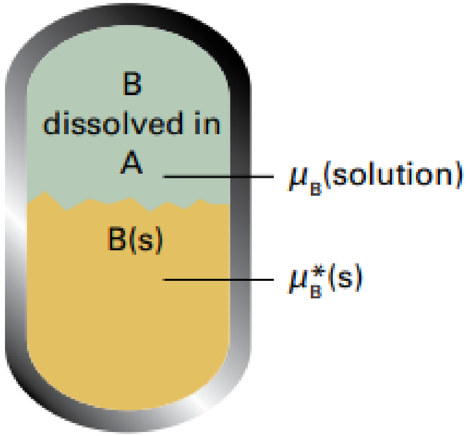
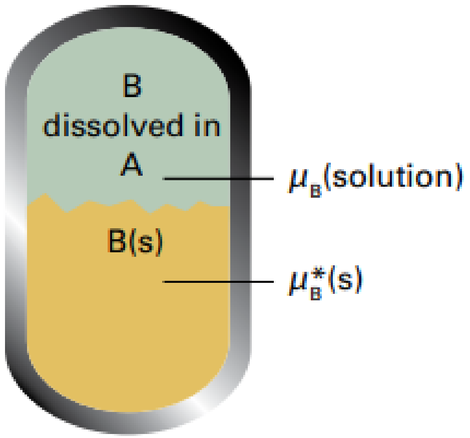
Solubility

Although solubility is not a colligative property—since it depends on the identity of the solute—it can sometimes be estimated using similar principles.



Solubility - Not a Colligative property

$$\mu_B^*(s) = \mu_B^*(l) + RT\ln x_B$$



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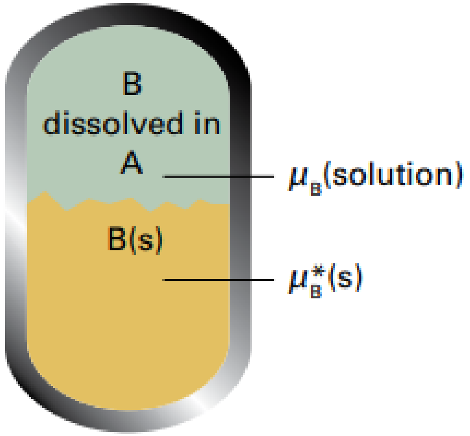

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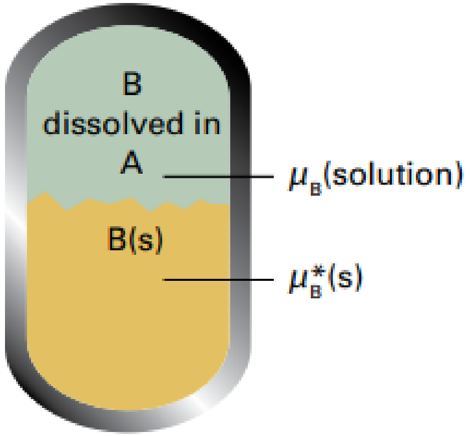
$$\ln x_B = \frac{\Delta_{fus} H}{R}\left(\frac{1}{T_f} - \frac{1}{T}\right)$$

Ideal solubility

Solubility - Not a Colligative property



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Solubility of a solid solute B in a liquid solvent A (assuming ideal solution behavior)

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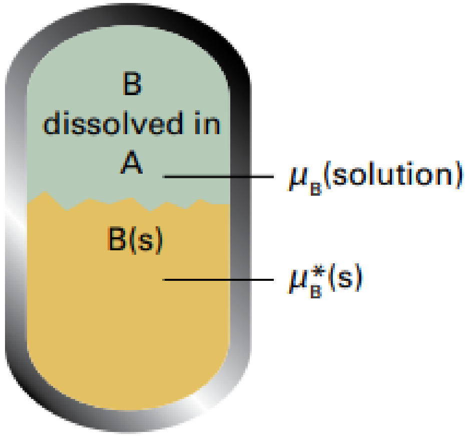

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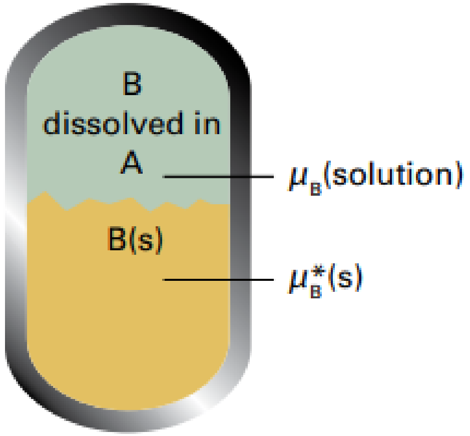
Ideal solubility

Solubility of a solid solute B in a liquid solvent A
(assuming ideal solution behavior)

Can not predict different solubilities in different solvents
(no solvent properties in the equation)

