HW 7: 1, 4, 6, 7, 8, 10, 13, 17, 21

1. UVA: highest energy \( \lambda = 315 \text{ nm} \)
   
   A. \( \nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{315 \times 10^{-9} \text{ m}} = 9.52 \times 10^{14} \text{ s}^{-1} = 9.52 \times 10^{14} \text{ Hz} \)

   B. \( E = h\nu = (6.626 \times 10^{-34} \text{ J s})(9.52 \times 10^{14} \text{ s}^{-1}) = 6.31 \times 10^{-19} \text{ J/photons} \)

   C. \( \frac{6.31 \times 10^{-19} \text{ J}}{6.022 \times 10^{23} \text{ photons}} \times \frac{1 \text{ kJ}}{1 \text{ mol photons}} \times 1000 = 3.80 \times 10^2 \text{ kJ/mol} \)

   D. \( \frac{100.0 \text{ J}}{6.31 \times 10^{-19} \text{ J}} = 1.58 \times 10^{20} \text{ photons} \)

UVB:

A. \( \nu = \frac{c}{\lambda} = 1.07 \times 10^{15} \text{ s}^{-1} \)

B. \( E = 7.69 \times 10^{-19} \text{ J/photons} \)

C. \( E = 427 \text{ kJ/mol} \)

D. \( 1.41 \times 10^{20} \text{ photons} \)
4. A. \( n_1 = 3 \) to \( n_2 = 4 \) for Li\(^{2+}\)

\[
E = -2.18 \times 10^{-18} \text{ J} \quad (3^2) \left( \frac{1}{4^2} - \frac{1}{3^2} \right) = 9.54 \times 10^{-19} \text{ J/photons}
\]

\[
E = \frac{hc}{\lambda} \quad \Rightarrow \quad \lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} \text{ J s})(3.00 \times 10^8 \text{ m/s})}{9.54 \times 10^{-19} \text{ J}}
\]

\[\lambda = 2.08 \times 10^{-7} \text{ m} = 208 \text{ nm} \quad \text{ultraviolet, absorbed}\]

B. \( n_1 = 2 \) to \( n_2 = 5 \) for Li\(^{2+}\)

\[
E = 4.12 \times 10^{-18} \text{ J/photons} \quad \lambda = 4.82 \times 10^{-8} \text{ m} = 482 \text{ nm}
\]

absorbed, deep UV (ultraviolet is a fine answer)

C. \( n_1 = 4 \) to \( n_2 = 1 \) \( E = 1.84 \times 10^{-17} \text{ J/photons} \)

\[
\lambda = -1.08 \times 10^{-8} \text{ m} = -10.8 \text{ nm}
\]

deep UV

"negative" wavelength just means it's emitted

D. \( E = 5.45 \times 10^{-19} \text{ J/photons} \)

\[
\lambda = 3.15 \times 10^{-7} \text{ nm} = 365 \text{ nm} \quad \text{UV absorbed}\]
6. A. 5p sublevel
   \[ n=5, \ell = 1, M_{\ell} = -1, 0, 1 \]
   3 possibilities = 3 orbitals in sublevel

B. 3s
   \[ n=3, \ell = 0, M_{\ell} = 0 \]

C. 4f
   \[ n=4, \ell = 3, M_{\ell} = -3, -2, -1, 0, 1, 2, 3 \]

8A. \[
\frac{2.4 \times 10^3 \text{ kJ/mol}}{1 \text{ mol e}^-} \frac{1 \text{ mol e}^-}{6.022 \times 10^{23} \text{ e}^-} \frac{1000 \text{ J}}{1 \text{ kJ}} = 3.99 \times 10^{-18} \text{ J/e}^- \]

KE = \( \frac{1}{2} mv^2 \)

\[
3.99 \times 10^{-18} \text{ J} = \frac{1}{2} (9.1 \times 10^{-31} \text{ kg})(v^2) \]

\[
v = 2.96 \times 10^6 \text{ m/s} \]

B. \( (\Delta x)(\Delta v) \geq \frac{\hbar}{4\pi} \) use equal sign for minimum uncertainty

\[
\Delta v = 10\% \text{ of } v = 2.96 \times 10^5 \text{ m/s} \]

\[
\Delta x = \frac{\hbar}{4\pi (\Delta v)} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{4\pi (9.1 \times 10^{-31} \text{ kg})(2.96 \times 10^5 \text{ m/s})} \]

\[
\Delta x = 1.96 \times 10^{-10} \text{ m} \]

C. 130 pm = 1.30 \times 10^{-10} \text{ m} \quad \text{Yes!}

10. resolution = 0.20 \text{ nm} = \lambda

\[
v = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{(9.1 \times 10^{-31} \text{ kg})(0.20 \times 10^{-9} \text{ m})} = 3.6 \times 10^6 \text{ m/s} \]

\[ \text{up, pretty fast! But remember, can't be faster than speed of light} \]
A. 

B. 

C. 

2pₓ does not touch nucleus.

2s and 2pₓ have the same outer radius.
13.a.

\[
\frac{1.020 \text{ oz}}{102} \rightarrow 0.0459 \text{ kg}
\]

\[
13.5 \text{ miles} | 1.609 \text{ km} | 1000 \text{ m} | 1 \text{ hr} | 1 \text{ min} = 60.3 \text{ m/s}
\]

\[
\frac{1 \text{ mile}}{1 \text{ km}} \rightarrow \frac{1 \text{ km}}{1 \text{ mile}} \text{ and } \frac{60 \text{ min}}{1 \text{ hr}} \rightarrow \frac{60 \text{ sec}}{1 \text{ min}}
\]

\[
J_{\text{golfball}} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{(0.0459 \text{ kg})(60.3 \text{ m/s})}
\]

\[
J_{\text{golfball}} = 2.39 \times 10^{-34} \text{ m}
\]

b. These \( J \) are impossible to see.
B. Based upon this answer, what general conclusion can you make regarding the wave properties of macroscopic objects? Are they observable with the unaided human eye?

14. A solar oven collects the visible light from the sun over a broad area and focuses it into a small area. This focused energy is used to cook food or heat water for cooking. Choose any wavelength in the visible light region of the spectrum and calculate the number of photons necessary to heat 125 g of water from 20°C to 100°C.

15. A muon is a particle with about 200 times more mass than an electron. To be exact, one muon has a mass of $1.89 \times 10^{-25}$ g. What is the wavelength (in nm) of a muon traveling at $2.88 \times 10^8$ m/s.

16. For the lowest energy emission in the Brackett series line spectrum of $Na^+$ (a one electron system) determine the wavelength of the emitted photon in nm. (For the Brackett series, $n_1 = 4$.)

17. This question is about relationships between the 1s, 2s and 2p, orbitals
   A. Draw the 1s, 2s and 2p, orbitals on the same set of axes. Clearly show their relative sizes.

B. The radial probability functions below are for the 1s, 2s and 2p, orbitals along the x-axis. Clearly label each line with the correct type of sublevel on the graph below.

C. Use what you know about electron shielding, orbital shape, and effective nuclear charge to explain why, for a multi-electron atom, electrons in the 2s sublevel are lower energy than electrons in the 2p, sublevel. (6 points)

D. The 2s and 2p, sublevels have the same energy in one-electron atoms. Why? (3 points)

17D. The 2s and 2p, orbitals are the same any distance.

18. Certain “transition-lens” sunglasses have small crystals of silver chloride (AgCl) incorporated in the lenses. When the lenses are exposed to light of the appropriate wavelength, the following reaction occurs:

   from the nucleus and experience the same effective nuclear charge.