NAME: _____ AP Chemistry

DATE: _____

POGIL: Colligative Properties – Part 2

Why?

In the winter, up here in the Great White North, people spread calcium chloride onto walkways to prevent them from icing over. Why do they use calcium chloride instead of sodium chloride, which is more plentiful and easier to obtain?

Success Criteria

- Calculate the freezing point depression for a solvent after the addition of a molecular or an ionic solute.
- Determine the osmotic pressure of a system, and the direction of water flow to equalize the pressure.

Phenomenon – Making Ice Cream

Materials

Ice Cream Recipe	**Extra Materials**
1 cup ½ & ½ Cream	2 Small Ziploc Bags
¼ tsp. Vanilla Extract	Coffee Can
¼ cup Sugar	Ice
	Rock salt

Procedure

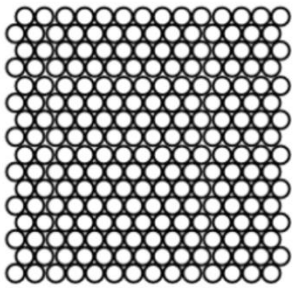
1. First wash your hands.
2. Obtain one coffee can and 2 small Ziploc bags.
3. Fill your small Ziploc bag with 1 cup of the Ice Cream Recipe mixture.
4. Carefully "zip" your bag with the ice cream mixture and then put this bag into the other small Ziploc bag. ***Check the seal, or you will end up with salty ice cream!***
5. Layer 1 inch of ice in the bottom of the coffee can. Place the baggie with your ice cream mixture on the ice and then finish filling the can with ice. Close the can.
6. Carefully roll the can for 5 minutes.
7. Remove the baggie from the ice and observe your mixture.
8. Take the temperature of the ice/water. Record. _____ °C. Dump the original ice.
9. Layer 1 inch of ice on the bottom of the can. Coat it with a layer of salt.
10. Place Ice-cream bag on top of salt and ice layer. Continue layering ice and salt until the bag is covered.
11. Close the can. Carefully roll the ice bag on the table until the ice cream is frozen (around 10 minutes).
12. Take the temperature of the salt/ice mixture. Record. _____ °C.
13. Before opening your small Ziploc bag, rinse it in the sink with cold water so the salt does not go inside.
14. Finally, eat and clean up.

Observations Without Salt Added to the Ice:

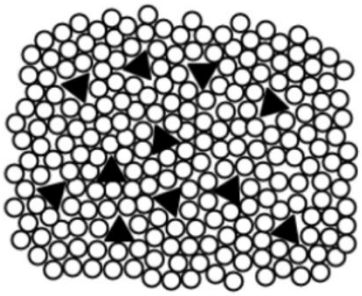
Observations With Salt Added to the Ice:

Possible Explanation:

Model 1: Intermolecular Forces and Melting Point



Compound "A": a pure crystalline solid
One Molecule of Compound A = ○



A mixture of solids A and B:
One molecule of compound B = ▲
One molecule of compound A = ○

Key Questions

1. Circle your choice for the following:
   a. Compound "A" will have stronger forces of attraction (intermolecular forces) between neighboring molecules in the (**PURE COMPOUND / MIXTURE**).

   b. As intermolecular forces increase in strength, the amount of thermal energy needed to separate molecules (**DECREASE / INCREASE / REMAIN THE SAME**).

   c. The (**PURE COMPOUND / MIXTURE**) will have the higher melting point.

2. To ensure that it will be safe to drive on the roadways where it snows, calcium chloride is spread on the pavement to prevent the water from freezing. Does this support your choice for 1c?

3. What is the difference between melting point and freezing point?

In the previous POGIL, you studied how the boiling point of a solvent was elevated with a nonvolatile solute. The degree to which it is elevated was calculated using: $\boldsymbol{\Delta T_b = i \cdot K_b \cdot m}$

The extent to which the freezing point is depressed is calculated using: $\boldsymbol{\Delta T_f = i \cdot K_f \cdot m}$

4. How are the two equations related?

5. An aqueous solution of ethylene glycol has a freezing point of -54.0°C and a boiling point of 110.0°C. Is the freezing point depression the same as the boiling point elevation? Explain your answer.

PRACTICE

A. On a hot summer day, a homemade popsicle can be very refreshing. You prepare a solution of 182 g of sucrose ($C_{12}H_{22}O_{11}$ = 342.3 g/mol in enough water to make 473 mL of solution. This solution has a density of 1.14 g/mL. At what temperature will this mixture freeze? (K_f H_2O = 1.853 °C/*m*)

1) How many moles of sucrose are in the solution?

2) What is the mass of the solution?

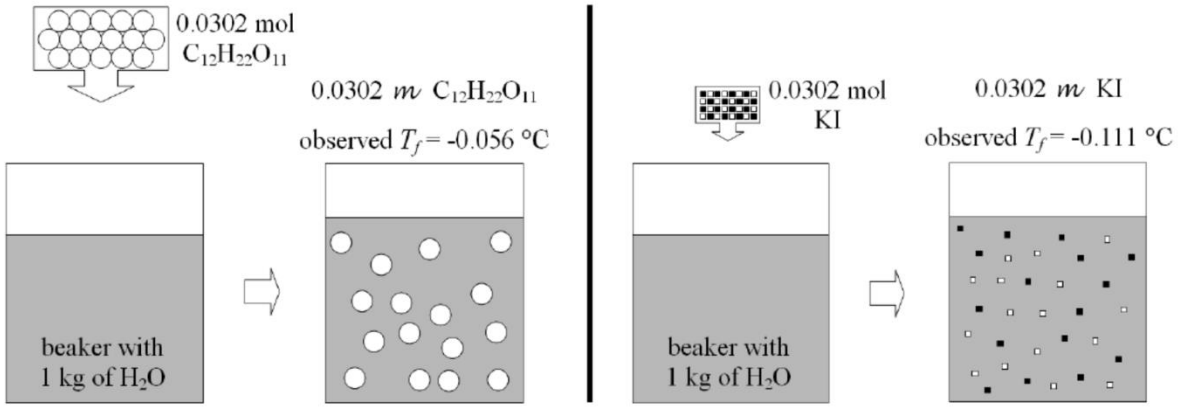
3) What is the mass in kg of the water?

