Chemistry 121 Honors

EXAM III

Show work for all numerical problems to receive full credit. Give answers to the correct number of significant figures and with the appropriate units. Answer questions with complete sentences. Watch your spelling and punctuation.

USEFUL CONSTANTS
\( c = 3.0 \times 10^8 \text{ m/sec} \); \( h = 6.6 \times 10^{-34} \text{ J-sec} \)

1. (10 pts) A 6.22-kg piece of copper metal is heated from 20.5°C to 324.3°C. The specific heat of copper is 0.385 J/g°C. Calculate the amount of heat absorbed by the metal.

\[
q = S \times m \times \Delta T = 0.385 \frac{\text{J}}{\text{g°C}} \times 6.22 \times 10^3 \text{ g} \times (324.3 - 20.5) \text{ °C}
\]

\[
q = 7.27 \times 10^5 \text{ J} = 72.7 \text{ kJ}
\]

2. (15 pts) A 0.1375-g sample of solid magnesium is burned in a constant-volume bomb calorimeter that has a heat capacity of 3024 J/°C. The temperature increases by 1.126°C. Calculate the heat of combustion of magnesium in kJ/mol.

\[
q = C \times \Delta T = 3024 \frac{\text{J}}{\text{°C}} \times 1.126 \text{ °C} = 3.405 \times 10^3 \text{ J}
\]

\[
0.1375 \text{ g} \times \frac{1 \text{ mol}}{24.305 \text{ g}} = 0.005657 \text{ mol Mg} \quad (5)
\]

\[
\Delta H_{\text{comb}} = -\frac{3.405 \times 10^3 \text{ J}}{0.005657 \text{ mol}} = -601.9 \text{ kJ/mol} \quad (3)
\]
3. (15 pts) An excess of Zn metal is added to 50.0 mL of a 0.100 M AgNO₃ solution in a coffee cup calorimeter. As a result of the reaction

\[ \text{Zn}(s) + 2\text{AgNO}_3(aq) \rightarrow \text{Zn(NO}_3)_2(aq) + 2\text{Ag}(s) \]

the temperature rises from 19.25°C to 22.17°C.

The heat capacity of the calorimeter is 98.6 J/°C and the specific heat of the Zn(NO₃)₂ solution is 4.184 J/°C. Assume that the density of the Zn(NO₃)₂ solution is 1.00 g/mL.

Calculate the molar enthalpy change for the reaction.

\[
\Delta H = \frac{-8.99 \times 10^2 \text{ J}}{5.00 \times 10^{-3} \text{ mol}} = -1.8 \times 10^5 \text{ J/mol AgNO₃} \]

4. (5 pts) List the following types of electromagnetic radiation in order of increasing wavelength:

blue light, gamma rays, microwaves, orange light, ultraviolet light

increasing λ = decreasing E

γ rays < UV light < blue < orange < microwaves
5. (5 pts) Calculate the wavelength of radiation that has a frequency \(2.45 \times 10^9\) Hz.

\[\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^8 \text{ m/sec}}{2.45 \times 10^9 \text{ Hz}} = 0.122 \text{ m}\]

6. (5 pts) Describe an instance in which it is more convenient to consider the wave properties of an electron, as opposed to its particle properties.

"It is best to describe the electron as a wave when explaining how the electron can exist on both sides of a nodal plane without passing through the node."

7. Answer the following questions for element 34, Se.
   a. (8 pts) Give the electron configuration. (Do not use the noble gas core notation)

   \[\text{Se: } 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4\]

   b. (8 pts) Draw an energy diagram, showing the relative energy of the orbitals.
c. (8 pts) Draw the photoelectron spectrum (PES). Be sure to label the axes.

![Photoelectron Spectrum](image)

d. (8 pts) Consider one of the valence electrons of Se. Specifically, choose the one with the lowest ionization energy. For this electron, specify each of the quantum number values:

\[ \text{n (shell)} = 4 \]
\[ \text{l (subshell)} = \,^p \]
\[ \text{m}_l \text{ (orbital)} = \,^p_x \]
\[ \text{m}_s \text{ (spin)} = \,^u \]

e. (5 pts) Draw the orbital of the electron you chose in part d.

![Electron Orbital](image)
8. (Extra Credit - 2 pts) Match each of the following with the name of the appropriate scientist.

It is impossible to determine exactly both the position and the energy of an electron. Louis De Broglie

All matter has both particle and wave properties. Werner Heisenberg

Each electron in an atom must be labeled uniquely. Friedrich Hund

Electrons in a degenerate set of orbitals are more stable if they each occupy one orbital, with spins aligned. Wolfgang Pauli