Colligative Properties

Name ____________________
Class ____________________

In this activity, you will explore the following:

- *the effects of solution concentration on freezing point*
- *the freezing-point depression constant for water*

Colligative properties are properties related to the concentration of a solution. These properties do not depend on the solute in the solution, just the number of particles of the solute. These properties are freezing point depression, boiling point elevation, vapor pressure lowering, and osmotic pressure. This lab will focus on freezing point depression. You will first determine the freezing-point depression constant for water experimentally. Then, you will use the theoretical, accepted value to solve several problems.

Problem 1 – Data Collection and Analysis

Step 1: Fill a 250 mL beaker with ice. Add enough water (tap water or distilled water) to fill the beaker halfway. Add a small handful of rock salt to the ice and water mixture. Swirl the beaker gently to mix the salt, ice, and water.

Step 2: Use the 10 mL graduated cylinder to measure 2 mL of distilled water. Pour the distilled water into the test tube.

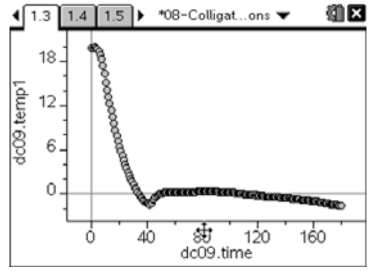
Step 3: Place the end of the EasyTemp™ probe in the water in the test tube.

Step 4: Open **the** file **08-Colligative_Properties.tns**, read the first two pages, and then connect the temperature probe to your handheld or computer. A data collection display should appear.

Step 5: Begin the temperature sampling. After sampling has begun, place the test tube in the beaker so that the water in the test tube is completely below the surface of the ice water, but keep the top of the test tube above the surface of the ice water.

Step 6: Move the test tube back and forth in the ice water, keeping the end of the temperature probe near the middle of the water in the test tube. Try not to let the temperature probe touch the sides or bottom of the test tube. Keep moving the test tube until the water inside is completely frozen.

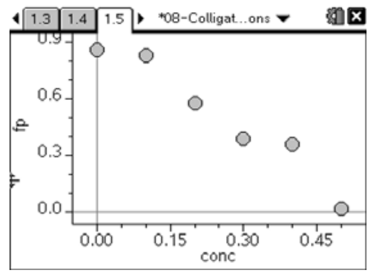
Step 7: Stop the data collection. Remove the probe from the test tube. Empty the ice from the test tube. Rinse the test tube and the probe with distilled water. Leave the ice water in the beaker.



Step 8: Move to page 1.3 to observe the temperature data. Identify the freezing point of the solution. The freezing point is the temperature at which the solution leveled off.

Step 9: Click on one of the points in the horizontal portion of the graph to view its coordinates. The *y*-value is the temperature. Record the freezing point of the pure water in the *Lists & Spreadsheet* application on page 1.4.

Step 10: Repeat steps 2, 3, and 5–9 for the five sucrose solutions. Make sure to rinse the test tube and probe with distilled water after each trial. If you are asked whether to save or overwrite your data, choose to overwrite it.



Step 11: In the *Data & Statistics* application on page 1.5, make a plot of freezing point (**fp**) vs. solution concentration (**conc**). Use the **Linear Regression** tool (**Menu > Analyze > Regression > Show Linear (mx + b)** to plot the best-fit line for the data.

Step 12: Answer questions 1–6.

Q1. What is the best-fit equation for the data?

Q2. What do *x* and *y* represent?

- o *x* is concentration, and *y* is freezing point
- o *x* is freezing point, and *y* is concentration
- o *x* is temperature change, and *y* is concentration
- o *x* is concentration, and *y* is temperature change

Q3. What is the slope? What does the slope represent?

Q4. The units for the slope are

- o $\frac{m}{^\circ\text{C}}$
- o $\frac{\text{g}}{^\circ\text{C}}$
- o $\frac{^\circ\text{C}}{m}$
- o $\frac{^\circ\text{C}}{\text{g}}$

Q5. Use your best-fit equation to calculate the freezing point of a 0.25 *m* sucrose solution.

Q6. Use your best-fit equation to calculate the molality of a sucrose solution with a freezing point of –2.50 °C.

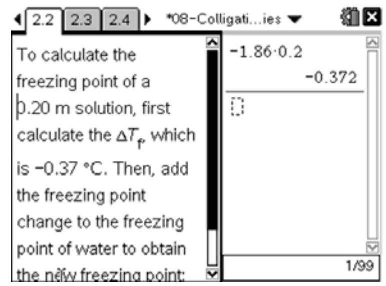
Problem 2 – Problem Solving

Step 1: Move to page 2.1 and read the text there. The accepted equation for freezing point depression is

$$\Delta T_f = k_f \times m$$

ΔT_f is the change in freezing point, k_f is the freezing point constant for a particular solvent (in our case water), and *m* is the molality of the solution. Once the ΔT_f for the solution has been calculated, the actual freezing point of the solution can be calculated by subtracting the ΔT_f from the freezing point of the pure solvent. Water has an accepted constant of freezing (k_f) of 1.86 °C/*m* and a freezing point of 0 °C.

Step 2: Review the example problem on page 2.2. Then, answer questions 7–10.



Q7. Calculate the freezing point of a 0.40 *m* aqueous glucose solution. (Glucose does not dissociate in water.)

Q8. If 5.0 g of glucose ($C_6H_{12}O_6$) is dissolved in 50.0 g of water, what is the freezing point of the resulting solution?

Q9. What is the freezing point of a solution formed by dissolving 15.0 g of sucrose ($C_{12}H_{22}O_{11}$) in 40.0 g of water?

Q10. How many moles of glucose must be dissolved in 50.0 g of water to decrease the freezing point of the water to –0.50 °C?