COLLIGATIVE PROPERTIES ICE CREAM LAB

Background Information/Theory: $\Delta T = m\,K_f$ molality, freezing point depression, thermodynamics

Colligative Properties: Physical properties determined by the concentration of dissolved particles in a mixture, and not affected by the type of dissolved particles. Osmotic pressure (tendency of water to flow from high water concentration to low water concentration as seen when applying salt to a slug), boiling point elevation and, most importantly in this activity, freezing point depression are examples of colligative properties. When 1 mole of NaCl dissolves in a liter of water it dissociates into 1 mole of sodium ions and 1 mole of chloride ions, or a total of 2 moles of particles per liter of mixture (a 2M concentration). When 1 mole of sugar dissolves in a liter of water there are just 1 mole of sugar molecules per liter (a 1M concentration). The greater the particle concentration, the stronger the colligative effect.

K_f of water = 1.86 (freezing point depression)

Ice cream, a mixture of milk, sugar and vanilla, is really an aqueous mixture with many particles in each liter. Because of this the freezing point of ice cream is lower that that of water, so to freeze ice cream, or to keep it frozen, you must keep its temperature significantly below 0 degrees Celsius. Adding rock salt to ice produces a melting ice and saltwater mixture with a depressed freezing point in which the ice cream can be frozen.

Heat of Fusion: Melting a solid to form a liquid is an endothermic process. The heat of fusion of a substance is the amount of energy needed to change 1 gram of solid to liquid. The heat of fusion of water is 334 joules/gram.

Since the room temperature and the milk mixture are both warmer than the freezing point of the ice mixture, energy will be transferred into the ice mixture on all sides. This energy will be used in melting the ice (334 joules per gram melted) and the temperature of the ice mixture will stay at its freezing point as long as there is still ice to melt. This process will effectively draw energy out of the milk mixture, lowering its temperature and, eventually, freezing it!

Hess' Law and Enthalpy Change: The energy absorbed by the ice mixture is transferred from the room and the milk mixture so ΔH ice = ΔH milk mix + ΔH room. This is an application of Hess' Law.

Prelab:

1. What quantity of heat is released when 44 g of liquid water of 0°C freezes to ice at the same temperature?
2. How does the boiling point of water rise?
3. How does the freezing point of water lower?
4. What is a mole fraction?
5. What is the difference between molarity and molality?

Materials:

A

1 cup milk
1/4 cup sucrose
1/4 teaspoon vanilla extract *

**if favored ice cream is desired, use 1/8 teaspoon vanilla extract + 1/8 teaspoon flavored extract*

B

1 gallon-size zip-lock baggie
1/2-2/3 gallon ice - *record the # of L*
generous amount of NaCl (s) - you have to measure this out...*(at least 100 and no more than 500 g)*

2 cups and 2 spoons (use spoon to measure teaspoon amount)
thermometer

Procedure:
1. Record the temperature of the ice.
2. Place "A" ingredients in quart-size Ziplock baggie. Be sure to remove as much air as possible before closing baggie.
3. Place "B" ingredients in gallon-size zip-lock baggie along with filled closed quart-size baggie.
4. Wrap your towel around the big baggie (with the quart-size inside) and toss back and forth until contents of the quart-size baggie are frozen.
5. Place baggie in the sink. Record temperature of salt/ice/water "solution" and remove small baggie of ice cream. Wipe the excess salt slurry off the bag BEFORE you open it or the ice cream will taste like rock salt
6. Transfer ice cream to cups and ENJOY!

Data: Record your observations. Make sure to include a data table keeping track of the temperature at 0 min through 15 min.

Calculations:

ex. $\frac{300\text{g NaCl}}{1000\text{ kg}} \times \frac{1\text{ mol}}{58\text{g}} = 5.17m$

Then, $\Delta T = K_f\, m$

$= 1.86 \times 5.17$

$= 9.6$ is the change in temperature....So,

If the freezing point of pure water is 0^oC, then $0^0 - 9.6^0 = -9.6\ ^0C$

1. What is the freezing point of water in degrees C?
2. What is the freezing point depression of water?
3. What was the freezing point of the water (milk)?
4. Calculate the molality of your salt water solution. (use answers to 2 and 3)
5. Calculate the change in temperature of the solvent after the salt has been added.

Discussion:
1. Why are we using molality to describe the concentration of the solution instead of molarity? (besides the fact that the formula calls for it)
2. How does your calculated ΔT compare to your measured temperature difference? If different, Why?
3. Have you ever heard of seaweed ice cream? Where can you get some? Why is it used? Who eats it?

5\. What other kinds of ice cream making techniques are there? Discuss at least two other kinds besides using salt/ice mixtures.

6\. What quantity of ice at 0^0C will be melted by 1.18×10^4J of heat?

7\. How much heat is released when 85.0 g of liquid water freezes to ice at 0^0C ?

Resources:

Conclusion: