Spontaneous Endothermic Reaction

Summary

Two solids are mixed together in a flask which is then set on a puddle of water on a wood block. The entropically driven endothermic reaction freezes the water, and thus the flask is frozen to the block.

Hazards

Acid soluble and water soluble salts of barium hydroxide are toxic.

Chemicals and Solutions

- 32g Barium Hydroxide octahydrate, solid
- 16g Ammonium thiocyanate, solid

Materials

- Small block of wood
- Pink litmus paper
- Small powder funnel
- Small beaker or squeeze bottle of water

Procedure

- Place 32g Ba(OH)$_2$·8H$_2$O in one dry stoppered 250ml flask.
- Place 16g NH$_4$SCN in the other dry stoppered 250ml flask.
- Make a small pool of water (2-3ml) on top of the block.
- Add the Ba(OH)$_2$ crystals to the NH$_4$SCN crystals.
- Stopper the flask and shake vigorously until the mass begins to liquefy.
- Place the flask on the pool of water and allow it to stand for about 10 minutes.
- Lift the flask by the neck and notice:
  - the change in character of the materials in the flask
  - the layer of ice binding the flask to the block.
- Open the flask and test the gas with wet, pink litmus paper.

Hints: It works best to add the barium hydroxide to the ammonium thiocyanate. The ammonium thiocyanate is damp, tending to stick to the inside of the flask, making it more troublesome to transfer.

Discussion

$$\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O} \text{ (s)} + 2\text{NH}_4\text{SCN} \text{ (s)} \rightarrow \text{Ba(SCN)}_2 \text{ (aq)} + 2\text{NH}_3 \text{ (g)} + 10\text{H}_2\text{O} \text{ (l)}$$
This reaction is entropically driven. Because the reaction occurs spontaneously, \( \Delta G \) is negative. Because heat is absorbed by the reaction from the surroundings, \( \Delta H \) is positive. \( \Delta S \) is positive because of the formation of ammonia gas and liquid water. The effect of increased entropy more than compensates for the positive enthalpy change.