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EDEXCEL GCSE PHYSICS: QUESTIONS BY TOPIC

## Light and the Electromagnetic Spectrum (5)

### GCSE Physics (Higher) Topic 5

11 questions · 107 marks · Mark schemes included

*Pearson Edexcel GCSE (9-1) Physics 1PH0, Higher Tier, June 2018 - June 2025*

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**HOW TO USE THIS BOOKLET**

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

| QUESTION                         | SOURCE                | MARKS | PAGE      |
|----------------------------------|-----------------------|-------|-----------|
| 1. <b>Q1</b>                     | Paper 1 June 2022     | 8     | <b>4</b>  |
| 2. <b>Q2</b>                     | Paper 1 June 2018     | 9     | <b>9</b>  |
| 3. <b>Q5</b> <i>also Topic 4</i> | Paper 1 November 2020 | 9     | <b>12</b> |
| 4. <b>Q5</b>                     | Paper 1 November 2021 | 9     | <b>14</b> |
| 5. <b>Q5</b>                     | Paper 1 June 2024     | 9     | <b>18</b> |
| 6. <b>Q6</b>                     | Paper 1 June 2024     | 9     | <b>20</b> |
| 7. <b>Q5</b>                     | Paper 1 June 2025     | 9     | <b>23</b> |
| 8. <b>Q8</b>                     | Paper 1 June 2023     | 10    | <b>27</b> |
| 9. <b>Q6</b> <i>also Topic 4</i> | Paper 1 June 2023     | 11    | <b>32</b> |
| 10. <b>Q7</b>                    | Paper 1 June 2025     | 11    | <b>35</b> |
| 11. <b>Q9</b>                    | Paper 1 June 2022     | 13    | <b>39</b> |



# QUESTIONS

11 questions · 107 marks · lowest tariff first



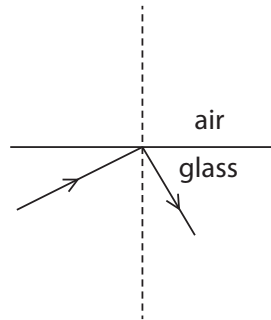
# 8-MARK QUESTIONS

1 question in this booklet

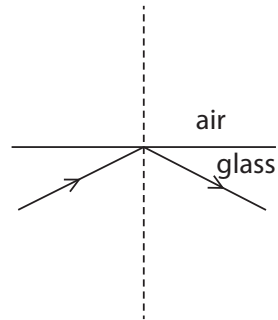


1 (a) Which ray diagram shows total internal reflection at an air and glass boundary?

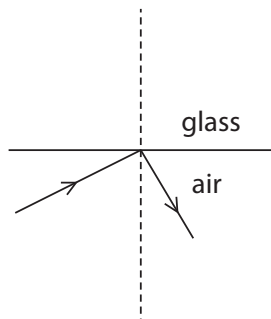
(1)



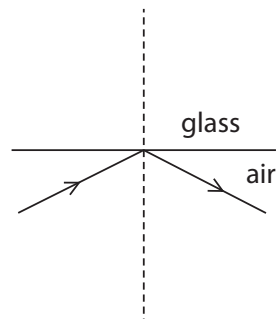
☐ A



☐ B



☐ C



☐ D

(b) Figure 1 is a ray diagram for a converging lens when used as a magnifying glass.

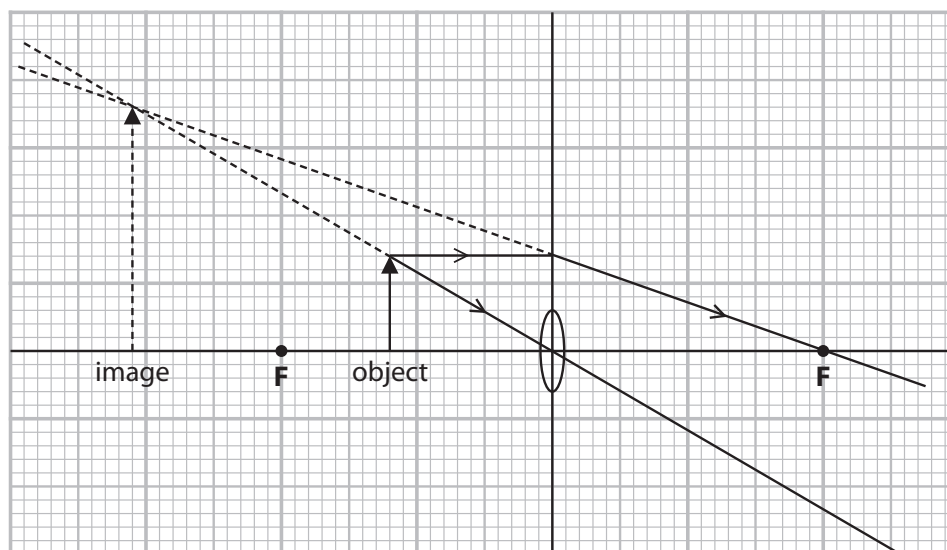


**Figure 1**

- (i) Using information from Figure 1, determine the magnification of the virtual image.

Use the equation

$$\text{magnification} = \frac{\text{height of image}}{\text{height of object}}$$

(2)

magnification = .....

(ii) Describe **one** way the magnification of the image could be increased.

(2)

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(c) Figure 2 shows a converging lens used to produce a real image on a screen.

The apparatus is used to find the focal length,  $f$ , of the lens.

The screen is moved to give a clear image of the object.

The distance from the **object** to the **lens**,  $a = 20$  cm.

The distance from the **image** to the **lens**,  $b = 40$  cm.

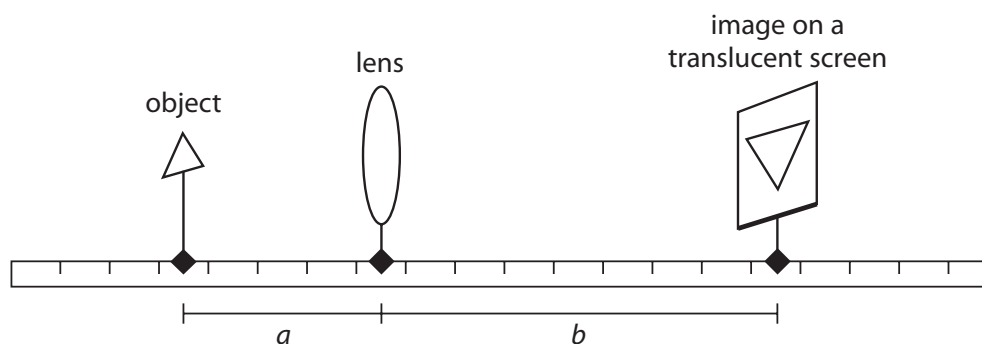


Figure 2

Calculate the focal length,  $f$ , of the lens.

Use the equation

$$\frac{1}{f} = \frac{a+b}{a \times b}$$

(3)

focal length  $f =$  ..... cm

(Total for Question 1 = 8 marks)

# 9-MARK QUESTIONS

6 questions in this booklet



- 2 (a) A student investigates what happens when light travels from air to glass.

Figure 2 shows some of the apparatus used in the investigation.

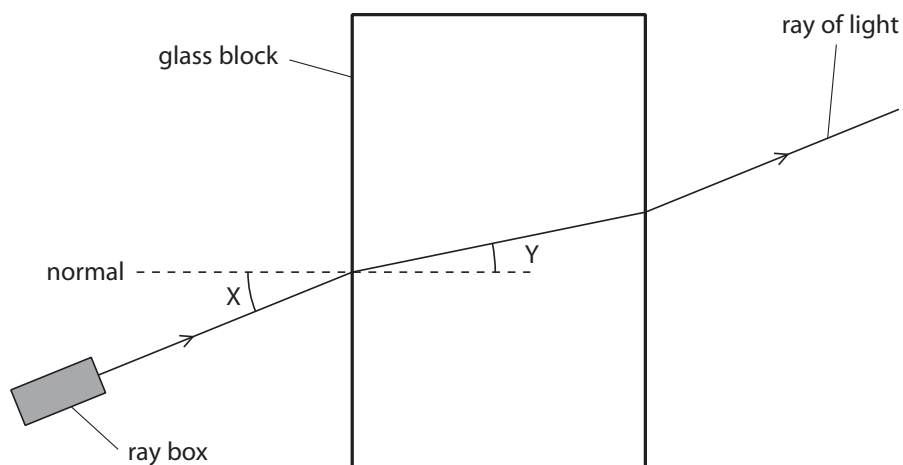


Figure 2

- (i) In Figure 2, angle Y is the angle of

(1)

- ☐ A deflection
- ☐ B incidence
- ☐ C reflection
- ☐ D refraction



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Figure 3 is a graph of the student's results.

