Waves part 4 AQA Triple Physics

Name: _____

Class: _____

Date: _____

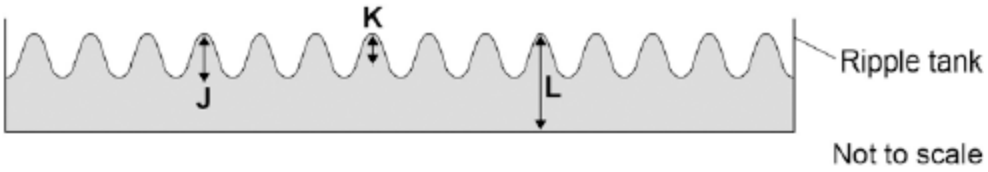
Time: **78 minutes**

Marks: **76 marks**

Comments:

1. Small water waves are created in a ripple tank by a wooden bar. The wooden bar vibrates up and down hitting the surface of the water.

The figure below shows a cross-section of the ripple tank and water.



(a) Which letter shows the amplitude of a water wave?

Tick **one** box.

J ☐

K ☐

L ☐

(1)

(b) The speed of the wooden bar is changed so that the bar hits the water fewer times each second.

What happens to the frequency of the waves produced?

Tick **one** box.

Increases ☐

Does not change ☐

Decreases ☐

(1)

(c) Describe how the wavelength of the water waves in a ripple tank can be measured accurately.

(2)

(d) The speed of a wave is calculated using the following equation.

wave speed = frequency × wavelength

The water waves in a ripple tank have a wavelength of 1.2 cm and a frequency of 18.5 Hz.

How does the speed of these water waves compare to the typical speed of a person walking?

(4)

(Total 8 marks)

2. The figure below shows an incomplete electromagnetic spectrum.

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

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

Tick **one** box.

infrared ☐

radio ☐

visible light ☐

X-ray ☐

(1)

(b) Electromagnetic waves have many practical uses.

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

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

(3)

(c) Complete the sentence.

Use an answer from the box.

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

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

_____ radiation.

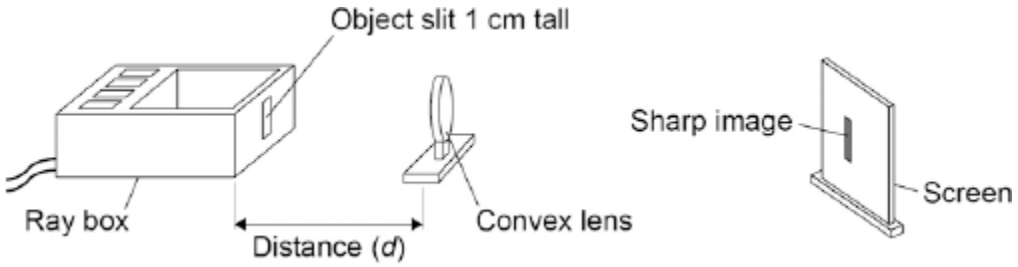
(1)

(Total 5 marks)

3. 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.

