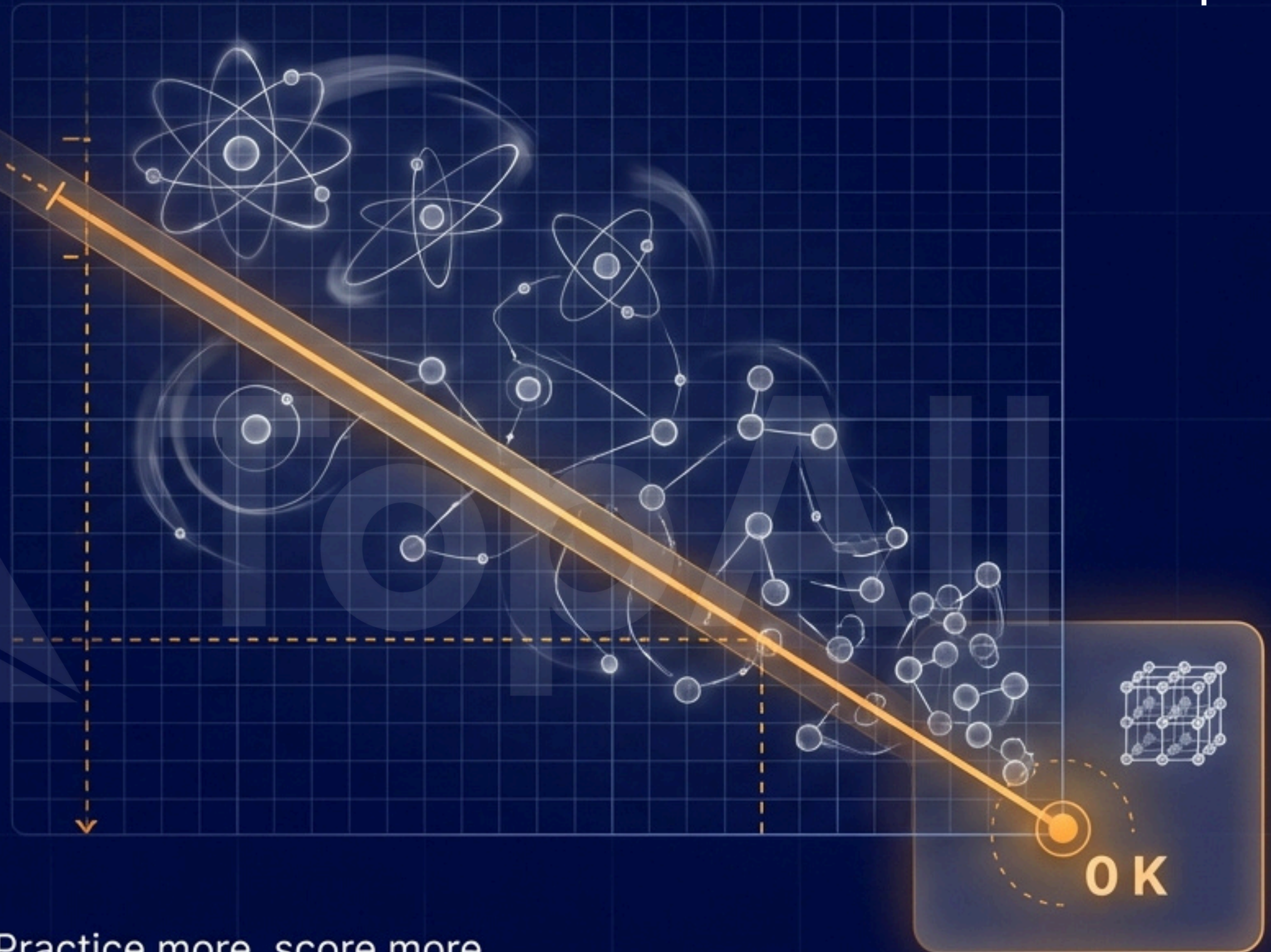


How Gases How Gases Lead Us to Absolute Zero

From macro-observations of pressure and volume to the discovery of the universe's ultimate temperature limit.



