Mr Baker's Science-Stuff

Using Waves

Name: _____

Class: _____

Date: _____

Time: **226 minutes**

Marks: **224 marks**

Comments:

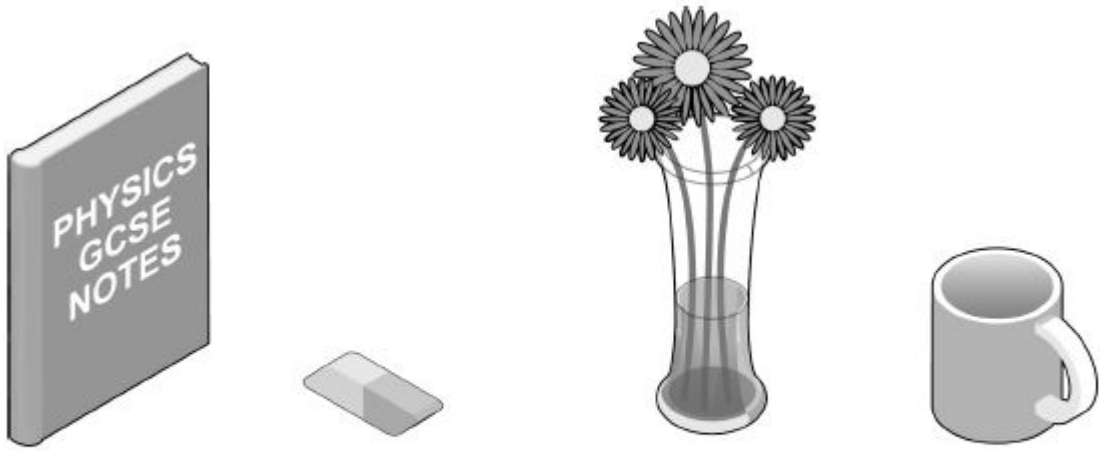
Q1.

Some objects are transparent and some objects are opaque.

(a) Which **one** of the objects in **Figure 1** is transparent?

Tick **one** box.

Figure 1



Book ☐ Pencil rubber ☐ Glass vase ☐ Ceramic mug ☐

(1)

(b) Complete the sentence.

Choose an answer from the box.

absorb	**reflect**	**transmit**

An opaque object does not _____ light.

(1)

A student wears a white T-shirt and a red baseball cap to a party.

(c) Why does the T-shirt look white in white light?

_____

_____

(1)

(d) Explain how the colour of the baseball cap appears to change when the room lights at the party change from white to blue.

_____

_____

_____

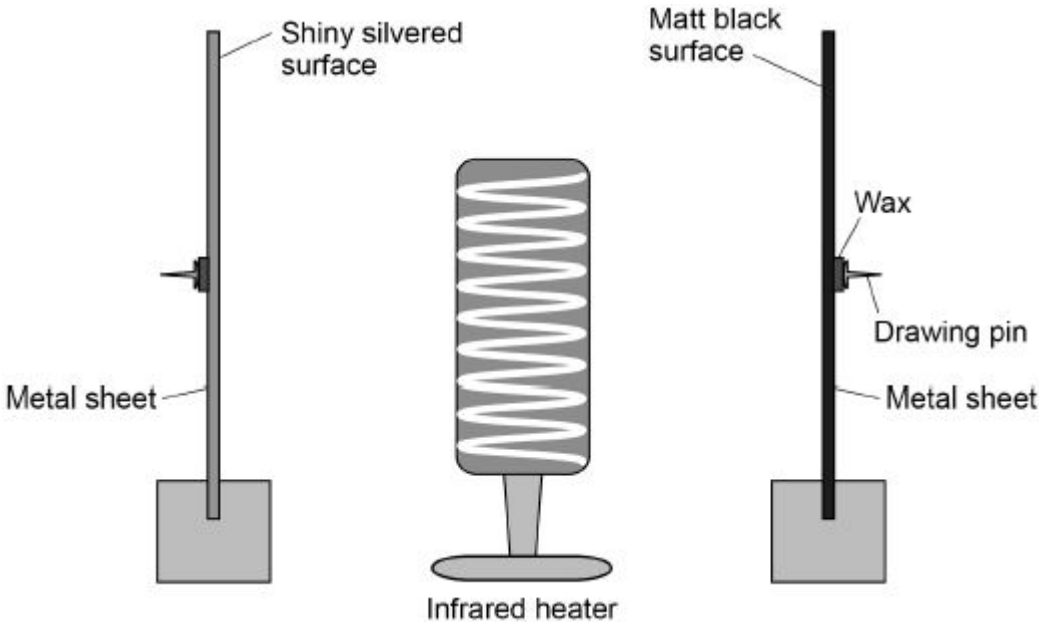
_____

(2)

A student investigated how the type of surface affects the amount of infrared radiation the surface absorbs.

Figure 2 shows the equipment that the student used.

Figure 2



The metal sheets absorb infrared radiation. The wax melts and the drawing pins fall off the surfaces.

(e) In the investigation there are several variables.

Draw **one** line from each variable to the correct description of that variable.

Variable	Description
Control	Distance from the metal sheets to the infrared heater.
Dependent	The surface colour of the metal sheets.
Independent	Time taken for the drawing pins to fall off.

(2)

(f) What is the main hazard in this investigation?

_____

_____

(1)

(g) The drawing pin attached to the matt black metal sheet fell off first.

What can be concluded from this result?

_____

_____

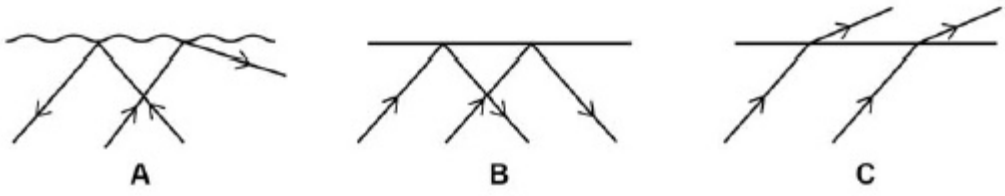
(1)

(Total 9 marks)

Q2.

(a) **Figure 1** shows what happens to rays of light incident on three different surfaces.

Figure 1



Which **one** of the diagrams shows diffuse reflection?

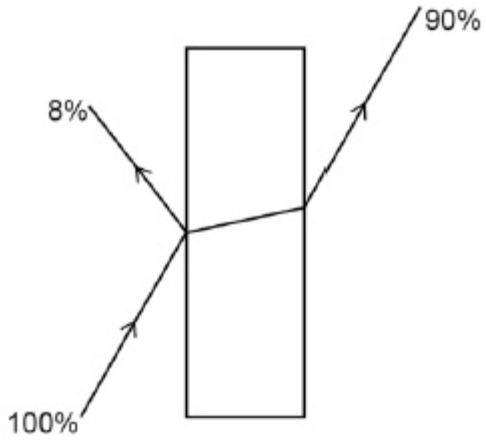
Tick **one** box.

A ☐ B ☐ C ☐

(1)

(b) **Figure 2** shows what happens to the energy transferred by a ray of light when the ray of light hits a glass block.

Figure 2



Calculate the percentage of the energy absorbed by the glass block.

_____

_____

Percentage of energy absorbed = _____ %

(1)

(c) Viewing an object through a colour filter may make the object look a different colour.

Complete the sentences.

Choose the answers from the box.

absorbs	**black**	**blue**
red	**reflects**	**transmits**

A red object viewed through a blue filter will look _____.

This is because the red object only _____ red light and the blue filter only _____ blue light.

(3)

(d) A white surface is viewed through a green filter.

What colour will the surface look?

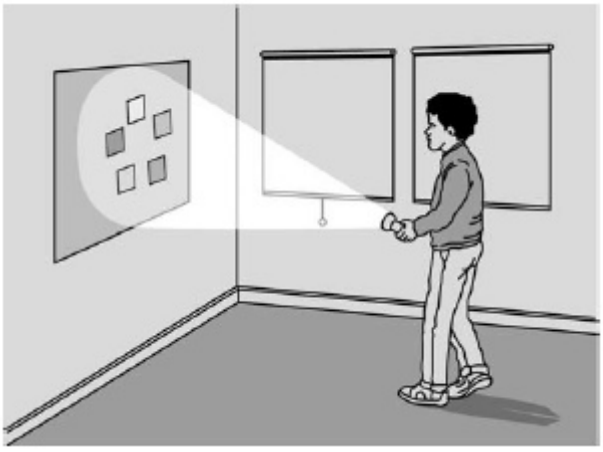
_____

(1)

Cyclists often wear clothing that reflects a lot of light.

Figure 3 shows a student investigating which colours are best at reflecting light.

Figure 3



This is the method used.

1. Small squares of different coloured material were stuck onto a piece of black paper at one end of a darkened laboratory.

2. The student switched on a torch and walked slowly towards the coloured squares.

3. The student stopped walking as soon as he could clearly see a coloured square.

4. The student measured the distance between the torch and the coloured square.

(e) Give a reason why it was important the student did the investigation in a darkened laboratory.

_____

_____

(1)

(f) Give a reason why it was important the area of each coloured square was the same.

_____

_____

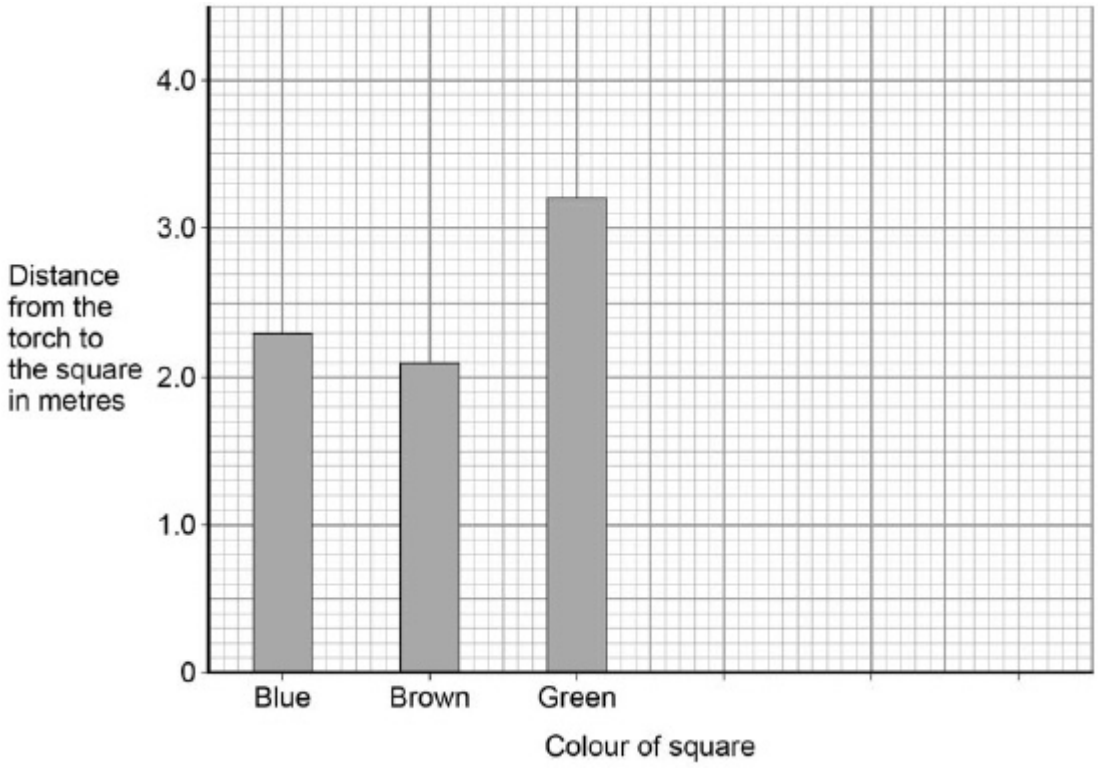
(1)

The table shows the student's results.

Colour of square	**Distance from the torch to the square in metres**
Blue	2.3
Brown	2.1
Green	3.2
Orange	3.4
Red	2.6

Figure 4 shows a bar chart with only three of the student's results.

Figure 4



(g) Complete the bar chart to show all of the results.

(3)

(h) Which colour clothing would be best for a cyclist to wear?

Use the data from the table.

Tick **one** box.

Blue ☐ Brown ☐ Green ☐ Orange ☐ Red ☐

Give a reason for your answer.

_____

_____

_____

(2)

(i) The student did the investigation again to obtain a second set of results.

The second set of results showed the same pattern as the first set.

Complete the sentence.

Choose the answer from the box.

accurate	**precise**	**repeatable**	**reproducible**

The measurements taken by the student were _____ .

(1)

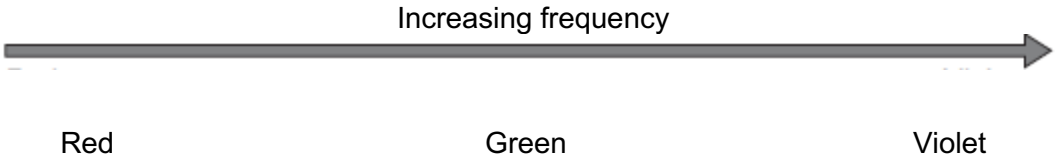
(Total 14 marks)

Q3.

(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

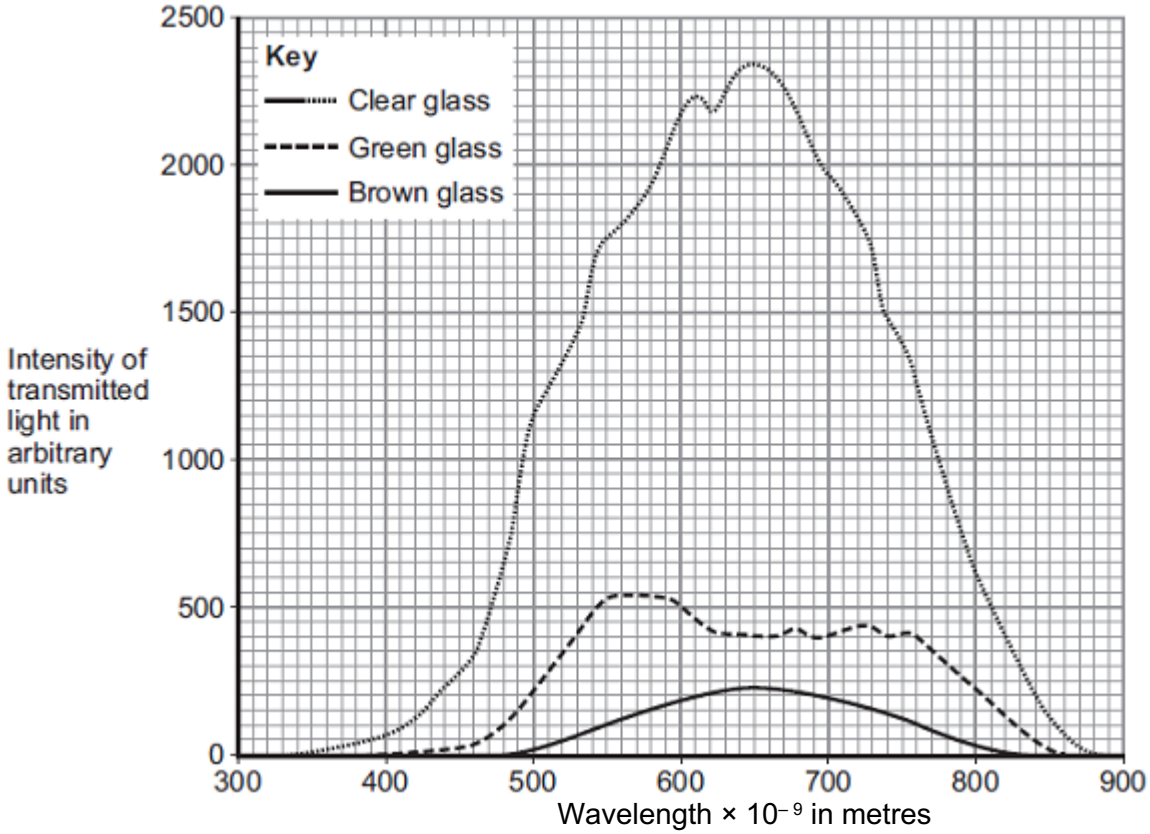
the energy of the light waves _____ .

(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)

Q4.

(a) Ultrasound is sound above the maximum frequency that humans can hear.

Tick (✓) **one** box.

