BTEC Level 3 National in Applied Science- Physics

First teaching September 2016

Sample Marked Learner Work

External Assessment

Unit 1: Principles and Applications of Science I

In preparation for the first teaching from September 2016 and as a part of the on-going support that we offer to our centres, we have been developing support materials to help you better understand the application of Nationals BTEC Level 3 qualification.

What is Sample Marked Learner Work (SMLW)?

The following learner work has been prepared as guidance for centres and learners. It can be used as a helpful tool when teaching and preparing for external units.

Each question explores two responses; one good response, followed by a poor response. These responses demonstrate how marks can be both attained and lost.

The SMLW includes examples of real learners' work, accompanied with examiner tips and comments based on the responses of how learners performed.

Below displays the format this booklet follows. Each question will show a learner response, followed by comments on the command verbs and the content of the question. Tips may be offered where possible.

The appendix has attached a mark scheme showing all the possible responses that perhaps were not explored in the SMLW, but can still be attained.

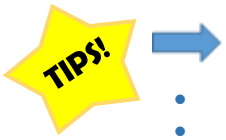
The red box comments on the command verbs used in the question. Command typically means; to instruct or order for something to be done. Likewise, in assessments, learners are required to answer questions, with the help of a command verb which gives them a sense of direction when answering a question.

This box may choose to highlight the command verb used and comments if the learner has successfully done this, or not.

The green box comments on the content words and phrases. Content makes reference to subject knowledge that originates from the specification. Learners are required to use subject specific knowledge to answer the questions in order to gain maximum marks.

The comments may include:

- *Any key words/phrases used in the learner's answer.*
- *Why has the learner gained x amount of marks? And why/how have they not gained any further marks?*
- *Any suggestions/ ideas regarding the structure of the answer.*
- *If the answer meets full marks- why it is a strong answer? What part of the content has been mentioned to gain these marks?*



Tips offer helpful hints that the learner may find useful. For example:

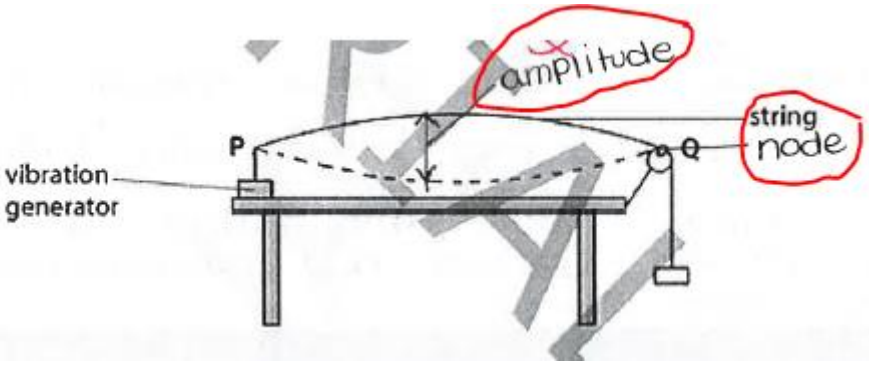
- *Recommended length of the answer*
- *Reference to the amount of marks awarded*
- *General advice for the learner when answering questions*

Question 10a: On the diagram, label a node and an antinode.

[Total marks for Q1a= 2 marks]

The diagram shows the first mode of vibration of the string.

(a) On the diagram, label a node and an antinode.



1

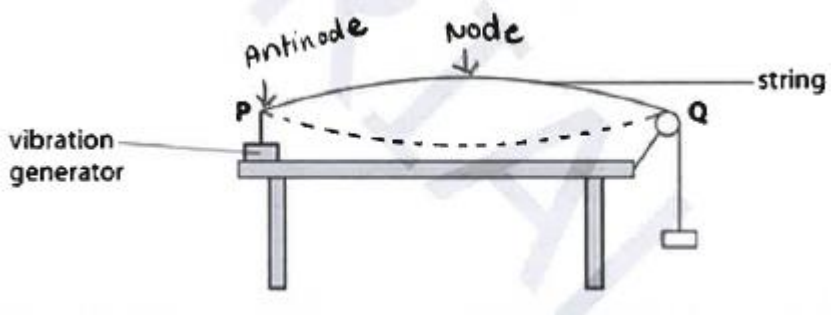
The command here is to label the diagram and this has been done with clear arrows pointing to the parts of the wave that the learner believes to be the node and the antinode.

Good response: The diagram has the node labelled correctly. However the second requirement to label the antinode has been misread and the label 'amplitude' has been added to the diagram. The answer gets one mark for correctly identifying a node the other node is at P.

Good response: The labelling of the node at Q is clear enough for the examiner to award a mark. However, it would be better for the line indicating the position of the node not to pass through the letter Q and to have an arrow on the end. The label for amplitude would get no mark even if it was correct as this was not asked for in the question. The amplitude is the displacement from the centre and not the total displacement of the wave.

The diagram shows the first mode of vibration of the string.

(a) On the diagram, label a node and an antinode.



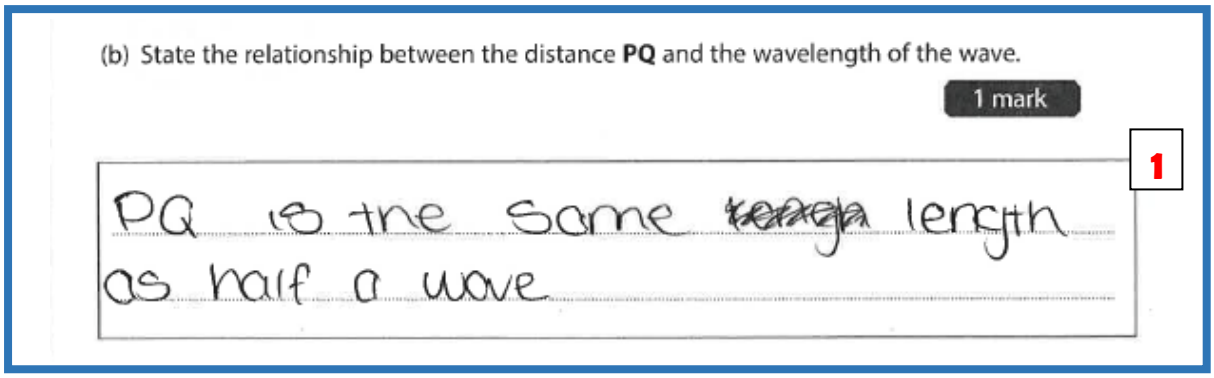
0

Poor response: However the labels are incorrect and therefore no marks are awarded.