Solubility - Not a Colligative property



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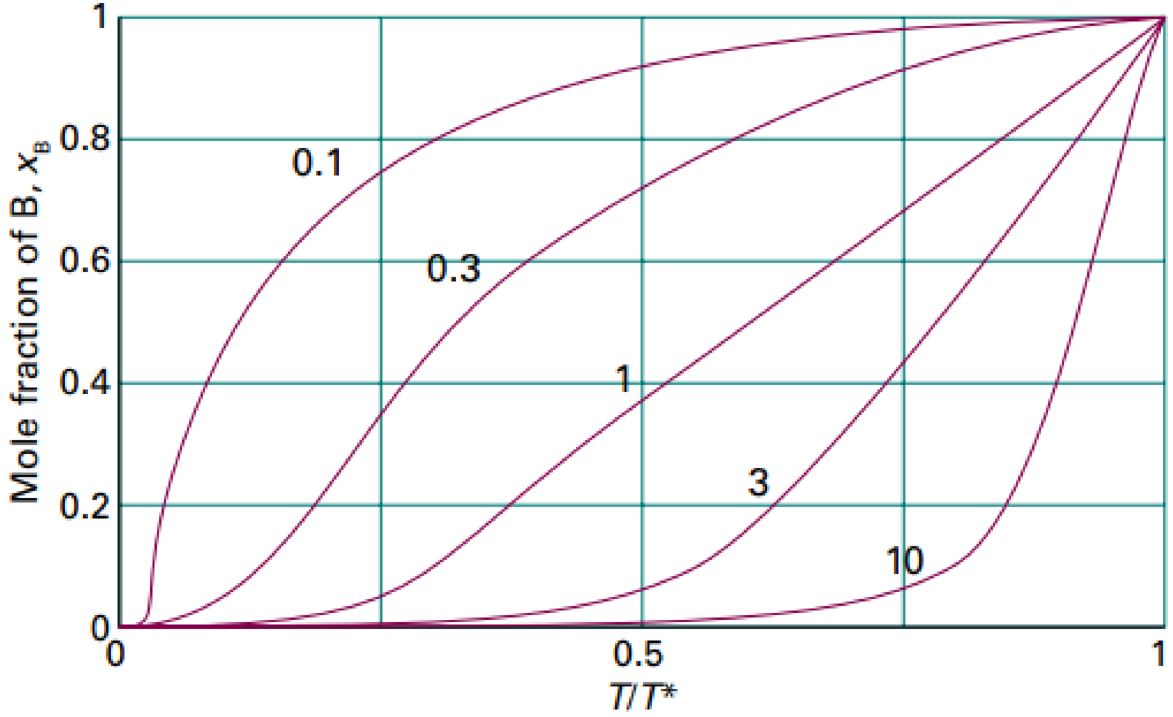
Ideal solubility

Individual curves are labelled with the value of $\Delta_{fus}H/RT^*$.



T^* is the freezing temperature of the solute.

Solubility

Calculate the ideal solubility of naphthalene in benzene at 20 °C by noting that the enthalpy of fusion of naphthalene is 18.80 $kJmol^{-1}$ and its melting point is 354 K.

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$$\ln x_{\mathrm{naphthalene}} = \frac{1.880\times10^{4}\,\mathrm{J\,mol^{-1}}}{8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}}}\left(\frac{1}{354\mathrm{K}} - \frac{1}{293\mathrm{K}}\right) = -1.32\ldots$$

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molality ?

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molality $4.5\,\mathrm{mol\,kg^{-1}}$

