

Exp 5. Calorimetry - CHEM 117-506

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Purpose: To learn how to measure the heat flow of a reaction using a calorimeter.

Procedure:

Part A: Styrofoam Cup

- ① Obtain two styrofoam cups and assemble a calorimeter by nesting them. Place a magnetic stir bar inside the nested cups and weigh the entire apparatus on the top-loading balance to the nearest 0.01 g. Record this mass in your lab notebook.
- ② Using a graduated cylinder, measure out ~40 mL of room temperature deionized water. Add it to the calorimeter and weigh the apparatus on the top-loading balance to the nearest 0.01 g. Record the mass in your lab notebook.
- ③ Measure out ~50 mL of deionized water, place it in a 125 mL Erlenmeyer flask, and heat it to boiling.
- ④ Place the calorimeter on a ring stand. Using the ring stand, secure a clamp so that it can hold the temperature probe inside of the calorimeter. Make sure that the temperature probe is not touching the sides or the bottom of the cup. Turn on the stir plate so that the stir bar is mixing the water.
- ⑤ Begin taking temperature readings using the appropriate LoggerPro file. The temperature readings should be stable for at least one minute.
- ⑥ Add the boiling water into the calorimeter, being careful to avoid splashing the water. Record the exact time that you added the boiling water in your lab notebook.
- ⑦ Take temperature readings for at least 5 minutes after the time that you added the boiling water. Record the time and temperature data in your lab notebook.
- ⑧ When you are done taking temperature readings, remove the temperature probe and weigh the calorimeter on the top-loading balance to the nearest 0.01 g. Record the mass in your lab notebook.

Part B: Beaker

- ① Obtain a 150 mL glass beaker; this is another calorimeter. Place a magnetic stir bar inside the beaker and weigh the entire apparatus on the top-loading balance to the nearest 0.01 g. Record this mass in your lab notebook.
- ② Repeat steps 2-9 from Part A with your new calorimeter.

Part C: Coffee Mug

- ① Obtain your "mug"; this is another calorimeter. Place a magnetic stir bar inside the "mug" and weigh the entire apparatus on the top-loading balance to the nearest 0.01 g. Record this mass in your lab notebook.

- ② Note in your lab notebook the height of the cup, the diameter of the opening, the material that the cup is made out of, and any other pertinent details about the cup.

- ③ Repeat steps 2-9 from part A with your new calorimeter.

Part D: Reaction between HCl and NaOH

- ① Use your nested styrofoam cups. Place a magnetic stir bar inside the cups and weigh the entire apparatus on the top-loading balance to the nearest 0.01 g. Record this mass in your lab notebook.
- ② Using a 50 mL graduated cylinder carefully measure 50.0 mL of 1.0 M HCl and transfer it to your calorimeter. Place the calorimeter on a ring stand. Using the ring stand, secure a clamp so that it can hold the temperature probe inside of the calorimeter. Make sure that the temperature probe is not touching the sides or the bottom of the cup. Turn on the stir plate so that the stir bar is mixing the solution.
- ③ Launch the LoggerPro software again and monitor the temperature of the HCl solution. The temperature must remain constant for at least 2 minutes before proceeding. Once the temperature is constant, record the temperature of HCl solution in your lab notebook. While you wait, rinse the 50 mL graduated cylinder with deionized water and then use it

to measure 50.00 mL of 1.00 M NaOH.

- ④ Click the green COLLECT button in LoggerPro and then add the NaOH solution quickly to the calorimeter. LoggerPro will automatically record the temperature of the solution every 30 seconds for 10 minutes. The temperature at zero seconds is the temperature of the HCl solution before the NaOH solution is added. Record all time and temperature data in your lab notebook.
- ⑤ After the 10 minute collection has completed, turn off the magnetic stirrer and remove the temperature probe from the calorimeter. Weigh the calorimeter and its contents on the top-loading balance, recording the mass to the nearest 0.01 g.
- ⑥ Discard the contents of the calorimeter into the appropriate waste container, taking care not to pour the magnetic stir bar into the waste container. Rinse the temperature probe and the inside of your calorimeter with deionized water and pour it out, again taking care not to pour the magnetic stir bar down the drain.
- ⑦ Repeat steps 1 through 6 for a second trial.

Safety:

Chemical splash goggles must be worn during lab. Use tongs to handle hot glassware. Do not place styrofoam cups directly on a hot plate surface.

