June 12 Q4

4   **Figure 5** shows a cross-section through an optical fibre used for communications.

Figure 5

refractive index of **X** = 1.41

refractive index of the core = 1.46
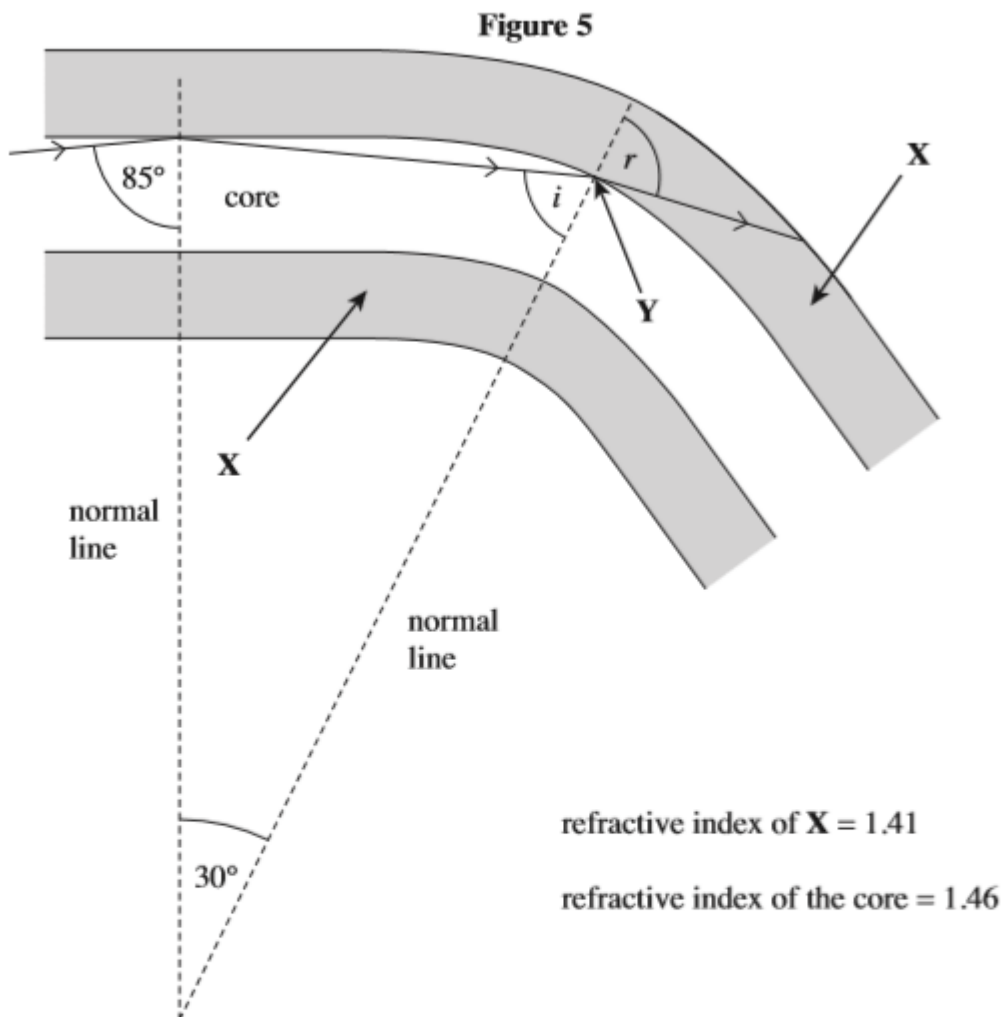
4 (a) (i)   Name the part of the fibre labelled **X**.

