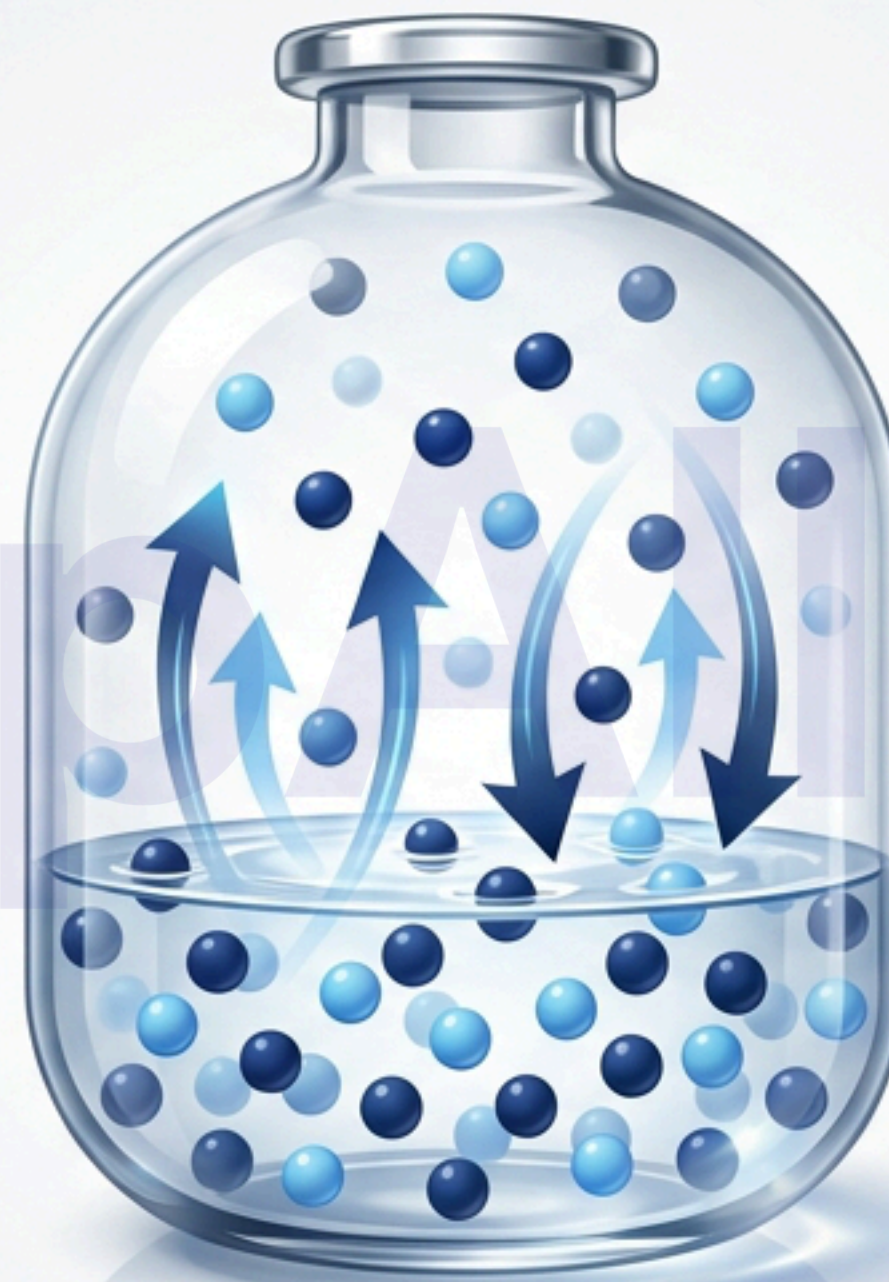


CLASS 12 CHEMISTRY • SOLUTIONS

Vapour Pressure of Liquid-Liquid Solutions

A visual guide to Raoult's Law, Dalton's Law, and ideal binary mixtures.



Raoult's Law for Component 1

In a solution of volatile liquids, the partial vapour pressure of each component is directly proportional to its mole fraction.

