Examiners' Report
June 2013

GCE Physics 6PH02 01

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June 2013

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Introduction

This is the fifth 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 less confusion about quantum phenomena than has sometimes been seen, with very few using spectra explanations when discussing the photoelectric effect, for example.

For many candidates, areas for improvement include learning definitions for standard terms in detail and being able to identify specific parts of longer explanations of phenomena that apply to particular situations.

Candidates seem unwilling in general to apply their experience of physical phenomena and common magnitudes of quantities to challenge conclusions arrived at by incorrect mathematics or mistaken application of formulae.

Section A - Multiple choice

Question	Percentage of Correct Responses
1	84
2	60
3	24
4	48
5	86
6	45
7	57
8	58
9	86
10	41

Some questions were more challenging, but the preferred incorrect choices may reveal some areas for development. In the following questions a large majority of candidates with incorrect answers made the same choice.

Q2. The 40% getting this wrong usually selected answer A, perhaps because *v* was mentioned and they thought they should use everything. These candidates should think about the mass moving at a steady speed, so the numerator in choice A will be constant while the denominator increases steadily with time, suggesting efficiency steadily decreases.

Q3. The majority opted for answer C. This would be true with distance travelled on the x axis, but the graph against time shows X reaching a maximum at time zero, whereas Y does so a quarter of a cycle later.

Q7. A was the preferred incorrect answer. This involved multiplying energy by time and dividing by area, rather than dividing energy by time. The root problem here is the relationship between energy, power and time, or their respective units, depending on the approach taken.

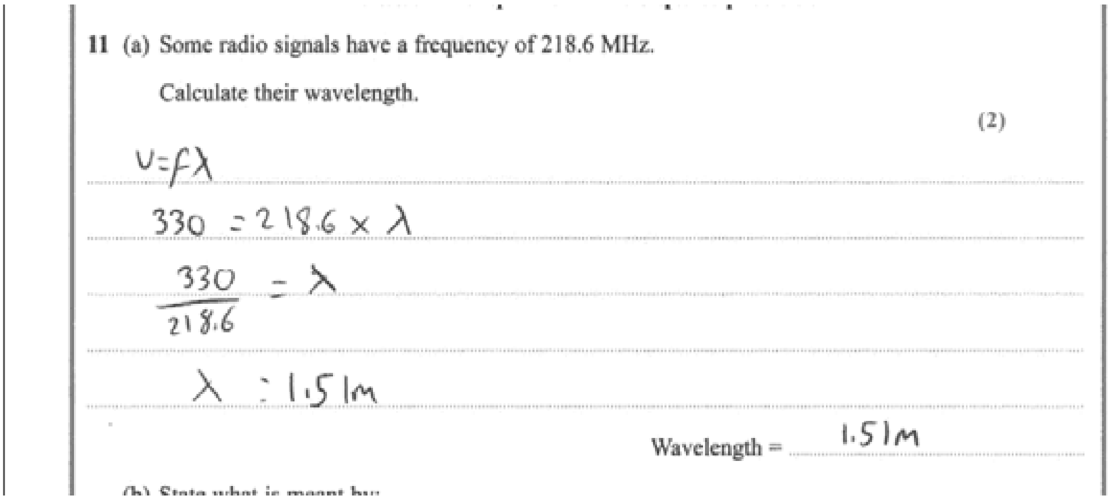
Q8. While C and D were both represented in the incorrect answers in the ratio of 3:2, what they had in common was an angle of refraction of 57°, i.e. the value seen on the diagram without using a normal.

Q9. While most got this correct, those who did not always selected C, failing to convert hours to seconds.

Q10. Despite past questions linking this to superposition, about half the entry thought it was not involved and clearly thinking that polarisation was. They may have been thinking of examples of polarisation by reflection.

Question 11 (a)

The majority of candidates were able to complete the calculation satisfactorily, although a number failed to get the power of 10 for MHz correct, applying kHz or GHz or even mHz. A small group omitted the final unit and some used the speed of sound in air, which was not given on the paper.



11 (a) Some radio signals have a frequency of 218.6 MHz.

Calculate their wavelength.

(2)

$v = f\lambda$

$330 = 218.6 \times \lambda$

$\frac{330}{218.6} = \lambda$

$\lambda = 1.51 \text{m}$

Wavelength = 1.51m

(b) State what is meant by:

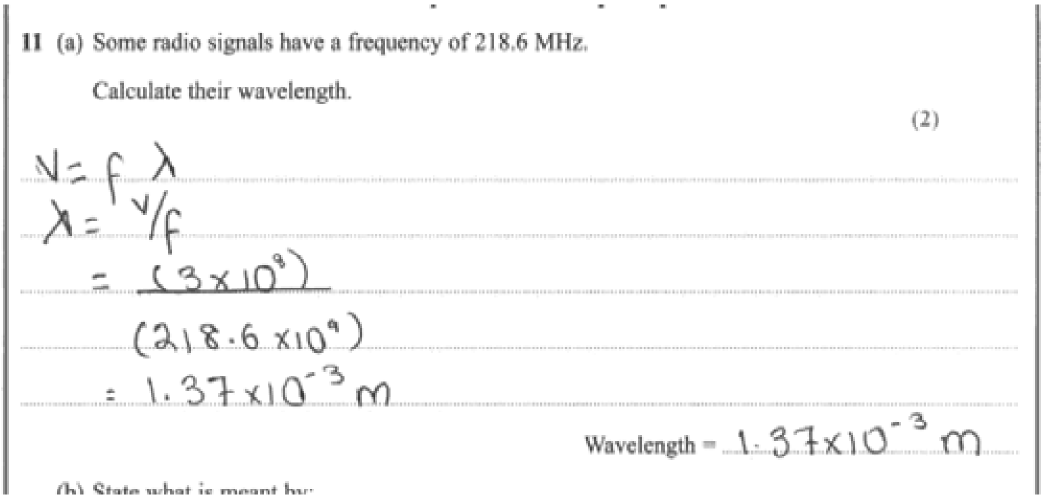
ResultsPlus
Examiner Comments

Wave speed is not stated in the question because candidates should know that radio signals are part of the electromagnetic spectrum and travel at the speed of light which is quoted in the list of data.

This candidate has used the speed of sound instead and gets no marks.

ResultsPlus
Examiner Tip

Make sure you are familiar with the list of data and know when to use them.


11 (a) Some radio signals have a frequency of 218.6 MHz.

Calculate their wavelength.

(2)

$v = f\lambda$

$\lambda = v/f$

$= \frac{(3 \times 10^8)}{(218.6 \times 10^9)}$

$= 1.37 \times 10^{-3}$ m

Wavelength = 1.37×10^{-3} m

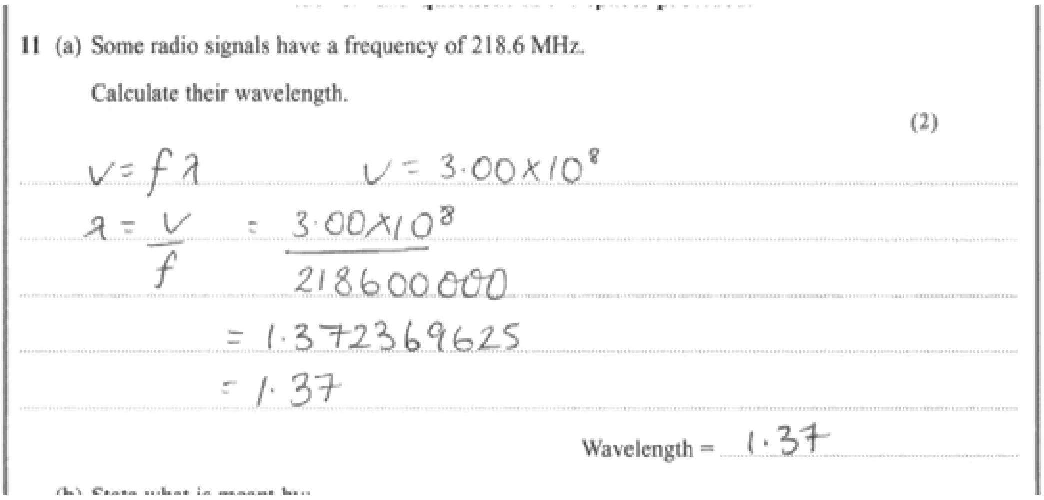
(b) State what is meant by:

ResultsPlus
Examiner Comments

Here the SI prefix M has been incorrectly interpreted as 10^9, which would actually be G.

ResultsPlus
Examiner Tip

Be sure to learn the SI prefixes.


11 (a) Some radio signals have a frequency of 218.6 MHz.

Calculate their wavelength.

(2)

$v = f\lambda$ $\quad v = 3.00 \times 10^8$

$\lambda = \frac{v}{f} \quad = \frac{3.00 \times 10^8}{218600000}$

$= 1.372369625$

$= 1.37$

Wavelength = 1.37

(b) State what is meant by:

ResultsPlus
Examiner Comments

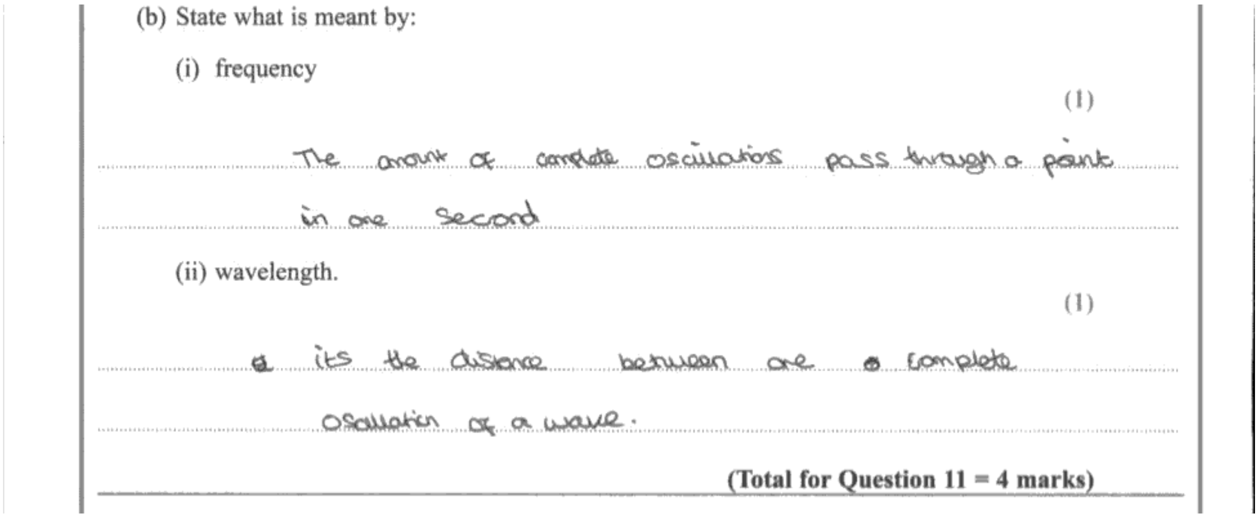
The calculation is correct, but there is no unit.Answers must have a magnitude and a unit to gain credit unless the unit is given, so this candidate gets one mark only.

ResultsPlus
Examiner Tip

Always include the unit with numerical answers.

Question 11 (b)

The majority gained a mark for stating what is meant by frequency, but only about a quarter of candidates completed both definitions with the required detail. Some lost the mark for frequency by writing about the number of oscillations 'in a given time'. With wavelength, the definitions often referred to the distance between crests without specifying that they must be adjacent. Others wrote about the length of an oscillation, an ambiguous answer which corresponds more closely to twice the amplitude.



(b) State what is meant by:

(i) frequency

(1)

The amount of complete oscillations pass through a point in one second

(ii) wavelength.

(1)

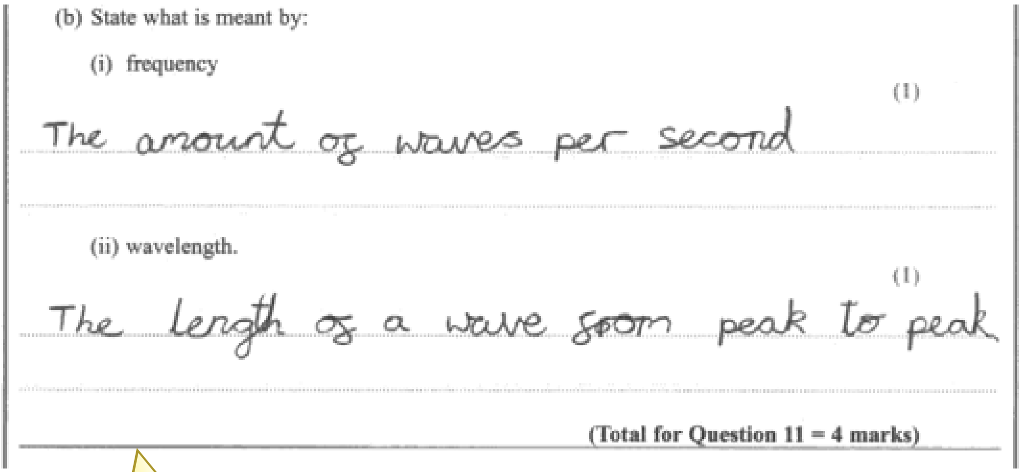
its the distance between one complete oscillation of a wave.

(Total for Question 11 = 4 marks)

ResultsPlus

Examiner Comments

This response scores the mark for frequency, but the wavelength description is too imprecise. It should say the distance travelled by the wave during one complete oscillation. The way this has been written, it could refer to 4 times the amplitude.



(b) State what is meant by:

(i) frequency

(1)

The amount of waves per second

(ii) wavelength.

(1)

The length of a wave from peak to peak

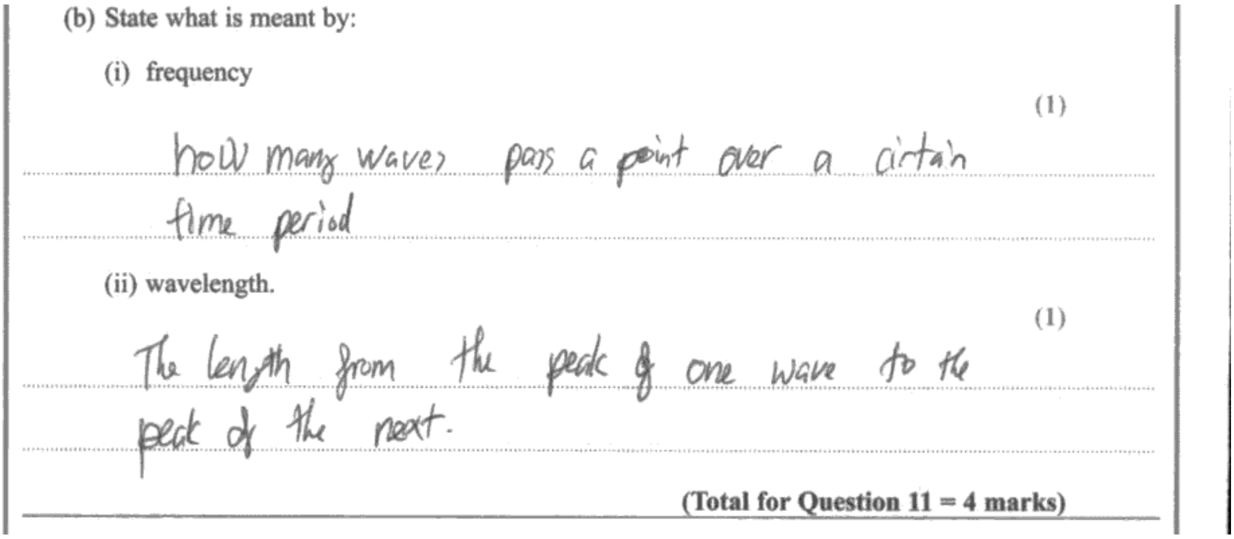
(Total for Question 11 = 4 marks)

ResultsPlus

Examiner Comments

The frequency mark is awarded, although it should say number of waves and not amount of waves.

'The length of a wave from peak to peak' does not indicate that the peaks are adjacent and could represent any number of wavelengths.



(b) State what is meant by:

(i) frequency

(1)

how many waves pass a point over a cirtain time period

(ii) wavelength.

(1)

The length from the peak of one wave to the peak of the next.

(Total for Question 11 = 4 marks)

ResultsPlus

Examiner Comments

The wavelength mark is awarded, but not the frequency mark. It refers to the number of waves in a given time, but a reference to unit time would be required here.

ResultsPlus

Examiner Tip

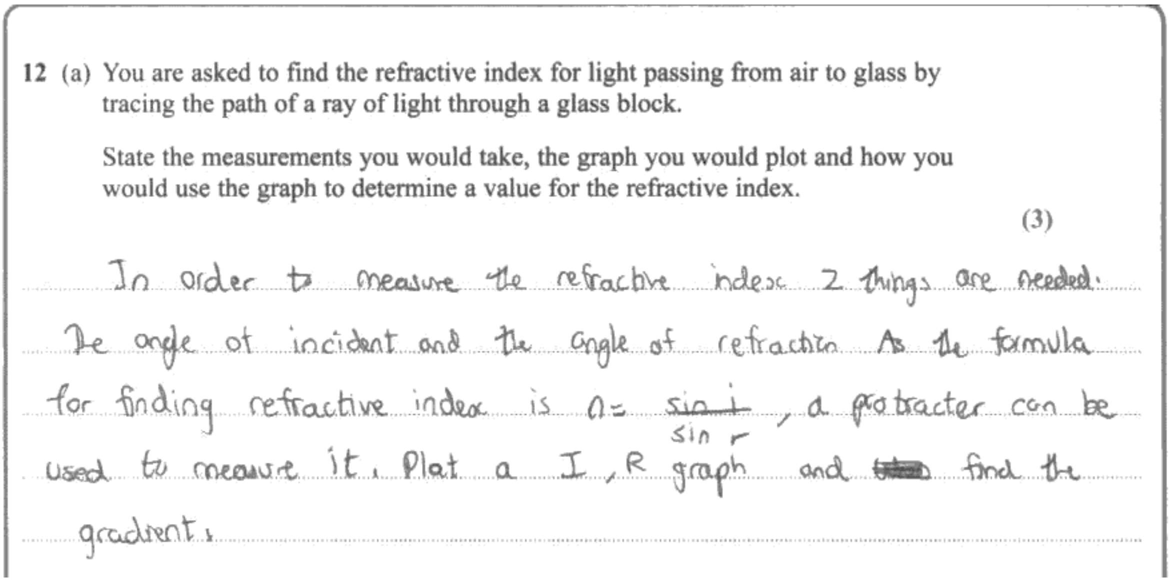
Learn the meanings of the terms listed throughout the specification so they can be quoted directly when required.

Question 12 (a)

Very few failed to get at least one mark for identifying the angles of incidence and refraction. Those who did not do so often attempted a method using critical angle, which did not lead to a graph, or suggested measuring the speed of light in both media. Unsurprisingly, the latter group did not suggest how this might be done. There was also a scattering of answers stating the angle of reflection.

About half of the candidates got all three marks, but those who did not either failed to refer to a graph or described a graph of angle of incidence against angle of refraction only.

Many candidates spent far too much time on the question, giving a detailed method. The question required them to 'state', not 'describe' or 'explain': their measurements and could have been answered with three short statements.



12 (a) You are asked to find the refractive index for light passing from air to glass by tracing the path of a ray of light through a glass block.

State the measurements you would take, the graph you would plot and how you would use the graph to determine a value for the refractive index.

(3)

In order to measure the refractive index 2 things are needed. The angle of incident and the angle of refraction As the formula for finding refractive index is $n = \frac{\sin i}{\sin r}$, a protracter can be used to meaure it. Plot a I, R graph and find the gradient.

ResultsPlus

Examiner Comments

This response identifies the required quantities, but identifies the wrong graph.

The correct formula is quoted, so it should be clear that the quantities plotted on the graph are those in the formula.

12 (a) You are asked to find the refractive index for light passing from air to glass by tracing the path of a ray of light through a glass block.

State the measurements you would take, the graph you would plot and how you would use the graph to determine a value for the refractive index.

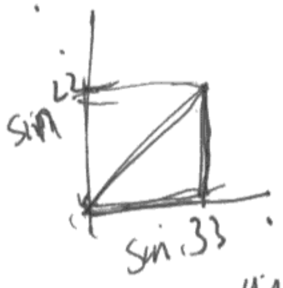
(3)

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

I would have a block of ~~la~~ glass. And shine light through it measuring the angle from the normal (Angle of incidence). ~~I will take many readings~~. I will also mark the light coming out on the other side and use it to work out the angle of refraction. I will take many readings at different angles.

Plot a graph of sin i - x axis
sin r - y axis

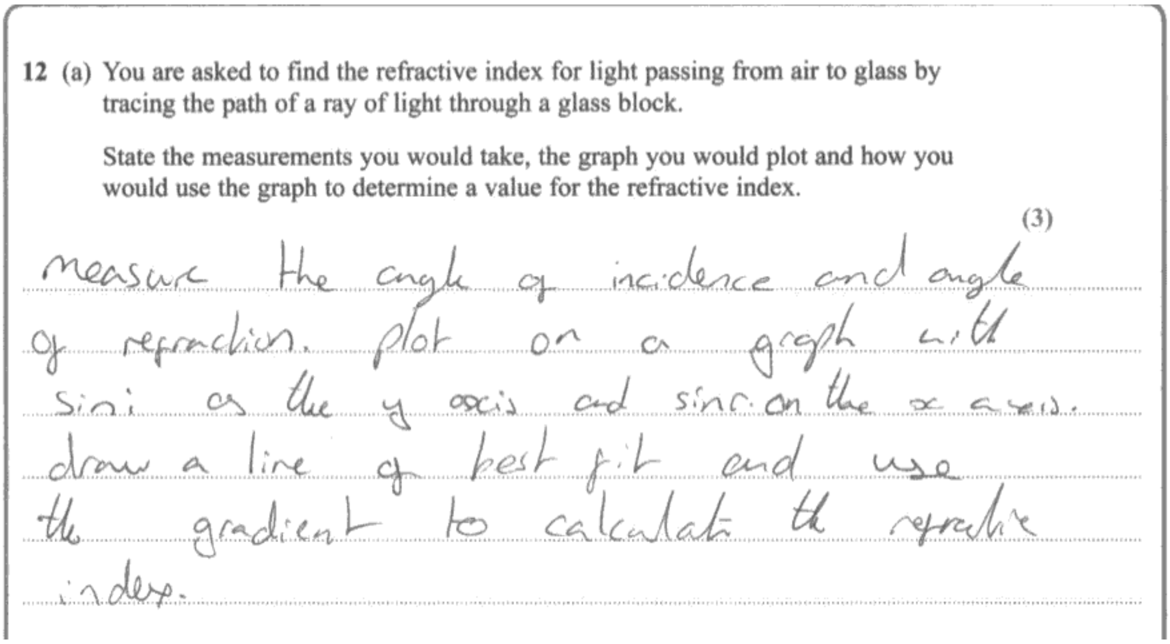
~~y axis~~ The gradient of line will give me the refractive index for light passing from air to glass



$m = \frac{y}{x}$.

