

Cool Reaction

The Endothermic Reaction Between Barium Hydroxide and Ammonium Thiocyanate



Introduction

Many reactions produce heat, in fact when people think of chemical reactions, heat production is often expected. However, endothermic reactions, reactions which consume heat, can be just as exciting. One of the most striking examples of this is when the solids barium hydroxide and ammonium thiocyanate are mixed together in a beaker.

Materials

Ammonium thiocyanate, NH_4SCN , 10 g	Stirring rod
Barium hydroxide octahydrate, $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$, 20 g	Thermometer graduated to at least -30°C
Erlenmeyer flask, small, with stopper, or a 50-mL beaker	

Safety Precautions

Barium salts are toxic by ingestion. Ammonium thiocyanate is also toxic by ingestion. Use caution when handling the beaker or flask. Use tongs if available. The temperatures involved are cold enough to freeze skin. Ammonia vapor is very irritating to eyes and the respiratory tract. Do not allow students to inhale this gas. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Transfer 20 g of barium hydroxide and 10 g of ammonium thiocyanate to a flask and mix with a glass or plastic stirring rod.
2. In less than two minutes the solids become liquid. A thermometer placed in the mixture shows the temperature falling far below freezing. An ammonia odor is evident to all who are near the flask.
3. Place the flask in a small puddle of water and your students will clearly see just how cool this reaction is; the water will freeze the flask to the counter top. Alternatively, spray the outside of the flask with water from a wash bottle.
4. After a short time the flask with stopper may be passed around so that everyone can feel it. We encourage the use of a stopper because ammonia gas can be very irritating.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Use Flinn Suggested Disposal Method #27h for the products of this reaction.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12

Systems, order, and organization
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 Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

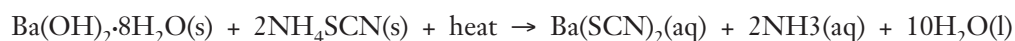
Tip

- A 50-mL beaker and Parafilm® M may be used in place of the Erlenmeyer flask and stopper.

Discussion

This demonstration would be a great way to introduce the concept of heat as a reactant or product. In this reaction, heat is a reactant. It is absorbed from the surroundings as the reaction proceeds. The surroundings lose so much heat that water freezes! A good companion demonstration to this is *The Chef*, which shows an exothermic reaction. *The Chef* shows that when calcium oxide and water react, enough heat is produced to fry an egg. You may request this experiment from Flinn Scientific by its name or as publication No. 203.

The reaction between the solids is:



This demonstration can be expanded into a lab on thermodynamics by using other ammonium salts. These include ammonium chloride (7 g) and ammonium nitrate (10 g). Have your energetic students (no pun intended) write the equations for these reactions. Thermodynamic data is available for the reaction between barium hydroxide and ammonium chloride or ammonium nitrate. These data can then be tested using calorimetry.

Compound	ΔH°_f (kJ/mol)	S°_{298} (J/mol·K)	C°_{p298} (J/mol·K)	ΔG°_f (kJ/mol)
$\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O(s)}$	-3334.2	427	—	-2793
$\text{Ba(NO}_3)_2\text{(s)}$	-992.07	214	151.4	-796.72
$\text{BaCl}_2 \cdot 2\text{H}_2\text{O(s)}$	-1460.1	203	162.0	-1296.5
$\text{NH}_4\text{NO}_3\text{(s)}$	-365.6	151.1	139	-184.0
$\text{NH}_4\text{Cl(s)}$	-314.4	94.6	84.1	-203.0
$\text{H}_2\text{O(l)}$	-285.83	69.91	75.29	-237.2
$\text{NH}_3\text{(aq)}$	-80.29	111	—	-26.6

References

Atkins, P. W. *General Chemistry*; W. H. Freeman: New York, 1989; p 188.

Shakhashiri, B. Z., *Chemical Demonstrations: A Handbook for Teachers of Chemistry*; University of Wisconsin: Madison, WI, 1983; pp 10–12.

Summerlin, L. R., Ealy, J. L., *Chemical Demonstrations: A Sourcebook for Teachers*; American Chemical Society: Washington, DC, 1988; Vol. 1, p 66.

Chemicals for *Cool Reaction* are available from Flinn Scientific, Inc.

Catalog No.	Description
A0065	Ammonium Thiocyanate, 100 g
A0066	Ammonium Thiocyanate, 500 g
B0009	Barium Hydroxide, Octahydrate, 100 g
B0174	Barium Hydroxide, Octahydrate, 500 g
A0266	Ammonium Chloride, 100 g
A0044	Ammonium Chloride, 500 g
A0241	Ammonium Nitrate, 100 g
A0055	Ammonium Nitrate, 500 g

Consult the [Flinn Scientific website](#) for current prices.