4) Calculate the molality (*m*) of the popsicle solution.

5) What is the freezing point depression of the solution?

6) What is the freezing point of your popsicle?

Model 2: Ionic Solutes and Colligative Properties



A **colligative property** is a property that is affected by the concentration of solute ***particles*** dissolved in solution.

Key Question

6. Explain why the freezing point of 0.0302 *m* $KI_{(aq)}$ is -0.111°C, but the freezing point for the 0.0302 *m* aqueous sucrose solution is -0.056°C.

PRACTICE

B. If 9.0 g of calcium chloride salt is spread onto a wet road for every 91.0 g of water on the road, at what temperature with the road freeze?
   1) Write the formula for calcium chloride and the equation for its ionization.

   2) How many moles of calcium chloride are being spread?

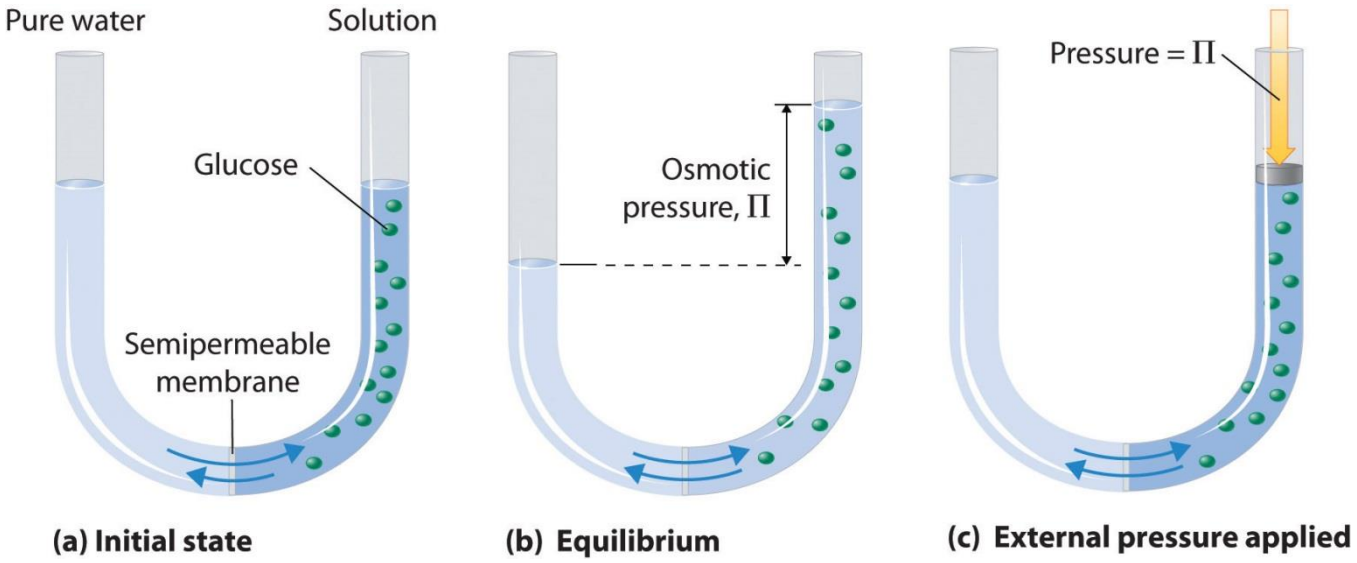
   3) What is the molality of the calcium chloride solution?

   4) Calculate the freezing point depression of the calcium chloride solution?

   5) At what temperature will the road freeze?

Model 3: Osmotic Pressure

Osmosis is the diffusion of water through a semi-permeable membrane from a solution of ***low*** solute concentration to a solution with ***high*** solute concentration. A **semi-permeable** membrane allows water molecules to pass through, but not the solute molecules. Osmosis is a passive process in which a solvent moves without the input of energy from the surrounding. **Osmotic pressure** is defined as the pressure required to maintain equilibrium, or no net movement of water. It is a colligative property because it depends on the concentration of solute, but not the identity of the solute.



$$\pi = MRT$$

- **π = osmotic pressure (atm)**
- ***M*** **= the MOLARITY of the solution** $\left(\frac{mol\ solute}{L\ solution}\right)$
- **R = gas constant** $\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)$
- **T = Kelvin temperature (K)**

Key Questions

7. Why is it sensible that the osmotic pressure should be directly proportional to the concentration of solute particles in the solution?

8. Remembering back to your solubility curves, why is it sensible that the osmotic pressure should be directly proportional to the temperature of the solution?

9. Why must the temperature be in Kelvin? (HINT: Can you have a negative pressure?)

PRACTICE

C. If blood is subjected to a solution with different osmotic pressure than the solution that is within the blood cells, the cells could swell or shrivel, causing cellular death. If a 0.15 M NaCl solution is isotonic with a blood cell, what is the cell's osmotic pressure?

1) What is the molarity of the solute particles?

2) What is the Kelvin temperature of normal human body temperature, 98.6°F?

3) What is the osmotic pressure of the blood cell in atm?