

Energetic Reactions: Ice Cream Experiment

Teacher Guide

Module Overview

Heat transfer is an important part of many chemical reactions, but it is often not directly observed. In this module students conduct an experiment – making homemade ice cream – that requires heat transfer to occur. Students measure temperatures and observe states of matter throughout the experiment in order to draw qualitative conclusions about the direction and amount of energy transfer that occurs in the reaction. Additionally, students are introduced to colligative properties as they manipulate freezing point of water in order to facilitate the reaction. At the end of the experiment, students get to do something not usually done in chemistry labs – eat the product of the reaction!

Curriculum Links

- 1.2.A** Forms of energy have a source, a means of transfer (work and heat), and a receiver
- 1.2.F** Energy can be transferred within a system as the total amount of energy remains constant (i.e. Law of Conservation of Energy)
- 7.1.B** Scientific inquiry includes relies upon gathering evidence from qualitative and quantitative observations

Goals

1. To understand **exothermic** and **endothermic reactions**.
2. To understand the **transfer of energy** within a system.
3. To understand **colligative properties** and the effect of salt on freezing point of water.

Timing

This module takes 1 to 2 hours to complete.

DVD

Included in this kit is an informational DVD. It is meant to demonstrate the demos described below and provide some hints to make the experiments run more smoothly. It will also go over the background information in attempts to provide a starting point/suggestions for communicating the pertinent background information to your students.

Kit Materials

Included by The Young Scientist Program:

- Sugar
- Vanilla
- Salt
- Ziploc Bags
- Thermometer
- Measuring Cups/Spoons
- Scissors
- Plastic Cups/Spoons

Materials Supplied by Teacher:

- Whole Milk
- Heavy whipping cream
- Additional ice cream toppings if desired



Energetic Reactions: Ice Cream Experiment

Teacher Guide

Lesson Design Tool

Course:
 Week of:

Teacher:
 Grade Level:

CONTENT AREA:		DIFFERENTIATED INSTRUCTION/CROSS CONTENT INTEGRATION
Goals: Big Idea/Concept		<i>HOW will you teach the Content? (groups, strategies, accommodations, content variation, etc.)</i>
To understand exothermic and endothermic reactions . To understand the transfer of energy within a system. To understand colligative properties and the effect of salt on freezing point of water.		Student handouts covered in large group. Small work in small groups to complete experiment. Students discuss and respond to questions on handout during experiment.
Grade Level Expectation/Objective: <i>(WHAT are you going to teach?)</i>		
1.2.A Forms of energy have a source, a means of transfer (work and heat), and a receiver 1.2.F Energy can be transferred within a system as the total amount of energy remains constant (i.e. Law of Conservation of Energy) 7.1.B Scientific inquiry includes relies upon gathering evidence from qualitative and quantitative observations		
Essential Questions(s)/DOK: <i>Higher Order Questions (scaffolded questions to get to Big Idea)</i>		
Why is salt put on icy roads during the winter? What is the difference between endothermic and exothermic reactions? How is energy transferred within the system when making ice cream?		
Assessment/Performance Task: <i>How will students SHOW what they have learned?</i>		Teacher Reflections/Student Work Analysis
Demonstrate understanding during experiments. Responses on handout/discussion questions.		
Vocabulary	Vocabulary Strategies	Reteaching Strategies
Exothermic Reaction Endothermic Reaction Colligative Properties Solute/Solvent		
Technology/Manipulatives		

Energetic Reactions: Ice Cream Experiment

Teacher Guide

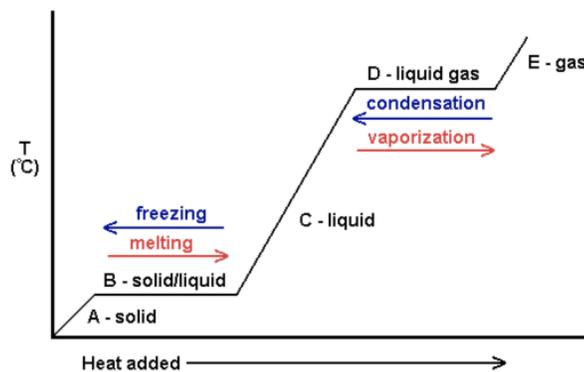
Background

Energy of Chemical Reactions

Chemical reactions occur when two or more molecules interact and change. When molecules undergo chemical changes, they may absorb or release energy from the environment. Reactions that release energy as heat, light, or sound are called *exothermic reactions*. Reactions that absorb energy are called *endothermic reactions*.

