Waves 1

Name: _____

Class: _____

Date: _____

Time: **83 minutes**

Marks: **76 marks**

Comments:

1. Food colouring can be used to change the colour of water.

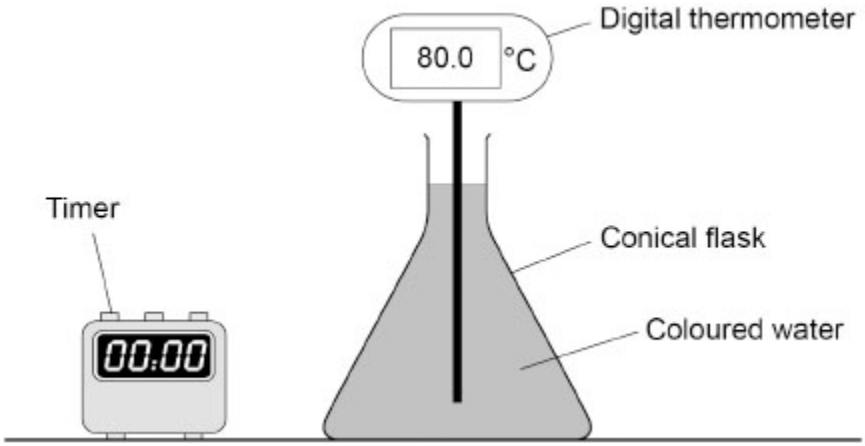
A student investigated how the colour of water affects the time taken for the water to cool.

This is the method used.

1. Put 200 cm^3 of hot water into a conical flask.
2. Add four drops of food colouring to the water.
3. Place a digital thermometer in the water.
4. Start a timer when the temperature of the water is 80.0 °C.
5. Record the time taken for the water to cool to 65.0 °C.
6. Repeat steps 1 to 5 using different colours of food colouring.

Figure 1 shows the apparatus.

Figure 1



(a) What was the independent variable in this investigation?

Tick (✓) **one** box.

Colour of water ☐

Final temperature of water ☐

Volume of water ☐

(1)

(b) Which of the following was a control variable in this investigation?

Tick (✓) **one** box.

Initial temperature of water ☐

Time taken for water to cool ☐

Type of thermometer used ☐

(1)

(c) What equipment should have been used to make sure 200 cm^3 of water was put in the conical flask?

Tick (✓) **one** box.

Beaker ☐

Measuring cylinder ☐

Metre rule ☐

(1)

(d) The student also tested water with no food colouring.

The temperature of the water changed from 80.0 °C to 65.0 °C in a time of 5.0 minutes.

Calculate the average rate of change of temperature of the water.

Use the equation:

$$\text{average rate of change of temperature} = \frac{\text{change in temperature}}{\text{time taken}}$$

_____

_____

_____

Average rate of change of temperature = _____ °C/minute

(2)

The table below shows the results for the different coloured water.

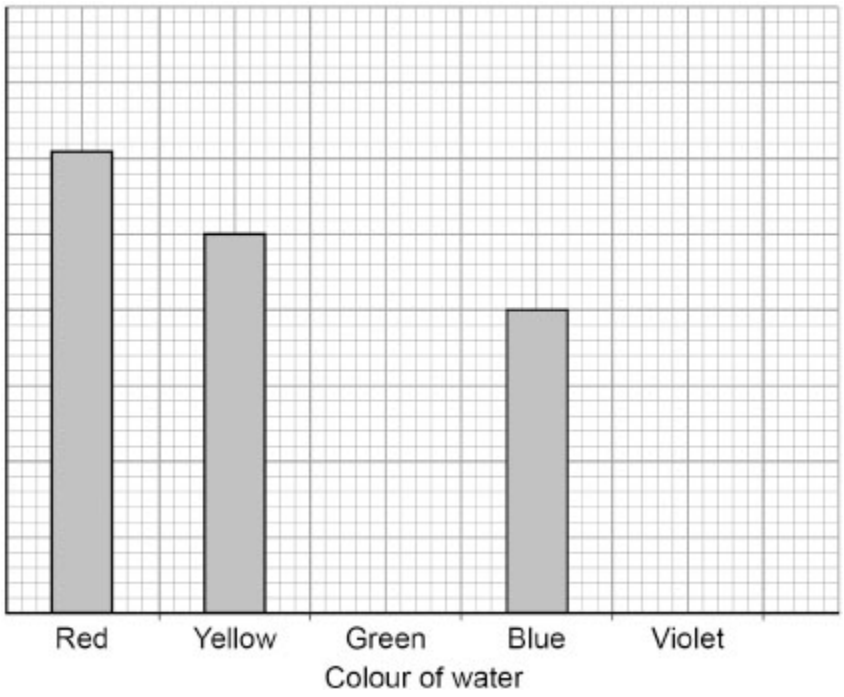
Colour of water	Rate of change of temperature in °C/minute
Red	6.1
Yellow	5.0
Green	4.3
Blue	4.0
Violet	3.7

