



## Waves - EM spectrum, wave characteristics, wavespeed, ray diagrams

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147 minutes



147 marks

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**Q1.** (i) Use the words frequency, wavelength and wave speed to write an equation which shows the relationship between them.

.....

(1)

(ii) Calculate the speed of a sound wave with a frequency of 250 Hz and a wavelength of 1.3 m.

Show how you get to your answer and give the unit.

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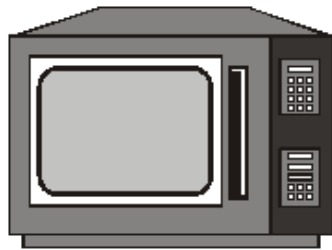
.....

Speed = .....

(2)

(Total 3 marks)

**Q2.** Microwave ovens can be used to heat many types of food.



(i) Describe, in as much detail as you can, how microwaves heat food.

.....

.....

.....

.....

(2)

(ii) Microwaves have a frequency of 10 000 million Hz. Their wavelength is 0.03 m.

Calculate the speed of microwaves.

Show clearly how you work out your answer.

.....  
.....  
.....

Speed of microwaves..... m/s

(2)  
(Total 4 marks)

**Q3.** All radio waves travel at 300 000 000 m/s in air.

(i) Give the equation that links the frequency, speed and wavelength of a wave.

.....

(1)

(ii) Calculate the wavelength, in metres, of a radio wave which is broadcast at a frequency of 909 kHz. Show clearly how you work out your answer.

.....  
.....  
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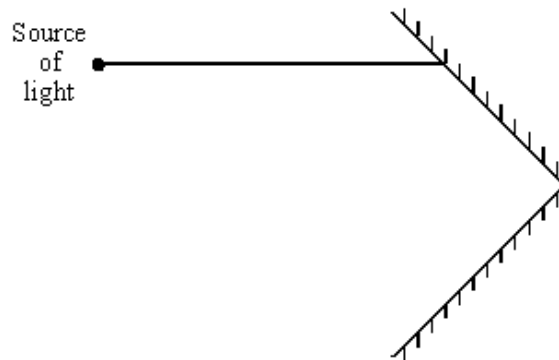
Wavelength = ..... metres

(2)  
(Total 3 marks)

**Q4.** (a) The diagram shows two mirrors at right angles to each other. A ray of light shines onto one mirror as shown.

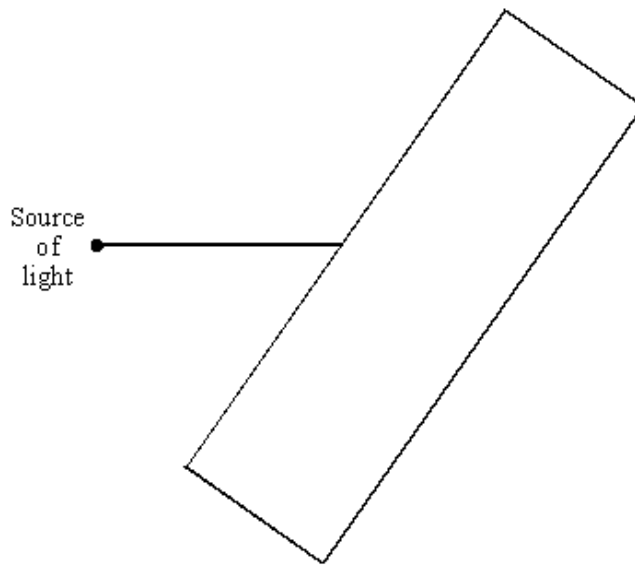
Carefully draw the path of the ray which is reflected from both mirrors.

Draw an arrow on the ray to show the direction of the light.



(3)

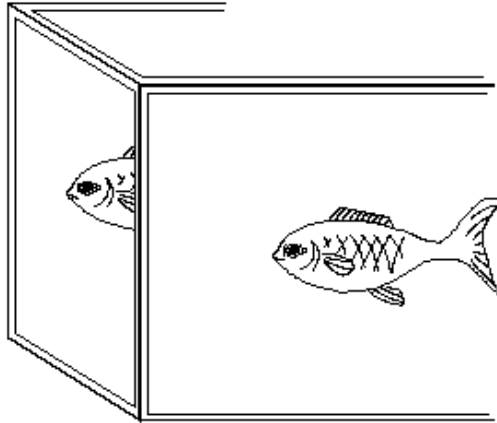
(b) Light can also be made to change direction as it passes into and out from a block of glass. Complete the ray diagram below.



(2)

(Total 5 marks)

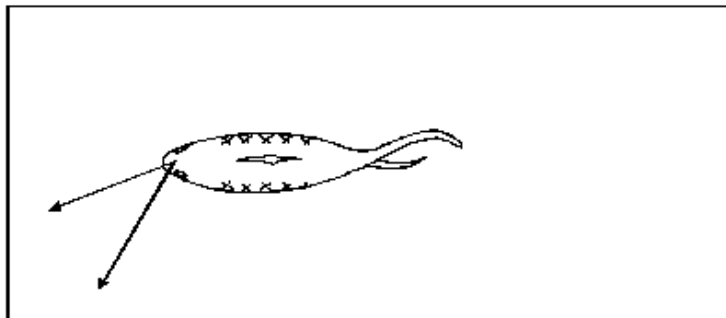
**Q5.** An aquarium contains only one fish. But if you look at the corner of the aquarium, there seem to be two fish.



The diagram below shows the top of the aquarium.

Two light waves have been drawn from the fish.

(a) Complete the diagram to show how the light waves reach the eye.



(2)

(b) Complete each sentence by using the correct words from the box.

colour	diffraction	longitudinal	reflection
refraction	speed	transverse	

When the light waves pass from glass into the air they change .....

This causes a change in direction called .....

Light waves are ..... waves.

(3)  
(Total 5 marks)

**Q6.** Telephone messages are sent by various means.

(a) Name the devices used to change:

(i) sound vibrations into electrical vibrations.

.....

(ii) electrical vibrations into sound vibrations.

.....

(2)

(b) Explain how information is transferred from one telephone to another when:

(i) both the telephones are mobile phones.

.....

.....

(ii) both telephones are directly linked by copper wiring.

.....

.....

(iii) both telephones are directly linked by optical fibres.

.....

.....

(3)

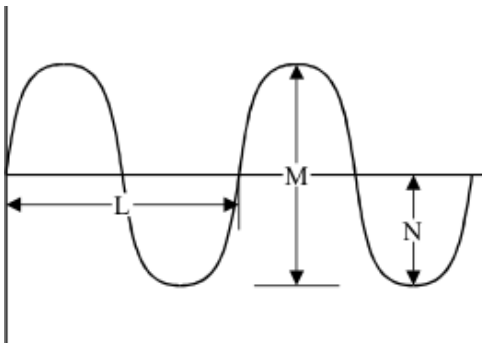
(c) The amplitude of the wave carrying the message is reduced during transmission. What effect will this have on the sound produced at the other telephone?

.....

(1)

(Total 6 marks)

**Q7.** (a) The diagram shows a wave pattern.



Which letter, **L**, **M** or **N** shows:

(i) the wavelength? .....

(ii) the amplitude? .....

(2)

(c) Describe how you could show that visible light travels in straight lines. You may wish to draw a diagram to help explain your answer.

.....

.....

.....