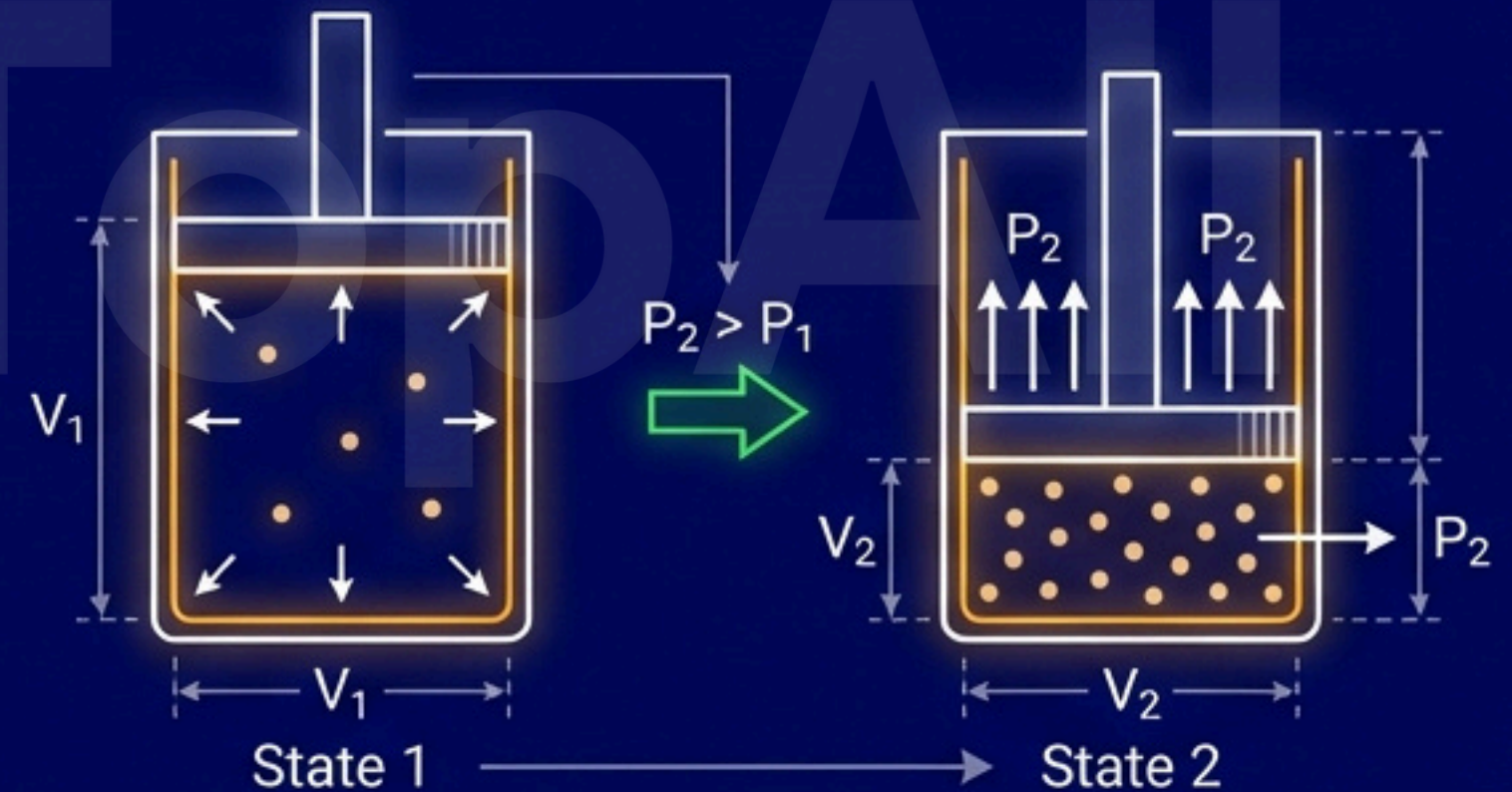
Practice more, score more

Boyle's Law: The Pressure-Volume Squeeze

Experiments show all gases at low densities exhibit the same expansion behavior.

