



## P6 WAVES

Question Practice

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **146 minutes**

Marks: **144 marks**

Comments: **HIGHER TIER**

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1

A baby monitor has a sensor unit that transmits an image of the baby and the noises the baby makes to a monitor unit.

The monitor unit then displays an image of the baby and emits the noises the baby makes.

- (a) Compare the properties of the waves that transmit images and noises from the monitor unit.

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(4)

- (b) The sensor unit can detect infrared and visible light.  
Suggest **one** advantage of being able to detect infrared.

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(1)

- (c) Write down the equation that links frequency, wave speed and wavelength.

Equation \_\_\_\_\_

(1)

- (d) The signals for the monitor unit are transmitted as electromagnetic waves with a wavelength of 0.125 m.

Wave speed of electromagnetic waves =  $3 \times 10^8$  m / s

Calculate the frequency of the signal.

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Frequency = \_\_\_\_\_ Hz

(3)

(Total 9 marks)

2

A note was played on an electric keyboard.

The frequency of the note was 440 Hz.

- (a) (i) What does a frequency of 440 Hz mean?

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(1)

- (ii) The sound waves produced by the keyboard travel at a speed of 340 m / s.

Calculate the wavelength of the note.

Give your answer to **three** significant figures.

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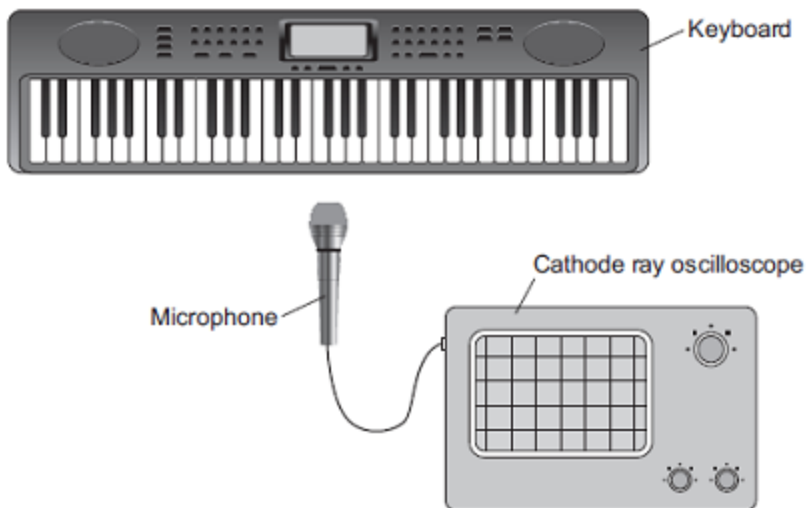
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Wavelength = \_\_\_\_\_ metres

(3)

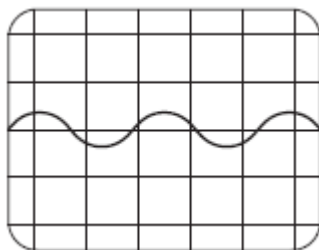
- (b) **Figure 1** shows a microphone connected to a cathode ray oscilloscope (CRO) being used to detect the note produced by the keyboard.

**Figure 1**



**Figure 2** shows the trace produced by the sound wave on the CRO.

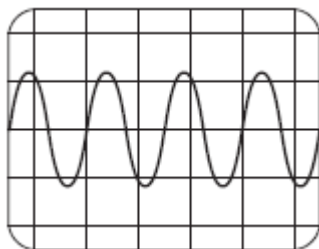
**Figure 2**



A second note, of different wavelength, was played on the keyboard.

**Figure 3** shows the trace produced by the sound wave of the second note on the CRO.

**Figure 3**



The settings on the CRO were unchanged.

What **two** conclusions should be made about the **second** sound wave produced by the keyboard compared with the **first** sound wave?

Give a reason for each conclusion.

Conclusion 1 \_\_\_\_\_

\_\_\_\_\_

Reason \_\_\_\_\_

\_\_\_\_\_

Conclusion 2 \_\_\_\_\_

\_\_\_\_\_

Reason \_\_\_\_\_

\_\_\_\_\_

(4)

(Total 8 marks)

3

Waves may be longitudinal or transverse.

(a) Describe the differences between longitudinal waves and transverse waves.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

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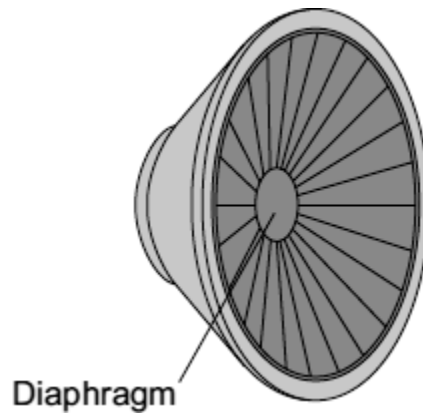
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(4)

(Total 7 marks)

**4** The diaphragm of a loudspeaker moves in and out.

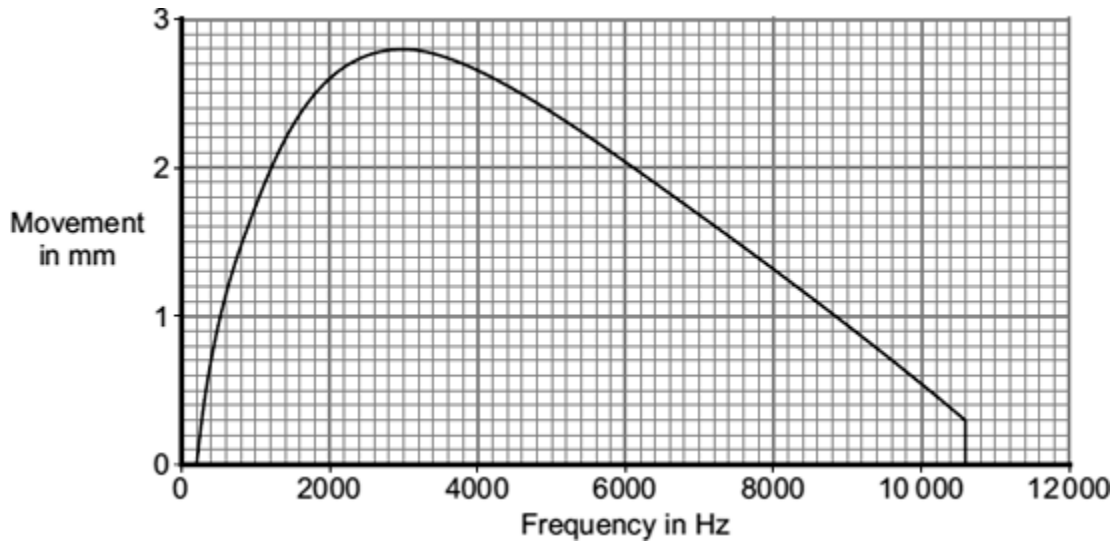


A team of scientists investigated loudspeakers.

The scientists measured the size of the movement of the diaphragm for signals of different frequencies.

They kept all the other variables constant.

The graph shows the average results for a large number of tests on one of the loudspeakers.



(a) What is the frequency of the highest pitched sound which this loudspeaker produces?

Frequency = \_\_\_\_\_ Hz

(1)

(b) The greater the movement of the diaphragm, the greater the amplitude of the sound produced.

What is the frequency of the loudest sound which this loudspeaker produces?

Show clearly on the graph how you get to your answer and then complete this answer space.

Frequency = \_\_\_\_\_ Hz

(2)

(c) Can this loudspeaker produce the full range of sound which most people can hear?

Put a tick (✓) in the box next to your answer.

Yes

No

Explain the reason for your answer.

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(2)

(d) Use **one** word to complete the sentence.

Repeating tests a large number of times and taking the average of the results improves the \_\_\_\_\_.

(1)

(e) Why did the scientists keep all the other variables constant?

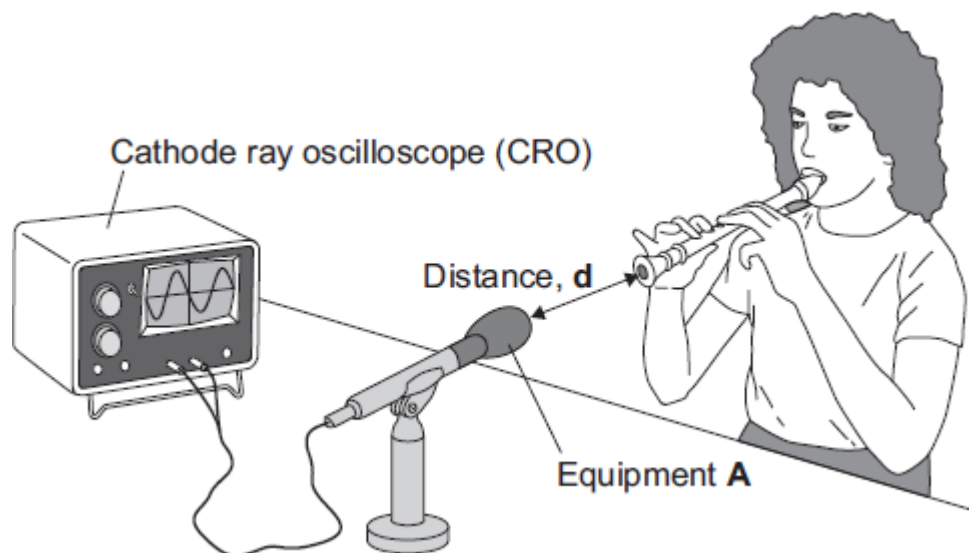
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(1)

(Total 7 marks)

**5** A group of students investigates sound waves.  
The diagram shows part of their investigation.





(a) Identify the equipment labelled **A**.

