Colligative Properties:

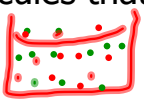
depend on the # of solute molecules/particles

4 properties:

1. lowering vapor pressure (Raoult's Law)
2. boiling point elevation
2. freezing point depression
3. osmotic pressure

Lowering vapor pressure:

vapor pressure caused by molecules that escape liquid phase and move into gaseous phase.



nonvolatile solutes reduce the ability of the surface solvent molecules to escape the liquid. (not as many solvent molecules at the surface)

vapor pressure is lowered because it dilutes the solvent
amount vapor pressure is lowered depends on the amount of solute

lower vapor pressure allows solution to stay liquid over a wider range of temperatures.
as a result it lowers the freezing pt. and elevates the boiling pt.

vapor pressure is directly proportional to the mole fraction of solvent

Raoult's Law:

$P_A = X_A \times P^0_A$

P_A = vapor pressure of solution (includes solute)
P^0_A = vapor pressure of pure solvent
X_A = mole fraction of solvent

Raoult's law doesn't work when the solvent-solvent and solute-solute intermolecular forces are much greater or weaker than the solvent-solute intermolecular forces.

Ideal solution--one that obeys Raoult's law
Real solution shows approximately ideal behavior when:

1. solute concentration is low
2. solute and solvent have similar sized molecules.
3. solute and solvent have similar intermolecular forces of attraction.

Ionic solutes lower vapor pressure more because of # of moles of ions when compound dissociates.

Ex. 1

Glycerin ($C_3H_8O_3$) is a nonvolatile nonelectrolyte with a density of 1.26 g/mL at 25°C. Calculate the vapor pressure at 25°C of a solution made by adding 50.0 mL of glycerin to 500.0 mL of water. The vapor pressure of pure water at 25°C is 23.8 torr.

$P_{soln} = \chi \; P^\circ_{solvent}$

$= \chi \; (23.8 \text{ torr})$

$\chi = \dfrac{\text{moles glycerin}}{\text{moles glycerin} + \text{moles } H_2O}$

for glycerin:

$D = \dfrac{m}{V}$

$1.26 \text{ g/mL} = \dfrac{x}{50.0 \text{ mL}}$

$x = 63 \text{ g glycerin}$

$63 \text{ g } C_3H_8O_3 \left(\dfrac{1 \text{ mole}}{92.11 \text{ g}}\right) = 0.684 \text{ moles } C_3H_8O_3$

$500.0 \text{ mL } H_2O \left(\dfrac{1 \text{ g}}{1 \text{ mL}}\right) = 500 \text{ g } H_2O$

$500.0 \text{ g } H_2O \left(\dfrac{1 \text{ mol}}{18.02 \text{ g}}\right) = 27.75 \text{ mol } H_2O$

$\chi = \dfrac{0.684 \text{ mol glycerin}}{0.684 \text{ mol} + 27.75 \text{ moles}}$

$\chi = 0.023$

$P_{soln} = \chi \cdot P^\circ_{solv.}$

$P_{soln} = (0.023)(23.8 \text{ torr})$

$P_{soln} = 0.547 \text{ torr}$

Ex. 2
The vapor pressure of pure water at 110°C is 1070 torr. A solution of ethylene glycol ($C_2H_6O_2$) and water has a vapor pressure of 1.00 atm at 110°C. Assuming Raoult's laws is obeyed, what is the mole fraction of ethylene glycol in the solution?