

Examiners' Report
June 2016

GCE Physics 8PH0 02

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Introduction

Section A of the paper contains eight multiple choice questions followed by questions of increasing length and increasing demand. This section examines the waves and materials component of the course providing a transition for candidates between GCSE and A Level.

Section B contains two questions, with the first question taking inspiration from a short passage. With a total of 20 marks, section B is designed to provide a synoptic element with responses from any part of the AS specification expected. In this case Q15(b) relied on knowledge of dc electricity and Q16(a) required a free-body force diagram. Some candidates seemed unaware of this and this may have caused them to misunderstand what was required of them. For example in Q15(b)(i) answers were often given in terms of the radiation falling on the photocell.

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Many candidates showed a good progression from GCSE to AS level, with prior knowledge extended. Some questions were not answered as well as would have been expected by many candidates. This was particularly noticeable in the new parts of the specification, for example questions centred around optics, Q9 and Q14. Candidates would benefit from more practise in a range of different contexts to become more confident with this topic.

Some practical and investigative skills were less well developed than would have been expected. The teaching and assessment of practical skills has changed with this new specification into a more progressive approach, allowing candidates to develop their skills over time. On this paper candidates were less well able to use a straight line graph to analyse data to find an unknown quantity, as in Q12.

Multiple choice questions were generally answered well with the most able candidates achieving at least 7 marks out of the possible 8 and the least able candidates able to score at least 5.

Question	Percentage scoring correctly	Common incorrect response	Comment
1	79	B and C	A well answered question which assessed candidates on their knowledge that a sound wave is a longitudinal wave and on how a longitudinal wave may be described.
2	78	B and D	A well answered question on units, drawing on the equation $I=P/A$. Incorrect answers B and D at least indicated that the candidate was thinking about power.
3	61	C	Some confusion over which point is the yield point.
4	77	A	Incorrect response indicates candidates who were unaware which direction the viscous drag was acting.
5	26	B	A very poorly answered question. Option B gave a correct value for the average but with too many significant figures. Candidates who selected B ignored the next correct option, maybe having stopped reading through the rest of the options.
6	68	A, B and C	Only two of the options gave valid units for phase difference (C and D). All incorrect options were seen indicating some lack of understanding of phase difference.
7	94	n/a	A very well answered question.
8	81	A	The incorrect response A gave the waves produced by the guitar string correctly as a transverse wave, so candidates who responded incorrectly were assuming the sound waves are transverse.

Question 9 (a)

Many candidates tried to start with $\sin C = 1/n$, a

new equation on this specification, but then struggled to know what to do with the two values of n given in the question. Averaging, adding, subtracting, multiplying the two values or simply ignoring one of the values were common. There was little evidence of the application of the expression to the critical case with many candidates jumping straight to $\sin C = n_1/n_2$. Although full credit was given, it is worthwhile noting that candidates need to be able to apply the equation to any situation for light passing between two mediums.

- 9 A simple optical fibre consists of a core surrounded by cladding. The refractive index of the core is 1.56 and the refractive index of the cladding is 1.20.

(a) Show that the critical angle for light between these two media is about 50° .

(3)

$$n_1 = 1.56, n_2 = 1.2, i = C, r = 90^\circ$$

$$n_1 \sin i = n_2 \sin r$$

$$1.56 \sin C = 1.2 \sin 90$$

$$\sin C = \frac{1.2}{1.56}$$

$$C = \sin^{-1}\left(\frac{1.2}{1.56}\right) = 50.3^\circ$$



ResultsPlus Examiner Comments

The candidate has shown all working clearly, using all the data given in the question, to arrive at the correct answer.



ResultsPlus Examiner Tip

In an AS examination it is rare that data given in the question is not needed.

- 9 A simple optical fibre consists of a core surrounded by cladding. The refractive index of the core is 1.56 and the refractive index of the cladding is 1.20.

(a) Show that the critical angle for light between these two media is about 50° .

$$\sin C = \frac{1}{n} = \frac{1}{1.2} = 0.83^{(3)}$$

$$\sin^{-1}(0.83)$$

$$= 56.44^\circ$$

about 50°



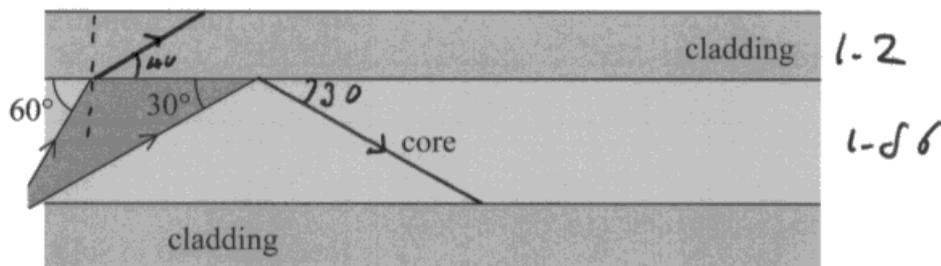
ResultsPlus Examiner Comments

This candidate has only used one value of n given in the question. 56.44 does not round to 50.

Question 9 (b)

In order to answer this question candidates needed to consider what happens to the two rays at either side of the diverging beam. The angles shown in the diagram are not the incident angles and this caused many candidates to draw the exact opposite to what was expected. Some candidates showed the left hand ray refracting the wrong way.

- (b) The diagram shows a diverging beam of light incident on the boundary between the core and the cladding. One side of the beam strikes the boundary at 60° and the other side at 30° as shown.



Three students each suggest a different outcome for the beam of light at the boundary.

Student A says "all the beam will totally internally reflect".

Student B says "all the beam will refract".

Student C says "some of the beam will totally internally reflect and some will refract".

State which student is correct, adding to the diagram to illustrate your answer.

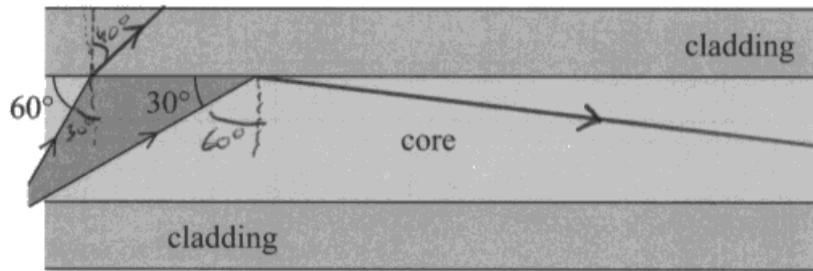
(3)

Student C is correct.



$$(1.56) =$$

- (b) The diagram shows a diverging beam of light incident on the boundary between the core and the cladding. One side of the beam strikes the boundary at 60° and the other side at 30° as shown.



Three students each suggest a different outcome for the beam of light at the boundary.

Student A says “all the beam will totally internally reflect”.

Student B says “all the beam will refract”.

Student C says “some of the beam will totally internally reflect and some will refract”.

State which student is correct, adding to the diagram to illustrate your answer.

(3)

Student C is correct



ResultsPlus
Examiner Comments

The reflected ray is clearly, by eye, not reflecting at the correct angle so would not be awarded the mark.



ResultsPlus
Examiner Tip

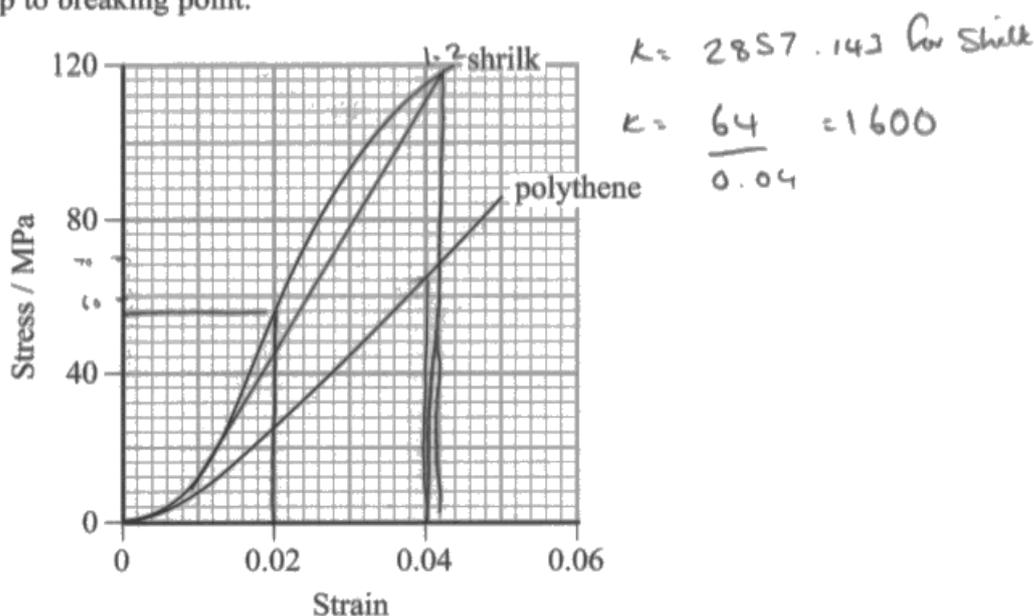
The question suggests adding to the diagram, this is where marks are awarded.

Question 10 (a)(i)

The calculation itself did not pose too much difficulty with most candidates using the correct equation for strain. Errors came with reading from the graph, using the polythene line instead of the shrilk line. Of those who used the shrilk line, some misread the scale to arrive at 48. Some candidates seemed unfamiliar with the "M" prefix in the unit MPa with unit of ten errors being a common mistake on this calculation.

- 10 Shrilk is a new material made from discarded shrimp shells. It is biodegradable and is easily moulded into different shapes. Shrilk is an alternative to polythene and could be used to make waste bags in the future.

The graph shows a stress-strain curve for a 25.0 cm length of shrilk and for a similar length of polythene, up to breaking point.



- (a) (i) Calculate the force applied to the shrilk at a strain of 0.02

cross-sectional area = $1.2 \times 10^{-6} \text{ m}^2$

(3)

$$\text{Stress} = \frac{\text{Force}}{\text{area}}$$

$$48 = \frac{\text{Force}}{1.2 \times 10^{-6}}$$

$$(1.2 \times 10^{-6}) \times 48 = 5.76 \times 10^{-5}$$

$$\text{Force} = 5.76 \times 10^{-5}$$



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Examiner Comments

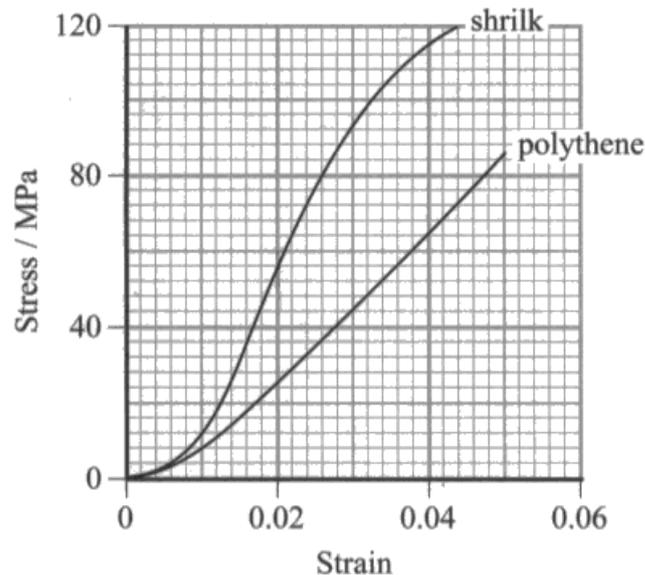
This candidate has used the shrink line to determine the stress but has misread the scale as 48.

Their value is then used correctly in the equation so although the incorrect answer is given they will score one method mark.



ResultsPlus
Examiner Tip

Always show your working clearly. If this candidate had not shown their working they would have scored 0.



(a) (i) Calculate the force applied to the shrink at a strain of 0.02

cross-sectional area = $1.2 \times 10^{-6} \text{ m}^2$

Stress MPa = 56

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$56 \times 10^6 = \frac{\text{Force}}{1.2 \times 10^{-6}}$$

$$\text{Force} = 56 \times 10^6 \times 1.2 \times 10^{-6}$$

$$= 67.2 \text{ N}$$

Force = 67.2 N



ResultsPlus
Examiner Comments

A clear correct answer. This candidate has remembered to convert MPa to Pa.



ResultsPlus
Examiner Tip

You need to be able to recognise and use prefixes to units.

Question 10 (a)(ii)

A calculation that was tackled confidently with units given.

(ii) Determine the extension of the shirk at a strain of 0.04

(2)

$$0.04 = \frac{\text{extension}}{0.25}$$

$$0.04 \times 0.25 = 0.01 \text{ m}$$

Extension = 0.01 m



ResultsPlus
Examiner Comments

Clear correct answer given in metres.

Question 10 (b)

Most candidates were able to achieve some marks in this short written question with all marking points observed regularly. The answer required a comparative description between shrilk and polythene. The term biodegradable was given in the question so this was given no credit.

(b) Deduce whether shrilk or polythene is better for making waste bags.

(3)

Shrilk is better for making waste bags as it can undergo higher stresses and therefore forces before breaking. Furthermore, it experiences lower strain than Polythene at the same stresses, so therefore stretches and extends less.



ResultsPlus Examiner Comments

This answer scores all three marks. There is a clear comparison between shrilk and polythene, demonstrated with comparative words such as higher, lower, less, with the conclusion that shrilk is better.



ResultsPlus Examiner Tip

If a question is asking for you to compare two or more things then your answer should be comparative, so use descriptors such as greater/smaller/more, rather than just large/small.

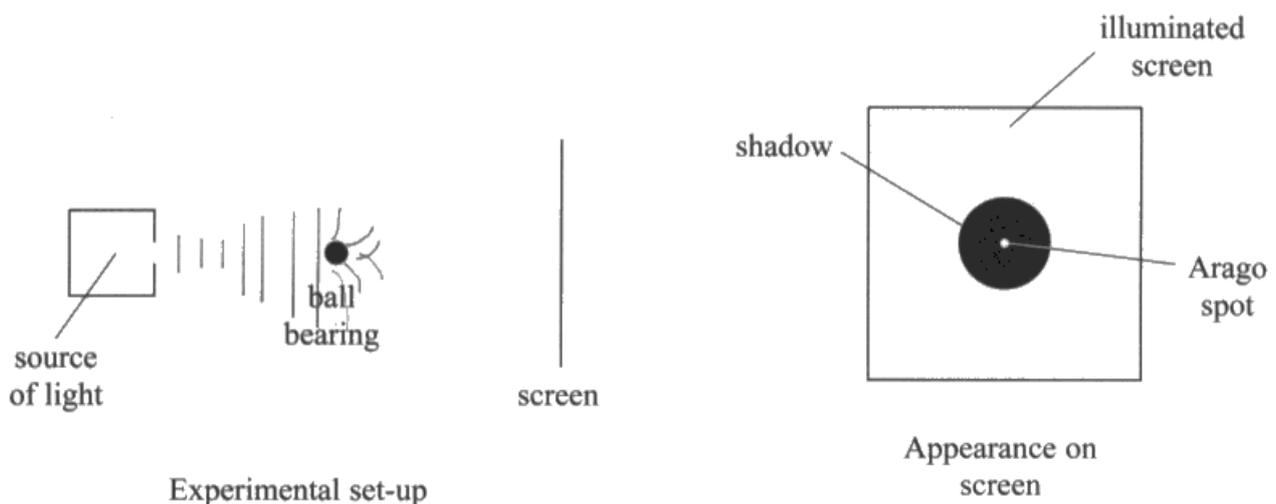
Question 11 (a)(b)

(a) Huygens construction is new to the specification this year. Most candidates recognised this to be about diffraction, with the word diffraction being spelt correctly. Memorising a good description of Huygens construction would have enabled candidates to gain a mark but, often, candidates struggled to find the correct terminology here.