....
(1 mark)

4 (a) (ii) Calculate the critical angle for the boundary between the core and **X**.

answer = ...degrees
(2 marks)

4 (b) (i) The ray leaves the core at **Y**. At this point the fibre has been bent through an angle of 30° as shown in **Figure 5**.
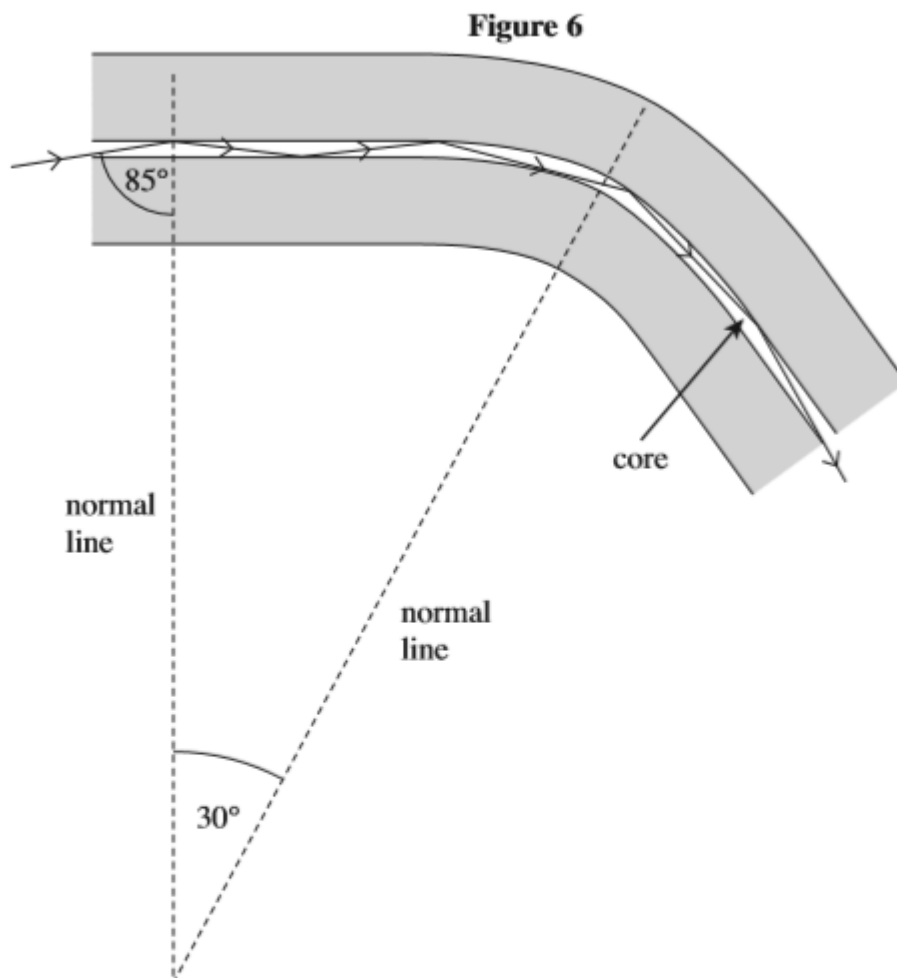
Calculate the value of the angle i.

answer = ...degrees

(1 mark)

4 (b) (ii) Calculate the angle r.

answer = ...degrees

(2 marks)

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4 (c) The core of another fibre is made with a smaller diameter than the first, as shown in **Figure 6**. The curvature is the same and the path of a ray of light is shown.

Figure 6

core

normal
line

normal
line

85°

30°

4 (c) State and explain **one** advantage associated with a smaller diameter core.

....

....

....

....

....

(2 marks)

Jan 13 Q5

5   **Figure 4** shows a section of a typical glass step-index optical fibre used for communications.

Figure 4
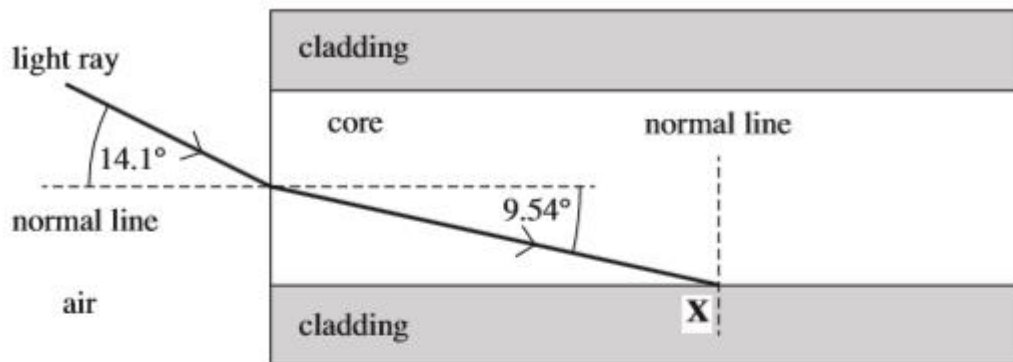
5 (a)   Show that the refractive index of the core is 1.47.

