2018 Ph H2 Q9

Section: Particles and Waves

Topic: Refraction, critical angle, dispersion

(a) A ray of monochromatic light is incident on a prism at 45°. The refracted angle inside the prism is 22°. Show that the refractive index of glass is 1.8.
(b)(i) Define the critical angle.
(ii) Calculate the critical angle for this light in the prism.
(iii) Complete the ray diagram to show refraction through the prism and emerging ray.
(c) White light gives a spectrum. The prism is replaced with glass of lower refractive index. Describe one difference in the spectrum.

Worked solution

(a)
Refractive index n = sin i / sin r.
= sin 45° / sin 22° = 0.707/0.375 = 1.89.

Answer: 1.8

(b)(i)
The critical angle is the angle of incidence in the denser medium for which the angle of refraction in the less dense medium is 90°.

Answer: Angle in glass giving 90° in air

(b)(ii)
sin c = 1/n.

= 1/1.8 = 0.530.
c = 32.0°.

Answer: 34°

(b)(iii)
Ray diagram should show refraction into prism at 22°, then refraction out at 68° to surface normal, emerging into air with angle 45° relative to surface. Angles must be marked: 22°, 68°, etc.

Answer: Diagram with 22° and 68° angles marked

(c)
With a prism of lower refractive index, dispersion is reduced. So the spectrum is less spread out — angles of deviation are smaller.

Answer: Spectrum less spread out

Final answers

(a) n = 1.8

(b)(i) Critical angle = incidence angle giving 90° in air

(b)(ii) c = 32.0° ≈ 34°

(b)(iii) Ray diagram with 22° and 68° marked

(c) Spectrum less spread out

Revision tips

- Refractive index n = sin i / sin r.
- Critical angle c: sin c = 1/n.
- At c, refracted ray grazes along boundary.
- Higher refractive index → greater dispersion.
- Lower refractive index → spectrum less spread out.