(e) Complete **Figure 2**.

You should:

- label the *y*-axis
- add a scale to the *y*-axis
- draw bars for the green water and the violet water.

Figure 2



(3)

(f) In the visible spectrum, orange light is between red light and yellow light.

Estimate the rate of change of temperature if orange food colouring was used.

Use the table above.

Estimated rate of change of temperature = _____ °C/minute

(1)

(g) Complete the sentence.

Choose the answer from the box.

infrared	**ultraviolet**	**x-rays**

The results show that the colour of the water affects the rate at which the water emits _____.

(1)

(h) Complete the sentence.

Choose the answer from the box.

energy	**rarefactions**	**temperature**

The water in each conical flask cools down because the electromagnetic radiation emitted by the water transfers _____.

(1)

(Total 11 marks)

2. Some homes are connected to the internet using satellites.

Electromagnetic waves are used to transmit data between Earth and the satellites.

(a) Which electromagnetic waves are used to transfer data between Earth and satellites?

Tick (✓) **one** box.

Gamma rays ☐

Microwaves ☐

Ultraviolet ☐

Visible light ☐

(1)

(b) Which of the following electromagnetic waves has the greatest frequency?

Tick (✓) **one** box.

Gamma rays ☐

Microwaves ☐

Ultraviolet ☐

Visible light ☐

(1)

(c) What is meant by the 'period of a wave'?

Tick (✓) **one** box.

The distance travelled by a wave in one second	☐
The number of waves passing a fixed point each second	☐
The time taken for one wave to pass a fixed point	☐

(1)

(d) Data is transmitted to the satellites by electromagnetic waves with a frequency of 48 GHz.

Calculate the period of waves with a frequency of 48 GHz.

Use the Physics Equations Sheet.

Choose the unit from the box.

J	**N/kg**	**s**

Period = _____ Unit _____

(4)

(e) The satellites receive and transmit data using electromagnetic waves with different frequencies.

Give **one** property that is the same for electromagnetic waves with different frequencies.

(1)

(f) Most homes are connected to the internet using cables.

Suggest **one** reason why homes in some areas of the UK are connected to the internet by satellites.

_____

_____

_____

(1)

(Total 9 marks)

3. A pair of sunglasses has lenses that absorb all ultraviolet and some visible light.

(a) Ultraviolet and visible light are both transverse waves.

What is meant by 'transverse waves'?

_____

_____

_____

_____

(2)

(b) Ultraviolet can cause sunburn and eye damage.

Give **one** other risk to health from exposure to ultraviolet.

_____

_____

(1)

(c) Complete the sentence.

Compared with the wavelength of visible light, the wavelength of ultraviolet

is _____.

(1)

(d) A wave of visible light has a frequency of 6.25×10^{14} Hz.

speed of light = 3.00×10^{8} m/s

Calculate the wavelength of this light.

Use the Physics Equations Sheet.

Give your answer in nanometres (nm).

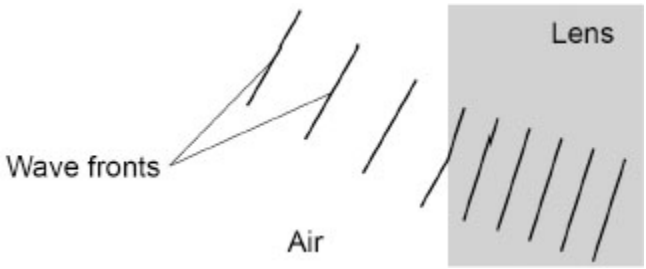
Wavelength = _____ nm

(4)

(e) A ray of visible light incident on the lens in a pair of sunglasses is refracted.

