

**Colligative properties** are properties that depend only upon the number of solute atoms, ions, or molecules in a solution and not on the nature of those atoms, ions or molecules. Freezing point depression and boiling point elevation are examples of colligative properties. Raoult discovered that the addition of solute particles causes the boiling point of a solution to be elevated and the freezing point to be depressed. It has been found that 1 mole of nonvolatile, nonionizing solute particles will raise the boiling point of 1.0 kg of water by 0.52 °C, to 100.52°C at 1 atm of pressure. The same concentration will lower the freezing point of 1.0 kg of water by 1.86°C, to -1.86°C. These two numbers apply only to water and are called the molal boiling point and freezing point constants for water. Other solvents have different constants.

PROPERTY	BOILING POINT ELEVATION	FREEZING POINT DEPRESSION
EQUATION	<b>Boiling Point Elevation:</b> A solution will boil at a higher temperature than the pure solvent.  $\Delta T_b = i K_b m$  $\Delta T_b$ = change in boiling temp. in (°C)  <i>i</i> = a unitless constant (called the van't Hoff factor) associated with the degree of dissociation of the solute in a solvent.  $K_b$ = molal boiling point elevation constant (°C/m)  <b>For H<sub>2</sub>O: <math>K_b</math> = .52°C/m</b>  <i>m</i> = molality of the solution	<b>Freezing Point Depression:</b> A solution will freeze at a lower temperature than the pure solvent.  $\Delta T_f = i K_f m$  $\Delta T_f$ = change in freezing temp. in (°C)  <i>i</i> = a unitless constant (called the van't Hoff factor) associated with the degree of dissociation of the solute in a solvent.  $K_f$ = molal freezing point lowering constant (°C/m)  <b>For H<sub>2</sub>O: <math>K_f</math> = 1.86°C/m</b>  <i>m</i> = molality of the solution
	<i>i</i> = 1 for substances that do not ionize 2 for substances which ionize into two ions like LiCl 3 for substances which ionize into three ions like CaCl <sub>2</sub> ...etc.  <i>i</i> may have to be calculated if a % of dissociation is given for a solute.  If the solvent is not water you must find its $K_b$ .	<i>i</i> = 1 for substances that do not ionize 2 for substances which ionize into two ions like LiCl 3 for substances which ionize into three ions like CaCl <sub>2</sub> ...etc.  <i>i</i> may have to be calculated if a % of dissociation is given for a solute.  If the solvent is not water you must find its $K_f$ .

**EXAMPLE #1**

If 90.0 g of nonionizing C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, are dissolved in 255 g of H<sub>2</sub>O, what will be the boiling point of the resulting solution?

First calculate the molality (*m*) of the solution:

$$m = \frac{92g}{\left(180 \frac{g}{mole}\right)(0.255 \text{ kg of solvent})} = 2.0 \text{ m}$$

Next apply the boiling point elevation equation:

[*i* = 1 for a nonionizing solute.]

$$\Delta T_b = i K_b m$$

$$\Delta T_b = (1)(0.52^\circ\text{C/m})(2.0 \text{ m})$$

$$\Delta T_b = 1.04^\circ\text{C}$$

$$BP = (\Delta T_b + 100.00^\circ\text{C})$$

$$BP = (1.04^\circ\text{C} + 100.00^\circ\text{C}) = \underline{101.04^\circ\text{C}}$$

# Modern Chemistry Study Guide Colligative Properties Answers

**F Rizvi**



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