REVIEW QUESTIONS
Chapter 7

1. Calculate the wavelength and energy of a photon of radiation with frequency of $2.85 \times 10^{12}\ s^{-1}$.

$$\lambda = \frac{c}{\upsilon} = \frac{3.00 \times 10^{8}\ m/\cancel{s}}{2.85 \times 10^{12}\ \cancel{s}^{-1}} = 1.05 \times 10^{-4} m$$

$$E = h\upsilon = (6.626 \times 10^{-34}\ J\cancel{s})(2.85 \times 10^{12}\ \cancel{s}^{-1}) = 1.89 \times 10^{-21}\ J$$

2. What is the wavelength of radiation with energy of 8.23×10^{-19} J? In what region of the electromagnetic spectrum would this radiation be found?

$$\upsilon = \frac{E}{h} = \frac{8.23 \times 10^{-19}\ \cancel{J}}{6.626 \times 10^{-34}\ \cancel{J}s} = 1.24 \times 10^{15}\ s^{-1}$$

$$\lambda = \frac{c}{\upsilon} = \frac{3.00 \times 10^{8}\ m/s}{1.24 \times 10^{15}\ s^{-1}} = 2.42 \times 10^{-7}\ m = 242\ nm\ (UV\ region)$$

3. For each of the following transitions in the hydrogen atom, calculate the energy, wavelength and frequency of the associated radiation and determine whether radiation is absorbed or emitted during the transition.

a) from n=5 to n=1

$$\frac{1}{\lambda} = 1.097 \times 10^{7}\ \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) m^{-1} = 1.097 \times 10^{7}\ \left(\frac{1}{1} - \frac{1}{25}\right)$$

$$\lambda = 9.50 \times 10^{-8}\ m$$

$$\upsilon = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ \cancel{m}/s}{9.50 \times 10^{-8}\ \cancel{m}} = 3.16 \times 10^{15}\ s^{-1}$$

$$E = h\upsilon = (6.626 \times 10^{-34}\ J\cancel{s})(3.16 \times 10^{15}\ \cancel{s}^{-1}) = 2.09 \times 10^{-18}\ J$$

Energy is emitted by this transition

b) from n=2 to n=6

$$\frac{1}{\lambda} = 1.097 \times 10^{7}\ \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) m^{-1} = 1.097 \times 10^{7}\ \left(\frac{1}{4} - \frac{1}{36}\right)$$

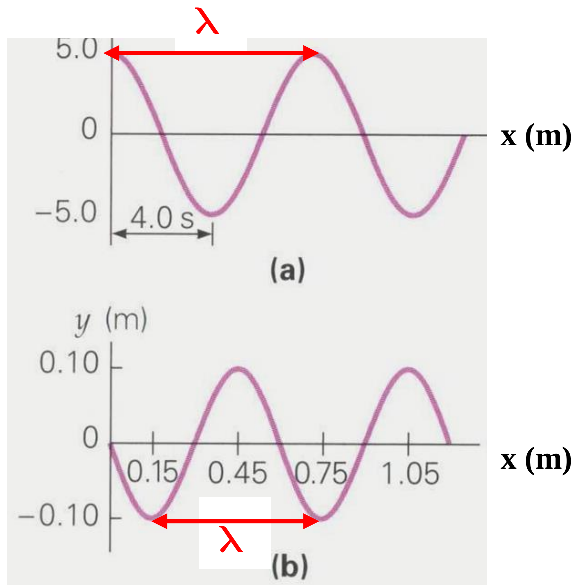
$$\lambda = 4.10 \times 10^{-7}\ m$$

$$\upsilon = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ \cancel{m}/s}{4.10 \times 10^{-7}\ \cancel{m}} = 7.31 \times 10^{14}\ s^{-1}$$

$$E = h\upsilon = (6.626 \times 10^{-34}\ J\cancel{s})(7.31 \times 10^{14}\ \cancel{s}^{-1}) = 4.84 \times 10^{-19}\ J$$

Energy is absorbed by this transition

4. Use the diagrams below to determine the wavelength and frequency of each wave shown. (Assume the same time and distance scale for both waves)



For wave (a)

$\lambda = 0.75$ m

$$\upsilon = \frac{1 \text{ wave}}{8.0 \text{ s}} = 0.125 \text{ s}^{-1}$$

For wave (b)

$\lambda = 0.60$ m

$$\upsilon = \frac{1 \text{ wave}}{6.0 \text{ s}} = 0.166 \text{ s}^{-1}$$

5. The energy needed to remove an electron completely from an atom is called its *ionization energy*. In terms of Bohr's model, ionization can be considered a process in which the electron moves to an "orbit" of infinite radius. The ionization of a ground-state hydrogen atom can therefore be calculated by assuming that the electron undergoes a transition from n_i=1 state to n_f=∞ state. Calculate this energy in kJ/mol.

$$\frac{1}{\lambda} = 1.097\text{x}10^{7}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{m}^{-1} = 1.097\text{x}10^{7}\left(\frac{1}{1} - \frac{1}{\infty}\right) \qquad \frac{1}{\infty} = 0$$

$$\lambda = 9.12\text{x}10^{-8} \text{ m}$$

$$\upsilon = \frac{c}{\lambda} = \frac{3.00\text{x}10^{8} \cancel{\text{m}}/\text{s}}{9.12\text{x}10^{-8} \cancel{\text{m}}} = 3.29\text{x}10^{15} \text{ s}^{-1}$$

$$E = h\upsilon = (6.626\text{x}10^{-34} \text{ J}\cancel{\text{s}})(3.29\text{x}10^{15} \cancel{\text{s}}^{-1}) = 2.18\text{x}10^{-18} \text{ J}$$

$$E = \frac{2.18\text{x}10^{-18} \text{ J}}{1 \cancel{\text{atom}}} \text{x} \frac{6.02\text{x}10^{23} \cancel{\text{atoms}}}{1 \text{ mol}} \text{x} \frac{1 \text{ kJ}}{10^{3} \text{ J}} = 1.31\text{x}10^{3} \text{ kJ/mol}$$

