The chemical potentials of liquids

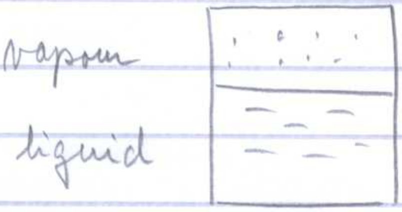
Ideal solutions,

$*$; signifies a pure substance, so
$\mu_A^*(l)$; is the chemical potential of a pure liquid A.

the vapour pressure of A; p_A^*

the chemicals potentials are equal:

$$\mu_A^*(l) = \mu_A^*(v) = \mu_A^\circ + RT \ln(p_A^*/p^\circ)$$



When a solute is also present in the liquid

$$\mu_A(l) = \mu_A(v) = \mu_A^\circ + RT \ln(p_A/p^\circ)$$

Combined:

$$\mu_A(l) = \left(\mu_A^*(l) - RT \ln(p_A^*/p^\circ)\right) + RT \ln(p_A/p^\circ)$$

$$= \mu_A^*(l) + RT \ln(p_A/p_A^*)$$

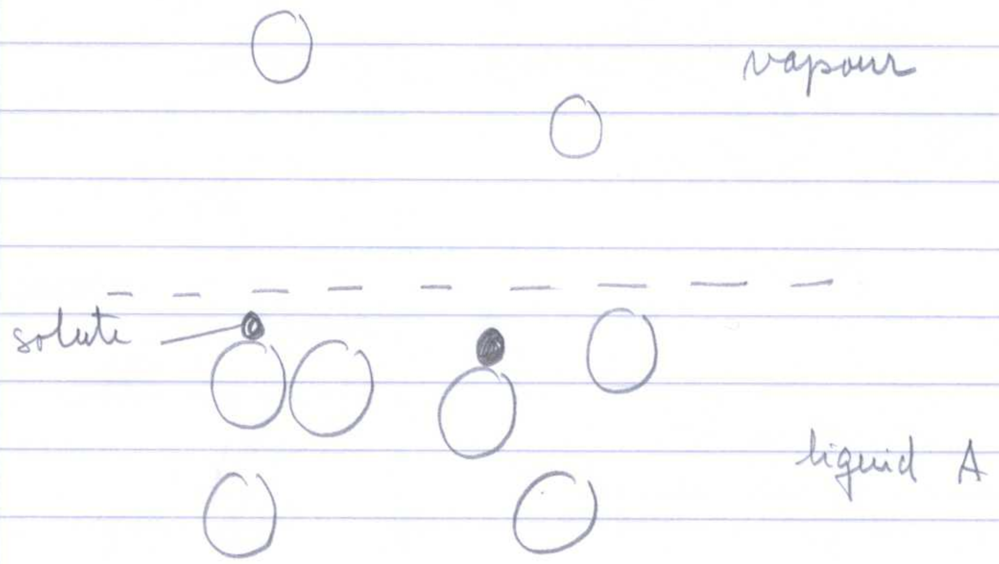
Francois Raoult found:

$$p_A = x_A \cdot p_A^*;$$

the ratio of the partial vapour pressure to the vapour pressure of a pure liquid, is equal to the mole fraction.

$$\Rightarrow \mu_A(l) = \mu_A^*(l) + RT \ln x_A$$

Molecular interpretation / derivation



Rate of molecules leaving the surface:
(rate of vaporization)

$$R_V = k \cdot x_A$$

x_A; mole fraction of solvent

Rate at which molecules condense
~ (proportional) to concentration in gas phase

$$R_C = k' \cdot p_A$$

at equilibrium: $k' \cdot p_A = k \cdot x_A$

$$\Rightarrow p_A = \frac{k}{k'} \cdot x_A$$

for a pure liquid, $x_A = 1 \Rightarrow p_A^* = k/k'$