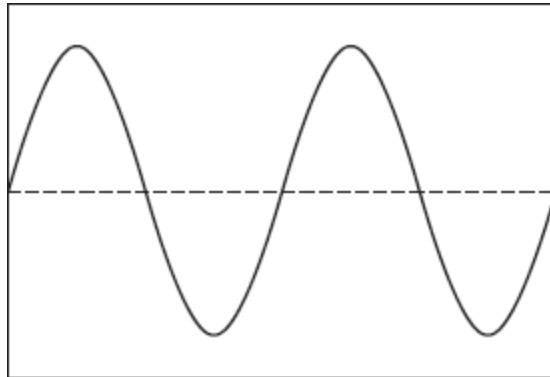
\_\_\_\_\_

**(1)**

(b) The student plays the same note in the same way at different distances from equipment **A**.

Another student records the amplitude of the wave shown on the cathode ray oscilloscope (CRO).

(i) Label this wave to show its amplitude.



**(1)**

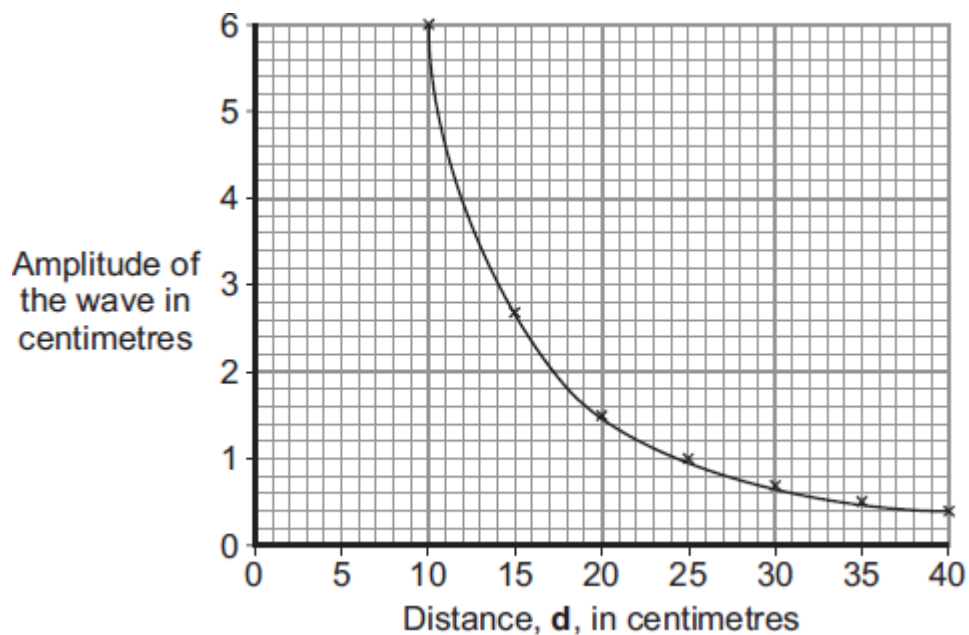
(ii) Complete the sentence.

Increasing the amplitude of a sound wave will increase the \_\_\_\_\_

of the sound.

**(1)**

(c) The graph shows the students' average results from several sets of measurements.



Use the graph to find the distance,  $d$ , in centimetres, at which the average amplitude is likely to be 2 centimetres.

Distance = \_\_\_\_\_ cm.

(1)

(d) Write a conclusion for this investigation.

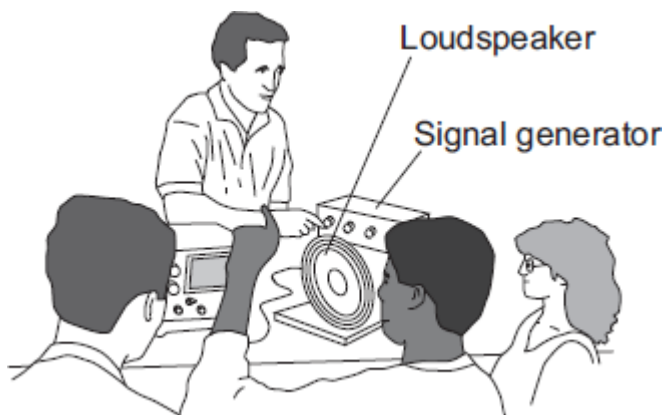
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(1)

(e) A physics teacher uses a signal generator and a loudspeaker to demonstrate the range of hearing of a group of students.



What is the range of frequencies most humans can hear?

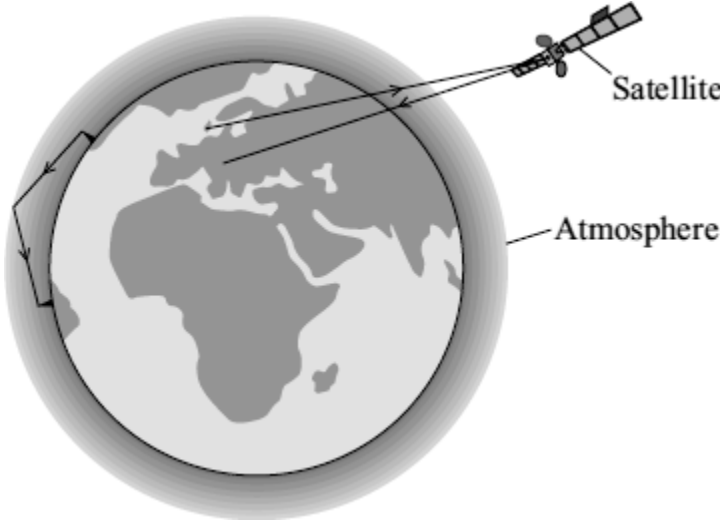
Most humans can hear from \_\_\_\_\_ Hz to \_\_\_\_\_ Hz.

(2)

(Total 7 marks)

6

(a) Electromagnetic waves have many uses. The diagram shows two ways of sending information using electromagnetic waves.



(i) What type of wave is used to send information to and from satellites?

\_\_\_\_\_

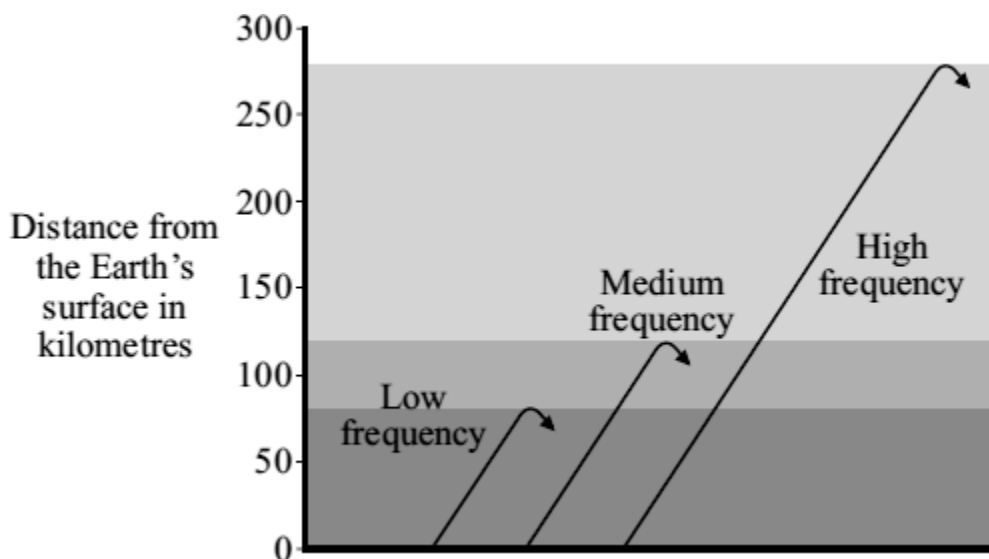
(1)

(ii) What property of this type of wave makes it suitable for satellite communications?

\_\_\_\_\_

(1)

- (b) Different frequency radio waves travel different distances through the atmosphere before being reflected.



Use the information in the diagram to describe the connection between the frequency of a radio wave and the distance the radio wave travels through the atmosphere before it is reflected.

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(1)

- (c) Electromagnetic waves travel at a speed of 300 000 000 m/s.

A radio station transmits waves with a wavelength of 20 metres.

