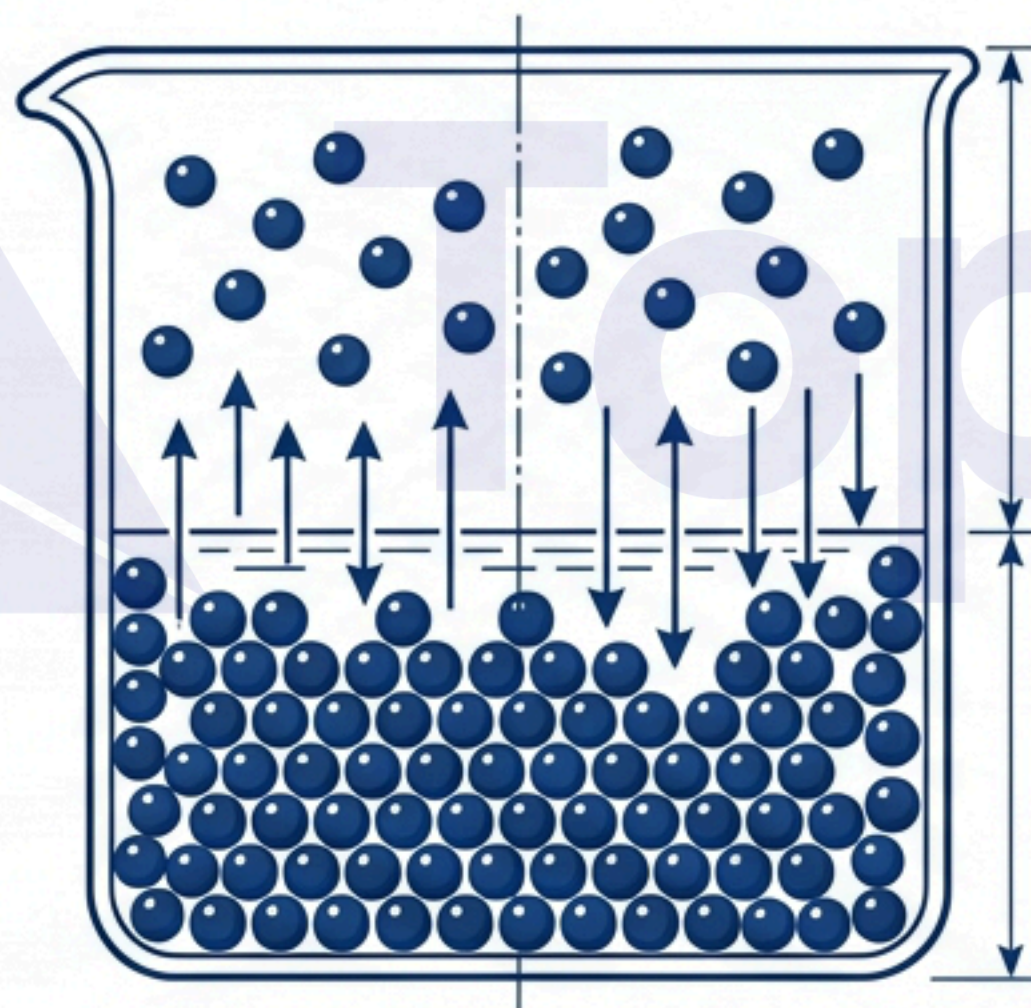


1.4.3 Vapour Pressure of Solutions of Solids in Liquids

Understanding the microscopic mechanisms and mathematical laws governing non-volatile solutes.



