1 The figure below shows an incomplete electromagnetic spectrum.

A	**microwaves**	**B**		**C**	**ultraviolet**	**D**	**gamma**

(a) What name is given to the group of waves at the position labelled **A** in the figure above?

Tick **one** box.

infrared ☐

radio ☐

visible light ☐

X-ray ☐

(1)

(b) Electromagnetic waves have many practical uses.

Draw **one** line from each type of electromagnetic wave to its use.

Electromagnetic wave	Use
Gamma rays	For fibre optic communications
Microwaves	For communicating with a satellite
Ultraviolet	To see security markings
	To sterilise surgical instruments

(3)

(c) Complete the sentence.

Use an answer from the box.

black body	**ionising**	**nuclear**

X-rays can be dangerous to people because X-rays are

_____ radiation.

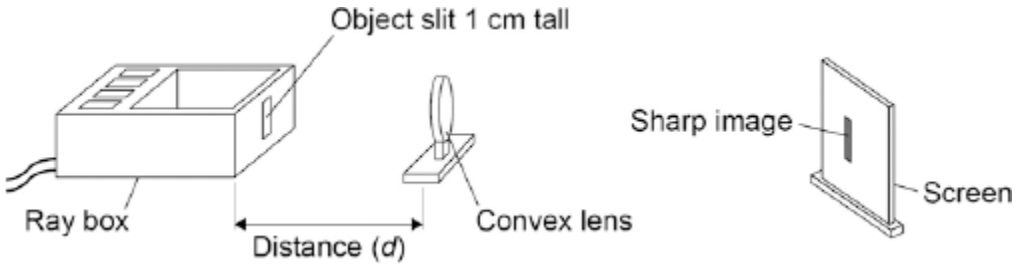
(1)

(Total 5 marks)

2 A student investigated how the magnification produced by a convex lens varies with the distance (*d*) between the object and the lens.

The student used the apparatus shown in **Figure 1**.

Figure 1



(a) The student measured the magnification produced by the lens by measuring the image height in centimetres.

Explain why the image height in centimetres was the same as the magnification.

_____

_____

_____

_____

(2)

(b) The data recorded by the student is given in **Table 1**.

Table 1

Distance between the object and the lens in cm	**Magnification**
25	4.0
30	2.0
40	1.0
50	0.7
60	0.5

It would be difficult to obtain accurate magnification values for distances greater than 60 cm.

Suggest **one** change that could be made so that accurate magnification values could be obtained for distances greater than 60 cm.

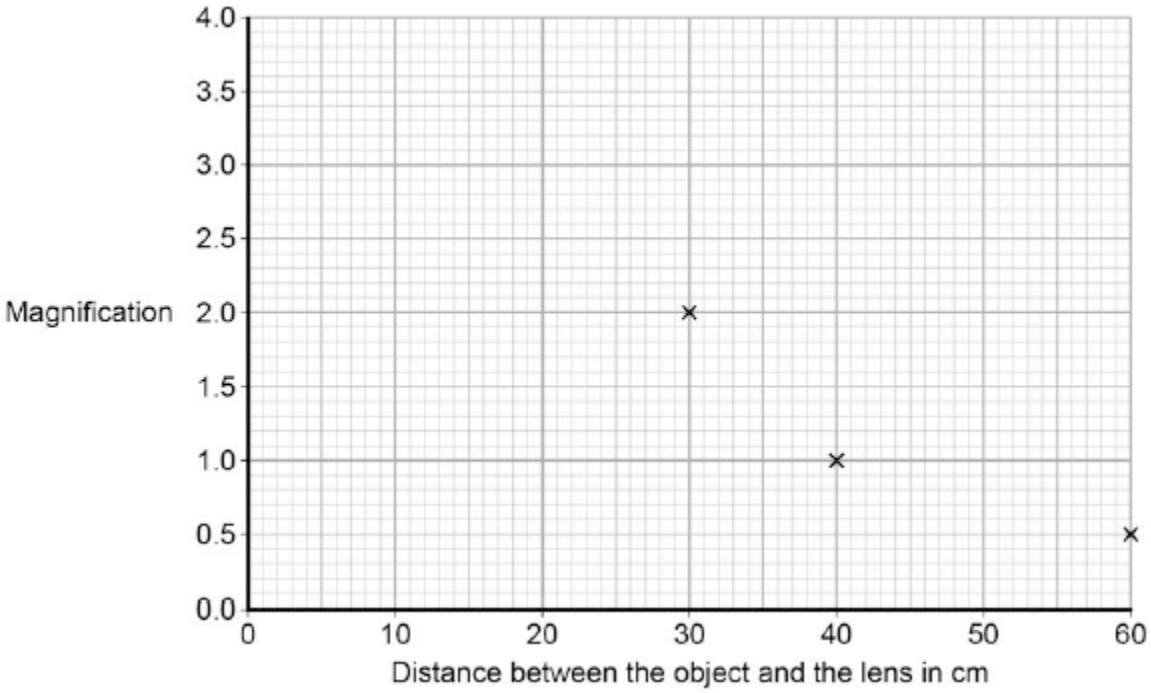
_____

_____

(1)

(c) The graph in **Figure 2** is incomplete.

Figure 2



Complete the graph in **Figure 2** by plotting the missing data and then drawing a line of best fit.

(2)

(d) How many times bigger is the image when the object is 35 cm from the lens compared to when the object is 55 cm from the lens?

_____

_____

_____

(2)

(e) During the investigation the student also measured the distance between the lens and the image.

Table 2 gives both of the distances measured and the magnification.

Table 2

Distance between the lens and the image in cm	Distance between the lens and the object in cm	Magnification
100	25	4.0
60	30	2.0
40	40	1.0
33	50	0.7
30	60	0.5

Consider the data in **Table 2**.

Give a second way that the student could have determined the magnification of the object.

Justify your answer with a calculation.

_____

_____

_____

_____

_____

(2)

(Total 9 marks)

3 The data given in the table below was obtained from an investigation into the refraction of light at an air to glass boundary.

Angle of incidence	Angle of refraction
20°	13°
30°	19°
40°	25°
50°	30°

Describe an investigation a student could complete in order to obtain similar data to that given in the table above.

Your answer should consider any cause of inaccuracy in the data.

A labelled diagram may be drawn as part of your answer.

(Total 6 marks)

4 The data given in the table below was obtained from an investigation into the refraction of light at an air to glass boundary.

Angle of incidence	Angle of refraction
20°	13°
30°	19°
40°	25°
50°	30°

(a) Describe an investigation a student could complete in order to obtain similar data to that given in the table above.

Your answer should consider any cause of inaccuracy in the data.

A labelled diagram may be drawn as part of your answer.

(6)

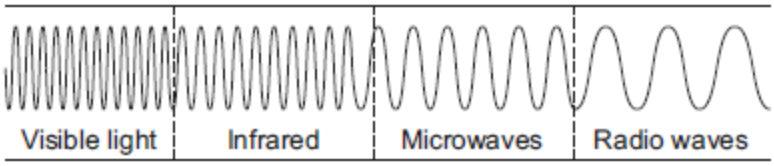
(b) State the reason why light is refracted as it crosses from air into glass.

(1)

(Total 7 marks)

5 Infrared and microwaves are two types of electromagnetic radiation.

The diagram below shows the positions of the two types of radiation within part of the electromagnetic spectrum.



(a) Name **one** type of electromagnetic radiation which has more energy than infrared.

_____

(1)

(b) Use the correct answer from the box to complete each sentence.

Each answer may be used once, more than once or not at all.

greater than	**less than**	**the same as**

The wavelength of infrared is _____ the wavelength of microwaves.

The frequency of microwaves is _____ the frequency of infrared.

The speed of microwaves in a vacuum is _____ the speed of infrared in a vacuum.

(3)

(Total 4 marks)

6 Infrared and microwaves are two types of electromagnetic radiation.

(a) State **one** example of the use of each type of radiation for communication.

Infrared: _____

Microwaves: _____

(2)

(b) Some of the properties of infrared and microwaves are the same.

State **two** of these properties.

1. _____

_____

2. _____

_____

(2)

(Total 4 marks)

7 **Figure 1** shows an X-ray of an arm with a broken bone.

Figure 1

© emmy-images/iStock

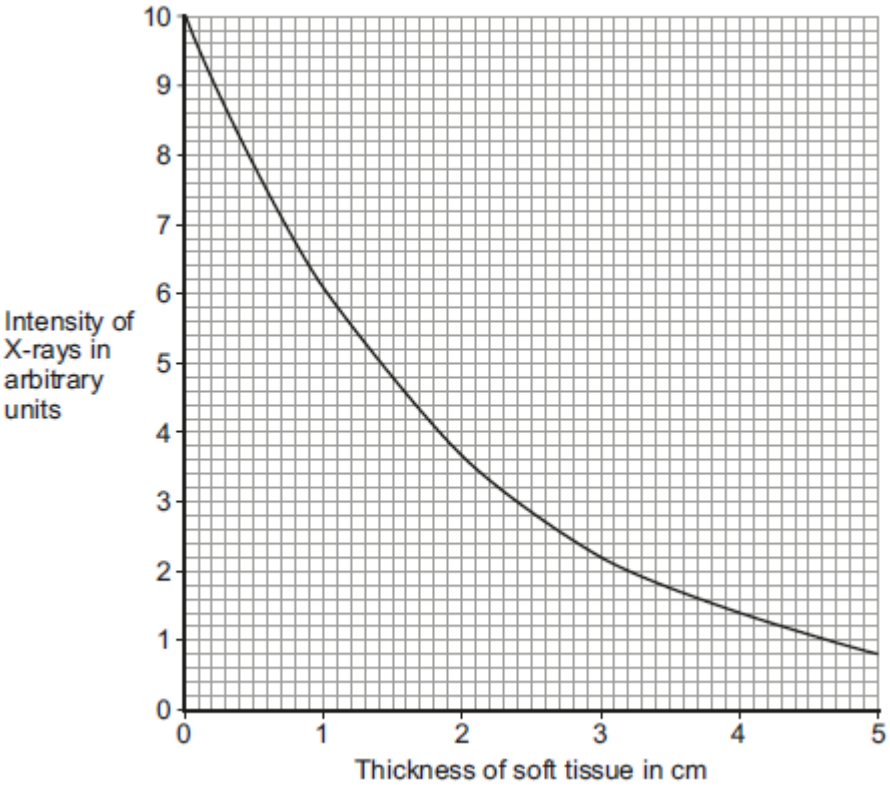
(a) Complete the following sentence.

X-rays are part of the _____ spectrum.

(1)

(b) **Figure 2** shows how the intensity of the X-rays changes as they pass through soft tissue and reach a detector.

Figure 2



(i) Use **Figure 2** to determine the intensity of X-rays reaching the detector for a 3 cm thickness of soft tissue.

Intensity of X-rays = _____ arbitrary units

(1)

(ii) Describe how the thickness of soft tissue affects the intensity of the X-rays.

_____

_____

_____

_____

(2)

(iii) The data in **Figure 2** are shown as a line graph and not as a bar chart.

Choose the reason why.

Tick (✓) **one** box.

Both variables are categoric ☐

Both variables are continuous ☐

One variable is continuous and one is categoric ☐

(1)

(c) What happens to X-rays when they enter a bone?

_____

_____

(1)

(d) How are images formed electronically in a modern X-ray machine?

Tick (✓) **one** box.

With a charge-coupled device (CCD) ☐

With an oscilloscope ☐

With photographic film ☐

(1)

(e) Radiographers who take X-ray photographs may be exposed to X-rays.

(i) X-rays can increase the risk of the radiographer getting cancer.

Why can X-rays increase the risk of getting cancer?

Tick (✓) **one** box.

X-rays travel at the speed of light ☐

X-rays can travel through a vacuum ☐

X-rays are ionising ☐

(1)

(ii) What should the radiographer do to reduce the risk from X-rays?

_____

_____

(1)

(Total 9 marks)

8 X-rays and ultrasound can both be used for scanning internal organs.

(a) Ultrasound is used to scan unborn babies but X-rays are **not** used to scan unborn babies.

Explain why.

_____

_____

_____

_____

_____

_____

(3)

(b) The behaviour of ultrasound waves when they meet a boundary between two different materials is used to produce an image.

Describe how.

_____

_____

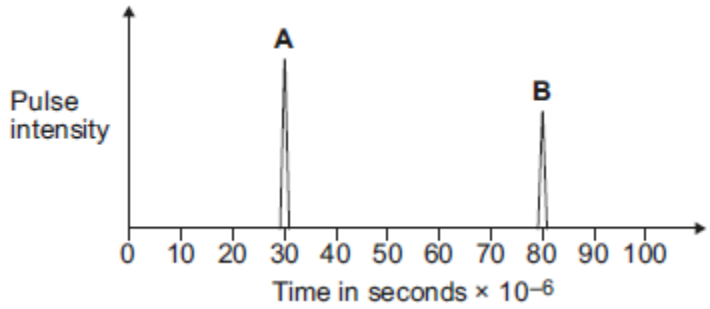
_____

_____

(2)

(c) **Figure 1** shows two pulses from a scan of an unborn baby. The emitted pulse is labelled **A**. The returning pulse picked up by the receiver is labelled **B**.

Figure 1



The closest distance between the unborn baby and the mother's skin is 4.0 cm.
Use information from **Figure 1** to calculate the average speed of the pulse.

_____

_____

_____

_____

_____

_____

Average speed = _____ m/s

(3)

(d) **Figure 2** shows an X-ray of an arm with a broken bone.

Figure 2

© emmy-images/iStock

(i) Describe how X-rays are able to produce an image of bones.

_____

_____

_____

_____

_____

_____

(3)

(ii) Complete the following sentence.

X-rays are able to produce detailed images because their wavelength

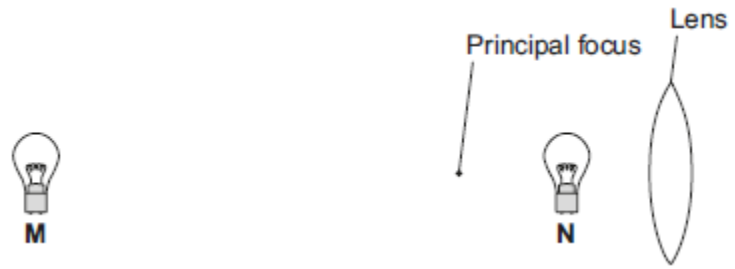
is very _____ .

(1)

(Total 12 marks)

9 (a) A light bulb is placed between a convex lens and the principle focus of this lens, at position **N** shown in **Figure 1**. The light bulb is then moved to position **M**, a large distance from the lens.

Figure 1



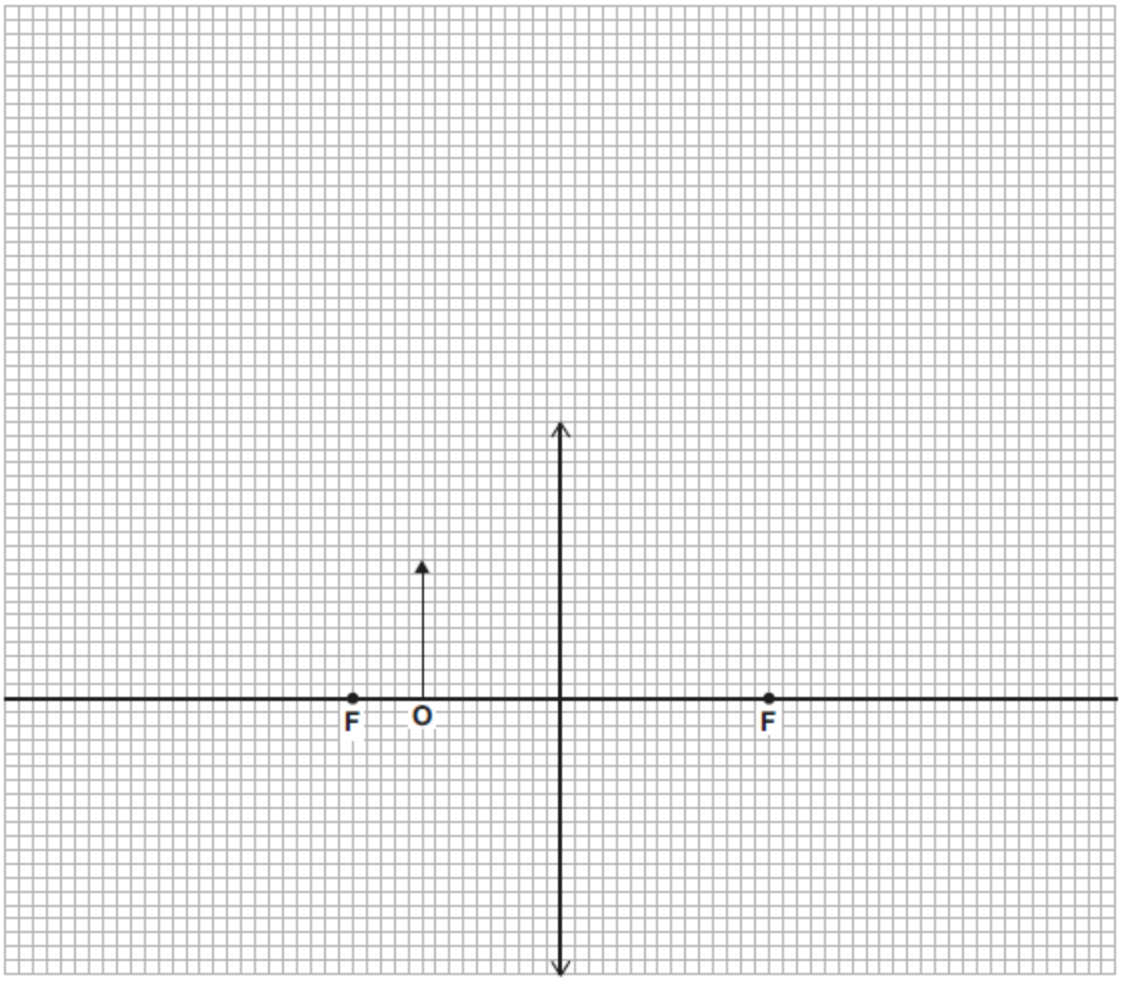
Describe how the nature of the image formed changes as the light bulb is moved from position **N** to position **M**.

(3)

(b) An object, **O**, is very near to a convex lens, as shown in **Figure 2**.

Complete **Figure 2** to show how rays of light from the object form an image.

