19.
$$\frac{\sin\theta_a}{\sin\theta_l} = \frac{n_l}{n_a}$$
$$\frac{\sin 50.0°}{\sin\theta_l} = \frac{1.50}{1.00}$$
$$\theta_l = 30.7°$$

We must now find the incident angle at the second surface using geometry. This angle is 39.3°.

$$\frac{\sin\theta_l}{\sin\theta_a} = \frac{n_a}{n_l}$$
$$\frac{\sin 39.3°}{\sin\theta_a} = \frac{1.00}{1.50}$$
$$\theta_a = 71.8°$$

20. First find the incident angle to the liquid surface using geometry. This angle is 61.0°

$$\frac{\sin\theta_a}{\sin\theta_l} = \frac{n_l}{n_a}$$
$$\frac{\sin 61.0°}{\sin 25.0°} = \frac{n_l}{1.00}$$
$$n_l = 2.07$$

21. First find the incident and refracted angles using trigonometry.

$$\tan\theta_l = \frac{o}{a}$$
$$= \frac{4.0\text{ cm}}{5.0\text{ cm}}$$
$$\theta_l = 38.7°$$

$$\tan\theta_p = \frac{o}{a}$$
$$= \frac{7.0\text{ cm}}{2.0\text{ cm}}$$
$$\theta_p = 74.0°$$

$$\frac{\sin\theta_l}{\sin\theta_p} = \frac{n_p}{n_l}$$
$$\frac{\sin 38.7°}{\sin 74.0°} = \frac{n_p}{n_l}$$
$$\frac{n_p}{n_l} = 0.65$$

22. Frequency does not change during refraction.

$\therefore$ frequency is 6.20×10^{14} Hz.

23. Frequency in Lucite is equal to the frequency in air. $\therefore$, find the frequency in air.

$$v_a = \lambda_a f$$
$$f = \frac{v_a}{\lambda_a}$$
$$= \frac{3.00\times10^8\text{ m/s}}{6.22\times10^{-7}\text{ m}}$$
$$= 4.82 \times 10^{14}\text{ Hz}$$

24. Period of light in water is equal to the period in air.
$\therefore$ find the period in air.

$$v_a = \lambda_a f$$
$$f = \frac{v_a}{\lambda_a}$$
$$= \frac{3.00\times10^8\text{ m/s}}{4.00\times10^{-7}\text{ m}}$$
$$= 7.50 \times 10^{14}\text{ Hz}$$
$$T = \frac{1}{f}$$
$$= \frac{1}{7.50\times10^{14}\text{ Hz}}$$
$$= 1.33 \times 10^{-15}\text{ s}$$

25. Find the wavelength in air first.

$$T = \frac{1}{f}$$
$$f = \frac{1}{T}$$
$$= \frac{1}{1.70\times10^{-15}\text{ s}}$$
$$= 5.88 \times 10^{14}\text{ Hz}$$
$$v = \lambda f$$
$$\lambda = \frac{v}{f}$$

