Questions

Q1.

A student investigates what happens when light travels from air to glass.

Figure 15 shows some of the apparatus used in the investigation.

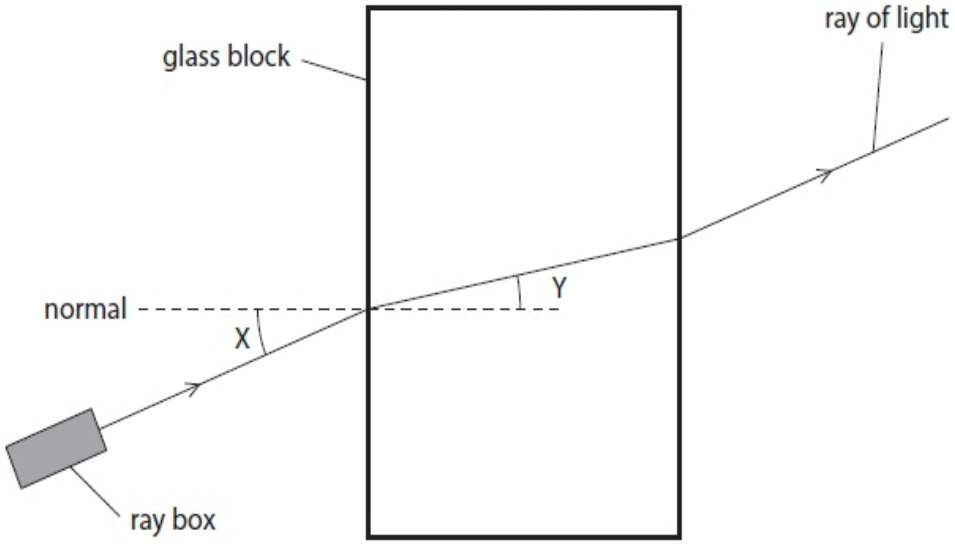

Figure 15

(i) In Figure 15, angle Y is the angle of

(1)

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

(ii) Figure 16 is a graph of the student's results.

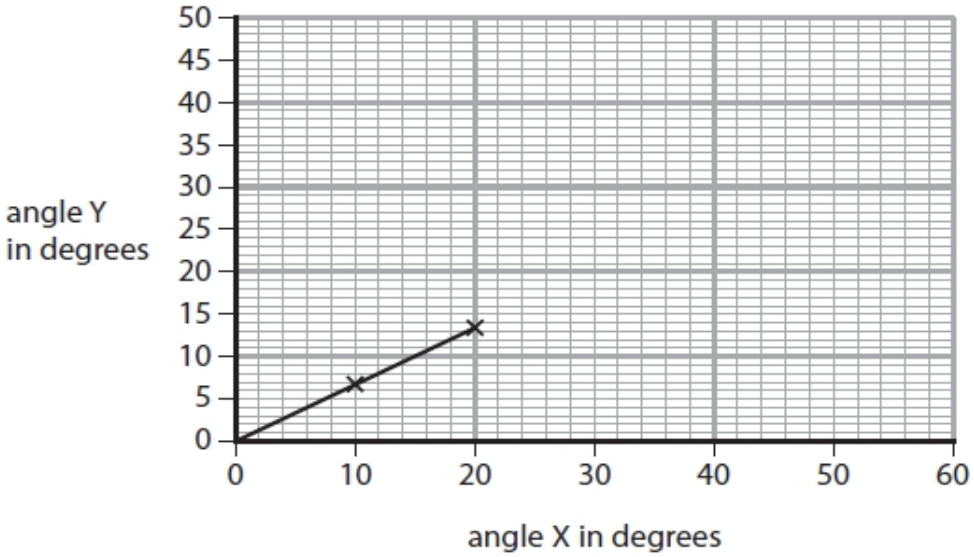

Figure 16

Use the graph to calculate a value for

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

(2)

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

(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.

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(Total for question = 6 marks)

Q2.

Figure 12 shows a semicircular glass block.

