Practice Problems 13 **Chapter 7** **CHE 151**
Graham/07

1.) A laser emits light of frequency 4.74×10^{14} sec^{-1}. What is the wavelength of the light in nm?

$$\lambda = \frac{c}{\nu} = 2.998 \times 10^{8}\ \frac{m}{s} \times \frac{1\ s}{4.74 \times 10^{14}} \times \frac{1\ nm}{10^{-9} m} = \boxed{6.32 \times 10^{2}\ nm}$$

2.) A certain electromagnetic wave has a wavelength of 625 nm.

a.) What is the frequency of the wave?

$$625\ nm \times \frac{10^{-9}\ m}{1\ nm} = 6.25 \times 10^{-7}\ m$$

$$\nu = \frac{c}{\lambda} = \frac{2.998 \times 10^{8}\ m/s}{6.25 \times 10^{-7}\ m}$$

$$\boxed{\nu = 4.80 \times 10^{14}\ s^{-1}}$$

b.) What region of the electromagnetic spectrum is it found?

Visible Region (~400 – 750 nm)

c.) What is the energy of the wave?

$$E = h\nu = (6.626 \times 10^{-34}\ J{\cdot}s)(4.80 \times 10^{14}\ s^{-1}) = \boxed{3.18 \times 10^{-19}\ J}$$

3.) How many minutes would it take a radio wave to travel from the planet Venus to Earth? (Average distance from Venus to Earth = 28 million miles).

(Note: All electromagnetic travels at the speed of light in a vacuum)

$$2.8 \times 10^{7}\ mi \times \frac{1\ km}{0.6214\ mi} \times \frac{10^{3}\ m}{1\ km} = 4.5 \times 10^{10}\ m$$

$$4.5 \times 10^{10}\ m \times \frac{1\ s}{2.998 \times 10^{8}\ m} \times \frac{1\ min}{60\ s} = \boxed{2.5\ min}$$

4.) The blue color of the sky results from the scattering of sunlight by air molecules. The blue light has a frequency of about 7.5×10^{14} Hz.

a.) Calculate the wavelength, in nm, associated with this radiation.

1 Hz = 1 s^{-1}

$$\lambda = \frac{c}{\nu} = \frac{2.998 \times 10^{8}\ m}{7.5 \times 10^{14}\ s^{-1}} \times \frac{1\ nm}{10^{-9}\ m} = \boxed{4.0 \times 10^{2}\ nm}$$

b.) Calculate the energy, in joules, of a single photon associated with this frequency.

$$E = h\nu = (6.626 \times 10^{-34}\ J{\cdot}s)(7.5 \times 10^{14}\ s^{-1}) = \boxed{5.0 \times 10^{-19}\ J}$$

5.) What is ΔE in joules for an atom that releases a photon with a wavelength of 3.2×10^{-7} meters? $\Delta E_{atom} = E_{photon} = h\nu = \frac{hc}{\lambda}$

$$\Delta E = \frac{(6.626 \times 10^{-34}\ J{\cdot}s)(2.998 \times 10^{8}\ m/s)}{3.2 \times 10^{-7}\ m} = \boxed{6.2 \times 10^{-19}\ J}$$

6.) Calculate the frequency (Hz) and wavelength (nm) of the emitted photon when an electron drops from the n=4 to n=2 state.

$$\Delta E = R_H \left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] = (2.179 \times 10^{-18} J)\left[\frac{1}{4^2} - \frac{1}{2^2}\right] = \frac{2.179 \times 10^{-18}}{16} - \frac{2.179 \times 10^{-18}}{4}$$

$$= 1.362 \times 10^{-19} - 5.448 \times 10^{-19} = -4.086 \times 10^{-19} J = \Delta E$$

$\Delta E = h\nu$

$$\nu = \frac{4.086 \times 10^{-19} J}{6.626 \times 10^{-34}\ J{\cdot}s} = 6.167 \times 10^{14} Hz = \nu$$

