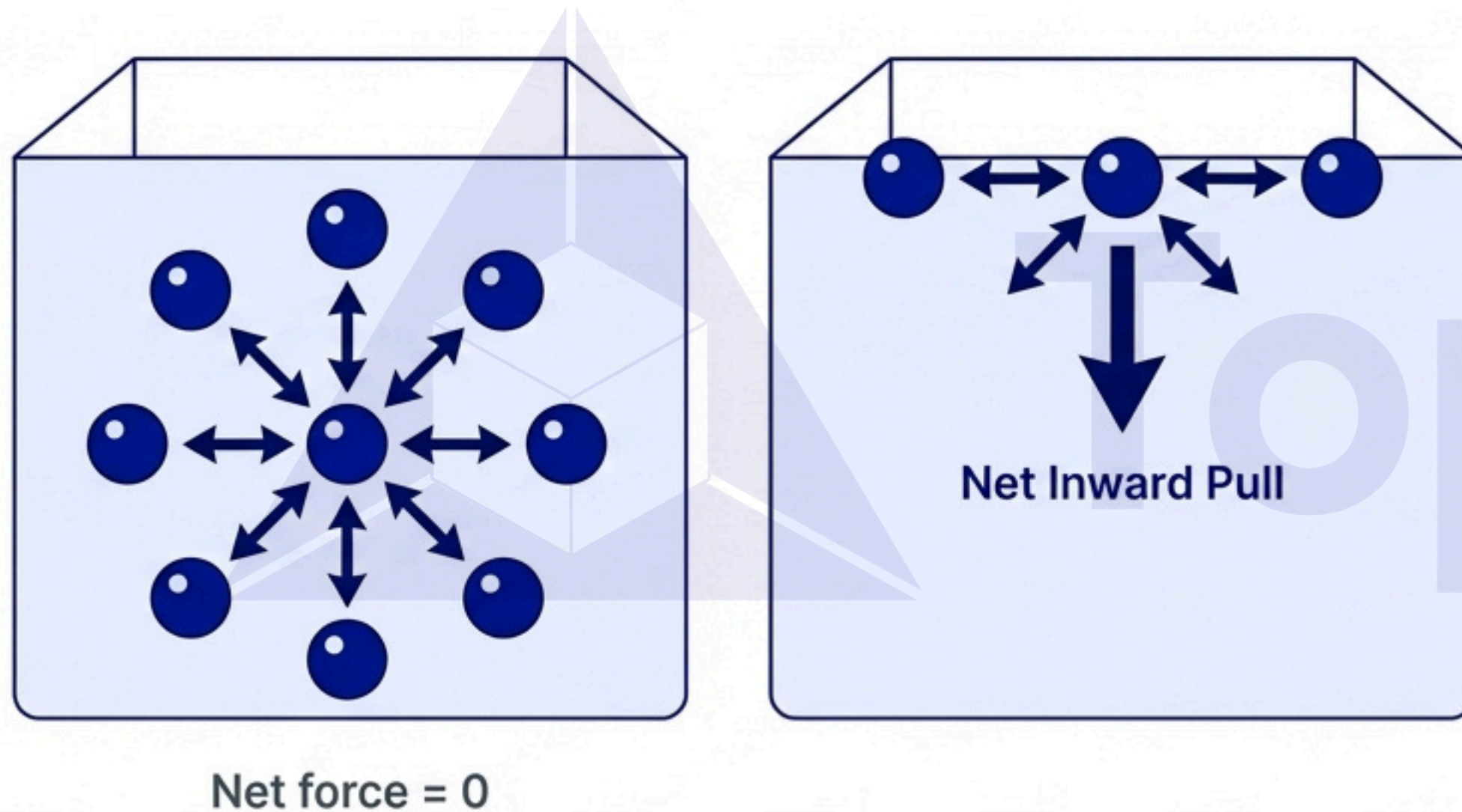


Surface Tension: The Stretched Skin of Liquids

Understanding the molecular forces that shape drops, bubbles, and fluid boundaries.



Why Does a Liquid Act Like a Stretched Membrane?