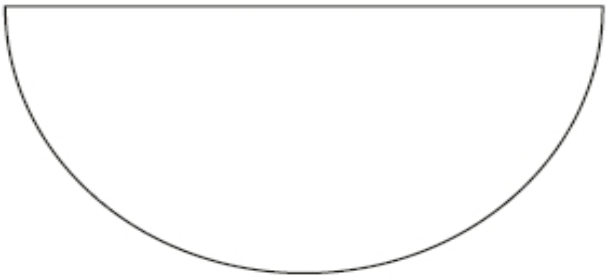

Figure 12

Describe how a student could use the semicircular glass block and other apparatus to determine the critical angle for a glass-air boundary.
You should add to the diagram in Figure 12 to help with your answer.

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(Total for question = 4 marks)

Q3.

Ultraviolet waves cover a range of frequencies.

Scientists divide this range into three types, UVA, UVB and UVC.

The table in Figure 14 shows the frequency range for each type.

type	frequency range in Hz
UVA	7.5×10^{14} to 9.4×10^{14}
UVB	9.4×10^{14} to 10×10^{14}
UVC	10×10^{14} to 30×10^{14}

Figure 14

Figure 15 is a diagram about the effect that the Earth's atmosphere has on three types of ultraviolet radiation.

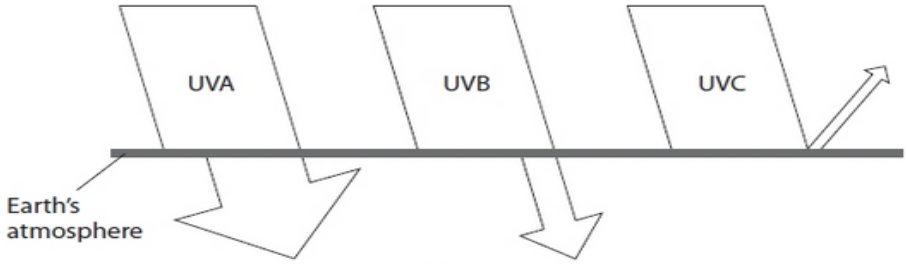

Figure 15

Describe how the effects change with wavelength, using information from Figure 14 and Figure 15.
The width of the arrows drawn indicates the amount of radiation that is involved.

Calculations are not required.

(4)

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(Total for question = 4 marks)

Q4.

Figure 7 shows some apparatus.

small infrared heating lamp

set of three cans of the same size and material but of different surfaces

Figure 7

Describe an investigation to find out how the nature of a surface affects the amount of thermal energy absorbed by the surface.

You should use the apparatus in Figure 7 and any additional items you choose.

Each can in Figure 7 has a bung in the top with a hole in it.

You may use a diagram if it helps your answer.

(6)

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(Total for question = 6 marks)

Q5.

Figure 6 shows two solid metal balls, P and Q.

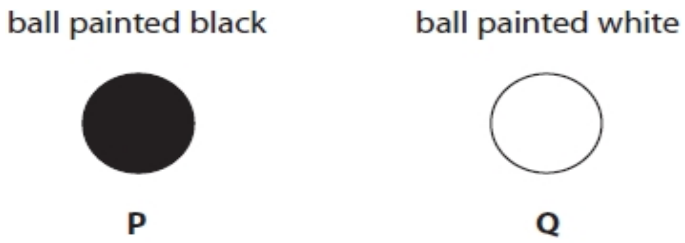

Figure 6

P and Q are made from the same metal and have the same radius.

P is painted black and Q is painted white.

Each ball is heated to a different temperature.

The balls then cool in the same room.

The graph in Figure 7 shows how the temperature of each ball changes with time.

