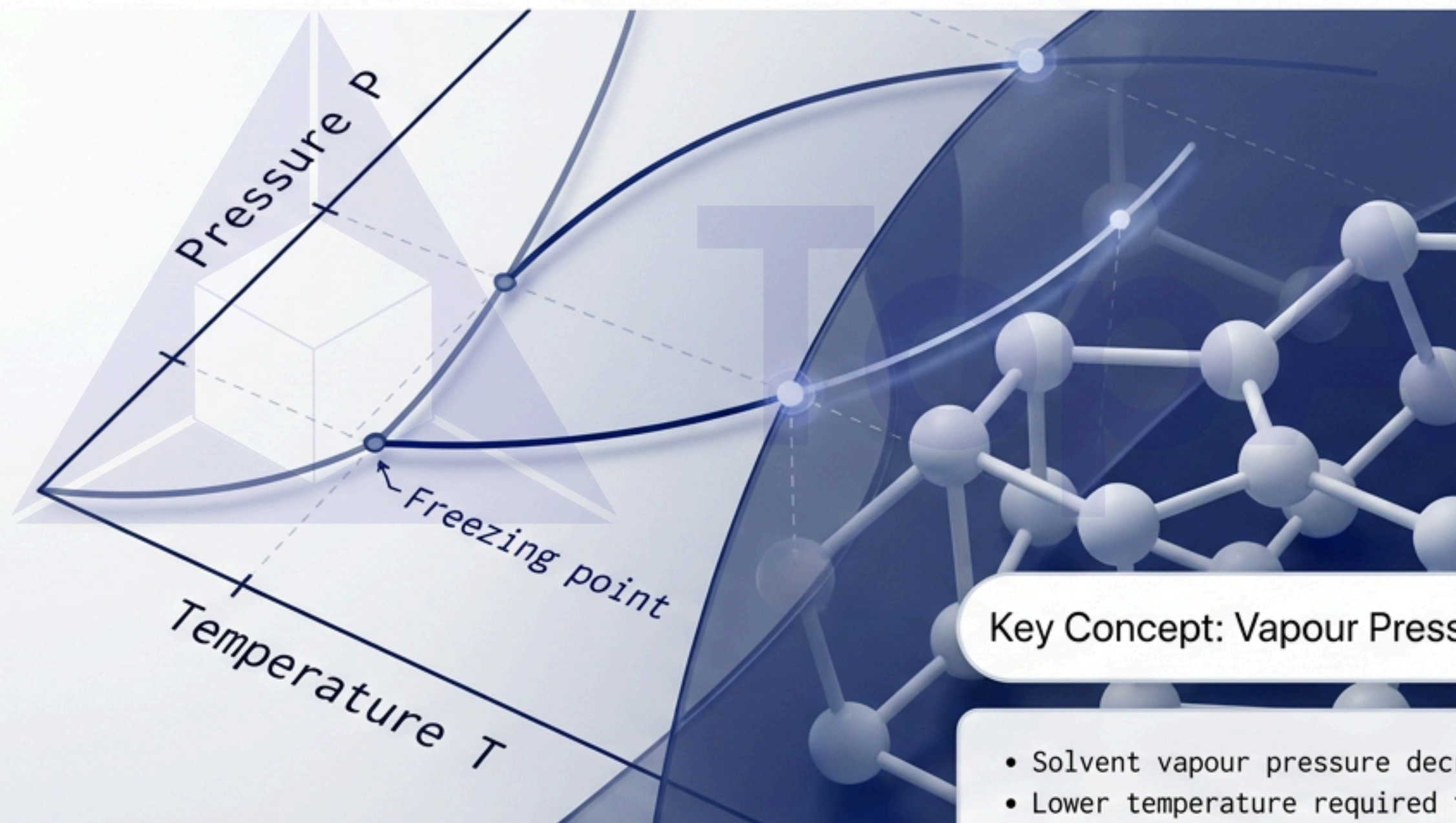


1.6.3 Depression of Freezing Point



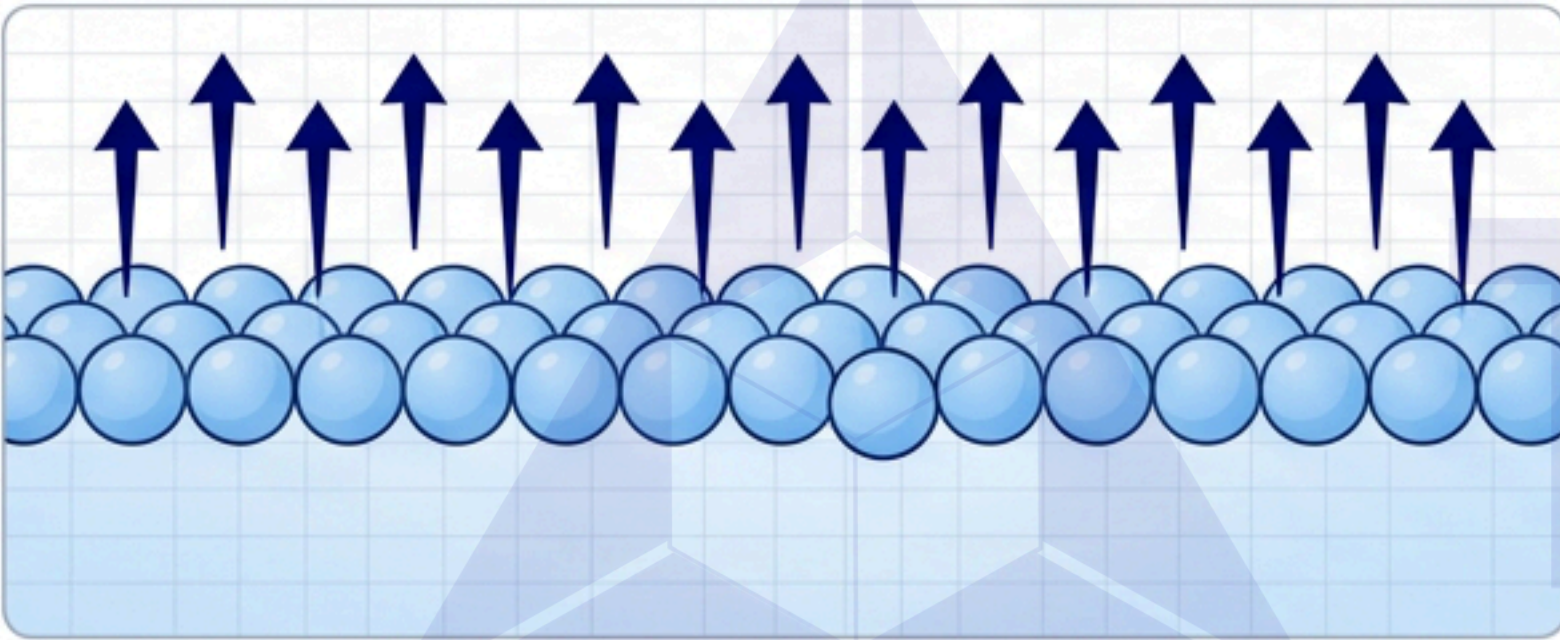
Key Concept: Vapour Pressure & Thermodynamics

- Solvent vapour pressure decreases upon solute addition.
- Lower temperature required to reach solid-liquid equilibrium (freezing point).