Osmosis

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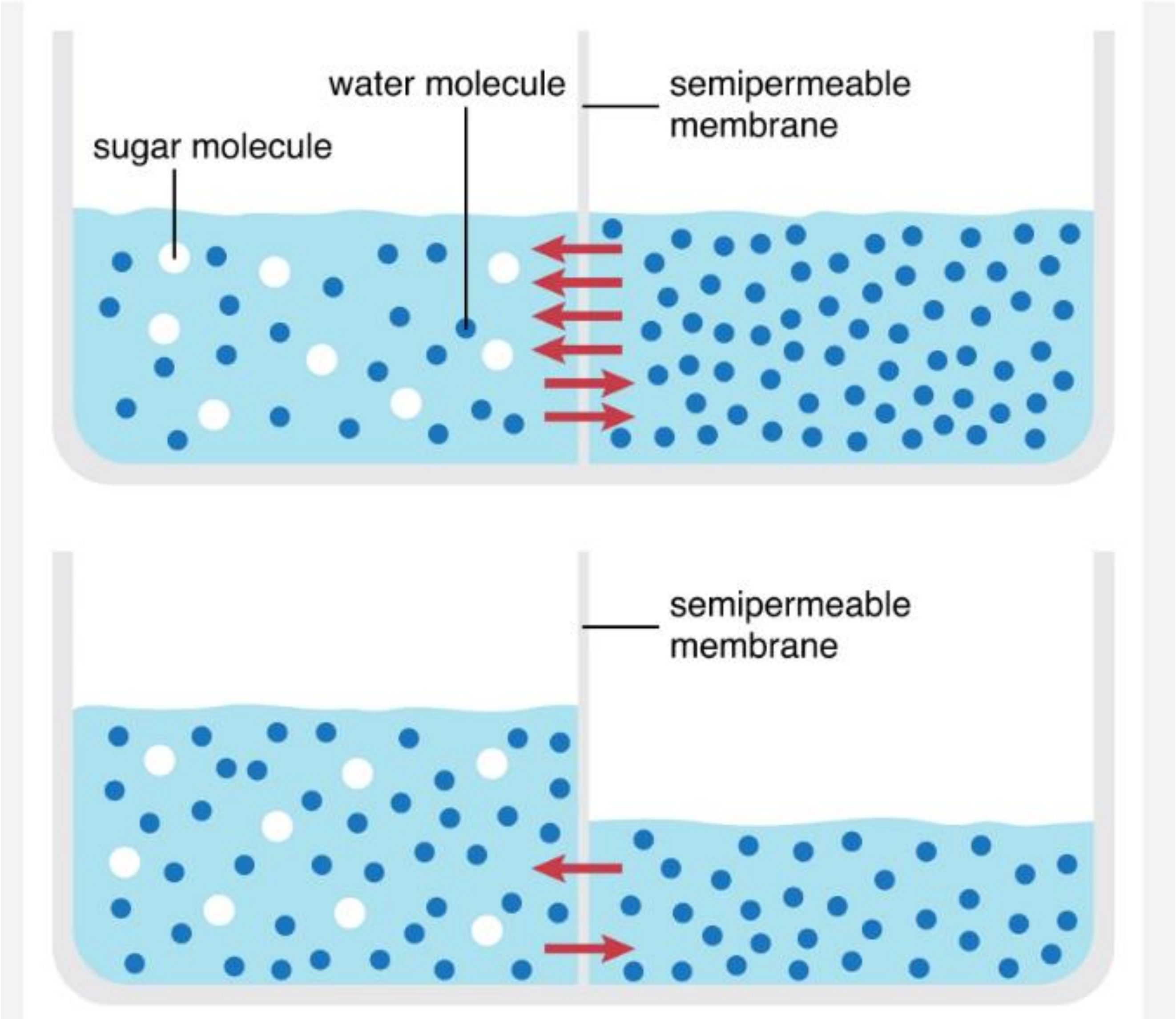
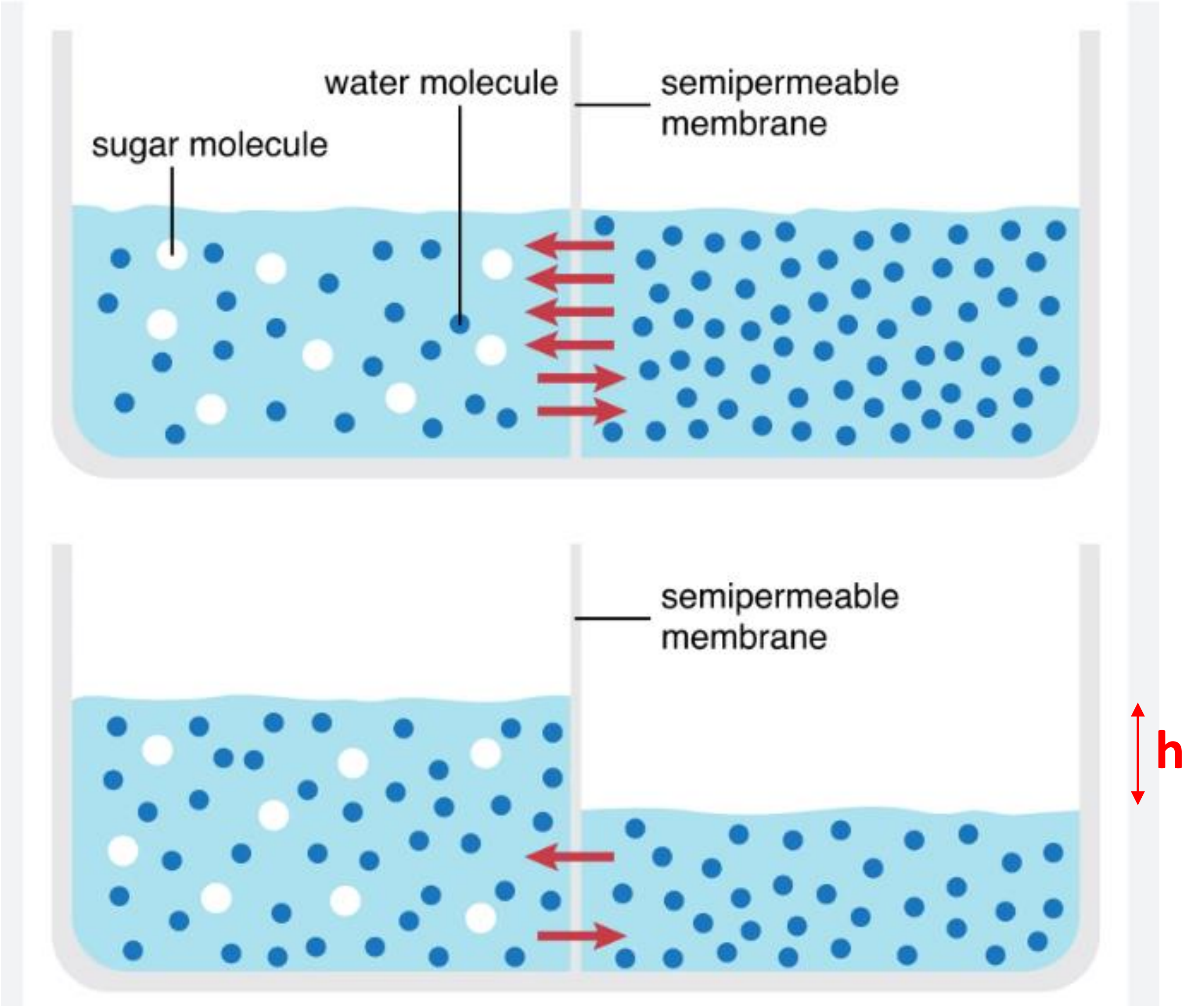


Osmosis is the movement of a solvent (usually water) across a semipermeable membrane from a region of lower solute concentration to a region of higher solute concentration.

