Name:_____Class:_____ Date:_____

Refraction

Problem A

SNELL'S LAW

PROBLEM

A ray of light traveling in air strikes the surface of a polished agate slab ($n = 1.544$) on display in your friend's home. If the ray in the agate makes an angle of 29.0° with the normal, what is the angle of incidence?

SOLUTION

Given: $n_r = 1.544$ $\theta_r = 29.0°$ $n_i = 1.00$

Unknown: $\theta_i = ?$

Choose the equation(s) or situation:
Use the equation for Snell's law.

$$n_i \sin \theta_i = n_r \sin \theta_r$$

$$\theta_i = \sin^{-1}\left[\frac{n_r}{n_i}(\sin \theta_r)\right] = \sin^{-1}\left[\frac{1.544}{1.000}(\sin 29.0°)\right] = \boxed{48.5°}$$

ADDITIONAL PRACTICE

1. An old Greek superstition was that amethyst would protect those who wore it from drunkenness—which is why they called it améthystos, meaning "not drunken." Until the discovery of the large Brazilian and Uruguayan deposits at the end of the nineteenth century, deep-colored amethyst was highly prized. Suppose a ray of light traveling in air strikes the surface of an amethyst crystal ($n = 1.553$). If the ray in the amethyst makes an angle of 35° with the normal, what is the angle of incidence?
2. If you were to set a calcite crystal on top of this sentence, you would see a double image of each word. This phenomenon is called "double refraction." Suppose a ray of light traveling in air strikes the surface of a calcite crystal ($n = 1.486$) used to demonstrate this phenomenon. If the ray in the calcite makes an angle of 41° with the normal, what is the angle of incidence?
3. The Chinese have skillfully carved figurines made of a translucent greenish material called serpentine. A ray of light traveling in air strikes the flat surface of a serpentine figurine ($n = 1.555$). If the ray in the serpentine makes an angle of 33° with the normal, what is the angle of incidence?
4. When light in air enters an opal mounted on a ring, it travels at a speed of 2.07×10^8 m/s. What is opal's index of refraction?
5. When light enters a pearl in a necklace, it travels at a speed of 1.97×10^8 m/s. What is the pearl's index of refraction?

6. When light enters albite, also called “moonstone”, it has a luminous albedo—like a full moon. When light in air enters albite, it travels at a velocity of 1.95×10^8 m/s. What is albite’s index of refraction?
7. Nephrite jade was once used virtually everywhere by Neolithic man for polished stone weapons. Nephrite jade was also important in ancient oriental art. Suppose light passes from air at an angle of incidence of 59.2° into a thin ornate handle of a nephrite jade vase ($n = 1.61$) on display at a museum. Determine the angle of refraction in the jade.
8. Malachite is characterized by wavy light- and dark-green bands and has double refraction ($n = 1.91$ and $n = 1.66$). Suppose a ray of light traveling in air strikes a malachite carving of an Aztec calendar at an angle of 35.2° with the normal. What are the two angles of refraction?
9. Amber is a fossil resin of trees that lived tens of millions of years ago. Sometimes insects were trapped by the resin and fossilized inside. Suppose a ray of light traveling in air strikes a 2 mm thick clear amber pendant ($n = 1.54$) at an angle of 17° with the normal. Find the angles of refraction at each surface.
10. The Museo degli Argenti, in Florence, displays a plate that was carved out of rock crystal in the sixteenth century. Suppose a ray of light traveling in air strikes this plate ($n = 1.544$) at an angle of 22° with the normal. Trace the light ray through the plate, and find the angles of refraction at each surface.