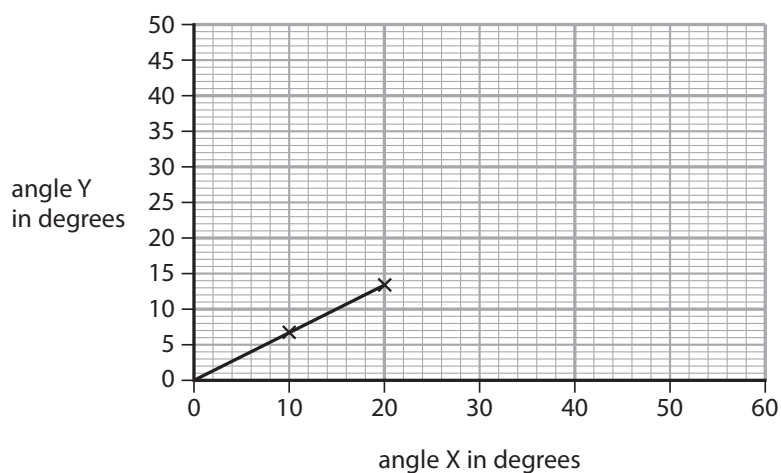


**Figure 3**

Use the graph to calculate a value for

$$\frac{\text{angle Y}}{\text{angle X}}$$

(2)

$$\frac{\text{angle Y}}{\text{angle X}} = \dots\dots\dots$$

(iii) The student concludes that angle Y is directly proportional to angle X.

Explain what the student must do to test this conclusion in more detail.

(3)

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(b) The speed of light is  $3.0 \times 10^8 \text{ m/s}$ .

The wavelength of yellow light is  $5.8 \times 10^{-7} \text{ m}$ .

Calculate the frequency of yellow light.

State the unit.

Use the equation

$$\text{frequency} = \frac{\text{speed}}{\text{wavelength}}$$

(3)

frequency = ..... unit .....

**(Total for Question 2 = 9 marks)**

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DO NOT WRITE IN THIS AREA



- 5 (a) A radio station transmits on 97.4 MHz.

To receive the waves an aerial needs a length equal to half the wavelength of the radio waves being transmitted.

Calculate the length of the aerial needed.

The speed of the radio waves is  $3.00 \times 10^8 \text{ m/s}$ .

(3)

length of aerial = ..... m

- (b) To investigate refraction in a rectangular glass block a student uses the apparatus shown in Figure 5.

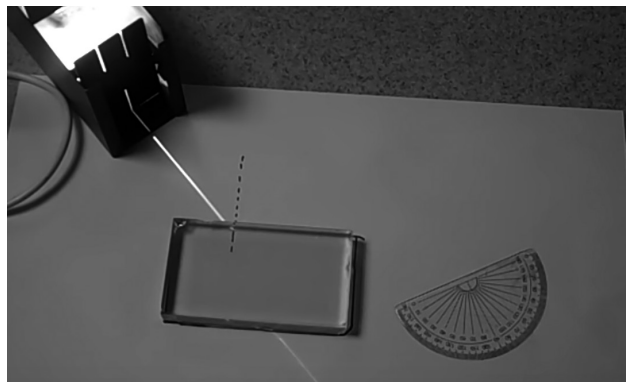


Figure 5

Describe how the student should measure the angle of refraction.

(2)

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- (c) Figure 6 is a simplified diagram to show radio waves from a transmitter moving upwards, then meeting a boundary between lower and upper layers of the atmosphere.

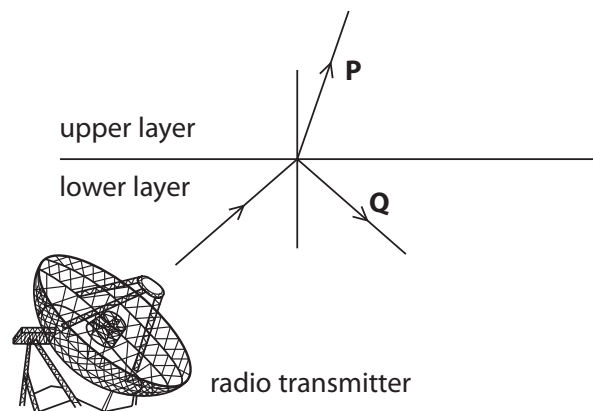


**Figure 6**

Explain what happens to the radio waves after they meet the boundary between the lower and upper layers as shown in Figure 6.

Your explanation should refer to changes in direction and speed of the waves.

(4)

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**(Total for Question 5 = 9 marks)**

5 A student is investigating the refraction of light.

Figure 5 shows part of the apparatus and the angles to be measured.

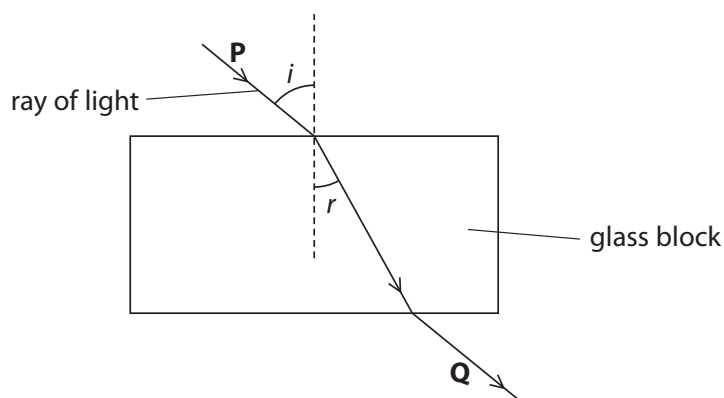


Figure 5

The student measures angle  $r$  for several different values of angle  $i$ .

Figure 6 shows the student's results.

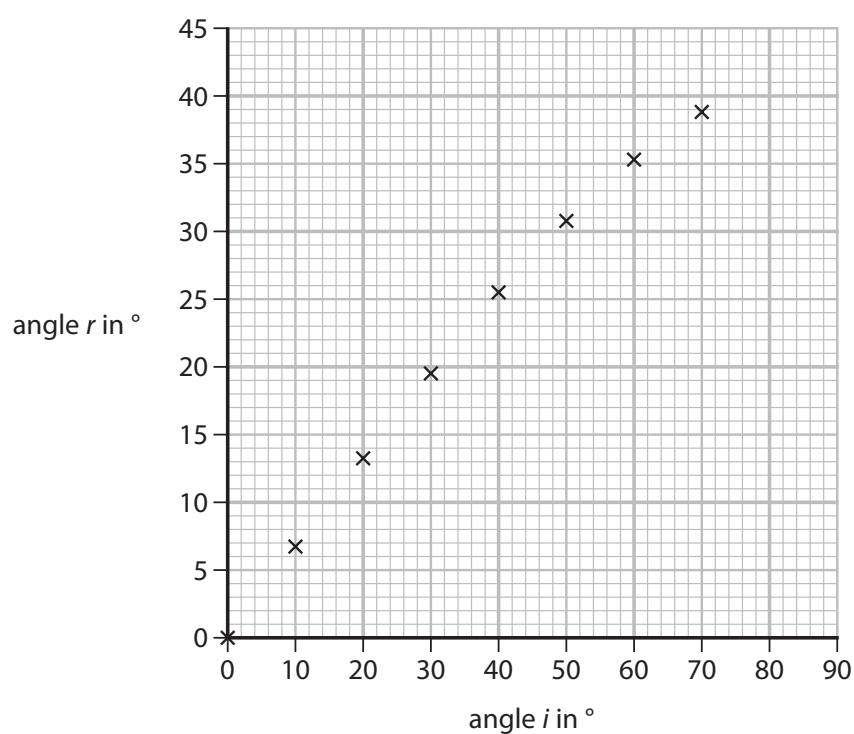


Figure 6

(a) (i) On the graph in Figure 6, draw the best fit curve.

(1)

(ii) Use the graph in Figure 6 to estimate the value of angle  $r$  when angle  $i$  is  $80^\circ$ .

(1)

angle  $r = \dots\dots\dots^\circ$

(iii) Describe how angle  $r$  changes with angle  $i$  for the results shown on the graph in Figure 6.

(2)

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(b) In Figure 5, the frequency of the light remains the same in glass as in air.

Which row of the table describes what happens to the wave velocity and to the wavelength of the light when the light travels from air to glass?

(1)

|                                   | wave velocity | wavelength |
|-----------------------------------|---------------|------------|
| <input type="checkbox"/> <b>A</b> | decreases     | decreases  |
| <input type="checkbox"/> <b>B</b> | decreases     | increases  |
| <input type="checkbox"/> <b>C</b> | increases     | decreases  |
| <input type="checkbox"/> <b>D</b> | increases     | increases  |



(c) In Figure 7, only refraction of light is shown.

Other things happen to the light as it travels from **P** to **Q**.

The intensity (brightness) of the light at **Q** is less than the intensity of the light at **P**.

