency = 2.96×10³³

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Examiner Comments

A mark has been awarded for the use of $E = hf$, without conversion from eV.

No unit has been given, but it does not affect the mark because the numerical answer is incorrect.

(b) Calculate the frequency of the photons produced as the neon atoms drop from level E_3 to level E_2.

(3)

$20.66 - 18.70 = 1.96\ Ev$

$= 3.136 \times 10^{-19}\ J$

$E = hf$

$\frac{3.136 \times 10^{-19}}{h} = 4.7 \times 10^{14}$

Frequency = 4.7×10^{14}

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Examiner Comments

The calculations are correct, but the unit has been omitted so only 2 marks are awarded.

Question 17 (c)

A number of suggestions were seen, but only one in twenty got the mark. Some missed out by only identifying kinetic energy or the atoms and not linking them.

(c) An electron in level E_3 of neon has 0.05 eV more energy than an electron in level E_2 of helium.

Suggest the source of the energy to make up this difference.

(1)

The kinetic energy of collision

ResultsPlus
Examiner Comments

Kinetic energy has been identified, but not the body with kinetic energy.

(c) An electron in level E_3 of neon has 0.05 eV more energy than an electron in level E_2 of helium.

Suggest the source of the energy to make up this difference.

(1)

~~Kinetic energy~~ - The collisions between the high speed helium atoms and the neon atoms.

ResultsPlus
Examiner Comments

The atoms have been identified, but kinetic energy has been crossed out.

(c) An electron in level E_3 of neon has 0.05 eV more energy than an electron in level E_2 of helium.

Suggest the source of the energy to make up this difference.

(1)

The KE from the Helium atoms colliding with the neon atoms goes to the neon electrons

ResultsPlus
Examiner Comments

This gets the mark for kinetic energy of the atoms.

Question 17 (d)

The great majority of candidates were able to identify diffraction as the relevant phenomenon. Most of those gained a further mark for describing the increase in the angle through which the wave is diffracted as the slit width decreases, although some of the answers were a bit indirect on this point. Some simply quoted ‘maximum diffraction occurs when the slit width equals the wavelength’ and did not get the additional mark because they did not link it to a decreasing slit width in this context.

Three marks were awarded to only about a quarter of responses because the link between the term ‘diffraction’ and the observation was not established by reference to the wave ‘spreading out’.

When the slit is fully open a laser beam is shone through it and a single point of light is seen on a screen.

As the slit is reduced in width the point of light becomes a horizontal line that gets longer as the slit gets narrower.

Explain this observation.

(3)

- As the silt gets narrower, diffraction of light wave is formed.
- When the size of slit is roughly equal to the wavelength of slit, substantial diffraction is the occured.

ResultsPlus

Examiner Comments

This identifies diffraction, but does not explain how it causes the effect seen or the change with slit width. The statement about slit size is almost a quote from the specification and has not been applied to the changing situation.

When the slit is fully open a laser beam is shone through it and a single point of light is seen on a screen.

As the slit is reduced in width the point of light becomes a horizontal line that gets longer as the slit gets narrower.

Explain this observation.

(3)

- This is due to diffraction
- As the slit gets ~~smaller~~ narrower (the gap gets smaller) is becomes more and more similar (or close) to the wavelength of ~~that~~ light, which causes diffraction to increase.

ResultsPlus
Examiner Comments

This response identifies the phenomenon of diffraction and states that diffraction increases with decreasing slit size, but does not link it to what is seen by describing what diffraction is.

When the slit is fully open a laser beam is shone through it and a single point of light is seen on a screen.

As the slit is reduced in width the point of light becomes a horizontal line that gets longer as the slit gets narrower.

Explain this observation.

(3)

This shows diffraction. Diffraction is when light interacts with an edge, and spreads out behind it. As the slit becomes narrower, the amount of diffraction increases. This is why as the slit becomes narrower, the horizontal line becomes longer.

ResultsPlus
Examiner Comments

A full mark answer, including the point that diffraction is the spreading of a wave, which explains the line.