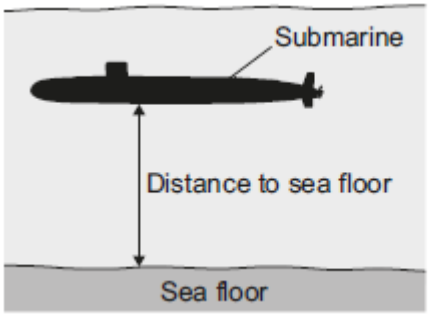
20 Hz ☐

2000 Hz ☐

20 000 Hz ☐

(1)

(b) The image shows a submerged submarine.



Not to scale

The submarine sends a pulse of ultrasound to the sea floor.
The pulse takes 0.25 seconds to travel from the submarine to the sea floor.

The speed of sound in water is 1600 m/s.

Calculate the distance from the submarine to the sea floor.

_____

_____

_____

_____

Distance = _____ m

(2)

(c) The ultrasound is reflected from the sea floor back to the submarine.
Use the correct answer from the box to complete the sentence.

half	**the same as**	**twice**

The total distance the ultrasound pulse travelled is _____ the distance to the sea floor.

(1)

(d) The submarine moves through the sea and every few seconds sends a pulse of

ultrasound to check the distance to the sea floor.

The table shows the time taken for five ultrasound pulses to travel from the submarine to the sea floor and back to the submarine.

Pulse number	Time for pulse to return in seconds
1	0.50
2	0.45
3	0.38
4	0.40
5	0.48

Describe how the distance from the submarine to the sea floor changed over these five pulses.

_____

_____

_____

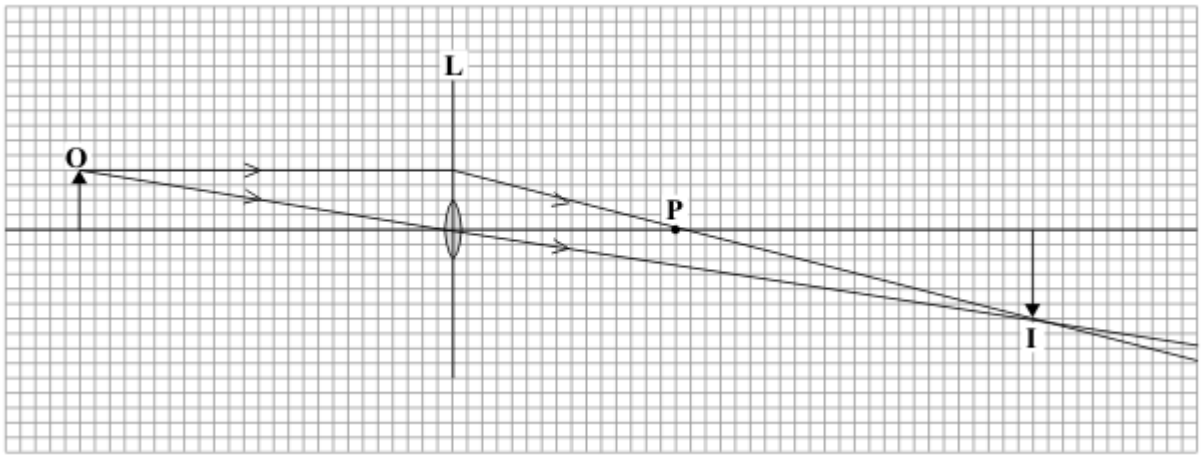
_____

(2)

(Total 6 marks)

Q5.

The ray diagram shows the position and size of the image, **I**, of an object, **O**, formed by a lens, **L**.



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

_____

(1)

(b) Name the point labelled **P**.

_____

(1)

(c) The ray diagram has been drawn to scale.

Use the equation to calculate the magnification.

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

Show clearly how you work out your answer.

_____

_____

Magnification = _____

(2)

(d) How can you tell from this ray diagram that the image is a real image?

_____

_____

(1)

(Total 5 marks)

Q6.

(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.

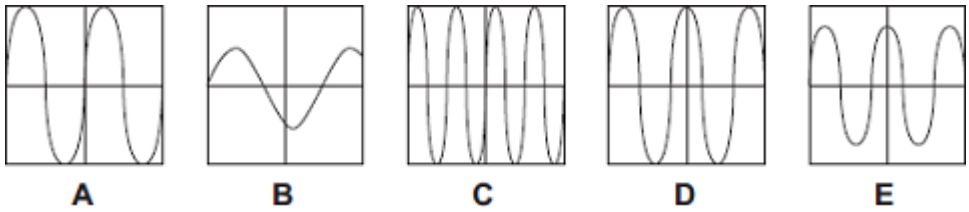
Include the unit in your answer.

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.

_____

_____

_____

_____

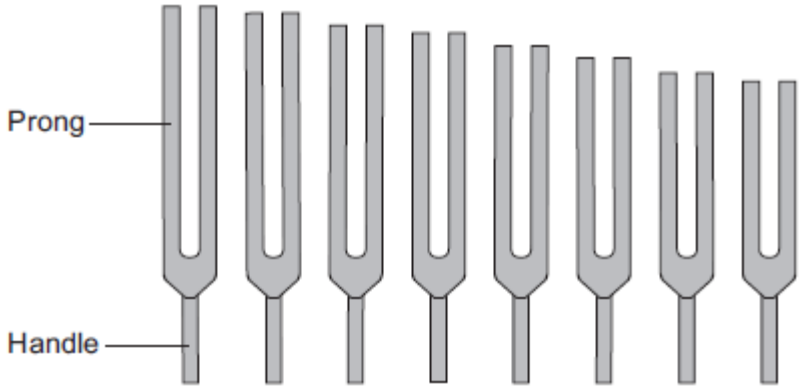
(2)

(Total 6 marks)

Q7.

Figure 1 shows a set of tuning forks.

Figure 1



A tuning fork has a handle and two prongs. It is made from metal.

When the prongs are struck on a hard object, the tuning fork makes a sound wave with a single frequency. The frequency depends on the length of the prongs.

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

direction	loudness	pitch	speed

The frequency of a sound wave determines its _____ .

The amplitude of a sound wave determines its _____ .

(2)

(b) Each tuning fork has its frequency engraved on it. A student measured the length of the prongs for each tuning fork.

Some of her data is shown in the table.

Frequency in hertz	Length of prongs in cm
320	9.5
384	8.7
480	7.8
512	7.5

(i) Describe the pattern shown in the table.

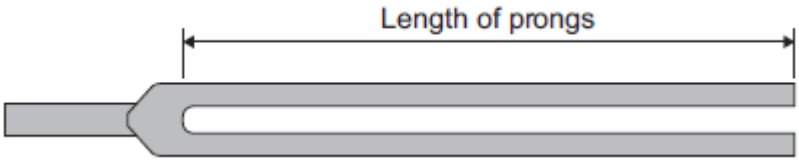
_____

_____

(1)

(ii) **Figure 2** shows a full-size drawing of a tuning fork.

Figure 2



Measure and record the length of the prongs.

Length of prongs = _____ cm

(1)

Use the data in the table above to estimate the frequency of the tuning fork in **Figure 2**.

Explain your answer.

_____

_____

_____

_____

_____

Estimated frequency = _____ Hz

(3)

(c) Ultrasound waves are used in hospitals.

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

electronic	**hydraulic**	**radioactive**

Ultrasound waves can be produced by _____ systems.

(1)

(ii) The frequency of an ultrasound wave used in a hospital is 2×10^6 Hz.

It is **not** possible to produce ultrasound waves of this frequency using a tuning fork.

Explain why.

_____

_____

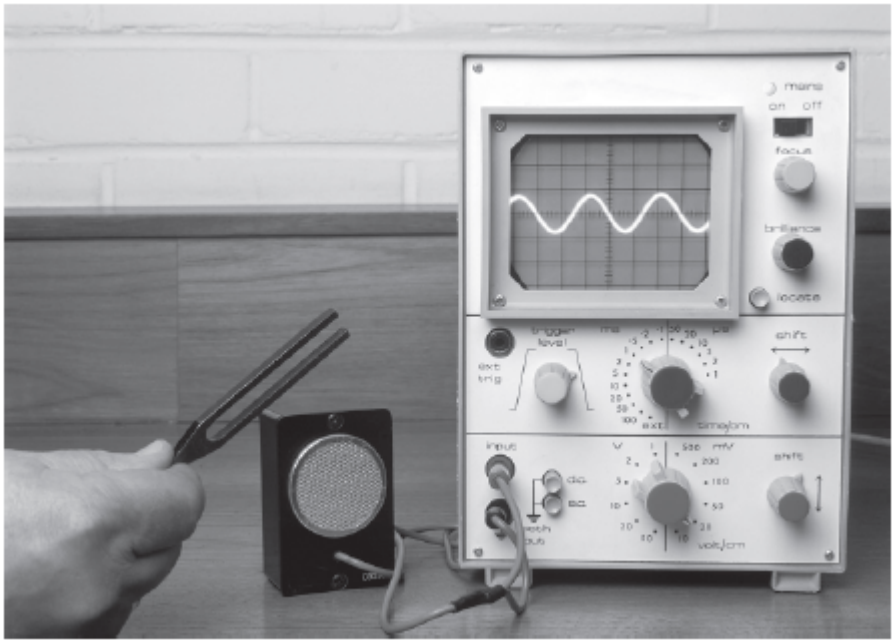
_____

_____

(2)

(d) **Figure 3** shows a tuning fork and a microphone. The microphone is connected to an oscilloscope.

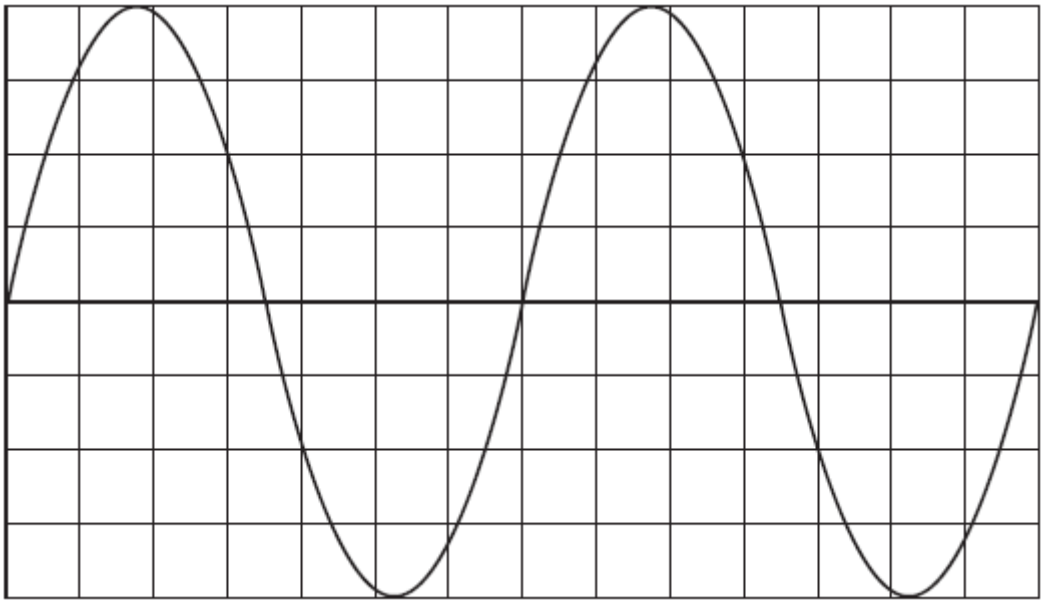
Figure 3



When the tuning fork is struck and then placed in front of the microphone, a trace appears on the oscilloscope screen.

Figure 4 shows part of the trace on the screen.

Figure 4



Each horizontal division in **Figure 4** represents a time of 0.0005 s.

What is the frequency of the tuning fork?

_____

_____

_____

Frequency = _____ Hz

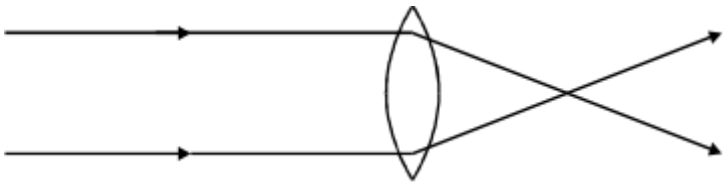
(3)

(Total 13 marks)

Q8.

(a) The diagram shows how parallel rays of light pass through a convex lens.

(i) Mark the position of the focus.



(1)

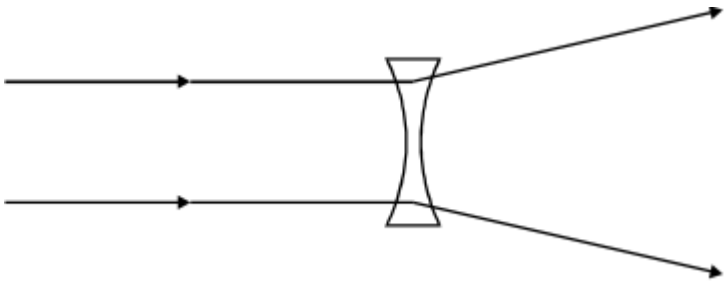
(ii) Is this a **converging** lens, a **diverging** lens, **both** or **neither**?

_____

(1)

(b) The diagram shows how parallel rays of light pass through a concave lens.

(i) Mark the position of the focus.



(1)

(ii) Is this a **converging** lens, a **diverging** lens, **both** or **neither**?

_____

(1)

(c) Complete these sentences by crossing out the **two** lines in each box that are wrong.

In a camera, a

converging
diverging
parallel

lens is used to produce an image of an object on a

film
lens
screen

.

The image is

larger than
smaller than
the same size as

the object.

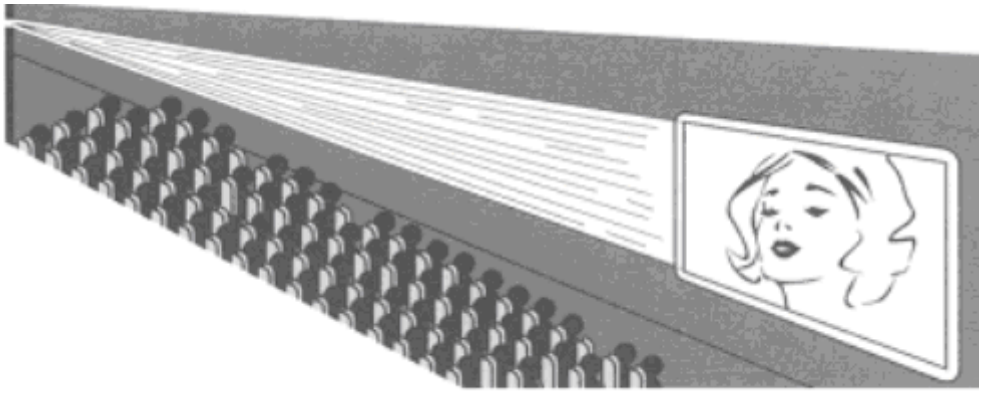
The image is

further from
nearer to
the same disrtance from

the lens, compared to the distance of the object from the lens.

(4)

(d) In a cinema projector, a convex lens is used to produce a *magnified*, *real* image.



(i) What does *magnified* mean?

_____

_____

(1)

(ii) What is a *real* image?

_____

_____

(1)

(e) You are in a dark room. You have a box containing some lenses. Only **one** of them is a converging lens.

Describe how, by just feeling the lenses, you can pick out the converging lens.

