Waves 4

Name: _____

Class: _____

Date: _____

Time: **75 minutes**

Marks: **74 marks**

Comments:

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

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

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

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) The sensor unit can detect infrared and visible light.

Suggest **one** advantage of being able to detect infrared.

_____

_____

(1)

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

Equation _____

(1)

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

Wave speed of electromagnetic waves = 3×10^8 m / s

Calculate the frequency of the signal.

_____

_____

_____

_____

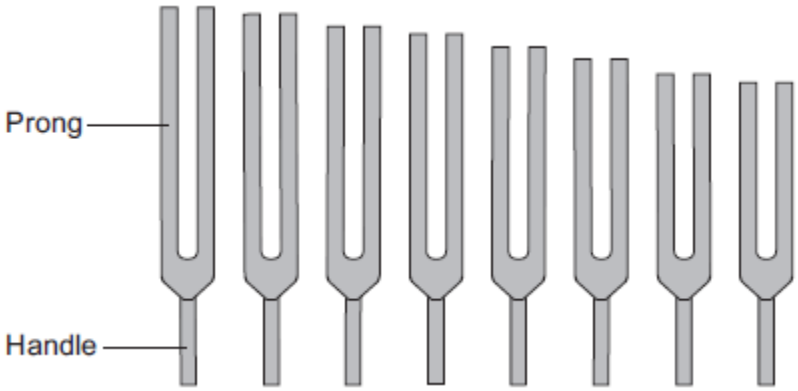
Frequency = _____ Hz

(3)

(Total 9 marks)

2. **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.

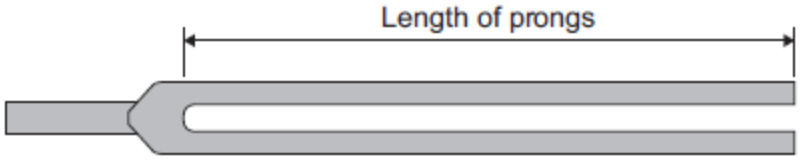
_____

_____

(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.

_____

_____

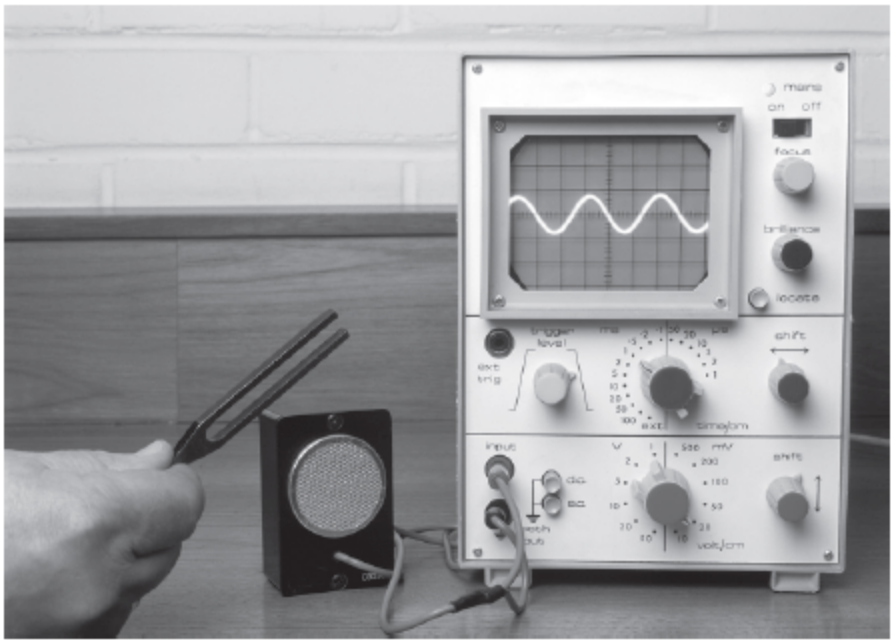
_____

_____

(2)