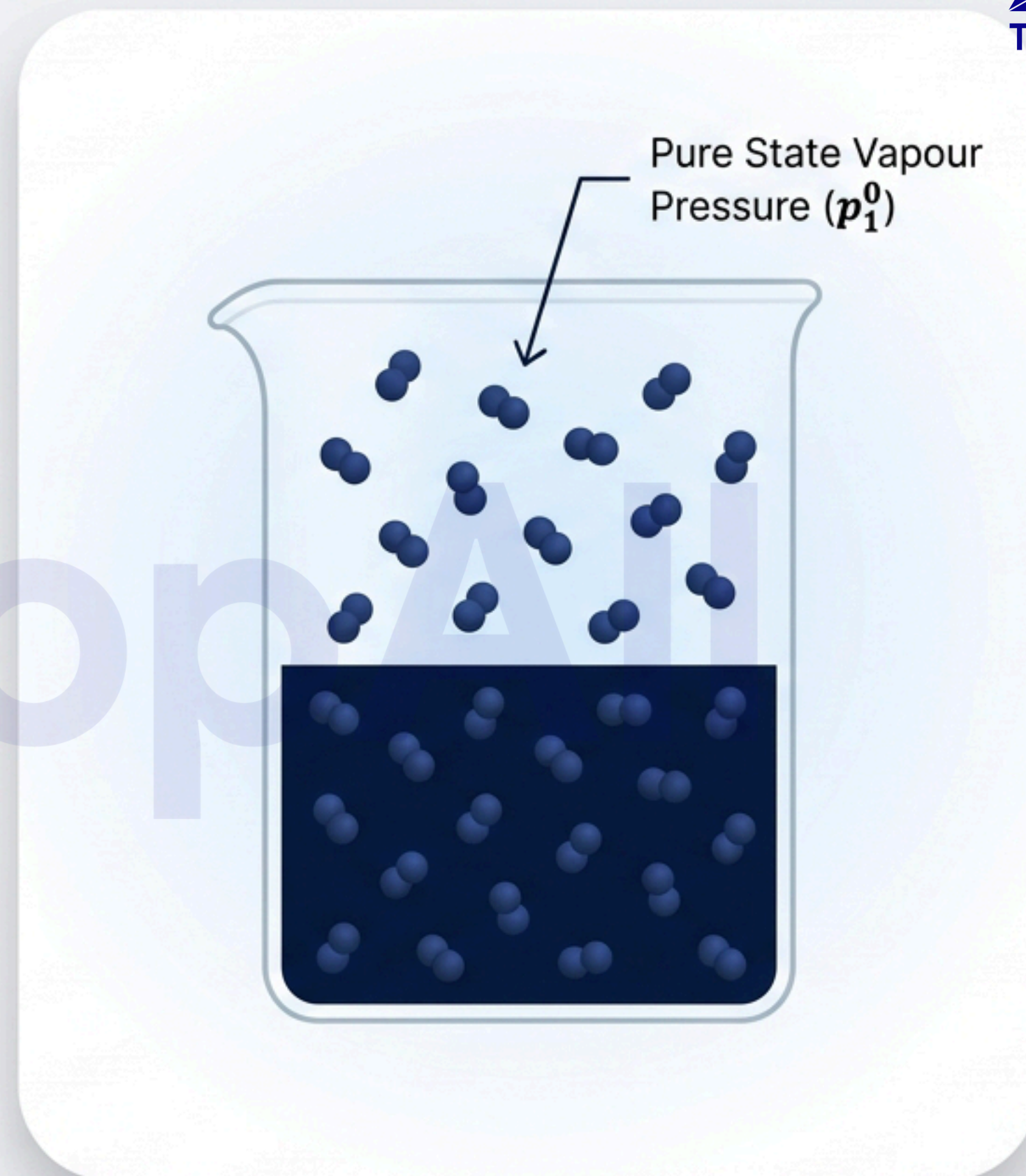
$$p_1 \propto x_1$$

$$p_1 = p_1^0 \cdot x_1$$

p_1 Partial vapour pressure in solution

p_1^0 Vapour pressure of pure component 1

x_1 Mole fraction in liquid phase



Raoult's Law for Component 2

The identical principle applies to the second volatile liquid in the binary mixture, contributing its own partial pressure to the system.

