Q1.

The diagram below shows a ripple tank that a student used to investigate water waves.

(a) The student adjusted the speed of the motor so that the bar hit the water more times each second.

What happened to the frequency of the waves produced?

Tick one box.

- Decreased
- Did not change
- Increased

(b) Describe how the frequency of the water waves in the ripple tank can be measured.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(c) The student measured the frequency of the water waves as 5 hertz.

Calculate the period of the water waves.

Use the equation:
Choose the unit.

<table>
<thead>
<tr>
<th>metres</th>
<th>metres / second</th>
<th>seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Period = ____________________
Unit = ____________________

(3)
(Total 6 marks)

Q2.

The diagram below shows the apparatus a student used to investigate the reflection of light by a plane mirror.

The student drew four ray diagrams for each angle of incidence.

The student measured the angle of reflection from each diagram.

The table below gives the student’s results.
Angle of reflection

<table>
<thead>
<tr>
<th>Angle of incidence</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°</td>
<td>19°</td>
<td>22°</td>
<td>20°</td>
<td>19°</td>
</tr>
<tr>
<td>30°</td>
<td>31°</td>
<td>28°</td>
<td>32°</td>
<td>30°</td>
</tr>
<tr>
<td>40°</td>
<td>42°</td>
<td>40°</td>
<td>43°</td>
<td>41°</td>
</tr>
<tr>
<td>50°</td>
<td>56°</td>
<td>49°</td>
<td>53°</td>
<td>46°</td>
</tr>
</tbody>
</table>

(a) For each angle of incidence, the angle of reflection has a range of values. This is caused by an error. What type of error will have caused each angle of reflection to have a range of values?

__________________________________________________________________________________________ (1)

(b) Suggest what the student may have done during the investigation to cause each angle of reflection to have a range of values.

__________________________________________________________________________________________ (1)

(c) Estimate the uncertainty in the angle of reflection when the angle of incidence is 50°. Show how you determine your estimate.

__________________________________________________________________________________________

__________________________________________________________________________________________

Uncertainty = ± _____________________ ° (2)

(d) The student concluded that for a plane mirror, the angle of incidence is equal to the angle of reflection. Explain whether you agree with this conclusion. Use examples from the results in the table below in your answer.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________ (2)
(e) What extra evidence could be collected to support the student’s conclusion?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(1)

(f) State one change the student should make to the apparatus if he wants to use the same method to investigate diffuse reflection.
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(1)
(Total 8 marks)

Q3.
(a) A light bulb is placed between a convex lens and the principle focus of this lens, at position \(N\) shown in Figure 1. The light bulb is then moved to position \(M\), a large distance from the lens.

![Figure 1](image)

Describe how the nature of the image formed changes as the light bulb is moved from position \(N\) to position \(M\).
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(3)

(b) An object, \(O\), is very near to a convex lens, as shown in Figure 2.

Complete Figure 2 to show how rays of light from the object form an image.

![Figure 2](image)
The object distance is the distance from an object to the lens. The image distance is the distance from the lens to the image.

Figure 3 shows how the image distance changes with the object distance, for two identically shaped convex lenses, A and B. Each lens is made from a different type of glass.
(i) When the object distance is 4 cm, the image distance for lens A is longer than for lens B.

State why.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

(1)

(ii) When the object is moved between lens B and the principal focus, the image size changes. The table shows the magnification produced by lens B for different object distances.

<table>
<thead>
<tr>
<th>Object distance in cm</th>
<th>Magnification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>5.0</td>
<td>2</td>
</tr>
<tr>
<td>6.7</td>
<td>3</td>
</tr>
<tr>
<td>7.5</td>
<td>4</td>
</tr>
<tr>
<td>8.0</td>
<td>5</td>
</tr>
</tbody>
</table>

Using information from Figure 3 and the table, describe the relationship between the image distance and the magnification produced by lens B.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________
(iii) A third convex lens, lens \( C \), is made from the same type of glass as lens \( B \), but has a shorter focal length than lens \( B \).

Lens \( B \) is shown in **Figure 4**.