Calculate the frequency, in kilohertz (kHz), of these waves.

Show clearly how you work out your answer.

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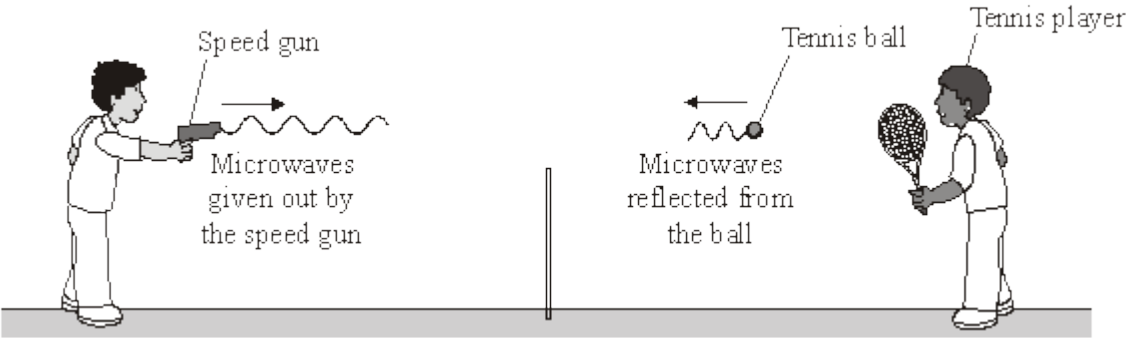
Frequency = \_\_\_\_\_ kHz

(2)

(Total 5 marks)

7

(a) The picture shows a speed gun being used to measure how fast a tennis player hits the ball.



Some of the microwaves from the speed gun are absorbed by the ball and some are reflected by the ball.

(i) Complete the following sentence by choosing **one** of the phrases from the box.

<b>longer than</b>	<b>the same as</b>	<b>shorter than</b>
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The wavelength of the microwaves reflected from the ball are \_\_\_\_\_ the wavelength of the microwaves from the speed gun.

(1)

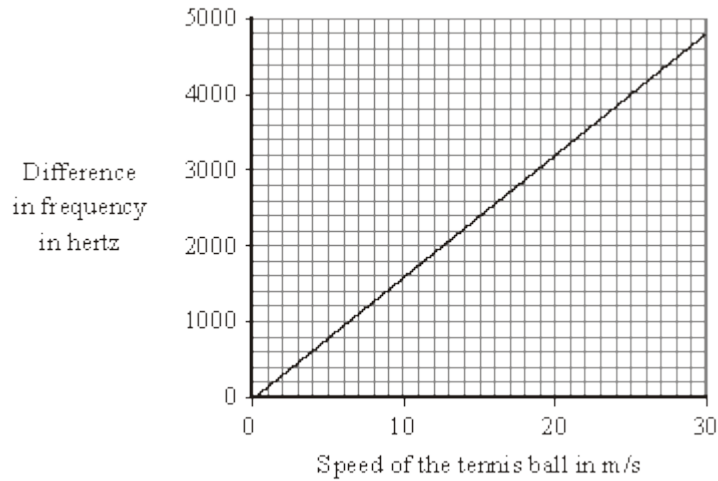
(ii) Complete the following sentence by drawing a ring around the correct line in the box.

When the ball absorbs microwaves, its temperature will

decrease slightly
not change
increase slightly

(1)

- (b) The microwaves reflected from the ball have a higher frequency than the microwaves from the speed gun.  
The graph shows how the difference between the two frequencies depends on the speed of the ball.



- (i) Describe the pattern that links the difference between the two frequencies and the speed of the ball.

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(1)

- (ii) The speed gun measures the difference between the two frequencies as 3200 Hz.

Use the graph to find the speed of the tennis ball.  
Show clearly on the graph how you obtain your answer.

Speed of the tennis ball = \_\_\_\_\_ m/s

(2)

- (iii) Which **one** of the following gives the reason why the data has been shown as a line graph and **not** as a bar chart?

Put a tick (✓) in the box next to your choice.

Frequency and speed are both categoric variables.

Frequency and speed are both continuous variables.

Speed is a continuous variable and frequency is a categoric variable.

(1)

(Total 6 marks)

8

(a) Some scientists think that there is a link between using a mobile phone and some types of illness. Other scientists disagree. They say that the evidence is limited and unreliable.

(i) Suggest what scientists could do to show a link between using a mobile phone and illness.

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(1)

(ii) How could scientists improve the reliability of the evidence?

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(1)

(iii) Complete the following passage by drawing a ring around the word in the box that is correct.

There has been little or no experimental research into the health of children who use mobile phones.

This is partly because of the

economic
environmental
ethical

issues involved in using

children in scientific research.

(1)

(b) Before being sold, new mobile phones must be tested and given a SAR value. The SAR value is a measure of the energy absorbed by the head while a mobile phone is being used.

The table gives the SAR value for three mobile phones made by different companies. To be sold in the UK, a mobile phone must have a SAR value lower than 2.0 W/kg.

Mobile phone	SAR value in W/kg
J	0.18
K	0.86
L	1.40

- (i) All companies use the same test to measure a SAR value.

Why is using the same test important?

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(1)

- (ii) Would the companies that make the mobile phones, **J**, **K** and **L**, be correct to claim that these three phones are totally safe to use?

Answer yes or no. \_\_\_\_\_

Give a reason for your answer.

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(1)

- (c) Devices designed to protect a mobile phone user from microwave radiation are now available.

Why is it important that these devices are tested by scientists who are **not** working for the company that makes the devices?

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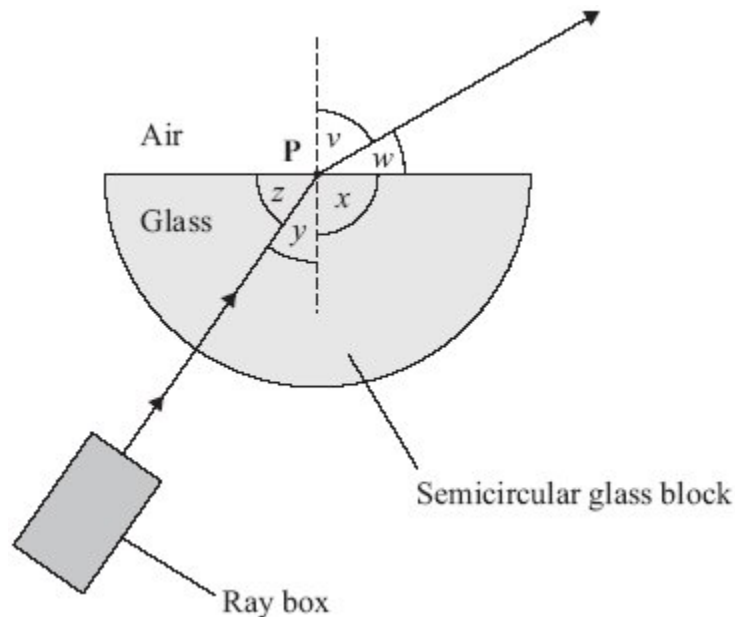
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(1)

(Total 6 marks)

9

A student uses a ray box and a semicircular glass block to investigate refraction.





(a) What is the vertical dashed line called?

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(1)

(b) Which angle,  $v$ ,  $w$ ,  $x$ ,  $y$  or  $z$ , is the angle of refraction?

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(1)

(c) Why has refraction taken place?

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(1)

(d) In an investigation, a student always aims the light from the ray box at point **P**. She moves the ray box to give different values of angle  $v$ . She records angle  $y$  for each of these values. The table shows her results.

Angle $v$ measured in degrees	Angle $y$ measured in degrees
30	19
40	25
50	31
60	35
70	39
80	41

The student studies the data and comes to the following conclusion.

Angle  $y$  is directly proportional to angle  $v$ .

Her friend says that this conclusion is **not** correct.

(i) Use data from the table to explain why the conclusion is **not** correct.

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(2)

(ii) Write a correct conclusion for the experiment.

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(1)

(iii) Why is your conclusion only valid when angle  $v$  is between  $30^\circ$  and  $80^\circ$ ?

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(1)

(Total 7 marks)

**10**

When sound waves reach a material, some of the energy of the sound is reflected and some is transmitted through the material.

(a) Complete the sentence.