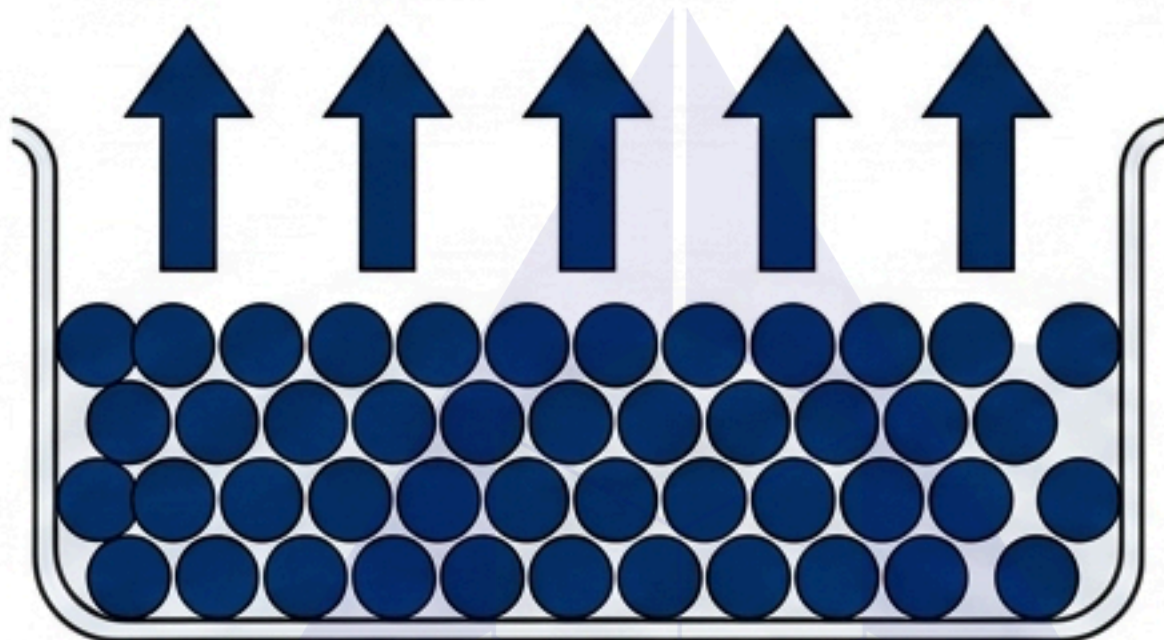
Non-Volatile Solutes

Surface Mechanisms

Raoult's Law

The Surface: Pure Solvent vs. Solution

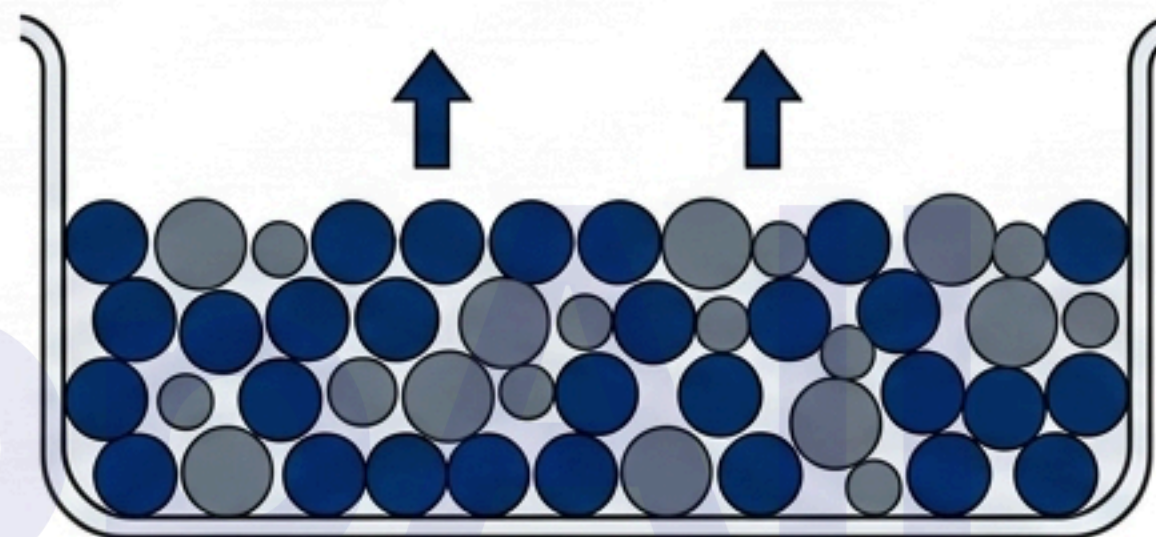
Pure Solvent



p_1^0 (Vapour Pressure of Pure Solvent)

The entire surface area is exclusively occupied by volatile solvent molecules.
Maximum escape tendency.

Solution (Solid in Liquid)



p_1 (Vapour Pressure of Solution)

The surface is shared. Grey solute spheres act as physical roadblocks. Fraction of surface covered by volatile solvent is reduced.