Complete **Figure 4** to show how lens \( C \) is different from lens \( B \).

**Figure 4**

![Figure 4](image)

Lens \( B \)  
Lens \( C \)

Q4.

Ultrasound and X-rays are waves used in hospitals to create images of the inside of the human body. To produce the images below, the waves must enter the human body.

**Ultrasound scan of an unborn child**  
**X-ray of a broken bone**

© Isabelle Limbach/Thinkstock  
© itsmejust/iStock

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

Describe the features of ultrasound and X-rays, and what happens to each type of wave after it has entered the human body.

___________________________________________________________________  
___________________________________________________________________  
___________________________________________________________________
Q5.

(b) It would **not** be safe to use X-rays to produce an image of an unborn child. Explain why.

(c) Ultrasound can be used for medical treatments as well as for imaging. Give one use of ultrasound for medical treatment.

Q5.

**Figure 1** shows what happens when a ray of light enters a tin can through a small hole.

**Figure 1**
(a) Explain why the small hole looks black.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(b) All objects absorb and emit radiation.

What is meant when an object is described as a perfect black body?

___________________________________________________________________
___________________________________________________________________

Figure 2 shows how the intensity of different wavelengths of radiation from a hot object varies with temperature.

Figure 2
(c) What can be concluded from Figure 2 about how the distribution of the intensity of radiation from an object changes as the temperature of the object increases?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(d) The wavelength at which the Sun emits the maximum intensity of radiation is approximately $5 \times 10^{-7}$ m

Estimate the surface temperature of the Sun.

Use Figure 2.
(e) **Figure 3** shows how the balance between the incident radiation from space and the radiation emitted by the Earth into space has changed over the last 200 years.

**Figure 3**

**200 years ago**

- Incident radiation from space: 170,000 TW
- 50,000 TW reflected into space

**Now**

- Incident radiation from space: 170,000 TW
- 116,620 TW emitted
- 50,000 TW reflected into space

Explain how the temperature of the Earth and its atmosphere has changed over the last 200 years.

Use the information in **Figure 3**.
Mark schemes

Q1.
  (a) increased 1
  (b) (count) how many waves pass a point 1
      in one second
      *this is dependent on the first mark point being awarded* 1
      or
      (count) number of waves that pass a point in a given time
      *allow a specific time for a given time* 1
      or
      (count) number of waves that are produced in a given time (1)
      and divide by that time in seconds
      *this is dependent on the first mark point being awarded*
      *allow an answer in terms of measuring the frequency of the*
      *vibrating bar* 1
      period = \( \frac{1}{5} \) 1
      period = 0.2 1
      seconds / s 1

Q2.
  (a) random 1
      *human error is insufficient*
  (b) accept any practical suggestion that could cause a range of values
      e.g. misjudging the centre of the ray
      e.g. not replacing mirror / ray box in the same position
      *measuring the angle incorrectly is insufficient*
      *moving the mirror / ray box is insufficient* 1
  (c) range = 10 1
      or
      mean of 51 calculated 1
5(°)

* an answer of 5(°) scores 2 marks

(d) within experimental accuracy the angle of incidence and the angle of reflection are the same

* allow the angle of incidence is nearly the same as the angle of reflection

or

the angle of reflection is usually different to the angle of incidence

* allow only a few of the values are the same /
  * similar
  * allow the idea of a range of values

relevant use of data

e.g.

at 20° / 30° / 40° there is at least one measurement of angle of reflection that is exactly the same

or

at 50° there are big differences

* allow 50° includes anomalous results
  * an answer in terms of calculated mean(s) may score both marks
  
e.g.
  * mean calculated for one or more angle of reflection (1)
  * conclusion correctly stating angle i = / ≠ angle r (1)

(e) results could be collected for angles (of incidence) not yet measured

* allow a stated angle of incidence e.g. 10° or 60°
  * changing the mirror is insufficient
  * ignore repeat the measurements

(f) replace the mirror with an irregular reflecting surface

* allow use an irregular reflecting surface
  * replace mirror with paper is insufficient
  * do not accept use a glass block

Q3.