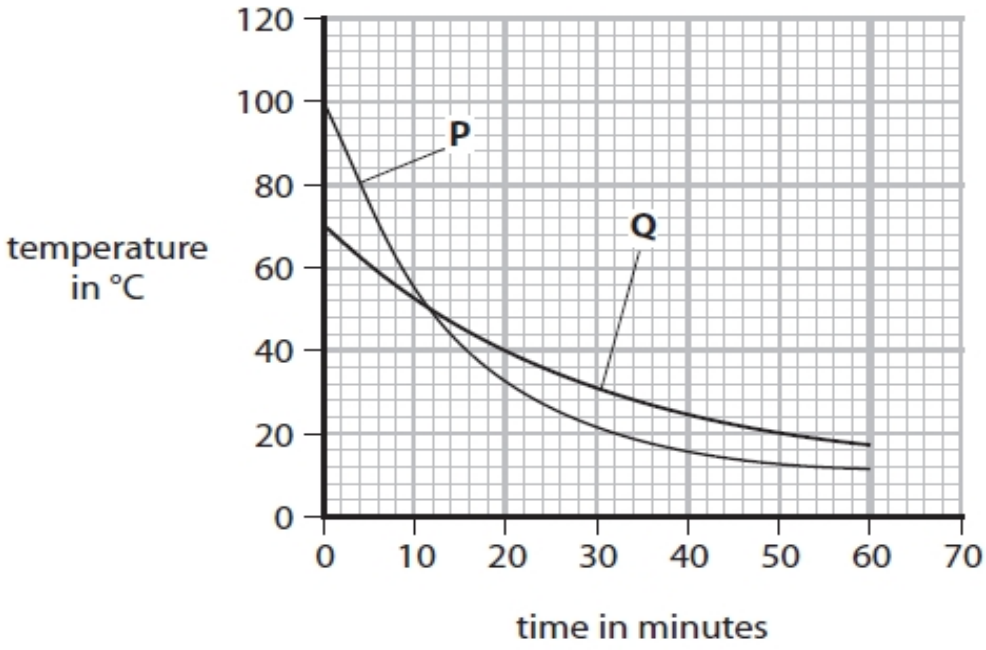

Figure 7

(i) Use the graph in Figure 7 to determine the time when P and Q were at the same temperature.

Show your working on the graph.

(2)

time = ... minutes

(ii) Which of these temperatures is most likely to be room temperature, as shown by the graph in Figure 7?

(1)

- ☒ A 100 °C
- ☒ B 70 °C
- ☒ C 10 °C 0
- ☒ D °C

(iii) Explain why the curve for P is different from the curve of Q. Use information from Figure 6 and Figure 7 to help your answer.

(2)

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(Total for question = 5 marks)

Q6.

A student is investigating the refraction of light.

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

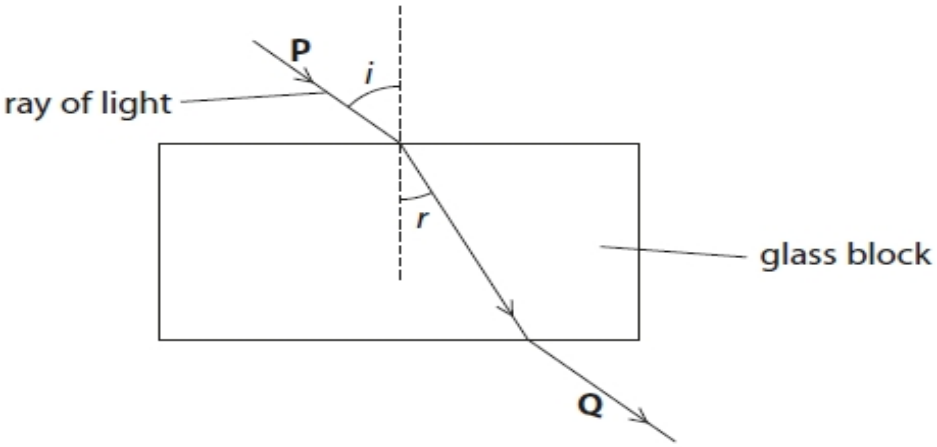

Figure 5

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

Figure 6 shows the student's results.