(b) This question commonly scored 2 marks: candidates recognising that the rays are in phase and the bright spot is a position of constructive interference. It was rare to see any mention that the path lengths are the same.

11 The diagram shows a coherent beam of light incident on a metal ball bearing.

A dark shadow is seen on a screen behind the ball bearing. There is a small spot of light in the centre of the shadow. This spot of light is known as the Arago spot.



(a) Use Huygens' construction to explain the behaviour of light as it travels past the edge of the ball bearing.

(2)

Each point on the wavefront can be considered a secondary source and a wavelet can be drawn from this. Therefore the light spreads (diffracts) around the ball and as it passes the edge

(b) Explain why a spot of light is produced at the centre of the shadow.

(3)

The wave diffracts around the ball. This causes waves diffracting from both sides of the ball to interfere. A superposition occurs and in the middle of the centre of the shadow the two waves (from each side of the ball) have

constructively interfered causing light to be seen (the path ~~difference~~ is the same) distance



ResultsPlus Examiner Comments

(a) Scores 2 marks. Clear description of wavelets and diffraction.

(b) The term "interfere" on the second line is insufficient. Fortunately this candidate then correctly states "constructively interfered" on the 5th line which does score the mark. Although not well expressed "a superposition occurs" could have also scored this mark.

"Path distance is the same" gains a second mark since they are clearly referring to the two waves either side of the ball. It was much more common to see references to the phase difference than path difference.



ResultsPlus Examiner Tip

Learn a good description of Huygens construction. The term "wavelets" is accepted as a description of secondary source of waves.

Question 11 (c)

This question was taken from Topic 1 (working as a physicist): spec point 7. It may be useful to ensure candidates are familiar with this topic and able to apply spec points 1 to 8 to all aspects of the course. Candidates recognised it was wave theory for 1 mark and those who achieved a second mark generally mentioned the idea of experimental evidence. Very few mentioned the need for results to be reproducible but it was very rare for full marks to be scored.

- (c) François Arago first demonstrated this experiment in 1818 for a group of eminent scientists, to show the behaviour of light.

State the model for the behaviour of light that this experiment demonstrated and explain why the scientific community accepted this model.

(3)

This experiment demonstrates the wave model for light and it was accepted because it was conclusive evidence that light did indeed have wave properties and behaved like a wave.



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Examiner Comments

This answer scores 2 marks. One for "wave model". The second mark for the idea of experimental evidence. Comments relating to only waves behaving in this way would not get a mark.



ResultsPlus
Examiner Tip

Make sure you are clear on the difference between reproducibility and repeatability.

This experiment demonstrated light as a model of being a ~~wave~~ ^{particle} and they accepted this theory because this experiment showed that only particles could produce such an effect.



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Examiner Comments

Scores 0 as the candidate is talking about particle theory.

Question 11 (d)

This question is assessing a practical skill about which knowledge is assumed. Most candidates were able to name a suitable device. Whilst candidates gave the idea of taking several readings to calculate an average, some did not state that the readings should be in different places.

(d) The ball bearing shown in the experimental set-up has a diameter of about 1 cm.

Describe how the diameter could be measured accurately.

(2)

By using a micrometer. ~~Take repeat~~ Take repeat readings from the micrometer across several different diameters of the ball (by rotating it) and then find the average and account for the zero error of the micrometer.



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Examiner Comments

This candidate scores both marks. They use a micrometer for 1 mark, then correctly describe how it is used with readings across different places and finding an average.

The diameter could be measured accurately using a calliper. This would give an accurate measurement.



ResultsPlus
Examiner Comments

It was not uncommon to see callipers written in the singular as a calliper.

Question 12 (a)

Although the question does not mention that the guitar string is removed from the guitar this is core practical 7 (spec point 69) and candidates are expected to know the procedure to investigate this. There was a clear distinction between those candidates who were familiar with this and those who were not.

- 12 A student carries out an experiment using a guitar string. She investigates the effect of varying the tension in the guitar string on the frequency of sound produced when the string is plucked.

(a) Describe a method of varying and measuring the tension in the string.

(2)

Hang weights at the end of the string over a pulley.
The weight of the weights can be assumed to be the tension in the string. You can change the weight by adding or removing weights to change the tension.



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Examiner Comments

This scores both marks in the first three lines.

(2)

using the tuning peg on the headstock of the guitar to tighten the string which would change tension.
She could measure the tension by calculating



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Examiner Comments

This is a candidate who has not recognised this as a core practical. Scores 0.



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Examiner Tip

Make sure you are familiar with the core practicals.

The string can be attached to an oscillator (in order to vary frequency) with the oscilloscope, with weights suspended from one end of the string. Weights can be added or removed to vary tension. (2)



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Examiner Comments

This answer is treating frequency as an independent variable but its description in the question is that of a dependent variable. The question, however, is only asking about the tension so there is no need to refer to frequency to answer it.

Question 12 (b)(c)

(b) Candidates coped well with a difficult size of graph with an awkward scale on the y-axis. A significant number did not appreciate that completing the graph meant drawing a line of best fit. Some leeway was given here due to the size of the axes but for an acceptable line of best fit there needs to be an approximately even distribution of points either side of the line.

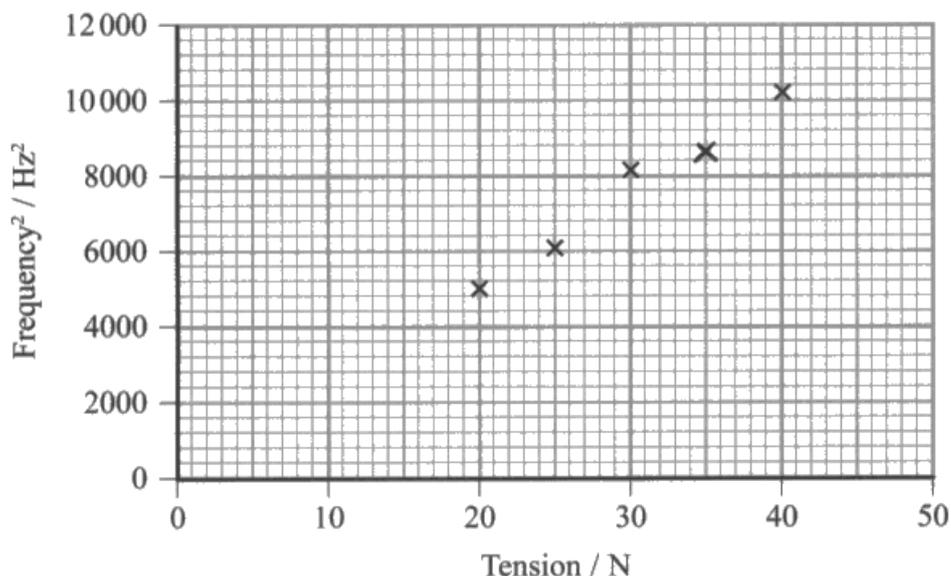
(c) Many failed to use a gradient from the graph to answer this question but simply substituted values from the graph or the table. The ability to manipulate an equation to give a straight line graph is an expected investigative skill. In this question candidates were expected to make a conclusion based upon the value they obtained. It was encouraging to see that candidates generally did this.

(b) The student records the following data and plots a graph.

Tension / N	20	25	30	35	40
Frequency / Hz	70	78	90	95	101
Frequency² / Hz²	4900	6084	8100	9025	10201

Complete the table and graph.

(3)



(c) The student reads that guitar strings have a mass per unit length of between $0.4 \times 10^{-3} \text{ kg m}^{-1}$ and $7 \times 10^{-3} \text{ kg m}^{-1}$.

Determine whether the guitar string used in this experiment lies within this range.

length of string vibrating = 0.40 m

$$v = \sqrt{\frac{T}{\mu}}$$

$$\text{length} = 0.4 \text{ m}$$

(5)



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Point plotted just out of tolerance.
No line of best fit. Scores 1 mark.



