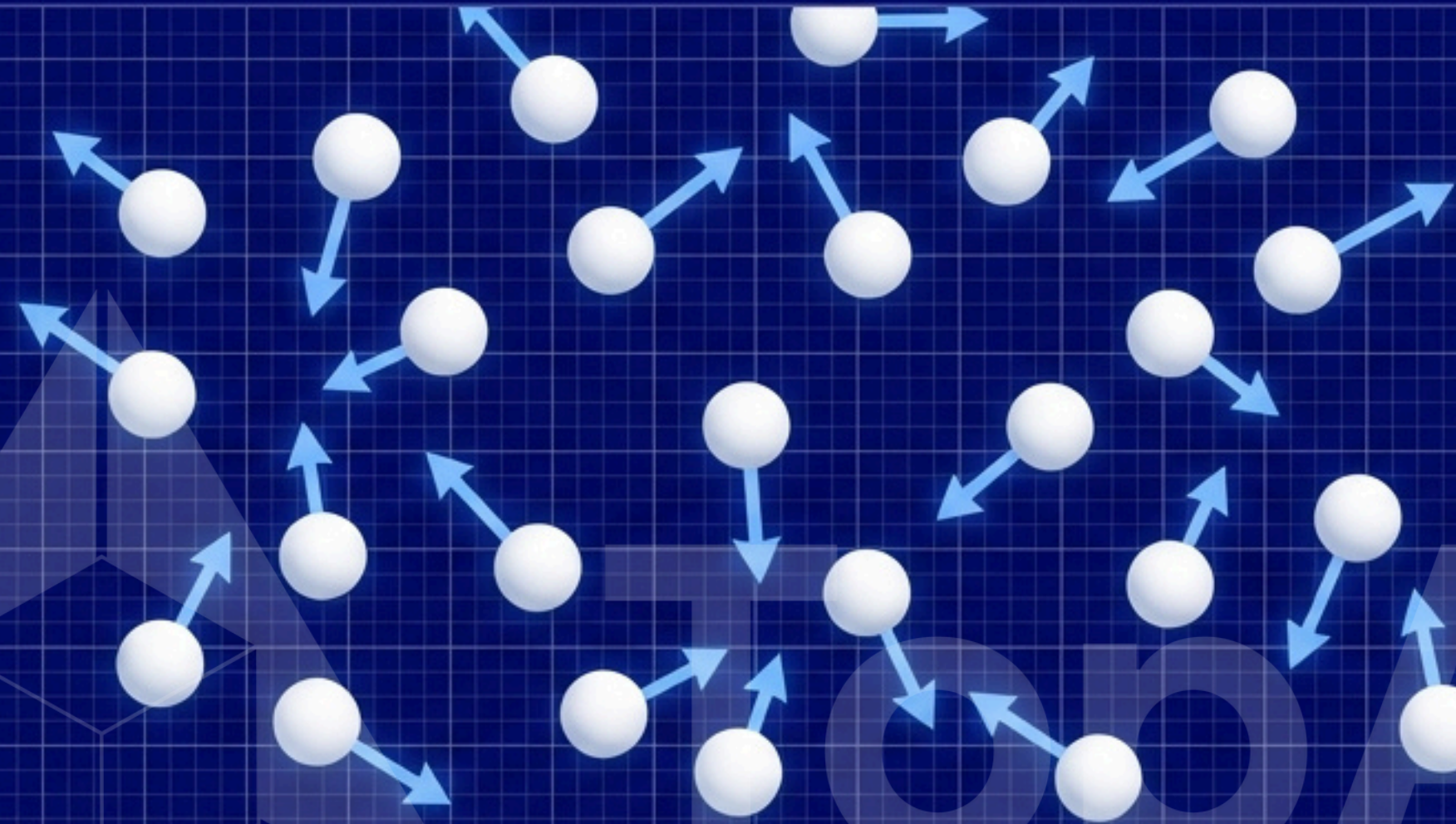




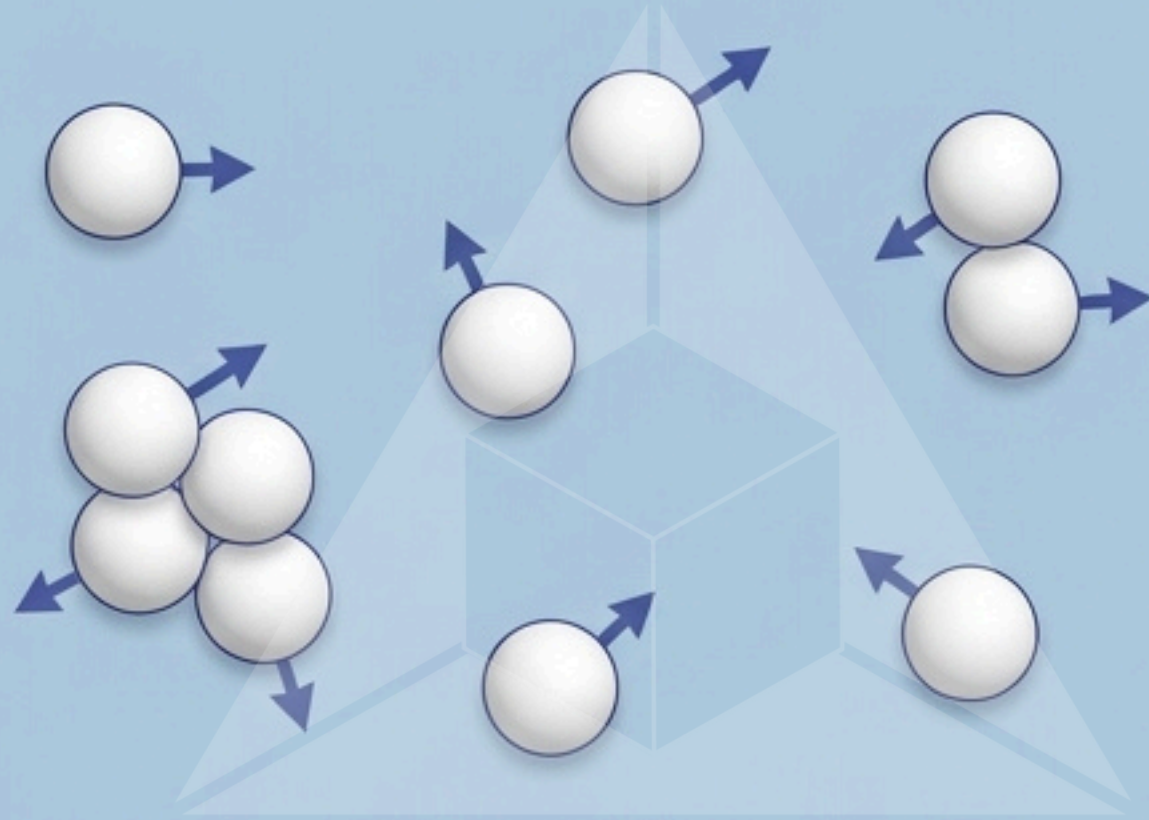
CLASS 11 PHYSICS • CHAPTER 12.4.2

The Kinetic Interpretation of Temperature

Bridging macroscopic heat with microscopic motion for NEET & JEE.