(1 mark)

5 (b)   The refracted ray meets the core-cladding boundary at an angle exactly equal to the critical angle.

5 (b) (i)   Complete **Figure 4** to show what happens to the ray after it strikes the boundary at **X**.

(2 marks)

5 (b) (ii)   Calculate the critical angle.

critical angle = ...degrees

(1 mark)

5 (b) (iii) Calculate the refractive index of the cladding.

refractive index = ...

(2 marks)

5 (c) Give **two** reasons why optical fibres used for communications have a cladding.

reason 1 ....

....

reason 2 ....

....
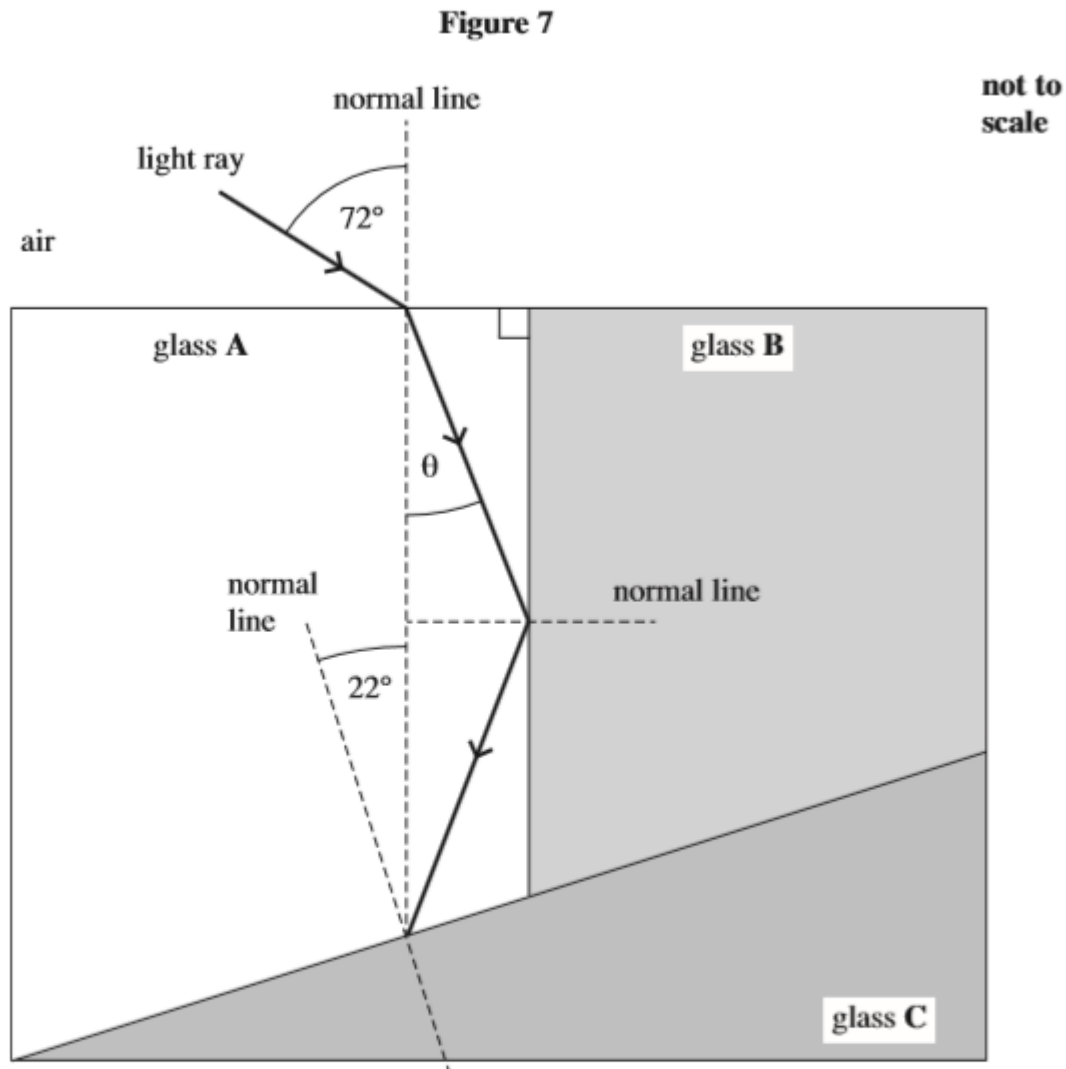
(2 marks)