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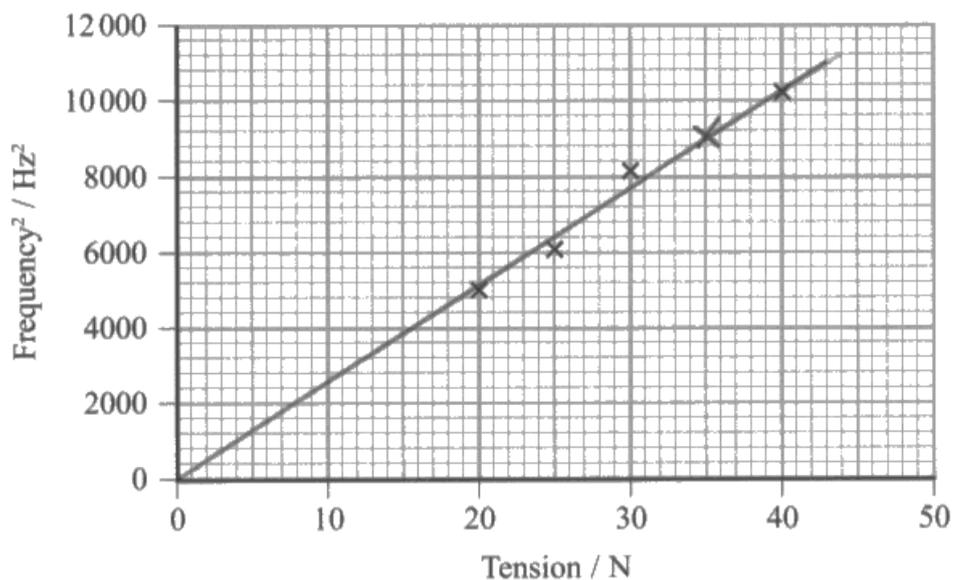
Generally, completing a graph means drawing a line of best fit which may be a straight line (using a ruler) or a smooth curve. The line should be drawn with roughly the same number of points either side of the line and should not be forced through the origin. When drawing a line of best fit on axes covering a full page a 30 cm ruler is preferable to avoid a disjointed line.

(b) The student records the following data and plots a graph.

Tension / N	20	25	30	35	40
Frequency / Hz	70	78	90	95	101
Frequency² / Hz²	4900	6084	8100	9025	10201

Complete the table and graph.

(3)



- 4×10^{-4}
(c) The student reads that guitar strings have a mass per unit length of between $0.4 \times 10^{-3} \text{ kg m}^{-1}$ and $7 \times 10^{-3} \text{ kg m}^{-1}$.

Determine whether the guitar string used in this experiment lies within this range.

length of string vibrating = 0.40 m

$$f\lambda = \sqrt{\frac{T}{\mu}}$$
$$101 \times 0.4 = \sqrt{\frac{40}{\mu}}$$

$$v = f\lambda$$

$$v = \sqrt{\frac{T}{\mu}} \quad (5)$$

$$(101 \times 0.4)^2 = 1632.16$$

$$\frac{1632.16}{40} = 0.0245 \mu$$

$$= 2.45 \times 10^{-2} \text{ kg m}^{-1}$$

so the guitar string in this experiment
does not lie in this range.



ResultsPlus Examiner Comments

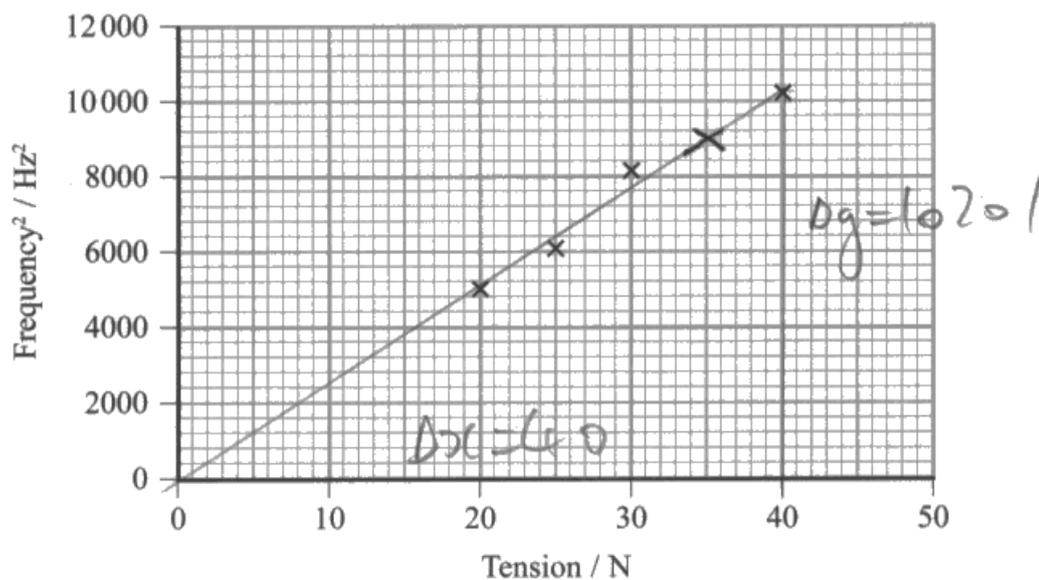
This candidate has equated the correct two equations but has used a value for wavelength of 0.4 m so arrives at an incorrect answer. Despite this, they make a valid conclusion based upon their answer so they can score a mark for a conclusion consistent with their value.

(b) The student records the following data and plots a graph.

Tension / N	20	25	30	35	40
Frequency / Hz	70	78	90	95	101
Frequency² / Hz²	4900	6084	8100	9025	10201

Complete the table and graph.

(3)



- (c) The student reads that guitar strings have a mass per unit length of between $0.4 \times 10^{-3} \text{ kg m}^{-1}$ and $7 \times 10^{-3} \text{ kg m}^{-1}$

Determine whether the guitar string used in this experiment lies within this range.

length of string vibrating = 0.40 m

(5)

$$v = \sqrt{\frac{T}{\mu}}, \quad v = fl$$

$$fl = \sqrt{\frac{T}{\mu}}$$

$$f = \frac{1}{2} \sqrt{\frac{T}{\mu}} \quad \mu = \frac{1}{4} = 255.025 \times 0.80^2$$

$$f^2 = \frac{1}{4} \times \frac{T}{\mu} \quad \mu = 6.13 \times 10^{-3} \text{ kg m}^{-1}$$

$$f^2 = \frac{T}{4\mu}, \quad \mu = \frac{1}{4f^2} \quad 0.4 \times 10^{-3} \text{ kg m}^{-1} < 6.13 \times 10^{-3} \text{ kg m}^{-1} < 7 \times 10^{-3} \text{ kg m}^{-1}$$

$$\mu = \frac{1020 \text{ Hz}}{40 \text{ N}} = 255.025$$

\therefore the guitar string lies within this range.

$$\frac{1}{4\mu} = 255.025$$

$$f_0, L = \frac{\lambda}{2}, 2L = \lambda$$

$$\lambda = 0.80 \text{ m}$$



ResultsPlus Examiner Comments

(b) Scores all 3 marks. Line of best fit is drawn with points on both sides of the line.

(c) This scores full marks. The x and y values of the gradient had been clearly shown on the graph and they have used this data in their calculation. The equations have been equated and rearranged and a wavelength of 0.8 m is used. The candidate gives the correct answer and makes a suitable conclusion at the end.

Question 13 (a)

This style of question is new to this specification and there will be one or two on each paper. Of the 6 marks available, 4 marks are awarded for the physics and 2 marks for the candidate's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Candidates of all abilities were able to gain marks in this written answer with most candidates scoring 3 marks.

Electron diffraction is new to the AS specification so it was encouraging to see that candidates had gained knowledge and understanding in this area.

- 13 An electron beam is directed onto crystalline graphite. A fluorescent screen on the other side of the crystal shows the pattern in Figure 1. The brighter areas correspond to higher electron intensity.

The speed of the electrons is increased and the resulting pattern is shown in Figure 2.

