Discovering Instant Cold Packs
Heat of Solution

Introduction

Instant cold packs are familiar first aid devices used to treat injuries when ice is unavailable. Most commercial cold packs consist of a plastic package containing a white solid and an inner pouch of water. Firmly squeezing the pack causes the inner pouch to break. The solid then dissolves in the water producing a change in temperature. Can we measure the temperature change that occurs when the cold pack solid dissolves in water and determine the heat change for this process?

Concepts

- Enthalpy change
- Heat of solution
- Calorimetry
- Dependent and independent variables

Background

The energy or enthalpy change associated with the process of a solute dissolving in a solvent is called the heat of solution (ΔH_{soln}). In the case of an ionic compound dissolving in water, the overall energy change is the net result of two processes—the energy required to break the attractive forces (ionic bonds) between the ions in the crystal lattice, and the energy released when the dissociated (free) ions form ion-dipole attractive forces with the water molecules.

Heats of solution and other enthalpy changes are generally measured in an insulated vessel called a *calorimeter* that reduces or prevents heat loss to the atmosphere outside the reaction vessel. The process of a solute dissolving in water may either release heat into the aqueous solution or absorb heat from the solution, but the amount of heat exchange between the calorimeter and the outside surroundings should be minimal. When using a calorimeter, the reagents being studied are mixed directly in the calorimeter and the temperature is recorded both before and after the reaction has occurred. The amount of heat change occurring in the calorimeter may be calculated using the following equation: $q = m \times s \times \Delta T$, where m is the total mass of the solution (solute plus solvent), s is the specific heat of the solution, and ΔT is the observed temperature change. The specific heat of the solution is generally assumed to be the same as that of water, namely, 4.18 J/g·°C.

Experiment Overview

The purpose of this inquiry-based experiment is to design and carry out a procedure to determine the enthalpy change that occurs when a "cold pack solid" dissolves in water.

Pre-Lab Questions

Consider the following questions or guidelines:

1. What information (data) is needed to calculate an enthalpy change for a reaction?
2. Identify the variables that will influence the experimental data.
3. What variables should be controlled (kept constant during the procedure)?

4. The independent variable in an experiment is the variable that is changed by the experimenter, while the dependent variable responds to (depends on) changes in the independent variable. Choose the dependent and independent variables for this experiment.
5. Discuss the factors that will affect the precision of the experimental results.

Materials

Beaker, 400-mL
"Cold pack solid," 15 g
Distilled or deionized water
Graduated cylinder, 100-mL
Insulated foam (Styrofoam™) cups, 6 oz
Balance, centigram (0.01 g precision)
Digital thermometer or temperature sensor
Spatula
Stirring rod
Weighing dishes

Safety Precautions

The cold pack solid is slightly toxic by ingestion and is a body tissue irritant. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles and chemical-resistant gloves and apron. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

Part A. What Is an Instant Cold Pack?

Complete the following activity to become familiar with the nature and amounts of materials in a commercial cold pack.

1. Obtain a label of a commercial cold pack and write the name of the solid used in the pack.
2. Read the warning information on the label and record any hazards associated with this product.
3. Using the known charges of ions, write the formula of the solid.
4. Calculate the molar mass of the solid.
5. Determine the total mass of the solid: Tare a large weighing dish or cup on the balance. Transfer the cold pack solid to the tared weighing dish. Record the mass of the solid to the nearest 0.01 g.
6. Calculate the number of moles of solid in the pack.
7. Measure the volume of water contained in the inner pouch.
8. Calculate the mass of water in the commercial cold pack (assume the density of water is 1.0 g/mL).

Name of solid	
Warning	
Formula of solid	
Molar mass	
Mass of solid	
Moles of solid	
Volume of water	
Mass of water	

Part B. Measuring the Heat of Solution

Design and carry out a procedure to determine the enthalpy change (ΔH_{soln}) that occurs when the cold pack solid dissolves in water. Use a maximum of 5 grams of solid per measurement. Write out the procedure in steps and construct a data table that clearly shows the data that will be collected and the measurements that will be made. Have your teacher check the procedure and data table before beginning the experiment.

Procedure

1.

2.

3.

4.

5.

6.

Data Table. Enthalpy Change for Dissolving the Cold Pack Solid

Name: _____

Class/Lab Period: _____

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Post-Lab Calculations and Analysis

1. Calculate the *heat energy change in joules* when the cold pack solid dissolved in water in your experiment. *Recall:* $q = m \times s \times \Delta T$, where s (specific heat of water) is equal to 4.18 J/g·°C.

2. Calculate the energy change in *joules per gram of solid* for the cold pack solid dissolving in water.

3. Calculate the energy change in units of *kilojoules per mole* of solid for the cold pack solid dissolving in water. To do this:

   (a) Convert the heat energy change found in Question #1 to kilojoules.

   (b) Convert the grams of solid used in the experiment to moles.

   (c) Divide the energy change in kilojoules by the number of moles of solid to determine the energy change in units of kJ/mole. If more than one trial was performed, calculate the *average value* of the heat of solution also.

4. Using the result from Question #3c and the information obtained in Part A, calculate the number of kilojoules involved when the entire cold pack is activated.

5. Circle the correct choices in the following sentence to summarize the heat change that occurs when the commercial cold pack is activated:

   "When the white solid in the commercial cold pack dissolves in water, the pack feels (*hot/cold*) because the temperature of the solution (*increases/decreases*). Energy is (*absorbed/released*) from the surroundings during this reaction and the reaction is classified as (*endothermic/exothermic*). The sign of ΔH for the heat of solution is (*positive/negative*)."