June 13 Q5

5   **Figure 7** shows three transparent glass blocks **A**, **B** and **C** joined together. Each glass block has a different refractive index.

Figure 7

5 (a)   State the **two** conditions necessary for a light ray to undergo total internal reflection at the boundary between two transparent media.

condition 1 ....

....

condition 2 ....

....

(2 marks)

5 (b)   Calculate the speed of light in glass **A**.

             refractive index of glass **A** = 1.80

speed of light .... m s^{-1}

(2 marks)

5 (c)   Show that angle θ is about 30°.

(2 marks)

5 (d)   The refractive index of glass **C** is 1.40.

             Calculate the critical angle between glass **A** and glass **C**.

critical angle .... degrees

(2 marks)

5 (e) (i)   State and explain what happens to the light ray when it reaches the boundary between glass **A** and glass **C**.

....

....

....

(2 marks)

5 (e) (ii)   On **Figure 7** continue the path of the light ray after it strikes the boundary between glass **A** and glass **C**.
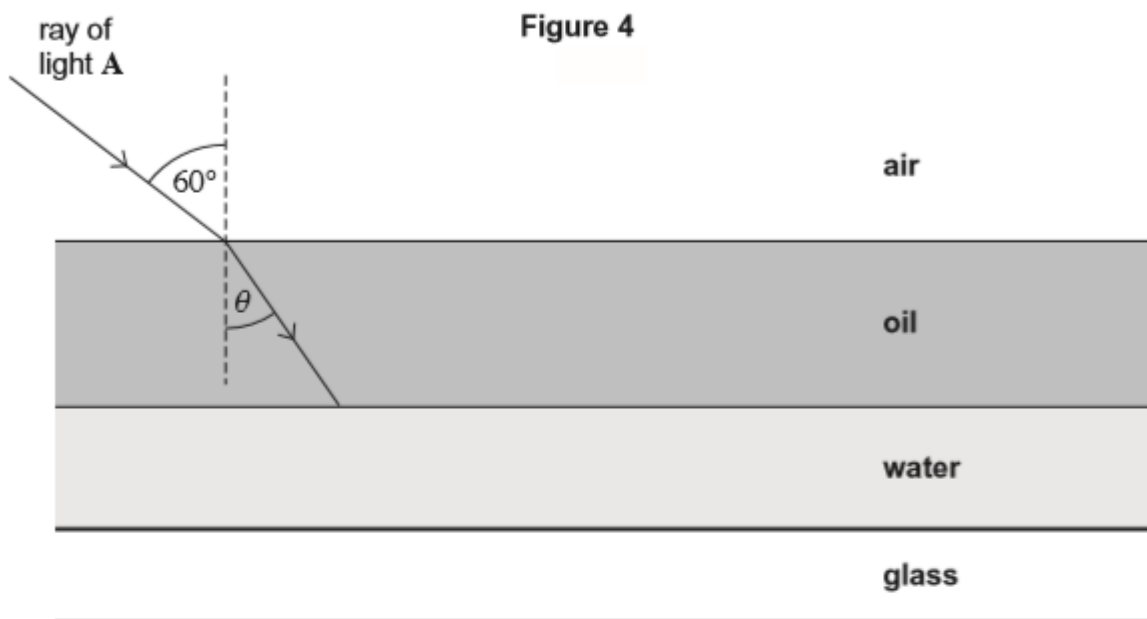
(1 mark)

