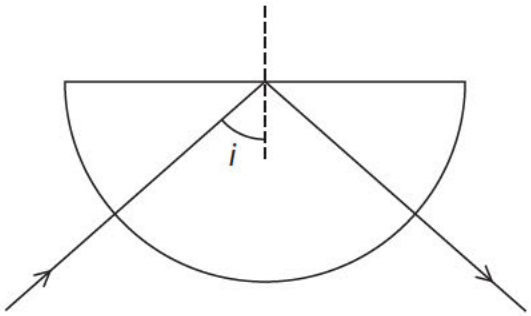
1 A student watches a demonstration of the total internal reflection of light in a semicircular glass block.



i = angle of incidence

(a) He takes notes, but some of his notes are wrong.

Place a tick (✓) or a cross (✗) in the table to show which statements are right or wrong.

The first statement is right and has been done for you.

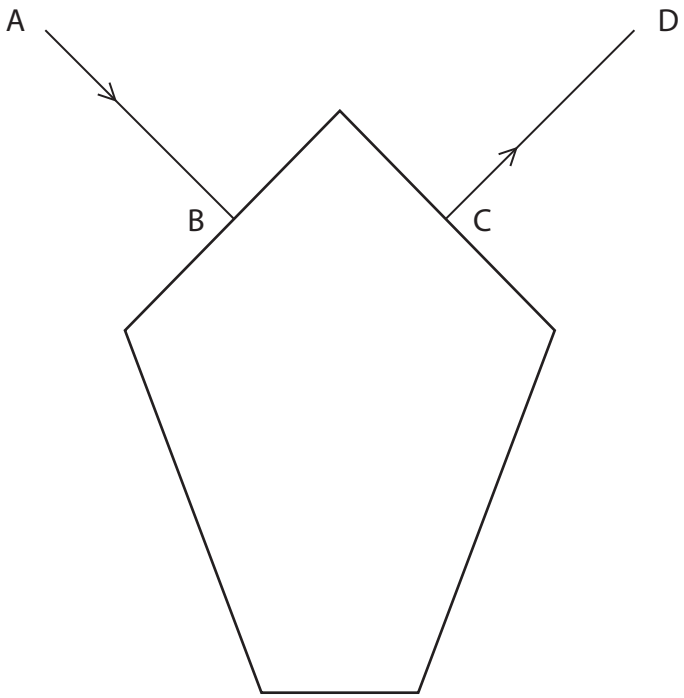
(2)

Notes about the total internal reflection of light	Right or wrong
the angle of incidence equals the angle of reflection	✓
light changes speed when it is internally reflected	
every ray entering the semicircular glass block is reflected by total internal reflection	
if $i = 0$ then the ray does not deviate	
the refractive index of glass is bigger than the refractive index of air	

(b) Jewellers cut jewels so that total internal reflection is more likely.

Light enters a jewel along the normal AB and leaves along the normal CD as shown.

Between B and C there are **two** total internal reflections.



Complete the path of the light through the jewel.

(3)

(c) (i) Show, by calculation, that the critical angle for a refractive index of 1.5 is about 42°.

(3)

(ii) Explain why the quantity called refractive index has no unit.

(2)

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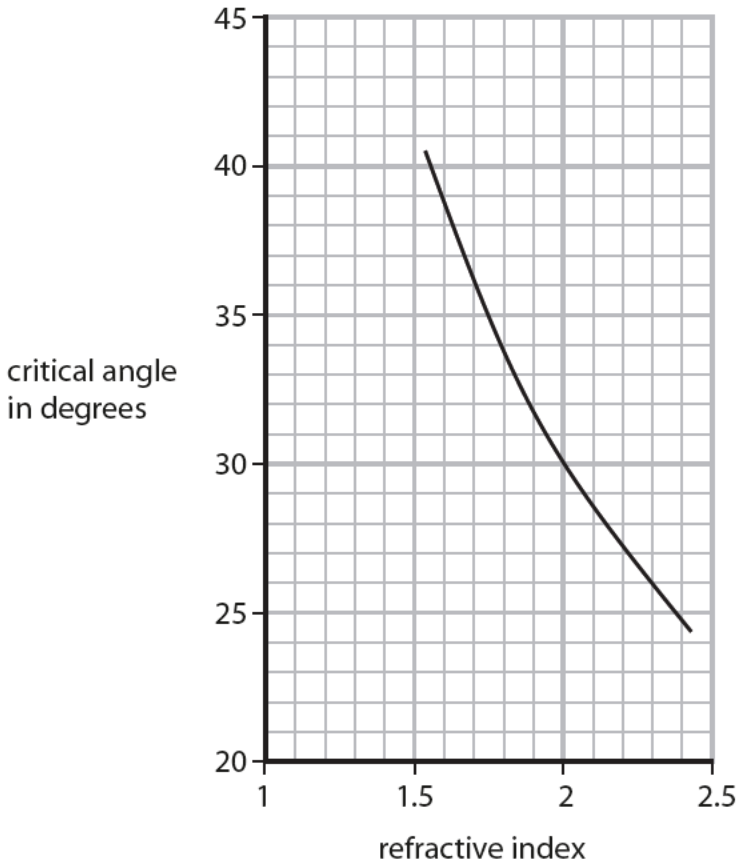
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(d) The graph shows how critical angle varies with refractive index.