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

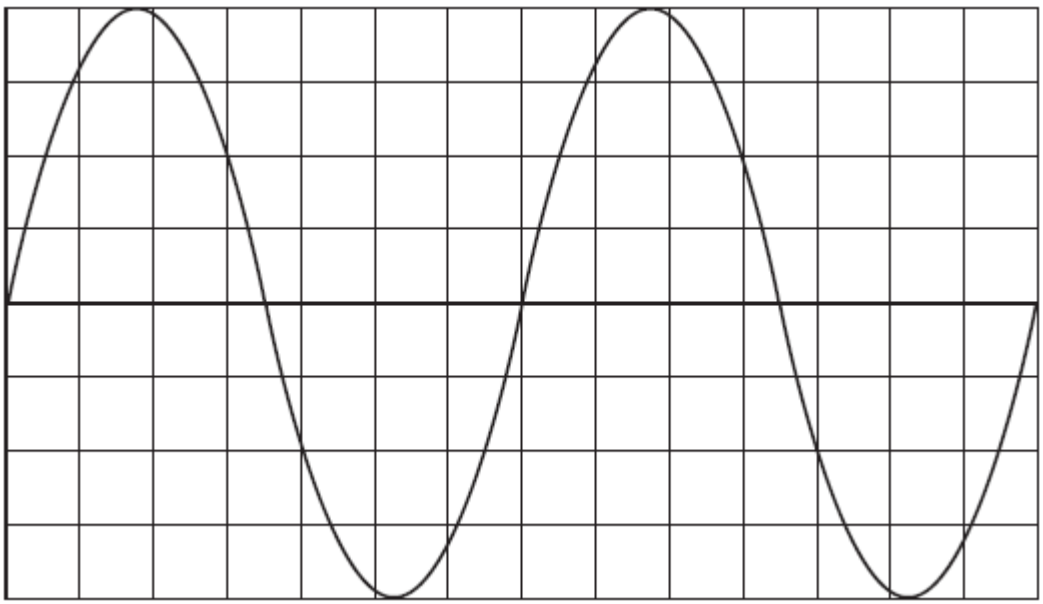
Figure 3



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

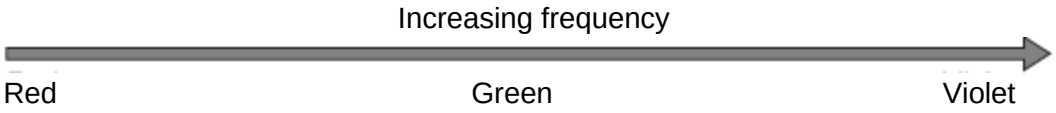
(3)

(Total 13 marks)

3. (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

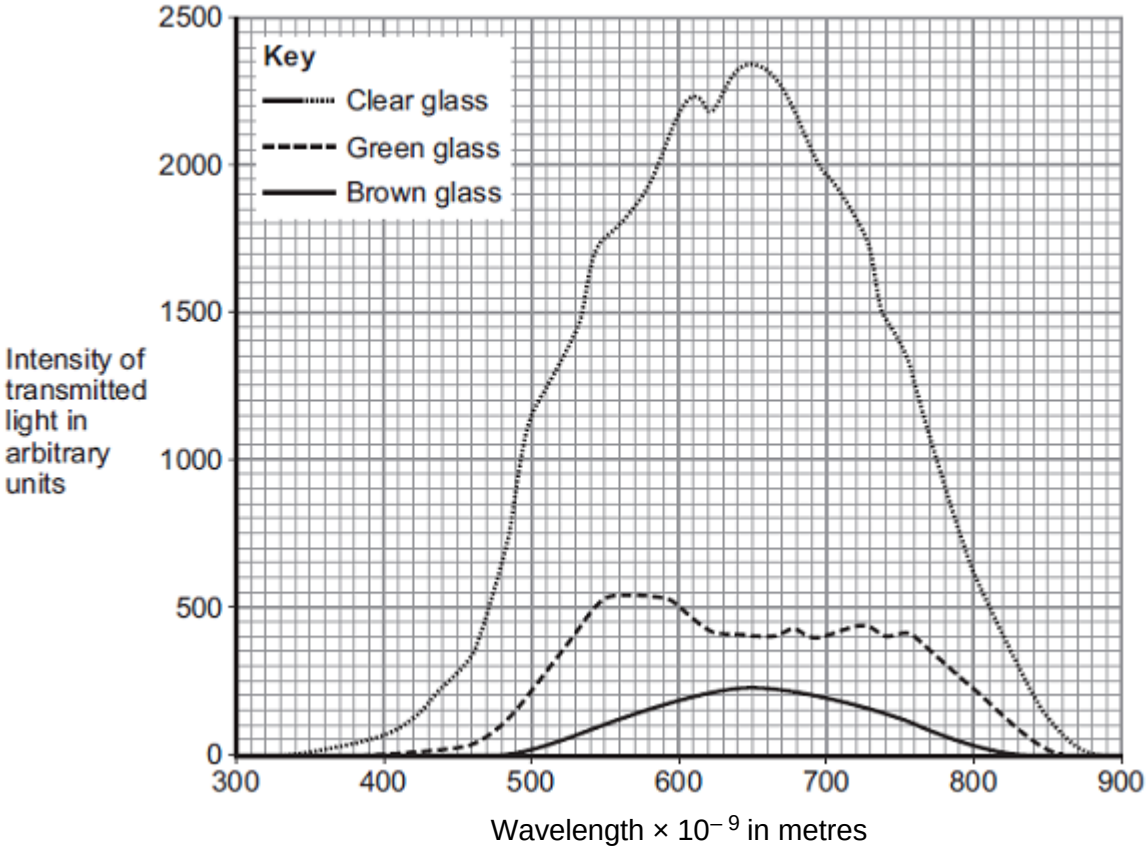
the energy of the light waves _____ .