Poor response: The question requires the learner to remember the names given to maximum and minimum displacement of a stationary wave. The nodes are at P and Q and the position might best be remembered because at a NODE there is NO Displacement. The antinode has been incorrectly labelled 'node' on the diagram. Common errors are to confuse the position of the node with the position of the antinode and to confuse antinode with amplitude.

- Read the question carefully and make sure your response answers the question
- Use arrows to make it clear which point the label refers to.

Question 10b: State the relationship between the distance PQ and the wavelength of the wave. *[Total marks for Q1b= 1 mark]*


(b) State the relationship between the distance **PQ** and the wavelength of the wave.

1 mark

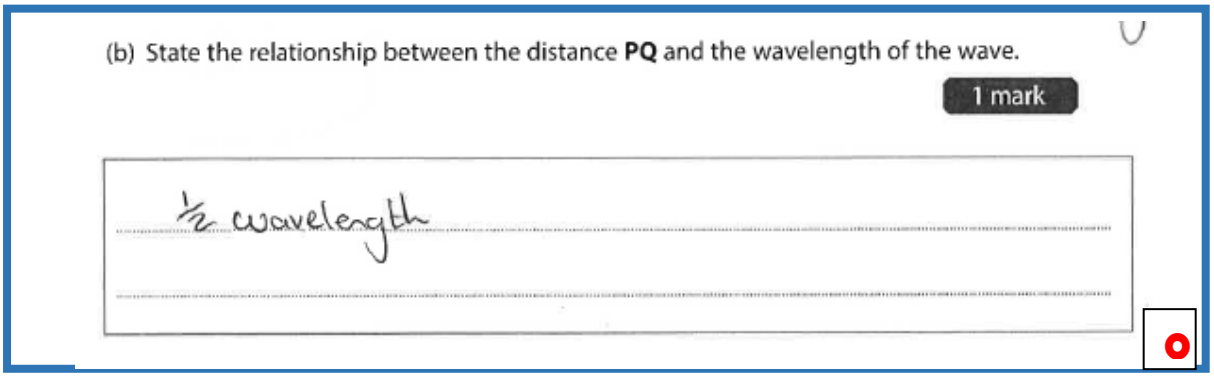
PQ is the same ~~length~~ length as half a wave

1

The command word is state and there is only one mark therefore the answer required will be straight forward or may be a definition.

Good response: The question asks for a relationship between PQ and the wavelength therefore the response must include both of these.

Good response: The response above is correct and is awarded the mark because it gives a relationship between PQ and the wavelength. However, keeping the term wavelength and referring to PQ as half the wavelength would be a better way of phrasing the answer, rather than 'same length as half a wave'.


(b) State the relationship between the distance **PQ** and the wavelength of the wave.

1 mark

½ wavelength

0

Poor response: The relationship between the two quantities has not been given and no mark is awarded.

Poor response: The answer given does not show a relationship between PQ and the wavelength. It is not clear what the '½ wavelength' is referring to. The correct relationship should be written either as an equation.

PQ =½ wavelength

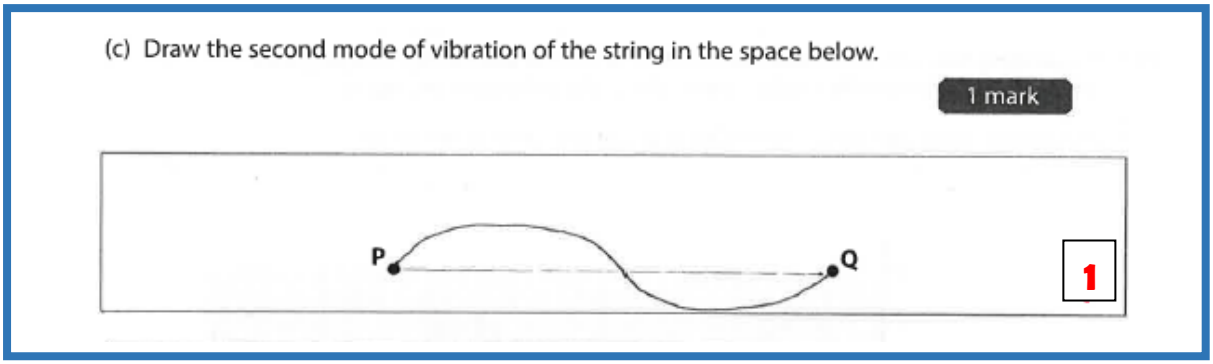
Or, in words as

PQ is half a wavelength

TIPS!

- If a relationship is asked for then relate the two quantities given in the question.
- Include both quantities required in a relationship to get the mark.

Question 10c: Draw the second mode of vibration of the string in the space below. *[Total marks for Q1c= 1 mark]*



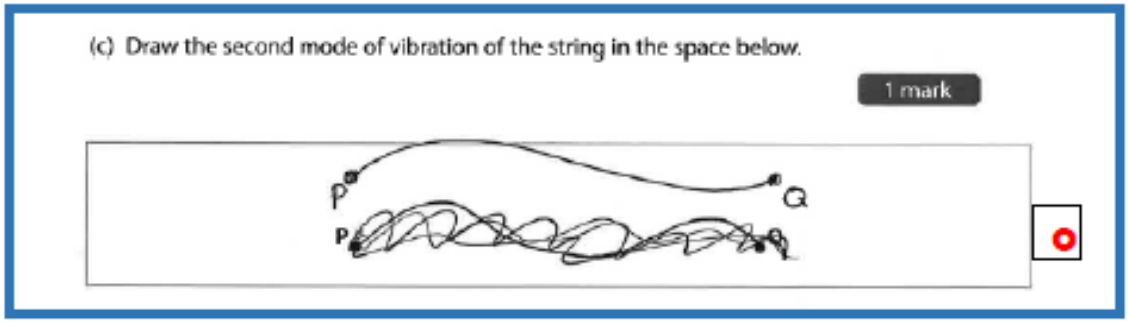
This question requires the learner to draw the second mode of vibration of the string. This is the second number of half wavelengths that will fit between P and Q.

Good response: The two half wavelengths are clearly shown and the mark is awarded.

Good response: The learner has shown the equilibrium position of the string, to make it clear that there are two half wavelengths, which make a complete wavelength between P and Q.

