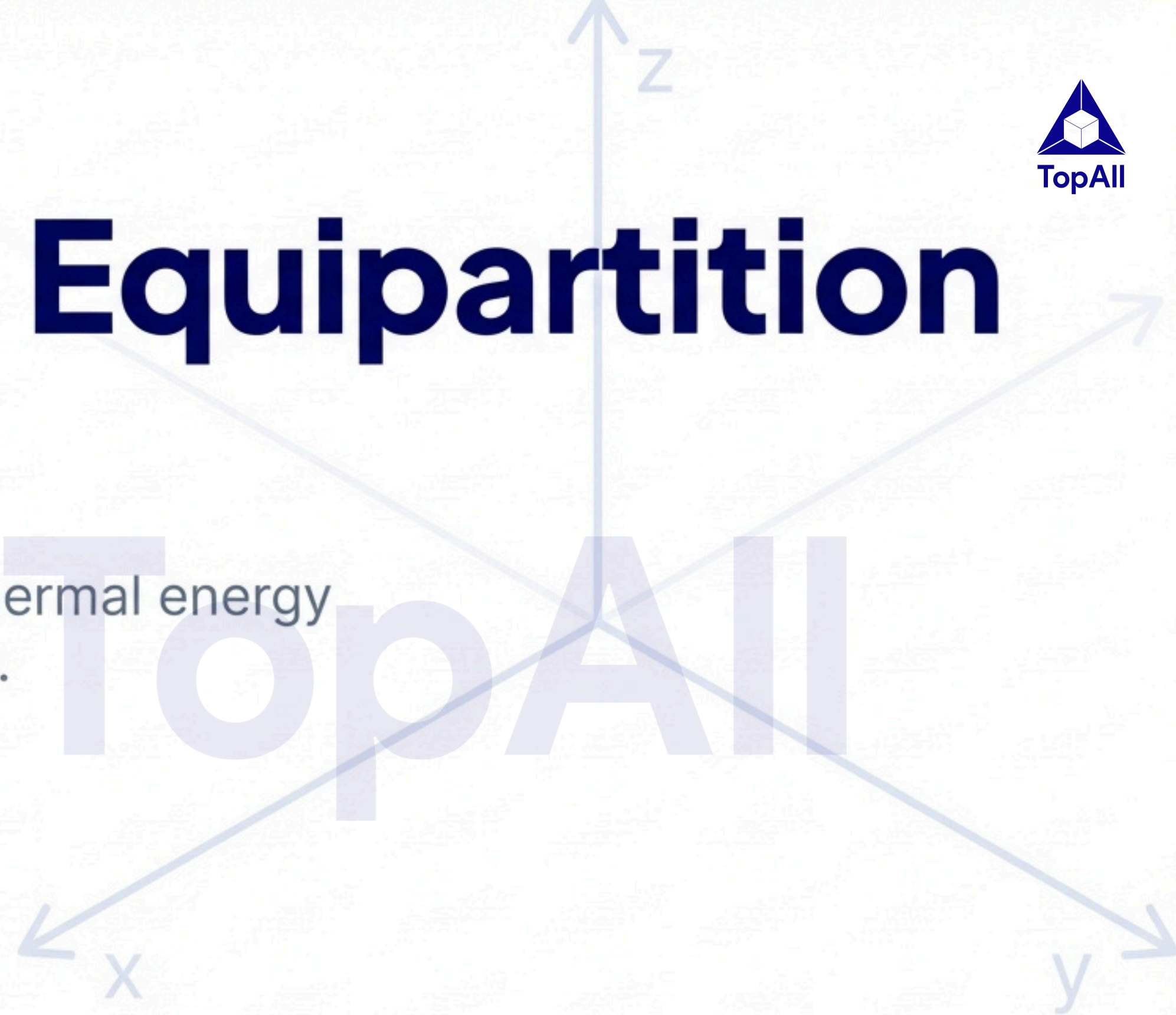
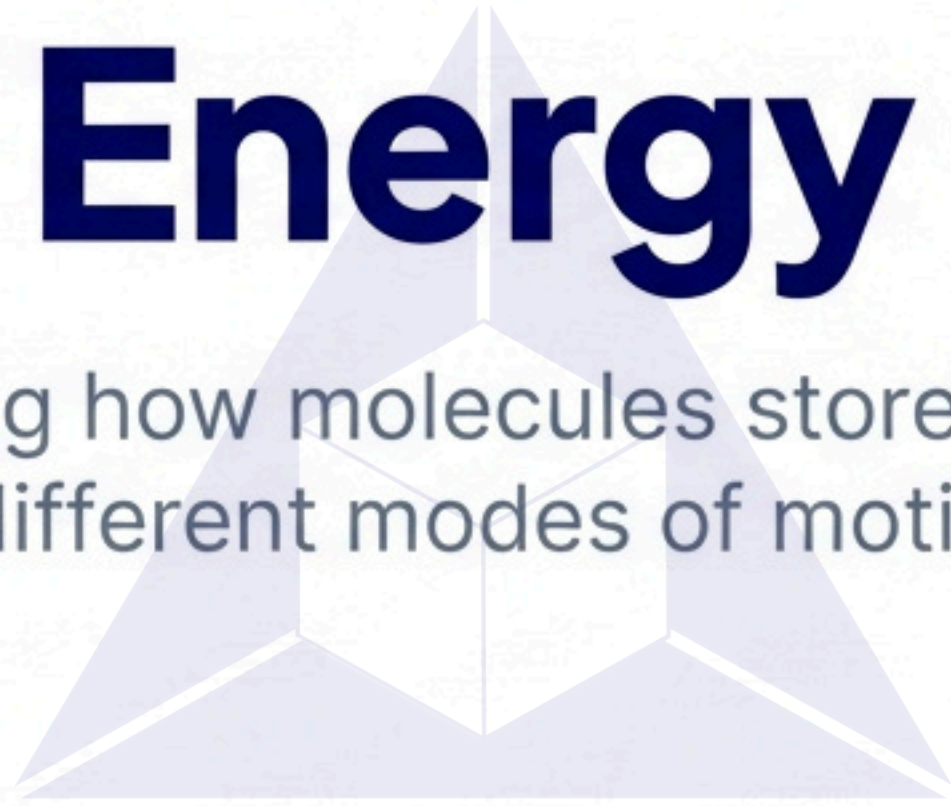


