$R_H = 2.179 \times 10^{-18} J$ $c = 3.00 \times 10^8 m/s$

$S.H._{H_2O} = 4.184 J/g^\circ$ $h = 6.63 \times 10^{-34} J \cdot s$

$mass_{neutron} = 1.67493 \times 10^{-27} kg$

Practice Problems – Quantum Theory of the Atom:

1. What is the wavelength of microwave radiation whose frequency is $1.258 \times 10^{10} s^{-1}$?

$\lambda = \frac{c}{\nu}$ $\lambda = 3.00 \times 10^8 m/s \,/\, 1.258 \times 10^{10} s^{-1} = 2.38 \times 10^{-2} m = \underline{2.38 cm}$

2. Light with a wavelength of 478nm lies in the blue region of the visible spectrum. Calculate the frequency of this light.

$\nu = \frac{c}{\lambda}$ $\nu = 3.00 \times 10^8 m/s \,/\, 478 \times 10^{-9} m = 0.00628 \times 10^{17} s^{-1} = \underline{6.28 \times 10^{14} s^{-1}}$

3. What is the energy of a photon corresponding to microwave radiation of frequency $1.258 \times 10^{10} s^{-1}$?

$E = h\nu$ $E = (6.63 \times 10^{-34} J \cdot s)(1.258 \times 10^{10} s^{-1}) = \underline{8.34 \times 10^{-24} J}$

4. An electron in a hydrogen atom in the level n=5 undergoes a transition to level n=3. What does the Bohr model of the atom predict for the frequency of the emitted radation?

$\Delta E = -R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) = -2.179 \times 10^{-18} J \left(\frac{1}{3^2} - \frac{1}{5^2} \right) = -1.55 \times 10^{-19} J$

$E = h\nu$

$\nu = \frac{E}{(6.63 \times 10^{-34})}$

$\nu = \frac{-1.55 \times 10^{-19}}{6.63 \times 10^{-34}}$

$\nu = 0.234 \times 10^{15}$

$\nu = 2.34 \times 10^{14} s^{-1}$

5. What is the wavelength of a neutron traveling at a speed of 4.15 km/s?

$\lambda = \frac{h}{mv}$ *note below $= \frac{(6.63 \times 10^{-34})}{(1.674 \times 10^{-27})(4.15 \times 10^3)} = \underline{9.54 \times 10^{-11} m}$

6. Explain why the following sets of quantum numbers never occur:

a. n=1 l=0 m_l=0 m_s=+1
b. n=1 l=3 m_l=+3 m_s=+½
c. n=3 l=2 m_l=+3 m_s=-½
d. n=0 l=1 m_l=0 m_s=+½
e. n=2 l=1 m_l=-1 m_s=+3/2

(a.) and (e.) are not allowed because m_s must always be $+\frac{1}{2}$ or $-\frac{1}{2}$. (b.) and (d.) are not allowed because l must always be less than n. (c.) is not allowed because m_l may not be greater than l.

7. The energy of a photon is $3.34 \times 10^{-19} J$. What is the wavelength of the light? What color is this?

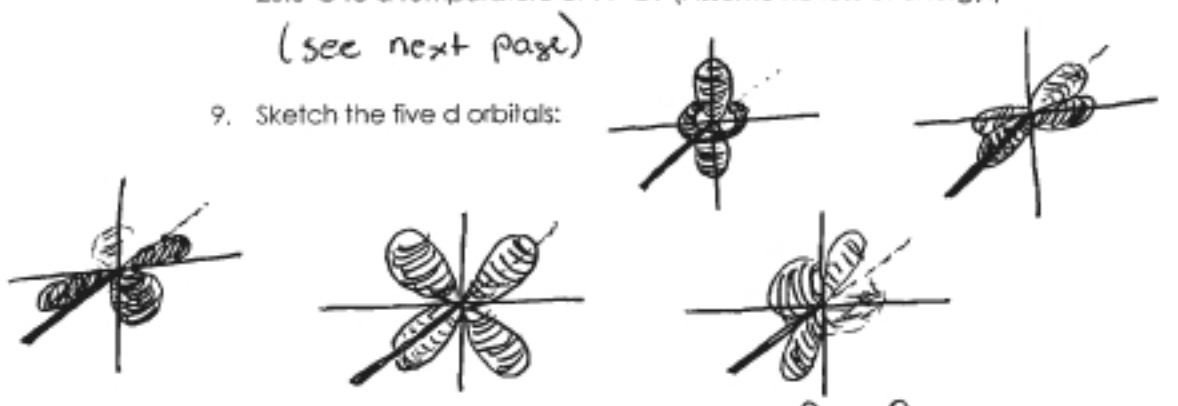
$\lambda = \frac{hc}{E}$ $E = h\nu = \frac{hc}{\lambda}$ $\frac{(6.63 \times 10^{-34} J \cdot s)(3.00 \times 10^8 m/s)}{(3.34 \times 10^{-19} J)} = 5.96 \times 10^{-7} m$ 596nm

yellow-orange

8. A microwave oven heats by radiating food with microwave radiation, which is absorbed by the food and converted to heat. If the radiation wavelength is 12.5 cm, how many photons of this radiation would be required to heat a container with 0.250 L of water from a temperature of 20.0°C to a temperature of 99°C? (Assume no loss of energy.)

(see next page)

9. Sketch the five d orbitals:



ν is "nu" and is the symbol for frequency

v is "vee" and is the symbol for velocity

$\lambda = 12.5\,cm$

$V = 0.250\,L\,H_2O \Rightarrow 250\,mL$

$\Delta T = 20°C \longrightarrow 99°C = 79°$

$q = \Delta T \cdot S.H_{H_2O} \cdot mass = (79)(4.184)(250) = 82,634\,J$

(assume density water = $1.00\,g/mL$)

$$E = h\nu = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{(12.5\times10^{-2})} = 1.59\times10^{-24}\,J$$

"one photon"

$$\#\ photons = \frac{\text{total energy}}{\text{energy per photon}} = \frac{82,634}{1.59\times10^{-24}}$$

$$\#\ photons = 5.2\times10^{28}$$