All problems on this quiz are homework problems, except problem #1.

1. True or False
   a) Albert Einstein won a Nobel Prize for his theory on the photoelectric effect. [1 pt]
      TRUE
   b) Blue light has a lower frequency than red light. [1 pt]
      FALSE

2. A 12.0 g sample of an unknown metal is heated to 91.0°C and is placed in a perfectly insulated container
   along with 136 g of water at an initial temperature of 21.45°C. After a short time the temperature of both the
   metal and water become equal at 24.65°C. The specific heat of water is 4.184 J/g°C in this temperature
   range. What is the specific heat, \( s \), of the metal? [4 pts]

   \[ q_{\text{metal}} = q_{\text{water}} \]
   \[ -m_{\text{m}}s_{\text{m}}\Delta T_{\text{m}} = +m_{\text{w}}s_{\text{w}}\Delta T_{\text{w}} \]
   \[ -(12.0 \text{ g})(s_{\text{m}})(24.65 - 91.0)\text{°C} = +(136 \text{ g})(4.184 \text{ J/g°C})(24.65 - 21.45)\text{°C} \]
   \[ s_{\text{metal}} = 2.29 \text{ J/g°C} \]

3. What is the frequency of an electromagnetic wave, the wavelength of which is \( 6.6 \times 10^{-8} \text{ m} \)?
   Circle the correct answer. [3 pts]
   a) \( 3.3 \times 10^{17} \text{ Hz} \)  b) \( 4.5 \times 10^{15} \text{ Hz} \)  c) 20 Hz  d) \( 2.2 \times 10^{-16} \text{ Hz} \)  e) \( 3.0 \times 10^{-18} \text{ Hz} \)

   \[ c = \lambda \nu \]
   \[ \nu = \frac{c}{\lambda} \]
   \[ \nu = \frac{3.00 \times 10^{8} \text{ m/s}}{6.6 \times 10^{-8} \text{ m}} \]
   \[ \nu = 4.5 \times 10^{15} \text{ Hz} \]

4. How much energy (in joules) is contained in one mole of photons of frequency \( 4.4 \times 10^{14} \text{ Hz} \)?
   Circle the correct answer. [3 pts]
   a) \( 1.4 \times 10^{9} \text{ J/mol} \)  b) \( 1.8 \times 10^{5} \text{ J/mol} \)  c) 46 J/mol
   d) \( 2.7 \times 10^{-16} \text{ J/mol} \)  e) \( 2.9 \times 10^{-19} \text{ J/mol} \)

   \[ E = h \nu \]
   \[ E = (6.626 \times 10^{-34} \text{ J⋅s})(4.4 \times 10^{14} /\text{s}) = 2.92 \times 10^{-19} \text{ J/photon} \]
   \[ \frac{2.92 \times 10^{-19} \text{ J}}{1 \text{ photon}} \times \frac{6.022 \times 10^{23} \text{ photons}}{1 \text{ mol}} = 1.8 \times 10^{5} \text{ J/mol} \]
5. **True or False.** When an electron in an (unbound) hydrogen atom \([H(g)]\) is excited from the ground state to the \(n = 3\) state:

a) The first excited state corresponds to \(n = 3\). [1 pt]

**FALSE, the first excited state is \(n = 2\).**

b) The electron is closer to the nucleus on average in the \(n = 3\) state than in the ground state. [1 pt]

**FALSE**

c) The wavelength of the light emitted when the electron returns to the ground state from \(n = 3\) is the same as the wavelength of light absorbed to go from \(n = 1\) to \(n = 3\). [1 pt]

**TRUE**

d) It takes less energy to ionize the electron from \(n = 3\) than it does from the ground state. [1 pt]

**TRUE**

e) The wavelength of light emitted when the electron drops from \(n = 3\) to \(n = 2\) is longer than the wavelength of light emitted if the electron falls from \(n = 3\) to \(n = 1\). [1 pt]

**TRUE**

6. The energy (in joules) of an electron energy level in the Bohr atom is given by the expression:

\[
E_n = -2.18 \times 10^{-18} \left( \frac{1}{n^2} \right) \]

where \(n\) is the principal quantum number for the energy level.

a) What is the energy (in J) of the electromagnetic radiation absorbed when an electron is raised up from level with \(n = 4\) to that with \(n = 8\)? [3 pts]

\[
\Delta E = -R_H \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = -2.18 \times 10^{-18} \left( \frac{1}{4^2} - \frac{1}{8^2} \right) = 1.02 \times 10^{-19} \text{ J}
\]

b) What is the frequency (in Hz) associated with the energy calculated in part (a)? [2 pts]

\[
E = h\nu
\]

\[
\nu = \frac{E}{h} = \frac{1.02 \times 10^{-19} \text{ J}}{6.626 \times 10^{-34} \text{ J} \cdot \text{s}} = 1.54 \times 10^{14} \text{ Hz}
\]

7. Calculate the de Broglie wavelength (in nm) of a neutron \((m_n = 1.67493 \times 10^{-27} \text{ kg})\) moving at one six thousandth of the speed of light \((c/6000)\). **Circle the correct answer.** [3 pts]

a) \(1.26 \times 10^{11} \text{ nm}\)  

b) \(7.91 \times 10^{-3} \text{ nm}\)  

c) \(2.20 \times 10^{-10} \text{ nm}\)  

d) \(7.91 \times 10^{-12} \text{ nm}\)  

e) \(2.20 \times 10^{-19} \text{ nm}\)

\[
\lambda = \frac{\hbar}{mu} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{(1.67493 \times 10^{-27} \text{ kg})(5.00 \times 10^4 \text{ m/s})} = 7.91 \times 10^{-12} \text{ m} = \text{7.91 \times 10^{-3} nm}
\]