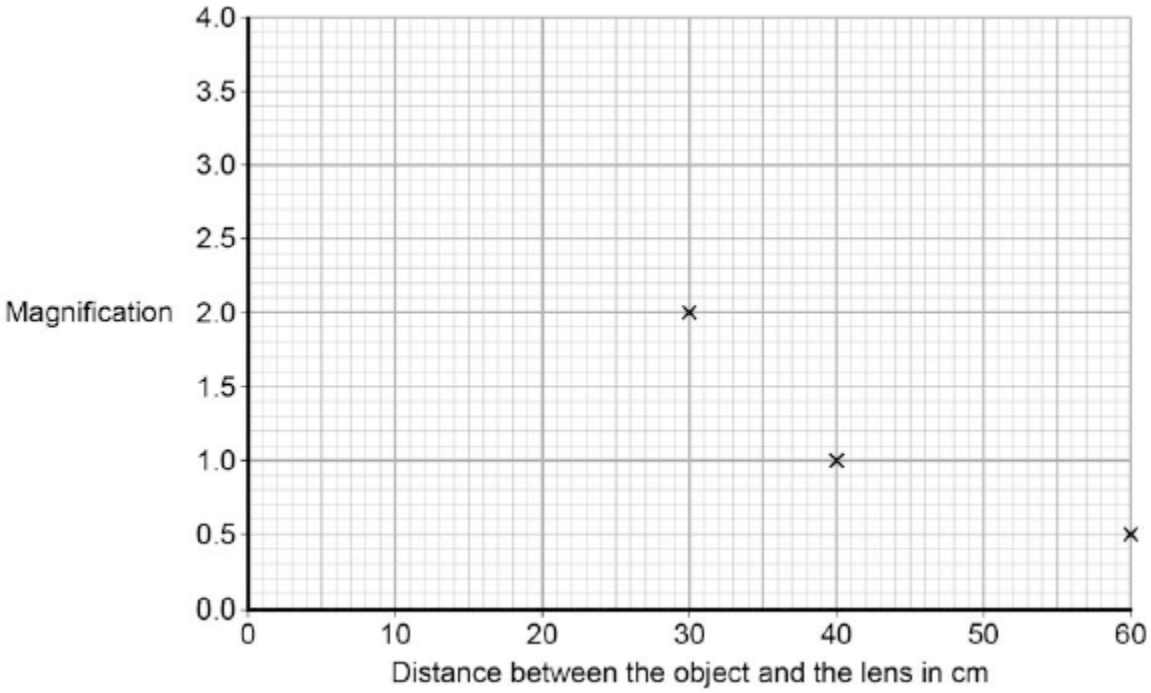
_____

_____

(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)

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

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

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

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

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

(Total 6 marks)

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

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

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

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

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

(6)

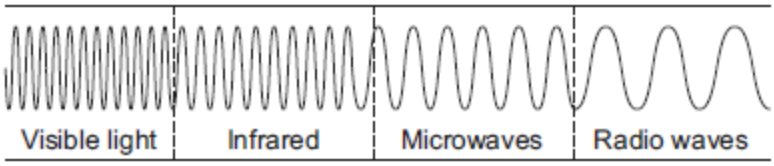
(b) State the reason why light is refracted as it crosses from air into glass.

(1)

(Total 7 marks)

6. Infrared and microwaves are two types of electromagnetic radiation.

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



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

_____

(1)

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

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

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

The wavelength of infrared is _____ the wavelength of microwaves.

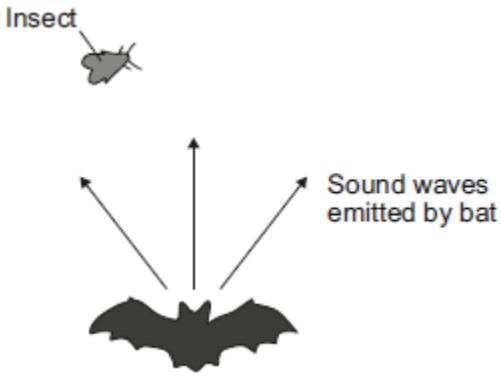
The frequency of microwaves is _____ the frequency of infrared.

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

(3)

(Total 4 marks)

7. 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)

8. Infrared and microwaves are two types of electromagnetic radiation.

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

Infrared: _____

Microwaves: _____

(2)

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

State **two** of these properties.

1. _____

_____

2. _____

_____

(2)

(Total 4 marks)