Osmosis

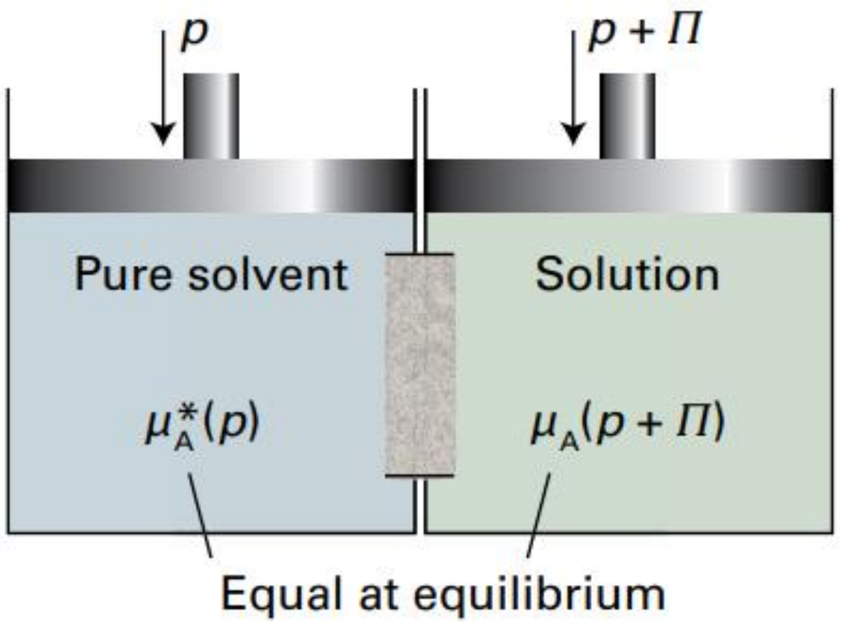


osmotic pressure, Π

The pressure that must be applied to the solution to stop the influx of solvent

Osmosis

$$\mu_A^*(p) = \mu_A(x_A, p + \Pi)$$



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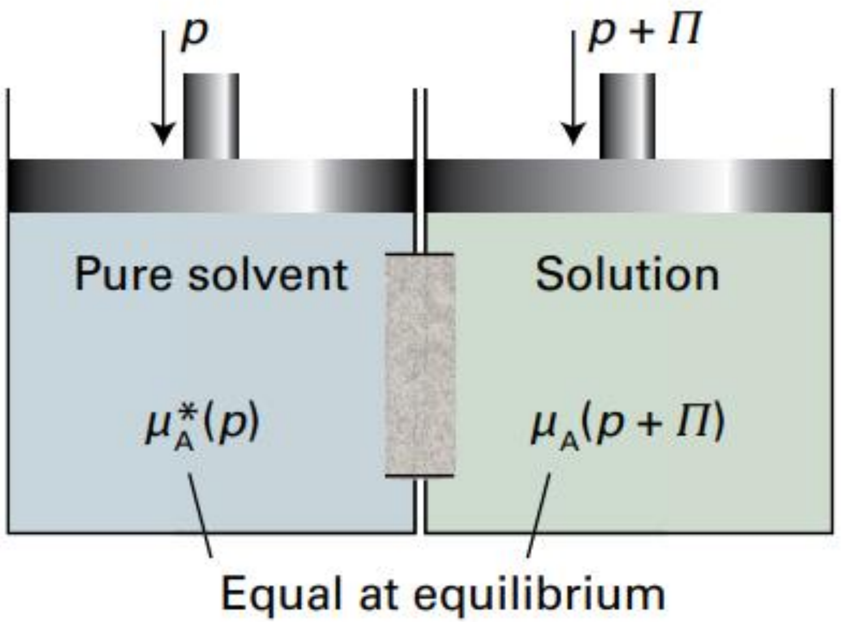

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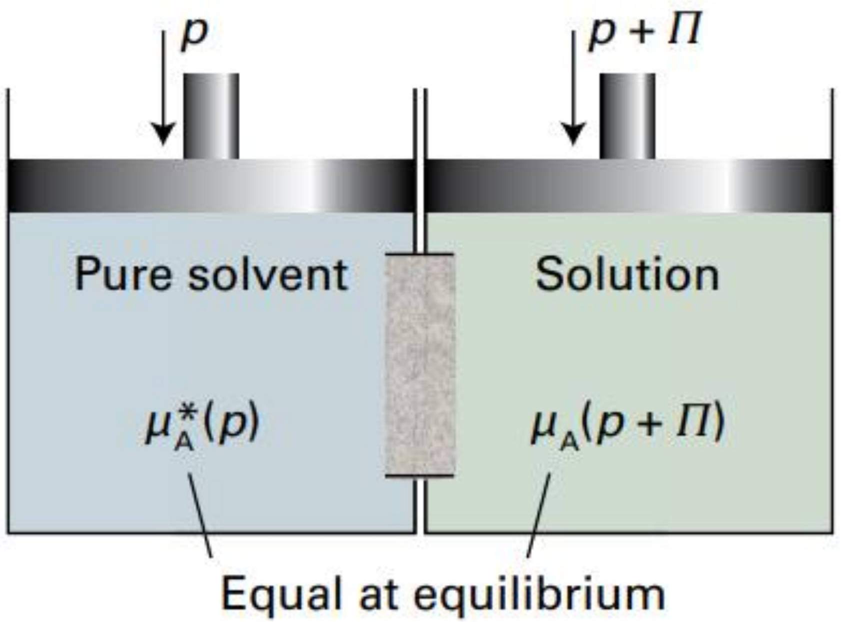