_____

_____

_____

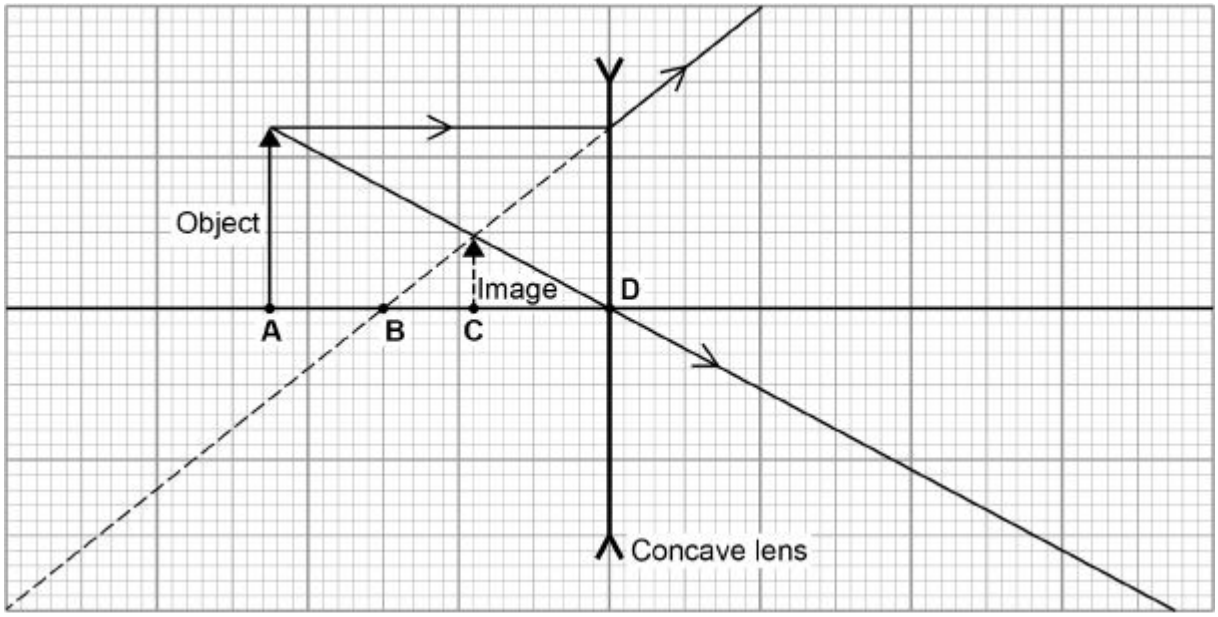
_____

(2)

(Total 12 marks)

Q9.

The graph shows how a concave lens forms an image of an object.



(a) Which point on the graph above marks the position of the principal focus of the lens?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

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

Tick **two** boxes.

Enlarged ☐

Inverted ☐

Real ☐

Upright ☐

Virtual ☐

(2)

(c) Calculate the magnification produced by the lens.

Use the equation:

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

Magnification = _____

(4)

(d) Complete the sentence.

Choose an answer from the box.

decrease	**increase**	**not change**

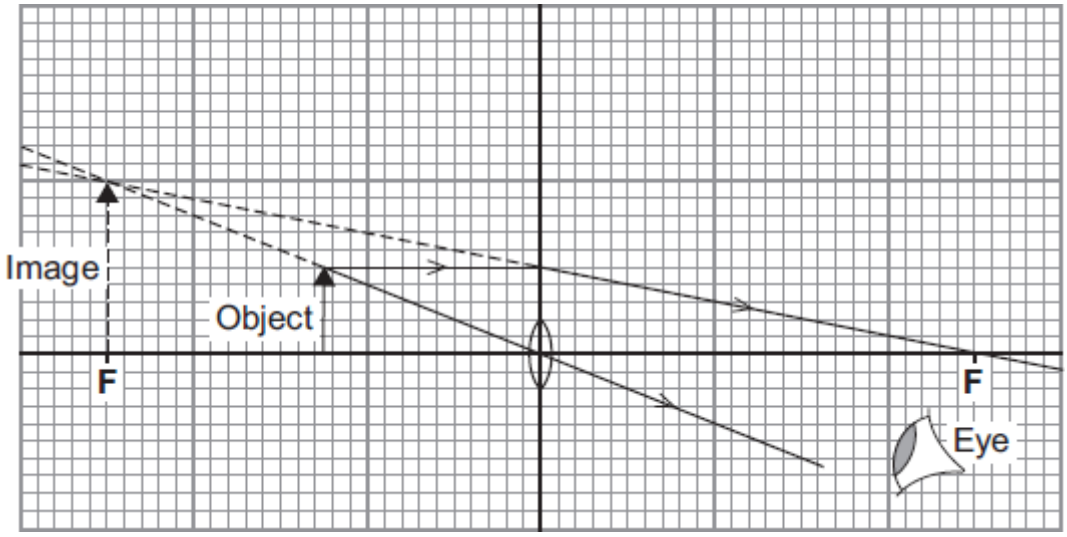
As the object is moved further away from the lens, the size of the image will _____ .

(1)

(Total 8 marks)

Q10.

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.

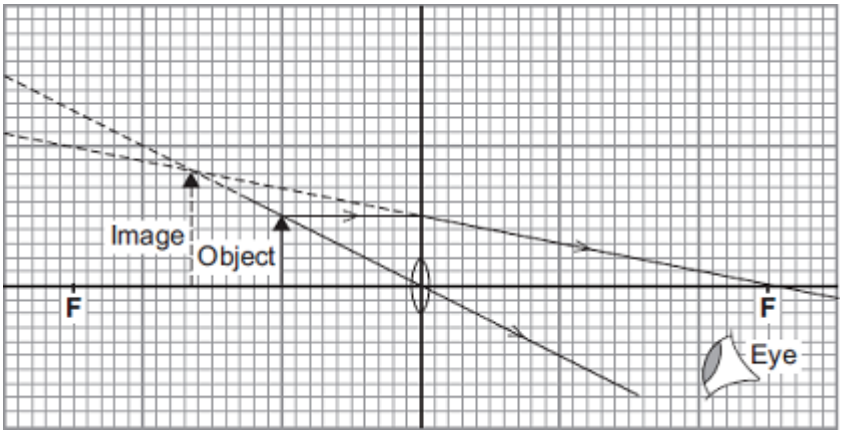
_____

_____

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)

Q11.

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

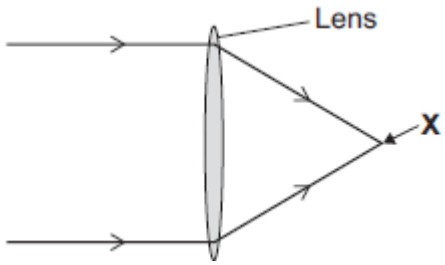
direction

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?

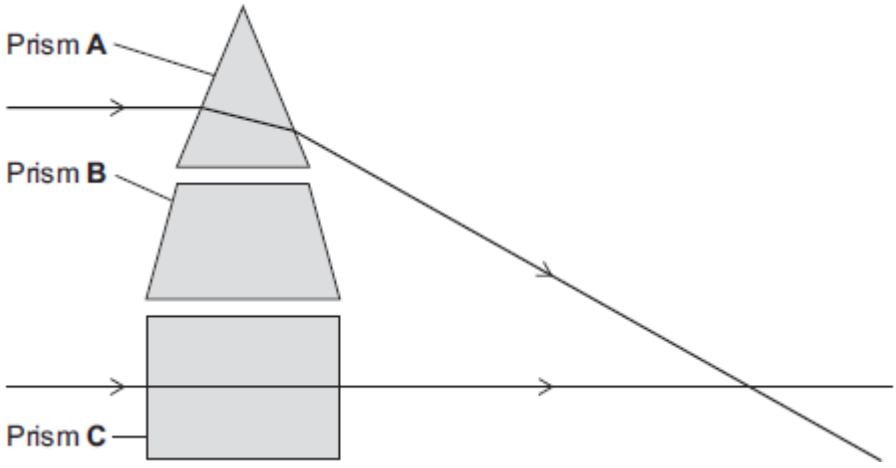
_____

(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)

Q12.

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.

_____

_____

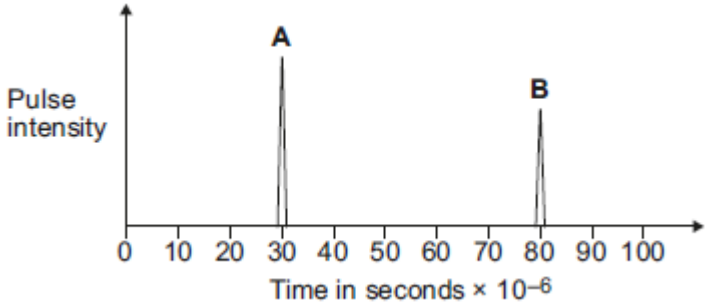
_____

_____

(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

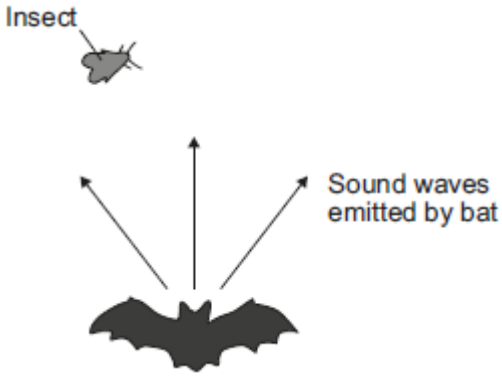
is very _____ .

(1)

(Total 12 marks)

Q13.

Bats use the reflection of high pitched sound waves to determine the position of objects. The image below shows a bat and an insect flying in front of the bat.



(a) What determines the pitch of a sound wave?

Tick (✓) **one** box.

	Tick (✓)
amplitude	
frequency	
speed	

(1)

(b) State the name given to reflected sound waves.

_____

(1)

(c) The bat emits a sound wave with a frequency of 25.0 kHz and a wavelength of 0.0136 metres.

Calculate the speed of this sound wave.

_____

_____

_____

Speed = _____ m/s

(2)

(d) Sound waves are longitudinal. Describe a longitudinal sound wave.

_____

_____

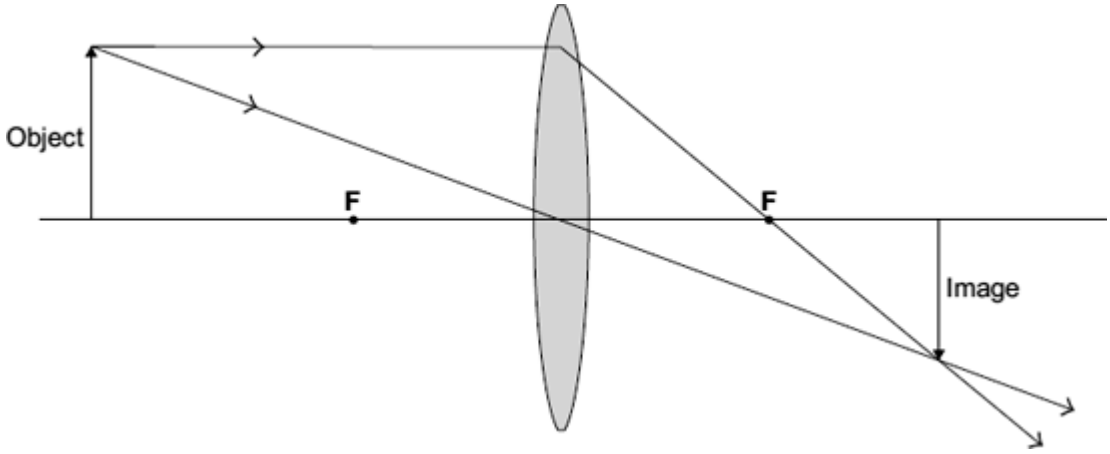
_____

(2)

(Total 6 marks)

Q14.

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.

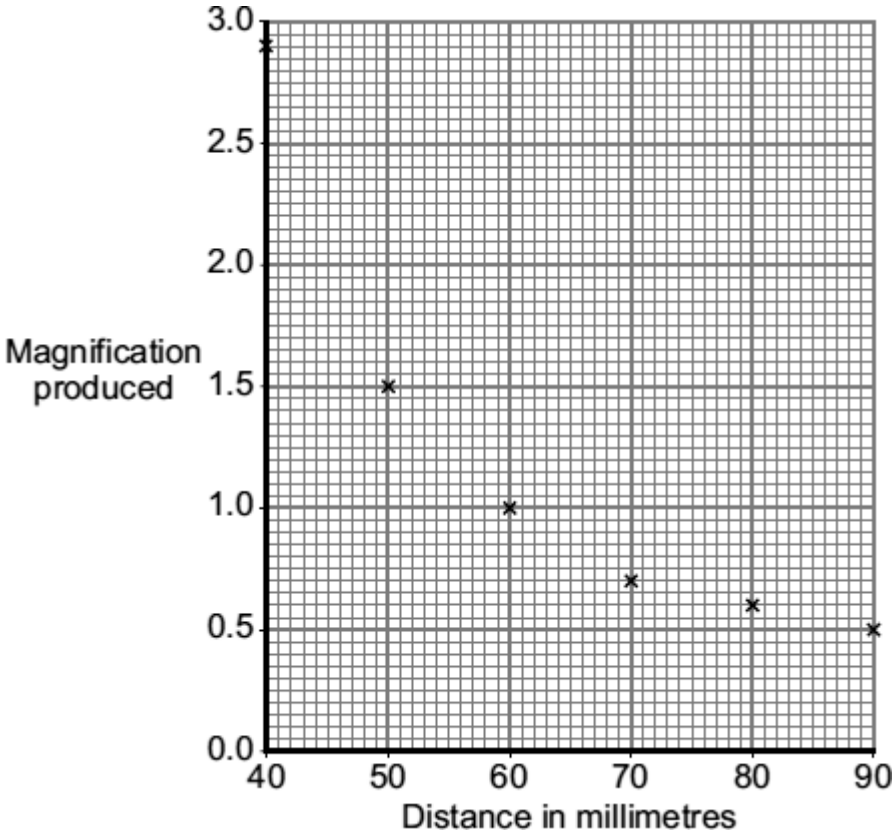
inverted	**larger**	**upright**

(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*.

_____

_____

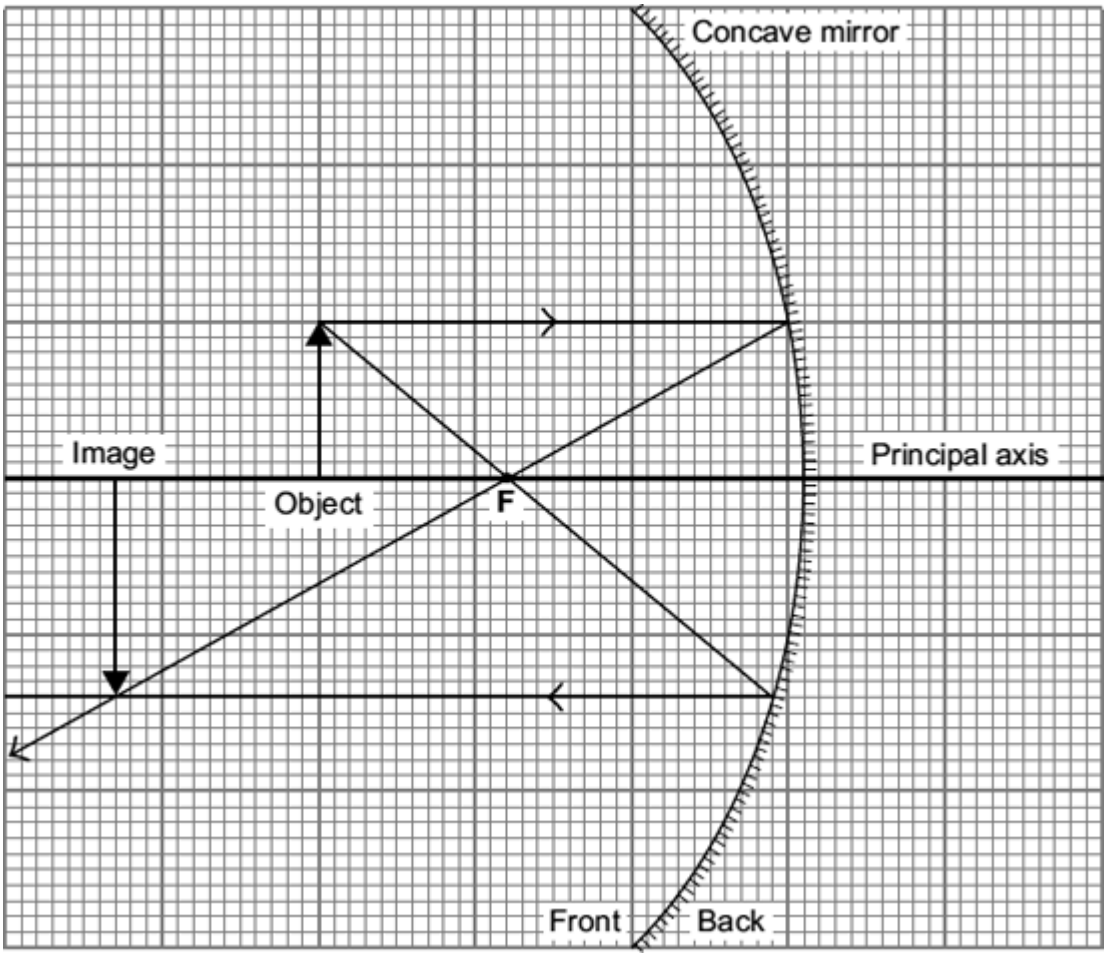
_____

(2)

(Total 8 marks)

Q15.

