Name _____ Period _____
Partner _____ Date _____

Heat of Reaction Lab

In this experiment you will determine and compare the quantity of heat energy released in three exothermic chemical reactions.

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

$$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq) + q_1 \text{ kJ}$$

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

$$Na^+(aq) + OH^-(aq) + H^+(aq) + Cl^-(aq) \rightarrow H_2O + Na^+(aq) + Cl^-(aq) + q_2 \text{ kJ}$$

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

$$NaOH(s) + H^+(aq) + Cl^-(aq) \rightarrow H_2O + Na^+(aq) + Cl^-(aq) + q_3 \text{ kJ}$$

A Styrofoam cup can be used as a calorimeter. The change in temperature that occurs for each reaction will be used to calculate the energy released in kJ per mole of sodium hydroxide used. We can assume for our calculations that any heat transferred to the Styrofoam and surrounding air will be negligible. We will also assume that 4.184 joules is needed to change the temperature of one milliliter of each solution one Celsius degree. Wear safety glasses.

Prelab Questions

1) What is meant by the symbol ΔH?

2) What is the significance of a negative ΔH?

3) How do you calculate the heat released in a reaction that takes place in aqueous solution?

4) What is Hess's Law?

Procedure

Reaction 1

1) Measure 100.0 mL of water (a few degrees below room temperature) into a calorimeter.
2) Obtain about 2g of solid NaOH(s) pellets, and record its mass.
3) Record the starting temperature of the water to the nearest 0.1 degrees Celsius.
4) Pour the pellets of sodium hydroxide into the water and stir the solution gently until all the solid has dissolved. Record the highest temperature reached during the reaction.
5) Dispose of the solution as directed by your teacher. Rinse the calorimeter and the thermometer thoroughly before proceeding to Reaction 2.

Data Table 1

1	Original temperature of water (t1)	
2	Final temperature of water (t2)	
3	Temperature change, Δt (t2 - t1 = Δt)	
4	Mass of 100 mL of water	
5	Heat evolved by reaction (ΔH)	
6	Mass of NaOH(s)	
7	Moles of NaOH	
8	Energy per mole of NaOH(q1)	

Reaction 2

1) Measure 50.0 mL of 1.0 M HCl solution into a calorimeter. Put 50.0 mL of 1.0 M NaOH solution in a clean beaker.
2) Record the temperature of each solution to the nearest 0.1ºC, but be sure to rinse it thoroughly before transferring it from one solution to another.
3) Pour NaOH solution into the HCl solution in the calorimeter. Stir the solution gently, and record the highest temperature obtained during the reaction. Discard the solutions. Rinse the calorimeter and the thermometer thoroughly before proceeding to Reaction 3.

Data Table 2

1	Original temperature of HCl (aq)	
2	Original temperature of NaOH (aq)	
3	Average original temperature (t1)	
4	Final temperature of solution (t2)	
5	Temperature change, Δt (t2 - t1 = Δt)	
6	Total mass of solution (assume 1mL = 1g)	
7	Heat evolved by reaction (ΔH)	
8	Molarity of NaOH solution	
9	Moles of NaOH	
10	Energy per mole of NaOH(q2)	

Reaction 3

1) The procedure for Reaction 3 is the same as for Reaction 1 except that 100.0 mL of 0.50 M HCl solution is used instead of the water.
2) After measuring 100.0 mL of the HCl solution into the calorimeter, proceed as before with steps 2 to 4 of the procedure.
3) Discard the solution and rinse the calorimeter.

Data Table 3

1	Original temperature of HCl (aq) (t1)	
2	Final temperature of solution (t2)	
3	Temperature change, Δt (t2 - t1 = Δt)	
4	Mass of HCl (assume 1mL = 1g)	
5	Heat evolved by reaction (ΔH)	
6	Mass of NaOH (s)	
7	Moles of NaOH	
8	Energy per mole of NaOH(q3)	

Post Lab Questions

1) What is the significance of reaction 3 compared to reaction 1 and reaction 2?

2) Does your value for q_3 equal $q_1 + q_2$?

3) Why should the thermometer be rinsed between readings in part 2?

4) Recommend one thing that could improve your results in this experiment.