**CHE1031 module 8 HW: Thermochemistry**

*Please solve these problems on green engineering graph paper.*

*Problems are assigned at each class meeting and are due at the next class.*

*Please number each problem, show all work for credit and box your answer.
Note that answers to quantitative problems are provided in blue.*

**8.1: Energy basics**

**1.** A burning match and a bonfire may have the same temperature, yet you would not sit around a burning match on a fall evening to stay warm. Why not?

**2.** Identify and describe several energy transitions that take place during the typical operation of an automobile.

**3.** Calculate the heat capacity, in joules per degree. You can find specific heat values for elements here (note that you must convert from kg to g, but don't have to convert K to C.): http://periodictable.com/Properties/A/SpecificHeat.al.html

(a) 45.8 g of nitrogen gas

(b) 1.00 pound of aluminum metal

*(a) 47.6 J/C*

*(b) 4.09 E2 J/C*

**4.** How much heat, in joules, must be added to a 75.0–g iron block with a specific heat of 0.449 J/g °C to increase its temperature from 25 °C to its melting temperature of 1535 °C?

*+ 5.08 E4 J*

**5.** How much would the temperature of 275 g of water increase if 36.5 kJ of heat were added?

*31.7°C*

**6.** An aluminum kettle weighs 1.05 kg.

(a) What is the heat capacity of the kettle?

(b) How much heat is required to increase the temperature of this kettle from 23.0 °C to 99.0 °C?

(c) How much heat is required to heat this kettle from 23.0 °C to 99.0 °C if it contains 1.25 L of water (density of 0.997 g/mL and a specific heat of 4.184 J/g °C)?

*(a) 955.5 J/C*

*(b) 7.26 E4 J*

*(c) 4.70 E5 J*

**8.2: Calorimetry**

**7.** A 500-mL bottle of water at room temperature and a 2-L bottle of water at the same temperature were placed in a refrigerator. After 30 minutes, the 500-mL bottle of water had cooled to the temperature of the refrigerator. An hour later, the 2-L of water had cooled to the same temperature. When asked which sample of water lost the most heat, one student replied that both bottles lost the same amount of heat because they started at the same temperature and finished at the same temperature. A second student thought that the 2-L bottle of water lost more heat because there was more water. A third student believed that the 500-mL bottle of water lost more heat because it cooled more quickly. A fourth student thought that it was not possible to tell because we do not know the initial temperature and the final temperature of the water. Indicate which of these answers is correct and describe the error in each of the other answers.

**8.** How many milliliters of water at 23 °C with a density of 1.00 g/mL must be mixed with 180 mL (about 6 oz) of coffee at 95 °C so that the resulting combination will have a temperature of 60 °C? Assume that coffee and water have the same density and the same specific heat.
*170 mL*

**9.** The temperature of the cooling water as it leaves the hot engine of an automobile is 240 °F. After it passes through the radiator it has a temperature of 175 °F. Calculate the amount of heat transferred from the engine to the surroundings by one gallon of water with a specific heat of 4.184 J/g °C.

*5.73 E5 J*

**10.** When 50.0 g of 0.200 M NaCl(aq) at 24.1 °C is added to 100.0 g of 0.100 M AgNO3(aq) at 24.1 °C in a calorimeter, the temperature increases to 25.2 °C as AgCl(s) forms. Assuming the specific heat of the solution and products is 4.20 J/g °C, calculate the approximate amount of heat in joules produced.
*- 693 J*

**11.** The reaction of 50 mL of acid and 50 mL of base described in Example 5.5 increased the temperature of the solution by 6.9 degrees. How much would the temperature have increased if 100 mL of acid and 100 mL of base had been used in the same calorimeter starting at the same temperature of 22.0 °C? Explain your answer.

*6.9°C*

**8.3: Enthalpy**

**12.** Explain how the heat measured in Example 5.5 differs from the enthalpy change for the exothermic reaction described by the following equation:

HCl(aq) + NaOH(aq) ⟶ NaCl(aq) + H2O(l)

**13.** When 2.50 g of methane burns in oxygen, 125 kJ of heat is produced. What is the enthalpy of combustion per mole of methane under these conditions?
*0.156 mol CH4; 801 kJ/mol CH4*

**14.** The following sequence of reactions occurs in the commercial production of aqueous nitric acid:

4NH3(g) + 5O2(g) ⟶ 4NO(g) + 6H2O(l) ΔH = −907 kJ

2NO(g) + O2(g) ⟶ 2NO2(g) ΔH = −113 kJ

3NO2 + H2 O(l) ⟶ 2HNO3(aq) + NO(g) ΔH = −139 kJ

Determine the total energy change for the production of one mole of aqueous nitric acid by this process.
*- 919.3 kJ*

**15.** Both graphite and diamond burn.

C(s, diamond) + O2(g) ⟶ CO2(g)

For the conversion of graphite to diamond:

C(s, graphite)⟶ C(s, diamond) ΔH°298 = 1.90 kJ

Which produces more heat, the combustion of graphite or the combustion of diamond?
Combustion of diamond would create more heat because the energy state of diamond is higher than that of graphite. Graphite + energy = diamond.

**16.** Calculate ΔH°298 for the process Sb(s) + 5/2Cl2(g) ⟶ SbCl5(g) from the following information:

Sb(s) + 3/2Cl2(g) ⟶ SbCl3(g) ΔH°298 = −314 kJ

SbCl3(s) + Cl2(g) ⟶ SbCl5(g) ΔH°298 = −80 kJ

Sb(s) + 3/2Cl2(g) ⟶ ~~SbCl3(g)~~ ΔH°298 = −314 kJ

~~SbCl3(s)~~ + Cl2(g) ⟶ SbCl5(g) ΔH°298 = −80 kJ

Sb(s) + 5/2Cl2(g) ⟶ SbCl5(g) = - 394 kJ