

# Borax Crystal Ornaments



## Introduction

Add some sparkle to your next holiday celebration by making ornaments of borax crystals. Simply dissolve sodium borate in hot water, suspend a shaped chenille wire into the solution, and wait. The next day remove a beautiful crystal-covered ornament from the solution!

## Concepts

- Crystal formation
- Solutions
- Solubility

## Materials

Sodium borate, $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ , 50 g	Ruler
Water, distilled or deionized (DI)	Scissors
Balance, 1-g precision	Scoop or spoon
Beaker, 400-mL, borosilicate glass	Stereoscope or magnifying lens
Beaker tongs	Stirring rod
Chenille wire	String
Heat-resistant surface	Thermometer
Hot plate	Weighing dish
Paper towel	Wood splint or pencil

## Safety Precautions

*Sodium borate may be harmful if swallowed and high doses may damage fertility or the unborn child. Use caution when handling hot glassware. Use beaker tongs or wear heat-resistant gloves. Handle the chenille wires carefully as the ends of the wires may be sharp. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Safety Data Sheets for additional safety, handling, and disposal information. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.*

## Procedure

1. Obtain one chenille wire. Bend the wire into desired ornament shape. *Note:* Chenille wires may be cut with scissors to shorter lengths. Be careful when bending or twisting the wire as the ends are sharp.
2. Cut a 9" piece of string and tie it to the shaped wire so the ornament will hang in balance.
3. Holding the string, lower the ornament into an empty 400-mL beaker to make sure the ornament will fit completely in the beaker without touching the sides or bottom. If the ornament does not fit, adjust the shape to make it smaller. Remove the ornament from the beaker and set aside for step 10. *Note:* Two smaller ornaments may fit into a 400-mL beaker if they do not touch each other or any part of the beaker.
4. Add 300 mL of distilled or deionized water to the beaker and place on a hot plate.
5. Heat the water to just below boiling, at least 80 °C.
6. While the water is heating, place a weighing dish on a balance and tare the balance.
7. Weigh 50 g of sodium borate in the weighing dish and then set aside for step 9.
8. When the water temperature has reached 80–85 °C, use beaker tongs to carefully remove the beaker from the hot plate and place it on a heat-resistant surface. Turn off the hot plate.
9. Carefully add the 50 g of sodium borate to the hot water and stir with a stirring rod until dissolved.
10. Holding the ornament by the end of the string, lower it into the sodium borate solution until the ornament is completely covered by the solution but is not touching the bottom or sides of the beaker.

11. Wrap the excess string around a wood splint or pencil and place the splint across the top of the beaker to keep the ornament suspended in the solution (see Figure 1).
12. Allow the solution to cool slowly overnight and the crystals to “grow” on the ornament.
13. The next day, carefully remove the ornament from the beaker and place on a folded paper towel to dry.
14. Look at the crystals with a strong magnifying lens or stereoscope and try to identify the shape.

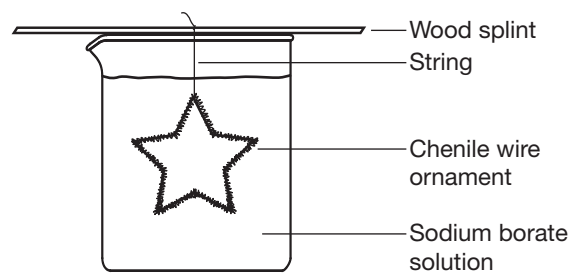


Figure 1.

## 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. Leftover sodium borate solution may be disposed of down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b. Excess solid sodium borate may be stored for future use in a Flinn Chem-Saf™ Bag or may be disposed of according to Flinn Suggested Disposal Method #26a.

## NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

### Disciplinary Core Ideas: Middle School

- MS-PS1 Matter and its Interactions
  - PS1.A: Structures and Properties of Matter
- MS-ESS2 Earth's Systems
  - ESS2.C: The Roles of Water in Earth's Surface Processes

### Disciplinary Core Ideas: High School

- HS-PS1 Matter and its Interactions
  - PS1.A: Structures and Properties of Matter
- HS-ESS2 Earth's Systems
  - ESS2.C: The Roles of Water in Earth's Surface Processes

### Science and Engineering Practices

- Planning and carrying out investigations
- Developing and using models

### Crosscutting Concepts

- Patterns
- Cause and effect
- Structure and function

## Tips

- This is a wonderful integrated activity that combines science and art and may be used as a science activity for any holiday or as a component for a unit on crystallization, solutions and solubility, or even mineral crystal shapes.
- Use the crystal ornaments to decorate your classroom or lab. It is not recommended to allow students to take chemicals home.
- If time permits, turn this into an inquiry activity. Allow students to design and carry out an experiment to test the variables of concentration or temperature of the sodium borate solution and observe the effects on the formation of the crystals.
- Students may also make ornaments with alum crystals (aluminum potassium sulfate). Follow the same procedure as with the borax crystal ornaments, but after step 3, use a small paintbrush to brush a small amount of white glue on the surface of the ornament. Before the glue dries, sprinkle the ornament with 10-15 g of alum. Allow the ornament to dry. Use 100 g of alum instead of 50 g of sodium borate in steps 7 and 9. Alum crystals will appear cubic or octahedral, depending upon the growing conditions.
- Have students look at salt (sodium chloride) crystals under magnification to compare their cubic shape to the monoclinic sodium borate crystals.
- If enough hot plates for a class are not available, an option for hot water is to use a large hot pot or coffee percolator.

Dispense the hot water into the beaker just prior to adding the pre-measured sodium borate. A laboratory microwave is another option. Be sure to use beaker tongs or wear heat-resistant gloves when handling glassware filled with hot water.

- Borosilicate glass beakers or canning jars of varying sizes may be used. Adjust the amount of water and sodium borate accordingly, keeping a 1:6 ratio of sodium borate to water. Lab partners may share a large beaker.
- The sodium borate crystals will not take up food dye and therefore coloring the solution will have no effect. The color of the chenille wire will determine the color of the ornament. You may wish to provide several different colored wires for students to cut and combine to expand the creative possibilities.
- If crystals have grown on the bottom or sides of the beaker, simply reheat the solution to dissolve the borax before disposal.

## Discussion

### Solutions and Solubility

A *solution* is a mixture of two or more pure substances that is homogeneous or uniform throughout. The substance that is being dissolved is called the *solute*, and the substance that does the dissolving is called the *solvent*. *Solubility* is the amount of solute that will dissolve in a given amount of solvent at a particular temperature. Solubility generally increases with increasing temperature when dissolving solids into liquids. Solubility also depends on the substance being dissolved. Some salts are very soluble in water, while others are only slightly soluble.

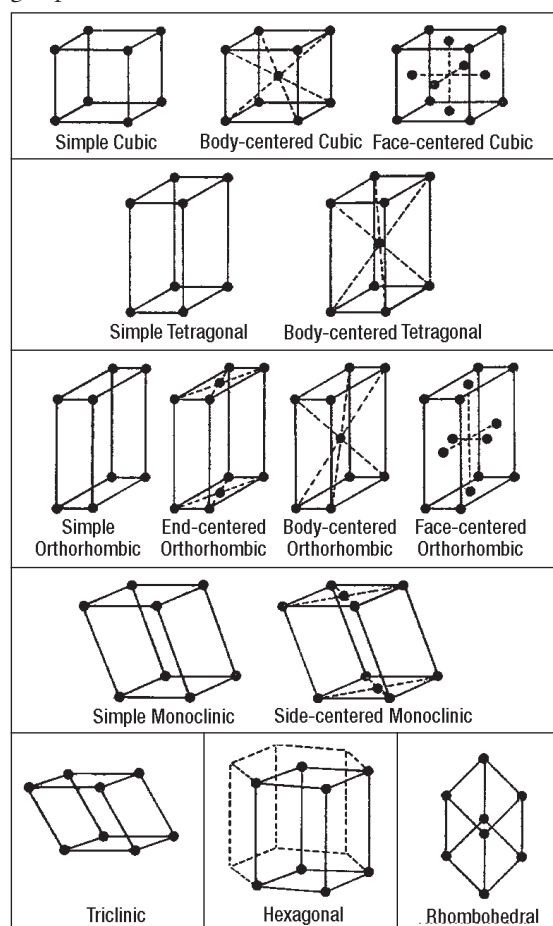
A solution is said to be *unsaturated* if its solute concentration is less than its solubility. When a solute's concentration is equal to its solubility, the solution is said to be *saturated*. At that temperature, no more solid can be dissolved in the solution. However, if a saturated solution is heated, the solubility of the solute may increase, making it possible to dissolve more solid in that same solution. If additional solid is added to the hot solution and then cooled, often the extra solid will precipitate or crystallize out of solution.