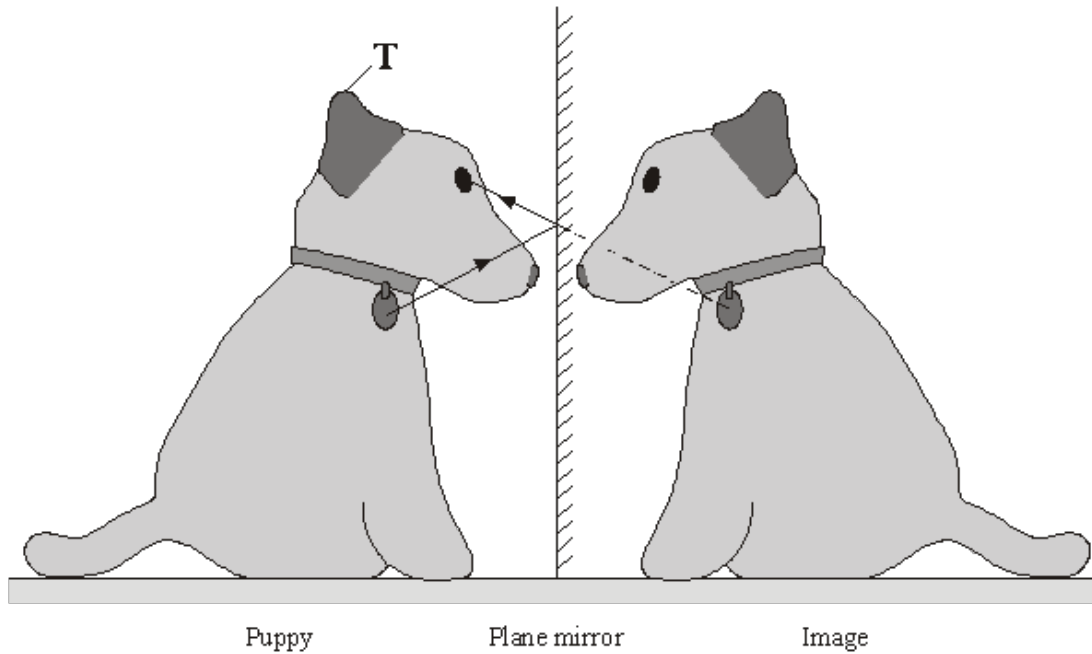
.....

.....

(2)

(Total 4 marks)

**Q8.** A puppy can see an image of himself in a plane mirror.



The diagram shows how the puppy can see his disc.

- (a) On the diagram, use a ruler to draw a ray to show how the puppy can see the top of his ear, which is marked as **T**.

(3)

- (b) What is a plane mirror?

.....  
.....

(1)

(Total 4 marks)

**Q9.** (a) Mobile phones send *digital* signals using electromagnetic waves.

- (i) Which **one** of the following types of electromagnetic wave is used to carry information between masts in a mobile phone network?

Draw a ring around your answer.

light	microwave	radio
-------	-----------	-------

(1)



- (b) Some people worry that using a mobile phone may be bad for their health.

Look at this information taken from a recent newspaper article.

- Scientists in Sweden found that the regular use of a mobile phone increases the risk of a cancerous growth between the ear and the brain.
- Some people who use mobile phones for a long time complain of headaches and tiredness. The same effect has not been noticed in laboratory tests.
- There is no reliable evidence to link using mobile phones with ill health.
- The waves from a mobile phone are not strong enough to cause long-term heat damage to cells in the body.

- (i) Complete the following sentence by drawing a ring around the word in the box that is correct.

The evidence from different scientists doing the same investigation is reliable if

all the scientists get

different  
identical  
random

results.

(1)

- (ii) What information in the article supports the idea that mobile phones are bad for your health?

.....  
.....  
.....  
.....

(2)

- (iii) Some scientists say that using a mobile phone is totally safe.

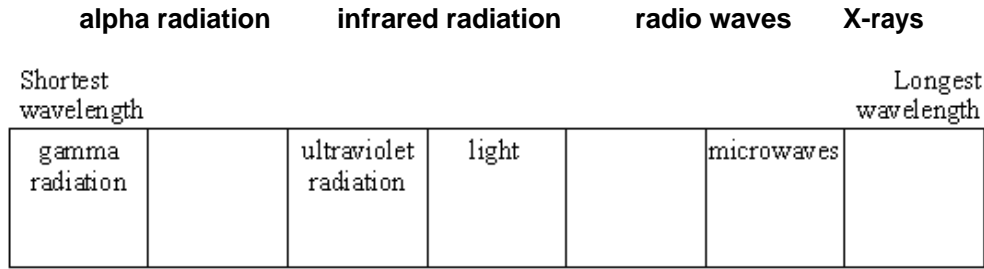
What information in the article supports this view?

.....  
.....  
.....  
.....

(2)

**(Total 6 marks)**

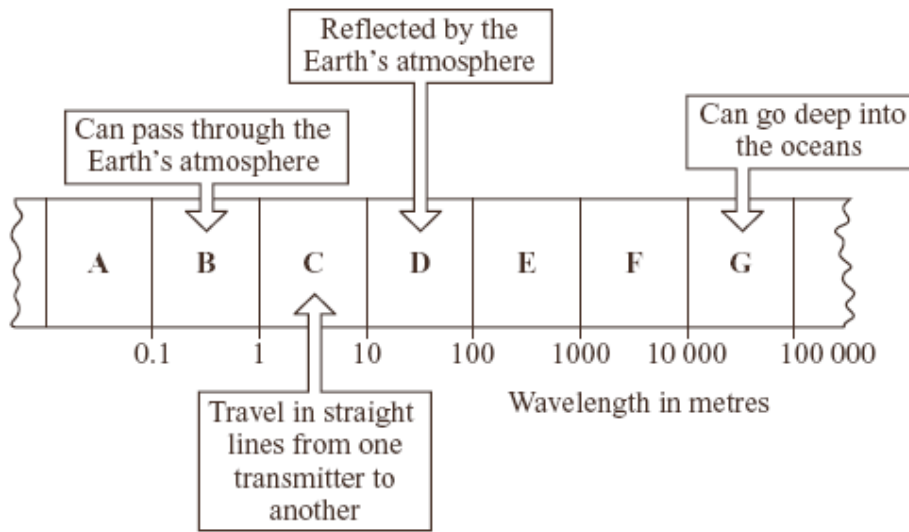
**Q10.** The diagram shows some of the kinds of waves in the electromagnetic spectrum. Choose words from this list to complete the empty boxes on the diagram.



**(Total 3 marks)**

**Q11.** The diagram shows a small part of the electromagnetic spectrum divided into seven sections.

The different properties of the waves in each section make them useful in different ways.



The waves in which section, **A**, **B**, **C**, **D**, **E**, **F** or **G**, are:

(a) used to send a signal to a satellite in space

.....

**(1)**

(b) used to communicate with a submarine under the water

.....

**(1)**

(c) used by a radio station to broadcast programmes around the world

.....

**(1)**

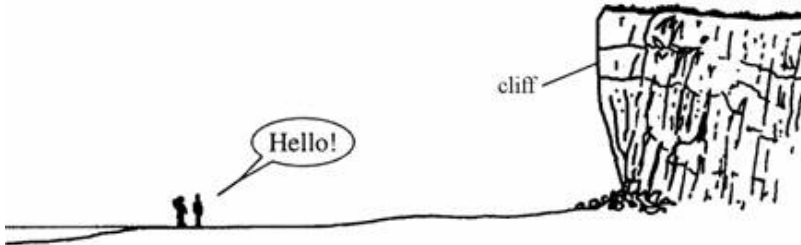
(d) the waves with the shortest wavelength?

.....

(1)  
(Total 4 marks)

**Q12.** Two friends are standing on a beach.

When they shout they can hear themselves a second later.