(a) the image would decrease in size

the image would change (from virtual) to real

* accept that the image (of bulb M) can be projected on to a screen

the image would change (from non-inverted) to inverted
(b) a ray through the centre of the lens
   rays should be drawn with a ruler
   ignore arrows

   a ray parallel to the principal axis and passing through the principal focus to the right of lens
   accept solid or dashed lines
   accept a ray drawn as if from the principal focus to the left of the lens, emerging parallel to the principal axis

   image drawn where rays cross
   image should be to left of the lens

(c) (i) (because the glass in) lens A has a greater refractive index
   accept lens A is more powerful
   accept lens A has a shorter focal length

   (ii) when the magnification increases by 1, the image distance increases by 10 cm
   accept for 1 mark it is a linear pattern
   or
   as the image distance increases, the magnification increases
   do not accept directly proportional
(iii) diagram showing the surfaces of a convex lens C having greater curvature than lens B

the size of the lens drawn is not important

Q4.

(a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant / correct content.

Level 1 (1-2 marks)
There is a basic description of either wave
OR
What happens to either wave when they enter the body. However there is little other detail.

Level 2 (3-4 marks)
There is either:
A clear description of BOTH waves
OR
A clear description as to what happens to BOTH waves inside the body
OR
A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

Level 3 (5-6 marks)
There is a detailed description of BOTH of the waves
AND
A detailed description as to what happens to EITHER wave inside the body.

Examples of the points made in the response:

Description of an X-ray

- X-rays are electromagnetic waves / part of the electromagnetic spectrum
do not allow a description of a property – eg X-rays travel
- X-rays are (very) high frequency (waves)
 through a vacuum / at the speed of light
- X-rays are (very) high energy (waves)
- X-rays have a (very) short wavelength
- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom
- X-rays are a transverse wave
 correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer
- X-rays are ionising radiation
**Description of ultrasound**

- ultrasound has a **frequency** above 20 000 (hertz)
  
  or

  ultra sound is above 20 000 hertz

- ultrasound is above / beyond the human (upper) limit (of hearing)
  *accept ultrasound cannot be heard by humans*

- ultrasound is a longitudinal wave
  *correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer*

**Statement(s) as to what happens to X-rays inside the human body:**

- X-rays are absorbed by bone

- X-rays travel through / are transmitted by tissue / skin

**Statement as to what happens to ultrasound inside body:**

- ultrasound is (partially) reflected at / when it meets a boundary between two different media

- travel at different speeds through different media

(b) (because the X-rays) are **ionising**

  *accept a description of what ionising is*

  (they will) damage cells

  *instead of cell, any of these words can be used:
  DNA / genes / chromosomes / nucleus*

  or

  mutate cells / cause mutations / increase chances of mutations

  or

  turn cells cancerous / produce abnormal growths / produce rapidly growing cells

  *do not accept they can be dangerous (to human health)*

  *do not accept damage to soft tissue*

  or

  kill cells

(c) any **one** from:

- removal / destruction of kidney / gall stones
• repair of damaged tissue / muscle
  accept examples of repair, eg alleviating bruising, repair scar
damage, ligament / tendon damage, joint inflammation
  accept physiotherapy
  accept curing prostate cancer or killing prostate cancer cells

• removing plaque from teeth
  cleaning teeth is insufficient

Q5.

(a) light (inside the tin can) is reflected many times before
incident on the hole

at each reflection energy / light is absorbed so (very) little
light / energy leaves the hole

(b) the object absorbs all of the radiation incident on it
  or
  the object does not reflect or transmit any radiation
  or
  the object is the best possible emitter of radiation

(c) the intensity of every wavelength increases

  the shorter the wavelength the more rapid the increase in
  intensity

  the peak intensity occurs at shorter wavelength

(d) accept any value between 1600 (°C) and 10 000 (°C)

(e) the temperature has increased

  as 200 years ago the energy / radiation from space = energy
  / radiation emitted (and reflected) into space

  but now less radiation is emitted so there is a net absorption
  allow energy for radiation