Solutions to Chapter 26 Exercises

- 4. The wavelengths of radio waves are longer than those of light waves, which are longer than the wavelengths of X-rays.
- 5. Ultraviolet has shorter wavelengths than infrared. Correspondingly, ultraviolet also has the higher frequencies.
- 11. Speed is *c*, the speed of light.
- 18. Sound requires a physical medium in which to travel. Light does not.
- 19. Radio waves most certainly travel at the speed of every other electromagnetic wave—the speed of light.
- 24. The instantaneous speed of the bullet after penetrating the tree is less than its incident speed, but not so with light. The instantaneous speed of light before meeting the glass, while passing through it, and when emerging is a constant, *c*. The fundamental difference between a bullet fired through a tree and light passing through glass is that the *same* bullet strikes and later emerges. Not so for light. The "bullet of light" (photon) that is incident upon glass is absorbed by its interaction with an atom or molecule. The atom or molecule in turn then emits, with some time delay, a new "bullet of light" in the same direction. This process cascades through the glass with the result being that the "bullet of light" emerging is not the same "bullet" that was first incident. In the space between the atoms in matter the instantaneous speed of light is *c*. Because of the time delay of the interactions, only its average speed is less than *c*. The light that emerges has speed *c*.
- 28. Transparency or opaqueness is determined by the match between incident light frequencies and the resonant frequency of the material. A substance that is transparent to a range of light frequencies will be opaque to those frequencies that match its own resonant frequency.

Chapter 26 Problem Solutions

1. In seconds, this time is 16.5 min \times 60 s = 990 s.

Speed = $\frac{\text{distance}}{\text{time}}$ = $\frac{300,000,000 \text{ km}}{990 \text{ s}}$ = 303,030 km/s. 3. From $v = \frac{d}{t}$, $t = \frac{d}{v}$ = $\frac{d}{c}$ = $\frac{1.5 \times 10^{11} \text{ m}}{3 \times 10^8 \text{ m/s}}$ = 500 s (which equals 8.3 min).

The time to cross the diameter of the Earth's orbit is twice this, or 1000 s, slightly more than 990 s in Problem 1.