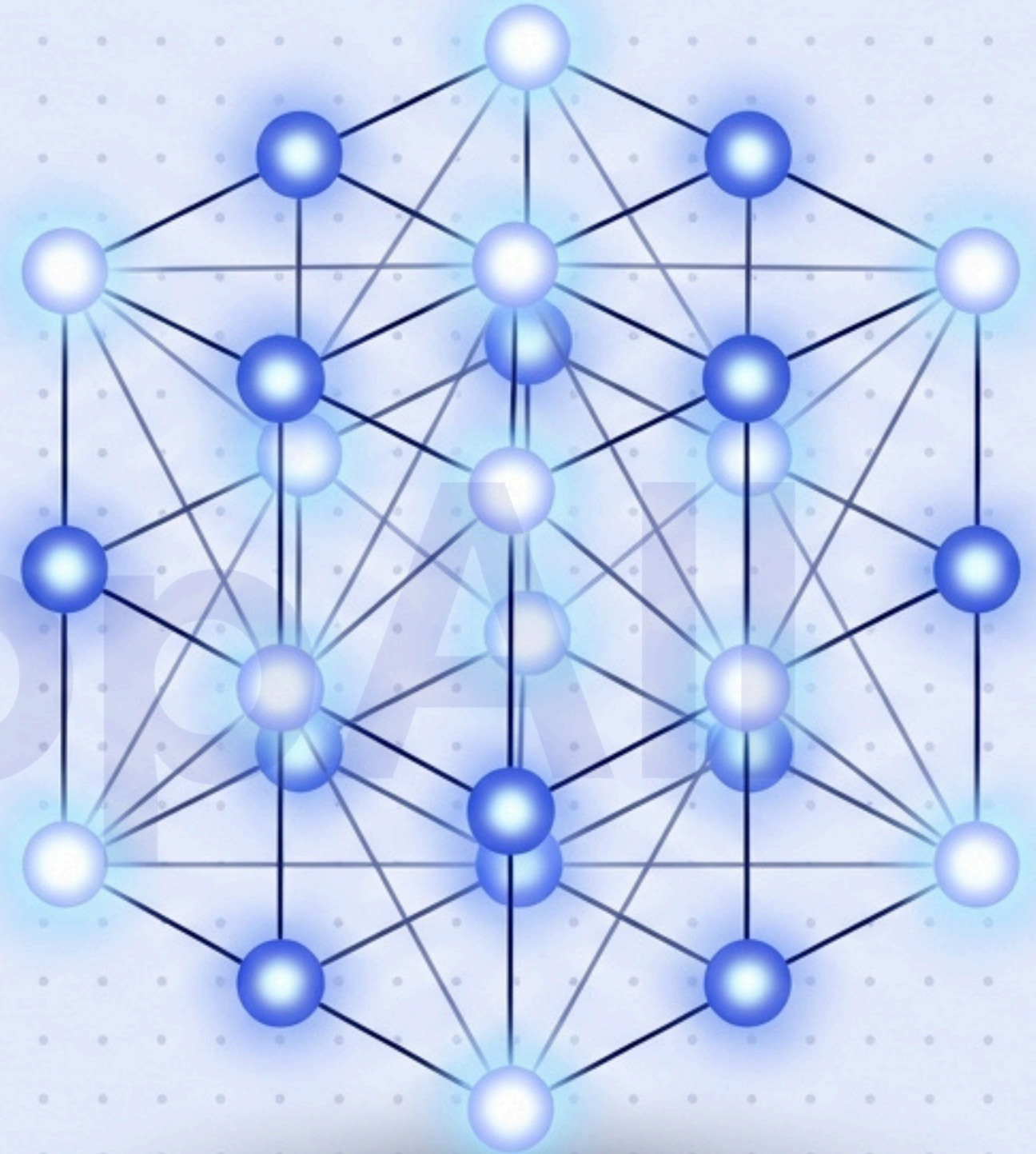


CHAPTER 12: KINETIC THEORY

Specific Heat Capacity of Solids

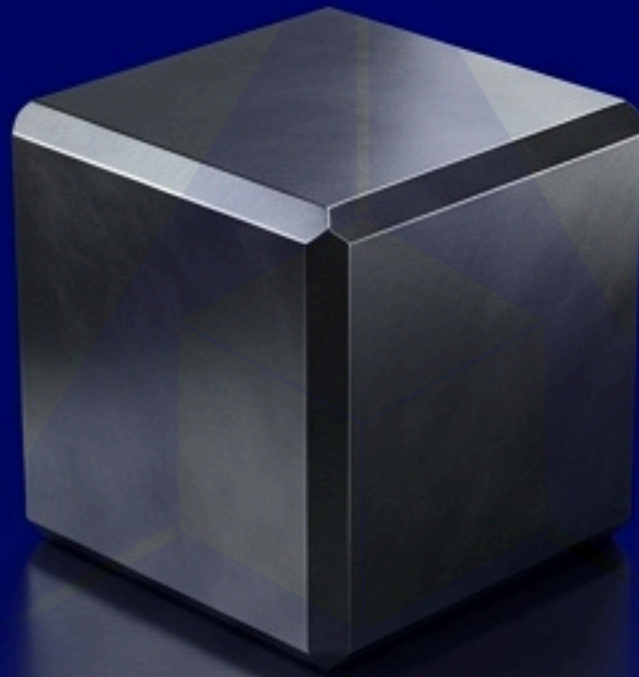
Understanding the Law of Equipartition of Energy in Solids