Figure 1 shows a wave front diagram for visible light incident on the lens.

Figure 1



For each wave front, one end of the wave front enters the lens before the other end.

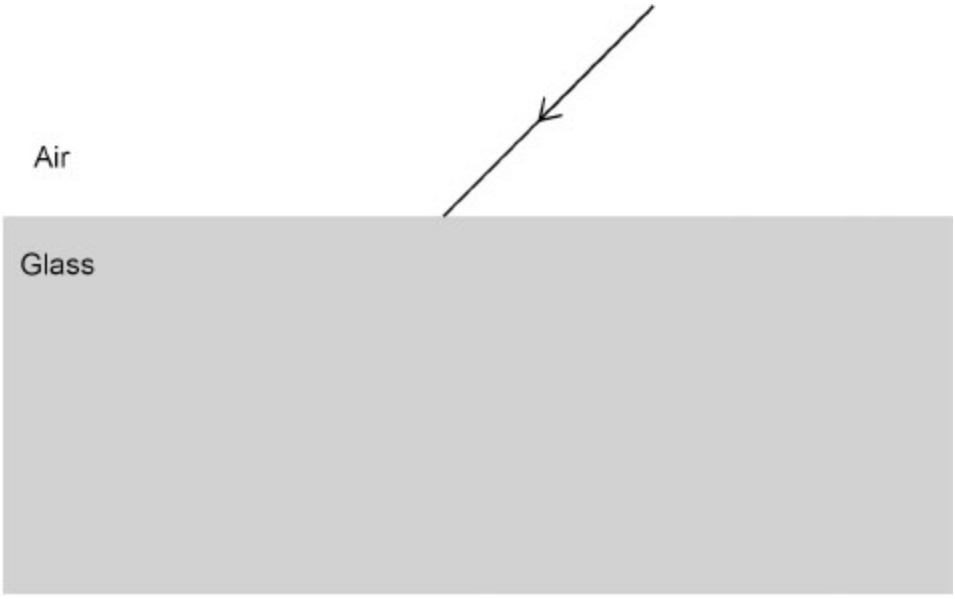
Explain why the light refracts as it enters the lens.

(2)

(f) **Figure 2** shows a ray of visible light incident on glass.

The angle of incidence is 45°.

Figure 2



The angle of refraction of the ray in the glass is 28°.

Complete the ray diagram in **Figure 2** to show the path of the ray in the glass.

You should:

- draw the normal line
- draw the refracted ray in the glass.

You do **not** need to draw the ray leaving the glass.

(2)

(Total 12 marks)

4. A student used a temperature probe to measure the temperature of melting ice.

This is the method used.

1. Place the temperature probe in iced water and record the temperature.
2. Remove the probe from the iced water and allow the probe to return to room temperature.
3. Repeat steps 1 and 2 four more times.

The measurements were:

−0.5 °C +0.2 °C −0.3 °C +0.5 °C +0.1 °C

(a) What type of error is shown by the measurements?

_____

_____

(1)

(b) Determine the uncertainty in the measurements.

_____

_____

_____

Uncertainty = ± _____ °C

(2)

The student investigated how the colour of an object affects the rate of change of temperature of the object.

This is the method used.

1. Make two identical cubes using clay.
2. Paint one cube black and paint one cube white.
3. Push a temperature probe into the centre of each cube.
4. Place the cubes 10 cm from an infrared heater.
5. Record the temperature of each cube every two minutes.

The table below shows the results for the white cube.