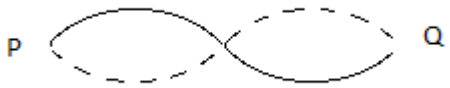
Above part (a) of the question and below the first diagram it is stated that the diagram shows the first mode of vibration of the string.
This information should be of help in drawing the second mode of vibration as it indicates the type of diagram that is required.

In the diagram above, the broken line has not been shown by the learner. However, this is sufficient to show clearly the two half wavelengths with the node at the centre, as the equilibrium position is shown.



Poor response: The learner has attempted to draw the second mode of vibration for the string but it is not clear that it is made up of two half wavelengths. No mark is awarded.

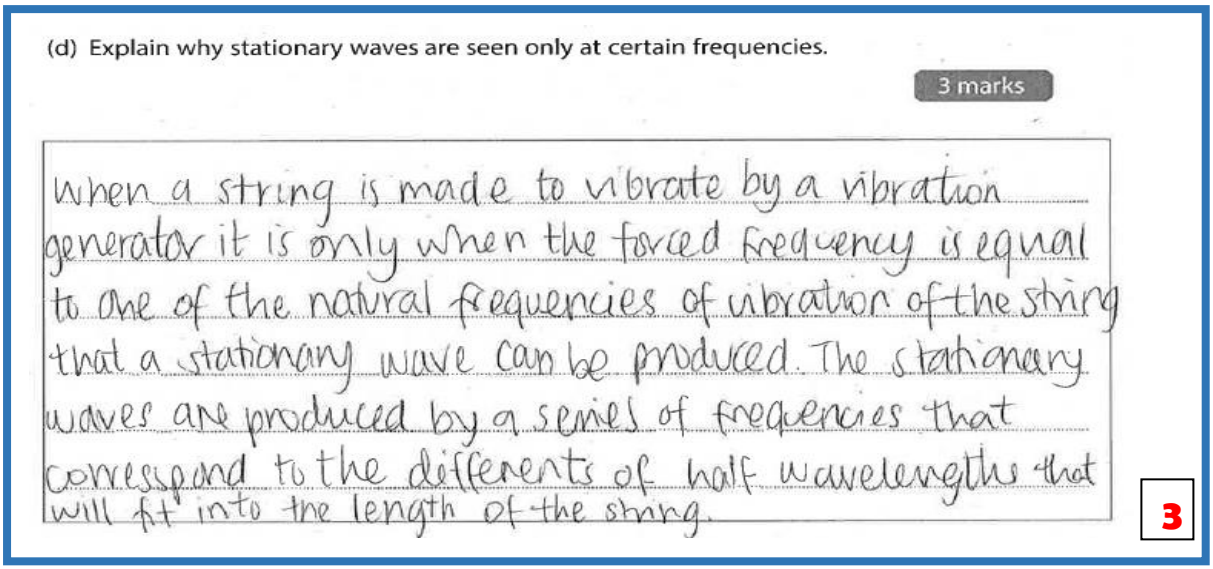
Poor response: The diagram must clearly indicate a node at the centre point between P and Q either by including in the drawing a straight line between P and Q showing the equilibrium position or by showing the maximum displacement on the opposite side of the equilibrium position by drawing it in as a broken line as shown in the sketch below



TIPS!

- Read all the information given in a question. Questions are generally progressive, look for clues at the start to help you through the question.
- Read all the information on the question paper and use it to inform your answers.

Question 10d: Explain why stationary waves are seen only at certain frequencies. *[Total marks for Q1d= 3 marks]*



(d) Explain why stationary waves are seen only at certain frequencies.

3 marks

When a string is made to vibrate by a vibration generator it is only when the forced frequency is equal to one of the natural frequencies of vibration of the string that a stationary wave can be produced. The stationary waves are produced by a series of frequencies that correspond to the differents of half wavelengths that will fit into the length of the string.

3

The question requires an explanation and the link in the explanation must be between stationary waves on a string and the frequencies of these waves.

Good response: The answer shown above explains that it is only the natural frequencies of vibration of a string that can give stationary waves and that the natural frequencies of vibration only occur when a number of half wavelengths can be seen on the string

.The frequency forced on the string by the vibration generator is then equal to one of the natural frequencies

The response uses correct science and logically orders the explanation by relating the forced frequencies to specific numbers of half wavelengths that appear on the string. This response is awarded three marks.

Good response: As the answer is worth three marks start by looking back at the whole of the question and focus on what you know about stationary waves.

The previous parts of the question do not mention frequency but do refer to stationary waves on a stretched string and show the first mode of vibration which is half a wavelength and has a node at each end of the string.

The learners explains that the vibration generator forces the string to vibrate and that when the forced frequency is the same as one of the natural frequencies a stationary wave is seen

Natural frequencies that are produced on a string correspond to the numbers of half wavelengths.

Changing the number of half wavelengths changes the frequency because the speed of the wave on a particular string is constant and $v=f\times\lambda$

For the explanation the learner has brought together individual pieces of knowledge and used them in a logical order.

Stationary waves are seen on the string only when the vibration generator is set to certain frequencies.

(d) Explain why stationary waves are seen only at certain frequencies.

3 marks

Due to their wavelength. This means that depending on the way the wavelength moves it produces its own frequency.

0

Poor response: This answer does not give an explanation and no marks are awarded.

Poor response: The learner does realise that the explanation is something to do with wavelength but does not explain that it is the number of half wavelengths that is important.

The half wavelengths have to fit into the length of the string and can only be produced by vibrating the string at a series of specific frequencies.

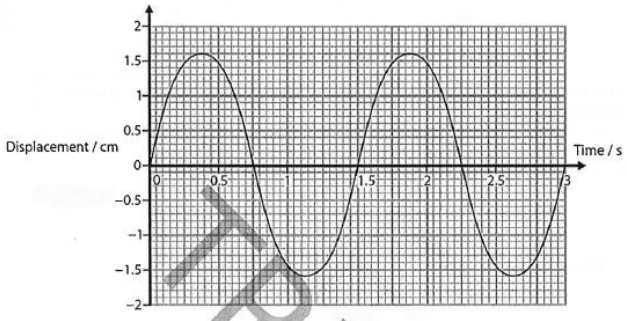
How a stationary wave is set up needs to be understood but first it is necessary to learn what a stationary wave is.

TIPS!

- Remember stationary waves on a string must have a node at each fixed end therefore only 1, 2,3,4,5 etc. half wavelengths, which have a node at each end, will fit on the string.
- Learn that stationary waves are set up when the natural frequency is equal to the forced frequency.
- Learn that stationary waves are only produced when a number of half wavelengths will fit into the length of the string.

Question 11a: Use the graph to: Give the amplitude of the wave.