The Role of Non-Volatile Solutes

Pure Solvent

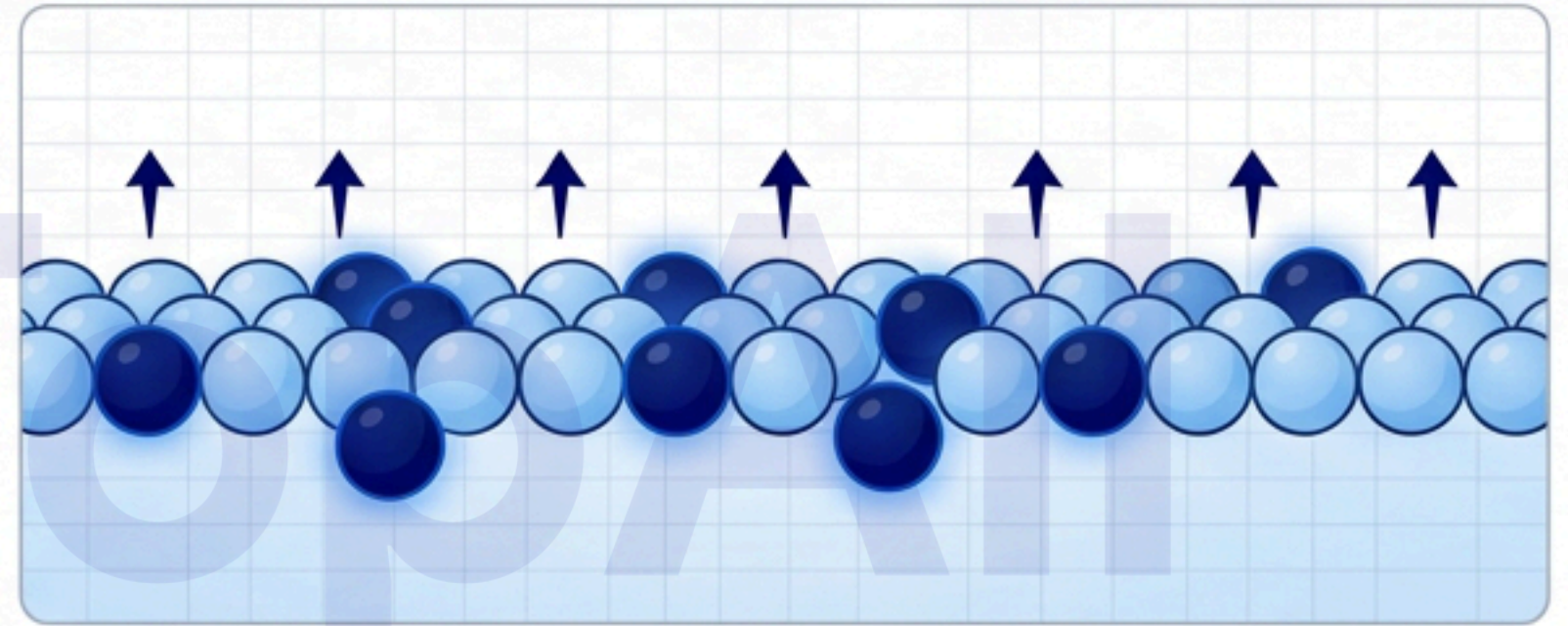
High Vapour Pressure



The addition of a non-volatile solute reduces the surface area available for solvent molecules.