Waste Disposal:

All waste solutions should be disposed of in the inorganic waste bottles in the hood.

Part A - Styrofoam Cups dry weight: 8.03 g

| seconds | trial 1 | trial 2 | trial 3 |
|----------------|---------|---------|---------|
| 0 | 19.6 | 20.8 | 21.2 |
| 30 | 29.5 | 50.2 | 51.9 |
| 60 | 44.6 | 49.6 | 51.3 |
| 90 | 44.1 | 49.0 | 50.7 |
| 120 | 43.7 | 48.5 | 50.2 |
| 150 | 43.4 | 48.0 | 49.6 |
| 180 | 43.0 | 47.5 | 49.1 |
| 210 | 42.6 | 47.0 | 48.6 |
| 240 | 42.3 | 46.5 | 48.2 |
| 270 | 41.9 | 46.1 | 47.6 |
| 300 | 41.5 | 45.7 | 47.2 |
| initial weight | 47.23 | 47.41 | 48.15 |
| final weight | 95.08 | 94.12 | 94.73 |

101.3 kPa room pressure

Part B - Beaker

dry weight: 75.10 g

| seconds | trial 1 | trial 2 | trial 3 |
|---------|---------|---------|---------|
| 0 | 21.1 | 23.3 | 22.4 |
| 30 | 49.9 | 52.2 | 50.8 |
| 60 | 48.9 | 50.9 | 49.7 |
| 90 | 48.0 | 49.9 | 48.8 |
| 120 | 47.2 | 49.1 | 47.9 |
| 150 | 46.5 | 48.3 | 47.1 |
| 180 | 45.8 | 47.6 | 46.3 |
| 210 | 45.2 | 46.7 | 45.5 |
| 240 | 44.5 | 46.1 | 44.8 |
| 270 | 43.9 | 45.4 | 44.1 |
| 300 | 43.3 | 44.8 | 43.4 |

| | | | |
|----------------|--------|--------|--------|
| initial weight | 114.90 | 115.11 | 115.33 |
| final weight | 162.16 | 162.83 | 162.54 |

Part C - Coffee Mugs

dry weight: 224.27 g

| seconds | trial 1 | trial 2 | trial 3 |
|---------|---------|---------|---------|
| 0 | 21.1 | 24.9 | 25.0 |
| 30 | 49.3 | 52.1 | 52.8 |
| 60 | 48.6 | 50.9 | 51.9 |
| 90 | 48.0 | 50.3 | 51.3 |
| 120 | 47.5 | 49.8 | 50.7 |
| 150 | 47.0 | 49.2 | 50.3 |
| 180 | 46.6 | 48.7 | 49.8 |
| 210 | 46.2 | 48.3 | 49.4 |
| 240 | 45.9 | 47.8 | 48.9 |
| 270 | 45.5 | 47.3 | 48.5 |
| 300 | 45.1 | 47.0 | 48.1 |

| | | | |
|----------------|--------|--------|--------|
| initial weight | 264.32 | 264.29 | 265.02 |
| final weight | 311.48 | 311.16 | 312.29 |

plastic construction

diameter ~ 3 inches

height ~ 6.25 inches

Part D - Reaction between HCl and NaOH

opposite weight: 8.61

| seconds | trial 1 | trial 2 |
|---------|---------|---------|
| 0 | 20.9 | 19.3 |
| 30 | 27.0 | 26.1 |
| 60 | 26.9 | 26.0 |
| 90 | 26.9 | 26.0 |
| 120 | 26.8 | 25.9 |
| 150 | 26.7 | 25.8 |
| 180 | 26.6 | 25.7 |
| 210 | 26.6 | 25.6 |
| 240 | 26.5 | 25.5 |
| 270 | 26.4 | 25.4 |
| 300 | 26.3 | 25.4 |
| 330 | 26.3 | 25.3 |
| 360 | 26.2 | 25.2 |
| 390 | 26.1 | 25.2 |
| 420 | 26.0 | 25.1 |
| 450 | 25.9 | 25.1 |
| 480 | 25.9 | 25.0 |
| 510 | 25.8 | 24.9 |
| 540 | 25.6 | 24.9 |
| 570 | 25.6 | 24.8 |
| 600 | 25.5 | 24.7 |

| | | |
|--------------|--------|--------|
| dry weight | 8.61 | 10.05 |
| final weight | 109.99 | 112.11 |

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