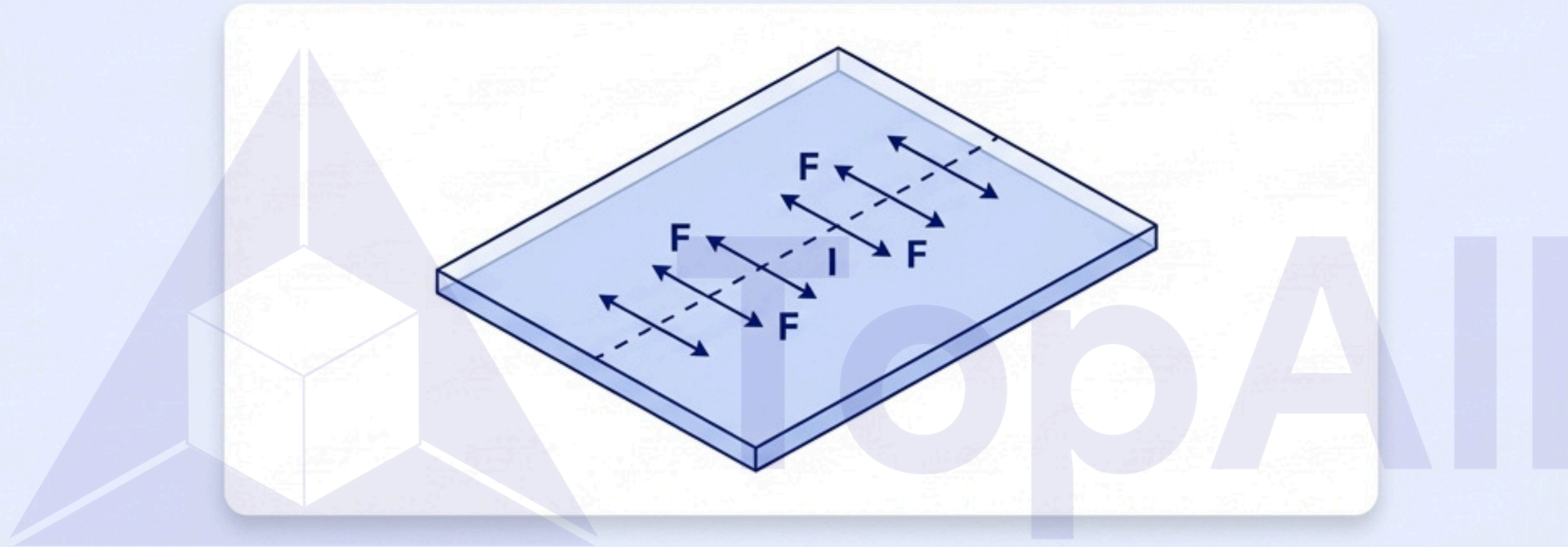
[CONCEPT EXPLAINER]

- **Inside the bulk:** Molecules are pulled equally in all directions. Net force is zero.
- **At the surface:** Molecules are only pulled inward and sideways by neighbors.
- **The Result:** This net inward pull creates tension that tries to minimize total surface area, making the fluid behave like an elastic sheet.

Surface Tension as Force Per Unit Length

[SI UNIT: N m⁻²]

Imagine a line drawn on the surface of a liquid. The liquid on one side pulls the liquid on the other side with a force F perpendicular to that line.



$$S = F / l$$

S = Surface Tension

F = Force applied (N)

l = Length of the line (m)