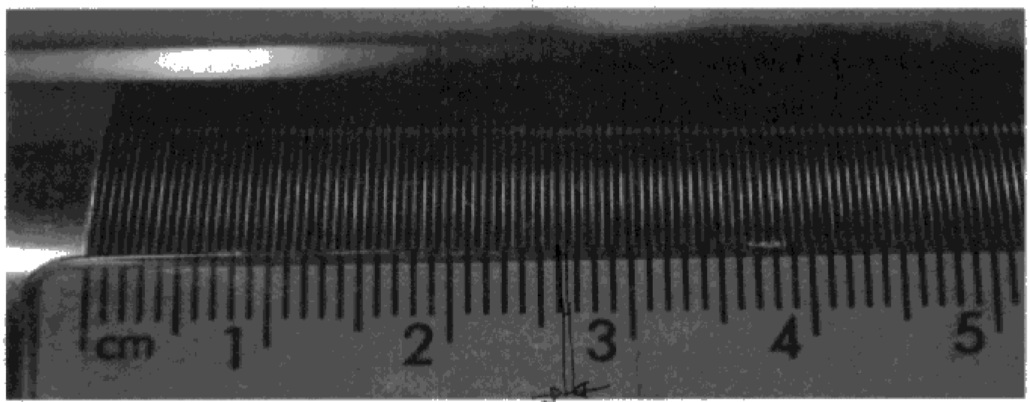
Question 18 (a)

Most candidates completed the calculations in this section. Although some went astray on part (i) they were able to use the quoted value to complete part (ii).

In part (i) candidates rarely took full advantage of the photograph and only measured one or two wires against the scale. Others either had difficulty counting or extrapolated their value for two widths of wire because they said there were 20 turns per cm. A few had problems with powers of 10 in part (i) or applied the factor of 2 incorrectly.

(a) A student decides to determine the resistivity of the material from which the wire is made by measuring the dimensions of the wire and its resistance.

Photograph 2 shows a section of the rheostat and a scale.



Photograph 2

(i) Take measurements from the photograph and use them to show that the cross-sectional area of the wire is about 2×10^{-7} m^2.

(3)

Diameter ≈ 0.3 mm ∴ $A = \pi r^2 = \pi \times (0.3 \times 10^{-3})^2 = 2.83 \times 10^{-7}$ m^2

(ii) Calculate the resistivity of the material from which the wire is made.

resistance of wire = 22 Ω

length of wire = 12 m

(3)

$R = \frac{\rho L}{a}$ $Ra = \rho L$ $\frac{Ra}{L} = \rho$

$\therefore \rho = \frac{Ra}{L} = \frac{22 \times (2.83 \times 10^{-7})}{12} = 5.19$ Ωm

Resistivity = 5.19 Ωm

(iii) Suggest an advantage for the student of using a photograph rather than taking direct measurements.

(1)

A photograph can be zoomed and enhanced to read the measurements on the rule more easily than with direct human sight.

ResultsPlus
Examiner Comments

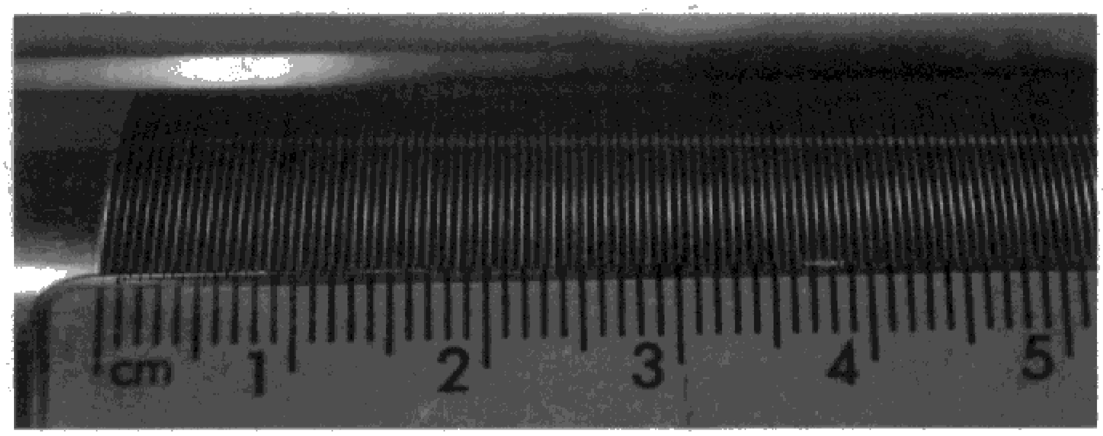
(i) Only one coil has been used, and the resulting diameter is far out of tolerance. This has not been used to determine the radius before calculating the area.

