

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.6.2 ELECTROMAGNETIC WAVES (PACK 5)

SCORE

/164

PERCENTAGE

%

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Q1.

The diagram below shows types of waves within the electromagnetic spectrum.

Some of the types of waves are represented by letters.

P	microwaves	Q	visible light	R	S	gamma rays
----------	-------------------	----------	----------------------	----------	----------	-------------------

- (a) Which letter shows the position of ultraviolet (UV) radiation within the electromagnetic spectrum?

Tick **one** box.

P	☐	Q	☐	R	☐	S	☐
----------	--------------------------	----------	--------------------------	----------	--------------------------	----------	--------------------------

(1)

- (b) A special lamp can produce UV radiation.

Which **two** statements describe the electromagnetic waves emitted by a UV lamp?

Tick **two** boxes.

They have a higher frequency than X-rays.

☐

They have the same wave speed as visible light.

☐

They have a longer wavelength than microwaves.

☐

They have a lower frequency than gamma rays.

☐

They have a greater wave speed than radio waves.

☐

(2)

- (c) UV radiation is used to treat a vitamin D deficiency.

People should **not** use a UV lamp for long periods of time.

State **two** risks of exposure to high levels of UV radiation.

1. _____

2. _____

(2)

- (d) Ionising radiation is used for some medical imaging.

Name **two** types of electromagnetic waves that are used.

1. _____

2. _____

(2)

(Total 7 marks)

Q2.

A car aerial receives radio waves from a radio transmitter.

Radio waves are transverse waves.

Sound waves are longitudinal waves.

- (a) Describe the difference between transverse waves and longitudinal waves.

(2)

- (b) The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

Wavelength = _____ m

(3)

- (c) Describe how the radio waves reaching the car aerial produce signals in the electrical circuit of the car radio.

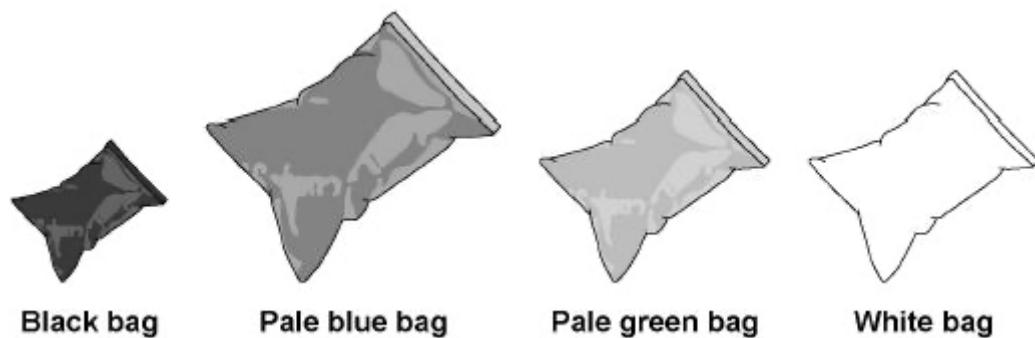
(3)
(Total 8 marks)

Q3.

A solar water bag can be used to heat water for an outdoor swimming pool.

A student wanted to find out if the colour of the solar water bag affects the temperature increase of the water inside the bag.

The diagram below shows some of the equipment used.



This is the method used.

1. Fill each bag with water.
2. Place the four bags on the ground outside.
3. After three hours, measure the temperature of the water inside each bag.
4. Repeat steps 1–3 on the next two days.

(a) Suggest three changes the student should make to this method to get valid results.

1. _____

2. _____

3. _____

(3)

The student repeated the investigation using an improved method.

The results obtained were valid.

The table below shows the results.

Colour of bag	Temperature increase in °C			
	Day 1	Day 2	Day 3	Mean
Black	44.0	31.4	43.4	39.6
Pale blue	38.5	23.6	38.1	33.4
Pale green	37.9	23.7	37.7	33.1
White	25.3	23.4	24.2	X

- (b) The student used a thermometer to measure the temperature of the water inside each bag.

What was the resolution of the thermometer?

Resolution = _____ °C

(1)

- (c) Suggest **one** reason why the temperatures increased less on Day 2 than on Day 1 and Day 3.

(1)

- (d) Calculate the mean temperature increase for the white bag.

Mean temperature increase = _____ °C

(1)

- (e) Which colour of bag would be best to use to heat water?

Give a reason for your answer.

Colour _____

Reason _____

(2)

(Total 8 marks)

Q4.

- (a) Complete the sentences.

Choose the answers from the box.

ionising	light	sound	transmitted	waves
-----------------	--------------	--------------	--------------------	--------------

X-rays travel at the speed of _____ .

X-rays can cause cancer because they are _____ .

(2)

- (b) How do X-rays compare with gamma rays?

Tick **one** box.

X-rays have a longer wavelength and a higher frequency

☐

X-rays have a longer wavelength and a lower frequency

☐

X-rays have a shorter wavelength and a higher frequency

☐

X-rays have a shorter wavelength and a lower frequency

☐**(1)**

A scientist measured the radiation dose that a person received at different distances from an X-ray machine.

The table shows the results.

Distance from machine in m	Dose in millisieverts/			Mean dose in millisieverts
	Test 1	Test 2	Test 3	
0.5	0.152	0.146	0.155	0.151
1.0	0.039	0.035	0.040	X
1.5	0.017	0.018	0.017	0.017
2.0	0.012	0.007	0.007	0.009
2.5	0.007	0.006	0.005	0.006

- (c) Calculate value
- X**
- in the table.

Mean dose = _____ millisieverts

(2)

- (d) What conclusion can be made from the results in the table?

Tick **one** box.

The dose decreases if you stand further from the machine.

☐

The dose is directly proportional to the distance.

☐

The dose is the same at all distances from the machine.

☐

There is a linear relationship between dose and distance.

☐

(1)

- (e) An X-ray gives a radiation dose of 0.180 millisieverts.

Natural sources give a dose of 0.012 millisieverts per day.

Calculate the time it would take for natural sources to give a dose of 0.180 millisieverts.

Time = _____ days

(2)

- (f) Suggest why doctors use X-rays even though this increases the risk of cancer to the patient.

(1)

- (g) X-rays can also be used to treat cancer.

A patient receives a dose of 20 millisieverts from an X-ray.

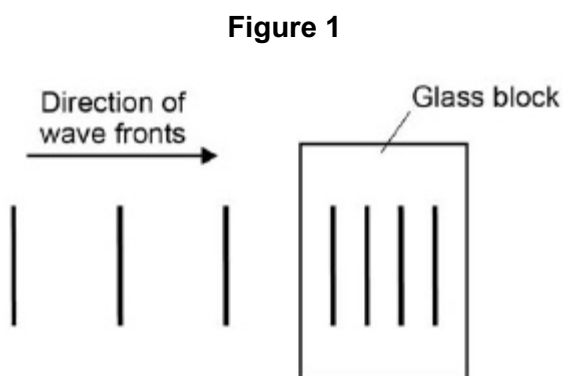
Proton beam therapy delivers 40% of this dose.

Calculate the dose delivered by proton beam therapy.

Dose = _____ millisieverts
(2)
(Total 11 marks)

Q5.

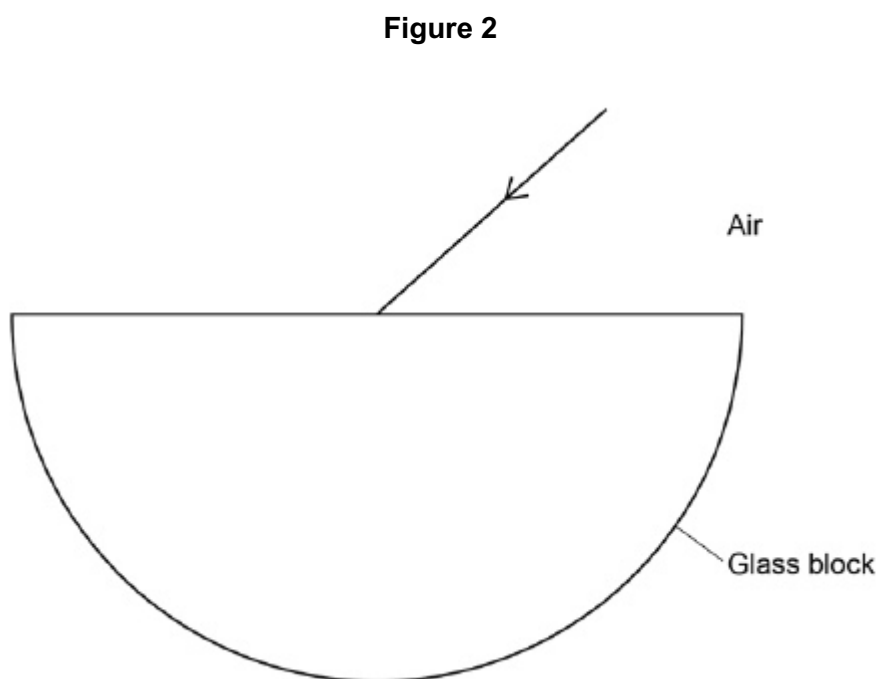
Figure 1 is a wave front diagram showing light travelling through the air and into a glass block.



- (a) Complete **Figure 1** by drawing wave fronts after they have left the glass block.

(1)

- (b) **Figure 2** shows a ray of light incident on a semi-circular glass block.



Complete the ray diagram in **Figure 2**.

- Draw the ray of light passing through and leaving the glass block.
- Label the angle of refraction.

(4)

- (c) Explain why the light is refracted.

(2)

- (d) A student investigated how different coloured light was refracted by glass.

The student aimed rays of different coloured light at a glass block.

She measured the angle of refraction for each colour.

Give **two** variables that the student should control.

1. _____

2. _____

(2)

The table shows the student's results.

Colour of light	Angle of refraction in degrees
Red	27.94
Orange	27.90
Yellow	27.82
Green	27.78
Blue	27.70

- (e) Explain why these results could **not** have been obtained with a normal protractor.

(2)

- (f) What conclusion can be made about the relationship between the wavelength of light and the angle of refraction?

(1)

- (g) Glass does **not** transmit ultraviolet radiation.

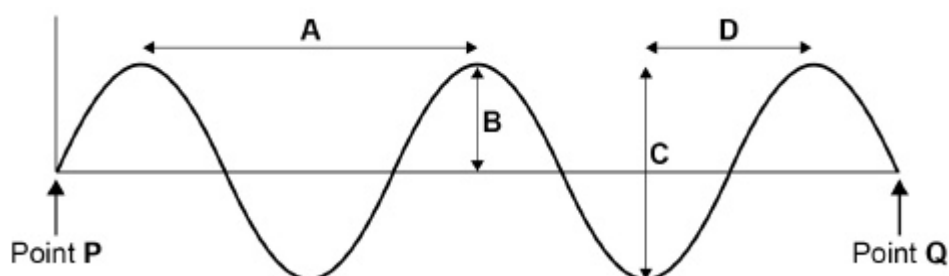
Suggest what happens to ultraviolet radiation when it is incident on glass.

(1)

(Total 13 marks)

Q6.

The diagram shows a wave.



- (a) Which arrow shows the amplitude of the wave?