Figure 2

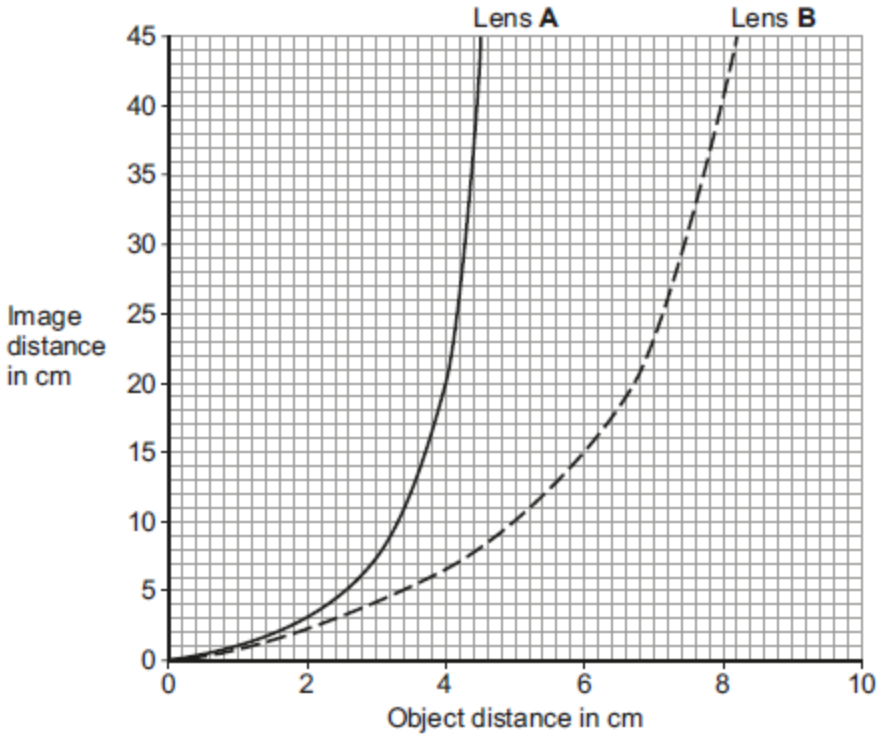


(3)

(c) The object distance is the distance from an object to the lens. The image distance is the distance from the lens to the image.

Figure 3 shows how the image distance changes with the object distance, for two identically shaped convex lenses, **A** and **B**. Each lens is made from a different type of glass.

Figure 3



(i) When the object distance is 4 cm, the image distance for lens **A** is longer than for lens **B**.

State why.

_____

_____

(1)

(ii) When the object is moved between lens **B** and the principal focus, the image size changes. The table shows the magnification produced by lens **B** for different object distances.

Object distance in cm	Magnification
0.0	1
5.0	2
6.7	3
7.5	4
8.0	5

Using information from **Figure 3** and the table, describe the relationship between the **image** distance and the magnification produced by lens **B**.

_____

_____

_____

(2)

(iii) A third convex lens, lens **C**, is made from the same type of glass as lens **B**, but has a shorter focal length than lens **B**.

Lens **B** is shown in **Figure 4**.

Complete **Figure 4** to show how lens **C** is different from lens **B**.

Figure 4

Lens **B**

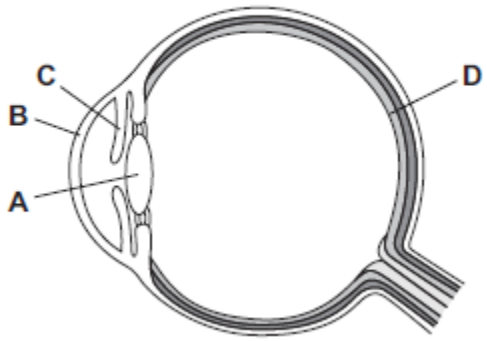
Lens **C**

(1)

(Total 10 marks)

10 (a) **Figure 1** shows a section through a human eye.

Figure 1



Write the correct letter, **A**, **B**, **C** or **D**, in each empty box to identify the parts of the eye labelled in **Figure 1**.

Part of the eye	**A, B, C or D**
Cornea	
Lens	
Retina	

(3)

(b) The table shows how the mass of 1 cm^3 of different materials varies with refractive index.

Material	**Refractive index**	**Mass in g**
Water	1.33	1.00
Glass **X**	1.52	2.54
Glass **Y**	1.70	2.93
Glass **Z**	1.81	3.37

(i) Describe the pattern shown in above table.

_____

_____

(1)

(ii) Lenses used for correcting visual defects often have a low refractive index.

State **one** advantage and **one** disadvantage of using lenses with a high refractive index for correcting visual defects.

Advantage _____

Disadvantage _____

(2)

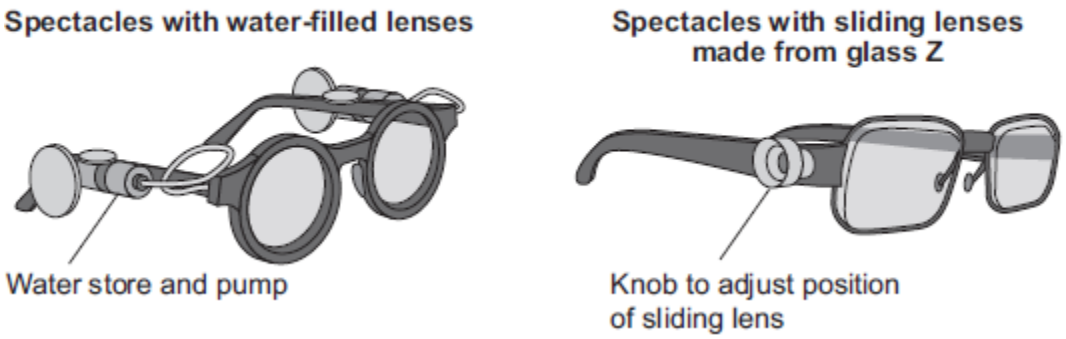
(iii) The eyesight of a person can change throughout their lifetime. Scientists have designed cheap spectacles that allow the wearer to change the focal length of the lenses as their eyesight changes.

Two designs are:

- using water-filled lenses where water is pumped in or out of the lens to change its shape
- using a pair of specially shaped lenses for each eye that are able to slide across each other.

Figure 2 shows these two designs.

Figure 2



Suggest **one** advantage and **one** disadvantage of each design.

_____

_____

_____

_____

_____

_____

_____

_____

_____

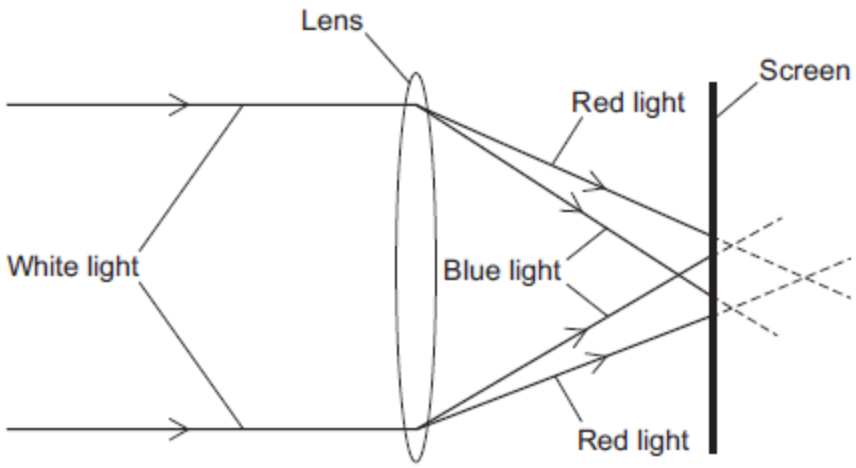
_____

(4)

(c) **Figure 3** shows parallel rays of white light from a distant point being refracted towards a screen by a lens.

The lens is made from a glass with a much greater refractive index than glass normally used for correcting visual defects.

Figure 3



What would you notice about the image on the screen?

State **two** observations.

1. _____

_____

2. _____

_____

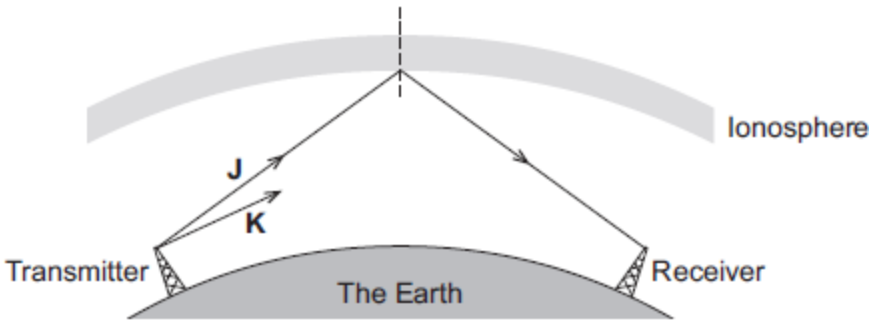
(2)

(Total 12 marks)

11 Different parts of the electromagnetic spectrum are useful for different methods of communication.

(a) **Figure 1** shows a transmitter emitting two electromagnetic waves, **J** and **K**.

Figure 1



Wave **J** is reflected by a layer in the atmosphere called the ionosphere.

(i) Wave **K** will also be reflected by the ionosphere.
On **Figure 1**, draw the path of wave **K** to show that it **does not** reach the receiver.

(2)

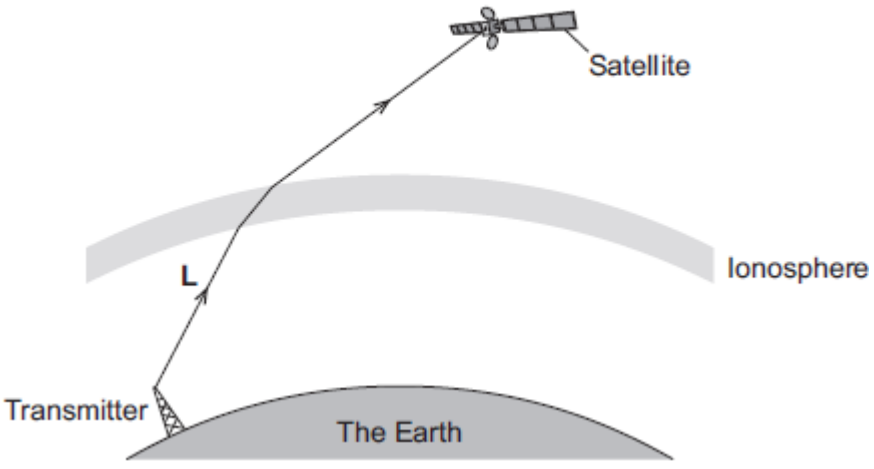
(ii) What is the name given to the dashed line in **Figure 1**?

_____

(1)

(b) **Figure 2** shows a transmitter sending a signal to a satellite orbiting the Earth.

Figure 2



(i) Which type of electromagnetic wave is used to send a signal to a satellite?

Draw a ring around the correct answer.

gamma **microwave** **ultraviolet**

(1)

(ii) What name is given to the process that occurs as wave **L** passes into the ionosphere?

Draw a ring around the correct answer.

diffraction **reflection** **refraction**

(1)

(c) Waves **J**, **K** and **L** are electromagnetic waves.

What are **two** properties of **all** electromagnetic waves?

Tick (✓) **two** boxes.

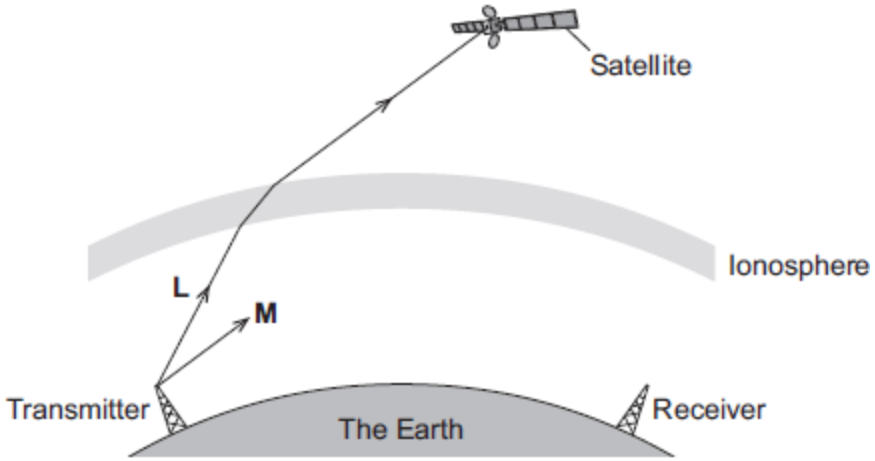
Property	**Tick (✓)**
All electromagnetic waves are longitudinal.	
All electromagnetic waves are transverse.	
All electromagnetic waves are mechanical.	
All electromagnetic waves have the same speed in a vacuum.	
All electromagnetic waves have the same frequency.	

(2)

(Total 7 marks)

12 Different parts of the electromagnetic spectrum are useful for different methods of communication.

The diagram shows a transmitter emitting two electromagnetic waves, **L** and **M**.



(a) (i) Wave **L** is used to send a signal to a satellite.
Which part of the electromagnetic spectrum does wave **L** belong to?

_____

(1)

(ii) What name is given to the process that occurs as wave **L** passes into the ionosphere?

_____

(1)

(b) Wave **M** is **reflected** by the ionosphere.

(i) On the diagram above, draw the path of wave **M** until it reaches the receiver.

(2)

(ii) On the daigram above, draw a line to show the normal where wave **M** meets the ionosphere. Label the line **N**.

(1)

(c) Give **two** properties of all electromagnetic waves.

1. _____

_____

2. _____

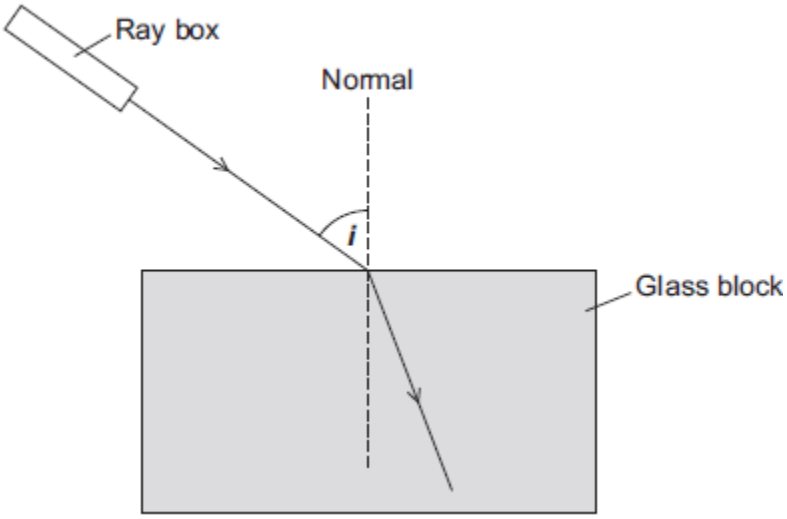
_____

(2)

(Total 7 marks)

13 (a) **Figure 1** shows a ray of light entering a glass block.

Figure 1



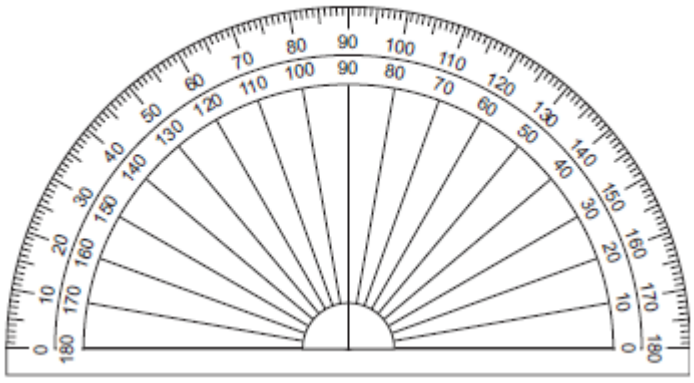
(i) The angle of incidence in **Figure 1** is labelled with the letter ***i***.

On **Figure 1**, use the letter ***r*** to label the angle of refraction.

(1)

(ii) **Figure 2** shows the protractor used to measure angles ***i*** and ***r***.

Figure 2



What is the resolution of the protractor?

Tick (✓) **one** box.

1 degree ☐ 5 degrees ☐ 10 degrees ☐

(1)

(iii) The table shows calculated values for angle ***i*** and angle ***r*** from an investigation.

Calculated values
sin ***i*** = 0.80
sin ***r*** = 0.50

Use the values from the table to calculate the refractive index of the glass.

_____

_____

_____

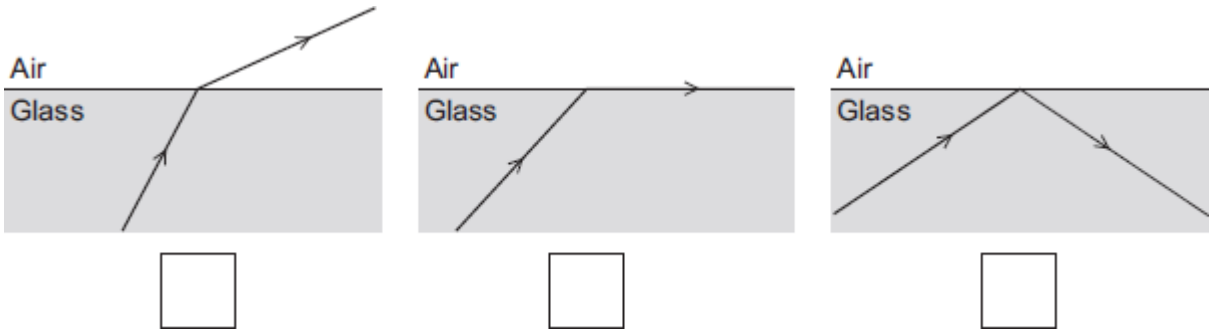
Refractive index = _____

(2)

(b) The diagrams below show a ray of light moving through glass.

Which diagram correctly shows what happens when the ray of light strikes the surface of the glass at the critical angle?

Tick (✓) **one** box.