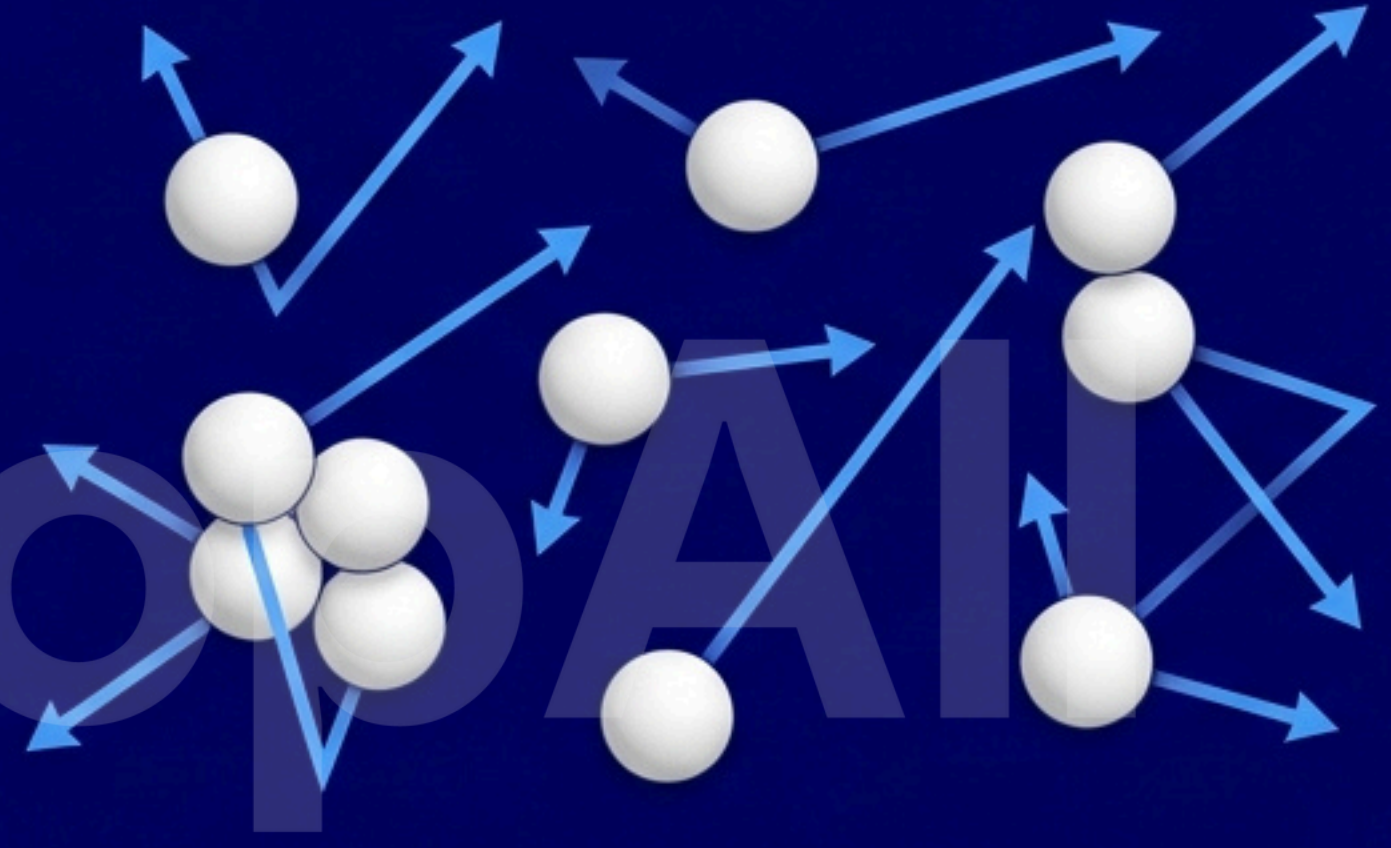
The Secret Identity of Temperature

Cold Gas



- Lower average molecular speed
- Less forceful collisions

Hot Gas



- Higher average molecular speed
- Highly energetic collisions

Temperature isn't a fluid or a distinct energy—it is a macroscopic measure of the **average random translational motion** of molecules.

Bridging Pressure and Kinetic Energy

The Pressure Equation

Eq. 12.15a

$$PV = \frac{1}{3}nV m \bar{v}^2$$



Rewrite to isolate Kinetic Energy:

$$PV = \frac{2}{3}N \times \left(\frac{1}{2} m \bar{v}^2 \right)$$



Since purely translational internal energy is $E = N \times \left(\frac{1}{2} m \bar{v}^2 \right) \dots$

