Raoult's Law: Vapour Pressure Lowering

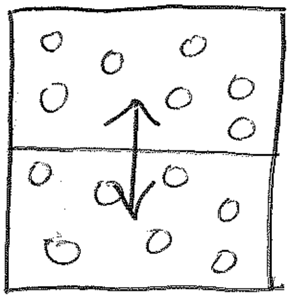
Non-volatile - does not have a tendency to form a vapor

Raoult's Law: The vapor pressure of a solution of a nonvolatile solute is equal to the vapor pressure of the pure solvent at that temp multiplied by its mole fraction

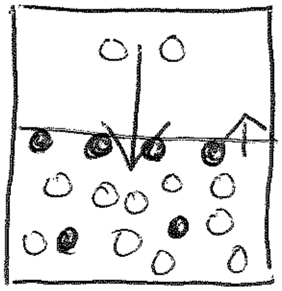
$$P = \underset{\uparrow}{X_{solv.}} \times P^{\circ}_{solv.} \leftarrow$$ vapor pressure of pure solvent

mole fraction $= \frac{\text{mol solvent}}{\text{total moles}}$

Explanation:

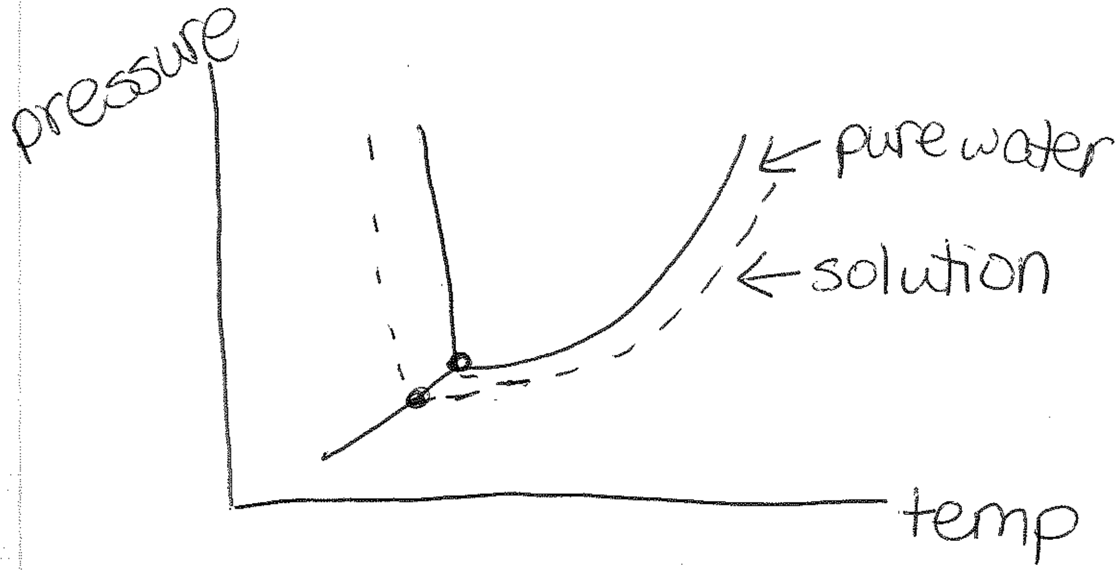


Closed container - equilibrium established of particles moving between liquid and vapor phase



When solvent particles are added, they take up room on the surface, so less escapes to the vapor. Vapor particles can still re-enter the solution. Fewer particles in the vapor means that the vapor pressure is lower.

☆Only works on ideal solutions.
- Dilute
- Weak solute-solvent interactions
- Solute does not ionize


pressure
pure water
solution
temp

Boiling Point Elevation

-A soln. boils at a higher temp than the pure solvent $\Delta T_b = iK_bm$

Freezing Point Depression

-A soln. freezes at a lower temp. than the pure solvent $\Delta T_f = iK_fm$

ex You add 1.00kg of ethylene glycol ($C_2H_6O_2$) antifreeze to your car radiator which contains 4450g of water. Find the BP. and FP.

($K_b = 0.512$ °C/m / $K_f = 1.86$ °C/m)

$$1.00\text{kg } C_2H_6O_2 \times \frac{1000\text{g}}{1\text{kg}} \times \frac{1\text{mol } C_2H_6O_2}{62.07\text{g}} = 16.1\text{ mol } C_2H_6O_2$$

$$4450\text{ g } H_2O \times \frac{1\text{kg}}{1000\text{g}} = 4.450\text{kg}$$

$$m = \frac{16.1\text{ mol } C_2H_6O_2}{4.450\text{ kg}} = 3.62\,m$$

$$\Delta T_b = (.512)(3.62) = 1.85°C$$

BP = 101.85°C

$$\Delta T_f = {}^-(1.86)(3.62) = {}^-6.73°C$$

FP = ⁻6.73°C

Suppose that 13g of a nonelectrolyte is dissolved in 0.50 kg of benzene. The boiling point of this solution is 80.61°C. What is the molecular mass of the solute?

$$\text{benzene}\begin{cases} bp = 80.1°C \\ kb = 2.53 \end{cases}$$

$$\Delta T_b = 80.61 - 80.1 = 0.51$$

$$\Delta T_b = iK_b m$$

$$.51 = (1)(2.53)\,m$$

$$m = 0.20$$

$$.20 = \frac{x}{.50\,kg}$$

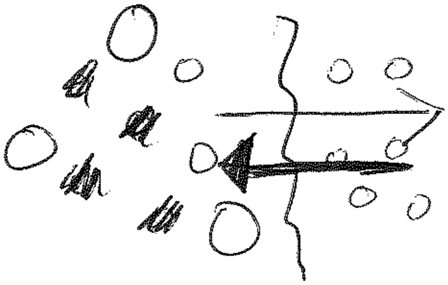
$$x = .1\,mol$$

$$M = \frac{13g}{.1\,mol} = 130g/mol$$

Osmotic Pressure

- Osmosis - a liquid passes through a membrane with pores that allow solvent molecules to pass but are too small to pass solute molecules

  ex. Movement across the cell membrane



solvent moves from high to low concentration (diffusion)

Applying pressure stops osmosis

$$\underset{\text{pressure}}{\text{osmotic}} \rightarrow \Pi = \frac{\overset{\text{moles solute}}{\overset{\downarrow}{n}}RT}{V} \leftarrow \text{T in Kelvin} \qquad R = \frac{.0821\,L\,atm}{mol\,K}$$

$$\Pi = MRT$$

ex. Sea water has dissolved salts with a total concentration of 1.13 M. What pressure must be applied to prevent osmotic flow of pure water into sea water through a semipermeable membrane at 25°C?

$$\Pi = MRT = (1.13\,M)(.0821)(298K) = 27.6\,atm$$