Crystal Art

Section PROPERTIES OF MATTER *Topic* SOLUBILITY

Estimated Time Setup: 5 minutes; Procedure: 30 minutes

OVERVIEW

Students mix a variety of solid crystals into water, then use the solutions to paint on black paper and watch solid crystals form again.

In this activity, students learn about the solubility of solids and the process of crystallization. Students dissolve a series of crystalline solids into water, then use the solutions to create designs on black paper. As the water evaporates they see their designs appear as clusters of crystals, each with a different appearance particular to the original crystalline solid used.

INQUIRY QUESTIONS

Getting Started:

- Is dissolving a solid in a solution a physical or chemical change?

Learning More:

- How can we use properties of solids to distinguish different solids from one another?

Diving Deeper:

- How are crystals formed and separated from a solution?

CONTENT TOPICS

This activity covers the following content topics: properties of matter, physical changes, solubility, saturation, phase changes (evaporation, crystallization), states of matter, crystalline and amorphous solids

This activity can be extended to discuss: molecular structures of crystalline solids, categories of crystalline solids

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **2-PS1-1:** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **5-PS1-3:** Make observations and measurements to identify materials based on their properties.
- **MS-PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures.

MATERIALS

For one setup:

- 3 Clear plastic cups
- 3 Cotton swabs
- 3 Teaspoons
- Table salt
- Epsom salt
- Sugar
- Warm water
- Black construction paper
- Masking tape
- Pen or marker

Optional materials:

- Hand lens

ACTIVITY NOTES

This activity is good for:

- Individuals
- Small groups
- Concept introduction

Safety Tips & Reminders:

- There is no eating or drinking in the laboratory—even when we are working with normally edible materials.
- This activity uses warm water in plastic cups. Be sure that the water is not too hot or it could melt the cups and injure students.
- Review the Safety First section in the Resource Guide for additional information.

ENGAGE

Use the following ideas to engage your students in learning about solubility:

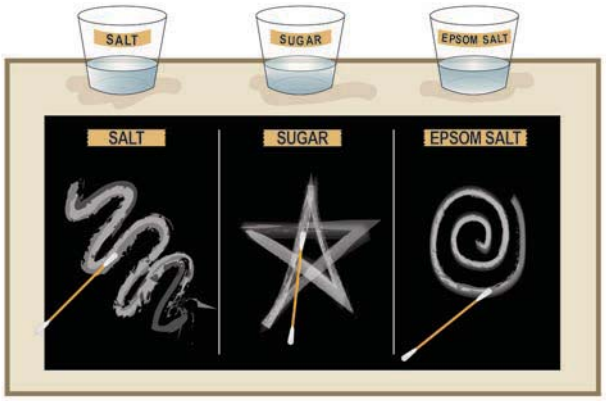
- Start by handing out samples of each crystalline solid. Ask students to compare and contrast the physical properties they observe. Can they guess the identity of each solid sample? Which might dissolve best in water? Why?
- Prepare a demonstration where it is a mystery which solution was used to make each design. Ask students to predict which is which by examining the solid crystals. After performing the activity, ask them to determine if their predictions were correct based on comparisons with their own results.
- Brainstorm a list of substances that are soluble in water. Based on their experiences, can students order them from most to least soluble? Where do they think salt, sugar, and Epsom salt will fall on this continuum?
- Pass around different water samples: some with varying amounts of dissolved crystals in them, some without. Ask students whether they can determine if there are things dissolved in the water by sight alone. How can they test whether their predictions are accurate?

See more ideas for engagement in the Solubility Background section! You can also look at the Elaborate section of this activity for other ideas to engage your students.

EXPLORE

Procedure:

1. Divide a piece of black construction paper into three equal sections. Using the masking tape and pen, label the sections “salt,” “sugar,” and “Epsom salt.”
2. Label the three plastic cups “salt,” “sugar,” and “Epsom salt.”
3. Fill ¼ of each cup with warm water and place on the corresponding labeled sections of the paper.
4. Add one level teaspoon of salt into the cup labeled “salt” and stir until all the crystals dissolve. Continue to add teaspoons of salt until no additional salt can be dissolved. (You will see crystals in the water even after stirring.)
5. Repeat step 4 with the sugar and Epsom salt in their corresponding cups.
6. Dip one end of a clean cotton swab into the salt solution, and use it to paint a design into the salt section of the paper. Using new cotton swabs, do the same with the sugar and Epsom salt solutions.
7. Allow water to evaporate (about 30+ minutes) and examine the designs.