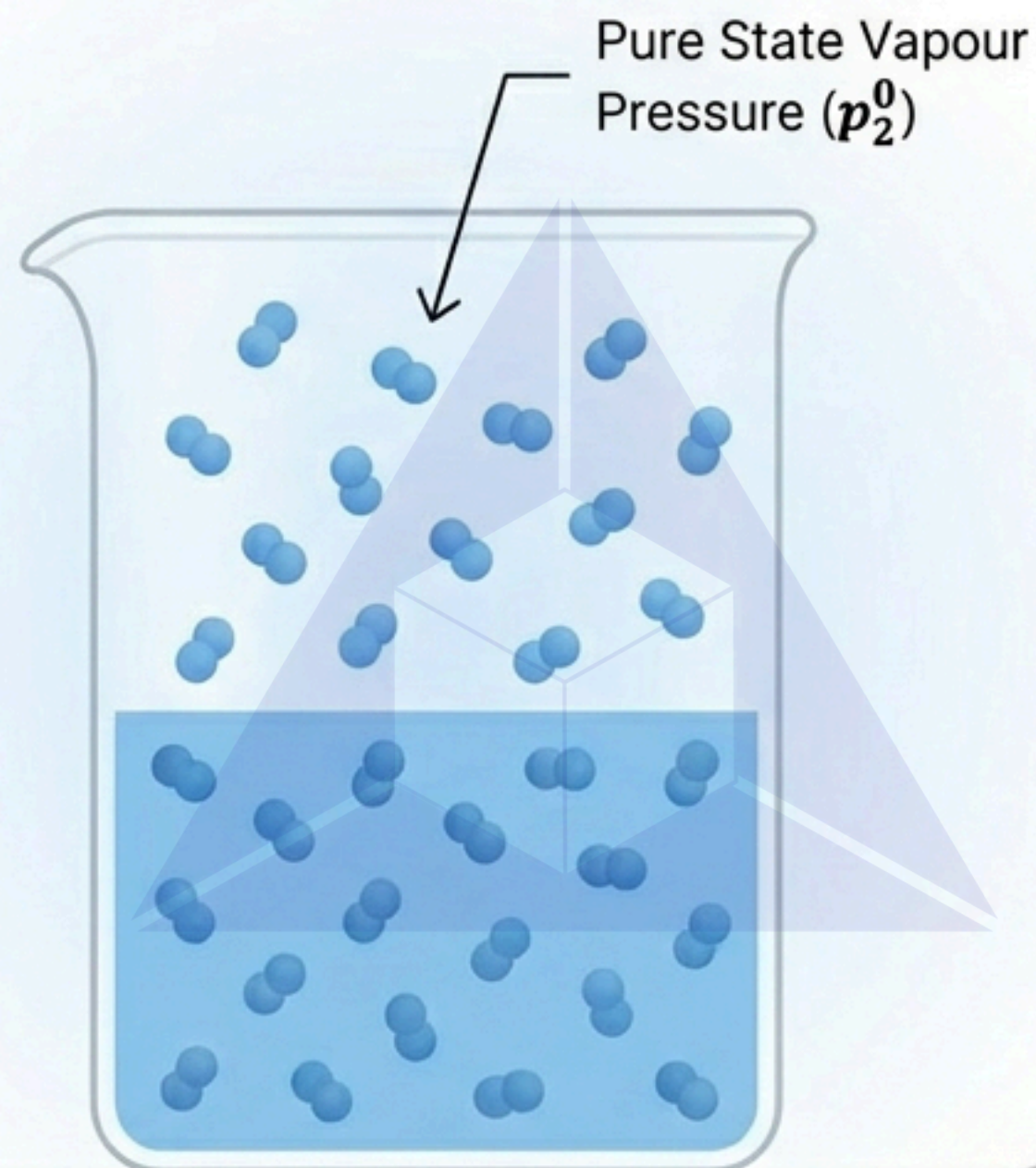
$$p_2 = p_2^0 \cdot x_2$$

p_2 Partial vapour pressure of component 2

p_2^0 Vapour pressure of pure component 2

x_2 Mole fraction in liquid phase

Both components evaporate simultaneously, establishing a shared equilibrium between the liquid and vapour phases.





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Dalton's Law & Total Vapour Pressure

Dalton's law dictates that the total pressure over the solution phase is the sum of individual partial pressures.