ResultsPlus
Examiner Comments

The correct measurements are identified and the correct quantities are plotted on the graph, but the gradient of this graph would give the inverse of the refractive index.



12 (a) You are asked to find the refractive index for light passing from air to glass by tracing the path of a ray of light through a glass block.

State the measurements you would take, the graph you would plot and how you would use the graph to determine a value for the refractive index.

(3)

measure the angle of incidence and angle of refraction. plot on a graph with sin i as the y axis and sin r on the x axis. draw a line of best fit and use the gradient to calculate the refractive index.

ResultsPlus

Examiner Comments

A number of candidates wrote a great deal more than required for this question. They were asked to state the measurements, not to describe them.

This response shows how the question could be answered for full marks without extra information.

It is equally important to write enough when required, and the command words indicate the depth of response required.

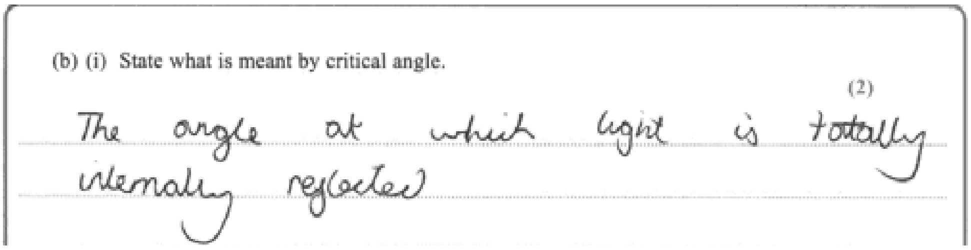
ResultsPlus

Examiner Tip

Be sure you are aware of the command words, such as state, describe, explain.

Question 12 (b) (i)

Candidates should be prepared to learn a number of basic definitions in quotable form, as many did not do for the critical angle. The simple 2 mark answer sometimes seen was, 'the angle of incidence when the angle of refraction is 90 degrees', but it was not seen most of the time with only a quarter getting both marks and just 50% picking up a single mark. The single mark was often for just about managing to describe the light leaving along the boundary. Marks were not awarded for references to the critical angle. The first mark was often not awarded because candidates wrote about 'the angle' rather than 'the angle of incidence'.



(b) (i) State what is meant by critical angle.

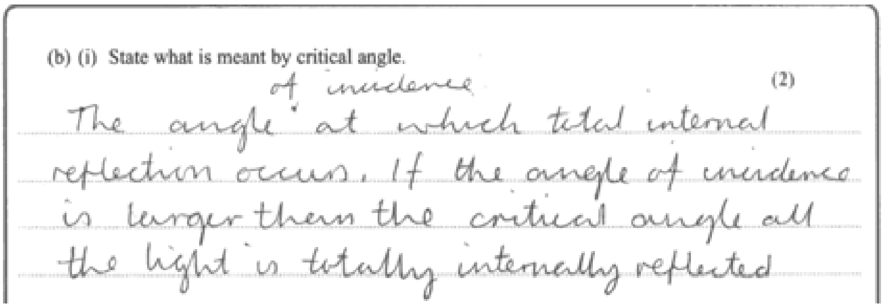
(2)

The angle at which light is totally internaly reflected

ResultsPlus

Examiner Comments

Answers in terms of total internal reflection were not sufficient. This response just refers to 'the angle' without specifying angle of incidence.



(b) (i) State what is meant by critical angle.

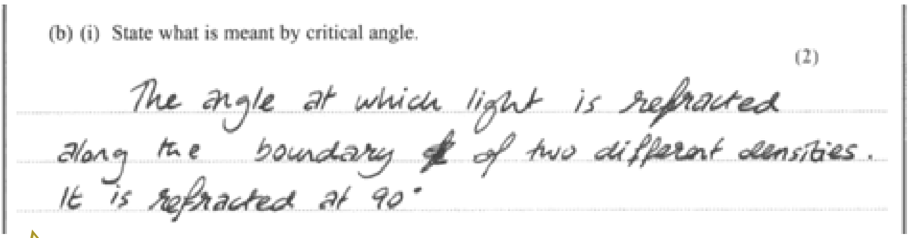
(2)

The angle of incidence at which total internal reflection occurs. If the angle of incidence is larger than the critical angle all the light is totally internally reflected

ResultsPlus

Examiner Comments

This gets credit for angle of incidence, but also refers to total internal reflection and not the angle of refraction.



(b) (i) State what is meant by critical angle.

(2)

The angle at which light is refracted along the boundary of two different densities. It is refracted at 90°

ResultsPlus

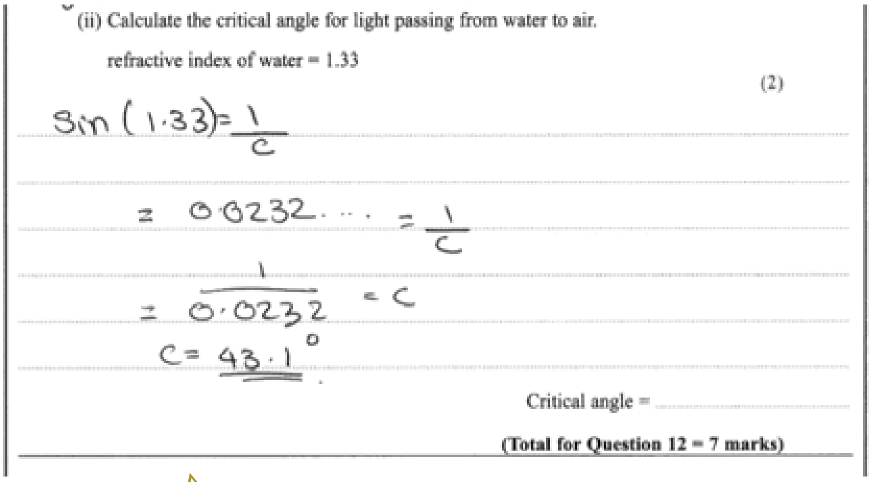
Examiner Comments

This gets the second part, about the angle of refraction, but does not specify the angle of incidence.

Question 12 (b) (ii)

About two thirds completed this calculation successfully, with a few hundred more writing the correct number but omitting the degree symbol. Those who got no marks often got the angle and refractive index mixed up in the equation, attempting to use sine of 1.33 in some way, e.g. c = 1/sin 1.33.

Many candidates used a value of 4/3 for the refractive index of water instead of 1.33. They were not penalised this time.



(ii) Calculate the critical angle for light passing from water to air.

refractive index of water = 1.33

(2)

$\sin(1.33) = \frac{1}{c}$

$= 0.0232 \ldots = \frac{1}{c}$

$= \frac{1}{0.0232} = c$

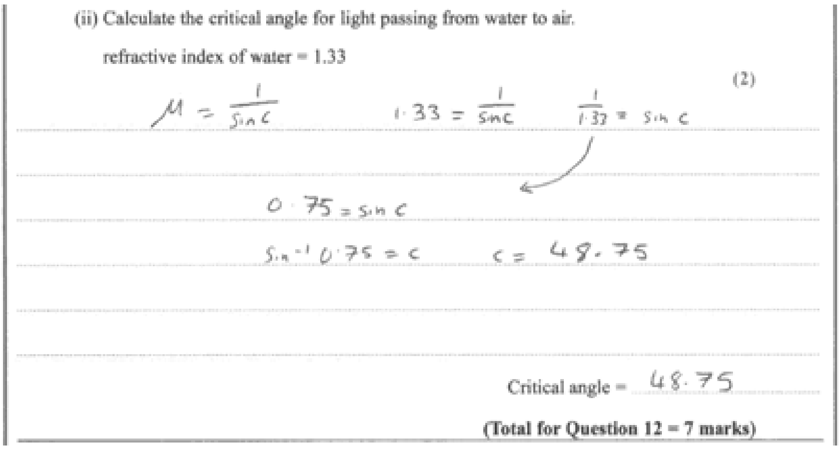
$C = 43.1^\circ$

Critical angle = ...

(Total for Question 12 = 7 marks)

ResultsPlus
Examiner Comments

The refractive index and critical angle have been reversed in this answer.



(ii) Calculate the critical angle for light passing from water to air.

refractive index of water = 1.33

(2)

$\mu = \frac{1}{\sin c}$ $\quad 1.33 = \frac{1}{\sin c}$ $\quad \frac{1}{1.33} = \sin c$

$0.75 = \sin c$

$\sin^{-1} 0.75 = c$ $\quad c = 48.75$

Critical angle = 48.75

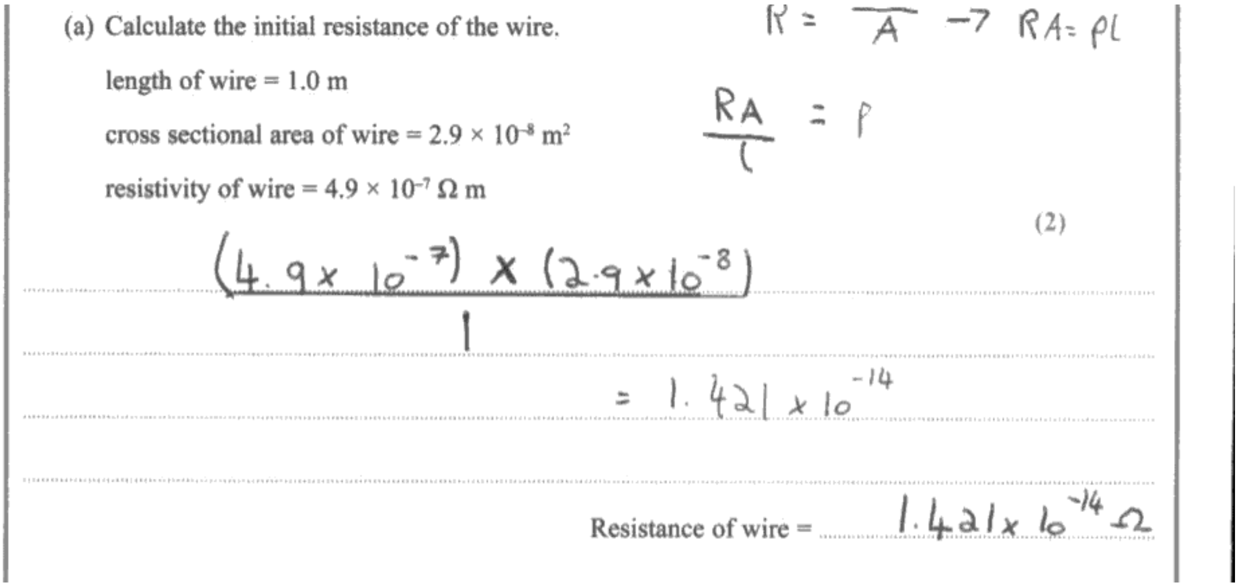
(Total for Question 12 = 7 marks)

ResultsPlus
Examiner Comments

The calculation is correct, but the degree symbol is missing, which is a unit error.

Question 13 (a)

The great majority completed this calculation successfully, although a few applied the unit Ωm to resistance. Some went wrong with powers of 10 and some reversed resistance and resistivity in the formula.



(a) Calculate the initial resistance of the wire.

length of wire = 1.0 m

cross sectional area of wire = 2.9×10^{-8} m^2

resistivity of wire = 4.9×10^{-7} Ω m

(2)

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

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

$$\frac{(4.9 \times 10^{-7}) \times (2.9 \times 10^{-8})}{1}$$

$= 1.421 \times 10^{-14}$

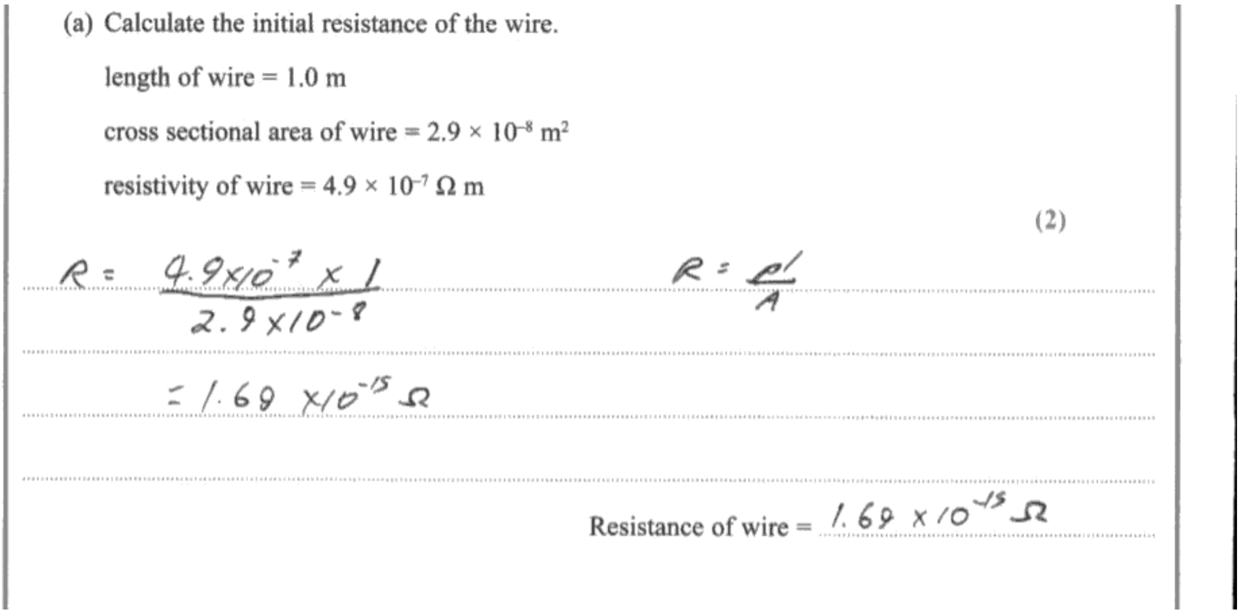
Resistance of wire = 1.421×10^{-14} Ω

ResultsPlus
Examiner Comments

The candidate has applied the correct formula, but is treating resistivity as resistance and vice versa. This may be because the symbols have not been learned correctly, so ρ is being treated as resistance and R as resistivity. This may in turn be because of the way the formula appears under the heading Resistivity in the list of formulae.

ResultsPlus
Examiner Tip

The list of data etc gives formulae in symbol form. Be sure to learn what each symbol represents.



(a) Calculate the initial resistance of the wire.

length of wire = 1.0 m

cross sectional area of wire = 2.9×10^{-8} m^2

resistivity of wire = 4.9×10^{-7} Ω m

(2)

$R = \frac{4.9 \times 10^{-7} \times 1}{2.9 \times 10^{-8}}$ $R = \frac{\rho l}{A}$

$= 1.69 \times 10^{-15}$ Ω

Resistance of wire = 1.69×10^{-15} Ω

ResultsPlus

Examiner Comments

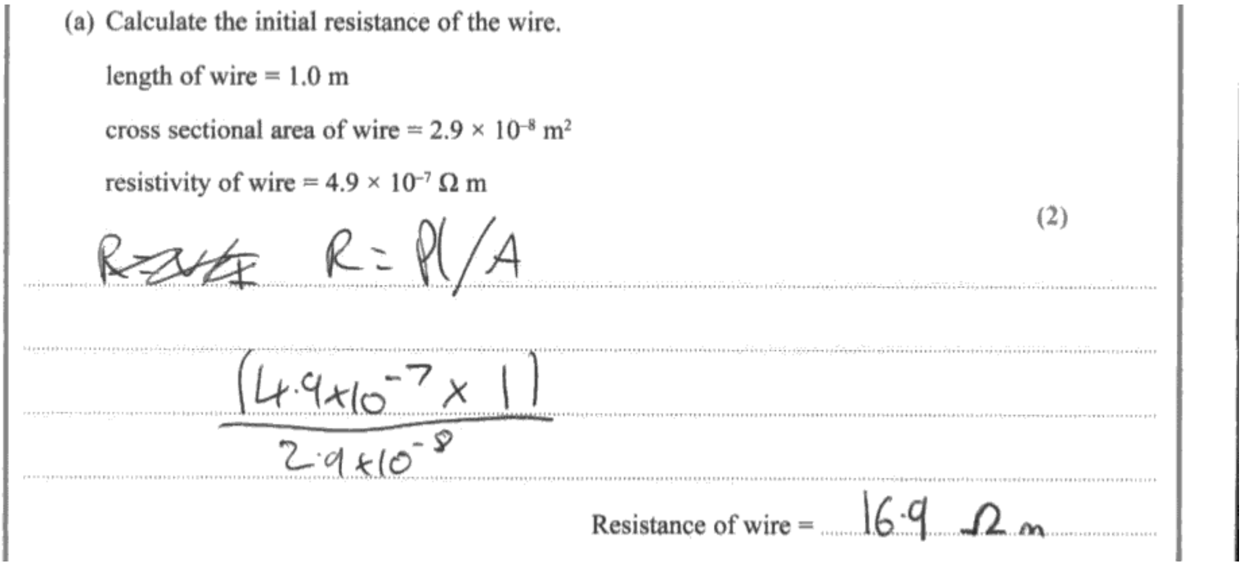
The formula and substitution are correct, but an error has been made in applying powers of ten so the answer is incorrect. It is so small that a candidate might have been expected to notice the error and check the calculation.

Questions are not set to test mathematics alone and will always give realistic answers.

ResultsPlus

Examiner Tip

Check that answers are realistic and attempt calculations again when they are not.



(a) Calculate the initial resistance of the wire.

length of wire = 1.0 m

cross sectional area of wire = 2.9×10^{-8} m^2

resistivity of wire = 4.9×10^{-7} Ω m

(2)

~~R=V/I~~ $R = \rho l / A$

$\frac{(4.9 \times 10^{-7} \times 1)}{2.9 \times 10^{-8}}$

Resistance of wire = 16.9 Ω m

ResultsPlus

Examiner Comments

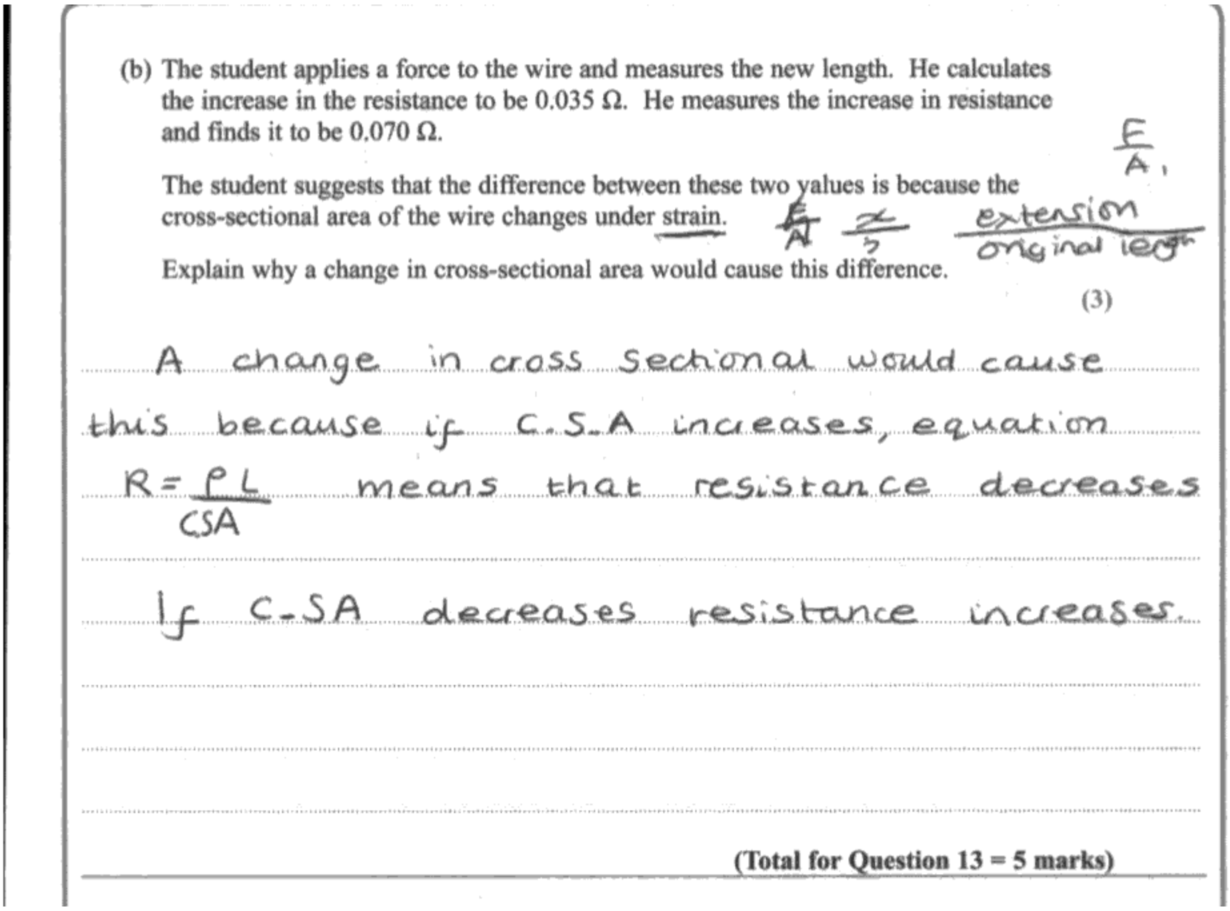
The working and numerical answer are fine, but the unit given is the unit of resistivity, not resistance.