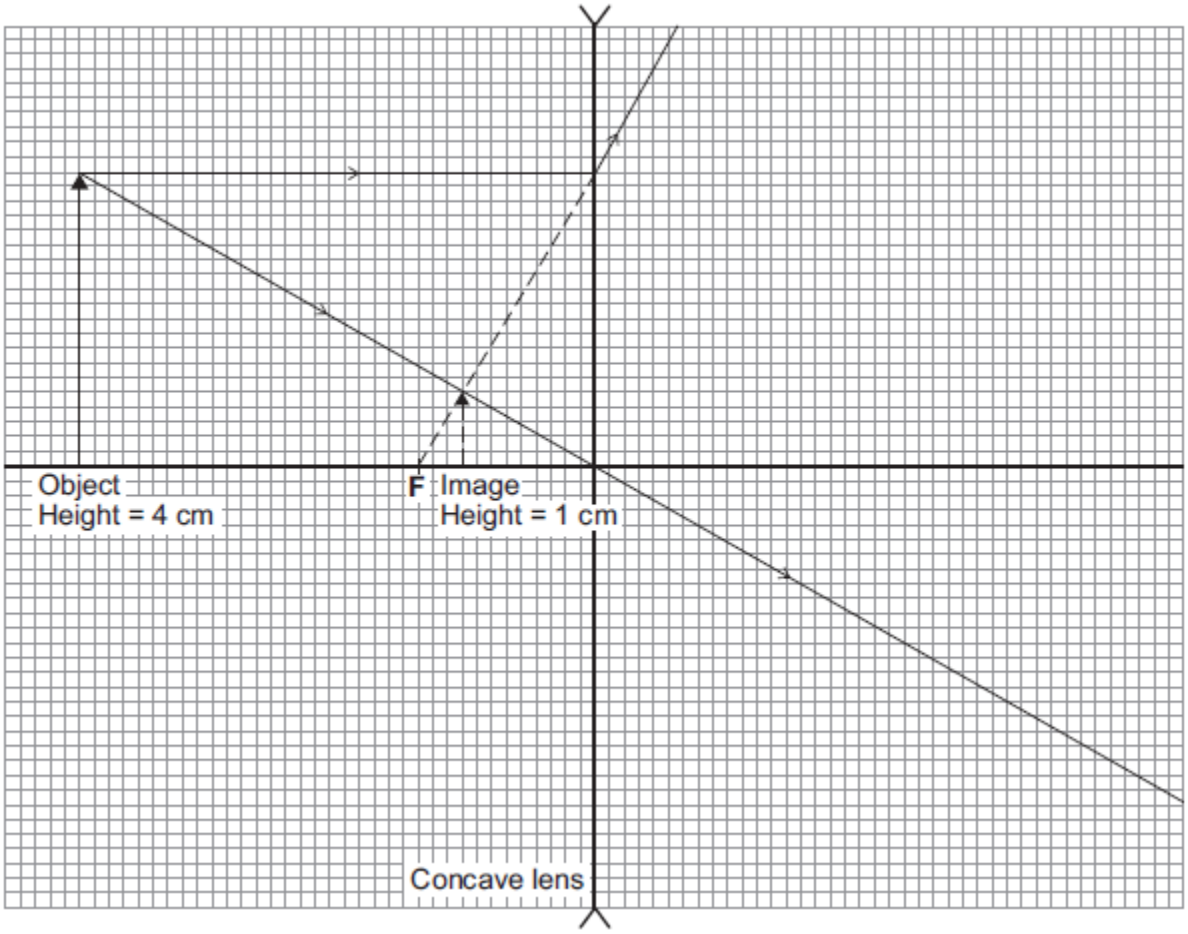


(1)

(c) A concave (diverging) lens is fitted into a door to make a security spyhole.

Figure 3 shows how this lens produces an image.

Figure 3



(i) State **one** word to describe the nature of the image in **Figure 3**.

_____

(1)

(ii) Use data from **Figure 3** to calculate the magnification of the image.

_____

_____

_____

Magnification = _____

(2)

(iii) What is another use for a concave lens?

Tick (✓) **one** box.

A magnifying glass ☐

Correcting short sight ☐

To focus an image in a camera ☐

(1)

(Total 9 marks)

14 (a) Complete the following sentences.

Ultrasound waves have a minimum frequency

of _____ hertz.

The wavelength of an X-ray is about the same as

the diameter of _____ .

(2)

(b) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The images show one medical use of ultrasound and one medical use of X-rays.

©monkeybusinessimages/iStock/Thinkstock

© targovecom/iStock/Thinkstock

Compare the medical uses of ultrasound and X-rays.

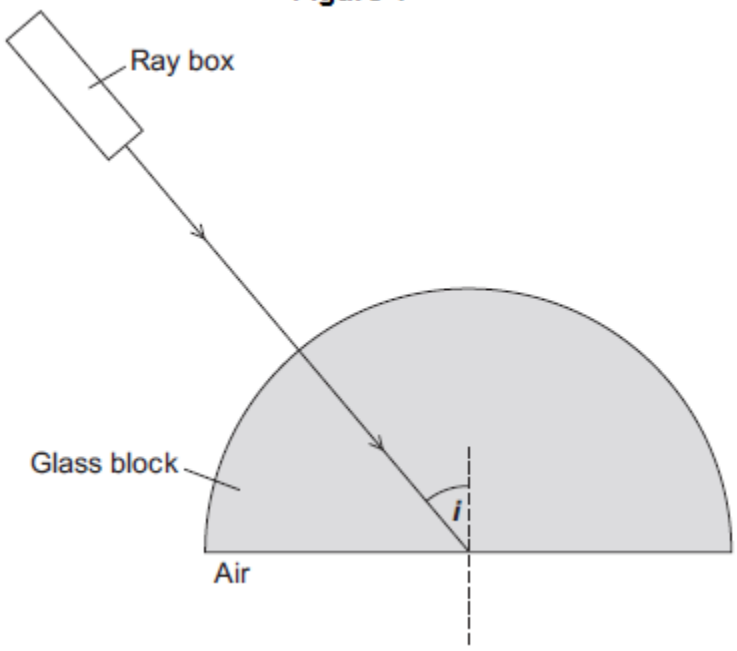
Your answer should include the risks, if any, and precautions, if any, associated with the use of ultrasound and X-rays.

(6)

(Total 8 marks)

15 **Figure 1** shows a ray of light travelling through a semicircular glass block.
The angle of incidence is labelled ***i***.

Figure 1



(a) (i) The angle of incidence ***i*** equals the critical angle for the glass.

Complete **Figure 1** to show what happens to the ray of light at the glass-to-air boundary.

(1)

(ii) The critical angle for the glass is 41°.

Calculate the refractive index of the glass.

_____

_____

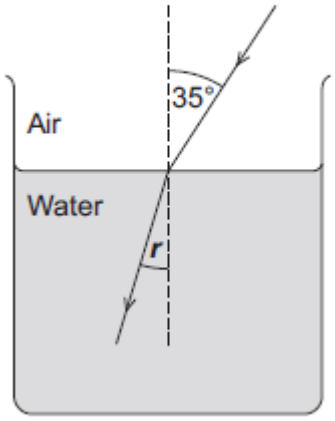
_____

Refractive index = _____

(2)

(b) **Figure 2** shows what happens to a ray of light as it meets the boundary between air and water.

Figure 2



Not to scale

The refractive index of the water is 1.3.

Calculate the angle of refraction ***r***.

_____

_____

_____

_____

_____

Angle of refraction = _____ degrees

(3)

(Total 6 marks)

16 Light changes direction as it passes from one medium to another.

(a) Use the correct answer from the box to complete the sentence.

diffraction	**reflection**	**refraction**

The change of direction when light passes from one medium to another is

called _____ .

(1)

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

When light passes from air into a glass block, it changes

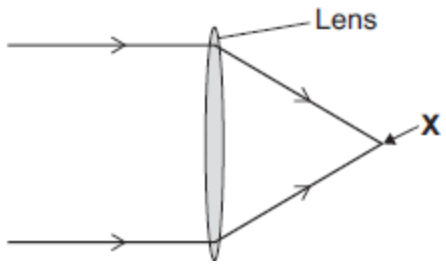
direction

away from the normal.
towards the normal.
to always travel along the normal.

(1)

(c) **Diagram 1** shows light rays entering and passing through a lens.

Diagram 1



(i) Which type of lens is shown in **Diagram 1**?

Draw a ring around the correct answer.

concave **convex** **diverging**

(1)

(ii) In **Diagram 1**, what is the point **X** called?

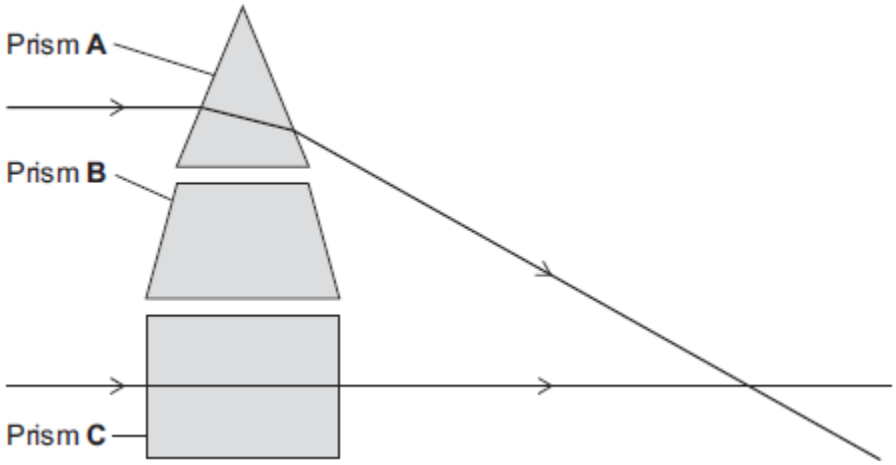
_____

(1)

(d) A lens acts like a number of prisms.

Diagram 2 shows two parallel rays of light entering and passing through prism **A** and prism **C**.

Diagram 2



Draw a third parallel ray entering and passing through prism **B**.

(4)

(e) What **two** factors determine the focal length of a lens?

1. _____

2. _____

(2)

(Total 10 marks)

17 Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

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

amplitude	**frequency**	**speed**	**wavelength**

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 3.0×10^{8} m / s.

Calculate the frequency of the radio wave.

Give the unit.

_____

_____

_____

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.

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

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

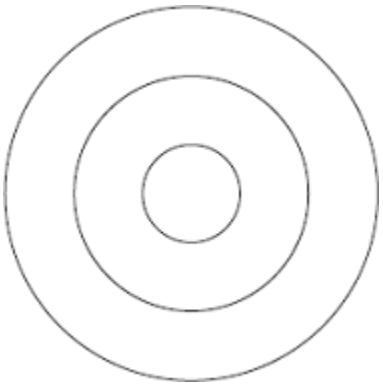
(3)

(Total 13 marks)

18 A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1



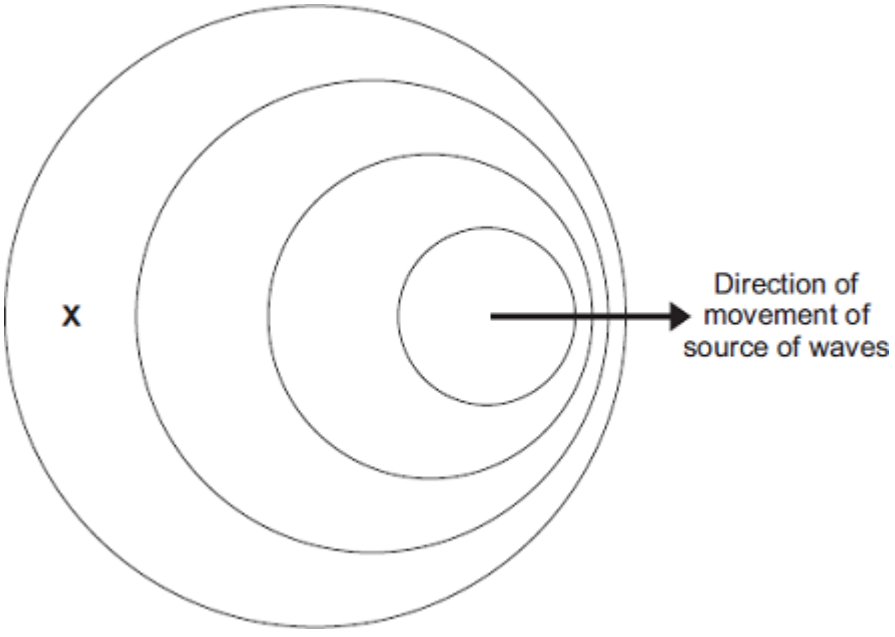
(a) Show on **Diagram 1** the wavelength of the waves.

(1)

(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)



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

decreased	**increased**	**stayed the same**

In **Diagram 2**, the observed wavelength of the waves at **X**

has _____ .

In **Diagram 2**, the frequency of the waves at **X**

has _____ .

(2)

(ii) Take measurements from **Diagram 2** to determine the wavelength of the waves received at **X**.

Give the unit.

_____

_____

Wavelength = _____

(3)

(c) The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

_____

(1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

_____

_____

(1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

(4)

(iv) State **one** other piece of evidence that supports the Big Bang theory of the formation of the Universe.

(1)

(Total 13 marks)

19 (a) Radio waves, microwaves and visible light are all electromagnetic waves that are used for communication.

(i) Name another electromagnetic wave that is used for communication.

(1)

(ii) Name an electromagnetic wave which is **not** used for communication.

State a use for this electromagnetic wave.

Electromagnetic wave _____

Use _____

(2)

(b) The table below shows the wavelengths for some electromagnetic waves, **A**, **B**, **C** and **D**.

Wave	Wavelength
A	1000 m
B	100 m
C	10 m
D	3 cm

A teacher is going to demonstrate diffraction of waves through a gap. She will carry out the demonstration in a classroom.

The teacher is able to generate waves **A**, **B**, **C** and **D**.

Which wave, **A**, **B**, **C** or **D**, would she use? ☐

Explain your answer.

_____

_____

_____

_____

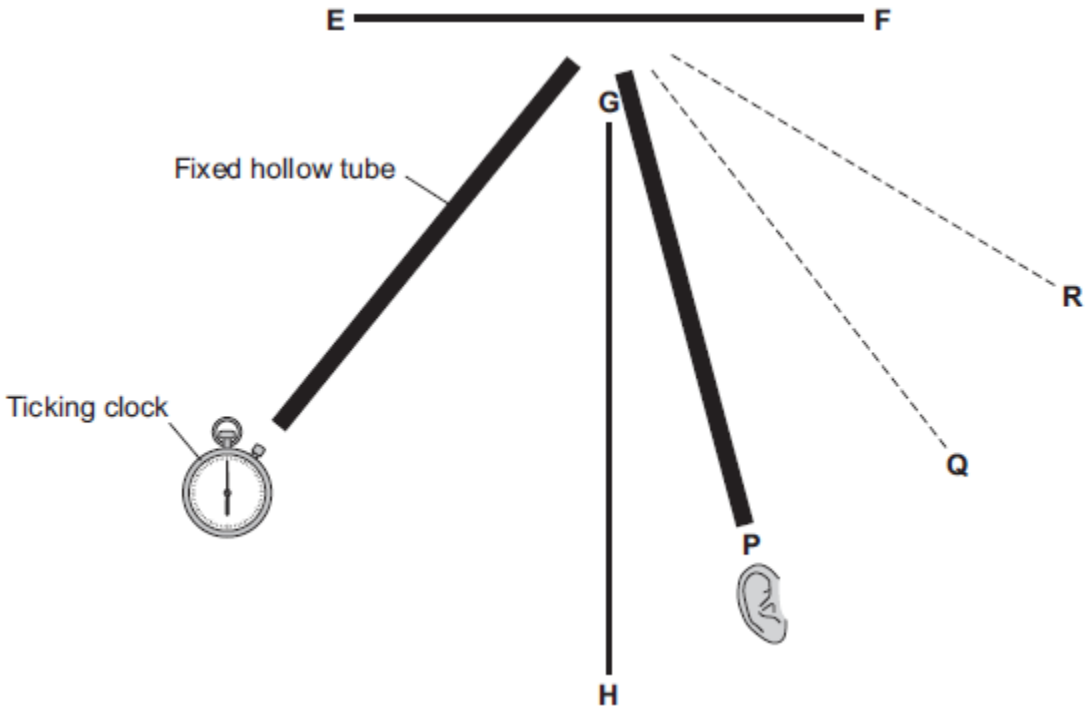
_____

_____

(3)

(c) In another demonstration, a teacher used a loud ticking clock as a source of sound, two hollow tubes and two smooth surfaces, **EF** and **GH**.

The figure below shows one of the hollow tubes fixed in position with a ticking clock at one end.



A student placed his ear at one end of the other hollow tube in position **P**. He moved this hollow tube, in turn, to positions **Q** and **R**.

(i) At which position, **P**, **Q** or **R**, did he hear the loudest sound? ☐

(1)

(ii) Explain your answer to part **(i)**.

_____

_____

_____

_____

_____

_____

(3)

(iii) Suggest why smooth surface **GH** in the figure above was needed.

_____

_____

(1)

(iv) The frequency of a sound wave is 15 Hz.

The speed of sound is 330 m / s.

Calculate the wavelength of the sound wave.

_____

_____

Wavelength = _____ m

(2)

(v) Give a reason why it would **not** be possible to do the demonstration in the figure above using sound waves with a frequency of 15 Hz.

_____

_____

(1)

(Total 14 marks)

20 Lenses can be used to correct visual defects.

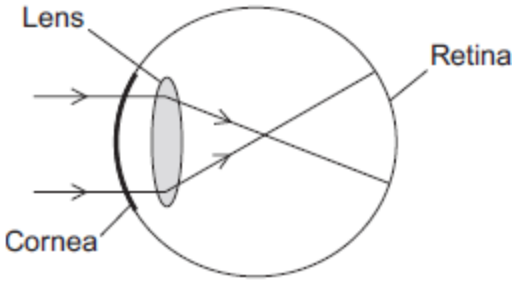
Figure 1 shows a child wearing glasses.
Wearing glasses allows a lens to correct a visual defect.

Figure 1

© monkeybusinessimages/iStock/Thinkstock

(a) **Figure 2** shows rays of light entering a child's eye and being focused at a point. This point is not on the retina so the child sees a blurred image.

Figure 2



(i) What is the visual defect of this eye?

_____

_____

(1)

(ii) Use the correct answer from the box to complete the sentence.

converging	**convex**	**diverging**

The type of lens used to correct this visual defect is a _____ lens.

(1)

(b) Visual defects may be corrected with eye surgery. A laser may be used in eye surgery.

Use the correct answer from the box to complete the sentence.

light	**sound**	**X-rays**

A laser is a concentrated source of _____ .

(1)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Lasers can be used to correct a visual defect by changing the shape of the cornea.

A knife is used to cut a flap in the cornea. The laser vaporises a portion of the cornea and permanently changes its shape. The flap is then replaced.

Most patients are back at work within a week. Driving may be unsafe for one to two weeks. Tinted glasses with ultraviolet protection are needed when out in the sun for the first three months.

Many people in their mid-40s need reading glasses. This is because the eye lens becomes less flexible with age. Laser surgery cannot cure this.

Laser surgery for both eyes costs £1000. A pair of glasses costs £250.

Describe the advantages and disadvantages of:

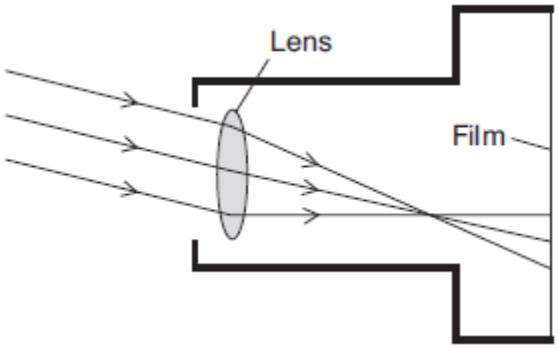
- having laser surgery to correct visual defects
- wearing glasses to correct visual defects.

Extra space

(6)

(d) **Figure 3** shows parallel rays of light, from a point on a distant object, entering a camera.

Figure 3



Describe the adjustment that has to be made to focus the image on the film.

_____

_____

_____

_____

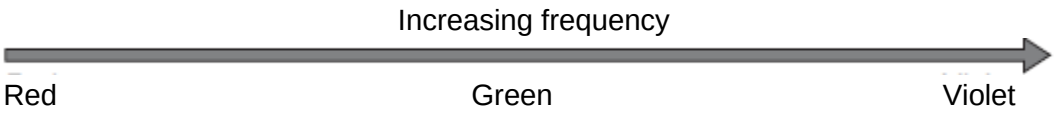
(2)

(Total 11 marks)

21 (a) The visible light spectrum has a range of frequencies.