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)

Q16.

(a) Human ears can detect a range of sound frequencies.

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

2	**20**	**200**	**2000**	**20 000**

The range of human hearing is from about _____ Hz to _____ Hz.

(2)

(ii) What is ultrasound?

_____

_____

(1)

(iii) Ultrasound can be used to find the speed of blood flow in an artery.

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

_____

(1)

(b) The speed of an ultrasound wave in soft tissue in the human body is 1.5×10^3 m / s and the frequency of the wave is 2.0×10^6 Hz.

Calculate the wavelength of the ultrasound wave.

_____

_____

Wavelength = _____ m

(2)

(c) When ultrasound is used to find the speed of blood flow in an artery:

- an ultrasound transducer is placed on a person's arm
- ultrasound is emitted by the transducer
- the ultrasound is reflected from blood cells moving **away** from the transducer
- the reflected ultrasound is detected at the transducer.

Describe the differences between the ultrasound waves emitted by the transducer and the reflected waves detected at the transducer.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q17.

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.

_____

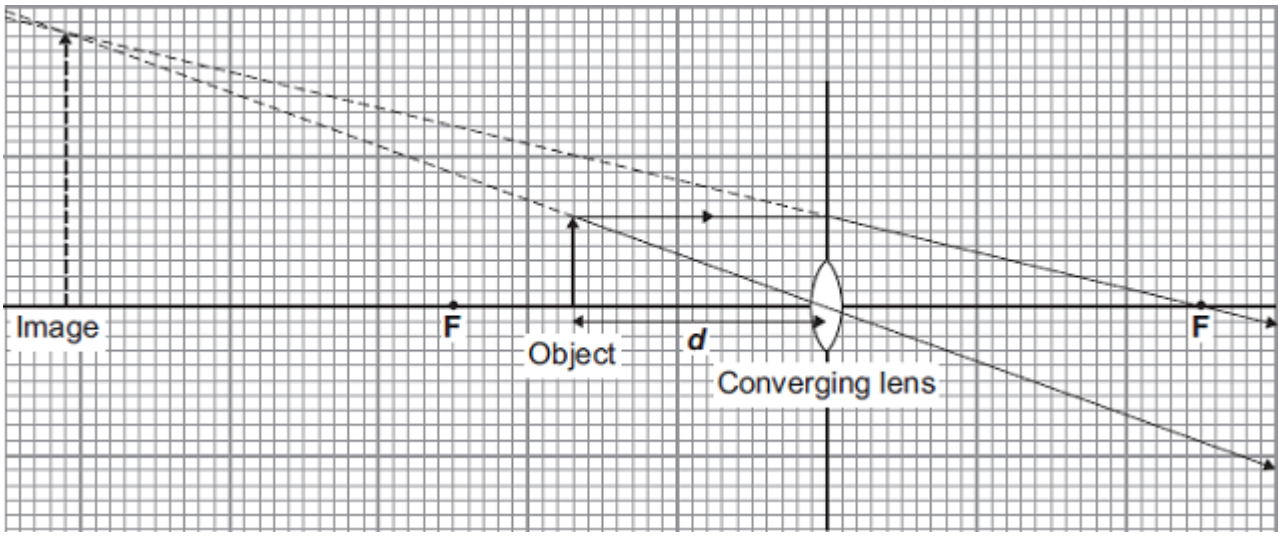
_____

(1)

(Total 9 marks)

Q18.

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.

_____

_____

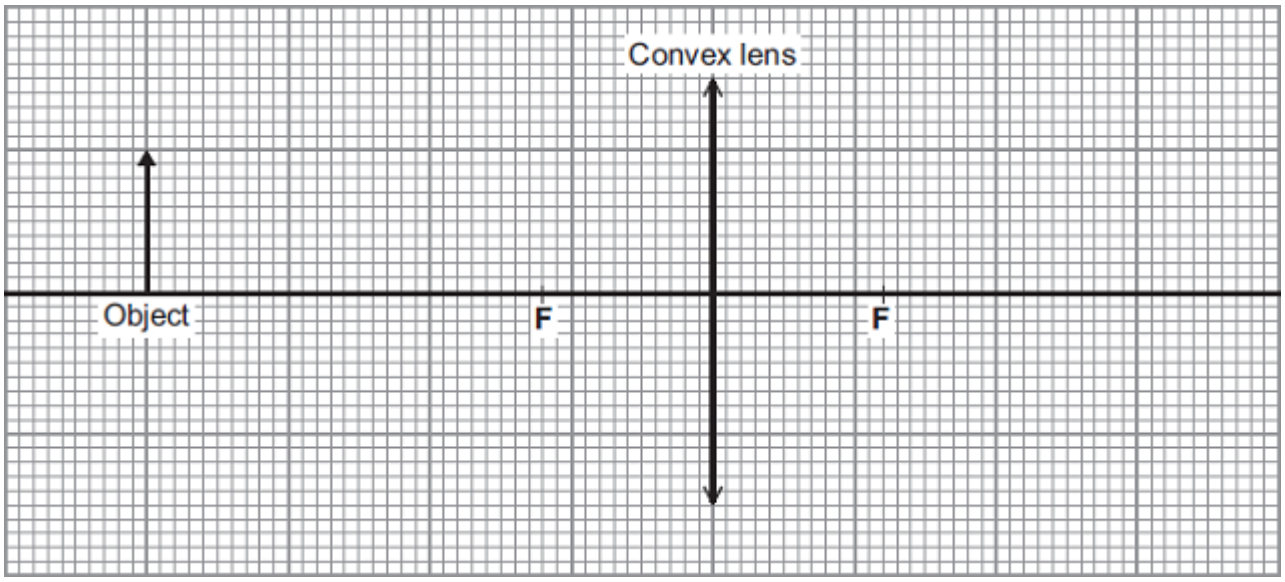
(1)

(Total 8 marks)

Q19.

(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. _____

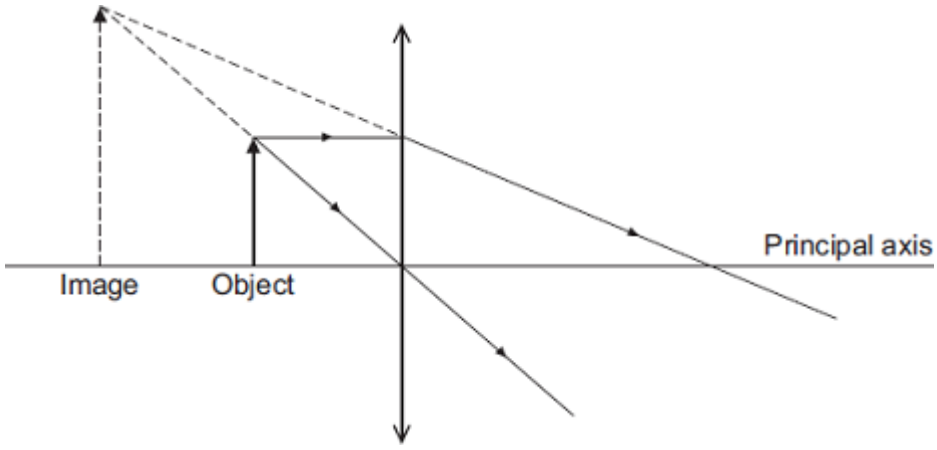
(2)

(Total 6 marks)

Q20.

(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)

Q21.

(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)

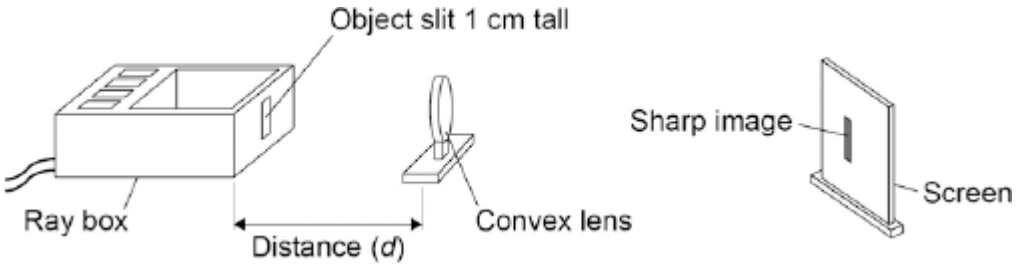
(Total 8 marks)

Q22.

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.

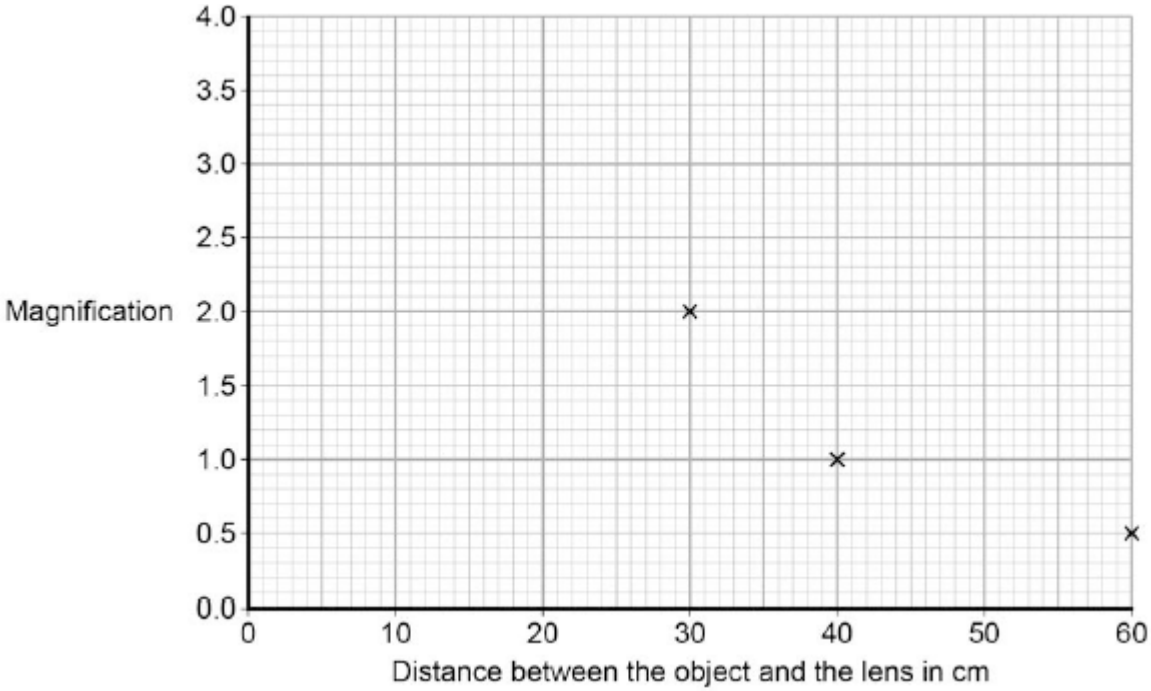
_____

_____

(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)

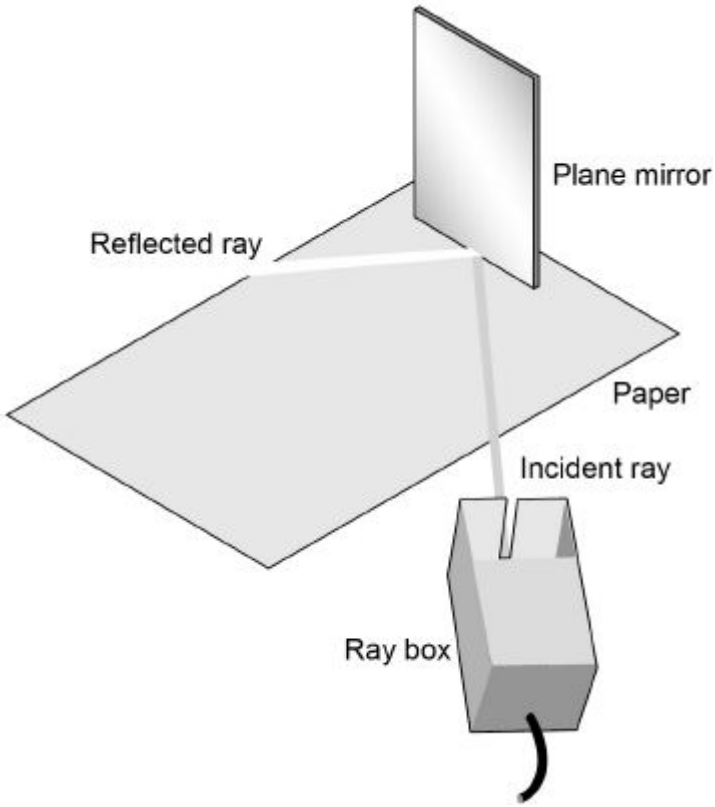
Q23.

The diagram below shows the apparatus a student used to investigate the reflection of light by a plane mirror.

The student drew four ray diagrams for each angle of incidence.

The student measured the angle of reflection from each diagram.

The table below gives the student's results.



	Angle of reflection			
Angle of incidence	**Test 1**	**Test 2**	**Test 3**	**Test 4**
20°	19°	22°	20°	19°
30°	31°	28°	32°	30°
40°	42°	40°	43°	41°
50°	56°	49°	53°	46°

(a) For each angle of incidence, the angle of reflection has a range of values.

This is caused by an error.

What type of error will have caused each angle of reflection to have a range of values?

_____

(1)

(b) Suggest what the student may have done during the investigation to cause each angle of reflection to have a range of values.

_____

_____

(1)

(c) Estimate the uncertainty in the angle of reflection when the angle of incidence is 50°.

Show how you determine your estimate.

_____

_____

_____

_____

Uncertainty = ± _____ °

(2)

(d) The student concluded that for a plane mirror, the angle of incidence is equal to the angle of reflection.

Explain whether you agree with this conclusion.

Use examples from the results in the table below in your answer.

_____

_____

_____

_____

(2)

(e) What extra evidence could be collected to support the student's conclusion?

_____

_____

(1)

(f) State **one** change the student should make to the apparatus if he wants to use the same method to investigate diffuse reflection.

_____

_____

(1)

(Total 8 marks)

Q24.

Ultrasound waves can be passed through the body to produce medical images.

When ultrasound waves are directed at human skin most of the waves are reflected.

If a material called a 'coupling agent ' is placed on the skin it allows most of the ultrasound waves to pass through the skin and into the body.

(a) What is 'ultrasound'?

_____

_____

_____

(2)

(b) Two ultrasound frequencies that are used are 1.1 MHz and 3.0 MHz.

The speed of ultrasound in water is 1500 m / s.

Calculate the wavelength of the 3.0 MHz waves in water.

_____

_____

_____

Wavelength = _____ m

(3)

(c) The coupling agent used with ultrasound is usually a gel.

Water would be a good coupling agent.

Suggest why water is **not** used.

_____

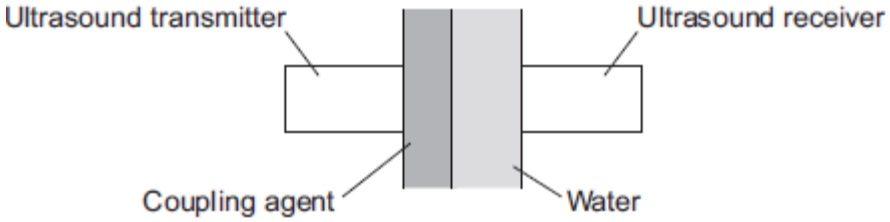
_____

(1)

(d) **Figure 1** shows a coupling agent being tested.

- An ultrasound transmitter emits waves.
- The waves pass through the coupling agent and then through the water.
- The waves are detected by the ultrasound receiver.

Figure 1



A scientist tests different coupling agents.

Suggest which variables she must control.

Tick (✓) **two** boxes.

	Tick (✓)
The amount of light in the room	
The colour of the coupling agent	
The width of the coupling agent	
The width of the water	

(2)

(e) The table shows the results for coupling agents **A**, **B**, **C**, **D**, **E**, **F** and **G**.

They were tested using the two frequencies, 1.1 MHz and 3.0 MHz.

The results show how well the waves pass through the coupling agent compared with how they pass through water. The results are shown as a percentage.

100% means that the coupling agent behaves the same as water.