Question 13 (b)

The great majority managed to get at least one mark, often for identifying the relationship between cross-sectional area and resistance. Those who invoked the formula were at a significant advantage. Many described in detail the effect of both an increase and a decrease in cross-sectional area, but failed to state which they thought had occurred, hence the common award of the second mark only. This is another example of failure to answer the specific question asked, which here was about ‘this difference’.

Some just wrote about change of area and change of resistance, with no reference to increase or decrease at all. Others got two marks for identifying the decrease in cross-sectional area and making a vague, descriptive link to increased resistance in terms of how hard it is for electrons to get through or crowding of electrons.

v



(b) The student applies a force to the wire and measures the new length. He calculates the increase in the resistance to be 0.035 Ω. He measures the increase in resistance and finds it to be 0.070 Ω.

$\frac{F}{A}$,

The student suggests that the difference between these two values is because the cross-sectional area of the wire changes under strain. $\cancel{\frac{F}{A}}$ $\frac{x}{l}$ $\frac{\text{extension}}{\text{original length}}$

Explain why a change in cross-sectional area would cause this difference.

(3)

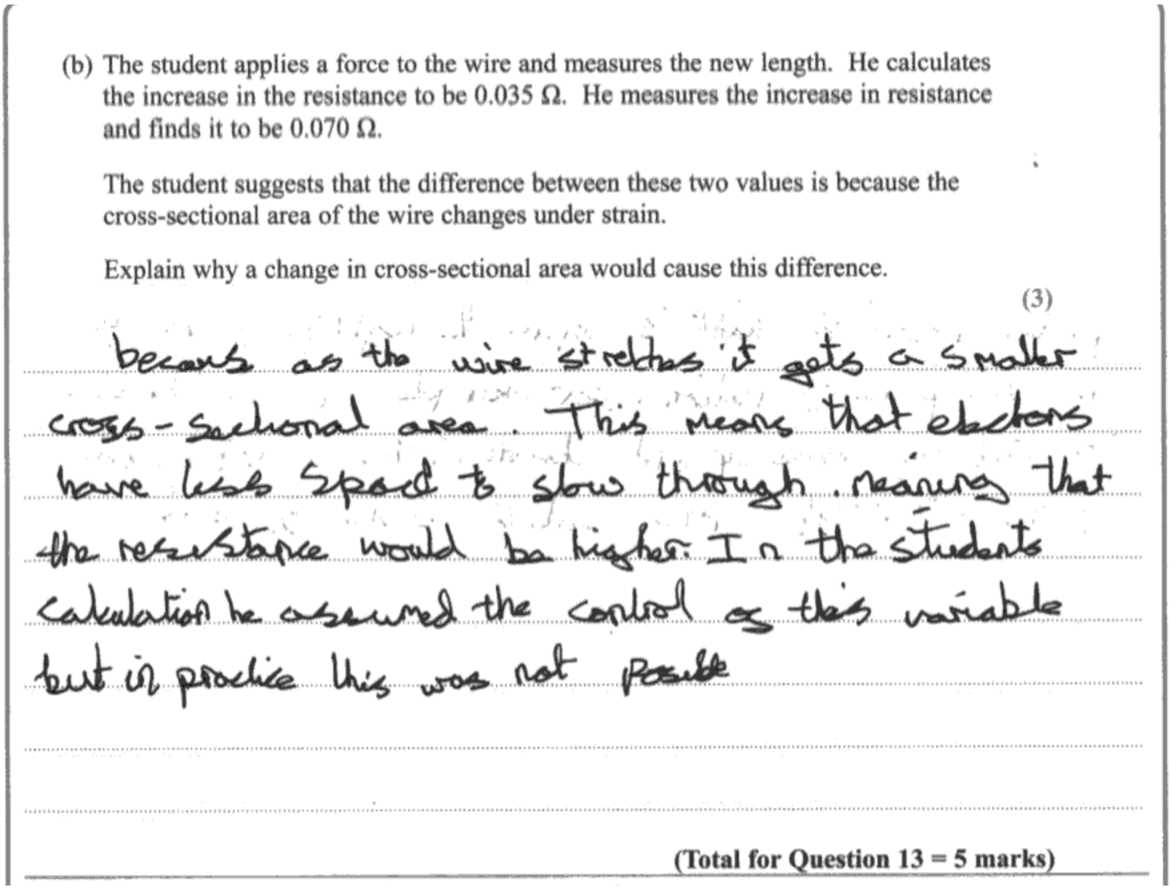
A change in cross sectional would cause this because if C.S.A increases, equation $R = \frac{\rho L}{CSA}$ means that resistance decreases

If C.SA decreases resistance increases.

(Total for Question 13 = 5 marks)

ResultsPlus
Examiner Comments

The candidate has demonstrated an understanding of the link between cross-sectional area and resistance, but has not stated which applies in this case, as required by the question where it says 'this difference' and not 'a difference'.



(b) The student applies a force to the wire and measures the new length. He calculates the increase in the resistance to be 0.035 Ω. He measures the increase in resistance and finds it to be 0.070 Ω.

The student suggests that the difference between these two values is because the cross-sectional area of the wire changes under strain.

Explain why a change in cross-sectional area would cause this difference.

(3)

becaus as the wire stretches it gets a smaller cross-sectional area. This means that electrons have less space to slow through. meaning that the resistance would be higher. In the students calculation he assumed the control of this variable but in practice this was not Possible

(Total for Question 13 = 5 marks)

ResultsPlus

Examiner Comments

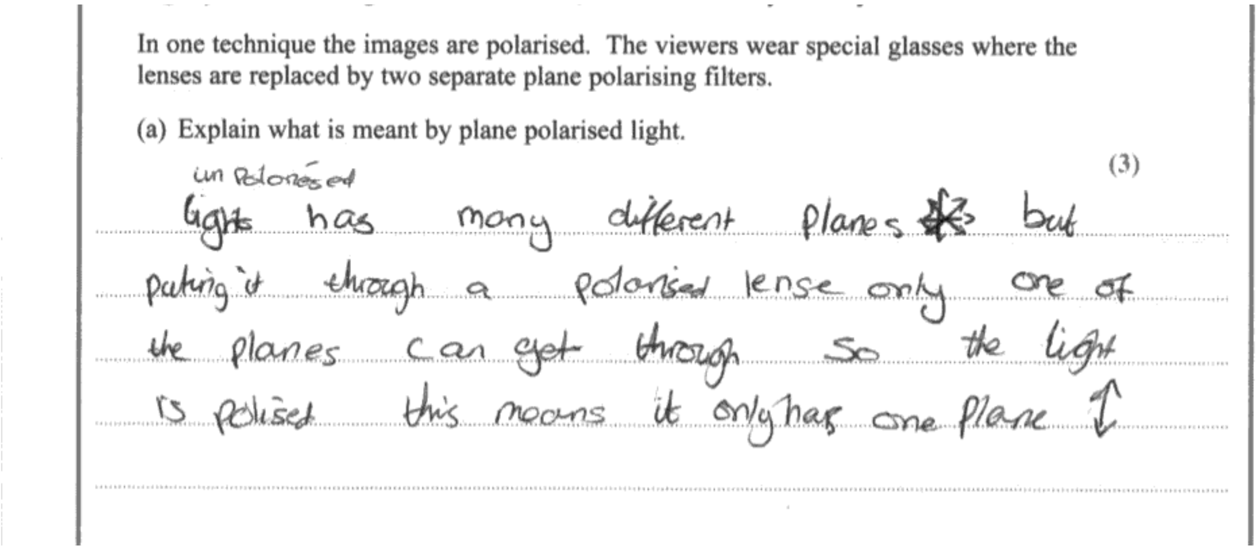
This candidate has successfully identified the decrease in cross-sectional area and has linked it to an increase in resistance for two marks. The explanation itself, in terms of less space for electrons, does not clearly establish the link.

When there is a straightforward formula linking the variables, as in this case, it is better to use the formula in explaining the outcome, such as in the previous example.

Question 14 (a)

There is knowledge of polarisation, but understanding was not so well demonstrated. A majority were able to describe oscillations in a single plane, but little more of merit. Some started by stating that it involved light travelling in a single plane, rather than oscillating. A very small minority made an attempt to describe what is oscillating – similar to sound in Question 16(a).

Most candidates who scored the mark for a single plane wrote something like 'oscillations in a single plane perpendicular to the direction of energy transfer', failing to gain the next mark. It was not always clear if these candidates were repeating part of a definition of transverse waves or stating that the single plane is perpendicular to the direction of energy transfer. The first did not gain any credit and the second is incorrect. The oscillations after polarisation are in a single plane which includes the direction of energy transfer.



In one technique the images are polarised. The viewers wear special glasses where the lenses are replaced by two separate plane polarising filters.

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

(3)

un Polonesed

lights has many different planes ✳ but puting it through a polorised lense only one of the planes can get through so the light is polised this means it only has one plane ↕

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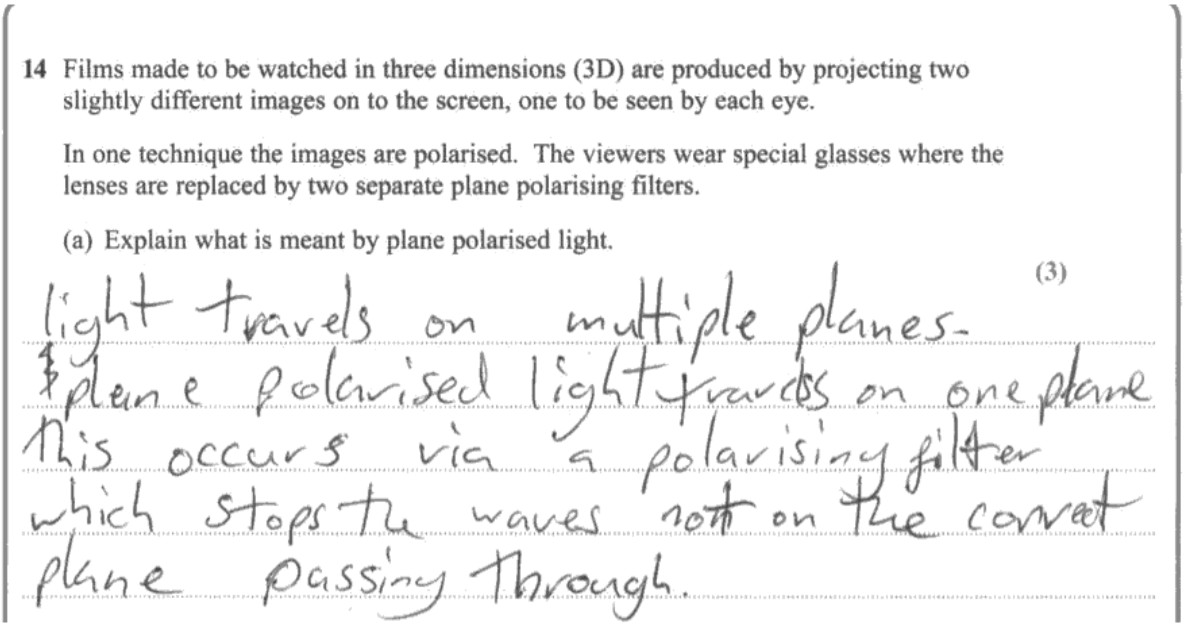
Examiner Comments

This answer refers to planes, and even has a little diagram, but the planes are not linked to oscillations.

This answer is another example where a definition should be learned.



14 Films made to be watched in three dimensions (3D) are produced by projecting two slightly different images on to the screen, one to be seen by each eye.

In one technique the images are polarised. The viewers wear special glasses where the lenses are replaced by two separate plane polarising filters.

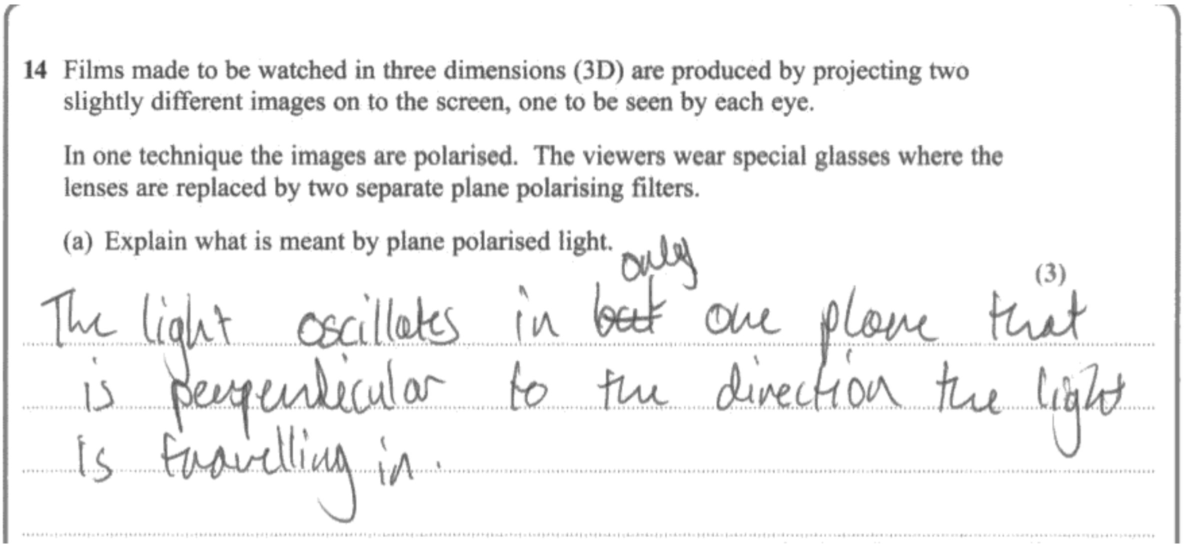
(a) Explain what is meant by plane polarised light.

(3)

light travels on multiple planes.
~~&~~ plane polarised light travels on one plane
This occurs via a polarising filter
which stops the waves not on the correct
plane passing through.

ResultsPlus
Examiner Comments

Candidates sometimes referred to the light travelling in different planes, as in this example, instead of oscillating in different planes.



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In one technique the images are polarised. The viewers wear special glasses where the lenses are replaced by two separate plane polarising filters.

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

(3)

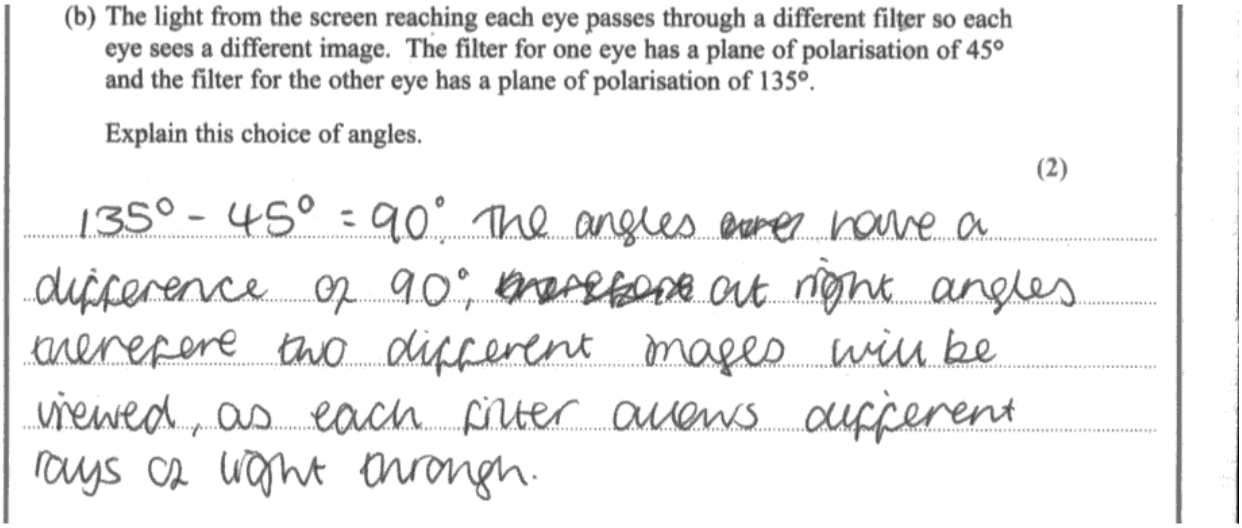
The light oscillates in ~~but~~ only one plane that
is perpendicular to the direction the light
is travelling in.

ResultsPlus
Examiner Comments

This response correctly has the oscillations in one plane. It then says that the plane is perpendicular to the direction the light is travelling in. This is true of the oscillations, but the plane includes the direction the light is travelling in.

Question 14 (b)

About half of the candidates scored a mark for identifying the 90 degree angle. Candidates often failed to realise the significance of this. The subsequent explanations of those who did understand it often failed to include sufficient detail to gain further credit. A number identified 180 degrees and based their answer on phase difference and interference. In this part of the question and the following parts, a number of candidates did not appreciate that the light leaving the screen was polarised and they only referred to polarisation of the light once it reached the glasses.



(b) The light from the screen reaching each eye passes through a different filter so each eye sees a different image. The filter for one eye has a plane of polarisation of 45° and the filter for the other eye has a plane of polarisation of 135°.

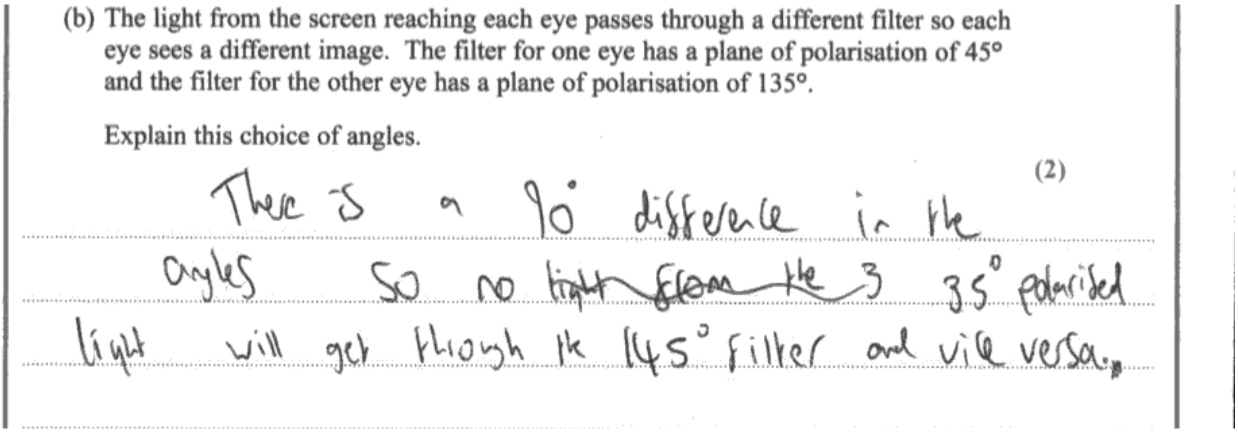
Explain this choice of angles.

(2)

135° - 45° = 90°. The angles ~~are~~ have a difference of 90°, ~~therefore~~ at right angles therefore two different images will be viewed, as each filter allows different rays of light through.

ResultsPlus
Examiner Comments

The difference between the angles has been correctly identified and there is some suggestion of the reason, but it lacks required detail, such as that shown by the next example.



(b) The light from the screen reaching each eye passes through a different filter so each eye sees a different image. The filter for one eye has a plane of polarisation of 45° and the filter for the other eye has a plane of polarisation of 135°.

Explain this choice of angles.

(2)

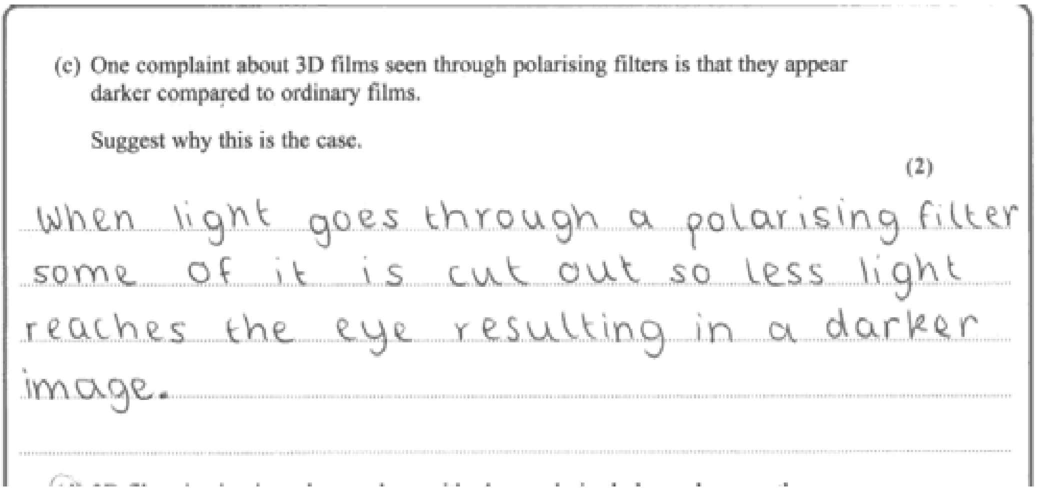
There is a 90° difference in the angles so no light from the 3 35° polarised light will get through the 145° filter and vice versa.

