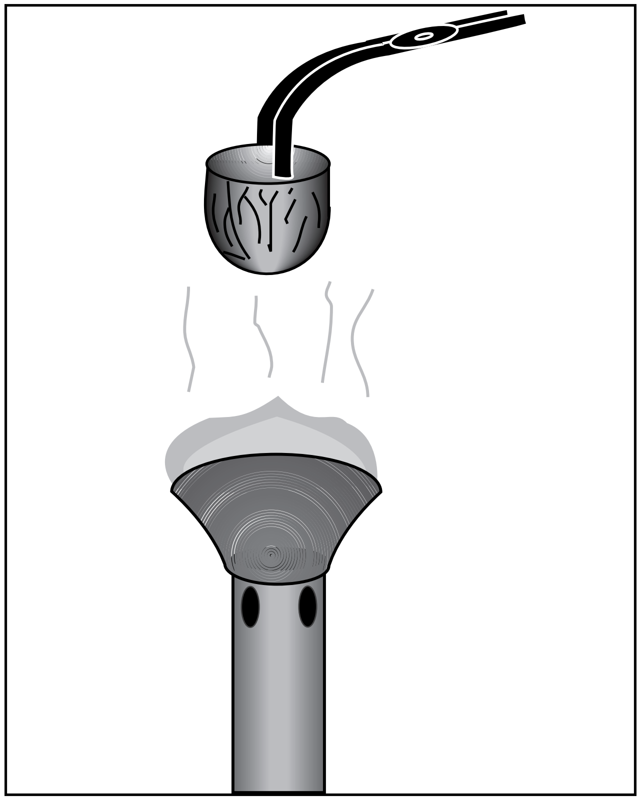
Activity 15

Rapid Crystallization



OBJECTIVE:

To investigate the growth of crystals by two different methods under different temperature conditions.

BACKGROUND:

Crystals are solids composed of atoms, ions, or molecules arranged in orderly patterns that repeat in three dimensions. The geometric form of a crystal visible to the naked eye can be an external expression of the orderly arrangement inside. Many of the unique properties of materials, such as strength and ductility, are a consequence of crystalline structure.

It is easy to get confused about the nature of crystals because the word crystal is frequently misused. For example, a crystal chandelier is not crystal at all. Crystal chandeliers are made of glass. Glass is an *amorphous* material because it lacks a regular interior arrangement of atoms.

Scientists are very interested in growing crystals in microgravity because gravity often interferes with the crystal growing process to indirectly produce different types of defects in the crystal structure. The goal of growing crystals in microgravity is not to develop crystal factories in space but to better understand the crystal growing process and the effects that gravity can have on it.

In this activity, crystal growth will be studied with chemicals that crystallize rapidly in two different ways. The first part of the activity demonstrates the difference between a crystalline material and an amorphous material by manipulating the cooling rate to control how fast the material freezes or solidifies from a molten state. The second part of the activity permits students to observe close-up crystallization from solution. It employs chemical hand warmers.

The hand warmers are sold in full-line camping and hunting stores. They consist of a plastic pouch filled with a food-grade solution of sodium acetate and water. Also in the pouch is a small disk of stainless steel. By snapping the disk, the precipitation and crystallization of the sodium acetate is triggered. As the solid material forms from solution (precipitation) the chemicals release heat (*heat of solution*) that maintains the pouch temperature at about 54 degrees Celsius for a half hour. This makes the pouch ideal for a hand warmer. Furthermore, the pouch is reusable indefinitely by reheating and dissolving the solid contents again.

The pouch is designed so that at room temperature, the water contains many more molecules of sodium acetate than would normally dissolve at that temperature. This is called a *supersaturated* solution. The solution remains that way until it comes in contact with a seed crystal or some way of rapidly introducing energy into the solution which acts as a trigger for the start of crystallization. Snapping the metal disk inside the pouch delivers a sharp mechanical energy input to the solution that triggers the crystallization process. Crystallization takes place so rapidly that the growth of crystals can easily be observed.

PROCEDURE: (Part 1, Crystalline or Amorphous?)

Note: This activity is a demonstration. Make sure you have adequate ventilation. A small quantity of sulfur fumes may be released. Be sure to wear eye protection while heating the sulfur.

MATERIALS, PART 1

Eye protection
Heavy duty aluminum foil
Scissors
Fat test tube
Tongs
Bunsen Burner
Powdered sulfur
Beaker of cold water
Heat resistant surface
Adequate ventilation

Step 1. Make two disposable aluminum crucibles by wrapping heavy duty aluminum foil around the lower end of a large test tube. Remove the foil and trim each crucible with scissors.

Step 2. Place enough sulfur in each crucible to cover the bottom to about 1 centimeter deep. Using the tongs to hold the first crucible, <u>gently and slowly</u> heat the crucible with a low flame from a Bunsen burner until the sulfur melts. Do not heat the sulfur enough to cause it to ignite. Place the crucible on a heat resistant surface to cool and cover it with a small beaker or another piece of foil.

Step 3. Repeat step 2 with the second crucible. When the sulfur melts, immediately thrust it into a beaker of cold water to cool.

Step 4. When both samples are cool to the touch, peel back the aluminum foil to examine the surface of the sulfur. One sample will show crystalline structure while the other will have a glassy surface. Break each sample in half and examine the edges of the break with a magnifying glass.