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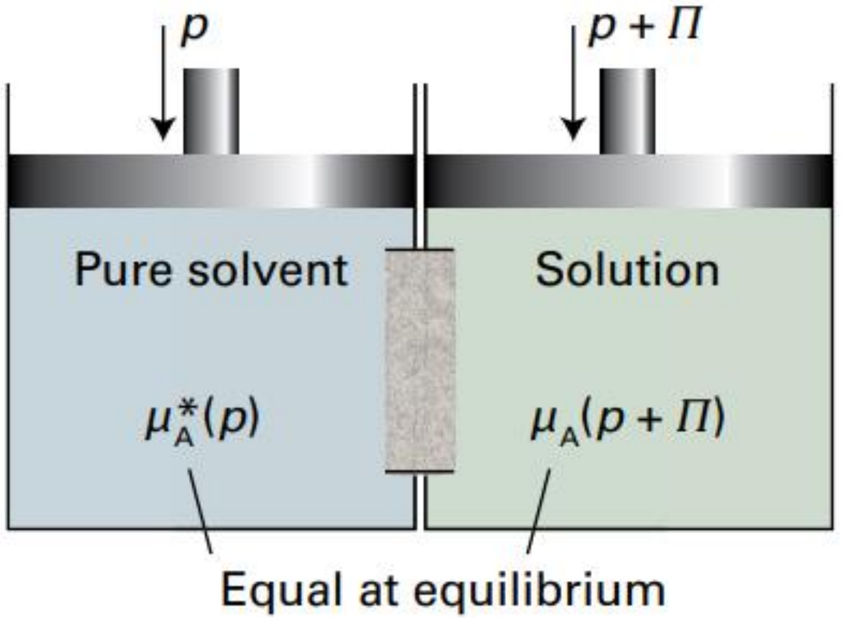

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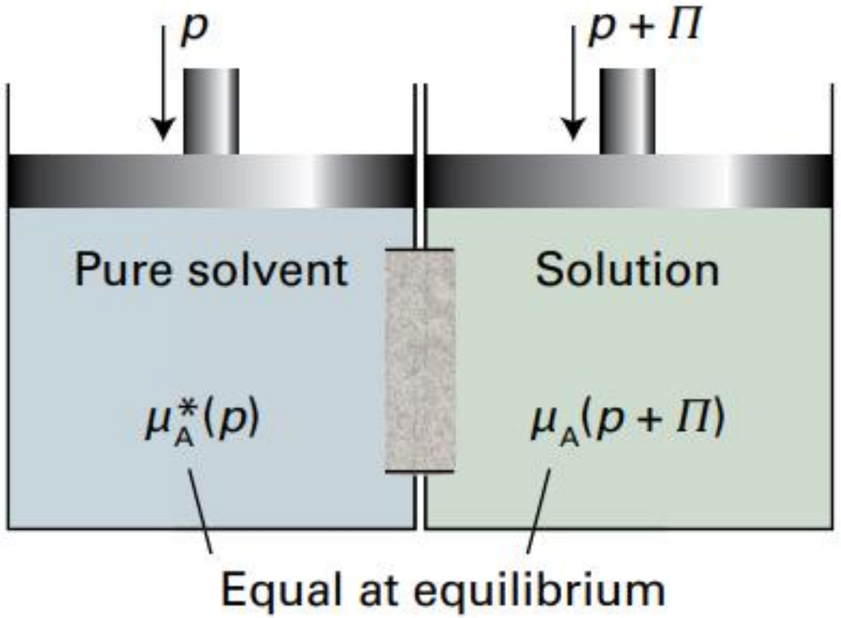
effect of pressure on the chemical potential,

$$G_m(p_f) = G_m(p_i) + \int_{p_i}^{p_f} V_m \, dp$$



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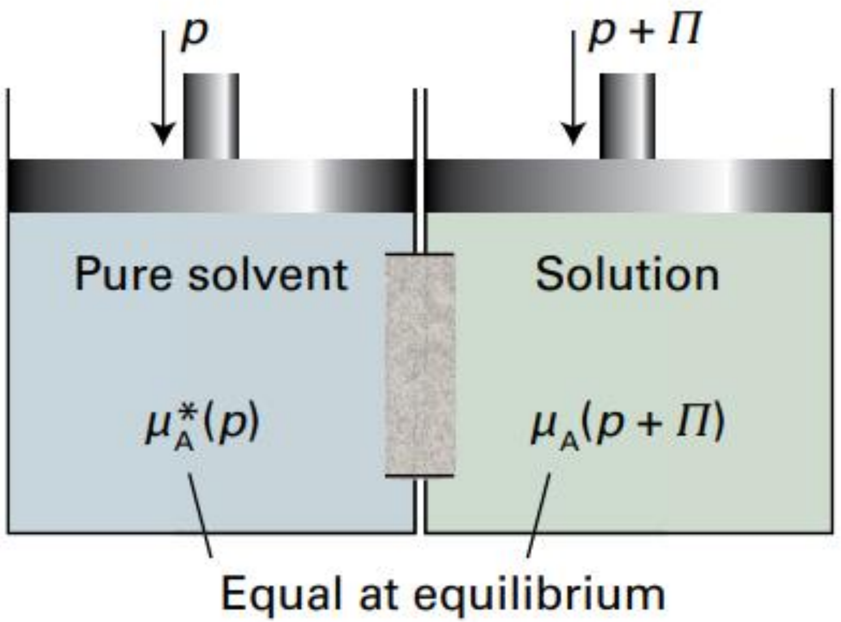