June 14 Q5

5 **Figure 4** shows a ray of light **A** incident at an angle of 60° to the surface of a layer of oil that is floating on water.

refractive index of oil = 1.47

refractive index of water = 1.33

Figure 4

5 (a) (i) Calculate the angle of refraction θ in **Figure 4**.

[2 marks]

angle .... degrees

5 (a) (ii) Calculate the critical angle for a ray of light travelling from oil to water.

[2 marks]

angle .... degrees

5 (a) (iii) On **Figure 4** continue the path of the ray of light **A** immediately after it strikes the boundary between the oil and the water.
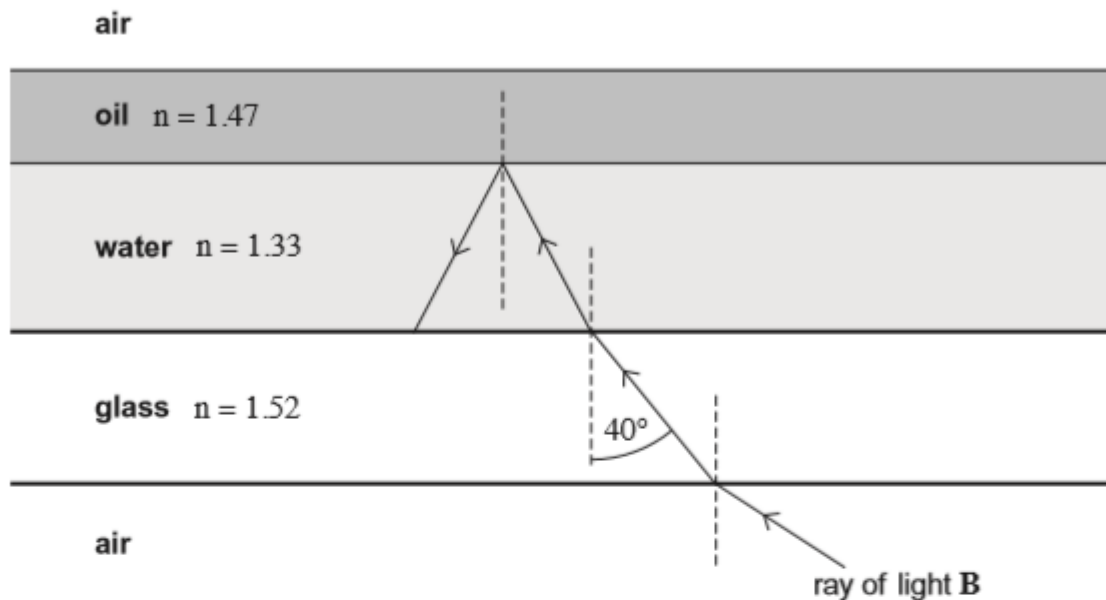
[2 marks]

5 (b) In **Figure 5** a student has incorrectly drawn a ray of light **B** entering the glass and then entering the water before totally internally reflecting from the water–oil boundary.

Figure 5

The refractive index of the glass is 1.52 and the critical angle for the glass–water boundary is about 60°.

Give **two** reasons why the ray of light **B** would **not** behave in this way. Explain your answers.

[4 marks]

reason 1 ....

....

explanation ....

....

....

reason 2 ....

....

explanation ....

....

....

