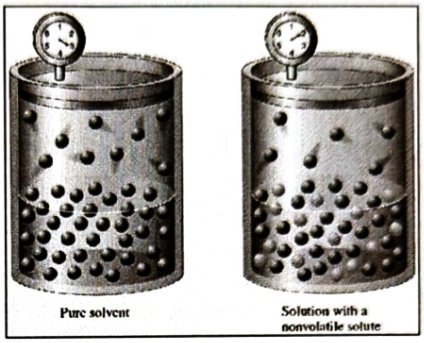
Vapor Pressure Lowering

Raoult's Law:

Vapor pressure of a solvent in a solution is lower than the vapor pressure of the pure solvent



$P_{solvent\ in\ solution} = X_{solvent} P^{\circ}_{solvent}$

X = mole fraction

$$\frac{\text{mol solvent}}{\text{mol solvent} + \text{mol solute}}$$

Raoult's Law and a Nonvolatile Solute

92 g/mol

Glycerin ($C_3H_8O_3$) is a nonvolatile compound. Calculate the vapor pressure of an aqueous solution made by adding 164 g $C_3H_8O_3$ to 338 mL of water at 39.8 °C.

Vapor pressure of pure water = 54.74 torr at 39.8 °C.

Density of pure water = 0.992 g/mL at 39.8 °C

$$X_{H_2O} = \frac{18.62}{18.62 + 1.78} = 0.913$$

$$\frac{338(0.992)}{18.01} = 18.62 \text{ mol}$$

$$\frac{164}{92} = 1.78 \text{ mol}$$

$$P_{solution} = 0.913(54.74) = 49.96 \text{ torr}$$

Raoult's Law and a Volatile Solute

Methanol (CH_3OH) and propanol (C_3H_7OH) are both volatile liquids.

Vapor pressure of pure CH_3OH = 303 torr at 40 °C

Vapor pressure of pure C_3H_7OH = 44.6 torr at 40 °C

Calculate the mole fractions of CH_3OH and C_3H_7OH in a solution that has a vapor pressure of 154 torr at 40 °C assuming ideal behavior.

$$154 = P_{CH_3OH} + P_{C_3H_7OH}$$

$$= X_{CH_3OH} P^\circ_{CH_3OH} + X_{C_3H_7OH} P^\circ_{C_3H_7OH}$$

$$1 = X_{CH_3OH} + X_{C_3H_7OH}$$

$$154 = X_{CH_3OH} P^\circ_{CH_3OH} + (1 - X_{CH_3OH}) P^\circ_{C_3H_7OH}$$

$$X_{CH_3OH} = 0.423$$

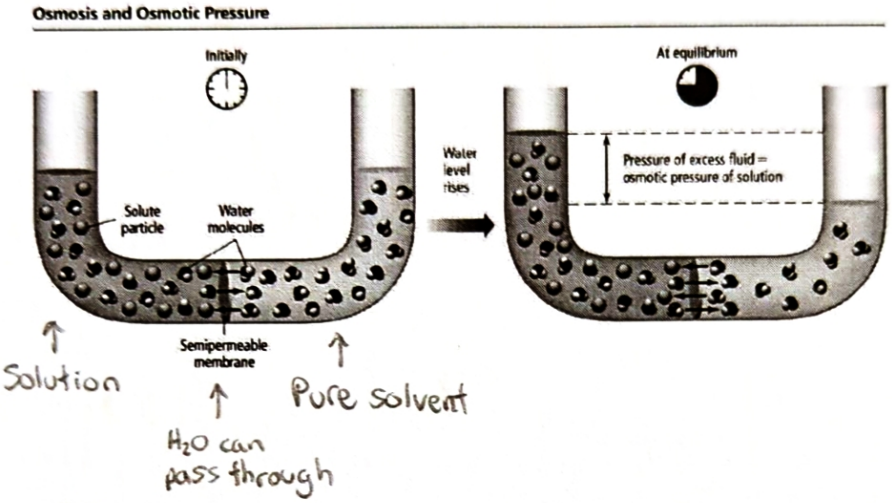
$$X_{C_3H_7OH} = 0.577$$

Raoult's Law and a Volatile Solute

Ideal solution:

Intermolecular forces between solute(s) and solvent are no different than those between the pure compounds

Osmotic Pressure



$PV = nRT$

$P = MRT$

$\pi = iMRT$

A solution was prepared by dissolving 8.92 g of $FeCl_3$ (s) in enough water to make 500.0 mL of solution. It exhibited an osmotic pressure of 9.15 atm at 25.0 °C. Calculate the molar mass of $FeCl_3$ (s).

$9.15 = \frac{n}{0.5}(0.08206)(298.15)(4)$

$n = 0.0467$

$MM = \frac{8.92}{0.0467} = 190.8\ g/mol$