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Quick Freeze

A Simple Demonstration of Freezing Point Depression Using Club Soda

Introduction

A bottle of liquid club soda is removed from an ice bath and opened. Moments later the club soda freezes inside the bottle.

Concepts

- Freezing point depression; the freezing point of a pure solvent will be lowered by the addition of a solute.
- Dissolved gases; carbon dioxide can act as a solute and its concentration is dependent on pressure.

Materials

Club soda, 10 oz. in a clear glass bottle
Rock salt
Ice, crushed
Beaker, 1-L
Thermometer, –20 to 110 °C

Safety Precautions

Do not shake the unopened bottle, this may cause the dissolved gas to come out of solution, causing the beverage to freeze and the bottle to explode. Cool the soda behind a safety shield or away from students. 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.

Preparation

1. Remove the labels from the club soda bottles so that the freezing action will be seen better.
2. Cool the club soda in a refrigerator or an ice chest for at least five hours before the demonstration.

Procedure

1. Place a thin layer of crushed ice at the bottom of a 1 liter beaker.
2. Sprinkle a thin layer of rock salt into the beaker, overlaying the ice.
3. Place the cooled bottle of club soda in the center of the beaker and continue alternating layers of ice and rock salt around the bottle. Be sure to completely cover the bottle.
4. Place a thermometer into the ice/salt mixture. The thermometer should be very close to or touching the bottle in order to obtain an accurate reading of the temperature of the mixture affecting the soda.
5. The club soda must reach a temperature of –8 °C (17.6 °F) and remain there for about 10 minutes. Do not allow the soda to get too cold. The soda may freeze, ruining the demonstration. If the soda gets too cold (<–10 °C), there is a possibility of the bottle exploding.
6. After 10 minutes, remove the bottle from the ice and observe (but do not shake). The soda is still a liquid at this point. Remind the students that pure water would have frozen at this temperature.
7. Open the bottle and notice how the club soda quickly solidifies.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Form and function
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter

Tip

- The freezing point of club soda is about –10 °C. Be sure to keep the ice mixture above this temperature. If the sealed bottle freezes, the change in volume will cause the bottle to break, possibly even explode.

Discussion

Freezing point depression is a colligative property. When a solute is mixed with a solvent, the freezing point of the resulting solution decreases. The amount that the freezing point falls is dependent on the concentration of solute, not the identity of the solute. In this demonstration, water is the solvent. Sodium chloride is the solute in the ice–water mixture and carbon dioxide is the primary solute in the club soda.

Why does the solute lower the freezing point? The carbon dioxide molecules disrupt the capacity of the water molecules to organize into the solid state. As more solute is added, the colder the mixture has to be in order to organize the water into a solid. These properties are seen in the students' world with the spreading of salt on icy roads, ice cream makers, and auto antifreeze.

The carbon dioxide dissolved in the club soda lowers the freezing point of the water. The high concentration of carbon dioxide is maintained by keeping the contents under pressure. When the pressure is released by opening the bottle, the concentration of dissolved carbon dioxide falls. The carbonated water solution now has a freezing point higher than –8 °C and quickly freezes.

Acknowledgement

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Reference

Bare, W. D. *J. Chem Ed.* **1991,** *68,* 1038.

Materials for *Quick Freeze* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0065	Sodium chloride, rock salt, 1 kg
AP1452	Thermometer, spirit-filled, –20 ° to 110 °C

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.