Crystal Ball

Recommended Grade Level(s):

Appropriate for: K–12

Time Requirements:

Activity Time: 10 minutes. Preparation: 15 minutes

Teaching Topics & Concepts:

- To illustrate the crystallization of a supersaturated solution.
- Exothermic crystallization.
- Evidence, models and explanation, constancy, change, and measurement.
- Structure and properties of matter, conservation of energy and increase in disorder, interactions of energy and matter.
- Enthalpy, entropy, and free energy.

Background:

On a cold winter day, those reusable instant hand warmers we buy at gas stations provide a little relief. Even football players use them during cold-weather games. Once the warmer is activated, it starts the formation of crystals from a supersaturated solution. The process is exothermic, generating heat. This effect can be reproduced in the lab to offer more control over the process and make scientific observations. This activity is a great way to introduce students to the exciting and challenging world of crystals and real-world applications.

Materials:

- Sodium acetate trihydrate, $NaC_2H_3O_2 \cdot 3H_2O$
- Round bottom flask or Erlenmeyer flask with a rubber stopper
- Hot plate or Bunsen burner
- Wash bottle
- Distilled water

Safety

- Sodium acetate is a skin, eye, and respiratory irritant. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron.
- Read the SDS sheets for all chemicals before using them.
- Wash hands thoroughly with soap and water before leaving the laboratory.
- Follow all laboratory safety guidelines.

Procedure:

1. Fill a very clean flask with sodium acetate trihydrate crystals.
2. Heat the flask on a hot plate (or gently with a Bunsen burner) until the crystals dissolve in their own water of hydration. (A small amount of water can be added if needed).
3. Continue heating the liquid for a couple of minutes but do not let it boil over.
4. Allow the liquid to cool to room temperature, undisturbed.
5. Wash down the sides of the flask with a small amount of distilled water; then gently stopper the flask. Be careful not to disturb the solution, as even slight movement may cause crystallization to occur before you're ready.
6. When ready, remove the cap and add one small crystal of sodium acetate trihydrate.
7. Have students feel the flask immediately after crystallization has taken place. The flask should feel warm.

Note:

- Use caution if substituting a non-Pyrex hydrometer cylinder for the flask in this demo. The temperature differential may crack the cylinder. Use a Pyrex cylinder instead or allow the supersaturated solution to cool slightly before pouring it into the cylinder.
- Adding too much water will result in leftover liquid after crystallization.

Expected Results:

The crystallization process is classified as an exothermic process, where heat is released and transported to the crystal and solution. Adding the single crystal to the supersaturated starts a chain reaction of crystallization; the crystal starts to grow outwards until the entire flask is solid white.

A supersaturated solution is a solution that contains a greater amount of dissolved substance than is present in a saturated solution at the same temperature. A saturated solution is a solution that contains the maximum amount of a dissolved substance at a given temperature. A supersaturated solution can be made by gradually cooling a saturated. Supersaturated solutions are extremely unstable and will precipitate or crystallize when just one solute crystal is added. Even slight shaking or agitation may be enough to cause crystallization to begin.

Follow up/Extensions:

- Use a video microscopy unit to provide a close-up view of the crystallization process.
- Slowly drip saturated sodium acetate solution on a desk from a buret to produce a crystal column.
- Help students connect the principles in this activity and spontaneous chemical reactions used in hot packs and hand warmers.
- How could these concepts be used in Earth Science to help explain the formation of stalactites and stalagmites?
- How could these concepts be used as a model for freezing?
- Atmospheric pressure, changes of state. Help students visualize the changes in the particles both inside and outside the can before and after heating.

Teaching notes:

- Explain that the flask feels warm because heat is released upon crystallization (an exothermic process).
- You can use the solution repeatedly by reheating it to re-dissolve the sodium acetate (you may need a small amount of water to aid dissolving).

Disposal/Clean-Up:

The flask can be sealed and reused many times; it can last for years.