Liquid Air

Introduction

Liquid nitrogen is a fascinating substance. The tremendously low temperature (–196 °C) allows students to see properties of gases that are not ordinarily observed. "Liquid air" demonstrates gas principles in a way that students will not soon forget.

Concepts

- Gas Laws—Pressure, volume, and temperature
- Kinetic molecular theory

Materials

Balloons
Dewar flask, demonstration
Gloves, high/low temperature, insulated
Liquid nitrogen
Tongs

Safety Precautions

Liquid nitrogen is very, very cold. The extremely low temperature may cause immediate frostbite. Never handle liquid nitrogen without the proper protective equipment. Wear insulated gloves, chemical splash goggles, and a chemical-resistant apron. Do not work with liquid nitrogen in an enclosed or poorly-ventilated area. Nitrogen gas will displace the air, limiting the amount of oxygen in the area, which may lead to asphyxiation.

Procedure

1. Blow up a number of balloons.
2. The Dewar flask should be about one-half full of liquid nitrogen. Place the balloons, one at a time, into the Dewar flask. The balloons should be pushed into the flask with the tongs. ***Do not use bare hands.***
3. Allow the balloons to sit in the liquid nitrogen for about one minute.
4. Using tongs and wearing insulated gloves, remove a balloon from the liquid nitrogen. Notice the size and rigidity of the rubber balloon when it is first removed from the liquid nitrogen. Observe the balloon as it warms up and re-inflates.
5. In light colored balloons such as yellow and pink, a liquid may be observed at the bottom of the deflated balloon as it is removed from the nitrogen. Ask the students to predict the identity of the liquid.

Tips

- Liquid nitrogen is available from local welding supply houses or universities. Look up "Gases, liquid" or "Welding supply" in the Yellow Pages. The cost ranges from approximately $2 to $8 per liter. In rural areas, liquid nitrogen may be used by local farmers or veterinarians to freeze cattle sperm.
- A Dewar flask is needed to transport the liquid nitrogen. Do not use the demonstration flask. Providers of liquid nitrogen will often lend or rent out the use of a Dewar flask. Some schools share a Dewar flask because of the expense and infrequent use.
- If a demonstration Dewar is unavailable, a good temporary substitute would be a polystyrene cube that 2.5-liter acid bottles are shipped in. The cube can hold a large amount of liquid nitrogen and the polystyrene is a very good insulator.

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Discussion

As an air-filled balloon is cooled in liquid nitrogen, the average kinetic energy of the air molecules (nitrogen, oxygen, and carbon dioxide) decreases and the molecules slow down. The gas molecules undergo fewer collisions with the "walls" of the balloon and thus exert less pressure on the balloon, causing it to deflate. Some of the gas molecules (nitrogen and oxygen) reach a low enough temperature that they will condense into the liquid phase.

When the balloon is brought back to room temperature, the molecules in the liquid phase evaporate into a gas, and sometimes even boiling is evident. The gas molecules move faster and faster as the balloon warms to room temperature. The fast-moving molecules exert a great amount of pressure on the walls of the balloon, thus inflating it.

The balloon is sometimes accidentally torn when it is very cold and rigid. A balloon at room temperature is a solid, but very elastic. The elasticity is due to the ability of chemical bonds in rubber polymer molecules to uncoil, stretch out, and then return to their original shape. The liquid nitrogen slows down and even stops the molecular motion in the rubber, thus limiting its ability to stretch. When stress is placed on the cold balloon, it tears easily because it has lost its elasticity.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Excess liquid nitrogen may be allowed to evaporate in a well-ventilated area. The balloons may be discarded in the trash.

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
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, motions and forces, interactions of energy and matter

Reference

Please see *Be Cool to Your School—Uses of Liquid Nitrogen*, available from Flinn Scientific, by Lee Marek for additional activities and lessons using liquid nitrogen.

Materials for *Liquid Air* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1490	Dewar Flask, 1000 mL
AP8560	Dewar Flask, Storage, 4 L
AP8613	Be Cool to Your School—Uses of Liquid Nitrogen

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