Solutions to the Extra Practice Problems for Chapter 11

1. The temperature is 28.4°C. Equation (11.2) relates the speed of sound to the temperature.

$$v_{sound} = (331.3 + 0.606 \cdot T_C)\frac{m}{s}$$

$$348.5\ \frac{\cancel{m}}{\cancel{s}} = (331.3 + 0.606 \cdot T_C)\frac{\cancel{m}}{\cancel{s}}$$

$$348.5 = 331.3 + 0.606 \cdot T_C$$

$$348.5 - 331.3 = 0.606 \cdot T_C$$

$$17.2 = 0.606 \cdot T_C$$

$$T_C = \frac{17.2}{0.606} = 28.4$$

You have to round after the subtraction, since division uses different rules. Because 348.5 has its last significant figure in the tenths place, the answer must as well, which leaves three significant figures for the division. Also, you don't have to cancel the units. You can just ignore them, since the equation is set up for the specific units of m/s and °C. Thus, you know your T will be in °C.

2. The frequency is 614 Hz. Equation (11.1) allows us to relate frequency and wavelength, but first, we need speed.

$$v_{sound} = (331.3 + 0.606 \cdot T_C)\frac{m}{s} = (331.3 + 0.606 \cdot 16.7)\frac{m}{s} = (331.3 + 10.1)\frac{m}{s} = 341.4\ \frac{m}{s}$$

Now we can use Equation (11.1):

$$f = \frac{v}{\lambda} = \frac{341.4\frac{\cancel{m}}{s}}{0.556\ \cancel{m}} = 614\ \frac{1}{s}$$

3. The wavelength is 0.360 m. Equation (11.1) allows us to relate frequency and wavelength, but first, we need speed.

$$v_{sound} = (331.3 + 0.606 \cdot T_C)\frac{m}{s} = (331.3 + 0.606 \cdot 21)\frac{m}{s} = (331.3 + 13)\frac{m}{s} = 344\ \frac{m}{s}$$

Now we can use Equation (11.1):

$$f = \frac{v}{\lambda}$$

$$955\ \text{Hz} = \frac{344\frac{m}{s}}{\lambda}$$

$$\lambda = \frac{344\frac{m}{s}}{955\ \text{Hz}} = \frac{344\frac{m}{\cancel{s}}}{955\ \frac{1}{\cancel{s}}} = 0.360\ m$$

4. The frequency will be 519 Hz. We need to use Equation (11.3), but that means we first need the speed of sound. We actually calculated that in the previous problem for the same temperature. It is 344 m/s. Now we can use Equation (11.3):

$$f_{observed} = \left(\frac{v_{sound} \pm v_{observer}}{v_{sound} \pm v_{source}}\right) \cdot f_{stationary}$$

The source is moving at 23.5 m/s, but it is moving away, which will lower the frequency. Since v_{source} is in the denominator, we must add it to make the fraction smaller.

$$f_{observed} = \left(\frac{344\ \frac{m}{s}}{344\ \frac{m}{s} + 23.5\ \frac{m}{s}}\right) \cdot 555\ Hz = \left(\frac{344\ \cancel{\frac{m}{s}}}{368\ \cancel{\frac{m}{s}}}\right) \cdot 555\ Hz = 519\ Hz$$

5. <u>The frequency will be 843 Hz</u>. We need to use Equation (11.3), but that means we first need the speed of sound at 21 °C. We have that from the past two problems: 344 m/s. Now we can use Equation (11.3):

$$f_{observed} = \left(\frac{v_{sound} \pm v_{observer}}{v_{sound} \pm v_{source}}\right) \cdot f_{stationary}$$

The source is moving at 19.4 m/s, but it is moving towards you, which will increase the frequency. Since v_{source} is in the denominator, we must subtract it to make the fraction smaller. You are moving towards it at 21.0 m/s , which will also increase the frequency, but since your speed is in the numerator, it must be added to increase the frequency:

$$f_{observed} = \left(\frac{344\ \frac{m}{s} + 21.0\ \frac{m}{s}}{344\ \frac{m}{s} - 19.4\ \frac{m}{s}}\right) \cdot 751\ Hz = \left(\frac{365\ \cancel{\frac{m}{s}}}{335\ \cancel{\frac{m}{s}}}\right) \cdot 751\ Hz = 843\ Hz$$