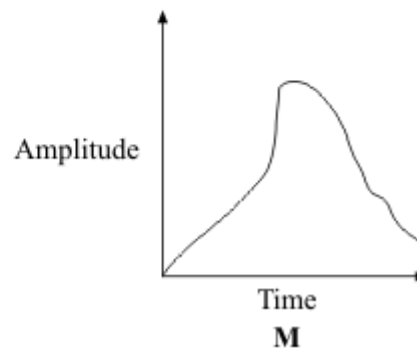
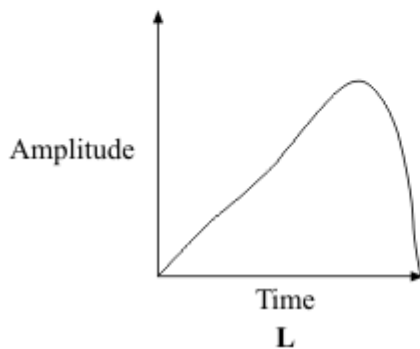
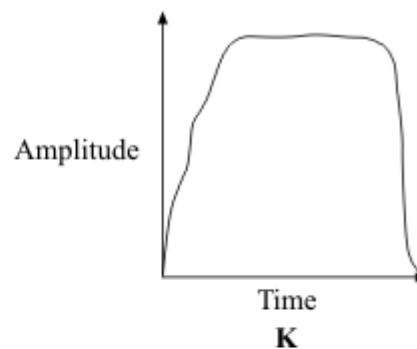
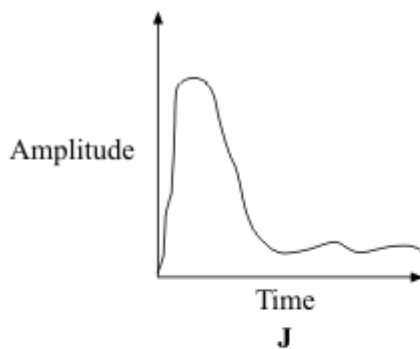
Sound waves are caused by \_\_\_\_\_

(1)

(b) The graphs **J**, **K**, **L** and **M** represent the sound energy reflected from a surface.

The graphs are all drawn to the same scale.

Which graph shows the greatest total sound energy output from the surface?



Graph \_\_\_\_\_

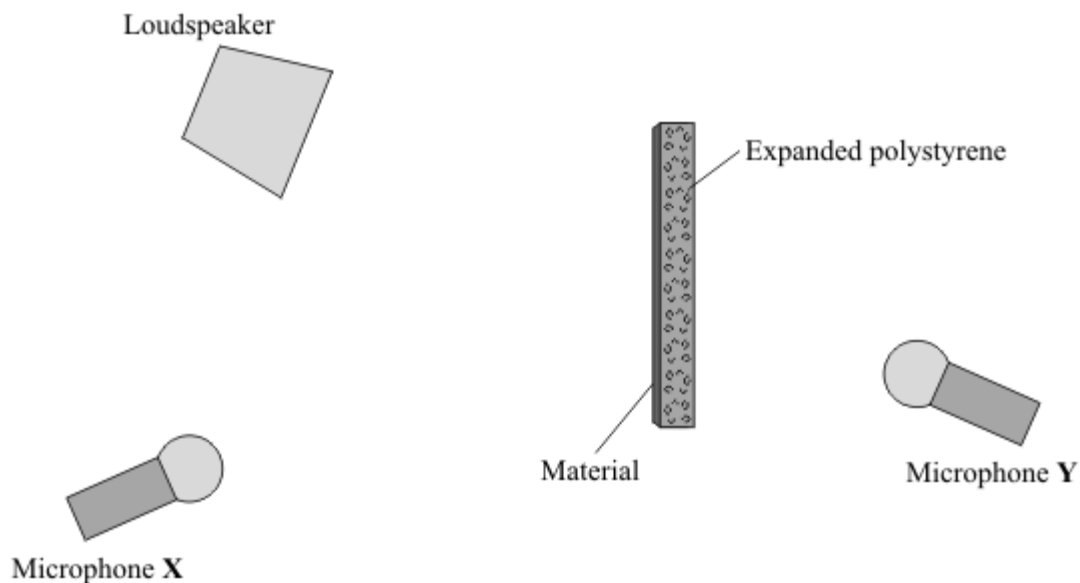
(1)

- (c) The proportion of the sound energy which is reflected or transmitted depends on the material which receives the sound.

A student investigates different materials.

The diagram shows how a student sets up her equipment.

- (i) Using a pencil and ruler to draw on the diagram, show how microphone X receives reflected sound.



(2)

- (ii) The student tests four materials. Each sheet of material is 1 mm thick. This has been glued onto a block of expanded polystyrene.

Why does the student use the same size of expanded polystyrene block and the same sound level for each test?

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(1)

(iii) The table shows the readings for the sound level transmitted to microphone Y.

Soundlevel from loudspeaker in arbitrary units	Surface material	Soundlevel transmitted to microphone Y in arbitrary units
60	paper	39
60	plaster	18
60	cloth	31
60	wood	15

[A] Which surface material transmits the smallest proportion of the sound?

\_\_\_\_\_

(1)

[B] What proportion is this?

\_\_\_\_\_

(1)

(d) People living in a flat have very noisy neighbours who are always playing loud music.

Suggest **one** practical idea to reduce the amount of noise transmitted into the flat through the walls and explain how your idea will work.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

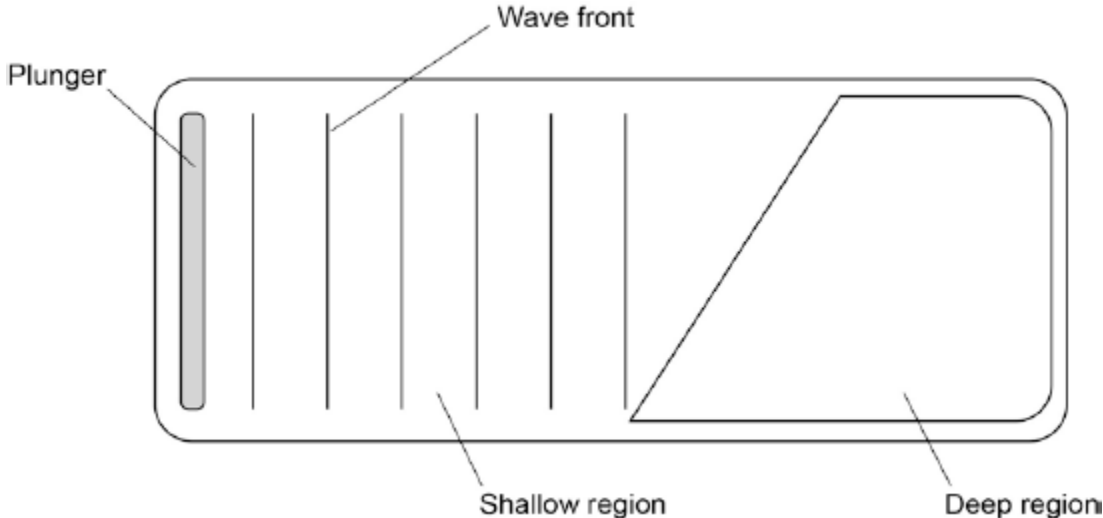
(2)

(Total 9 marks)

11

Some students did an investigation to study the behaviour of waves.

The figure below shows a ripple tank that they used to model the behaviour of waves.



(a) Complete the wave fronts on the figure above.

Show how the wave is refracted as it passes from the shallow region into the deep region.

(1)

(b) Explain what happens to the waves as they pass into the deep region.

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(2)

(c) The waves generated on the surface of the water are transverse waves.

Describe the differences between longitudinal waves and transverse waves.

You may include labelled diagrams to help your answer.

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(3)

- (d) Some students investigate the properties of the waves generated in the figure above.  
Student **A** says 'the waves move water from one end of the tank to the other'.  
Student **B** says 'that's wrong. Only the waves move, not the water'.  
Suggest what the students could do to decide which of them is correct.

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(2)

- (e) Another student uses a ripple tank where all the water is the same depth.  
She measures the wavelength of each wave as 0.34 m.  
The period of each wave is 0.42 s.  
Calculate the speed of the wave.  
Use the correct equation from the Physics Equation Sheet.  
Give the unit.  
Give your answer to three significant figures.

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Speed = \_\_\_\_\_

Unit = \_\_\_\_\_

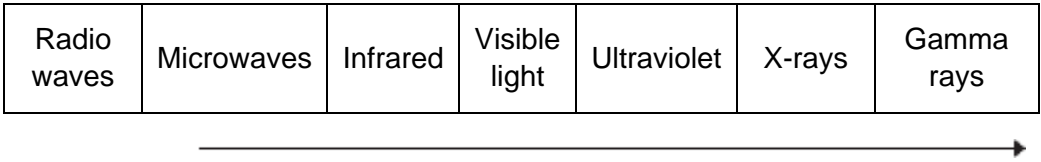
(5)

(Total 13 marks)

12

Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.



(i) Use the correct answers from the box to complete the sentence.

amplitude	frequency	speed	wavelength
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The arrow in the diagram is in the direction of increasing \_\_\_\_\_ and decreasing \_\_\_\_\_ .

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

The range of wavelengths for waves in the electromagnetic

spectrum is approximately

$10^{-15}$ to $10^4$
$10^{-4}$ to $10^4$
$10^4$ to $10^{15}$

metres.

(1)

(b) The wavelength of a radio wave is 1500 m.  
The speed of radio waves is  $3.0 \times 10^8$  m / s.

Calculate the frequency of the radio wave.

Give the unit.

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Frequency = \_\_\_\_\_

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

\_\_\_\_\_

(1)

(ii) State **one** hazard of exposure to ultraviolet radiation.