Figure 1 shows that the frequency increases from red light to violet light.

Figure 1



Use the correct answers from the box to complete the sentence.

decreases	**stays the same**	**increases**

As the frequency of the light waves increases, the wavelength

of the light waves _____ and

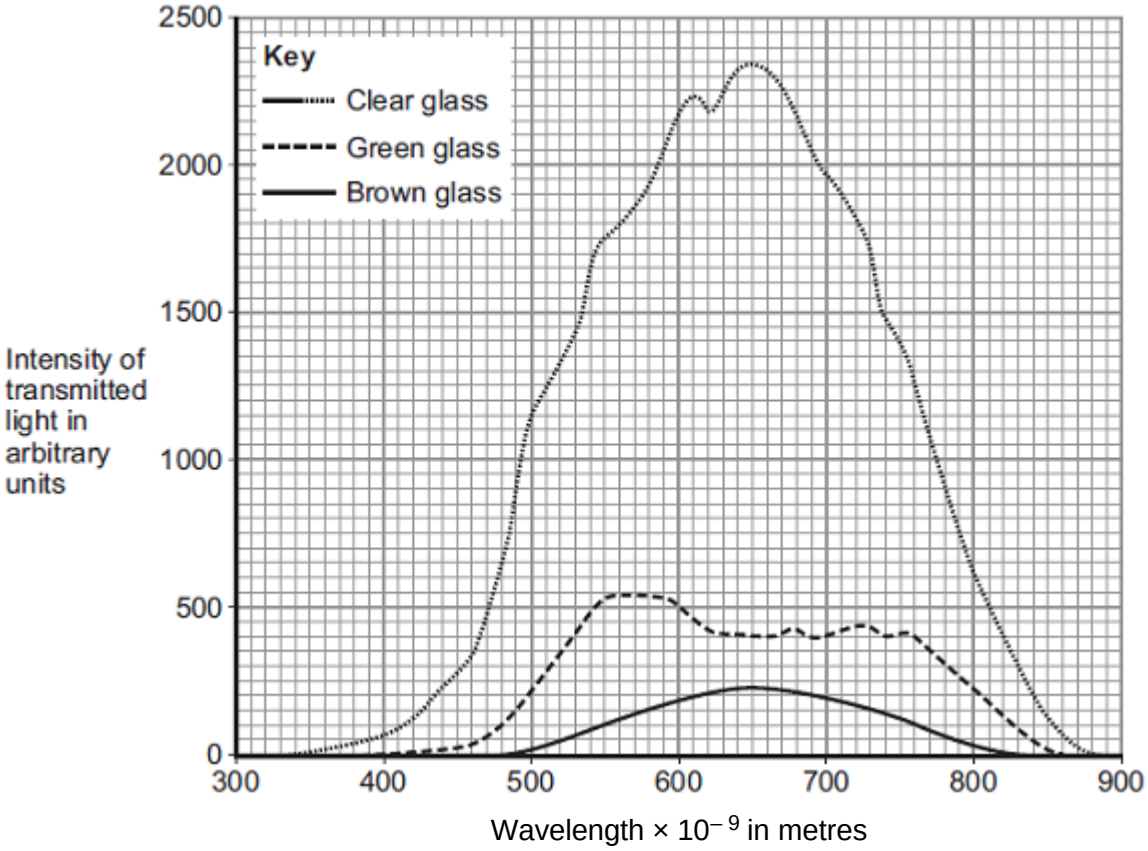
the energy of the light waves _____ .

(2)

(b) Bottled beer will spoil if the intensity of the light passing through the glass bottle into the beer is too high.

Figure 3 shows the intensity of the light that is transmitted through three different pieces of glass.

Figure 3



(i) The pieces of glass all had the same thickness.

Suggest why.

_____

_____

(1)

(ii) Bottles made of brown glass are suitable for storing beer.

Suggest why.

_____

_____

(1)

(Total 4 marks)

22 The figure below shows an X-ray image of a human skull.

Stockdevil/iStock/Thinkstock

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

absorbs	**ionises**	**reflects**	**transmits**

When X-rays enter the human body, soft tissue _____ X-rays and bone _____ X-rays.

(2)

(b) Complete the following sentence.

The X-rays affect photographic film in the same way that _____ does.

(1)

(c) The table below shows the total dose of X-rays received by the human body when different parts are X-rayed.

Part of body X-rayed	**Dose of X-rays received by human body in arbitrary units**
Head	3
Chest	4
Pelvis	60

Calculate the number of head X-rays that are equal in dose to one pelvis X-ray.

_____

_____

_____

Number of head X-rays = _____

(2)

(d) Which **one** of the following is another use of X-rays?

Tick (✓) **one** box.

Cleaning stained teeth ☐

Killing cancer cells ☐

Scanning of unborn babies ☐

(1)

(Total 6 marks)

23 (a) Some humans are short-sighted.

Complete the following sentence.

Short sight can be caused by the eyeball being too _____ .

(1)

(b) Spectacles can be worn to correct short sight.

The table below gives information about three different lenses that can be used in spectacles.

	Lens feature		
	Material	**Mass in grams**	**Type**
Lens A	Plastic	5.0	Concave (diverging)
Lens B	Glass	6.0	Convex (converging)
Lens C	Glass	5.5	Convex (converging)

Which lens from **Table 2** would be used to correct short sight?

Draw a ring around the correct answer.

Lens A **Lens B** **Lens C**

Give the reason for your answer.

_____

_____

(2)

(c) Every lens has a focal length.

Which factor affects the focal length of a lens?

Tick (✓) **one** box.

The colour of the lens ☐

The refractive index of the lens material ☐

The size of the object being viewed ☐

(1)

(d) A lens has a focal length of 0.25 metres.

Calculate the power of the lens.

_____

_____

_____

Power of lens = _____ dioptres

(2)

(e) Laser eye surgery can correct some types of eye defect.

Which of the following is another medical use for a laser?

Tick (✓) **one** box.

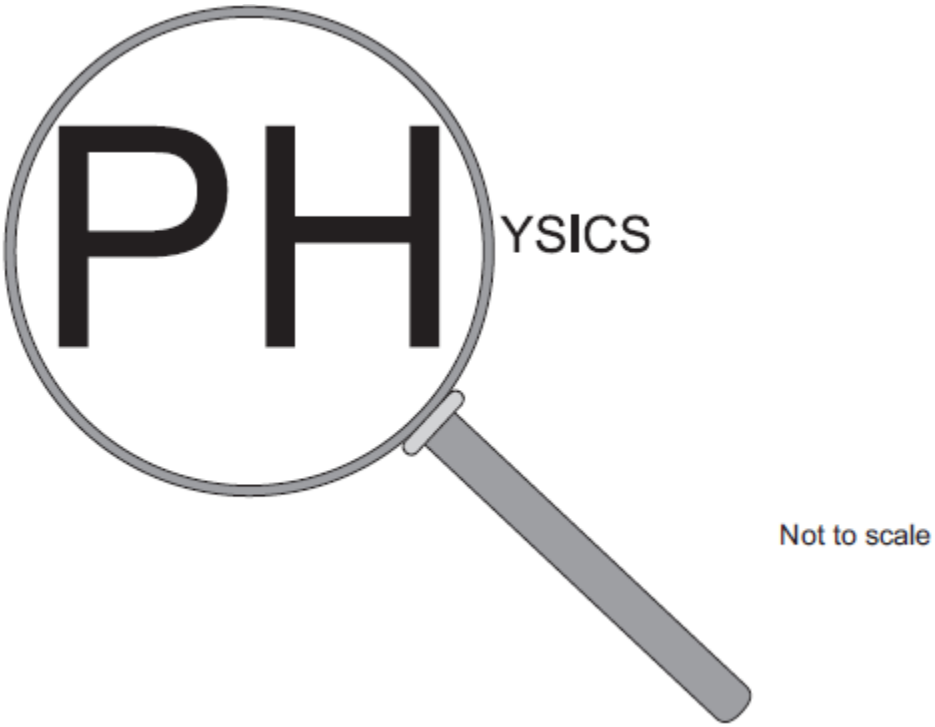
Cauterising open blood vessels ☐

Detecting broken bones ☐

Imaging the lungs ☐

(1)

(f) The figure shows a convex lens being used as a magnifying glass.



An object of height 14 mm is viewed through a magnifying glass.

The image height is 70 mm.

Calculate the magnification produced by the lens in the magnifying glass.

_____

_____

_____

Magnification = _____

(2)

(Total 9 marks)

24 (a) What is ultrasound?

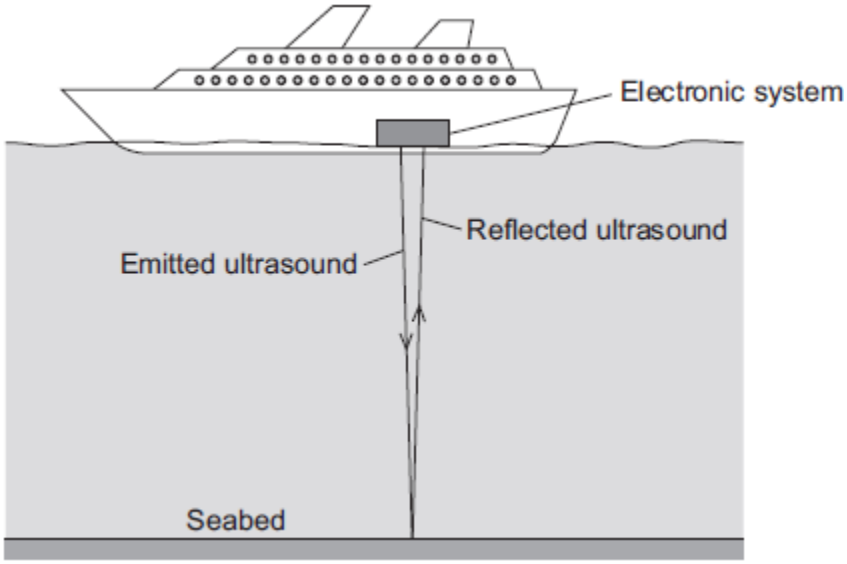
_____

_____

(1)

(b) **Figure 1** shows how ultrasound is used to measure the depth of water below a ship.

Figure 1



A pulse of ultrasound is sent out from an electronic system on-board the ship.

It takes 0.80 seconds for the emitted ultrasound to be received back at the ship.

Calculate the depth of the water.

Speed of ultrasound in water = 1600 m / s

_____

_____

_____

_____

Depth of water = _____ metres

(3)

(c) Ultrasound can be used in medicine for scanning.

State **one** medical use of ultrasound scanning.

_____

(1)

(d) Images of the inside of the human body can be made using a Computerised Tomography (CT) scanner. The CT scanner in **Figure 2** uses X-rays to produce these images.

Figure 2

monkeybusinessimages/iStock/Thinkstock

State **one** advantage and **one** disadvantage of using a CT scanner, compared with ultrasound scanning, for forming images of the inside of the human body.

Advantage of CT scanning _____

_____

_____

Disadvantage of CT scanning _____

_____

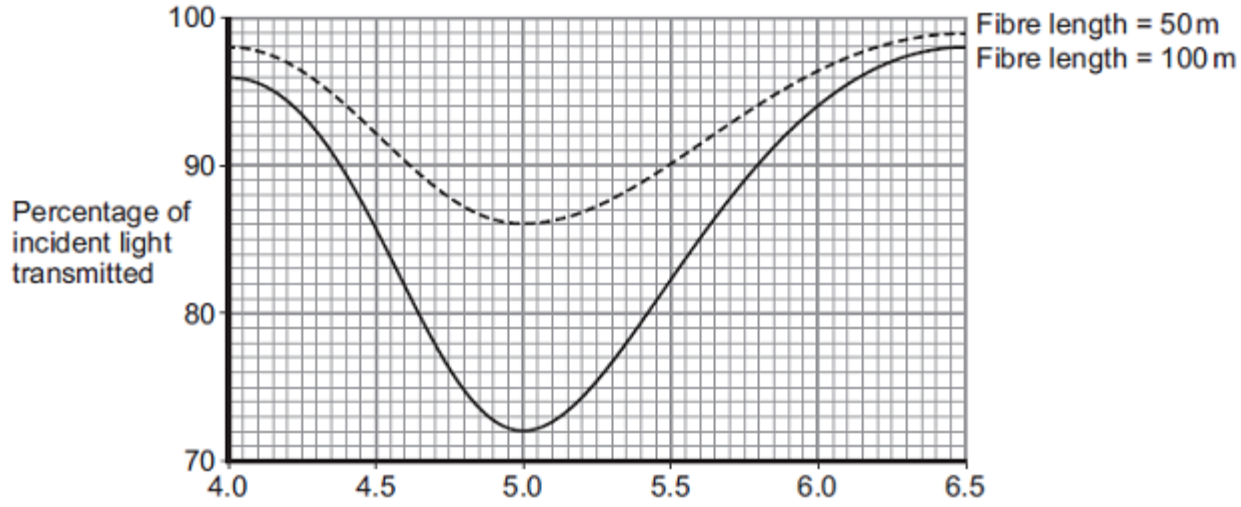
_____

(2)

(Total 7 marks)

25 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.

(Total 3 marks)

26 Waves may be longitudinal or transverse.

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

(3)

(b) Radio waves are electromagnetic waves.

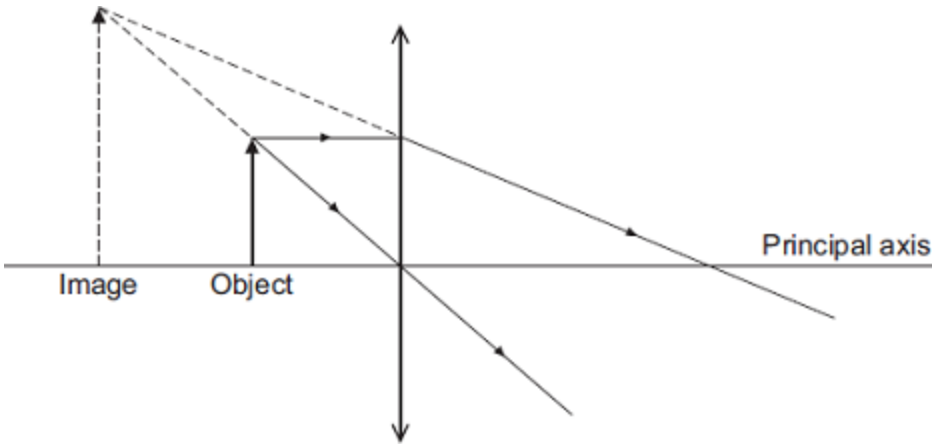
Describe how radio waves are different from sound waves.

(4)

(Total 7 marks)

27 (a) The diagram shows how a convex lens forms an image of an object.

This diagram is **not** drawn to scale.



(i) Which **two** words describe the image?

Draw a ring around each correct answer.

diminished **inverted** **magnified** **real** **upright**

(2)

(ii) The object is 4 cm from the lens. The lens has a focal length of 12 cm.

Calculate the image distance.

_____

_____

_____

Image distance = _____ cm

(3)

(b) What does a minus sign for an image distance tell us about the nature of the image?

_____

(1)

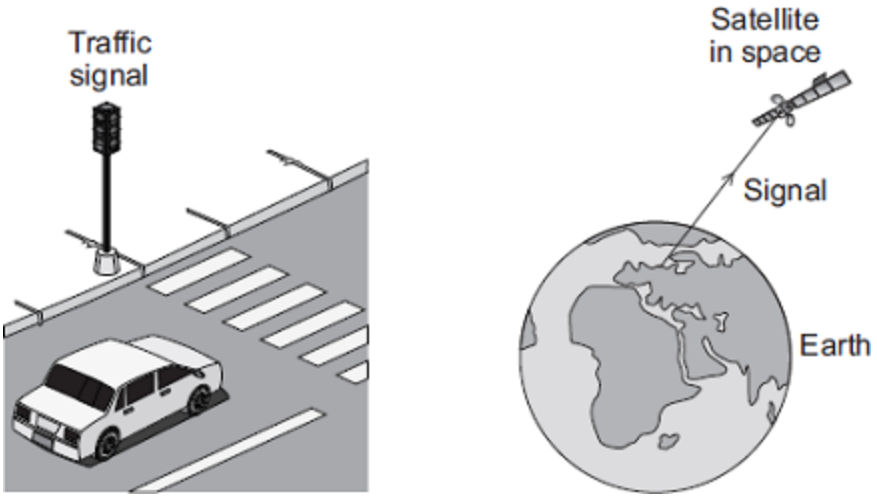
(Total 6 marks)

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

Diagram 1

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

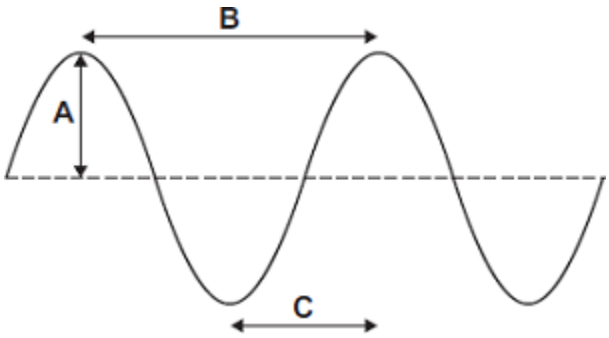
Draw a ring around the correct answer.

J **K** **L**

(1)

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

Diagram 2



(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.

_____

_____

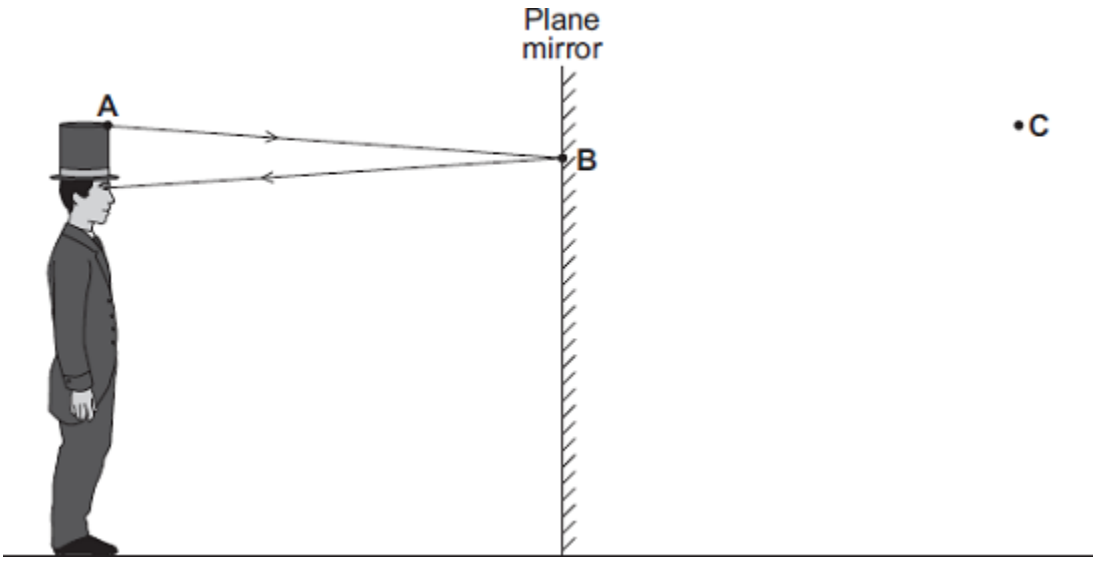
_____

_____

(2)

(Total 8 marks)

29 A person can see an image of himself in a tall plane mirror.



The diagram shows how the person can see his hat.

