1. A cylinder and piston assembly (defined as the system) is warmed by an external flame. The contents of the cylinder expand, doing work on the surroundings by pushing the piston outward against the external pressure. If the system absorbs 559 J of heat and does 488 J of work during the expansion, what is the change in the internal energy of the system?

2. A 55.0 g aluminum block initially at 57.5 °C is placed in a refrigerator and looses 725 J of heat. What is the final temperature of the aluminum? The specific heat of aluminum is 0.903 J g^{-1} $°C^{-1}$.

3. How much will the temperature of a cup (180 g) of coffee (specific heat 4.184 J g^{-1} $°C^{-1}$) at 95 °C be reduced when a 45 g silver spoon (specific heat 0.24 J g^{-1} $°C^{-1}$) at 25 °C is placed in the coffee and the two are allowed to reach the same temperature?

4. Ammonia reacts with oxygen according to the following equation:

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g) \quad \Delta H_{rxn} = -906\ kJ$$

   Calculate the heat (in kJ) associated with the complete reaction of 155 g of NH_3.

5. Find ΔH_{rxn} for the following reaction in kJ:

$$N_2O(g) + NO_2(g) \rightarrow 3\ NO(g)$$

   Use the following reactions with known ΔH′s:

$$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g) \quad \Delta H_1 = -113.1\ kJ$$
$$N_2(g) + O_2(g) \rightarrow 2\ NO(g) \quad \Delta H_2 = +182.6\ kJ$$
$$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g) \quad \Delta H_3 = -163.2\ kJ$$

6. Use the standard enthalpies of formation to determine $\Delta H°_{rxn}$ for the following reaction in kJ/mol:

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

   The enthalpies of formation of NH_3, NO, and H_2O are -45.9, 91.3, and −241.3 kJ/mol, respectively.

7. When 1.00 L of 1.00 M $Ba(NO_3)_2$ solution at 25.0°C is mixed with 2.00 L of 0.400 M Na_2SO_4 solution at 25.0°C in a calorimeter, the temperature of the mixture increases to 28.1°C. The reaction proceeds as shown below:

$$Ba(NO)_3(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2\ NaNO_3(aq).$$

   Assuming that the specific heat capacity of the solution is 4.184 J g^{-1} $°C^{-1}$ and that the density of the final solution is 1.00 g/mL, calculate the enthalpy change in kJ per mole of $BaSO_4$ formed.

8. Calculate the (A) frequency in s^{-1} and (B) energy of solar radiation with a wavelength of 503 nm.

9. An electron in the $n = 7$ level of the hydrogen atom relaxes to a lower energy level, emitting light of 397 nm. What is the value of n for the level to which the electron relaxed?

10. Answer the following concerning quantum numbers.
    A. What are the possible values of l for $n = 4$?
    B. What are the possible values of m_l for $l = 2$?
    C. What is the maximum number of electrons that can occupy the $n = 4$ shell?
    D. Provide all (10) possible sets of quantum numbers to describe an electron in a 4d orbital?
    E. Multiple Choice: Which set of quantum numbers cannot occur together to specify an electron?
        A. $\mathrm{n} = 2, \mathrm{l} = 1, \mathrm{m_l} = -1, \mathrm{m_s} = +\frac{1}{2}$
        B. $\mathrm{n} = 3, \mathrm{l} = 2, \mathrm{m_l} = 0, \mathrm{m_s} = -\frac{1}{2}$
        C. $\mathrm{n} = 3, \mathrm{l} = 3, \mathrm{m_l} = 2, \mathrm{m_s} = -\frac{1}{2}$
        D. $\mathrm{n} = 4, \mathrm{l} = 3, \mathrm{m_l} = 0, \mathrm{m_s} = +\frac{1}{2}$

11. Write electron configurations for each of the following elements using the indicated forms.

    A. P (orbital box)
    B. N^{2-} (orbital box)
    C. Na (spdf)
    D. Cr (spdf)
    E. Mn^{+} (noble gas)
    F. Sg (noble gas)

12. Determine the number of valence electrons in the following elements?
    A. Cs
    B. S

13. Pick the larger species of the following pairs.

    A. Si or N
    B. Li or Li^{+}
    C. O or O^{2-}
    D. S^{2-} or Ca^{2+}

14. Arrange the following elements in order of increasing electron affinity: Al, F, In, N.

15. For each of the following elements, predict where the quantum leap occurs for successive ionization energies. (For example, does the quantum leap occur between the first and second ionization energies, the second and third, or the third and fourth)
    A. Be
    B. N
    C. O

16. Explain why beryllium has a greater ionization energy than boron despite boron being to the right of beryllium on the periodic table.