CHEM 130 **Key begins on page 3.**
Problem Set 7

1. Give the equation for each of the following important mathematical relations in this chapter:

    a) The relationship between wavelength, frequency, and speed of light.

    b) The relation between energy and frequency of radiation.

    c) The energy of an electron in a given energy state of the H atom.

2. The U.S. Navy has a system for communicating with submerged submarines. The system uses radio waves with a frequency of 76 s^{-1}. What is the wavelength of this radiation in meters? In miles?

3. The most prominent line in the line spectrum of aluminum is found at 396.15 nm.

    a) What is the frequency of this line?

    b) What is the energy of one photon with this wavelength?

    c) Of 1 mole of these photons?

4. When copper is bombarded with high-energy electrons, X-rays are emitted. Calculate the energy (in joules) associated with the photons if the wavelength of the X rays is 0.154 nm.

5. Calculate the wavelength of a photon emitted by a hydrogen atom when its electron drops from the $n = 5$ state to the $n = 3$ state.

6. Does a baseball in flight possess wave properties? If so, why can we not determine its wave properties?

7. What is the de Broglie wavelength associated with a 2.5 g Ping-Pong ball traveling at 35 mph?

8. Exposure to high does of microwaves can cause damage. Estimate how many photons, with $\lambda = 12$ cm, must be absorbed to raise the temperature of your eye by 3.0 ^{o}C. Assume the mass of an eye is 10. g and its specific heat is 4.0 J/g-^{o}C.

9. Explain the process of emission of light by an atom.

10. When a compound containing cesium ions is heated in a Bunsen burner flame, photons with an energy of 4.30×10^{-19} J are emitted. What color is the cesium flame?

CHEM 1
Problem Set 7

1. Give the equation for each of the following important mathematical relations in this chapter:

   a) The relationship between wavelength, frequency, and speed of light. $\nu = \frac{c}{\lambda}$

   b) The relation between energy and frequency of radiation. $E = h\nu$

   c) The energy of an electron in a given energy state of the H atom.

   $$E = \frac{-R_H}{n^2}$$

2. The U.S. Navy has a system for communicating with submerged submarines. The system uses radio waves with a frequency of 76 s^{-1}. What is the wavelength of this radiation in meters? In miles?

   $$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^8 \text{ m/s}}{76 \text{ s}^{-1}} = 3.95 \times 10^6 \text{ m}$$

   I'll leave the conversion for you.

   ~2,453 miles.

3. The most prominent line in the line spectrum of aluminum is found at 396.15 nm.

   a) What is the frequency of this line? $\nu = \frac{3 \times 10^8 \text{ m/s}}{3.9615 \times 10^{-7} \text{ m}} = 7.57 \times 10^{14} \text{ s}^{-1}$

   b) What is the energy of one photon with this wavelength?

   $$E = (6.626 \times 10^{-34} \text{ J·s})(7.57 \times 10^{14} \text{ s}^{-1}) = 5.02 \times 10^{-19} \text{ J}$$

   c) Of 1 mole of these photons?

   $$(5.02 \times 10^{-19} \text{ J})(6.02 \times 10^{23}) = 3.02 \times 10^5 \text{ J or } 302 \text{ kJ}.$$

4. When copper is bombarded with high-energy electrons, X-rays are emitted. Calculate the energy (in joules) associated with the photons if the wavelength of the X rays is 0.154 nm.

   $$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J·s})(3 \times 10^8 \text{ m/s})}{(0.154 \times 10^{-9} \text{ m})} = 1.29 \times 10^{-15} \text{ J}$$

5. Calculate the wavelength of a photon emitted by a hydrogen atom when its electron drops from the $n = 5$ state to the $n = 3$ state.

$$\frac{1}{\lambda} = \frac{R_H}{hc}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = \frac{2.18\times10^{-18}\ J}{(6.626\times10^{-34}\ J\cdot s)(3\times10^{8}\ m/s)}\left[\left(\frac{1}{3^2}\right) - \left(\frac{1}{5^2}\right)\right]$$

$$\frac{1}{\lambda} = 7.80\times10^{5}\ m^{-1} \quad \text{so} \quad \lambda = \frac{1}{7.80\times10^{5}\ m^{-1}} = 1.28\times10^{-6}\ m$$

6. Does a baseball in flight possess wave properties? If so, why can we not determine its wave properties?

YES

ITS WAVELENGTH IS SO SHORT THAT IT CANNOT BE DETECTED.

7. What is the de Broglie wavelength associated with a 2.5 g Ping-Pong ball traveling at 35 mph?

$$\lambda = \frac{h}{mv} = \frac{(6.626\times10^{-34}\ J\cdot s)}{(.0025\ kg)(15.64\ m/s)}$$

→ 15.64 m/s.

$$= 1.69\times10^{-32}\ m.$$

8. Exposure to high does of microwaves can cause damage. Estimate how many photons, with $\lambda = 12$ cm, must be absorbed to raise the temperature of your eye by 3.0 °C. Assume the mass of an eye is 10. g and its specific heat is 4.0 J/g-°C.

$$q = (4.0\ J/g^\circ)(10.0\ g)(3^\circ) = 120\ J \rightarrow \frac{120\ J}{1.657\times10^{-24}\ J/\text{photon}} = 7.24\times10^{25}\ \text{photons}$$

$$E_{\text{per photon}} = \frac{(6.626\times10^{-34}\ J\cdot s)(3\times10^{10}\ cm/s)}{12\ cm} = 1.657\times10^{-24}\ J/\text{photon}$$

9. Explain the process of emission of light by an atom.

WHEN $e^\ominus$ ABSORBS ENERGY AN $e^\ominus$ CAN MOVE TO AN UPPER ENERGY level.... WHEN IT RETURNS TO ITS "GROUND STATE" THE ABSORBED ENERGY CAN BE REEMITTED AS A PHOTON.

10. When a compound containing cesium ions is heated in a Bunsen burner flame, photons with an energy of 4.30×10^{-19} J are emitted. What color is the cesium flame?

$$\nu = \frac{E}{h} = \frac{4.30\times10^{-19}\ J}{6.626\times10^{-34}\ J\cdot s} = 6.49\times10^{14}\ s^{-1} \quad (\text{OR } \lambda = 462\ nm)$$

ACCORDING TO FIG 7.5 (p 276) THIS FREQUENCY CORRESPONDS TO BLUE LIGHT