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$$E=mc^2$$



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Expanding the Film

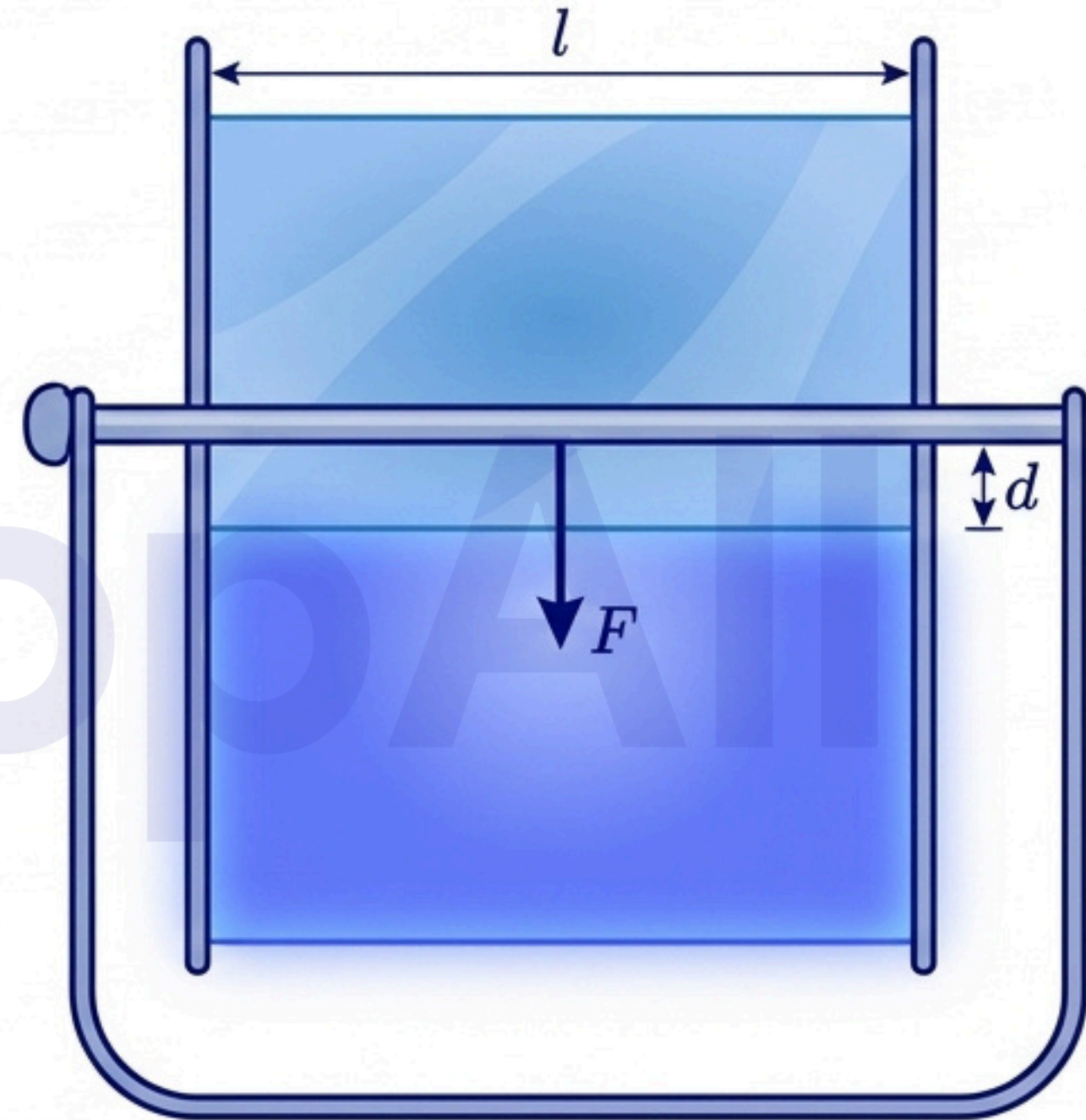
When we pull a sliding bar on a soap-film frame, we do work against the internal force F .

The **extra area** created is $2dl$ (because a soap film has two surfaces—top and bottom).

[EQ. 9.19] Work Done = $F \times d = S \times (2dl)$

[EQ. 9.20] Surface Tension = $S = \frac{F}{2l}$

[EXAM TIP] Always account for 2 surfaces in thin films and bubbles!



Two Sides of the Same Coin: Force vs. Energy

Surface Tension

- Definition: Force per unit length pulling the surface together.

Formula: $S = F / l$

- Units: N/m



Surface Energy

- Definition: Extra potential energy per unit area of the surface molecules.

Formula: $S = \text{Energy} / \text{Area}$

- Units: J/m²

Dimensionally and numerically, N/m is exactly equal to J/m².
They measure the same physical property.