[Total marks for Q11a= 1 mark]



Use the graph to:

(a) Give the amplitude of the wave.

1 mark

Amplitude = 1.6 cm

1

To give the answer it is necessary to read the graph correctly.

Good response: The learner, in the response above, has used the graph to give the correct answer of 1.6 cm and is awarded one mark.

Good response: The scale on the graph has been noted, one division on the y-axis is 0.1cm.

One division above 1.5 cm is therefore 1.6 cm.

This gives the maximum displacement from the centre line as 1.6 cm and this is the amplitude.

Use the graph to:

(a) Give the amplitude of the wave.

1 mark

Amplitude = 1.5 cm

0

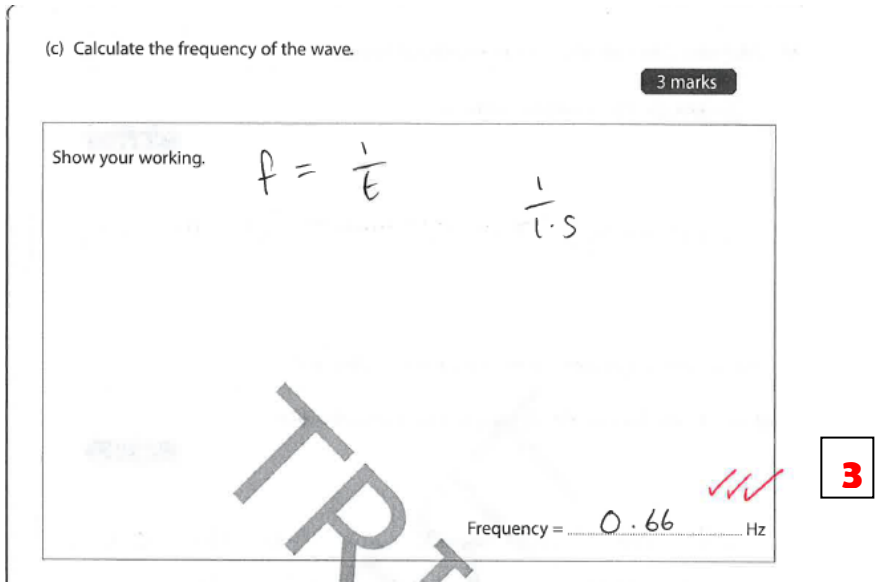
Poor response: This answer is close to being correct but is outside the tolerance of half a square that is allowed by the examiner and therefore does not get the mark. In this case any value between 1.55 and 1.65 would have been awarded the mark.

Poor response: The amplitude of the wave is clearly 1.6 cm being the distance from the maximum displacement to the equilibrium position (the zero line on the graph). The tolerance for adding points to graphs and taking readings from graphs is ±½ square.

- Work out the value of each division on the scale of the graph to read the graph accurately.
- Read the scale on a graph carefully and plot or read points to an accuracy of ±½ square.

Question11c: Calculate the frequency of the wave.

[Total marks for Q11c= 3 marks]



(c) Calculate the frequency of the wave.

3 marks

Show your working. $f = \frac{1}{T}$ $\frac{1}{1.5}$

Frequency = 0.66 Hz

3

As the question requires a calculation the answer must be a number which is in the correct units. In this case the unit Hertz (Hz) is given in the answer line.

Good response: The response above shows the learner has taken the correct value for the period of one wave from the graph that is 1.5s. This value is then substituted into the correct equation to evaluate an answer which is awarded three marks.

The answer is acceptable even though it has not been rounded up to 0.67Hz by the learner

Good response: To answer this question information must be obtained from the graph. The labelling on the x-axis must be noted as time. The time for one wave is 1.5s this is the period T.

The equation that links T (periodic time) to frequency (f) must then be recalled as this is not given on the formulae sheet at the back of the paper. The equation f=1/T should then be written down as this will gain one mark as the start of the calculation. The value of T is then substituted for the next mark and the final mark is for the getting the correct answer.

If you manage to get the correct answer without going through the process you will still get three marks but showing the correct process without getting the right answer will still get marks.

(c) Calculate the frequency of the wave.

3 marks

Show your working.

$c = f \lambda$

$1.5 = f \times 1.6$

$\frac{1.5}{1.6} = f$

$f = 0.99$

Frequency = 0.99 Hz

0

Poor response: This response gives a calculation in which the working is shown.

However, the wrong equation has been used and therefore what follows is incorrect and no marks are awarded.

Poor response: A form of the equation used is given on the formulae sheet as v=f x λ.

This has been written in the response as c= f x λ. The c and the v are both symbols for velocity but the velocity of the wave is not given in the question.

The learner has put in the value found for wavelength as the velocity and the value found for amplitude as the wavelength. Although the equation has been used correctly with these values no marks can be awarded.

TIPS!

- Do all calculations by giving the equation, showing the substitution and then working out the answer.
- Practice rounding values correctly.
- Learn the meanings of all the symbols used in the equations on the formulae sheet.
- Learn the equations that have to be recalled.

Question 12a: Use the graph to: Give the amplitude of the wave.

[Total marks for Q12a= 1 mark]

(a) Give **one** use of fibre optics in medicine.

1 mark

Coloscopy, Viewing inside of the body.

1

The question asks for ONE use of fibre optics.

Good response: The response shown above gives one use of fibre optics in medicine, 'viewing inside the body'. This is sufficient for the award of a mark.

Good response: 'Coloscopy' has been taken as an incorrect spelling of colonoscopy and is therefore not an incorrect answer and 'viewing inside the body' supports this to allow the mark is awarded. It is always better to get the spelling of technical and medical terms right.

12 Fibre optic cables are used in some broadband networks.

(a) Give **one** use of fibre optics in medicine.

1 mark

Microscopes/camera's that enter the body

0

Poor response: This response gives the examiner a choice of two answers of which one is incorrect and so no mark is awarded.

Poor response: Fibre optics are not used in microscopes. 'Camera's that enter the body' would have been be acceptable (as an equivalent to endoscopes) as this is given in the mark scheme. However, with one right and one wrong answer this response is not awarded a mark.

TIPS!

- Read each question carefully and only give in the response the amount of information required.
- Learn to spell technical and medical terms correctly.

Question 12b: Explain why there is total internal reflection in an optical fibre.

[Total marks for Q12b= 3 marks]

(b) Explain why there is total internal reflection in an optical fibre.