Tick **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

- (b) Which arrow shows the wavelength of the wave?

Tick **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

- (c) It takes 0.5 seconds for a wave in the diagram to travel from point **P** to point **Q**.

Calculate the frequency of the waves shown in the diagram.

Frequency = _____ Hz

(2)

- (d) What type of wave is sound?

Tick **one** box.

Electromagnetic	☐
Longitudinal	☐
Transverse	☐

(1)

Two students carried out an experiment to determine the speed of sound.

This is the method used.

1. Student A stands 100 m away from Student B.
2. Student A bangs two blocks of wood together making a loud sound.
3. Student B starts a stopclock when he sees the blocks of wood bang together.
4. Student B stops the stopclock when he hears the sound and records the time.
5. The students repeat steps 2–4 several times.

The students calculated the speed of sound from their results.

- (e) Suggest the most likely source of error in the experiment.

(1)

- (f) The speed of sound calculated was lower than the true speed of sound in air.

Suggest **one** improvement to the students' method that would give a more accurate value for the speed of sound.

(1)

- (g) A student compares the properties of visible light waves and radio waves.

Which **two** properties are the same for both visible light waves **and** radio waves?

Tick **two** boxes.

Both are transverse waves	☐
Both can travel through a vacuum	☐
Both have the same amplitude	☐

Both have the same frequency

☐

Both have the same wavelength

☐

(2)

(Total 9 marks)

Q7.

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)

Q71.

Light rays can be reflected and refracted.

Figure 1 shows how a plane mirror reflects a ray of light.

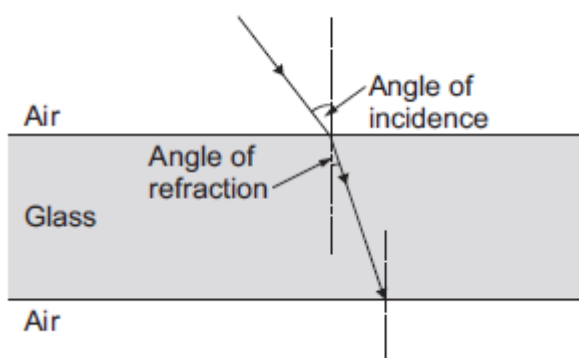
Figure 1



- (a) Light is refracted when passing from air into glass.

Figure 2 shows a ray of light as it passes from air into a glass block.

Figure 2



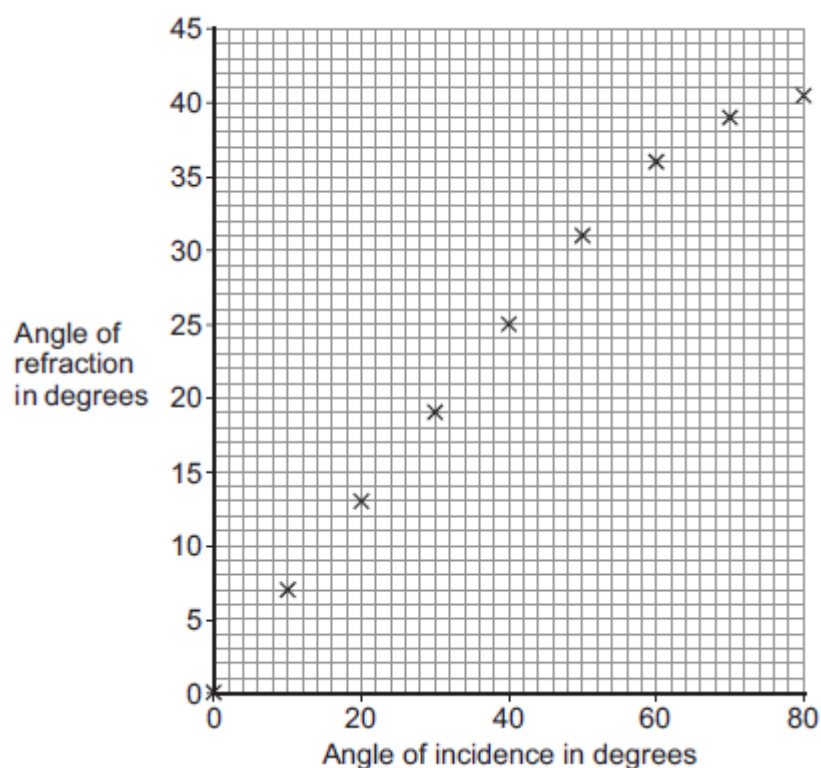
- (i) Draw a line on **Figure 2** to show the path of the ray as it leaves the glass block.
- (ii) Name the dashed lines drawn at 90° to the glass in **Figure 2**.

(1)

(1)

- (b) A student investigated the relationship between the angle of incidence and the angle of refraction as light passes from air into glass. Her results are shown in **Figure 3**.

Figure 3



- (i) Draw a line of best fit on **Figure 3**.

(1)

- (ii) Use **Figure 3** to describe the relationship between the angle of incidence and the angle of refraction.

(2)

(Total 5 marks)

Q72.

Electromagnetic waves can be diffracted, reflected and refracted.

Infrared, microwaves, radio waves and visible light can all be used for communication.

Draw **one** line from each part of the electromagnetic spectrum to its use.

Part	Use
	Photography
Microwaves	
	Remote controls
Radio waves	
	Mobile phones
Visible light	
	TV broadcasts

(Total 3 marks)

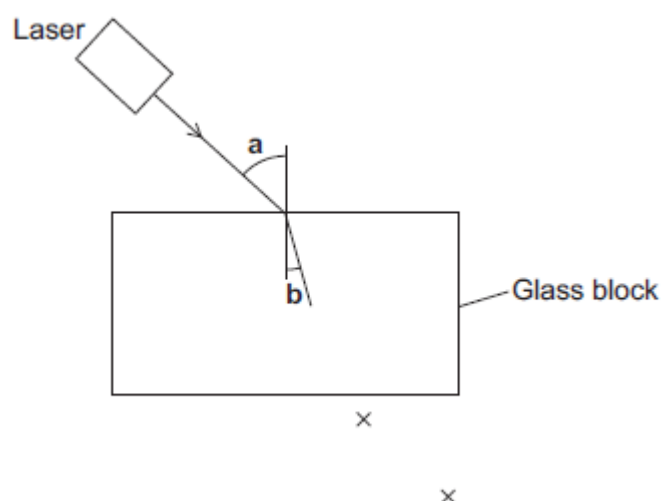
Q73.

A student used a laser to investigate the change of direction of light as it entered a glass block.

The apparatus is shown in **Figure 1**.

The path of a ray of light as it enters the glass block is shown.

Figure 1



- (a) The student marked crosses to show the path of the ray of light that left the glass block.

Use a ruler to help you to draw the path of the ray of light through and out of the glass block.

(2)

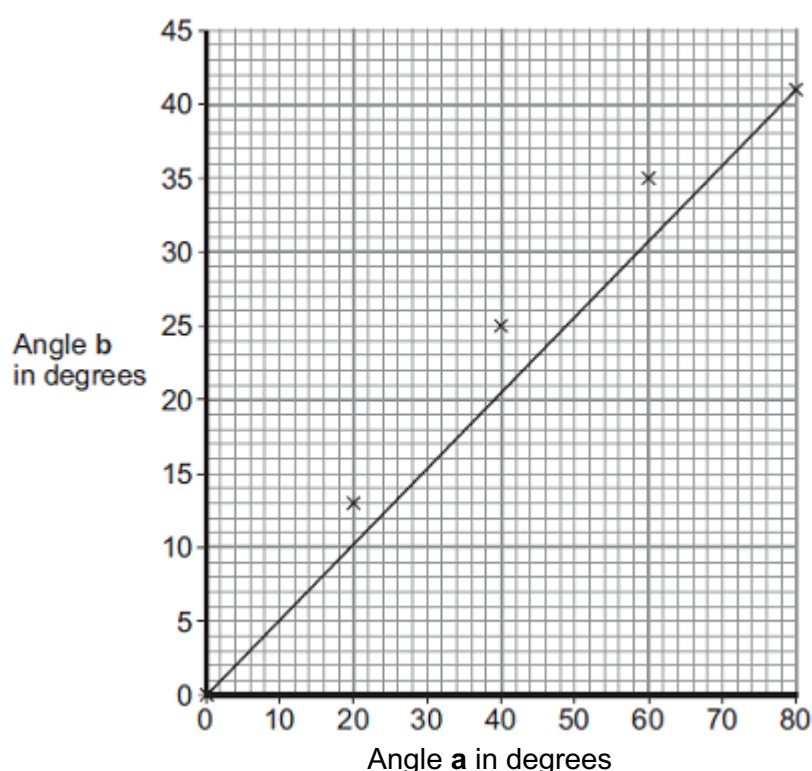
- (b) Light from lasers can damage your eyes.

Suggest **one** safety precaution that the student should have taken during his investigation.

(1)

- (c) The student measured **angle a** and **angle b** when the ray of light was incident at 5 different angles. He measured each set of values once. The student's results are shown in **Figure 2**.

Figure 2



- (i) The student's line of best fit is **incorrect**.

Give **one** reason why.

(1)

- (ii) The student measured 5 different values of **angle a** in his investigation.

Suggest **two** ways the student could improve his investigation.

(2)
(Total 6 marks)

Q74.

During the day, the Sun transfers energy to an outdoor swimming pool.



© Volodymyr Burdiak/iStock

- (a) By which method of energy transfer does the pool receive energy from the Sun?

(1)

- (b) (i) The mass of water in the pool is 5000 kg. The specific heat capacity of water is 4200 J/kg°C.

Calculate how much energy needs to be supplied to increase the water temperature by 5°C and state the correct unit.

Use the correct equation from the Physics Equations Sheet.

Give the unit.

Energy = _____

(3)

- (ii) The Sun supplies energy to the water in the pool at a rate of 16 kJ every second.

Calculate how much time it would take for energy from the Sun to raise the water temperature by 5 °C.

You will need to use your answer to **(b)(i)** and the correct equation from the Physics Equations Sheet.

Time = _____ seconds

(3)

- (iii) On one day, the temperature of the pool is 7 °C lower than the air temperature.

The time it takes for the pool temperature to rise by 5 °C is less than the answer to part **(b)(ii)**.

Suggest a reason why.

(1)

(Total 8 marks)

Q75.

The electromagnetic spectrum is made up of electromagnetic waves.

The electromagnetic waves form a continuous spectrum of different wavelengths.

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

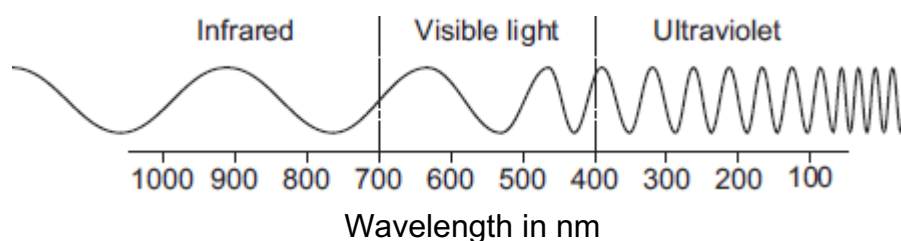
All electromagnetic waves are

longitudinal
mechanical
transverse

waves.

