Ch 17: Properties of Solutions

- **Colligative Properties**
  - Difference between dilute solution and pure solvent depends on the amount of solute present, not its identity
  - The Vapor Pressures of Solutions
    - Boiling Point Elevation and Freezing Point Depression

**Practice Problems**

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**Raoult’s Law**

- Substances have lower vapor pressures in solution than in pure form

\[
P_{\text{solution}} = X_{\text{solvent}} P^\circ_{\text{solvent}}
\]

\[
\Delta P = P^\circ_{\text{solvent}} - P_{\text{solution}}
\]

\[
P_{\text{solution}} = (1-X_{\text{solvent}}) P^\circ_{\text{solvent}}
\]

\[
\Delta P = P^\circ_{\text{solvent}} - P_{\text{solution}} = X_{\text{solute}} P^\circ_{\text{solvent}}
\]

Deviations from Ideal Vapor P

- Positive deviation = solute-solvent attractions < solvent-solvent attractions

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Week 7
CHEM 1310 - Sections L and M
Deviations from Ideal Vapor P

Negative deviation = solute-solvent attractions > solvent-solvent attractions

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Practice Problem

CCl₄ (MW = 154 g/mol) has a vapor pressure of 100 torr at 23 °C. CCl₄ is able to dissolve candle wax.

[Wax is a mixture, but assume C₂₂H₄₆, MW = 311 g/mol].

What is the change in vapor pressure at 23 °C of a solution prepared by dissolving 10.0 g of wax in 40.0 g of CCl₄?

\[ \Delta P = X_{\text{solute}}P^\circ_{\text{solvent}} \]

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Freezing & Boiling Points

Solutions have lower freezing points and higher boiling points than pure solvents

Ethylene Glycol is the active ingredient in antifreeze

Lowers \( T_f \) to -34 °F and increases \( T_b \) to 276 °F

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Boiling Point Elevation

\[ \Delta T = K_b \text{ m}_{\text{solute}} \]

\[ \Delta T = \text{BP elevation} \]

\[ K_b = \text{solvent constant} \]

\[ m_{\text{solute}} = \text{molality of solute} = \text{moles solute/kg solvent} \]

Volatile = evaporates easily (e.g. acetone in fingernail polish remover)

Nonvolatile solutes lower the vapor pressure of a solvent

Nonvolatile solutes elevate the \( T_b \) of a solvent.

Example 17.2

Dissolve 18.00 g of glucose in 150.0 g of water. Solution has \( T_b = 100.34 \) °C at 1 atm. Calculate the molar mass of glucose.

\[ \Delta T = K_b \text{ m}_{\text{solute}} \]

\[ m_{\text{solute}} = \frac{\Delta T}{K_b} \]

\[ \Delta T = K_b \text{ m}_{\text{solute}} \]

\[ m_{\text{solute}} = \frac{0.34 \text{ °C}}{0.51 \text{ °C kg/mol}} = 0.67 \text{ mol/kg} \]

TABLE 17.5

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Boiling Point (°C)</th>
<th>( K_b ) (°C kg/mol)</th>
<th>Freezing Point (°C)</th>
<th>( E_f ) (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (H₂O)</td>
<td>100.0</td>
<td>0.51</td>
<td>0</td>
<td>1.86</td>
</tr>
</tbody>
</table>

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Example 17.2

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\[
\text{mole glucose} = \frac{0.67 \text{ mol/kg}}{0.1500 \text{ kg water}} = 0.10 \text{ mol}
\]

Molar Mass Glucose = 18.00 g / 0.10 mol = 180 g/mol

Freezing Point Depression

\[
\Delta T = K_f \cdot m_{\text{solute}}
\]