(ii) The previous answer has been substituted correctly, but the powers of 10 have disappeared during the calculation.

(iii) The use of a photograph by zooming in has been identified, although making measurements more easily isn't sufficient and it might better refer to increased accuracy.

(a) A student decides to determine the resistivity of the material from which the wire is made by measuring the dimensions of the wire and its resistance.

Photograph 2 shows a section of the rheostat and a scale.



Photograph 2

(i) Take measurements from the photograph and use them to show that the cross-sectional area of the wire is about 2×10^{-7} m^2.

(3)

55 coils in 3 cm

$\frac{3\times10^{-2}}{55} = 0.000545455$m diameter

$\frac{0.000545455}{2} = 0.00027273$

$\pi \times 0.00027273^2 = 2.346\times10^{-7}$ m^2

(ii) Calculate the resistivity of the material from which the wire is made.

resistance of wire = 22 Ω

length of wire = 12 m

(3)

$R = \rho l / A$

$\frac{AR}{l} = \rho \qquad \frac{2.34 \times 10^{-7} \times 22}{12} = 4.28 \times 10^{-7}$

Resistivity = 4.28×10^{-7} Ωm

(iii) Suggest an advantage for the student of using a photograph rather than taking direct measurements.

(1)

using a photograph means the error that could be caused by human imbalance is removed. Human error is reduced.

ResultsPlus

Examiner Comments

A good number of coils have been used and the area calculated correctly and the resistivity has been calculated.

The identified advantage is not justified as there could still be 'human error', particularly in counting, as evidenced by the many different answers seen for the diameter of the wires.

Question 18 (b)

This was straightforward for most, although some could not rearrange the relevant equation or did not know which of R and ρ is resistance and which is resistivity. The unit was quite frequently omitted or a power applied to metre, usually -1 or 2.

(b) The coil of the rheostat is 10.2 cm long. A potential difference of 12 V is applied across AB and the slider C is 7.0 cm from the end of the coil near A.

Calculate the potential difference across AC.

(2)

$10.2 - 7.0 = 3.2$ $\quad \frac{3.2}{10.2} \times 100 = 31.37\%$

31.37% of 12 is 3.7644 V

Potential difference = 3.7644 V

ResultsPlus
Examiner Comments

The correct principles have been applied, but for the wrong portion of the coil.

(b) The coil of the rheostat is 10.2 cm long. A potential difference of 12 V is applied across AB and the slider C is 7.0 cm from the end of the coil near A.

Calculate the potential difference across AC.

(2)

ratio AC : ~~AB~~ BC : ~~[illegible]~~ AB

7 : ~~3.2~~ 3.2 : ~~7.0~~ : 10.2

~~$\frac{7}{10.2} \times 12 = 3.76$ V~~

$\frac{R_1}{R_1+R_2} = \frac{7.0}{10.2} \times 12 = 8.24$ V

Potential difference = ~~3.76 V~~ 8.24 V

ResultsPlus
Examiner Comments

A typical correct answer.

Question 19 (a)

With a quarter of candidates scoring 0, a quarter 1, a quarter 2 and a quarter more than 2, this was not that well answered in terms of applying the correct physics in sufficient detail. In terms of the underlying understanding it was somewhat better, and the way candidates set out their answers was very encouraging, with neatly delineated sections for the three parts and attempts at logical sequences within them. The key to the lack of marks was often the lack of detail for distance and speed, with amount of rain being a bit less well understood.

