



LESSON 26: Melting Ice with Salt

ESTIMATED TIME Setup: 3–5 minutes | Procedure: 15–30 minutes

DESCRIPTION

Use salt to melt ice and demonstrate the effects of salt on the freezing point of water.

OBJECTIVE

This lesson explores the physical changes of melting and freezing. Students observe the effect that salt has on the freezing point of water. The lesson can be extended to introduce solutions and nonvolatile solutes.

CONTENT TOPICS

Scientific inquiry; states of matter; properties of matter; physical changes (freezing, melting); elements and compounds; mixtures (solutions)

MATERIALS

- Ice
- Table salt
- Two clear cups
- Metric ruler
- Tablespoon



If possible, observe the changes every 5 minutes.



Always remember to use the appropriate safety equipment when conducting your experiment. Refer to the *Safety First* section in the *Resource Guide* on pages 421–423 for more detailed information about safety in the classroom.



Jump ahead to page 321 to view the Experimental Procedure.

NATIONAL SCIENCE EDUCATION STANDARDS SUBJECT MATTER

This lesson applies both *Dimension 1: Scientific and Engineering Practices* and *Dimension 2: Crosscutting Concepts* from “A Framework for K–12 Science Education,” established as a guide for the updated National Science Education Standards. In addition, this lesson covers the following Disciplinary Core Ideas from that framework:

- PS1.A: Structure and Properties of Matter
- ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World
(see *Analysis & Conclusion*)

OBSERVATION & RESEARCH



BACKGROUND

All matter is made up of basic elements. **Elements** are pure substances that cannot be broken down further by normal chemical means. They are known as the building blocks of matter. A **compound** is a pure substance made up of two or more elements joined in a defined ratio. For example, water is a compound made up of the elements hydrogen and oxygen in a 2:1 ratio. Two hydrogen atoms and one oxygen atom join together, giving water the chemical formula H_2O .

However, the water that comes out of a sink is not a pure substance. It is a mixture, generally called tap water. Tap water usually contains dissolved minerals and other

substances. The water that is considered to be a pure substance is called distilled water (or pure water).

Common table salt is mainly made up of the compound sodium chloride (NaCl). Calcium chloride ($CaCl_2$) and potassium iodide (KI) are also salts. While common table salt is used in this experiment, other salts may work just as well, or possibly better.

As temperature changes, matter may change from one state to another. Changes between states of matter are physical changes. A **physical change** is any change in a substance’s form that does not change its chemical makeup. The chemical formula of the substance stays

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the same before and after the change. For example, ice (solid), water (liquid), and water vapor (gas) are all H₂O in different physical states. The chemical formula remains H₂O regardless of whether it is in the solid, liquid, or gaseous state.

Freezing is a change in state from a liquid to a solid. The temperature at which a liquid begins to form a solid is known as the **freezing point**. The freezing point of water is 0 °C or 32 °F. However, the freezing 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. Thus, the ice will begin to melt back into liquid form. **Melting** is a change in state from a solid to a liquid. It is the opposite of freezing.

Keep in mind that salt can only lower the freezing point of water by a certain amount, and this amount depends on how much salt is used. If the temperature is extremely cold, such as -20 °C or 0 °F, the ice will not melt, and water will still freeze even with salt present.

FORMULAS & EQUATIONS

Pure water is comprised of two hydrogen atoms and one oxygen atom.

The chemical formula for pure water is **H₂O**.

Tap water is a mixture of pure water, dissolved minerals, and other substances.

During a physical change, the structure or chemical formula of the substance does not change. As energy (in the form of heat) is added or removed from the substance, it changes from one state of matter to another. The following equation illustrates the process of melting.



Keep in mind, enough energy has to be added to cause this change. The temperature of the solid substance must reach its melting point. The **melting point** is the temperature at which a substance begins changing its state from a solid to a liquid. The melting point and freezing point of a substance are generally the same.

Common table salt is mainly made up of the compound sodium chloride.

The chemical formula for sodium chloride is **NaCl**.

Most table salts are made of about 97–99% NaCl. The remaining 1–3% is usually iodine and other ingredients.



CONNECT TO THE YOU BE THE CHEMIST CHALLENGE

For additional background information, please review CEF's Challenge study materials online at <http://www.chemed.org/ybtc/challenge/study.aspx>.

- Additional information on elements, compounds, states of matter, and physical changes can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.

HYPOTHESIS

▶ A combination of salt and ice will melt faster than pure ice because the salt lowers the freezing point of water.



Fun Fact

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, protecting the crop.



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DIFFERENTIATION IN THE CLASSROOM

LOWER GRADE LEVELS/BEGINNERS

Perform the experiment as described on page 321, but focus on states of matter and physical changes. Show students the salt, and ask them in which state of matter it is and how they know. Show students the ice, and again ask them its state and how they know. Then, show them liquid water, and have them identify its state of matter. Is it the same substance as the ice? How do they know? Ask them what is different, and discuss physical changes. Use the experiment to show that temperature changes can cause a substance to change from one state to another, but other substances can impact those changes as well.

