CHEM-1105 THERMOCHEMISTRY

1. A 46.2 g sample of copper is heated to 95.4^oC and then placed in a calorimeter containing 75.0 g water at 19.6^oC. The final temperature of the metal and water is 21.8^oC. Calculate the specific heat of copper, assuming that all the heat lost by the copper is gained by water.
   (0.203J/g ^oC)
2. In a coffee-cup calorimeter, 100.0 mL of 1.0 M NaOH and 100.0 mL of 1.0 M HCl are mixed. Both solutions were originally at 24.6^oC. After the reaction, the final temperature is 31.3^oC. Assuming that all the solutions have a density of 1.0g/mL and a specific heat of 4.184 J/g^oC, calculate the enthalpy change for the neutralization of HCl by NaOH.
   (-56.1kJ/mol)
3. Consider the reaction
   $2\ HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l) \quad \Delta H = -118kJ$
   Calculate the heat when 100.0 mL of 0.500 M HCl is mixed with 300.0 mL of 0.500 M $Ba(OH)_2$. Calculate the final temperature of the mixture assuming that the initial temperature was 25.0^oC. **(26.76^{o}C)**

4. The bombardier beetle uses an explosive discharge as a defensive measure. The chemical reaction involved is the oxidation of hydroquinone by hydrogen peroxide to produce quinone and water.
   $$C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2\ H_2O(l)$$

   Calculate ΔH^o for the reaction from the following data: **(-203 kJ)**

   $C_6H_4(OH)_2(aq) \rightarrow C_6H_4O_2(aq) + H_2(g) \qquad \Delta H^o = +177.4$ kJ

   $H_2(g) + O_2(g) \rightarrow H_2O_2(aq) \qquad \Delta H^o = -191.2$ kJ

   $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g) \qquad \Delta H^o = -483.6$ kJ

   $H_2O(g) \rightarrow H_2O(l) \qquad \Delta H^o = -43.8$ kJ

5. A 0.1964 g sample of quinone, $C_6H_4O_2$, is burned in a bomb calorimeter that has a heat capacity of 1.56 kJ/^oC. The temperature of the calorimeter increases by 3.2^oC. Calculate the energy of combustion of quinone per mole. **(-2745kJ/mol)**

6. Use ΔH^o_f data to

a) calculate the enthalpy change for the reaction: **(-1367kJ)**

$$C_2H_5OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(l)$$

b) calculate ΔH^o_f of $C_3H_8(g)$ and the following information: **(104kJ)**

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l) \qquad \Delta H^o = -2220\ kJ$$

7. Write a balanced thermochemical equation depicting the formation of the following substances.

a) $CH_3OH(l)$ b) $NH_4NO_3(s)$

For the following problems assume that specific heat and density of the solution is same as that for water.

8. When a 4.25 g $NH_4NO_3(s)$ dissolves in 60.0 mL of water in a coffee-cup calorimeter, the temperature drops from 22.0°C to 16.9°C. Calculate ΔH for **(+25.8kJ/mol)**

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

9. Suppose you place 0.500 g of Mg in a coffee-cup calorimeter and then add 100.0 mL of 1.00 M HCl. That reaction occurs

$$Mg(s) + HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Calculate ΔH if the temperature of the solution changes from 22.2°C to 44.8°C. **(-462kJ/mol)**

10. 50.0 mL of 1.00 M HCl is mixed with 50.0 mL of 1.00 M NaOH. The temperature of the solution changes from 21.0°C to 27.5°C. Calculate ΔH. **(-54.4 kJ/mol)**

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$