CHEM 105 PROBLEM SET 4 THERMOCHEMISTRY

1. Given the following data

$Na(s) + \frac{1}{2}Cl_2(g) \rightarrow Na(g) + Cl(g)$; $\Delta H = +230$ kJ

$Na(g) + Cl(g) \rightarrow Na^+(g) + Cl^-(g)$; $\Delta H = +147$ kJ

$Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$; $\Delta H = -411$ kJ

calculate ΔH for the reaction

$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$

2. Given the following data

$V(s) + 2Cl_2(g) \rightarrow VCl_4(l)$; $\Delta H = -569.4$ kJ

$VCl_3(s) \rightarrow VCl_2(s) + \frac{1}{2}Cl_2(g)$; $\Delta H = +128.9$ kJ

$2VCl_3(s) \rightarrow VCl_2(s) + VCl_4(l)$; $\Delta H = +140.2$ kJ

calculate ΔH_f^0 of $VCl_3(s)$.

3. Given $2Al_2O_3(s) \rightarrow 4Al(s) + 3O_2(g)$; $\Delta H = +3340$ kJ

(a) what is ΔH_f^0 for $Al_2O_3(s)$?

(b) what is ΔH for the decomposition of 10.0 g of Al_2O_3?

4. When 3.17 g of $KClO_3$ is dissolved in 50.0 g of water (SH = 4.18 J/g·°C) in a coffee-cup calorimeter (C_{cal} = 75.0 J/°C), the temperature fell from 25.00°C to 21.18°C. Calculate ΔH for the process

$KClO_3(s) \rightarrow K^+(aq) + ClO_3^-(aq)$

5. Consider the reaction

$Ni(s) + Cu^{2+}(aq) \rightarrow Ni^{2+}(aq) + Cu(s)$; $\Delta H = -128.4$ kJ

The reaction is carried out in a coffee-cup calorimeter (C_{cal} = 75.0 J/°C) using 125 mL of the Cu^{2+} solution (d ≈ 1.00 g/mL; SH ≈ 4.18 J/g·°C) at 22.50°C. The copper formed weighed 2.48 g. Calculate the final temperature of the calorimeter and contents.

6. When 155 mL of 0.1250 *M* H_3PO_4 at 24.00°C was mixed with 260.0 mL of 0.1000 *M* $Sr(OH)_2$ at 24.00°C in a calorimeter (calorimeter constant = 40.4 J/°C), the temperature rose to 25.54°C. Calculate ΔH for the reaction. Specific heat for water = 4.184 J/g.°C.

$$2H_3PO_4(aq) + 3Sr(OH)_2(aq) \longrightarrow Sr_3(PO_4)_2(s) + 6H_2O(l)$$

In calculating heat flow, treat the solutions as if they were pure water and ignore the small amount of water formed in the reaction.

7. When a sample of sucrose, $C_{12}H_{22}O_{11}(s)$, weighing 3.85 g is burned in a bomb calorimeter (C_{cal} = 3.180 kJ/°C) containing 6.00 kg of water (SH = 4.184 J/g·°C) at 23.40°C, the temperature rose to 25.64°C. Given that ΔH_f^0 for $CO_2(g)$ = -393.5 kJ/mol and ΔH_f^0 for $H_2O(l)$ = -285.8 kJ/mol, calculate ΔH_f^0 for $C_{12}H_{22}O_{11}(s)$. HINT: Write the balanced equation for the combustion of $C_{12}H_{22}O_{11}(s)$ to form $CO_2(g)$ and $H_2O(l)$.

8. When 3.16 g of salicylic acid, $C_7H_6O_3$, was burned in a bomb calorimeter (C_{cal} = 3.612 kJ/°C) containing 5.00 kg of water at 23.00°C, 69.3 kJ of heat was given off. Calculate the final temperature.

9. Given: ΔH_f^0 of HI(*g*) = 25.9 kJ/mole and $\Delta H_{sublimation}$ of I_2 = 62.4 kJ/mole.

   Calculate ΔH for the reaction $\frac{1}{2}H_2(g) + \frac{1}{2}I_2(g) \rightarrow HI(g)$

10. If 125 g of solid acetic acid (CH_3COOH) at 16.7°C is mixed with 755 g of acetic acid at 33.8°C, what will be the temperature of the system when equilibrium is attained? Assume no heat exchange with the surroundings. The melting point of acetic acid is 16.7°C, the specific heat (*S.H.*) of liquid acetic acid is 125 J/°C.mole, and the latent heat of fusion (ΔH_{fusion}) of acetic acid is 11.7 kJ/mole.

11. The thermite reaction, shown below, was once used to weld rails.

$$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$$

   (a) Calculate ΔH for this reaction using heat of formation data from Appendix C.

   (b) The specific heats of Al_2O_3 and Fe are 0.79 and 0.45 J/g·°C, respectively. Calculate the temperature to which the products would be raised, starting at 25.0°C, by the heat given off in this reaction.

   (c) Will the reaction produce molten iron? (mp Fe = 1535°C; ΔH_{fus} = 270 J/g)