LaGuardia Community College

Natural Sciences Department

SCC205 Introduction to Chemistry

Experiment # 7

Heat of Solution of a Salt

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Objectives

At the end of this experiment, you will know how to use calorimetry to measure the heat absorbed or released in physical and chemical processes, and be able to classify these processes as endothermic or exothermic.

Introduction

Thermodynamics is the study of energy and its transformations. Thermochemistry is a subset of this field that studies the energy changes that accompany physical changes (such as melting or dissolution) and chemical reactions. There are many forms of energy and heat is one of the most familiar kinds. Heat is the amount of thermal energy contained in a substance and is a form of kinetic energy due to the motions of molecules (vibrations, rotations and translations). When a process results in heat being absorbed *from* the surroundings, it is described as ***endothermic***; if heat is released *to* the surroundings, the process is ***exothermic***.

The amount of heat absorbed or released by a physical or chemical process can be measured using a technique called calorimetry. A simple calorimeter can be constructed using two Styrofoam cups with a lid (Figure 1). In the calorimeter, heat is transferred to or from a known mass of water by the process, which in this case, is the dissolution of a salt. If the process releases heat (exothermic), then the temperature of the water rises and this increase in temperature is measured using a thermometer.

The amount of heat absorbed or released by the water can be calculated by the following formula:

$$\mathbf{q = m\ s\ \Delta t}$$

where q = heat absorbed or released (Joules, J)

m = mass of the water/solution in the calorimeter (grams, g)

s = specific heat of the water (4.184 J/g·°C), and

Δt = change in temperature = final – initial temperature of the water (°C)

(Note that a negative value for Δt indicates that the water has cooled down or lost heat.)

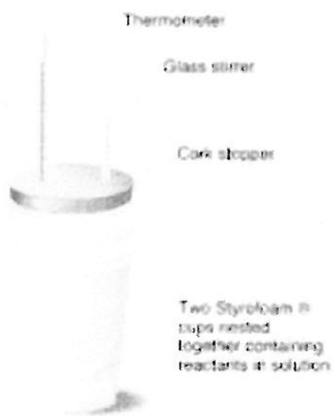

Figure 1: Diagram of a Simple Calorimeter

If the amount of heat absorbed by the water is known, calorimetry assumes that this was the exact amount of heat lost by the process (energy cannot be created or destroyed!) and vice versa. This of course assumes that the calorimeter allows no heat to escape to the surroundings.

When salts dissolve, there is a breakdown of the crystal structure and interaction of the ions with the water molecules. In this experiment you will measure the heat that is absorbed or released by a known mass of water when a salt dissolves and determine whether the dissolution process is endothermic or exothermic.

Materials

Calcium chloride ($CaCl_2$), Ammonium chloride (NH_4Cl), two Styrofoam cups with lid, thermometer, glass stirrer, spatulas, 50 mL graduated cylinder, weighing paper or weighing boats, electronic balance.

Safety

1. Wear your safety goggles at all times during this lab.

Do not stir with the thermometer and be careful not to break the thermometer by hitting the glass rod against the thermometer bulb.

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Procedure

Weigh out accurately about 4 g of calcium chloride in a weighing boat (or weighing paper) and record the mass on your results sheet. Using a graduated cylinder, accurately measure between 30 – 40 mL of distilled water; record your measurement to *one decimal place* on your results sheet. Pour the water into a calorimeter constructed of two stacked Styrofoam cups. (Styrofoam is a good heat insulator and prevents the heat involved in the process from escaping into the surroundings.) Determine and record the initial temperature of the water in the calorimeter, again recording your results to *one decimal place.* Quickly transfer the weighed calcium chloride to the calorimeter and cover with the lid. Insert the stirrer and stir to dissolve the salt. Record the final temperature of the solution (highest or lowest temperature attained). Calculate the amount of heat in Joules (J) absorbed or liberated per gram of salt and determine whether the process is exothermic or endothermic. Assume the specific heat of the solution is the same as the specific heat of water (4.184 J/g$\cdot$°C) and that the mass of water in grams = volume of water in milliliters (since density of water ~ 1.00 g/mL).

Repeat the procedure using ammonium chloride.

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SCC205 Introduction to Chemistry:

Experiment: Heat of Solution of a Salt

Report Sheet

Name________________________________ Section___________ Date_____________

RESULTS:

	$CaCl_2$	NH_4Cl
a. Mass of salt (g)		
b. Volume of water in calorimeter (mL)		
c. Mass of water in calorimeter (g)		
d. Grams of solution (a + c), (g)		

e. Initial temperature of water, (°C)		
f. Final temperature of solution, (°C)		
g. Temperature change (f – e), (°C)		

1. Calculate the heat absorbed or released by the calcium chloride solution (show your work):

2. Is the process endothermic or exothermic? ______________________

Calculate the heat of solution per gram of $CaCl_2$ (1/a). What does the sign of q indicate?

3. Calculate the heat absorbed or released by the ammonium chloride solution (show your work):

4. Is the process endothermic or exothermic? ______________________

Calculate the heat of solution per gram of NH_4Cl (1/a). What does the sign of q indicate?

5. Hot and cold packs are available in many pharmacies to treat simple injuries.

   Which salt would be suitable for a cold pack? ____________________.

Which salt would be suitable for a hot pack? ______________________.