The Law Of Equipartition Of Energy

Decoding how molecules store thermal energy
across different modes of motion.

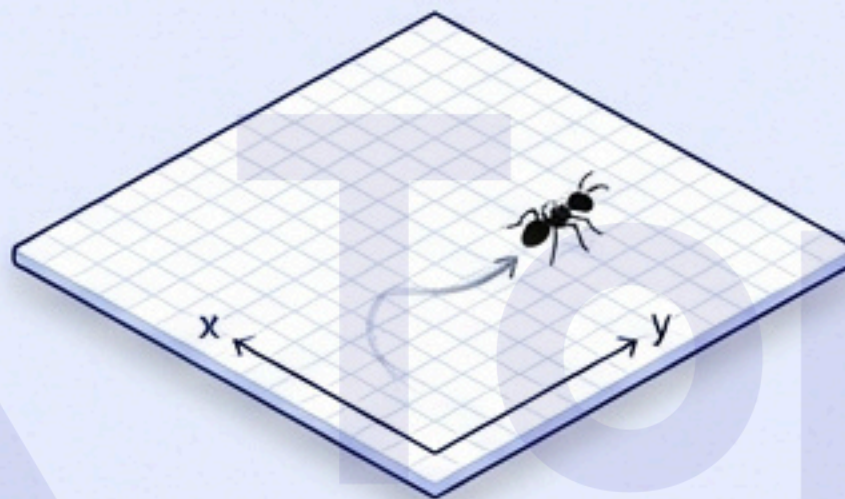


Defining 'Degree Of Freedom'

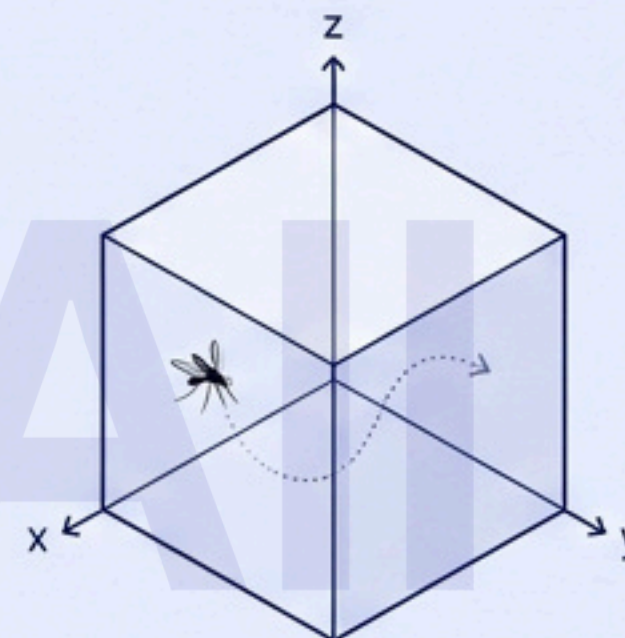
A degree of freedom is the number of independent coordinates required to specify a molecule's exact position and motion in space.