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

Figure 1

© emmy-images/iStock

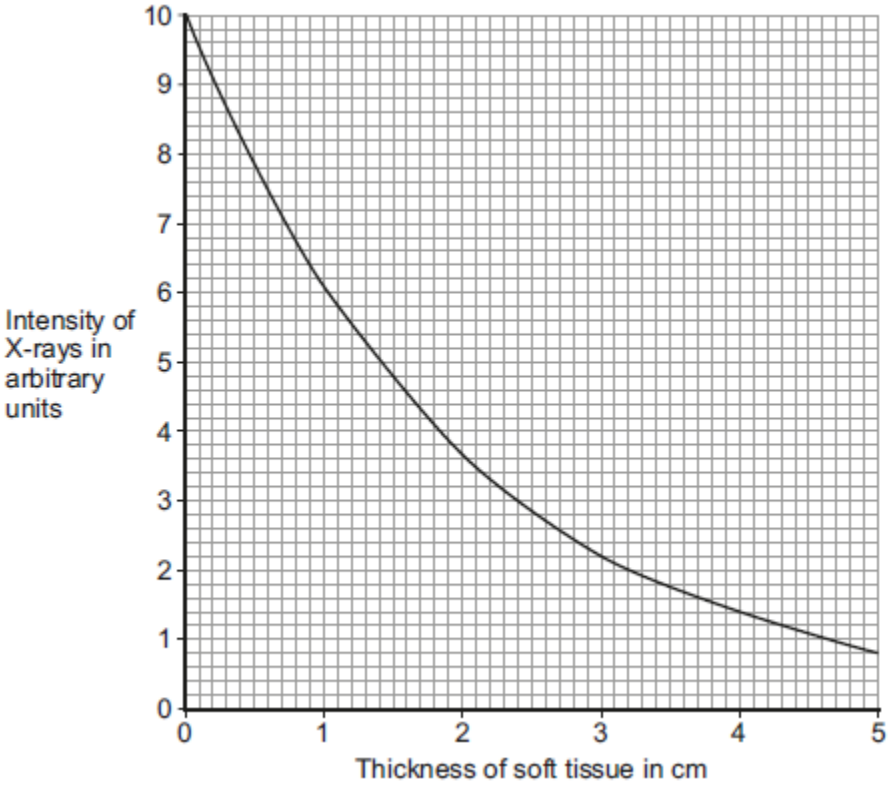
(a) Complete the following sentence.

X-rays are part of the _____ spectrum.

(1)

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

Figure 2



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

Intensity of X-rays = _____ arbitrary units

(1)

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

_____

_____

_____

_____

(2)

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

Choose the reason why.

Tick (✓) **one** box.

Both variables are categoric ☐

Both variables are continuous ☐

One variable is continuous and one is categoric ☐

(1)

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

_____

_____

(1)

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

Tick (✓) **one** box.

With a charge-coupled device (CCD) ☐

With an oscilloscope ☐

With photographic film ☐

(1)

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

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

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

Tick (✓) **one** box.

X-rays travel at the speed of light	☐
X-rays can travel through a vacuum	☐
X-rays are ionising	☐

(1)

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

_____

_____

(1)

(Total 9 marks)

10. 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.

_____

_____

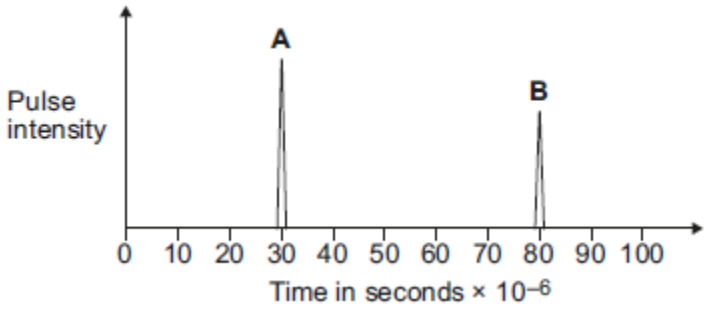
_____

_____

(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)

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

Tick (✓) **one** box.

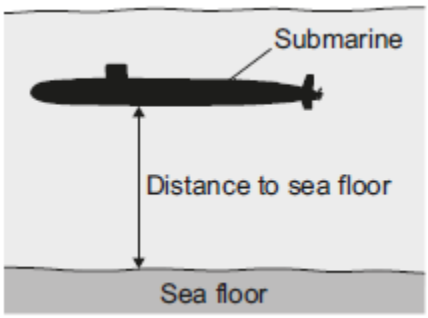
20 Hz ☐

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)

1.