HIGHER GRADE LEVELS/ADVANCED STUDENTS DESCRIPTION

Use salt to melt ice and demonstrate the effects of salt on the freezing point of water.

OBJECTIVE

This lesson explores the physical changes of melting and freezing and demonstrates the effect that salt, a nonvolatile solute, has on the freezing point of water.

OBSERVATION & RESEARCH

Matter can be classified into pure substances and mixtures. All matter is made up of basic elements. **Elements** are pure substances that cannot be broken down further by normal chemical means. They are known as the building blocks of matter. A **compound** is a pure substance made up of two or more elements joined in a defined ratio. For example, water is a compound made up of the elements hydrogen and oxygen in a 2:1 ratio. Two hydrogen atoms and one oxygen atom join together, giving water the chemical formula H_2O . However, the water that comes out of a sink is not a pure substance. It is a mixture, generally called tap water.

Mixtures are two or more substances that are combined physically. A **solution** is a uniform mixture in which one or more substances (solutes) are dissolved into another substance (solvent). Tap water usually contains dissolved minerals and other substances.

Likewise, common table salt is a mixture mainly made up of the compound sodium chloride ($NaCl$). Water and salt can be easily combined to form a saltwater solution. Salt is the solute, and water is the solvent. Salt is considered to

be a nonvolatile solute. **Volatility** describes the tendency of a substance to vaporize (change into a gaseous state). A **nonvolatile solute** is a solute which has little tendency to escape from the solution. When heated, a solution with a nonvolatile solute will produce a vapor of the pure solvent. Solutions with volatile solutes will produce a vapor that is a mixture of the solvent and solute.

Nonvolatile solutes can be used to lower the freezing point of a liquid. Therefore, salt can be used to lower the freezing point of water. The temperature at which a liquid begins to form a solid is known as the **freezing point**. The freezing point of water is $0\text{ }^{\circ}\text{C}$ or $32\text{ }^{\circ}\text{F}$. When salt is added to water, the water will no longer freeze. If salt is added to ice, the ice can no longer stay frozen at $0\text{ }^{\circ}\text{C}$, so the ice will begin to melt back into liquid form. **Melting** is a change in state from a solid to a liquid. It is the opposite of freezing.

Keep in mind that salt can only lower the freezing point of water by a certain amount, and this amount depends on how much salt is used. Additionally, if the temperature is extremely cold, such as $-20\text{ }^{\circ}\text{C}$ or $0\text{ }^{\circ}\text{F}$, the ice will not melt, and water will still freeze even with salt present.



CONNECT TO THE YOU BE THE CHEMIST CHALLENGE

For additional background information, please review CEF's Challenge study materials online at <http://www.chemed.org/ybtc/challenge/study.aspx>.

- Additional information on elements, compounds, states of matter, physical changes, and solutions can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.



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ANALYSIS & CONCLUSION

Use the questions from the activity sheet or your own questions to discuss the experimental data. Ask students to determine whether they should accept or reject their hypotheses. Review the information in the *Scientific Inquiry* section on pages 14–16 to discuss valid and invalid hypotheses.

ASSESSMENT/GOALS

Upon completion of this lesson, students should be able to ...

- Apply a scientific inquiry process and perform an experiment.
- Define and provide examples of matter, elements, compounds, and mixtures.
- Explain and give examples of physical changes, specifically melting and freezing.
- Understand that salt lowers the freezing point of water.
- Describe and identify solutions, solutes, and solvents (see *Differentiation in the Classroom*).
- Describe volatility and nonvolatile solutes (see *Differentiation in the Classroom*).

MODIFICATIONS/EXTENSIONS

Modifications and extensions provide alternative methods for performing the lesson or similar lessons. They also introduce ways to expand on the content topics presented and think beyond those topics. Use the following examples, or have a discussion to generate other ideas as a class.

- Use the concepts in this experiment to introduce how ice cream is made. You can even research a recipe, gather the necessary materials, and try making ice cream with your class.
- Have the students test other solutes, such as sugar. Sugar is also a nonvolatile solute. Does the sugar cause the ice to melt faster than the pure ice? Does the sugar cause the ice to melt as quickly as the salt does? Discuss these differences as a class.

REAL-WORLD APPLICATIONS

- When snow or ice covers the ground, trucks spread salt on roads to prevent water from freezing and/or to cause the snow and ice to melt. You may also notice people buying containers of salt to use on their sidewalks or driveways for the same purpose.
- Nonvolatile solutes, such as salt, also raise the boiling point of water. In high altitudes, there is a decrease in air pressure. As a result of the pressure decrease, water boils at a lower temperature. Therefore, the temperature at which the water boils may not be high enough to cook the food properly. Salt is added to raise the boiling point to a higher temperature and make sure that the food is cooked properly.

COMMUNICATION

Discuss the results as a class and review the activity sheet. Review the information in the *Scientific Inquiry* section on pages 14–16 to discuss the importance of communication to scientific progress.