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$RTn_B \approx \Pi V$ n_B/V is the molar concentration, [B], of the solute B

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$\Pi = [B]RT$ **van 't Hoff equation**

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concentration of solute

Assumes ideal behavior of solute particles in solution

Osmotic pressure

LAW - Don't Drink the Sea, Matey!

After being stranded on a desert island, Pirate Salty Sam gets excited when he finds plenty of sea water and starts chugging it like it's coconut juice. A few hours later, he's more dehydrated than before, his parrot is concerned, and he's starting to hallucinate a talking sea cucumber.

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Using your knowledge of osmosis, explain:

1. What happened to Salty Sam's cells after drinking sea water?
2. Why didn't drinking all that water actually help?
3. What should he have done instead (besides not becoming a pirate)?

Osmotic virial expansion

An extension of the ideal osmotic pressure equation

$$\Pi = \Pi_{\text{ideal}} + B_2 c + B_3 c^2 + B_4 c^3 + \ldots$$

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Osmotic virial expansion

An extension of the ideal osmotic pressure equation

$$\Pi = \Pi_{\text{ideal}} + B_2 c + B_3 c^2 + B_4 c^3 + \ldots$$

osmotic pressure predicted by the ideal solution model

c = concentration of solute particles

B_2,B_3, B_4,… are the second, third, fourth, etc., osmotic virial coefficients

Focus 5: Simple mixtures

TD description of mixtures

Properties of solutions

Phase diagrams of binary systems

Phase diagrams of ternary systems

Thermodynamic activity

Vapor pressure diagrams – Binary Mixtures of Liquids

Raoult's law $p_A = x_A p_A^*$ $p_B = x_B p_B^*$

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At some fixed temperature

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Vapor pressure diagrams - Binary Mixtures of Liquids

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$x_B = 1 - x_A$

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Vapor pressure diagrams

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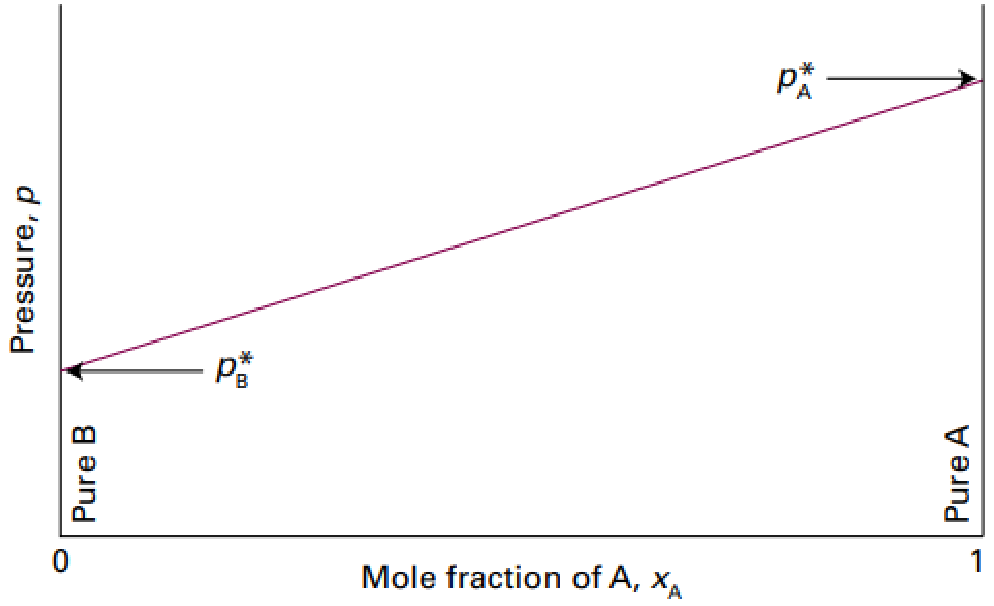