ResultsPlus
Examiner Comments

Both marks are awarded to this response. The angle has been identified and the way different images are seen by each eye has been explained.

Question 14 (c)

Only a quarter of candidates scored even one mark. Most just repeated their definition of polarisation in some way, describing the process as if happening to unpolarised light on reaching the glasses and then repeating the question by saying this makes it darker with no reference to amplitude or intensity.



(c) One complaint about 3D films seen through polarising filters is that they appear darker compared to ordinary films.

Suggest why this is the case.

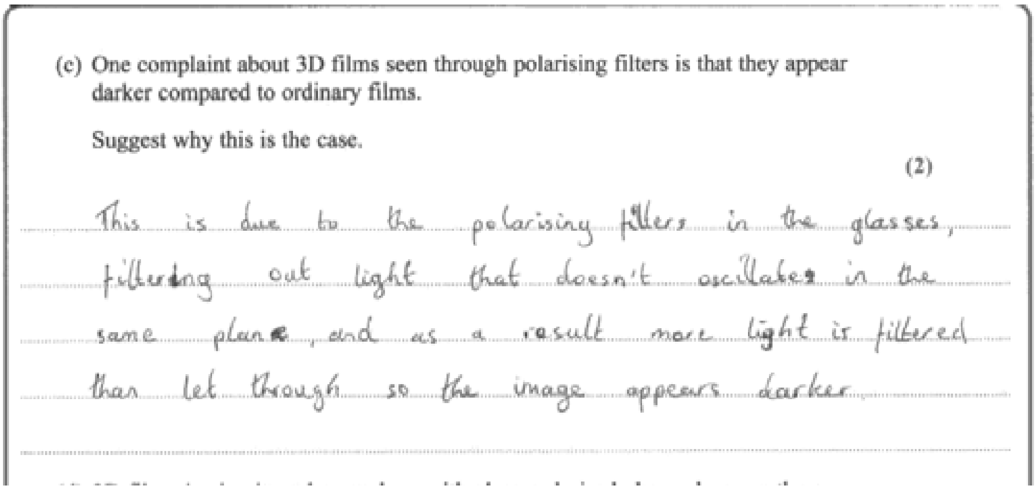
(2)

When light goes through a polarising filter some of it is cut out so less light reaches the eye resulting in a darker image.

ResultsPlus

Examiner Comments

The candidate has some idea, but neither part of the answer has the required detail. It does not explain why some light is cut out and 'darker' does not add to the information in the question.



(c) One complaint about 3D films seen through polarising filters is that they appear darker compared to ordinary films.

Suggest why this is the case.

(2)

This is due to the polarising filters in the glasses, filtering out light that doesn't oscillate in the same plane, and as a result more light is filtered than let through so the image appears darker.

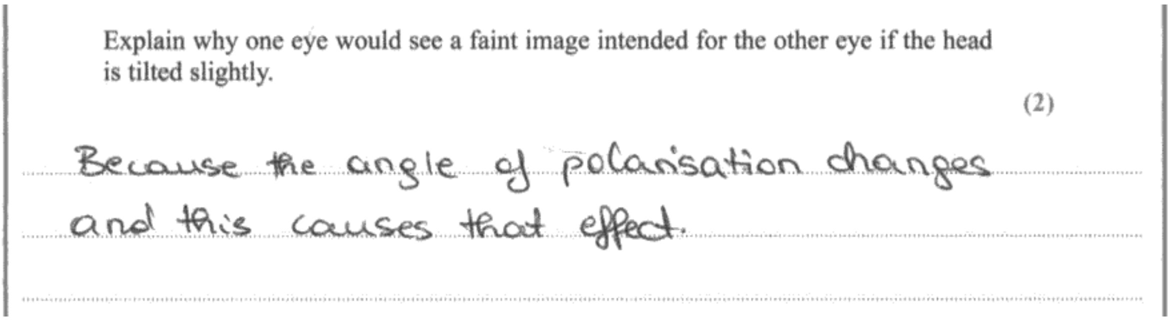
ResultsPlus

Examiner Comments

The process of absorption is explained here for one mark, but it still only refers to a darker image. Marks are not awarded for repeating the question without added detail.

Question 14 (d)

Under a quarter gained a mark for this part. They usually thought the plane of polarisation of the light changed, again failing to appreciate that the light from the screen was already polarised. The best answers seen referred to the light in one plane no longer being completely absorbed by the filter. References to components in any way were very rare. Candidates seemed unaware of descriptions of polarisation in terms of vectors.



Explain why one eye would see a faint image intended for the other eye if the head is tilted slightly.

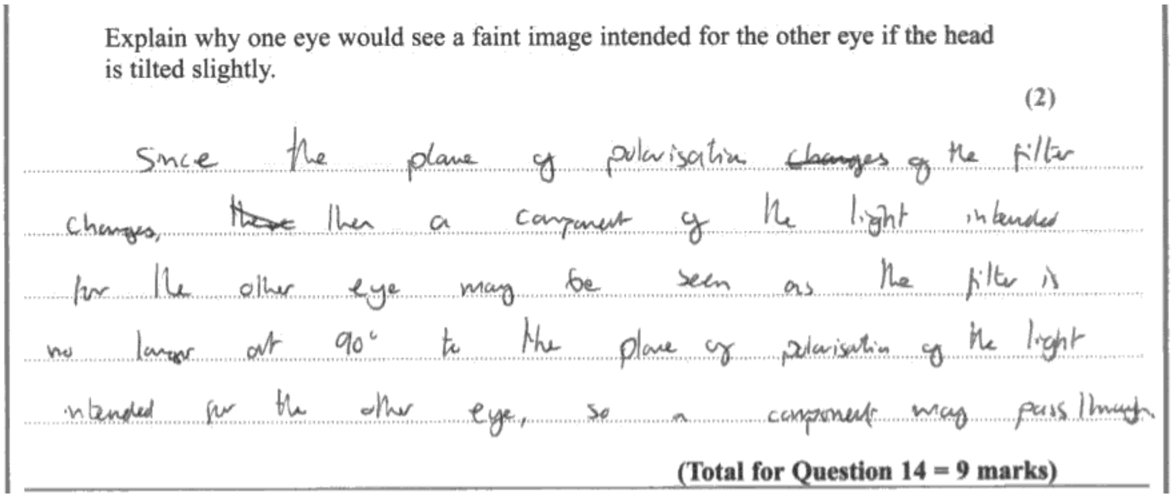
(2)

Because the angle of polarisation changes and this causes that effect.

ResultsPlus

Examiner Comments

This seems to suggest that the plane of polarisation of the light leaving the screen is changed. It needs to refer to the angle between the planes of polarisation of the light from the screen and of the filter.



Explain why one eye would see a faint image intended for the other eye if the head is tilted slightly.

(2)

Since the plane of polarisation ~~changes~~ of the filter changes, ~~these~~ then a component of the light intended for the other eye may be seen as the filter is no longer at 90° to the plane of polarisation of the light intended for the other eye, so a component may pass through.

(Total for Question 14 = 9 marks)

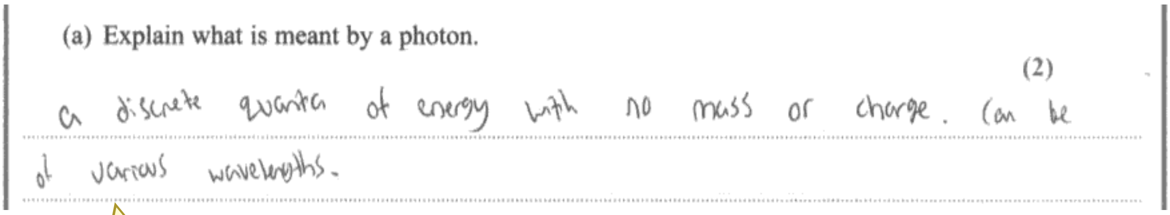
ResultsPlus

Examiner Comments

This response correctly refers to the change in the relative angle and how it allows a component of the light to be transmitted for two marks.

Question 15 (a)

Two thirds made a satisfactory reference to quantum, packet etc and gained the first mark, and a sixth of those candidates linked it to electromagnetic radiation. There were a number of vague references, such as to bundles of light. Some candidates described the process of photon production as in atomic spectra without explaining 'what is meant by a photon'. Many only referred to packets of light energy, ignoring the rest of the electromagnetic spectrum.



(a) Explain what is meant by a photon.

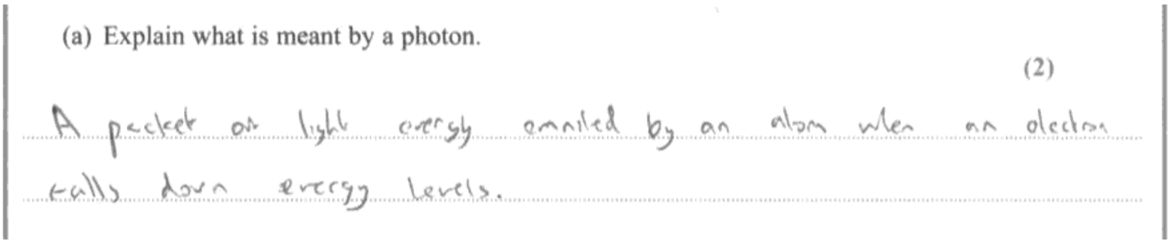
(2)

a discrete quanta of energy with no mass or charge. Can be of various wavelengths.

ResultsPlus

Examiner Comments

Many answers score the first mark and have additional information that is not required. They do not include reference to electromagnetic radiation.



(a) Explain what is meant by a photon.

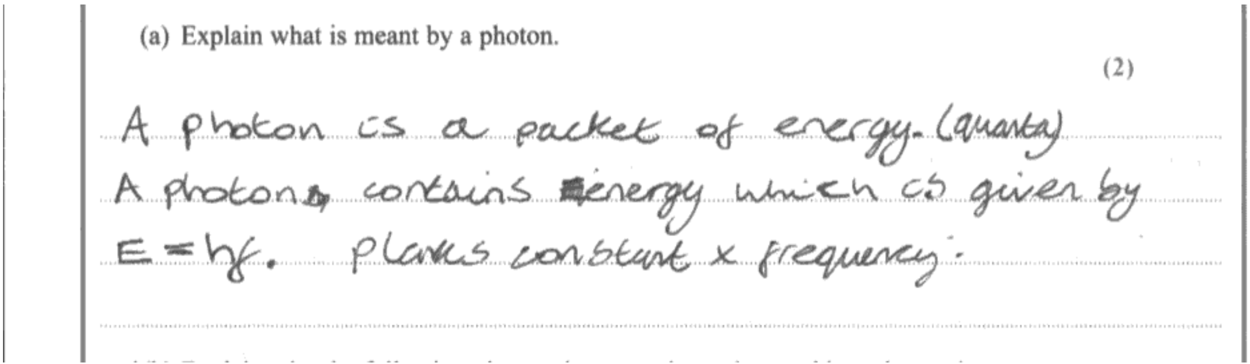
(2)

A packet of light energy emitted by an atom when an electron falls down energy levels.

ResultsPlus

Examiner Comments

In this example the extra information is about photon production.



(a) Explain what is meant by a photon.

(2)

A photon is a packet of energy. (quanta)
A photon contains energy which is given by
E=hf. plancks constant x frequency.

ResultsPlus

Examiner Comments

Extra information, $E = hf$, but not sufficient for the second mark.

Question 15 (b)

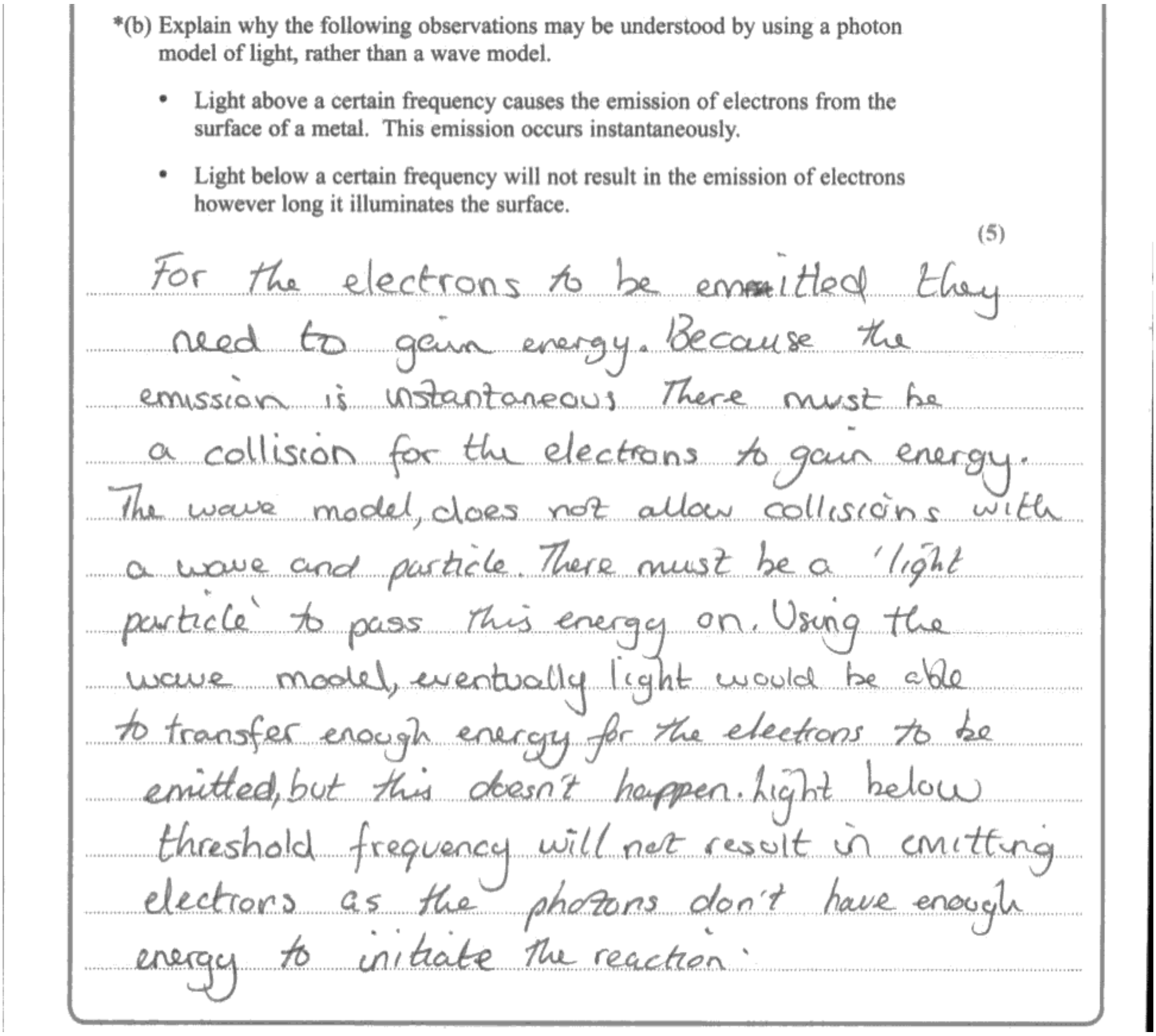
Candidates are clearly familiar with the photoelectric effect, and also familiar with the mark schemes to previous questions, e.g. ‘reference to E = hf’ was sometimes seen exactly like that. They are not so clear about reading the question carefully and then choosing the aspects of their knowledge relevant to the particular question.

Although a lot of correct information about the photoelectric effect was seen, much was essentially repetition of the question or not relevant to this question. For example, many candidates discussed the effect of intensity predicted by wave and photon models, but the question was about frequency.

Overall, about half of candidates gained 2 or more marks. They tended to get their marks for the photon description or the wave description rather than from each, with the photon model being the more common source of credit. Of the marks awarded, the most common were for one photon to one electron on the photon model and energy building up on the wave model.

Work function was poorly described, if mentioned. Candidates restated the second bullet point replacing ‘a certain frequency’ with ‘threshold frequency’ without explaining this. They sometimes treated threshold frequency as energy, as in ‘electrons are only emitted if the energy supplied is equal to the threshold frequency’. Although the question explicitly referred to the photon model, many did not link the photon energy to the work function, or even make it clear that the energy supplied to the electron is supplied by the photon.

References to atomic spectra production were only occasionally seen this time.



*(b) Explain why the following observations may be understood by using a photon model of light, rather than a wave model.

- Light above a certain frequency causes the emission of electrons from the surface of a metal. This emission occurs instantaneously.
- Light below a certain frequency will not result in the emission of electrons however long it illuminates the surface.

(5)

For the electrons to be emitted they need to gain energy. Because the emission is instantaneous There must be a collision for the electrons to gain energy. The wave model, does not allow collisions with a wave and particle. There must be a 'light particle' to pass this energy on. Using the wave model, eventually light would be able to transfer enough energy for the electrons to be emitted, but this doesn't happen. light below threshold frequency will not result in emitting electrons as the photons don't have enough energy to initiate the reaction.

ResultsPlus

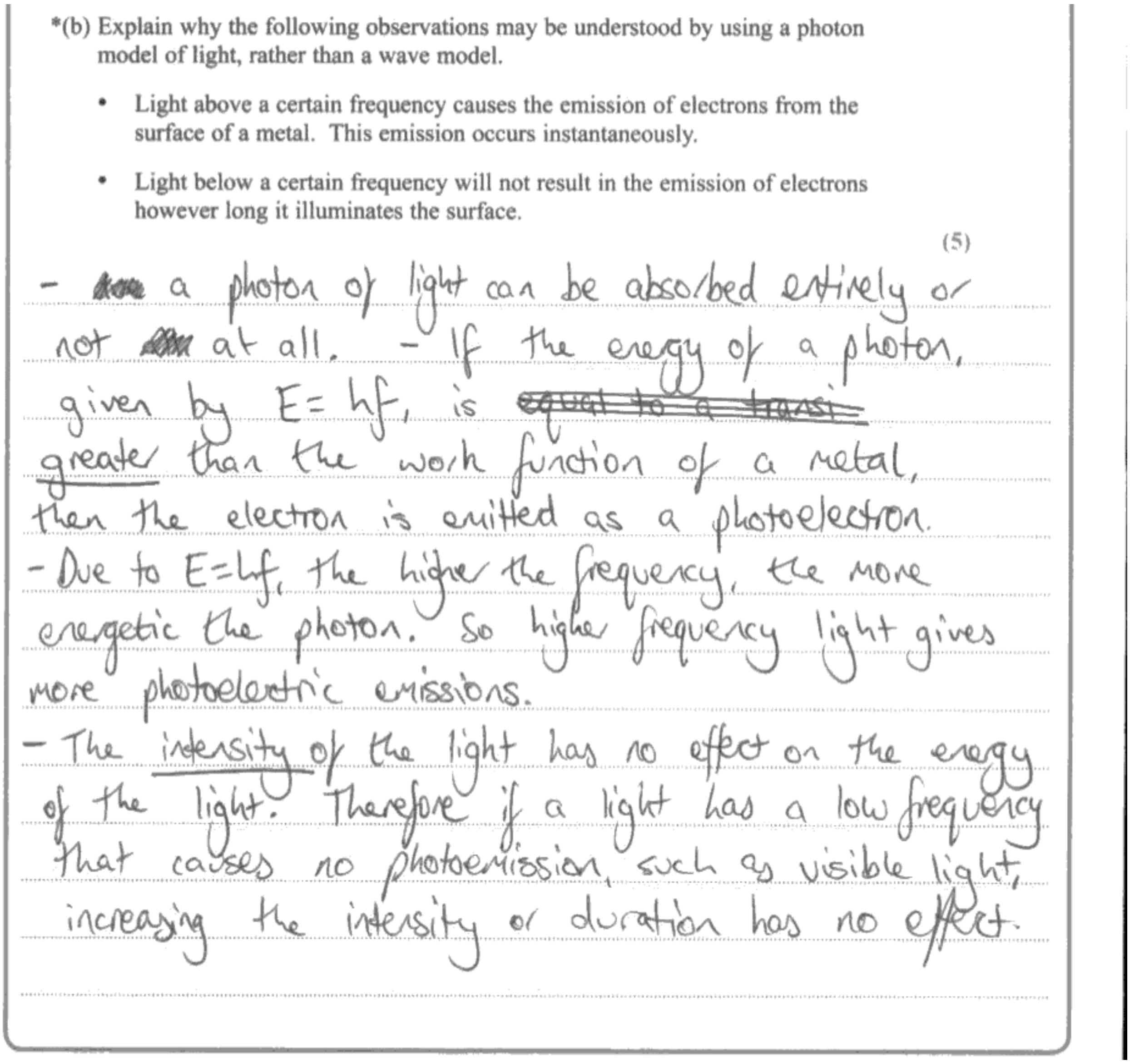
Examiner Comments

This gets the two marks for the wave model, but does not address the photon model points clearly.

ResultsPlus

Examiner Tip

Learn the key points for standard descriptions, such as the photoelectric effect. When used in an explanation, carefully select the points you need to use.



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- Light above a certain frequency causes the emission of electrons from the surface of a metal. This emission occurs instantaneously.
- Light below a certain frequency will not result in the emission of electrons however long it illuminates the surface.

(5)

- a photon of light can be absorbed entirely or not at all. - If the energy of a photon, given by $E = hf$, is ~~equal to a transi~~ greater than the work function of a metal, then the electron is emitted as a photoelectron.

- Due to $E=hf$, the higher the frequency, the more energetic the photon. So higher frequency light gives more photoelectric emissions.

- The intensity of the light has no effect on the energy of the light. Therefore if a light has a low frequency that causes no photoemission, such as visible light, increasing the intensity or duration has no effect.

ResultsPlus

Examiner Comments

This response scores three for the photon model.

The candidate then starts to explain the wave model in terms of intensity, which, although relevant to explanations of the photoelectric effect, is not relevant to this question with its focus on frequency.

*(b) Explain why the following observations may be understood by using a photon model of light, rather than a wave model.