(1)

- (b) Part of the electromagnetic spectrum is shown in the diagram.



- (i) What is the range of wavelengths the human eye can detect?

The range is from _____ nm to _____ nm.

(2)

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

As the frequency of the waves in the electromagnetic spectrum increases,

the wave speed

decreases.

increases.

stays the same.

(1)

(Total 4 marks)

Q76.

This question is about the properties of light.

- (a) Which diagram, 1, 2 or 3, shows the path a ray of light takes when travelling from air **into** glass?

Tick (✓) the box under the correct diagram.

Diagram 1

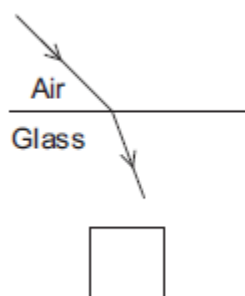


Diagram 2

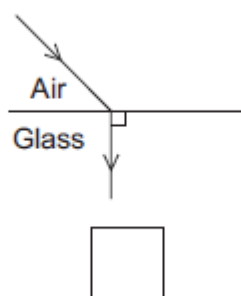
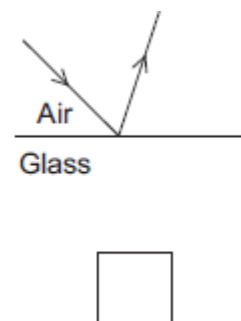


Diagram 3

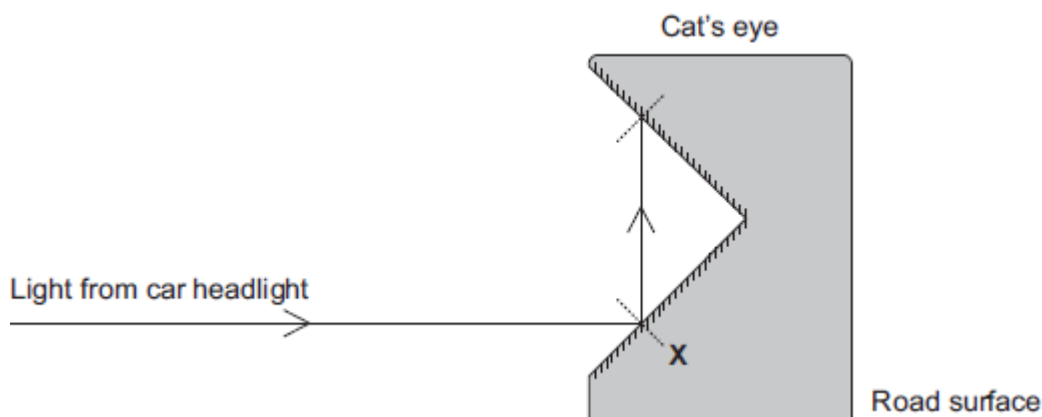


(1)

- (b) 'Cat's eyes' are used on roads as markers. They reflect light from car headlights.

Diagram 4 shows the path of a ray of light entering a 'cat's eye'.

Diagram 4



- (i) Continue the path of the ray of light on **Diagram 4**.

Show the direction of the ray.

(2)

- (ii) What is the name given to the dotted line on **Diagram 4** labelled **X**?

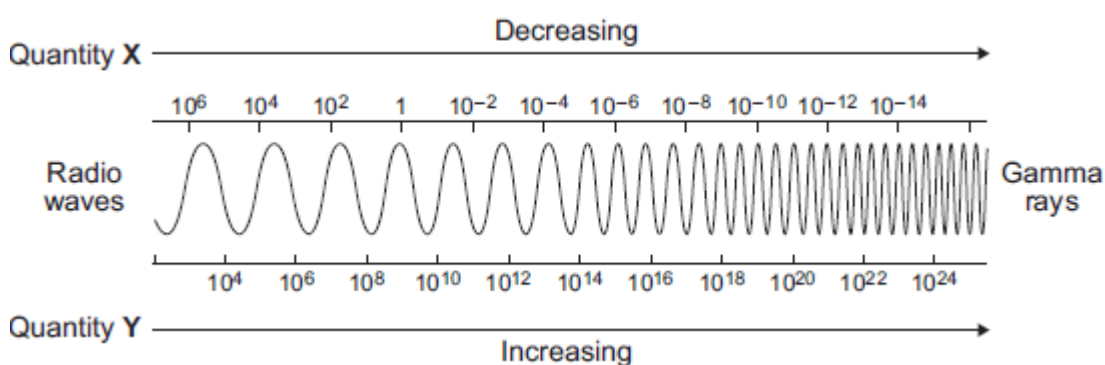
(1)

(Total 4 marks)

Q77.

The electromagnetic spectrum is shown in the diagram below.

Diagram 1



- (a) Name quantities **X** and **Y**, and state the units they are measured in.

Quantity **X**: _____ Unit for Quantity **X**: _____

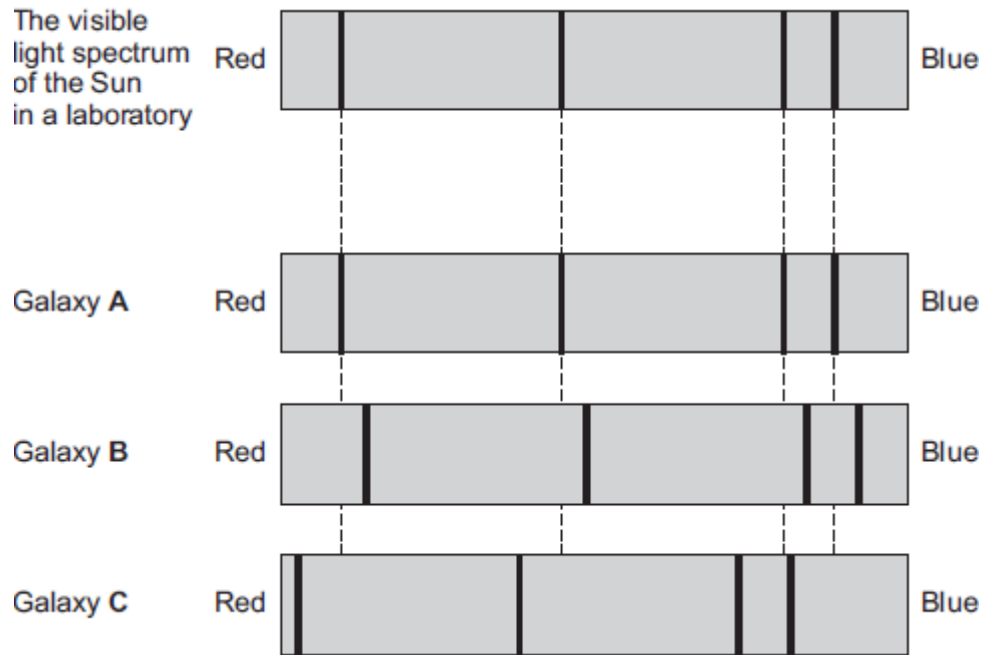
Quantity **Y**: _____ Unit for Quantity **Y**: _____

(3)

- (b) The visible part of the electromagnetic spectrum from stars includes dark lines. These lines are at specific wavelengths.

Diagram 2 shows the visible light spectra for three galaxies, **A**, **B** and **C**, compared to the visible light spectrum of the Sun as seen in a laboratory.

Diagram 2



- (i) Using evidence from the spectra, what conclusions can be made about the movement of galaxies **A**, **B** and **C** relative to the Earth?

(3)

- (ii) Compare the speed of galaxy **B** with the speed of galaxy **C** relative to the observer.

(1)

- (iii) Explain why it is **not** valid to make conclusions about all galaxies in the Universe from these spectra.

Q78.

A student investigates the infrared radiation being emitted by different coloured surfaces to the surroundings.

- (a) Draw a ring around each correct answer to complete the sentences.

- (i) All objects emit and _____ infrared radiation.

absorb
conduct
insulate

(1)

- (ii) Compared with cooler objects, hotter objects emit _____

less
the same amount of
more

infrared radiation.

(1)

- (b) The student pours 300 cm³ of hot water into each of 3 metal cubes and seals the top of each cube.

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

Energy is transferred through the sides of the metal cubes by _____

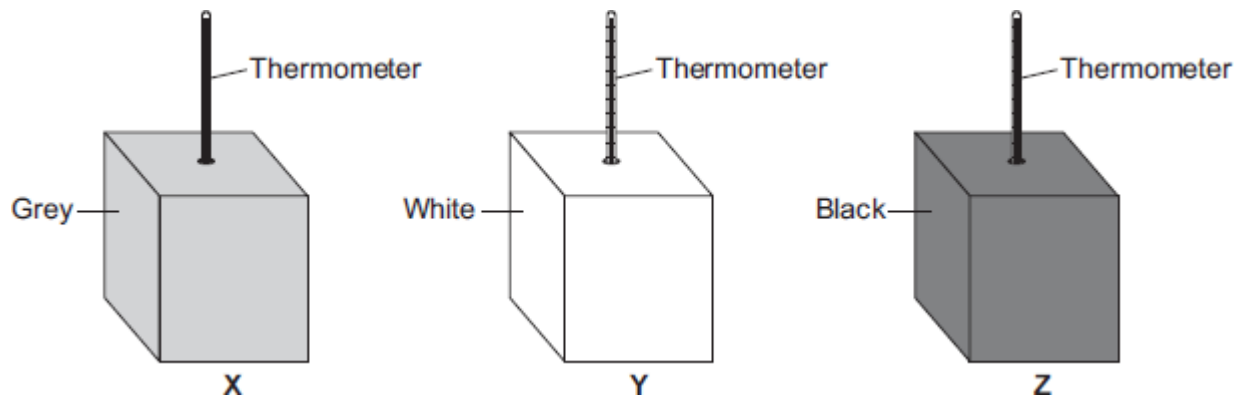
conduction.
convection.
radiation.

(1)

Each cube has the same volume.

Each cube is a different colour.