\_\_\_\_\_

(1)

(d) X-rays are used in hospitals for computed tomography (CT) scans.

(i) State **one** other medical use for X-rays.

\_\_\_\_\_

\_\_\_\_\_

(1)

(ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

\_\_\_\_\_

\_\_\_\_\_

(1)

(iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

<b>Part of the body</b>	<b>X-ray dose in mSv</b>	<b>Time it would take to get the same dose from background radiation</b>
Abdomen	9.0	3 years
Sinuses	0.5	2 months
Spine	4.0	16 months

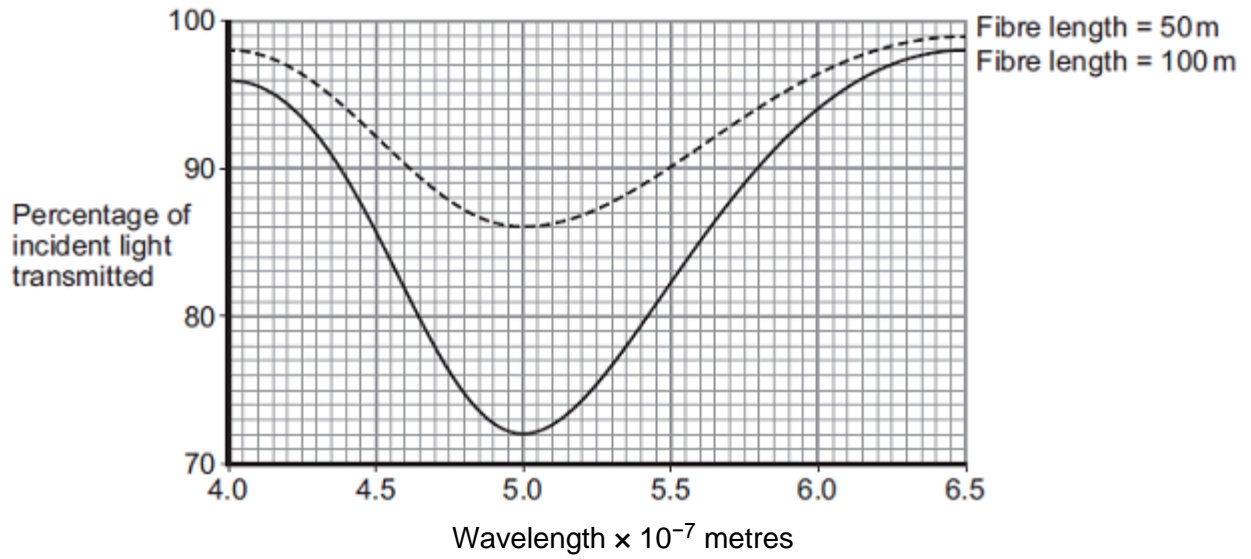




13

Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

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(Total 3 marks)

14

(a) Electromagnetic waves form a continuous spectrum with a range of wavelengths.

What is the approximate range of wavelengths of electromagnetic waves?

Tick (✓) **one** box.

$10^{-15}$  metres to  $10^4$  metres

$10^{-4}$  metres to  $10^{15}$  metres

$10^{-6}$  metres to  $10^6$  metres

(1)

(b) Infrared waves and microwaves are used for communications.

(i) Give **one** example of infrared waves being used for communication.

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(1)

(ii) A mobile phone network uses microwaves to transmit signals through the air. The microwaves have a frequency of  $1.8 \times 10^9$  Hz and travel at a speed of  $3.0 \times 10^8$  m/s.

Calculate the wavelength of the microwaves.

Give your answer to **two** significant figures.

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Wavelength = \_\_\_\_\_ m

(3)

- (c) Some scientists suggest there is a possible link between using a mobile phone and male fertility.

The results of their study are given in the table.

Mobile phone use in hours per day	Sperm count in millions of sperm cells per cm <sup>3</sup> of semen
0	86
less than 2	69
2 – 4	59
more than 4	50

The results show a negative correlation: the more hours a mobile phone is used each day, the lower the sperm count. However, the results do **not** necessarily mean using a mobile phone causes the reduced sperm count.

Suggest **one** reason why.

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(1)

(Total 6 marks)

15

- (a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	Wavelength
Visible light	0.0005 mm
<b>A</b>	1.1 km
<b>B</b>	100 mm
<b>C</b>	0.18 mm

Which of the waves, **A**, **B**, or **C**, is an infra red wave?

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(1)

- (b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Calculate the wavelength of the waves broadcast by this station.

Show clearly how you work out your answer.

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Wavelength = \_\_\_\_\_ m

**(2)**

- (c) What happens when a metal aerial absorbs radio waves?

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**(2)**

- (d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

Why would an X-ray telescope based on Earth **not** be able to detect X-rays emitted from distant stars?

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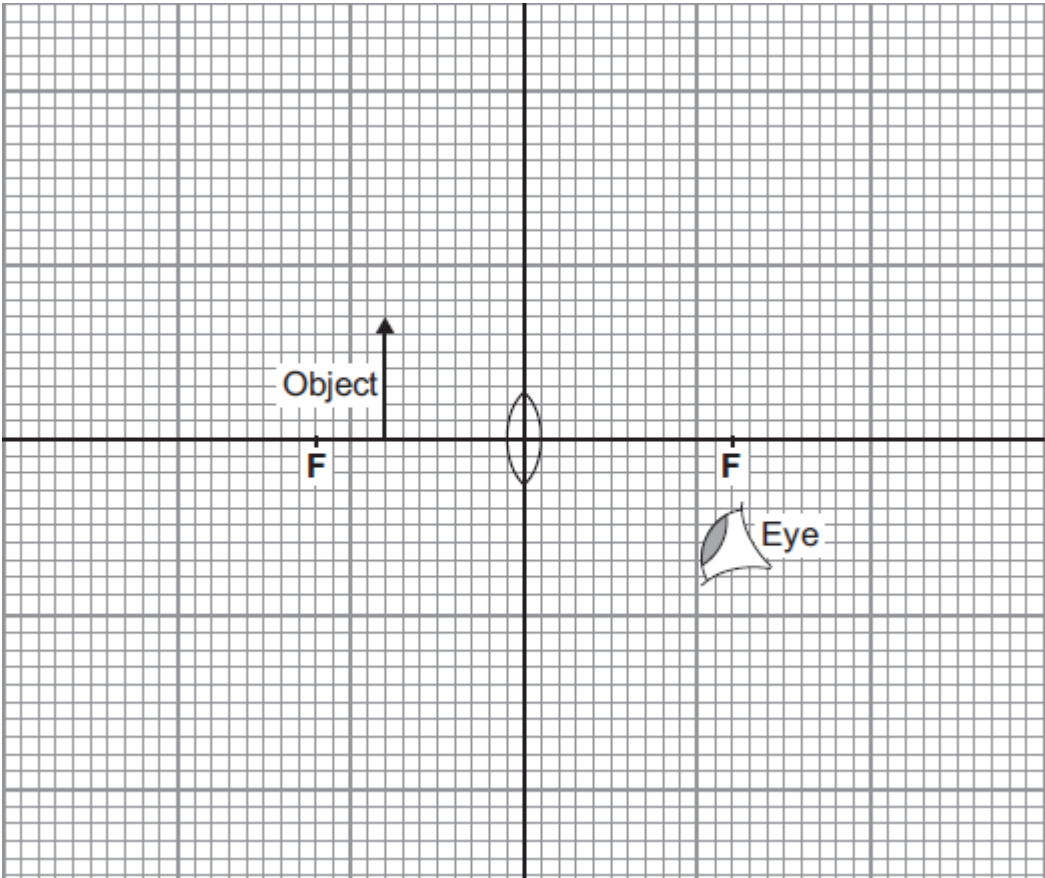
**(1)**

**(Total 6 marks)**

16

(a) The diagram shows a converging lens being used as a magnifying glass.

(i) On the diagram, use a ruler to draw two rays from the top of the object which show how and where the image is formed. Represent the image by an arrow drawn at the correct position.



(3)

(ii) Use the equation in the box to calculate the magnification produced by the lens.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

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Magnification = \_\_\_\_\_

(2)

(b) A camera also uses a converging lens to form an image.

Describe how the image formed by the lens in a camera is different from the image formed by a lens used as a magnifying glass.

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(2)  
(Total 7 marks)

17

Radio waves and microwaves are two types of electromagnetic wave.

Both waves:

- can be used for communications
- travel at the same speed through air.

(a) Give **two** more properties that are the same for both radio waves and microwaves.

1. \_\_\_\_\_

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2. \_\_\_\_\_

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(2)

(b) Some satellites are used to transmit television programmes. Signals are sent to, and transmitted from, the satellites using microwaves.

What is the property of microwaves that allows them to be used for satellite communications?

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(1)

- (c) Electromagnetic waves travel at a speed of  $3.0 \times 10^8$  m/s.

A radio station transmits waves with a wavelength of  $2.5 \times 10^2$  m.

Calculate the frequency of the radio waves.

