ACTIVITY # 2 HEAT EFFECTS AND CALORIMETRY

REMARKS

INTRODUCTION

Physical and chemical changes are usually accompanied by some form of energy changes. This energy change. This energy change is most commonly observed as a flow of heat either into or out of a system. Measurement of heat flow is called *calorimetry* and the instrument used is the *calorimeter.*

When heat flows into a substance, the temperature of that substance will increase. The quantity of heat, Q, required to cause a temperature change, ΔT, of any substance is proportional to the mass, m, of the substance and the temperature change, as shown in the equation:

$$Q = Cp \times m \times \Delta T$$

The constant of proportionality is called the *specific heat*, Cp, of the substance.

The *specific heat* is the amount of heat required to raise the temperature of one (1) gram of substance by 1 ^{O}C. amounts of heat are measured in either joules or calories. To raise the temperature of one (1) gram of water by one 1 ^{O}C, 4.18 joules of heat must be supplied to the water. The specific heat of water is therefore 4.18 joules/g ^{O}C. Since 4.818 joules equals one calorie, the specific heat of water can also be expressed as 1 calorie/g ^{O}C. Ordinarily, heat flow in and out of a substance is determined by the effect which that flow has on the temperature of a known amount of water.

The basic principle behind calorimetry is the law of conservation of energy which states that energy cannot be created nor destroyed. The heat lost by a system is gained by the surroundings or vice versa. When a chemical reaction occurs in aqueous solution, there is an exchange of heat between the reaction mixture (the system) and the solvent water and the container (the surroundings). $Q_{reaction}$, is equal in magnitude but opposite in sign to that of water and the calorimeter. The heat flow associated with the reaction mixture is also equal to the enthalpy change, ΔH, for the reaction.

$$\Delta H_{reaction} = Q_{reaction} = -(Q_{H2O} + Q_{calorimeter})$$

Before the H of any physical or chemical change can be determined using the calorimeter, it has to be calibrated first. A measured quantity of cold water is placed in the calorimeter to be calibrated. Then a measured quantity of warm water is added to the cold water in the calorimeter. Since energy is conserved, the heat lost by the war water is gained by the cold water and the calorimeter.

$$Q_{warm\ water} = -(Q_{cold\ water} + Q_{calorimeter})$$

where:

$$Q_{calorimeter} = C_{cal} \times \Delta T$$

The calorimeter constant, C_{cal} is then used for the succeeding portions of the experiment.

OBJECTIVES

1. Introduce the principles of calorimetry and the measurement of enthalpy changes.
2. Determine calorimeter constant for a given calorimeter.
3. Calculate the ΔH of solution of ammonium nitrate and calcium chloride
4. Calculate the ΔH of reaction between NaOH and HCl and between KOH and HNO_3.

MATERIALS

Reagents

- Ammonium nitrate
- Calcium chloride
- 0.1M NaOH
- 0.1M HCl
- 0.1M KOH
- 0.1M HNO_3

Apparatuses

- Calorimeter
- 250-mL beaker
- 100-mL graduated cylinder
- Thermometer
- Heating set-up

Papers Needed:

- Laboratory Performance Rubrics
- Laboratory Report (after the activity)

SAFETY

Wear your goggles and lab apron at all times during the investigation.

PROCEDURE

A. Determination of the Calorimeter Constant C_{cal}

Assemble the calorimeter. Place 20 mL of cold water in to the small cup. In a separate beaker, measure 20 mL of water and heat to about 70^{O}C. While the water is heating, monitor the temperature of the cold water in the calorimeter for 2-3 minutes to make sure that is has become constant. Record the temperature of the cold water.

When the water in the beaker has reached approximately 70^{O}C, let the beaker stand for 2-3 min, then record the temperature of the warm water. Quickly remove the lid from the calorimeter and pour the warm water into the bold water. Immediately replace the lid and stir the water for 30 seconds. Begin monitoring the temperature of the water in the calorimeter, recording the highest temperature reached by the water.

Calculate the ***calorimeter constant*** for your calorimeter. Show sample calculations.

B. Heat of Solution

Place 10 mL of distilled water in the calorimeter and record its temperature. Weigh about 2.0 grams of ammonium nitrate. Place the ammonium nitrate into the calorimeter and replace the lid quickly. Stir and determine the temperature of the solution. Repeat the procedure using calcium chloride instead of ammonium nitrate.

1. Calculate the H of the solution in (joules/mole solute) of ammonium nitrate and calcium chloride.
2. Is the dissolution of ammonium nitrate endothermic or exothermic?
3. Is the dissolution of calcium chloride endothermic or exothermic?
4. Write the balanced chemical equation for the dissolution of ammonium nitrate and calcium chloride.

C. Heat of Reaction $\Delta H_{reaction}$

Obtain 10 mL of 0.1M NaOH and place it in the calorimeter. Then measure 10 mL of 0.1M HCl into a clean and dry beaker. Allow the two solutions to stand until their temperature are the same. Be sure to rinse off and dry the thermometer when transferring between solutions. Record the temperature of the solutions.

Add HCl to the calorimeter, cover the calorimeter quickly, stir the mixture for 15 seconds, and record the highest temperature reached by the mixture. Repeat the procedure using 0.1M KNOH and 0.1M HNO_3 5. Write the balanced equation between NaOH and HCl 6. Write the balanced equation between KOH and HNO_3 7. Calculate the **ΔH** of the reaction between NaOH and HCl (in joules/mole H_2O) 8. Calculate the **ΔH** of the reaction between KOH and HNO_3 (in joules/mole H_2O)	
REFERENCE	
Laboratory Instruction Manual, Chemistry 16, General Chemistry I General Chemistry and Chemical Education Division Institute of Chemistry, UPLB	