Solution

Lower Vapour Pressure

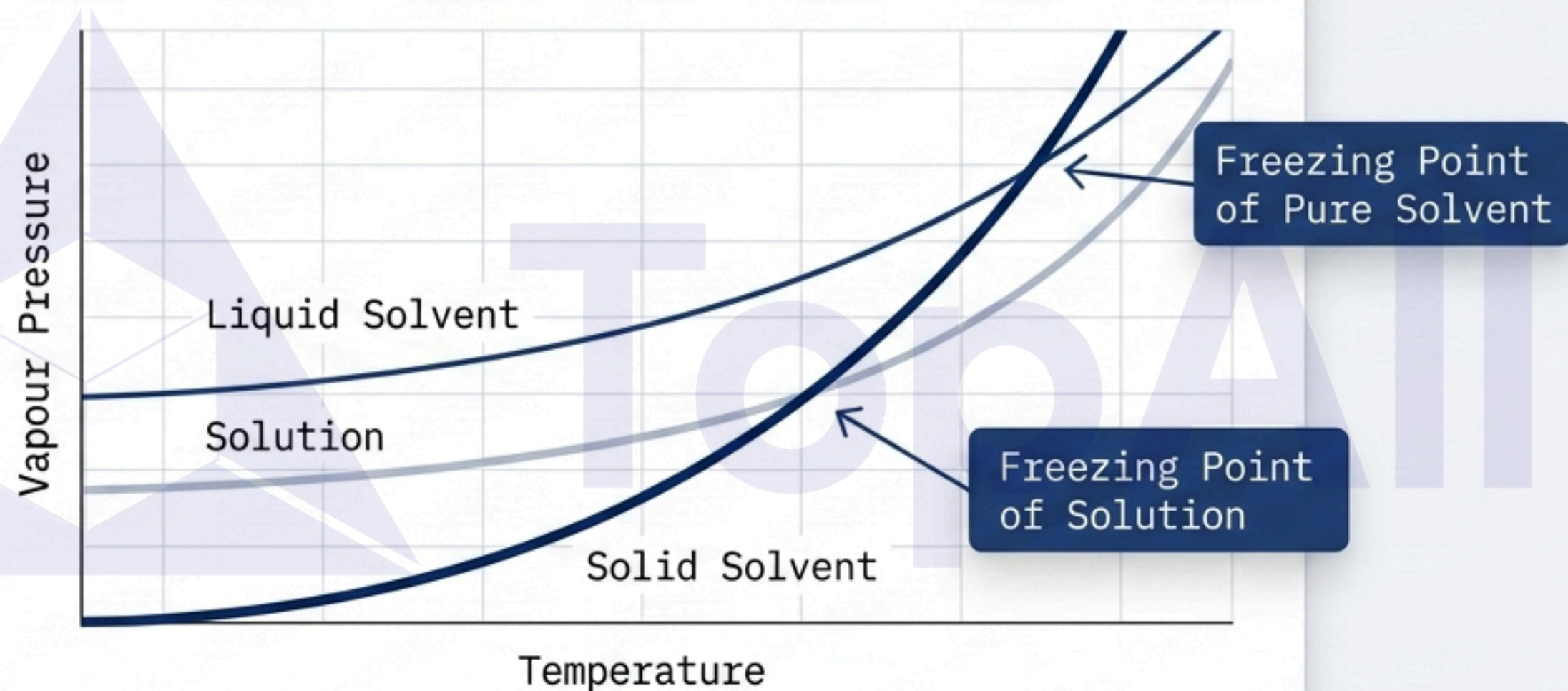


This physical blocking leads directly to a **lowering of vapour pressure** across all temperatures.

Recap Box: Lower vapour pressure means the solution must reach a lower temperature to freeze.

The Intersection of Phases

Phase Diagram: Vapour Pressure vs. Temperature



Concept Box

A liquid freezes only when its vapour pressure exactly equals the vapour pressure of its solid phase. Because the solution's curve is shifted down, it intersects the solid curve at a lower temperature.



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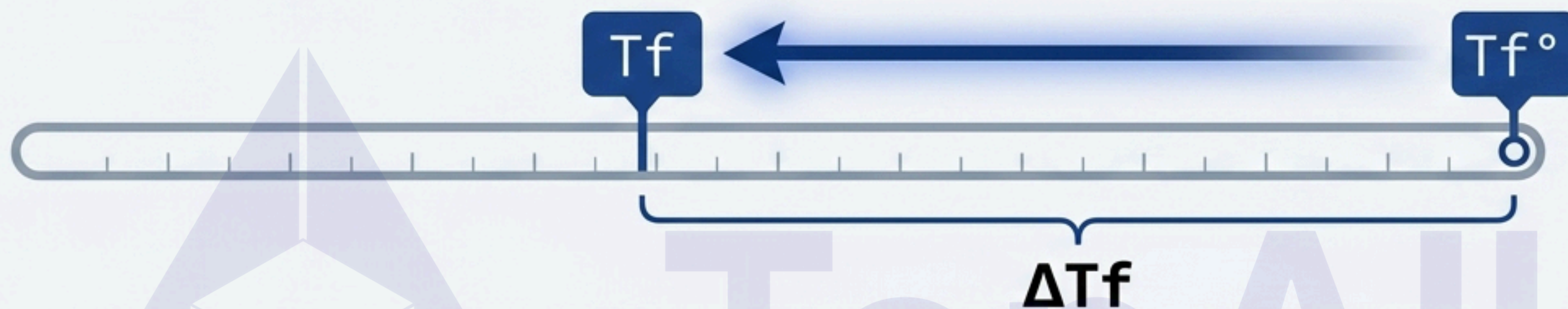
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Defining Depression in Freezing Point



$$\Delta T_f = T_f^\circ - T_f$$

T_f°

Freezing point of pure solvent.