(i) Add the point (1.5, 42°) to the graph.

(1)



(ii) How can you tell that the point (1.5, 42°) is **not** anomalous?

(1)

.....

.....

(iii) Suggest two reasons why the axes of the graph do not start from zero.

(2)

1 .....

.....

2 .....

.....

(Total for Question 1 = 14 marks)

2 A student uses a semicircular glass block to investigate refraction in glass.

(a) List three other pieces of equipment that he needs for this investigation.

(3)

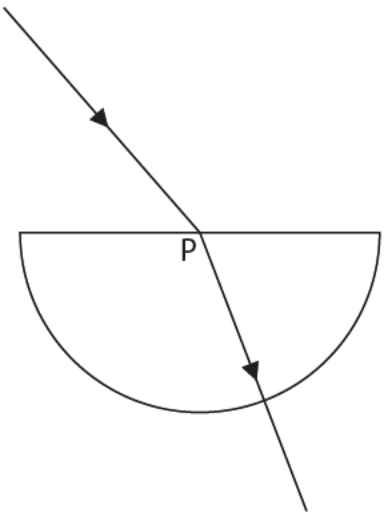
1 .....

2 .....

3 .....

(b) He shines a ray of light into the block at point P, as shown.

P is the middle of the flat surface.



(i) On the diagram, draw the normal at P.

(1)

(ii) Measure the angle of incidence and the angle of refraction.

(2)

angle of incidence .....

angle of refraction .....

(iii) Explain why the ray of light changes direction at P.

(2)

.....

.....

.....

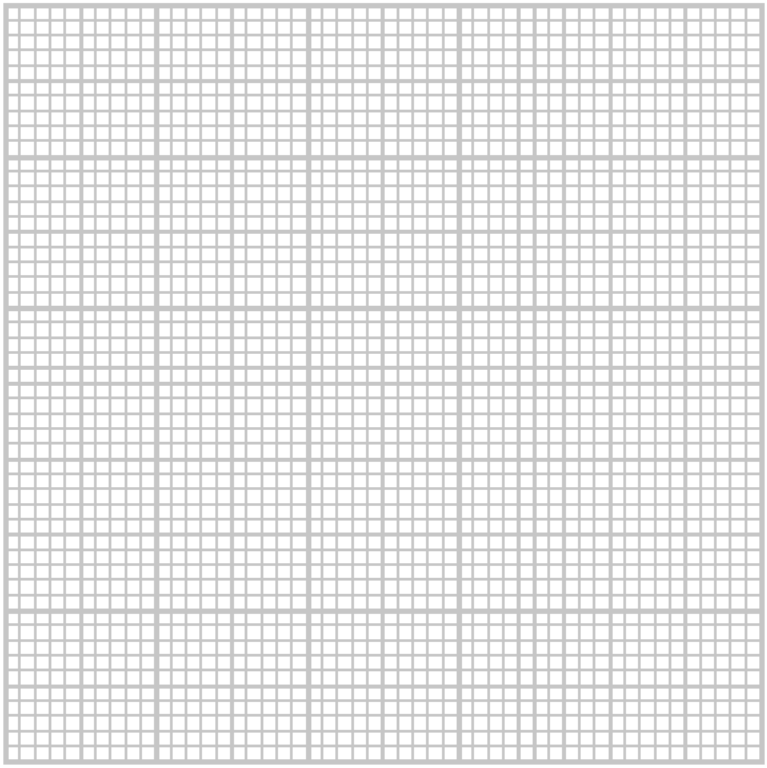
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(c) The student varies the angle of incidence and obtains this table of results.

Angle of incidence *i*	Angle of refraction *r*	sin *i*	sin *r*
11°	7°	0.19	0.12
24°	15°	0.41	0.26
47°	28°	0.73	0.47
65°	36°	0.91	0.59
90°	40°	1.00	0.64

(i) Plot a graph of sin *i* against sin *r*.

