Materials
For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions
- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information
- The marks for the questions are shown in brackets
All objects emit and absorb infrared radiation.

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

<table>
<thead>
<tr>
<th>dark matt</th>
<th>dark shiny</th>
<th>light matt</th>
<th>light shiny</th>
</tr>
</thead>
</table>

The best emitters of infrared radiation have ................................................................. surfaces.

The worst emitters of infrared radiation have ................................................................. surfaces.

(b) **Diagram 1** shows a sphere which is at a much higher temperature than its surroundings.

![Diagram 1](image)

Energy is transferred from the sphere to the surroundings.

The table shows readings for the sphere in three different conditions, A, B and C.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Temperature of sphere in °C</th>
<th>Temperature of surroundings in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>70</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>90</td>
<td>30</td>
</tr>
</tbody>
</table>
In each of the conditions, A, B and C, the sphere transfers energy to the surroundings at a different rate.

Put conditions A, B and C in the correct order.

Give a reason for your answer.

..........................................................................................................................
..........................................................................................................................

(2)

(c) Diagram 2 shows a can containing water.

A student investigates how quickly a can of water heats up when it is cooler than room temperature.

The student has four cans, each made of the same material, with the following outer surfaces.

<table>
<thead>
<tr>
<th>dark matt</th>
<th>dark shiny</th>
<th>light matt</th>
<th>light shiny</th>
</tr>
</thead>
</table>
The student times how long it takes the water in each can to reach room temperature.

Each can contains the same mass of water at the same starting temperature.

(i) Which can of water will reach room temperature the quickest?

Give a reason for your answer.

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(ii) Apart from material of the can, mass of water and starting temperature, suggest three control variables for the student’s investigation.

1 ............................................................................................................
................................................................................................................

2 ............................................................................................................
................................................................................................................

3 ............................................................................................................
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(d) The photographs show two different foxes.

![Fox A](By Algkalv (Own work) [CC-BY-3.0], via Wikimedia Commons)

![Fox B](© EcoPic/iStock)
Which fox is better adapted to survive cold conditions?
Give reasons for your answer.

A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1

(a) Show on Diagram 1 the wavelength of the waves.
(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)

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

<table>
<thead>
<tr>
<th>decreased</th>
<th>increased</th>
<th>stayed the same</th>
</tr>
</thead>
</table>

In Diagram 2, the observed wavelength of the waves at X has ........................................................ ......................................................... 

In Diagram 2, the frequency of the waves at X has ........................................................ ......................................................... 

(ii) Take measurements from Diagram 2 to determine the wavelength of the waves received at X.

Give the unit.
...................................................................................................................................................................................
...................................................................................................................................................................................
Wavelength = ........................................
The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

............................................................................................................................................................................. (1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

............................................................................................................................................................................. (1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

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............................................................................................................................................................................. (4)

(iv) State one other piece of evidence that supports the Big Bang theory of the formation of the Universe.

............................................................................................................................................................................. (1)

(Total 13 marks)
(a) Radio waves, microwaves and visible light are all electromagnetic waves that are used for communication.

(i) Name another electromagnetic wave that is used for communication.

.....................................................................................................................

(1)

(ii) Name an electromagnetic wave which is **not** used for communication.

State a use for this electromagnetic wave.

Electromagnetic wave ..................................................................................

Use ...............................................................................................................

.....................................................................................................................

(2)

(b) The table below shows the wavelengths for some electromagnetic waves, A, B, C and D.

<table>
<thead>
<tr>
<th>Wave</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1000 m</td>
</tr>
<tr>
<td>B</td>
<td>100 m</td>
</tr>
<tr>
<td>C</td>
<td>10 m</td>
</tr>
<tr>
<td>D</td>
<td>3 cm</td>
</tr>
</tbody>
</table>

A teacher is going to demonstrate diffraction of waves through a gap. She will carry out the demonstration in a classroom.

The teacher is able to generate waves A, B, C and D.

Which wave, A, B, C or D, would she use? [ ]

Explain your answer.

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(3)
In another demonstration, a teacher used a loud ticking clock as a source of sound, two hollow tubes and two smooth surfaces, EF and GH.

The figure below shows one of the hollow tubes fixed in position with a ticking clock at one end.

A student placed his ear at one end of the other hollow tube in position P. He moved this hollow tube, in turn, to positions Q and R.

(i) At which position, P, Q or R, did he hear the loudest sound?