Condition: When temperature (T) is held constant.

$$PV = \text{constant}$$

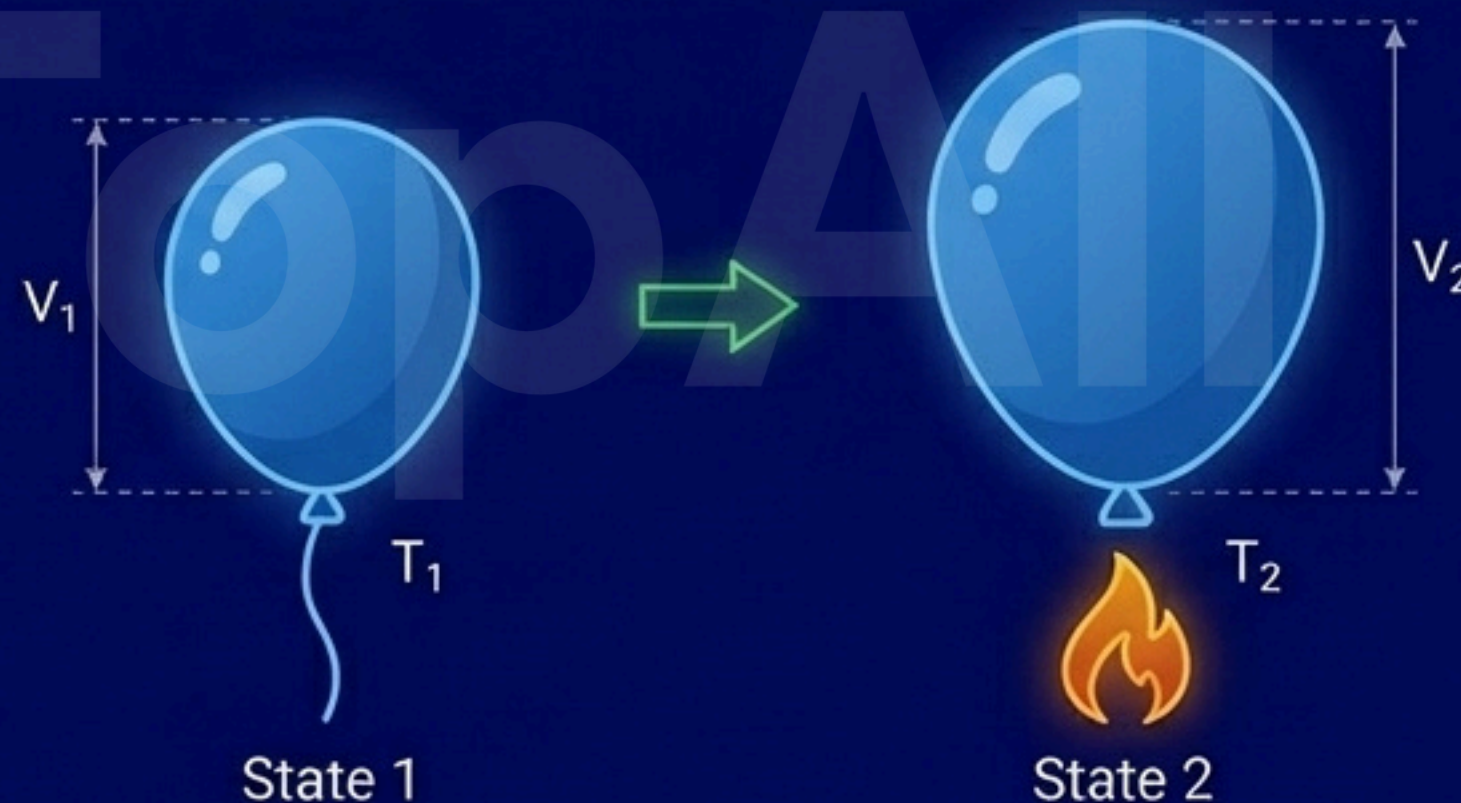


Charles' Law: The Volume-Temperature Swell

Jacques Charles discovered that low-density gases expand consistently when heated.

Condition: When pressure (P) is held constant.

$$V/T = \text{constant}$$



The Ideal-Gas Equation

Since $PV = \text{constant}$ and $V/T = \text{constant}$, then PV/T must also be constant for any low-density gas.

$$PV = \mu RT$$

μ = number of moles
 R = universal gas constant ($8.31 \text{ J mol}^{-1} \text{ K}^{-1}$)



EXAM TRAP:
Always use
Temperature (T) in
Kelvin, never Celsius!