- Light above a certain frequency causes the emission of electrons from the surface of a metal. This emission occurs instantaneously.
- Light below a certain frequency will not result in the emission of electrons however long it illuminates the surface.

(5)

- Intensity affects the number of photons incident per second, ~~the~~ thus affects the number of electrons emitted.
- Frequency affects the maximum kinetic energy of an electron.
- Below the threshold frequency there is no emission of electrons.
- One photon releases one electron.
- Energy of photon is related to by $E=hf$.
- If energy of photon is below the work function of metal, no electrons are released.
- $hf \geq \phi$. Energy of photon must be greater than or equal to the work function of the metal, or no electrons are released.
- In a wave energy can build up, so electron should eventually be released (~~which it doesn't~~) (which does not happen).

ResultsPlus

Examiner Comments

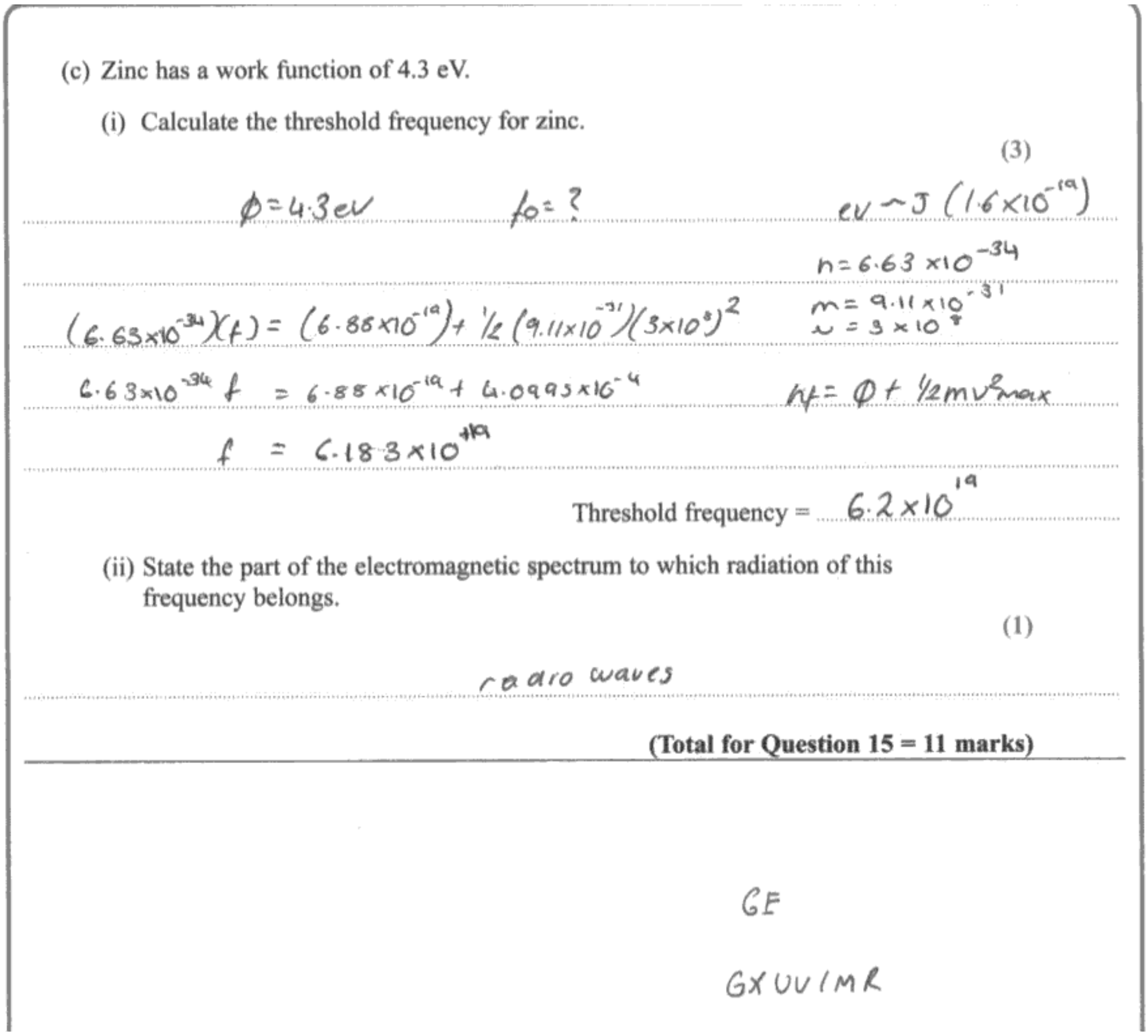
An example of a five mark answer - but this still includes irrelevant information as the first two bullet points.

Question 15 (c)

The majority could complete the calculation, although they did not always identify ultraviolet which they should have been able to suggest without calculations.

Some candidates failed to convert eV to J. Some tried to include a kinetic energy. Units were occasionally omitted.

Candidates who got impossibly low frequencies with negative powers of ten rarely saw this as a reason to try again.



(c) Zinc has a work function of 4.3 eV.

(i) Calculate the threshold frequency for zinc.

(3)

$\phi = 4.3 eV$ $f_0 = ?$ $eV \sim J\ (1.6\times10^{-19})$

$h = 6.63\times10^{-34}$

$(6.63\times10^{-34})(f) = (6.88\times10^{-19}) + \frac{1}{2}(9.11\times10^{-31})(3\times10^{8})^2$ $m = 9.11\times10^{-31}$ $v = 3\times10^{8}$

$6.63\times10^{-34} f = 6.88\times10^{-19} + 4.0995\times10^{-4}$ $hf = \phi + \frac{1}{2}mv^2_{max}$

$f = 6.183\times10^{+19}$

Threshold frequency = 6.2×10^{19}

(ii) State the part of the electromagnetic spectrum to which radiation of this frequency belongs.

(1)

radio waves

(Total for Question 15 = 11 marks)

GE

GX UV/MR

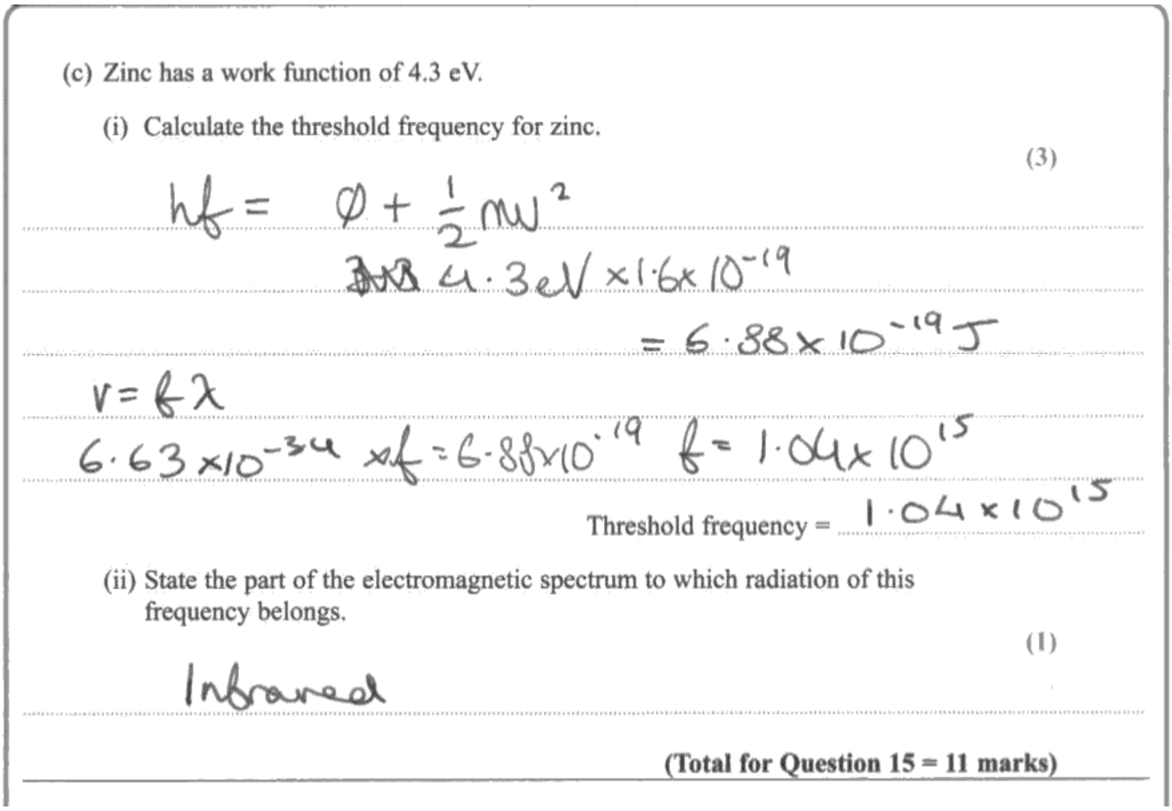
ResultsPlus
Examiner Comments

This gets one mark for the electron Volt conversion. The candidate then tries to add kinetic energy for the electron and, in the apparent absence of a velocity, uses the velocity of light. In fact, as it is for threshold frequency, the velocity is zero.

An extremely high frequency is calculated, but the candidate suggests it is for radio waves.

ResultsPlus
Examiner Tip

Make sure you know the order of the electromagnetic spectrum in terms of both wavelength and frequency.



(c) Zinc has a work function of 4.3 eV.

(i) Calculate the threshold frequency for zinc.

(3)

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

$4.3eV \times 1.6 \times 10^{-19}$

$= 6.88 \times 10^{-19} J$

$v = f\lambda$

$6.63 \times 10^{-34} \times f = 6.88 \times 10^{-19}$ $f = 1.04 \times 10^{15}$

Threshold frequency = 1.04×10^{15}

(ii) State the part of the electromagnetic spectrum to which radiation of this frequency belongs.

(1)

Infrared

(Total for Question 15 = 11 marks)

ResultsPlus
Examiner Comments

The calculation is correct, but the unit is missing.

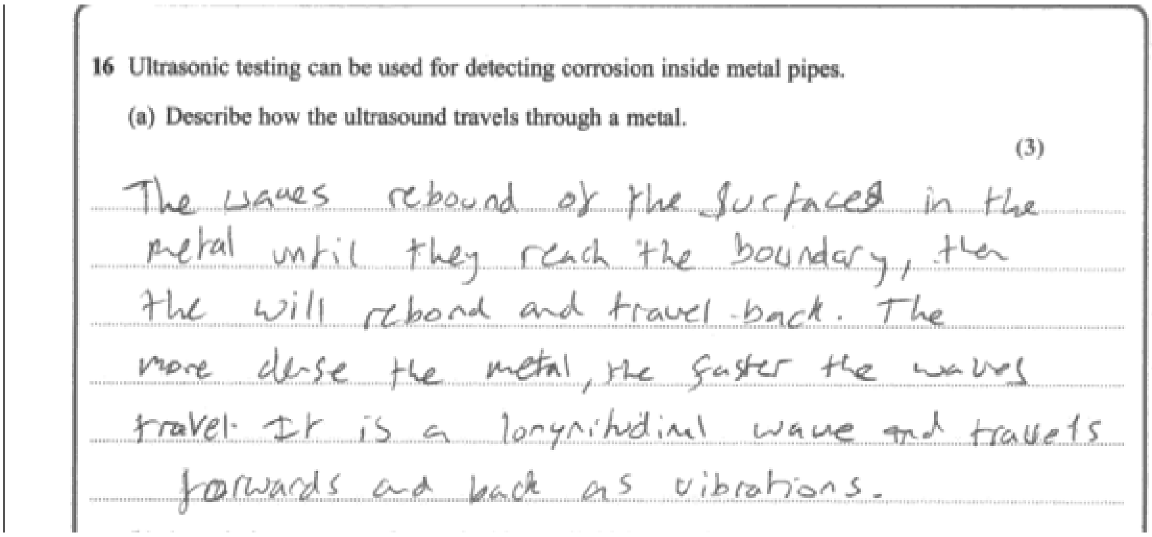
Again, a lower frequency radiation has been identified. Many candidates were able to identify UV from their knowledge of the photoelectric effect, whatever the result of their calculations.

Question 16 (a)

Lack of precision in standard descriptions that should be learned again meant that only half the entry got one mark or more, with fewer than one in ten getting a very straightforward three marks.

The most common mark was for identifying longitudinal waves and compressions and rarefactions – frequently with both versions of the mark. Vibrations were usually mentioned, but not what it is that is vibrating. Many attempted to describe the direction of vibrations, but the mark was sometimes lost by saying that vibrations are parallel to the direction of wave motion. Motion could apply to the vibrations or the propagation of the wave, so it is not sufficient.

A fair number described the pulse-echo technique in some detail at this stage.



16 Ultrasonic testing can be used for detecting corrosion inside metal pipes.

(a) Describe how the ultrasound travels through a metal.

(3)

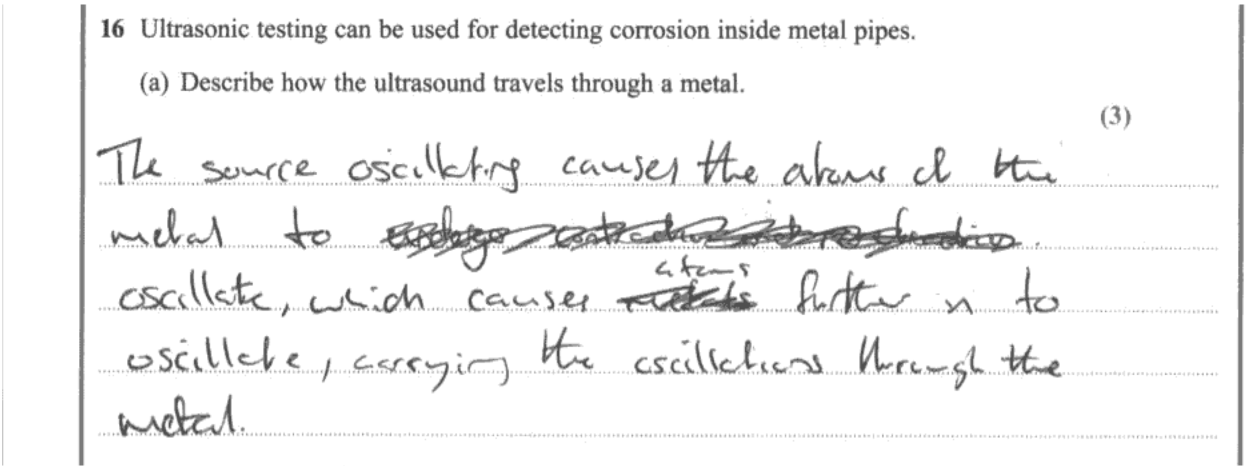
The waves rebound of the surfaces in the metal until they reach the boundary, then the will rebond and travel back. The more dense the metal, the faster the waves travel. It is a longitudinal wave and travels forwards and back as vibrations.

ResultsPlus

Examiner Comments

This gets a mark for identifying longitudinal waves. Vibrations are mentioned, but not what it is that is vibrating.

This is another standard description that should be learned.



16 Ultrasonic testing can be used for detecting corrosion inside metal pipes.

(a) Describe how the ultrasound travels through a metal.

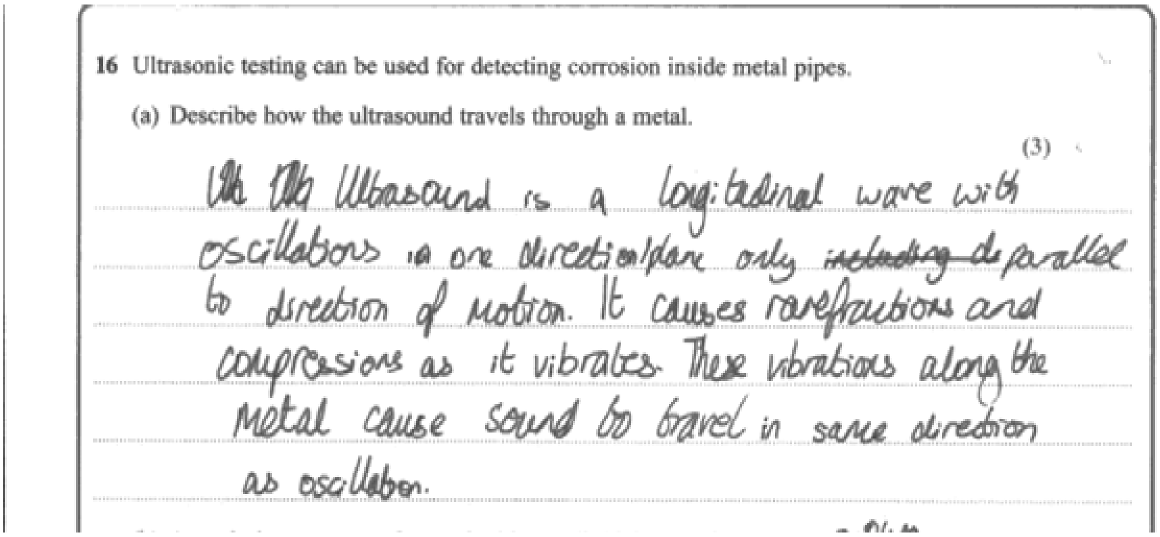
(3)

The source oscillating causes the atoms of the metal to ~~[illegible]~~. oscillate, which causes ~~metals~~ atoms further in to oscillate, carrying the oscillations through the metal.

ResultsPlus

Examiner Comments

In this case the oscillations of atoms are identified, but nothing more of merit about the direction of the oscillations or the mode of transmission.



16 Ultrasonic testing can be used for detecting corrosion inside metal pipes.

(a) Describe how the ultrasound travels through a metal.

(3)

~~The~~ ~~The~~ Ultrasound is a longitudinal wave with oscillations in one direction/plane only ~~including de~~ parallel to direction of motion. It causes rarefactions and compressions as it vibrates. These vibrations along the metal cause sound to travel in same direction as oscillation.

ResultsPlus

Examiner Comments

The mark for longitudinal waves and compressions and rarefactions is awarded. The other two parts are incompletely mentioned. It refers to vibrations, but not what is vibrating. The vibrations are described as being parallel to the direction of motion. 'Motion' and 'movement' are ambiguous in this context because the particles are in motion. It is better to refer to the direction of energy transfer.

ResultsPlus

Examiner Tip

When describing transverse or longitudinal waves, avoid use of the words 'motion' and 'movement' because they may be taken to refer to the oscillations or to the energy transfer.

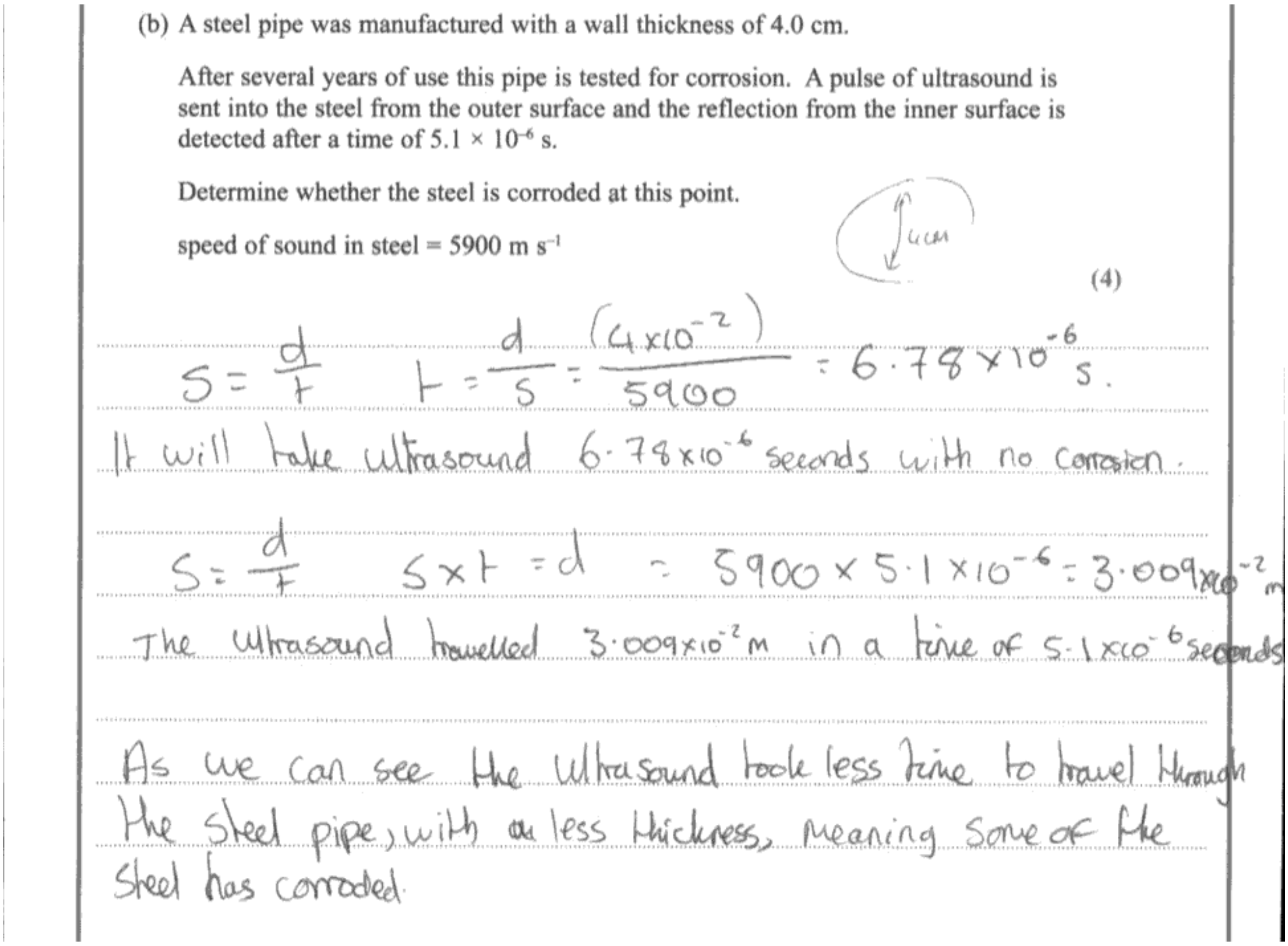
Question 16 (b)

The most common score for this question was four marks, representing a satisfactory calculation and a conclusion including a comparison of the dimensions of the test pipe with a new pipe.