Notes

Fun Fact #1

Epsom salt has a variety of uses: crop fertilizer, pain reliever, sunburn treatment, facewash, hair product, aid for splinter removal, and more!

DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Record the number of teaspoons needed to completely saturate each solution.

SUBSTANCE	NUMBER OF TEASPOONS
SALT **Sodium chloride (NaCl)**	
SUGAR **Sucrose ($C_{12}H_{22}O_{11}$)**	
EPSOM SALT **Magnesium sulfate (MgO_4S)**	

- Which substance has the highest saturation point (dissolves the most in water)?
- Which substance has the lowest saturation point (dissolves the least in water)?
- What happens when you first draw on the paper with the cotton swabs? Are crystals visible? Why or why not?
- What happens after the liquid evaporates? Are crystals visible? Why or why not?
- What does each crystal look like? Compare the original solid crystals to what appears on the paper and draw a close-up of the "before" and "after" of each crystal sample. What are the similarities and differences? Compare and discuss with a peer.

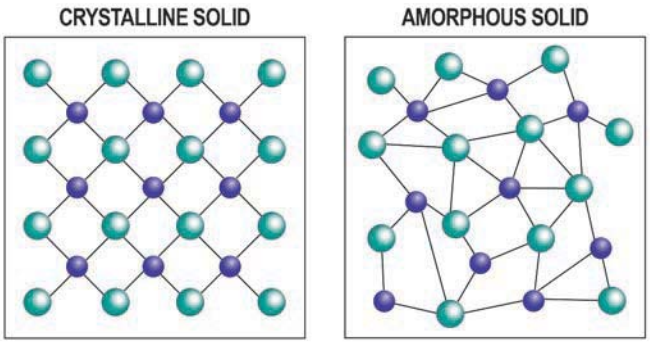
EXPLAIN

What's happening in this Activity?

First review the Solubility Background section to gain a deeper understanding of the scientific principles behind this activity. You can also review the States of Matter Background section for a review of states of matter and phase changes.

Matter is commonly described and categorized by an important physical property: its **state**. There are three major states of matter: solid, liquid and gas. There are many different ways to categorize matter in each of the states. For example, there are two main types of solids: amorphous solids and crystalline solids.

- **Crystalline solids** are made up of atoms or molecules that are organized in specific repeating patterns, which form crystals. Examples include ice, sugar, salt, and diamonds.
- **Amorphous solids** are made up of atoms or molecules that are locked in place, but are not arranged in a specific repeating pattern or structure. Examples include cotton candy, glass, rubber, and plastic.



Notes

EXPLAIN continued

The same compound can take different shapes a solid. For example, sugar is found as a crystalline solid as sugar cubes or as granulated sugar. However, sugar is also the main ingredient of cotton candy. Cotton candy is made by melting down sugar, then solidifying it in a different form. Although sugar cubes and cotton candy are both created from sugar ($C_{12}H_{22}O_{11}$), it exhibits different properties as each type of solid.

Salt, sugar, and Epsom salt are all crystalline solids, and have molecules arranged in specific repeating patterns. In this activity, a type of mixture called a **solution** is created by dissolving different crystalline solids in water. **Solubility** is a physical property that describes the ability of one substance (the solute) to dissolve in another substance (the solvent) to create a uniform solution. A substance that dissolves in another substance is **soluble** in that substance. If a substance does not dissolve in another substance, it is **insoluble**.

In this case, the solutes are sugar, salt, and Epsom salt because they are being dissolved in the solution. The solvent is water because it is the substance doing the dissolving. As more of each solute is added to the water, the solution reaches its saturation point. The **saturation point** of a solution is when no more solute can be dissolved in a solvent. Each solution becomes saturated when no more of each solute (salt, sugar, or Epsom salt) can be dissolved in the water.