$\nu = \frac{\Delta E}{h}$

$$\lambda = \frac{c}{\nu} = \frac{2.998 \times 10^{8}\ m/s}{6.167 \times 10^{14}\ s^{-1}} \times \frac{1\ nm}{10^{-9} m} = \boxed{486.1\ nm}$$

7.) An electron in the hydrogen atom makes a transition from an energy state of principal quantum numbers n_i to the n = 2 state. If the photon emitted has a wavelength of 434 nm, what is the value of n_i?

$$\Delta E_{atom} = E_{photon} = h\nu = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J{\cdot}s)(2.998 \times 10^{8}\ m/s)}{434 \times 10^{-9} m} = -4.58 \times 10^{-19}\ J$$

(negative number because it is an emission process)

$$\Delta E = R_H \left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] = -4.58 \times 10^{-19} J = (2.179 \times 10^{-18} J)\left[\frac{1}{n_i^2} - \frac{1}{2^2}\right]$$

$$\frac{-4.58 \times 10^{-19} J}{2.179 \times 10^{-18} J} = \frac{1}{n_i^2} - 0.250 \quad \text{(keep 3 sf)} \qquad -0.210 + 0.250 = \frac{1}{n_i^2} = 0.040$$

$$n_i = \frac{1}{\sqrt{0.040}} \qquad \boxed{n_i = 5}$$

8.) Protons can be accelerated to speeds near that of light in particle accelerators. Estimate the deBroglie wavelength (in nm) of such a proton moving at 2.90×10^{8} m/s. (mass of a proton = 1.673×10^{-27} kg).

$$1\ J = \frac{1\ kg{\cdot}m^2}{s^2} \qquad \lambda = \frac{h}{mu}$$

$$h = 6.626 \times 10^{-34}\ J{\cdot}s \times \frac{1\ kg{\cdot}m^2}{s^2} = 6.626 \times 10^{-34}\ \frac{kg{\cdot}m^2}{s}$$

$$\lambda = \frac{6.626 \times 10^{-34}\ kg{\cdot}m^2/s}{(1.673 \times 10^{-27}\ kg)(2.90 \times 10^{8}\ m/s)} = 1.37 \times 10^{-15}\ m$$

$$1.37 \times 10^{-15}\ m \times \frac{1nm}{10^{-9}m} = \boxed{1.37 \times 10^{-6}\ nm}$$

9.) **Calculate the deBroglie wavelength (in nm) of a 3000. lb automobile traveling at 55 mi/hr.**

$$3000.\text{ lb} \times \frac{1\text{ kg}}{2.2046\text{ lb}} = 1361\text{ kg} \qquad \frac{55\text{ mi}}{1\text{ hr}} \times \frac{1\text{ km}}{0.6214\text{ mi}} \times \frac{10^3\text{ m}}{1\text{ km}} \times \frac{1\text{ hr}}{60\text{ min}} \times \frac{1\text{ min}}{60\text{ sec}} = 25\,\frac{\text{m}}{\text{s}}$$

$$\lambda = \frac{h}{mu} = \frac{6.626 \times 10^{-34}\ \text{kg}\cdot\text{m}^2/\text{s}}{(1361\text{ kg})(25\text{ m/s})} = 1.9 \times 10^{-38}\text{ m} \times \frac{1\text{ nm}}{10^{-9}\text{ m}} = \boxed{1.9 \times 10^{-29}\text{ nm}}$$

10.) **What are the possible values of *l* for an electron with n=3?**

$l = (0\ldots.n\text{-}1)$ $\qquad$ $l = 0,1,2$

11.) **For the following subshells give the values of the quantum numbers (n, l and m_l) and the number of orbitals in each subshell.**

(a) 4*p*	(b) 3*d*	(c) 3s	(d) 5f
$n = 4$	$n = 3$	$n = 3$	$n = 5$
$l = 1$	$l = 2$	$l = 0$	$l = 3$
$m_l = -1,0,+1$	$m_l = -2,-1,0,+1,+2$	$m_l = 0$	$m_l = -3,-2,-1, 0,+1,+2,+3$
(3 p orbitals)	*(5 d orbitals)*	*(1 s orbital)*	*(7 f orbitals)*