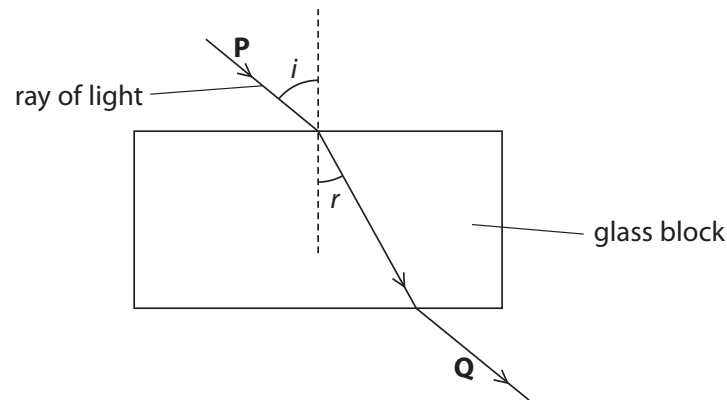


**Figure 7**

Explain the decrease in intensity as the light travels from **P** to **Q**.

You may add to Figure 7 to help your answer.

(3)

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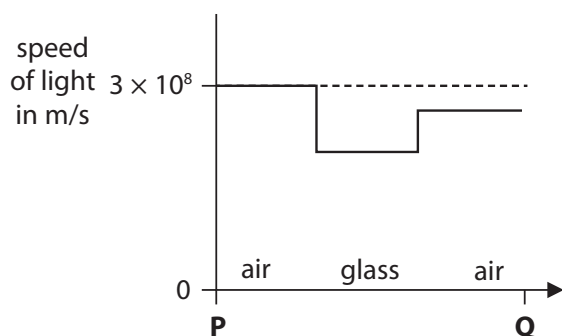
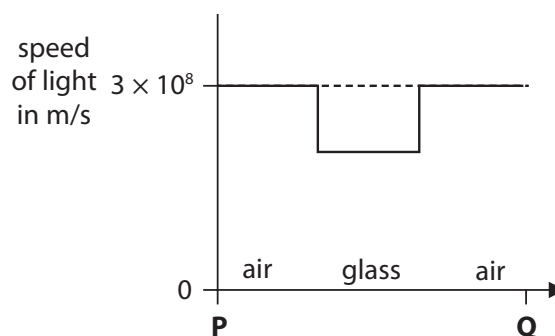
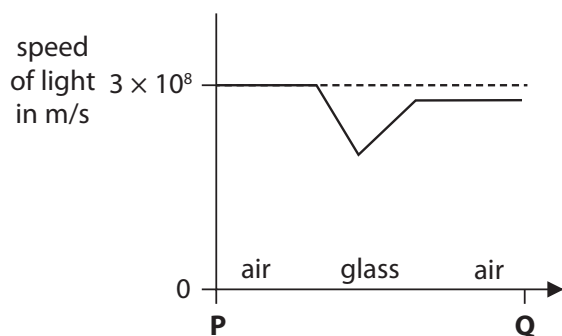
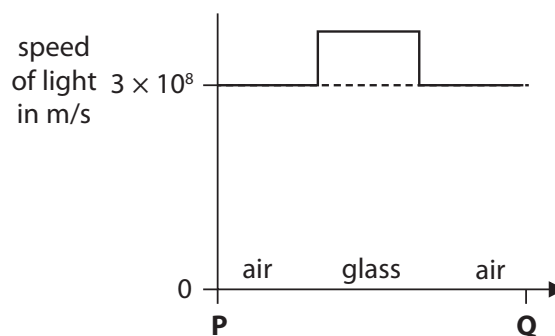
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(d) Which of these sketch graphs represents the speed of light as it travels from **P** to **Q**? (1)

☒ **A**☒ **B**☒ **C**☒ **D**

(Total for Question 5 = 9 marks)

5 Ultraviolet (UV) waves from the Sun travel towards the Earth.

Ultraviolet waves can be grouped by wavelength.

The three groups of wavelengths are UVA, UVB and UVC.

Figure 7 shows, for each group,

- the wavelength range
- the effect of the Earth’s atmosphere on each type of UV wave.

|                                             | UVA              | UVB              | UVC              |
|---------------------------------------------|------------------|------------------|------------------|
| wavelength range                            | 400 nm to 315 nm | 314 nm to 280 nm | 279 nm to 100 nm |
| % energy absorbed by the Earth’s atmosphere | 5%               | 95%              | 100%             |

Figure 7

(a) (i) Explain why UVC is potentially the most dangerous ultraviolet radiation but does not cause harm to people.

(2)

(ii) The speed of electromagnetic radiation is  $3.00 \times 10^8$  m/s.

Calculate the frequency of the shortest wavelength of UVB radiation.

(3)

frequency = ..... Hz

(b) UV radiation of wavelength 365 nm is used to detect forged banknotes.

In a genuine banknote there are marks that **cannot** be seen using visible light. These marks **can** be seen using UV radiation.

Explain why the marks can be seen when the UV radiation shines on the banknote.

Your answer should refer to the energy of electrons in atoms.

You may draw a diagram to help with your answer.

(4)

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(Total for Question 5 = 9 marks)



6 (a) (i) The law of reflection of light applies to reflections from

(1)

- ☐ A all surfaces
- ☐ B only shiny surfaces
- ☐ C only rough surfaces
- ☐ D only smooth surfaces

(ii) A student uses a mirror to demonstrate that the angle of incidence is equal to the angle of reflection.

Figure 8 shows the apparatus the student uses.

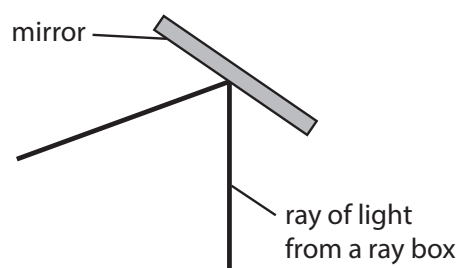


Figure 8

Describe the procedure the student should use with the ray and mirror in the position shown in Figure 8.

You should include any extra equipment needed.

You may add to Figure 8 to help your answer.

(3)

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- (b) Figure 9 shows a ray of light from a ray box passing through a semi-circular glass block.

A student uses the apparatus in Figure 9 to determine the critical angle for glass.

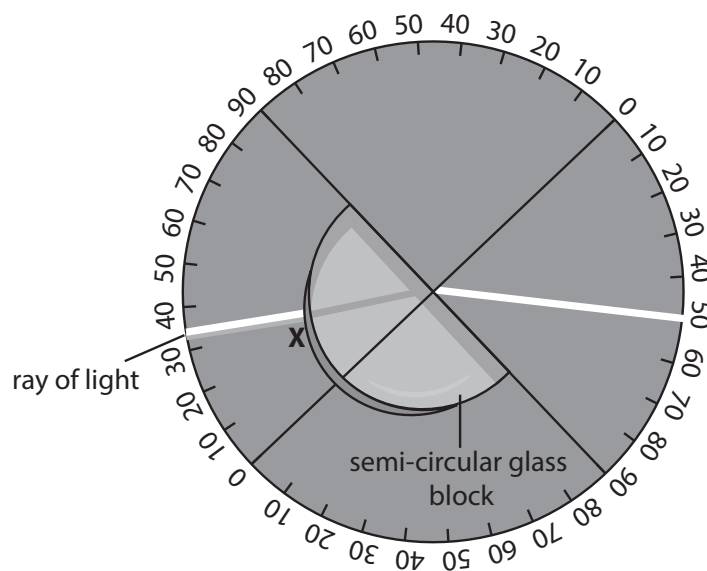


**Figure 9**

- (i) State why the ray of light does not change direction as it enters the glass block at **X**.

(1)

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- (ii) Describe how the critical angle for glass can be determined using the apparatus shown in Figure 9.

(3)

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(c) Figure 10 shows a ray diagram of the **virtual image** produced by a diverging lens.

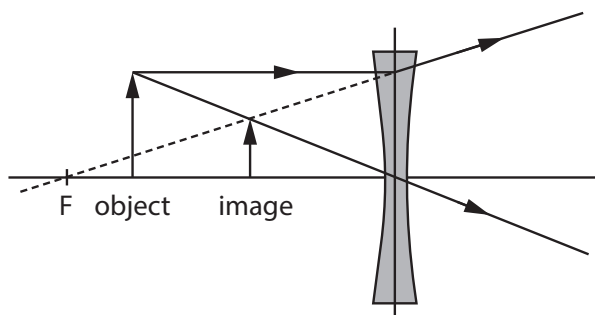


Figure 10

State what is meant by the term **virtual image**.

(1)

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(Total for Question 6 = 9 marks)

5 (a) When light travels from air into glass, it is refracted.

To investigate this, a student has a rectangular glass block and a ray box.

The ray box produces a ray of light.

Describe how the student should use the glass block and ray box to produce a refracted ray and mark its position.

You may draw a diagram to help your answer.

(4)

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(b) Figure 9 is a table of data for three coloured beams of light travelling from air into glass.

|              | wavelength<br>in air | frequency<br>in air     | wavelength<br>in glass | frequency<br>in glass   |
|--------------|----------------------|-------------------------|------------------------|-------------------------|
| red light    | 650 nm               | $4.6 \times 10^{14}$ Hz | 490 nm                 | $4.6 \times 10^{14}$ Hz |
| yellow light | 580 nm               | $5.2 \times 10^{14}$ Hz | 440 nm                 | $5.2 \times 10^{14}$ Hz |
| blue light   | 470 nm               | $6.4 \times 10^{14}$ Hz | 350 nm                 | $6.4 \times 10^{14}$ Hz |

Figure 9

Using data from Figure 9,

- (i) state what happens to the wavelength of light when the light travels from glass into air

(1)

- (ii) state what happens to the frequency of light when the light travels from glass into air.

