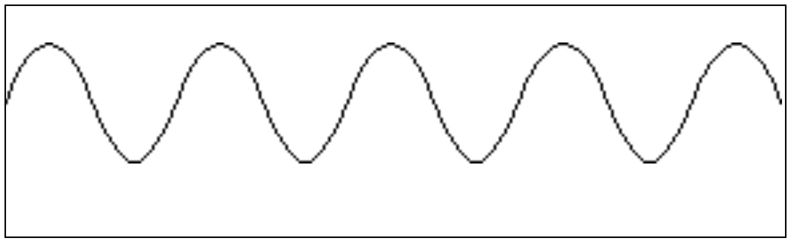
Electromagnetic Radiation

Name ________________________________ Section____

1a. In the space below draw a wave that has four wavelengths



b)If the distance from one side of the box to the other side is 1 meter, what is the wavelength of the wave you have drawn?

Distance = 1 meter with four wavelengths over that distance, then

$$\boldsymbol{\lambda = \frac{1 \text{ meter}}{4} = 0.25 \text{ meters}}$$

c) What is the frequency of the wave?

$$\boldsymbol{\lambda \cdot \nu = c}$$

$$\boldsymbol{\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8} \text{ m s}^{-1}}{0.25 \text{ m}} = 1.20 \times 10^{9} \text{ s}^{-1}}$$

2. Calculate the frequency of light that has a wavelength of 6.7×10^{-5} cm.

$$\boldsymbol{\lambda \cdot \nu = c}$$

$$\boldsymbol{\nu = \frac{c}{\lambda}}$$

$$\boldsymbol{\nu = \left(\frac{3.00 \times 10^{8} \text{ m/s}}{6.7 \times 10^{-5} \text{ cm}}\right)\left(\frac{100 \text{ cm}}{1 \text{ m}}\right)}$$

$$\boldsymbol{= 4.5 \times 10^{14} \text{ s}^{-1}}$$

3. Describe the difference between the appearances of an emission spectrum and an absorption spectrum for any element.

When the light emitted by the atoms of an element, which have been excited by heating, is passed through a prism, a series of sharp colored lines on a black background is produced. Since the light seemed to come from the elements the spectra were called emission spectra. The spectrum of an element is made up of spectral lines unique to that element.

Light passed *through* a sample of an element is absorbed by the atoms or molecules. The light collected after passing through the sample produces a series of black lines on a continuous colored spectrum. For a given element, the absorption and emission lines are the same.

4a. Define quantization. What is a quantum of matter? What is a quantum of light (radiant energy)?

Quantization is the idea that matter or light is composed of discrete packets or units. For example, matter is composed of discrete units called atoms. We do not find fractions of atoms. The quantum of light is called a photon. It is an energy packet of light.

5. Calculate the energy of a photon of orange light with a frequency of $5.0 \times 10^{14}\ \text{sec}^{-1}$.

$$\mathbf{E = h\upsilon = 6.626 \times 10^{-34}\ J{\cdot}s\ (5.0 \times 10^{14}\ s^{-1}) = 3.3 \times 10^{-19}\ J}$$

This is the energy of a photon of orange light.

6. Calculate the energy of a mol of photons of orange light with a frequency of $5.0 \times 10^{14}\ \text{sec}^{-1}$.

From above we know one photon of orange light has 3.3×10^{-19} J.

$$\mathbf{\left(3.3 \times 10^{-19}\ \frac{J}{photon}\right)\left(6.02 \times 10^{23}\ \frac{photon}{mole}\right) = 2.0 \times 10^{5}\ \frac{J}{mole}}$$

7. Calculate the energy of a photon of light with a wavelength of 425 nm.

$$\mathbf{\lambda \cdot \upsilon = c\ ; \quad \upsilon = \frac{c}{\lambda}\ ; \qquad E = h\upsilon}$$

$$\mathbf{E = h\left(\frac{c}{\lambda}\right) = (6.626 \times 10^{-34}\ J{\cdot}s)\ \frac{3.00 \times 10^{8}\ \frac{m}{s}}{425 \times 10^{-9}\ m} = 4.68 \times 10^{-19}\ J}$$

8. The energy required to break the oxygen-oxygen bond in O_2 is $496\ \frac{\text{kJ}}{\text{mol}}$. Calculate the minimum wavelength of light that can break the oxygen-oxygen bond.

First we need to convert the bond energy from $\frac{kJ}{mol}$ to $\frac{J}{molecule}$

$$\mathbf{\frac{496 \times 10^{3}\ J}{6.023 \times 10^{23}\ molecules} = 8.24 \times 10^{-19}\ \frac{J}{molecule}}$$

Now we can calculate the wavelength of a photon with this amount of energy.

$$\mathbf{E = \frac{hc}{\lambda}\ ; \quad \lambda = \frac{hc}{E}}$$

$$\mathbf{\lambda = \frac{6.626 \times 10^{-34}\ J{\cdot}s \cdot 2.998 \times 10^{8}\ \frac{m}{s}}{8.24 \times 10^{-19}\ \frac{J}{molecule}}}$$

$$\mathbf{= 2.41 \times 10^{-7}\ m\ \left(\frac{10^{9}\ nm}{1\ m}\right) = 241\ nm}$$