(a) Which point, **A**, **B** or **C**, shows the position of the image of his hat?

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

(1)

(b) On the diagram, use a ruler to draw a light ray to show how the person can see his shoe.

(3)

(c) Which **one** of the words in the box is used to describe the image formed by a plane mirror?

Draw a ring around the correct answer.

imaginary	**real**	**virtual**

(1)

(Total 5 marks)

30 A lorry has an air horn. The air horn produces sound waves in the air.

(a) Use **one** word to complete the following sentence.

Sound waves cause air particles to _____ .

(1)

(b) The air horn produces sound waves at a constant frequency of 420 Hz.

The wavelength of the sound waves is 0.80 m.

Calculate the speed of the sound waves.

_____

_____

_____

Speed = _____ m/s

(2)

(Total 3 marks)

31 (a) Light waves transfer energy.

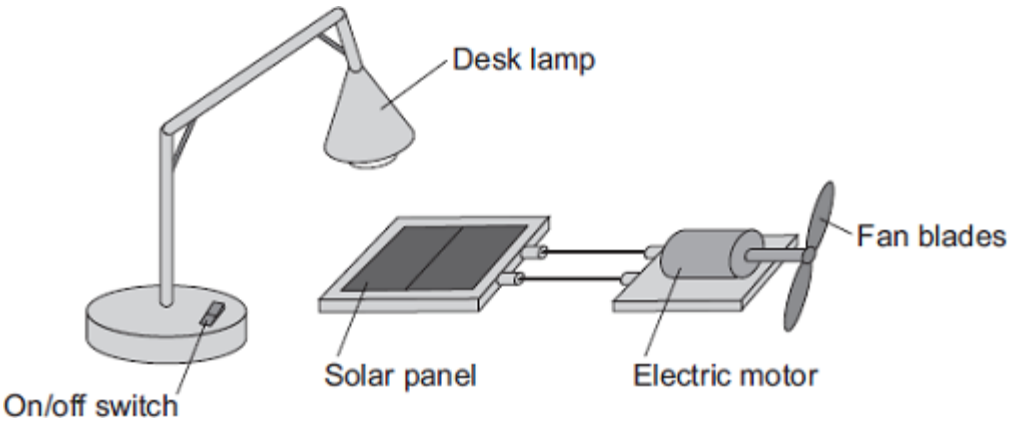
(i) Complete the following sentence.

The oscillations producing a light wave are _____

to the direction of the energy transfer by the light wave.

(1)

(ii) The apparatus in the diagram shows that light waves transfer energy.



Describe how switching the desk lamp on and off shows that light waves transfer energy.

You do **not** need to describe the energy transfers.

_____

_____

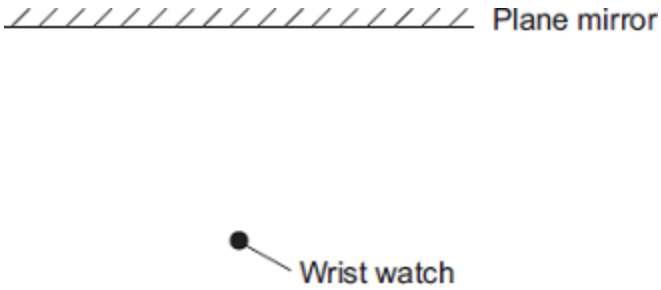
_____

_____

(2)

(b) A student holds a wrist watch in front of a plane mirror. The student can see an image of the wrist watch in the mirror.

The diagram shows the position of the wrist watch and the mirror.



Draw a ray diagram showing how the image of the wrist watch is formed.

Mark the position of the image.

(4)

(c) The image of the wrist watch seen by the student is virtual.

What is a virtual image?

_____

_____

(1)

(Total 8 marks)

32 (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 1.8×10^{9} Hz and travel at a speed of 3.0×10^{8} m/s.

Calculate the wavelength of the microwaves.

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^3 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)

33 Ultrasound and X-rays are waves used in hospitals to create images of the inside of the human body. To produce the images below, the waves must enter the human body.

Ultrasound scan of an unborn child

© Isabelle Limbach/Thinkstock

X-ray of a broken bone

© itsmejust/iStock

(a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

Describe the features of ultrasound and X-rays, and what happens to each type of wave after it has entered the human body.

(6)

(b) It would **not** be safe to use X-rays to produce an image of an unborn child.

Explain why.

_____

_____

_____

_____

(2)

(c) Ultrasound can be used for medical treatments as well as for imaging.

Give **one** use of ultrasound for medical treatment.

_____

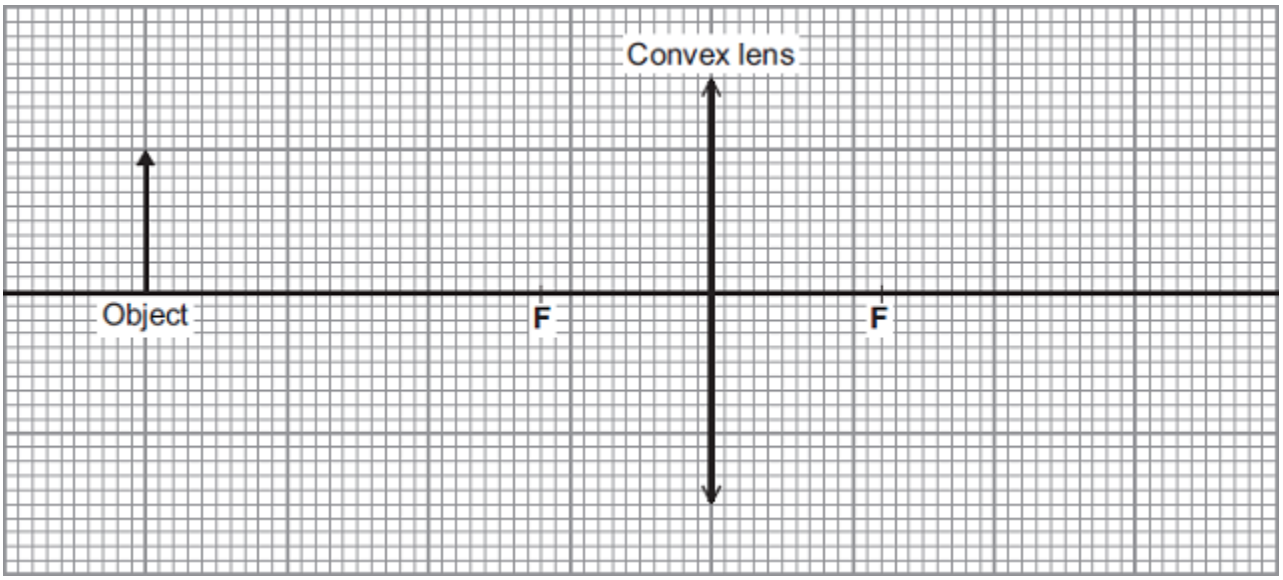
_____

(1)

(Total 9 marks)

34 (a) A camera was used to take a photograph. The camera contains a convex (converging) lens.

Complete the ray diagram to show how the lens produces an image of the object.



F = Principal focus

(4)

(b) State **two** words to describe the nature of the image produced by the lens in the camera.

1. _____

2. _____

(2)

(Total 6 marks)

35 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 3.0×10^8 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.

_____

_____

_____

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?

_____

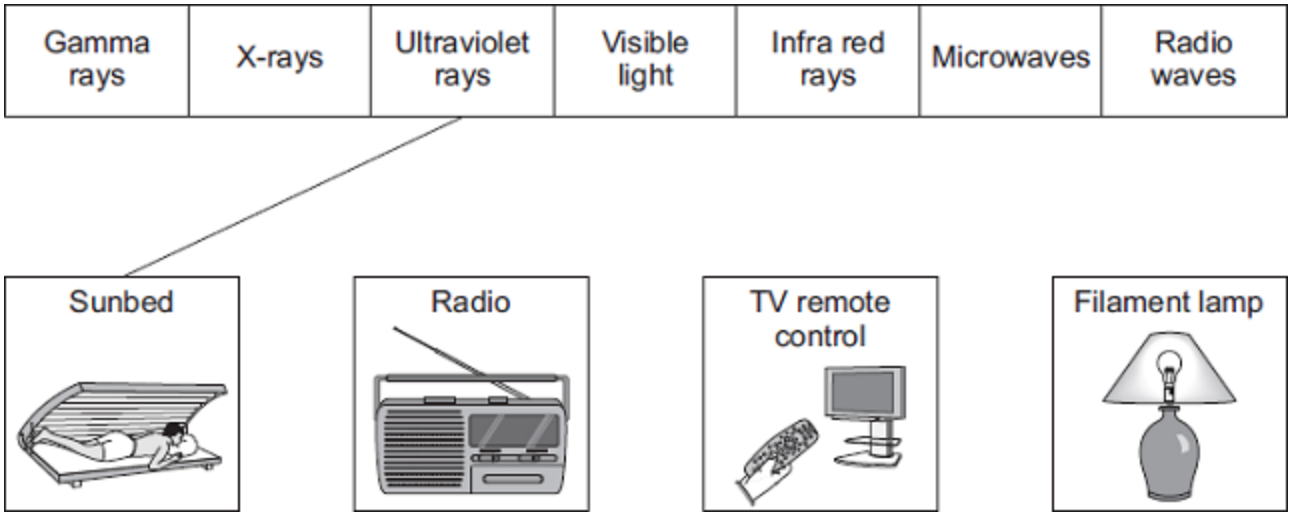
_____

(1)

(Total 9 marks)

36 (a) The diagram shows the electromagnetic spectrum.
The pictures show four devices that use electromagnetic waves. Each device uses a different type of electromagnetic wave.

Draw a line from each device to the type of electromagnetic wave that it uses. One has been done for you.



(3)

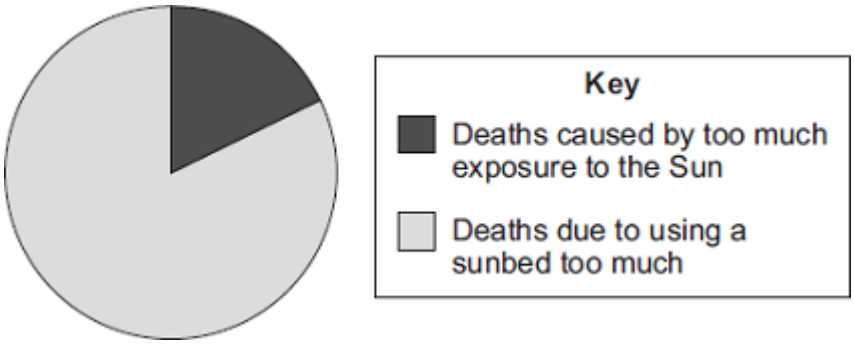
(b) A headline from a recent newspaper article is shown below.

(i) What serious health problem may be caused by using a sunbed too much?

_____

(1)

(ii) The pie chart compares the number of deaths in Britain each year which may have been caused by using sunbeds too much, with those which may have been caused by too much exposure to the Sun.



It is difficult for a doctor to be certain that a person has died because of using a sunbed too much.

Suggest why.

_____

_____

(1)

(iii) A spokesperson for a leading cancer charity said:

> 'We want people, especially young people, to know he possible dangers of using a sunbed.'

Why is it important that you know the possible dangers of using a sunbed?

_____

_____

(1)

(Total 6 marks)

37 Using an optical telescope to look at stars is not always easy because:

- too many street lights often make it too light to see faint stars
- clouds reduce the light getting to the telescope
- atmospheric pollution often distorts the images.

Large optical telescopes are often positioned high up a mountain.

Describe the advantages of positioning a telescope high up a mountain.

_____

_____

_____

_____

_____

_____

(Total 3 marks)

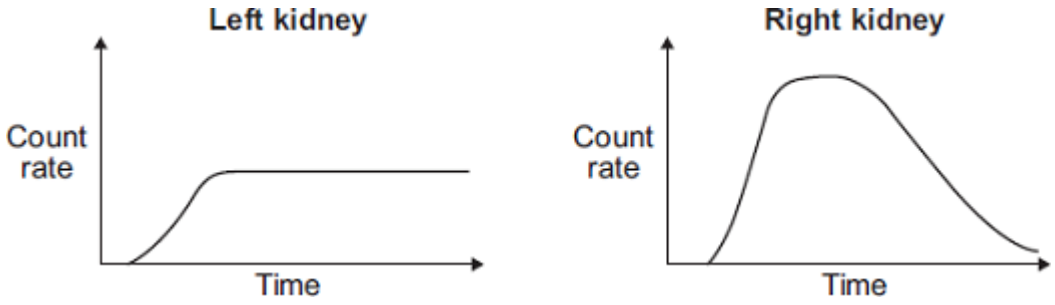
38 A doctor uses the radioactive isotope technetium-99 to find out if a patient's kidneys are working correctly.

The doctor injects a small amount of technetium-99 into the patient's bloodstream. Technetium-99 emits gamma radiation.

If the patient's kidneys are working correctly, the technetium-99 will pass from the bloodstream into the kidneys and then into the patient's urine.

Detectors are used to measure the radiation emitted from the kidneys.

The level of radiation emitted from each kidney is recorded on a graph.



(a) How do the graphs show that technetium-99 is passing from the bloodstream into each kidney?

_____

_____

(1)

(b) By looking at the graphs, the doctor is able to tell if there is a problem with the patient's kidneys.

Which **one** of the following statements is correct?

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

Only the right kidney is working correctly. ☐

Only the left kidney is working correctly. ☐

Both kidneys are working correctly. ☐

Explain the reason for your answer.

_____

_____

_____

_____

(3)

(Total 4 marks)

39 (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.

Calculate the wavelength of the waves broadcast by this station.

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?

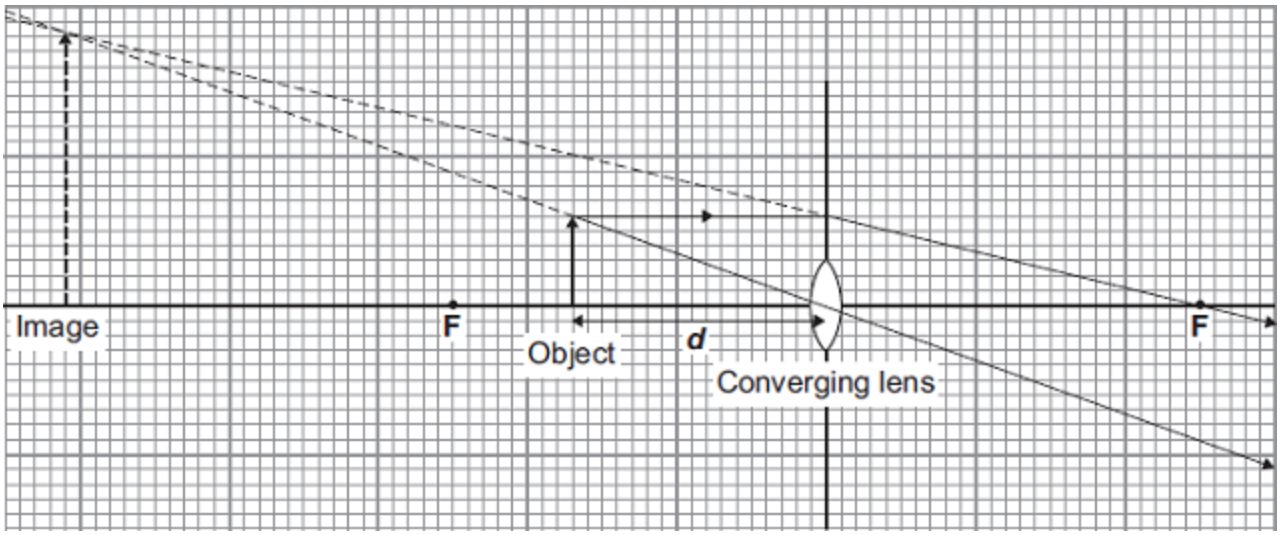
_____

_____

(1)

(Total 6 marks)

40 A student investigates how the magnification of an object changes at different distances from a converging lens.
The diagram shows an object at distance ***d*** from a converging lens.



(a) (i) The height of the object and the height of its image are drawn to scale.

Use the equation in the box to calculate the magnification produced by the lens shown in the diagram.

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

Show clearly how you work out your answer.

Magnification = _____

(2)

(ii) The points **F** are at equal distances on either side of the centre of the lens.

State the name of these points.

(1)

(iii) Explain how you can tell, **from the diagram**, that the image is virtual.

(1)

(b) The student now uses a different converging lens. He places the object between the lens and the point **F** on the left.

The table shows the set of results that he gets for the distance ***d*** and for the magnification produced.

Distance *d* measured in cm	**Magnification**
5	1.2
10	1.5
15	2.0
20	3.0
25	6.0

His friend looks at the table and observes that when the distance doubles from 10 cm to 20 cm, the magnification doubles from 1.5 to 3.0.

His friend's conclusion is that:

The magnification is directly proportional to the distance of the object from the lens.

His friend's observation is correct.

His friend's conclusion is wrong.

(i) Explain using data from the table why his friend's conclusion is wrong.

_____

_____

_____

_____

(2)

(ii) Write a correct conclusion.

_____

_____

(1)

(iii) The maximum range of measurements for ***d*** is from the centre of the lens to **F** on the left.

The student **cannot** make a correct conclusion outside this range.

Explain why.

_____

_____

(1)

(Total 8 marks)

41 (a) The diagram below shows six of the seven types of wave that make up the electromagnetic spectrum.

Gamma rays		Ultraviolet	Visible light	Infrared	Microwaves	Radio waves

(i) What type of electromagnetic wave is missing from the diagram?

_____

(1)

(ii) Which of the following electromagnetic waves has the most energy?

Draw a ring around the correct answer.

gamma rays **radio waves** **visible light**

(1)

(iii) Which of the following electromagnetic waves is given out by a TV remote control?

