LAB – CALORIMETRY (NEUTRALIZATION)

Determining the Enthalpy of a Neutralization Reaction Lab

The neutralization of hydrochloric acid with sodium hydroxide solution is represented by the following equation.

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

Using a coffee-cup calorimeter, you will determine the enthalpy change for this reaction.

Question

What is the heat of neutralization for hydrochloric acid and sodium hydroxide solution?

Prediction

Will the neutralization reaction be endothermic or exothermic? Record your prediction and give reasons.

Safety Precautions

If you get any hydrochloric acid or sodium hydroxide solution on your skin, flush your skin with plenty of cold water.

Materials

50 mL graduated cylinder	2 polystyrene cups	polystyrene lid	Thermometer
1.00 mol/L $HCl_{(aq)}$	1.00 mol/L $NaOH_{(aq)}$		

Procedure

1. Your teacher will allow the hydrochloric acid and sodium hydroxide solution to come to room temperature overnight.
2. Read the rest of this Procedure carefully before you continue. Set up a graph to record your temperature observations.
3. Build a coffee-cup calorimeter, using the diagram above as a guide. You will need to make two holes in the polystyrene lid one for the thermometer and one for the stirring rod. The holes should be as small as possible to minimize heat loss to the surroundings.
4. Rinse the graduated cylinder with a small quantity of 1.00 mol/L $NaOH_{(aq)}$. Use the cylinder to add 50.0 mL of 1.00 mol/L $NaOH_{(aq)}$ to the calorimeter. Record the initial temperature of the $NaOH_{(aq)}$. (This will also represent the initial temperature of the $HCl_{(aq)}$.) Use with caution, $NaOH_{(aq)}$ can burn your skin.
5. Rinse the graduated cylinder with tap water. Then rinse it with a small quantity of 1.00 mol/L $HCl_{(aq)}$. Quickly and carefully, add 50.0 mL of 1.00 mol/L $HCl_{(aq)}$ to the $NaOH_{(aq)}$ in the calorimeter. The $HCl_{(aq)}$ can burn your skin.
6. Cover the calorimeter. Record the temperature every 30 s, stirring gently and continuously.
7. When the temperature levels off, record the final temperature, T_f .
8. If time permits, repeat steps 4 to 7.

Analysis

1. Determine the amount of heat that is absorbed by the solution in the calorimeter.
2. Use the following equation to determine the amount of heat that is released by the reaction:

$-Q_{reaction} = Q_{solution}$

3. Determine the number of moles of $HCl_{(aq)}$ and $NaOH_{(aq)}$ that were involved in the reaction.
4. Use your knowledge of solutions to explain what happens during a neutralization reaction. Use equations in your answer. Was heat released or absorbed during the neutralization reaction? Explain your answer.

Conclusion

5. Use your results to determine the enthalpy change of the neutralization reaction, in kJ/mol of NaOH. Write the thermochemical equation for the neutralization reaction.

Applications

6. When an acid gets on your skin, why must you flush the area with plenty of water rather than neutralizing the acid with a base?

7. Suppose that you had added solid sodium hydroxide pellets to hydrochloric acid, instead of adding hydrochloric acid to sodium hydroxide solution?

(a) Do you think you would have obtained a different enthalpy change?

(b) Would the enthalpy change have been higher or lower?

(c) How can you test your answer? Design an investigation and carry it out with the permission of your teacher.

(d) What change do you need to make to the thermochemical equation if you perform the investigation using solid sodium
hydroxide?

Extension Question

8. In Investigation 5-A, you assumed that the heat capacity of your calorimeter was 0 J/°C.

(a) Design an investigation to determine the actual heat capacity of your coffee-cup calorimeter, $C_{calorimeter}$. Include equations for any calculations you will need to do. If time permits, have your teacher approve your procedure and carry out the investigation. *Note:* $Q_{warm} = -(Q_{cold} + Q_{calorimeter})$

Hint: If you mix hot and cold water together and no heat is absorbed by the calorimeter itself, then the amount of heat absorbed by the cold water should equal the amount of heat released by the hot water. If more heat is released by the hot water than is absorbed by the cold water, the difference must be absorbed by the calorimeter.

(b) Include the heat capacity of your calorimeter in your calculations for $\Delta H_{neutralization}$. Use the following equation:

$-Q_{reaction} = (m_{solution} \times C_{solution} \times \Delta T) + (C_{calorimeter} \times \Delta T)$

HOMEFUN: COMPLETE Q1-8