6. <u>It struck 580 m away</u>. We can assume that the light gets to your eyes almost instantly, so the time it takes the sound to travel will determine the distance. First, we need the speed of sound:

$$v_{sound} = (331.3\ + 0.606 \cdot T_C)\frac{m}{s} = (331.3 + 0.606 \cdot 17.2)\frac{m}{s} = (331.3 + 10.4)\frac{m}{s} = 341.7\ \frac{m}{s}$$

We can use Equation (2.16) to get the distance, which is the magnitude of the displacement. The speed of light is constant, so a=0.

$$\Delta\mathbf{x}\ =\ \mathbf{v}_0 t + \frac{1}{2}\mathbf{a}t^2 = \left(341.7\ \frac{m}{\cancel{s}}\right)(1.7\ \cancel{s}) + 0 = 580\ m$$

7. <u>The frequency is 5.21×10^{14} Hz. The frequency of the blue light would be higher</u>. Equation (11.1) relates frequency and wavelength, but the speed of light is in m/s, so we need to convert:

$$\frac{575\ \cancel{nm}}{1} \times \frac{10^{-9}\ m}{1\ \cancel{nm}} = 5.75 \times 10^{-7}\ m$$

$$f = \frac{v}{\lambda} = \frac{2.998 \times 10^8\ \frac{m}{s}}{5.75 \times 10^{-7}\ m} = 5.21 \times 10^{14}\ \frac{1}{s}$$

Roy G. Biv tells us that blue has shorter wavelengths than yellow, which means higher frequencies.

8. <u>The wavelength is 5.0×10^{-7} m</u>. Equation (11.1) relates frequency and wavelength:

$$f = \frac{v}{\lambda}$$

$$6.0 \times 10^{14}\ \text{Hz} = \frac{2.998 \times 10^{8}\ \frac{\text{m}}{\text{s}}}{\lambda}$$

$$\lambda = \frac{2.998 \times 10^{8}\ \frac{\text{m}}{\cancel{\text{s}}}}{6.0 \times 10^{14}\ \frac{1}{\cancel{\text{s}}}} = 5.0 \times 10^{-7}\ \text{m}$$

9. <u>The maximum kinetic energy is 0.6 eV</u>. Equation (11.5) governs the photoelectric effect, but we need the frequency, not the wavelength.

$$\frac{475\ \cancel{\text{nm}}}{1} \times \frac{10^{-9}\ \text{m}}{1\ \cancel{\text{nm}}} = 4.75 \times 10^{-7}\ \text{m}$$

$$\text{f} = \frac{\text{v}}{\lambda} = \frac{2.998 \times 10^{8}\ \frac{\text{m}}{\text{s}}}{4.75 \times 10^{-7}\ \text{m}} = 6.31 \times 10^{14}\ \frac{1}{\text{s}}$$

Now we can use Equation (11.5):

$$\text{maximum electron kinetic energy} = \text{h} \cdot \text{f} - \Phi$$

$$\text{maximum electron kinetic energy} = (4.14 \times 10^{-15}\text{eV} \cdot \text{s}) \cdot 6.31 \times 10^{14}\ \frac{1}{\text{s}} - 2.0\ \text{eV} = 2.61\ \text{eV} - 2.0\ \text{eV}$$

$$\text{maximum electron kinetic energy} = 0.6\ \text{eV}$$

10. <u>The frequency is 1.2×10^{15} Hz</u>. Equation (11.5) governs the photoelectric effect.

$$\text{maximum electron kinetic energy} = \text{h} \cdot \text{f} - \Phi$$

$$3.2\ \text{eV} = (4.14 \times 10^{-15}\text{eV} \cdot \text{s}) \cdot \text{f} - 1.9\ \text{eV}$$

$$5.1\ \text{eV} = (4.14 \times 10^{-15}\text{eV} \cdot \text{s}) \cdot \text{f}$$

$$\text{f} = \frac{5.1\ \text{eV}}{4.14 \times 10^{-15}\text{eV} \cdot \text{s}} = 1.2 \times 10^{15}\ \frac{1}{\text{s}}$$