3 marks

Light in optical fibres stays inside the fibre because glass is denser than air and light bends away from the normal when it goes into a less dense medium. So when the angle in the glass gets big, the light can't get out. The angle at which the light can just get out is called the critical angle. The light hits the insides of the glass tube at greater than the critical angle and it is reflected. This is called total internal reflection.

3

The question requires an explanation, it is not sufficient to describe what happens to the light, the explanation is why this happens to the light.

The question states that total internal reflection occurs in an optical fibre and therefore repeating this is not credit worthy.

Good response: The answer above gives a full explanation which correctly uses the science related to total internal reflection and is awarded 3 marks.

Good response: The learner starts by comparing the density of glass and air and then explains that light bends away from the normal when it goes into a less dense medium, for example, from glass into air.

The learner explained that when the light is incident on the glass –air boundary at an angle greater than the critical angle the light cannot pass out of the glass and is totally internally reflected.

The answer covers all three of the marking points and is logically ordered.

The use of fibre optic cables relies on total internal reflection.

(b) Explain why there is total internal reflection in an optical fibre.

3 marks

If the light bends more than the Critical angle then we get a total internal reflection, because the light being shined in is larger than we always get total internal reflection.

1

Poor response: This response gets one mark for 'light bends more than the critical angle' as this is part of the reason for total internal reflection happening.

Poor response: The learner has made an attempt at explaining why total internal reflection occurs in an optical fibre by making reference to the critical angle and is awarded one mark. To gain the full three marks for an answer the following three points need to be made:-

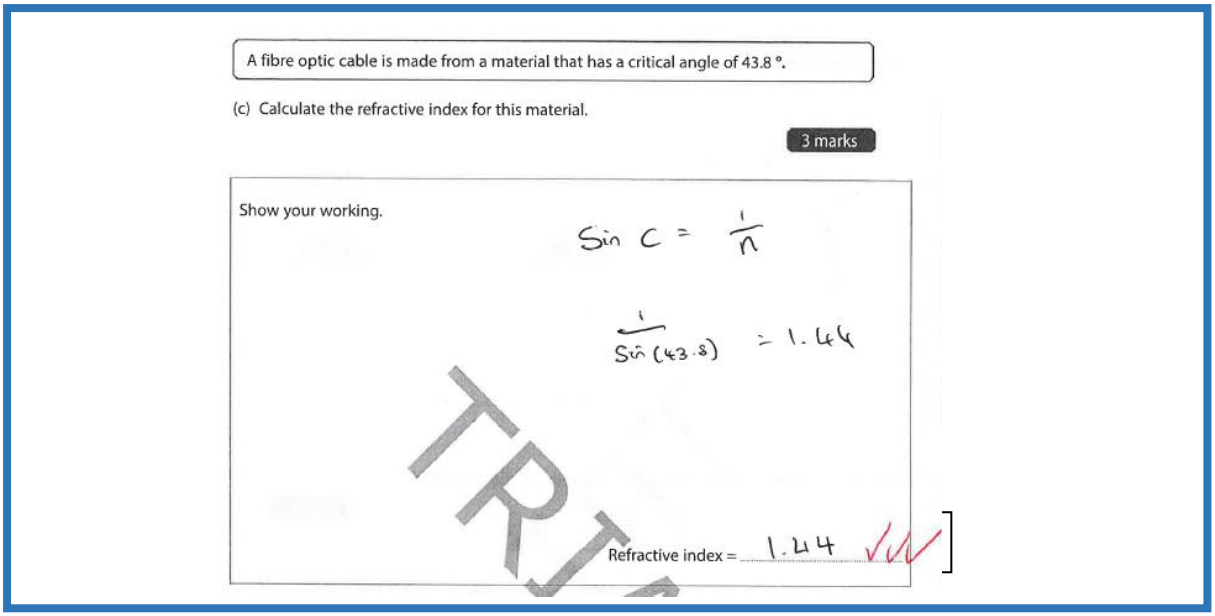
1. Glass is denser than air/ has a larger refractive index
2. Light ray in the glass reflected at the glass air boundary
3. If incident angle is greater than the critical angle

A labelled diagram could be used to gain at least two of these marks and should be used to add to or clarify explanations.

- Learn the reasons why light can be totally internally reflected.
- Remember to use a diagram if it helps with your explanation.
- Remember total internal reflection can only occur when light is trying to pass into a less dense medium.

Question 12c: Calculate the refractive index for this material.

[Total marks for Q12c= 3 marks]



A fibre optic cable is made from a material that has a critical angle of 43.8 °.

(c) Calculate the refractive index for this material.

3 marks

Show your working.

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

$\frac{1}{\sin(43.8)} = 1.44$

Refractive index = 1.44 ✓✓

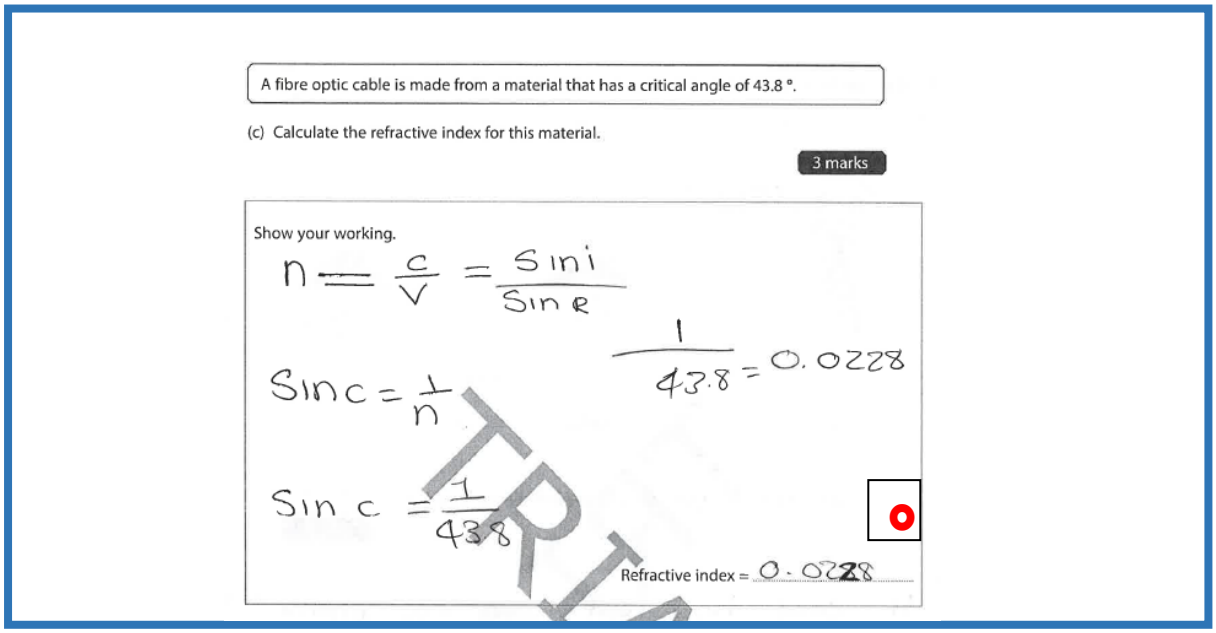
The question requires a numerical answer as it asks the learner to calculate.