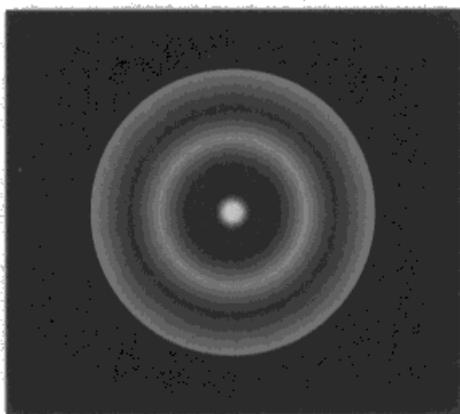


Figure 1

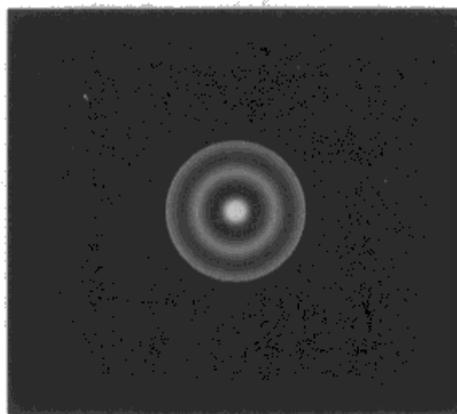


Figure 2

- *(a) Discuss the conclusions that can be drawn from this information about the behaviour of electrons and the structure of graphite.

(6)

In the diagrams it can be seen that when this experiment is performed electrons behave as waves and produce an interference pattern. While this does not mean that electrons are waves it shows that they exhibit wave-like properties.

Diffraction can only occur when the gap it occurs through is of a similar size to that which is being diffracted. From this we can conclude that the structure of

Crystalline graphite is such that the gaps between atoms is similar to the wavelength of the electron given by $\lambda = \frac{h}{p}$ - de Broglie's equation - when travelling at a certain speed.



ResultsPlus Examiner Comments

In the first paragraph there are two physics points: recognising an interference pattern and that this demonstrates electrons exhibiting wave properties, which gets 2 marking marks. One linkage mark from the first paragraph is also awarded. A total of 3 marks.

In the second paragraph the candidate goes on to talk about the size of gaps in graphite being linked to the amount of diffraction. This was commonly seen. Whilst the de Broglie equation is given, it has not been linked to the speed and wavelength of electrons. Neither is there any mention of the pattern getting smaller as speed increases. No marks can be awarded in the second paragraph.



ResultsPlus Examiner Tip

Quoting an equation in a written answer can be a useful way to justify the physics behind what you are saying. However, all terms in the equation must be defined.

- 13 An electron beam is directed onto crystalline graphite. A fluorescent screen on the other side of the crystal shows the pattern in Figure 1. The brighter areas correspond to higher electron intensity.

The speed of the electrons is increased and the resulting pattern is shown in Figure 2.

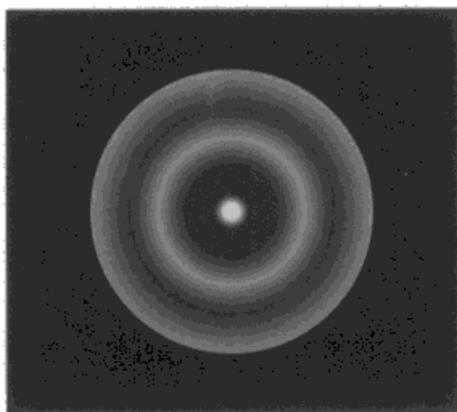


Figure 1

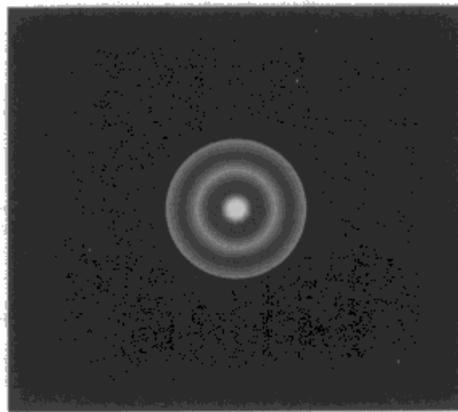


Figure 2

- *(a) Discuss the conclusions that can be drawn from this information about the behaviour of electrons and the structure of graphite.

(6)

The bright areas are caused by electron diffraction.

Only waves can undergo diffraction, which shows that electrons can exhibit wave-like properties.

Higher electron ~~velocity~~^{speed} causes the bright rings to become sharper and closer together which suggests that the de Broglie's wavelength of electrons decreases as speed increases because smaller wavelength diffract less and therefore lead to a narrower pattern. $\lambda = \frac{h}{p} = \frac{h}{mv}$

so a larger value for v results

in a smaller wavelength. For diffraction to occur the electrons must go through a gap which suggests that there must be spaces between the carbon atoms in graphite whose width is similar to the de Broglie's wavelength of the beam of electrons.



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Examiner Comments

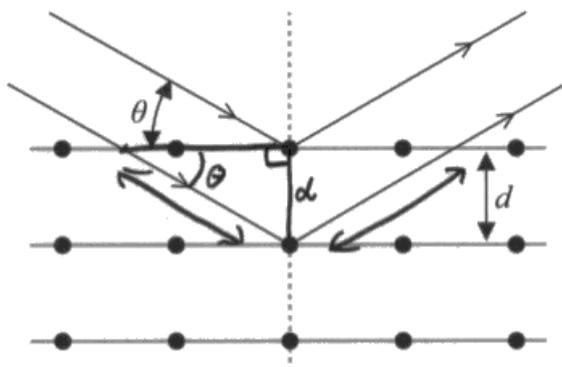
This answer scores a total of 5. There are 5 physics points in the answer for which 3 marks are gained, plus 2 linkage marks.

The only physics point missing is the reference to angles and wavelength, the 4th Physics point on the mark scheme. This point was rarely seen.

Question 13 (b)(i)

To answer this question candidates needed to show a clear derivation of an equation using the diagram. As the equation was given in the question this meant that there was some fudging going on and the mark scheme was designed to avoid awarding marks to these candidates. Many candidates were unable to recognise the total extra distance travelled by the beam from the diagram which meant that they were unable to pick up any marks as their derivation went nowhere. Most candidates were awarded 0 marks.

- (b) An electron beam can be used to explore the structure of solid materials. The diagram shows an electron beam reflected by the top two layers of atoms within a material. The two layers are separated by a distance d .



- (i) Show that the extra distance travelled by the electron beam reflecting off the second layer of atoms is given by $2d\sin\theta$.

θ is the angle between the beam and each layer of atoms.

You may add to the diagram.

d r θ
 $r = \frac{d}{\sin(\theta)}$

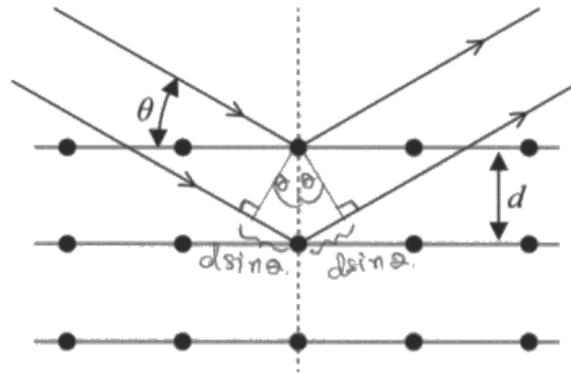
(2)

$$2 \times \frac{d}{\sin(\theta)} = \frac{2d}{\sin\theta}$$



ResultsPlus
Examiner Comments

Incorrect labelling of the angle was common, as was the lack of recognition of what the extra distance was, as seen in this example scoring 0.



$$2d \sin \theta = n\lambda$$

- (i) Show that the extra distance travelled by the electron beam reflecting off the second layer of atoms is given by $2d \sin \theta$.

θ is the angle between the beam and each layer of atoms.

You may add to the diagram.