Practice more, score more

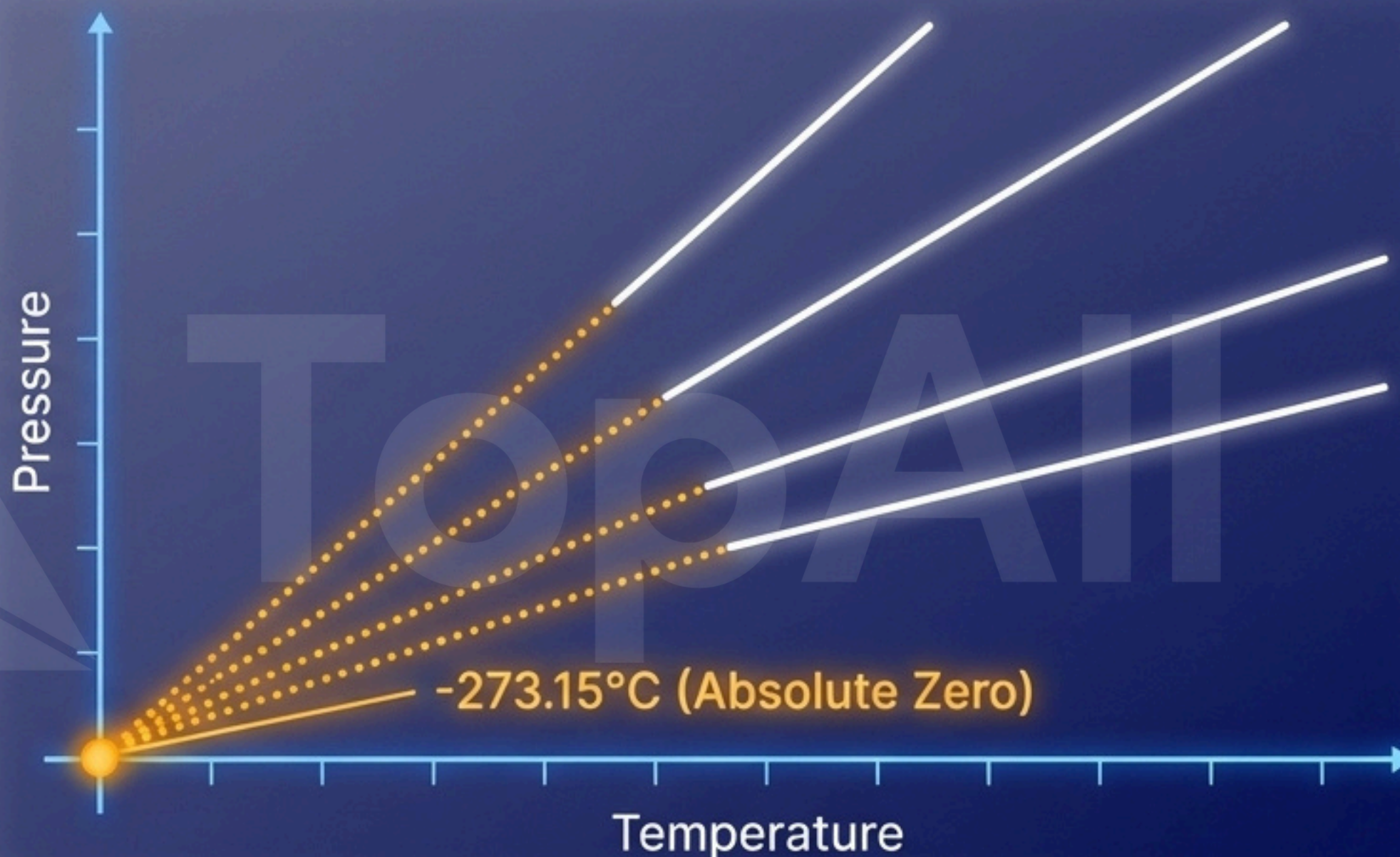
Discovering Absolute Zero

Insight

At constant volume, $P \propto T$. A constant-volume gas thermometer reads temperature in terms of pressure.

The Discovery

Real gases deviate at low temps, but if we extrapolate the linear relationship, pressure reaches zero at exactly -273.15°C .