If chemicals gain or lose enough heat during a reaction, they may change state. Solids have the lowest amount of energy and their molecules are arranged in an organized lattice. As heat is added to a solid, the molecules begin to move more freely. Eventually the solid melts into a liquid and then the liquid vaporizes to become a gas. The diagram at the right shows these changes graphically.

In this experiment we will combine ice cream ingredients and put them in a cold environment to facilitate the reaction and freezing process that turns the raw ingredients into ice cream. At home we often put things in the freezer to make them cold and we turn a dial to control the temperature. Today we will use ice cubes to create the cold environment and we will control the freezing temperature by taking advantage of *colligative properties*.



Colligative Properties

A *solution* is a mixture of two or more substances formed when a *solute* (minor substance) is dissolved in a *solvent* (major substance, like water). Dissolving a solute in a solvent changes some physical properties of the solvent like the freezing point and boiling point. These are called *colligative properties* and the amount they change depends on the total concentration of solute particles, but not the identity of those particles. Today we will use the effect of a solute (salt) on the freezing point of a solvent (water) to help our ice cream reaction.

References and Further Information

Scientific American

Why do we put salt on icy sidewalks in the winter?

<http://www.scientificamerican.com/article.cfm?id=why-do-we-put-salt-on-icy>

How Stuff Works

Why do they use salt to melt ice on the road in the winter?

<http://science.howstuffworks.com/nature/climate-weather/atmospheric/road-salt.htm>

Energetic Reactions: Ice Cream Experiment

Teacher Guide

Materials

Each group of students needs:

- 3 Tablespoons of sugar
- 1/2 cup of whole milk
- 1/2 cup of heavy whipping cream
- 1/4 teaspoon of vanilla
- 3/4 cup of salt (rock salt works best, but table salt works too)
- 3 cups of ice cubes (enough to half fill the gallon Ziploc)
- 1-quart Ziploc bag (Note: use freezer-safe Ziplocs if possible for stronger seal)
- 1-gallon Ziploc bag
- Thermometer
- Measuring cups and spoons (these could be made by pre-marking lines on disposable cups)

Additional materials needed for the class

- Scissors
- Plastic cups and plastic spoons (one per student)
- Additional ice cream toppings as desired

Safety

1. Ensure no students have allergies to the food ingredients (ex. lactose intolerance)
2. Students should wash their hands before beginning the lab.

Protocol

Students should work in groups of 2

Small Bag (1 quart Ziploc bag)

1. Add 3 Tablespoons of sugar to the **small** ziplock bag.
2. Pour in 1/2 cup of whole milk.
3. Pour in 1/2 cup of heavy whipping cream.
4. Add 1/4 teaspoon of vanilla.
5. Close the bag VERY tightly (otherwise salt and ice will leak in later on—yuck!). Optional: double-bag the small bag for extra protection.

Take a moment to observe the appearance of the ingredients at this initial stage. Be sure to consider the color, state of matter, and homogeneity. Record your observations below.

Big Bag (1 gallon Ziploc bag)

6. Pour ice (about 3 cups) into the **big** ziplock bag to half-fill the bag.
7. Use the thermometer to measure the temperature of the ice. *Record the temperature below.*
8. Add 3/4 cup of salt into the big bag.

Freezing

9. Put the small bag (the one with the milk, sugar, and vanilla) into the big bag. Again, make sure the small bag stays closed so nothing leaks in). There should be enough ice in the big bag that the small bag is well surrounded. Squeeze the extra air out from the big bag and close it tightly. Double check that this seal is tight!
10. Rock the gallon bag from side to side. Trade off with your partner so that your hands don't get too cold. Continue to rock the bag for 10-15 minutes. Record any changes that occur in the bag.



Energetic Reactions: Ice Cream Experiment

Teacher Guide

While you are mixing, predict what you think will happen to the ice and salt in the big bag. How will appearance change? Will temperature change? If so, will it increase or decrease? By how much? Why do you think that? Record your predictions below.