(2)

The angle between the normal drawn and the lines perpendicular to both rays of the electron beam is equal to θ . So the extra distance travelled by the electron beam reflecting off the second layer of atoms is $d \sin \theta + d \sin \theta = 2d \sin \theta$. #



ResultsPlus Examiner Comments

This answer scores full marks from just the annotations made to the diagram. The angle is labelled correctly and the extra distance is shown. The written explanation confirms that this candidate understood what they were doing.



ResultsPlus Examiner Tip

If the question suggests you add to the diagram then remember that marks may be awarded for doing this correctly.

Question 13 (b)(ii)

Most candidates scored 0. Many candidates thought that this is something to do with energy levels. Those that did have some idea, but hadn't got the terminology of different orders, usually couldn't describe it well enough to score.

- (ii) Give one reason why there is more than one ring shown in both Figure 1 and Figure 2.

(1)

They represent different orders, - each is where the wave length of electrons are in phase with each other. The dark spots are out of phase - anti-phase.



ResultsPlus
Examiner Comments

Use of the word "orders" is acceptable as a suitable technical term in this situation.

- (ii) Give one reason why there is more than one ring shown in both Figure 1 and Figure 2.

(1)

When the light reflects off different layers of material it will produce another ring.



ResultsPlus
Examiner Comments

This candidate needed to replace the word material for atom.

Question 14 (a)

Most candidates scored full marks on this straight forward calculation using an equation that is new to this specification but simple mistakes with rounding were made.

(a) Show that the focal length of the objective lens is about 1200 mm.

(2)

~~0.820 = 1.2~~

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

$$f = \frac{1}{p} \quad f = \frac{1}{0.820} \quad f = 1.2195 \text{ m}$$

$$f = 1220 \text{ mm} \quad \text{So its about } 1200 \text{ mm}$$



ResultsPlus
Examiner Comments

This scores both marks.

(a) Show that the focal length of the objective lens is about 1200 mm.

(2)

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad p = \frac{1}{f} \quad \rightarrow \quad f = \frac{1}{p}$$

$$f = \frac{1}{0.820} = 1.2 \text{ m} = 1200 \text{ mm}$$



ResultsPlus
Examiner Comments

Scores 1 mark only. Does not give their answer to at least one more significant figure than given in question.



ResultsPlus
Examiner Tip

In a show that question you must give you answer to at least one more significant value than given in the question.

(a) Show that the focal length of the objective lens is about 1200 mm.

(2)

$$P_{\text{ow}} = 0.82$$

$$P_{\text{ow}} = \frac{1}{f}$$

$$0.82 = \frac{1}{f}$$

$$0.82f = 1$$

$$f = \frac{1}{0.82} = \underline{1210 \text{ mm}}$$



ResultsPlus
Examiner Comments

This scores 1 as the answer has been rounded incorrectly to 1.21



ResultsPlus
Examiner Tip

You are expected to be able to round numbers correctly.

Question 14 (b)(i)

Candidates were being assessed on their knowledge that the focal point is the point at which an image is formed when the object is a long way away. In this situation the rays from a point on the object are parallel when they are incident at the lens. The use of the word parallel was needed. Alternatively a mathematical approach was accepted. Attempt at a written answer was more common but a mathematical approach was also used frequently, and usually more successfully.

(b) Telescopes can be used to observe distant objects such as the Moon.

(i) Explain why the image of the Moon produced at P by the objective lens will be at a distance of about 1200 mm from this lens.

(2)

The Moon is at infinity, so the rays will be parallel and will be focused to the focal point of the objective lens which is ~~1200~~ 1200 mm (about 1200 mm) from the centre of the lens.



ResultsPlus

Examiner Comments

This answer scores both marks for correct use of the word parallel and a recognition that the rays are focused at the focal point.

As the rays of ~~the~~ ^{converge} light ^{converge} from the Moon are ^{more} so distant so u is very large so $\frac{1}{u} \approx 0$ meaning $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ becomes $\frac{1}{f} = \frac{1}{v}$ so as $f \approx 1200 \text{ mm}$ $v \approx 1200$.



ResultsPlus

Examiner Comments

This is a correct response using a mathematical approach.

Question 14 (b)(ii)

The property of an image can be described as upright or inverted, diminished or magnified, and real or virtual. It was clear from candidate responses that there were those who were used to using these three descriptors and those who were not. More practise at drawing ray diagrams and describing the image would make this more intuitive.

(ii) State the properties of the image at P.

(2)

Inverted

diminished

real



ResultsPlus
Examiner Comments

A perfect full mark answer using correct terminology.



ResultsPlus
Examiner Tip

When describing the properties of an image usually just three words will do: upright or inverted, diminished or magnified, and real or virtual. Sometimes you may also be expected to calculate or measure the position of the image.

(ii) State the properties of the image at P.

(2)

It is a real image, the light rays are actually there as they've passed through another point in space and can be captured on a screen.



ResultsPlus
Examiner Comments

This candidate has not used the three descriptors to give the properties of the image although has mentioned one of them for 1 mark.

Question 14 (c)

Candidates were expected to use $1/f = 1/u + 1/v$ to calculate the focal length f . They needed to remember to use a negative value v for a virtual image but very few seemed to know and use the sign convention for real and virtual images, convex and concave lenses.

- (c) The eyepiece is at a distance of 100 mm from the image at P. To give a reasonable magnification, the final image at Q should be a virtual image at a distance of 300 mm from the eyepiece.

The following lenses are available:

diverging lens focal length 150 mm,
converging lens focal length 150 mm,
diverging lens focal length 100 mm,
converging lens focal length 100 mm.

Deduce which lens should be used for the eyepiece.

(3)

$$1/u + 1/v = 1/f$$

$$1/100 + 1/-300 = 1/f$$

$$\Rightarrow 1/f = 1/150 \Rightarrow f = 150 \text{ mm}$$

The lens should be a converging lens of focal length 150 mm



ResultsPlus
Examiner Comments

A well laid out answer, gaining full marks.

- (c) The eyepiece is at a distance of 100 mm from the image at P. To give a reasonable magnification, the final image at Q should be a virtual image at a distance of 300 mm from the eyepiece.

The following lenses are available:

diverging lens focal length 150 mm,
 converging lens focal length 150 mm,
 diverging lens focal length 100 mm,
 converging lens focal length 100 mm.

Deduce which lens should be used for the eyepiece.

(3)

Must be diverging because the image
 is virtual, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, $\frac{1}{f} = \frac{1}{100} + \frac{1}{300}$
 $\Rightarrow f = 75 \text{ mm}$. Closest lens is diverging
 lens focal length 100 mm



ResultsPlus
 Examiner Comments

This candidate did not use -v and arrived at an incorrect answer of 75 mm. As they showed their use of the equation this answer will have scored 1.



ResultsPlus
 Examiner Tip

A common misconception is that because the image is virtual the lens must be a diverging lens. A virtual image may be formed from a converging lens – for example, a magnifying glass. Make sure you are familiar with the sign convention for real and virtual images and converging and diverging lenses.

Question 15 (a)

Section B can draw on knowledge from all parts of the specification across papers 1 and 2. This question uses a short text to provide stimulus for the question.

Candidates recognised this to be about the photoelectric effect or some referred to ionisation. The mark scheme enabled candidates to achieve marks whichever approach they took. Correct reference to photons was necessary for 1 mark. The idea of a one to one interaction has come up on past papers but it is not being stated. Many candidates found it difficult to express the physics clearly for the last marking point. The question refers to radiation being able to "knock electrons out of atoms". There is an expectation here that candidates understand that this is referring to the release of electrons and no marks were given for a candidate who simply repeated this phrase from the question. It was also common to see phrases such as "when the energy overcomes the work function" or "when frequency satisfies the threshold frequency". This is not specific enough; the inclusion of the words "is greater than" instead of overcome or satisfies would score a mark.

15 Read the following extract and then answer the questions that follow.

Powdery dust, the by-product of fearsome meteor storms that pounded the Moon, coats much of the lunar surface. A build-up of this dust could damage sensitive machinery.