(a) K

1

(b) Decreases

1

(c) use a metre rule / 30 cm ruler to measure across 10 (projected) waves

accept any practical number of waves number for 10

1

and then divide by 10

1

(d) 1.2 cm = 0.012 m

1

18.5 × 0.012 = 0.22(2) (m / s)

1

*allow 0.22(2) with no working shown for **2** marks*

typical walking speed = 1.5m / s

accept any value e.g. in the range 0.7 to 2.0 m / s

1

so the water waves are slower (than a typical walking speed)

this cannot score on its own

1

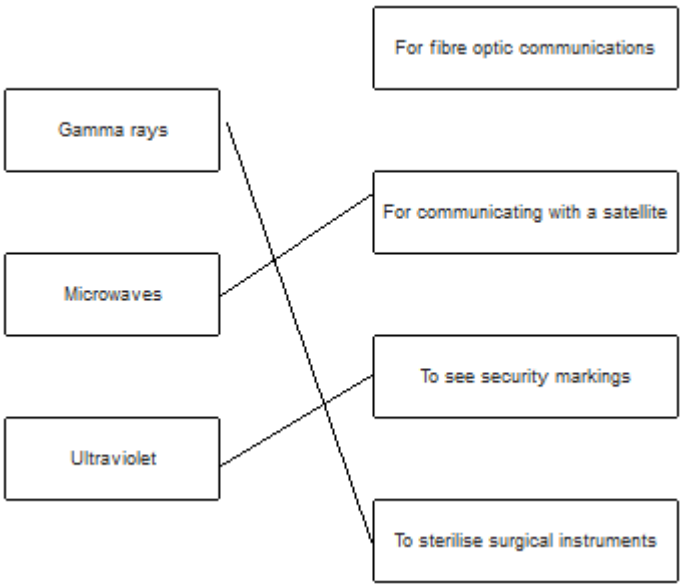
[8]

2.

(a) radio

1

(b)



*award **1** mark for each correct line*

if more than one line is drawn from any em wave then none of those lines gain credit

3

(c) ionising

1

[5]

3. (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]

4.

Level 3 (5–6 marks):
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

draw around the glass block and then remove from the paper

draw a line at 90° to one side of the block (the normal)

use a protractor to measure and then draw a line at an angle of 20° to the normal

replace the glass block

using a ray box and slit point the ray of light down the drawn line

mark the ray of light emerging from the block

remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

[6]

5.

(a) **Level 3 (5–6 marks):**
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

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repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

6

(b) velocity / speed of the light decreases

allow velocity / speed of the light changes

1

[7]

6. (a) any **one** from:

- (visible) light
- UV / ultra violet
- X-ray
- gamma / γ-ray

1

(b) less than

1

less than

1

the same as

1

[4]

7. (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]

8. (a) **use of infrared:**
remote controls
fibre optic (communications)

1

use of microwaves:
mobile/cell phones

accept mobiles

accept phone signals

satellite (communications/TV)
wi-fi
Bluetooth

1

(b) any **two** from

- same speed
  or
  travel at the speed of light (in a vacuum)
- transverse

  accept a full description of a transverse wave
- transfer energy (from one place to another)
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed / transmitted
- can travel through a vacuum/space
- can be polarised

  travels in straight lines is insufficient

2

[4]

9. (a) electromagnetic

accept e.m.

1

(b) (i) 2.2 (arbitrary units)

allow an answer between 2.1 and 2.3

1

(ii) the thicker the tissue the lower the intensity

accept more intensity is needed to pass through thicker tissue

1

the relationship is not linear

accept the line is not straight

*allow for **1** mark*

it still goes through with thicker tissue

or

intensity does not reach zero

or

at 5 cm X rays still pass through

1

(iii) Both variables are continuous

1

(c) (they are) absorbed

accept (they are) stopped

1

(d) With a charge-coupled device (CCD).

1

(e) (i) X-rays are ionising

1

(ii) stand behind a (protective) screen

accept leave the room

accept wear a lead apron

1

[9]

10. (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 <u>reflected</u>

(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]

11. (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]