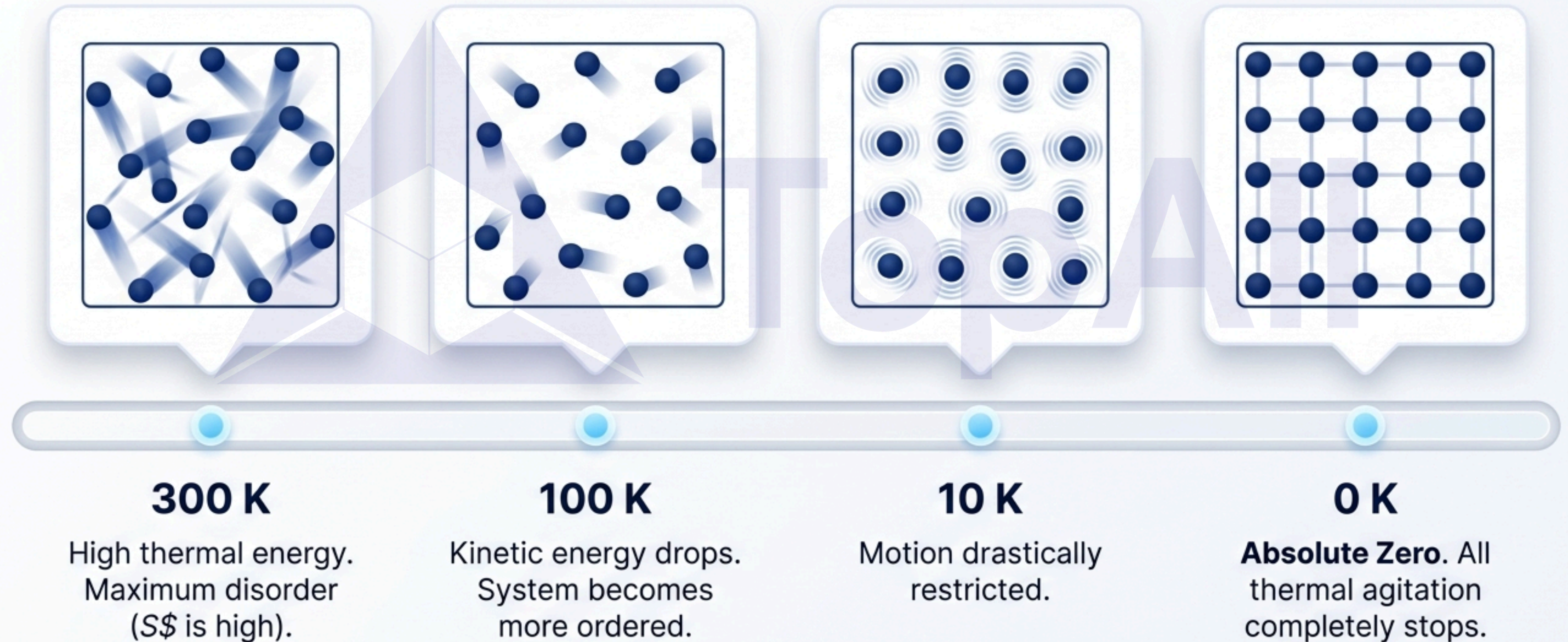


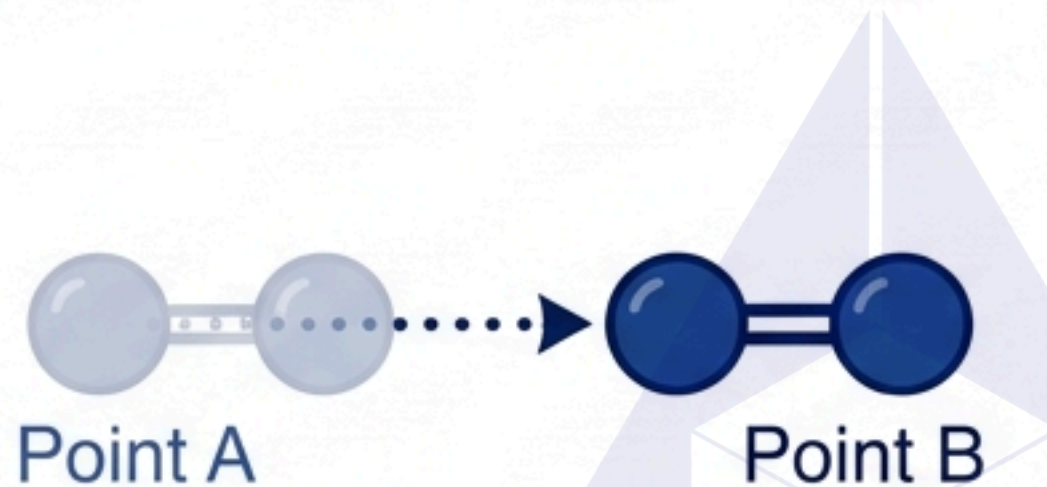
Temperature & Kinetic Energy

The macroscopic journey to absolute zero (0 K)



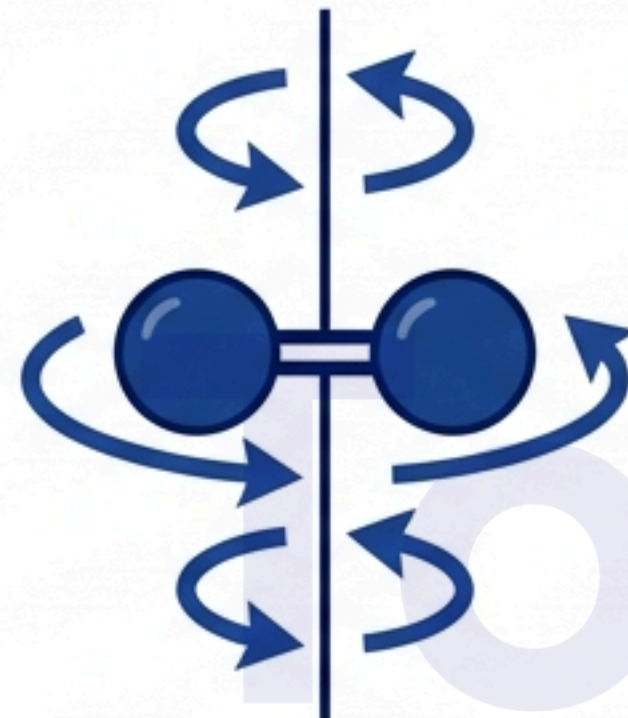
The Freezing of Molecular Motions

As T falls, chaotic movements are systematically restricted



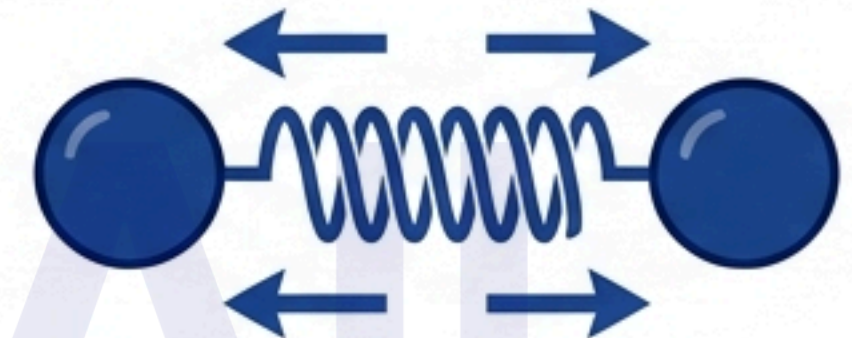
Translational Motion

Movement in straight lines.
(Freezes first).



Rotational Motion

Spinning around a
central axis.



Vibrational Motion

Bonds stretching and
compressing. (Freezes last—
ceases only at absolute zero).

Decreasing Temperature ($T \downarrow$)



The State of Perfect Order

Pure crystalline substances achieve absolute perfection at 0 K



Perfect Order

At absolute zero (0 K), all thermal agitation and lattice vibrations completely cease.

Minimum Randomness

The constituent particles lock into a state of minimum energy and maximum spatial regularity. There is only one possible arrangement (microstate) for the entire system.



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$$E=mc^2$$



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The Third Law of Thermodynamics

The mathematical limit of absolute entropy


$$T \rightarrow 0 \text{ K}$$

$$S \rightarrow 0$$

The entropy of any **pure, perfectly crystalline substance** approaches zero as the temperature approaches absolute zero.

