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Discovering Instant Cold Packs

An Inquiry Activity

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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 the temperature change that occurs when the cold pack solid dissolves in water be measured and the heat change for this process determined?

(1) **Concepts + Terms** to be defined - on a separate piece of notebook paper:

- Enthalpy change
- Heat of solution
- Exothermic Rxn
- Molar Mass
- Calorimetry
- Dependent and independent variables
- Endothermic Rxn
- Solute
- Solvent
- System vs. Surroundings

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. The process of a solute dissolving in water may either release heat into the aqueous solution or absorb heat from the solution.

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. 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.

(2)

Pre-Lab Questions

Answer the following questions on your notebook paper.

1. What information (data) is needed to calculate the enthalpy change for a reaction?
2. Identify the possible variables in this experiment.
3. 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.
4. What variables should be controlled (kept constant during the procedure) in this experiment?
5. Discuss the factors that will affect the precision of the experimental results.

Materials

- Beaker (to stabilize cups)
- Cold pack
- Distilled or deionized water
- Graduated cylinder, 100-mL
- Insulated foam (Styrofoam™) cups, 6-oz, 2
- Goggles
- Gloves
- Scissors
- Balance
- Thermometer (set to °C)
- Spoon
- Stirring rod
- Weighing dish (plastic)

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

(3)

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	Ammonium nitrate
Warning(s)	
Formula of solid	
Molar mass (g/mol)	
Mass of solid (g)	
Moles of solid (mol)	Mass of Solid / Molar Mass = Moles of Solid
Volume of water (mL)	
Mass of water (g)	

(4)

Measuring the Heat of Solution

a. Design and b. 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 __ grams of solid per measurement. Write out the procedure in steps

Have your teacher check the procedure before beginning the experiment.

Procedure

(5)

Data Table. Enthalpy Change for Dissolving the Cold Pack Solid

Trial	Mass of Cold Pack Solid (g)	Volume of Water (mL)	Mass of Solution (g)	Initial Temperature (°C)	Final Temperature (°C + °F)	Temperature Change, ΔT (°C)
1					°C °F	
2					°C °F	
3					°C °F	

$F = (C \times 9/5) + 32$

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(6)

Post-Lab Calculations and Analysis

Show your work! Use significant figures!

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, also calculate the average value of the heat of solution.

4. Using the result from Question #3*c* 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 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)*."

6. what is the average temperature (°F) reached with instant cold packs?