Formulas for Colligative Properties

Lowering of Vapor Pressure

Elevating the BOILING Point

Molality Formula

$$\text{Molality} = \frac{\text{moles of solute}}{\text{kilograms of solvent}}$$

$$m = \frac{\text{moles}}{\text{kg}}$$

Depression of the FREEZING Point

Osmotic Pressure

Vapor Pressure

$$P = X P^o$$

P = vapor pressure of the solvent

X = the mole fraction of the solvent

P^o = vapor pressure of the pure solvent (a book value, CRC reference)

Reference Only

For calculating changes in colligative properties the **van't Hoff factor (i)** is used.

Example:

LiCl dissociates into **Li+** and **Cl-** so **i = 2**
$BaCl_2$ dissociates into Ba+ and **2Cl-** so **i = 3**

This allows the researchers to account for the number of solute particles without being concerned about the type of particle being used.

The boiling point and freezing point change according to the number of particles that go into the solution.
The boiling point elevates and the freezing point becomes depressed.

Note:

- Nonpolar substances don't dissociate into ions so they are given a factor of 1.
- Ionic substances will dissociate into ions and so each ion must be counted.

$$\Delta T = i\, k_b\, m$$

ΔT = change in temperature
i = the van't Hoff factor
k_b = the boiling point elevation constant (a book value, CRC reference tables) for the solvent.

Example:
What is the boiling point of a 2 m solution of NaCl in water if the boiling point elevation constant is **0.5^o C / m**?

Solution:

i = 2 **Na^+** and **CL^-**

$\Delta T = i\, k_b\, m$ = (2) (0.5^o C m) (2m) = 2^oC

Note: The boiling point of water is 100^o C so **ADD** the value to obtain the elevated boiling point.

$$\Delta T = i\, k_f\, m$$

ΔT = change in temperature
i = the van't Hoff factor
k_f = the freezing point depression constant (a book value, CRC reference tables) for the solvent.

Example:
What is the freezing point of a 2 m solution of NaCl in water if the freezing point elevation constant is **-1.858^o C /m**?

Solution:

i = 2 Na^+ and CL^-

$\Delta T = i\, k_f\, m$ = (2) (0.5^o Cl m) (2m) = 2^oC

Note: The freezing point of water is 0^o C so **SUBTRACT** the value to obtain the elevated boiling point.

$$O_p = M\,R\,T$$

O_p *= Osmotic Pressure atm*

M = molarity of the solution

R = gas constant

T = temperature in Kelvin (K) Units

Reference Only