Good response: The value of the refractive index is calculated correctly and is awarded three marks.

Good response: The working is shown, starting with the selection of the correct equation from the formulae sheet.

The value of 43.8° is correctly substituted for the critical angle c and the equation is correctly transposed to find n which is n=1/sin c.
sin43.8° is determined and then the reciprocal taken to give the value for n.

The refractive index has no units as it is a ratio.



A fibre optic cable is made from a material that has a critical angle of 43.8 °.

(c) Calculate the refractive index for this material.

3 marks

Show your working.

$n = \frac{c}{v} = \frac{\sin i}{\sin r}$

$\sin c = \frac{1}{n}$

$\frac{1}{43.8} = 0.0228$

$\sin c = \frac{1}{43.8}$

Refractive index = 0.0228

Poor response: All the equations have been quoted from the formulae sheet at the back of the paper and although they are correct they do not get a mark. The substitution is incorrect and the answer is incorrect. No marks can be awarded.

Poor response: It should be noted that the question refers to a critical angle of 43.8° and this must be linked to the sine of an angle. The letter 'n' in the equation is the refractive index, which is a number without a unit as it comes from a ratio.

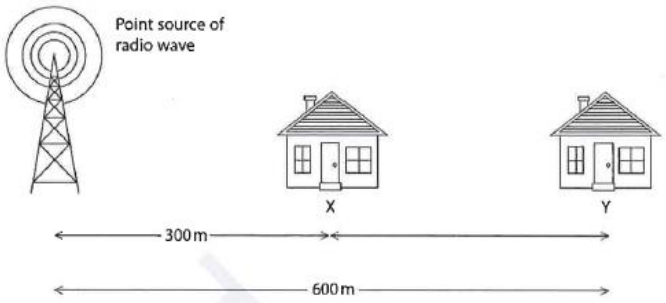
In this response n which is a number has been substituted by 43.8° which is an angle.

If the learner had correctly substituted for c in the equation sin c =1/n to give sin43.8°=1/n then at least one mark would have been awarded.

The correct solution is sin43.8°=1/n.
rearranged to give n=1/sin43.8°
evaluated to give n= 1.44

- Learn the meanings of all the symbols given in the formulae sheet.
- Learn to correctly transpose equations.

Question 13a: Determine how the intensity at Y, I compares with the intensity at X,I. *[Total marks for Q12b= 3 marks]*



(a) Determine how the intensity at Y, I_y, compares with the intensity at X, I_x.

1 mark

1

The intensity at Y is ¼ of the intensity at X.

The command word is determine rather than calculate but as numerical values are given in the question a numerical answer is expected in the response.

Good response: This answer uses the values shown in the question to determine how the intensities can be compared and gives a numerical and gives the numerical answer of ¼.

Good response: The learner has realised that the intensity of a wave varies with the inverse square of its distance from the source. $I = k/r^2$.

When the distance is doubled the intensity goes down by a factor of 4.

(a) Determine how the intensity at Y, I_y, compares with the intensity at X, I_x.

1 mark

X will be more intense than Y

0

Poor response: Although the intensity of the wave is more at X than it Is at Y this is not sufficient for the mark to be awarded. The answer must give a value for how much more the intensity at X is compared with the intensity at Y.

Poor response: The question is based on realising that intensity decreases with the square of the distance as given by the equation $I = k/r^2$ which is given on the formulae sheet at the back of the paper.

The response only describes that the intensity at X will be greater than it is at Y but does not give the numerical relationship and is therefore not awarded a mark.

The diagram shows the distances 300 m and 600 m for X and Y from the source of the radio waves. The point to note about the distances is that Y is twice as far away from the radio transmitter as X. Therefore $r_Y = 2r_X$. However the equation shows that the drop in intensity does not depend on r but on r^2.

If anything is doubled then the square of its value is multiplied by 4, for example, 3 x 3 = 9 but 6 x 6 = 36. The distance is doubled but the square of the distance goes up by a factor of 4.

Since the intensity is k divided by r^2, when the distance is doubled the intensity goes down by a factor of 4.

- Remember the relationship between intensity and distance from the source of a wave.
- Learn that if any quantity is doubled then the square of that quantity goes up by a factor of 4.

Question 13b: Compare the use of mobile phones, Bluetooth and Wi-Fi in communications. *[Total marks for Q13b= 6 marks]*

(b) Compare the use of mobile phones, Bluetooth® and Wi-Fi in communications.

Your answer should include reference to their uses, frequencies and range.

6 marks

Mobile phones, Bluetooth & wifi all use the same frequency, range about 2·4 GHz This frequency is in the microwave region of the electromagnetic spectrum. Mobile phones use the lowest of the frequencies in this band. All the devices are used to communicate in some way but work over different distances. Bluetooth & wifi work over a shorter distance than Mobile phones. Bluetooth is very low power & goes a short distance from one device to another & will not go through walls Wi fi is more powerful and will work all over a house, if the router is in the middle of the house, it will go through the walls. Mobile phone signals are more powerful than either Wifi and Bluetooth and have a much bigger range because the signal has to go to base station in the area to be transmitted so that mobile phones can be used to communicate over large distances.

6

This question asks for a comparison of the use of mobile phones, Bluetooth© and Wi-Fi. A comparison must include similarities and differences. The second line of the question then clarifies the main points of science to be included, that is, uses, frequency and range.

A comparative is for example shorter, longer, higher, lower or more powerful and these types of words should be used to give the differences in the use.

