2023 Ph H2 Q11

Section: Particles and Waves

Topic: Refraction of Light — Prisms and Critical Angle

Summary of Question:

A ray of blue light is incident on an equilateral glass prism. (a) Calculate angle A and angle B inside the prism. (b) Define critical angle and calculate it for blue light (n=1.53). (c) Show and label the ray path after striking the prism boundary, marking the emerging angle.

(a)(i) Calculate angle A

Given prism apex angle = 60.0°, and internal refraction angle at first surface = 36.0°. Using geometry, angle A = 60.0° − 36.0° = 24.0°.

(a)(ii) Determine angle B

Triangle relation: A + B + internal apex angle = 180°. So B = 180° − (60.0° + 24.0°) = 96.0°.

(b)(i) State what is meant by the term critical angle

The critical angle is the angle of incidence in the denser medium (glass) at which the refracted ray emerges along the boundary (angle of refraction = 90°).

(b)(ii) Calculate the critical angle

n = 1.53. Critical angle c satisfies sin(c) = 1/n = 1/1.53 = 0.654. c = arcsin(0.654) = 40.9°.

(c) Path of the ray and emerging angle

At second boundary, incidence angle B = 96.0° (measured inside prism). This corresponds to incidence relative to the normal: 96.0° − 60.0° = 36.0° inside prism. Since 36.0° < 40.9° (critical angle), the ray emerges into air.

Apply Snell's law: $n \sin\theta_{glass} = \sin\theta_{air}$. $1.53 \times \sin 36.0° = \sin\theta_{air}$. $\sin\theta_{air} = 1.53 \times 0.588 = 0.900 \rightarrow \theta_{air} = 64.0°$.

The emergent ray makes 64.0° with the normal at the boundary.

Final Answers

(a)(i) A = 24.0°

(a)(ii) B = 96.0°

(b)(i) Critical angle = angle of incidence in glass giving 90° refraction.

(b)(ii) c = 40.9°

(c) Emergent ray at 64.0° to the normal.

Revision Tips

• For prisms, use geometry carefully: apex angle and triangle angle sums.

• Critical angle c = arcsin(1/n). Check whether incidence > c for total internal reflection.

• Always define angles relative to the normal when applying Snell’s law.