Show clearly how you work out your answer and give the unit.

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Frequency = \_\_\_\_\_

(3)

(Total 6 marks)

18

- (a) Microwaves and visible light are two types of electromagnetic wave. Both can be used for communications.

- (i) Give **two** properties that are common to both visible light and microwaves.

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

(2)

- (ii) Name **two** more types of electromagnetic wave that can be used for communications.

\_\_\_\_\_ and \_\_\_\_\_

(1)

- (b) Wi-Fi is a system that joins computers to the internet without using wires. Microwaves, with a wavelength of 12.5 cm, are used to link a computer to a device called a router. Microwaves travel through the air at 300 000 000 m/s.

Calculate the frequency of the microwaves used to link the computer to the router.

Show clearly how you work out your answer and give the unit.

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Frequency = \_\_\_\_\_

(3)



(c) Wi-Fi is used widely in schools. However, not everyone thinks that this is a good idea.

A politician commented on the increasing use of Wi-Fi. He said: 'I believe that these systems may be harmful to children.'

However, one group of scientists said that there is no reason why Wi-Fi should not be used in schools. These scientists also suggested that there is a need for further research.

(i) Suggest what the politician could have done to persuade people that what he said was not just an opinion.

---

---

(1)

(ii) Why did the group of scientists suggest that there is a need for further research?

---

---

(1)

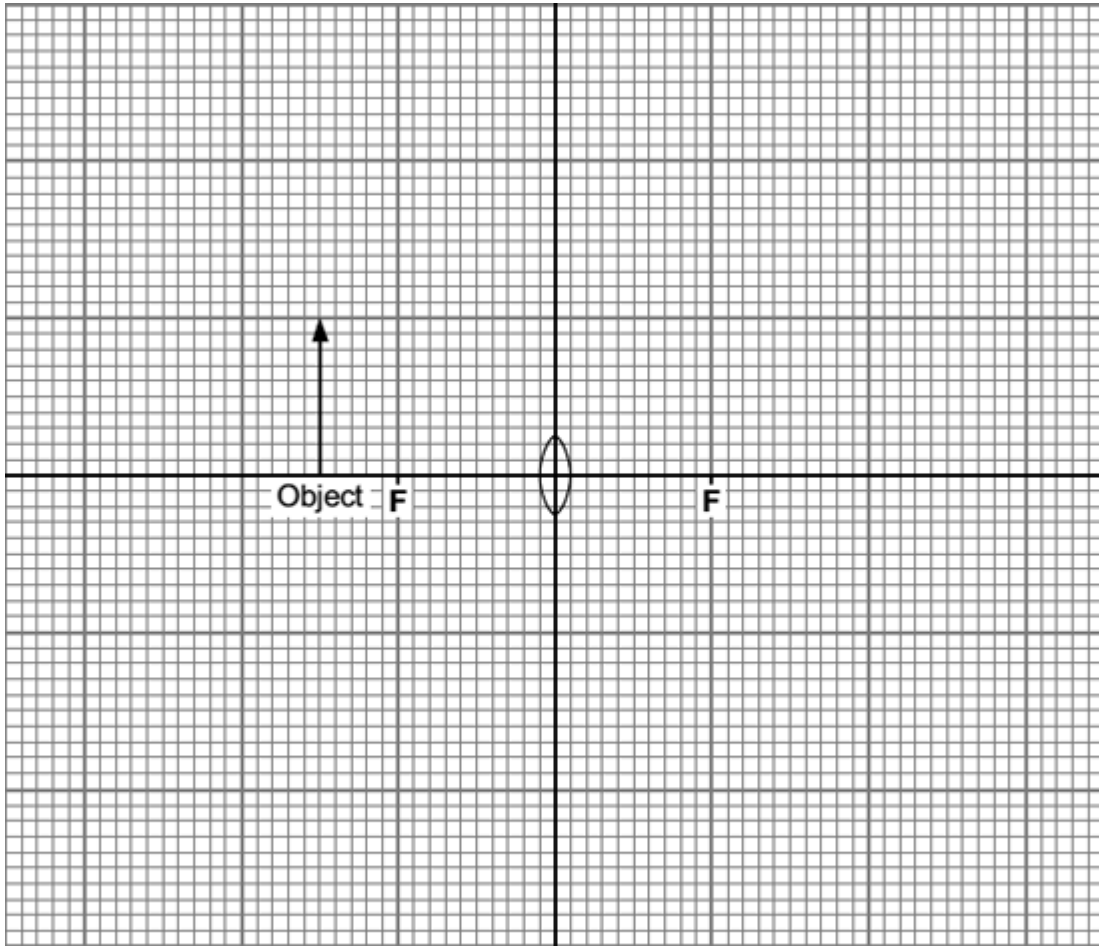
**(Total 8 marks)**

19

A student investigated how the nature of the image depends on the position of the object in front of a large converging lens.

The diagram shows one position for the object.

- (a) Use a ruler to complete a ray diagram to show how the image of the object is formed.



Key: F = principal focus

(4)

- (b) Describe the nature of this image relative to the object.

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(2)

(Total 6 marks)

20

- (a) Microwaves are one type of electromagnetic wave.

- (i) Which type of electromagnetic wave has a lower frequency than microwaves?

---

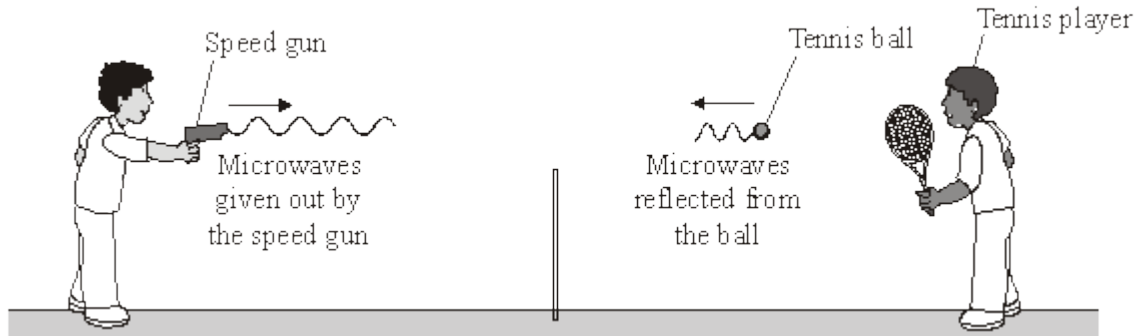
(1)

(ii) What do all types of electromagnetic wave transfer from one place to another?

\_\_\_\_\_

(1)

(b) The picture shows a tennis coach using a speed gun to measure how fast the player serves the ball.



(i) The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz and travel through the air at 300 000 000 m/s.

Calculate the wavelength of the microwaves emitted from the speed gun.

Show clearly how you work out your answer.

\_\_\_\_\_  
\_\_\_\_\_

Wavelength = \_\_\_\_\_ m

(2)

(ii) Some of the microwaves transmitted by the speed gun are absorbed by the ball.

What effect will the absorbed microwaves have on the ball?

\_\_\_\_\_  
\_\_\_\_\_

(1)

(Total 5 marks)

## Mark schemes

1

(a) any **four** from:

- light waves are transverse whereas sound waves are longitudinal
- light waves travel faster than sound waves
- light waves have a higher frequency than sound waves
- light waves have a shorter wavelength than sound waves
- light waves have oscillations perpendicular (to the direction of energy transfer) whereas sound waves are parallel (to the direction of energy transfer)

4

(b) the baby can be seen in the dark

1

(c) wave speed = frequency  $\times$  wavelength

*accept  $v = f \lambda$*

1

(d)  $3 \times 10^8 = f \times 0.125$

1

$$f = 3 \times 10^8 / 0.125$$

1

$$f = 2.4 \times 10^9 \text{ (Hz)}$$

*allow  $2.4 \times 10^9$  with no working for 3 marks*

1

[9]

2

(a) (i) 440 (sound) waves produced in one second

*accept vibrations / oscillations for waves*

1

(ii) 0.773 (metres)

*allow 2 marks for an answer that rounds to 0.773*

*allow 2 marks for an answer of 0.772*

*allow 2 marks for an answer of 0.772*

*allow 1 mark for correct substitution ie  $340 = 440 \times \lambda$*

3

(b) (sound is) louder

*do **not** accept the converse*

1

as amplitude is larger

*waves are taller is insufficient*

1

higher pitch / frequency

1

as more waves are seen

*reference to wavelengths alone is insufficient*

*waves are closer together is insufficient*

1

[8]

3

(a) the oscillation / vibration (causing the wave)

*a movement causes the wave is insufficient*

1

for a transverse wave is perpendicular to the direction of energy transfer

*accept direction of wave travel*

1

and for a longitudinal wave is parallel to the direction of energy transfer

*accept direction of wave travel*

*if no marks awarded allow 1 mark for correctly linking perpendicular with transverse and parallel with longitudinal*

*the marks may be scored by the drawing of two correctly labelled diagrams*

1

(b) for radio waves:

