

Heat of Neutralization Lab

Advanced Chemistry

NIVA International School 2010-2011

Thoroughly read the entire procedure before starting the lab.

Note: This lab will be submitted as a formal lab report. All observations must be properly recorded, in pen, on your data sheet (use the back if needed) and submitted with your formal lab report.

Introduction:

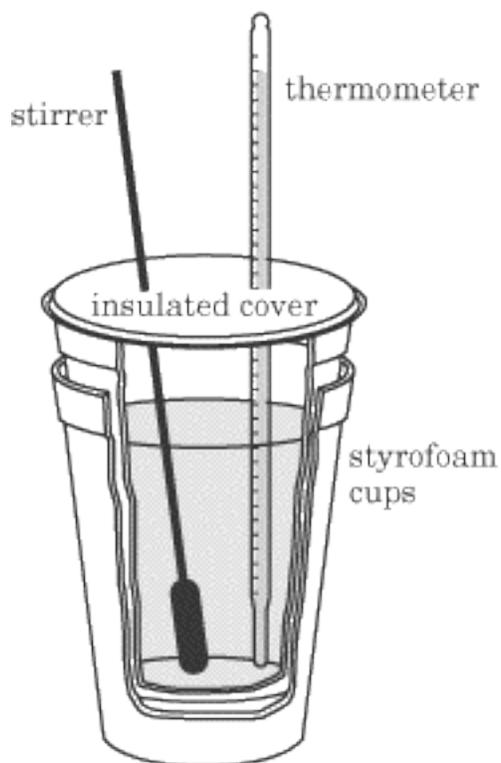
Every chemical change is accompanied by a change in energy, usually in the form of heat. The energy change of a reaction that occurs at constant pressure is termed the heat of reaction or the enthalpy change. The symbol ΔH is used to denote the enthalpy change. In this experiment, you will measure the heat of neutralization when an acid and base react to form 1 mole of water.

This quantity of heat is measured experimentally by allowing the reaction to take place in a thermally insulated Styrofoam cup calorimeter. The heat liberated in the neutralization reaction will cause an increase in the temperature of the solution and of the calorimeter. The heat lost by the neutralization reaction will equal the heat gained by the water and calorimeter. Because we are concerned with the heat of the reaction and because some heat is absorbed by the calorimeter itself, in the first part of this lab, we will determine the heat capacity of the calorimeter. This will be done by measuring the temperature change that occurs when a known amount of hot water is added to a known amount of cold water in the calorimeter. The heat lost by the water is equal to the heat gained by the cold water and the calorimeter. Once the heat capacity of the calorimeter is determined, we will then determine the heat released in the neutralization reaction as instructed in the procedure.

Materials: 2 Styrofoam cups
1 insulated cover (cardboard or Styrofoam)
1 thermometer (or Vernier LabQuest with Temperature Probe)
1-400 mL beaker
1-100 mL graduated cylinder

Chemicals: 1M HCl
1M NaOH
Tap Water

Note: For this lab, one group will use the digital temperature probe attached to the Vernier LabQuest, while the other group will use a standard liquid thermometer.



Procedure:

PART A: Determine Heat Capacity of Calorimeter

1. Construct a calorimeter by nesting two styrofoam cups in a 400-mL beaker to provide stability. The calorimeter lid should have a slit to hold a thermometer.
2. Place close to 50.0mL of tap water in the calorimeter cup and replace the cover and thermometer, be sure that the thermometer is not resting on the bottom of the calorimeter.
3. Leave the thermometer in the calorimeter. Measure close to 50.0mL of warm water from the sink at the front of the room. This water should be 15 to 20 degrees Celsius above room temperature.
4. Allow the hot water to stand for a minute or two, using another thermometer, quickly record its temperature and pour its contents completely into the calorimeter.
5. Replace the lid (incorporated with the thermometer) and carefully swirl the calorimeter. Observe the temperature for the next three minutes. You should see the temperature go up sharply and then, after a short time, it will start to cool back down (losing heat to surroundings).
6. Record in your data table the absolute HIGHEST temperature that you note. Calculate the heat capacity of the calorimeter.

PART B: Determine the Heat of Neutralization (ΔH°) of HCl + NaOH

1. Dry the calorimeter and thermometer with paper towel.
2. Measure out 50.0mL of 1.0M NaOH and add it to the calorimeter. Place the lid on the calorimeter but leave the thermometer out.
3. Measure out exactly 50.0mL of 1M HCl into a dry graduated cylinder. Allow it to stand near the calorimeter for about 3 minutes. Measure the temperature of the acid. Rinse the thermometer with tap water and wipe dry.
4. Insert the thermometer into the calorimeter and measure the temperature of the NaOH solution. The temperature of the NaOH and the HCl should not differ by more than 0.5° C. If the difference is greater than that, adjust the temperature of the HCl by either warming it by holding the graduated cylinder in your hand or cooling the outside with tap water until the temperature is within 0.5° C of the NaOH.
5. Record the temperature of the NaOH solution.
6. Lift the lid carefully and add the 1M HCl all at once. Be careful not to splash any on the upper side of the cup. Swirl the solution (gently) and observe the temperature for the next 3 minutes.
7. Record the absolute HIGHEST temperature that you note. Calculate the heat of neutralization per mole of water formed. You may assume that the NaCl solution has the same density and specific heat as water. [Note: this is not exactly true, it may be useful when explaining your errors.**]
8. Contents of calorimeter can safely be poured into the sink. Be sure to clean out your calorimeter.

These questions must be answered and attached to your lab report on a separate piece of paper. They can be typed or hand-written, but must be completed neatly and legibly. They will be marked in addition to your formal lab report.

To be clear: You are required to write a formal lab report, and attach your responses to these questions to your report when you submit it.

Analysis Questions

1. Using the equation: $q_{(\text{lost by warm water})} = -[q_{(\text{gained by cold water})} + q_{(\text{gained by calorimeter})}]$, solve for the heat gained by the calorimeter. **[2 marks]**
2. After this, determine the heat capacity of the calorimeter (the heat needed to raise the temperature of the calorimeter 1 degree Celsius). $C = -q/\Delta T$. Be sure that ΔT only refers to the change in temperature of the calorimeter! **[2 marks]**
3. Using the equation $q_{\text{rxn}} = -[q_{\text{soln}} + q_{\text{cal}}]$, calculate the heat released in the neutralization reaction, q_{rxn} . $\text{HCl}_{(\text{aq})} + \text{NaOH}_{(\text{aq})} \rightarrow \text{H}_2\text{O}_{(\text{l})} + \text{NaCl}_{(\text{aq})}$ **[2 marks]**
4. We are interested in the heat released per the coefficient of the balanced equation mole, ΔH_{rxn} . $\Delta H_{\text{rxn}} = q_{\text{rxn}}/\text{mol of water}$. Since you are given amounts of both reactions and products, you need to think a little about limiting reactants before you get too far. **[2 marks]**
5. The theoretical (accepted) ΔH_{rxn} for this neutralization reaction is -56.2 kJ. Calculate the percentage error for your value. **[2 marks]**

Formal Lab Report: 40 marks (see attached rubric)

Analysis Questions: 10 marks

TOTAL: 50 marks