Overall, about half included the factor of 2 correctly and half did not.

Although there have been questions in the past requiring a distance calculation from an echo time and a speed, a number chose to calculate the time for an uncorroded pipe for comparison. This worked equally well if they remembered to double the distance from the 4 cm thickness given.

Some candidates attempted a calculation based on speed using the uncorroded distance and the sample time, but they were not able to explain how this could be used to draw a conclusion because it did not correspond to any real physical quantity.



(b) A steel pipe was manufactured with a wall thickness of 4.0 cm.

After several years of use this pipe is tested for corrosion. A pulse of ultrasound is sent into the steel from the outer surface and the reflection from the inner surface is detected after a time of 5.1 × 10^{-6} s.

Determine whether the steel is corroded at this point.

speed of sound in steel = 5900 m s^{-1}

4cm

(4)

$S = \frac{d}{t} \quad t = \frac{d}{s} = \frac{(4 \times 10^{-2})}{5900} = 6.78 \times 10^{-6}$ s.

It will take ultrasound 6.78x10^{-6} seconds with no Corrosion.

$S = \frac{d}{t} \quad S \times t = d = 5900 \times 5.1 \times 10^{-6} = 3.009 \times 10^{-2}$ m

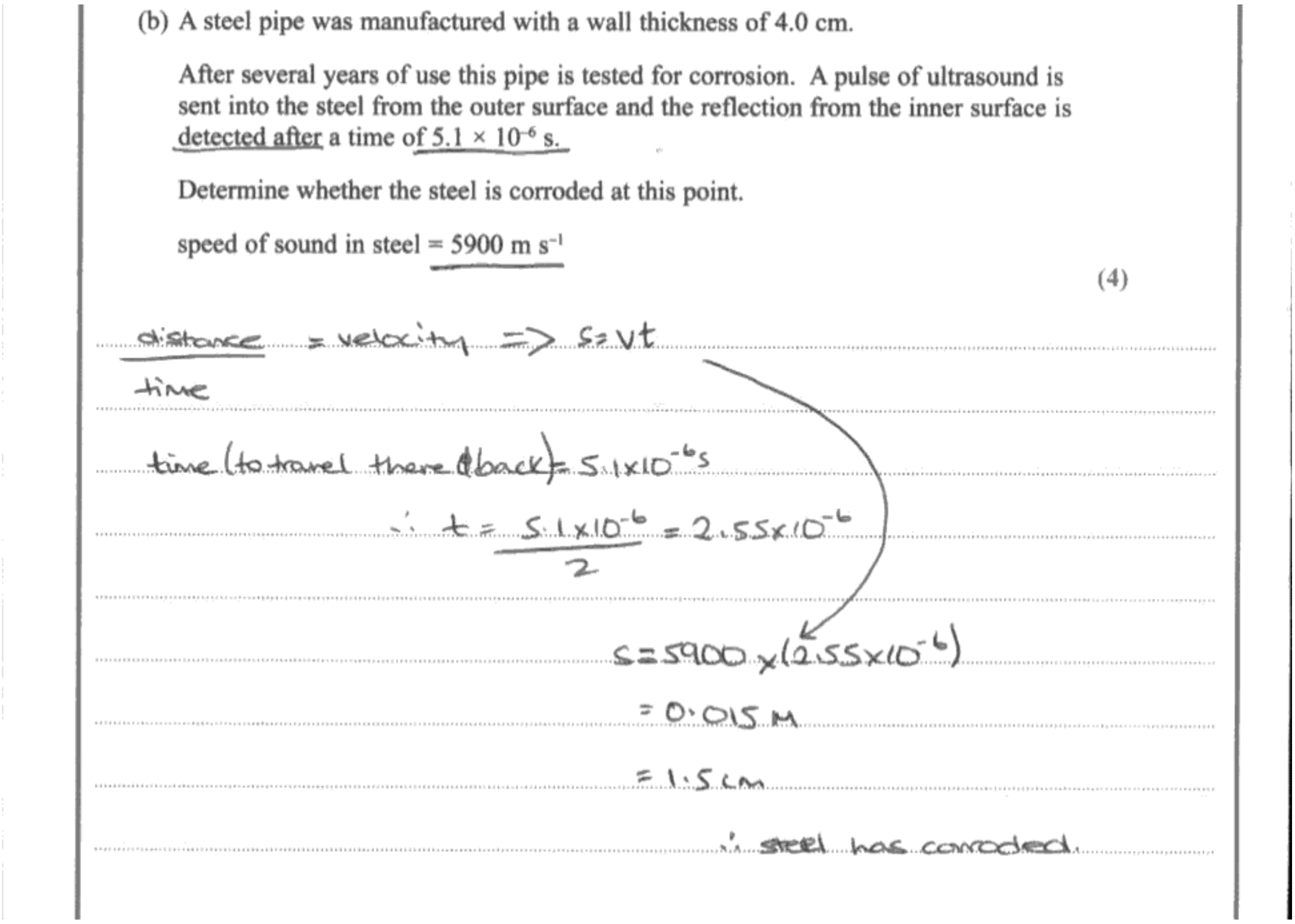
The ultrasound travelled 3.009x10^{-2}m in a time of 5.1x10^{-6} seconds

As we can see the ultrasound took less time to travel through the steel pipe, with a less thickness, meaning some of the steel has corroded.

ResultsPlus

Examiner Comments

It was possible to complete this question by calculating distance or time, and this candidate has done both. The candidate has failed to include the required factor of two in both of the calculations, but has made a comparison at the end, so two marks are awarded.



(b) A steel pipe was manufactured with a wall thickness of 4.0 cm.

After several years of use this pipe is tested for corrosion. A pulse of ultrasound is sent into the steel from the outer surface and the reflection from the inner surface is detected after a time of 5.1×10^{-6} s.

Determine whether the steel is corroded at this point.

speed of sound in steel = 5900 m s^{-1}

(4)

$\frac{\text{distance}}{\text{time}} = \text{velocity} \Rightarrow s = vt$

time (to travel there & back) = 5.1×10^{-6} s

$\therefore t = \frac{5.1 \times 10^{-6}}{2} = 2.55 \times 10^{-6}$

$s = 5900 \times (2.55 \times 10^{-6})$

$= 0.015$ m

$= 1.5$ cm

∴ steel has corroded.

ResultsPlus

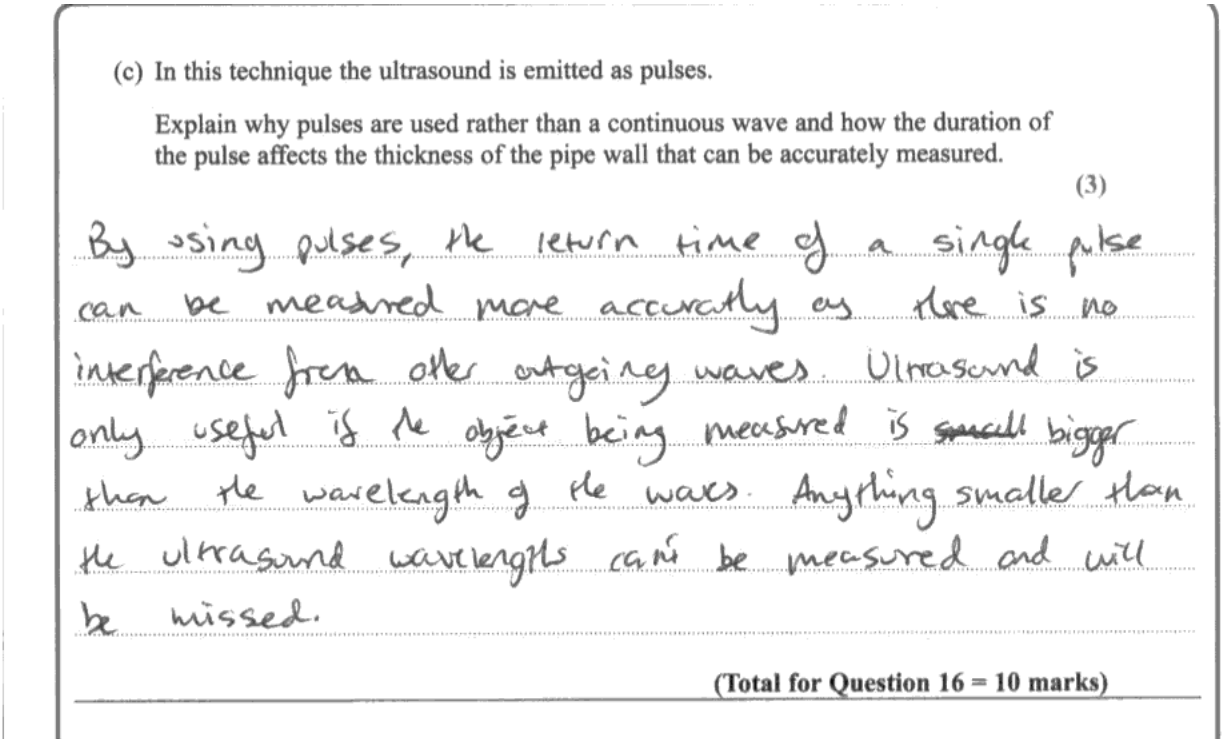
Examiner Comments

The calculation has been completed successfully and the answer stated in as much as there is a conclusion that 'steel has corroded'. The last mark requires a comparison, however, and not just a bare statement, so the final mark has not been given.

Question 16 (c)

The majority gained a mark for discussing the arrival of one pulse before the next pulse is emitted, but little else.

Many candidates either ignored the part of the question following 'and' or focused on the word 'accurately' and attempted to answer a different question about resolution, saying shorter pulses are more accurate, or even that shorter pulse would have a shorter wavelength, making them more accurate at measuring distances.



(c) In this technique the ultrasound is emitted as pulses.

Explain why pulses are used rather than a continuous wave and how the duration of the pulse affects the thickness of the pipe wall that can be accurately measured.

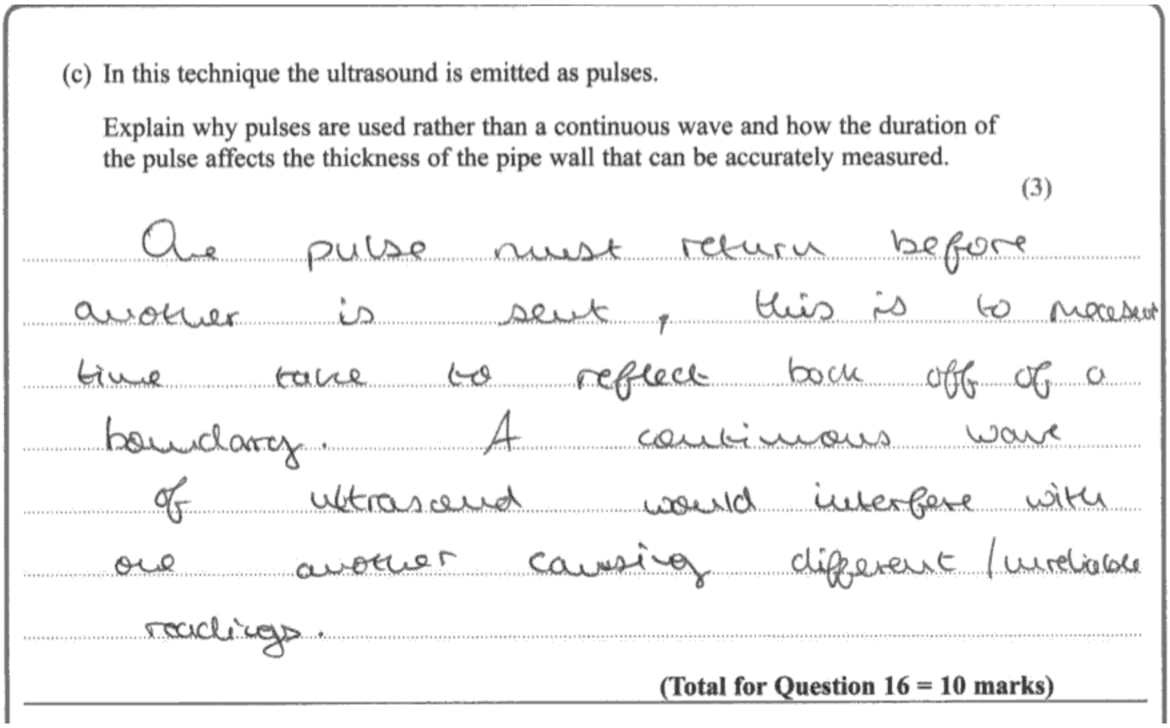
(3)

By using pulses, the return time of a single pulse can be measured more accuratly as there is no interference from other outgoing waves. Ultrasound is only useful if the object being measured is ~~small~~ bigger than the wavelength of the waves. Anything smaller than the ultrasound wavelengths can't be measured and will be missed.

(Total for Question 16 = 10 marks)

ResultsPlus
Examiner Comments

One mark is awarded for the comment about measuring the return time. The answer goes on to discuss wavelength, however, instead of pulse length, which was required by the question.



(c) In this technique the ultrasound is emitted as pulses.

Explain why pulses are used rather than a continuous wave and how the duration of the pulse affects the thickness of the pipe wall that can be accurately measured.

(3)

The pulse must return before another is sent, this is to measure time take to reflect back off of a boundary. A continuous wave of ultrasound would interfere with one another causing different / unreliable readings.

(Total for Question 16 = 10 marks)

ResultsPlus

Examiner Comments

This gets two marks for the first sentence. The last part of the question, 'and how ...', is not addressed at all.

ResultsPlus

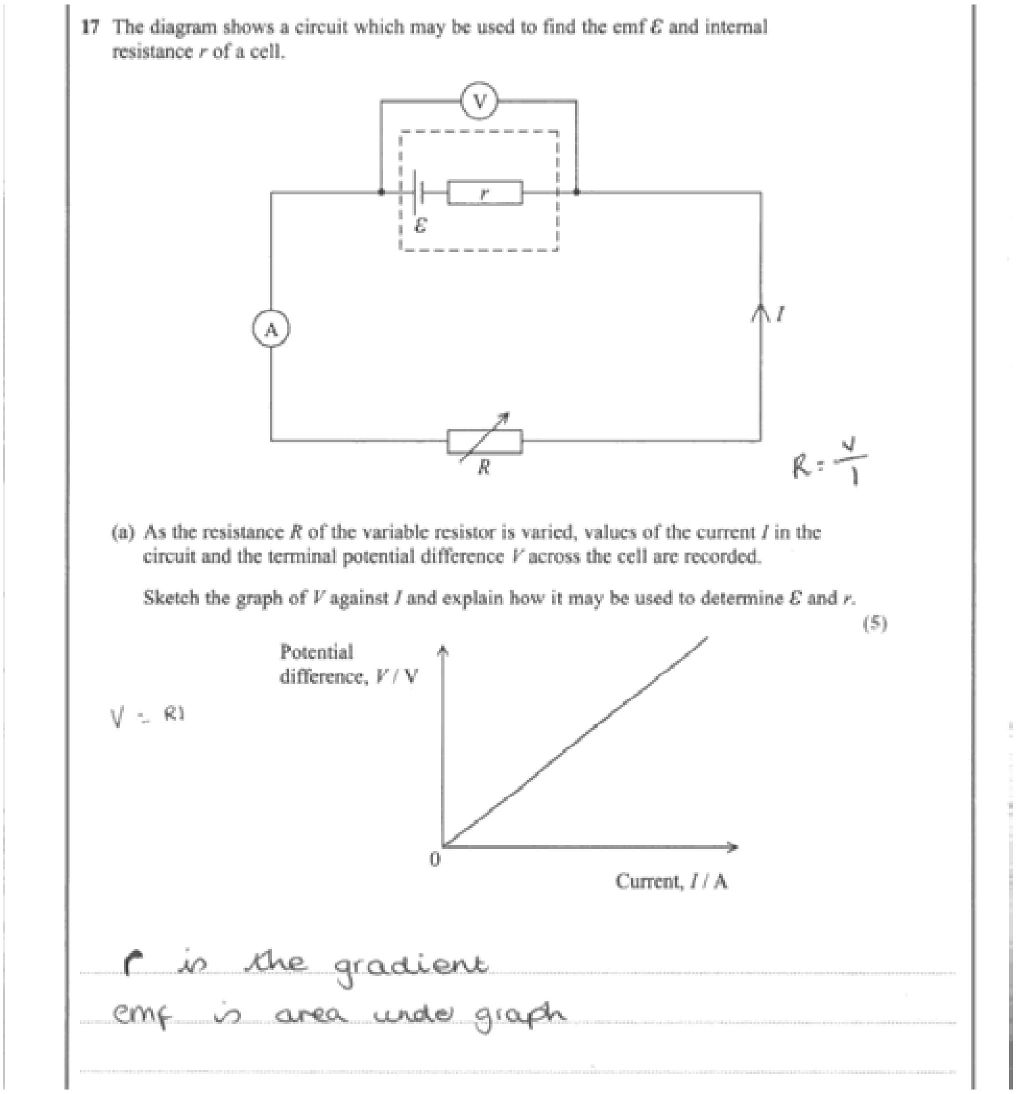
Examiner Tip

Read the question carefully, answering all parts, and make sure you address the points in the particular question and don't just write something else you know about the topic or learned answering a past question.

Question 17 (a)

A large minority of candidates got no marks, simply drawing a graph for an ohmic conductor and trying to link the required quantities to area under the graph and gradient. Some candidates with the wrong graph stated a correct equation, but failed to relate it to the graph.

The majority got at least one mark, with about a third gaining three or more marks. The mark for e.m.f. was awarded more often than the mark for *r* because the 'negative' wasn't always included with gradient. A number of candidates gained three or four marks for the graph and derivatives, but did not include the equation. This made the difference between describing the use of the graph and explaining it. Others used an equation without *V*, which could not be used to explain a graph with *V* as an axis.



17 The diagram shows a circuit which may be used to find the emf $\mathcal{E}$ and internal resistance r of a cell.

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

(a) As the resistance R of the variable resistor is varied, values of the current I in the circuit and the terminal potential difference V across the cell are recorded.

Sketch the graph of V against I and explain how it may be used to determine $\mathcal{E}$ and r.

(5)

$V = RI$

r is the gradient

emf is area under graph

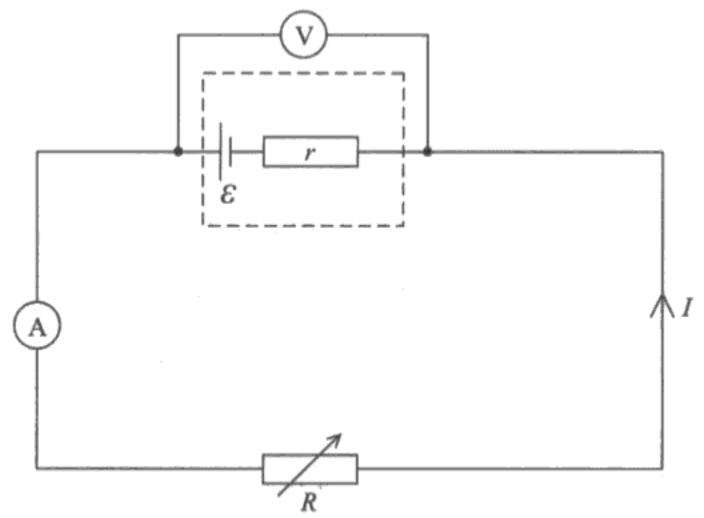
ResultsPlus

Examiner Comments

Many candidates, possibly not familiar with the experiment, completed a graph for a fixed resistor. Credit was not given for reference to the gradient unless 'negative' was indicated in some way.

Writing the equation for terminal potential difference might have helped.

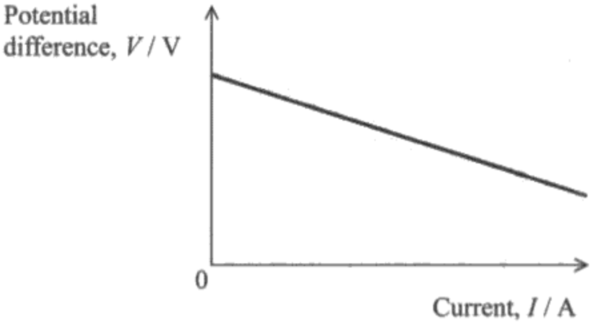
17 The diagram shows a circuit which may be used to find the emf $\mathcal{E}$ and internal resistance r of a cell.



(a) As the resistance R of the variable resistor is varied, values of the current I in the circuit and the terminal potential difference V across the cell are recorded.

Sketch the graph of V against I and explain how it may be used to determine $\mathcal{E}$ and r.

(5)



It can be determined to find E, the e.mf because it is the y-intercept, where I=0 V=Emf. r, the internal resistance would be the gradient of the graph.

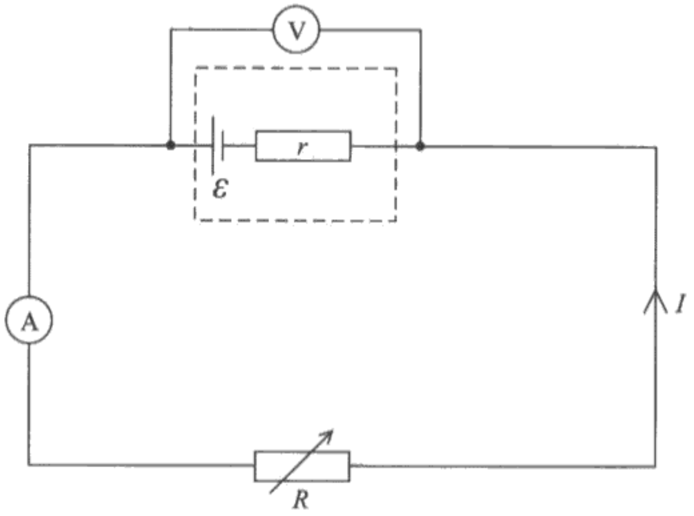
~~$\mathcal{E} = V + Ir$~~

ResultsPlus

Examiner Comments

This gets two marks for the graph and one for e.m.f. The equation was written, but crossed out. Rewriting it with V as the subject would have helped with the resistance mark.

