COLORFUL PRACTICE WITH LIGHT! KEY

***Instructions**: Show your work completely in your journal when answering the following questions.*

1. It is often estimated that light will travel one foot in one nanosecond (ns). Modern lasers can create a light pulse that lasts only a few femtoseconds (fs)!
   a. How far, in meters and in feet, will light actually travel in exactly 1 ns?

$$d = v \cdot t = (3.00 \times 10^8\ {}^{\mathrm{m}}/_{\mathrm{s}})(1.00 \times 10^{-9}\ \mathrm{s})$$

$$\boxed{d = 0.300\ \mathrm{m} = 0.984\ \mathrm{ft}}$$

   b. What is the length of the light pulse created in 6.0 fs?

$$d = v \cdot t = (3.00 \times 10^8\ {}^{\mathrm{m}}/_{\mathrm{s}})(6.0 \times 10^{-15}\ \mathrm{s})$$

$$\boxed{d = 1.8 \times 10^{-6}\ \mathrm{m}}$$

   c. How many wavelengths of red light (wavelength = 700. nm) are included in such a pulse?

$$\frac{distance}{wavelength} = \frac{1.8 \times 10^{-6}\ \mathrm{m}}{700 \times 10^{-9}\ \mathrm{m}}$$

$$\boxed{\#of\ wavelengths = 2.5}$$

2. A low frequency electromagnetic wave has a frequency of 10 Hz.
   a. What is the wavelength of the wave with a frequency of 10 Hz?

$$v = f\lambda \rightsquigarrow \lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ {}^{\mathrm{m}}/_{\mathrm{s}}}{10\ \mathrm{Hz}}$$

$$\boxed{\lambda = 3 \times 10^7\ \mathrm{m}}$$

   b. If blue light has a wavelength of 400 nm, how does its frequency compare to red light? Which one has more energy?

$$v = f\lambda \rightsquigarrow f = \frac{v}{\lambda} = \frac{3.00 \times 10^8\ {}^{\mathrm{m}}/_{\mathrm{s}}}{4.00 \times 10^{-7}\mathrm{m}}$$

$$\boxed{f = 7.50 \times 10^{14}\mathrm{Hz}}$$

The frequency of blue light is higher than red light; it also has more energy!

3. H.G. Wells wrote a famous novel about a man who made himself invisible by changing his index of refraction. What would his index of refraction have to be to accomplish this? Would the invisible man be able to see anything?

His index of refraction would have to be the same as the air. If his index of refraction were any larger, the images behind him would appear distorted, giving away his position.
No, he would not be able to see, because light rays would not be bent by his cornea or lens. Thus, no image would be formed on his retina.

4. Sunlight passes into a raindrop at an angle of 22.5° from the normal at one point on the droplet. What is the angle of refraction?

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

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{1.0 \sin(22.5°)}{1.3}$$

$$\sin\theta_2 = 0.29$$

$$\theta_2 = \sin^{-1}(0.29)$$

$$\boxed{\theta_2 = 17°}$$

5. A ray of light traveling through air is incident upon a sheet of pure crown glass at 30.0°.
   a. What is the angle of refraction?

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

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{1.0 \sin(30.0°)}{1.5}$$

$$\sin\theta_2 = 0.33$$

$$\theta_2 = \sin^{-1}(0.33)$$

$$\boxed{\theta_2 = 19°}$$

   b. A ray of light is incident upon a diamond at 45.0°. What is the angle of refraction?

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

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{1.0 \sin(45.0°)}{2.4}$$

$$\sin\theta_2 = 0.29$$

$$\theta_2 = \sin^{-1}(0.29)$$

$$\boxed{\theta_2 = 17°}$$

   c. Does crown glass or diamond bend light more?

   The diamond does; it has a higher index of refraction, so we know it bends light more. This contributes to why diamonds sparkle more than glass! IT has a smaller critical angle, which means it is harder for light to escape and it just keeps bouncing around in the diamond!

6. Fill in the blanks: Magenta ink absorbs ***green*** light and reflects ***blue*** and ***red*** light.

7. What color would a yellow pepper look like under the following colors of light? Explain WHY.

   A yellow pepper absorbs blue light and reflects red and green light. THEREFORE:

   a. Red Light

      The pepper will look red

   b. Green Light

      The pepper will look green

   c. Blue Light

      The pepper will look black

   d. Yellow Light

      The pepper will look yellow

   e. Cyan Light

      The pepper will look green

   f. Magenta Light

      The pepper will look red