Solutions **Name**_____

Colligative Properties

Read from **Lesson 3: Colligative Properties** in the **Chemistry Tutorial Section, Chapter 13** of **The Physics Classroom**:

Part a: Vapor Pressure Lowering Part b: Boiling Point Elevation Part c: Freezing Point Depression

Colligative Properties

Why is salt used to melt ice on roads? How does antifreeze work? These questions can be answered by studying *colligative properties*—physical properties of solutions that depend solely on the number of solute particles present, not their chemical identity. Some colligative properties—vapor pressure lowering, boiling point elevation, freezing point depression—help explain how the presence of solute particles alters the behavior of solvents.

Formulas:

Vapor Pressure Lowering	Boiling Point Elevation	Freezing Point Depression
$P_{solution} = X_{solvent} \bullet P_{pure\ solvent}$	$\Delta T_b = i \bullet K_b \bullet molality$	$\Delta T_f = i \bullet K_f \bullet molality$

Answer these questions about colligative properties:

1. Why does the addition of a solute (like NaCl or $CaCl_2$) lower the vapor pressure of a solvent like H_2O?

2. Arrange the following solutions in order of decreasing vapor pressure at 25 °C. Explain your ranking.
   Solution A: 1.0 mol NaCl in 1.0 kg H_2O Solution B: 1.0 mol sugar in 1.0 kg H_2O
   Solution C: 1.0 mol $CaCl_2$ in 1.0 kg H_2O Solution D: 1.0 kg H_2O

3. What is the van't Hoff factor (i) and how does it influence the magnitude of colligative properties?

4. Describe how antifreeze affects both the freezing point and boiling point of a solution. Why is it particularly useful in car engines?

Solutions

5. A solution is prepared by dissolving 100 g of magnesium chloride in 200 g of water.

   a. What is the molality of this solution?

   b. What is the molality of particles in the solution? Is it the same as your answer to part a? Why or why not?

   c. What is the freezing point of this solution?

6. An aqueous solution of sugar freezes at −7.10 °C. What temperature would you expect it to boil?

7. Crystal Lettuce and Aaron Agin are working on the Mystery Compound Lab. Their unknown is a white waxy compound. Their first procedure is to determine the molar mass of their compound. For their first set of trials, they dissolve 100.0 g of the compound in 1.00 kg of water and measure the boiling point of the solution. The observed boiling points are 100.28 °C, 100.25 °C, and 100.29 °C. Using these results, calculate the molar mass of the unknown compound.

8. For a fourth trial, Crystal asks Aaron to retrieve more of their unknown compound. Aaron finds a bottle of a white crystalline solid on the teacher's desk. He measures out 100.0 g of this solid and dissolves it in 1.00 kg of water. The boiling point of this new solution is recorded as 101.75 °C. Explain why this boiling point is significantly different from the values in the earlier trials. What type of experimental error did Aaron likely make, and how would it affect the calculated molar mass?