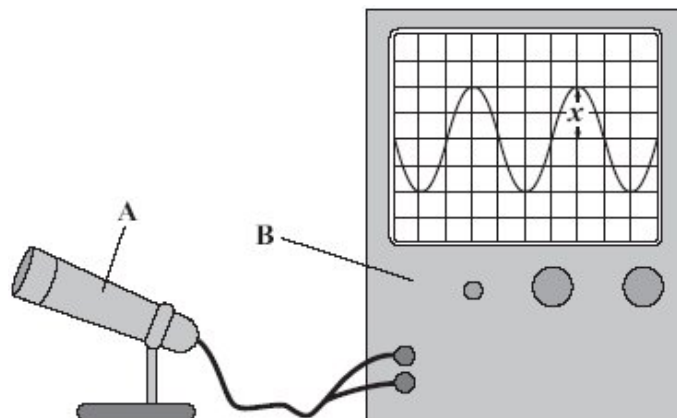


Explain, as fully as you can, why this happens.  
(You may answer on the diagram if you want to.)

.....  
.....

(Total 2 marks)

**Q13.** (a) A student uses two pieces of equipment, **A** and **B**, to display a sound wave.



(i) Use words from the box to complete the sentence.

**a loudspeaker   a microphone   an oscilloscope   a screen**

A is ..... and B is .....

(2)

(ii) Use words from the box to complete the sentence.

**the amplitude    half the amplitude    the frequency    half the frequency**

The distance **x** marked on the diagram measures ..... of the sound wave. (1)

(iii) Complete the sentence.

The distance **x** becomes smaller. This is because the sound has become ..... (1)

(b) There is no air in space.

Astronauts in space cannot hear sounds from outside their spacesuits.

Explain this.

.....  
.....  
.....  
.....

(2)  
(Total 6 marks)

**Q14.** The table shows the electromagnetic spectrum. Three types of wave have been missed out.

Gamma rays		Ultraviolet rays	Visible light		Micro-waves	
------------	--	------------------	---------------	--	-------------	--

Shortest wavelength ← → Longest wavelength

(i) Use words from the box to complete the table.

**infra red rays    radio waves    X-rays**

(2)

(ii) Which **one** of the following gives a use of gamma rays?

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

to communicate with satellites

to see objects

to kill cancer cells

(1)

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

All electromagnetic waves move

energy  
gases  
particles

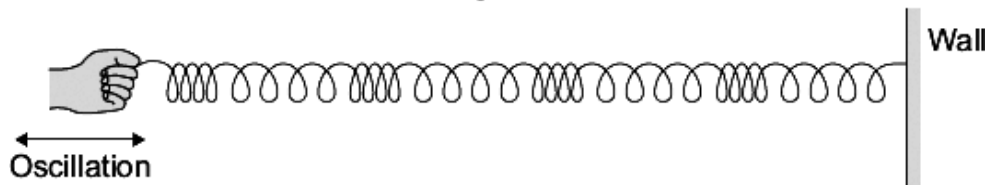
from one place to another.

(1)

(Total 4 marks)

**Q15.** **Diagram 1** shows a longitudinal wave being produced in a stretched spring.

**Diagram 1**



(a) A longitudinal wave has areas of compression and areas of rarefaction.

Mark with the letter **C**, **one** area of compression shown in **Diagram 1**.

(1)

- (b) **Diagram 2** shows the apparatus a teacher uses to demonstrate that sound can be reflected.

**Diagram 2**



- (i) Using a ruler, draw on **Diagram 2** to show how sound from the loudspeaker is reflected by the sheet of metal to the sound sensor. (2)

- (ii) The teacher replaced the sheet of metal with a sheet of glass.  
When he did this, the reading on the sound level meter went down.  
Suggest why.

.....  
.....

(1)

- (iii) The teacher changed the output from the loudspeaker to increase the amplitude of the sound wave produced.

What effect, if any, does this increase of amplitude have on the loudness of the sound?

Draw a ring around the correct answer.

**makes the  
sound quieter**

**does not change  
the loudness of  
the sound**

**makes the  
sound louder**

(1)

- (iv) The loudspeaker produces a sound wave at a frequency of 850 Hz. The wavelength of the sound wave is 0.4 m.

Calculate the speed of the sound wave.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

.....  
.....  
.....

Speed = ..... m/s

(2)

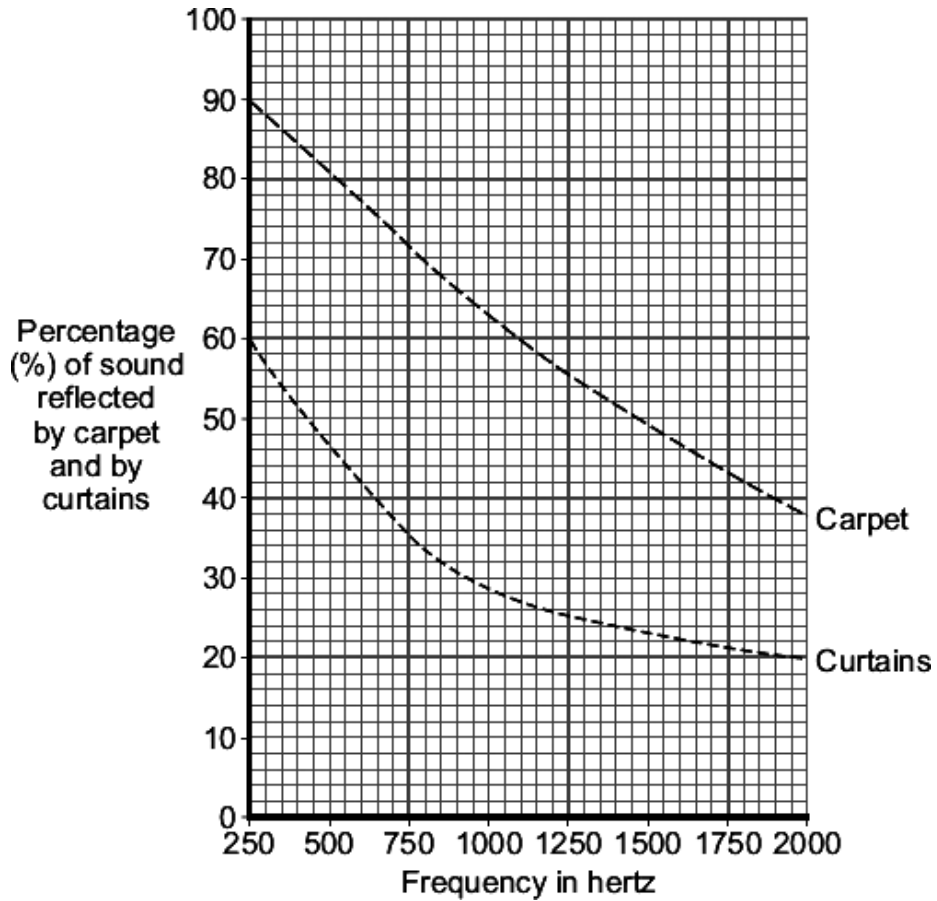
- (c) Music concerts are sometimes performed in sports halls. The concerts can be spoilt because of the sound reflected from the floor and walls.

What word is used to describe a reflected sound?

.....

(1)

- (d) The graph shows how the percentage of sound reflected from the floor and from the walls of a large room can be reduced by carpets and by curtains.



- (i) Over which range of frequencies do curtains reduce the percentage of sound reflected the most?

Tick (✓) **two** boxes.

from 250 Hz to 750 Hz

from 750 Hz to 1250 Hz

from 1250 Hz to 1750 Hz

(1)



- (ii) The manager of a sports hall plans to use the hall for regular music concerts. He has enough money to buy either carpet or curtains, but not both.

To improve the sound an audience hears, it would be better to hang curtains on the walls rather than laying a carpet over the floor.

Use the data in the graph to explain why.

.....