Motion in a straight line
= 1 Degree of Freedom



Motion in a plane =
2 Degrees of Freedom



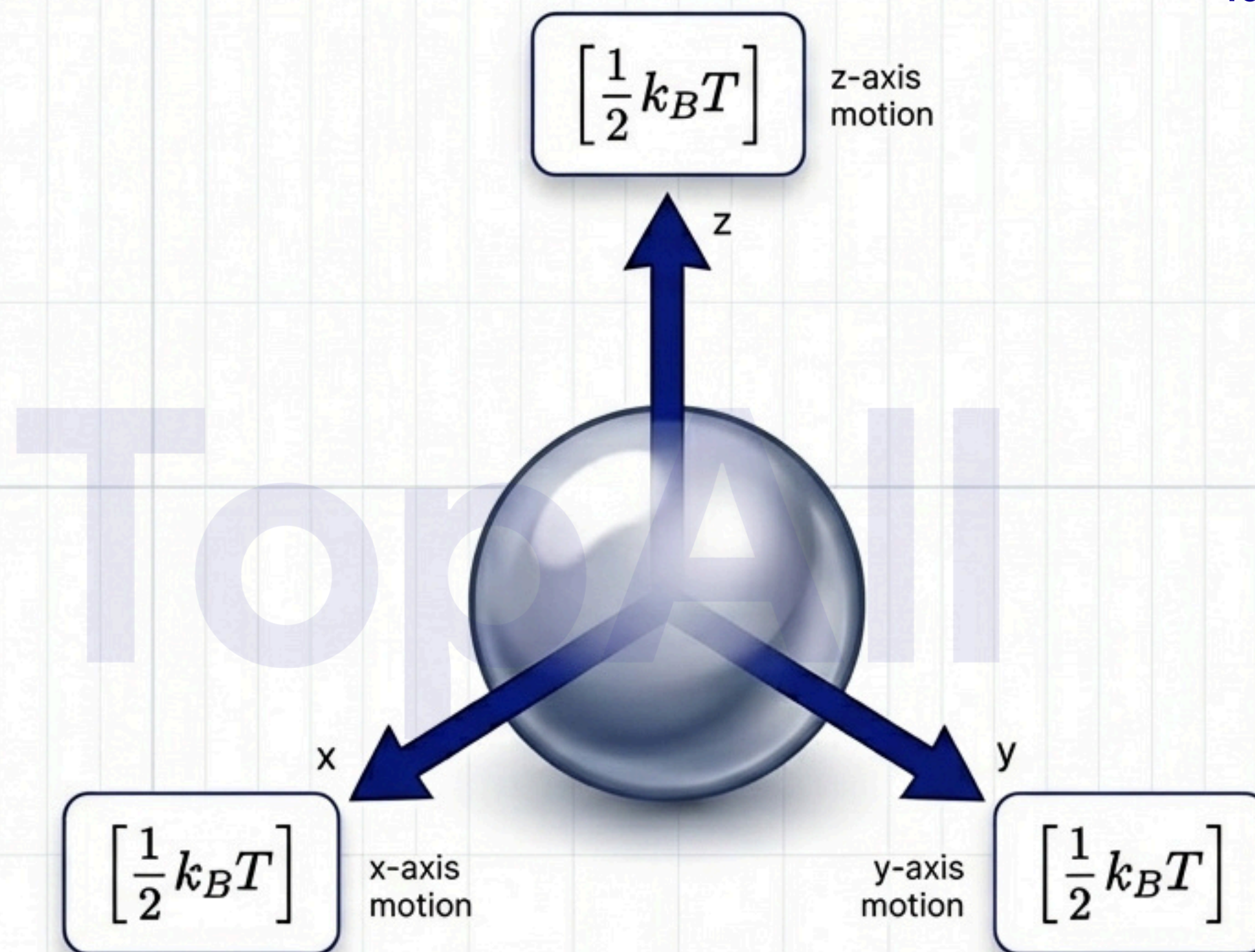
Motion in 3D space =
3 Degrees of Freedom

EXAM TIP: Think of it as the number of independent 'ways' a molecule can move!

Translational Motion

Motion of the molecule as a whole from one point to another in 3D space.

- Applies to all gases (monatomic, diatomic, polyatomic).
- Always yields exactly 3 translational degrees of freedom.
- Each translational mode contributes exactly $\frac{1}{2} k_B T$ to the average kinetic energy.





