**Frozen Board**

**An Endothermic Reaction Demonstration**

<http://chemdemos.uoregon.edu/pages/detail.php?s%5B%5D=Acids%20and%20Bases&page=2&id=6976ab2e21953dc02edc6360a5151557>

A beaker is placed in a small puddle of water on a balsa wood board. Two white powders, barium hydroxide octahydrate and ammonium chloride, are introduced into the beaker and stirred, forming a slurry. After two minutes, the beaker is picked up. The board is attached to it because the water between the beaker and the board has frozen. A great example of an endothermic reaction.

**Curriculum Notes**

This demo is usually performed when thermochemistry or thermodynamics are being discussed. It illustrates how entropy can act to drive a reaction to spontaneity. This demo works well if performed by a student volunteer, but ask them discretely if they have any respiratory disorders such as asthma before you allow them to do the demo, because the ammonia vapors could cause an adverse reaction to someone with a respiratory disorder. Allow about 10 minutes for this demo. One day of lead time is required for this project.

**Discussion**

The equation representing this endothermic reaction shows that it is entropy driven: Ba(OH)2\*8 H2O(*s*) + 2 NH4Cl(*s*) --> BaCl2\*2 H2O(*s*) + 2 NH3(*aq*) + 8 H2O(*l*) This is a neutralization reaction with the hydroxide ion acting as the base and the ammonium ion acting as the acid. The two relatively low entropy crystalline solid reactants react to form many small molecules in the high entropy liquid and aqueous states. The positive enthalpy change in this reaction (63.6 kJ/mol) is more than offset by the entropy change near room temperature (368 J/mol\*K) to yield a strongly negative free energy change (-47.7 kJ/mol). Thus the reaction is spontaneous and endothermic.

**Materials**

* 32 g barium hydroxide octahydrate
* 11 g ammonium chloride
* 250 ml beaker
* stir rod
* deionized water in wash bottle
* 1 m "2x4" balsa wood board

**Procedure**

Set the board on a table in front of the class, broad (4") side facing up. Squirt about 2-3 mL of DI water onto the center of the board to make a puddle. Set the beaker in the center of the puddle. Add the barium hydroxide and the ammonium chloride to the beaker. Stir vigorously while holding the beaker firmly in place. After two minutes, lift up the beaker. It should be frozen to the board. If it is not, replace it in the puddle of water and continue stirring for another minute or so and try again.

**Safety Precautions**

Barium hydroxide is toxic and corrosive and ammonium hydroxide is an irritant. The small quantity of ammonia gas gas evolved during the demonstration could act as an irritant. Avoid beathing dust or fumes from demo. If it any chemicals get on your skin, wash thoroughly and flush with water for 15 minutes. If any chemicals get in your eyes, flush with water for 15 minutes and seek medical attention.