6. The energy required to ionize sodium atom is 496 kJ/mol. What minimum frequency of light is required to ionize sodium?

$$E = \frac{496 \text{ kJ}}{1 \text{ mol}} \text{x} \frac{10^{3} \text{ J}}{1 \text{ kJ}} \text{x} \frac{1 \text{ mol}}{6.02\text{x}10^{23} \text{ atoms}} = 8.2\underline{3}9\text{x}10^{-19} \text{ J/atom}$$

$$\upsilon = \frac{E}{h} = \frac{8.2\underline{3}9\text{x}10^{-19} \text{ J}}{6.626\text{x}10^{-34} \text{ Js}} = 1.24\text{x}10^{15} \text{ s}^{-1}$$

7. The binding energy of electrons in a metal is 193 kJ/mol. Determine the threshold frequency for this metal.

$$\mathbf{E = \frac{193\ kJ}{1\ mol} x \frac{10^3\ J}{1\ kJ} x \frac{1\ mol}{6.02x10^{23}\ atoms} = 3.2\underline{0}6x10^{-19}\ J/atom}$$

$$\mathbf{\upsilon = \frac{E}{h} = \frac{3.2\underline{0}6x10^{-19}\ J}{6.626x10^{-34}\ Js} = 4.84x10^{14}\ s^{-1}}$$

8. Determine the velocity of an electron emitted by a metal whose threshold frequency is $2.25x10^{14}$ s^{-1} when it is exposed to visible light of $5.00x10^{-7}$ m. (mass of electron= $9.11x10^{-28}$ g)

Threshold Energy (E_{thr}) = hυ= ($6.626x10^{-34}$Js)($2.25x10^{14}$ s) = $1.49x10^{-19}$ J

Energy of visible light (E_{vis}) = $$\mathbf{\frac{hc}{\lambda} = \frac{(6.626x10^{-34}Js)(3.00x10^{8}\ m/s)}{5.00x10^{-7}\ m} = 3.98x10^{-19}\ J}$$

Excess energy available to accelerate the electron = E_{vis} - E_{thr} = $2.49x10^{-19}$ J

$$\mathbf{v = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2(2.49x10^{-19}\ J)}{9.11x10^{-31}\ kg}} = 7.39x10^{5}\ m/s}$$

9. Determine if each set of quantum numbers below is permissible or not. If yes, write the orbital designation for each.

a)	n= 2	l=1	m_l= +1	**Yes**	**2p**
b)	n= 1	l=0	m_l= –1	**No (m$_l$ cannot be greater than l)**	
c)	n= 4	l= 2	m_l= +1	**Yes**	**4d**
d)	n= 3	l= 3	m_l= 0	**No (l values cannot exceed n–1)**	

10. Write the quantum numbers associated with each of the following orbitals:

a)	4p	n= **4**	l= **1**	m_l= **+1, 0 or –1**
b)	3d	n= **3**	l= **2**	m_l= **+2, +1, 0, –1 or –2**
c)	7s	n= **7**	l= **0**	m_l= **0**
d)	5f	n= **5**	l= **3**	m_l= **+3, +2, +1, 0, –1, –2 or –3**

11. The quantum numbers listed below are for four different orbitals. List them in order of increasing energy. Indicate whether any two have the same energy.

a)	n= 4	l= 0	m_l= 0	**4s**
b)	n= 3	l= 2	m_l= +1	**3d**
c)	n= 3	l= 1	m_l= –1	**3p**
d)	n= 3	l= 2	m_l= 0	**3d**

c < a < b = d

12. When a compound containing cesium is heated in a Bunsen burner flame, photons with energy of 4.30 x10^{-19} J are emitted. What color is the cesium flame?

$$\upsilon = \frac{E}{h} = \frac{4.30\text{x}10^{-19}\ \cancel{J}}{6.626\text{x}10^{-34}\ \cancel{J}s} = 6.49\text{x}10^{14}\ s^{-1}$$

$$\lambda = \frac{c}{\upsilon} = \frac{3.00\text{x}10^{8}\ m/s}{6.49\text{x}10^{14}\ s^{-1}} = 4.62\text{x}10^{-7}\ m = 462\ nm \quad \textbf{(Blue-green color)}$$

13. The He^+ ion contains one electron and is therefore a hydrogen-like ion. Calculate the wavelength of the first four electron transitions (6→2, 5→2, 4→2 and 3→2) for this ion and compare with the same transitions in the H atom. Comment on the differences.
(R for He^+=$8.72x10^{-18}$ J)

$$\frac{1}{\lambda} = \frac{R_{He}}{hc}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 4.39x10^7\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) m^{-1}$$

$$\frac{R_{He}}{hc} = \frac{8.72x10^{-18}\ \cancel{J}}{(6.626x10^{-34}\ \cancel{Js})(3.00x10^8\ \cancel{m}/s)} = 4.39x10^7 m^{-1}$$

For transition 6 → 2 $\lambda = 1.03x10^{-7}$ **m = 103 nm (H= 411 nm)**

For transition 5 → 2 $\lambda = 1.08x10^{-7}$ **m = 108 nm (H= 434 nm)**

For transition 4 → 2 $\lambda = 1.21x10^{-7}$ **m = 121 nm (H= 487 nm)**

For transition 3 → 2 $\lambda = 1.64x10^{-7}$ **m = 164 nm (H= 657 nm)**

All H transitions are in the visible region, while He^+ transitions are in the UV region