The Pluses and Minuses of Enthalpy, Entropy, and Free Energy

Enthalpy, Entropy, and Free Energy

Introduction

Introduce students to the concept of spontaneous reactions using the same materials found in hand warmers!

Concepts

- Enthalpy
- Entropy
- Spontaneous reactions

Materials

Sodium acetate, trihydrate, $CH_3CO_2Na \cdot 3H_2O$, 160 g
Water, distilled or deionized, 30 mL
Erlenmeyer flask, 500-mL, Pyrex® Stirring rod, glass
Graduated cylinder, 100-mL or 50-mL
Heat-resistant gloves or tongs
Hot plate or Bunsen burner
Parafilm M® or stopper to fit flask
Washing bottle filled with distilled water

Safety Precautions

Sodium acetate is a skin, eye and respiratory irritant. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Preparation

1. Weigh out 160 g of sodium acetate trihydrate in a 500-mL Erlenmeyer flask.
2. Using a graduated cylinder, measure out 30 mL of distilled water, and add it to the flask of sodium acetate trihydrate.
3. Heat the mixture on a hot plate or over a Bunsen burner, stirring occasionally until the entire solid is dissolved. (This may take 15 minutes or so.) Make sure the sides of the flask are free of solid sodium acetate. To remove crystals from the sides of the flask, rinse them down with small squirts of water from the washing bottle.
4. Cover the flask with Parafilm or a 100-mL beaker. Allow the solution to cool to room temperature undisturbed or, to speed up the cooling process, run cool water over the sides of the flask making sure no tap water gets into the flask contaminating the solution.
5. The flask can now sit undisturbed until you are ready for the presentation. Take care not to disturb the solution as even slight movement may cause crystallization to occur before you're ready.

Procedure

1. While holding a single sodium acetate trihydrate crystal over the open mouth of the flask, snap your fingers and allow the crystal to drop into the flask. You might want to say some magic words like "abracadabra presto" as you snap your fingers. The single crystal should start a chain reaction of crystallization.
2. Immediately turn the flask upside down as crystallization occurs. The crystallized sodium acetate will not fall out.
3. Feel the sides of the flask. The flask will be warm since this is an exothermic process.
4. The solution may be used over again by reheating it to re-dissolve the sodium acetate.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes. The solidified sodium acetate may be disposed of according to Flinn Suggested Disposal Method #26a.

Tips

- Use caution if substituting a non-Pryex hydrometer cylinder for the flask in this demo. The temperature differential may crack the cylinder. Use a Pyrex cylinder instead or allow the supersaturated solution to cool slightly before pouring it into the cylinder.
- The addition of too much water will result in leftover liquid after crystallization.
- This demonstration can be performed for a larger audience by using 640 g sodium acetate trihydrate and 120 mL water.
- Topics of discussion may include saturated solutions, supersaturated solutions, crystallization, and exothermic processes.
- Uses for supersaturated sodium acetate solutions include hot packs and hand warmers.
- Use a Flinn ChemCam™ or other video microscopy unit to provide a close-up view of the crystallization process.

Discussion

A supersaturated solution of sodium acetate trihydrate (the clear solution) will crystallize by the addition of a single crystal of the solid. A supersaturated solution is a solution which contains a greater amount of dissolved substance than is present in a saturated solution at the same temperature. A saturated solution is a solution which contains the maximum amount of a dissolved substance at a given temperature.

A supersaturated solution can be made by gradually cooling a saturated solution without agitation so that crystals do not form. Supersaturated solutions are extremely unstable and will precipitate, or crystallize, upon addition of just one crystal of the solute. Even slight shaking or agitation may be enough to cause crystallization to begin. The supersaturated sodium acetate solution will begin to crystallize if the system is slightly disturbed via physical movement or upon addition of more sodium acetate crystals.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy
Content Standard E: Science and Technology
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions, conservation of energy and increase in disorder, interactions of energy and matter
Content Standard E: Science and Technology

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of *The Pluses and Minuses of Enthalpy, Entropy, and Free Energy* activity, presented by Peg Convery, is available in *Enthalpy, Entropy, and Free Energy*, part of Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *The Pluses and Minuses of Enthalpy, Entropy, and Free Energy* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0037	Sodium Acetate, 500 g

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.