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Group No.: 04

Date of Exp.: 2022/11/25

**Exp. 25 Calorimetry**

**Purpose:**

* To determine the specific heat of a metal.
* To determine the enthalpy of neutralization for a strong acid–strong base reaction.
* To determine the enthalpy of solution for the dissolution of a salt.

**Materials and Reactions (if any):**

* 10-30 g unknown metal
* 200-mm test tube
* 400-mL beaker
* two 6- or 8-oz Styrofoam coffee cups
* a plastic lid
* stirrer
* 110° glass or digital thermometer
* graduated cylinder
* 50.0 mL 1.1 M HNO3
* 50.0 mL 1.1 M HCl
* 50.0 mL of a standard 1.0 M NaOH
* salt

**Procedure:**

* **Safety precautions**
  + Carefully handle a glass thermometer. If the thermometer is accidentally broken, notify your instructor immediately.

1. Specific Heat of a Metal
   1. Prepare the metal. Obtain 10–30 g of an unknown dry metal from your instructor. Record the number of the unknown metal on the Report Sheet. Use weighing paper to measure its mass on your assigned balance. Transfer the metal to a dry, 200-mm test tube. Place the 200-mm test tube in a 400-mL beaker filled with water well above the level of the metal sample in the test tube. Heat the water to boiling and maintain this temperature for ~10 minutes so that the metal reaches thermal equilibrium with the boiling water.
   2. Prepare the water in the calorimeter. Obtain two 6- or 8-oz Styrofoam coffee cups, a plastic lid, stirrer, and a 110° glass or digital thermometer. Thoroughly clean the Styrofoam cups with several rinses of deionized water. Measure and record the combined mass (±0.01 g) of the calorimeter (the two Styrofoam cups, the plastic lid, and the stirrer). Using a graduated cylinder, add ~20.0 mL of water and measure and record the mass of the calorimeter plus water. Secure the glass or digital thermometer with a clamp and position the bulb or thermal sensor below the water surface.
   3. Measure and record the temperatures of the metal and water. Once thermal equilibrium (after ~10 minutes) has been reached in Parts A.1 and A.2, measure and record the temperatures of the boiling water and the water in the calorimeter. Record the temperatures using all certain digits plus one uncertain digit.
   4. Transfer the hot metal to the cool water and record the data. Remove the test tube from the boiling water and quickly transfer only the metal to the water in the calorimeter. Replace the lid and swirl the contents gently. Record the water temperature as a function of time (about 5-second intervals for 1 minute and then 30–45-second intervals for ~5 minutes) on the table at the end of the Report Sheet.
   5. Plot the data. Plot the temperature (y-axis) versus time (x-axis) on the top half of a sheet of linear graph paper or by using appropriate software. The maximum temperature is the intersection point of two lines: (1) the best line drawn through the data points on the cooling portion of the curve and (2) a line drawn perpendicular to the time axis at the mixing time [when the metal is added to the water (Figure 25.5)].5 Have your instructor approve your graph.
   6. Do it again. Repeat Parts A.1 through A.5 for the same dry metal sample. Plot the data on the bottom half of the same sheet of linear graph paper.
2. Enthalpy (Heat) of Neutralization for an Acid–Base Reaction
   1. Measure the volume and temperature of the HCl. Measure 50.0 mL of 1.1 M HCl in a clean graduated cylinder. Measure and record its temperature.
   2. Measure the volume and temperature of the NaOH. Using a second clean graduated cylinder, transfer 50.0 mL of a standard 1.0 M NaOH solution to the dry calorimeter. Record the temperature and exact molar concentration of the NaOH solution.
   3. Collect the data. Carefully but quickly add the acid to the base, replace the calorimeter lid, and swirl gently. Read and record the temperature and time every 5 seconds for 1 minute and thereafter every 30–45 seconds for ~5 minutes.
   4. Plot the data. Plot the temperature (y-axis) versus time (x-axis) on the top half of a sheet of linear graph paper or by using appropriate software. Determine the maximum temperature as was done in Part A.5.
   5. Do it again. Repeat the acid–base experiment, Parts B.1 through B.4. Plot the data on the bottom half of the same sheet of graph paper.
   6. Change the acid and repeat the neutralization reaction. Repeat Parts B.1 through B.5, substituting 1.1 M HNO3 for 1.1 M HCl. On the Report Sheet, compare the ∆Hn values for the two strong acid–strong base reactions
3. Enthalpy (Heat) of Solution for the Dissolution of a Salt
   1. Prepare the salt. On weighing paper, measure ~5.0 g (±0.001 g) of the assigned salt. Record the name of the salt and its mass on the Report Sheet.
   2. Prepare the calorimeter. Measure the mass of the dry calorimeter. Using your clean graduated cylinder, add ~20.0 mL of deionized water to the calorimeter. Measure the combined mass of the calorimeter and water. Secure the thermometer with a clamp and position the bulb or thermal sensor below the water surface and record its temperature.
   3. Collect the temperature data. Carefully add (do not spill) the salt to the calorimeter, replace the lid, and swirl gently. Read and record the temperature and time at 5-second intervals for 1 minute and thereafter every 30–45 seconds for ~5 minutes.
   4. Plot the data. Plot the temperature (y-axis) versus time (x-axis) on the top half of a sheet of linear graph paper or by using appropriate software. Determine the maximum (for an exothermic process) or minimum (for an endothermic process) temperature as was done in Part A.5. Have your instructor approve your graph.
   5. Do it again. With a second salt sample, repeat the dissolution of your assigned salt, Parts C.1 through C.4. Plot the data on the bottom half of the same sheet of linear graph paper.

**Calculations (if any):**