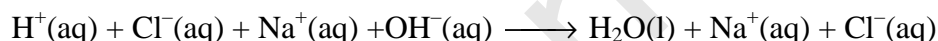


PRELIMINARY ACTIVITY FOR Enthalpy Changes

Open Inquiry Version

The heat absorbed or released during a chemical reaction is equal to the *enthalpy change* (ΔH) for the reaction, at constant pressure. *Calorimetry* is the measurement of heat absorbed or released during chemical and physical processes.

In the Preliminary Activity, you will gain experience using a Temperature Probe and a calorimeter as you determine the enthalpy change as a hydrochloric acid solution is neutralized by a solution of sodium hydroxide. You will use a Styrofoam cup nested in a beaker as a calorimeter, as shown in Figure 1. For purposes of this experiment, you may assume that the heat lost to the calorimeter and the surrounding air is negligible. Hydrochloric acid will be the limiting reactant in this experiment, and you will accordingly be determining the enthalpy, ΔH , of neutralization of the acid. Selecting a limiting reactant helps ensure that the temperature measurements and subsequent calculations are as precise as possible. Hydrogen ions from the HCl react with hydroxide ions from the NaOH in a one-to-one ratio to produce water in the overall reaction:



After completing the Preliminary Activity, you will first use reference sources to find out more about heat, enthalpy, enthalpy changes, and calorimetry before you choose and investigate a researchable question involving enthalpy changes. Some topics to consider in your reference search are:

- heat
- heat content
- enthalpy
- enthalpy changes
- endothermic
- exothermic
- enthalpy of reaction
- enthalpy of solution
- calorimetry

PROCEDURE

1. Obtain and wear goggles.
2. Connect the Temperature Probe to the data-collection interface.
3. Place a Styrofoam cup into a 400 mL beaker as shown in Figure 1. Measure out 50.0 mL of ~1.00 M HCl into the Styrofoam cup. Record the precise concentration of the HCl solution. **CAUTION:** Handle the hydrochloric acid with care. It can cause painful burns if it comes in contact with the skin.

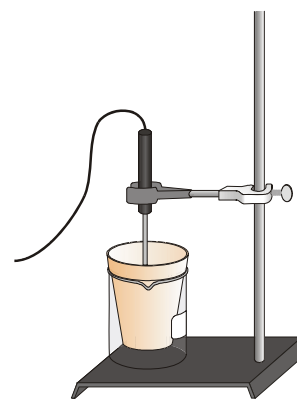


Figure 1

Experiment 9

4. Use a utility clamp to suspend a Temperature Probe from a ring stand as shown in Figure 1. Lower the Temperature Probe into the solution. **Note:** It may take up to 15 seconds for the Temperature Probe to equilibrate at the temperature of the HCl solution.
5. Measure out 50.0 mL of 1.05 M NaOH solution. **CAUTION:** Sodium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.
6. Start data collection. After 3–4 readings at the same temperature have been plotted, add the 50.0 mL of NaOH solution to the foam cup all at once. Stir the reaction mixture gently.
7. Data collection will stop after 180 seconds.
8. Use the Statistics function to display the initial and maximum temperature readings during the reaction. Record these values. If the minimum temperature is not a suitable initial temperature, examine the graph and determine the initial temperature.
9. Rinse and dry the Temperature Probe, Styrofoam cup, and stirring rod. Dispose of the solution as directed.

QUESTIONS

1. Subtract the initial temperature from the final temperature to determine the temperature change, Δt , for the process.
2. Determine the total mass of the product solution (assume its density is 1.00 g/mL).
3. Use the equation below to calculate the amount of heat energy, q , produced in the reaction.
 $C_p = 4.18 \text{ J/g}^\circ\text{C}$
$$q = C_p \cdot m \cdot \Delta t$$
4. Find ΔH ($\Delta H = -q$).
5. Calculate moles of HCl used in the reaction.

6. Use the results of the Step 4 and Step 5 calculations to determine ΔH /mol HCl.
7. (Optional) An accepted value for the ΔH of neutralization for HCl is -55.8 kJ/mol. Calculate the percent difference between this value and your experimental value.
8. List at least one researchable question concerning enthalpy changes.

Note: The plan that you submit for instructor approval should list laboratory safety concerns, including chemical safety concerns, and specify how you will address these safety concerns during your investigation.

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs

The complete *Investigating Chemistry through Inquiry* lab manual includes 25 inquiry-based labs and essential teacher information. The full lab book is available for purchase at:

<http://www.vernier.com/cmat/chemi.html>

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