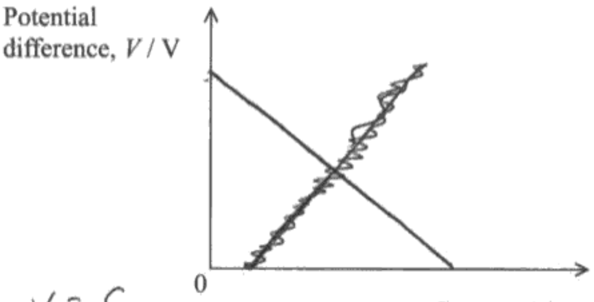
17 The diagram shows a circuit which may be used to find the emf $\mathcal{E}$ and internal resistance r of a cell.



(a) As the resistance R of the variable resistor is varied, values of the current I in the circuit and the terminal potential difference V across the cell are recorded.

Sketch the graph of V against I and explain how it may be used to determine $\mathcal{E}$ and r.

(5)



$\mathcal{E} = V + v \quad V = \mathcal{E} - v$

~~$\mathcal{E} = V - Ir$~~ ~~[illegible]~~ ~~[illegible]~~

$V = -rI + \mathcal{E}$ The gradient is - internal

$y = mx + c$ resistance and the

y intercept is the ~~[illegible] potential difference~~ EMF.

ResultsPlus

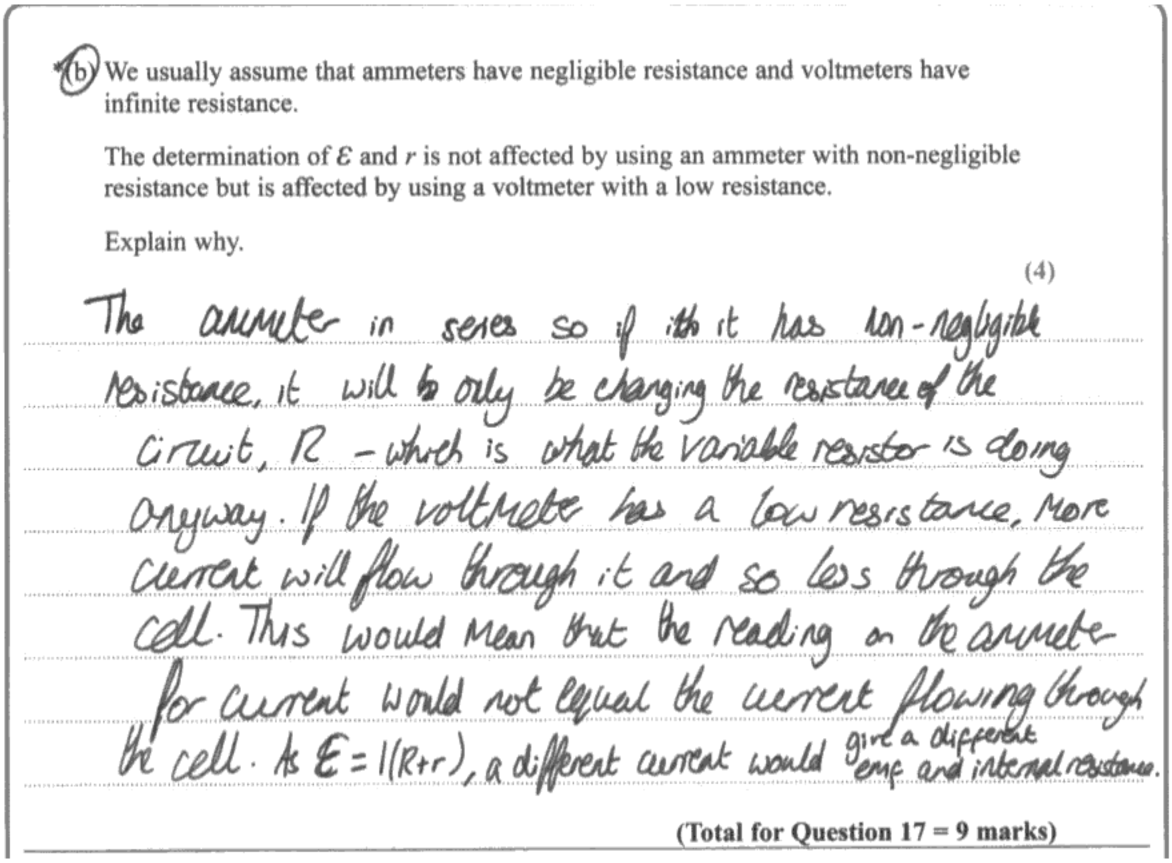
Examiner Comments

An example of a response that gained full marks. Notice that the candidate changed the equation to match the equation of a straight line and was then able to correct the graph and answer the question.

Question 17 (b)

This showed a complete misunderstanding of the circuit by most candidates. About a third got one or more marks, the single mark usually awarded for current through the voltmeter. The problem was treating the current as coming to the junction from the variable resistor and splitting into two paths, one through the cell and one through the voltmeter. They described this as reducing the current through the cell, whereas current from the cell would follow two paths and a low resistance voltmeter would increase the current through the cell and, more importantly, make it unequal to the current through the ammeter.

Others tried to explain the effect of a low resistance in parallel with another resistance, whether for the cell or the variable resistor. It was possible to use this idea to explain an increased current through the cell, but they did not. These candidates went on to say that having a low resistance in parallel would increase the resistance of the combination. They did not recognise that a parallel combination always has a resistance lower than either individual resistance - except for an infinite resistance, which would have been helpful here.



(b) We usually assume that ammeters have negligible resistance and voltmeters have infinite resistance.

The determination of $\mathcal{E}$ and r is not affected by using an ammeter with non-negligible resistance but is affected by using a voltmeter with a low resistance.

Explain why.

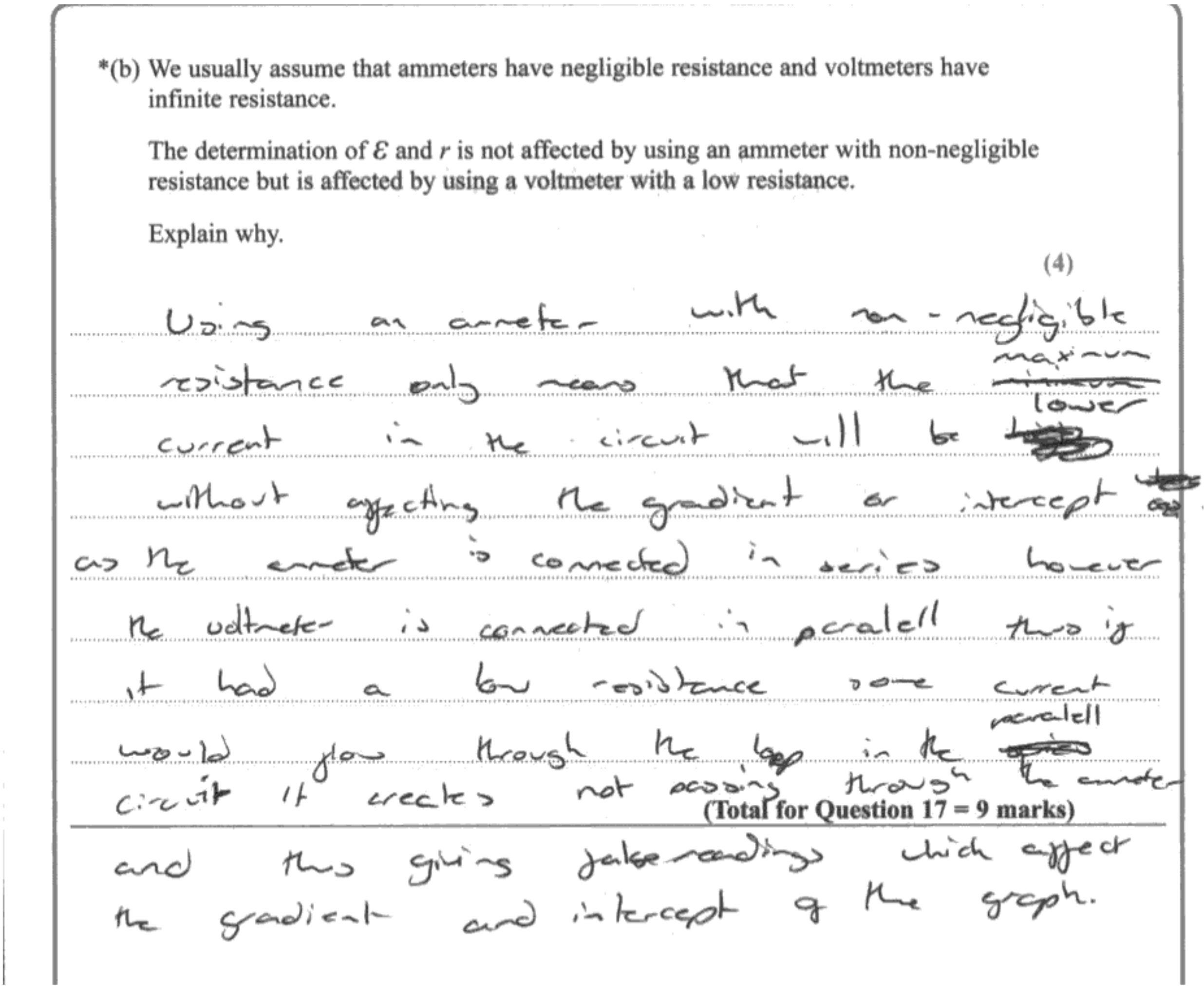
(4)

The ammeter in series so if ~~ith~~ it has non-negligible resistance, it will ~~to~~ only be changing the resistance of the circuit, R - which is what the variable resistor is doing anyway. If the voltmeter has a low resistance, more current will flow through it and so less through the cell. This would mean that the reading on the ammeter for current would not equal the current flowing through the cell. As $\mathcal{E} = I(R+r)$, a different current would give a different emf and internal resistance.

(Total for Question 17 = 9 marks)

ResultsPlus
Examiner Comments

This answer shows a correct appreciation of the ammeter and also refers to current through the voltmeter. The candidate shares the common misconception that current splits to go through either the voltmeter or the cell, possibly because *I* is shown on the right of the circuit rather than the left. Tracing the current around from the cell might help with correcting this.



*(b) We usually assume that ammeters have negligible resistance and voltmeters have infinite resistance.

The determination of $\mathcal{E}$ and r is not affected by using an ammeter with non-negligible resistance but is affected by using a voltmeter with a low resistance.

Explain why.

(4)

Using an ammeter with non-negligible resistance only means that the maximum ~~minimum~~ lower current in the circuit will be without affecting the gradient or intercept as the ammeter is connected in series however the voltmeter is connected in parallell thus if it had a low resistance some current would flow through the loop in the parallell circuit it creates not passing through the ammeter and thus giving false readings which affect the gradient and intercept of the graph.

(Total for Question 17 = 9 marks)

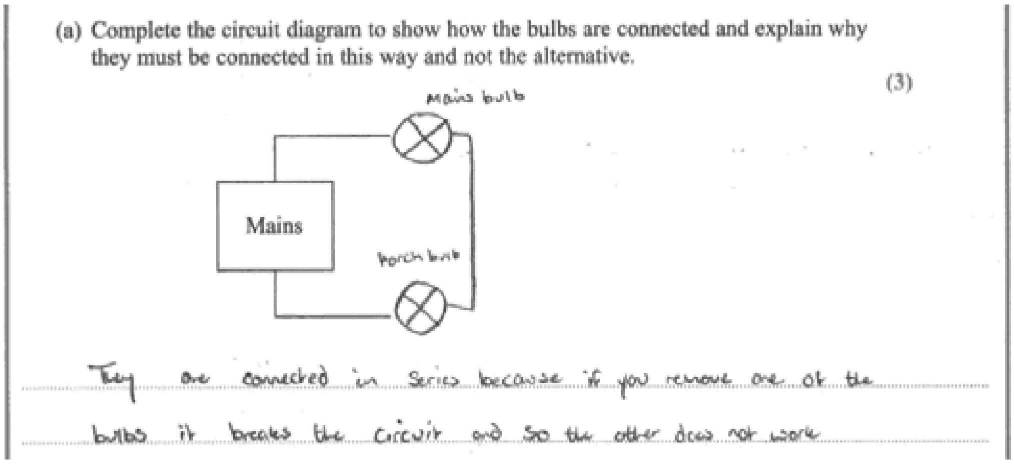
ResultsPlus

Examiner Comments

This candidate correctly states that, with a low resistance voltmeter, some current goes through the voltmeter rather than the ammeter.

Question 18 (a)

Most candidates correctly drew the circuit, although some added extra cells or other components. A number drew a parallel circuit and some just added bulbs in a line sticking out. A majority also explained satisfactorily why it must be series or why it could not be parallel. Only about a sixth explained both. Some missed a mark because they only addressed one type of circuit. Some missed marks because they just repeated the observations from the question without mentioning a break in the circuit or alternative paths.



(a) Complete the circuit diagram to show how the bulbs are connected and explain why they must be connected in this way and not the alternative.

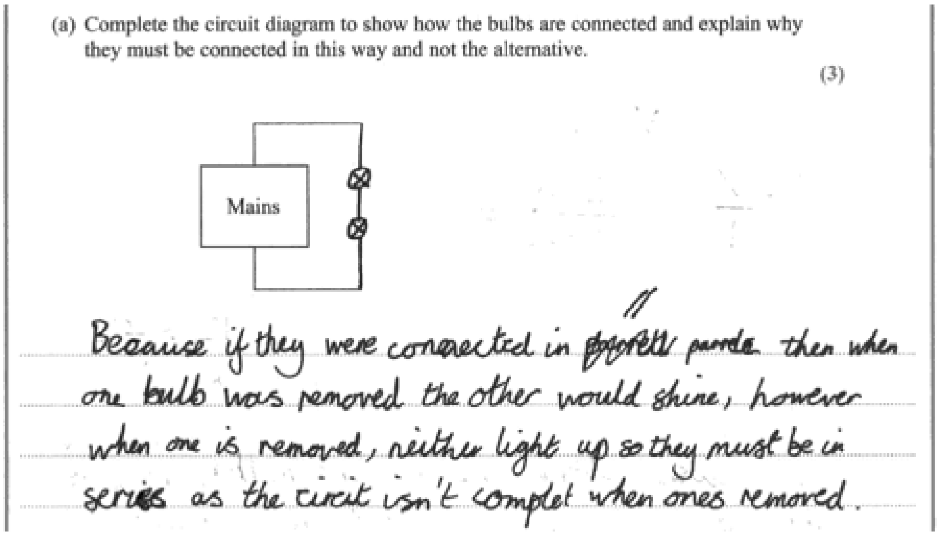
(3)

They are connected in Series because if you remove one of the bulbs it breaks the circuit and so the other does not work

ResultsPlus

Examiner Comments

A correct circuit, but only this circuit is discussed and not the alternative, as required by the question.



(a) Complete the circuit diagram to show how the bulbs are connected and explain why they must be connected in this way and not the alternative.

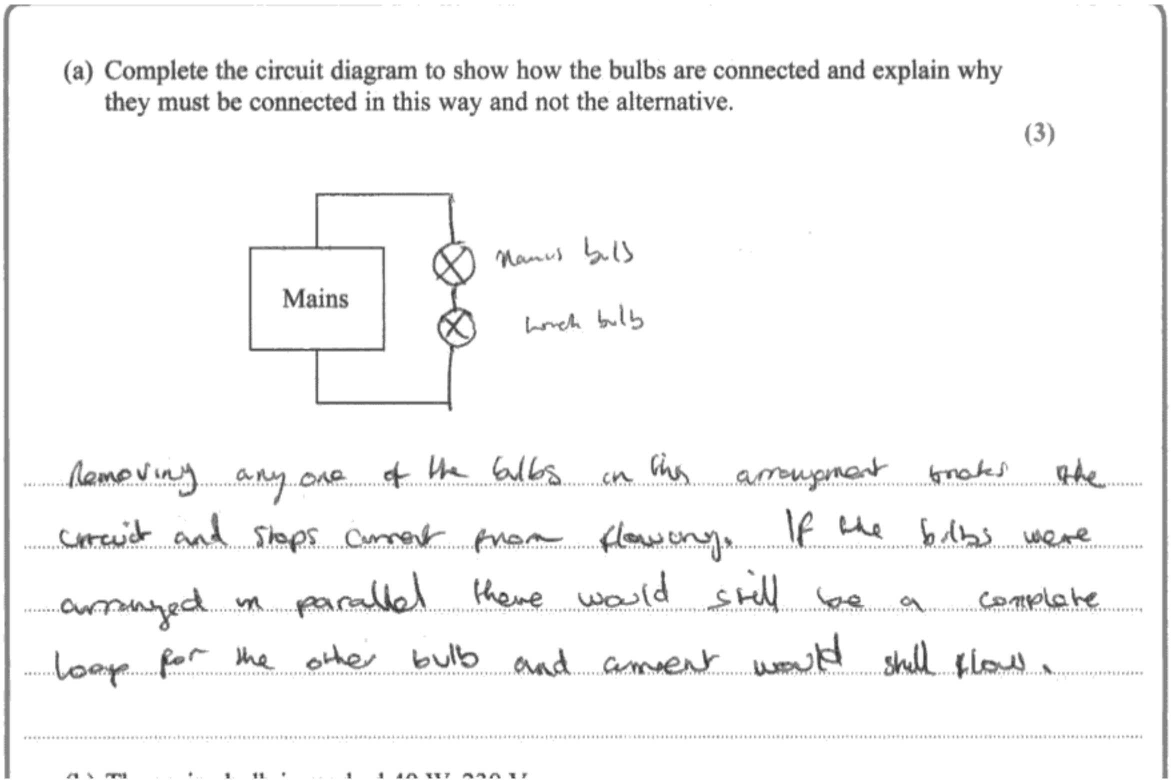
(3)

Because if they were connected in ~~parell~~ // paralle then when one bulb was removed the other would shine, however when one is removed, neither light up so they must be in series as the circit isn't complet when ones removed.

ResultsPlus

Examiner Comments

Marks are given for the correct circuit and series explanation again. A parallel circuit is mentioned, but only to the extent of saying what happens to the appearance of the bulbs and not why.



(a) Complete the circuit diagram to show how the bulbs are connected and explain why they must be connected in this way and not the alternative.

(3)

Removing any one of the bulbs in this arrangement breaks the circuit and stops current from flowing. If the bulbs were arranged in parallel there would still be a complete loop for the other bulb and current would still flow.

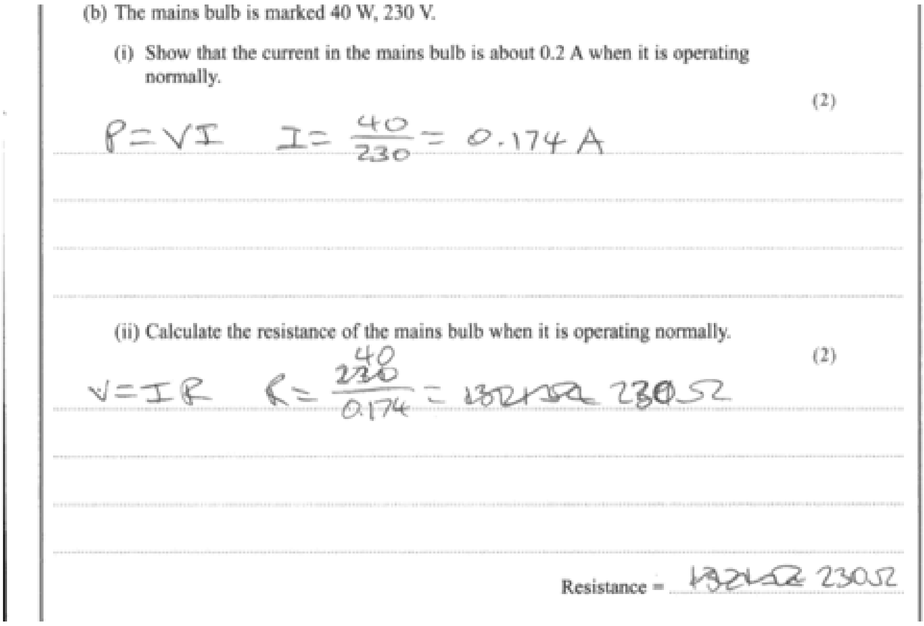
ResultsPlus

Examiner Comments

An example of a response gaining full marks, addressing all points in the required detail.

Question 18 (b) (c)

The great majority of candidates completed all three calculations correctly. Units of resistance were occasionally omitted, but few other errors were seen. About a quarter of the entry got one or more marks for this part; the answers were often along the right lines but lacking in detail. They often mentioned the same current, but that is expected in series and they needed to comment that they both required about the same current for normal operation. Similarly, many referred to shared voltage, but that is also expected for a series circuit and they needed to add detail about the quantities required in this case. A number of responses seen referred to the mains bulb shielding the torch bulb in some way, blocking most of the current from getting to it.



(b) The mains bulb is marked 40 W, 230 V.

(i) Show that the current in the mains bulb is about 0.2 A when it is operating normally.