LESSON 26 ACTIVITY SHEET: Melting Ice with Salt

OBSERVE & RESEARCH

1. Write down the materials you observe. _____

2. Predict how these materials may be used. _____

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Element		
Compound		
Physical change		
Freezing		
Freezing point		
Melting		
Melting point		

4. Consider how adding salt to ice will affect the rate at which the ice melts.

► Write your hypothesis. _____



LESSON 26 ACTIVITY SHEET: Melting Ice with Salt

PERFORM YOUR EXPERIMENT

1. Fill a cup halfway with ice only.
2. Fill another cup halfway with the same amount of ice, and add one tablespoon of salt.
3. Observe the two cups every five minutes for 15–30 minutes. Look to see which cup is melting faster by observing the amount of water that is collecting at the bottom of the cups.
4. Use a ruler to measure the amount of water in each cup every five minutes.

ANALYZE & CONCLUDE

1. Measure the amount of water in the cups, and record below.

Time	Amount of Water (cm) in the Cup of Ice	Amount of Water (cm) in the Cup of Ice and Salt
5 minutes		
10 minutes		
15 minutes		
20 minutes		
25 minutes		
30 minutes		

2. Does the ice melt faster in the regular cup or in the cup with salt? Why? _____

3. What is your control in this experiment? Explain. _____

4. Is your hypothesis valid? Why or why not? If not, what would be your next steps? _____

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EXPAND YOUR KNOWLEDGE—ADVANCED

1. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Solution		
Volatility		
Nonvolatile solute		

2. How can salt be used in freezing temperatures? _____

3. Salt is also placed in water when water is boiled at high altitudes. Why? _____

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ANSWER KEY: Below are suggested answers. Other answers may also be acceptable.

OBSERVE & RESEARCH

1. Write down the materials you observe. Ice, salt, cups, ruler ...

2. Predict how these materials may be used. Ice may be used as a way to cool down a substance. Salt may be used in cooking.

Cups may be used to hold a substance. A ruler may be used to measure a substance. These materials may be used together to

demonstrate the effects of salt on ice.

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Element	A pure substance that cannot be broken down into simpler substances by ordinary chemical or physical means; an element is made up of only one type of atom.	
Compound	A pure substance made up of two or more elements joined in a defined ratio.	
Physical change	A change that alters the form or appearance of a substance but does not change its chemical makeup or create a new substance.	
Freezing	A physical change in which a substance changes states from a liquid to a solid.	
Freezing point	The temperature at which a substance begins to change from a liquid to a solid.	
Melting	A physical change in which a substance changes states from a solid to a liquid.	
Melting point	The temperature at which a substance begins to change from a solid to a liquid.	

4. Consider how adding salt to ice will affect the rate at which the ice melts.

► Write your hypothesis. A combination of salt and ice will melt faster than pure ice because the salt lowers

the freezing point of water.



LESSON 26 ACTIVITY SHEET: Melting Ice with Salt

ANSWER KEY: Below are suggested answers. Other answers may also be acceptable.

PERFORM YOUR EXPERIMENT

1. Fill a cup halfway with ice only.
2. Fill another cup halfway with the same amount of ice, and add one tablespoon of salt.
3. Observe the two cups every five minutes for 15–30 minutes. Look to see which cup is melting faster by observing the amount of water that is collecting at the bottom of the cups.
4. Use a ruler to measure the amount of water in each cup every five minutes.

ANALYZE & CONCLUDE

1. Measure the amount of water in the cups, and record below.

Time	Amount of Water (cm) in the Cup of Ice	Amount of Water (cm) in the Cup of Ice and Salt
5 minutes	Answers will vary	Answers will vary
10 minutes		
15 minutes		
20 minutes		
25 minutes		
30 minutes		

2. Does the ice melt faster in the regular cup or in the cup with salt? Why? Ice melts faster in the cup with salt because salt lowers the freezing point of the ice, causing the ice to melt faster than it normally would.

3. What is your control in this experiment? Explain. The control is the cup with pure ice because no changes are made to the ice in this cup.

4. Is your hypothesis valid? Why or why not? If not, what would be your next steps?
Answer 1: Valid because the data support my hypothesis.
Answer 2: Invalid because the data do not support my hypothesis. I would reject my hypothesis and could form a new one, such as ...

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ANSWER KEY: Below are suggested answers. Other answers may also be acceptable.

EXPAND YOUR KNOWLEDGE—ADVANCED

Have students complete this section if you used the advanced differentiation information, or challenge them to find the answers to these questions at home and discuss how these terms relate to the experiment in class the next day.

1. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Solution	A homogeneous (uniform) mixture in which one or more substances (solutes) are dissolved in another substance (solvent).	
Volatility	The tendency of a substance to vaporize (change into a gaseous state).	
Nonvolatile solute	A solute which has little tendency to escape from a solution.	

2. How can salt be used in freezing temperatures? Salt is used to melt ice and snow on sidewalks and roads so that it is safer to walk and drive during freezing conditions.

3. Salt is also placed in water when water is boiled at high altitudes. Why? In high altitudes, water boils at a lower temperature. The lower temperature might not be high enough to cook food properly, so salt is added to raise the boiling point and make sure the food is properly cooked.