Chapter 3 Practice Problems:

1. In the visible range of the electromagnetic spectrum, which color has the longest wavelength?
2. In the visible range of the electromagnetic spectrum, which color has the highest frequency?
3. Which color has the most energy associated with it?
4. Calculate the frequency of light that has a wavelength of 562 nm.
5. Calculate the wavelength of light (in nm) with a frequency of 4.33×10^{14} Hz. What color might this be?
6. Calculate the frequency of light with a wavelength 2.50×10^{-7}m.
7. What is the energy (in Joules) of green light with a frequency of 5.26×10^{14} hz?
8. What is the frequency of a wave with 8.35×10^{-18} J of energy?
9. What is the energy of a wave with a wavelength of 5.62×10^{-7} m?
10. What is the wavelength of a 3.537×10^{-19} J wave?
11. Calculate the energy of the photon emitted when an electron transitions from the $n = 3$ state to the $n = 1$ state in a hydrogen atom.
12. Calculate the wavelength of the photon emitted when an electron in a hydrogen atom transitions from energy level 4 to n = 3.
13. An electron moves with a velocity of 2.5×10^{8} cm/s. What is its wavelength?
14. Calculate the wavelength (in nanometers) associated with a 1.10×10^{2} g golf ball moving at 31.0 m/s (about 67 mph). How fast must the ball travel to have a wavelength of 5.65×10^{-3} nm?
15. State the four quantum numbers, then explain the possible values they may have and what they actually represent.
16. Which of the following sets of quantum numbers describe an impossible situation? Explain why.

    a. $n = 2, l = 1, m_l = 2, m_s = +½$

    b. $n = 5, l = 2, m_l = 1, m_s = -½$

    c. $n = 6, l = 6, m_l = 0, m_s = -½$

    d. $n = 3, l = 2, m_l = 1, m_s = 0$

    e. $n = 4, l = 2, m_l = 1, m_s = +½$

17. Give the n and l values for the following orbitals
    a. 1s b. 3s c. 2p d. 4d e. 5f
18. What is the ml values for the following types of orbitals?
    a. s b. p c. d d. f
19. How many possible orbitals are there for n =
    a. 4 b. 3

ANSWERS:

1. In the visible range of the electromagnetic spectrum, which color has the longest wavelength?
   red
2. In the visible range of the electromagnetic spectrum, which color has the highest frequency?
   Violet
3. Which color has the most energy associated with it?
   Violet
4. Calculate the frequency of light that has a wavelength of 562 nm.

   $c = \upsilon\lambda$ rearrange: $\upsilon = c/\lambda$ $\quad\upsilon = \frac{(2.998 \times 10^{8}\ m/s)}{(562\ nm \times \frac{1\ m}{1 \times 10^{9} nm})} = 5.33 \times 10^{14}$ Hz (recall Hz $= \frac{1}{s}$)

5. Calculate the wavelength of light (in nm), with a frequency of 4.33×10^{14} Hz. What color might this be?

   $\lambda = c/\upsilon$ $\quad\lambda = \frac{2.998 \times 10^{8}\ m/s}{4.33 \times 10^{14} s^{-1}} = 6.92 \times 10^{-7}\ m \times \frac{1 \times 10^{9}\ nm}{1\ m} = 692$ nm; red

6. Calculate the frequency of light with a wavelength 2.50×10^{-7}m.

   $\upsilon = c/\lambda$ $\quad\upsilon = \frac{2.998 \times 10^{8}\ m/s}{2.50 \times 10^{-7} m} = 1.20 \times 10^{15}$ Hz

7. What is the energy (in Joules) of green light with a frequency of 5.26×10^{14} hz?

   $E = h\upsilon$ $\quad E = (6.626 \times 10^{-34}\ J\ s)(5.26 \times 10^{14} s^{-1}) = 3.49 \times 10^{-19}$ J

8. What is the frequency of a wave with 8.35×10^{-18} J of energy?

   $E = h\upsilon$ $\quad\upsilon = E/h$ $\quad\upsilon = \frac{(8.35 \times 10^{-18} J)}{(6.626 \times 10^{-34} J\ s)} = 1.26 \times 10^{16}$ Hz

9. What is the energy of a wave with a wavelength of 5.62×10^{-7} m?

   $E = h\upsilon$ and $\upsilon = c/\lambda$ so, $E = hc/\lambda$ $\quad E = \frac{(6.626 \times 10^{-34} Js)(\frac{2.998 \times 10^{8} m}{s})}{5.62 \times 10^{-7} m} = 3.53 \times 10^{-19}$ J