Coupling agent	Coupling agent percentage using 1.1 MHz	Coupling agent percentage using 3.0 MHz
A	108	100
B	105	100
C	104	98
D	100	98
E	98	98
F	95	99
G	89	88

(i) Which coupling agent allows most ultrasound to pass through at both frequencies? ☐

(1)

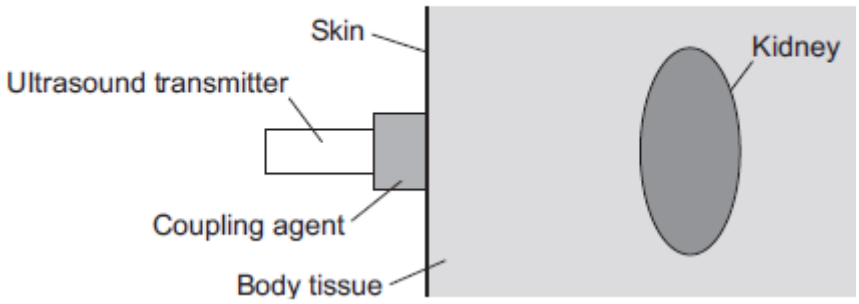
(ii) Which coupling agent performs the same for both frequencies? ☐

(1)

(f) **Figure 2** shows an ultrasound transmitter sending waves into a patient's body.

The waves enter the body and move towards a kidney.

Figure 2



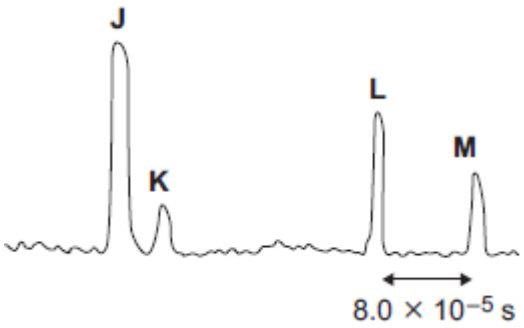
The transmitter also detects the ultrasound waves.

The transmitter is connected to an oscilloscope.

Figure 3 shows the trace on the screen of the oscilloscope.

J represents the intensity of the waves emitted by the transmitter.

Figure 3



(i) Explain the intensities at **K**, **L** and **M**.

(6)

(ii) The speed of ultrasound waves in the body is 1500 m/s.

Use information from **Figure 3** to calculate the maximum width of the kidney.

_____

_____

_____

Maximum width of kidney = _____ m

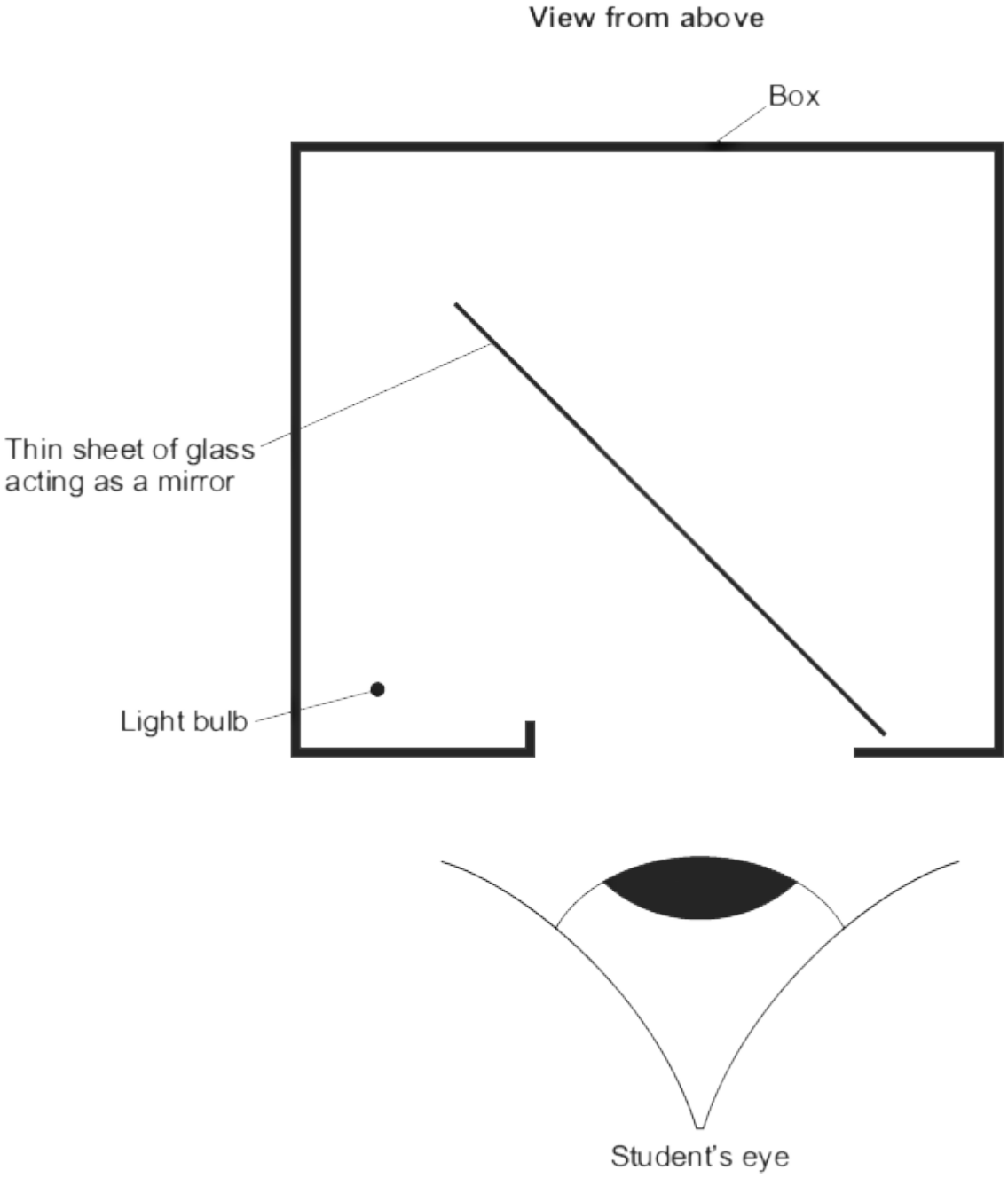
(3)

(Total 19 marks)

Q25.

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?

_____

_____

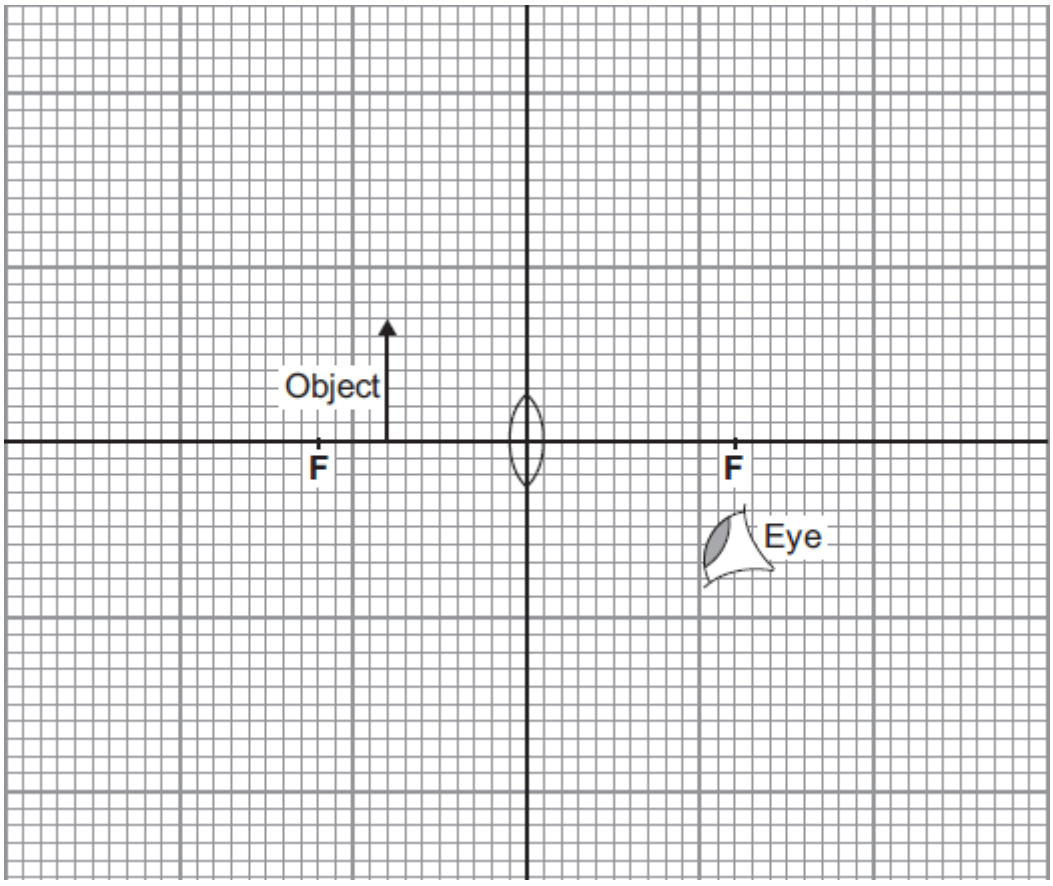
(1)

(Total 5 marks)

Q26.

(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.

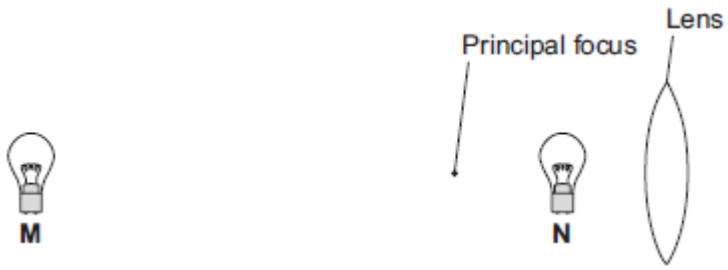
(2)

(Total 7 marks)

Q27.

(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



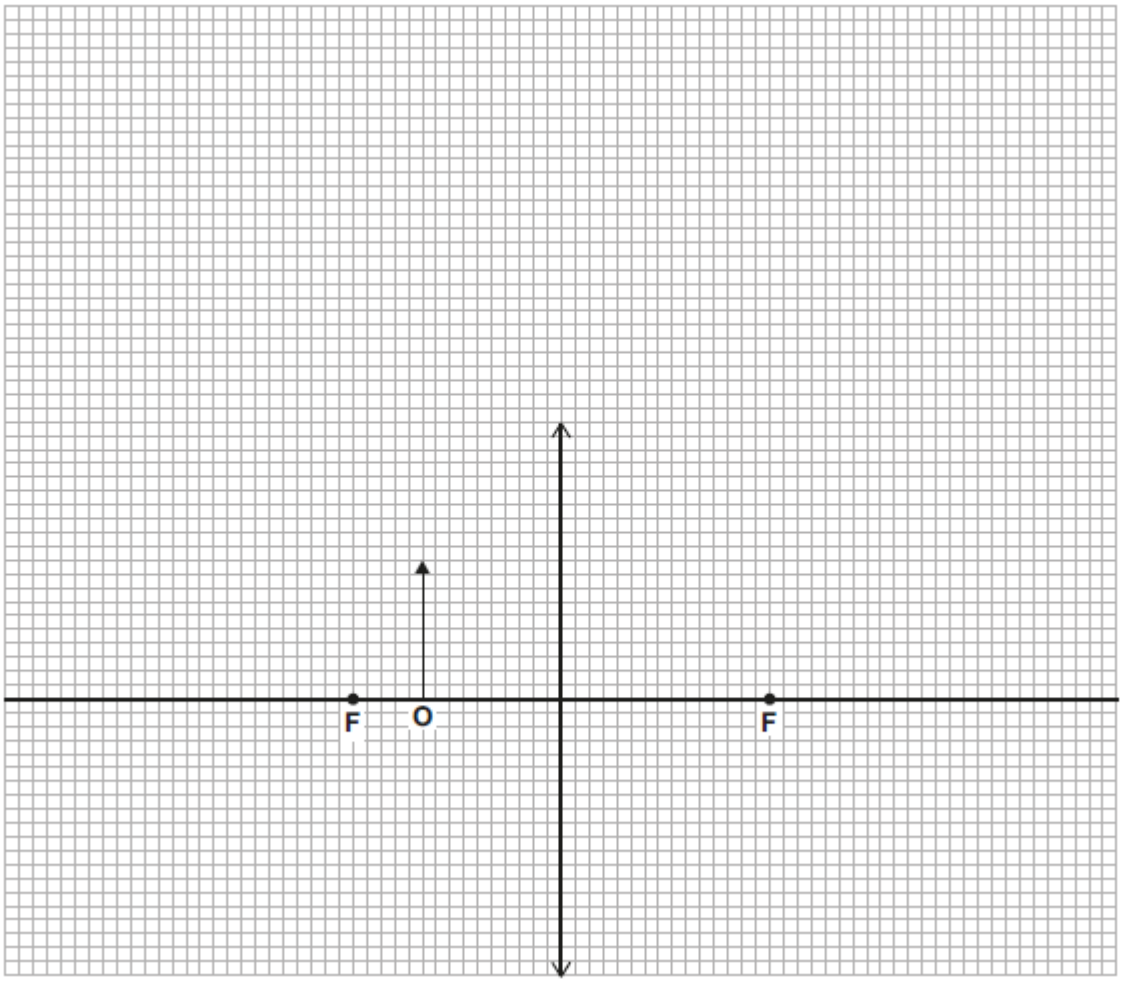
Describe how the nature of the image formed changes as the light bulb is moved from position **N** to position **M**.

(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

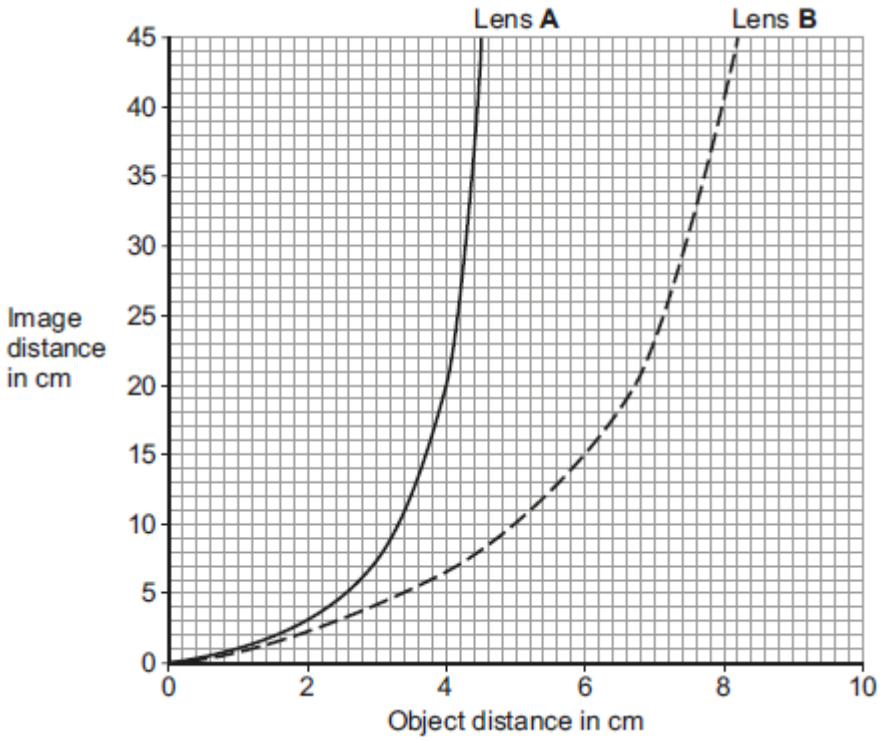


(3)

(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)

Q1.

(a) glass vase

1

(b) transmit

1

(c) the T-shirt reflects all wavelengths / colours of light (equally)

allow T-shirt reflects (white / all) light

1

(d) changes from red to black

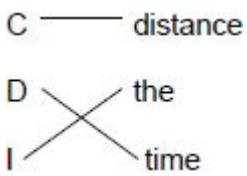
it appears black
it is darker is insufficient

1

as the cap absorbs (all) the (blue) light
or
as the cap does not reflect the (blue) light

1

(e)



all 3 lines correct

*allow **1** mark for 1 line correct*

if more than one line drawn from a variable all of those lines do not score

2

(f) the (infrared) heater

allow infrared (radiation)

*do **not** accept answers where burning yourself is given as the hazard*

1

(g) answer must be a comparison, e.g. the matt / black surface is the better absorber (of infrared radiation)

matt black is a good absorber is insufficient

1

[9]

Q2.