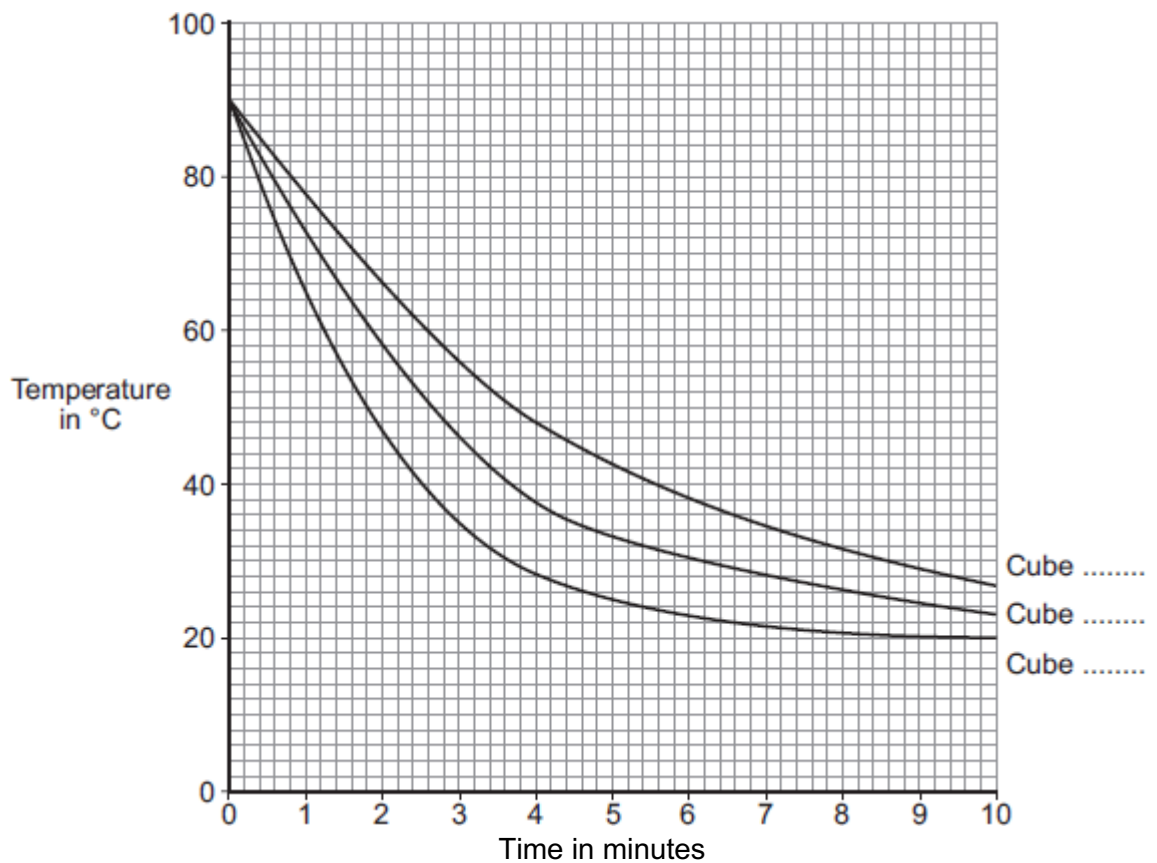
The temperature of each cube is recorded over 10 minutes.



- (ii) What is the independent variable in the investigation?

(1)

The results of the investigation are shown on the graph.



- (iii) Write the correct letter for each cube, **X**, **Y** or **Z**, next to the lines shown on the graph.

(2)

- (iv) All three cubes had the same starting temperature. This was important in the investigation.

Suggest why.

- What name is given to these variables?

Q79.

His body produces sweat to help him cool down.

-
- This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

(b) At the end of the race, the athlete is covered with a 'space blanket' made from shiny foil to prevent him from cooling too quickly.



© Fuse/Thinkstock

He wraps the space blanket around his body to reduce energy transfer to the surroundings.

How does the space blanket reduce energy transfer to the surroundings?

(3)

(Total 7 marks)

Q80.

Electromagnetic waves form a continuous spectrum.

Three parts of the electromagnetic spectrum are:

- gamma rays
- infrared
- visible light.

(a) Place the parts in order of increasing energy.

Increasing energy

(2)

- (b) The parts of the electromagnetic spectrum all have different properties.

Draw a ring around the correct answer to complete each sentence.

- (i) The number of waves passing a point in 1 second is called the

frequency.
speed.
wavelength.

(1)

- (ii) All parts of the electromagnetic spectrum travel at the same speed

through

a vacuum.
glass.
water.

(1)

- (c) The different parts of the electromagnetic spectrum are used for different methods of communication.

Complete the table by giving an example of a use of each part of the electromagnetic spectrum for communication.

Part of electromagnetic spectrum	Use for communication
Infrared	
Microwave	
Radio wave	
Visible light	

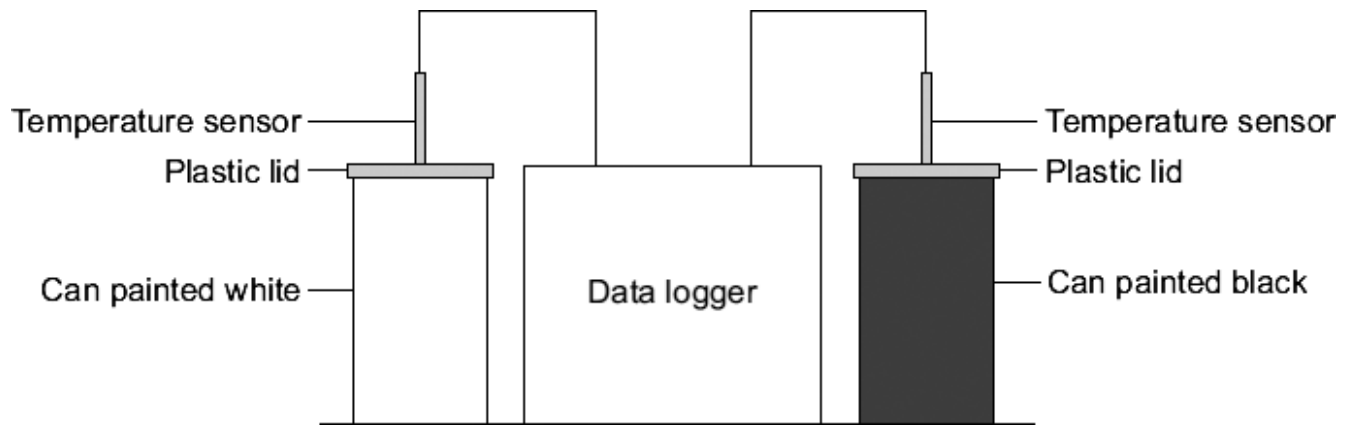
(4)

(Total 8 marks)

Q81.

A student investigated the emission of infrared radiation from two cans.

- ϕ The two cans were the same size.
- ϕ One can was painted white and the other can was painted black.
- ϕ The student poured the same volume of boiling water into each can.
- ϕ A data logger recorded the temperature in each can for the next 14 minutes.



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

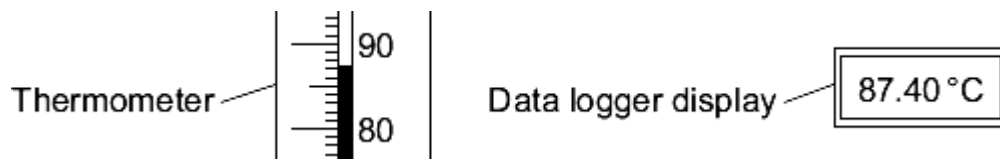
The plastic lids prevent energy loss by

conduction.
convection.
infrared radiation.

(1)

- (b) The data logger takes two temperature readings each second, and then plots a graph for the student.

The student could have used a thermometer to measure the temperature.

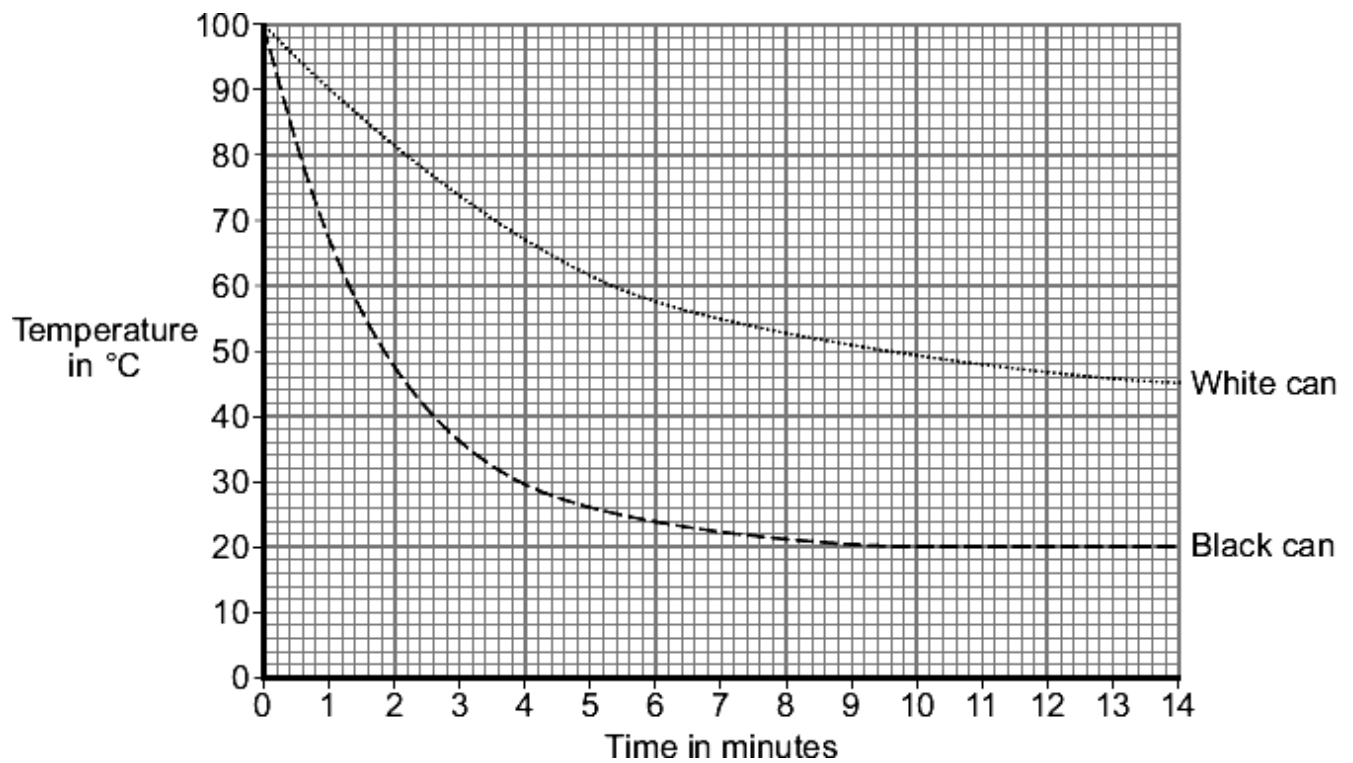


Give **two advantages** of using a data logger instead of the thermometer

1. _____
2. _____

(2)

- (c) The graph shows the student's results.



- (i) Explain the difference in temperature between the water in the two cans after 14 minutes.

(2)

- (ii) The student decided to repeat the investigation using a can painted grey.

On the graph, draw a line for the results you would expect for the can painted grey.

(2)

(Total 7 marks)

Q82.

Waves have many different properties.

- (a) Draw a ring around the correct answer in the boxes to complete each sentence.

Light waves

are longitudinal.

are transverse.

may be either longitudinal or transverse.