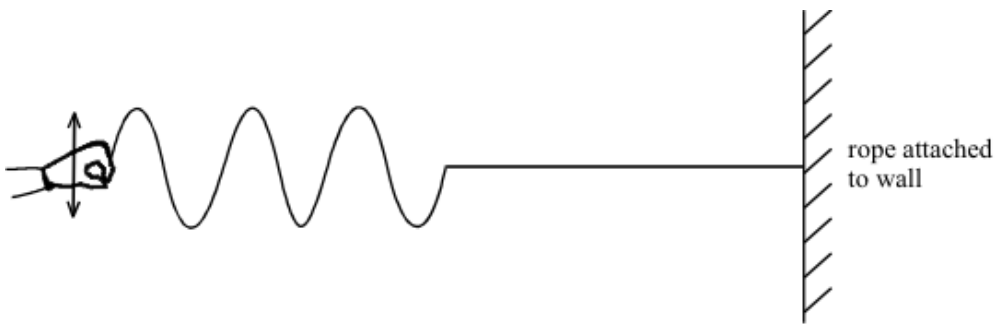
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(2)  
(Total 11 marks)

- Q16.** The diagram shows some waves travelling along a rope.



- (a) Show on the diagram

- (i) the wavelength of one of the waves
- (ii) the amplitude of one of the waves

(2)

(2)

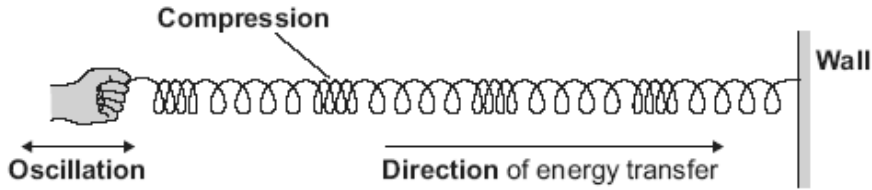
- (b) The waves shown on the diagram were produced in two seconds.

What is the frequency of the waves?

.....

(2)  
(Total 6 marks)

**Q17.** (a) The diagram shows a longitudinal wave being produced in a stretched spring.



(i) Use the bold words from the diagram to complete the following sentence. Put only **one** word in each space.

A longitudinal wave is one in which the ..... causing  
the wave is parallel to the ..... of energy transfer.

(2)

(ii) Name the type of energy that is transferred by longitudinal waves.

.....

(1)

(b) The diagram shows water waves made by a wave machine in a swimming pool.



Every second, two waves go past a person standing in the swimming pool.

The waves have a wavelength of 0.8 metres.

Calculate the speed of the water waves.

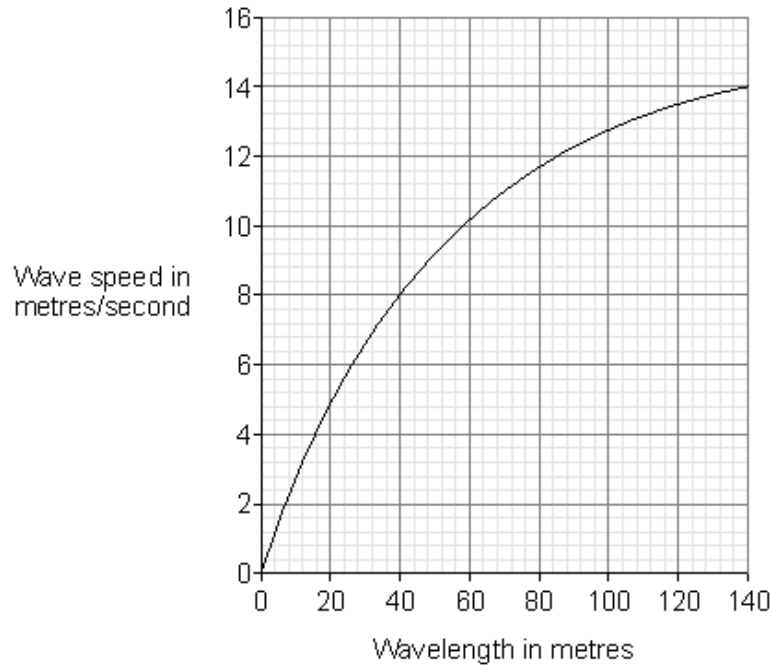
Write down the equation you use, and then show clearly how you work out your answer.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....

Wave speed = ..... m/s

(2)

- (c) The graph shows how the speed of deep ocean waves depends on the wavelength of the waves.



What can you conclude from the graph?

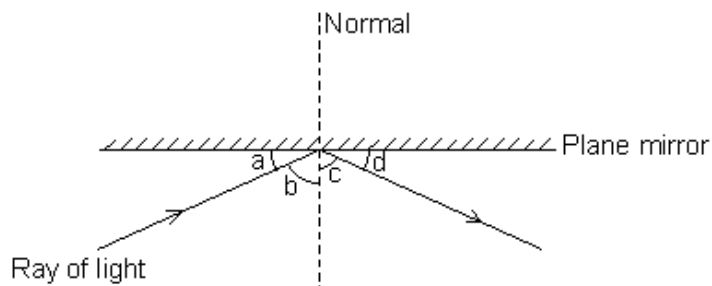
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.....

.....

(2)  
(Total 7 marks)

- Q18.** (a) The diagram shows a ray of light being reflected by a plane mirror.



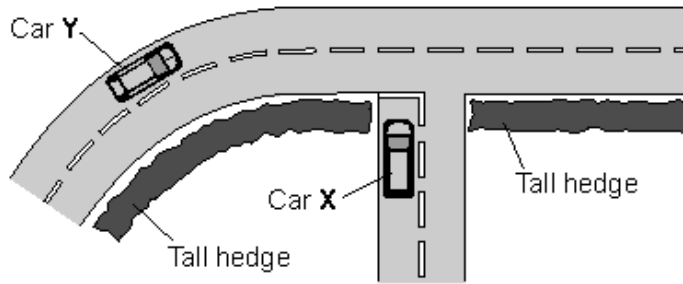
Which of the angles, **a**, **b**, **c** or **d**, is:

the angle of incidence;

the angle of reflection?

(2)

(b) The diagram shows a road junction seen from above.



A mirror placed at the side of the road allows the driver of car X to see car Y.

Using the same mirror symbol given in part (a), draw a plane mirror to show how it should be placed so that the driver of car X can see car Y.

(2)  
(Total 4 marks)

**Q19.** (a) The table gives information about the frequencies in the hearing ranges of six different mammals.

Name of mammal	Frequencies in hearing range
Bat	20 Hz → 160 kHz
Dog	20 Hz → 30 kHz
Dolphin	40 Hz → 110 kHz
Elephant	5 Hz → 10 kHz
Human	20 Hz → 20 kHz
Tiger	30 Hz → 50 kHz

(i) Which mammal in the table can hear the highest frequency?

.....

(1)

(ii) Which mammal in the table, apart from humans, **cannot** hear ultrasound?

.....

(1)

(iii) Give **one** example of a frequency which an elephant can hear but which a tiger **cannot** hear.