(1)



(iii) The speed of blue light in air is  $3.0 \times 10^8 \text{ m/s}$ .

Calculate the change in the speed of blue light when it travels from air into glass.

Use the equation

$$v = f \times \lambda$$

(3)

change in speed = ..... m/s

**(Total for Question 5 = 9 marks)**



# 10-MARK QUESTIONS

1 question in this booklet



- 8 (a) A student does an experiment to determine the critical angle for glass.

The student shines a ray of light into a semicircular glass block and measures the angles  $i$  and  $r$ , as shown in Figure 14.

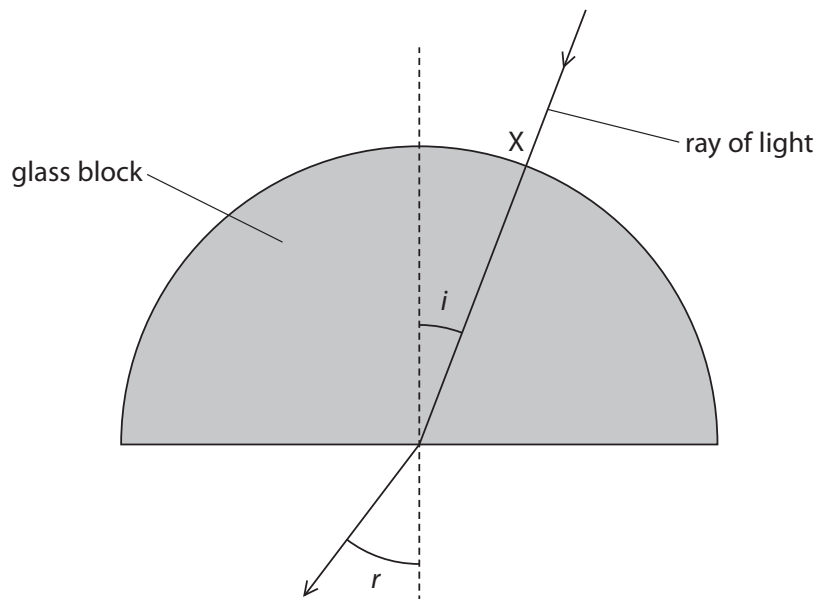


Figure 14

- (i) The ray of light does not change direction when it enters the glass block at point X.

Which of these **explains** why the ray of light does not change direction when it enters the glass block at point X.

(1)

- ☐ A The ray enters along a normal to the edge of the block.
- ☐ B The ray enters at right angles to a normal to the edge of the block.
- ☐ C The ray speeds up as it enters the glass.
- ☐ D The ray slows down as it enters the glass.

- (ii) The student repeats the procedure for different values of angle  $i$ .

Figure 15 is a graph of the student's results.

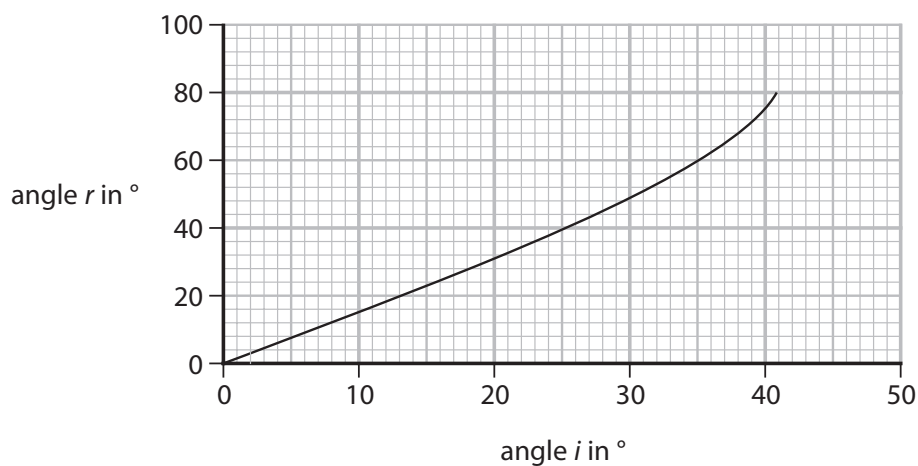


**Figure 15**

Describe how the student should use the graph in Figure 15 to determine the critical angle for glass.

(3)

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- (b) Figure 16 shows two iron spheres, **P** and **Q**, near to a radiant heater. **P** is painted black and **Q** is painted white.

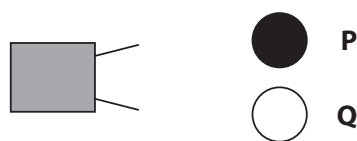


**Figure 16**

Each sphere is the same distance away from the heater.

The spheres have the same radius.

The heater is switched on and the spheres heat up.

The temperature of each sphere is monitored.

- (i) Explain why the temperature of sphere **P** increases at a faster rate than the temperature of sphere **Q**.

(2)

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- (ii) The heater remains switched on.

Figure 17 shows how the temperature of sphere **P** changes with time.

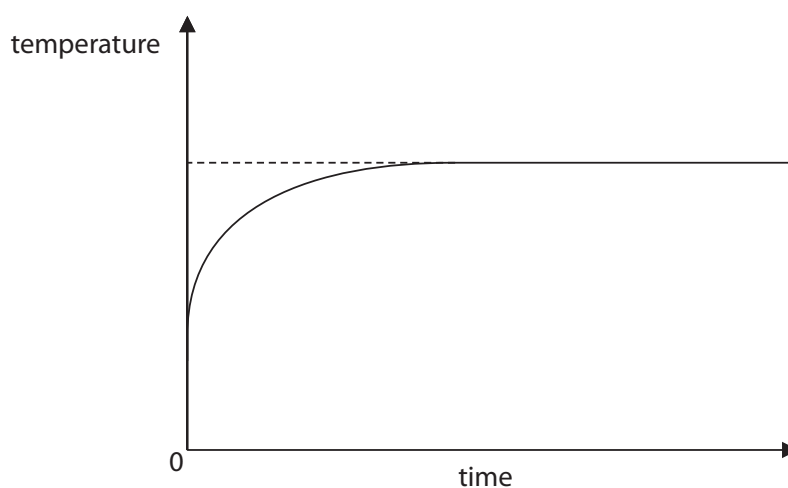


**Figure 17**

Explain why the temperature of **P** reaches a constant value, even though the heater remains switched on.

(4)

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(Total for Question 8 = 10 marks)



# 11-MARK QUESTIONS

2 questions in this booklet



- 6 (a) Figure 9 shows two technicians, L and M, measuring the speed of sound in air.

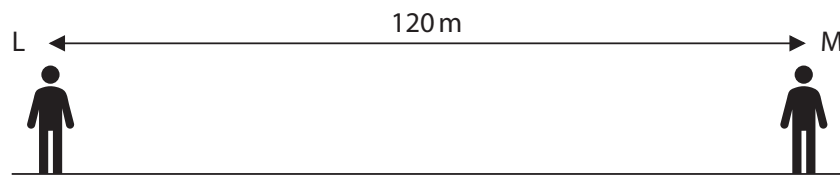


Figure 9

L fires a starting pistol.

M starts a stopwatch when first seeing the smoke from the starting pistol.

M stops the stopwatch when hearing the bang made by the starting pistol.

The distance between L and M is 120 m.

M's reaction time is 0.23 s.

The speed of sound in air is 330 m/s.

- (i) Calculate M's reaction time as a percentage of the time sound takes to travel from L to M.

(3)

.....%

- (ii) Which of these would improve the technicians' measurement of the speed of sound?

(1)

- ☐ A Use a firework 'banger' instead of the starting pistol.
- ☐ B Use a stop clock that measures time in minutes.
- ☐ C Increase the distance between L and M.
- ☐ D Decrease the distance between L and M.

- (b) Figure 10 shows the difference in refraction of sound waves and light waves when these waves travel from air into water.

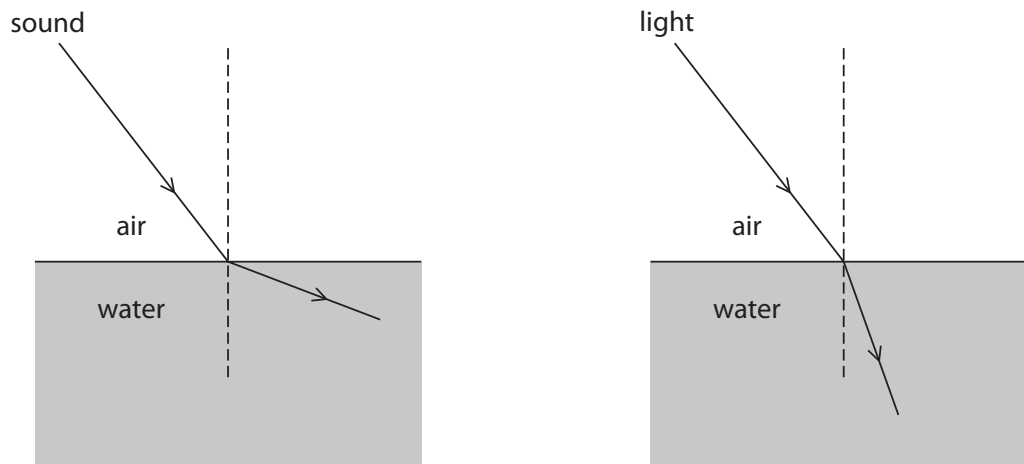


**Figure 10**

Explain why the refraction of the sound wave is different from the refraction of the light wave in Figure 10.