Total Vapor Pressure vs X_A

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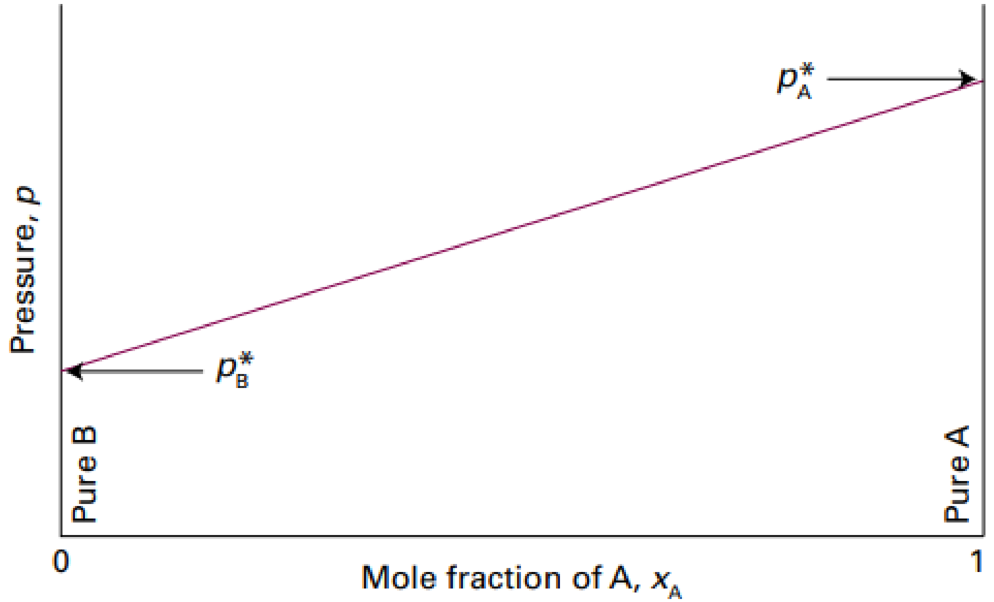

Composition of vapour

$$y_A = \frac{p_A}{p} \qquad y_B = \frac{p_B}{p}$$

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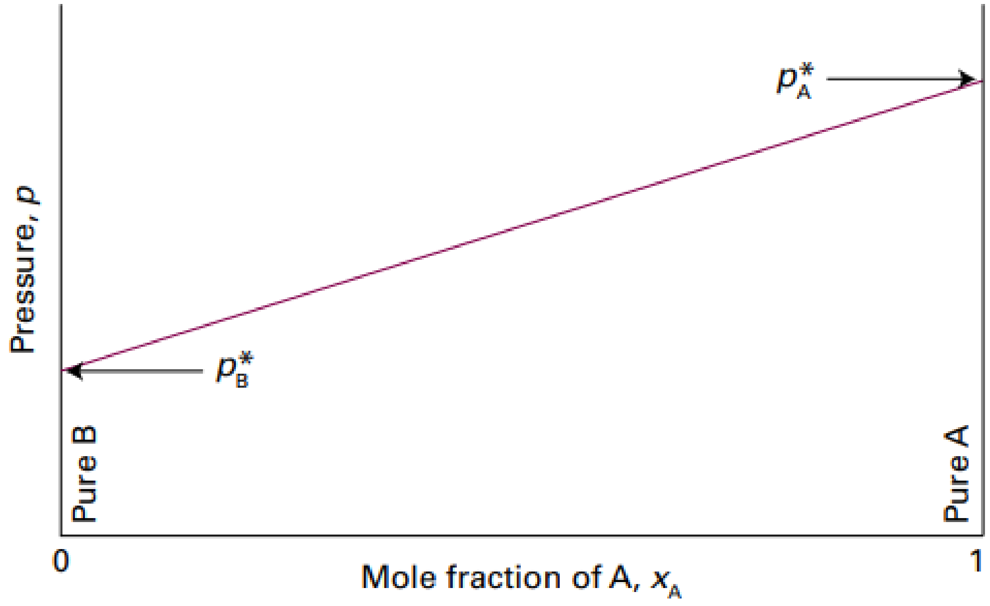

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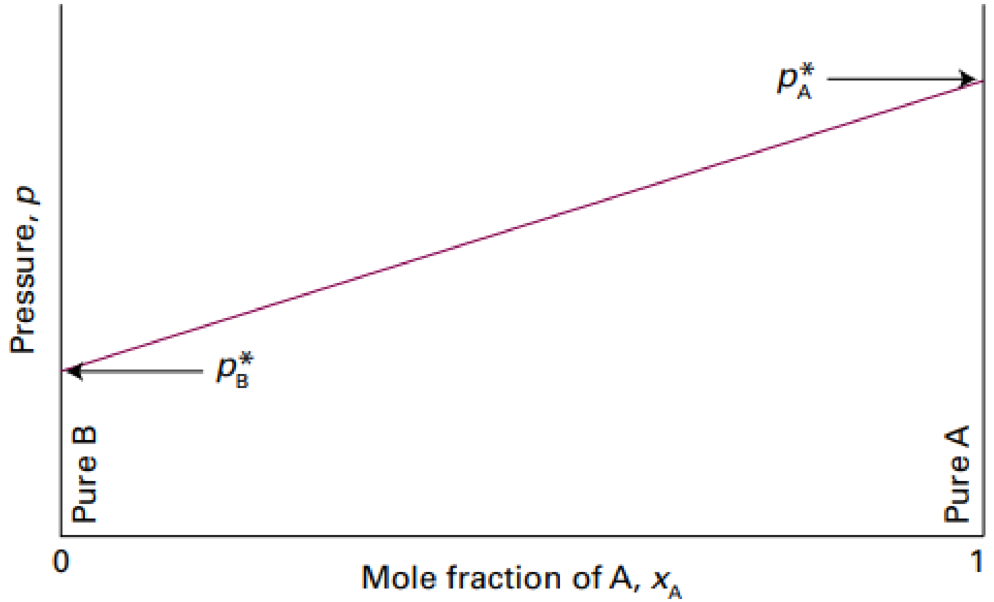

