ffect of Solution Concentration on Freezing Point

addition of solute causes the freezing point of a solvent to be ressed. The freezing temperature of the resulting solution can be culated by using the equation

$$\Delta T_f = K_f \times m.$$

ΔT_f is the change in freezing point in degrees Celsius, K_f is a constant lled the freezing point depression constant, and m is the molality of the lution.

When molecular solutes dissolve in a solution, they remain as mol- cules. In the case of ionic solutes, such as sodium chloride, the solid issociates into its component ions.

$$NaCl(s) \longrightarrow Na^+(aq) + Cl^-(aq)$$

Since the depression of the freezing point depends on the number of particles in solution, the effective molality, or concentration, is increased by a factor equal to the number of ions produced. In the case of sodium chloride, two ions are produced. Therefore, for NaCl, the freezing point expression is

$$\Delta T_f = K_f \times m \times 2.$$

In this experiment, the molal concentration of three solutions will be experimentally determined by measuring their freezing point depressions and using the following equations. The equations are obtained by rear- ranging the equations above.

For molecular solutes: $m = \dfrac{\Delta T_f}{K_f}$

For ionic solutes: $m = \dfrac{\Delta T_f}{K_f n}$

ΔT_f is the change in freezing point in degrees Celsius, K_f is 1.86°C/m for a water solution, m is the molality of the solution in moles of solute per kg of water, and n is the number of ions produced in the dissociation of an ionic solute.

Objectives

1. ***Calculate*** the molality of nonionic and ionic solutions from freezing point depression data.
2. ***Demonstrate*** an understanding of the effects of ionic and nonionic solutes on the freezing points of solutions.
3. ***Relate*** the information from this experiment to the salting of icy roads

Materials

Apparatus	Reagents
thermometer	crushed ice (made from distilled water)
2 100-mL beakers	distilled water
25-mL graduated cylinder	frozen solutions of
stirring rod	sucrose
safety goggles	sodium chloride
laboratory apron	calcium chloride
plastic gloves	liquid solutions of
	sucrose
	sodium chloride
	calcium chloride

Prelab

1. Read the introduction and procedure before you begin.
2. Answer prelab questions 1–8 on the Report Sheet.

Procedure

CAUTION: Some of the solutions you will work with are toxic. Wear gloves. Do not touch any of the frozen or melted solutions with your bare hands. Do not get any in your mouth.

1. Put on your safety goggles, laboratory apron, and plastic gloves.
2. Obtain about 15 mL of crushed ice and place in the 100-mL beaker. Add about 5–10 mL of distilled water.
3. Find the freezing point of the ice by placing the thermometer in the ice/water mixture. Wait until the temperature stabilizes before you record the temperature. This data is necessary for the calibration of the thermometer.
4. Obtain about 15 mL of one of the frozen solutions and place in a beaker. If it is frozen solid, you may crush the solid before putting it in the beake Add about 5–10 mL of the liquid solution of the same compound. Wait until the temperature stabilizes before you record the temperature.
5. Repeat step 4 with each of the solutions to be tested. Record all temperatures in the data table.
6. Dispose of the solutions as your teacher instructs. Before leaving the lab, clean up all materials and wash your hands thoroughly.

Name ______________________

Class ______________________

Date ______________________

Experiment 15-2

Report Sheet

Effect of Solution Concentration on Freezing Point

Prelab Questions

1. When a solute is added to water, or any solvent, what will happen to the freezing point of the solution?

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2. Molality is one way of expressing solution concentration. What are the units of molality?

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3. What difference is there in the dissolving of an ionic solid and a nonionic solid?

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4. Suppose you had a 1 *m* solution of sucrose (nonionic). Predict the freezing point of this solution.

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5. Suppose you had a 1 *m* solution of sodium chloride (ionic). Predict the freezing point of this solution.

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6. Explain how salting an icy road helps to clear that road.

7. What is the purpose of finding the freezing point of pure distilled water at the beginning of the experiment?

8. In your own words, write the purpose of this experiment.

Data and Observations

Data Table

freezing point of distilled water	
freezing point of sucrose solution	
freezing point of NaCl solution	
freezing point of $CaCl_2$ solution	

Calculations

or each of the calculations, show your work in the space provided. Then, summarize your results in Data Table 2.

1. Find the change in freezing points for each of the three solutions by subtracting the freezing point from the freezing point of distilled water.

2. Find the molal concentration of each of the solutions, using the information found in the introduction to the experiment.

Data Table 2

molality of sucrose solution	
molality of NaCl solution	
molality of $CaCl_2$ solution	

Analysis and Conclusions

1. Approximately how many grams of solute would you find in 100 mL of each of the solutions you used in this experiment? You can assume that the density of water is 1 g/mL.

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Data Table 3

grams of sucrose in 100 ml solution	
grams of NaCl in 100 ml solution	
grams of $CaCl_2$ in 100 ml solution	

2. Suppose you had a 1.00 *m* solution of $AlCl_3$. Assuming complete dissociation, what is the freezing point of this solution?

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3. Explain the difference between a 1.00 molal solution of sodium chloride and a 1.00 molar solution of sodium chloride.

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Real World Connections

1. Local and state highway departments use either rock salt, NaCl, or calcium chloride, $CaCl_2$, to melt ice on the roads. These salts reduce the freezing point of water, thus turning the ice on the roads to slush. If you had a 50 kg bag of each salt, which would give the greatest amount of melting? Justify your answer by using calculations.

2. Salting roads is not accepted by everyone. What are some drawbacks to using any salt on the roads?