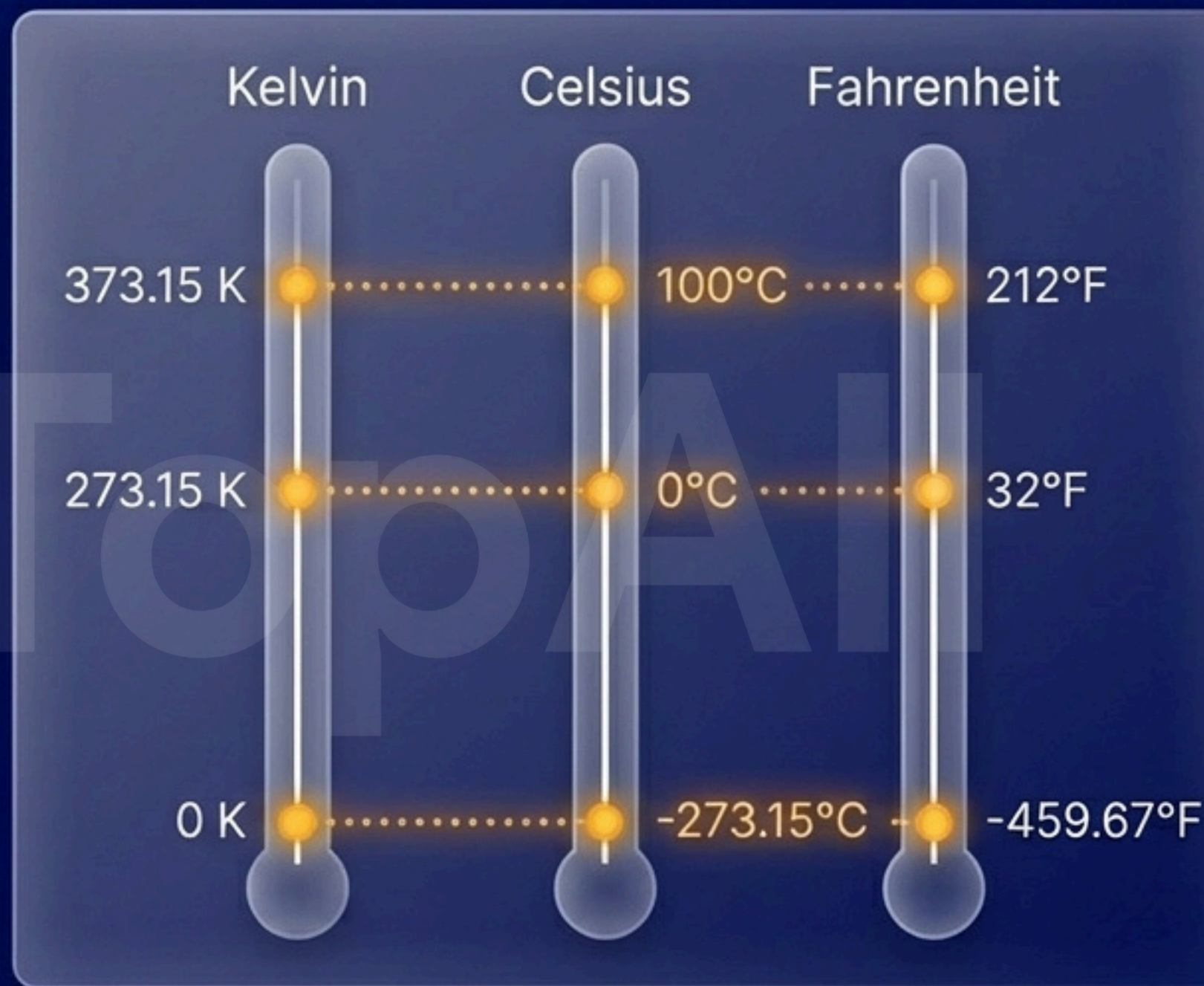
Practice more, score more

The Absolute Scale: Kelvin vs. Celsius

Absolute zero is the foundation of the Kelvin (absolute) temperature scale.

$$T = t_c + 273.15$$

Unit step size is identical for Kelvin and Celsius.



Key Takeaways

Boyle's Law: $P \propto \frac{1}{V}$ (constant T)

Charles' Law: $V \propto T$ (constant P)

Ideal-Gas Law: $PV = \mu RT$ ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$)

Absolute Zero: The extrapolated temperature (-273.15°C) where ideal gas pressure hits zero.

Kelvin Conversion: $T = t_c + 273.15$