Thermochemistry

1. Given: $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g) + 92.5$ KJ, what is ΔH_f° for $NH_3(g)$?

2. Given: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ $\Delta H = 175$ kJ
$Ca(OH)_2(s) \rightarrow H_2O(l) + CaO(s)$ $\Delta H = 67$ kJ
$Ca(OH)_2(s) + 2\ HCl(g) \rightarrow CaCl_2(s) + 2\ H_2O(l)$ $\Delta H = -198$ kJ
Calculate ΔH_{rx} for $CaCO_3(s) + 2\ HCl(g) \rightarrow CaCl_2(s) + H_2O(l) + CO_2(g)$

3. The heat of combustion of naphthalene, $C_{10}H_8(s)$ is –5162 kJ. What is the heat of formation of naphthalene?

4. Calculate the amount of heat given off when 100.0 g of $C_7H_8(l)$ burns. The: $\Delta H_f = 50.0$ kJ/mol for $C_7H_8(l)$,

5. The standard enthalpy of combustion of $C_2H_2(g)$ is –1301 kJ/mol. What is the standard enthalpy of formation for $C_2H_2(g)$?

6. How much heat will be required to make 1.00 kg of $CaC_2(s)$ according to the reaction given below? The ΔH_f value for $CaC_2(s)$ is –63 kJ/mol.
$$CaO(s) + 3\ C(s) \rightarrow CaC_2(s) + CO(g)$$

7. 150.0 mL of 0.200 mol/L HCl was added to 150.0 mL of 0.200 mol/L NaOH in a styrene cup. Initial temperature of both solutions was 25.0˚C. The final temperature was 27.1˚C. Calculate the heat of reaction per mole of hydrochloric acid.

8. In an aluminum calorimeter, 20.0 g of nitrogen was burned in oxygen to produce nitrogen monoxide. From the following data, find the heat of reaction per mole of nitrogen burned.
   - Mass of nitrogen burned 20.0 g
   - Mass of aluminum calorimeter 70.37 g
   - Volume of water in calorimeter 500.0 mL
   - Initial temperature 72.60˚C
   - Final temperature 82.80˚C

9. In a styrene cup, some solid copper was oxidized in excess oxygen to produce copper(II) oxide. Use the data below to establish the heat of reaction per mole of copper.
   - Mass of copper 1.00 g
   - Mass of water in calorimeter 100.0 g
   - Initial temperature of water 21.0˚C
   - Final temperature of water 26.9˚C

10. In an aluminum calorimeter, 25.00 g of iodine was burned in excess hydrogen to produce hydrogen iodide gas. From the data below, establish the heat of reaction per mole of iodine.
   - Mass of iodine 25.00 g
   - Mass of aluminum calorimeter 70.0 g
   - Volume of water in calorimeter 100.0 mL
   - Initial temperature 23.8˚C
   - Final temperature 34.6˚C

11. Sodium was burned in oxygen to burn sodium oxide. An aluminum calorimeter was used. Calculate the heat of reaction per mole of sodium oxide formed.
   - Mass of sodium 1.00 g
   - Mass of aluminum calorimeter 25.31 g
   - Volume of water in calorimeter 350.0 mL
   - Initial temperature 27.51˚C
   - Final temperature 31.82˚C

12. 0.844 g of formaldehyde (methanal), HCHO, reacted with oxygen in a styrofoam calorimeter to produce carbon dioxide and water. The mass of water in the calorimeter was 150.0 g and the temperature increased from 21.8˚C to 45.1˚C. Calculate the heat of reaction per mole of formaldehyde burned.

13. Exactly 3.00 g of C(s) was burned to $CO_2(g)$ in a copper calorimeter. The mass of the calorimeter was 1.500 kg and the mass of the water in which the calorimeter was immersed was 2.000 kg. The initial temperature of the system was 20.0°C and the final temperature was 31.0°C. Calculate the heat of formation of $CO_2(g)$, under the conditions present in the calorimeter.

14. The specific heat capacity of Ni(s) is 0.444 kJ/Kg°C. A 3.85 g sample of benzoic acid, $C_6H_5COOH(s)$, was burned in a nickel calorimeter having a mass of 0.850 kg and immersed in 1.200 kg of water. The initial temperature of the system was 23.0°C and the final temperature was 41.0°C. Calculate the heat of combustion of benzoic acid, under the conditions present inside the calorimeter.

15. A 2.50g sample of sucrose, $C_{12}H_{22}O_{11}(s)$ was burned in a 2.100 kg iron calorimeter immersed in 1.450 kg of water. The initial temperature of the system was 24.32°C and the final temperature was 30.20°C. Determine the heat of combustion of sucrose, under the conditions present inside the calorimeter.

16. 50.0 mL of 0.800 mol/L hydrobromic acid was added to 50.0 mL of 0.800 mol/L potassium hydroxide in a styrene cup. Initial temperature of both solutions was 23.18˚C. Final temperature was 26.38˚C. Calculate the heat of reaction per mole of hydrobromic acid.

17. When 50.0mL of 1.00mol/L HCl(aq) and 50.0 mL of 1.00mol/L NaOH(aq) are mixed in a "coffee cup" calorimeter, the temperature of the resulting solution increases from 21.0°C to 27.5°C. Use the specific heat capacity of $H_2O(l)$, given on page one of the Chemistry Data Booklet, to calculate the heat of this reaction measured in kilojoules per mole of HCl(aq).
$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

18. We often have to make assumptions when we conduct laboratory experiments. Consider carefully the experiment described in question 17, and list four unstated assumptions that must be made in order for one to determine the heat of reaction.