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$$E=mc^2$$



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Key Highlights

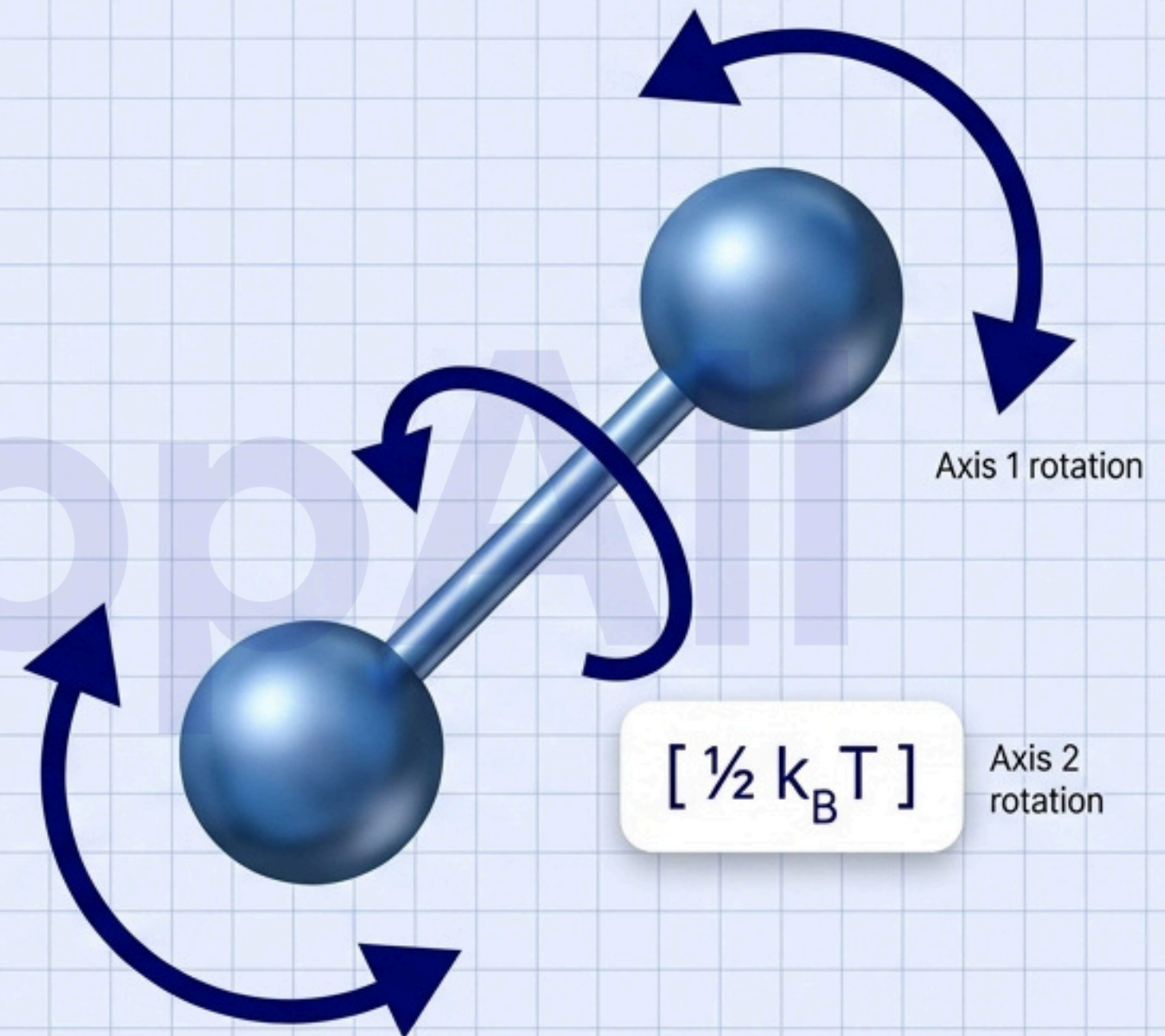
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Rotational Motion

Molecules with structure (like O₂ or N₂) can tumble and spin around their center of mass.