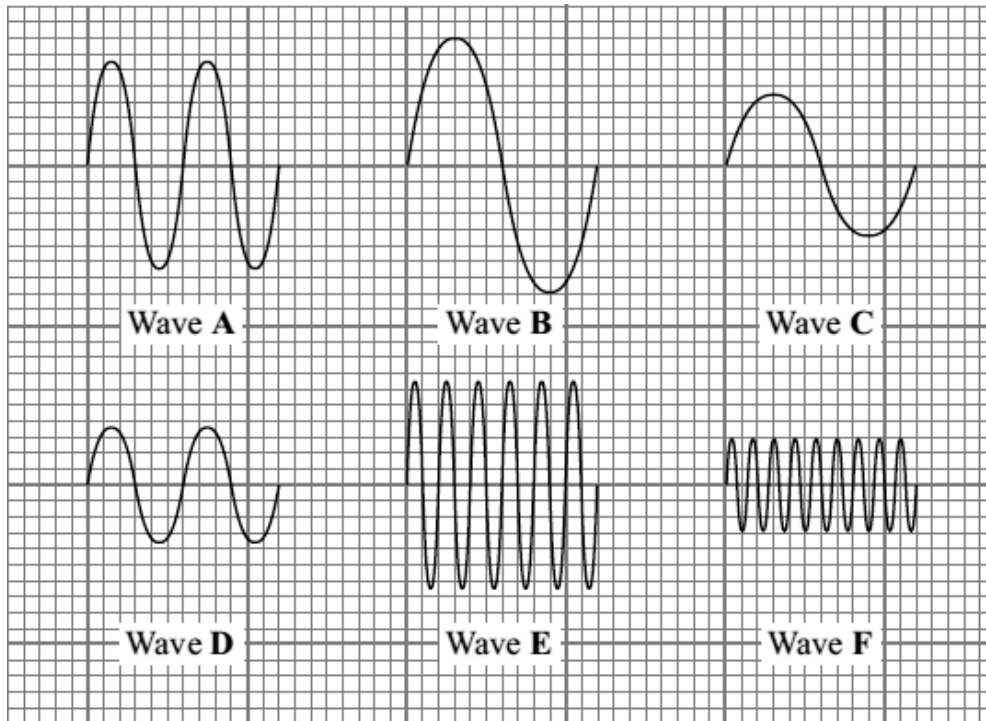
Include the unit in your answer.

Frequency .....

(1)

- (b) The diagrams show six sound waves, **A**, **B**, **C**, **D**, **E** and **F**, represented on an oscilloscope screen.

They are all drawn to the same scale.



- (i) Which **one** of the waves has the greatest amplitude?

Wave .....

(1)

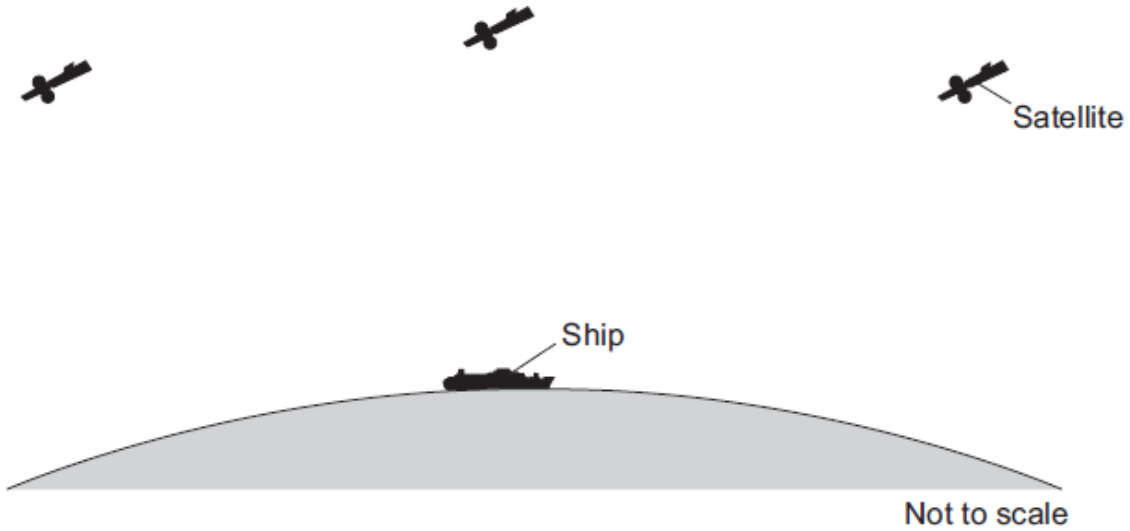
- (ii) Which **one** of the waves has the highest frequency?

Wave .....

(1)

(Total 5 marks)

**Q20.** The ship in the diagram is fitted with a navigation system. The navigation system works out the location of the ship by timing the microwave signals transmitted from at least three satellites.



(a) Microwaves are one type of electromagnetic wave.

Give **two** properties that all electromagnetic waves have.

- 1 .....
- .....
- 2 .....
- .....

(2)

(b) The microwaves used in the navigation system are transmitted at a frequency of 1575 MHz.

Use the equation and information in the box to calculate the wavelength of the microwaves used in the navigation system.

$\text{wave speed} = \text{frequency} \times \text{wavelength}$ <p>microwaves travel at 300 000 000 m/s</p> <p>1 MHz = 1 000 000 Hz</p>
---

Show clearly how you work out your answer.

- .....
- .....
- .....
- .....

Wavelength = ..... m

(3)

- (c) The ship is fitted with a metal aerial that receives the microwave signals from the satellites.

For the navigation system to work, what effect must the microwave signals have on the aerial?

.....  
.....

(1)  
(Total 6 marks)

**Q21.** (a) Water waves are transverse waves. Sound waves are longitudinal waves.

- (i) Explain the difference between a transverse wave and a longitudinal wave.

You may include labelled diagrams in your answer.

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.....  
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.....  
.....  
.....  
.....

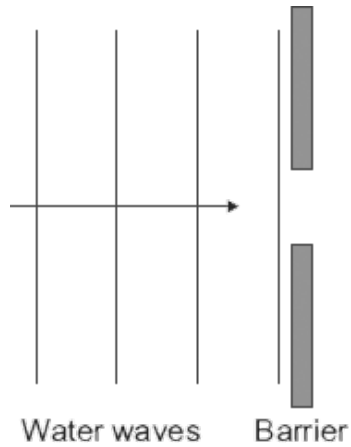
(3)

- (ii) Name **one** type of wave that may be either transverse or longitudinal.

.....

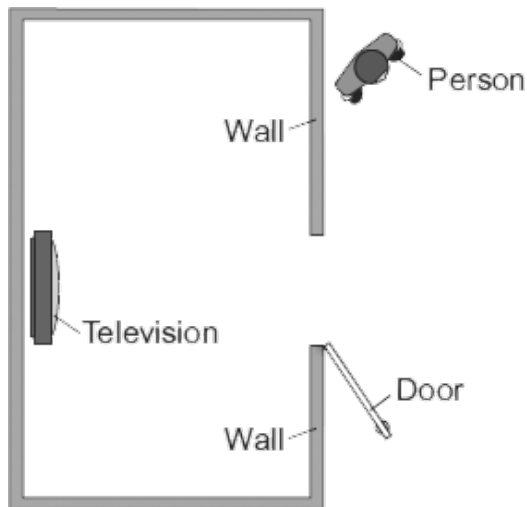
(1)

- (b) The diagram shows water waves in a ripple tank moving towards a gap in a barrier. The water waves diffract as they pass through the gap. Complete the diagram to show the diffracted water waves.



(1)

- (c) A television is switched on inside a room. A person outside the room can hear the television, but only when the door is open.



When the door is open, the person can hear the sound but cannot see the television.

Explain why.

.....

.....

.....

.....

(2)  
(Total 7 marks)



- Q22.** (a) The table gives information about the frequencies in the hearing ranges of six different mammals.

Name of mammal	Frequencies in hearing range
Bat	20 Hz → 160 kHz
Dog	20 Hz → 30 kHz
Dolphin	40 Hz → 110 kHz
Elephant	5 Hz → 10 kHz
Human	20 Hz → 20 kHz
Tiger	30 Hz → 50 kHz

- (i) Which mammal in the table can hear the highest frequency?

.....

(1)

- (ii) Give **one** example of a frequency which an elephant can hear but which a tiger **cannot** hear.

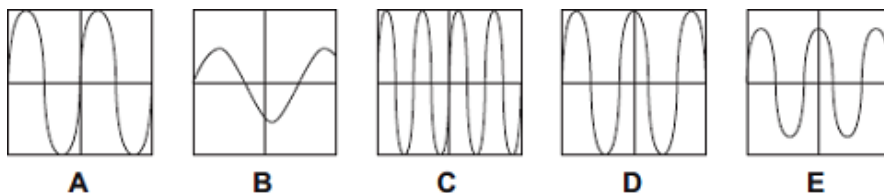
Include the unit in your answer.