Draw a ring around the correct answer.

infrared **microwaves** **ultraviolet**

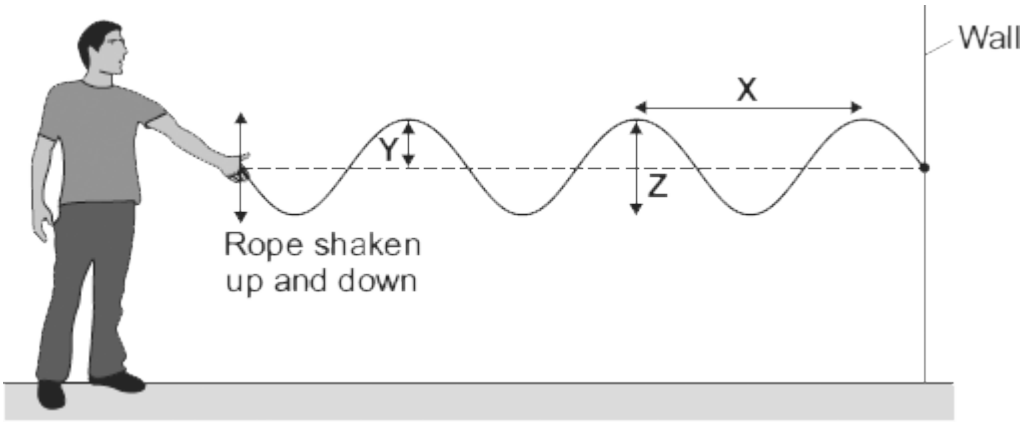
(1)

(b) Draw a ring around the correct answer in the box to complete the sentence.

Microwaves travel through a vacuum at [a slower speed than / the same speed as / a faster speed than] radio waves.

(1)

(c) The diagram shows waves being produced on a rope.
The waves are **not** reflected by the wall.



(i) Draw an arrow on the diagram to show the direction in which the waves transfer energy.

(1)

(ii) Which **one** of the arrows, labelled, **X**, **Y** or **Z**, shows the amplitude of a wave?

Write the correct answer in the box. ☐

(1)

(iii) The waves produced on the rope are transverse.

Name **one** other type of transverse wave.

_____

(1)

(d) The rope is shaken up and down, producing 3 waves every second.
The waves have a wavelength of 1.2 metres.

(i) State the frequency of the waves.

_____ Hz

(1)

(ii) Calculate the speed of the waves.

Show clearly how you work out your answer.

_____

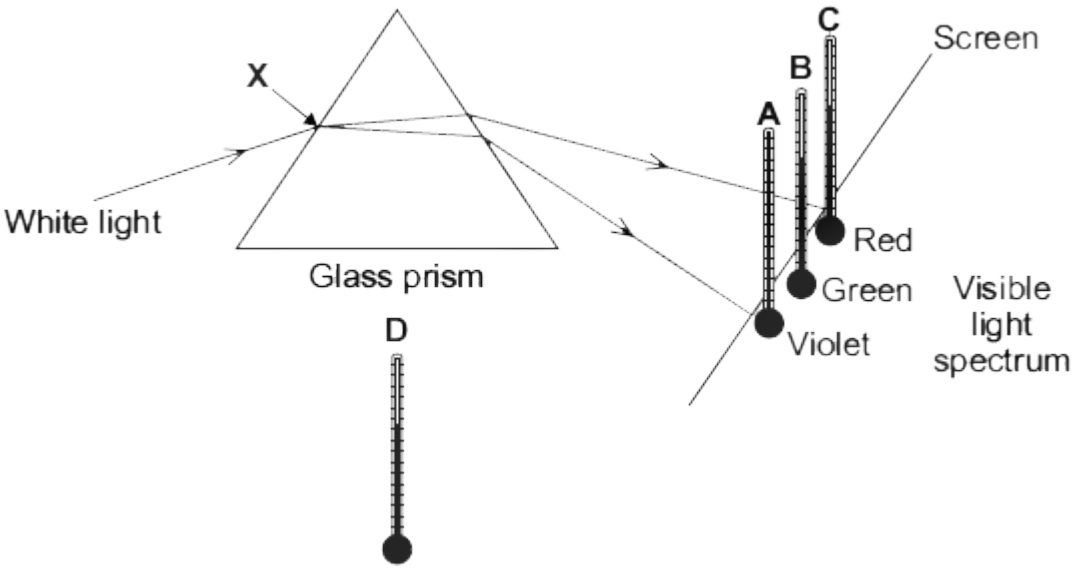
_____

Wave speed = _____ m/s

(2)

(Total 10 marks)

42 The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



(a) (i) The student put thermometer **D** outside of the light spectrum.

Suggest why.

_____

_____

(1)

(ii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

_____

_____

_____

_____

(2)

(b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

_____

_____

_____

_____

(2)

(c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^{8} m/s.

Show clearly how you work out your answer.

_____

_____

_____

_____

Wavelength = _____ m

(2)

(d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

_____

_____

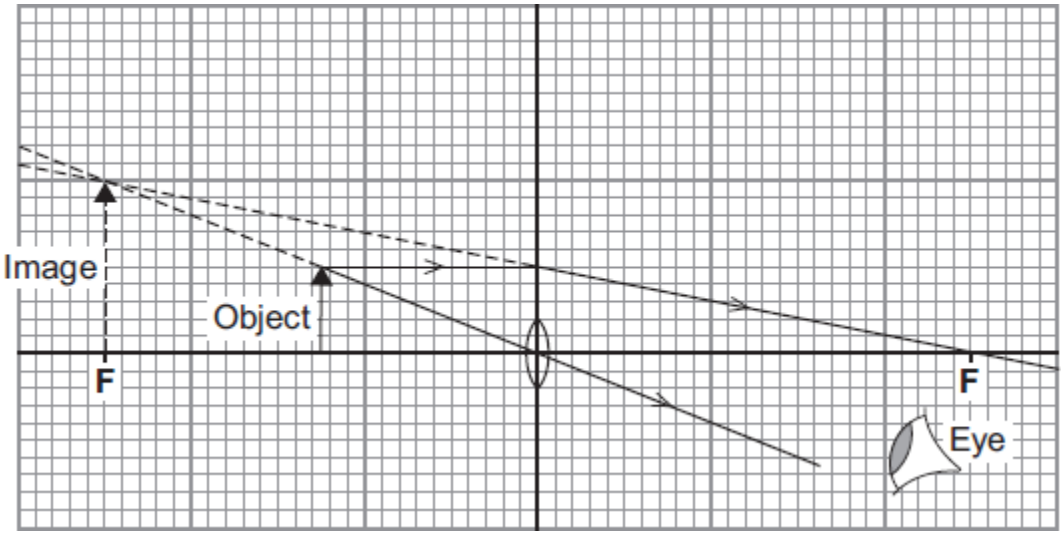
_____

_____

(2)

(Total 9 marks)

43 The diagram shows a lens being used as a magnifying glass.



(a) (i) What type of lens is shown in the diagram?

Draw a circle around your answer.

concave **converging** **diverging**

(1)

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

The object and image in the diagram have been drawn to full size.

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

Show clearly how you work out your answer.

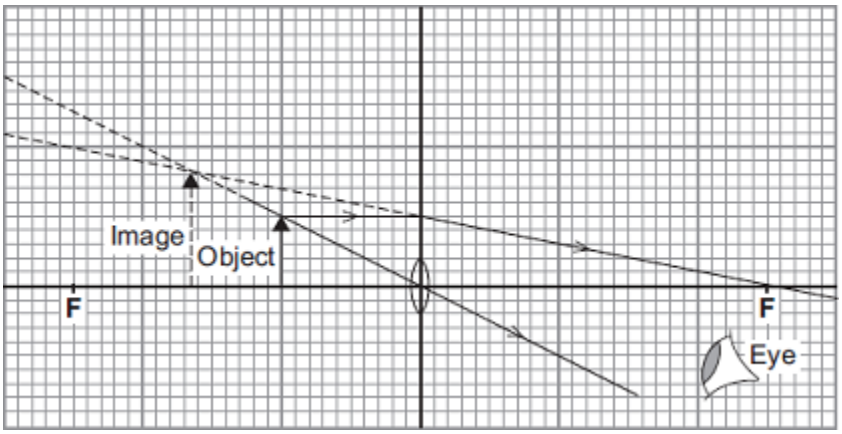
_____

_____

Magnification = _____

(2)

(b) The diagram shows how the image changes when the object has been moved closer to the lens.



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

Moving the object closer to the lens

increases
does not change
decreases

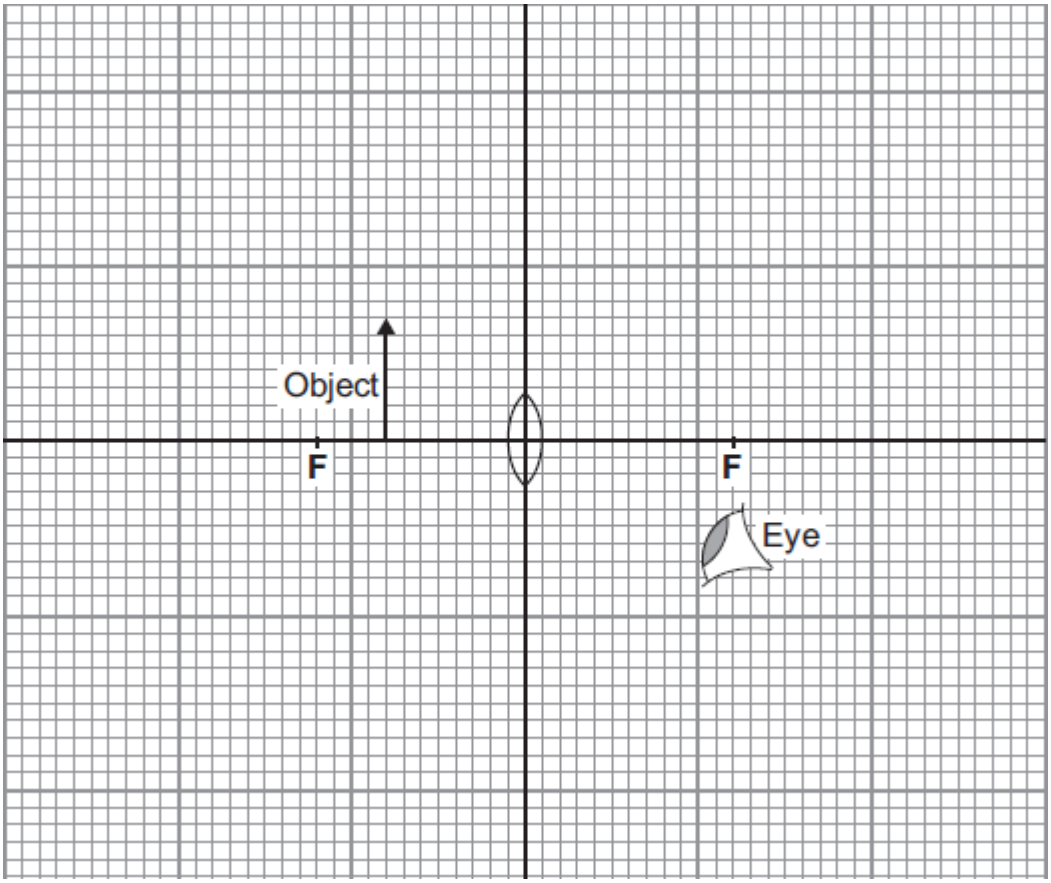
the magnification produced by the lens.

(1)

(Total 4 marks)

44 (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.

_____

_____

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.

_____

_____

_____

_____

(2)

(Total 7 marks)

45 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. _____

_____

2. _____

_____

(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?

_____

_____

(1)

(c) Electromagnetic waves travel at a speed of 3.0×10^8 m/s.

A radio station transmits waves with a wavelength of 2.5×10^2 m.

Calculate the frequency of the radio waves.

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

_____

_____

_____

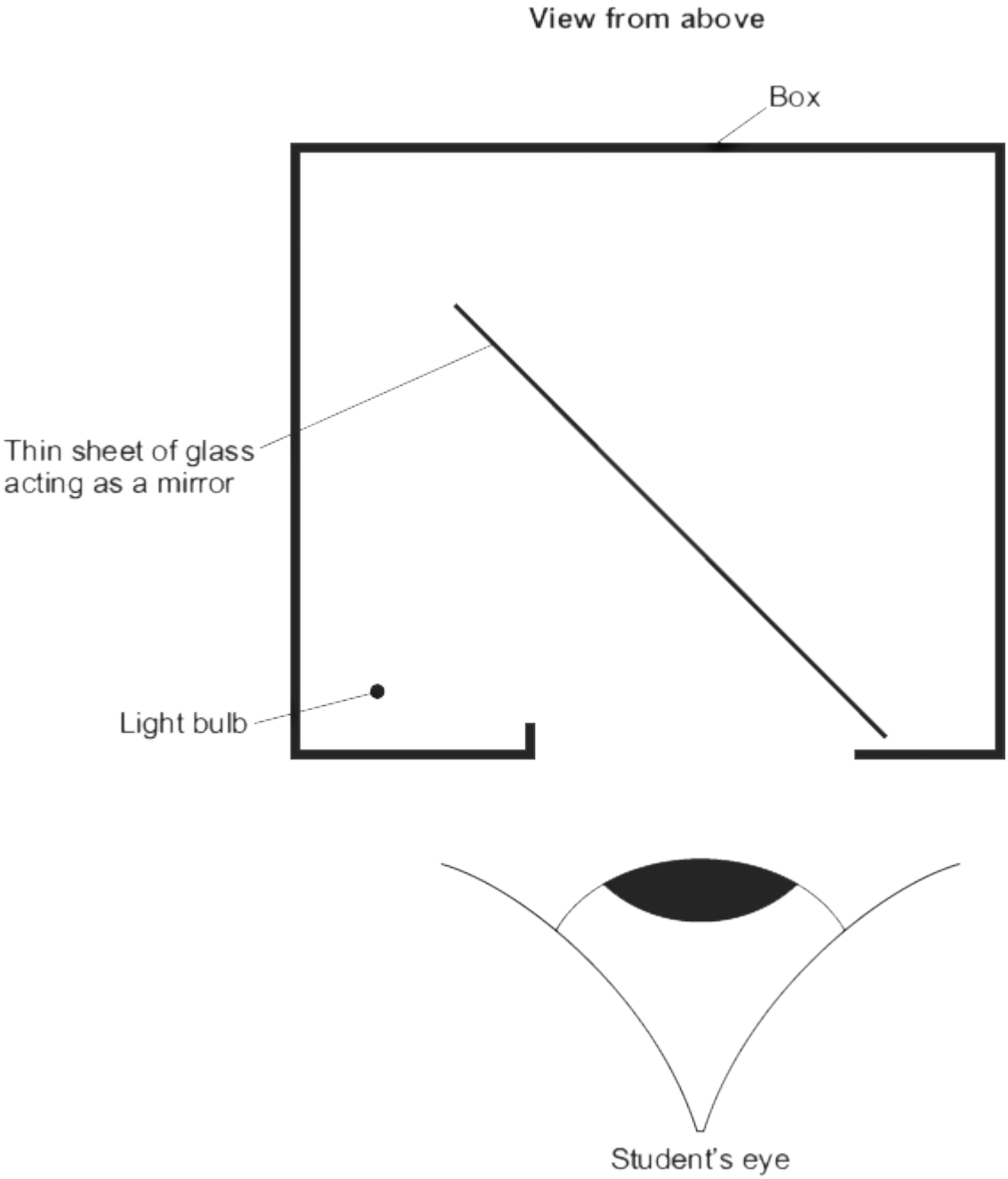
Frequency = _____

(3)

(Total 6 marks)

46 The diagram shows a model used to demonstrate an illusion known as ‘Pepper’s Ghost’.

A small light bulb and thin sheet of glass are put inside a box. The thin sheet of glass acts as a mirror. Although the light bulb is switched on, a student looking into the box cannot see the bulb. What the student does see is a virtual image of the bulb.



(a) Use a ruler to complete a ray diagram to show how the image of the light bulb is formed. Mark and label the position of the image.

(4)

(b) The image seen by the student is virtual.

Why?

_____

_____

(1)

(Total 5 marks)

47 Small sailing boats can be fitted with a passive radar device. The device increases the chance that the small boat will be seen on the radar screen of a large ship.
The radar transmitter on the large ship emits microwaves.

(a) Microwaves and radio waves are both part of the electromagnetic spectrum.

How are microwaves different from radio waves?

_____

_____

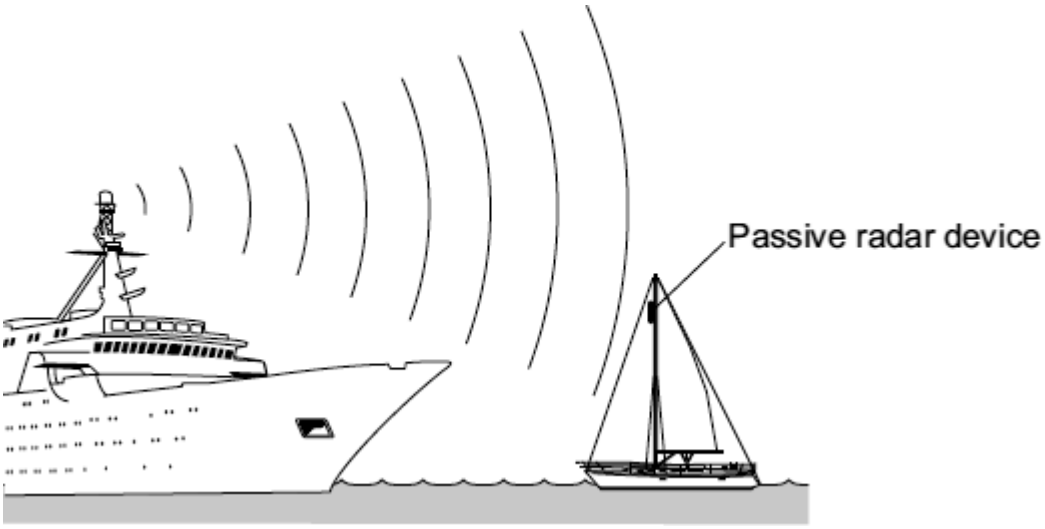
(1)

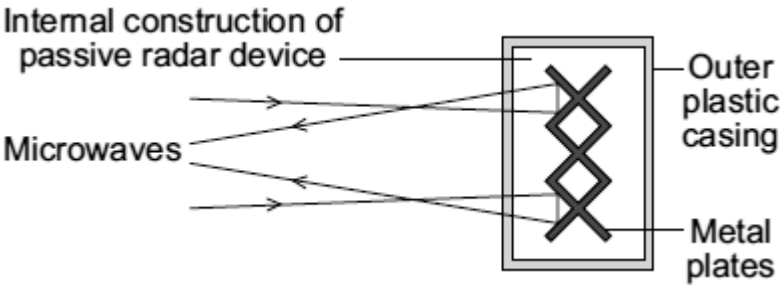
(b) How fast do microwaves travel through the air or a vacuum compared to radio waves?

_____

(1)

(c) The diagrams show the position of a passive radar device on a small boat and the internal construction of one type of passive radar device.





Microwaves can be absorbed, reflected or transmitted by different materials and types of surface.

Explain what happens to the microwaves from the ship's transmitter when they reach the passive radar device.

