

Freezer Flask Demonstration

Recommended Grade Level(s):

Appropriate for: Middle school and High school

Time Requirements:

Activity Time: 30 minutes

Teaching Topics & Concepts:

- To illustrate an endothermic reaction involving reactants in the solid state.
- Structure and properties of matter, interactions of energy and matter.
- Enthalpy, entropy, and free energy.
- Chemical reactions
- Analyzing and interpreting data

Background:

Endothermic reactions suck—they suck up the heat from their surroundings. Consider the handy cold packs we use for first aid. These packs consist of two bags: one containing water, inside a bag containing ammonium nitrate, calcium ammonium nitrate, or urea. When the inner bag of water is broken by squeezing the package, it dissolves the solid in an endothermic process. This entropy-driven reaction takes heat from the surroundings—just sucks the heat right up. Studying the science behind endothermic reactions will help students understand why $\text{NH}_4\text{NO}_3(\text{s}) + \Delta\text{H}_2\text{O} \rightarrow \text{NH}_4 + \text{NO}_3$ brings so much relief to a sprained ankle. Use this Freezer Flask activity to demonstrate an even colder reaction!

Materials:

- Barium hydroxide 8—hydrate, $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$
- Ammonium thiocyanate, NH_4SCN
- 500 mL Erlenmeyer flask with rubber stopper
- Wood board
- Electronic balance
- Water



Safety

- Read the SDS sheets for all chemicals before using them.
- Ammonia gas is produced. Avoid inhalation. (You may wish to do this demonstration in a fume hood.)
- Wear safety glasses, gloves, and a lab coat.
- Firmly hold the rubber stopper to prevent it from popping off.
- Do not drink the contents of the flask. Avoid skin contact. If you get any solution on your skin, rinse it off with water.



Freezer Flask Demonstration (continued)

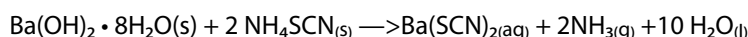
Procedure:

1. Pour a small amount of water (enough to ensure good contact with the base of the Erlenmeyer flask) on a square wooden board.
2. Place 50 g of barium hydroxide octahydrate and 25 g ammonium thiocyanate into the Erlenmeyer flask. Place a rubber stopper in the flask. Swirl to mix.
3. Place the flask in the puddle of water on the board. (You can touch the outside of the flask but don't hold it in your hand while performing the reaction.)
4. Lift the flask after a few minutes.

Expected Results:

As the two compounds in the flask are mixed, an endothermic reaction occurs, creating a freezing slush that will make the flask bottom stick to the piece of moistened wood. The reaction vessel gets cold enough to freeze the water between the board and the flask. Energy absorbed by the reaction freezes the water so that the board will be attached to the flask.

The solid barium hydroxide reacted with solid ammonium thiocyanate produces barium thiocyanate, ammonia gas, and liquid water. This reaction gets down to -20°C or -30°C , which is more than cold enough to freeze water. The reaction proceeds according to the following equation:



Follow up/Extension:

- Ammonium nitrate can be a substitute for ammonium thiocyanate.
 - Enthalpy and heat of reaction, the reaction between two solids.
 - Demonstration of an endothermic reaction: dissolve ammonium chloride in water.
 - Demonstration of an exothermic reaction: dissolve calcium chloride in water.
- Have your students write the equations for these reactions.

Disposal/Clean-Up:

Open the flask in a fume hood and allow the ammonia to evaporate overnight.

The remaining contents can be placed in the science department's heavy metal waste container for proper disposal.

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