AQA 2 Questions – Refractive Index (set 2)

June 15 Q5

5 (a)   Tick (✓) the appropriate boxes in **Table 3** to indicate how the wavelength, frequency and speed of light are affected when a ray of light travels from air into glass.
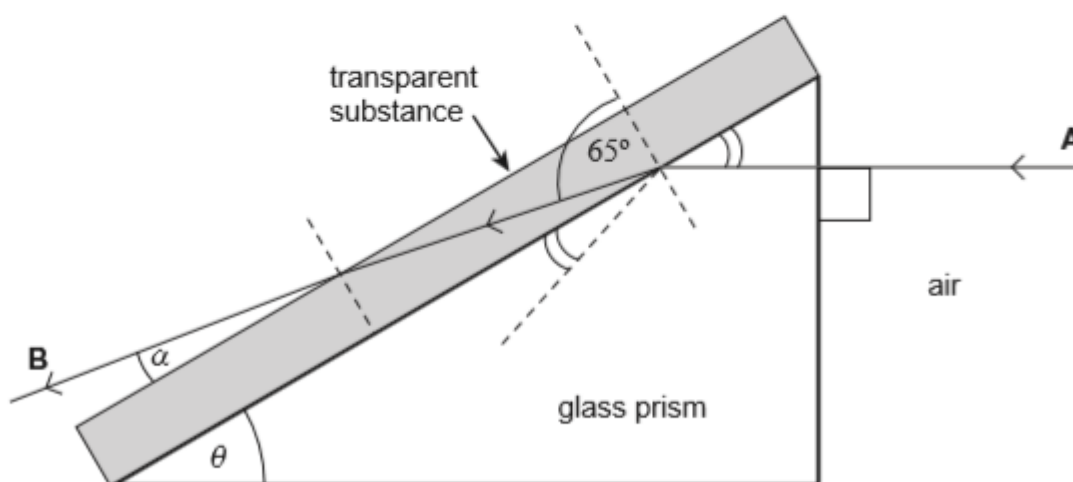
[2 marks]

Table 3

	Wavelength	Frequency	Speed
increases			
stays the same			
decreases			

5 (b)   **Figure 5** shows a right-angled glass prism in contact with a transparent substance on one of the faces. One of the other angles of the prism is θ.

Figure 5

refractive index of glass prism   = 1.70
refractive index of transparent substance   = 1.09

angles are not shown to scale

5 (b) (i) A ray **A** enters perpendicularly to one face of the prism. It is partially refracted and partially reflected at the interface between the glass and the transparent substance. The angle of refraction is 65.0°. The ray eventually leaves at an angle α to the surface of the transparent substance.

Determine the angle α.

[2 marks]

angle α = ... degree

5 (b) (ii) Determine the angle θ in **Figure 5**.

[2 marks]

angle θ = ... degree

5 (c)   **Figure 6** shows another ray entering the prism.

Figure 6
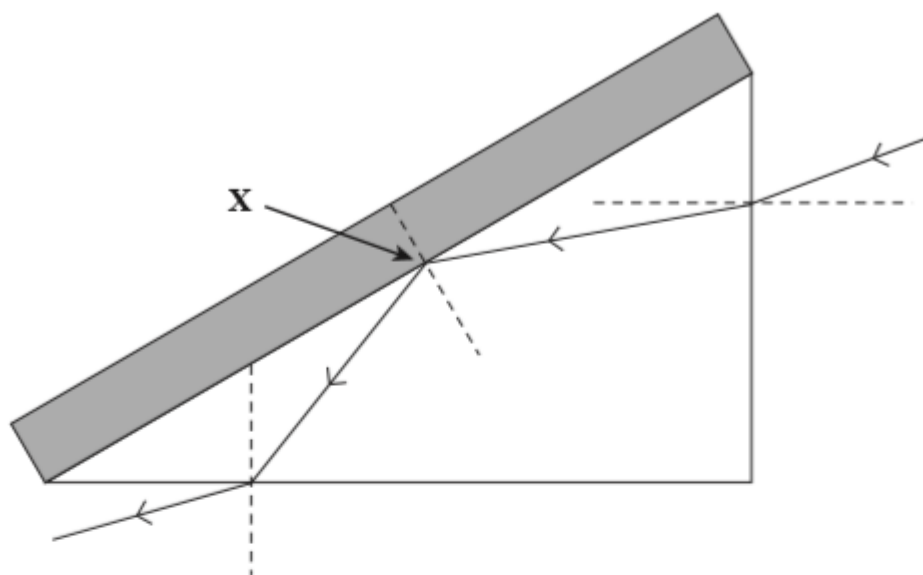
5 (c) (i)   Identify the effect that takes place at **X** in **Figure 6**.