The Premise

$$p_{total} = p_1 + p_2$$

Substitute Raoult's Law

$$p_{total} = (x_1 \cdot p_1^0) + (x_2 \cdot p_2^0)$$

Apply Binary Rule $x_1 = 1 - x_2$

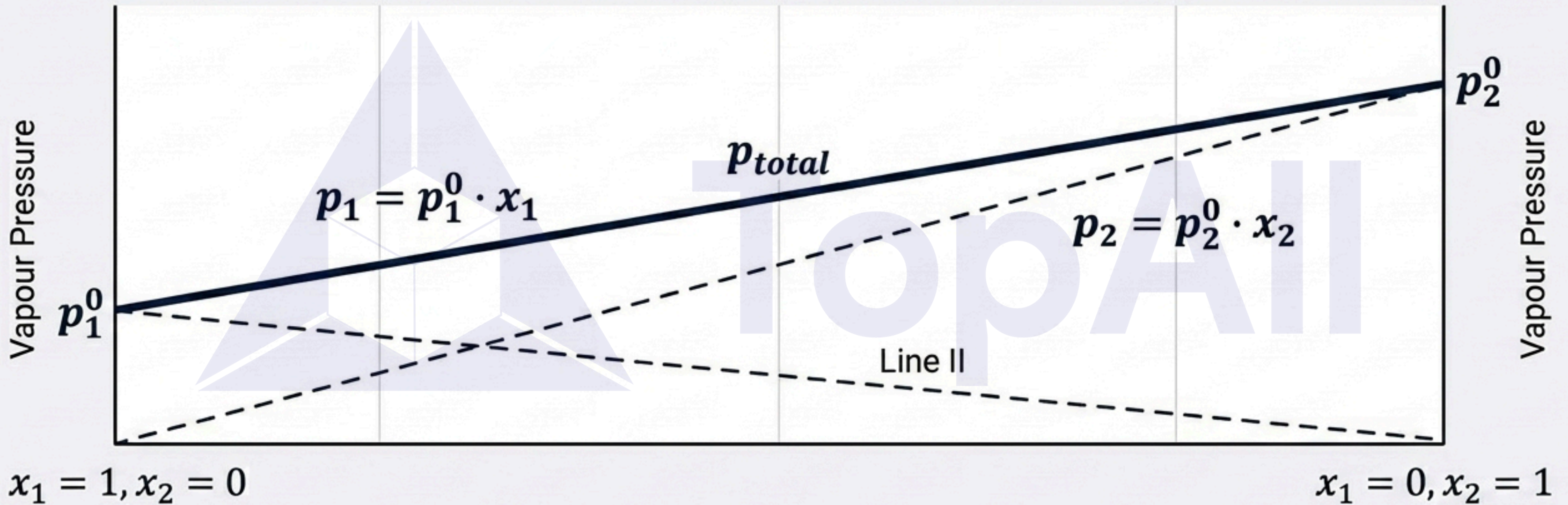
$$p_{total} = (1 - x_2)p_1^0 + x_2p_2^0$$

Hero Formula Card

$$p_{total} = p_1^0 + (p_2^0 - p_1^0)x_2$$

Notice the transformation: Total vapour pressure can now be calculated using the mole fraction of just ONE component (x_2).

Linear Variation of Vapour Pressure



Key-Takeaway

Total vapour pressure varies linearly with the mole fraction of component 2. The minimum value is p_1^0 and the maximum is p_2^0 .

Vapour Phase Mole Fractions (y)

Liquid Phase

x_1 and x_2

Controlled physically by the amount of each liquid mixed in the vessel.

Vapour Phase

y_1 and y_2

Controlled thermodynamically by Dalton's Law and respective volatilities.

$$p_i = y_i \cdot p_{total} \Rightarrow y_i = p_i / p_{total}$$

Insight Chip

At equilibrium, the vapour phase is always richer in the component which is more volatile.
If $p_2^0 > p_1^0$, then $y_2 > x_2$.

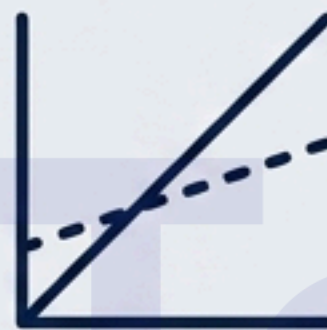
The Blueprint of Liquid-Liquid Solutions



The Principle

Raoult's Law dictates that partial pressure scales with liquid mole fraction.

$$p_i = p_i^0 \cdot x_i$$



The Math

Total pressure is a linear combination, simplifiable to a single mole fraction.

$$p_{total} = p_1^0 + (p_2^0 - p_1^0)x_2$$



The Result

Vapour composition shifts. The more volatile liquid dominates the vapour space.

$$y_i = p_i / p_{total}$$



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