Wet Dry Ice

Triple Point of CO_2

Introduction

The solid form of carbon dioxide is called "dry ice" because it does not melt, as ordinary ice does, but rather goes directly from a solid to a gas—it sublimes. The liquid form of dry ice is not stable at "ordinary" pressures and temperatures (atmospheric conditions). If dry ice is allowed to sublime in a closed system, however, the pressure will increase to a point where the liquid form of carbon dioxide can be seen.

Concepts

- Phase changes
- Phase diagrams
- Triple Point
- Sublimation

Materials

Beral-type pipets, wide-stem, 2
Cup, clear plastic, 8- or 10-oz
Dry ice
Flinn ChemCam™ Video Camera (optional)
Gloves, insulated
Hammer, small
Pliers
Scissors

**Use a Flinn ChemCam video camera to provide a close-up of the demonstration.*

Safety Precautions

Dry ice is extremely cold and may cause frostbite. Handle only with insulated or heavy cloth gloves and never with wet hands. Do not add more than a small amount of dry ice to the pipet. The demonstrator and all observers must wear chemical splash goggles.Do not attempt this demonstration on a larger scale in plastic bottles or other containers—the plactic may shatter violently and cause injury.

Procedure

1. Pulverize the dry ice into small pieces about the size of rice grains or sugar crystals. *Observe that the dry ice does not melt, it sublimes. The resulting "fog" is due to water vapor condensing on the extremely cold CO_2 gas that is produced.*
2. Cut off the tapered end of a wide-stem, Beral-type pipet. Scoop about 8–10 pieces of dry ice into the stem of the pipet and tap the dry ice down into the bulb.
3. Add tap water to a clear plastic cup to a depth of about 4–5 cm.
4. Fold the open end of the pipet stem over and clamp it shut with a pair of pliers. (No gas should be able to escape from the pipet.) Immediately lower the pipet bulb into the water in the cup.
5. Observe the phase changes. *The dry ice will sublime (turn to a gas). After about 20–30 seconds, the dry ice will melt and liquid will appear in the pipet bulb. Soon after, the liquid will begin to boil, and the pipet bulb will swell. Three phases will be visible at the same time (solid, liquid, and gas).*
6. Release the grip on the pliers to relieve some of the pressure in the pipet. *A loud pop is produced and the CO_2 immediately returns to a solid—the dry ice looks like fluffy snow.*
7. Repeat the demonstration by folding the open end of the pipet stem over again and reclamping the pipet shut with the pliers. *The CO_2 appears to liquefy quicker than it did the first time. Depending on the amount of dry ice used, the process may be repeated 3–4 times.*
8. Your students will undoubtedly ask: "What will happen if you don't release the pressure?" Repeat the demonstration, but don't release the pressure when the liquid ("wet dry ice") begins to boil. *Caution: Everyone should be wearing goggles as explained in the Safety Precautions. The pipet will continue to expand until the gas "explodes" and the bulb ruptures. Water goes everywhere, the cup cracks, and your nerves may be a little more frayed—but the students think it is great fun!*

Publication No. 10957
061616

Disposal

Allow excess dry ice to sublime and discard the used pipets 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
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter

Tips

- This activity is written as a demonstration, but it is safe enough to be used as a student activity. Monitor students so they do not add too much dry ice to their pipets, and strictly enforce the "wear your goggles rule."
- Wide-stem pipets (Flinn Catalog Nos. AP2253 and AP8480) work best. Use only plastic cups (plastic will absorb the shock and the cup will crack, not shatter). The water in the cup acts as a heat source for sublimation and melting. It also keeps condensation from forming on the outside of the pipet, which would make it difficult to see the contents.
- Do not attempt this demonstration on a larger scale, such as in a plastic bottle. The pressurized bottles shatter with great force, causing serious injuries in some cases. Accidents of this type have been reported in school science labs.
- "Demonstrating Phase Changes of CO_2" is available as a demonstration kit from Flinn Scientific (Catalog No. AP4505). The kit contains a triple point apparatus with a pressure gauge and a large valve and provides a larger scale version of this demonstration.

Discussion

From making "fog" to "boiling in water," dry ice is well-known for creating special effects. At atmospheric pressure, carbon dioxide can exist only as a solid or a gas. In order to exist as a liquid, carbon dioxide must be subjected to a pressure of at least 5.1 atmospheres. The *phase diagram* shows how the phase of carbon dioxide depends on pressure and temperature. The boundaries (lines) between the phases in the phase diagram show the values of pressure and temperature when two phases will be in equilibrium. The point at which all three phase boundaries meet is called the *triple point* and signifies the temperature and pressure at which all three phases exist and are in equilibrium.

If a sample of dry ice is sealed in a closed system, the pressure begins to rise as CO_2 gas is produced. The increased pressure, in turn, allows the solid to exist at a higher temperature. Equilibrium continues to exist between the solid and gaseous CO_2 as the temperature and pressure increase. When the triple point is reached, the solid can now sublime or melt. The solid–gas, solid–liquid, and liquid–gas phases are all in equilibrium. As long as solid, liquid, and gaseous CO_2 are in contact with each other, the temperature and pressure will remain at the triple point of 5.1 atm and –56.6 °C.

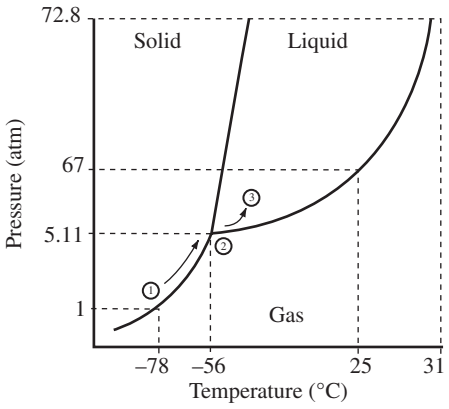

Figure 1.

Reference

This activity was adapted from *Solids and Liquids*, Volume 11 in the *Flinn ChemTopic™ Labs* series; Cesa, I., Editor; Flinn Scientific: Batavia, IL (2005).

Materials for *Wet Dry Ice* are available from Flinn Scientific, Inc.

Catalog No.	Description
SE1031	Gloves, Insulated
AP2253	Beral-Type Pipets, Wide-Stem, Pkg. 20
AP8480	Beral-Type Pipets, Wide-Stem, Pkg. 500
AP6543	Cups, Clear Plastic
AP4436	Hammer
AP8389	Pliers, Long Nose
AP5394	Scissors, Student

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