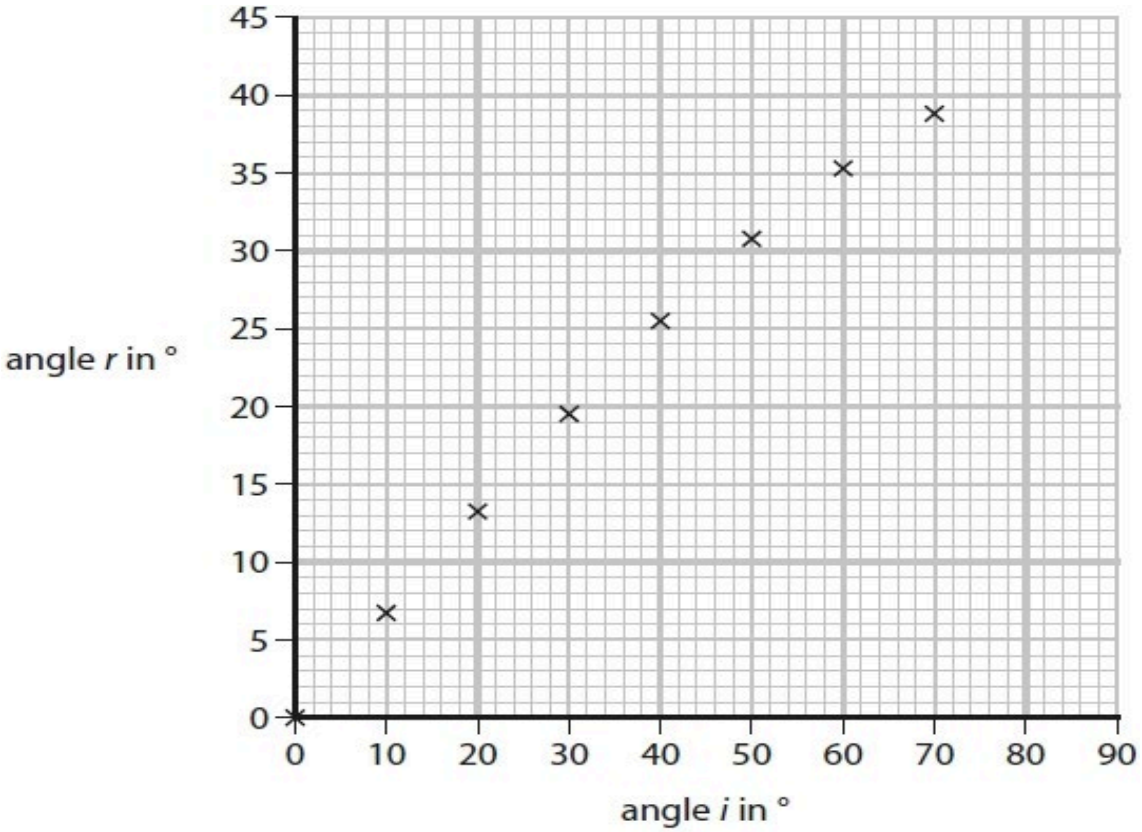

Figure 6

(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°.

(1)

angle *r* = ... °

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

(2)

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(Total for question = 4 marks)

Q7.

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.

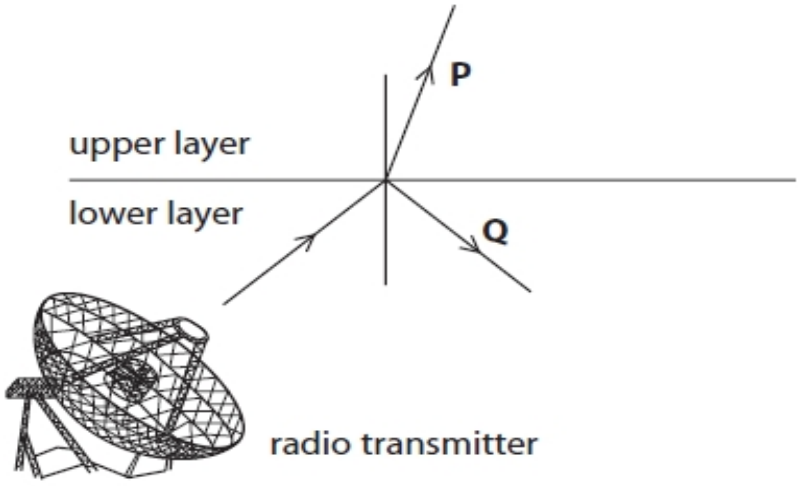

Figure 6

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.