Scientists theorise that lunar dust must be electrostatically charged by ultraviolet solar radiation from the Sun. When ultraviolet radiation hits the Moon's "day side", the half that faces the Sun, it knocks electrons out of atoms in the lunar soil.

(a) Describe the particle model of ultraviolet radiation that explains how it can "knock electrons out of atoms".

(3)

Ultraviolet light has a high frequency so has high energy photons which are absorbed by the atoms in the lunar soil, and if enough energy is absorbed then an electron is emitted knocked out of the atom with kinetic energy



ResultsPlus
Examiner Comments

This scores 1 mark for photons. There is no one to one interaction; a photon is absorbed by an electron would have been sufficient. In line 4 they are half way to the last mark but then repeat the phrase in the question "knocked out". If they had rephrased it as "released" the candidate would have been awarded this mark.



ResultsPlus
Examiner Tip

It is good practise to refer to the question in your answer but no credit is given for simply repeating what you have been told in the question.

15 Read the following extract and then answer the questions that follow.

Powdery dust, the by-product of fearsome meteor storms that pounded the Moon, coats much of the lunar surface. A build-up of this dust could damage sensitive machinery.

Scientists theorise that lunar dust must be electrostatically charged by ultraviolet solar radiation from the Sun. When ultraviolet radiation hits the Moon's "day side", the half that faces the Sun, it knocks electrons out of atoms in the lunar soil.

(a) Describe the particle model of ultraviolet radiation that explains how it can "knock electrons out of atoms".

As the ^{UV} light increases the energy in the atoms, the electrons get excited causing them to raise up energy bands. When the light is gone again the electrons ~~to lose~~ lose energy, causing them to be "knocked off" the atoms. (3)



ResultsPlus
Examiner Comments

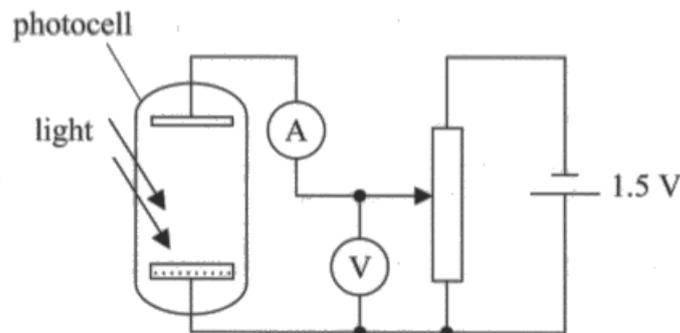
This candidate is talking about energy levels. Whilst a candidate who does refer to energy levels could score some marks, this candidate scores 0.

Question 15 (b)(i)

Nearly half of all candidates failed to score on this question. This may have been a consequence of candidates not being fully aware of the synoptic element and so did not expect to be answering a question about potential dividers. Careful reading of the question indicates that they are to write about the potential divider circuit but instead they looked at the circuit as a whole. Of those who realised that this was about potential dividers they struggled to express their answer clearly. The question refers to 0 and 1.5 V so candidates were expected to describe what has to happen to the slider to get 0 V and similarly for 1.5 V. A significant number got these the wrong way round: 1.5 V achieved with the slider at the bottom and vice versa.

- (b) A teacher uses the arrangement below to demonstrate that electrons can be knocked out of a metal surface in a photocell by visible light.

The arrangement can also be used to measure the maximum kinetic energy of these electrons.



- (i) Explain how the potential divider circuit can produce a range of values from 0 to 1.5 V on the voltmeter.

(3)

If the wire is placed at the minimum value on the rheostat, then ~~the rheostat will have 0 resistance~~ and therefore 0 potential difference, so the voltmeter will read 0V. If the wire is placed at the maximum resistance position on the rheostat the voltmeter will be across the total resistance which receives the total potential difference of 1.5V from the cell as voltage is shared in the ratio of resistances. ~~the voltmeter will be across~~



ResultsPlus
Examiner Comments

A rare 3 mark answer. They have recognised and linked the position of the slider with the resistance across the voltmeter and the reading on the voltmeter at the two positions of maximum and minimum resistance.

- (i) Explain how the potential divider circuit can produce a range of values from 0 to 1.5 V on the voltmeter.

No light, means the photocell does not undergoes the photoelectric effect, which means the voltage is 1.5V as all the metals electrons are in the current. As the light intensity increases, the photoelectric effect occurs and the photocell produces photoelectrons. This means less go to the current and there would be a lower voltage (all the way to 0V). ⁽³⁾



ResultsPlus
Examiner Comments

This candidate has not answered the question about the potential divider but has described what is happening to the photocell. This was a common incorrect approach.



ResultsPlus
Examiner Tip

Read the question carefully to make sure you are answering the correct question.

- (i) Explain how the potential divider circuit can produce a range of values from 0 to 1.5 V on the voltmeter.

(3)
If the slider is at the very top of the circuit then it would produce 1.5 V if it is at the bottom the resistance is alot higher and will cause 0v to flow.



ResultsPlus
Examiner Comments

This candidate is attempting to answer the question but is struggling to find the correct language. One mark is given in the first 3 lines for 1.5 V produced when the slider is at the top, but there is nothing after that. They have a higher resistance when the slider is at the bottom which is incorrect. In the last line the expression "0 V to flow" is poorly expressed physics.



ResultsPlus
Examiner Tip

Potential difference (voltage) does not "flow". There is a potential difference across a component.

Question 15 (b)(ii)

Most candidates failed to score. Most common mistake was to multiply or divide 0.6V by the charge on an electron. At least this demonstrated some recognition of electronvolts. An answer of 0 V was also common.

- (ii) The potential difference on the voltmeter is increased until the ammeter reading is zero.

The voltmeter reads 0.6 V at this instant.

State the maximum kinetic energy of the electrons in eV.

$$0.6 \times 1.6 \times 10^{-19}$$

Maximum kinetic energy = 9.6×10^{-20} eV ⁽¹⁾



ResultsPlus
Examiner Comments

A common incorrect answer – multiplying by e.



ResultsPlus
Examiner Tip

The question asks candidates to "state". This means that no calculation is needed.

Question 15 (c)

The command word used here in the question is discuss. Here, the candidate is expected to explore all aspects of whether the photocell arrangement is a valid demonstration. This requires the candidate to give reasons for why it is valid and why it is not valid. Overall less than half scored any marks but most candidates made an attempt. The most common points awarded were: for the same concept, one using UV for the other light, and the idea of different materials. The other points were hardly, if ever, seen. There were 4 independent marks for this question, so a candidate should try and give four different reasons and not spend too long repeating or explaining just one idea.

(c) Discuss whether the photocell arrangement in part (b) gives a valid demonstration of how dust particles become charged on the Moon.

(4)

On the Moon, ultraviolet radiation is used and not visible light like the arrangement in b. This means that they will both have a different maximum kinetic energy. Different 'materials' are also used so they will have different work functions so therefore different frequencies. It may show the same principle but it isn't a valid demonstration



ResultsPlus

Examiner Comments

This candidate scores 3 marks. They give two reasons why it is not a valid demonstration: different wavelengths and different materials. At the end they make the point that they show the same principle.

(c) Discuss whether the photocell arrangement in part (b) gives a valid demonstration of how dust particles become charged on the Moon.

(4)

The photocell arrangement in part(b) does give a valid demonstration of how dust particles become charged as the light used in this experiment uses visible light as oppose to ultraviolet light. The dust is also being represented as a metal sheet in this experiment which is inaccurate as the metal and dust have different properties however the experiment does demonstrate the same effect of which has the same concept of how the particles become charged.



ResultsPlus Examiner Comments

This also scores 3 marks: light v UV, dust v metal and uses the same concept. The first sentence is a little misleading as it seems to suggest that it is valid as one uses light and the other uses UV – matching an invalid argument with the statement that it is valid. It does not apply in this response as only 3 physics points are awarded but it may have prevented the candidate achieving full marks if there had been 4 physics points made (see additional guidance on mark scheme).



ResultsPlus Examiner Tip

There are two points of view. Structure your answer with two paragraphs; one starting "Valid because..." and the other starting "Not valid because..." putting the correct arguments in each paragraph.