(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)

4. A note was played on an electric keyboard.

The frequency of the note was 440 Hz.

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

_____

_____

(1)

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

Calculate the wavelength of the note.

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

_____

_____

_____

Wavelength = _____ metres

(3)

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

Figure 1

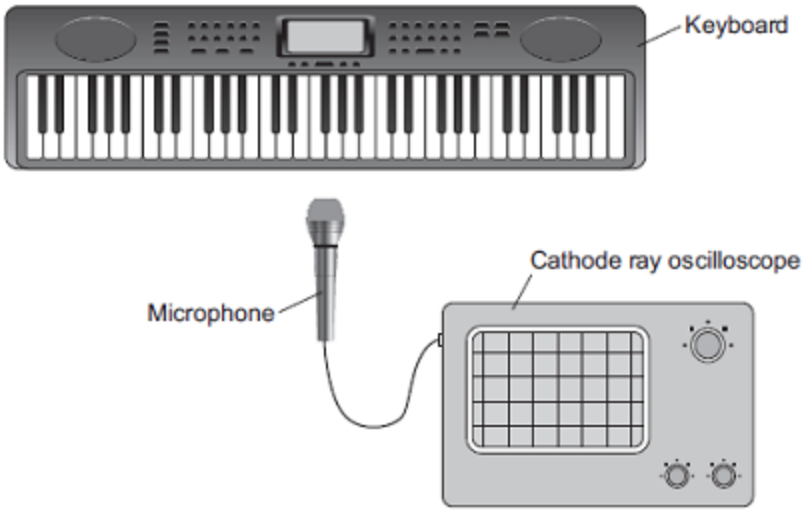
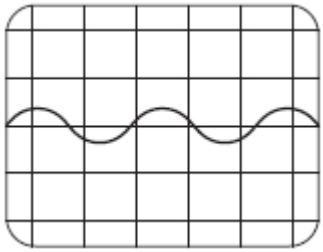


Figure 2 shows the trace produced by the sound wave on the CRO.

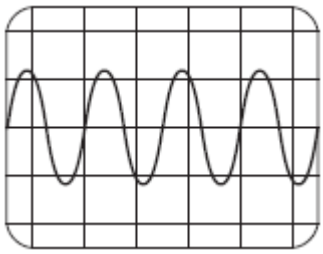
Figure 2



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

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

Figure 3



The settings on the CRO were unchanged.

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

Give a reason for each conclusion.

Conclusion 1 _____

_____

Reason _____

_____

Conclusion 2 _____

_____

Reason _____

_____

(4)

(Total 8 marks)

5. Waves may be longitudinal or transverse.

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

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

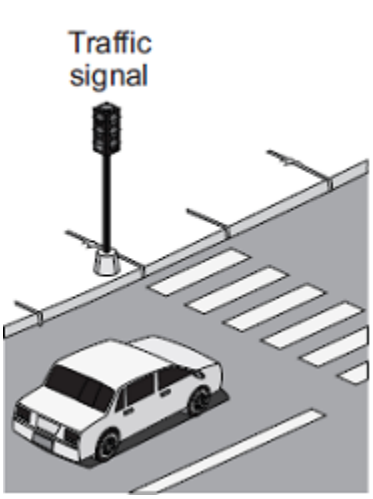
(Total 7 marks)