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(Total for question = 4 marks)

Q8.

Equal volumes of hot water are added to two cans.
The cans are identical apart from their surfaces.
One can has a black surface and the other can has a silver surface.

The cans are left to cool and their temperatures are monitored.

The graph in Figure 6 shows the results.

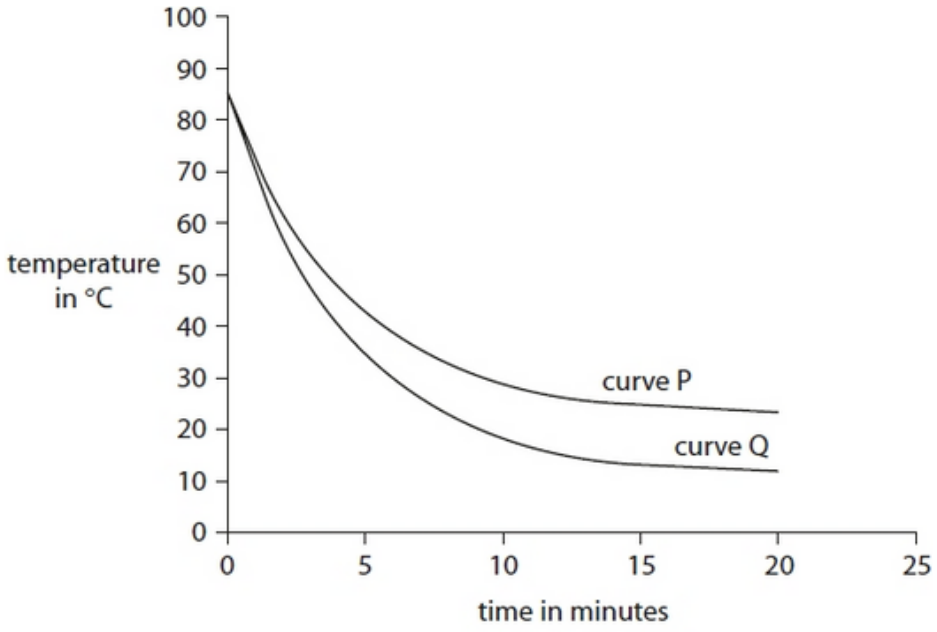

Figure 6

Explain, using evidence from the graph, which curve is for the black can and which curve is for the silver can.

(2)

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(Total for question = 2 marks)

Q9.

This question is about light.

* Figure 11a shows refraction of light at a boundary between glass and air.
Figure 11b shows total internal reflection of light at a boundary between glass and air.