The most common mark was for describing the application of the pulse echo technique, the factor of 2 usually being included. Discussion of the speed to be used was often absent, although the numerical value was seen as often as a description of the speed to be used.

The Doppler effect was fairly frequently named when describing determination of speed, but the actual effect – a change in frequency – was not always mentioned. When it was, the discussion generally went on to the difference between an approaching source and a receding source but did not often extend to a link between the velocity and the size of the frequency change.

Candidate who gained the second mark often did so by quoting the relevant equation. Some answers were given only in terms of wavelength, but the question asked about frequency. There were quite a few references to red shift and blue shift, generally correct in terms of recession or approach but of no merit for this question.

Some candidates appeared to mentally insert the word 'respectively' as they read the question, assuming the order of the measurements was the same as the order of the quantities being determined. This resulted in explanations of the amount of rain in terms of frequency – often with the idea that pulses would be reflected more frequently if there was more rain. Some candidates linked the intensity to the amount of rain, but some used intensity to describe the amount of rain as well or instead. Some tried to apply the formula intensity x area. Others were thinking of microwave ovens – perhaps after looking at question 20 – and thought that there would be greater absorption with more rain. In this case it was not clear how a signal would ever be received as there would be no reflection with no rain and maximum absorption with a lot of rain. Perhaps candidates thought the source was on the other side of the rain.

19 Meteorologists use radar to monitor rain.

Radar uses pulses of microwaves. The emitted pulses are directed horizontally towards rain. The pulses are reflected from the rain and detected. The time taken for the reflected pulses to return, their intensity and frequency are all measured.

*(a) Explain how these measurements can be used to determine the distance to the rain, the relative speed of the rain towards the detector and the amount of rain falling.

(6)

The distance to the rain can be worked out by using the equation distance = speed x time. Microwaves are an electromagnetic wave so they travel at approximately 3×10^{8} ms^{-1}. So the distance is the time taken between the pulse hitting the rain and returning, multiplied by $3\times10^8 ms^{-1}$. The higher the frequency, the more rain that's falling. This is because there must be a lot of rain in order for more pulses to be reflected. The intensity of the pulses can then be used to work out the relative speed of the rain towards the detector.

ResultsPlus
Examiner Comments

This candidate has taken the measurements made and the quantities determined to be in the same order and has consequently been unable to answer the last two parts. Given this error, it has still been structured well and set out in a sensible sequence.

The first part has been identified and described correctly in outline, but lacks the detail of the application of the factor of two to the distance 'there and back'.

19 Meteorologists use radar to monitor rain.

Radar uses pulses of microwaves. The emitted pulses are directed horizontally towards rain. The pulses are reflected from the rain and detected. The time taken for the reflected pulses to return, their intensity and frequency are all measured.

*(a) Explain how these measurements can be used to determine the distance to the rain, the relative speed of the rain towards the detector and the amount of rain falling.

(6)

- The distance of the rain can be identified by ~~using~~ finding the time taken for the pulse to reach the rain and come back, and place it in the formula → $s = vt$

- The speed of the rain can be found by using /finding the frequency at different times, and using the knowledge of the doppler effect, were if the frequency increases, the rain is getting closer, and if the frequency is decreasing it is moving away. And the rate of change of frequency can be used to measure and find out the speed of the rain.
- The intensity of the pulses can be used to find out the amount of rain falling, as the intensity of returning pulses increases, there is more rain. (more pulses returning, means more rain)

ResultsPlus
Examiner Comments

This response demonstrates the identification of all the right phenomena and techniques, but lacks sufficient detail to gain more than 2 marks.

The distance part doesn't include the factor of two or the speed of light.

The next part refers to the change in frequency for a mark, but when it says 'the rate of change of frequency can be used to measure and find out the speed of the rain', it should be using the change in frequency and linking a greater change to a greater speed.

