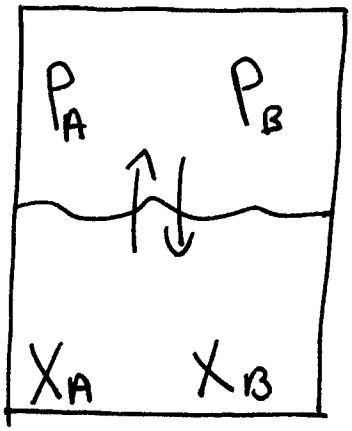
Mixture of Volatile Liquids



$$P_{vap} = P_A + P_B$$

Raoult's Law (ideal behavior)

$$P_i = X_i P_i^\circ$$

where P_i° is the pure vapor pressure of solvent at T.

Example

Benzene + Toluene at 25°C

$P_B^\circ = 385$ torr

$P_T^\circ = 139$ torr

For $X_T = 0.60$ $X_B = 0.40$

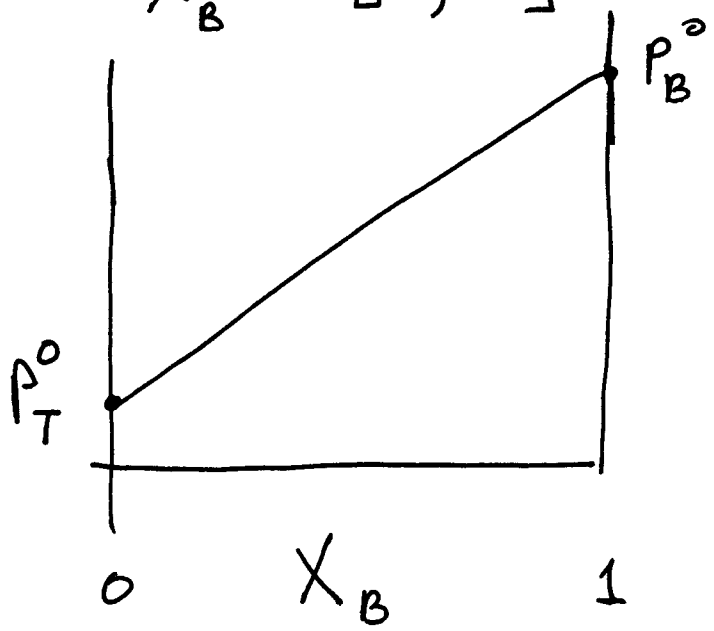
$$P_{total} = X_B P_B^\circ + X_T P_T^\circ$$

BUT

$$X_B + X_T = 1$$

$$P_{total} = P_T^\circ + (P_B^\circ - P_T^\circ) X_B$$

$X_B \in [0, 1]$



FOR low MOLE FRACTION X_2

$$P_2 = k_2 X_2$$

FOR X_1 small ($X_2 \simeq 1$)

$$P_1 = k_1 X_1 = k_1 (1 - X_2)$$

RAOULT'S Law → Solvent

Henry's Law → Solute

$X_1 \simeq 1$ Solvent $P_1 = P_1^{\circ} X_1$

$X_2 \simeq 0$ Solute $P_2 = k_2 X_2$

Vapor-Pressore Lowering

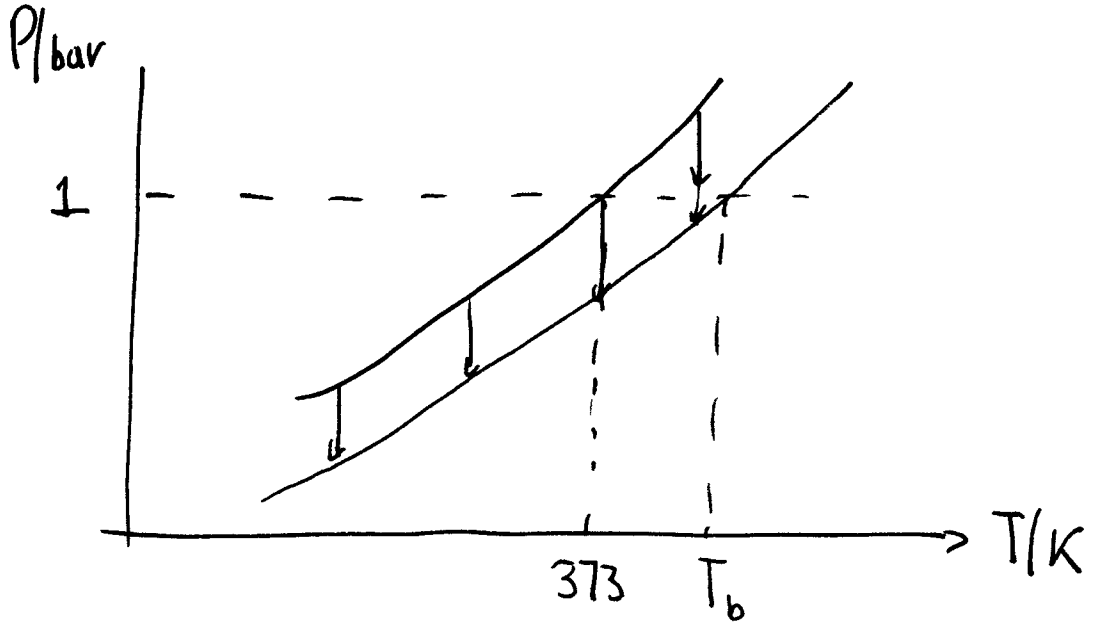
$$\Delta P_i = P_i - P_i^\circ = x_i P_i^\circ - P_i^\circ$$