Eq. 12.17

$$PV = \frac{2}{3}E$$



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$$E=mc^2$$



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The Grand Synthesis

Kinetic Theory

$$PV = \frac{2}{3} E$$

Ideal Gas Law

$$PV = k_B N T$$

Eq. 12.18

$$E = \frac{3}{2} k_B N T$$

Eq. 12.19

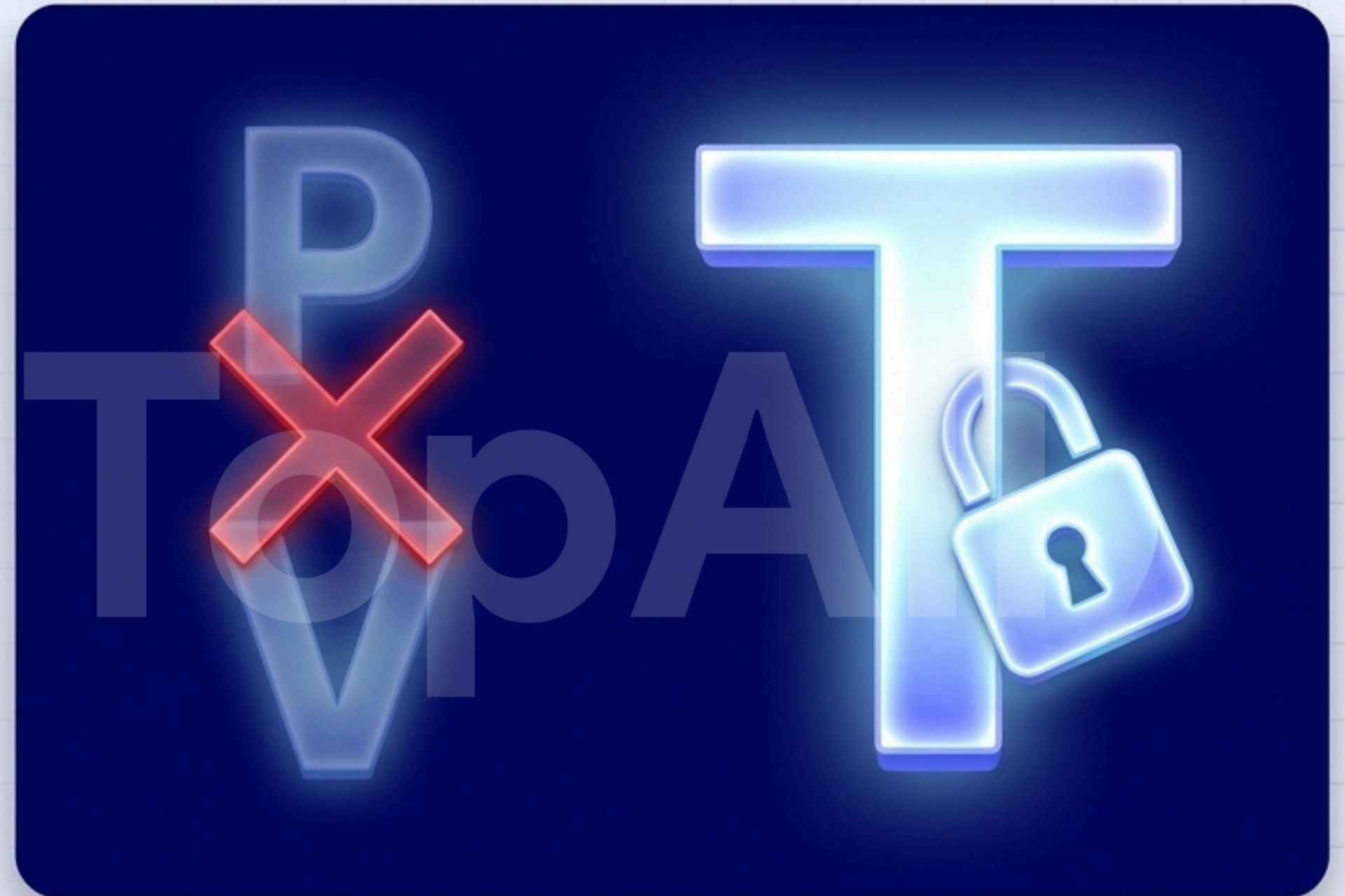
Average KE per molecule: $\frac{E}{N} = \frac{1}{2} m \overline{v^2} = \frac{3}{2} k_B T$

 EXAM TIP: k_B is the Boltzmann constant (1.38×10^{-23} J/K).

A Fundamental Thermodynamic Result

- Look closely at the formula
 $E = \frac{3}{2} k_B N T$.
- Notice what is missing? There is no Pressure (P) or Volume (V) anywhere in this equation.

For an ideal gas, internal energy depends solely on its absolute temperature.



NEET/JEE TRAP

If an ideal gas expands isothermally (constant T), its internal energy change (ΔE) is exactly ZERO, regardless of how much the volume or pressure changes!

How Fast Are They Really Moving?