QUESTIONS

1. What is the difference between the two sulfur samples?

2. How do the properties of these samples relate to the rate in which they cooled?

FOR FURTHER RESEARCH

1. Compare a piece of granite with a piece of obsidian. Both rocks have approximately the same composition. Why are they different from each other.

2. Learn about some of the applications of crystalline and amorphous materials.

PROCEDURE: (Part 2, Heat Packs)

Note: This activity is an activity involving small groups of students. Because the activity involves boiling water, students should be cautioned to remove the heat packs from the boiler carefully to avoid scalding burns. If you would prefer, handle this part of the activity yourself.

Step 1. Prepare the heat packs by boiling each until all crystals have dissolved. Using tongs, remove the pouches and place them down on towels so that the remaining hot water can be dried off.

Step 2. Each student group should place a pouch on a styrofoam food tray and slide the bulb of a thermometer under the pack. When the pouch temperature is below 54º C, the internal metal disk can be snapped to trigger crystal growth. Before doing so, the disk should be moved to one corner of the pouch.

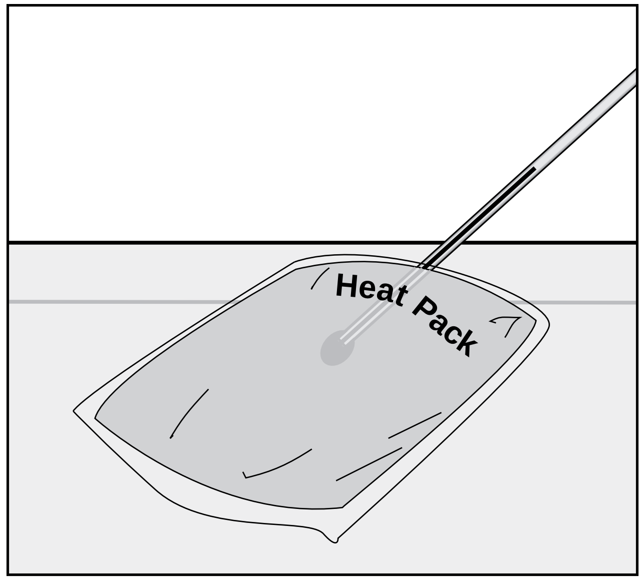
Step 3. Using the data sheet on the next page, the students should observe the crystal growth in the pouch.

Step 4. Repeat the activity several times but cool the pouch to different temperatures. To encourage the pouch to cool more rapidly, place it on a hard surface such as a metal cookie sheet or a table top. Return it to the styrofoam to measure its temperature and trigger the crystallization.

QUESTIONS

1. Is there any relationship between the initial temperature of the pouch and the temperature of the pouch during crystallization?

2. Is there a relationship between the initial temperature of the pouch and the time it takes for the pouch to completely solidify?



3. Do other materials, such as water, release heat when they freeze?

FOR FURTHER RESEARCH

1. What do you think would happen if the heat pack were crystallized in microgravity? What effect does gravity have? Hold the pack vertically with the steel disk at the bottom and trigger the solidification. Repeat with the disk at the top. Using two thermometers, measure the temperature of the top and bottom of the pack during crystallization.

2. Try chilling a heat pack pouch in a freezer and then triggering the solidification.

3. Identify other ways the word "crystal" is misused.

MATERIALS, PART 2

Heat pack hand warmers (1 or more per group)
Water boiler (an electric kitchen hot pot can be used)
Styrofoam meat tray (1 per group)
Metric thermometer (1 or more per group)
Observation and data table (1 per student)

Heat Pack Experiment Data Sheet

Name: ______________________________

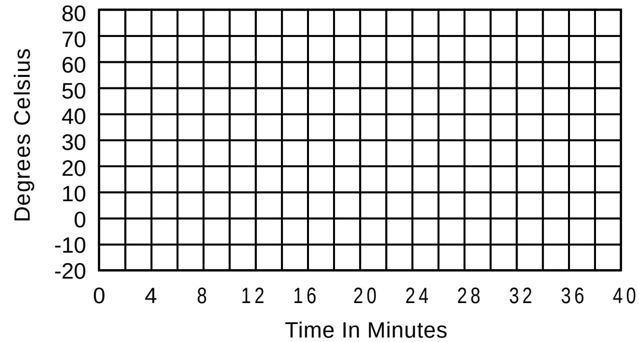
Test Number: ___________

Initial Temperature of Pouch: ___________

Final Temperature
at end of crystallization: ___________

Describe the crystals
(shape, growth rate, size, etc.)

Cooling Graph



Sketch of Crystals

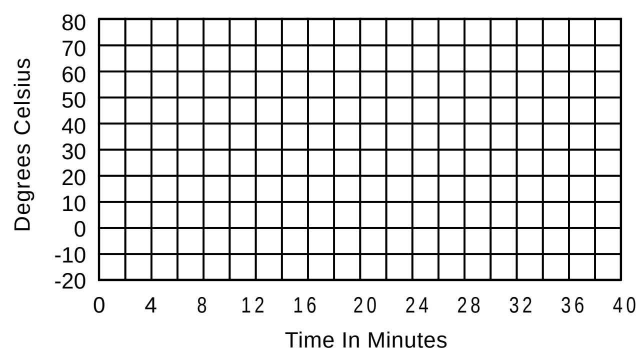
Test Number: ___________

Initial Temperature of Pouch: ___________

Final Temperature
at end of crystallization: ___________

Describe the crystals
(shape, growth rate, size, etc.)

Cooling Graph



Sketch of Crystals