

PRE-LAB DISCUSSION

The energy involved in chemical reaction is expressed in terms of the amounts of heat released or absorbed during a reaction. This heat or reaction (ΔH) is measured in kilo-joules per mole. ΔH of an exothermic reaction (heat is released) has a negative sign; ΔH of an endothermic reaction (heat is absorbed) has a positive sign.

In this experiment, you will study three related exothermic reactions involving sodium hydroxide. In the first reaction, solid sodium hydroxide will dissociate into water. The heat produced this reaction (ΔH_1) is called the heat of solution of NaOH. In the second reaction, an aqueous solution of NaOH will react with an aqueous solution of HCl. The heat of this reaction (ΔH_2) is called the heat of neutralization of NaOH. In the third reaction, solid NaOH will be reacted with an aqueous solution of HCl. This reaction is actually a combination of the first two reactions. The solid NaOH will dissociate into its ions as it dissolves in the acid solution and then is neutralized by the acid. Thus, the heat of the reaction (ΔH_3) could be equal to ($\Delta H_1 + \Delta H_2$). Using calculations based on data collected in this experiment you will attempt to verify the additive nature of heats of reaction.

PURPOSE

To determine the heats of three exothermic reactions and investigate Hess' Law.

EQUIPMENT

balance	thermometer
graduated cylinder	small beaker
spatula	test tube holder

MATERIALS

Solid NaOH	test tube holder
0.5 M and 1M HCl	1 M NaOH solution
distilled water	

SAFETY

Solid NaOH and concentrated solution of NaOH are highly corrosive to the skin and eyes. Wear safety goggles.

PROCEDURE

PART A: Heat of Solution of Solid NaOH

1. Measure 100mL of distilled water into a graduated cylinder. Pour the water into a clean, dry beaker and allow it to stand until it reaches the room temperature.
2. Using a spatula weigh exactly 2.00 g of sodium hydroxide.
3. Measure the temperature of the water in the beaker. Record this as T_i in Part A of the data table.
4. Add the solid NaOH to the water in the beaker. Use the thermometer to stir the mixture until all the NaOH has dissolved temperature stops rising. Record the highest temperature as T_f in Part A of the data table.
5. Discard the solution. Rinse off the thermometer and dry the beaker.

PART B: Heat of Neutralization of HCl and NaOH Solutions

6. Measure 50.0mL of 1M HCl and pour it into the beaker. Allow the acid to stand until it reaches the room temperature. Record this temperature as T_i in Part B of the data table.
7. Add exactly 50.0mL of 1M NaOH solution to HCl solution. Stir with the thermometer and record the highest temperature as T_f in Part B of the data table.
8. Discard the solution. Rinse off the thermometer and dry the beaker.

PART C: Heat of solution of solid NaOH

9. Measure 100mL of 0.5M HCl and pour it into the beaker. Handle this acid carefully. Allow it to stand until it reaches the room temperature.
10. Using a spatula weigh exactly 2.00 g of sodium hydroxide.
11. Measure the temperature of the acid in the beaker. Record this as T_i in Part C of the data table.
12. Add the solid NaOH to the acid and stir the mixture with the thermometer. Record the highest temperature as T_f in Part C of the data table.

OBSERVATIONS AND DATA

DATA TABLE

PART A: Heat of Solution of Solid NaOH

Mass of 100mL of H ₂ O	100g
Mass of solid NaOH	2.00g
T _i	_____ °C
T _f	_____ °C

PART B: Heat of Neutralization of HCl and NaOH Solutions

Approximate mass of 50mL NaOH _(aq) + 50mL HCl _(aq)	100g
T _i	_____ °C
T _f	_____ °C

CALCULATIONS

PART A: Heat of solution of solid NaOH

1. Find the number of joules absorbed by the H₂O (released by NaOH). Number of joules = mass of H₂O x (T_f - T_i) x 4.2 J / g °C
2. Find the number of joules released per gram of NaOH. J / g °C = joules (from 1) / 2.00 g NaOH
3. Find ?H₁ in kJ/mole NaOH. ?H₁ = J / g NaOH x 40 g / mole NaOH x 1/1000 kJ / J

PART C: Heat of solution of solid NaOH

Approximate mass of 100mL HCl _(aq)	100g
T _i	_____ °C
T _f	_____ °C

PART B: Heat of Neutralization of HCl and NaOH Soln

4. Find the number of joules produced by the reaction of NaOH_(aq) and HCl_(aq)
Number of joules = mass of solutions (in grams) x (T_f - T_i) x 4.2 J / g °C
5. Find ?H₂ in kJ/mole NaOH.
?H₂ = joules (from 1) / 0.050 x 1/1000 kJ / J

PART C: Heat of solution of solid NaOH

6. Find the number of joules absorbed by the HCl solution (released by NaOH).

$$\text{Number of joules} = \text{mass HCl}_{(\text{aq})} \times (T_f - T_i) \times 4.2 \text{ J / g } ^\circ\text{C}$$

7. Find the number of joules released per gram of NaOH.
 $\text{J / g NaOH} = \text{joules (from 1)} / 2.00 \text{ g NaOH}$

8. Find ΔH_3 in kJ/mole NaOH
 $\Delta H_3 = \text{J / g NaOH} \times 40 \text{ g / mole NaOH} \times 1/1000 \text{ kJ / J}$

CONCLUSIONS AND QUESTIONS

1. Write the ionic equations for the three reactions observed in this experiment.
2. Write the Hess' Law, using the symbol ΔH with subscripts, to show the relationship between the heats of reaction of the three reactions.
3. Does your experimental data verify the equation in question 2?
4. What are some possible sources of error in this experiment?