The last part links the intensity of the detected signal to the quantity of rain, but not in a causal way, so 1 mark is awarded for this.

Question 19 (b) (i)

An answer seen a number of times on this paper, but only a quarter got the mark. There was often reference to avoiding interference or a statement that the transducer could not emit and receive at the same time, perhaps thinking of another specific application. Many said it was necessary to enable the time to be measured, or the converse, but without suggesting what difference it made.

(b) (i) Explain why pulses of microwaves are used rather than a continuous beam.

(1)

So that the time for a pulse to be emitted and detected can be measured.

ResultsPlus
Examiner Comments

The stated answer is clearly a requirement of the technique, but the answer does not suggest how pulses help with this.

(b) (i) Explain why pulses of microwaves are used rather than a continuous beam.

(1)

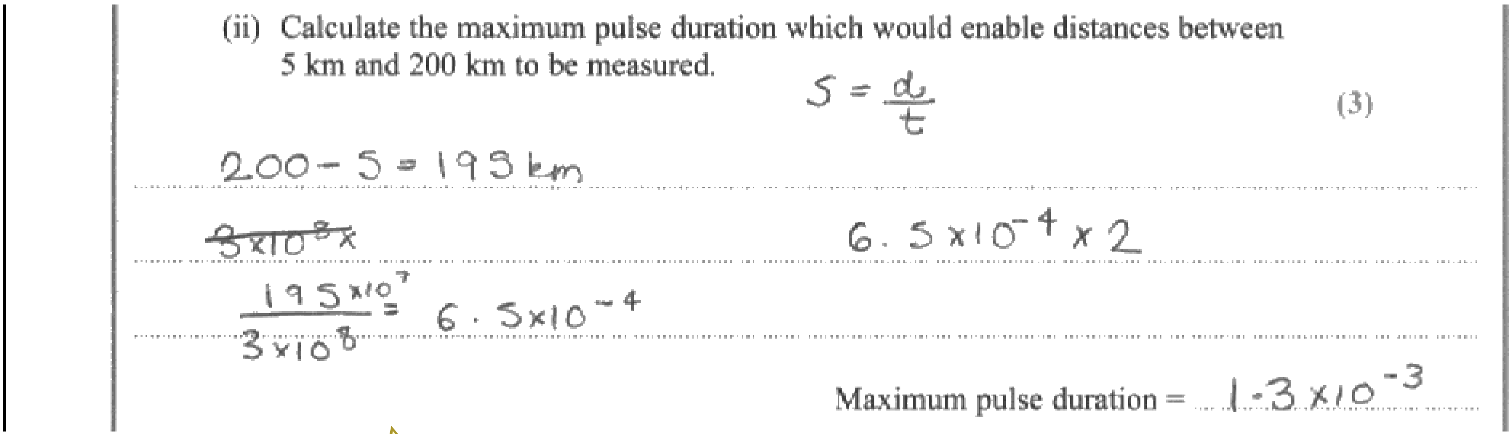
So you ~~know~~ can dectect a pulse you've sent before Sending out another.

ResultsPlus
Examiner Comments

A fairly standard answer for this technique.

Question 19 (b) (ii)

This showed that many candidates can apply the pulse-echo technique in general, but they do not really understand the significance of pulse length. About two thirds could apply the speed equation, although a number went wrong rearranging it to calculate time and they were not awarded the first mark if they did this before substituting values. Many used both quoted distance values and chose one answer after calculating both times. They nearly always chose the wrong value – the value calculated using 200 km. Others used 200 – 5 = 195 km, presumably because the question said distances between 5 km and 200 km. Some neglected the factor of 2 – even though they generally included it in their descriptions in part (a). Overall, only one in seven identified 5 km as the relevant distance for the calculation and only one in twenty completed the calculation correctly, the difference generally being due to missing the factor of 2 or getting powers of 10 wrong for km.



(ii) Calculate the maximum pulse duration which would enable distances between 5 km and 200 km to be measured.