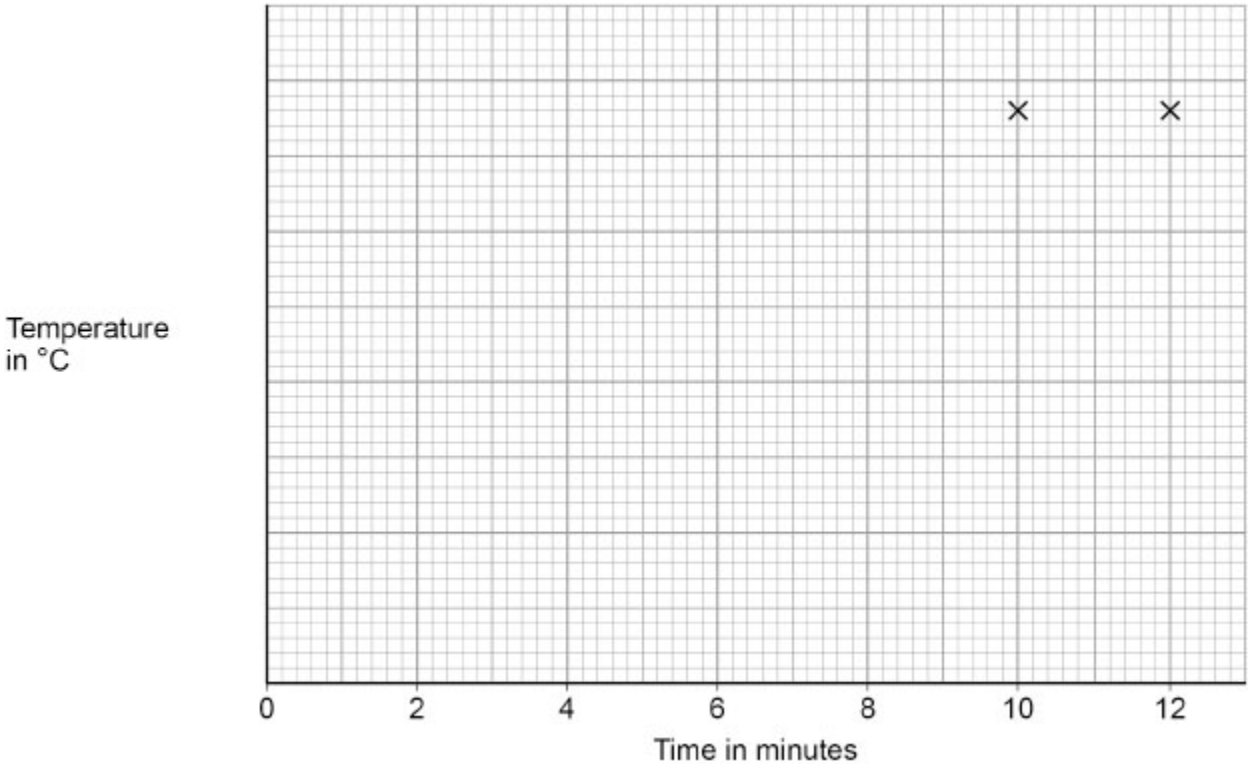
Time in minutes	**Temperature in °C**
0	18
2	55
4	68
6	73
8	65
10	76
12	76

(c) Complete the figure below.

You should:

- use a suitable scale for the *y*-axis
- plot the data from the table above
- draw a line of best fit.

The data for 10 minutes and 12 minutes have been plotted for you.



(4)

(d) The temperature of the black cube increased from 18 °C to 63 °C in the first 2.0 minutes.

Calculate the average rate of change of temperature of the black cube in the first 2.0 minutes.

Give your answer in °C/s.

Average rate of change of temperature = _____ °C/s

(3)

(e) The student made two observations:

1. The rate of change of temperature was initially greater for the black cube than for the white cube.

2. After a few minutes, both cubes stopped changing temperature.

Explain the student's observations.

You should refer to the absorption and emission of radiation from the surfaces of the cubes.

(4)

(Total 14 marks)

5. **Figure 1** shows an electronic whistle used by a referee in a football match.

Figure 1

When the button is pressed the whistle emits sound waves that travel through the air.

(a) What is transferred by the sound waves as they travel through the air?

Tick (✓) **one** box.

Energy ☐

Mass ☐

Temperature ☐

(1)

(b) What is a typical value for the speed of sound in air?

Tick (✓) **one** box.