(a) **A**

1

(b) 2 (%)

1

(c) black

correct order only

1

reflects

1

transmits

1

(d) green

1

(e) without a darkened laboratory would not be able to see reflected light

allow would see all squares all of the time

1

(f) so same 'amount' of light is incident on each square

a fair test is insufficient

control variable is insufficient

1

(g) two bars drawn at the correct height

*allow **1** mark for 1 correct bar*

2

both bars correctly labelled

1

(h) orange

reason only scores if orange chosen

1

can be seen from the furthest away

allow it reflects the most light

1

(i) repeatable

1

[14]

Q3.

(a) decreases

correct order only

1

increases

1

(b) (i) intensity (of transmitted light) depends on thickness

or

to enable a valid comparison

or

it is a control variable

accept absorption depends on thickness

it would affect the results is insufficient
fair test is insufficient

1

(ii) transmits the least light
or
absorbs the most light

accept very little light is transmitted
*do **not** accept transmits none of the light*
*do **not** accept absorbs all of the light*
any reference to heat negates this mark

1

[4]

Q4.

(a) 20 000 Hz

1

(b) 400 (m)

*allow **1** mark for correct*
substitution ie 1600 × 0.25
provided no subsequent steps shown
*an answer of 200 (m) gains **1** mark*

2

(c) twice

1

(d) From pulse 1 to pulse 3 the distance (to the sea floor) decreased

accept the sea got shallower
or
the submarine went deeper for the distance decreased

1

then (after pulse 3) the distance (to the sea floor) increased

accept the sea got deeper
or
the submarine rose for the distance increased
*An answer of the distance decreased then increased gains **1** mark*

1

[6]

Q5.

(a) converging

or convex

1

(b) (principal) focus

or focal point

1

(c) **either** (×)1.5 **or** (×)1½ **or** 150%

*unambiguous evidence of appropriate measurements for **1** mark only eg 4 and 6 **or** 8 and 12 **or** 0.8 and 1.2*

2

(d) real rays cross to form it / formed at the intersection of real rays

accept 'image on the opposite side of the lens to the object'
accept 'can be put onto a screen'

1

[5]

Q6.

(a) (i) bat(s)

1

(ii) any example in the inclusive range 5 ↔ 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]

Q7.

(a) pitch

1

loudness

1

(b) (i) as length (of prongs) decreases frequency / pitch increases

accept converse
accept negative correlation
ignore inversely proportional

1

(ii) 8.3 (cm)

accept 8.3 ± 0.1 cm

1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)

*ecf from part **(ii)***

1

(so *f* must be) between 384 (Hz) and 480 (Hz)

1

410 (Hz) ≤ *f* ≤ 450 (Hz)

*if only the estimated frequency given, accept for **1** mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high

accept frequency above
*20 000 (Hz) **or** audible range*

1

so tuning fork ***or*** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)

accept any correct rounding 286, 290, 300
*allow **2** marks for 285*
*allow **2** marks for correct substitution 0.0035 = 1 / f*
*allow **1** mark for T = 0.0035 s*
*allow **1** mark for an answer of 2000*

3

[13]

Q8.

(a) (i) point where the rays cross

do not credit if ambiguous

1

(ii) converging (lens)

*do **not** accept convex*

1

(b) (i) point where the rays appear to diverge from

this should appear to be within 10mm in front of the back of the arrows on the approximate centre line
need not be accurately constructed using a ruler

1

(ii) diverging (lens)

*do **not** accept concave*

1

(c) converging

1

film

1

smaller than

nearer to

accept any clear indication of the response e.g. ticking, ringing, writing in after a mistake

1

(d) (i) (image) bigger than object enlarge

accept just 'made bigger'

1

(ii) it / real image can be put on a screen **or** real image on the opposite side of the lens to the object

accept 'not an imaginary or virtual image'

assume 'it' refers to a real image

*do **not** credit 'it can be seen'*

1

(e) **either** (the converging lens is) thick in the middle thin(ner) at the edge

1

*thickest in the middle gains **2** marks*

1

or (both) sides bend outwards (1) in the middle (1)

*convex gains **2** marks*

*suitable diagrams gains **2** marks*

or one side bends in the middle (1) more than the other side bends inwards (in the middle) (1)

1

[12]

Q9.

(a) B

1

(b) upright

1

virtual

1

(c) image height = 9.5(mm)

allow any value between 9 and 10 inclusive

allow 5 (squares)

1

object height = 24(mm)

allow 12 (squares)

1

$$\text{magnification} = \frac{9.5}{24}$$

or

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

1

magnification = 0.4

allow an answer that rounds to 0.4 provided both object height and image height are correct

or

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

ignore any units

correctly calculated

1

*an answer of 0.4 scores **4** marks*

(d) decrease

1

[8]

Q10.

(a) (i) converging

1

(ii) (x) 2

*allow **1** mark for correct substitution*
*ie 10/5 **or** 20/10 **or** 2/1*
ignore any units

2

(b) decreases

1

[4]

Q11.

(a) refraction

1

(b) towards the normal

1

(c) (i) convex

1

(ii) principal focus

accept focal point

1

(d) parallel on left

1

refracted towards the normal at first surface

1

refraction away from normal at second surface

1

passes through or heads towards principal focus

1

(e) refractive index

accept material from which it is made

1

(radius of) curvature (of the sides)

accept shape / radius

*do **not** accept power of lens*

ignore thickness / length

1

[10]

Q12.

(a) ultrasound is not ionising

allow ultrasound does not harm the (unborn) baby

1

but X-rays are ionising

1

so X-rays increase the health risk to the (unborn) baby

accept specific examples of health risks, eg cancer, stunted growth, impaired brain function etc

X-rays are dangerous is insufficient

1

(b) ultrasound/waves are partially reflected

(when they meet a boundary) (between two different media / substances / tissues)

must be clear that not all of the wave is reflected

1

the time taken is measured (and is used to determine distances)

1

(c) 1600 (m/s)

*800 (m/s) gains **2** marks*

*160 000 (m/s) gains **2** marks*

*0.0016 (m/s) gains **2** marks*

*allow **2** marks for*

$$\frac{0.04}{25 \times 10^{-6}}$$

or

$$\frac{0.08}{50 \times 10^{-6}}$$

*80 000 (m/s) gains **1** mark*

*0.0008 (m/s) gains **1** mark*

*allow **1** mark for*

$\frac{0.04}{25}$

or

$\frac{0.08}{50}$

*allow **1** mark for evidence of doubling the distance or halving the time*

3

(d) (i) they are absorbed by bone

allow stopped for absorbed

X-rays are reflected negates this mark

1

they are transmitted by soft tissue

allow pass through for transmitted

allow flesh / muscle / fat

accept less (optically) dense material for soft tissue

1

(the transmitted) X-rays are detected

1

(ii) short

accept small

1

[12]

Q13.

(a) frequency

1

(b) echo(es)

1

(c) 340 (m/s)

*allow **1** mark for correct substitution ie 25 000 × 0.0136 provided no subsequent step*

or

*allow **1** mark for a correct calculation showing an incorrect value from conversion to hertz × 0.0136*

*an answer of 0.34 gains **1** mark*

2

(d) (a wave where the) oscillations are parallel to the direction of energy transfer

both marking points may appear as labels on a diagram

accept vibrations for oscillations
accept in same direction as for parallel to
allow direction of wave (motion) for direction of energy transfer

*allow **1** mark for a correct calculation showing an incorrect value from conversion to hertz × 0.0136*

1

causing (areas of) compression and rarefaction

accept correct description in terms of particles

mechanical wave is insufficient
needs a medium to travel through is insufficient

1

[6]

Q14.

(a) converging (lens)

accept 'convex (lens)'

accept biconvex

1

(b) (principal) foci

accept 'focus' / 'focuses' / 'focis'

focal point(s)

1

(c) (i) formed where (real) rays (of light) intersect / meet / cross

accept rays (of light) pass through the image

accept 'image is on the opposite side (of the lens to the object)'

accept (construction) lines cross over

a response relating to a screen or similar is neutral

lines are solid and not dotted is neutral

1

(ii) inverted

accept any unambiguous correct indication

1

(d) (i) smooth curve which matches the points

*judge by eye but do **not** accept point to point by ruler or otherwise*

1

(ii) continuous

1

(iii) as distance increases, magnification decreases

accept negative correlation

*a statement 'inversely proportional' is incorrect and limits maximum mark for this part question to **1***

1

further detail eg magnification falls steeply between 40 and 50 cm
or
magnification begins to level out after / at 70 cm

1

[8]

Q15.

1.4

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

ie 14 ÷ 10

or

28 ÷ 20

[2]

Q16.

(a) (i) 20

1

20 000

either order

accept ringed answers in box

1

(ii) (frequency) above human range

accept pitch for frequency

or

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning

  accept any other appropriate scanning use

  *do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  accept curing prostate cancer or killing prostate cancer cells
- removing plaque from teeth

  cleaning teeth is insufficient

1

(b) 7.5×10^{-4} (m)

*$1.5 \times 10^{3} = 2.0 \times 10^{6} \times \lambda$ gains **1** mark*

2

(c) for reflected waves

must be clear whether referring to emitted or detected / reflected waves

if not specified assume it refers to reflected wave

any **two** from:

- frequency decreased
- wavelength increased

- intensity has decreased

  allow amplitude / energy has decreased
  allow the beam is weaker

2

[8]

Q17.

(a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant / correct content.

Level 1 (1-2 marks)
There is a basic description of either wave
OR
What happens to either wave when they enter the body. However there is little other detail.

Level 2 (3-4 marks)
There is either:
A clear description of BOTH waves
OR
A clear description as to what happens to BOTH waves inside the body
OR
A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

Level 3 (5-6 marks)
There is a detailed description of BOTH of the waves
AND
A detailed description as to what happens to EITHER wave inside the body.

Examples of the points made in the response:

Description of an X-ray

- X-rays are electromagnetic waves / part of the electromagnetic spectrum

  *do **not** allow a description of a property – eg X-rays travel*

- X-rays are (very) high frequency (waves)

  through a vacuum / at the speed of light

- X-rays are (very) high energy (waves)

- X-rays have a (very) short wavelength

- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom

- X-rays are a transverse wave

  correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer

- X-rays are ionising radiation

Description of ultrasound

- ultrasound has a frequency above 20 000 (hertz)

  or

  ultra sound is above 20 000 hertz

- ultrasound is above / beyond the human (upper) limit (of hearing)

  accept ultrasound cannot be heard by humans

- ultrasound is a longitudinal wave

  correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer

Statement(s) as to what happens to X-rays inside the human body:

- X-rays are absorbed by bone

- X-rays travel through / are transmitted by tissue / skin

Statement as to what happens to ultrasound inside body:

- ultrasound is (partially) reflected at / when it meets a boundary between two different media

- travel at different speeds through different media

6

(b) (because the X-rays) are ionising

accept a description of what ionising is

1

(they will) damage cells

instead of cell, any of these words can be used:
DNA / genes / chromosomes / nucleus

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells

*do **not** accept they can be dangerous (to human health)*
*do **not** accept damage to soft tissue*

or

kill cells

1

(c) any **one** from:

- removal / destruction of kidney / gall stones

- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  *accept curing prostate cancer **or** killing prostate cancer cells*

- removing plaque from teeth

  cleaning teeth is insufficient

1

[9]

Q18.

(a) (i) answer in the range 3.0 ↔ 3.1 inclusive

*accept for **1** mark*

3.6 ÷ 1.2 or 3.7 ÷ 1.2

***or** 36 ÷ 12 or 37 ÷ 12*

***or** 18 ÷ 6 or 18.5 ÷ 6*

***or** 10.2 ÷ 3.4 or 102 ÷ 34*

***or** answer in the range but with a unit eg 3 cm*

2

(ii) (principal) focus / focal (point(s)) / foci / focus

accept 'focusses'

accept focals

*do **not** accept focal length*

1

(iii) at the intersection of virtual / imaginary rays

***or** 'where virtual / imaginary rays cross'*

***or** the rays of (real) light do not cross*

***or** the image on the same side (of the lens) as the object*

***or** the image is drawn as a dotted line*

***or** the image is upright*

*do **not** accept 'cannot be put on a screen'*

*do **not** accept any response which refers to reflected rays*

1

(b) (i) another correct observation about relationship between values of **d**

example

15 is three times bigger than 5 but

1

(but) not the relationship between corresponding values for magnification

2.0 is not three times bigger than 1.2

1

(ii) when the distance / **d** increases the magnification increases

***or** the converse*

accept 'there is a positive correlation'

*do **not** accept any response in terms of proportion / inverse*

proportion

1

(iii) (student has) no evidence (outside this range)

accept data / results / facts for 'evidence'

1

[8]

Q19.

(a) any **two** correct construction lines:

if more than 2 construction lines treat as a list

2

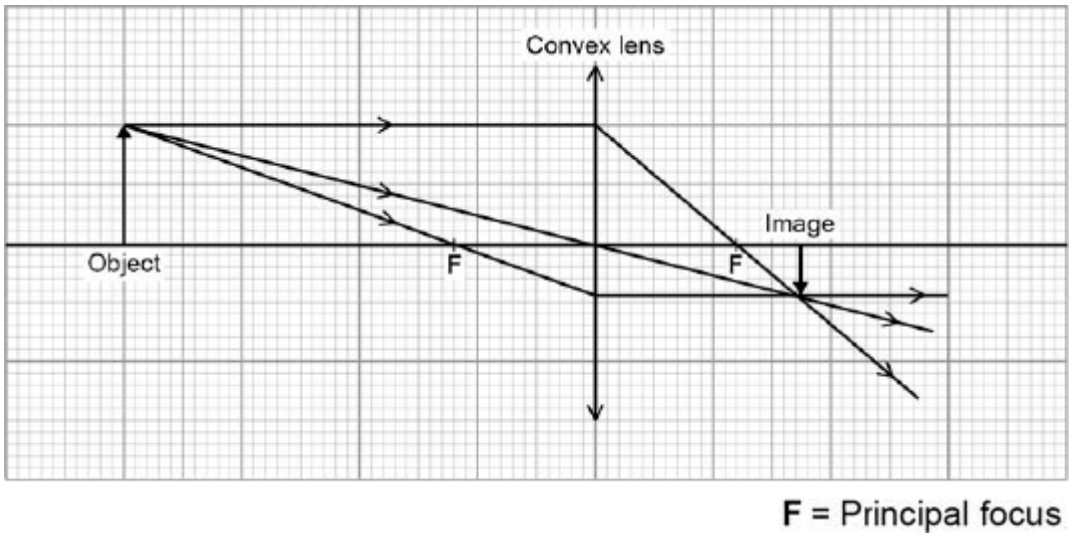
- line passing straight through centre of lens (& out other side)
- line travelling parallel to principal axis & then being refracted through principal focus (on RHS)
- line travelling through principal focus (on LHS) & then being refracted to be parallel to principal axis (on RHS)

inverted image drawn (with arrow) in correct location

1

one arrowhead from object to image on any construction ray

conflicting arrowheads negate this mark



1

(b) any **two** from:

- inverted

  accept upside down

- real
- diminished / smaller

  *allow ecf if ray diagram wrongly drawn but descriptions must relate to **their image***

a converse negates mark, eg real and virtual scores zero

2

[6]

Q20.

(a) (i) magnified

1

upright

1

(ii) v = −6(cm)

*max **2** marks if no minus sign*
*6(cm) gains **2** marks*
1/v = 1/12 − 1/4 = −1/6
*gains **2** marks*
1/12 = 1/4 + 1/v
*gains **1** mark*
−5.99(cm)
*using decimals gains **3** marks*

3

(b) it is <u>virtual</u>

1

[6]

Q21.

(a) 20,000

accept 20 kilo
or
20 k
***or** 20 001*

1

an atom

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer in the Marking Guidance and apply a 'best-fit' approach to the marking.

0 marks
no relevant content

Level 1 (1−2 marks)
At least one relevant statement is given for either type of wave

Level 2 (3−4 marks)
either
a use, risk and precaution is given for one type of wave
or
A medical use is given for both types of wave
plus

a risk or precaution for one type of wave

Level 3 (5−6 marks)
At least one medical use is given for both types of wave linked to the risks and any precautions necessary

Examples of the points made in the response

Medical use of X-rays
Any one from:
- Detecting bone fractures
- Detecting dental problems
- Killing cancer cells
- CT scanning.

