Please show your work for all calculations, and report answers to the proper number of significant digits to receive full credit. For calculations, circle your final answer.

1. A certain electromagnetic wave have a wavelength of 3.50 cm.
   a. Determine the frequency of the radiation.

   \[ c = \lambda \nu \]
   \[ \nu = \frac{c}{\lambda} = \frac{2.998 \times 10^8 \text{ m/s}}{3.50 \times 10^{-2} \text{ m}} = 8.57 \times 10^9 \text{ Hz} = 8.57 \times 10^9 \text{ s}^{-1} \]

   b. Determine the energy of a photon of the radiation.

   \[ E = h\nu \quad \text{or} \quad E = \frac{hc}{\lambda} \]
   \[ E = (6.626 \times 10^{-34} \text{ Js})(8.57 \times 10^9 \text{ s}^{-1}) = 5.68 \times 10^{-24} \text{ J} \]

   c. In what region of the electromagnetic spectrum does this radiation fall.

   microwave radiation

   d. Determine the mass of a photon of the radiation.

   \[ \lambda = \frac{h}{mc^2} \quad \text{or} \quad E = mc^2 \]
   \[ m = \frac{h}{\lambda c} = \frac{(6.626 \times 10^{-34} \text{ Js})}{(3.50 \times 10^{-2} \text{ m}) \times (2.998 \times 10^8 \text{ m/s})} = 6.31 \times 10^{-41} \text{ kg} \]

2. In your own words, explain how the idea of photons can be used to rationalize the photoelectric effect.

   Each photon knocks one electron off the surface of the metal. If the photon does not have enough energy to break the attraction between the negative electron and the positive nucleus, then an electron will not be ejected. Since frequency is proportional to the energy of a photon \(E = h\nu\) this means there is a minimum frequency of radiation that will cause electrons to be ejected from the metal.

   Continued on reverse.
3. Determine \( \lambda \) for an electron traveling at \( 2.00 \times 10^9 \text{ m/s} \). You will need to look up the mass of an electron in your book.

\[
\lambda = \frac{h}{m_v} = \frac{6.626 \times 10^{-34} \text{ Js}}{(9.11 \times 10^{-31} \text{ kg})(2.00 \times 10^8 \text{ m/s})} = 3.64 \times 10^{-12} \text{ m}
\]

4. BONUS The enthalpy changes for the following two reactions are known:

\[
2 \text{C (graphite) + 2 H}_2 (g) \rightarrow \text{C}_2\text{H}_4 (g) \quad \Delta H^0 = 52.3 \text{ kJ/mol rxn}
\]

\[
2 \text{C}_2\text{H}_4\text{Cl}_2 (l) \rightarrow 2 \text{Cl}_2 (g) + 2 \text{C}_2\text{H}_4 (g) \quad \Delta H^0 = 435.0 \text{ kJ/mol rxn}
\]

Determine the standard enthalpy of formation of dichloroethane, \( \text{C}_2\text{H}_4\text{Cl}_2 (l) \), and write a formation reaction for dichloroethane.

\[
2\text{C (graphite) + 2H}_2 (g) + \text{Cl}_2 (g) \rightarrow \text{C}_2\text{H}_4\text{Cl}_2 (l)
\]

\[
\Delta H^0 = 52.3 \text{ kJ/mol}
\]

\[
2\text{H}_2\text{Cl}_2 (g) \rightarrow \text{C}_2\text{H}_4 (g) + \text{Cl}_2 (g)
\]

\[
\Delta H^\circ = -\frac{1}{2} (434.0 \text{ kJ/mol})
\]

\[
2\text{C (graphite) + 2H}_2 (g) + \text{Cl}_2 (g) \rightarrow \text{C}_2\text{H}_4\text{Cl}_2 (l)
\]

\[
\Delta H^0 = 52.3 \frac{\text{kJ}}{\text{mol}} - \frac{1}{2} (435.0 \frac{\text{kJ}}{\text{mol}})
\]

\[
\Delta H^\circ_f = -165.2 \frac{\text{kJ}}{\text{mol rxn}}
\]