Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Heat of Neutralization Experiment**

**Purpose:** To determine the enthalpies or heats of reaction, using Styrofoam cups as calorimeter, and to study Hess’s Law.

**Performance Objectives:** Following these investigations, you should be familiar with Calorimetry. You should be able to calculate enthalpies of solution and neutralization and to apply Hess’s law.

**Material:** Two (2) Styrofoam cups stacked together as calorimeter and one (1) Styrofoam cup trimmed one inch from the top and placed upside down in the other for the lid, 0.1°C thermometer, water, solid sodium hydroxide, Hydrochloric acid (HCl)

**Background Information:**

In this experiment you will use a Styrofoam cup as the reaction vessel and as a simple calorimeter to measure the heat evolved or absorbed during the reactions.

You may assume that the enthalpy or heat of reaction will be used to change the temperature of the aqueous solution only. Neglect small losses of heat to surroundings. Recall that it takes one calorie to change the temperature of one gram of water one degree Celsius. This is the specific heat of water, 1cal/gram °C.

You do not need to weigh the water used because the mass of one millimeter of water is very nearly one gram, and you will measure its volume to the nearest millimeter. When the reactants are added to your reaction flask you should note the change in temperature to the nearest 0.1° C. From this change in temperature, **ΔT,** and the mass of the reactants you can calculate the numbers of calories evolves or absorbed, **Q.**

Mass X **ΔT°C** X specific Heat = **Q**

In this experiment you will measure and compare the quantity of the heat involved in three reactions:

REACTION 1: Solid Sodium Hydroxide dissolves in water to form an aqueous solution of ions:

NaOH(s) 🡪Na+(aq) + OH-(aq) + X1 cal

ΔH1 = -X1 cal

REACTION 2: Solid Sodium Hydroxide reacts with an aqueous solution of hydrogen and chloride ions to form water and an aqueous solution of Sodium Chloride:

NaOH(s) + H+(aq) + Cl-(aq) 🡪H2O + Na+(aq) + Cl-(aq) + X2 cal

ΔH2 = -X2 cal

REACTION 3: An aqueous solution of Sodium Hydroxide reacts with a solution of hydrogen and chloride ions to form water and an aqueous solution of Sodium Chloride:

NaOH(s) + H+(aq) + Cl-(aq) 🡪H2O + Na+(aq) + Cl-(aq) + X3 cal

ΔH2 = -X3 cal

**Procedure:**

To determine the heat of Reaction (1):

1. Pour 150mL (± 1mL) of cool tap water into a cup. Stir carefully with a thermometer until a constant temperature is reached (about room temperature). Record this temperature to the nearest 0.1° C.
2. Weigh about 1.6 grams of solid Sodium Hydroxide (NaOH) to the nearest 0.01g. Since Sodium hydroxide become moist in open air, make weighing quickly.
3. Pour the weighed NaOH(s) into the water in the cup. Swirl the cup to dissolve the sodium hydroxide. Place the thermometer into the cup and record the highest temperature reached.
4. Before proceeding to REACTION 2, dispose of waste material into waste container and rinse cup thoroughly with water.

To determine the heat of Reaction (2):

1. Repeat steps a, b, and c above except in step (a) substitute 160mL of 0.25M HCl for tap water.
2. Rinse the cup again and proceed to REACTION 3:

To determine the heat of Reaction 3:

1. Measure out into a beaker 80mL of 0.5 M NaOH. Place 80mL 0.5 M NaOH in a calorimeter. Be sure that both of these solutions are slightly below room temperature. You should check the temperature of each solution with a thermometer being careful to rinse and dry it before transferring it from one solution to the other. Record the temperatures of birth the solutions. The average of these temperatures may be taken as the initial temperature. Add the sodium hydroxide solution to the hydrochloric acid solution. Mix quickly and note the highest temperature reached.

|  |  |  |  |
| --- | --- | --- | --- |
| **Heat of Reaction Data Table** | | | |
|  | **Reaction 1** | **Reaction 2** | **Reaction 3** |
| 1. **Initial temperature** |  |  |  |
| 1. **Final temperature** |  |  |  |
| 1. **The change in temperature, ΔT** |  |  |  |
| 1. **The amount of heat, Q, absorbed by the solution=mass X ΔT X cal/gram °C** |  |  |  |
| 1. **The amount of heat absorbed by the cup (neglect this quantity)** |  |  |  |
| 1. **The total amount of heat absorbed by the cup (neglect this quantity)** |  |  |  |
| 1. **The number of moles of NaOH used in the reaction** |  |  |  |
| 1. **The heat of reaction per mole of NaOH, ΔH, include sign (Line 6/Line7)** |  |  |  |

**Questions:**

1. Write a net ionic equation for the reaction (1) (2) and (3).

1. In reaction (1), ΔH1 represents the heat of solution of NaOH (s). Look at the net ionic equations for reactions (2) and (3) and make a statement concerning the significance of ΔH2, that is, what has happened to produce the energy change. Explain the meaning of ΔH3 also.

1. Compare ΔH2 with ΔH1+ ΔH3 and explain.

1. Calculate the percent difference between ΔH2 and the sum of ΔH1+ ΔH3, assuming ΔH2 to be correct.

**ΔH1+ ΔH3 X 100% =**

**ΔH2**

1. Supposed you had used 4g of NaOH(s) in reaction 1
   1. What would be the number of calories evolved?

* 1. What effect would this have on your calculations of ΔH1, the heat evolved per mole of NaOH?

**Conclusion:**