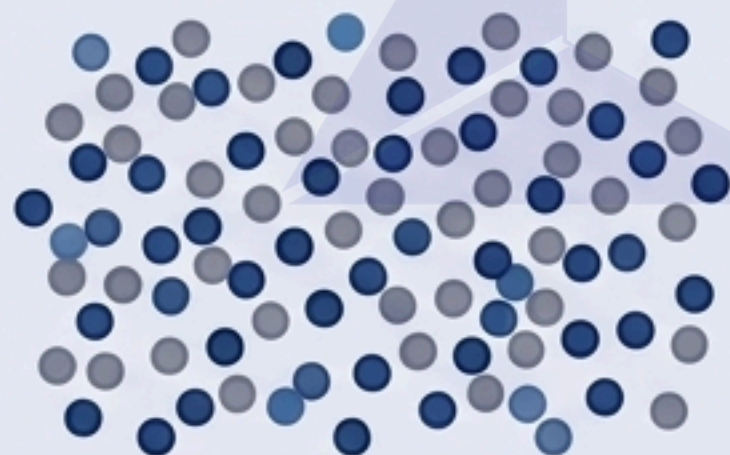
Where the Law Breaks Down

Do not blindly generalize the Third Law to all substances at 0 K



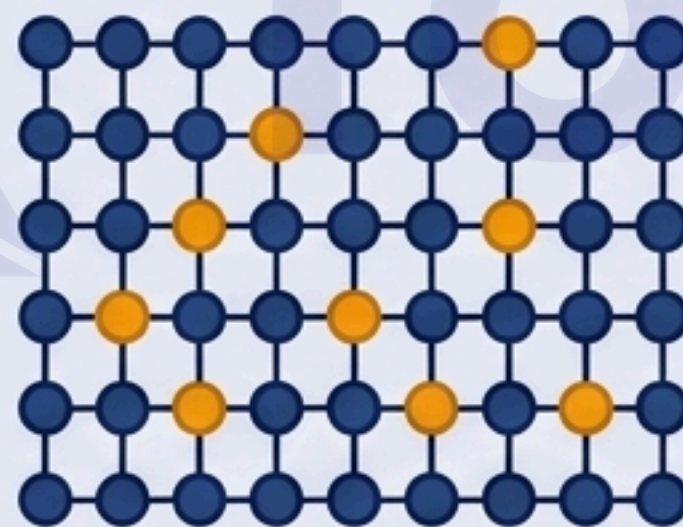
JEE TRAP: $S \neq 0$ at 0 K for systems lacking perfect order.
These systems retain **Residual Entropy**.

Supercooled Liquids (Glasses)



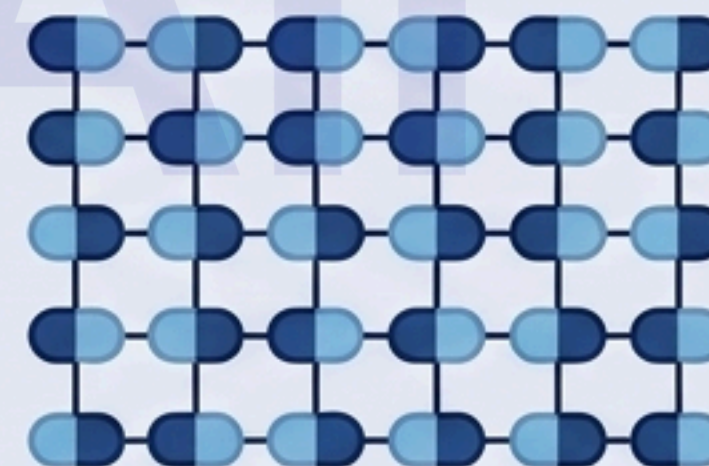
Frozen too fast to form an ordered crystal. Molecules lock into chaotic, random positions.

Solutions & Mixtures



The presence of different types of atoms or molecules prevents perfect uniformity.

Imperfect Crystals



Molecules (like CO or NO) that can lock into the solid lattice in multiple spatial orientations (e.g., CO-CO-OC-CO).

Key Takeaways

Why the Third Law matters in chemical thermodynamics



Absolute Zero Limit

Entropy reaches its absolute minimum at $T = 0$ K.



The Strict Condition

For $S = 0$, the substance must be a **pure** and **perfectly crystalline** solid. (Beware of residual entropy in glasses and mixtures!).



Practical Application

Unlike internal energy (U) or enthalpy (H), we *can* find the absolute value of entropy. The Third Law provides the essential zero-point reference to calculate the **absolute entropy** of substances at any temperature using thermal heat capacity data.



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