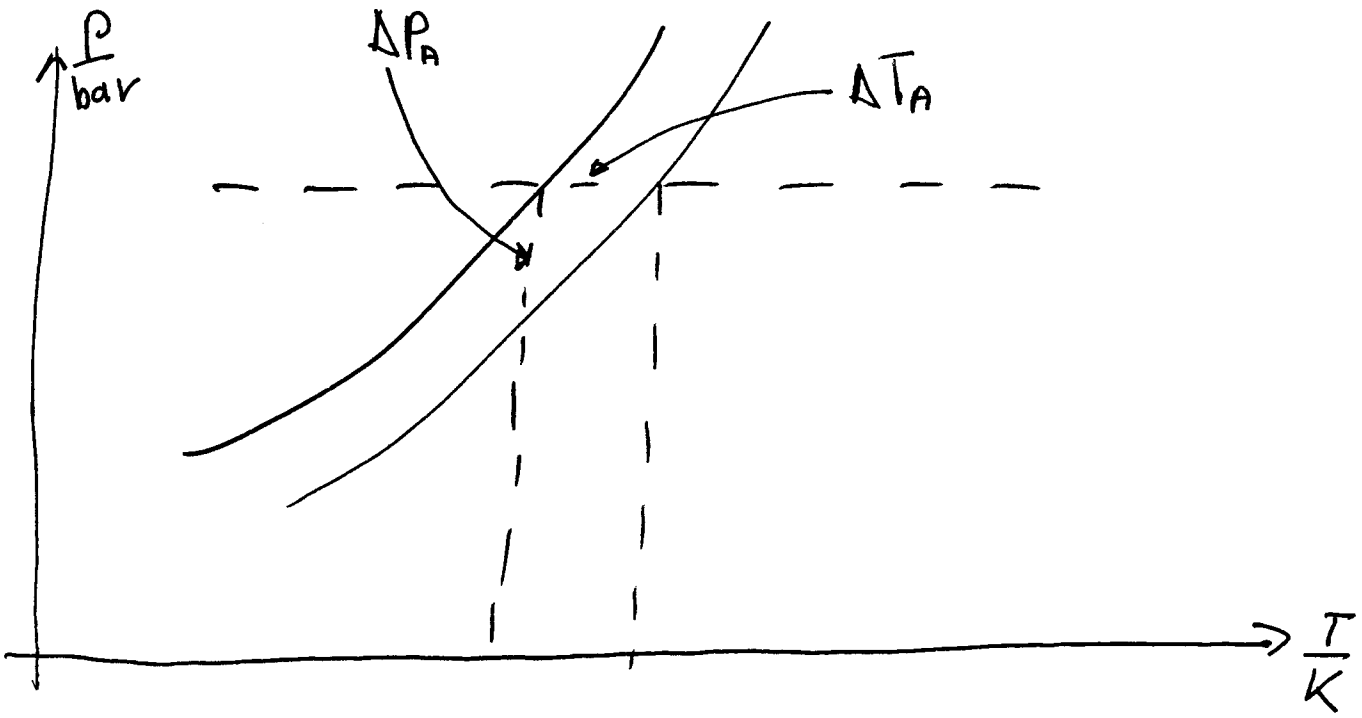
$$= (x_i - 1) P_i^\circ$$

BUT $x_i < 1$

$$\Rightarrow \Delta P_i < 0$$

Boiling-Point Elevation





FOR NON VOLATILE SOLUTES (B)

$$\Delta P_A = (X_A - 1) P_A^o = -(1 - X_A) P_A^o$$

$$\Delta P_A = -X_B P_A^o$$

$$-\frac{\Delta P_A}{\Delta T_A} = S$$

$$\Delta T_A = -\frac{1}{S} \Delta P_A = \frac{X_B}{S} \qquad P_A^o = 1 \text{ bar}$$

$$\Delta T_A = \frac{n_B}{n_A + n_B} \left(\frac{1}{S}\right)$$

$K_b = 0.512\ K\ kg\ mol^{-1}$ FOR WATER

$\Delta T_A = 2\ K$

$$[B] = \frac{2\ K \quad mol}{0.512\ K\ kg} \simeq 4\ \frac{mol}{kg}$$

IN THE CASE OF NaCl AND WATER

A 4 molal solution WILL RAISE THE BOILING TEMPERATURE BY 2 K

THUS WE NEED $4(58.44\ g\ mol^{-1})$ OF NaCl DISSOLVED IN 1 LITER OF WATER !

233.76 g per liter !

$$\Delta T_A = \frac{n_B}{n_A}\left(\frac{1}{S}\right) \qquad n_A >> n_B$$

$$= \frac{\frac{m_B}{M_B}}{\frac{m_A}{M_A}}\left(\frac{1}{S}\right)$$

$$= \frac{m_B / M_B}{(m_A / 1000\,g\,kg^{-1})}\left(\frac{M_A}{S\,(1000\,g\,kg^{-1})}\right)$$

$$\boxed{\Delta T_A = [B]\,K_b}$$

$[B]$ IS THE MOLALITY OF THE SOLUTION

OSMOTIC PRESSURE

$$\Pi = C R T$$

Π easy to MEASURE