

Endothermic Glue

Kitchen Table Demonstration

The Rundown

Time: 15 minutes

Content: thermochemistry, heat, endothermic reactions

Safety Concerns: This reaction gets cold enough that it can potentially cause frostbite.

Materials Availability: Ammonium thiocyanate and barium hydroxide octahydrate are necessary for this demo. All other materials are common. If ammonium thiocyanate is not available, ammonium nitrate can be used.

We oftentimes are witnesses to heat flow when we do not even realize it. Although we cannot actually see heat transferring from one substance to another, we can see evidence of it. Everyone has observed ice melting, water boiling, or water condensing on a cool glass of water. These are all physical changes which occur and which involve the transfer of heat. What we may not be witness to quite as often is the same kind of significant heat flow during a chemical change or *chemical reaction*.



Content Application

- Thermochemistry
- Heat
- Endo/Exothermic Processes



Enduring Understandings

- Endothermic processes involve the flow of heat from the surroundings to the system.
- Exothermic processes involve the flow of heat from the system to the surroundings.



Chemistry

Thermochemistry is the study of heat changes during physical and chemical processes.

During a physical change, such as melting, freezing, condensing, etc, heat flows from a warmer substance to a cooler substance when the temperatures of the substances differ. For example, when ice melts, heat is transferred from the surroundings to the ice. In this case we say that the ice absorbs heat, and this is called an **endothermic process**. On the other hand, when water freezes, heat is transferred from the water to the surroundings. In this case, the water releases heat, and this is called an **exothermic process**.

During a chemical change, heat transfer depends on the breaking or forming of bonds within the reactants and products. The breaking of chemical bonds in reactants requires heat energy absorption, which is an endothermic process. On the other hand, the formation of chemical bonds within the products of a reaction involves the release of heat, which is an exothermic process.

We can say that if the total energy absorbed by the reactants to break the appropriate bonds is greater than the total amount of energy released by forming new bonds in the products, then the overall reaction is endothermic. We can also say that if the total energy absorbed by the reactants in order to break the appropriate bonds is less than the total amount of energy release by forming new bonds, in the products, then the overall reaction is exothermic.

In this demonstration, an endothermic reaction between two solid compounds is observed. The reaction that takes place is the following:



In this reaction, the amount of heat absorbed in breaking down the reactants is greater than the total amount of heat released in forming the products. The surroundings of the reaction actually become so cold (between -20 and -30°C) that the conditions are capable of freezing water.

Other topics for discussion could include **entropy**, **enthalpy**, and **free energy changes**.



Materials

- 250 mL beaker
- 16 g ammonium thiocyanate, $\text{NH}_4\text{SCN(s)}$
- 32 g barium hydroxide octahydrate, $\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O(s)}$
- digital thermometer (if available, otherwise use a stirring rod)
- small wooden block (see picture on previous page)



Safety

- Goggles – In case of exposure to chemicals
- Ammonium thiocyanate is an eye and skin irritant. It is also a respiratory tract irritant.
- Barium hydroxide causes eye and skin burns. Harmful if inhaled.



Procedure

1. Pour and spread 3-5 mL of water over the top of the wooden block about the size of the bottom of the beaker.
2. Add the 16 g of ammonium thiocyanate to the beaker, followed by the 32 g of barium hydroxide octahydrate. Stir this mixture rapidly with the digital thermometer. Note: The thermometer allows you to monitor the temperature of the reaction. It is not really required, so a stirring rod will do if a digital thermometer is not available.
3. While you stir, place the beaker down on top of the water that was poured onto the wooden block. Note: As the reaction proceeds, the smell of ammonia will evolve due to the production of ammonia gas, the mixture will become a slushy mixture due to the production of water, and the beaker contents will drop in temperature.
4. Test the beaker to see if it is stuck to the wooden block through the freezing of the water about every ten seconds. When the beaker seems to be stuck, lift the entire wood/beaker combination to show the students that the reaction dropped in temperature enough to freeze the beaker to the wood.



Disposal

- Dispose of contents according to MSDS sheets.



Student Participation and Follow-Up

Suggestions:

1. While the demonstration is taking place, have the students write down observations about what happens during each part.

Try the following follow-up activities:

1. Based on student observations (production of ammonia smell and slushy mixture), have students predict the products of this reaction.
2. Hold a piece of moist litmus paper over the mixture as the reaction produces products. This should indicate that a basic gas is being produced (ammonia).
3. One real life application of exothermic and endothermic reactions is the use of hot or cold packs for injured athletes. Have the students answer the following: Which of the following substances would make a good hot pack or cold pack? Ammonium nitrate (NH_4NO_3), calcium chloride (CaCl_2), sodium chloride (NaCl), sodium acetate ($\text{NaC}_2\text{H}_3\text{O}_2$), ammonium chloride (NH_4Cl). Have the students answer this by dissolving 20 grams of each compound in 20 mL of water in a baggy. Have the students pass it around to make observations about temperature changes which may or may not occur.