(3)

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(c) Light is one example of an electromagnetic wave.

Light can transfer energy from a lamp to the leaf of a plant, causing chemical reactions in the leaf.

Describe examples of **two** other electromagnetic waves transferring energy.

(4)

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2 .....

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(Total for Question 6 = 11 marks)



- 7 (a) Describe how the power of a lens is related to its focal length and the shape of the lens.

(2)

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- (b) (i) Give **one** example of a virtual image that a lens could produce.

(1)

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- (ii) Give **one** example of a real image that a lens could produce.

(1)

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- (c) A student investigates what happens when a ray of light shines into a semicircular block made of transparent plastic.

The ray meets the straight edge at an angle of  $20^\circ$ , as shown in Figure 13.

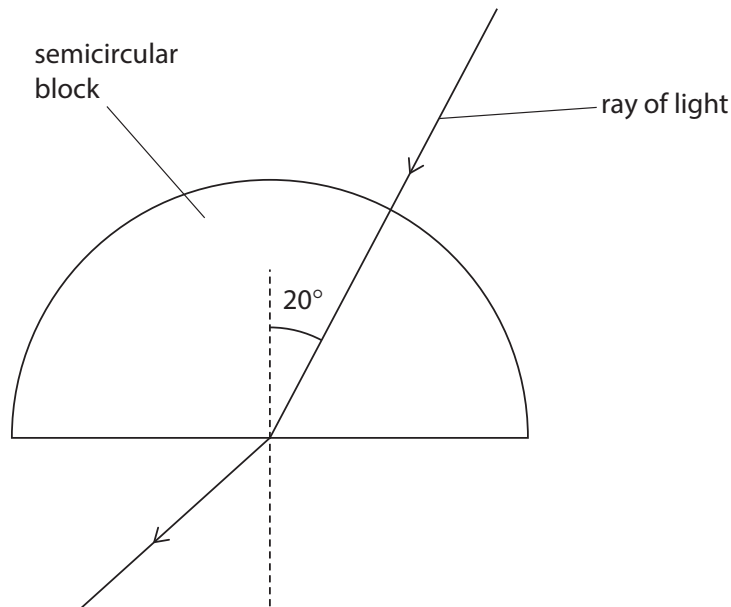


**Figure 13**

The student gradually increases the angle at the straight edge from  $20^\circ$  to  $50^\circ$  and observes what happens to the ray of light.

The critical angle for the transparent plastic is  $38^\circ$ .

Describe what you would expect to happen to the ray of light as the angle at the straight edge increases from  $20^\circ$  to  $50^\circ$ .

You may add to the diagram in Figure 13 to help your answer.

(3)

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(d) The asteroid Ceres orbits the Sun between Mars and Jupiter.

During its orbit, Ceres receives electromagnetic radiation from the Sun.

The average temperature of Ceres is constant.

Explain why the average temperature of Ceres remains constant.

(4)

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**(Total for Question 7 = 11 marks)**



# 13-MARK QUESTIONS

1 question in this booklet



9 This question is about waves in the electromagnetic (e.m.) spectrum.

(a) The potential danger associated with the waves of the e.m. spectrum increases as

(1)

- ☐ A frequency decreases
- ☐ B frequency increases
- ☐ C velocity decreases
- ☐ D velocity increases

(b) (i) A microwave oven uses waves of frequency 2.45 GHz.

Calculate the wavelength of the microwaves.

The velocity of light is  $3.00 \times 10^8$  m/s.

(3)

wavelength = ..... m



- (ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

(3)

energy supplied to oven = ..... J



\*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

(6)

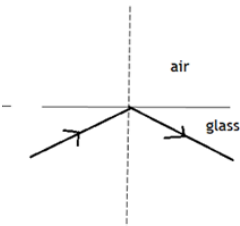
(Total for Question 9 = 13 marks)



# MARK SCHEMES

official Pearson Edexcel mark schemes



|    |                                                                                                                                                                                                                                                                                                                                                                                                                         |            |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 1a | <p><b>B</b></p>  <p>Once DTP redraw image, crop and insert here.</p> <p><i>A is not correct because the angle of incidence is not equal to the angle of reflection</i></p> <p><i>C is not correct because glass is more optically dense than air</i></p> <p><i>D is not correct because glass is more optically dense than air</i></p> | (1)<br>AO1 |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------------|
| 1(b)(ii)        | <p>a description to including one pair of:</p> <p>use different lens/replace lens (1)</p> <p>{higher power / shorter focal length / fatter / thicker / more curved / greater refractive index / more convex} lens (1)</p> <p><b>OR</b></p> <p>change the distance / move the lens / move the object (1)</p> <p>further away (from the object/lens) (1)</p> | <p>accept stronger</p> <p>curvature of lens increased (2)</p> <p>increase distance between object and lens (2)</p> | (2)<br>AO3 |

| Question Number | Answer                                                                                                                                                       | Additional guidance                                                                                                                                                                                                                                                                                                                                                              | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 1(c)            | substitution (1)<br>$\frac{1}{f} = \frac{20+40}{20 \times 40}$<br><br>evaluation of $\frac{1}{f}$ (1)<br><br>0.075<br><br>evaluation of f (1)<br><br>13 (cm) | accept<br>$\frac{1}{f} = \frac{60}{800}$ OR $\frac{1}{f} = \frac{3}{40}$<br><br><br><br><br>accept<br>13.3 (cm)<br>13.33 (cm)<br>power of ten error on 13<br>gains 2 marks<br><br>0.075 on answer line<br>gains 2 marks<br><br>power of ten error on<br>0.075 gains 1 mark<br><br>$\frac{40}{3}$ scores 2 marks<br><br>award full marks for<br>correct answer without<br>working | (3)<br>AO2 |

(Total for Question 1 = 8 marks)

| Question Number | Answer                                                                                                                                                                                                                                                                                | Mark                            |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| 2(a)(i)         | <p><b>D</b> refraction <b>is the only correct answer</b></p> <p><i>A 'deflection' is an incorrect distracting description</i></p> <p><i>B 'incidence' is incorrect, that would be angle X</i></p> <p><i>C 'reflection' is incorrect, no reflection being shown in the diagram</i></p> | <p><b>(1)</b></p> <p>AO 1 1</p> |

| Question Number | Answer                                                                                           | Additional guidance                                                                                                                         | Mark                            |
|-----------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| 2(a)(ii)        | <p>any pair of coordinates selected from the line (1)</p> <p>in range → 0.6(0) to 0.7(0) (1)</p> | <p>e.g. 20 and (13 or 14) or 10 and (6 or 7)</p> <p>ignore any units given</p> <p>award full marks for a correct answer without working</p> | <p><b>(2)</b></p> <p>AO 2 1</p> |

| Question Number | Answer                                                                                                                                     | Additional guidance                                                                        | Mark                             |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|----------------------------------|
| 2(a)(iii)       | <p>an explanation linking:</p> <p>repeat (1)</p> <p>different angles / more values of X (1)</p> <p>for larger angles / values of X (1)</p> | <p>allow 'more measurements' / 'repeat experiment' / collect more data</p> <p>&gt; 20°</p> | <p><b>(3)</b></p> <p>AO 3 3a</p> |

| Question Number | Answer                                                                                                                           | Additional guidance                                                                                                                                                                                                                                                                                             | Mark                 |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| 2(b)            | substitution (1)<br>$\frac{3.0 (\times 10^8)}{5.8 (\times 10^{-7})}$<br>evaluation (1)<br>$5.2 \times 10^{14}$<br>unit (1)<br>Hz | answers that round to $5.2 \times 10^{14}$<br>award 2 marks for a correct answer without working<br>allow 1 mark for answers that round to 5.2 to any power of ten<br>independent mark<br>accept hz or $s^{-1}$ or per sec(ond) or hertz<br>accept kHz, MHz etc with correct power ( $10^{11}$ kHz, $10^8$ MHz) | <b>(3)</b><br>AO 2 1 |