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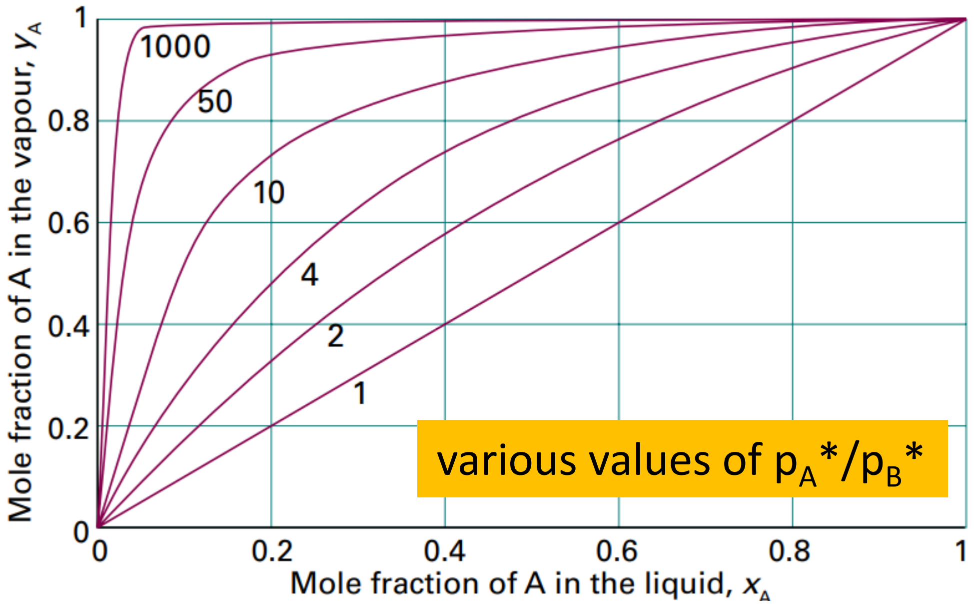

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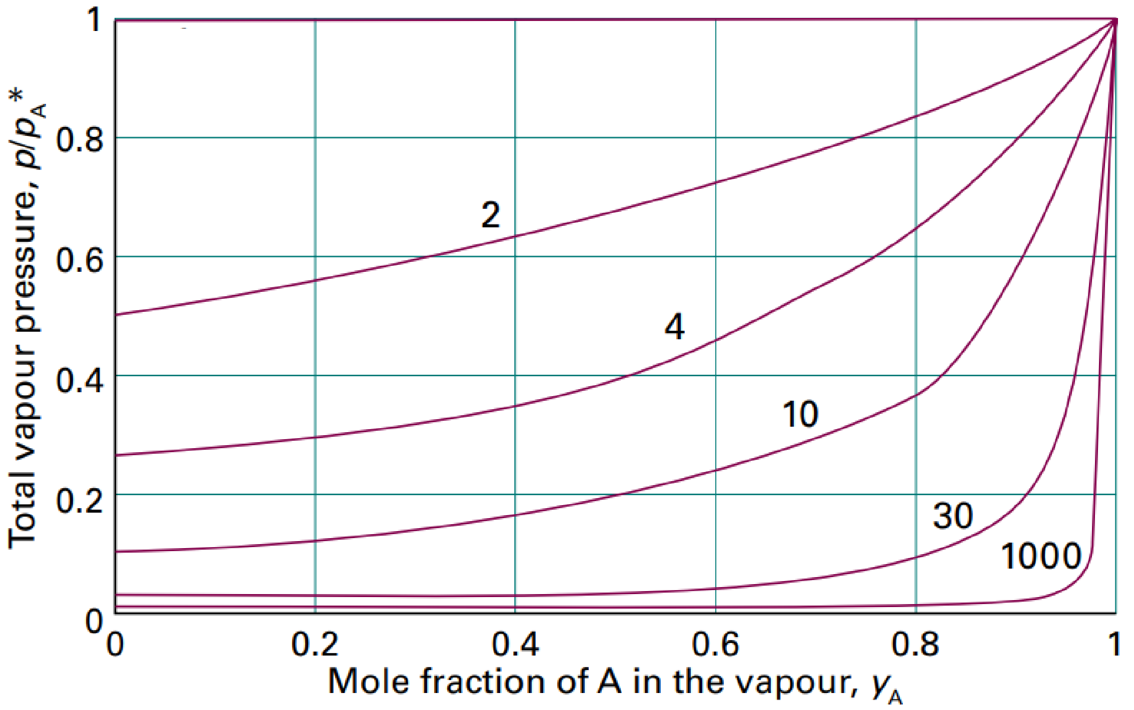
$$p = \frac{p_A^* p_B^*}{p_A^* + (p_B^* - p_A^*)y_A}$$

Total Vapor Pressure vs Y_A

$$p = p_B^* + (p_A^* - p_B^*)x_A$$

$$y_A = \frac{x_A p_A^*}{p_B^* + (p_A^* - p_B^*)x_A}$$

$$p = \frac{p_A^* p_B^*}{p_A^* + (p_B^* - p_A^*)y_A}$$



Individual curves are labeled with the value of p_A^*/p_B^*