*accept converse for each mark*

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

*accept sound waves are not electromagnetic for 1 mark*

1

[7]

4

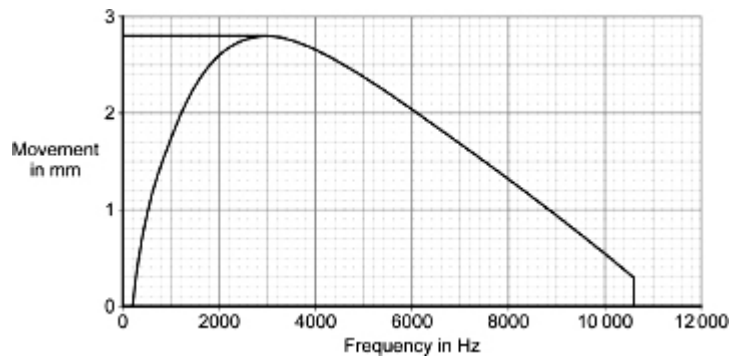
(a) 10 600 (Hz)

*accept 10.6 kHz*

1

(b) 3000 (Hz)

*allow 1 mark for a line drawn to show greatest movement  
(allow only if frequency is between 2800 and 3200)  
accept other indication of correctly using the graph*



2

(c) (No)

*no marks for just the ticked box  
reasons can score even if yes is ticked*

(human hearing) range is 20 – 20 000 (Hz)

*accept (most) people hear up to 20 000 (Hz) / 20 kHz*

1

any **one** from:

- range on graph is within this range
- range on graph starts after 20 Hz
- range on graph is from to 200 – 10 600 (Hz)
- range on graph finishes before 20 000 Hz

1

(d) reliability

*this answer only*

1

(e) only 1 variable affects dependent variable / size of movement

*accept 'results' for 'size of movement'*

**or**

there is only one independent variable

*fair test is insufficient*

*do **not** accept to control the experiment*

**or**

to be able to compare (effect of different frequencies)

1

[7]

5

(a) microphone

1

- (c) (i) vertical line from any maxima or minima to axis  
do **not** penalise minor errors but  
do **not** allow unless intention is clear 1
- (ii) loudness / volume / intensity / energy  
do **not** accept noise 1
- (c) 17  
*this answer only* 1
- (d) the greater the distance, the smaller the amplitude  
accept volume / intensity / energy / loudness for amplitude  
**or**  
there is a (strong) negative correlation between distance and amplitude  
**or**  
there is an inverse square relationship between distance and amplitude  
do **not** accept distance and amplitude are inversely proportional 1
- (e) 20 Hz  
*either order* 1
- 20,000 Hz  
accept 20 kHz provided unit has been clearly changed 1

[7]

6

- (a) (i) microwaves 1
- (ii) can pass through the ionosphere  
accept travels in a straight line  
accept atmosphere for ionosphere  
do **not** accept air for ionosphere 1
- (b) higher the frequency, further the wave travels  
(into the atmosphere before reflection) 1

(c) 15 000

*allow 1 mark for correct transformation and substitution*

*ie  $\frac{300\,000\,000}{20}$*

*an answer of 15 000 000 only gains 1 mark*

*allow both marks for an answer of 15 MHz (unit must be changed)*

*an answer of 15 gains no credit*

2

[5]

7

(a) (i) shorter than

1

(ii) increase slightly

1

(b) (i) go up in the same ratio  
**or** (directly) proportional **or** as speed (of the tennis ball) increases so does the (difference in) frequency

*accept as one goes up, so does the other*

*accept positive correlation*

1

(ii) 20 (m/s)

*allow 1 mark for showing correct method on graph  
(ie horizontal or vertical line anywhere on graph)*

*if indicated by a cross, must be  $\pm$  half square of correct value)*

2

(iii) frequency and speed are both continuous variables

1

[6]

8

(a) (i) compare (the health of) mobile phone users with non-mobile phone users

*must be an implied comparison between users and non-users*

*any idea of doing an experiment negates the mark*

1

(ii) increase the sample size

*accept use more people*

*accept have a large sample size*

*repeat the research / test is neutral*

1

(iii) ethical

1



(b) (i) so the phones can be compared (fairly)  
*a fair test is insufficient*  
*accept different tests (may) give different results*  
*do **not** accept to make the results reliable, unless qualified*  
*eg all variables are controlled*  
*do **not** accept bias unless qualified*

1

(ii) yes all are below the legal limit / 2 (W/kg)

**or** no and any **one** from:

- even absorbing a small amount of energy may be harmful  
*accept microwaves for energy*  
*accept emits energy absorbed by head / other parts of body*
- no proof that small amounts of energy are not harmful  
*accept because the SAR value is not 0 (W/kg)*

1

(c) any **one** from:

- to get an independent opinion
- company scientists may be biased  
*accept company scientists may manipulate results*

1

[6]

9 (a) the normal

1

(b) v

1

(c) any **one** from:

- light has moved from glass to air / from air to glass  
*accept light has changed medium*
- speed of light has changed  
*beware of contradictions for this marking point eg light has moved from glass to air and slowed down gets zero*
- angle of incidence is less than the critical angle  
*or (angle)  $i < c$  or (angle)  $y$  is less than the critical angle*
- change in density (of medium)  
*eg glass is more (optically) dense than air*

1

(d) (i) ratio of  $v$  to  $y$  does not give the same answer (in every case)

**or** value of  $v$  doubles value of  $y$  does not double

1

**or** increments for  $v$  are the same but increments for  $y$  are not the same

*allow for 1 mark a calculation but no conclusion*

*eg  $30 \rightarrow 60$   $19 \rightarrow 35$  (38)*

1

(ii) as (angle)  $v$  increases, angle  $y$  increases

*accept as the angle of incidence increases, the angle of refraction increases*

**or** *there is a (strong) positive(non-linear) relationship between the variables*

**or** *ratio of sines is constant*

*do **not** accept angle  $y$  is not directly proportional to angle  $v$*

1

(iii) no evidence outside this range

*OWTTE*

**or** when angle  $y$  is greater than the critical angle total internal reflection occurs

1

[7]

10

(a) (mechanical) vibration(s)

**not** *just 'particles knocking into each other'*

*not reference to 'sound particles'*

1

(b) K

1

(c) (i) reflected by the material from loudspeaker to microphone X

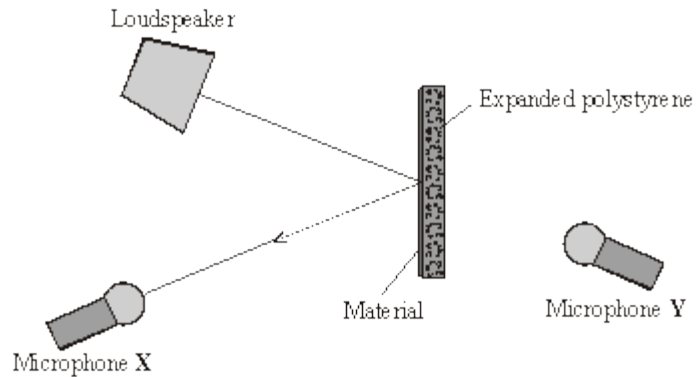
1

shown by straight lines with angle of incidence = angle of reflection  
(by eye) **and** at least one arrow in the correct direction

*do not credit if the direction is contradicted by any incorrect arrow /  
may be shown by waves / wavefronts in the direction of straight  
lines*

*ignore any sound to Y or which 'misses' the material*

*example*



1

(ii) any **one** from:

- so (the student) can compare results
- so only one (independent) variable
- to get reliable / accurate results
- because (the expanded) polystyrene absorbs some of the sound  
*do not credit just 'so it's a fair test'*

1

(iii) **[A]** wood

1

**[B]** either 0.25 or 1/4 or 25 % or 15/60 or 1:3

*do not credit 1 : 4*

1

(d) practical suggestion

1

appropriate reason / explanation

**example** line / panel the walls with wood / plasterboard / increase the thickness of the plaster (on the walls) (1)

(this) will absorb / reflect (back) (most / some of) the sound (1)

credit legal suggestions for attempting to limit the noise made by the neighbours

**example** ask the neighbours to make less noise (1)

by limiting the time(s) music played (1)

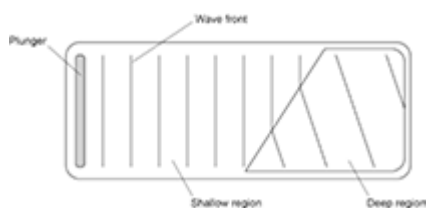
do **not** credit reference to 'sound particles' for second mark

1

[9]

11

(a)



lines should be further apart with the bottom of the wave fronts further to the right than the top

1

(b) they will speed up

1

so wave (fronts) move further apart

1

(c) longitudinal waves:

- the oscillations are parallel to the direction of energy transfer

1

- show areas of compression and rarefaction

1

transverse waves:

- the oscillations / movement are perpendicular to the direction of energy transfer.