Root Mean Square (rms) Speed:

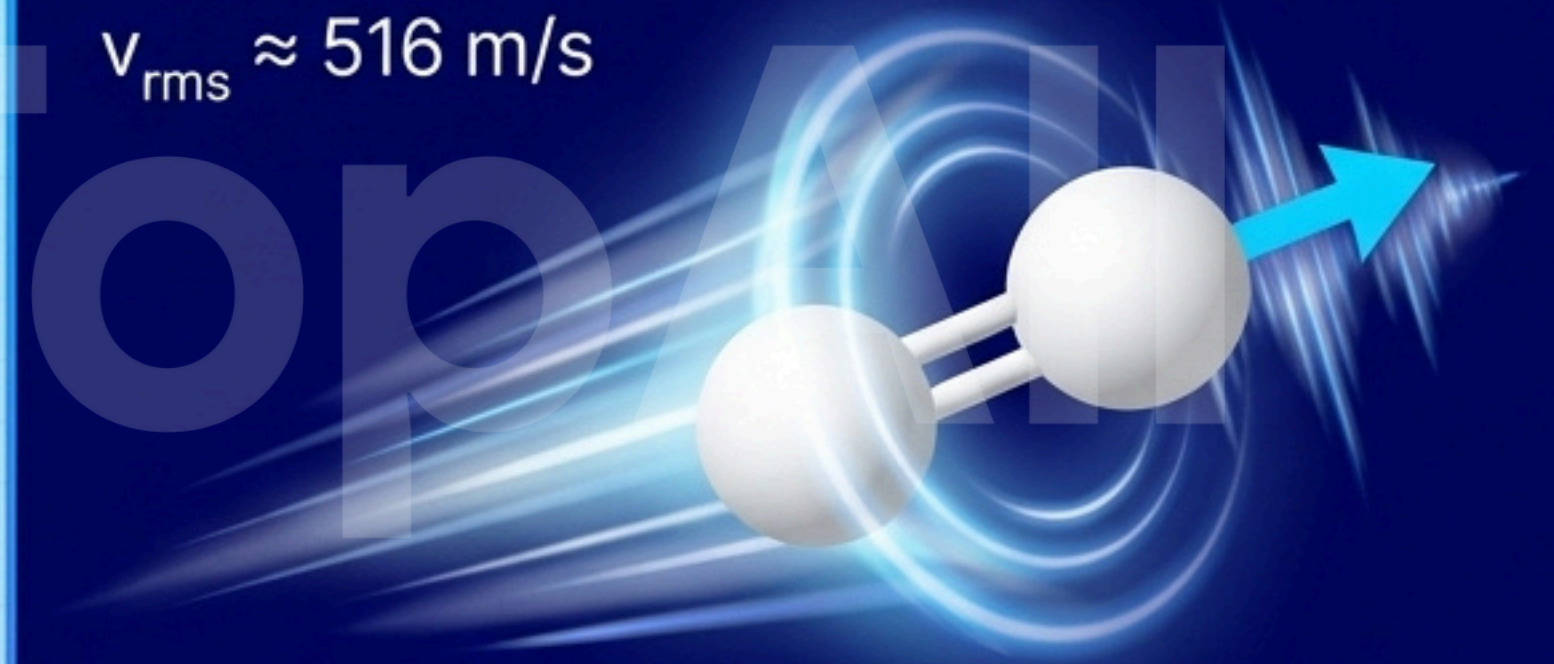
$$v_{\text{rms}} = \sqrt{v^2} = \sqrt{\frac{3k_B T}{m}}$$

Concept Note: At the exact same temperature, lighter molecules move faster!

Nitrogen (N_2) at Room Temp (300 K):

Mass (m) = 4.65×10^{-26} kg

$v_{\text{rms}} \approx 516$ m/s



Context: This is significantly faster than the speed of sound in air!

Master the Kinetic Interpretation

- ✓ **Temperature is Kinetic Energy:** Absolute temperature T is a direct measure of average translational KE per molecule ($E/N = 3/2 k_B T$).
- ✓ **Internal Energy Rule:** For an ideal gas, internal energy E depends only on temperature, never on P or V .
- ✓ **RMS Speed:** $v_{\text{rms}} = \sqrt{(3 k_B T / m)}$. Lighter gases at the same temperature always have higher v_{rms} .

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