Thermochemistry: An Endothermic Reaction

A Carolina Essentials™ Demonstration

Overview

In this thermochemistry demonstration, students observe an extreme, spontaneous endothermic reaction between 2 solid compounds, measure changes in temperature, and make observations. The demonstration may be used with physical science or chemistry students as an introduction to thermochemistry or as an introductory example of enthalpy calculations for chemistry students. Prior to the demonstration, students can review reaction writing and product prediction.

Chemistry and Physical Science
Grades: 6–12

Essential Question

How does energy flow during a chemical reaction?

Investigation Objectives

1. Observe an endothermic reaction.
2. Describe the flow of heat energy during the reaction.
3. Construct an energy diagram for the reaction.

Next Generation Science Standards* (NGSS)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations • Students will observe an endothermic reaction and explain the energy differences between reactants to products.	**DCI: Physical Sciences: Energy** • Students will explain the flow of energy between the reaction process and the surroundings for an endothermic reaction.	**Energy and Matter: Flows, Cycles, and Conservation** • Students will explain the difference in energy between reactants and products and the flow of energy into and out of the surroundings.

Safety Procedures and Precautions

This reaction produces ammonia gas and should be performed in a fume hood. If no fume hood is available, perform in a large, well-ventilated area and stir the contents of the beaker at a safe distance from your nose. An alternative venting method is to use a faucet aspirator connected to an inverted funnel over the reaction beaker.

Disposal

Follow all federal, state, and local regulations as well as school district guidelines for the disposal of laboratory wastes. The activity involves barium, which requires special handling.

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TIME REQUIREMENTS

PREP	ACTIVITY
15 min	30 min

Teacher Prep: 15 min
Demonstration: 10 min

MATERIALS (PER GROUP)

Barium hydroxide octahydrate $Ba(OH)_2 \cdot 8H_2O$, 32.0 g

Ammonium chloride NH_4Cl, 11.0 g

Tap water

Weighing boats or weighing paper

Digital centigram balance

150-mL beaker (flat bottom)

10-mL graduated cylinder

Glass stirring rod

Thermometer

Wood block

Cold-resistant gloves

HELPFUL LINKS

Carolina Science Online

REFERENCE KITS

Carolina Chemonstrations®: Beaker Freezer Kit

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Teacher Procedure	Teacher Preparation and Tips
1. Weigh 32.0 g of $Ba(OH)_2$ and place it in the beaker.	*Allow students to examine both reactants (barium and ammonium chloride) before beginning.*
2. Weigh 11.0 g of ammonium chloride. Leave it in the weigh boat.	*Review or introduce the terms* exothermic *and* endothermic.
3. Pour enough tap water on the wood block (about 2 mL) to create a small puddle.	*Introduce the term* enthalpy.
4. Place the wooden block in a fume hood or on a lab bench in a well-ventilated room.	*Use a beaker with a flat bottom. The bottom must make complete contact with the puddle.*
5. Turn on the fume hood.	*For the block, a piece of 1" × 4" unfinished pine, cut 2 inches wider than the beaker, works well.*
6. Take the temperature of the beaker contents.	*Record the temperature on the board.*
7. Put on temperature-resistant gloves.	*Winter gloves work well.*
8. Add 11.0 g of ammonium chloride to the barium hydroxide octahydrate	*Ammonia gas will be generated. Ask students if they can identify the smell. If not, inform them ammonia is a product*
9. Set the beaker at the center of the water puddle on the block.	*Make sure the puddle covers the entire area of the beaker bottom.*
10. Hold the beaker with one hand while you stir the 2 solids with a stirring rod.	*Record the temperatures on the board.*
11. Take the temperature of the beaker contents 3 to 4 times during the reaction process, which takes 3 to 5 minutes.	*Look for the formation of ice on the board and a temperature in the beaker of below -5.0° C.*
12. Grasp the top of the beaker and lift it. The block will be lifted as well.	*Have students record their observations. You may want to walk around the classroom for students to observe the ice formation.*

Data and Observations

	Temperature (C°)	Observations
1	23	
2	17	
3	5	
4	0	
5	-30	

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Analysis and Discussion

Physical Science

1. Fill in the blank in the title.

   Endothermic

2. Was the reaction exothermic or endothermic? What data support your answer? (Use your sketch above to support your answer.)

   Endothermic because the temperature decreased

3. Did energy flow from the system (beaker with chemicals) to the environment or from the environment to the beaker? Explain your thinking.

   Energy flowed from the environment to the system. I know this because the temperature decreased.

4. Did the products or the reactants have more energy? Explain

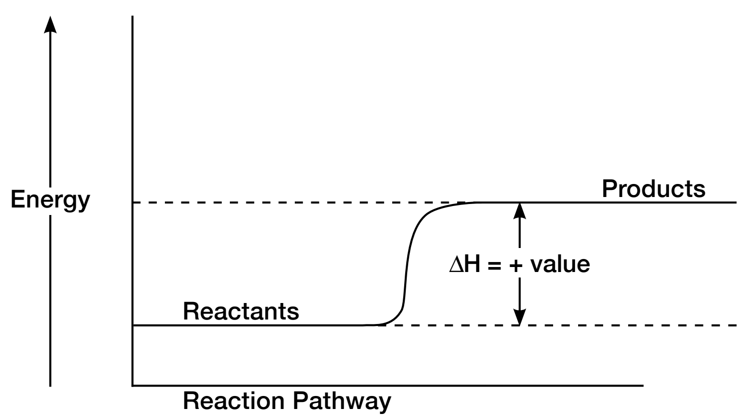
   The products have more energy than the reactants. To obtain the additional energy, energy is transferred from the surroundings, including the liquid water on the board, to the products, resulting in the environment cooling.

5. Balance the reaction and include the symbol H on the appropriate side. Identify the reaction type.

   $H + Ba(OH)_2 \bullet 8H_2O(s) + 2NH_4Cl(s) \rightarrow BaCl_2(aq) + 2NH_3(g) + 10H_2O(l)$ *Endothermic*

Chemistry

6. Draw an energy diagram for the reaction progress.



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7. Calculate ΔH for the reaction. Show your work.

Compound	ΔH_f^o/kJ mol^{-1}
$Ba(OH)_2 \cdot 8H_2O(s)$	-3345
$NH_4Cl(s)$	-314
$NH_3(g)$	-46
$H_2O(l)$	-286
$BaCl_2(s)$	-859
$BaCl_2 \cdot 2H_2O(s)$	-1460

$\Delta H = \Sigma H_{products} - \Sigma H_{reactants}$

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$\Delta H = +164 kJ/mole$

TEACHER NOTES

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