Crucial Note: Only the solvent is volatile. Solutes like sodium chloride, glucose, or urea do not evaporate.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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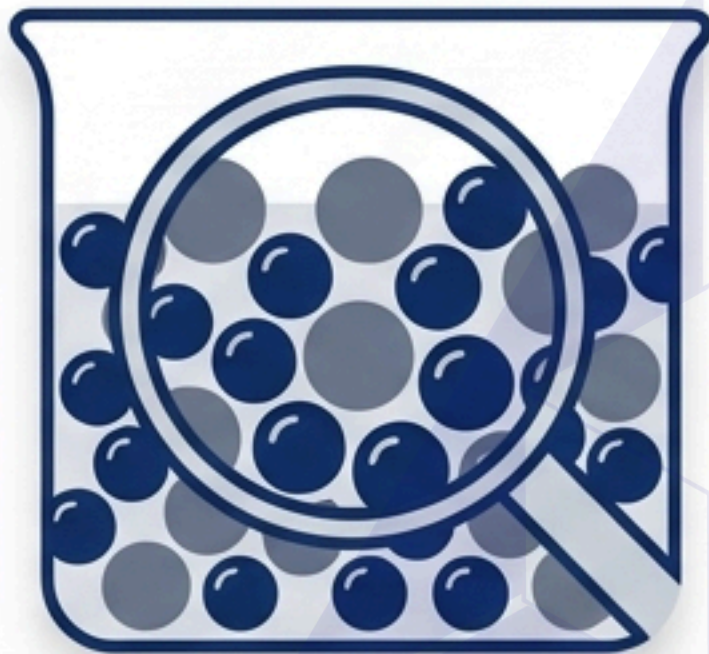
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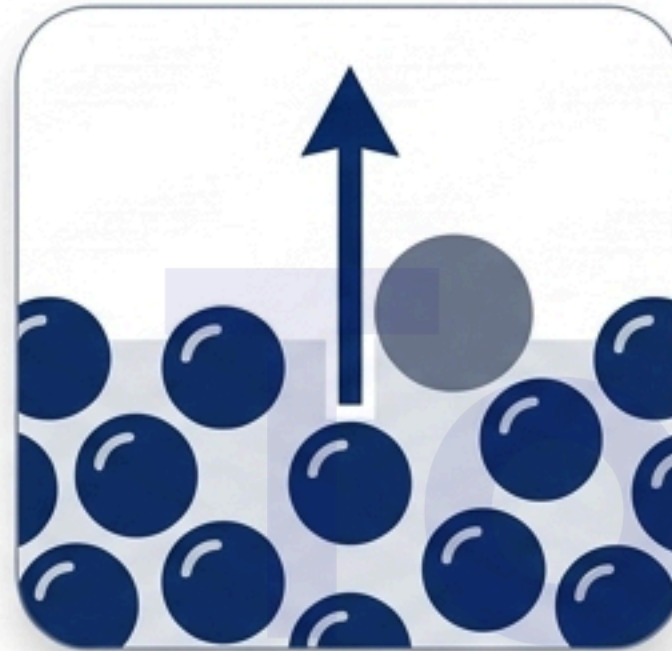
The Mechanism of Pressure Reduction

Step 1: Surface Blockage



When a non-volatile solute (e.g., sugar or salt) is added, its particles occupy physical space at the liquid's surface.

Step 2: Hindered Escape



Because the fraction of surface covered by solvent molecules is smaller, fewer solvent molecules have the opportunity to escape into the vapour phase.

Step 3: Macroscopic Drop



A lower rate of escape results in fewer vapour molecules at equilibrium, causing a measurable drop in the overall vapour pressure.

Key Takeaway: Vapour pressure reduction is a direct physical consequence of reduced solvent surface area.

