

Melting Ice with Salt

Section PROPERTIES OF MATTER *Topic* STATES OF MATTER

Estimated Time ⌚ Setup: 5 minutes; Procedure: 30 minutes

OVERVIEW

Students explore the physical changes of melting and freezing and the effect that salt has on the freezing point of water.

What effect does salt have on the freezing point of water? Water changes states from solid to liquid (melting) or liquid to solid (freezing) at a certain temperature, but adding salt lowers the temperature at which water freezes.

INQUIRY QUESTIONS

Getting Started:

❓ Do pure substances freeze and melt at the same temperatures?

Learning More:

❓ Can we change the temperature at which ice melts?

Diving Deeper:

❓ What effect does salt have on the freezing point of water?

CONTENT TOPICS

This activity covers the following content topics: states of matter, properties of matter, physical changes (freezing, melting), elements and compounds, mixtures (solutions), transfer of energy

This activity can be extended to discuss the following: hydrogen bonding, ionic and covalent bonding, crystalline structure, solutions, nonvolatile solute

NGSS CONNECTIONS

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

💡 **2-PS1-4:** Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

💡 **MS-PS1-4:** Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MATERIALS

For one setup:

- ✓ 1 tablespoon
- ✓ 1 metric ruler
- ✓ 2 clear cups
- ✓ 2 cups of ice
- ✓ Salt (1 tablespoon)

Optional Materials:

- ✓ Beaker or graduated cylinder wide enough to hold ice

ACTIVITY NOTES

This activity is good for:

- ✓ Demonstration
- ✓ Small groups

Safety Tips & Reminders:

- ⚠ If possible, observe the changes every 5 minutes.
- ⚠ Review the Safety First section in the Resource Guide for additional information.

Fun Fact #1

Salts aren't limited to what we put on food and the roads. They are any non-water product of a neutralization reaction between an acid and a base, meaning that there are hundreds of types in a variety of colors.

ENGAGE

Use the following ideas to engage your students in learning about states of matter:

- Pose a challenge to your students to see who can melt a cup or bag of ice the fastest using materials in the room.
- Show a video or picture of preparations for snowstorms where roads and walkways are treated.
- Set up the activity as a demonstration. Add salt to one cup prior to the start, and have students discuss what they think is happening and why one ice is melting faster in one cup than the other.

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

EXPLORE

Procedure:

1. Fill 2 clear cups halfway with equal amounts of ice
2. Add 1 tablespoon of salt to one cup, but do not add any salt to the other.
3. Observe the two cups every five minutes for 30 minutes. Observe how much water is collecting at the bottom of the cups.
4. Measure the depth of the water in each cup using a metric ruler.

Fun Fact #2

In Florida the temperature rarely drops below freezing. When it does, however, it threatens Florida's orange crops. To protect the oranges from a freeze, farmers may spray the crops with water. As the water freezes it releases heat. The heat is transferred to the orange, thereby keeping them warmer and protecting the crop.



DATA COLLECTION & ANALYSIS

- Research & record the temperatures at which pure water changes states from liquid to solid (freezing point).
- Record your observations after 5 minutes of when salt is added to the cup. Does the ice in each cup look different? What changes are happening? What does the salt do to the ice?
- Use the table below to measure and record the amount of collected in each cup.

TIME	AMOUNT OF WATER (CM) IN THE CUP	AMOUNT OF WATER (CM) IN THE CUP
5 MINUTES		
10 MINUTES		
15 MINUTES		
20 MINUTES		
25 MINUTES		
30 MINUTES		

- Does the ice melt faster in the regular cup or in the cup with salt? Why?
- What are some examples of how salt can be used in freezing temperatures?
- Salt is also placed in water when water is boiled at high altitudes. Why?

Notes

EXPLAIN

What's happening in this Activity?

First review the States of Matter Background section to gain a deeper understanding of the scientific principles behind this activity.

Matter can be in different states: solid, liquid, gas, or plasma. Matter may change from one state to another and back again depending on a variety of factors, including temperature or pressure. A change in the state of matter is a **physical change** because it is a change in form but does not change the chemical makeup of the material. For example, water vapor (gas), water (liquid), or ice (solid) all have the chemical formula H₂O. As energy is added to a substance it will eventually change from a solid to a liquid to a gas, and as energy is removed from a substance it will eventually change from a gas to a liquid and finally to a solid.

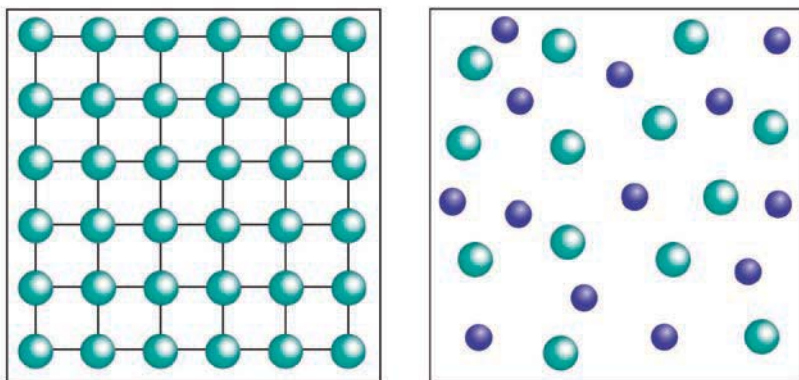
When matter changes state from a liquid to a solid that is called **freezing**. The temperature at which this happens is the **freezing point**. For water the freezing point is 0 °C (32 °F), which means that if liquid water is cooled to 0 °C or below it will turn into solid ice. Conversely, when solid ice is heated to 0 °C or higher it will **melt** into liquid water again. The freezing point is also the **melting point**: the temperature at which the solid substance turns to liquid. Each substance has a unique freezing and melting point, and also a unique boiling point (when liquid turns to gas).

Although each substance has a unique and identifiable freezing and melting point, this point can be altered by changing the conditions of the substance. For example, the freezing

EXPLAIN continued

point of water can be lowered by adding salt to the water. With the salt added, the water will no longer freeze or stay frozen at 0 °C.

If an impurity or different substance is added to a substance, it can change its freezing and melting point or the boiling point. In this example, the addition of salt lowers the freezing point of ice, causing the ice melts faster. Water freezes in a specific pattern (making ice a **crystalline solid**), so the addition of salt disrupts the formation of ice and makes it more difficult for the water to freeze in that pattern.



Although salt does lower the freezing point of water, it can only lower it by a certain amount depending on how much salt is added. An increase of salt should further lower the freezing point of water. Additionally, this is only effective to a certain extent. If the temperature is much lower than the freezing point of water, the ice will not melt even with salt present.

Taking a closer look at the differences in melting and freezing points when salt is added to the ice, there is also another factor at play that changes the rate at which the ice melts. Adding salt to ice disrupts the **intramolecular forces**, or interactions between molecules in a substance, and disrupts how the water molecules in ice interact with one another. Because these forces are disrupted when salt is added, the interactions between water molecules are changed, making the freezing and melting point different compared to the freezing/melting point of pure ice and water.

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

For younger students, emphasize the following concepts:

- Matter exists in different forms and can be classified as a solid, liquid, gas, or plasma.
- Matter has observable properties.
- Heating or cooling matter can cause physical changes, such as melting or freezing.

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- Water molecules freeze to form a crystalline solid.
- The formation of ice can be disrupted with the addition of impurities disrupts that pattern, affecting the rate at which it freezes.
- Melting and freezing points are affected by various factors, including pressure and impurities.

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.

- Replicate the experiment and adjust the variables: amount of ice, amount of solvent, temperature, material of cup, type of solute (i.e. sand, sugar), amount of surface area of ice (i.e. crushed vs. cubed). Students should record their observations and determine which variables change the freezing point and which solute is most effective at lowering the freezing point.
- Put thermometers into cups with various frozen solvents (i.e. water, juice, soda) and ask students to record the temperature every minute, then note at which temperature the solid turned to liquid (freezing point). Try adding a solute to each sample and see if it melts faster.
- Introduce a hypothetical impending snow storm and have teams of students create disaster management plans using materials in the classroom, then have them test their hypotheses using models.
- Show or demonstrate the process of making ice cream using ice and salt to cool the liquid ice cream mixture. Use the concepts in this activity to discuss why salt is added in the process of making ice cream. You can research a recipe and try making ice cream with your students.

CHEMISTRY IN ACTION

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

Real-World Applications

Salt is added to roads and walkways to prevent water from freezing and to melt ice or snow on the road. What environmental impacts might this have for nearby plants and animals?



One of the reasons why the ocean does not freeze in winter is because it has a high salt content, whereas freshwater lakes and streams will freeze. Due to runoff from human activity sometimes freshwater systems are polluted. What effect might this have on the ecosystem if the freezing point of the water changes?



At high altitudes there is less air pressure and water will have a lower boiling point. Salt is sometimes added to raise the boiling point so food cooks properly.



EVALUATE

- As a take-home assignment, have students categorize household items into each state. Students can also try to identify something in their home that can change into all 3 states.
- As a project, have students create a model that shows the three different states of matter. They can use any crafts you provide to develop their solid, liquid, and gas models.
- Have students apply their new learning to a real world chemistry connection. Other than the water cycle, what are some examples of phase changes in our lives? Have students come up with or research some examples of phase changes in our lives, and explain what changes occur as the states change from one to another.

Fun Fact #3

Antarctica is home to approximately 85% of the world's ice, and 80% of earth's fresh water. That translates to about **27 million billion** tons of ice!

If freezing and boiling points are known, they can be used to test how pure a substance is. If a sample changes states at a different temperature than expected, it has impurities.

Careers in Chemistry

- Pharmaceutical chemists can test if the medicine they synthesize (create in the laboratory) is pure by testing its melting point and comparing it to the true known value of the substance they are developing. If the sample they produce contains impurities, the melting point will be lower than the expected value, and will help scientists determine whether the sample is pure.