Frequency .....

(1)

- (b) A sound wave can be represented as a trace on the screen of an oscilloscope.

The diagrams show five traces, **A**, **B**, **C**, **D** and **E**, on the oscilloscope. All the traces are drawn to the same scale.



- (i) Which **three** diagrams show traces with the same amplitude?

Diagrams ....., ..... and .....

(1)

- (ii) Which **two** diagrams show traces with the same frequency?

Diagrams ..... and .....

(1)

(c) There is no air in space.

Astronauts in space cannot hear sounds from outside their spacesuits.

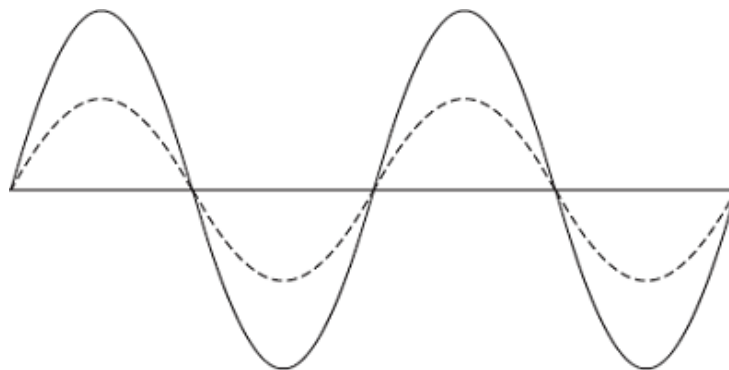
Explain this.

.....  
.....  
.....  
.....

(2)  
(Total 6 marks)

**Q23.** (a) **Diagram 1** shows two waves.

**Diagram 1**



(i) Name **one** wave quantity that is the same for the two waves.

.....

(1)

(ii) Name **one** wave quantity that is different for the two waves.

.....

(1)

(iii) The waves in **Diagram 1** are transverse.

Which **one** of the following types of wave is **not** a transverse wave?

Draw a ring around the correct answer.

**gamma rays**

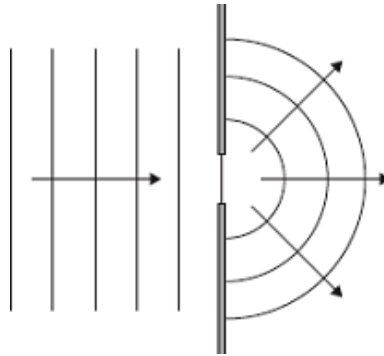
**sound**

**visible light**

(1)

- (b) **Diagram 2** shows water waves in a ripple tank moving towards and passing through a gap in a barrier.

**Diagram 2**



- (i) The water waves spread out after passing through the gap in the barrier.

What name is given to the process causing the waves to spread out?

.....

(1)

- (ii) Every second, 8 waves pass through the gap in the barrier. The waves have a wavelength of 0.015 metres.

Calculate the speed of the water waves and give the unit.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

Speed = .....

(3)

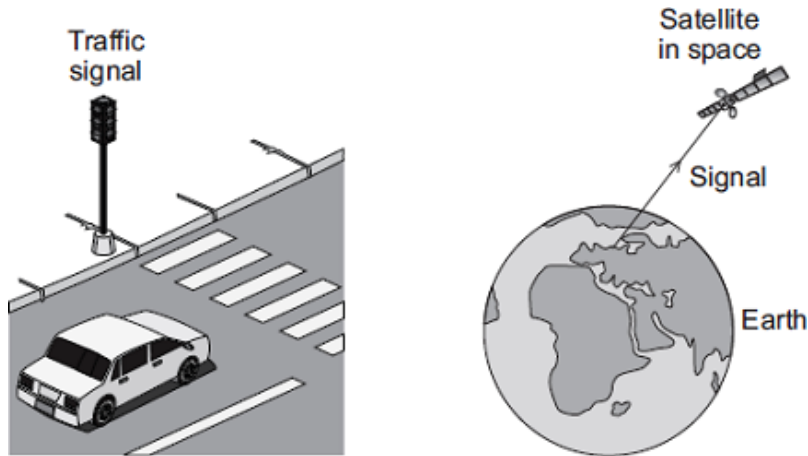
(Total 7 marks)

**Q24.** **Diagram 1** shows four of the seven types of wave in the electromagnetic spectrum.

**Diagram 1**

<b>J</b>	<b>K</b>	<b>L</b>	Visible light	Infrared	Microwaves	Radio waves
----------	----------	----------	---------------	----------	------------	-------------

(a) The **four** types of electromagnetic wave named in **Diagram 1** above are used for communication.



(i) Which type of electromagnetic wave is used when a traffic signal communicates with a car driver?

.....

(1)

(ii) Which type of electromagnetic wave is used to communicate with a satellite in space?

.....

(1)

(b) Gamma rays are part of the electromagnetic spectrum.

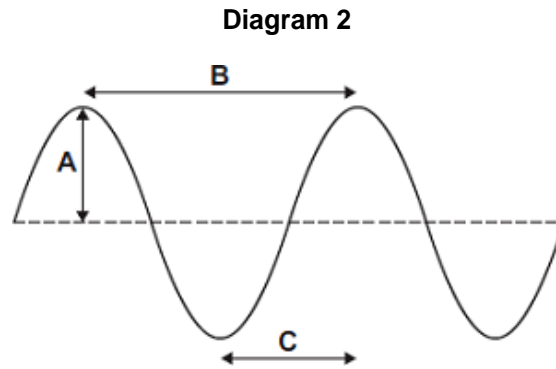
Which letter, **J**, **K** or **L**, shows the position of gamma rays in the electromagnetic spectrum?

Draw a ring around the correct answer.

**J**                      **K**                      **L**

(1)

(c) **Diagram 2** shows an infrared wave.



(i) Which **one** of the arrows, labelled **A**, **B** or **C**, shows the wavelength of the wave?

Write the correct answer, **A**, **B** or **C**, in the box.

(1)

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

The wavelength of infrared waves is

shorter than
the same as
longer than

the wavelength of radio waves.

(1)

(d) Mobile phone networks send signals using microwaves. Some people think the energy a person's head absorbs when using a mobile phone may be harmful to health.

(i) Scientists have compared the health of people who use mobile phones with the health of people who do not use mobile phones.

Which **one** of the following statements gives a reason why scientists have done this?

Tick (✓) **one** box.

To find out if using a mobile phone is harmful to health.

To find out if mobile phones give out radiation.

To find out why some people are healthy.

(1)

- (ii) The table gives the specific absorption rate (SAR) value for two different mobile phones.

The SAR value is a measure of the maximum energy a person's head absorbs when a mobile phone is used.

Mobile Phone	SAR value in W/kg
X	0.28
Y	1.35

A parent buys mobile phone X for her daughter.

Using the information in the table, suggest why buying mobile phone X was the best choice.

.....

.....

.....

.....

(2)  
(Total 8 marks)

- Q25.** (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.

.....

.....

(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.

Use the correct equation from the Physics Equations Sheet.

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

.....  
.....  
.....

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.

.....  
.....

(1)  
(Total 6 marks)

- Q26.** (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
A	1.1 km
B	100 mm
C	0.18 mm

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

.....

(1)

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

Use the equation in the box to calculate the wavelength of the waves broadcast by this station.

$\text{wave speed} = \text{frequency} \times \text{wavelength}$
---

Show clearly how you work out your answer.

.....  
 .....

Wavelength = ..... m

(2)

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

.....  
 .....  
 .....  
 .....

(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?

.....  
 .....

(1)

**(Total 6 marks)**



**Q27.** Galaxies emit all types of electromagnetic wave.

(a) (i) Which type of electromagnetic wave has the shortest wavelength?

.....