1

(d) place a floating object / plastic duck on the surface of the water

1

it will stay in the same place **or** only bob up and down if the water doesn't move

1

(e)  $0.42 = 1 / f$

1

$f = 2.38$

1

$$v = 2.38 \times 0.34$$

1

$$= 0.809$$

*allow 0.809 with no working shown for 4 marks*

1

*incorrect sig. figs max 3 marks*

m / s

*correct unit*

1

[13]

12

(a) (i) frequency

1

wavelength

1

(ii)  $10^{-15}$  to  $10^4$

1

(b)  $2.0 \times 10^5$

*correct substitution of  
 $3.0 \times 10^8 / 1500$  gains 1 mark*

2

Hz

1

(c) (i) (skin) burns

1

(ii) skin cancer / blindness

1

(d) (i) any **one** from:

- (detecting) bone fractures
- (detecting) dental problems
- treating cancer

1

(ii) any **one** from:

- affect photographic film
- absorbed by bone
- transmitted by soft tissue
- kill (cancer) cells

*answer must link to answer given in (d)(i)*

1

(iii)  $9 / 36 = 0.25$

$0.5 / 2 = 0.25$

$4 / 16 = 0.25$

*accept:*

$36 / 9 = 4$

$2 / 0.5 = 4$

$16 / 4 = 4$

2

conclusion based on calculation

*two calculations correct with a valid conclusion scores 2 marks*

*one correct calculation of k scores 1 mark*

1

[13]

13

(for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted

*accept for 1 mark:*

*(for both fibres) increasing the wavelength (of light) to  $5 \times 10^{-7}$  metres), decreases the (percentage) transmission*

1

(for both fibres) the minimum transmission happens at  $5 \times 10^{-7}$  metres)

**or**

maximum transmission occurs at  $6.5 \times 10^{-7}$  metres)

*accept for a further 1 mark:*

*(for both fibres) increasing the wavelength of the light from  $5 \times 10^{-7}$  metres) increases the amount of light transmitted*

*increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own*

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for 1 mark:*

*Any statement that correctly processes data to compare the fibres*

1

[3]

14

(a)  $10^{-15}$  metres to  $10^4$  metres

1

(b) (i) any **one** from:

- (TV / video / DVD) remote controls  
*mobile phones is insufficient*
- (short range) data transmission  
*accept specific example, eg linking computer peripherals*
- optical fibre (signals)  
*do **not** accept Bluetooth*

1

(ii) 0.17

*an answer 17 cm gains **3** marks*

*an answer given to more than 2 significant figures that rounds to 0.17 gains **2** marks*

*allow **1** mark for correct substitution, ie  $3 \times 10^8 = 1.8 \times 10^9 \times \lambda$*

3

(c) (maybe) other factors involved

*accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age*

*not testing enough people is insufficient*

*unreliable data is insufficient*

1

[6]

15

(a) C or 0.18 mm

1

(b) 0.6 (m)

*allow **1** mark for correct substitution and/or transformation **or 1***

*mark for changing frequency to Hz*

*answer 600 gains **1** mark*

2

(c) creates an alternating current

*accept 'ac' for alternating current*

*accept alternating voltage*

1

with the same frequency as the radio wave

*accept signal for radio wave*

*accept it gets hotter for **1** mark provided no other marks scored*

1

- (d) X-rays cannot penetrate the atmosphere  
*accept atmosphere stops X-rays*  
*do **not** accept atmosphere in the way*

**or**

X-rays are absorbed (by the atmosphere) before reaching Earth  
*ignore explanations*

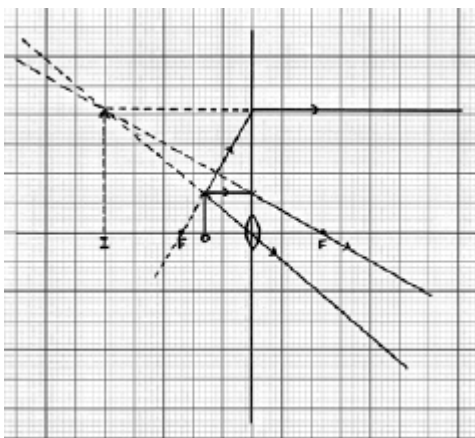
1

[6]

16

- (a) (i) **two** correct rays drawn  
*1 mark for each correct ray*

- ray parallel to axis from top of object **and** refracted through focus **and** traced back beyond object
- ray through centre of lens **and** traced back beyond object
- ray joining top of object to focus on left of lens taken to the lens refracted parallel to axis **and** traced back parallel to axis beyond object



2

an arrow showing the position **and** correct orientation of the image for their rays  
*to gain this mark, the arrow must go from the intersection of the traced-back rays to the axis **and** the image must be on the same side of the lens as the object and above the axis*

1



- (ii) (x) 3.0  
*accept 3.0 to 3.5 inclusive*

**or**

$$\frac{\text{their image height}}{\text{object height}}$$

correctly calculated

*allow 1 mark for correct substitution into equation using their figures  
ignore any units*

2

- (b) any **two** from:

in a camera the image is:

- real not virtual
- inverted and not upright  
*accept upside down for inverted*
- diminished and not magnified  
*accept smaller and bigger  
accept converse answers but it must be clear the direction of the comparison  
both parts of each marking point are required*

2

[7]

17

- (a) any **two** from:

- travel (at same speed) through a vacuum / space  
*do **not** accept air for vacuum*
- transverse
- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- travel in straight lines

2

(b) can pass through the ionosphere  
*accept atmosphere for ionosphere*  
*do **not** accept air for ionosphere*  
*accept travel in straight lines*  
*accept not refracted / reflected / absorbed by the ionosphere*

1

(c)  $v = f \times \lambda$

$$1.2 \times 10^6 / 1200\ 000$$

*allow **1** mark for correct substitution*

$$\text{ie } 3.0 \times 10^8 = f \times 2.5 \times 10^2$$

2

hertz / Hz

*do **not** accept hz **or** HZ*

*accept kHz **or** MHz*

*answers 1.2 MHz **or** 1200 kHz gain all **3** marks*

*for full credit the unit and numerical value must be consistent*

1

**[6]**

**18**

(a) (i) any **two** from:

- travel at the same speed (through a vacuum)

*accept travel at the speed of light*

*accept air for vacuum*

- can travel through a vacuum / space

*do **not** accept air for vacuum*

- transfer energy

- can be reflected

- can be refracted

- can be diffracted

- can be absorbed

- can be transmitted

- transverse

*accept any other property common to electromagnetic waves*

*accept travel at the same speed through a vacuum for both marks*

*do **not** accept both radiated from the Sun*

2

(ii) infra red  
**both** required for the mark

radio(waves)  
accept IR for infra red

1

(b) 2 400 000 000  
correct transformation and substitution gains 1 mark

ie  or 

an answer of 24 000 000 gains 1 mark

**either** 2 400 000 kHz

**or** 2 400 MHz scores 3 marks but the symbol only scores the 3<sup>d</sup> mark if it is correct in every detail

2

hertz

accept Hz

do **not** accept hz

1

(c) (i) presented (scientific) evidence / data  
do an experiment / investigation is insufficient

1

(ii) to find out if there is a hazard (or not)  
accept to find out if it is safe  
accept not enough evidence to make a decision  
not enough evidence is insufficient

1

**[8]**

19

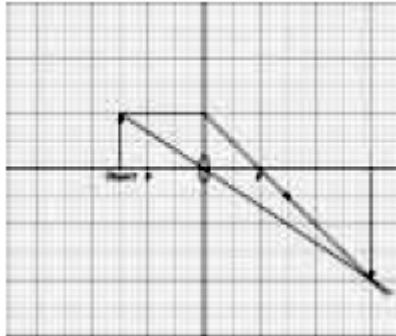
(a) any **two** for **1** mark each

*deduct (1) from the first two marks if a ruler has not been used but the intention is clear*

ray from the object's arrowhead

- through centre of lens
- parallel to the axis then, when it reaches the lens, through F on the right
- through F on the left then, when it reaches the lens parallel to the axis

*example of a 4 mark response*



*if more than two construction lines have been drawn all must be correct to gain 2 marks*

*construction lines drawn as dashed lines do not score credit*

2

image shown as vertical line from axis to where their rays intersect

*image need not be marked with an arrowhead but, if it is, it must be correct*

1

ray direction shown

*only one correct direction*

*arrow needed but there must not be any contradiction*

1

(b) any **two** from:

- inverted  
*accept 'upside down'*
- magnified  
*accept 'bigger'*
- real  
*accept 'not virtual / not imaginary'*  
*one correct feature gains 1 mark*  
*ignore any reference to position*  
*an incorrect feature negates a correct response*

2

[6]

20

- (a) (i) radio(waves) 1
- (ii) energy  
*correct answer only* 1
- (b) (i) 0.0125 (m)  
*allow 1 mark for correct transformation and substitution* 2
- (ii) make it hot(ter)  
*do **not** accept cook it*  
*accept (air) particles inside ball will move faster*  
*accept water in the ball gets hotter* 1

[5]