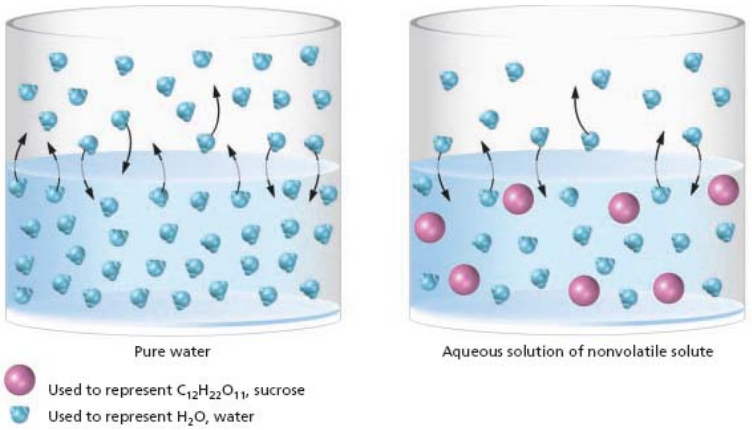
Colligative Properties

Colligative Properties – properties that depend on the concentration of a solute particles (instead of what the solute is)

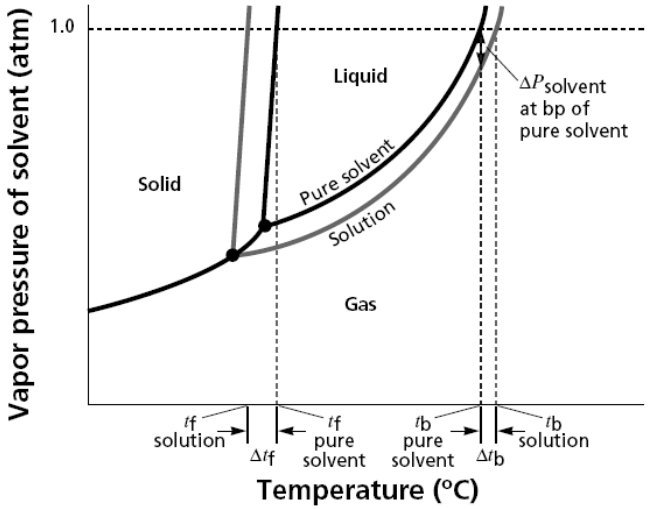
With higher concentration of a solute:

- Vapor pressure lowers
- Freezing point lowers
- Boiling point raises

Vapor Pressure Lowers



Freezing and Boiling Point Changes



Colligative Properties

Molal Freezing Point Constant (K_f) – freezing point drop for a 1 *m* solution

For water → $K_f = 1.86 \frac{°C}{m}$

Freezing Point Depression – the difference of freezing points between a pure substance and a solution

$\Delta t_f = K_f \, m \cdot$ (Number of ions/particles)

Nonelectrolytes dissolve as one particle. Electrolytes split into each ion.

Ex. $Ca(NO_3)_2 \rightarrow 1\ Ca^{2+} + 2\ NO_3^{1+} \rightarrow$ Three ions

Colligative Properties

Molal Boiling Point Constant (K_b) – boiling point increase for a 1 *m* solution

For water → $K_b = 0.51 \frac{°C}{m}$

Boiling Point Elevation – the difference of boiling points between a pure substance and a solution

$\Delta t_b = K_b \ m \cdot$ (Number of ions/particles)

Nonelectrolytes dissolve as one particle. Electrolytes split into each ion.

Ex. $Ca(NO_3)_2 \rightarrow 1\ Ca^{2+} + 2\ NO_3^{1-} \rightarrow$ Three ions

Colligative Properties

What is the expected boiling-point elevation of water for a solution that contains 150 g of sodium chloride dissolved in 1.0 kg of water?

$150\ g\ NaCl \left(\frac{mol}{58.5\ g} \right) = 2.56$ mol NaCl

$\frac{2.56 \text{ mol NaCl}}{1.0 \text{ kg Water}} = 2.6\ m$ NaCl

Ex. $NaCl \rightarrow 1\ Na^{1+} + 1\ Cl^{1-} \rightarrow$ Two ions

$\Delta t_b = K_b\ m \cdot$ (Number of ions/particles)

$\Delta t_b = (0.51 \frac{°C}{m})(2.6\ m)(2) = 2.7°C$ increase

This solution will boil at 102.7°C

Colligative Properties

What is the expected freezing point of a solution containing 85.0 g of NaCl dissolved in 0.45 kg of water?

$85.0\ g\ NaCl \left(\frac{mol}{58.5\ g} \right) = 1.45$ mol NaCl

$\frac{1.45 \text{ mol NaCl}}{0.45 \text{ kg Water}} = 3.22\ m$ NaCl

Ex. $NaCl \rightarrow 1\ Na^{1+} + 1\ Cl^{1-} \rightarrow$ Two ions

$\Delta t_f = K_f\ m \cdot$ (Number of ions/particles)

$\Delta t_f = (1.86 \frac{°C}{m})(3.22\ m)(2) = 11.8°C$ drop

This solution will freeze at -11.8°C