Dissolving a solute in a solvent is a physical change. Even though the solutes (salt, sugar, Epsom salt) dissolve in water and the solutions may appear to have formed just one type of substance, both components of the solution maintain their properties. We can't see the crystals when they are dissolved in the water so it may appear to be a pure substance. However, when the solution is used to draw on the black construction paper and the water evaporates, we can see that the solute crystals from the solution remain. Water naturally evaporates over time, but the crystalline solids have very high boiling points, and therefore remain on the paper even after water has evaporated.

Because salt, sugar, and Epsom salt are crystalline solids, they re-form into their regular, crystalline structure, and leave distinct patterns on the paper.

Diving deeper into solubility, there are several factors can affect solubility, including temperature, pressure, and the amount of solute or solvent in a solution. In general, solid and liquid substances are more soluble in solvents at higher temperatures compared with the same solvents at lower temperatures. (Think of how more sugar can be dissolved in hot water than in cold water.) Gases are more soluble in a solvent when it is at a lower temperature. Gases are also more soluble in solvents at higher pressures.

Fun Fact #2

Table salt may be inexpensive today, but it used to be so valuable that it was a form of payment! Roman soldiers were given an allowance to buy salt, and the Latin word for salt, sal, is where our modern word "salary" comes from!

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED	DIVING DEEPER
For younger students, emphasize the following concepts: • States of matter – solids, liquids, gases • Types of solids – crystalline and amorphous • Solutions and mixtures	**For more advanced students, emphasize the following concepts:** • Molecular differences between crystalline and amorphous solids • Variation of saturation point by solute and solvent type • Factors affecting solubility

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- Explore how the temperature of the water affects solubility. Try steps 2–5 of the activity again, but with cold water, room temperature water, warm water, and hot water. (Use hot water only if you have a glass; the plastic will melt with hot water!) Add each solid into the cups slowly and record how many teaspoons of each solid can dissolve at each temperature. How does the temperature of the water affect the saturation point? Why might this be the case?
- Explore how motion affects solubility. Repeat steps 2–5, but this time do not stir. How long does it take each teaspoon of crystalline solid to dissolve?
- Explore how surface area affects solubility. Repeat steps 2–5, but this time use powdered sugar, granulated sugar, and a sugar cube in three separate cups. Which one takes longest to dissolve? Why? When you draw with each solution, do you think the designs will look the same? Try it out!
- Explore how concentration affects recrystallization. Repeat the activity, using different concentrations of salt. (In other words, use the same amount of water every time, but vary the amount of salt with the final cup as fully saturated.) Do the crystal drawings look different depending on how much salt was dissolved? Why?
- If you live in a place that gets snow in the winter and your community puts salt on the roads and walkways, see if there are similar patterns outside after the snow has melted and the ground is dry.
- Have students graph or plot the solubility of each solute on a graph that shows grams of solute (y-axis) and liters of solvent (x-axis). There will have to be measurement of the solvent at the start and slow addition of solute solvent to ensure the data is accurate. Are there trends or commonalities in the data? Try it again, but this time with water at a different temperature, or with a different amount of solvent. Does this change the graph?

EVALUATE

- There are many examples of crystalline solids in nature. Ask students to research an example (e.g., ice, minerals, different types of rocks) and present their findings to the class. What does it look like at a molecular and macro level? Where can you find it? What makes it unique? What are some uses?
- Have students look up the molecular structures of Epsom salt, sugar, and table salt. Draw the molecular structures for one molecule and a group of molecules in a crystal. Do these structures relate to the appearance of these substances?
- Discuss factors that affect the solubility of solutes in a solvent. Challenge students to devise a method to create an image with the largest quantity of crystals remaining on the paper. What solute would be best to use and what solvent (and at what temperature!) will be best for accomplishing this?

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

The maple syrup you buy at the store is a supersaturated solution. That means that the solvent (water) contains more of the solute (sugar) than is normally possible. To achieve this, manufacturers create solutions of sugar water, and then boil off water until the solution reaches the ideal consistency.

Rock candy is created by dissolving sugar in hot water (where it is more soluble!) and creating a saturated solution. When the temperature of the hot water and sugar solution decreases, sugar crystals begin to form and separate from the solution, creating rock candy!

Careers in Chemistry

- Chemists can create medications by understanding the solubility of different solvents and solutes. If a certain ingredient that is vital to the medication is not easily dissolved in the human body, scientists can dissolve it in a solvent to create a medication that can easily be absorbed into the bloodstream.