33 m/s ☐

330 m/s ☐

3300 m/s ☐

33 000 m/s ☐

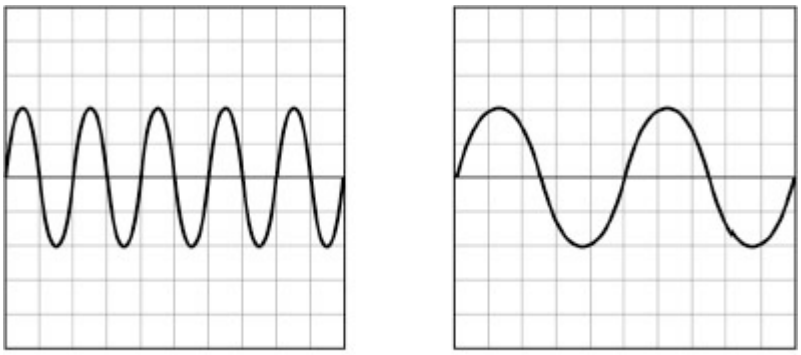
(1)

The whistle can emit two different sound waves, **A** and **B**.

Figure 2 shows the two different sound waves as displayed on a screen.

The sound waves are drawn to the same scale.

Figure 2



(c) Complete the sentences to describe a difference and a similarity between the two waves.

Choose answers from the box.

amplitude	frequency	wavelength	period

Difference

Wave **A** has a greater _____ than wave **B**.

Similarity

Wave **A** has the same _____ as wave **B**.

(2)

(d) Wave **A** has a frequency of 4.0 kHz.

Which of the following is the same as 4.0 kHz?

Tick (✓) **one** box.

4.0 Hz ☐

4000 Hz ☐

4 000 000 Hz ☐

4 000 000 000 Hz ☐

(1)

(e) Calculate the period of wave **A**.

Use your answer from part (d) and the equation:

$$\text{period} = \frac{1}{\text{frequency}}$$

_____

_____

_____

Period = _____ s

(2)

(f) Sound waves in air are longitudinal waves.

Complete the sentence to describe a sound wave.

Choose answers from the box.

compression	**deflection**	**diffraction**	**rarefaction**	**reflection**

When sound waves travel through air they create areas

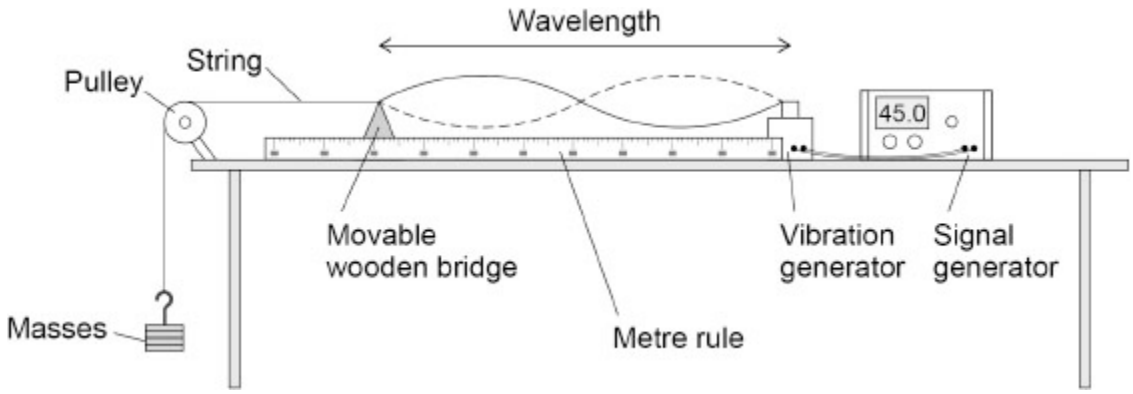
of _____ and _____ .

(2)

(Total 9 marks)

6. A teacher demonstrated how the frequency of a wave on a string affects the wavelength of the wave.

The figure below shows the equipment used.



The frequency of the signal generator is adjusted so that the wave shown in the figure above is seen.

At this frequency the string vibrates between the two positions shown in the figure above.

(a) Describe a method the teacher could use to investigate how the frequency of the wave affects the wavelength.

(4)

Use the Physics Equations Sheet to answer parts (b) and (c).

(b) Which equation links frequency (f), wavelength (λ) and wave speed (v)?

Tick (✓) **one** box.

$f = \lambda \times v$ ☐

$\lambda = f \times v$ ☐

$v = f \times \lambda$ ☐

(1)

(c) The wave on the string has a frequency of 45.0 Hz.

The wave speed is 35.1 m/s.

Calculate the wavelength of the wave.