10. What is the wavelength of a 3.537×10^{-19} J wave (J = Energy)?

    $E = h\upsilon$ or $E/h = \upsilon$ $\quad\upsilon = \frac{3.537 \times 10^{-19} J}{6.626 \times 10^{-34} J\ s} = 5.338062179 \times 10^{14}\ s^{-1}$ plug into $\lambda = c/\upsilon$

    $\lambda = \frac{2.998 \times 10^{8} m/s}{5.338062179 \times 10^{14} s^{-1}} = 5.62 \times 10^{-7}$ or 562 nm (green light)

11. Calculate the energy of the photon emitted when an electron transitions from the $n = 3$ state to the $n = 1$ state in a hydrogen atom.

Use the Rydberg equation: $E = 2.18\text{x}10^{-18}\text{J}\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 1.94\text{x}10^{-18}$ J

12. Calculate the wavelength of the photon emitted when an electron in a hydrogen atom transitions from energy level 4 to n = 3.

Use the Rydberg equation: $E = 2.18\text{x}10^{-18}\text{J}\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = 1.0\underline{5}97222\text{x}10^{-19}$ J (energy)

$E = hc/\lambda$ so $\lambda = hc/E = \dfrac{(6.626x\,10^{-34}Js)(\frac{2.998\,x\,10^{8}m}{s})}{1.0597222\,x\,10^{-19}J} = 1.88\text{x }10^{-6}\text{m}$

13. An electron moves with a velocity of $2.5 \text{ x } 10^8$ cm/s. What is its wavelength?

Use De Broglie equation: $\lambda = h/mv = \dfrac{6.626\,x10^{-34\,J\,s}}{(9.10938\,x10^{-31}kg)(\frac{2.5\,x10^{8}cm}{s})(\frac{1\,m}{100\,cm})} = 2.9\text{x}10^{-10}\text{m}$

Look at units…Remember J =kg m^2/s^2 So, $\lambda = \dfrac{\frac{kg\,m^2}{s^2}*s}{kg*\frac{m}{s}} = m$

14. Calculate the wavelength (in nanometers) associated with a $1.10 \text{ x } 10^2$ g golf ball moving at 31.0 m/s (about 67 mph). How fast must the ball travel to have a wavelength of $5.65 \text{ x } 10^{-3}$ nm?

$\lambda = h/mv$ $\qquad \lambda = \dfrac{6.626\,x10^{-34\,J\,s}}{(110.g)(\frac{1\,kg}{1000\,g})(\frac{31.0m}{s})} = 1.94\text{x}10^{-34}\text{m}$

$v = h/m\lambda$ $\qquad v = \dfrac{6.626\,x10^{-34\,J\,s}}{(0.110\,kg)(5.65x10^{-3}nm)(\frac{1\,m}{1x10^{9}nm})} = 1.07\text{x}10^{-21}$ m/s

15. State the four quantum numbers, then explain the possible values they may have and what they actually represent.

n – Principal Quantum Number: represents the energy level (periods 1-7)

l – Angular Momentum Quantum number: represents the shape of the orbital- s, p, d, f (0…n-1)

m_l – Magnetic quantum number: number of orbitals possible. ($-l$,…0…$+l$)

m_s – Spin Quantum number: direction of electron spin. (+1/2 or -1/2)

16. Which of the following sets of quantum numbers describe an impossible situation? Explain why.

a. $n = 2,\ l = 1,\ m_l = 2,\ m_s = +½$ l = 1 then m_l can only = -1, 0, 1

b. $n = 5,\ l = 2,\ m_l = 1,\ m_s = -½$

c. $n = 6,\ l = 6,\ m_l = 0,\ m_s = -½$ n = 6, then l can = 5 or less (s, p, d, f)

d. $n = 3,\ l = 2,\ m_l = 1,\ m_s = 0$ m_s can't = 0

e. $n = 4,\ l = 2,\ m_l = 1,\ m_s = +½$

17. Give the n and l values for the following orbitals
   a. 1s n=1, l = 0 b. 3s n=3, l = 0 c. 2p n=2, l = 1 d. 4d n=4, l = 2 e. 5f n=5, l = 3

18. What is the ml values for the following types of orbitals?
   b. s 0 b. p -1,0,+1 c. d -2,-1,0,+1,+2 d. f -3-2,-1,0,+1,+2,+3

19. How many possible orbitals are there for n =
   b. 4 s=1, p=3, d=5, f=7 = 16 total b. 3 9 orbitals