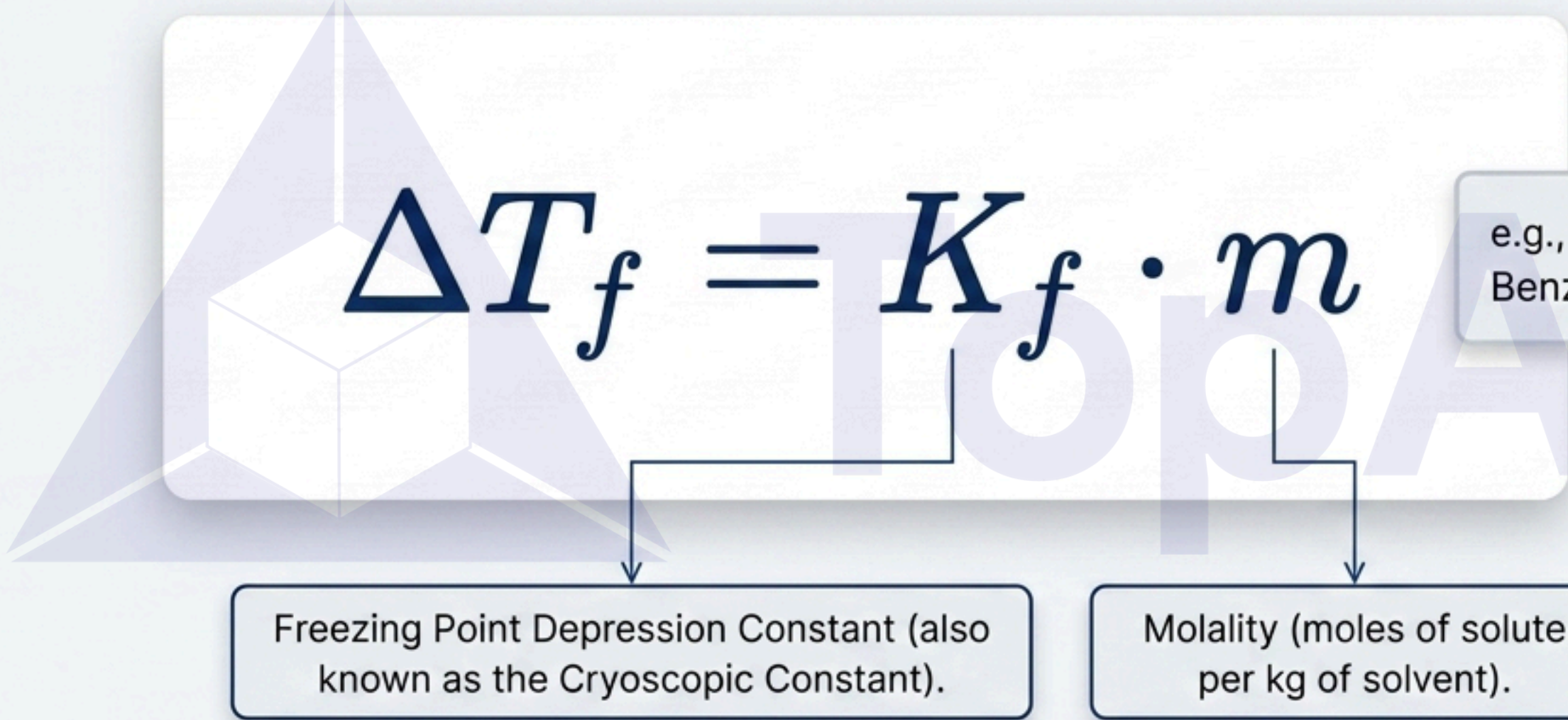
T_f

Freezing point of the solution.

ΔT_f

The magnitude of the temperature drop.