(4)



(ii) Draw the straight line of best fit.

(1)

(iii) State the relationship between refractive index, angle of incidence and angle of refraction.

(1)

(iv) Use your graph to find the refractive index of glass.

(2)

refractive index = ...

(Total for Question 2 = 16 marks)

3 A light ray can undergo total internal reflection.

(a) (i) What is meant by the term **total internal reflection**?

(2)

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(ii) State two uses of total internal reflection.

(2)

1 .....

.....

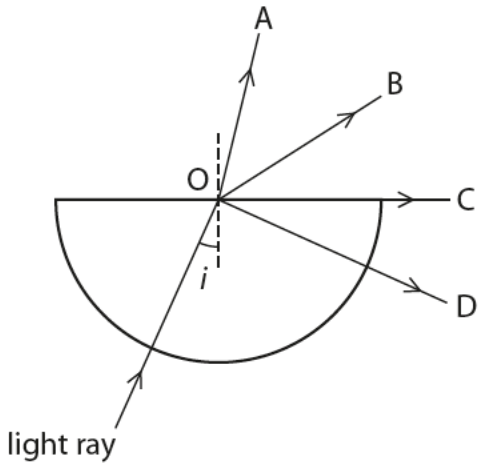
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2 .....

.....

.....

(b) The diagram shows a light ray entering a glass block and travelling towards point O.



The angle *i* is 25°.

The critical angle of the glass is 42°.

(i) Which path does the ray take after reaching point O?

(1)

☒ **A** OA

☒ **B** OB

☒ **C** OC

☒ **D** OD

(ii) State the equation linking critical angle and refractive index.

(1)

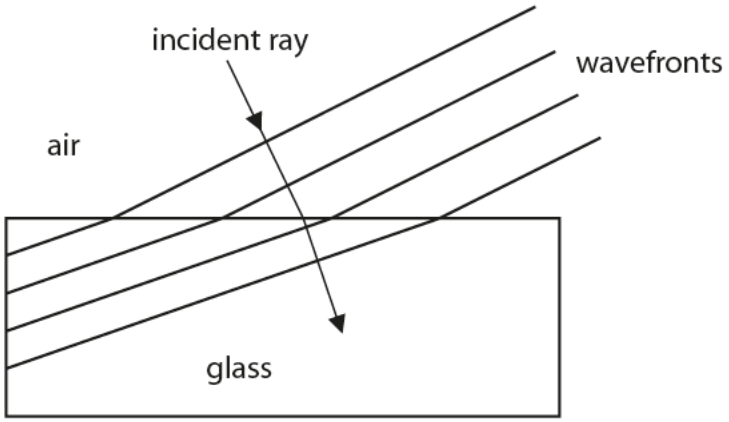
(iii) Calculate the refractive index of the glass.

(2)

refractive index = ...

(Total for Question 3 = 8 marks)

4 The diagram shows changes to light waves passing from air into glass.



(a) (i) The effect shown in the diagram is

(1)

- ☒ **A** diffraction
- ☒ **B** dispersion
- ☒ **C** reflection
- ☒ **D** refraction

(ii) State two ways in which the light waves change as they pass into the glass.

(2)

1 .....

2 .....

(b) (i) Draw the normal to the incident ray on the diagram.

(1)

(ii) Label the angle of incidence on the diagram.

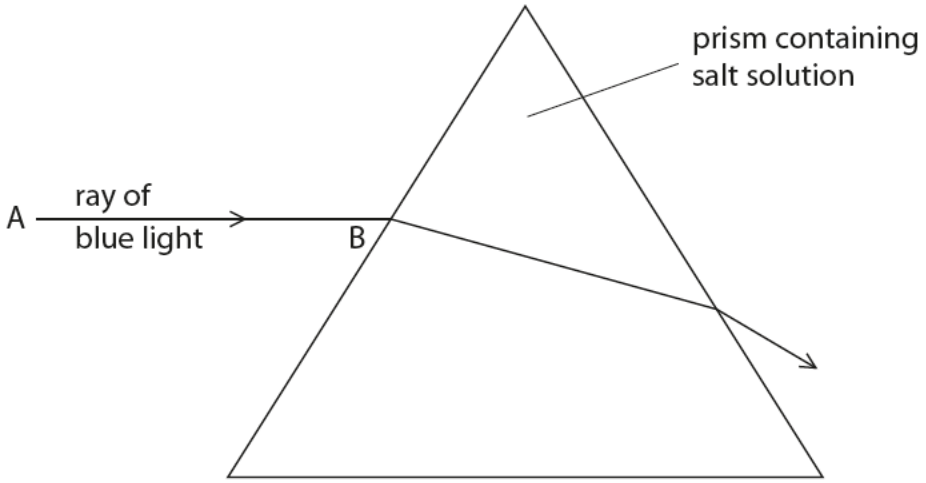
(1)

(Total for Question 4 = 5 marks)

5 (a) A student investigates refraction of light by using a salt solution in a hollow prism.