Question 16

This question contains a synoptic element, drawing on mechanics from paper 1 and materials. Most candidates were able to score marks within this question.

(a) There was some uncertainty about drawing the force arrows. Tension and weight were the most commonly recognised but for many candidates the reaction force was either mislabelled (push of foot on rock, normal) or drawn horizontally to the right.

(b)(i) This question was done well. Resolving the force to either cos or sin (cos preferred) and equating to the weight.

(b)(ii) Most candidates scored marks. The two main pitfalls were: either not including the $1/2$ within the equation, or not converting cm to m.

(b)(iii) Only a minority of candidates scored the mark. It was common to see references to energy loss or other forces in action. Those who came close to the correct answer stated that it was the elastic limit that should not be exceeded.

- 16 The diagram shows a rock climber of mass 55 kg. She is hanging on a rope with one foot in contact with a rock face. She uses this foot to push herself horizontally away from the rock face. The rope is inclined at 20° to the vertical.



- (a) Complete the free-body force diagram below to represent the forces acting on the climber.



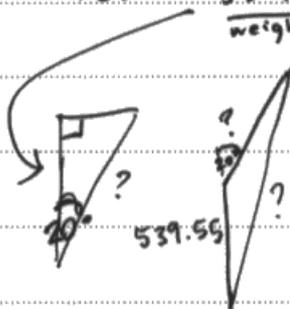
(3)

(b) (i) Show that the tension in the rope is about 600 N.

(3)

$$55 \times 9.81 = 539.55 \text{ N}$$

weight



(ii) The rope extends by 2.5 cm when used as shown.

Calculate the energy stored within the rope.

(2)

$$\Delta E_{el} = \frac{1}{2} F \Delta x$$

$$\frac{600 \times 2.5}{2} = 750$$

Energy stored = 750 J

(iii) State one assumption made in this calculation.

(1)

Rope has not stretched past yield point.



ResultsPlus Examiner Comments

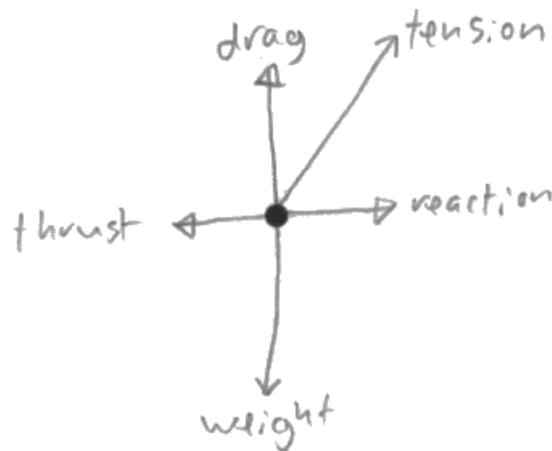
- (a) 2 marks for the tension arrow and weight arrow.
- (b)(i) Weight has been calculated but the candidate has done nothing with it so no marks awarded.
- (b)(ii) The candidate has not converted cm to m. Working is clearly shown so the candidate scores 1 mark.
- (b)(iii) Yield point is beyond the limit of proportionality. No mark.



ResultsPlus Examiner Tip

You need to know the difference between the limit of proportionality, the elastic limit and the yield point.

- (a) Complete the free-body force diagram below to represent the forces acting on the climber.



(3)

- (b) (i) Show that the tension in the rope is about 600 N.

(3)

$$w = mg$$

$$= 55 \times 9.81 = 539.55 \text{ N}$$



$$\cos 20^\circ = \frac{539.55}{x}$$

$$x = \frac{539.55}{\cos 20} = 574.18 \text{ N} = \text{tension} \approx 600 \text{ N}$$

- (ii) The rope extends by 2.5 cm when used as shown.

Calculate the energy stored within the rope.

(2)

$$E = \frac{1}{2} F \Delta x$$

$$= 0.5 \times 600 \times 0.025 = 7.5 \text{ J}$$

Energy stored = 7.5 J

- (iii) State one assumption made in this calculation.

(1)

the force has not exceeded the elastic limit of the rope



ResultsPlus

Examiner Comments

(a) This gets 2 marks: one for the tension arrow and one for the weight arrow. Even if the arrow horizontally to the left had been labelled correctly, full marks could not be awarded as there are too many arrows drawn.

(b)(i) Correct calculation of weight used correctly with the vertical component of T.

(b)(ii) Shows correct calculation using the show that value – scores 2 marks.

(b)(iii) The elastic limit usually exceeds the limit of proportionality so this is not accepted.

(ii) The rope extends by 2.5 cm when used as shown.

Calculate the energy stored within the rope.

(2)

$$574.2 \times 0.025 = 14.43$$

$$\text{Energy stored} = 14.43$$

(iii) State one assumption made in this calculation.

(1)

Assuming none is lost through sound, heat etc.



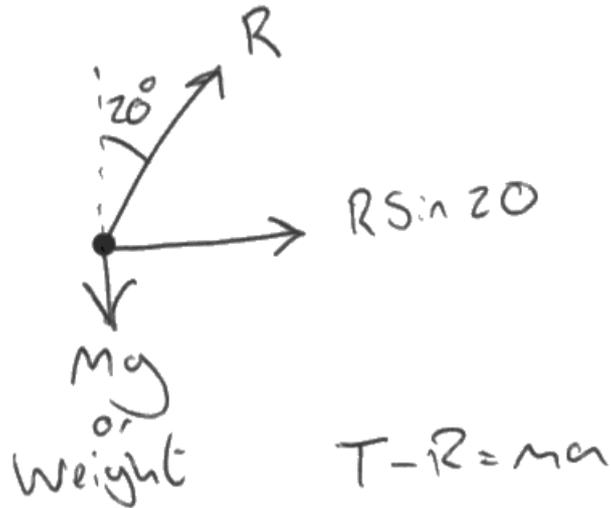
ResultsPlus

Examiner Comments

b(ii) Wrong equation – the candidate has not multiplied by 1/2. Scores 0. This equation is given on the data sheet.

b(iii) An incorrect reference to energy.

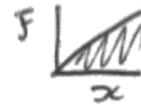
- (a) Complete the free-body force diagram below to represent the forces acting on the climber. (3)



- (b) (i) Show that the tension in the rope is about 600 N. (3)

$$55 \times 9.81 = 539.55 \text{ N} = mg \text{ or } T$$

- (ii) The rope extends by 2.5 cm when used as shown. (2)



Calculate the energy stored within the rope.

$$F = kx$$

$$\text{Energy} = \frac{1}{2} Fx$$

$$= 0.5 \times 600 \times 0.025$$

$$= 7.5 \text{ J}$$

Energy stored = 7.5

- (iii) State one assumption made in this calculation. (1)

The rope returns to its original dimensions.



ResultsPlus
Examiner Comments

- (a) Only the weight arrow is correct. 1 mark.
 (b)(i) The weight has been correctly calculated but the candidate has then done nothing with it. 0 marks.
 (b)(ii) Correct answer using the show that value of 600 N from (i). Scores 2 marks.
 (b)(iii) This is referring to the elastic limit and not the limit of proportionality so does not get the mark.

Paper Summary

This paper provided candidates with a wide range of contexts from which their knowledge and understanding of the physics contained within this unit could be tested.

Whilst a sound knowledge of the subject was evident for many, sometimes candidates struggled to find the language to use in order to write precise and unambiguous answers. This will have prevented marks being awarded.

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

- More practise of a wider range of questions on the newer parts of the specification is needed in order to become more confident in these areas, for example, optics.
- Thoroughly learn the procedures of the core practicals and the practical skills involved. Knowledge of each of the core practicals is assumed and being able to apply practical skills in different contexts is required.
- Become familiar with the specification points within topic 1, which may be applied to any part of the specification.
- Learn to recognise and use prefixes in front of units.
- Look at the number of marks available for the question and ensure you include a sufficient number of different points in your answer. Remember that you gain no credit for simply repeating the 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>

Ofqual
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with its registered office at 80 Strand, London WC2R 0RL.