Proportionality to Molality


$$\Delta T_f = K_f \cdot m$$

e.g., Water $K_f = 1.86 \text{ K kg mol}^{-1}$ |
Benzene $K_f = 5.12 \text{ K kg mol}^{-1}$

Freezing Point Depression Constant (also known as the Cryoscopic Constant).

Molality (moles of solute per kg of solvent).

As a colligative property, the temperature depression depends *only* on the number of solute particles (molality), not their chemical identity.

PRACTICAL APPLICATION



Determining Unknown Molar Mass

1. Expand Molality

$$m = \frac{\frac{w_2}{M_2}}{\frac{w_1}{1000}}$$

2. Plug into Law

$$\Delta T_f = K_f \cdot \left[\frac{w_2 \cdot 1000}{M_2 \cdot w_1} \right]$$

3. Rearrange for Molar Mass

$$M_2 = \frac{K_f \cdot w_2 \cdot 1000}{\Delta T_f \cdot w_1}$$

Variable Key

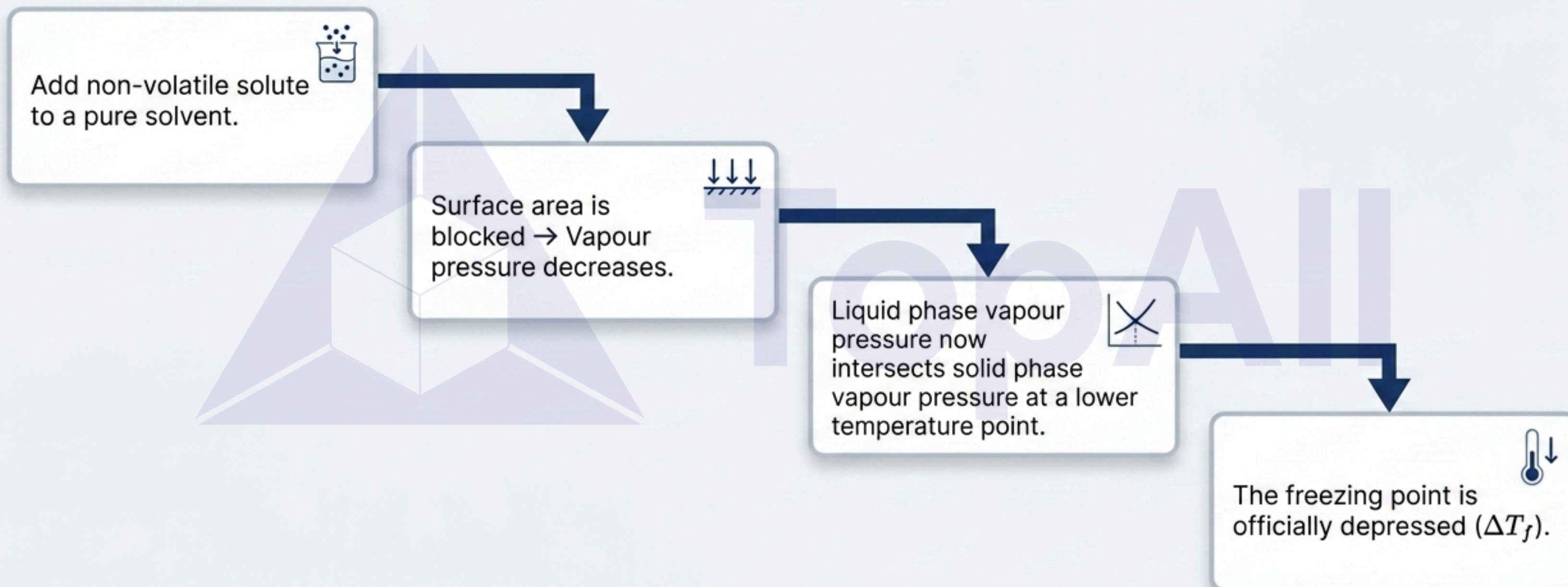
w1 = mass of solvent

w2 = mass of solute

M2 = molar mass of solute

By measuring the temperature drop (ΔT_f), chemists can precisely calculate the molar mass (M_2) of a completely unknown solute.

The Colligative Chain Reaction



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