The Young Scientist Program
Washington University School of Medicine
http://ysp.wustl.edu
Funding Provided by Leon Lowenstein Foundation

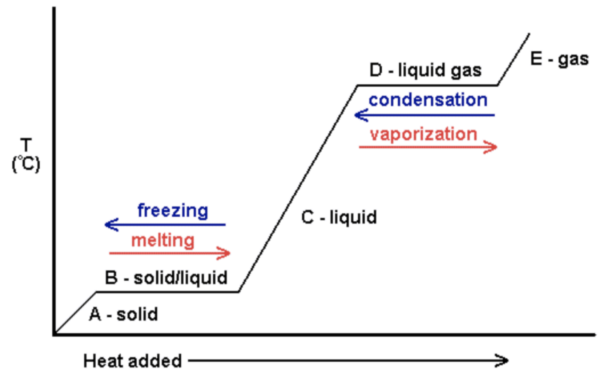
Energetic Reactions: Ice Cream Experiment
Student Handout

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

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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 ½ cup of whole milk.
3. Pour in ½ cup of heavy whipping cream.
4. Add ¼ 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 ¾ 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.

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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

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Vocabulary

Using class and group discussions, along with your results from the experiments, develop working definitions for each of the following terms:

Exothermic Reaction:

Endothermic Reaction:

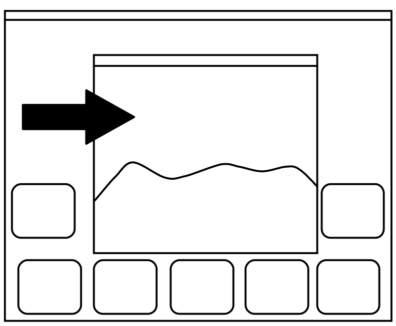
Colligative Property:

Solute:

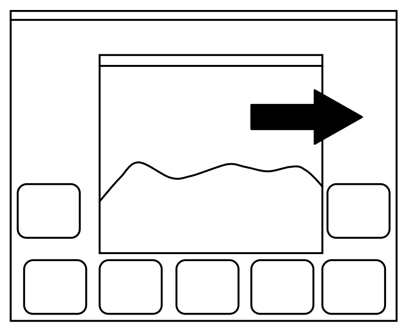
Solvent:

Discussion Questions

1. Which direction does energy flow in this experiment? Choose from the two options below.



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



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

   a. Is the reaction in the small bag (ingredients) endothermic or exothermic? Why?

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

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2. 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?

   b. Did any state changes occur in the small bag? If so, describe them. If not, why not?

3. What happened to the temperature of outer bag over the course of the experiment? Why?

4. 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?

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

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Extension Questions

6. Graphing phase transitions
    a. 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
    b. 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?

7. Why do highway maintenance crews put salt on icy roads?
    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?
    b. Is the reaction in the large bag (salt and ice) endothermic or exothermic? Why?
    c. What might be a negative effect of spreading lots of salt on the roads?