Wavelength = _____ m

(3)

(Total 8 marks)

7. Electromagnetic waves are grouped according to their wavelength and frequency.

Electromagnetic waves are transverse waves and can travel through a vacuum.

(a) Give one **other** property that is the same for all types of electromagnetic wave.

(1)

(b) What is meant by 'transverse wave'?

(1)

(c) Which group of electromagnetic waves is used for satellite communications?

(1)

(d) Visible light is the only group of electromagnetic waves that the human eye can detect.

Which colour of visible light has the shortest wavelength?

(1)

(e) The three highest frequency groups of electromagnetic waves are hazardous.

Describe a risk linked to each group of high frequency electromagnetic wave.

_____

_____

_____

_____

(2)

The figure below shows a person using a mobile phone to allow a laptop to access the Internet.

The electromagnetic waves emitted by the mobile phone send information to the laptop.

(f) The electromagnetic waves emitted by the mobile phone have a period of 4.0×10^{-10} s.

Calculate the frequency of the waves.

Use the Physics Equations Sheet.

Give your answer in standard form.

Frequency (in standard form) = _____ Hz

(3)

(g) The electromagnetic waves are produced by oscillations in the transmitter of the mobile phone.

Explain how oscillations in the transmitter enable information to be transferred to the detector in the laptop.

(4)

(Total 13 marks)

1. (a) colour of water

1

(b) initial temperature of water

1

(c) measuring cylinder

1

(d)

$$\frac{80.0 - 65.0}{5.0}$$

allow $\frac{65.0 - 80.0}{5.0}$

allow $\frac{15.0}{5.0}$

1

= 3 (°C / minute)

allow – 3 (°C / minute)

1

(e) *y*-axis labelled rate of change of temperature in °C / minute

unit must be present

1

y-axis scale of 1.0 °C / minute per cm

1

bars plotted correctly

allow a tolerance of ± ½ small square

ignore width of bars

1

(f) answer between 5.0 and 6.1 (°C / minute)

*do **not** accept 5.0 (°C / minute)*

*do **not** accept 6.1 (°C / minute)*

1

(g) infrared

1

(h) energy

1

[11]

2. (a) microwaves

1

(b) gamma rays

1

(c) the time taken for one wave to pass a fixed point

1

(d) 48 GHz = 48 000 000 000 Hz

allow 48 GHz = 48 × 10^9 Hz

subsequent marks may be awarded if an incorrectly / not converted value of f is used

1

$$T = \frac{1}{48\,000\,000\,000}$$

1

T = 2.08… × 10^{-11}

allow 0.000 000 000 0208…

allow 0.000 000 000 021

allow 2.1 × 10^{-11}

1

s

allow seconds

1

(e) any **one** from:

- speed (in a vacuum / air)
- they can travel through a vacuum
- they transfer energy
- they are transverse

1

(f) cables may not go to remote areas

or

it is expensive to lay cables

allow satellites may give faster data transfer

1

[9]

3. (a) oscillations / vibrations are perpendicular to the direction of energy transfer

allow oscillations / vibrations are perpendicular to the direction of wave travel

*allow **1** mark for oscillations/ vibrations are perpendicular*

2

(b) skin cancer

or

causes skin to age (prematurely)

allow skin cell mutation

ignore cancer unqualified

1

(c) shorter

1

(d) $3.00 \times 10^8 = 6.25 \times 10^{14} \times \lambda$

1

$$\lambda = \frac{3.00 \times 10^8}{6.25 \times 10^{14}}$$

1

$\lambda = 4.80 \times 10^{-7}$ (m)

1

$\lambda = 480$ (nm)

allow a correct conversion to nm of their incorrectly calculated value of λ using the numbers from the question

1

(e) the speed of the light / waves / wavefronts decreases (when entering the lens)

allow the speed of light / waves / wavefronts is less in the lens (than in air)