12.) **For each of the following, give the subshell designation, the allowable m_l values, and the number of orbitals.**

(a) n = 2, $l = 0$ 2*s*, $m_l = 0$, (1 orbital)

(b) n = 3, $l = 2$ 3*d*, $m_l = -2,-1,0,+1,+2$ (5 orbitals)

(c) n = 5, $l = 1$ 5*p*, $m_l = -1,0,+1$ (3 orbitals)

13.) **Are the following quantum number combinations allowed? If not, show two ways to correct them.**

(a) n = 1; $l = 0$; $m_l = 0$ yes. 1*s*

(b) n = 2; $l = 2$; $m_l = +1$ No
$n = 3$; $l = 2$; $m_l = +1$ or $n = 2$; $l = 1$; $m_l = +1$

(c) n = 7; $l = 1$; $m_l = +2$ No
$n = 7$; $l = 1$; $m_l = +1$ or $n = 7$; $l = 2$; $m_l = +2$

(d) n = 3; $l = 1$; $m_l = -2$ No
$n = 3$; $l = 1$; $m_l = -1$ or $n = 3$; $l = 2$; $m_l = -2$

14.) The energy required to remove an electron from metal X is $\Delta E = 3.31 \times 10^{-20}$ J. Calculate the maximum wavelength of light that can photo eject an electron from metal X.

$$E = \frac{hc}{\lambda} \rightarrow \quad \lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34}\ \text{J·s})(2.998 \times 10^{8}\ \text{m/s})}{3.31 \times 10^{-20}\ \text{J}}$$

$$\lambda = 6.00 \times 10^{-6}\ \text{m} \times \frac{1\text{nm}}{10^{-9}\text{m}} = \boxed{6.00 \times 10^{3}\ \text{nm}}$$

15.) If an electron has a velocity of 5.0×10^{5} m/s, what is its wavelength in m?

$$1\ \text{J} = \frac{1\ \text{kg} \cdot \text{m}^2}{\text{s}^2}$$

$$\lambda = \frac{h}{mu}$$

$$m = \text{mass of electron} = 9.109 \times 10^{-28}\text{g} \times \frac{1\ \text{kg}}{10^{3}} = 9.109 \times 10^{-31}\ \text{kg}$$

$$h = 6.626 \times 10^{-34}\ \text{J·s} \times \frac{1\ \text{kg} \cdot \text{m}^2}{\text{s}^2} = 6.626 \times 10^{-34}\ \frac{\text{kg} \cdot \text{m}^2}{\text{s}}$$

$$\lambda = \frac{6.626 \times 10^{-34}\ \text{kg} \cdot \text{m}^2/\text{s}}{(9.109 \times 10^{-31}\ \text{kg})(5.0 \times 10^{5}\ \text{m/s})} \qquad \boxed{\lambda = 1.5 \times 10^{-9}\ \text{m}}$$

16.) The laser used to read information from a compact disk has a wavelength of 780 nm. What is the energy associated with one photon of this radiation?

$$E_{photon} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J·s})(2.998 \times 10^{8}\ \text{m/s})}{780 \times 10^{-9}\ \text{nm}} = \boxed{2.55 \times 10^{-19}\ \text{J}}$$

17.) The retina of a human eye can detect light when radiant energy incident on it is at least 4.0×10^{-17} J. For light of 600 nm wavelength, how many photons does this correspond to?

1.) Determine the energy of 1 photon:

$$E_{photon} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J·s})(2.998 \times 10^{8}\ \text{m/s})}{600 \times 10^{-9}\ \text{nm}} = 3.31 \times 10^{-19}\ \text{J/ photon}$$

2.) Calculate # photons needed to produce given amount of energy:

$$4.0 \times 10^{-17}\ \text{J} \times \frac{1\ \text{photon}}{3.31 \times 10^{-19}\ \text{J}} = \boxed{1.2 \times 10^{2}\ \text{photons}}$$