(3)

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

200 − 5 = 195 km

~~$3 \times 10^8 \times$~~

$\frac{195 \times 10^7}{3 \times 10^8} = 6.5 \times 10^{-4}$

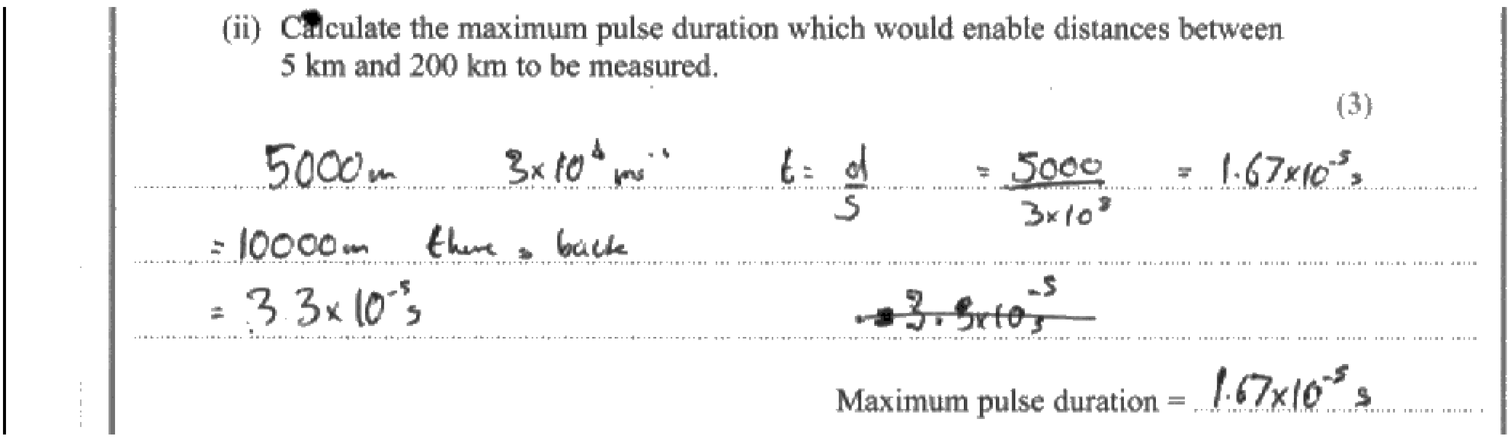
$6.5 \times 10^{-4} \times 2$

Maximum pulse duration = 1.3×10^{-3}

ResultsPlus

Examiner Comments

The correct method is applied to an incorrect distance to get 1 mark. The missing unit does not affect the mark as the final answer is not numerically correct.



(ii) Calculate the maximum pulse duration which would enable distances between 5 km and 200 km to be measured.

(3)

5000 m 3×10^8 m s^{-1} $t = \frac{d}{s}$ $= \frac{5000}{3 \times 10^8} = 1.67 \times 10^{-5}$ s

