2019 Ph H2 Q11

Section: Particles and Waves

Topic: Refraction, Critical Angle and Sparkle

(a) Light enters a diamond at 49.0°. Refractive index of diamond = 2.42. Calculate angle of refraction. (b) Calculate the critical angle of the diamond. (c) Moissanite has higher refractive index than diamond. Would it sparkle more or less than diamond? Justify.

Worked solution

(a) Using Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$.
Here $n_1 = 1.00$ (air), $n_2 = 2.42$, $\theta_1 = 49.0°$.
$\sin\theta_2 = \sin(49.0°)/2.42 = 0.312$.
$\theta_2 = 18.2°$.

Answer: 18.9°

(b) Critical angle c is given by $\sin c = 1/n$.
$= 1/2.42 = 0.413$.
$c = 24.4°$.

Answer: 24.4°

(c) A higher refractive index means a smaller critical angle. This increases the range of angles for total internal reflection, so more light is reflected inside the material and emerges later, enhancing sparkle.

Answer: Moissanite sparkles more than diamond.

Final answers

(a) $\theta_2 = 18.9°$

(b) c = 24.4°

(c) Moissanite sparkles more (smaller critical angle → more TIR)

Revision tips

- Snell’s Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$.
- Critical angle: $\sin c = 1/n$.
- Smaller critical angle → more total internal reflection.
- Greater TIR → more sparkle.
- Gemstones sparkle because of multiple internal reflections.