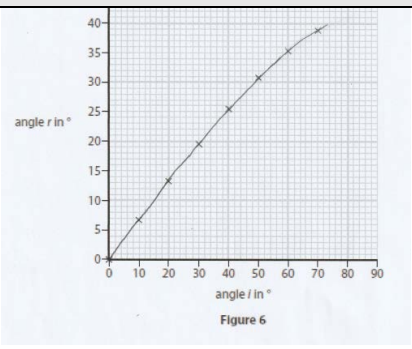
**(Total for Question 2 = 9 marks)**

| Question number | Answer                                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 5 (a)           | <p>recall <b>and</b> rearrangement (1)</p> $\lambda = \frac{v}{f}$ <p>evaluation (1)</p> <p>3.08 (m)</p> <p>(so) length of aerial = 1.54 m (1)</p> <p>check working<br/> <math>\frac{3 \times 10^8}{2} = 1.5 \times 10^8</math><br/> gets only 1 mark for ecf</p> | <p><math>\frac{3.0 \times 10^8}{97.4 \times 10^6}</math></p> <p>accept 3.1 (m)</p> <p>award 1 mark for wavelength that rounds to 3.1 to any other power of 10</p> <p>independent mark.<br/>allow ECF from candidate's wavelength</p> <p>accept 1.5 (m)<br/>award 2 marks for 1.5 to any other power of 10</p> <p>award full marks for the correct answer without working</p> <p>Allow 1.46 rounded to 1.5 for 1 mark only if it is ecf from mp2</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                     | Additional guidance  | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------|
| 5 (b)           | <p>A description including two from:</p> <p>trace / mark where the ray went into and out of( through) the glass block / line on either side of glass block(1)</p> <p>(remove block) join entry and exit points (of ray of light) (1)</p> <p>use the protractor to measure the angle between the refracted/drawn ray and the normal (1)</p> | accept 90° line etc. | (2)  |

| Question number | Answer                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                                                                                                                         | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 5 (c)           | <p>explanation linking:</p> <p>wave P refracts (towards the normal) (1)</p> <p>because P slows down (1)</p> <p>AND</p> <p>wave Q is reflected (at an equal angle from the boundary) (1)</p> <p>without change of speed of Q (1)</p> | <p>accept 'upper layer' for 'P'</p> <p>accept 'wavelength decreases'</p> <p>accept 'bends' for 'refracts' in this instance</p> <p>accept 'lower layer' for 'Q'</p> <p>accept 'wavelength unchanged'</p> <p>accept 'wave Q bounces off' (at an equal angle)</p> <p>allow one mark for refraction and reflection if no other mark awarded</p> | (4)  |

**Total for Question 5 = 9 marks**

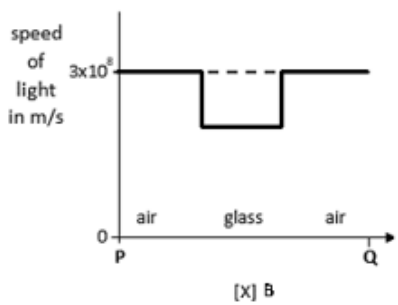
| Question number | Answer                                                | Additional guidance                                                                                | Mark       |
|-----------------|-------------------------------------------------------|----------------------------------------------------------------------------------------------------|------------|
| 5 (a)(i)<br>CS3 | curve through origin, through all points – by eye (1) |  <p>Figure 6</p> | (1)<br>AO1 |

| Question number  | Answer                                   | Additional guidance | Mark       |
|------------------|------------------------------------------|---------------------|------------|
| 5 (a)(ii)<br>CS3 | $(r =) 42(^{\circ}) \pm 2(^{\circ})$ (1) | ECF their graph     | (1)<br>AO3 |

| Question number   | Answer                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                                            | Mark       |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 5 (a)(iii)<br>CS3 | <p>Description to include two from:</p> <p><math>r</math> increases as <math>i</math> increases (1)</p> <p>(but) not in proportion (1)</p> <p>increase in <math>r</math> becomes less (for same increase in <math>i</math>) (1)</p> | <p><math>r</math> increases as <math>i</math> increases</p> <p>(but) not in even steps/not straight line/non-linear/gradient changes</p> <p><math>r</math> always less than <math>i</math></p> | (2)<br>AO3 |

| Question number | Answer                                                                                                                                                                                                                                                                                       | Mark       |               |            |       |           |           |            |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|------------|-------|-----------|-----------|------------|
| 5 (b)<br>CS3    | <table border="1"> <tr> <td></td><td>wave velocity</td><td>wavelength</td></tr> <tr> <td>[x] A</td><td>decreases</td><td>decreases</td></tr> </table> <p>B is not correct because the wavelength does not increase<br/>C and are not correct because the wave velocity does not increase</p> |            | wave velocity | wavelength | [x] A | decreases | decreases | (1)<br>AO1 |
|                 | wave velocity                                                                                                                                                                                                                                                                                | wavelength |               |            |       |           |           |            |
| [x] A           | decreases                                                                                                                                                                                                                                                                                    | decreases  |               |            |       |           |           |            |

| Question number | Answer                                                                                                                                                                                    | Additional guidance                                                                                                                                   | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 5 (c)<br>CS3    | <p>Explanation linking <b>three</b> from:</p> <p>(some) light is <u>reflected</u> (1)</p> <p>(at) the top edge (1)</p> <p>(some) light is <u>absorbed</u> (1)</p> <p>by the glass (1)</p> | <p>in the air</p> <p>in the (glass) block</p> <p>credit responses in terms of attenuation/ dispersion/reflection at the second face/spreading out</p> | (3)<br>AO2 |

| Question number | Answer                                                                                                                                 | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------|------------|
| 5 (d)<br>CS3    |  <p>[x] B</p> <p><b>B</b> is the correct answer</p> | (1)<br>AO3 |

|  |                                                                                                                                                                                                                                                                   |  |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|  | <p>A is not correct because the velocity in air is the same before and after the glass</p> <p>C is not correct because the velocity is constant inside the glass</p> <p>D is no correct because the velocity in glass is not greater than the velocity in air</p> |  |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

**Total for Question 5 = 9 marks)**



|               |                                                                                                                                                                                                                                                                      |                                                                                                         |                                     |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>5a (i)</b> | <p>An explanation linking</p> <p>UVC/it has the smallest wavelength / highest frequency/ highest energy/most ionising (1)</p> <p>(it doesn't cause harm to people because) 100% absorbed by the Earth's atmosphere/no UVC reaches the Earth's surface/people (1)</p> | <p>allow shortest wavelength</p> <p>allow smaller for smallest / higher for highest / more for most</p> | <p><b>2</b></p> <p><b>AO3.2</b></p> |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------|

|  |  |                                                                                         |  |
|--|--|-----------------------------------------------------------------------------------------|--|
|  |  | <p>wavelength for 1 mark</p> <p>award full marks for correct answer without working</p> |  |
|--|--|-----------------------------------------------------------------------------------------|--|

| Question    | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                               | Mark                                |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-------------------------------------|
| <b>5(b)</b> | <p>an explanation linking any <b>four</b> of the following:-</p> <p>UV/energy absorbed by electrons (1)</p> <p>electrons change orbit/energy level/shell (1)</p> <p>electrons in an 'excited' state (1)</p> <p>electrons emit energy/ move to lower energy level/fall down/de-excite (1)</p> <p>(energy) emitted as (visible) light / at a different frequency/wavelength (1)</p> <p>(process is called) fluorescence / (light emitted is) fluorescent (1)</p> | <p>a labelled diagram can score up to 4 marks</p> | <p><b>4</b></p> <p><b>AO1.1</b></p> |

**Total Question 5= 9 marks**

| Question | Answer | Mark |
|----------|--------|------|
|----------|--------|------|

|              |                                                                   |                          |
|--------------|-------------------------------------------------------------------|--------------------------|
| <b>6a(i)</b> | <b>A</b> all surfaces<br><br>the laws of reflection always apply. | <b>1</b><br><b>AO1.2</b> |
|--------------|-------------------------------------------------------------------|--------------------------|

| Question       | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional guidance                                                                                                                                                                                     | Mark                     |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| <b>6 a(ii)</b> | <p>an explanation linking <b>three</b> from</p> <p>mark the position of the mirror /<br/>mark the position of the rays of light/<br/>place all apparatus on a sheet of paper (1)</p> <p>put in the normal to the mirror which is perpendicular to mirror (at the point of reflection) (1)</p> <p>identify/label angle of incidence and angle of reflection from the normal (1)</p> <p>use a protractor (to measure the angles of incidence / reflection / to find the normal) (1)</p> | <p>marks can be given for additions to diagram</p> <p>may be shown on diagram</p> <p>may be shown as <i>i</i> and <i>r</i> on diagram</p> <p>do not allow a mark for the use of angle of refraction</p> | <b>3</b><br><b>A03.3</b> |

| Question        | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                          | Mark                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------------------------|
| <b>6(b)(ii)</b> | <p>a description to include three from the following</p> <p>to increase the angle in the glass / angle of incidence (1)</p> <p>observe the refracted beam until the angle of refraction is <math>90^\circ</math> / the beam is along the edge / the beam just reflects into the glass block / the beams starts to total internally reflect (1)</p> <p>the angle in the glass / angle of incidence is the critical angle (1)</p> <p>repeat and take the average value(1)</p> | <p>accept move ray clockwise</p> <p>if no other mark scored award 1 mark</p> | <b>3</b><br><b>A03.3</b> |

|  |  |                           |  |
|--|--|---------------------------|--|
|  |  | for move the ray of light |  |
|--|--|---------------------------|--|

| Question    | Answer                                                                                                                                                                                                                                                                                              | Additional guidance                                                                                               | Mark                     |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|--------------------------|
| <b>6(c)</b> | <p>one from</p> <p>the image/ it cannot be produced /projected (on a screen) (1)</p> <p>the rays do not actually pass through the image (1)</p> <p>image formed when imaginary rays meet (1)</p> <p>the image is on the same side of the lens as the object (1)</p> <p>the image is upright (1)</p> | <p>ignore image is not real</p> <p>allow the image is in front of the lens</p> <p>not inverted / up side down</p> | <b>1</b><br><b>A01.1</b> |