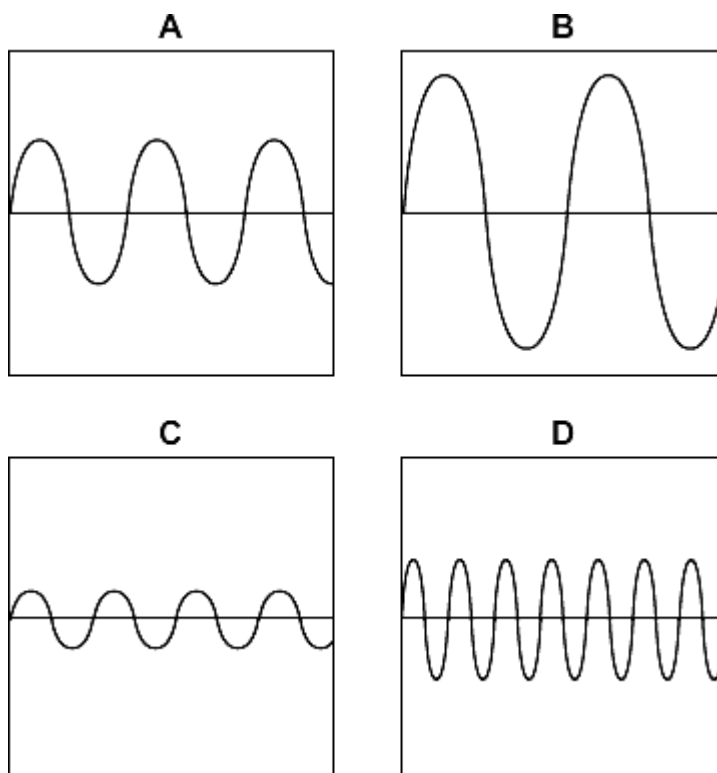
Sound waves

are longitudinal.
are transverse.
may be either longitudinal or transverse.

(2)

(b) Diagrams **A**, **B**, **C** and **D** show oscilloscope traces of four different sound waves.

The oscilloscope settings are the same each time.



(i) Give the letter of the loudest sound.

(1)

(ii) Give the letter of the highest pitch sound.

(1)

(Total 4 marks)

Q83.

(a) The diagram shows the electromagnetic spectrum.

Two types of wave have been missed out.

Write the names of the missing waves in the empty boxes.

	X-rays	Ultraviolet rays		Infrared rays	Microwave	Radio waves
--	--------	------------------	--	---------------	-----------	-------------

(2)

- (b) Different types of waves are used by different types of communications equipment.

Draw **one** line from each situation in **List A** to the wave used to communicate in **List B**.

List A Situation	List B Wave used to communicate
TV remote control	Microwave
Satellite TV	Infrared rays
Terrestrial TV	Radio waves
	Ultraviolet rays

(3)

(Total 5 marks)

Q84.

Electromagnetic waves behave differently in different situations.

Electromagnetic waves travel at a speed of 3×10^8 m/s in a vacuum.

Microwave radiation has a wavelength of 2 cm.

Calculate the frequency of microwave radiation.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

Frequency = _____ hertz

Q85.

The different parts of the electromagnetic spectrum are shown below.

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

(a) Name a part of the electromagnetic spectrum with:

(i) a longer wavelength than microwaves: _____

(1)

(ii) greater energy than X-rays: _____

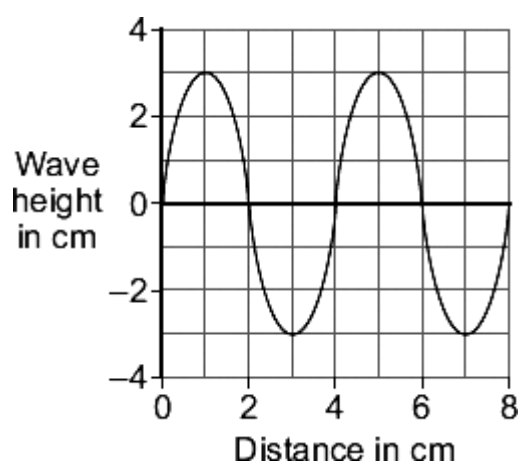
(1)

(iii) a higher frequency than ultraviolet: _____

(1)

(b) The properties of water waves can be measured easily in a school lab.

The diagram shows information about waves.



(i) How many complete waves are shown in the diagram?

(1)

(ii) What is the wavelength of each wave in the diagram?

_____ cm

(1)

(iii) What is the amplitude of the waves?

_____ cm

(1)

(iv) Complete the sentence below.

The oscillations of the waves in the diagram are perpendicular to the direction of energy transfer. They are called _____ waves.

(1)

(Total 7 marks)

Q86.

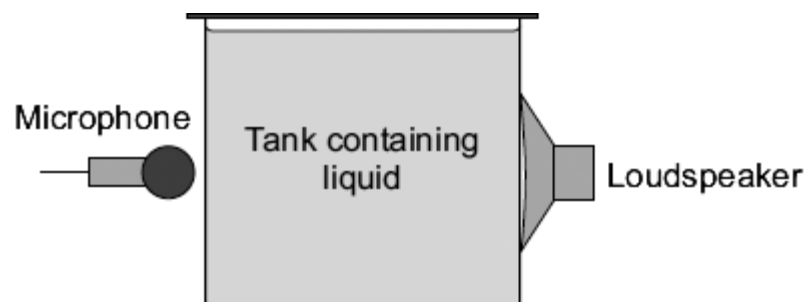
- (a) Sound and light are different types of waves.

Give **two** similarities and **two** differences between sound waves and light waves.

(4)

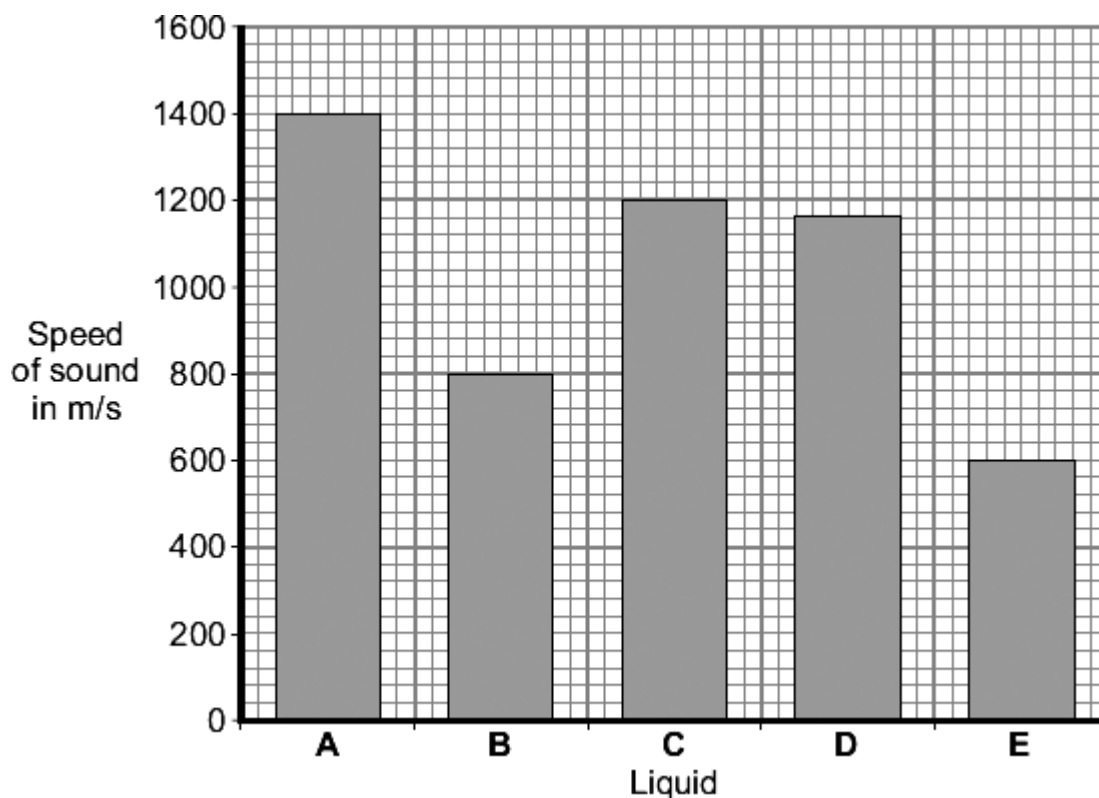
- (b) A student does an experiment to investigate the speed of sound in different liquids.

The student uses the apparatus shown.



A loudspeaker makes a sound wave. The sound wave travels through the liquid in the tank. The time it takes to travel this distance is used to calculate the speed of sound.

The bar chart shows the student's results.



- (i) When a sound wave with a frequency of 4800 hertz passes through one of the liquids, it has a wavelength of 0.25 m.

Calculate the speed of the wave and identify the liquid used.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

Speed = _____ m/s

The liquid used was _____

(3)

- (ii) The student's hypothesis was:
'There is a link between the density of a liquid and the speed of sound in the same liquid.'

Liquid	Density in g/cm ³	Speed of sound in m/s
Ethoxyethane	0.71	985

Ethanol	0.80	1150
Kerosene	0.82	1300
Water	1.00	1500
Mercury	13.50	1450

Use the information in the table to decide whether the student's hypothesis was completely correct or not.

Was the student's hypothesis completely correct?

Draw a ring around your answer. **Yes / No**

Give reasons for your answer.

(2)

(Total 9 marks)

Q87.

Some TV signals are transmitted to a satellite in space and back to Earth. A satellite dish is fixed to a house. The satellite dish receives the TV signal. Microwaves are used for satellite TV transmission.



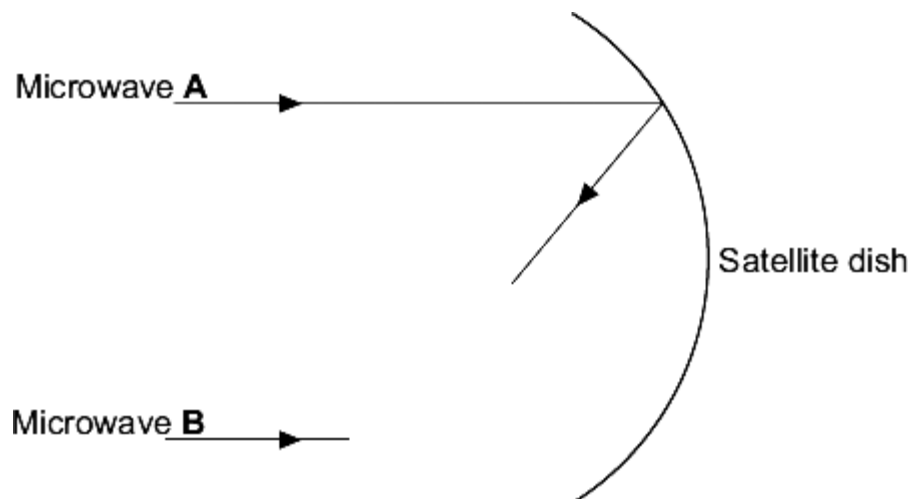
Receiver

Photograph supplied by iStockphoto/Thinkstock

- (a) Why are microwaves used, rather than radio waves, to transmit TV signals to and from satellites in space?

(1)

- (b) The shape of the satellite dish allows microwaves to be focused at the receiver. The diagram shows how microwave **A** is reflected by the satellite dish.



- (i) Complete the diagram to show how microwave **B** is reflected by the satellite dish.

(1)

(ii) Draw on the diagram where the receiver should be placed.

For the receiver, use this symbol: 

(1)
(Total 3 marks)

Mark schemes

Q1.