= 10000 m there & back

$= 3.3 \times 10^{-5}$ s ~~3.3×10^{-5} s~~

Maximum pulse duration = 1.67×10^{-5} s

ResultsPlus

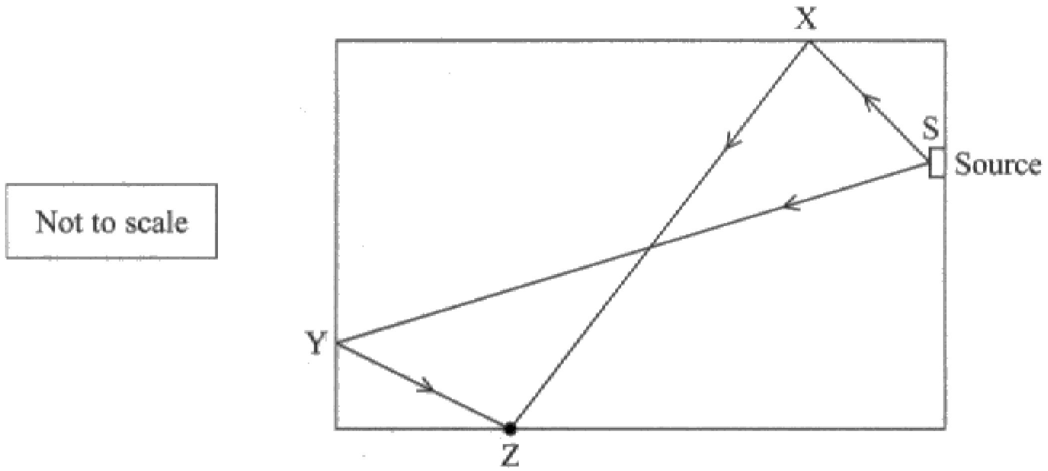
Examiner Comments

The full correct answer is given here, but the chosen answer on the answer line is not the correct one, so this is awarded 2 marks.

Question 20 (a)

About two thirds were able to calculate the path difference in cm or wavelengths, but fewer than half of them went on to identify the correct phase difference. Most just quoted 12 cm or λ or 1. Some gave alternative answers, like 12 cm/λ/2π. This did not get the mark because the candidate needs to select the correct answer, not the examiner.

(a) The diagram shows two different paths by which microwaves can reach the point Z.



SX = 9 cm, XZ = 23 cm, SY = 36 cm, YZ = 8 cm

Calculate the phase difference between microwaves from the source at S reaching point Z by the two different paths.

(2)

SX + XZ = 9 + 23 = 32 cm

SY + YZ = 36 + 8 = 44 cm

44 − 32 = 12 → $\frac{12}{12}$ = λ

Phase difference = 1 λ

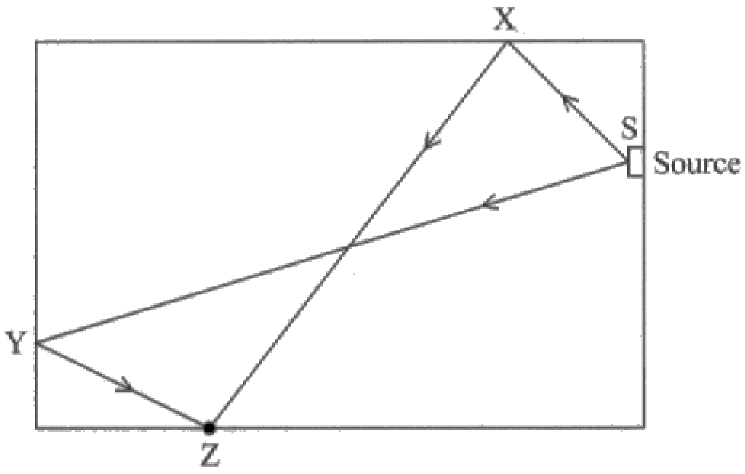
ResultsPlus

Examiner Comments

The path difference has been calculated and equated to one wavelength, but this has not been used to determine the phase difference, suggesting that the difference between path difference and phase difference is not appreciated.

(a) The diagram shows two different paths by which microwaves can reach the point Z.

Not to scale



SX = 9 cm, XZ = 23 cm, SY = 36 cm, YZ = 8 cm

Calculate the phase difference between microwaves from the source at S reaching point Z by the two different paths.

(2)

Wavelength = 12 cm. 9+23 = 32 36+8 = 44

44−12 = 32 So 1 Wavelength out (λ) (2π)

Phase difference = 12cm / 1λ / 2π

ResultsPlus

Examiner Comments

The calculations are correct, but the fact that the final answer is given as three alternatives suggests that the candidate is not sure which is correct. In such a case, the mark will not be awarded if any of the choices are not correct. An answer 0 / 2π / 360°, although still not ideal, would have been accepted as they are individually acceptable answers.

Question 20 (b)

The majority got two marks, a large minority got three, but very few got full marks. Some candidates just described uneven heating in terms of distance from the source or the number of reflections, but most mentioned superposition or interference. They generally linked constructive interference to hot and destructive to cold. While the path difference was reasonably described for these points, the phase difference was often not mentioned, or reference was made to 'out of phase' rather than 'antiphase'. Correct and sufficient mention of the effect on amplitude was quite rare. Some answers discussed waves, or even peaks and troughs, adding up or cancelling. Others discussed increased displacement or zero displacement – but not constant zero displacement.

