# *HW 8*

1. **Find the energy of (a) a photon having a frequency of 5.00 3 ×10[17] Hz and (b) a photon having a wavelength of 3.00 ×10 2 nm. Express your answers in units of electron volts, noting that 1eV =1.60 ×10[-19] J.**

   We find the energy of the photons from Equation 35.1, $E = hf$.

$$\text{(a)}\quad E = hf = (6.63\times10^{-34}\ \text{J}\cdot\text{s})(5.00\times10^{17}\ \text{Hz})\left(\frac{1\ \text{eV}}{1.60\times10^{-19}\ \text{J}}\right)$$

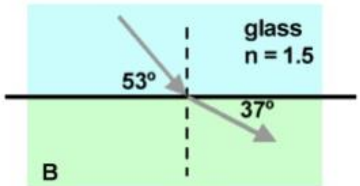
$$= \boxed{2.07\times10^{3}\ \text{eV}} = 2.07\ \text{keV}$$

$$\text{(b)}\quad E = hf = \frac{hc}{\lambda}$$

$$= \frac{(6.63\times10^{-34}\ \text{J}\cdot\text{s})(3.00\times10^{8}\ \text{m/s})}{3.00\times10^{2}\ \text{nm}}\left(\frac{1\ \text{nm}}{10^{-9}\ \text{m}}\right)\left(\frac{1\ \text{eV}}{1.60\times10^{-19}\ \text{J}}\right)$$

$$= \boxed{4.14\ \text{eV}}$$

2. **Calculate the refracted index for medium B**



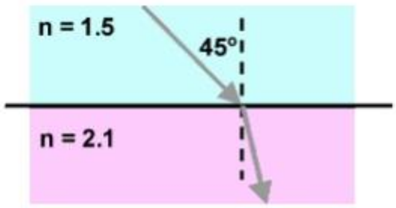

From Snell law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$1.5 \sin 53^{o} = n_B \sin 37^{0}$$

$$n_B = 1.5\,\frac{\sin 53^{o}}{\sin 37^{0}} = 1.99$$

3. **Calculate the refracted angle.**




From Snell law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$1.5 \sin 45^{o} = 2.1 \sin\theta_2$$

$$\sin\theta_2 = \frac{1.5}{2.1}\sin 45^{o} = 0.5$$

$$\theta_2 = 30$$

4. **A ray of light in air strikes a block of quartz at an angle of incidence of 30°. The angle of refraction is 20°. What is the index of refraction of the quartz?**

From Snell law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$n_1 \sin\theta_1 = n_q \sin\theta_2$$

$$(1) \sin 30^o = (n_q) \sin 20^0$$

$$n_q = 1.\frac{\sin 30^o}{\sin 20^0} = 1.46$$

5. **The wavelength of red helium–neon laser light in air is 632.8 nm. (a) What is its frequency? (b) What is its wavelength in glass that has an index of refraction of 1.50? (c) What is its speed in the glass?**

(a) $$f = \frac{c}{\lambda} = \frac{3.00\times10^8 \text{ m/s}}{6.328\times10^{-7} \text{ m}} = \boxed{4.74\times10^{14} \text{ Hz}}$$

(b) $$\lambda_{\text{glass}} = \frac{\lambda_{\text{air}}}{n} = \frac{632.8 \text{ nm}}{1.50} = \boxed{422 \text{ nm}}$$

(c) $$v_{\text{glass}} = \frac{c_{\text{air}}}{n} = \frac{3.00\times10^8 \text{ m/s}}{1.50} = 2.00\times10^8 \text{ m/s} = \boxed{200 \text{ Mm/s}}$$

6. **Figure P35.8 shows a refracted light beam in linseed oil making an angle of φ= 20.0° with the normal line NN. The index of refraction of linseed oil is 1.48. Determine the angles (a) Θ and (b) Θ'.**

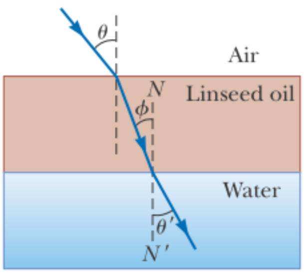



Figure P35.8

(a) The dashed lines are parallel, and alternate interior angles are equal between parallel lines, so the angle of refraction law at the air-oil interface is 20.0°. Applying Snell's law,

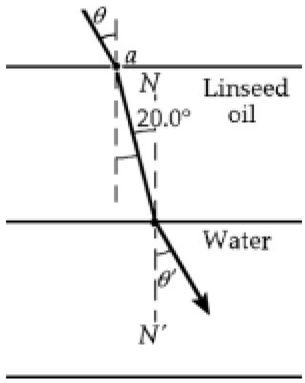
$$n_{air} \sin\theta = n_{oil} \sin\alpha$$
$$1.00 \sin\theta = 1.48 \sin 20.0°$$

yields $\boxed{\theta = 30.4°}$.

(b) The angle of incidence $\alpha = 20.0°$. Applying Snell's law at the oil-water interface,

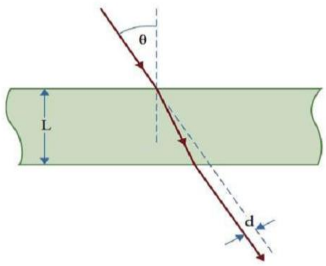
$$n_{water} \sin\theta' = n_{oil} \sin\alpha$$
$$1.33 \sin\theta' = 1.48 \sin 20.0°$$

yields $\boxed{\theta' = 22.3°}$.




**ANS. FIG. P35.8**

7. **A ray of light strikes a flat block of glass (n 5 1.50) of thickness 2.00 cm at an angle of 30.0° with the normal. Trace the light beam through the glass and find the angles of incidence and refraction at each surface. Calculate the lateral shift of the light ray d**




$n_1 \sin\theta_1 = n_2 \sin\theta_2$: $\qquad \theta_2 = \sin^{-1}\left(\dfrac{n_1 \sin\theta_1}{n_2}\right)$

$$\theta_2 = \sin^{-1}\left\{\frac{1.00 \sin 30°}{1.50}\right\} = \boxed{19.5°}$$

$\theta_2$ and $\theta_3$ are alternate interior angles formed by the ray cutting parallel normals.

So, $\qquad \theta_3 = \theta_2 = \boxed{19.5°}$

$$1.50 \sin\theta_3 = 1.00 \sin\theta_4$$
$$\theta_4 = \boxed{30.0°}$$

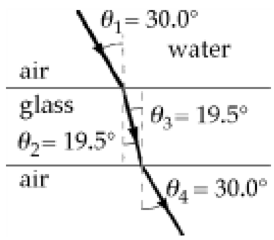



**FIG. P35.19**

8. For 589-nm light, calculate the critical angle for the following materials surrounded by air: (a) cubic zirconia, n= 2.20, (b) flint glass, n= 1.66 and (c) ice, n= 1.309.

From Equation 35.10, $\sin\theta_c = \frac{n_2}{n_1}$, where $n_2 = 1.000\ 293$. Values for $n_1$ come from Table 35.1,

(a) $\theta_c = \sin^{-1}\left(\frac{1.000\ 293}{2.20}\right) = \boxed{27.0°}$

(b) $\theta_c = \sin^{-1}\left(\frac{1.000\ 293}{1.66}\right) = \boxed{37.1°}$

(c) $\theta_c = \sin^{-1}\left(\frac{1.000\ 293}{1.309}\right) = \boxed{49.8°}$