**Total Question 6 = 9 marks**

| Question | Answer | Additional guidance | Mark |
|----------|--------|---------------------|------|
|----------|--------|---------------------|------|

|             |                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                  |                                    |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>5(a)</b> | <p>a description of method to include <b>four</b> from:</p> <p>draw around the block (1)</p> <p>shine a ray on the block (1)</p> <p>mark/draw/trace where the ray enters (1)</p> <p>mark/draw/trace where the ray exits (1)</p> <p>join point of entry to point of exit (1)</p> | <p>point the ray box at the block</p> <p>can credit from drawing with glass block and ray box/light box labelled</p> <p>mark/draw/trace incident ray</p> <p>mark/draw/trace emerging ray</p> <p>allow 'draw light rays' for 1 mark if mp3 and mp4 not scored</p> | <p><b>(4)</b><br/><b>AO1.2</b></p> |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|

|                | Answer                                     | Additional guidance                                                                                             | Mark                               |
|----------------|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>5(b)(i)</b> | (wavelength) increases (from glass to air) | <p>gets longer/gets bigger</p> <p>allow quoted values</p> <p>allow (wavelength) decreases from air to glass</p> | <p><b>(1)</b><br/><b>AO3.1</b></p> |

|                 | Answer                     | Additional guidance                                                           | Mark                               |
|-----------------|----------------------------|-------------------------------------------------------------------------------|------------------------------------|
| <b>5(b)(ii)</b> | (frequency) doesn't change | <p>remains constant / stays the same / nothing</p> <p>allow quoted values</p> | <p><b>(1)</b><br/><b>AO3.1</b></p> |

|           | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                                                                                       | Mark         |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 5(b)(iii) | <p>substitution (1)</p> <p>(speed in glass =) <math>6.4 \times 10^{14} \times 350 \times 10^{-9}</math></p> <p>evaluation of speed in glass (1)</p> <p><math>2.2 \times 10^8</math> (m/s)</p> <p>subtraction involving <math>3 \times 10^8</math> (m/s) (1)</p> <p>ALTERNATIVE METHOD</p> <p>calculation of change in wavelength for blue light (1)</p> <p><math>470 \times 10^{-9} - 350 \times 10^{-9}</math> OR <math>120 \times 10^{-9}</math></p> <p>substitution (1)</p> <p>(difference in speed =) <math>6.4 \times 10^{14} \times 120 \times 10^{-9}</math></p> <p>evaluation (1)</p> <p><math>7.7 \times 10^7</math> (m/s)</p> | <p>allow numbers that round to <math>2.2 \times 10^8</math></p> <p>e.g. <math>2.24 \times 10^8</math></p> <p>independent mark</p> <p><math>7.6 \times 10^7</math> (m/s)</p> <p>scores 3 marks</p> <p>ecf their change in wavelength for this mark only</p> <p>award full marks for the correct answer without working</p> | (3)<br>AO3.2 |

Total for Question 5 = 9 marks

|                |                                                                                                                                                                                            |                                  |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>8(a)(i)</b> | <p><b>A</b> The ray enters along a normal to the edge of the block.</p> <p><b>B, C</b> and <b>D</b> are incorrect as these do not explain why the light ray does not change direction.</p> | <p><b>(1)</b><br/><b>AO2</b></p> |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|

|                 | Answer                                                                                                                                                                                    | Additional guidance                                                                                                                                                                  | Mark                             |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>8(a)(ii)</b> | <p>explanation linking:</p> <p>extrapolate / extend the graph/curve (1)</p> <p>(until it reaches) <math>r = 90^\circ</math> (1)</p> <p>read corresponding value of <math>i</math> (1)</p> | <p>Allow annotation on graph:</p> <p>extension of line on graph</p> <p>to at least <math>r = 90^\circ</math></p> <p>line down from line to x axis and labelled as critical angle</p> | <p><b>(3)</b><br/><b>AO2</b></p> |

|                | Answer                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                                                                                                                                           | Mark                             |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>8(b)(i)</b> | <p>explanation linking any 2 of:</p> <p>black / P is good absorber / poor reflector (1)</p> <p>white / Q is good reflector poor absorber (1)</p> <p>different colour of surfaces absorb differently (1)</p> | <p>allow any one statement for 2 marks:</p> <ul style="list-style-type: none"> <li>black / P <b>better</b> absorber</li> <li>black / P <b>worse</b> reflector</li> <li>white / Q <b>worse</b> absorber</li> <li>white / Q <b>better</b> reflector</li> <li>black / P absorbs (radiation) <b>and</b> white / Q reflects (radiation)</li> </ul> | <p><b>(2)</b><br/><b>AO1</b></p> |

|          | Answer                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                                           | Mark       |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 8(b)(ii) | <p>explanation linking <b>four</b> from:</p> <p>P is absorbing radiation/(thermal) energy (1)</p> <p>P is (also) emitting radiation/(thermal) energy (1)</p> <p>(rate of) emission increases with temperature (1)</p> <p>(temperature constant) when (rate of) emission = (rate of) absorption (1)</p> <p>mention of rate in either mp3 or mp4 (1)</p> | <p>allow heat in this context</p> <p>temperature of P constant when rate of emission of radiation = (rate of) absorption of radiation scores 4 marks</p> <p>(rate of) absorption of radiation is greater than (rate of) emission of radiation (so temperature increases) scores MP1 and 2</p> | (4)<br>AO1 |

**Total for Question 8 = 10 marks.**

|  | Answer | Additional guidance | Mark |
|--|--------|---------------------|------|
|--|--------|---------------------|------|



|                |                                                                                                                                                                                                  |                                                                                                                                                                                                          |                          |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| <b>6(a)(i)</b> | <p>calculation of time of travel (1)<br/> <math>(120/330 =) 0.36(36) \text{ (s)}</math></p> <p>substitution (1)</p> $\frac{0.23 \times 100}{0.36(36)}$ <p>evaluation (1)<br/>         63 (%)</p> | <p>ecf from MP1 for MP2&amp;3</p> <p>accept values that round to 64 or 63</p> <p>accept values that round to 0.64 or 0.63 for 2 marks</p> <p>award full marks for the correct answer without working</p> | <b>(3)</b><br><b>AO2</b> |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|

|                 | <b>Answer</b>                                                                                                                                         | <b>Mark</b>              |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| <b>6(a)(ii)</b> | <p><b>C</b> Increase the distance between L and M.</p> <p><b>A, B and D</b> are incorrect as these would not improve the technicians' measurement</p> | <b>(1)</b><br><b>AO3</b> |

|      | Answer                                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                         | Mark       |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 6(b) | <p>an explanation linking:</p> <p>(refraction caused by) change in speed (1)</p> <p>sound speeds up (when entering water) (1)</p> <p>light slows down (when entering water) (1)</p> | <p>allow 3 marks for sound speeds up and light slows down (when entering water)</p> <p>allow 2 marks for sound speeds up (when entering water)</p> <p>OR</p> <p>light slows down (when entering water)</p> <p>if no other marks scored allow 1 mark for description of any speed change (when entering water)</p> <p>if no other marks scored allow 1 mark for wavelength changes</p> <p>ignore references to transverse, longitudinal.</p> | (3)<br>AO1 |

|      | Answer                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Mark       |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 6(c) | <p>example 1<br/>e-m wave (1)<br/>corresponding result of energy transfer (1)</p> <p>example 2<br/>e-m wave (1)<br/>corresponding result of energy transfer (1)</p> | <p>e.g.<br/>radio waves: communication, oscillations (of electrons) in wires</p> <p>microwaves: cooking, communications and satellite transmissions, internal heating of body cells, increase KE/vibration of water molecules</p> <p>infrared: cooking, thermal imaging, optical fibres, television remote controls, skin burns</p> <p>ultraviolet: security marking, fluorescent lamps, detecting forged bank notes and disinfecting water, damage to surface cells and eyes, skin cancer</p> <p>x-rays: observing the internal structure of objects, airport security scanners and medical x-rays, mutation or damage to cells in the body, cancer</p> <p>gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment, mutation or damage to cells in the body, cancer</p> <p>additional effect for visible light scores 1 mark e.g. : including vision, photography and illumination</p> | (4)<br>AO1 |