- (a) R 1
- (b) they have the same wave speed as visible light 1
- they have a lower frequency than gamma rays 1
- (c) any **two** from:
- ageing of the skin
allow sunburn
burn unqualified is insufficient
 - skin cancer
cancer is insufficient
allow mutation of genes in skin cells
 - eye damage
allow blindness
- 2
- (d) any **two** from:
- gamma (rays)
 - X-rays
 - ultraviolet
- 2
- [7]**

Q2.

- (a) in a longitudinal wave, the oscillations / vibrations are parallel to the direction of energy transfer
- allow direction of travel for energy transfer*
- 1
- in a transverse wave, the oscillations / vibrations are perpendicular to the direction of energy transfer
- allow direction of travel for energy transfer*
*if no other mark scored allow 1 mark for (oscillations / vibrations of) longitudinal waves are parallel **and** (oscillations / vibrations of) transverse waves are perpendicular*
*if no other mark scored allow 1 mark for transverse waves have peaks and troughs **and** longitudinal waves have compressions and rarefactions*
- 1
- (b) $3.0 \times 10^8 = 4.8 \times 10^9 \times \lambda$

$$\text{allow } \lambda = \frac{3.0 \times 10^8}{4.8 \times 10^9}$$

this mark may be awarded if the standard form values are incorrectly converted

1

$$\lambda = 0.0625 \text{ (m)}$$

1

$$\lambda = 0.063 \text{ (m)}$$

or

$$\lambda = 6.3 \times 10^{-2} \text{ (m)}$$

allow an answer to 2 sig figs that is consistent with their calculated value of λ and has required rounding

1

an answer of 0.063 (m) scores 3 marks

(c) any **three** from:

- (the car aerial) absorbs radio waves or energy
- electrons are made to vibrate (in the aerial)
- creating an alternating current (in the aerial circuit)
- the (signal) frequency is the same (as the radio wave)

3

[8]

Q3.

(a) any **three** from:

- same surface area of bag (exposed to sun)
allow same sized bag
- same volume / mass of water
allow same amount of water
- use same starting temperature of water
allow measure temperature at the start
- place all bags out at the same time
- place all bags out in same area / conditions
- same thickness of material / bag
- same type of material (for each bag)
- use IR lamp in a lab

3

(b) 0.1 (°C)

1

(c) any **one** from:

- more cloudy
- less sunny

ignore less Sun

• less sunlight	
• cooler day	1
(d) 24.3 (°C)	1
(e) black	1
(it has the) greatest (temperature) rise	
allow it is the best absorber of IR (radiation)	
ignore best emitter of IR (radiation)	1
reason only scores if black is given	
	[8]

Q4.

(a) light	1
ionising	1
(b) x-rays have a longer wavelength and a lower frequency	1
(c) $\frac{0.039 + 0.035 + 0.040}{3}$	1
= 0.038 (millisieverts)	
an answer of 0.038 scores 2 marks	1
(d) the dose decreases if you stand further from the machine	1
(e) $\frac{0.180}{0.012}$	1
= 15 days	
an answer of 15 days scores 2 marks	1
(f) the benefit (of a correct diagnosis) outweighs the risk	
allow the (increased) risk of cancer is very small for an x-ray	
allow for medical imaging, eg to see broken bones	1
(g) $20 \times \frac{40}{100}$	
allow $20 \times 40\%$	1

= 8 (millisieverts)

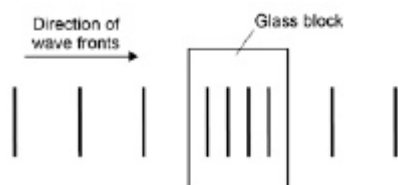
an answer of 8 (millisieverts) scores 2 marks

1

[11]

Q5.

- (a) at least two wave fronts drawn to the right of the glass block, parallel to the other wave fronts and with equal spacing compared with the wave fronts to the left of the glass block



1

- (b) ray of light refracts towards the normal where it is incident on the glass block

1

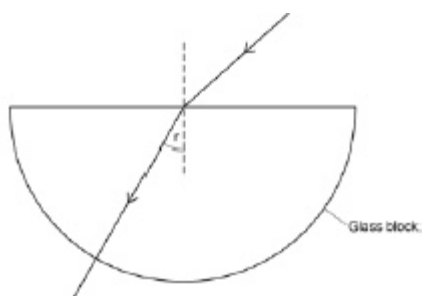
ray of light does not refract when it exits the glass block

1

a normal is drawn on where the ray is incident on the glass block

1

the angle of refraction is labelled



lines should be drawn with a ruler

1

- (c) light travels more slowly (in the glass block than in the air)

1

so it changes direction

allow so it bends towards the normal

1

- (d) the angle of incidence

1

the type of glass used

allow the glass block

1

- (e) the resolution of a normal protractor is too big

1

so it could not measure the difference between results
allow so it could not read angles to 2 decimal places

1

(f) a longer wavelength gives a greater angle of refraction

1

(g) absorbed / reflected

1

[13]

Q6.

(a) **B**

1

(b) **A**

1

(c) $\frac{2.5 \text{ (waves)}}{0.5 \text{ (s)}}$

1

5(.0)(Hz)

1

(d) longitudinal

1

(e) timing (from seeing the blocks bang together and hearing the sound)

or

risk of cancelling the timer

ignore human error unqualified

*allow reaction time (of student **B**)*

1

(f) student to stand further away (so there is a greater time lag to measure)

allow other correct methods, eg using echoes

1

(g) both are transverse waves

1

both can travel through a vacuum

1

[9]

Q7.

(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 $\times$ 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]

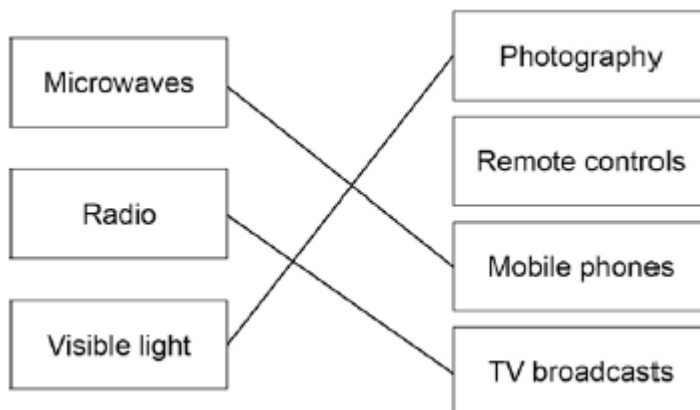
Q71.

- (a) (i) a ray drawn leaving the block parallel to the incident ray
straight, continuous line judged by eye
do **not** accept a ray of light with an arrow towards the block 1
- (ii) normal 1
- (b) (i) a smooth curve drawn through the points 1
- (ii) as the angle of incidence increases the angle of refraction increases
allow correct description of their answer to (i)
ignore the angle of incidence is always larger than the angle of refraction 1
- it is a non-linear graph
or
not directly proportional
allow a correct description of the graph / points 1
- [5]

Q72.

Part

Use



any extra line negates mark

3

[3]

Q73.

- (a) *straight line continued through glass block to meet edge of the block*
do not allow dotted / dashed lines
judge by eye

1

straight line drawn through crosses to meet the edge of block
judge by eye
ignore reflection within the block
ignore 'normal' line

1

- (b) *any **one** from*

- *safety / dark glasses*
ignore goggles / glasses
unqualified
- *safety / dark goggles*
ignore special goggles / glasses
ignore sunglasses / eye protection
- *don't look at laser (directly)*
allow don't shine laser into someone's eyes

1

- (c) (i) *any **one** from:*

- *too many points above line*
allow line of best fit only goes through 2 points
allow line doesn't go through most points
allow line should go through more / most points
allow 3 points have been ignored
- *no points below the line*
- *line should be curved*
allow there should be equal numbers of points on both sides of line

1

(ii) any **two** from:

- use smaller interval between readings
eg allow go up in 10's
- take readings at more angles
allow take readings at different angles / named angles
- repeat the experiment / readings *and calculate a mean*
allow repeat the experiment to identify anomalies
- use a narrower ray of light
ignore take more readings
ignore compare results (with other students)

2

[6]

Q74.

(a) radiation

ignore infra red, IR, or heat

1

(b) (i) 105 000 000

($E = mc\theta$)

accept answers in standard form eg. 1.05×10^8

*$E = 5000 \times 4200 \times 5$ gains **1** mark*

Unit mark is independent, but must match value given for full marks

if no other marks gained 1 mark for any correct unit of energy

2

J / joules

not lower case j

allow Joules

allow units in words eg kilojoules

*allow 105 000 kJ or 105 MJ for **3** marks. These figures must have units.*

allow units written as words Eg. kilojoules

not KJ, kj, mJ, Mj

1

(ii) 6600(s) / 6560(s) / 6563(s) / 6562.5(s)

($E = Pt$)

allow ecf from (b)(ii)

allow answers in minutes and hours provided correct and unit changed on answer line

eg. 109 / 110 minutes or 1.8 hours

*if correct answer given with incorrect unit, maximum mark of **2** eg 6600 minutes*

*$105\,000\,000 = 16\,000 \times t$ gains **1** mark*

*$t = 105\,000\,000 / 16\,000$ gains **2** marks*

*$t = 105\,000\,000 / 16$ gains **1** mark*

or

6 562 500(s) gains 2 marks

3

- (iii) energy gained from surroundings / air
allow heat
ignore air is warmer or pool is colder

1

[8]

Q75.

- (a) transverse

1

- (b) (i) 700
in either order

1

400

1

- (ii) stays the same

1

[4]

Q76.

- (a) 1st box ticked

1

- (b) (i) continuous reflected ray parallel to incident ray (by eye)

1

an arrow shown correctly

arrow must be drawn on a continuous ray reflected by top mirror

1

- (ii) normal

1

[4]

Q77.

- (a) X = wavelength

1

Y = frequency

1

wavelength in metres / m and frequency in hertz / Hz

both units correct for 1 mark (independent of first two marking points)

correct units must match correctly named quantities

allow Hertz

allow multiples of the units eg kHz, km (or in words)

- 1
- (b) (i) galaxy A is stationary (relative to Earth / us) 1
- galaxy B is moving towards (Earth / us)
allow 1 mark for identifying galaxies B and C are moving in opposite directions 1
- galaxy C is moving away from (Earth / us)
*allow 1 mark if say all moving away / towards **or** stationary* 1
- (ii) galaxy C is faster (than galaxy B)
allow converse statement
*do **not** accept galaxy C expanding faster* 1
- (iii) sample is too small
accept three is too few
allow not enough evidence
ignore inaccurate, invalid, anomalous 1
- compared to the size of the population
accept there are a very large number of galaxies in the Universe
allow A, B and C are moving differently (from each other) for 1 mark 1

[9]

Q78.

- (a) (i) absorb 1
- (ii) more 1
- (b) (i) conduction 1
- (ii) colour (of cube)
allow colour (of box) 1
- (iii) Cube Y
all three in correct order for 2 marks
- Cube X
- Cube Z
one or two correct for 1 mark
allow grey for X

allow white for Y
allow black for Z

2

- (iv) results can be compared
accept start temperature affects rate of energy transfer
or
start temperature affects how quickly the cube cools down
ignore fair test / reliability / accuracy / control variable / valid
- (v) control (variable)
allow controls / controlled

1

1

[8]

Q79.