(ii) Explain your answer to part (i).

(iii) Suggest why smooth surface GH in the figure above was needed.
(iv) The frequency of a sound wave is 15 Hz.
The speed of sound is 330 m/s.
Calculate the wavelength of the sound wave.

\[
\text{Wavelength} = \frac{\text{speed}}{\text{frequency}} = \frac{330 \text{ m/s}}{15 \text{ Hz}} = \frac{330}{15} = 22 \text{ m}
\]

(v) Give a reason why it would not be possible to do the demonstration in the figure above using sound waves with a frequency of 15 Hz.

Lenses can be used to correct visual defects.

**Figure 1** shows a child wearing glasses. Wearing glasses allows a lens to correct a visual defect.

© monkeybusinessimages/iStock/Thinkstock
(a) **Figure 2** shows rays of light entering a child’s eye and being focused at a point. This point is not on the retina so the child sees a blurred image.

![Figure 2](image)

(i) What is the visual defect of this eye?

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........................................................................................................................................................................

(1)

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

<table>
<thead>
<tr>
<th>converging</th>
<th>convex</th>
<th>diverging</th>
</tr>
</thead>
</table>

The type of lens used to correct this visual defect is a ................................... lens.

(1)

(b) Visual defects may be corrected with eye surgery. A laser may be used in eye surgery.

Use the correct answer from the box to complete the sentence.

<table>
<thead>
<tr>
<th>light</th>
<th>sound</th>
<th>X-rays</th>
</tr>
</thead>
</table>

A laser is a concentrated source of .................................

(1)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Lasers can be used to correct a visual defect by changing the shape of the cornea.

A knife is used to cut a flap in the cornea. The laser vaporises a portion of the cornea and permanently changes its shape. The flap is then replaced.

Most patients are back at work within a week. Driving may be unsafe for one to two weeks. Tinted glasses with ultraviolet protection are needed when out in the sun for the first three months.

Many people in their mid-40s need reading glasses. This is because the eye lens becomes less flexible with age. Laser surgery cannot cure this.

Laser surgery for both eyes costs £1000. A pair of glasses costs £250.
Describe the advantages and disadvantages of:

- having laser surgery to correct visual defects
- wearing glasses to correct visual defects.

Extra space
(d) **Figure 3** shows parallel rays of light, from a point on a distant object, entering a camera.

**Figure 3**

Describe the adjustment that has to be made to focus the image on the film.

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(2)  
(Total 11 marks)
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.

<table>
<thead>
<tr>
<th>direction</th>
<th>loudness</th>
<th>pitch</th>
<th>speed</th>
</tr>
</thead>
</table>

The frequency of a sound wave determines its ......................................... .

The amplitude of a sound wave determines its ......................................... .

(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.

<table>
<thead>
<tr>
<th>Frequency in hertz</th>
<th>Length of prongs in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>320</td>
<td>9.5</td>
</tr>
<tr>
<td>384</td>
<td>8.7</td>
</tr>
<tr>
<td>480</td>
<td>7.8</td>
</tr>
<tr>
<td>512</td>
<td>7.5</td>
</tr>
</tbody>
</table>

(i) Describe the pattern shown in the table.

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

![Figure 2](image)

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.

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.............................................................................................................
.............................................................................................................

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 $2 \times 10^6$ Hz.

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

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

**Figure 3**

![Image of a tuning fork and microphone connected to an oscilloscope](https://image.com)

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**

![Image of the oscilloscope trace](https://image.com)

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

What is the frequency of the tuning fork?
(a) A company is developing a system which can heat up and melt ice on roads in the winter. This system is called ‘energy storage’.

During the summer, the black surface of the road will heat up in the sunshine.

This energy will be stored in a large amount of soil deep under the road surface. Pipes will run through the soil. In winter, cold water entering the pipes will be warmed and brought to the surface to melt ice.

The system could work well because the road surface is black.

Suggest why.

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(b) (i) What is meant by specific latent heat of fusion?

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(ii) Calculate the amount of energy required to melt 15 kg of ice at 0 °C.

Specific latent heat of fusion of ice = $3.4 \times 10^5$ J/kg.

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Energy = ...................................... J
Another way to keep roads clear of ice is to spread salt on them. When salt is added to ice, the melting point of the ice changes.

A student investigated how the melting point of ice varies with the mass of salt added. The figure below shows the equipment that she used.