_____

_____

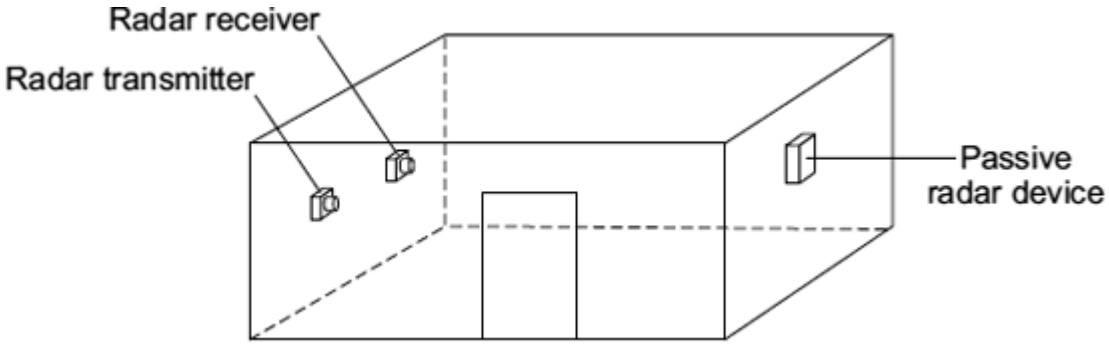
_____

_____

(2)

(d) Each type of passive radar device has an RCS value. The larger the RCS value, the easier it is for a small boat fitted with the device to be detected.

An independent group of scientists measured the RCS values of 4 different types of device. The RCS value for each device was measured in the same room using the same equipment.



(i) Why are the walls of the room covered in a material that absorbs the waves emitted by the radar transmitter?

_____

_____

(1)

(ii) Why is it important to use the same room and the same equipment?

_____

_____

(1)

(iii) Why is it important that the measurements are made by an independent group of scientists?

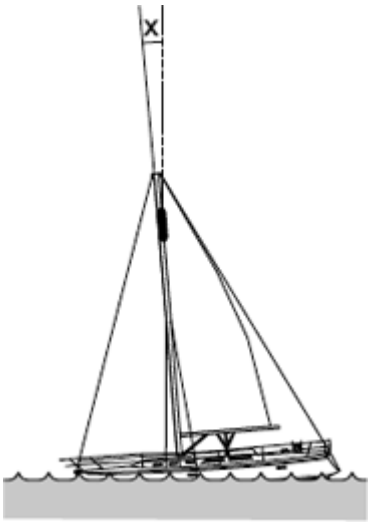
_____

_____

(1)

(e) The movement of a small boat causes the mast and device to lean over, therefore the RCS values were measured at different angles.

The table gives the RCS values obtained by the scientists.



Device	Angle X			
	0 °	**5 °**	**10 °**	**15 °**
A	1.4	1.6	1.7	1.8
B	4.7	2.6	2.3	1.9
C	9.3	3.3	1.9	1.1
D	4.5	4.8	5.0	4.6

(i) Describe how the RCS values for **device A** are different to the RCS values for **device B**.

_____

_____

_____

_____

(2)

(ii) The scientists recommended that a passive radar device fitted to a small boat should have:

- the largest possible RCS value
- an RCS value consistently above 2.0

Which **one** of the devices, **A**, **B**, **C** or **D**, would you recommend that someone fits to their boat?

_____

Give a reason for your answer.

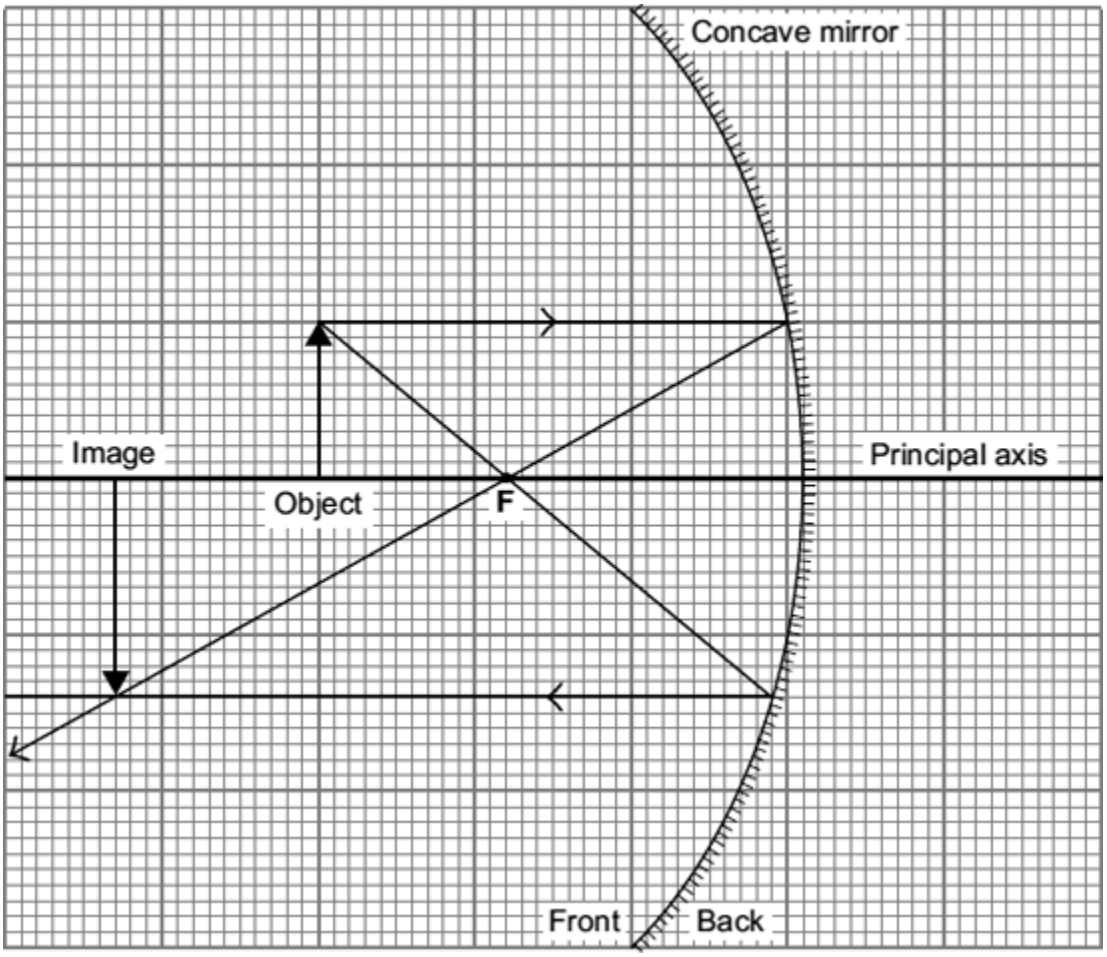
_____

_____

(1)

(Total 10 marks)

48 The ray diagram shows the image formed by a concave mirror.



Use the equation in the box to calculate the magnification.

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

Show clearly how you work out your answer.

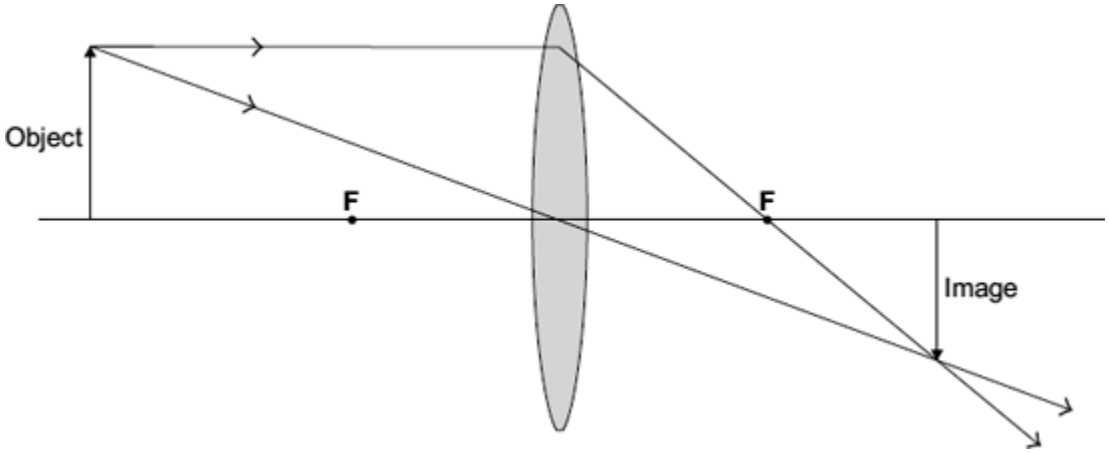
_____

_____

Magnification = _____

(Total 2 marks)

49 The diagram shows a lens, the position of an object and the position of the image of the object.



(a) What type of lens is shown?

_____

(1)

(b) What is the name of the points, **F**, shown each side of the lens?

_____

(1)

(c) (i) The image is real and can be put on a screen.

How can you tell **from the diagram** that the image is real?

_____

_____

(1)

(ii) Draw a ring around a word in the box which describes the image produced by the lens.

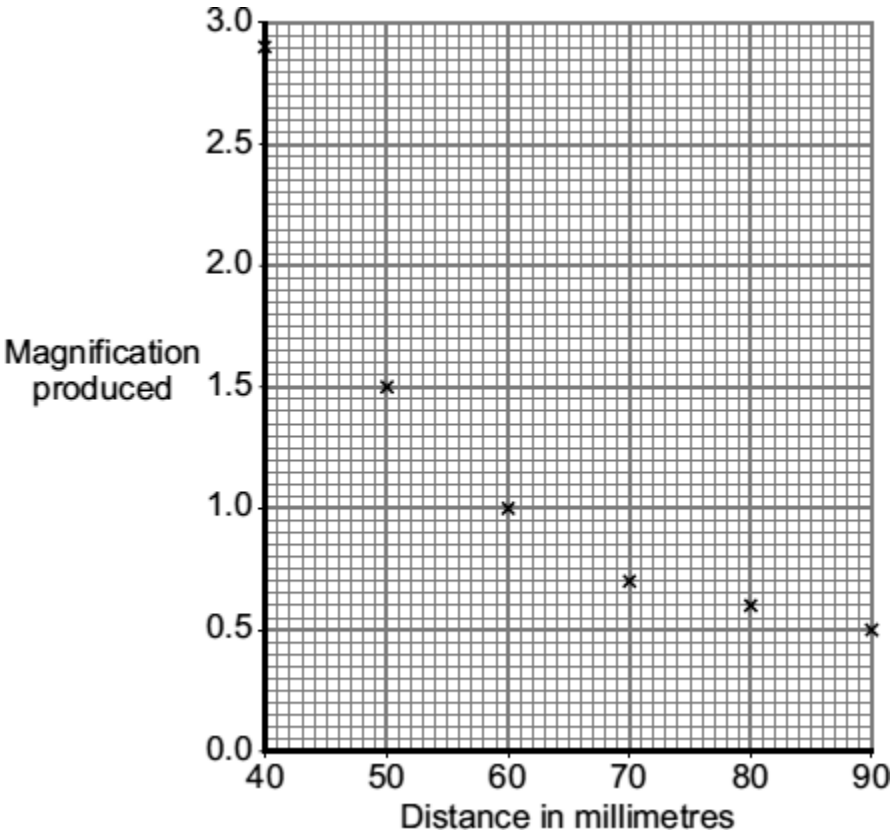
inverted	**larger**	**upright**

(1)

(d) A student investigates the relationship between the distance from the object to the lens and the magnification produced by the lens.
The student's results are given in the table.
The student did not repeat any measurements.

Distance in millimetres	Height of object in millimetres	Height of image in millimetres	Magnification produced
40	20	58	2.9
50	20	30	1.5
60	20	20	1.0
70	20	14	0.7
80	20	12	0.6
90	20	10	0.5

The student plots the points for a graph of *magnification produced* against *distance*.



(i) Draw a *line of best fit* for these points.

(1)

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

A line graph has been drawn because both variables are

described as being

categoric.
continuous.
discrete.

(1)

(iii) Describe the relationship between *magnification produced* and *distance*.

_____

_____

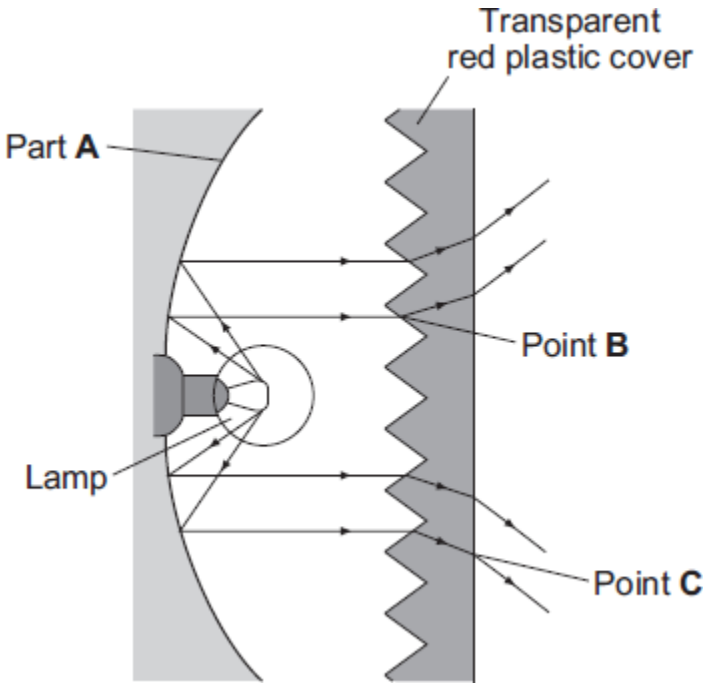
_____

(2)

(Total 8 marks)

50 At night, it is important that the lights of a car can be seen by other drivers but it is dangerous if these lights dazzle them.

The diagram shows a rear light of a car.



(a) (i) Name part **A**.

_____

(1)

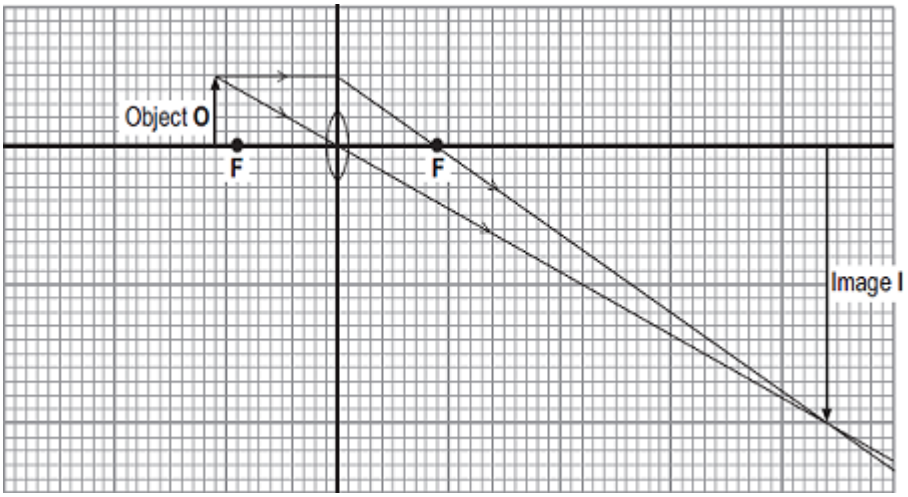
(ii) Name the process which occurs at point **B** and at point **C**.

_____

(1)

(b) A headlamp of a car contains a lens.

The ray diagram shows the position and size of the image, **I**, of an object, **O**, formed by a lens similar to the one inside a car headlamp.



(i) What type of lens is shown in the ray diagram?

Draw a ring around your answer.

converging **diverging** **plane**

(1)

(ii) The ray diagram is drawn to scale.

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.

_____

_____

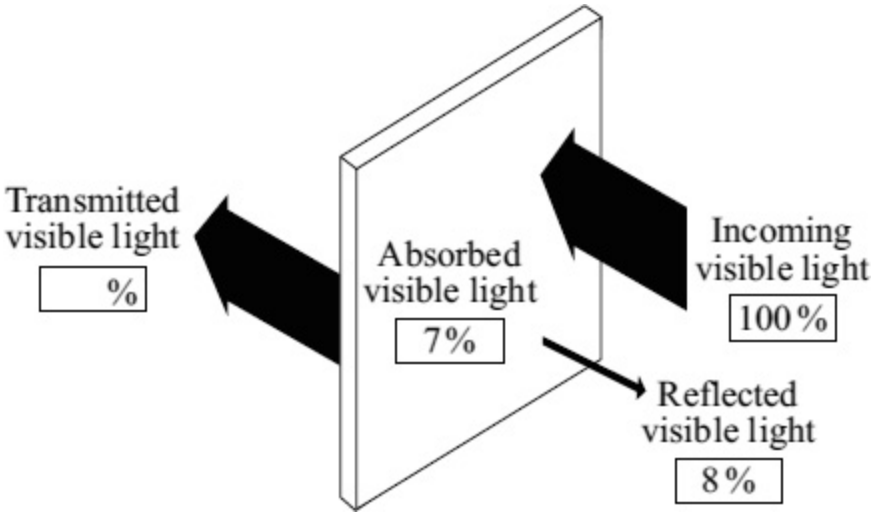
Magnification = _____

(2)

(Total 5 marks)

51 Glass reflects, absorbs and transmits both infra red radiation and visible light.

(a) /The diagram shows the percentages of visible light that are reflected and absorbed by one type of glass.

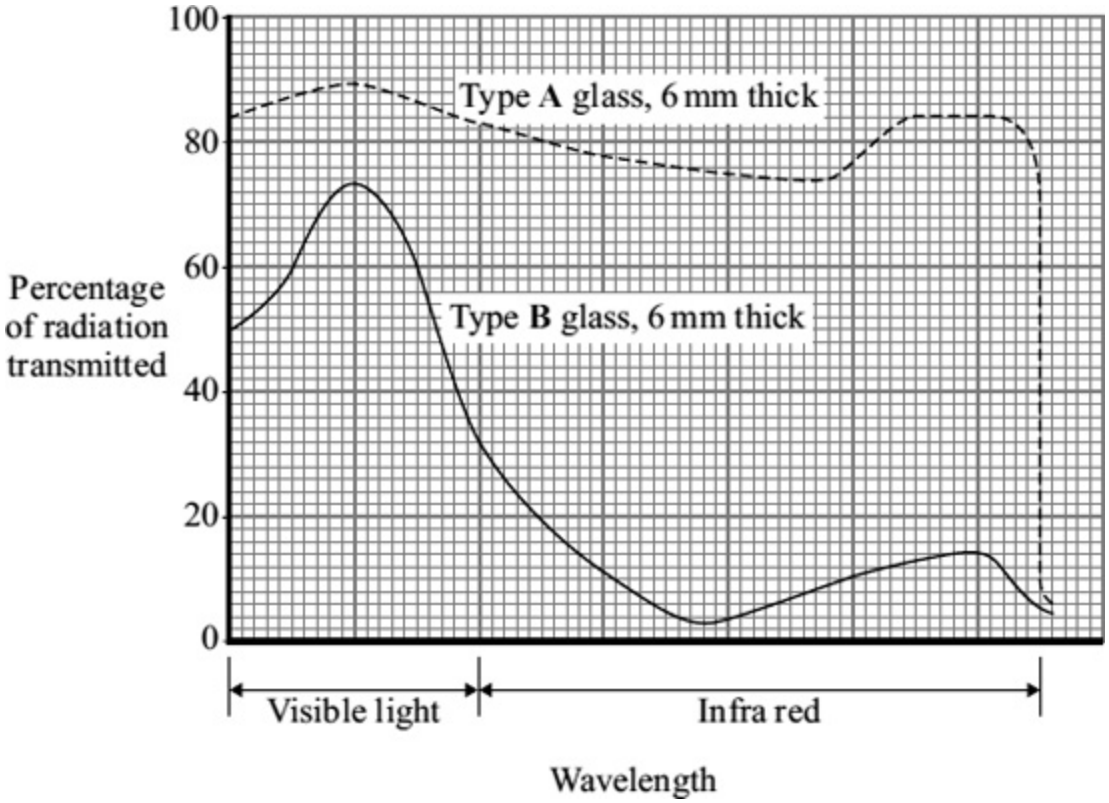


What percentage of visible light is transmitted by this type of glass?