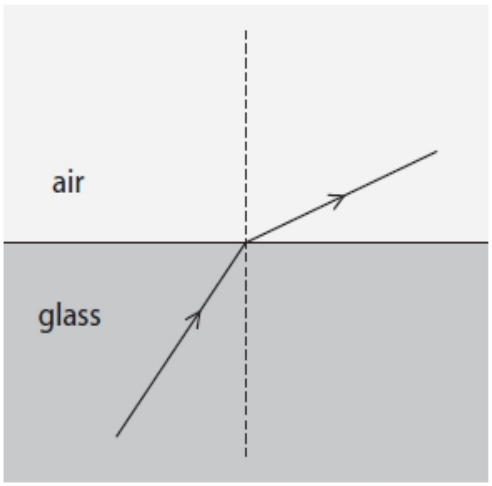

Figure 11a

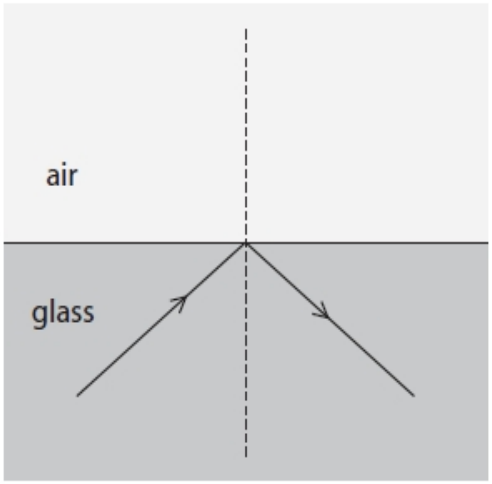

Figure 11b

Use Figure 11a and Figure 11b to explain refraction and total internal reflection.

You may add to Figure 11a and Figure 11b to help with your answer.

(6)

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(Total for question = 6 marks)

Q10.

This question is about light.

White light includes all the colours in the visible spectrum.

A beam of white light is the only light that shines on a book.
The book appears green.
A red filter is placed between the source of white light and the book.

What colour does the book appear now?

(1)

- ☒ A black
- ☒ B blue
- ☒ C green
- ☒ D red

(Total for question = 1 mark)

Q11.

Which colour of visible light has the longest wavelength?

(1)

- ☒ A blue
- ☒ B green
- ☒ C red
- ☒ D yellow

(Total for question = 1 mark)

Q12.

Ultraviolet light has a higher frequency than infrared light.

Which of these colours of visible light has the highest frequency?

(1)

- ☒ A blue
- ☒ B green
- ☒ C orange
- ☒ D yellow

(Total for question = 1 mark)

Q13.

A student investigates how different surfaces radiate energy as they cool.

Figure 9 shows some of the apparatus used in a part of the investigation.

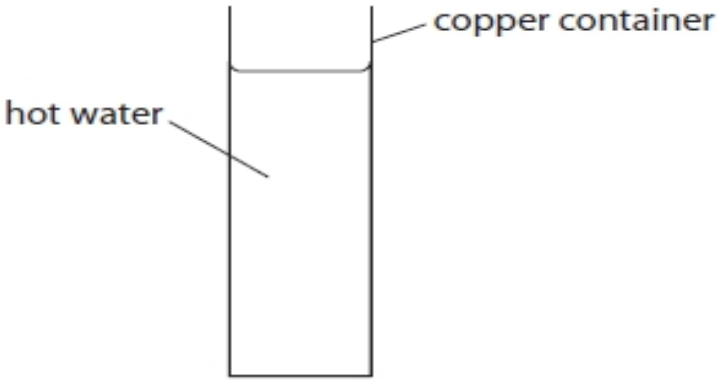

Figure 9

Describe how the student could collect data to show how the rate of cooling of the container and water change with time.

(2)

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(Total for question = 2 marks)

Q14.

When white light crosses the boundary between air and glass, it can split up into the colours of the spectrum.
Explain, in terms of speed, why the light behaves like this.

(3)

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(Total for question = 3 marks)

Q15.

(i) Give one colour of light that has a longer wavelength than yellow light.

(1)

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(ii) Give one colour of light that has a higher frequency than yellow light.

(1)

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(Total for question = 2 marks)

Mark Scheme – Light and Colour

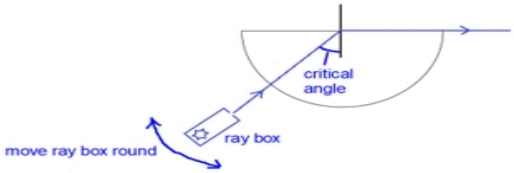
Q1.

Question Number	Answer	Mark
(i)	**D** refraction **The only correct answer is D** *A 'deflection' is an incorrect distracting description* *B 'incidence' is incorrect, that would be angle X* *C 'reflection' is incorrect, no reflection being shown in the diagram*	**(1)** AO 1 1

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

Question Number	Answer	Additional guidance	Mark
(iii)	an explanation linking: repeat (1) different angles / more values of X (1) for larger angles / values of X (1)	 allow 'more measurements' / 'repeat experiment' / collect more data > 20°	**(3)** AO 3 3a

Q2.