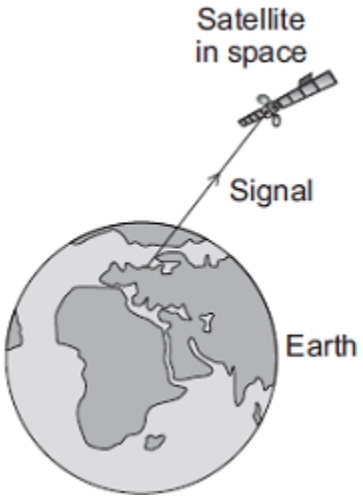
6. **Diagram 1** shows four of the seven types of wave in the electromagnetic spectrum.

Diagram 1

J	**K**	**L**	Visible light	Infrared	Microwaves	Radio waves

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





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

_____

(1)

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

_____

(1)

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

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

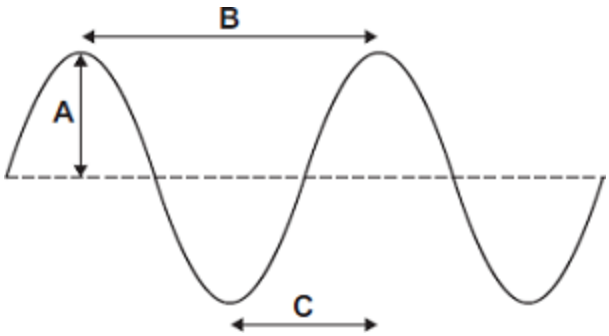
Draw a ring around the correct answer.

J **K** **L**

(1)

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

Diagram 2



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

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

(1)

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

The wavelength of infrared waves is

shorter than
the same as
longer than

the wavelength of radio waves.

(1)

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

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

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

Tick (✓) **one** box.

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

To find out if mobile phones give out radiation. ☐

To find out why some people are healthy. ☐

(1)

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

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

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

A parent buys mobile phone **X** for her daughter.

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

_____

_____

_____

_____

(2)

(Total 8 marks)

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

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

Sound waves cause air particles to _____ .

(1)

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

The wavelength of the sound waves is 0.80 m.

Calculate the speed of the sound waves.

_____

_____

_____

Speed = _____ m/s

(2)

(Total 3 marks)

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

Type of wave	Wavelength
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

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

_____

(1)

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

Calculate the wavelength of the waves broadcast by this station.

Show clearly how you work out your answer.

_____

_____

Wavelength = _____ m

(2)

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

_____

_____

_____

_____

(2)

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

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

_____

_____

(1)

(Total 6 marks)

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

Gamma rays		Ultraviolet	Visible light	Infrared	Microwaves	Radio waves

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

_____

(1)

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

Draw a ring around the correct answer.

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

(1)

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

Draw a ring around the correct answer.

infrared **microwaves** **ultraviolet**

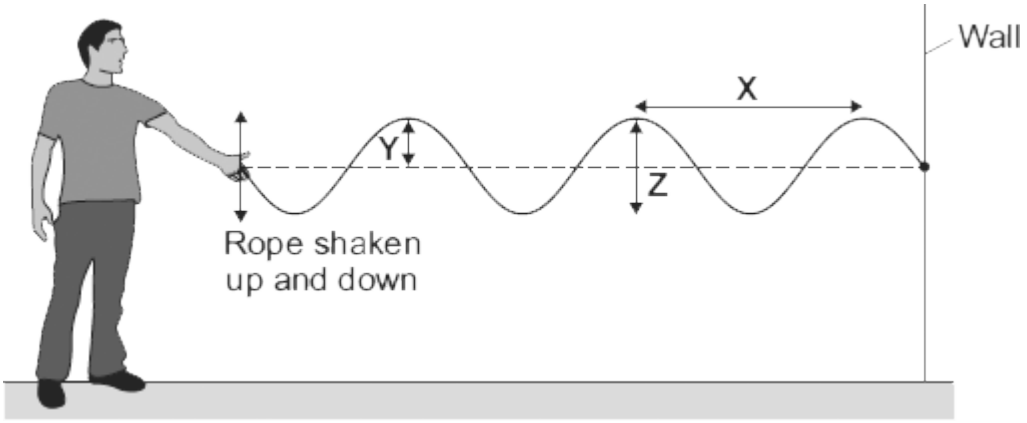
(1)

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

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

(1)

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



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

(1)

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

Write the correct answer in the box. ☐

(1)

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

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

_____

(1)

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

(i) State the frequency of the waves.