_____ %

(1)

(b) The amounts of infra red radiation and visible light transmitted by glass depend on the type and thickness of glass. The data obtained from tests on two different types of glass is displayed in the graph below.



(i) To be able to compare the two types of glass, it was important to control one variable.

What variable was controlled in the tests?

_____

(1)

(ii) A homeowner has a glass conservatory built on the back of the house. The homeowner tells the builder that the inside of the conservatory should stay as cool as possible throughout the summer.

Explain why the builder uses 'type **B**' glass for the conservatory.

_____

_____

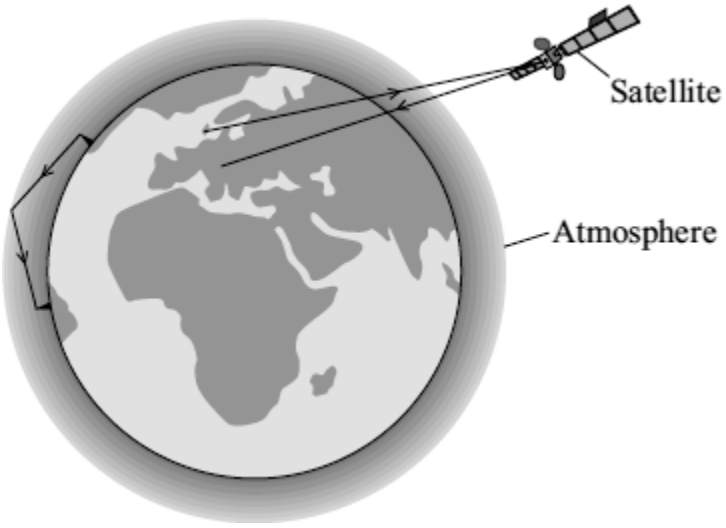
_____

_____

(2)

(Total 4 marks)

52 (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?

_____

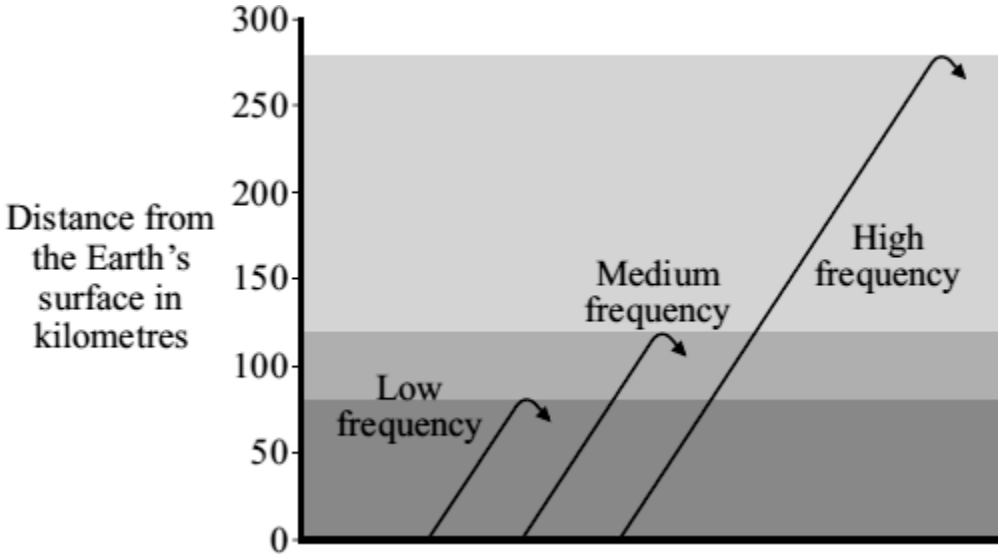
(1)

(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.

_____

_____

(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.

_____

_____

_____

_____

Frequency = _____ kHz

(2)

(Total 5 marks)

53 (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.

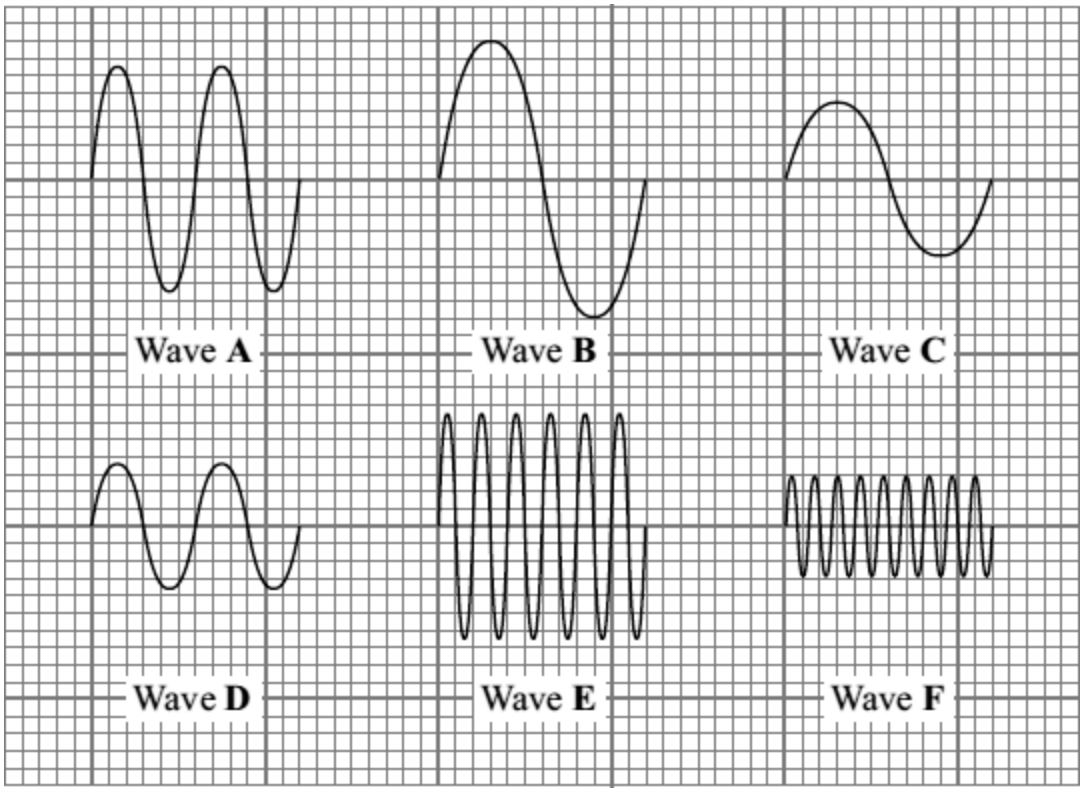
Include the unit in your answer.

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?

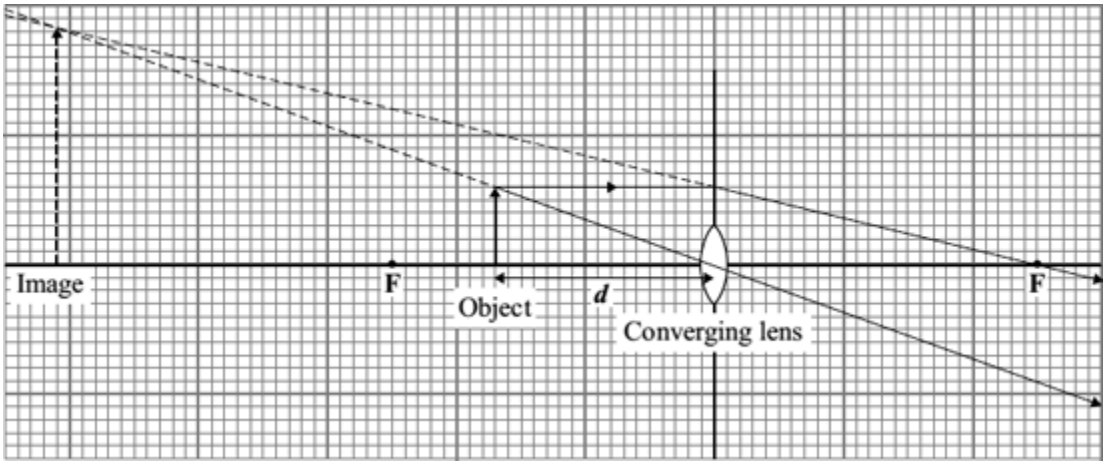
Wave _____

(1)

(Total 5 marks)

54 A student investigates how the magnification of an object changes at different distances from a converging lens.

The diagram shows an object at distance ***d*** from a converging lens.



(a) (i) The height of the object and the height of its image are drawn to scale.

Use the equation in the box to calculate the magnification produced by the lens shown in the diagram.

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

Show clearly how you work out your answer.

_____

_____

_____

Magnification = _____

(2)

(ii) The points **F** are at equal distances on either side of the centre of the lens.

State the name of these points.

_____

(1)

(iii) Explain how you can tell, **from the diagram**, that the image is virtual.

_____

_____

(1)

(b) The student now uses a different converging lens. He places the object between the lens and point **F** on the left.

The table shows the set of results that he gets for the distance d and for the magnification produced.

Distance d measured in cm	**Magnification**
5	1.2
10	1.5
15	2.0
20	3.0
25	6.0

His friend looks at the table and observes that when the distance doubles from 10 cm to 20 cm, the magnification doubles from 1.5 to 3.0.

His friend's conclusion is that:

The magnification is directly proportional to the distance of the object from the lens.

His friend's observation is correct but his friend's conclusion is **not** correct.

(i) Explain, with an example, why his friend's conclusion is **not** correct.

_____

_____

_____

_____

(2)

(ii) Write a correct conclusion.

_____

_____

(1)

(iii) The maximum range of measurements for d is from the centre of the lens to **F** on the left.

The student **cannot** make a correct conclusion outside this range.

Explain why.

_____

_____

(1)

(Total 8 marks)

55 The diagram shows the seven types of wave that make up the electromagnetic spectrum.

Gamma rays	X-rays	Ultraviolet rays	Visible light	Infra red rays	Micro-waves	Radio waves

(a) (i) Microwaves and visible light can be used for communications.

Name **one** more type of electromagnetic wave that can be used for communications.

_____

(1)

(ii) Name **one** type of electromagnetic wave that has a longer wavelength than microwaves.

_____

(1)

(b) Wi-Fi is a system that joins a laptop computer to the internet without using wires.
A 2400 megahertz microwave signal is used to link a computer to a device called a router.

What quantity is measured in hertz?

Draw a ring around your answer.

frequency **wavelength** **wave speed**

(1)

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

(i) Suggest **one** reason why more scientific research into the safety of Wi-Fi systems is needed.

_____

_____

(1)

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

What the politician said was

a fact.
an opinion.
a prediction.

(1)

(Total 5 marks)

56 (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.

_____

_____

_____

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?

_____

_____

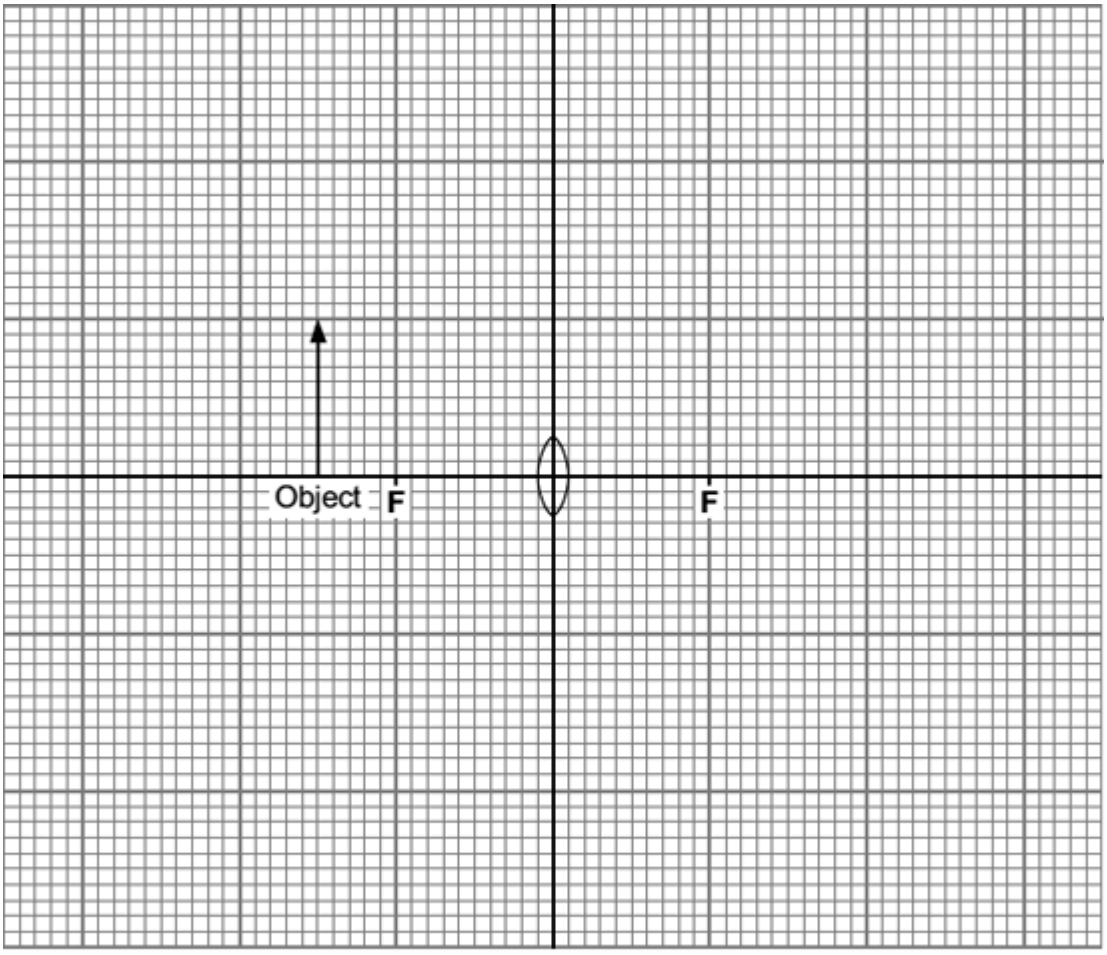
(1)

(Total 8 marks)

57 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.

_____

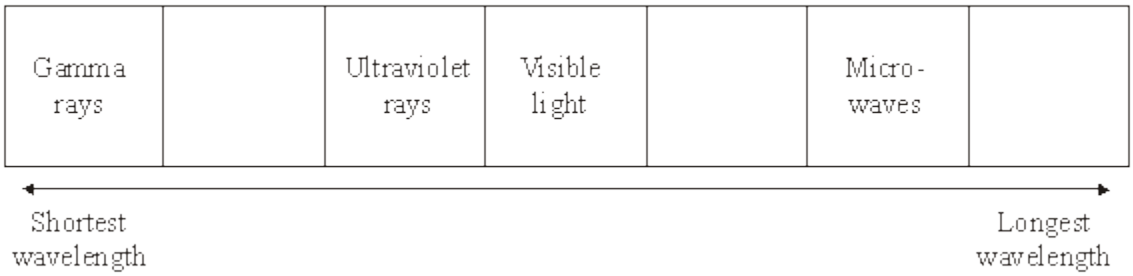
_____

_____

(2)

(Total 6 marks)

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



(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)

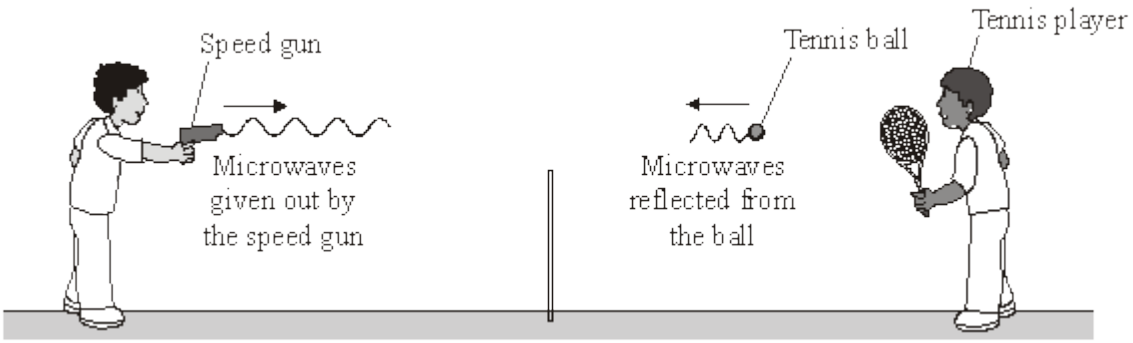
(iii) Complete the following sentence by drawing a ring around the correct word in the box.

All electromagnetic waves move | energy / gases / particles | from one place to another.

(1)

(Total 4 marks)

59 (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.

longer than	**the same as**	**shorter than**

The wavelength of the microwaves reflected from the ball are

_____ the wavelength of the microwaves

from the speed gun.

(1)

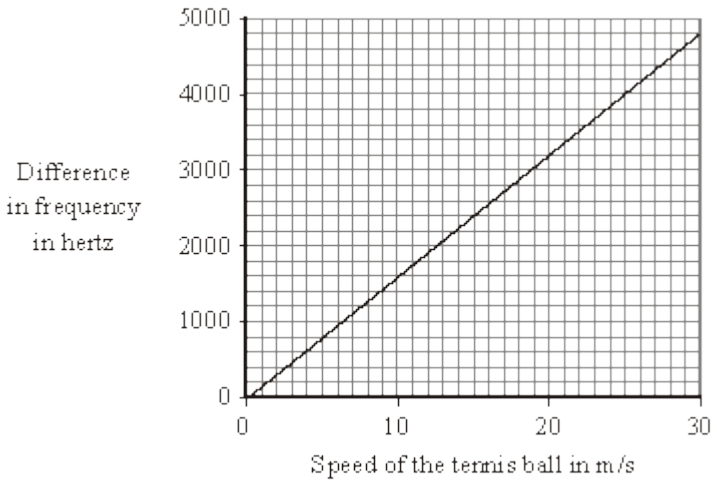
(ii) Complete the following sentence by drawing a ring around the correct line in the box.

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.

_____

_____

(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)