Thermochemistry Practice Problems (Ch. 6)

1. Consider 2 metals, A and B, each having a mass of 100 g and an initial temperature of 20°C. The specific heat of A is larger than that of B. Under the same heating conditions, which metal would take longer to reach 21°C? Explain your reasoning.

2. A 10.0-g sheet of gold at a temperature of 18°C is placed flat on a 20.0-g sheet of iron at 55.6°C. What is the final temperature of the metals? Assume no heat is lost to the surroundings. (c_{Au} = 0.129 J/g°C, c_{Fe} = 0.444 J/g°C)

3. A 8.6-g piece of aluminum, heated to 100°C, is placed in a coffee cup calorimeter that initially contains 402.4 grams of water at 25°C. If the final temperature is 26.4°C, what is the specific heat of aluminum in J/g°C?

4. Sulfur (2.56 g) is burned in a bomb calorimeter with excess O_2(g). The temperature increases from 21.25 °C to 26.72 °C. The bomb has a heat capacity of 923 J/K, and the calorimeter contains 815 g of water. Calculate the heat evolved, per mole of SO_2 formed, in the course of the reaction

$$S_8(s) + 8\ O_2(g) \rightarrow 8\ SO_2(g)$$

5. Assume you mix 100.0 mL of 0.200 M CsOH with 50.0 mL of 0.400 M HCl in a coffee-cup calorimeter. The following reaction occurs:

$$CsOH(aq) + HCl(aq) \rightarrow CsCl(aq) + H_2O(l)$$

   The temperature of both solutions before mixing was 22.50 °C, and it rises to 24.28 °C after the acid-base reaction. What is the enthalpy of the reaction per mole of CsOH? Assume the densities of the solutions are 1.00 g/mL and the heat capacities of the solutions are 4.2 J/g·K.

6. Consider the following reaction:

$$2\ CH_3OH_{(l)} + 3\ O_{2(g)} \rightarrow 4\ H_2O_{(l)} + 2\ CO_{2(g)} \qquad \Delta H = -1452.8\text{ kJ}$$

   What is the value of ΔH if (a) the equation is multiplied throughout by 2? (b) the direction of the reaction is reversed? (c) water vapor instead of liquid water is formed?

7. Using standard heats of formation, calculate ΔH for the following reactions:
   a) $HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$
   b) $2\ NaOH(s) + CO_2(g) \rightarrow Na_2CO_3(s) + H_2O(g)$
   c) $C_2H_2(g) + H_2(g) \rightarrow C_2H_4(g)$
   d) $NO_2(g) \rightarrow N_2O_4(g)$

8. Given that ΔH for the following reaction is –534 kJ, determine the standard heat of formation of hydrazine, N_2H_4(l).

$$N_2H_4(l) + O_2(g) \rightarrow 2\ H_2O(g) + N_2(g)$$

9. Given the following thermochemical data, calculate ΔH for:

$$Ca(s) + 2\,H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$$

$H_2(g) + \frac{1}{2}\,O_2(g) \rightarrow H_2O(l)$	$\Delta H = -285$ kJ/mol
$CaO_{(s)} + H_2O(l) \rightarrow Ca(OH)_2(s)$	$\Delta H = -64$ kJ/mol
$Ca(s) + \frac{1}{2}\,O_2(g) \rightarrow CaO(s)$	$\Delta H = -635$ kJ/mol

10. One reaction involved in the conversion of iron ore to the metal is

$$FeO\,(s) + CO\,(g) \rightarrow Fe\,(s) + CO_2\,(g)$$

Calculate the enthalpy change for this reaction from these reactions of iron oxides with CO :

$3\,Fe_2O_3\,(s) + CO\,(g) \rightarrow 2\,Fe_3O_4\,(s) + CO_2\,(g)$	$\Delta H = -47$ kJ
$Fe_2O_3\,(s) + 3\,CO\,(g) \rightarrow 2\,Fe\,(s) + 3\,CO_2\,(g)$	$\Delta H = -25$ kJ
$Fe_3O_4\,(s) + CO\,(g) \rightarrow 3\,FeO\,(s) + CO_2\,(g)$	$\Delta H = +19$ kJ

Answers:

1. A, its specific heat is larger so it takes more energy to raise its temp. 1 °C than metal B's

2. T_f = 50.8 °C

3. c_{Al} = 3.72 J/g°C

4. 296.3 kJ

5. -56 kJ/mol

6. a) -2905.6 kJ
   b) +1452.8 kJ
   c) -1276.8 kJ

7. a) -75 kJ
   b) -125.5 kJ
   c) -175 kJ
   d) -58 kJ

8. 50 kJ/mol

9. -414 kJ

10. -11 kJ