Quantifying the Drop: Raoult's Law

Raoult's Law for a Volatile Solvent

$$p_1 = x_1 p_1^0$$

p_1 = Partial vapour pressure of solvent in solution

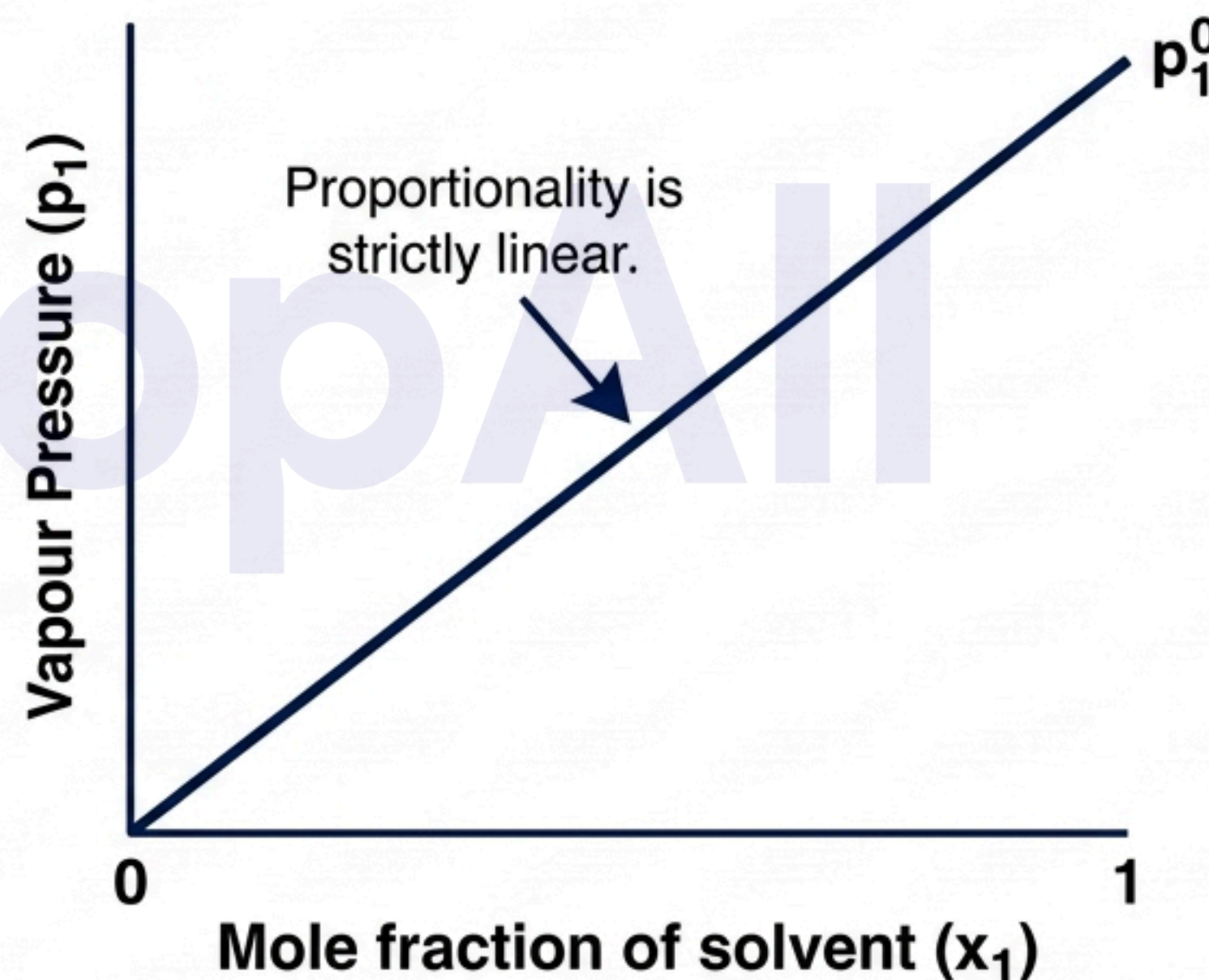
x_1 = Mole fraction of the solvent

p_1^0 = Vapour pressure of pure solvent

p_1^0 = Vapour pressure of pure solvent

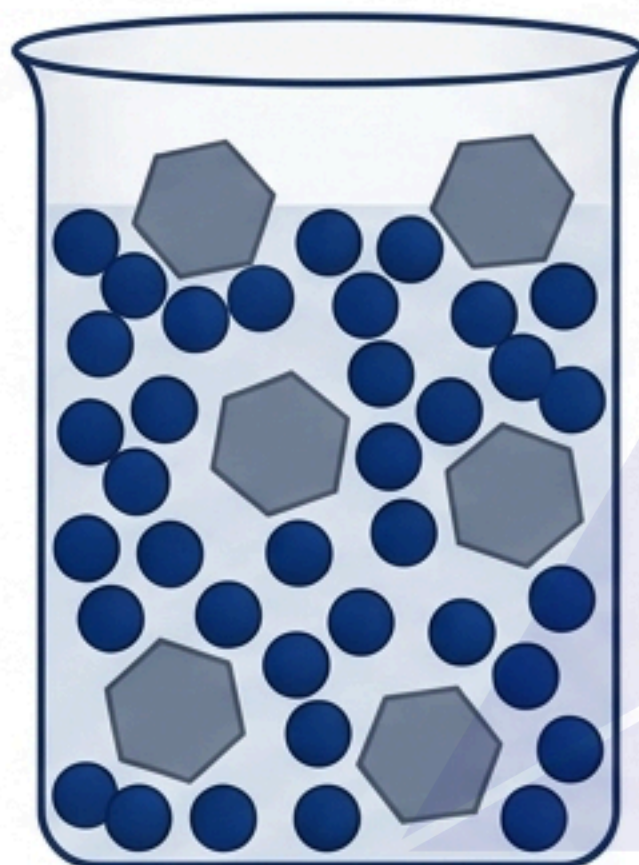
The partial vapour pressure of a volatile component is directly proportional to its mole fraction in the solution.

The Graph Card



Quantity Over Identity

The decrease depends on the number of particles, not their nature.

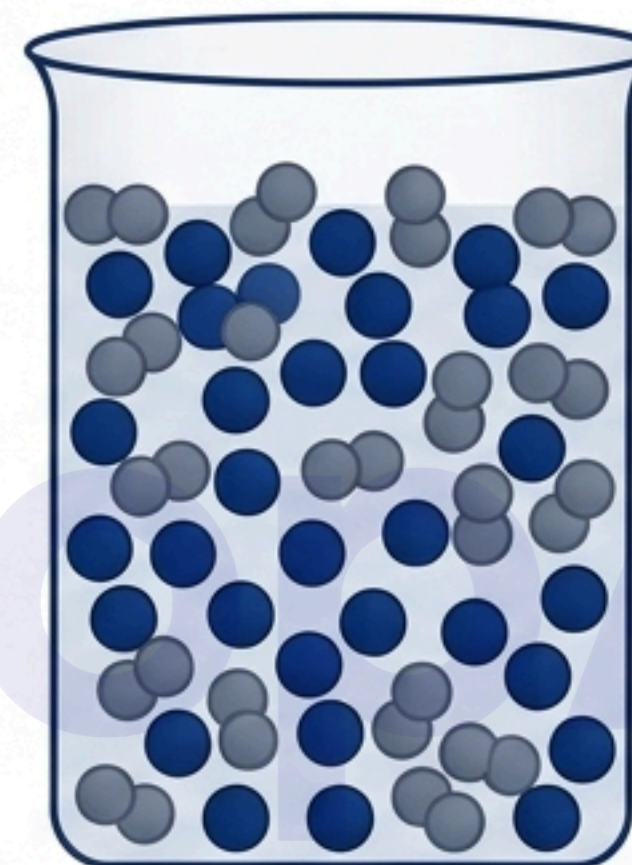


Sucrose Solution

Number of molecules are
1 kg of water

1.0 mol of Sucrose
molecules

Blocks 'X' fraction of
surface



Urea Solution

Number of molecules are
1 kg of water

1.0 mol of Urea
molecules

Blocks exactly the same
'X' fraction of surface

The Result is Identical

Because 1.0 mol of sucrose and 1.0 mol of urea contain the exact same number of particles, they block the exact same amount of surface area. Therefore, the decrease in water's vapour pressure is nearly identical for both.

Foundation of Colligative Properties

Final Recap: The Vapour Pressure Blueprint



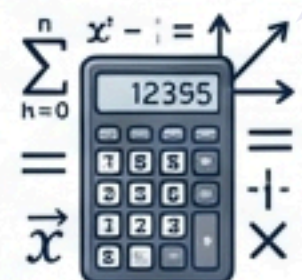
The Microscopic Cause

Non-volatile solutes physically displace solvent molecules at the liquid surface, reducing the escaping tendency.



The Macroscopic Effect

Fewer escaping molecules lead to a lower concentration of vapour at equilibrium, strictly dropping the measured vapour pressure.



The Mathematical Rule

This relationship is perfectly linear and defined by Raoult's Law: $p_1 = x_1 p_1^0$.

Fewer solvent molecules escape, so vapour pressure falls. This principle is universally dependent on the quantity of solute particles, irrespective of their chemical identity.



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