He shines a ray of blue light from A to B and traces the path of the ray through the prism.

The diagram shows the path of the ray of blue light.



(i) Explain what is meant by the term **refraction**.

(1)

.....

.....

.....

(ii) On the diagram, draw the normal at B and measure the angle of incidence.

(3)

angle of incidence = ...

(iii) The student then shines a ray of red light from A to B.

The refractive index of the salt solution is lower for red light than it is for blue light.

On the diagram, sketch a possible path for the red light through the solution and out of the prism.

(3)

(iv) Suggest what would happen to the path of the blue light if the student used a salt solution with a higher refractive index.

(2)

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(b) echnician working in a soft drinks factory uses refraction of light to measure sugar concentration in drinks.

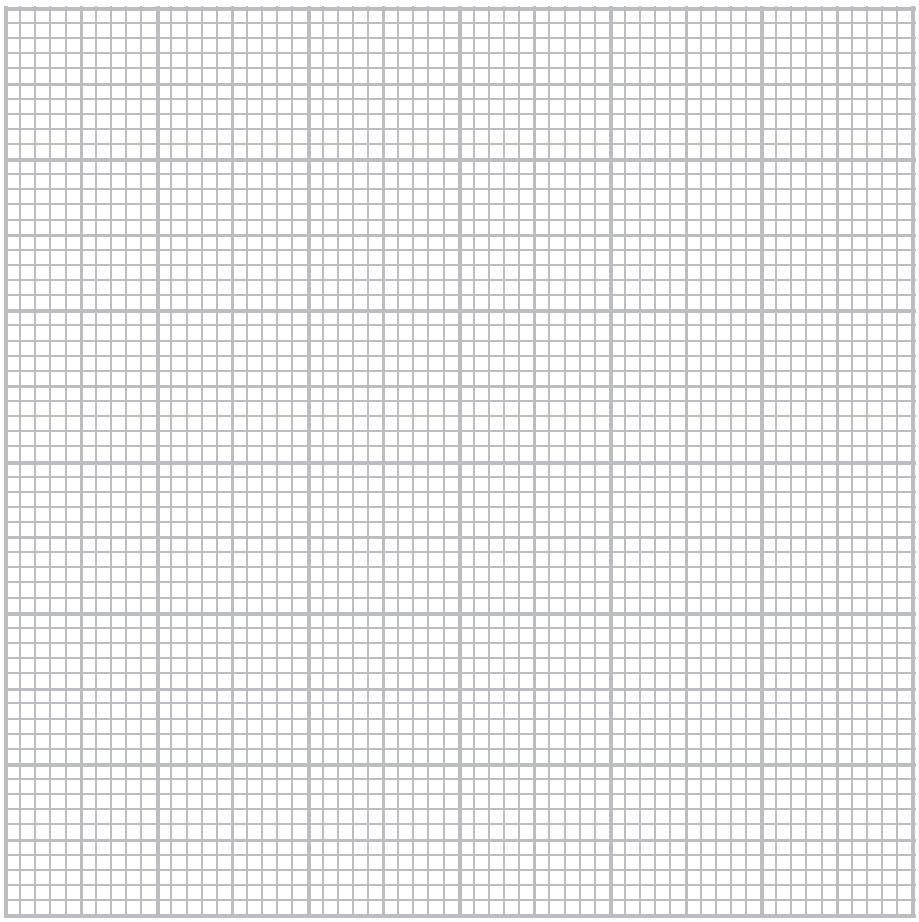
She takes readings using a refractometer. Different sugar concentrations give different scale readings on the refractometer.

The table shows her results.

Sugar concentration (%)	Refractometer reading
0	48
10	60
30	57
50	69
70	86
90	108

(i) Plot a graph of the refractometer reading against sugar concentration and draw the curve of best fit.

(5)



(ii) Circle the anomalous point on your graph and suggest what the correct refractometer reading should be.

(2)

refractometer reading = ...

(iii) Use your graph to find the sugar concentration when the refractometer reading is 80.

(1)

sugar concentration = ... %

(iv) Describe the pattern shown by your graph.

(2)

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(Total for Question 5 = 19 marks)