11. Once the ice cream has solidified, open the big bag and use the thermometer to measure the temperature of the ice/salt mixture. Record the temperature below.
12. Remove the small bag, cut off a corner, and squeeze the ice cream into an individual cups (one per student).
13. Serve with spoons and enjoy!!

Helpful Tips

- Use freezer-safe Ziploc bags if available. The seals on these bags are tighter which helps prevent the inner bag from breaking open as the students agitate the bags during freezing process. If strong Ziplocs are not available, double-bag the inner bag for added protection.
- Be patient during the freezing process. It should take more than 10 minutes before solidification.
- The bag gets very cold; students should take turns agitating it. Students may use paper towels, hand towels, gloves, or sweatshirts to hold them hold the bag during agitation.

Optional Variation

For a longer version of this experiment, assign each group of students to one of three conditions: no salt, regular salt (3/4 cup), or high salt (2 cups). Have each group of students use that amount of salt in their outer bag. Students should time and record how long they rock the bag before their ice cream forms. Record the results on the board and discuss together as a class. Students should discover that the more salt that is present, the faster the ice cream will form. The ice of the “no salt” groups will not be cold enough and therefore the ice cream will not solidify. As the other groups finish forming their ice cream and take it out to serve, the “no salt” groups may add salt to their large bags and complete the experiment so that they too can enjoy the delicious treat.

Data and Analysis

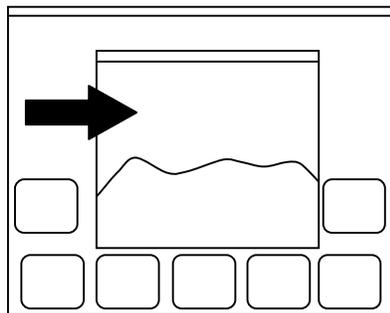
1. Record your data below:
 - a. Initial temperature of large bag (ice, before shaking): _____
 - b. Predicted final temperature of large bag (ice and salt, after shaking): _____
 - c. Final temperature of large bag (ice and salt, after shaking): _____
 - d. Description of the initial contents of the bag:
 - e. Description of the final contents of the bag

Energetic Reactions: Ice Cream Experiment

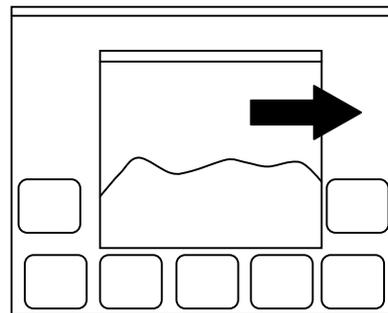
Teacher Guide

Discussion Questions

1. Describe the difference between an endothermic reaction and an exothermic reaction
Endothermic reactions release energy. Exothermic reactions absorb energy. Note: energy may be in the form of heat, light, or sound
2. Which direction does energy flow in this experiment? Choose from the two option below.



a) Energy flows from the large bag into the small bag



b) Energy flows out of the small bag into the large bag

B is the correct answer. The ice absorbs energy from the ingredients.

- a. Is the reaction in the small bag (ingredients) endothermic or exothermic? Why?
The ingredients undergo an exothermic reaction; they release energy as heat.
 - b. Is the reaction in the large bag (salt and ice) endothermic or exothermic? Why?
The salt and ice undergo an endothermic reaction; they absorb energy as heat.
3. Consider the state of matter of each part of the experiment.
 - a. Did any state changes occurred in the large bag? If so, describe them. If not, why?
The ice began as a solid. Some of the ice melted during the experiment, resulting in a mixture of solid and liquid. The salt began as a solid and dissolved into water that resulted from the melting ice. Addition of heat facilitated the melting process.
 - b. Did any state changes occur in the small bag? If so, describe them. If not, why not?
The ingredients began as a combination of liquids and some undissolved solids (ex. sugar) before mixing. The ingredients solidified during the experiment. Students should describe the final consistency of their ice cream. Students may tend to describe their ice cream as a solid. Remind them that solids hold their own shape whereas liquids conform to the shape of their container and exhibit flow. Without more aggressive freezing (ex. in a freezer), it is unlikely that the ice cream in this experiment will complete the phase transition into a true solid.
 4. What happened to the temperature of outer bag over the course of the experiment? Why?
The temperature of the outer bag decreased. All ice has a thin layer of water at its surface. When salt (the solute) dissolves into this water (the solvent), the resulting solution has a lower freezing point than the pure water. The ice will have to draw more heat out of the bag in order to melt and the freezing point (ie temperature at which the phase transition from solid to liquid occurs) will be at a lower temperature.