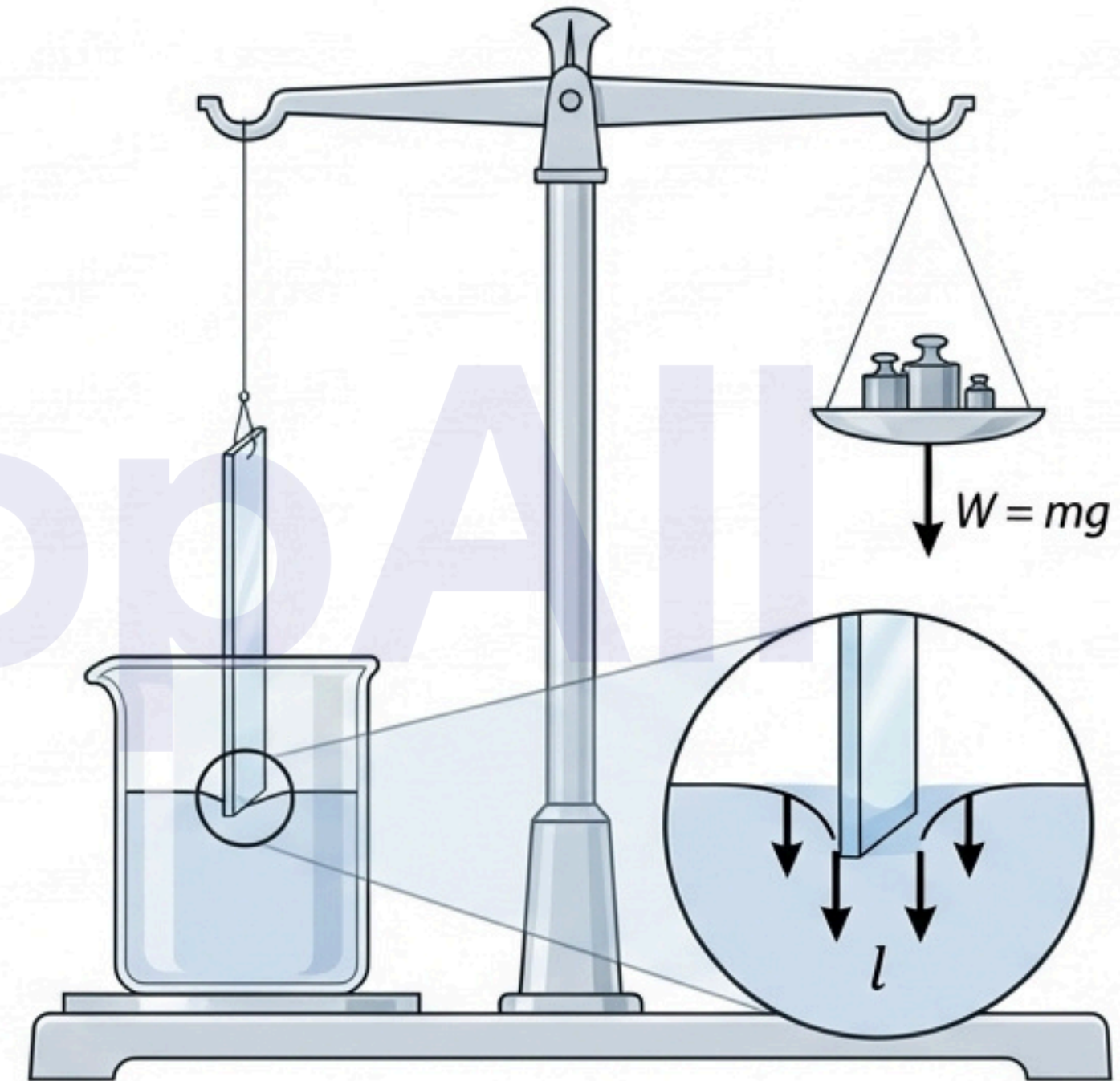
Experimental Measurement: Weighing the Pull

A vertical glass plate is balanced. A beaker of liquid is raised until it touches the plate. The liquid's surface tension pulls the plate downward.

Step: Add extra weight ($W = mg$) to the other side until the plate just clears the water.

$$\text{[EQ. 9.21]} \quad S_{la} = \frac{W}{2l} = \frac{mg}{2l}$$

(l = length of plate edge, l_a = liquid-air interface). Again, $2l$ is used because the liquid pulls on both sides of the plate's edge!



Chapter Summary

Key Takeaways

1. Liquids minimize their surface area due to the net inward pull on surface molecules.
2. Surface Tension (S) is the force per unit length (F/l) acting on the interface.
3. It is numerically and dimensionally equal to the Surface Energy per unit area.
4. Crucial: For thin films and plates, always account for both sides of the interface (use $2l$).

Ready for the Exam?

Test your understanding of formulas 9.19 – 9.21.

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