

**Lab Procedure**

**Thermochemistry: Measuring Enthalpy Change in Chemical Reactions**

Experiment created by the UMaine InterChemNet© Team. Adapted with permission.

During the pre-laboratory class, ask your instructor to explain any new terms or any aspects of the procedures that you do not understand.

**Work in pairs**, with one person starting reactions while the other watches time and records data. As always, your report should be your own individual work. As you work, keep full, legible records of your data and observations in the proper sections of your printed **Report Form**. Both students should have all lab data before leaving lab.

**Preparation**

Assemble a calorimeter, consisting of two nested Styrofoam cups, a lid with two holes, a stirrer and a thermometer. To avoid having the calorimeter tip over when the thermometer is inserted into the inner Styrofoam cup, place the whole assembly in a snug-fitting beaker.

All students will carry out Part 1 of this experiment. Your instructor will assign other parts to individual pairs. **NOTE: Record all temperature measurements to the nearest 0.2° C.**

**Part 1. Heat Capacity of the Calorimeter**

1. Use a 100-mL graduated cylinder to obtain 50.0 mL of room-temperature water and add it to your calorimeter (the pure water in the carboys and your wash bottle will likely be at room temperature). Allow a few minutes for the apparatus to come to thermal equilibrium and record the temperature of the water in the calorimeter **to the nearest 0.2°C**.
2. Using your graduated cylinder, measure 50.0 mL of water into a small beaker and heat until it is about 30 degrees above room temperature. Record the exact temperature.
3. At time zero, carefully pour the warm water into the calorimeter, replace the lid (including the thermometer and stirrer), and stir the mixture. **Important: the process of heat exchange starts upon addition of the warm water - this is zero time!** In Table 1 of the **Report Form**, under **Trial 1**, record the temperature as soon as possible after adding the warm water and then every fifteen seconds until it reaches a maximum. Then record the temperature every 30 seconds for three minutes.
4. Empty your calorimeter, dry all parts completely, and allow it to return to room temperature (about 5 minutes).
5. Repeat this experiment (steps 1-4), entering the data in Table 1 under **Trial 2**.

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**Part 2. Enthalpy Change for an Acid-Base Reaction (Heat of Neutralization)**

***WARNING: 2.0 M NaOH and HCl can cause burns to skin and eyes. Wash spills with plenty of water.***

1. Pour 50.0 mL of 2.0 M sodium hydroxide (NaOH), measured with your graduated cylinder, into your clean, dry, room-temperature calorimeter. Make sure that the thermometer bulb is below the solution's surface. Allow the solution to reach equilibrium, and record the temperature.
2. Measure 50.0 mL of 2.0 M hydrochloric acid (HCl) in clean, graduated cylinder. Rinse and dry the thermometer to remove any NaOH, and then measure the temperature of the HCl solution. When the temperature is within 0.5 °C of that of the NaOH solution, carefully, but quickly, do the following:
  - a. Add the acid (HCl) to the base (NaOH) in the calorimeter.
  - b. Record the time (or start your stop watch).
  - c. Replace the calorimeter lid, with the thermometer and stirrer, and stir the solution gently.
  - e. Record the solution temperature to  $\pm 0.2$  °C (as well as the time).
  - f. After recording the initial temperature at mixing, keep stirring gently, and record the temperature at 15-second intervals for 3 minutes, or until the only change is a slow drift to lower temperatures. Enter your data in Table 2 of the **Report Form**, under **Trial 1**.
3. Empty your calorimeter in the appropriate container, rinse and dry all parts completely, and allow it to return to room temperature (about 5 minutes).
4. Repeat the experiment. Enter data into Table 2, under **Trial 2**.

**Part 3. Enthalpy Change for Dissolving Ammonium Chloride in Water (Heat of Solution)**

You will set up and record the temperature changes for this reaction the same way as the **Acid-Base Reaction**.

1. Pour 100.0 mL of distilled water (room temperature) into your clean, dry, room-temperature calorimeter. Allow the solution to reach equilibrium and record the temperature.

***WARNING: Ammonium chloride is an irritant to skin, respiratory tract, and eyes. Avoid contact. Wash spills with plenty of water. Keep weighed samples in dry glassware until ready for use.***

2. Weigh out about 10 g of ammonium chloride in clean, **DRY** plastic weigh boat. Record the mass to the nearest 0.001 g. Add the ammonium chloride to the water in the calorimeter, close the calorimeter, stir, and then record the temperature immediately, and every 15 seconds for three minutes, or until the only change is a slow drift to higher temperatures (while continuing to stir). Record your data in Table 3 of the **Report Form**, under **Trial 1**.

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3. Empty your calorimeter, dry all parts completely, and allow it to return to room temperature (about 5 minutes).
4. Repeat the experiment. Enter data in Table 3, under **Trial 2**.

**Part 4. Enthalpy Change for Oxidation of Calcium by HCl (Heat of Reaction)**

You will set up and record the temperature changes for this reaction the same way as you did in the **Acid-Base Reaction**.

1. Pour 100.0 mL of 2.0 M HCl into your clean, dry, room-temperature calorimeter. Allow the solution to reach equilibrium and record the temperature.

***WARNING: Calcium metal reacts with water (such as moisture in the air or on your skin) to produce caustic calcium hydroxide and flammable hydrogen gas. Keep calcium DRY until ready for use. Avoid contact with skin.***

2. Weigh out about 1 gram of calcium into a clean **DRY** weigh boat. Record the mass to the nearest 0.001 g. Make sure the metal is clean and shiny; otherwise, the oxide coating will prevent a fast reaction. Add it to the solution in the calorimeter, cover, stir gently, and start to record the temperature immediately as the mixture is stirred. Record time and temperature every 15 seconds for three minutes, or until the only change is a slow drift to lower temperature (while continuing to stir). Enter data in Table 4 of the **Report Form**, under **Trial 1**.

2. Empty your calorimeter, dry all parts completely, and allow it to return to room temperature (about 5 minutes).

3. Repeat the experiment. Enter data in Table 4, under **Trial 2**.

Finally, clean up and put away all lab equipment. Be sure to return calorimeter cups, stirrers, and thermometers to the side table. Please do not put them into your lab drawers.

Complete the **Report Form** for this experiment.