If students did not measure and record a decrease in temperature, they can consider what experimental factors might have affected their recordings (thermometer placement, not

Energetic Reactions: Ice Cream Experiment

Teacher Guide

waiting long enough before reading the thermometer, etc). It may also be informative to compile the results of all groups and discuss possible causes of any variation present.

5. Why did we add salt to the ice in the large bag? What do you think would happen if you didn't add any salt? What if you added a lot more salt?

Adding salt to the ice lowers the freezing point of the ice. As a result, even more energy must be absorbed from the surroundings to melt the ice. Adding salt to the ice improves the ice cream reaction by causing more heat to be drawn out of the ingredients. This improves cooling and solidification of the ice cream. Adding more salt would lower the freezing point of the ice/salt even more. This would in turn speed up the ice cream's reaction rate and make it get more solid. If you did not add any salt, the freezing point of the ice would remain at 0°C and the ice cream would not solidify very well.

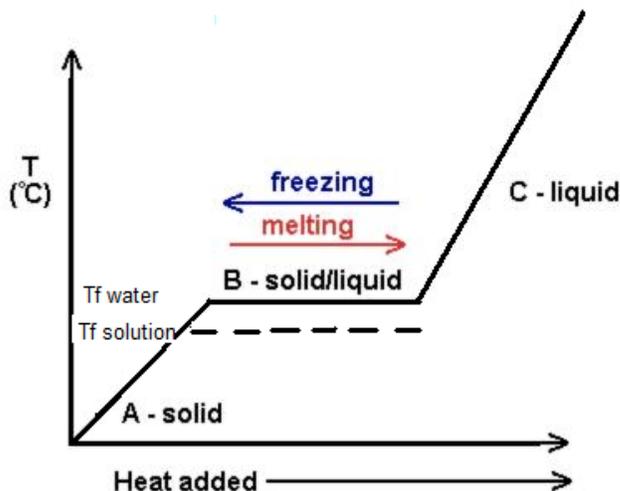
6. Why do we shake the bag? What would happen if you didn't shake it?

Shaking the bag helps mix air into the ice cream so that the consistency is correct. It also improves energy transfer by increasing the contact between the warm ingredients and the cold ice/salt mixture. If you didn't shake the bag, the reaction would take much longer and the ice cream would not be the right consistency.

Extension Questions

7. Graphing phase transitions

- Draw a graph of the normal phase transition for ice melting into water. The x-axis should be amount of heat added and the y-axis should be temperature. Label the freezing point of ice. Hint: refer to the diagram in the Background section
- Add a dashed line to the graph to show what happens when salt is added to the ice. Hint: will the new freezing point be higher or lower?



8. Why do highway maintenance crews put salt on icy roads?

Icy surfaces actually have small puddles of water on them. When you put salt on it, the salt (solute) dissolves into the liquid water (solvent) on the roads and lowers its freezing point. The adjacent ice will then melt faster.

Energetic Reactions: Ice Cream Experiment

Teacher Guide

- a. Freezing point is a colligative property and as more salt is added, the freezing point will be further depressed. Do you think there is a limit to how far the freezing point can be disrupted? Why or why not?

There is a limit to how much salt can be dissolved water (solubility). The freezing point of water with the maximum amount of salt dissolved is about -18°C (0°F). If the air temperature is lower than this, the addition of salt will not help melt the ice. In very cold conditions road crews may put sand on the road instead of ice. Sand helps increase the friction.

- b. Is the reaction in the large bag (salt and ice) endothermic or exothermic? Why?

Cars help the ice melt faster for two reasons. Friction provides energy to the ice, speeding up the melting process. Pressure helps force the salt into the ice, increasing its ability to effectively lower the freezing point.

- c. What might be a negative effect of spreading lots of salt on the roads?

There are many possible answers: salt on metal (cars, highway fenders, etc) speeds corrosion; salt in storm runoff may harm the environment