CHEM 360 L

EXPERIMENT 2

Heat of Neutralization

Introduction

This experiment shows how one determines the heat evolved in an aqueous acid-base reaction. For strong acids and bases reacting in sufficiently dilute solutions, the heat evolved is approximately 57 kJ mol^{-1} at 298 K. Increasing the concentration will often result in a higher heat of reaction, while using a weaker acid or base will reduce the evolved heat. In this experiment, the student will neutralize a series of acids with aqueous sodium hydroxide, calorimetrically determining the heat evolved.

Procedure

The instructor will show you how to set up the calorimeter. The base used will be 0.2 N NaOH, the acids will be 0.8 N hydrochloric, phosphoric, and sulfuric acids.

In order to measure the heat capacity of the calorimeter system, 225 mL of distilled water is added to the clean, dry Dewar. Stir the water and read the temperature every 20 seconds until it becomes constant within +/- 0.05 ^{o}C. Then pipette 25 mL of ice water (record the ice water temperature) into the flask. Stir the mixture and read the temperature until constant readings are obtained. This process is performed three times.

Dry the Dewar flask and carefully measure 200 mL of the 0.2 N NaOH solution into the calorimeter. Stir and measure the temperature as above. Quickly add 50 mL of the 0.8 N HCl solution (at a temperature close to that of the NaOH solution), stir and measure the temperature until constant readings are obtained. This should be performed three times. Repeat this process for the sulfuric and phosphoric acid solutions.

Calculations

The heat capacity of the calorimeter system makes use of the fact that the heat gained by the ice water is equal in magnitude to the heat lost by the calorimeter and its 225 mL of water:

$$25\ (T_f - T) = C'\ \Delta T$$

where T_f is the final temperature, T is the initial temperature of the ice water, ΔT is the calorimeter temperature change, and C' the heat capacity of the calorimeter and 225 mL of water. The heat capacity used in the subsequent calculations is **not** C', since C' does not include the additional 25 mL used in the neutralization reactions. We must add an additional 104 J/^{o}C to the value of C' to get C, the calorimeter heat capacity used in the neutralization calculations:

$$Q \text{ (heat of neutralization per mole)} = C\,\Delta T/N$$

where N is the number of equivalents neutralized.

Report the values obtained in the measured heats, and explain any observed trends. Calculate the precision of the measurements.