THE HEAT OF REACTION

In this experiment, you will measure and compare the quantity of heat involved in three chemical reactions. The reactions are:

Reaction 1: Solid sodium hydroxide dissolves in water to form an aqueous solution of ions:

$$NaOH(s) \rightarrow [Na]^+(aq) + [OH]^-(aq) + x_1J \qquad \Delta H = -x_1J$$

Reaction 2: Solid sodium hydroxide reacts with an aqueous solution of hydrogen chloride to form water and an aqueous solution of sodium chloride:

$$NaOH(s) + [H]^+(aq) + [Cl]^-(aq) \rightarrow H_2O + [Na]^+(aq) + [Cl]^-(aq) + x_2J \qquad \Delta H = -x_2J$$

Reaction 3: An aqueous solution of sodium hydroxide reacts with an aqueous solution of hydrogen chloride to form water and an aqueous solution of sodium chloride:

$$[Na]^+(aq) + [OH]^-(aq) + [H]^+(aq) + [Cl]^- \rightarrow H_2O + [Na]^+(aq) + [Cl]^-(aq) + x_3J \quad \Delta H = -x_3J$$

Note that the energy term is shown both as part of the equation and separately with the "ΔH" notation. You will calculate the amount of energy after measuring the temperature change of a known quantity of water. An expanded polystyrene cup will serve as the calorimeter in this experiment. Assume that the heat of *reaction will be used to change the temperature of the aqueous solution only. Neglect small losses to the surroundings. You do not need to find the mass of the water used since 1.0mL of water has a mass of 1.0g* and you will measure the volume of water to the nearest millilitre.

Procedure

Part 1 - DETERMINATION OF THE HEAT OF REACTION 1

Caution: Sodium hydroxide is extremely corrosive to the skin and causes blindness.

1. Put 150mL of cool tap water into an expanded polystyrene cup. Stir carefully with a thermometer until a constant temperature is reached (about room temperature). Measure this temperature as precisely as possible and record it.

2. Weigh out about 4g of solid sodium hydroxide, NaOH(s), as precisely as possible. Since sodium hydroxide becomes moist as it is being weighed in the open air, *your teacher* will demonstrate the rapid weighing of a prescribed number of solid pellets which will approximate 4g (between 3.9 and 4.1).

3. Pour the weighed NaOH(s) into the water in the expanded polystyrene cup. Place the thermometer into the solution and stir *gently but continuously* until the sodium hydroxide is dissolved. Record the extreme temperature reached. Before proceeding to reaction 2, discard the solution and rinse the cup thoroughly with water.

Part 2 - DETERMINATION OF THE HEAT OF REACTION 2

1. Repeat steps 1, 2 and 3 of Part 1, but substitute 150mL of 0.50M HCl for the tap water in step 1.

2. Discard the solution and rinse the cup before proceeding to reaction 3.

Part 3 - DETERMINATION OF THE HEAT OF REACTION 3

1. Measure 75mL of 1.0M HCl into the expanded polystyrene cup and 75mL of 1.0M NaOH into a 250mL beaker. Both of these solutions should be at, or slightly below, room temperature. Check this with the thermometer (rinse and dry the thermometer before changing from one solution to the other). Record the temperatures.

2. Add the sodium hydroxide solution to the hydrochloric acid solution in the expanded polystyrene cup. Mix quickly and record the extreme temperature reached.

Calculations and Results

1. For each reaction, calculate:
   a) the change in temperature
   b) the amount of heat absorbed by the solution
   c) the number of moles of NaOH used
   d) the amount of heat evolved *per mole* of NaOH

2. Express the above results as heats of reaction: ΔH_1, ΔH_2, ΔH_3.

3. Write the net ionic equation for reactions 2 and 3.

4. In reaction 1, ΔH_1 represents the heat evolved as solid NaOH dissolves. Look at the net ionic equations for reactions 2 and 3 and make similar statements as to what ΔH_2 and ΔH_3 represent.

5a. Compare ΔH_2 with $(\Delta H_1 + \Delta H_3)$ and explain your answer referring to question 4.
 b. Calculate the percentage difference between ΔH_2 with $(\Delta H_1 + \Delta H_3)$, assuming ΔH_2 to be the correct value. $[\Delta H_2 - (\Delta H_1 + \Delta H_3)]/ \Delta H_2 * 100\%$

6. Suppose you had used 8g of NaOH(s) in reaction 1.
   a) How would this have affected the change in temperature?
   b) What would have been the number of joules evolved in your experiment?
   c) What effect would this have on your calculations of ΔH_1, the heat evolved *per mole*?

Data Table format:

Experiment #	m_{NaOH}	V_{NaOH}	C_{NaOH}	V_{HCl}	C_{HCl}	V_{H2O}	n_{NaOH}	n_{HCl}	$m_{heat\ absorber}$	T_1	T_2	ΔT	Q	ΔH

Note: not all columns will be filled in for each of the three experiments