Question 20 (c)

Only about a quarter included a reference to constant phase difference, often just saying coherence means the same frequency. The requirement for coherence frequently did no more than rephrase the question with the addition of one new word, saying that if they are not coherent, interference cannot occur. Only one in forty managed a full explanation.

(c) Explain why the microwaves reaching a point in the chocolate must be coherent for this effect to occur.

(2)

They must be coherant to be able to ~~superpose together.~~ superpose together.

ResultsPlus
Examiner Comments

This not a typical answer and does not get a mark.

(c) Explain why the microwaves reaching a point in the chocolate must be coherent for this effect to occur.

(2)

if the microwaves are not coherent, they will be oscillating at different rates, so there ~~[illegible]~~ areas of high amplitude and low amplitude will not be in the same position.

ResultsPlus
Examiner Comments

It is possible that the candidate has some understanding, in that the areas of high and low amplitude would not be in the same positions over time, but that is not sufficiently well expressed. The key point of the constant phase relationship is not included here.

Question 20 (d)

Most candidates realised that they needed to carry out a calculation and most of those got it correct. They didn't all calculate wavespeed. Some used the microwave frequency and the speed of light to calculate wavelength, comparing it to 12 cm, and some used wavelength to calculate frequency, comparing it to 2450 MHz.

The unit MHz caused a problem for some, and some weren't sure of the wavelength. Overall, half of the entrants completed one of the calculations correctly and compared it to the relevant given value.

(d) The microwave frequency is stated on the oven as 2450 MHz.

Evaluate the success of this experiment at determining the speed of light.

(3)

This is not a very good experiment for determining the speed of light because you are unable to track the ~~microwav~~ microwaves accurately and effectivly just by looking at how the chocolate is melted.

ResultsPlus
Examiner Comments

Answers without calculation could not score on this question. The answer depends on the specific outcome.

(d) The microwave frequency is stated on the oven as 2450 MHz.

Evaluate the success of this experiment at determining the speed of light.

(3)

Speed of light is 3.00×10^8 ms-1 and if the frequency is 2450 MHz it would ~~take around~~ mean that the wavelength should be around 12cm so the sucess of the experiment ~~has~~ is fairly good as all outcomes suit eachother.

ResultsPlus
Examiner Comments

As suggested for the previous sample, a calculation is required to be awarded marks. Here, all the relevant numbers have been quoted, but there is no evidence of a calculation. A calculated speed would be the quoted speed to 1 s.f. and the wavelength as quoted to 2 s.f., but they are exactly as stated in the available data and it is not clear that the candidate understands the required relationship. If the answers had been quoted to extra s.f., as in a 'show that' question, the marks could have been awarded as the answer would have shown that a calculation had been carried out.

(d) The microwave frequency is stated on the oven as 2450 MHz. $\times 10^{6}$ Hz

Evaluate the success of this experiment at determining the speed of light.

(3)

$f = 2450 \times 10^{6}$ $v = f\lambda$

$\lambda = 12 \times 10^{-2}$ $v = (2450 \times 10^{6}) \times (12 \times 10^{-2})$

$v = 2.94 \times 10^{8}\ ms^{-1}$

speed of light $= 3 \times 10^{8}\ ms^{-1}$

ResultsPlus

Examiner Comments

The calculation is correct and the speed of light has been quoted, but there is no comment comparing the values to evaluate the success of the experiment, so the third mark is not awarded. An evaluation will always require a conclusion of some sort.

Paper Summary

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

- learn definitions thoroughly so they can be quoted fully when required.
- use past papers and mark schemes for revision, but don't repeat sections of previous mark schemes verbatim in the answers to new contexts.
- learn standard descriptions of physical processes, such as the photoelectric effect, and be able 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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