Ignore details about how X-rays / ultrasound work

accept any specific use of X-rays, eg

- *detecting heart / lung disorders (with chest X-rays)*
- *mammograms / breast cancer detection*
- *detecting stones / bowel disease (with abdominal X-rays)*

Risks with X-rays
X-rays pose a risk / danger / hazard

accept are harmful

X-rays cause ionisation / damage to cells
or
mutate cells / cause mutations / increase chances of mutations
or
turn cells cancerous / produce abnormal growths / produce rapidly growing cells
or
kill cells

accept a description of what ionising is

instead of cell, any of these words can be used: DNA / genes / chromosomes / nucleus

accept (may) cause cancer

Operator precautions with X-rays
The X-ray operator should go behind a (metal / glass) screen / leave the room when making an X-ray / wear a lead lined apron

accept appropriate precautions for the patient e.g. limit the total exposure / dose (in one year)

wear a radiation badge is insufficient

Medical use of ultrasound

Any one from:
- Pre-natal scanning
- Imaging (a named body part).
- removal / destruction of kidney / gall stones
- removing plaque from teeth

cleaning teeth is insufficient

- accept examples of repair, eg alleviating bruising, repair scar damage,

ligament / tendon damage, joint inflammation.

accept physiotherapy

*accept curing prostate cancer **or** killing prostate cancer cells*

Risks with ultrasound

Ultrasound poses no risk / danger / hazard (to the user / patient)

accept ultrasound is safer than using X-rays

Ultrasound is not ionising
or
Ultrasound does not damage (human) cells

Precautions with ultrasound

The operator needs to take no precautions when making an ultrasound scan

this can be assumed if it is stated that ultrasound is harmless or it is safer than using x-rays or it is non-ionising

6

[8]

Q22.

(a) magnification = $\frac{\text{image height}}{\text{object height}}$

1

dividing by an object height of 1 cm gives the same (numerical) value

1

(b) accept anything practical that would work eg:

use a taller object

use a (travelling) microscope

attach a scale to the screen and use a magnifying glass

1

(c) both points plotted correctly

1

correct line of best fit drawn

a curve passing through all points (within ½ square), judge by eye

1

(d) values of 1.4 and 0.6 extracted from the graph

1

2.33 times bigger

accept any number between 2.3 and 2.5 inclusive

1

(e) by dividing the distance between the lens and the image by the distance between the lens and the object

1

at least one correct calculation and comparison eg 100÷25 = 4 which is the same as

the measured magnification

1

[9]

Q23.

(a) random

human error is insufficient

1

(b) accept any practical suggestion that could cause a range of values
e.g. misjudging the centre of the ray
e.g. not replacing mirror / ray box in the same position

measuring the angle incorrectly is insufficient
moving the mirror / ray box is insufficient

1

(c) range = 10
or
mean of 51 calculated

1

5(°)

*an answer of 5(°) scores **2** marks*

1

(d) within experimental accuracy the angle of incidence and the angle of reflection are the same

allow the angle of incidence is nearly the same as the angle of reflection

or
the angle of reflection is usually different to the angle of incidence

allow only a few of the values are the same / similar
allow the idea of a range of values

1

relevant use of data
e.g.
at 20° / 30° / 40° there is at least one measurement of angle of reflection that is exactly the same
or
at 50° there are big differences

allow 50° includes anomalous results

an answer in terms of calculated mean(s) may score both marks
e.g.
mean calculated for one or more angle of reflection (1)
conclusion correctly stating angle i = / ≠ angle r (1)

1

(e) results could be collected for angles (of incidence) not yet measured

allow a stated angle of incidence e.g. 10° or 60°

changing the mirror is insufficient
ignore repeat the measurements

1

(f) replace the mirror with an irregular reflecting surface

allow use an irregular reflecting surface
replace mirror with paper is insufficient
*do **not** accept use a glass block*

1

[8]

Q24.

(a) high frequency sound (waves)

1

with a frequency above limit of human hearing
or with a frequency greater than 20 000 Hz

above limit of human hearing
***or** greater than 20 000 Hz gains maximum **1** mark*

1

(b) $5(.0) \times 10^{-4}$ (m)
or
0.0005 (m)

*$1500 = 3 \times 10^{6}\ \lambda$ gains **2** marks*
*answer of 500 gains **2** marks*
*$1500 = 3.0\ \lambda$ gains **1** mark*

3

(c) it will run off the surface of the skin
or
water is not a gel

accept water would evaporate

1

(d) The width of the coupling agent

1

The width of the water

1

(e) (i) A

1

(ii) E

1

(f) (i) **K**
reflection from skin

maximum 5 marks if no mention of reflection

1

very little reflection, so small peak

1

L
reflection from front of kidney

1

large amount of reflection, so large peak

1

M
reflection from back of kidney

1

smaller peak due to absorption of ultrasound in kidney
or
smaller peak as further from source
or
front of the kidney already reflected a lot, so there is now less to be reflected

reflection from a boundary gains 1 mark if no other mark given

1

(ii) 0.06 (m)
or
$6(.0) \times 10^{-2}$

*0.12 (m) gains **2** marks*

*distance = $1500 \times 8 \times 10^{-5} \times 0.5$ gains **2** marks*

*distance = $1500 \times 8 \times 10^{-5}$ gains **1** mark*

3

[19]

Q25.

(a) two rays drawn from the bulb and reflected by the glass

*angle **I** = angle **R** judged by eye*

*allow **1** mark for one incident and reflected ray even if angle **I** doesn't equal angle **R***

2

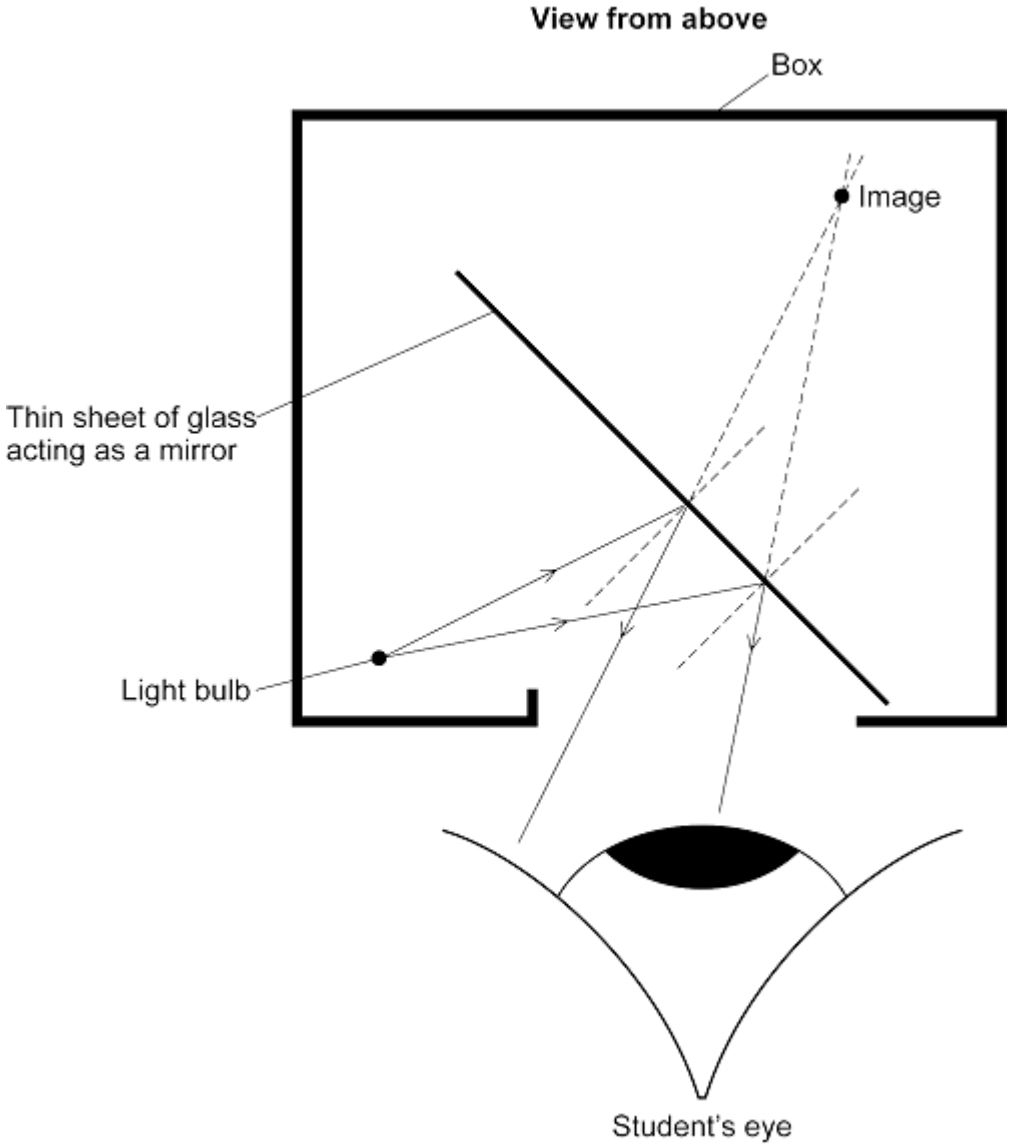
at least one arrow drawn in correct direction

any conflicting arrows negate this mark

ignore any arrows drawn on construction lines behind the glass

1

position of image correct



judged by eye

1

(b) image is formed by virtual / imaginary rays crossing

accept construction lines only show where the light seems to come from

accept the image is behind the glass / mirror

accept image is seen through the glass / mirror

accept (real) rays of light do not pass through the image

accept (real) rays do not cross

accept the image is a reflection (of the object)

accept the image is formed by reflection

*do **not** accept a virtual image can't be formed on a screen*

*do **not** accept the object / image is reflected*

1

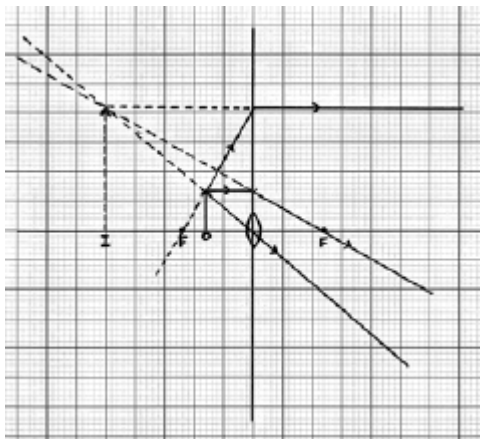
[5]

Q26.

(a) (i) **two** correct rays drawn

***1** mark for each correct ray*

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



2

an arrow showing the position **and** correct orientation of the image for their rays

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

1

(ii) (x) 3.0

accept 3.0 to 3.5 inclusive

or

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

correctly calculated

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

ignore any units

2

(b) any **two** from:

in a camera the image is:

- real not virtual
- inverted and not upright

  accept upside down for inverted
- diminished and not magnified

  accept smaller and bigger

accept converse answers but it must be clear the direction of the comparison

both parts of each marking point are required

2

[7]

Q27.

(a) the image would decrease in size

1

the image would change (from virtual) to real

accept that the image (of bulb M) can be projected on to a screen

1

the image would change (from non-inverted) to inverted

1

(b) a ray through the centre of the lens

rays should be drawn with a ruler

ignore arrows

1

a ray parallel to the principal axis and passing through the principal focus to the right of lens

accept solid or dashed lines

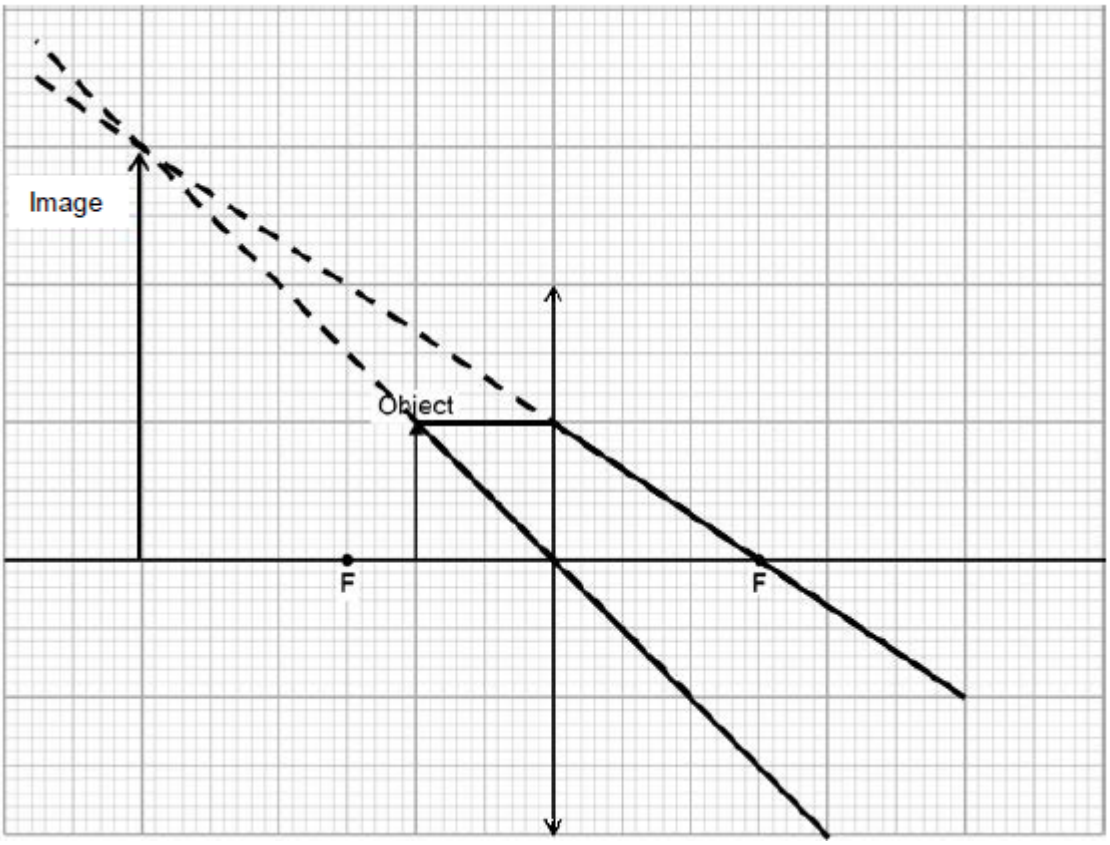
accept a ray drawn as if from the principal focus to the left of the lens, emerging parallel to the principal axis

1

image drawn where rays cross

image should be to left of the lens

1



(c) (i) (because the glass in) lens A has a greater refractive index

accept lens A is more powerful

accept lens A has a shorter focal length

1

(ii) when the magnification increases by 1, the image distance increases by 10 cm

*accept for **1** mark it is a linear pattern*

or

as the image distance increases, the magnification increases

*do **not** accept directly proportional*

2

(iii) diagram showing the surfaces of a convex lens C having greater curvature than lens B

the size of the lens drawn is not important

1

[10]

Q1.

(a) 96% of students scored this mark.

(b) Answers were split almost equally between the three options.

(c) Many students seemed confused about the fact that white is not in itself a colour but is made up of the colours of the spectrum. It was common to see answers such as 'the T-shirt absorbs all the colours but reflects white'. The terms reflection, absorption, transmission and emission were often used incorrectly and many students confused their answers with comments such as 'the white light reflected the T-shirt'. Vague answers such as 'It looks white because it is white' were commonly seen.

(d) About 25% of the students realised that the red cap would absorb the blue light. Of those only 3% said the cap would look black, most of the students suggested that the red and blue would mix to give purple or dark blue.

(e) 46% of students scored both marks, with a further 32% scoring one mark.

(f) The difficulty in this question was distinguishing between the main hazard in the investigation and the risk that the hazard presented. The acceptable hazards were the heater, the infrared radiation and the hot metal surface. Over half of the students only stated the risk and so scored zero.

(g) The majority of the students were able to correctly compare the absorption of infra-red radiation by a matt black and a shiny silvered surface. Common misconceptions are that the matt black surface attracted the infra-red radiation better and that it is a better conductor.

Q3.

(a) About a third of the students correctly identified the change in the wavelength and energy of a light wave when its frequency is increased.

(b) (i) The majority of students failed to go further than stating the thickness was kept constant to make the test fair. A low proportion of students were able to state that the intensity of transmitted light depended on the thickness of glass and therefore needed to be controlled.

(ii) Many students were distracted by the fact that brown colours are good absorbers of thermal energy. About two fifths of the students correctly stated that brown glass had the smallest intensity of transmitted light.