[1 mark]

....

5 (c) (ii)   Explain, with a diagram, how the effect that occurs at **X** is used to transmit information along an optic fibre.
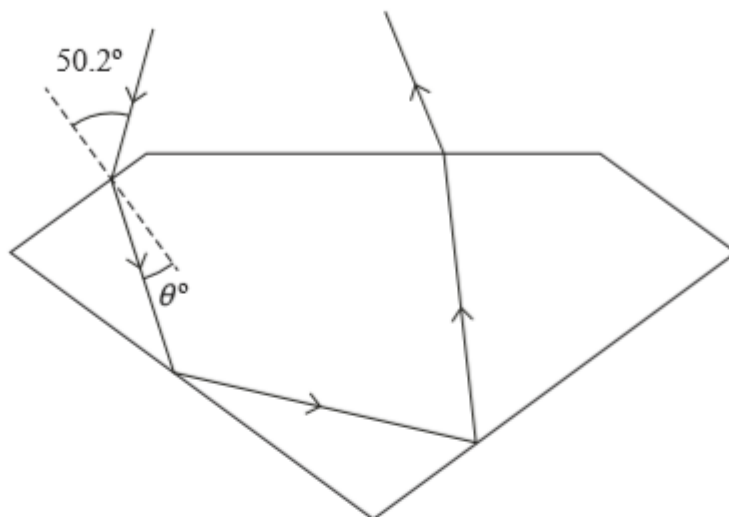
[3 marks]

....

....

....

....

....

June 16 Q8

8   Diamond jewels sparkle because light that enters the diamond at different incident angles is reflected back to an observer. **Figure 13** shows the path of one of these incident rays through a diamond.

Figure 13

8 (a) (i)   Calculate the critical angle for diamond.

[2 marks]

Refractive index of diamond = 2.42

critical angle = _____ degree

8 (a) (ii)   The ray shown in **Figure 13** enters at an angle of incidence of 50.2°. Calculate the angle of refraction θ.

[2 marks]

θ = _____ degree

8 (a) (iii) The angles of a diamond are chosen to maximise the amount of light reflected.
Figure 14 shows a diamond with different angles to that of a normally shaped diamond.
The dotted lines show the normal shape of a diamond.

Figure 14
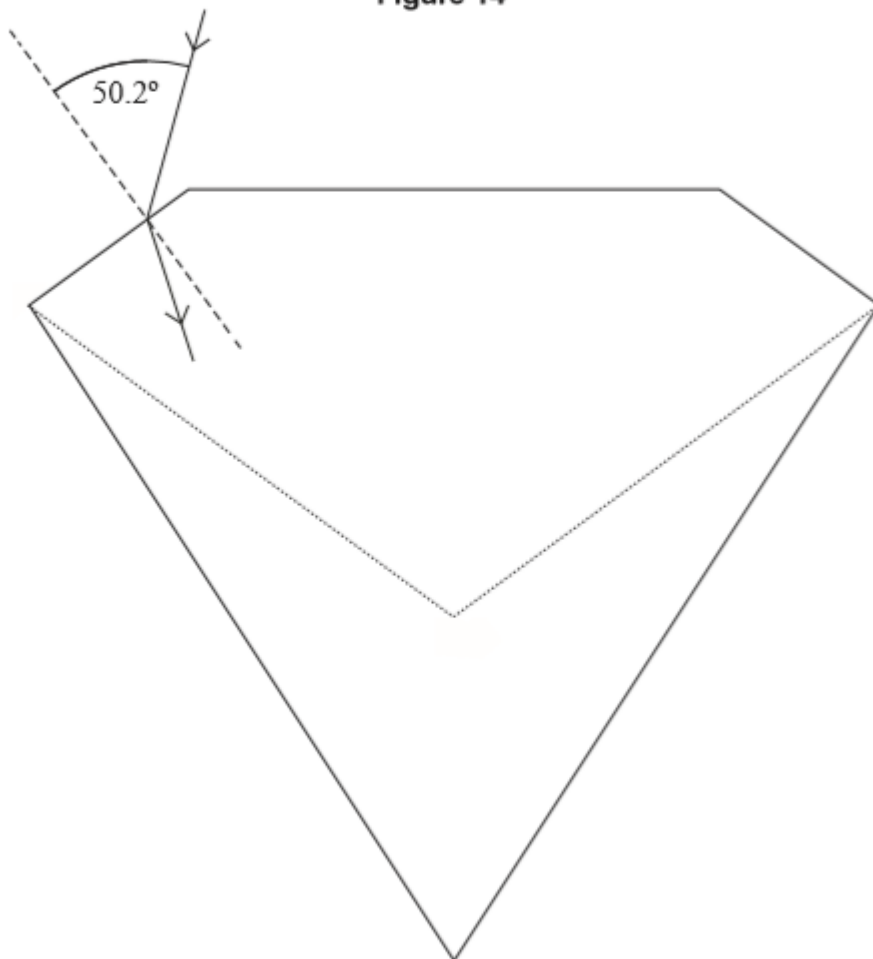
Draw on **Figure 14** the path of the ray until it leaves the diamond.