### Unit Cells

The macroscopic regularity in the shapes of ice crystals, snowflakes, crystal-line salts, and gemstones suggests that crystals must possess some sort of atomic-level regularity. This regularity is called a crystal lattice, and every crystal is built upon one. A *crystal lattice* is a repeating, orderly arrangement of atoms, molecules, and ions. The specific repeating pattern unique to each crystal lattice is called a *unit cell*, the smallest repeating pattern that reflects the macroscopic shape of the crystal. Sodium borate is an ionic compound. Sodium and borate ions are arranged into a regular three-dimensional pattern resulting from a net balance of attractive and repulsive forces. This arrangement forms an extended network, constructed by repeating the unit cell pattern over and over again in all three dimensions and the crystal "grows."

Seven types of unit cells occur in nature—cubic, tetragonal, orthorhombic, monoclinic, triclinic, hexagonal and rhombohedral. Several of these types of unit cells have variations. The base unit cell plus its variations make up the unit cells for a given crystal system. The seven types of unit cells, their variations, and associated crystal structures are illustrated in Figure 2.

Although the unit cell for a particular solid will always be uniform, variations in crystal shapes occur because the growing solution's concentration varies from one point to another around the crystal. If a particular face of the crystal is surrounded by solution that is more concentrated, it will grow faster than other faces which are surrounded by less concentrated solution. In addition, the different types of faces have different inherent growth rates. The specific shape of the crystal that forms is determined by the rates at which its various faces grow.



**Figure 2.** The seven types of unit cells—cubic, tetragonal, orthorhombic, monoclinic, triclinic, hexagonal, and rhombohedral

## Borax Crystal Ornaments *continued*

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Other factors also affect crystal growth. One of the most important factors is the temperature at which crystals are grown. A constant temperature is very important for growing large crystals. If the temperature varies during crystal growth, the solubility of the solute changes. If the solubility increases, then the crystals may begin to dissolve since the solvent can now accept more solute in solution. Another factor affecting the quality and size of crystals is the rate at which they are grown. Slow growth results in larger quality crystals. If crystals are grown too fast—for example, if the solutions are cooled too quickly after heating—the crystals will be smaller and cloudy in appearance. Crystals also need room to grow and may be smaller or overlap if there is a limited area for growth.

## Reference

Borax Snow Crystals, Indiana Alliance of Chemistry Teachers, 2009 HASTI Presentations, <http://www.chem.purdue.edu/iact/HASTI.htm> (accessed September 2016).

## Materials for *Borax Crystal Ornaments* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7413	Crystal Ornaments—Holiday Laboratory Kit
S0435	Sodium Borate, 500 g
AP8910	Chenille Wires, 1-ft, 10/pkg, White
AP8859	Chenille Wires, 1-ft, 10/pkg, Red
AP8860	Chenille Wires, 1-ft, 10/pkg, Blue
AP8861	Chenille Wires, 1-ft, 10/pkg, Green
AP8862	Chenille Wires, 1-ft, 10/pkg, Black
GP1025	Beaker, Borosilicate Glass, 400-mL
AP1240	Ceramic Fiber Squares, 4" × 4"
AB1134	Dual Lens Magnifier
AP9807	Flinn Digital Hot Plate, 7" × 7"

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