**Total for Question 6 = 11 marks.**

|  | Answer | Mark |
|--|--------|------|
|--|--------|------|



| Question number | Answer                                                                                                                                                        | Additional guidance                                                                             | Mark         |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--------------|
| 7(a)            | <p>a description to include:</p> <p>a more powerful lens has a shorter focal length (1)</p> <p>a more powerful lens has a smaller radius of curvature (1)</p> | <p>stronger for more powerful</p> <p>allow thicker or fatter or more convex or more concave</p> | (2)<br>AO1.1 |

| Question number | Answer                                                                                                                                     | Additional guidance                                                                                            | Mark         |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------|
| 7(b)(i)         | <p><b>one</b> from</p> <p>(with converging lens when used as) a magnifying glass (1)</p> <p>image of an object in a diverging lens (1)</p> | <p>(when) object is closer to lens than focal length</p> <p>do not accept telescope / microscope / glasses</p> | (1)<br>AO2.1 |

| Question number | Answer                                                                                                                                                                                      | Additional guidance                                                             | Mark         |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------|
| 7(b)(ii)        | <p><b>one</b> from</p> <p>image of a distant object (by a converging lens) (1)</p> <p>photograph / image in a camera (1)</p> <p>projector image (1)</p> <p>image in eye / on retina (1)</p> | <p>(when) object is further from lens than focal length</p> <p>ignore phone</p> | (1)<br>AO2.1 |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                                                                                                                                                  | Mark         |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 7(c)            | <p>description to include <b>three</b> from</p> <p>when the angle inside (the block) increases the angle outside the block increases (1)</p> <p>when the angle inside the block = <math>38^\circ</math> the angle outside the block = <math>90^\circ</math> (1)</p> <p>when the angle inside the block <math>&gt; 38^\circ</math> ray reflected back inside (1)</p> <p>when the angle inside the block <math>&gt; 38^\circ</math> angle <math>i</math> = angle <math>r</math> OWTTE (1)</p> | <p>ignore partial reflections<br/>marks can be gained from labelled diagram</p> <p>outside ray (moves/bends) away from the normal OR towards the block<br/>refract mores</p> <p>allow critical angle for <math>38^\circ</math><br/>the ray goes along the straight edge</p> <p>total internal reflection or TIR just after <math>38^\circ</math></p> | (3)<br>AO2.2 |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Mark         |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 7(d)            | <p>explanation linking <b>four</b> from:</p> <p>Ceres is absorbing radiation/(thermal) energy from the Sun (1)</p> <p>Ceres is (also) emitting radiation/(thermal) energy (1)</p> <p>(rate of) emission increases with temperature (1)</p> <p>(temperature constant) when (rate of) emission = (rate of) absorption (1)</p> <p>mention of rate in either mp3 or mp4 (1)</p> | <p>allow heat in this context<br/>energy is transferred to ceres<br/>ceres gains energy<br/>(the Sun is) heating it<br/>ignore receiving (in stem)</p> <p>allow giving out / releasing / losing / dissipating for emitting</p> <p>accept power for rate</p> <p>temperature of Ceres constant<br/>when rate of emission of radiation = (rate of) absorption of radiation scores 4 marks</p> <p>absorption of radiation is greater than emission of radiation (so temperature increases) scores MP1 and 2</p> | (4)<br>A02.1 |

Total for Question 7 = 11 marks

| Question Number | Answer                                                                                                                                                                                                                                                                                                                    | Mark                             |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>9a</b>       | <p><b>B</b> frequency increases</p> <p><i>A is not correct because the danger does not increase with decreasing frequency</i></p> <p><i>C is not correct because all waves in the e-m spectrum have the same velocity</i></p> <p><i>D is not correct because all waves in the e-m spectrum have the same velocity</i></p> | <p><b>(1)</b><br/><b>AO1</b></p> |

| Question Number | Answer                                                                                                                                                                                                                    | Additional guidance                                                                                                                                                                                                                                                         | Mark                             |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>9b(i)</b>    | <p>selection and substitution (1)</p> $3(.00) \times 10^8 = 2.45 (\times 10^9) \times \lambda$ <p>rearrangement (1)</p> $(\lambda =) \frac{3(.00) \times 10^8}{2.45 (\times 10^9)}$ <p>evaluation (1)</p> <p>0.12 (m)</p> | <p>allow substitution and rearrangement in either order</p> $2.45 (\times 10^9) = \frac{3(.00) \times 10^8}{\lambda}$ $\lambda = \frac{v}{f}$ <p>accept 0.122(m)</p> <p>power of ten error gains 2 marks</p> <p>award full marks for the correct answer without working</p> | <p><b>(3)</b><br/><b>AO2</b></p> |

| Question Number | Answer                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                               | Mark                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| <b>9b(ii)</b>   | <p>selection and substitution (1)</p> $(0.)55 = \frac{42\,000}{\text{total energy supplied (to device)}}$ <p>rearrangement (1)</p> $(\text{total energy supplied to device}) = \frac{42\,000}{(0.)55}$ <p>evaluation (1)</p> <p>76 000(J)</p> | <p>allow substitution and rearrangement in either order</p> $(0.)55 = \frac{42\,000}{x}$ <p>accept any value that rounds to 76 000(J)</p> <p>760/764/763(J)<br/>gains 2 marks</p> <p>any other power of ten error gains 1 mark</p> <p>award full marks for the correct answer without working</p> | <b>(3)</b><br><b>AO2</b> |

| Question number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 9c              | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p style="text-align: center;">AO1</p> <p><b>Comparison</b><br/> X-rays: high frequency / short wavelength / ionising / high energy<br/> Radio waves: low frequency / long wavelength / not ionising / low energy</p> <p><b>X ray are used</b></p> <ul style="list-style-type: none"> <li>• in medical diagnosis, to find broken bones, damage to lungs</li> <li>• radiotherapy</li> <li>• treatment of cancer</li> <li>• airport security</li> <li>• revealing counterfeit art</li> </ul> <p><b>X-rays are emitted when electrons change energy levels because</b></p> <ul style="list-style-type: none"> <li>• electrons in lower energy levels can absorb energy</li> <li>• the electrons move to higher energy levels</li> <li>• when the electrons return to a lower energy level</li> <li>• the electrons lose energy as radiation.</li> <li>• the electrons need to lose a large amount of energy</li> <li>• (so that) they emit x-ray radiation of high energy/frequency</li> <li>•</li> </ul> <p><b>Radio waves are used</b></p> <ul style="list-style-type: none"> <li>• broadcasting television</li> <li>• broadcasting radio</li> <li>• communications</li> <li>• satellite transmissions</li> <li>• mobile phones</li> <li>• radar</li> </ul> | (6)<br>AO1 |



|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|  | <p><b>Radio-waves are emitted when</b></p> <ul style="list-style-type: none"> <li>• electrons oscillate in electrical circuits</li> </ul> <p><b>oscillations are</b></p> <ul style="list-style-type: none"> <li>• current (flow of electrons) that continually change direction</li> <li>• current flows up and down in a (transmitting) aerial</li> <li>• alternating current (AC)</li> <li>• this generates radio waves in the air around the aerial</li> <li>• the frequency of the radio waves corresponds to the oscillation frequency</li> </ul> <p><b>N.B. No credit is given for:</b><br/> <b>Electrons within an atom go through energy changes</b><br/> <b>OR</b><br/> <b>Radio waves are produced in electrons in circuits</b><br/> <b>These phrases are in the stem of the question</b></p> |  |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

| Level   | Mark | Descriptor                                                                                                                                                                                                                                                                                                                                                                 |
|---------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | 0    | No rewardable material.                                                                                                                                                                                                                                                                                                                                                    |
| Level 1 | 1–2  | <p>Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1)</p> <p>Presents a description which is not logically ordered and with significant gaps. (AO1)</p>                                                                                                      |
| Level 2 | 3–4  | <p>Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1)</p> <p>Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)</p> |
| Level 3 | 5–6  | <p>Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1)</p> <p>Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)</p>                                                                 |

| Level   | Mark | Additional Guidance                                                                                                                | General additional guidance – the decisions within levels                                                                                                                                                                                                                                     |
|---------|------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | 0    | No rewardable material                                                                                                             |                                                                                                                                                                                                                                                                                               |
| Level 1 | 1-2  | <u>Additional guidance</u><br>Elements of physics present i.e. isolated knowledge of principles, <b>two</b> unconnected statements | <u>Possible candidate response</u><br>any use of X rays<br>any use of radio waves<br>any comparison<br>electrons are around the nucleus<br>a current is electrons (moving)<br>electrons oscillate                                                                                             |
| Level 2 | 3-4  | <u>Additional guidance</u><br>Some knowledge of principles with limited detail on use and a comparison or process                  | <u>Possible candidate response</u><br>any use of x-rays and of radio waves with limited detail<br>and one of:<br>a comparison<br>or<br>electrons lose energy to emit X-rays<br>or<br>electrons oscillate in circuits                                                                          |
| Level 3 | 5-6  | <u>Additional guidance</u><br>Detailed knowledge of principles on use with logical connections made about one process              | <u>Possible candidate response</u><br>Use of X-rays and of radio waves with detail<br>and one of:<br>electrons lose energy to change to lower energy level and emit energy as X-rays<br>or<br>electrons oscillate in circuit and currents move up and down in aerials to generate radio waves |

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**Total for Question 9 = 13 marks**