- (a) energy transferred from athlete / skin / body to water / sweat
allow water / sweat heated by athlete
- (so) more energetic (water / sweat) particles escape (from the liquid)
accept particles with higher speeds escape (from the liquid)
- water / sweat evaporates
accept particles escape from the (surface of the) liquid
- (which) lowers the average energy of (remaining) water / sweat particles
allow reference to the total energy of the liquid reducing
allow lowers the athlete's temperature
ignore cool down
- (b) any **three** from:
accept IR / radiation / heat / infrared / energy throughout
- the blanket traps air
 - air is an insulator
accept for 2 marks trapped air reduces conduction / convection
 - space blanket reflects infrared radiation (back to the body)
ignore incident solar radiation
ignore reflects light
ignore bounces off
 - space blanket is a poor emitter / radiator of infrared radiation
do **not** accept does not emit infrared radiation

1

1

1

1

3

[7]

Q80.

(a)

increasing energy
infrared visible light gamma
 (rays)

3 correct = **2 marks**

1 or 2 correct = 1 mark

allow IR for infrared

allow visible or light for visible light

2

(b) (i) frequency

1

(ii) vacuum

1

(c) IR - remote control / fibre optic

ignore phones and cables unless qualified

1

microwave - mobile phone / satellite (TV)

1

radio – (terrestrial) TV / radio transmissions

allow walkie talkies

1

visible light – photography / fibre optic

allow valid examples of communication using visible light

e.g. traffic lights, sign language

1

[8]

Q81.

(a) convection

1

(b) any **two** from:

- easier / clearer to read **or** reading error less likely / takes readings for you
- greater resolution / temperature displayed to two decimal places
ignore precision / accurate / reliable / sensitivity
- more frequent readings
ignore readings every second / plots graph / quicker
- more data
- live graphical representation
allow references to safety
allow no need to open lid (thus preventing cooling)

2

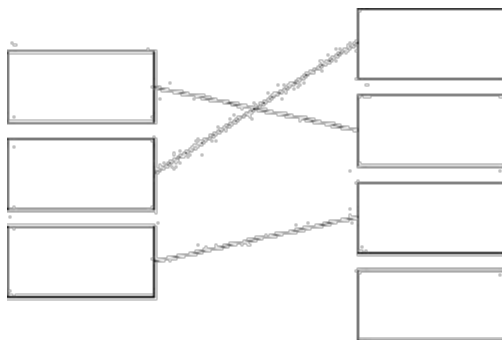
- (c) (i) black is a better emitter / radiator of energy / infrared radiation
allow heat
for full marks there must be a comparison in terms of emission / radiation
allow 1 mark for: temperature of black can decreases faster / more
or
water in black can has reached room / constant temperature whilst water in white can is still cooling
or
correct description of temperature drop in both cans after 14 minutes
2
- (ii) (any) line drawn between the white can and black can lines on graph
starting at 100 (°C)
1
- line shows the same trend as white can line **or** black can line
second mark only scores if first marking point correct
*do **not** award this mark if line shows intentional rise at any point*
1
- [7]

Q82.

- (a) (light waves) are transverse
1
- (sound waves) are longitudinal
1
- (b) (i) B
1
- (ii) D
1
- [4]

Q83.

- (a) *correct order only*
- gamma (rays)
allow waves
1
- (visible) light
1
- (b)



extra line from statement cancels the mark

1
1
1

[5]

Q84.

$$v = f \times \lambda$$

$$1.5 \times 10^{10} \text{ (hertz)}$$

or

$$15\,000\,000\,000$$

allow **1** mark for correct substitution and transformation

$$(3 \times 10^8 / 0.02)$$

allow **1** mark for 1.5×10^8

or 150 000 000

2

[2]

Q85.

(a) (i) radio (waves)

1

(ii) gamma (rays)

accept γ

do **not** accept α

1

(iii) X-rays

or

gamma (rays)

accept γ

do **not** accept α

1

(b) (i) 2

1

(ii) 4(cm)

1

(iii) 3(cm)

ignore + or – in front of 3(cm)

1

Q86.

- (a) any **two** similarities and any **two** differences

read whole answer to ensure that there are no contradictory statements which negates that mark

ignore reference to senses in similarities and differences

similarities

- (both can be) reflected
- (both can be) refracted
allow both travel through any correctly named solid / gas / liquid
- (both can be) diffracted
- (both) interfere
- (both) transfer energy
ignore both are types of energy / waves / oscillations
- (both exhibit) Doppler effect
*do **not** accept statements like both are transverse as a similarity*

differences

- light can travel through a vacuum
or
sound cannot travel through a vacuum
allow sound requires a medium / particles to travel through
- (different) speed / velocity
- one is longitudinal and one is transverse
accept light is faster than sound
*do **not** accept sound is transverse and light is longitudinal*
allow correct description:
(longitudinal) the oscillations / vibrations are parallel to / same direction as (the direction of energy transfer)
and
(transverse) the oscillations / vibrations are 90° to / perpendicular to (the direction of energy transfer)
- sound is a mechanical wave / caused by vibrations and light is an electromagnetic wave
accept sound waves have a longer wavelength / lower frequency
if no other marks gained allow 1 mark for any correct

*difference(s) where the waves are not specified
eg one is transverse
eg have different wavelengths / frequencies*

4

(b) (i) *working must be shown for 3 marks*

4800 x 0.25

1

1200(m/s)

1

(liquid) C

ignore water / named liquid

1

(ii) (yes / no)

ignore yes / no, marks are for the explanation

speed increases as density increases

allow positive correlation

allow the more dense the liquid the less time (for sound to travel through)

ignore they both increase

ignore there was no pattern

1

but, mercury should have a (much) greater speed given the higher density

allow mercury does not fit the pattern / is an anomaly

1

[9]

Q87.

(a) *accept 'they' as referring to microwaves*

microwaves can travel through the atmosphere / ionosphere

accept not reflected by ionosphere

or

radio waves cannot (escape from the atmosphere)

allow cannot penetrate / travel through

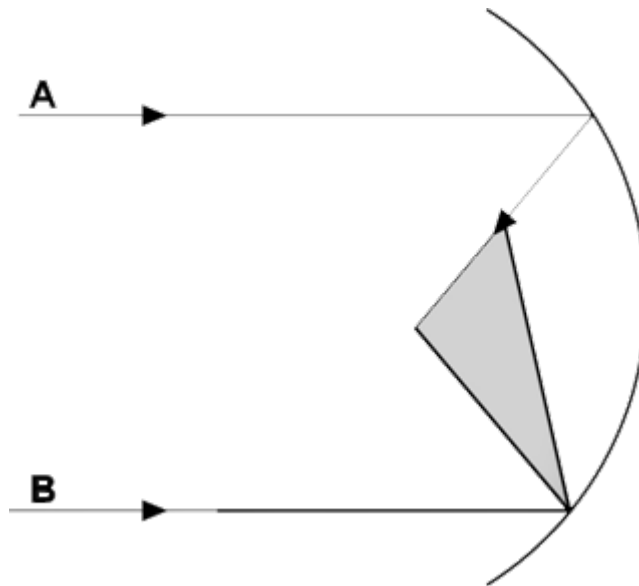
ignore frequency / wavelength

ignore reference to speed of waves

1

(b) (i) straight continuous lines drawn to show microwave B reflected by satellite dish

reflected ray should be within limits of grey area



1

- (ii) receiver drawn using rectangle symbol where microwaves A and B meet / cross over

allow ecf from (b)(i)

if (b)(i) not attempted no marks can be awarded for (b)(ii)

if lines do not meet / cross over allow receiver where extended lines would meet

allow any clear indication where receiver should be

1

[3]

Examiner reports

Q1.

- (a) Just over 50% of students were able to identify the position of ultraviolet light within the electromagnetic spectrum. Many believed it came between microwaves and visible light.
- (b) Only 15% gained both marks with a further 52% gaining one mark. It was noticeable the number of students who ticked more than the required number on this question. In this situation the list principle is applied. The most common error was that they would have a longer wavelength than microwaves.
- (c) 41% of students gained one mark on this question, however only 15% managed to score both marks. Many of those failing to gain marks gave weaker responses of “cancer” or “burning” without further qualification.
- (d) Many students failed to read the question carefully and so gave examples of medical imaging or other applications. 32% did gain two marks and a further 35%, one mark. Other incorrect responses of note were longitudinal, transverse and ultrasound.

Q2.

- (a) Nearly 13% gave accurate answers to score both marks. A further 20% were able to score a compensation mark by vague references to parallel and perpendicular, but it was clear that many students do not realise the importance of what is oscillating and the direction of energy transfer. There were many vague incorrect descriptions of ‘up and down’ and ‘side to side’.
- (b) 25% gained full marks, and a further 18% gained two marks, usually not giving the answer to two significant figures. There were a large number of responses using an incorrect rearrangement of the equation and generally the use of standard form was not the cause of the errors.
- (c) This was very poorly done, with just over 1% gaining full marks. There were many vague responses and a significant number of candidates wrote about transverse and longitudinal waves. There was also considerable reference to radio waves being reflected off the ionosphere.

A significant minority of students did not attempt this question which might suggest that they were unfamiliar with the material.

Q3.

Foundation

- (a) Most students attempted to improve this method. Using the same size bags was the most common correct answer, followed by using the same volume of water. Many students gave answers to extend the investigation instead, such as suggesting using more colours.

The common answer of repeating for more time or on more days did not gain credit. 69% of students gained some credit.

- (b) Resolution appears to be a concept that is not well understood, with 6% of students providing a correct answer. 22% of students did not attempt to answer this question.

- (c) This was generally well understood, but all too often inaccuracy in expression resulted in the mark not being awarded.
- (d) The mean value was correctly calculated by 67% of students.
- (e) 87% of students concluded that it was black bag that would be best to use. However, approximately half of these students did not gain the mark for their reason. Those that did so usually referred to the greatest rise in temperature. A very common misconception is that the colour black 'attracts the Sun / heat'.

Higher

- (a) 60% of students achieved two or more marks for this question. Answers such as, 'the size of the bag' and, 'the volume of water' were not uncommon, but do not answer the question. The most common correct answer seen was 'use the same size bag'.
- (b) Resolution appears to be a concept that is not well understood with 31% giving a correct answer.
- (c) The stem of the question requires an answer which is comparative, so 'it was a cold day' was not awarded the mark. 64% of students achieved the mark.
- (d) This proved a successful question for 93% of students. However, poor formation of numerals meant that '4' could often easily be interpreted as '7' or '9'.
- (e) Most students selected 'black bag' with reasons based on evidence or knowledge that black is the best absorber of heat. The statement based on evidence from Table 1 required an answer such as 'because it had the **greatest** temperature rise'. A common misconception is that that black **attracts** heat and light.

Q71.