Q4.

(a) Just under two thirds scored this mark for identifying the maximum frequency of human hearing.

(b) The vast majority of students gained both marks for calculating the distance.

(c) Just over two thirds answered this correctly.

(d) A large number of students did not understand that the trend shown in the table

needed to be identified. Only about a quarter of students gained both marks on this question. Under one fifth of students gained one mark, which was most commonly for realising that the distance decreased and increased again. A significant number of students talked about the time decreasing and increasing, without linking this to the distance between the submarine and the sea floor. A common response was to merely quote figures from the table, giving their answer in terms of time.

Q5.

(a) Usually the lens was incorrectly identified as a diverging or concave lens rather than as a converging or convex lens.

(b) Only about a quarter of candidates recognised that the point is a principal focus or a (focal) point.

(c) More able candidates were able to take appropriate values from the diagram and to calculate the magnification.

(d) A very small minority of candidates gained the mark because they stated that the image could be put on a screen. No one referred to a correct diagram and stated that the image is real because it is formed where real rays cross.

Q6.

(a) (i) The majority of students correctly identified the bat.

(ii) Over half of students could identify the relevant frequencies and the correct unit.Some spoiled their answers by putting kHz whilst others gave a large range of frequencies.

(b) Students did better than in other years in identifying the correct oscilloscope traces.

(c) Given that questions about sound travelling in a vacuum or through space has been asked quite often it was very disappointing that only a very low number of students obtained the 2 marks and just over half did not get any marks.

Q7.

(a) Nearly all students knew that frequency determines the pitch of a sound and that amplitude determines the loudness of a sound.

(b) (i) Nearly all students correctly described the trend shown in the table of length of tuning fork prong and frequency.

(ii) Nearly all students correctly measured the length of a tuning fork prong.

(iii) Over half of the students were able to correctly estimate the frequency of the tuning fork measured in part (i) from a table listing prong lengths and frequency. Some students mistakenly assumed a relationship of direct proportionality between prong length and frequency.

(c) (i) Nearly all students knew that ultrasound waves were produced by electronic systems.

(ii) Less than half of the students could explain that ultrasound waves could not be produced by a tuning fork because the very high frequency would require an extremely small fork according to the evidence given. Many wrote that

'tuning forks can only produce frequencies within the human audible range' so scored neither mark.

(d) Just under half of the students scored full marks for correctly determining a frequency from a trace on an oscilloscope screen. Many calculated frequency from 1 / 0.0005 instead of from 1 / (7 × 0.0005).

Q8.

(a) In part (a)(i) most candidates were able to identify this as a converging lens and to indicate the position of the focus.

(b) Though most candidates identified this as a diverging lens, only a small minority were able to indicate the position of the focus. Many made no effort to do so and this may indicate that some candidates did not think that a diverging lens has a focus.

(c) Nearly all candidates attempted this part and followed the instructions. Some gained all four marks.

(d) Attempts at explaining the word *magnified* were much more successful than attempts at *real*. The many, wildly incorrect responses indicated that few had been able to find any clues in the artwork.

(e) Only a minority of candidates had the confidence to simply state that the converging lens would be convex. However, 'thicker in the middle and thinner at the edges' was a fairly popular correct answer. Some candidates were not assisted by their limited ability to communicate clearly. A minority claimed that if only one lens was a converging lens then all the others would be the same. This is not correct; each lens in the box might be a different shape.

Q9.

(a) The position of the principal focus was not well known. Only 15% of the students gave the correct answer 'B'.

(b) Despite having the diagram, only 10% of the students chose the two correct words to describe the image. A further 60% were able to correctly choose one correct word. Many students chose mutually exclusive pairs of words such as 'real and virtual' or 'inverted and upright'.

(c) Just over 50% of the students measured both the image height and object height accurately and completed a correct calculation to score all 4 marks. A further 22% measured one height accurately and completed the calculation correctly to score 3 marks.

(d) Nearly 70% of students scored this mark.

Q10.

(a) (i) Nearly 62% of candidates knew that the diagram showed a converging lens.

(ii) Those candidates able to read the diagram found that the calculation very simple. However a significant proportion of candidates multiplied their two numbers rather than divide them and therefore gained no marks, this was despite being given the equation.

(b) Although the information required was provided in the diagram, only 58% of

candidates correctly identified the effect on the image of moving the object closer to the lens.

Q12.

(a) The vast majority of students gained at least one mark, but less than half went on to give a complete answer including a reference to the ionising properties of X-rays.

(b) Just under half of students gained marks on this question. Many students understood that the sound reflected, but did not add that it was only partial reflection. The notion of time being recorded and used to calculate distance was only expressed by about one tenth of students.

(c) This calculation caused problems for students with only a tiny minority managing to obtain the correct final answer. The majority of students neglected to either halve the time or double the distance from the mother's skin to the fetus.

(d) (i) A common misconception here was that bone reflected X-rays and the reflected X-rays were then detected. It was also not uncommon to see students stating that X-rays contained gamma rays or alpha particles. Many students who gained two marks neglected to mention that the X-rays passing through are detected. Around a quarter of students gained three marks.

(ii) This question was well answered with just over three quarters of students identifying why X-rays are able to produce detailed images.

Q13.

Foundation

(a) Two fifths of students scored this mark.

(b) Less than a fifth of students scored a mark for this question. Many incorrect responses stated 'longitudinal', or another wave property like 'refraction' of 'diffraction.'

(c) Almost four fifths of students scored 1 mark for the answer of '0.34' failing to convert 25.0 kHz into Hz. If a conversion was attempted it needed to be seen before the calculation otherwise it counted as a subsequent (incorrect) step, which means they scored zero.

(d) Four fifths of students scored 0 marks for this question, most students believing that a longitudinal sound wave is a long sound wave. Most responses referred to amplitude, wavelength or frequency.

Higher

(a) Three quarters of students scored a mark for this question.

(b) Just under half the students scored a mark for this question. Many students, however, were baffled and gave an assortment of answers that ranged from wave behaviour (e.g. refraction) to wave properties (e.g. wavelength).

(c) The vast majority of students scored 1 mark for the answer of ‘0.34’. Some students incorrectly rearranged the equation and scored zero. A few students realised that the frequency needed converting, but didn’t do this correctly, but scored 1 mark for their final answer. One fifth of students scored 2 marks for the correct answer.

(d) Lots of partial descriptions of 'waves parallel to energy transfer', without stating what was parallel, the word oscillation (or vibration) was needed for this mark. Compressions and rarefactions was more likely to be credited. A third of students scored 1 mark, but less than a tenth of students scored 2 marks.

Q14.

(a) Just over half of the candidates could identify the type of lens shown in the diagram.

(b) Just over three-fifths of candidates were able to correctly name the points labelled F.

(c) (i) Explaining how a diagram shows whether an image is real or virtual continues to be a problem. Many candidates mention 'in front' or 'behind' the lens without identifying what they mean. Candidates need to state whether it is the same or opposite side of the lens to the object. A number of candidates negated any answer by mentioning reflections and / or mirrors.

(ii) Although just over three quarters of candidates scored this mark, it is surprising that most of the remainder thought that the image was upright.

(d) (i) The response to drawing the line of best fit on given plotted points was extremely disappointing. Many candidates ignored the point at (40,2.9). The majority of candidates tried to draw a straight line through an obvious curve while others joined up the points with a ruler. Only a third of candidates drew an acceptable curve through the points.

(ii) Just over two-thirds of candidates gave the correct answer to this part question.

(iii) A large majority of candidates managed to give the basic relationship linking magnification and distance but a very small number of candidates gained the second mark by giving more detail.

Q15.

Just over half of the candidates, who read the diagram correctly had no difficulty with this question and scored full marks. However, a substantial number of candidates made errors in taking the measurements.

It was disappointing that, once again, some candidates added a unit to the magnification.

Q16.

(a) (i) Three-quarters of the students knew the frequency range of human hearing.

(ii) Three-quarters of students knew what ultrasound is.

(iii) Nearly all students could state a medical use of ultrasound. Most referred to viewing a fetus but other statements such as 'pregnancy testing' and 'looking at babies' did not score the mark.

(b) The calculation which involved rearranging the wave equation and using data given in standard form was very well answered by the vast majority of students.

(c) Ultrasound waves were emitted and the reflected waves from an object, moving away, were detected. Less than one-fifth of the students could correctly describe the

differences between the emitted and reflected waves because it was often not clear which wave was being referred to in the answers.

Q17.

(a) Very few candidates obtained level 3 (5 or 6 marks), about half obtained level 1 (1 or 2 marks). In general, the responses regarding X-rays were answered in more detail than ultrasound. Many candidates were able to describe what the wave did, but failed to give accurate or detailed descriptions of the waves. Wavelength and frequency descriptions were often muddled. In many wrong responses, candidates failed to answer the question posed, often just appearing to write down any facts they had learned.

(b) Almost half of the candidates failed to gain any mark on this question. Often wrong responses detailed how X-rays affected the human body, organs or tissues; rather than damage at a cellular level.

(c) Less than one third of candidates could give a medical treatment using ultrasound. The most common correct response related to the treatment or removal of kidney stones. Many candidates with incorrect responses failed to note that the question asked for ‘other than imaging’ and stated scans of a fetus as their answer.

Q18.

(a) (i) Students did not read the diagram carefully enough so that just over half of students achieved full marks on the calculation and many scored zero.

(ii) The majority of the students were able to name the points.

(iii) Less than a quarter of the students could explain how the diagram showed that the image was virtual. Students described the image as being 'in front of', 'behind', ' to the left of' or 'to the right of' the lens without any reference to the position of the object. These statements are therefore meaningless.

(b) (i) Many students relied too much on the information in the stem of the question and did not therefore give enough further detail to gain both marks. Just over half of the students gained at least one mark.

(ii) Just over half of the students gave the correct conclusion many of the others restated the original incorrect conclusion or simply stated that it was not correct.

(iii) The majority of students were unable to explain why a conclusion could not be made outside the range of the experiment.

Q19.

(a) Only a quarter of candidates gained full marks for this ray diagram. A further third gained 3 marks, the most common mistake being a failure to put an arrow on any of the rays.

(b) The majority of candidates were able to identify the nature of the image correctly with two descriptions.

Q20.

(a) (i) Less than three-quarters of students identified the image in the ray diagram

as being magnified and upright.

(ii) More than half of the students gained full marks for a calculation using the lens formula that required a minus sign in the answer. Most of the remaining students forgot to invert the value for the final answer.

(b) Most students knew that a minus sign meant that the image was virtual.

Q21.

(a) Many of the students did not attempt to write down the minimum frequency of ultrasound, and a lot of the students were not aware that the wavelength of an X-ray is similar to the diameter of an atom, leading to some interesting responses. Only a small proportion of the students scored both marks with a further third of the students scoring one mark.

(b) This question was attempted by the vast majority of students, most of whom wrote a reasonably lengthy answer. Almost half of the students scored at least 4 marks. Some students chose to write down everything they knew about X rays or ultrasound, including lots of details about how they work which was not asked for in the question. There was a common misconception that X-ray photography uses gamma rays to produce images, and also that X-rays are radioactive. A lot of students limited themselves to level 2 by failing to write about the precautions necessary when using X-rays. Most students (perhaps prompted by the photographs in the question) were aware that ultrasound is used for fetal scanning, but a fair number of students stated that it was just used for scanning for babies, failing to mention that the babies in question were still in the womb. A lot of students stated that ultrasound was used to look for babies in the mother's stomach, which was allowed here but raises some questions about their knowledge of biology. A number of students got mixed up between CT scans and MRI scans.

Q23.

(a) There were very few correct answers. Most answers described a specific error rather than a type of error. Many students incorrectly think that 'human error' is an acceptable answer.

(b) There were many vague answers such as; 'knocked the ray box' that were not worthy of credit. Many students simply stated that there was a measuring error without further detail. Few students took the hint from the diagram that the rays were wide and so there would be difficulty in marking the exact position of each ray.

(c) Nearly 70% of the students scored at least one mark for either calculating the mean or for calculating the range. Around 33% then calculated the uncertainty correctly.

(d) Over 90% of the students scored at least one mark for either writing 'I agree / disagree' and quoting relevant data but not identifying the trend or for doing the converse.

(e) About 23% of the students realised that the extra evidence would come from using a larger number of angles of incidence. Most answered in terms of repeating the same angles or comparing with another student's results.

(f) Many students simply wrote 'change the mirror' but did not say for what. Others suggested' replacing the mirror but with a non-reflecting surface or a glass block. In this question it was important to realise that the replacement was in the context of an investigation and not simply recalling the meaning of diffuse reflection.

Q24.

(a) Two -fifths of students gained both marks. Some students omitted to include 'frequency' in their answer, and would simply talk about 'sound above the limit of human hearing' or 'sound over 20 000Hz'. Those scoring no marks would talk about 'sound outside the human hearing range' or 'sound that humans cannot hear'. Some students gave answers that explained what ultrasound is used for and referred to electromagnetic waves.

(b) Half of the students gained two marks and a quarter gained all three. Those who were awarded two marks had usually made a mistake in either not translating megahertz to hertz or had done so incorrectly. Expressing numbers in standard form was a problem for many and also what the letter M meant in MHz.

(c) Two thirds of students gained the mark here for a reasonable suggestion, with answers varying between 'running off', 'too runny', 'not viscous like gel' and 'evaporating'.

(d) This question was well answered with nine tenths of students gaining both marks. Some students did not tick two boxes.

(e) (i) Nine tenths of students gained the mark here.

(ii) Almost all students gained this mark.

(f) (i) This question required students to identify the reflections of ultrasound from three boundaries and explain the intensity of each. Two fifths of the students gained no marks at all. Some students simply repeated the information given in the stem of the question. Others had not related the trace to the diagram and described bones and kidney stones which were not in the diagram. Many wrote about transmission through the boundaries but never mentioned reflection.
In K: students often gave the boundary as gel or body tissue − not skin − and sometimes the kidney; the second mark for a small amount of reflection was rarely seen
In L: there was a lack of precision in terms of identifying the reflection from the *front* of kidney, however the large amount reflected often scored.
In M: there was a lack of precision about the rear of kidney and lack of understanding of why this gave a smaller reflection.
Quite a few students scored one mark for describing a reflection from a boundary.
Three marks were often scored by the first marking point for each of K, L and M.

(ii) Three quarters of students gained at least two marks. Apart from the occasional conversion of metres into kilometres, the majority of students correctly worked out the total distance travelled by the waves whilst in the kidneys and gained two marks. Few remembered to halve this distance, because they forgot about the reflection of the waves at the back wall of the kidney. Using speed = distance x time was a common error, as was misuse of the powers of ten.

Q25.

(a) Very few students were able to locate the correct position of the image. Many students were able to draw one ray from the object to the glass and show it reflecting towards the eye, but in most cases, the angle of incidence was significantly and obviously different to the angle of reflection. If arrows were drawn

on the rays, they were mostly shown in the correct direction. A second ray from the object and construction rays behind the glass were rarely seen. Less than a tenth of students achieved three or four marks.

(b) Very few answers explained that the image is formed by virtual / imaginary rays crossing.

Q26.

(a) (i) Although over 37% of candidates gained all three marks, 50% of candidates scored zero!
Those scoring zero clearly had no idea how to draw a ray diagram for a converging lens used as a magnifying glass.

(ii) Many candidates knew how to use the magnification equation and even candidates that had not scored any marks in part (a)(i) were able to gain these two marks through 'error carried forward'.

(b) Again poorly answered with 50% of candidates scoring zero. Many candidates failed to gain any marks as there was no comparison made between the camera and the magnifying glass.

Q27.

(a) Just under two thirds gained at least one mark on this question, with just under a fifth gaining all three marks. Many students who gained no marks referred to the image being blurry or more focussed, rather than describing the image as being inverted or upright, diminished or magnified and real or virtual.

(b) Slightly more than two thirds of students gained at least one mark on this question, with just under a third gaining all three marks. Many students forced their rays to cross to the right of the lens rather than forming a virtual image to the left of the lens.

(c) (i) Just under a fifth of students gained this mark, with many just stating that the refractive indices were different which was insufficient. A significant proportion of students suggested that the lenses were of different shapes, whereas the question stated that they were identical.

(ii) About half of students gained one mark on this question, but it was rare for students to gain both marks. The common cause of students failing to gain any credit was to describe the link between object distance and magnification, rather than image distance as was asked for.

(iii) Just under one third of students were able to show how the lens was different.