The student added salt to crushed ice and measured the temperature at which the ice melted.

(i) State one variable that the student should have controlled.

...........................................................................................................................................................................  
...........................................................................................................................................................................

(ii) During the investigation the student stirred the crushed ice.

Suggest two reasons why.

Tick (✓) two boxes.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Tick (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To raise the melting point of the ice</td>
<td></td>
</tr>
<tr>
<td>To lower the melting point of the ice</td>
<td></td>
</tr>
<tr>
<td>To distribute the salt throughout the ice</td>
<td></td>
</tr>
<tr>
<td>To keep all the ice at the same temperature</td>
<td></td>
</tr>
<tr>
<td>To reduce energy transfer from the surroundings to the ice</td>
<td></td>
</tr>
</tbody>
</table>
(iii) The table below shows the data that the student obtained.

<table>
<thead>
<tr>
<th>Mass of salt added in grams</th>
<th>0</th>
<th>10</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point of ice in °C</td>
<td>0</td>
<td>-6</td>
<td>-16</td>
</tr>
</tbody>
</table>

Describe the pattern shown in the table.

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

(d) Undersoil electrical heating systems are used in greenhouses. This system could also be used under a road.

A cable just below the ground carries an electric current. One greenhouse system has a power output of 0.50 kW.

Calculate the energy transferred in 2 minutes.

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

Energy transferred = ...................................... J

(3)
A local council wants to keep a particular section of a road clear of ice in the winter. Describe the advantages and disadvantages of keeping the road clear of ice using:

- energy storage
- salt
- undersoil electrical heating.

Extra space

(6)
(Total 18 marks)
The visible light spectrum has a range of frequencies.

Figure 1 shows that the frequency increases from red light to violet light.

Use the correct answers from the box to complete the sentence.

As the frequency of the light waves increases, the wavelength of the light waves decreases and the energy of the light waves increases.
(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

![Figure 3: Graph showing intensity of light transmitted through clear, green, and brown glass.]

(i) The pieces of glass all had the same thickness. Suggest why.

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............................................................................................................................................................
............................................................................................................................................................
............................................................................................................................................................
............................................................................................................................................................
............................................................................................................................................................

(1)

(ii) Bottles made of brown glass are suitable for storing beer. Suggest why.

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............................................................................................................................................................
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............................................................................................................................................................
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(1)

(Total 4 marks)
**Figure 1** shows one way that biscuit manufacturers cook large quantities of biscuits.

The uncooked biscuits are placed on a moving metal grid.

The biscuits pass between two hot electrical heating elements inside an oven.

The biscuits turn brown as they cook.

![Figure 1](image)

The oven has two control knobs, as shown in **Figure 2**.

![Figure 2](image)

(a) Which type of electromagnetic radiation makes the biscuits turn brown?

........................................................................................................................

(1)

(b) Suggest **two** ways of cooking the biscuits in this oven, to make them turn browner.

1 .....................................................................................................................

........................................................................................................................

2 .....................................................................................................................

........................................................................................................................

(2)
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?

(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
(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](image1.png)

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

![Figure 2](image2.png)

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](image3.png)

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.
The figure below shows an X-ray image of a human skull.

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

<table>
<thead>
<tr>
<th>absorbs</th>
<th>ionises</th>
<th>reflects</th>
<th>transmits</th>
</tr>
</thead>
</table>

When X-rays enter the human body, soft tissue \(\text{.................................} \) X-rays and bone \(\text{.................................} \) X-rays.

(b) Complete the following sentence.

The X-rays affect photographic film in the same way that \(\text{.................................} \) does.
(c) The table below shows the total dose of X-rays received by the human body when different parts are X-rayed.

<table>
<thead>
<tr>
<th>Part of body X-rayed</th>
<th>Dose of X-rays received by human body in arbitrary units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>3</td>
</tr>
<tr>
<td>Chest</td>
<td>4</td>
</tr>
<tr>
<td>Pelvis</td>
<td>60</td>
</tr>
</tbody>
</table>

Calculate the number of head X-rays that are equal in dose to one pelvis X-ray.

..........................................................................................................................................................
..........................................................................................................................................................
..........................................................................................................................................................

Number of head X-rays = ..................................................

(2)

(d) Which one of the following is another use of X-rays?

Tick (✓) one box.

Cleaning stained teeth

Killing cancer cells

Scanning of unborn babies

(1)
(Total 6 marks)