(2)

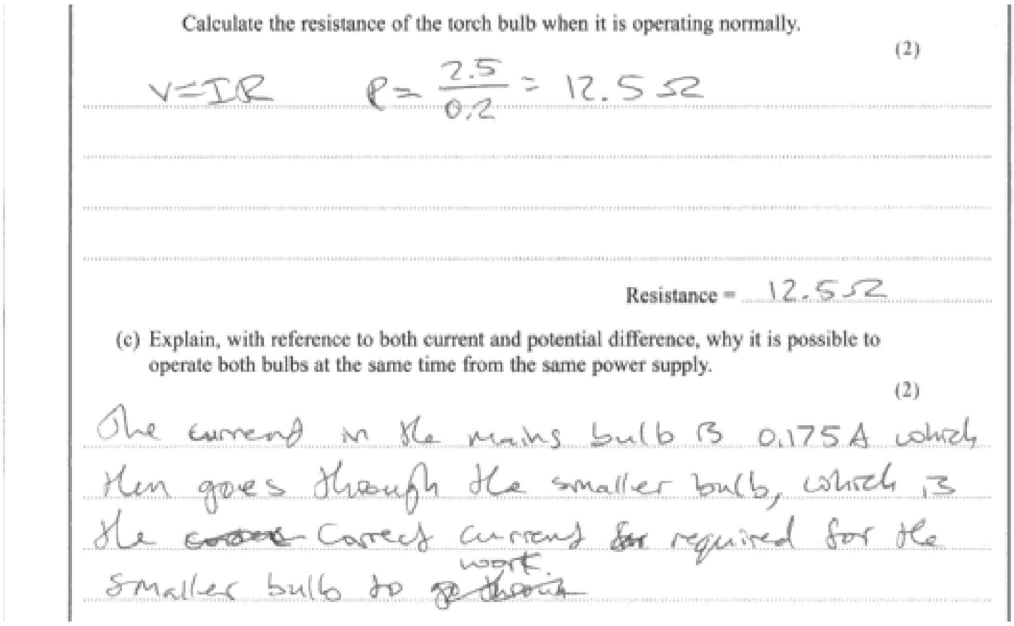
$P = VI \quad I = \frac{40}{230} = 0.174\text{ A}$

(ii) Calculate the resistance of the mains bulb when it is operating normally.

(2)

$V = IR \quad R = \frac{\overset{40}{\cancel{230}}}{0.174} =$ ~~1321Ω~~ 230Ω

Resistance = ~~1321Ω~~ 230Ω



Calculate the resistance of the torch bulb when it is operating normally.

(2)

$V = IR \quad R = \frac{2.5}{0.2} = 12.5\,\Omega$

Resistance = 12.5Ω

(c) Explain, with reference to both current and potential difference, why it is possible to operate both bulbs at the same time from the same power supply.

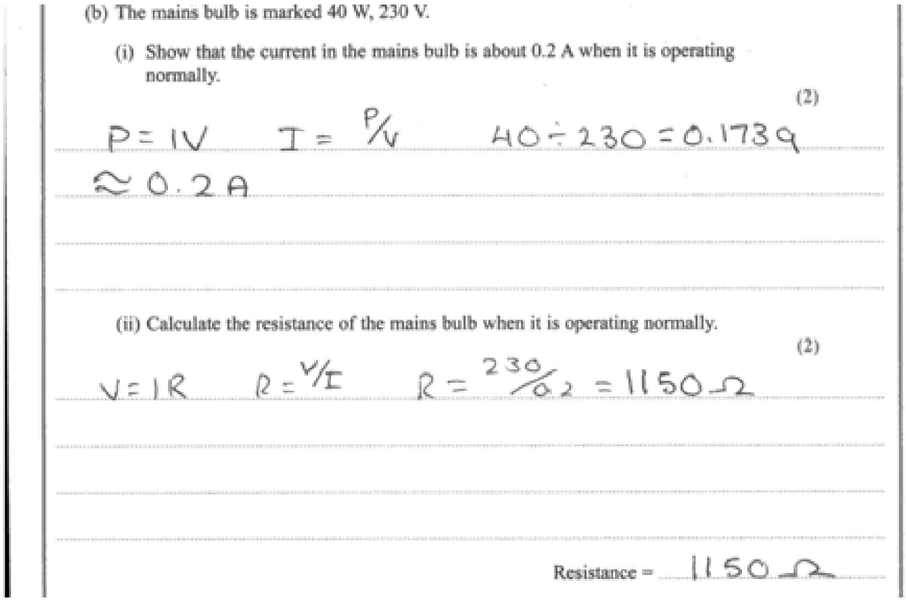
(2)

The current in the mains bulb is 0.175 A which then goes through the smaller bulb, which is the ~~[illegible]~~ correct current ~~for~~ required for the smaller bulb to ~~go through~~ work

ResultsPlus

Examiner Comments

V is incorrectly substituted in part (ii), but the rest of the calculations are correct. There is a satisfactory explanation in terms of current, but reference to potential difference, as in the question, is not made.



(b) The mains bulb is marked 40 W, 230 V.

(i) Show that the current in the mains bulb is about 0.2 A when it is operating normally.

(2)

$P = IV \quad I = P/V \quad 40 \div 230 = 0.1739$

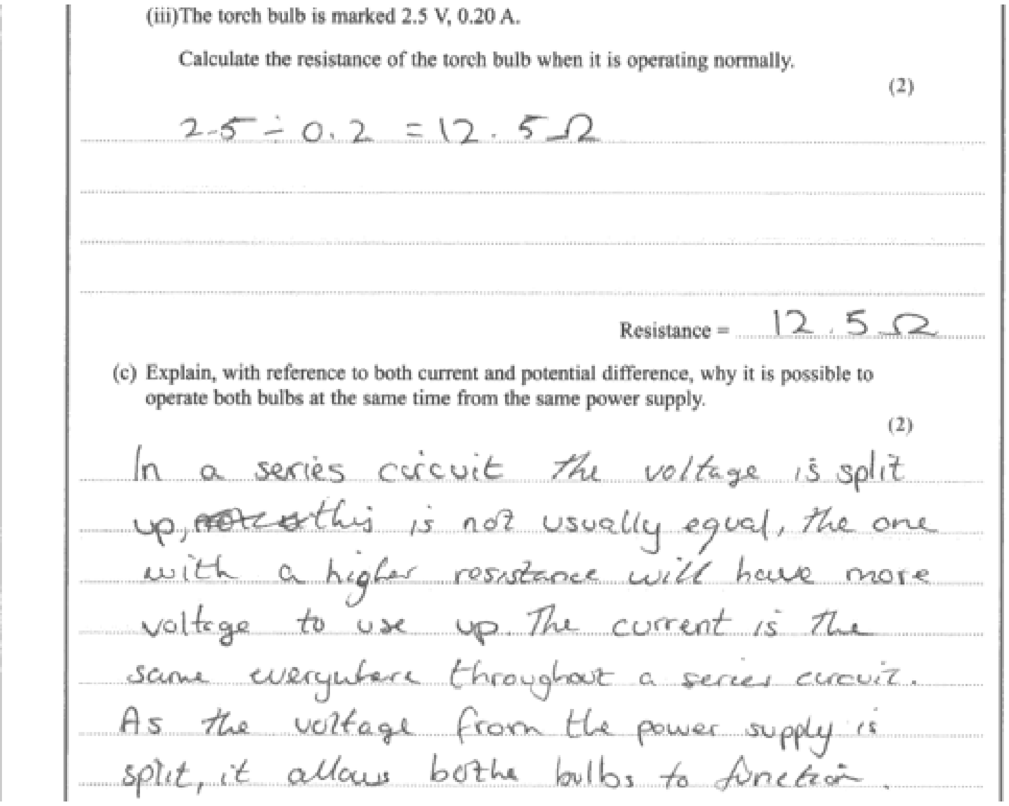
$\approx 0.2\,A$

(ii) Calculate the resistance of the mains bulb when it is operating normally.

(2)

$V = IR \quad R = V/I \quad R = 230/0.2 = 1150\,\Omega$

Resistance = $1150\,\Omega$



(iii) The torch bulb is marked 2.5 V, 0.20 A.

Calculate the resistance of the torch bulb when it is operating normally.

(2)

$2.5 \div 0.2 = 12.5\,\Omega$

Resistance = $12.5\,\Omega$

(c) Explain, with reference to both current and potential difference, why it is possible to operate both bulbs at the same time from the same power supply.

(2)

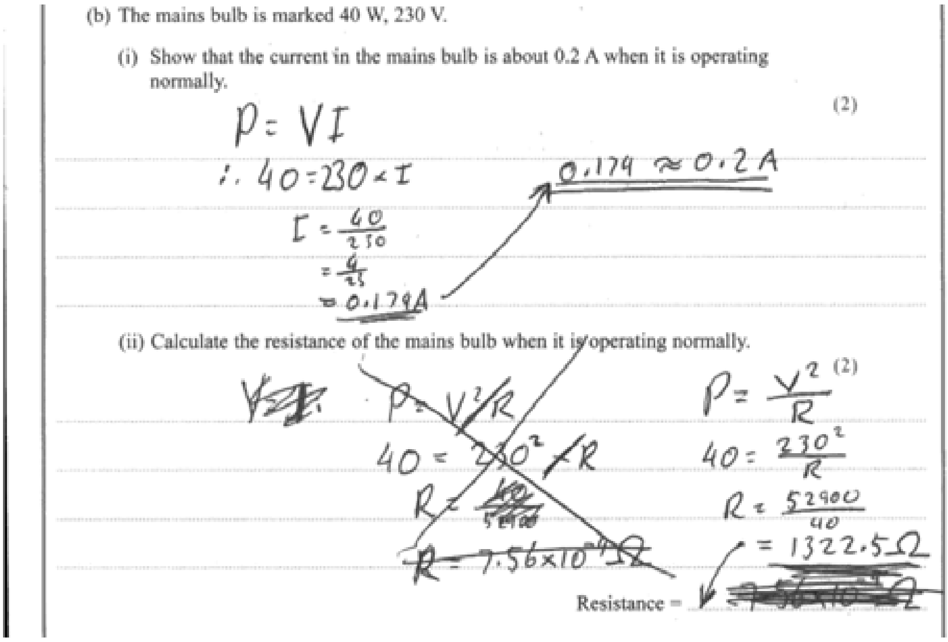
In a series circuit the voltage is split up, ~~not~~ this is not usually equal, the one with a higher resistance will have more voltage to use up. The current is the same everywhere throughout a series circuit. As the voltage from the power supply is split, it allows both the bulbs to function.

ResultsPlus

Examiner Comments

The calculations are correct.

The explanation makes a number of true statements about series circuits, but these are true of such circuits in general and do not address the particular situation in this question.



(b) The mains bulb is marked 40 W, 230 V.

(i) Show that the current in the mains bulb is about 0.2 A when it is operating normally.

(2)

$P = VI$

$\therefore 40 = 230 \times I$

$I = \frac{40}{230}$

$= \frac{4}{23}$

$\approx 0.174A$

$\underline{0.174 \approx 0.2A}$

(ii) Calculate the resistance of the mains bulb when it is operating normally.

(2)

~~$P = V^2/R$~~

~~$40 = 230^2/R$~~

~~$R = \frac{40}{52900}$~~

~~$R = 7.56\times10^{-4}\Omega$~~

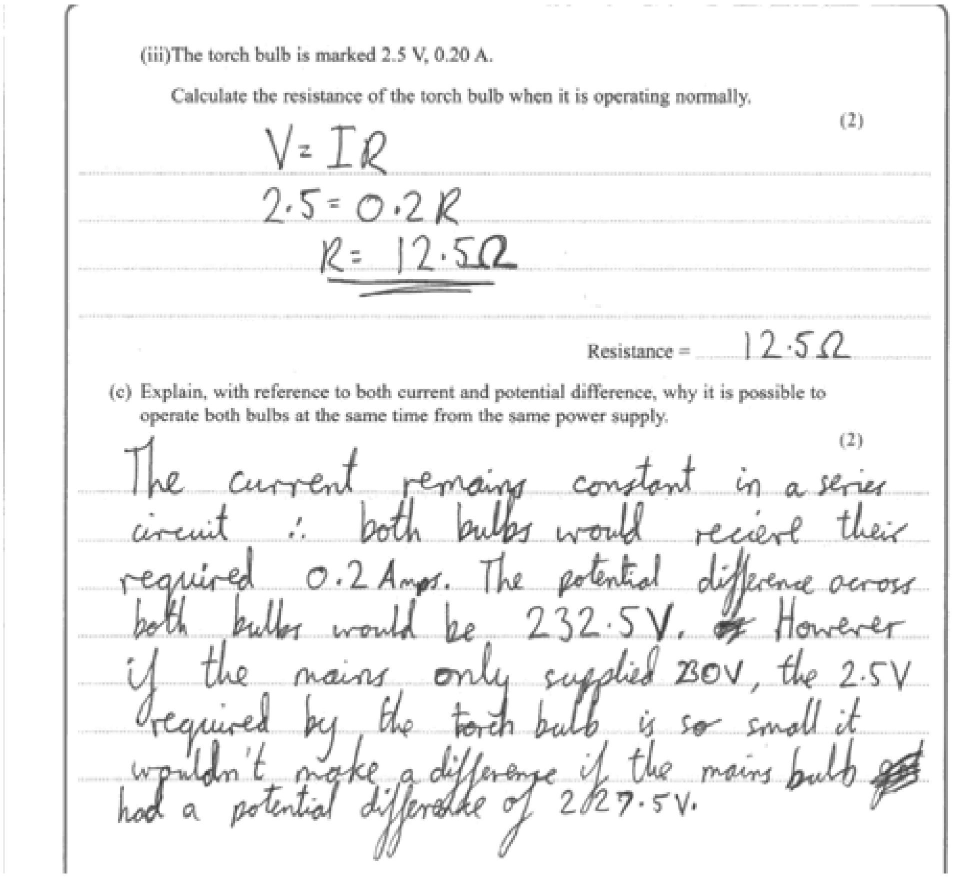
$P = \frac{V^2}{R}$

$40 = \frac{230^2}{R}$

$R = \frac{52900}{40}$

$= 1322.5\Omega$

Resistance = ~~$7.56\times10^{-4}\Omega$~~



(iii) The torch bulb is marked 2.5 V, 0.20 A.

Calculate the resistance of the torch bulb when it is operating normally.

(2)

$V = IR$

$2.5 = 0.2R$

$R = 12.5\Omega$

Resistance = 12.5Ω

(c) Explain, with reference to both current and potential difference, why it is possible to operate both bulbs at the same time from the same power supply.

(2)

The current remains constant in a series circuit ∴ both bulbs would recieve their required 0.2 Amps. The potential difference across both bulbs would be 232.5V. However if the mains only supplied 230V, the 2.5V required by the torch bulb is so small it wouldn't make a difference if the mains bulb had a potential differenke of 227.5V.

ResultsPlus

Examiner Comments

An example of a fully correct answer.

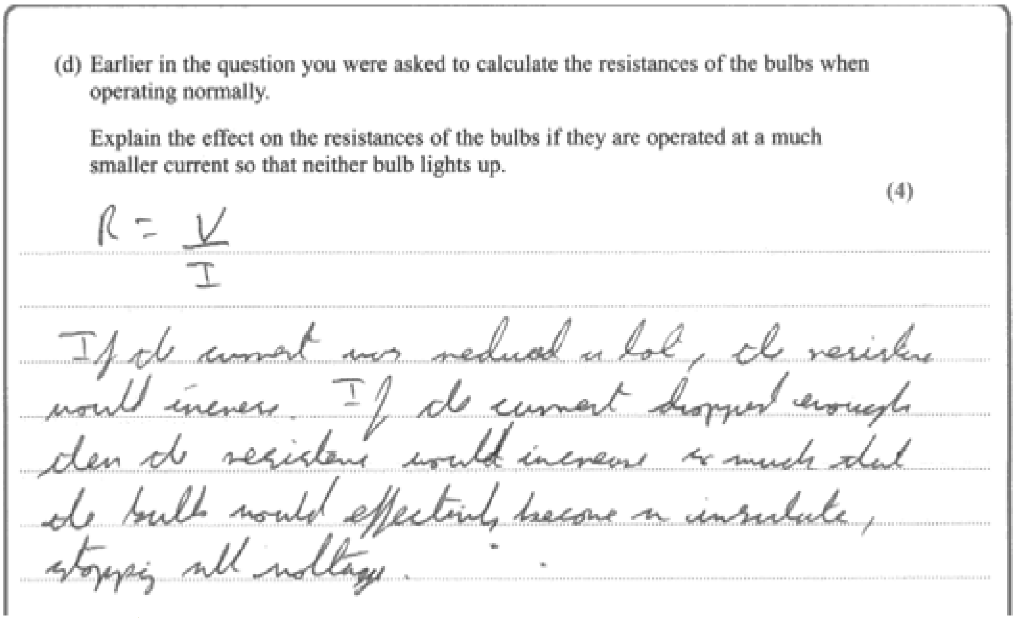
Question 18 (d)

Only about a sixth of the candidates gained one or more marks for this question, and they sometimes had the same misconception as the rest but made a true statement about temperature.

Nearly all candidates thought it was possible - in an unexplained way - to reduce the current in the circuit without changing the potential difference or the light bulbs. They are often encouraged to use relevant formulae to help explain changes, and here they focused on the resistance equation, $R = V/I$. They were told about current and they were asked about resistance so they identified a formula linking them and, in the absence of any comment about it, they made an assumption about the third quantity, potential difference, leading to the conclusion that resistance increased. Candidates ignored everything else in their experience that contradicted this, sometimes coming up with extreme explanations to avoid rejecting their logical conclusion (from a false premise). They often referred to huge resistances and some said this caused the generation of large amounts of wasted energy, so there was none left for light.

Candidates are sure to know by common experience the difference between a hot, glowing light bulb and a non-glowing bulb. They should have studied and explained the I-V graph for a filament lamp. They are expected to recall that the resistance of metallic conductors increases with increasing temperature, and they will have used this to explain the graph. They are also expected to use a lattice vibration model to explain changes of resistance with temperature. These should all have suggested the correct answer.

Of the minority who did adopt the correct approach, most were limited to the marks for lower resistance and lower temperature, sometimes because the collisions they mentioned were between electrons only.



(d) Earlier in the question you were asked to calculate the resistances of the bulbs when operating normally.

Explain the effect on the resistances of the bulbs if they are operated at a much smaller current so that neither bulb lights up.

(4)

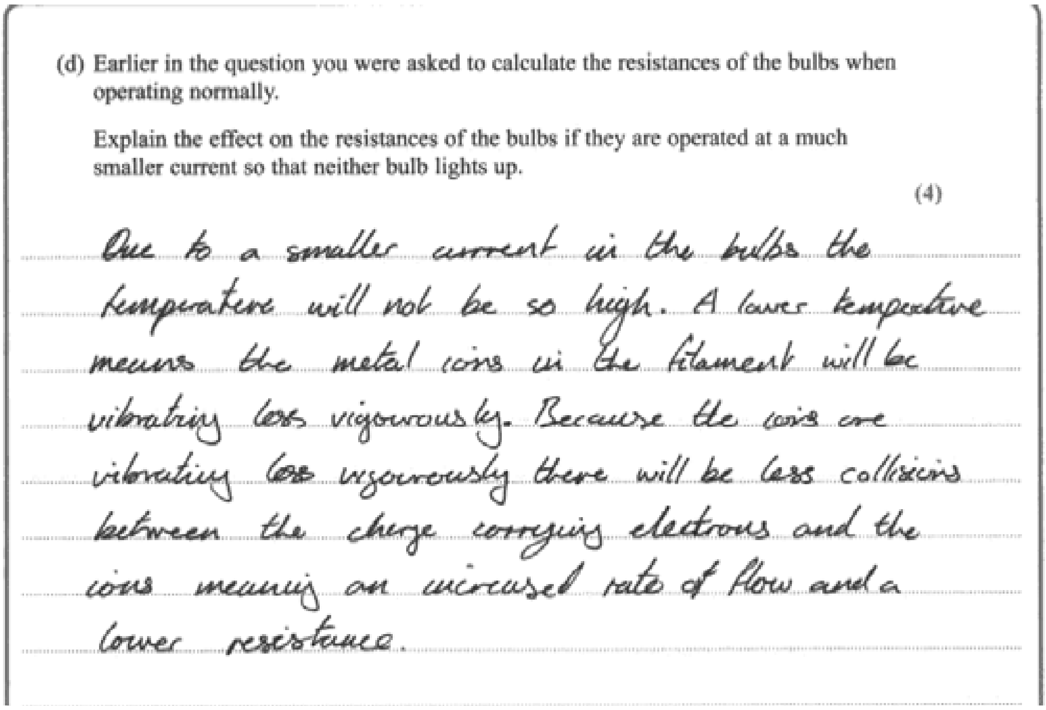
$R = \frac{V}{I}$

If the current was reduced a lot, the resistance would increase. If the current dropped enough then the resistance would increase so much that the bulb would effectively become an insulator, stopping all voltage.

ResultsPlus

Examiner Comments

This is a common response. P.d. is taken to be constant, so it is concluded that resistance would increase.



(d) Earlier in the question you were asked to calculate the resistances of the bulbs when operating normally.

Explain the effect on the resistances of the bulbs if they are operated at a much smaller current so that neither bulb lights up.

(4)

Due to a smaller current in the bulbs the temperature will not be so high. A lower temperature means the metal ions in the filament will be vibrating less vigorously. Because the ions are vibrating less vigorously there will be less collisions between the charge carrying electrons and the ions meaning an increased rate of flow and a lower resistance.

ResultsPlus

Examiner Comments

Three marks are awarded for this response. The lower temperature is identified, as are fewer collisions between electrons and lattice ions and a lower resistance. The only thing missing is the connection between the collisions and the temperature - the energy dissipated.

Paper Summary

- This paper has demonstrated to future candidates the need to learn definitions thoroughly so they can be quoted fully when required.
- They should practise using the data sheet at the end of the paper and make sure they understand the information it contains.
- They should 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.
- When an answer appears contrary to general experience, that is usually time to think about it again and students should pause to consider whether their results are reasonable. This also applies to explanations without calculation.

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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