ignore lens has a higher density than air

ignore references to refractive index

1

(so) one end of the wavefront slows before the other end

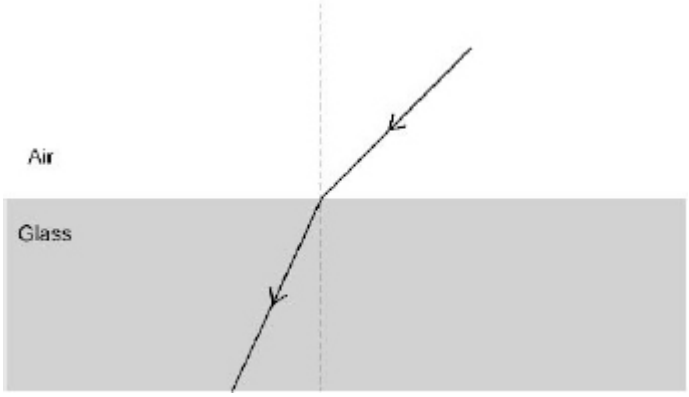
1

(f) normal line drawn

allow a normal line that only extends from the boundary into the glass

1

ray drawn with an angle of refraction of 28°



ignore ray below the glass

1

[12]

4. (a) random

1

(b) range = 0.5 – (–0.5)

or

range = 1

or

$$\text{uncertainty} = \frac{0.5 - (-0.5)}{2}$$

allow

$$0.5 - \left(\frac{0.5+0.2-0.3+0.5+0.1}{5}\right)$$

allow

$$\left(\frac{0.5+0.2-0.3+0.5+0.1}{5}\right) - 0.5$$

1

uncertainty = (±) 0.5 (°C)

1

(c) *y*-axis scale of 10 °C per cm

1

all points plotted correctly

*allow **1** mark for 3 or 4 points plotted correctly*

allow a tolerance of ± ½ small square'

2

curved line of best fit ignoring anomalous point at 8 minutes

1

(d) 2 minutes = 120 seconds

subsequent marks may be awarded if time is incorrectly / not converted

1

$$\text{rate} = \frac{63 - 18}{120}$$

1

rate = 0.375 (°C/s)

allow 0.38 (°C/s)

1

(e) black surfaces are good absorbers (and emitters of infrared / radiation)

ignore references to heat throughout

1

white surfaces are poor absorbers (and emitters of infrared / radiation)

1

as the temperature of the cubes increases the cubes emit infrared / radiation at a greater rate

1

at maximum / constant temperature, each cube emits infrared /radiation at the same rate that it absorbs infrared / radiation

1

[14]

5. (a) energy

1

(b) 330 m/s

1

(c) frequency

1

amplitude

1

(d) 4000 Hz

1

(e)

$$T = \frac{1}{4000}$$

1

0.00025 (s)

*allow ecf from question **(d)***

1

(f) compression

1

rarefaction

either order

1

[9]

6. (a) **Level 2:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- use the signal generator to adjust the frequency
- keep the number of masses the same
- move the wooden bridge
- observe a steady / stationary wave pattern
- use the metre rule to measure the wavelength
- repeat using different values of frequency
- repeat for different stationary wave patterns

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

1

(c) $35.1 = 45.0 \times \lambda$

1

$$\lambda = \frac{35.1}{45.0}$$

1

$\lambda = 0.78$

allow 0.780

1

[8]

7. (a) speed (in a vacuum/air)
or
transfer energy

ignore they can travel through air

allow they can be reflected / refracted

1

(b) oscillations / vibrations are perpendicular to the direction of energy transfer

allow wave travel for energy transfer

1

(c) microwaves

allow radio waves

1

(d) violet

allow purple

1

(e) any **two** from

- (ultraviolet and /or X-rays and / or gamma rays) can cause mutations in genes / DNA

  allow can damage / kill cells

  ignore mutations in cells

- ultraviolet can cause skin to age and / or skin cancer

  allow ultraviolet can cause sunburn or eye damage

- X-rays and / or gamma rays increase the risk of cancers

  allow X-rays and / or gamma rays can cause cancers

  *if no other mark awarded allow **1** mark for (the three highest frequency groups) can cause cancer*

2

(f)

$$4.0 \times 10^{-10} = \frac{1}{\text{frequency}}$$

1

$$\text{frequency} = \frac{1}{4.0 \times 10^{-10}}$$

1

2.5×10^{9} (Hz)

only award if answer is in standard form

1

(g) radio waves are produced (by the transmitter)

allow microwaves are produced (by the transmitter)

1

the detector absorbs the waves / energy

1

(which produces) an alternating current

allow causing electrons to oscillate

1

with the same frequency as the (transmitted) waves

allow with the same frequency as the oscillations in the transmitter

1

[13]