Question Number	Answer	Additional guidance	Mark
	a description to include any **four** from: shine a ray (of light) into the block (1) into the block through the curved surface along a radius (1) {change angle / move ray(box)} until the angle of refraction is 90° / TIR just occurs (1) **measure** angle of incidence {when refracted angle is 90° / when TIR just occurs} (1) repeat measurement of critical angle (1)	 credit marking points in the diagram if they are clear allow 'calculate' for 'measure' plot angle i against angle r if light only enters block at straight edge, maximum 1 mark (for MP1)	**(4)**

Q3.

Question Number	Answer	Additional guidance	Mark
	a description including: UVA **mostly** transmitted OR **some** absorbed (1) UVB **some** transmitted OR **mostly** absorbed (1) UVC **not** transmitted OR **mostly** absorbed OR **some** reflected (1) correct relationship of absorption/ transmission to wavelength / □ (1)	UVA **mostly** travels through accept **less** transmitted than UVA **more** absorbed than UVA or UVB wavelength decreasing (with) absorption increasing OR longer wavelengths transmit more □ / abs / trans inc / dec / inc dec / inc / dec	**(4)**

Q4.

Question Number	Answer	Mark
	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. 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. **AO targeting: 6 marks AO1 strand 2 (6 marks)** • uses a thermometer • inserted into the can • uses a stopwatch / timer • uses a measuring cylinder / beaker with markings • sets up apparatus with lamp a fixed distance from each can • that distance is the same for each can • the measured volume is the same for each can • a starting temperature is measured • (aiming) to get the same start temperature • each, in turn, is heated for the same time • as measured on a stopwatch • a final (maximum) temperature is read • OR takes a series of temperature readings with time • and plots a graph of temperature(s) against time • the one heating up the most is the best absorber N.B. fully credit any of these in a diagram e.g. bullet points 1-8 may all be seen in a diagram	**(6)**

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

Summary for guidance			
Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** Eg - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance isolated statement about apparatus or procedure or the science involved	Possible candidate responses (diag?) uses/puts a thermometer in the can/water OR measures a temperature OR uses heater to heat the cans Or puts water in the cans
Level 2	3–4	Additional guidance some procedure detail but with omissions	Possible candidate responses (diag?) uses a thermometer to measure the temperature rise in the cans OR uses the heater to heat the cans for a fixed time Or uses the same amount of water in each can
Level 3	5–6	Additional guidance more detailed and structured procedure	Possible candidate responses (diag?) uses a thermometer to measure the temperature rise in the cans AND uses the heater to heat the cans for a fixed time Or uses the same amount of water in each can

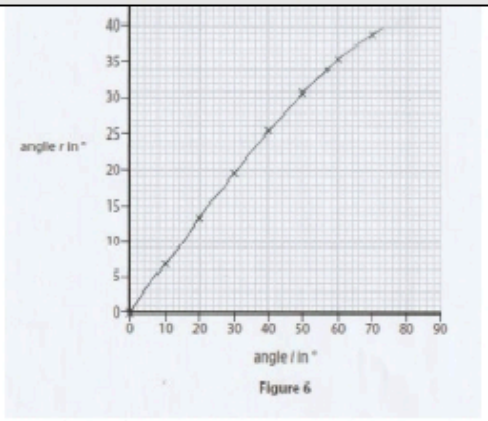
Q5.

Question number	Answer	Additional guidance	Mark
(i)	line shown on graph from intersection of two curves (1) answer in range 11 – 13 (minutes) inclusive (1)	 award full marks for the correct answer without working	**(2)**

Question number	Answer	Mark
(ii)	☒ **C** 10 °C	**(1)**

Question number	Answer	Additional guidance	Mark
(iii)	an explanation linking: the gradient for **P** is greater/steeper than the gradient for **Q** (1) (because) **P**/black is a better emitter (of radiation) (than **Q**/white) (1)	 **P** cools quicker than **Q** **P** loses thermal energy/heat quicker than **Q** allow reverse arguments credit answers in terms of absorption in this context	**(2)**

Q6.