- (a)
 - (i) Ray diagrams are difficult to draw without a ruler. We do allow some tolerance, but the line must look straight by eye. Rays were drawn in many directions – reflected from the top surface, reflected internally at both possible and impossible angles, emerging directly down the normal and at very large or very small angles. The easiest way to draw the refracted ray is to position a ruler along the incident ray and then move it parallel to this until it meets the normal on the lower surface of the block.
 - (ii) Less than half of the students knew that the dashed line drawn on ray diagrams is called the normal.
- (b)
 - (i) In science a line of best fit may be a straight line or a curve. Many students drew a straight line, rather than a smooth curve. Others did not include the point drawn at 0,0. The curve had to touch at least some part of each point, and could not be constructed from a series of straight lines drawn from point to point.
 - (ii) Most students gained the first marking point for stating that as the angle of incidence increased, the angle of refraction increased. The mark was not awarded if cause and effect were written the wrong way round, i.e. as the angle of refraction increased, the angle of incidence increased. The second marking point was rarely attempted.

Q72.

There was 1 mark for each of three correct lines. Almost all students gained at least 1 mark, usually for visible light being used for photography. Many thought that either microwaves or radio waves are used for remote controls.

Q73.

- (a) Many students did not use a ruler to draw the rays, and many drew rays that were too thick. Those students who gained 1 mark usually gained it for correctly drawing the ray that was outside the block. A large number of students drew the first ray from the end of the ray within the block to the first cross, and therefore did not draw a straight line. As they had not extended the ray already printed within the block they could not gain the first marking point. This often meant they did not gain the second mark, which was for drawing a ray through the two crosses to meet the edge of the block, as their ray only went to the first cross, and did not reach the block.
- (b) Just under half of the students gained the mark for saying “Wear safety glasses”, “Don’t shine the laser into someone’s eyes”, or “Don’t look directly at the laser light”. Goggles, glasses, sunglasses or eye protection were insufficient responses. The idea of safety, or ideally dark, glasses was needed.
- (c)
 - (i) A wide range of correct responses was given. Many said the line should go through more points or they said there should be an equal number of points on both sides of the line. Identifying that there were too many points above the line, or that the line simply connected two points, the first and the last, was also creditworthy. Only a few recognised that the line should have been drawn as a curve. Incorrect statements made reference to anomalies, when there were no anomalies in the data, or students said that the line didn’t go through any points, when it went through two points.
 - (ii) Many students said the investigation could have been improved by repeating it. This was not enough to gain the mark; they had to continue and add that a mean should then be calculated, or that it would allow anomalies to be identified. The most common correct response was to measure more angles. An incorrect answer that was frequently seen was to measure five different values for angle b. This was what had been done in the investigation, so perhaps students had just got the idea from the question, which told them the student measured five different values for angle a. Others said they should compare the results with other students, which was ignored.

Q74.

- (a) The question asked for a method of energy transfer, but many students gave infrared radiation as the answer. In this instance, infrared was ignored, so they gained the mark.
- (b)
 - (i) Most students gained at least 1 mark for $5000 \times 4200 \times 5$, however they often then wrote down an incorrect answer. It is always good to check the answer. Some made avoidable errors when writing down the number of noughts. A variety of units was given.

Any unit of energy could gain a mark, if no other marks had been given, as long as it was written correctly. Many wrote j instead of J, or KJ instead of kJ.
 - (ii) Most students managed to substitute into the correct equation and many also reorganised the equation to find the time. However, a lot of students forgot to convert the kJ to J, so could only gain 2 marks.

- (iii) Many responses referred to the air being warmer than the pool, but did not go on to explain that the water would absorb energy from the air or surroundings. Some talked about the Sun being hotter or cooler, or the use of heaters.

Q75.

- (a) Less than half the students knew that electromagnetic waves are transverse waves, the majority thought they were longitudinal.
- (b) (ii) Less than ten per cent of the students knew that the wave speed of an electromagnetic wave would stay the same if the frequency increased.

Q76.

- (a) More than half the students selected the correct diagram showing a ray of light travelling from air into glass.
- (b) (i) Some very untidy rays were drawn by hand. Ray diagrams should be drawn with a ruler. There were 2 marks for this question. 1 mark is for drawing a continuous straight line parallel to the incident ray and a second mark for showing an arrow on the ray. If the ray was shown to reflect into the shaded part of the cat's eye no marks were given.
- (ii) Very few students knew the dotted line is called the normal.

Q77.

- (a) Most students did not know what quantities X and Y were, but those who did often scored the third mark for naming the correct units.
- (b) (i) Many responses referred to the speed that the galaxies were travelling at, rather than their directions relative to Earth. Others gave their relative distances from Earth. Many gained 1 mark for realising that galaxies B and C were moving in opposite directions. A few gave detailed explanations for their conclusions in terms of red and blue shift.
- (ii) The question asked for a comparison between the speed of galaxy B and the speed of galaxy C, relative to the observer. Many responses did not refer to one being faster or slower than the other, but to relative distances from the observer, or amount of red or blue shift.
- (iii) Only a few students realised that there wasn't enough evidence, or that 3 galaxies were too few to base conclusions about all galaxies on. Even fewer mentioned that there are a very large number of galaxies in the Universe.

Q78.

- (a) (i) Almost two thirds of the students knew that all objects absorb infrared radiation. The most common incorrect answer was that they conduct infrared radiation.
- (ii) Just over two thirds of the students knew that hotter objects emit more infrared radiation. The most common incorrect answer was that they emit less infrared radiation.
- (b) (i) Less than half of the students said that energy is transferred through the

sides of the metal cubes by conduction. Only slightly fewer students thought that energy was transferred through the metal by convection.

- (ii) Only half of the students identified the independent variable as being the colour of the cube.
- (iii) The majority of students gained 1 mark for this question, usually for realising that Cube X would follow the middle line of the three on the graph.
- (iv) Few students scored on this question. The vast majority said that the starting temperatures had to be the same to make it a fair test, which was too vague. If they went on to explain the effect of different starting temperatures on the rate of heat loss they could have gained the mark.
- (v) Less than half of the students said that variables kept the same in an investigation are called control variables. Some students had not read the question properly and gave an example of a control variable.

Q79.

- (a) Many responses included biological explanations of thermoregulation, much of which did not relate to this question. Few students mentioned that energy is transferred from the athlete to the sweat. Some explained that the particles would gain energy, but did not go on to say that the most energetic or fastest particles would escape. The third marking point was the one that most students gained, for stating that the sweat evaporated. However, many thought that particles evaporated, rather than the liquid. Reference to lowering the average energy of the particles that were left on the skin was rarely seen. "Lowering temperature" was seen more often.
- (b) Most students gained a mark for saying that the foil blanket would reflect energy back to the athlete, although others thought it would reflect radiation from the Sun, which was ignored. Some mentioned that shiny surfaces are poor emitters of infrared radiation, but students could not gain this mark if they said no energy was emitted. The idea that air was trapped by the blanket was rarely seen.

Q80.

- (a) Most common 1 mark responses identified gamma as the part of the spectrum with the most energy. Many students mixed up visible and infrared in terms of energy.
- (b)
 - (i) Just under two thirds of students knew that the number of waves passing a point in 1 second is called the frequency. The most common incorrect response was wavelength.
 - (ii) Over half of the students knew that electromagnetic waves travel at the same speed through a vacuum.
- (c) The specification focusses on the uses of parts of the electromagnetic spectrum for communication only. Microwave ovens are not used for communication, so did not gain credit. Many students gave remote control as a use for infrared, and mobile phones for microwave. Few correct answers were seen for radio waves and visible light, as to see things was insufficient for light.

Q81.

- (a) Many students thought the lid prevented energy loss by conduction rather than convection.
- (b) This question was not answered well with a very small proportion of students able to gain both marks. Schools are reminded to use the correct version of the glossary. Many students said the data logger was more precise, which related to the glossary used with the previous specification and was therefore ignored. The required answer was greater resolution, although a description of this would gain the mark. Many responses were simply copies of information given in the stem of the question or that it was faster.
- (c)
 - (i) An explanation for the difference in temperature was required, but one mark was allowed for a description of the temperature difference as long as the answer was comparative and not just a statement about one can. Many students thought that the cans were warming up or explained the greater temperature drop in the black can as being because black surfaces absorb more energy. In relation to radiation, students should understand the difference between absorption and emission.
 - (ii) This question was well answered with over three-quarters of students gaining full credit.

Q82.

- (a) Most students scored a mark for this question. For incorrect answers, longitudinal and transverse were often given the wrong way round.
- (b) (i)+(ii) These questions were well answered with a few students putting answers B and D the wrong way round.

Q83.

- (a) A range of errors was made in this question. Some students gave the names of rays already given in the spectrum, the names of appliances or words such as transverse, sound, solar, electric, gametes, satellite and indicator. Some wrote visible but with no mention of light and a few wrote invisible. The position of gamma in the electromagnetic spectrum was better known than that of light.
- (b) Once again extra lines were drawn. The methods of transmission for satellite and terrestrial TV were not well known, with most thinking that satellite TV was transmitted by radio waves and terrestrial TV by microwaves or UV rays. Almost a fifth of students achieved full marks.

Q84.

It was apparent that most students are unfamiliar with working in standard form, a mathematical requirement for Higher Tier students on this new specification. Only one third of the students scored one mark, the majority of which for 1.5×10^8 .

Q85.

- (a)
 - (i) Two-thirds of students identified radio waves as having a wavelength longer than microwaves.
 - (ii) Almost two-thirds of students identified gamma rays as having more energy than X-rays.
 - (iii) Despite the high number of correct responses for questions (a)(i) and (a)(ii), less than half the students could identify a part of the electromagnetic spectrum with a higher frequency than ultraviolet.
- (b)
 - (i) Just under two-thirds of students identified that two complete waves were shown on the diagram.
 - (ii) Only a quarter of students were able to work out the correct wavelength from the diagram.
 - (iii) Just over half the students gave the correct amplitude of the waves.
 - (iv) Only a quarter of students were able to identify the type of wave as transverse.

Q86.

- (a) Very few students gained three or four marks. Most students struggled to give two similarities of light and sound waves. The most common difference given was that light travels faster than sound. A few said sound waves cannot travel through a vacuum. Many got transverse and longitudinal waves mixed up. Many students said light can be seen, but sound cannot, rather than focussing on the properties of the waves themselves.
- (b)
 - (i) Many students identified the wavelength and frequency from the question, but had trouble substituting into the equation. Although almost half the students scored full marks, a number of students attempted to guess what the liquid was; a common answer was 'water', rather than choosing a letter from the bar chart.
 - (ii) Over half the students did not score any marks on this question. Many students gained one mark for either identifying the pattern (up to mercury) or by identifying the fact that mercury did not fit the pattern. The irregular intervals between values in the table confused many students and they were unfamiliar with the way that the hypothesis was stated: 'There is a link between...'. Some students attempted to find a mathematical relationship between the two quantities rather than simply identifying the trend.

Q87.

- (a) Most responses referred to the speed, wavelength or frequency of the waves or to the strength or amount of energy they transferred. All of these were ignored. Very few students said microwaves can travel through the atmosphere or that radio waves cannot.

- (b) (i) Most students drew a reflected ray that met the end of microwave A. This was allowed, although it should have been reflected at a slightly larger angle than this. Most students drew a straight continuous line, but should be encouraged to use a ruler.
- (ii) The receiver was usually positioned where the two reflected rays met. Students could still gain a mark for question (b)(ii) even if they had drawn the position of the reflected ray incorrectly. Several students used their own symbol for a receiver, rather than the one shown in the question. This was allowed.