(1)

(ii) State **one** difference between an ultraviolet wave and a visible light wave.

.....

.....

(1)

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

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

Frequency = .....

(3)

(c) Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

(i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

.....

.....

(1)

(ii) The size of the red-shift is **not** the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

.....

.....

.....

.....

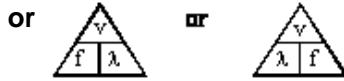
(2)

(iii) What does the observation of red-shift suggest is happening to the Universe?

.....  
.....

(1)  
**(Total 9 marks)**

- M1.** (i) (wave) speed = frequency  $\times$  wavelength  
*or any correctly transposed version*  
*accept  $v = f \times \lambda$*   
*or transposed version*  
*accept  $m/s = 1 / s \times m$*   
*or transposed version*



*but only if subsequently used correctly*

1

- (i) 325

1

metres per second

*or m / s or 0.325 km/s for 2 marks*

1

[3]

- M2.** (i) absorbed by water / water heated

1

hot water heats (rest of) food / idea of particle vibration

1

- (ii) 300 000 000 /  $3 \times 10^8$

*correct answer with no working = 2*

*allow 1 mark for  $s = f \times w$  or correct working i.e., 10000 (000000)  $\times$  0.03*

*N.B. correct answer from incorrectly recalled relationship / substitution = 0*

2

[4]

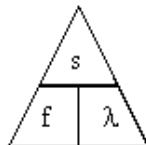
- M3.** (i) speed = frequency  $\times$  wavelength

*accept the equation rearranged*

*accept  $v$  or  $s = f \times \lambda$*

*do not allow  $w$  for wavelength*

*do not accept*



*unless subsequent calculation correct*

1

(ii) 330 (m)

*allow 1 mark for*

$$\lambda = \frac{300\,000\,000}{909\,000}$$

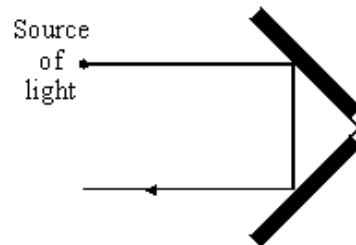
*or*  $300\,000\,000 = 909\,000 \times \lambda$

*or* answer of 330000(m) *or* 330033(m)

2

[3]

- M4.** (a) first reflection vertically down to the fourth hatch line or just to the left of it reaching mirror (must come from incident ray given)



1

second reflection back parallel to incident ray must be linked to first part of ray

1

appropriate arrow on a part of the ray (may be given if lines wrong)

*(must come from source of light)*

*maximum of one mark to be lost for poor diagrams not using a ruler for straight lines*

*first time you come across wavy line, it is penalised*

1

- (b) ray in block bent downwards, not beyond the normal

*do not credit if exactly on normal*

1

emergent ray parallel to incident ray

*do not credit a continuation of the line straight through the block*  
*these are independent*

1

[5]

- M5.** (a) one mark for each ray correctly drawn straight to glass then bent towards pupil  
*accept both rays hitting any part of eye*  
*judge straightness by eye*  
*accept dotted **or** dashed lines*  
*ignore any arrows*  
*N.B. the rays must reach the eye* 2
- (b) speed 1
- refraction 1
- transverse 1
- [5]

- M6.** (a) (i) Microphone 1
- (ii) Loudspeaker 1
- (b) (i) By **radio** waves
- (ii) By electrical vibrations or a.c.
- (iii) By **light** waves  
*for 1 mark each* 3
- (c) Quieter (not softer/lower) 1
- [6]

- M7.** (a) (i) L 1
- (ii) N 1
- (c) the answer should be in the form:  
**not** inside the eye
- either** for **both** marks an arrangement which could demonstrate visibly light travels in straight lines  
*full credit should be given for answer presented as a diagram*
- and**  
 an explanation of how it shows the straightness

or for one mark

named device which uses principle of light travelling in straight lines to work

*examples*

*light (from a street lamp) strikes an object producing a shadow*

*laser light travelling through (fine) dust shows a straight beam*

*three pieces of card with central holes need to be lined up to be able to see through the third hole from the first*

*ray box type experiment using mirrors/prisms, etc*

*beams on paper or in smoke*

*torch beams through smoke*

*example devices:-*

*-pinhole camera (qualification may get second mark)*

*-periscope*

*-optical fibre*

*-reflection 'in a **mirror***

2

[4]

- M8.** (a) reflection at the mirror of ray from tip of real puppy's ear to real puppy's eye (1)  
*may be drawn freehand*

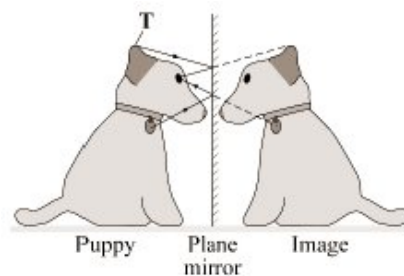
accurate (1)

*ruler must have been used and the reflected ray is an extension of the straight line from point virtual ear however the virtual part of the line need not be shown*

arrow to show correct direction (1)

*only one arrow needs to be shown but there must be no contradiction*

*example of (3) mark response*



3

- (b) flat

*accept 'it's not curved/bent'*

*accept 'it's straight'*

1

[4]

- M9.** (a) (i) microwave 1
- (b) (i) identical 1
- (ii) • increased risk of cancerous growth (between ear and brain) 1
- complaints of headaches and tiredness 1
- (iii) any **two** from:
- tests in a laboratory did not give effects of tiredness or headaches
  - waves not strong enough to cause long term heat damage to cells
  - evidence to link mobile phones and ill health is not reliable 2
- [6]**

- M10.** X-rays      { infrared }      { radio }
- { radiation }      { waves }
- for 1 mark each*
- [3]**

- M12.**
- idea that (in words or on diagram)
  - sound reflects / bounces off cliff
  - returns the way it came / produces an echo
- each for 1 mark*
- [2]**

- M13.** (a) (i)
- correct order essential*
- (A =) a microphone 1
- (B =) an oscilloscope
- or cathode ray oscilloscope or CRO*
- 1

- (ii) the amplitude  
*accept any unambiguous indication* 1
- (iii) quieter / softer  
*do **not** accept less (which could refer to the amplitude, frequency or wavelength)* 1
- (b) sound cannot travel through a vacuum / (empty) space / free space  
*accept there is no medium for the sound to travel through* 1
- (because) there is / are nothing / no particles to vibrate  
*accept (because) there is / are nothing / no particles between them and the source (of the sound)* 1

[6]

##

- (i) X-rays  
infra red (rays)  
radio (waves)  
*all three in correct order  
allow 1 mark for 1 correct* 2
- (ii) to kill cancer cells 1
- (iii) energy 1

[4]

- M15.** (a) letter C clearly marking a compression  
*accept C at any point in a compression  
if more than one letter C marked  
all must be correct* 1
- (b) (i) straight continuous line drawn from loudspeaker to metal to sound sensor  
*judge by eye* 1
- angle I = angle R  
*judge by eye  
ignore any arrows on lines* 1



(ii) less sound reflected  
*accept energy for sound*

**or**

(some) sound passes through the glass  
*accept (some) sound absorbed by the glass*

1

(iii) makes the sound louder

1

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

340

*allow 1 mark for correct substitution  
ie  $850 \times 0.4$   
provided no subsequent step shown*

2

(c) echo

1

(d) (i) from 250 Hz to 750 Hz

1

(ii) curtains reduce (percentage of) sound reflected more (than carpet)  
*accept curtains absorb more sound (than carpet)*

1

for all frequencies (shown)

*accept for both marks an answer in terms of walls having a larger  
(surface) area to reflect sound and curtains reducing the amount of  
reflected sound more (than carpet)*

*answers less noisy or walls / curtains have a larger area gain 1  
mark only*

*do **not** accept curtains are cheaper*

1

[11]