Question number	Answer	Additional guidance	Mark
(i) CS3	curve through origin, through all points – by eye (1)	 Figure 6	(1) AO1

Question number	Answer	Additional guidance	Mark
(ii) CS3	(***r*** =) 42(°) ± 2(°) (1)	ECF their graph	(1) AO3

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

Q7.

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

Q8.

Question Number	Answer	Additional guidance	Mark
	an explanation linking **two** from: identifies curve Q is the black can OR that curve P is for the silver can (1) (because, as) black is a better emitter (then) (curve) Q shows a faster rate of cooling (1) OR (curve) Q is steeper (1)	 IGNORE reference to absorb allow Q is at a lower temperature/stays cooler OR P is at a higher temperature /stays hotter may quote numbers from graph e.g. curve Q cools by 75(°C) in 20 minutes but curve P only shows a 60(°C) in the same time	**(2)**

Q9.

Question number	Indicative content	Mark
*	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. 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. **Refraction** • Angle of incidence marked • Angle of refraction marked • Angles are measured from the normal • Angle of refraction is bigger than the angle of incidence • Rays of light travel in straight lines • Refraction occurs at a boundary between two materials of different (optical) density • The angle of incidence is less than the angle of refraction when light passes into a less dense medium (glass into air) • Refraction is a change in direction of a light ray. • Refracted rays bend away from the normal when light passes into a less dense medium (glass into air) • The ray in the more dense medium (glass) travels more slowly ORA **Total Internal Reflection** • Possible critical angle marked • Light stays inside the glass • Only occurs when the incident light is in the more dense medium • Only occurs when the incident angle is equal to greater than the critical angle • Critical angle for glass is about 42° • Angle of incidence is equal to the angle of reflection	**(6)** **AO1**

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

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance isolated fact(s) about refraction or total internal reflection(TIR)	Possible candidate responses naming of any rays of light or any angles in text or on diagrams light changes direction/bends TIR ray stays inside the glass / does not go into air refracted ray goes through glass and air
Level 2	3–4	Additional guidance simple description of refraction and TIR or facts about one and more detail of the other	Possible candidate responses Angle or ray identified For refraction light changes direction from glass into air or TIR angles are equal inside the glass
Level 3	5–6	Additional guidance detailed description of refraction and TIR	Possible candidate responses For refraction light changes direction from glass into air AND TIR angles are equal inside the glass

Q10.

Question number	Answer	Mark
	A black B is incorrect as no blue light shines on the object C is incorrect as no green light shines on the object D is incorrect as no red light is reflected from the object	(1) AO3

Q11.

Question Number	Answer	Mark
	C red **The only correct answer is C red** **A** is not correct because blue has a shorter wavelength than red **B** is not correct because green has a shorter wavelength than red **D** is not correct because yellow has a shorter wavelength than red	**(1)**

Q12.

Question number	Answer	Mark
	☒ A blue Green, orange and yellow all have a lower frequency than blue	(1)

Q13.

Question Number	Answer	Additional guidance	Mark
	a description to include: use a thermometer (1) measure temperature at regular intervals (1)	 temp. sensor datalogger it must be clear that it is a number of readings – not just 2 eg measure temperature over time	**(2)** AO 1 2

Q14.

Question Number	Answer	Additional guidance	Mark
	an explanation linking: (the colours have) different wavelengths (1) different wavelengths / colours travel at different speeds (1) so refract by different amounts (1)	 allow the word frequencies for wavelengths for refract allow bend/change direction/follow different path	**(3)** AO 2 1

Q15.

Question Number	Answer	Mark
(i)	red **or** orange	**(1)** AO 1 1

Question Number	Answer	Additional guidance	Mark
(ii)	green **or** blue **or** indigo **or** violet		**(1)** AO 1 1