Thermochemistry Study Questions and Problems

1. Describe in sentence format the transfer of energy that takes place when:
   a. A saucepan of water is heated to boiling
   b. A chemical reaction liberates heat.

2. If the temperature of 50.0 gram block of aluminum increases by 10.9 K when heated by 500 joules, calculate the:
   a. heat capacity of the aluminum block
   b. molar heat capacity of aluminum
   c. specific heat of aluminum

3. The specific heat of gold is 0.128 $JK^{-1}g^{-1}$ and the specific heat of iron is 0.451 $JK^{-1}g^{-1}$. Calculate the molar heat capacities of these two metals and compare to the value for aluminum calculated in question #2.

4. Calculate the heat necessary to change the temperature of one kg of iron from 25°C to 1000°C (FYI: the melting point of Fe=1811 K). The specific heat of iron is 0.451 $JK^{-1}g^{-1}$.

5. If a 40 g block of copper at 100°C is added to 100 grams of water at 25°C, calculate the final temperature assuming no heat is lost to the surroundings. The specific heat of copper is 0.385 $JK^{-1}g^{-1}$ and the specific heat of water is 4.185 $JK^{-1}g^{-1}$.

6. Calculate the amount of heat necessary to melt 27.0 grams of ice if the heat of fusion of ice is 6.009 kJ/mol.

7. If 27.0 grams of ice at 0°C is added to 123 grams of water at 100°C in an insulated container, calculate the final temperature. Assume that the specific heat of water is 4.185 $JK^{-1}g^{-1}$. (Hint: utilize the information from problem #6.)

8. A 50 g block of an unknown metal alloy at 100°C is dropped into an insulated flask containing approximately 200 g of ice. It was determined that 10.5 g of the ice melted. What is the specific heat capacity of the unknown alloy? (Hint: use info from Problem #6.)

9. If the enthalpy change for the combustion of propane is -2220 kJ/mol propane, what quantity is released when 1 kg of propane is burned?
   $C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(l)}$ Δ= -2220 kJ

10. Using the following thermochemical data, calculate the molar heat of combustion $\Delta H°$ of methane, CH_4: $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(l)}$

    $2\ CH_{4(g)} + 3\ O_{2(g)} \rightarrow 2\ CO_{(g)} + 4\ H_2O_{(l)}$ $\Delta H° = -1215$ kJ

    $2\ C_{(s)} + O_{2(g)} \rightarrow 2\ CO_{(g)}$ $\Delta H° = -221$ kJ

    $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H° = -394$ kJ

11. Calculate the standard molar enthalpy of formation of methane from the data given in question 10, your answer to question 10 and the following: $\Delta H_f°\ (H_2O_{(l)}) = -286$ kJ/mol

12. When ammonia is oxidized to nitrogen dioxide and water, the quantity of heat released equals 349 kJ per mol of ammonia: $2\ NH_{3(g)} + 7/2\ O_{2(g)} \rightarrow 2\ NO_{2(g)} + 3\ H_2O_{(g)}$ $\Delta H° = -698$ kJ
Calculate the standard molar enthalpy of formation of ammonia if:
$\Delta H_f°\ (H_2O_{(l)}) = -286$ kJ/mol and $\Delta H_f°\ (NO_{2(g)}) = +33$ kJ/mol

13. A 0.915 gram sample of sugar ($C_{12}H_{22}O_{11}$; molar mass 342 g/mol) was ignited in a bomb calorimeter in the presence of excess oxygen. Combustion was complete. The temperature of the calorimeter and its contents rose by 3.53°C. If the heat capacity of the calorimeter and its contents is 4250 JK^{-1}, calculate the heat released per mole of sugar.

14. When 40 g of ammonium nitrate is dissolved in 100 g of water in a constant-pressure coffee cup calorimeter, the temperature of the solution drops by 22.4 °C. If the specific heat capacity of the solution is 4.18 $JK^{-1}g^{-1}$, calculate the enthalpy of solution of ammonium nitrate.