**M16.** (a) (i) a horizontal distance indicated and labelled  
*gains 1 mark*

**but**

horizontal distance indicated between identical points on  
adjacent waves (to within 3-4mm) and labelled

*gains 2 marks*

2

(ii) peak ↔ trough indicated\*

*gains 1 mark*

**but**

peak / trough ↔ mean indicated\*

(\* to within 1-2mm either end)

*gains 2 marks*

*(allow 1 mark if both lines unlabelled or 2 marks if both lines accurately drawn and unlabelled)*

2

(b) • 1.5

• hertz / Hz **or** (waves / cycles) per second

*for 1 mark each*

*(do not allow wavelength / hertz per second)*

2

[6]

**M17.** (a) (i) oscillation

1

direction

1

*correct order only*

(ii) sound

1

(b) 1.6

*allow 1 mark for correct*

*substitution into correct equation ie  $2 \times 0.8$*

2

(c) as the wavelength increases so does the wave speed

1

extra information eg wave speed increases faster between 0-40 m than between 100-140 m

**or**

not in proportion

1

[7]

<b>M18.</b>	(a)	<b>b</b>	1	
		<b>c</b>	1	
		<i>correct order only</i>		
	(b)	mirror opposite road junction	1	
		mirror facing correct way, angle correct <i>judged by eye</i>	1	
				<b>[4]</b>

<b>M19.</b>	(a)	(i)	bat(s)	1	
		(ii)	elephant(s)	1	
		(iii)	any example in the inclusive range 5 ↔ 29 Hz / hertz <i>appropriate number and unit both required</i>	1	
	(b)	(i)	<b>B</b>	1	
		(ii)	<b>F</b>	1	
					<b>[5]</b>

**M20.**

(a) any **two** from:

- travel at the same speed (through a vacuum)  
*if a value is given it must be correct*  
*accept air for vacuum*  
*accept travel at the speed of light*
- 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
- transverse
- travel in straight lines  
*accept any other property common to electromagnetic waves*  
*accept travel at the same speed through a vacuum for **both** marks*  
*both radiated from the Sun is insufficient*

2

(b) 0.19 (0)

*accept any answer that rounds to 0.19*  
*accept 0.2 for all **3** marks provided working is shown*  
*0.2 without working gains **2** marks*  
*allow **2** marks for a correct substitution and transformation using*  
*frequency in hertz*

$$\text{ie wavelength} = \frac{300\,000\,000}{1575\,000\,000}$$

**or**

*allow **1** mark for changing MHz to Hz*  
*allow **1** mark for correct substitution using 1575 or incorrectly*  
*converted frequency*  
*answers 190476 and 190000 gain **2** marks*

3

(c) create an alternating current with the same frequency  
(as the microwaves / signals / 1575 (MHz))

*ignore reference to change in temperature*

1

[6]

**M21.**

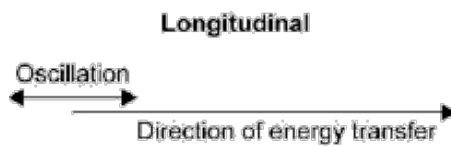
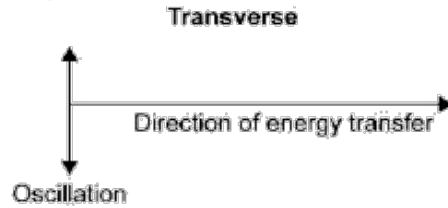
(a) (i) the oscillation / vibration (causing the wave)  
*a movement causes the wave is insufficient*

1

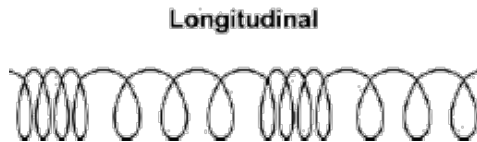
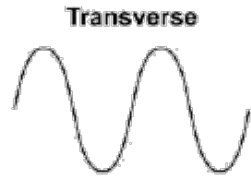
for a transverse wave is perpendicular to the direction of energy transfer  
*answers given in terms of direction of wave travel and not energy transfer for both types of wave, score 1 mark for these two mark points*

1

and for a longitudinal wave is parallel to the direction of energy transfer  
*the marks may be scored by the drawing of two correctly labelled diagrams ie*



*two labelled diagrams showing the general form of a transverse and longitudinal wave gain 1 mark if no other mark has been awarded eg*



1

(ii) mechanical wave

*accept specific examples, eg waves on a spring / slinky / seismic / earthquake waves*

*accept water waves*

*do **not** accept shock waves*

1

(b) semicircular waves drawn

*judged by eye*

*do not need to be full semicircles*

*ignore any rays*

1

(c) sound (waves) will diffract (towards the person)

1

**or**

light (waves) do not diffract (towards the person)

(because) width of door way similar to / less than wavelength of sound (waves)

**or**

(because) width of doorway much greater than wavelength of light (waves)

*a general statement that waves (only) diffract when the width of a gap is similar to the wavelength of the waves can be awarded 1 mark*

1

[7]

**M22.** (a) (i) bat(s)

1

(ii) any example in the inclusive range  $5 \leftrightarrow 29$  Hz / hertz  
*appropriate number and unit both required*

1

(b) (i) A, C, D

*all three required and no other*

1

(ii) D, E

*both required and no other*

1

(c) sound cannot travel through a vacuum / (empty) space / free space  
*accept there is no medium (for the sound to travel through)*  
*do **not** accept there is no air (for the sound to travel through)*

1

(because) there is / are nothing / no particles to vibrate

*accept because there is / are nothing / no particles between them and the source (of the sound)*

1

[6]

**M23.** (a) (i) wavelength  
*accept frequency*  
*accept speed*

1

(ii) amplitude

*accept energy*  
*height is insufficient*

1

(iii) sound

1

	(b)	(i)	diffraction <i>accept diffract</i> <i>a description is insufficient</i>	1	
		(ii)	0.12 <i>allow 1 mark for correct substitution, ie <math>8 \times 0.015</math> provided no subsequent step shown</i>	2	
			metre per second <b>or</b> m/s <b>or</b> metre/second <i>do <b>not</b> accept mps</i> <i>units must be consistent with numerical answers</i>	1	[7]
<b>M24.</b>	(a)	(i)	(visible) light <i>accept visible</i>	1	
		(ii)	microwaves	1	
	(b)		J	1	
	(c)	(i)	B	1	
		(ii)	shorter than	1	
	(d)	(i)	To find out if using a mobile phone is harmful to health	1	
		(ii)	any <b>two</b> from: <ul style="list-style-type: none"> <li>• (X has a) low(er) SAR value <i>"it" refers to mobile phone</i> <i>accept has a low(er) rate</i></li> <li>• (maximum) energy absorbed (by the head) is less <i>accept energy emitted (by phone) is less</i> <i>accept radiation for energy</i></li> <li>• (if mobiles are harmful) less likely to cause harm <i>accept will not cause harm</i> <i>accept it is safer</i></li> </ul>	2	[8]
<b>M25.</b>	(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]

**M26.** (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]

- M27.** (a) (i) gamma  
*accept correct symbol*

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency  
*ultraviolet cannot be seen is insufficient*
- (ultraviolet has a) greater energy
- (ultraviolet has a) shorter wavelength  
*ignore ultraviolet causes cancer etc*

1

- (b)  $1.2 \times 10^7 / 12\,000\,000$   
*allow 1 mark for correct substitution, ie  $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

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

*answers 12 000 kHz **or** 12 MHz gain 3 marks*

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

1

- (c) (i) away (from each other)  
*accept away (from the Earth)*  
*accept receding*

1

(ii) distance (from the Earth)  
*accept how far away (it is)*

1

speed galaxy is moving

1

(iii) (Universe is) expanding

1

[9]