_____ Hz

(1)

(ii) Calculate the speed of the waves.

Show clearly how you work out your answer.

_____

_____

Wave speed = _____ m/s

(2)

(Total 10 marks)

10. (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.

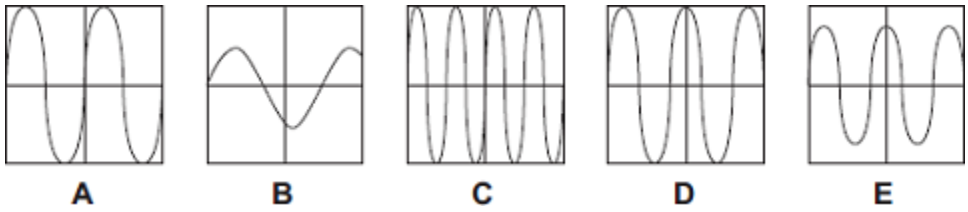
Include the unit in your answer.

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)

1.

(a) any **four** from:

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

4

(b) the baby can be seen in the dark

1

(c) wave speed = frequency × wavelength

accept $v = f \lambda$

1

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

1

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

1

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

allow 2.4×10^9 *with no working for* ***3*** *marks*

1

[9]

2.

(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]

3. (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]

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

accept vibrations / oscillations for waves

1

(ii) 0.773 (metres)

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

*allow **2** marks for an answer of* $0.7\dot{7}\dot{2}$

*allow **2** marks for an answer of 0.772*

*allow **1** mark for correct substitution ie 340 = 440 × λ*

3

(b) (sound is) louder

*do **not** accept the converse*

1

as amplitude is larger

waves are taller is insufficient

1

higher pitch / frequency

1

as more waves are seen

reference to wavelengths alone is insufficient

waves are closer together is insufficient

1

[8]

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

a movement causes the wave is insufficient

1

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

accept direction of wave travel

1

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

accept direction of wave travel

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

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

1

(b) for radio waves:

accept converse for each mark

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

*accept sound waves are not electromagnetic for **1** mark*

1

[7]

6.

(a) (i) (visible) light

accept visible

1

(ii) microwaves

1

(b) J

1

(c) (i) B

1

(ii) shorter than

1

(d) (i) To find out if using a mobile phone is harmful to health

1

(ii) any **two** from:

- (X has a) low(er) SAR value

  "it" refers to mobile phone

  accept has a low(er) rate

- (maximum) energy absorbed (by the head) is less

  accept energy emitted (by phone) is less
  accept radiation for energy

- (if mobiles are harmful) less likely to cause harm

  accept will not cause harm
  accept it is safer

2

[8]

7.

(a) vibrate / oscillate

accept a correct description

move is insufficient

1

(b) 336

*allow **1** mark for correct substitution, ie 420 × 0.8(0) provided no subsequent step shown*

2

[3]

8. (a) C or 0.18 mm

1

(b) 0.6 (m)

*allow **1** mark for correct substitution and/or transformation **or 1** mark for changing frequency to Hz*
*answer 600 gains **1** mark*

2

(c) creates an alternating current

accept 'ac' for alternating current
accept alternating voltage

1

with the same frequency as the radio wave

accept signal for radio wave

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

1

(d) X-rays cannot penetrate the atmosphere

accept atmosphere stops X-rays

*do **not** accept atmosphere in the way*

or

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

ignore explanations

1

[6]

9. (a) (i) X-ray(s)

1

(ii) gamma rays

1

(iii) infrared

1

(b) the same speed as

1

(c) (i) horizontal arrow drawn pointing to the right

judge by eye

accept drawn anywhere on diagram

1

(ii) **Y**

1

(iii) any **one** from:

- any type of electromagnetic wave
  accept electromagnetic wave(s)
- water (wave)
  *do **not** accept seismic waves*
- (earthquake / seismic) S waves
  *do **not** accept P waves*
  *do **not** accept earthquakes*

1

(d) (i) 3

1

(ii) 3.6

or

their (d)(i) × 1.2 correctly calculated

v = f × λ
*allow **1** mark for correct substitution*
ie 3 or their (d)(i) × 1.2 provided that no subsequent step is shown

2

[10]

10. (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]