[2 marks]

8 (a) (iv) Moissanite is a transparent material with a refractive index of 2.67.

Discuss whether this material, if made to the diamond shape shown in **Figure 13**, would reflect light back more or less than diamond.

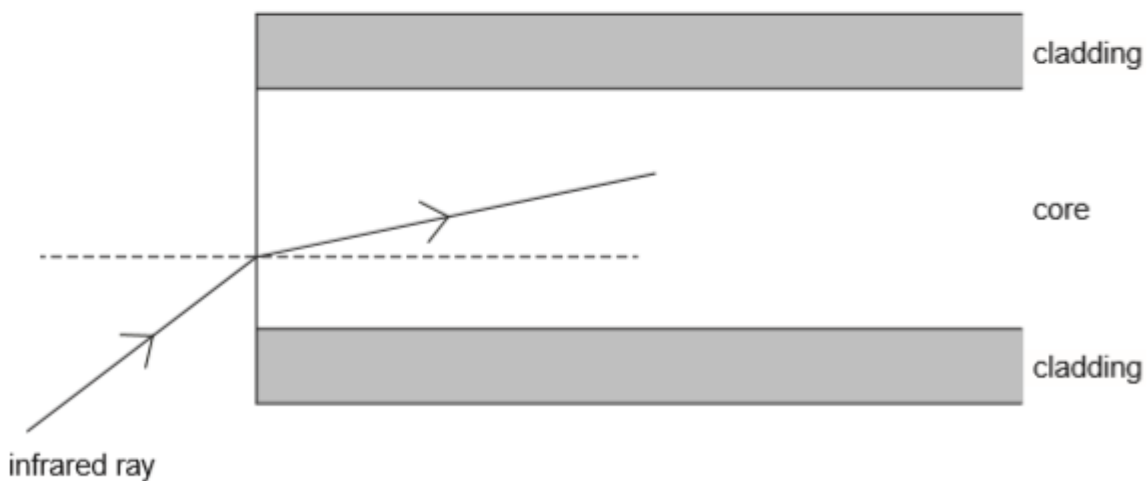**[2 marks]**

_____

_____

_____

_____

_____

_____

_____

_____

8 (b) **Figure 15** shows an infrared ray entering an optical fibre. The refractive index of the core is 1.55 at infrared frequencies.

Figure 15

8 (b) (i) Calculate the speed at which infrared radiation travels in the core.

[1 mark]

speed = _____ m s^{-1}

8 (b) (ii) The wavelength of this infrared radiation is 1300 nm in air.
Calculate the wavelength of infrared in the core.

[2 marks]

wavelength = _____ m

8 (b) (iii) State **one** reason for surrounding the core with cladding.

[1 mark]

_____

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