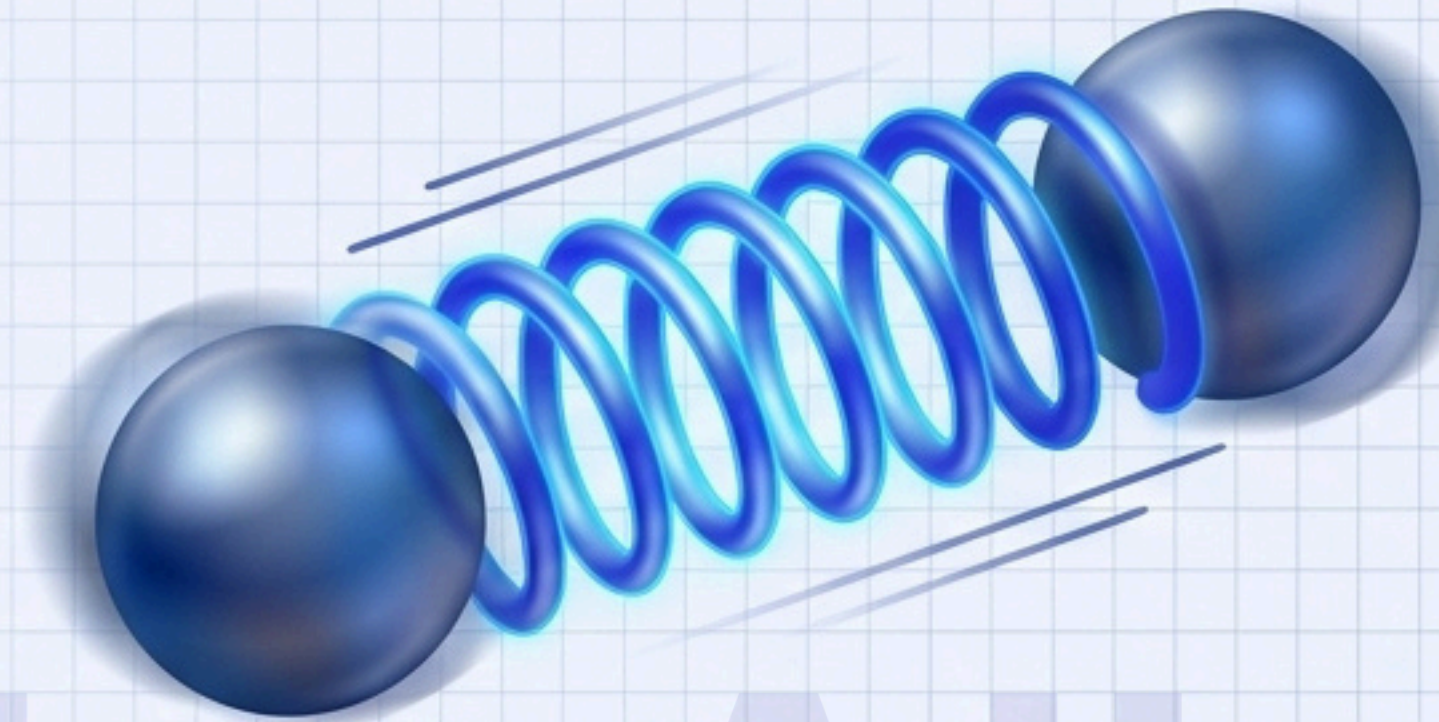
- A rigid diatomic molecule has 2 independent axes of rotation.
- (Rotation along the atomic bond axis is negligible).
- Just like translation, each active rotational mode contributes $\frac{1}{2} k_B T$.



Vibrational Motion

At higher temperatures, atoms within non-rigid molecules can oscillate along their axis like a 1D spring.

- Vibration is unique: it involves moving masses (Kinetic) AND stretching bonds (Potential).
- Because it contains two energy forms, one vibrational mode contributes a full $k_B T$.



Kinetic Energy
 $[\frac{1}{2} k_B T]$

+

Potential Energy
 $[\frac{1}{2} k_B T]$

=

Total
 $[k_B T]$

The Law In Action: Predicting Specific Heat

Mode	Energy/Mode	Energy Type
Translation	$[\frac{1}{2} k_B T]$	Purely Kinetic
Rotation	$[\frac{1}{2} k_B T]$	Purely Kinetic
Vibration	$[k_B T]$	Kinetic + Potential

At thermal equilibrium, total energy is distributed equally among all possible energy modes.

- **The Macroscopic Link:** By simply counting a molecule's degrees of freedom, we calculate its total internal energy.
- This total energy allows us to theoretically predict the gas's Specific Heat Capacity with remarkable accuracy.

Key Takeaways

- ✓ **Degree of Freedom:** An independent way a molecule can move or store energy.
- ✓ **Translation & Rotation:** Each mode contributes $\frac{1}{2} k_B T$ to the molecule's average energy.
- ✓ **Vibration:** Contributes a full $k_B T$ (combining both kinetic and potential energy).
- ✓ **The Big Picture:** The Equipartition Law bridges microscopic motion directly to macroscopic specific heat capacities.

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