# Properties of Solutions

## Raoult's Law

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The presence of a nonvolatile solute lowers the vapor pressure of the solvent.

$$P_{solution} = \chi_{solvent} P^0_{solvent}$$

$P_{solution}$ = Observed Vapor pressure of the solution

$\chi_{solvent}$ = Mole fraction of the solvent

$P^0_{solvent}$ = Vapor pressure of the pure solvent

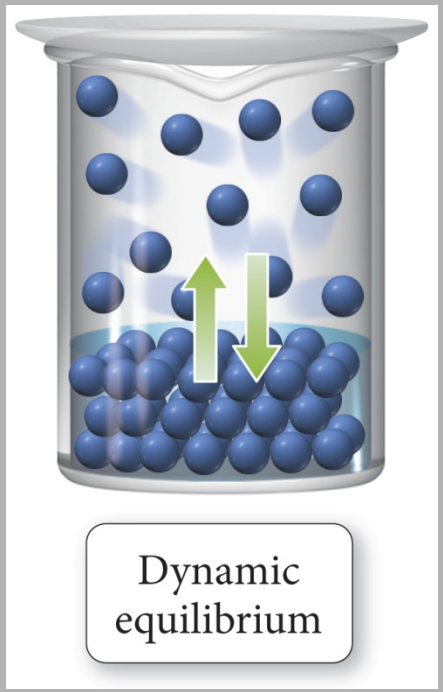
# Vapor Pressure Lowering

- The vapor pressure of a solvent in a solution is always lower than the vapor pressure of the pure solvent.
- The vapor pressure of the solution is directly proportional to the amount of the solvent in the solution.
- The difference between the vapor pressure of the pure solvent and the vapor pressure of the solvent in solution is called the **vapor pressure lowering.**

$$\Delta P = P^\circ_{\text{solvent}} - P_{\text{solution}} = \chi_{\text{solute}} \cdot P^\circ_{\text{solvent}}$$

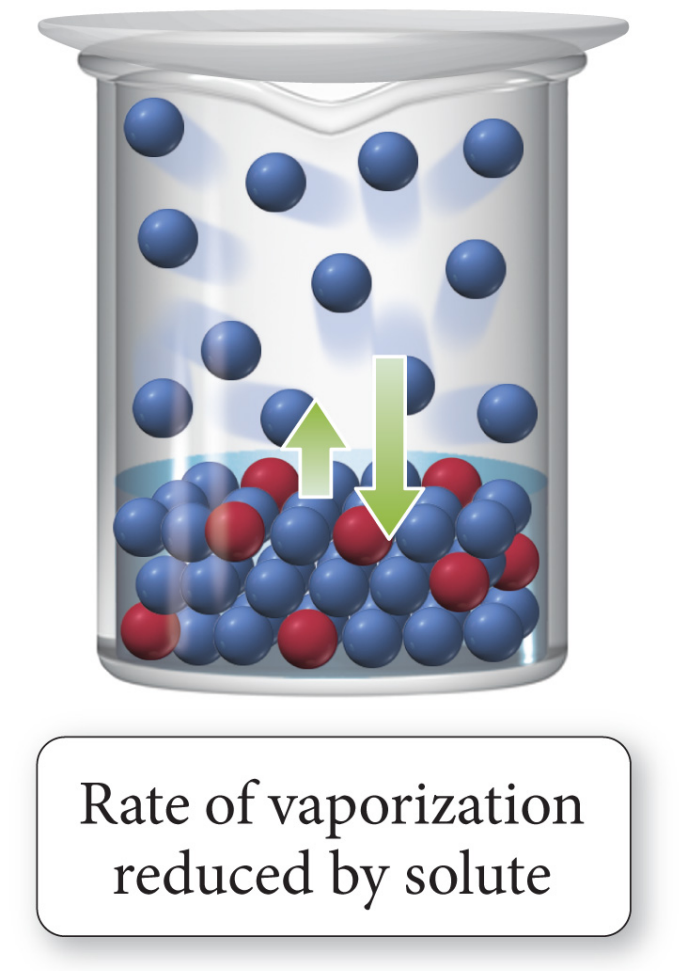
# Vapor Pressure of Solutions

- The vapor pressure of a solvent above a solution is lower than the vapor pressure of the pure solvent.
  - The solute particles replace some of the solvent molecules at the surface.
  - The pure solvent establishes a liquid vapor equilibrium.



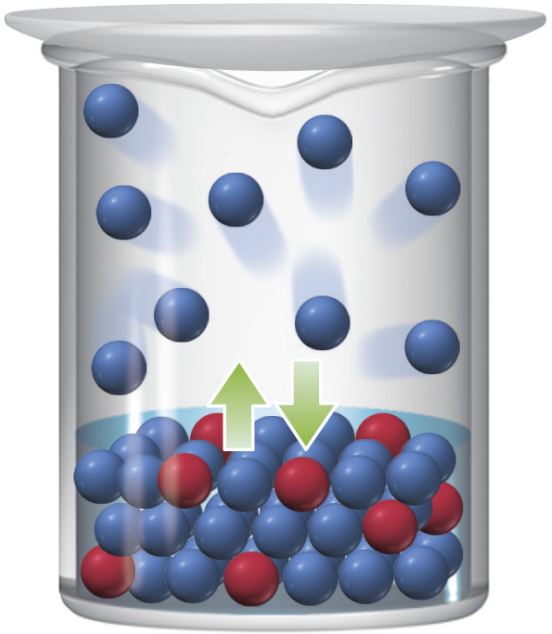
# Vapor Pressure of Solutions

- Addition of a nonvolatile solute reduces the rate of vaporization, decreasing the amount of vapor.



# Vapor Pressure of Solutions

- Eventually, equilibrium is re-established, but with a smaller number of vapor molecules; therefore, the vapor pressure will be lower.



Equilibrium reestablished but with fewer molecules in gas phase

# Liquid-liquid solutions in which both components are volatile (Non-Ideal)

## Modified Raoult's Law:

$$P_{TOTAL} = P_A + P_B = \chi_A P_A^0 + \chi_B P_B^0$$

$P^0$ is the vapor pressure of the pure solvent

$P_A$ and $P_B$ are the partial pressures

# Ideal Sol'n

- 1. **Liquid-liquid** solution that obeys Raoult's law
  - a. No solution is perfectly ideal, though some are close
- 2. **Negative deviations** from Raoult's law (lower than predicted vapor pressure for the solution)
  - a. Solute and solvent are similar, with strong forces of attraction
  - b. $\Delta H_{sol'n}$ is large and negative
- 3. **Positive deviations** from Raoult's law (higher than predicted vapor pressure for the solution)
  - a. Solute and solvent are dissimiliar, with only weak forces of attraction
  - b. Particles easily escape attractions in solution to enter the vapor phase

# Ideal versus Nonideal Solution

- In ideal solutions, the made solute–solvent interactions are equal to the sum of the broken solute–solute and solvent–solvent interactions.
  - Ideal solutions follow Raoult's law
- Effectively, the solute is diluting the solvent.
- If the solute–solvent interactions are stronger or weaker than the broken interactions the solution is nonideal.

# Vapor Pressure of a Non-ideal Solution

- When the solute–solvent interactions are stronger than the solute–solute + solvent–solvent, the total vapor pressure of the solution will be less than predicted by Raoult's law, because the vapor pressures of the solute and solvent are lower than ideal.
- When the solute–solvent interactions are weaker than the solute–solute + solvent–solvent, the total vapor pressure of the solution will be more than predicted by Raoult's Law.

# Deviations from Raoult's Law