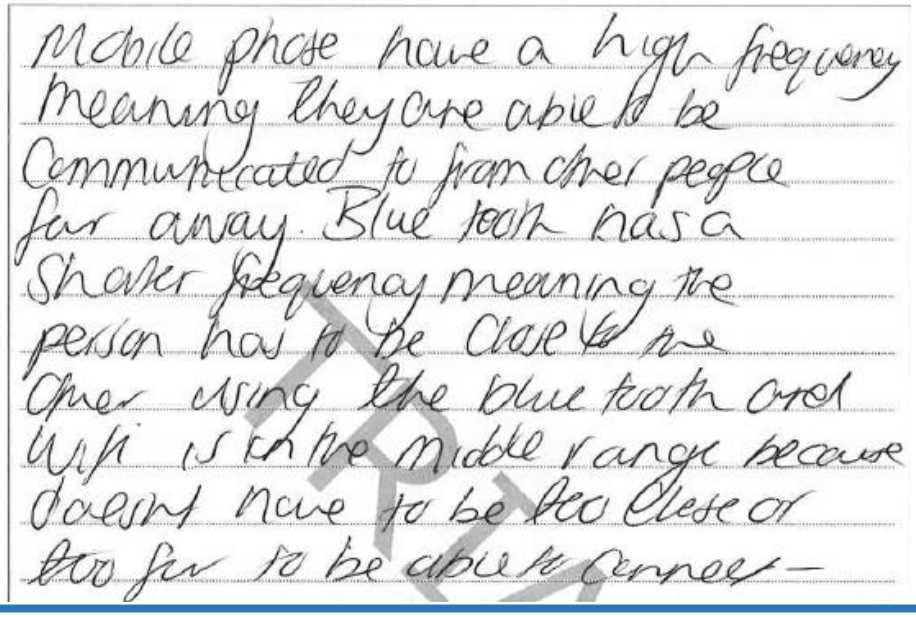
Good response: This answer makes a comparison which gives both similarities and differences of uses, frequencies and range. The response gives relevant knowledge and there is a logical progression through the answer linking the similarities and differences to the devices. The response would gain 6 marks on a level based mark scheme.

Good response: The answer above starts with similarities and then compares the range and power of the devices. Using words and phrases such as 'shorter distance', 'more powerful' shows this comparison of differences.

(b) Compare the use of mobile phones, Bluetooth® and Wi-Fi in communications.

Your answer should include reference to their uses, frequencies and range.

6 marks



1

Poor response: Gains only one mark because the only correct information is a comparison of distances over which the devices can be used. An attempt has been made to compare frequencies by stating 'mobile phones have a high frequency'. This is not a comparison as the frequency used by mobile phones has not been compared to that used by any of the other devices.

Poor response: This answer gains one mark for the comparison of distance over which the devices can be used.

The comparison of frequency is incorrect.

A full answer should include both similarities and differences with relevant scientific knowledge and logical reasoning to support the comparisons made.

The question asks for the comparison to include uses, frequency and range and in writing the answer the question should be continually referred to so that none of these points are missed.

It may be helpful to make a list of the things you know about the devices so that you can sort out the similarities and differences. These points provide a focus and can then be put together in a logical order and used as a basis for the comparison.

The space below the answer lines can be used to make a list.

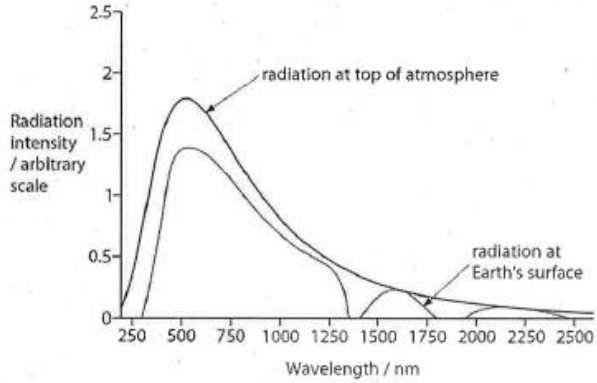
TIPS!

- Remember comparisons need similarities and differences.
- Use 'er' words or 'more',' less' when making a comparison.

Question 13c: Describe what the regions of the graph show about the effect of the atmosphere on the amount of radiation that reaches the Earth.

[Total marks for Q13c= 4 marks]

The diagram shows the solar radiation spectrum at the top of the atmosphere and at sea level.



(c) Describe what the regions of the graph show about the effect of the atmosphere on the amount of radiation that reaches the Earth.

4 marks

Ultraviolet around 250nm does not reach the Earth it is absorbed by the atmosphere but the long wavelength UV does reach the surface. Most of the visible light that reaches the top of the atmosphere gets to the Earth. Lots of the infared gets to the Earth's surface but there are two ranges of infared that are absorbed one at about 1375nm and the other between 1800 and 1950nm.

4

The question asks for a description of what the regions of the graph show about the radiation that reaches the surface of the Earth. This answer needs a description of the amount of radiation that reaches the Earth's surface.

This information can be found using the lower line on the graph which is labelled 'radiation at the Earth's surface'.

Good response: The learner has added to the diagram the regions of the electromagnetic spectrum that the graph covers as wavelengths. This makes it easier to provide a full answer to the question and gain 4 marks.

Good response: The response above shows that the learner has marked the regions of the electromagnetic spectrum on the graph and can then see more easily what is happening to the radiation when it reaches the Earth's surface in every region.

The line labelled 'radiation at the Earth's surface' has been followed and the wavelengths where the radiation intensity is zero at the Earth's surface have been noted. These wavelengths are then related to relate to either the ultra violet or infrared regions of the spectrum.

(c) Describe what the regions of the graph show about the effect of the atmosphere on the amount of radiation that reaches the Earth.

4 marks

at wavelength 1375nm, 1800nm and 2500nm the radiation at the earth Surface is zero. The radiation in the atmosphere is always highe than the radiation at earth except at 1675 wavelength wee is is equal to eachother.

Ther is no radiation at the earth Surface below 300nm wavelength

1

Poor response: The response uses the graph to give some information about the wavelengths where there is no radiation reaching the Earth's surface. However, the values of the wavelengths are not related to the regions of the electromagnetic spectrum that the wavelengths cover. Only one mark awarded.

Poor response: In the above response the wavelengths of radiation that have been absorbed by the atmosphere have been correctly given but these have not been related to the ultraviolet and infrared regions of the spectrum and only one mark is awarded.

It is very important to understand the graph and the introduction to the question must be read to make this possible.

The labelling on the axes is the next thing to note.

The y axis, radiation intensity indicates how much more radiation there is as the numbers increase.

The x axis gives the wavelengths of the radiation and this has to be converted into regions to answer the question. Ultraviolet (UV) goes up to 400nm then visible light from 400nm to 750nm and above 750nm on the graph is infrared (IR).

It would be useful to add vertical lines to the graph to indicate these regions. At around 250nm no ultraviolet reaches the Earth's surface.

There are two wavelength ranges around 1375nm and 1800 nm where all the infrared is absorbed and none reaches the surface of the Earth.

TIPS!

- Learn the wavelength boundaries of the different parts of the electromagnetic spectrum.
- Add to diagrams if this helps in answering the question.

Unit 1: Principles and Applications of Science I – sample mark scheme

General marking guidance

- All learners must receive the same treatment. Examiners must mark the first learner in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Learners must be rewarded for what they have shown they can do, rather than be penalised for omissions.
- Examiners should mark according to the mark scheme, not according to their perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks, if the learner's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a learner's response, the team leader must be consulted.
- Crossed-out work should be marked, UNLESS the learner has replaced it with an alternative response.
- You will not see 'or words to that effect' (OWTTE). Alternative correct wording should be credited in every answer, unless the mark scheme has specified specific wording that must be present.
- Round brackets () indicate words that are not essential, e.g. '(hence) distance is increased'.
- Error carried forward (ECF), means that a wrong answer given in an earlier part of a question is used correctly in a later part of a question.
- / indicates that the responses are alternatives and either answer should receive full credit.

Specific marking guidance for levels-based mark schemes*

Levels-based mark schemes (LBMS) have been designed to assess learners' work holistically. They consist of two parts: indicative content and levels-based descriptors. Indicative content reflects specific content-related points that a learner might make. Levels-based descriptors articulate the skills that a learner is likely to demonstrate, in relation to the assessment outcomes being targeted by the question. Different rows in the levels, represent the progression of these skills.

When using a levels-based mark scheme, the 'best fit' approach should be used.

- Examiners should first make a holistic judgement on which band most closely matches the learner's response, and place it within that band. Learners will be placed in the band that best describes their answer.
- The mark awarded within the band will be decided based on the quality of the answer, in response to the assessment focus/objective and will be modified according to how securely all bullet points are displayed at that band.
- Marks will be awarded towards the top or bottom of that band, depending on how they have evidenced each of the descriptor bullet points.

Section C – Waves in communication

Question number	Answer	Additional guidance	Mark
10(a)	• node/N labelled at either P or Q **(1)** • antinode/A labelled at mid-point of PQ **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
10(b)	• PQ = $\frac{1}{2}$ × wavelength **(1)**	Accept wavelength = 2 × PQ	**(1)**

Question number	Answer	Additional guidance	Mark
10(c)	**P**  **Q**		**(1)**

Question number	Answer	Additional guidance	Mark
10(d)	An explanation that makes reference to the following points: • a string has a series of natural frequencies **(1)** • corresponding to a number of half wavelengths **(1)** • a stationary wave is produced only when the frequency of the vibration generator produces waves of those wavelengths **(1)**	Forced frequency = natural frequency. Without reference to this situation award 2 marks.	**(3)**

Question number	Answer	Additional guidance	Mark
11(a)	• 1.6 (cm)	Allow $\pm\frac{1}{2}$ square	**(1)**

Question number	Answer	Additional guidance	Mark
11(b)	• 4.8 (cm)	Allow $\pm\frac{1}{2}$ square	**(1)**

Question number	Answer	Additional guidance	Mark
11(c)	• Use of formula $f = \frac{1}{T}$ **(1)** • Substitution $f = \frac{1}{1.5}$ **(1)** • Answer 0.67 (Hz) **(1)**	Maximum 2 marks for incorrect value of *T* taken as 0.75	**(3)**

Question number	Answer	Additional guidance	Mark
12(a)	• any one valid use **(1)** For example endoscopy/endoscopes/keyhole surgery		**(1)**

Question number	Answer	Additional guidance	Mark
12(b)	An explanation that makes reference to the following points: • fibre optic cable denser than outside/ air **(1)** • (therefore) incidence at boundary/reflection **(1)** • at greater than the critical angle **(1)**	Accept reference to refractive index being greater in fibre optic cable. Accept rays are reflected back, inside the fibre.	**(3)**

Question number	Answer	Additional guidance	Mark
12(c)	• substitution **(1)** $\sin 43.8 = \frac{1}{n}$ • transposition **(1)** $n = \frac{1}{0.692}$ • evaluation **(1)** 1.44		**(3)**

Question number	Answer	Additional guidance	Mark
13(a)	• (intensity at Y =) $\frac{1}{4}$ (of intensity at X)		**(1)**

Question number	Indicative content
13(b)	Answers will be credited according to the learner's demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content, but learners should be rewarded for other relevant answers. **Similarities:** • frequencies for all in same range (2 GHz) • frequencies are all microwave • Wi-Fi and mobile phones networked • Wi-Fi and mobile phone signals can go through walls • Bluetooth® and Wi-Fi over short range **Differences:** • mobile phones communicate over larger distances • mobile phone transmitters are high powered • Bluetooth® low power, Wi-Fi mid power • Wi-Fi allows wider communication • Wi-Fi range is average house/small office • Bluetooth® is only device to device • mobile phones communicate with each other, via a base station • mobile phones use the lowest of the frequencies bands

Mark scheme (award up to 6 marks) refer to the guidance on the cover of this document for how to apply levels-based mark schemes*.		
Level	**Mark**	**Descriptor**
	0	no rewardable content
Level 1	1–2	• demonstrates adequate knowledge and understanding of scientific facts/concepts to the given context with generalised comments made • generic statements may be presented rather than linkages to the context being made, so that lines of reasoning are unsupported or partially supported • the comparison will contain some similarities and differences, showing some structure and coherence
Level 2	3–4	• demonstrates good knowledge and understanding by selecting and applying some relevant scientific facts/concepts to provide the comparison being presented • lines of argument mostly supported through the application of relevant evidence drawn from the context • demonstrate an awareness of both similarities and differences, leading to a comparison that has a structure that is mostly clear, coherent and logical
Level 3	5–6	• demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of scientific facts/concepts to provide the comparison being presented • line(s) of argument consistently supported throughout by sustained application of relevant evidence drawn from the context • the comparison shows a logical chain of reasoning that is supported throughout by sustained application of relevant evidence

Question number	Answer	Additional guidance	Mark
13(c)	A description that makes reference to any four of the following points: • some long wavelength UV reaches the Earth **(1)** • IR absorbed (by atmosphere) **(1)** • but mainly long wavelength IR **(1)** • quantitative reference to UV wavelength **(1)** • quantitative reference to IR wavelength **(1)**	Accept UV absorbed (by atmosphere) **(1)**	**(4)**