Class 11 Physics | Target: NEET / JEE

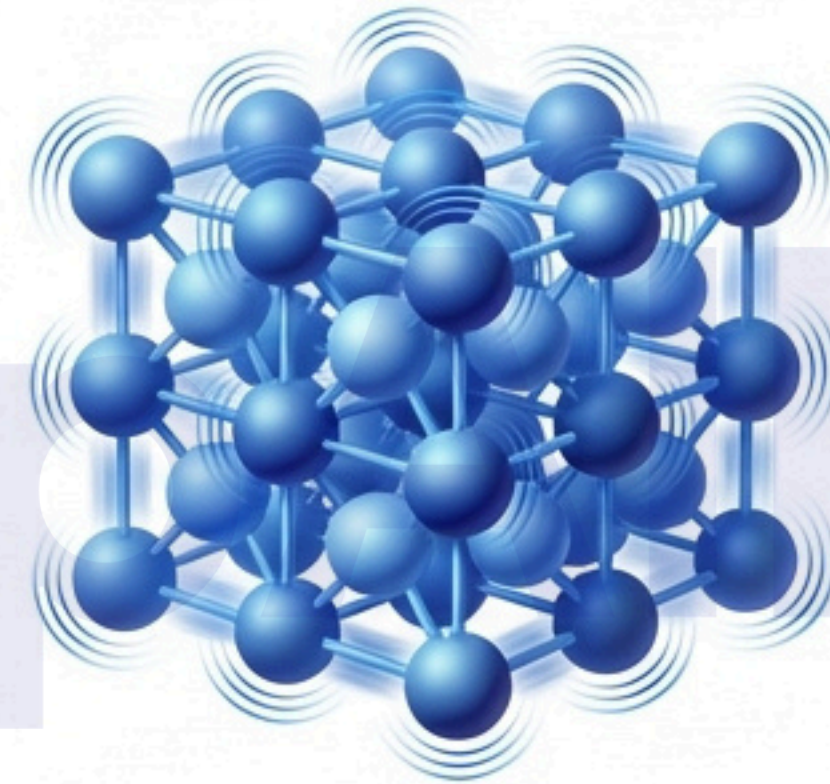


H2. The Illusion of a Static Solid

Macroscopic View: Appears Static



Microscopic View: Constant Vibration



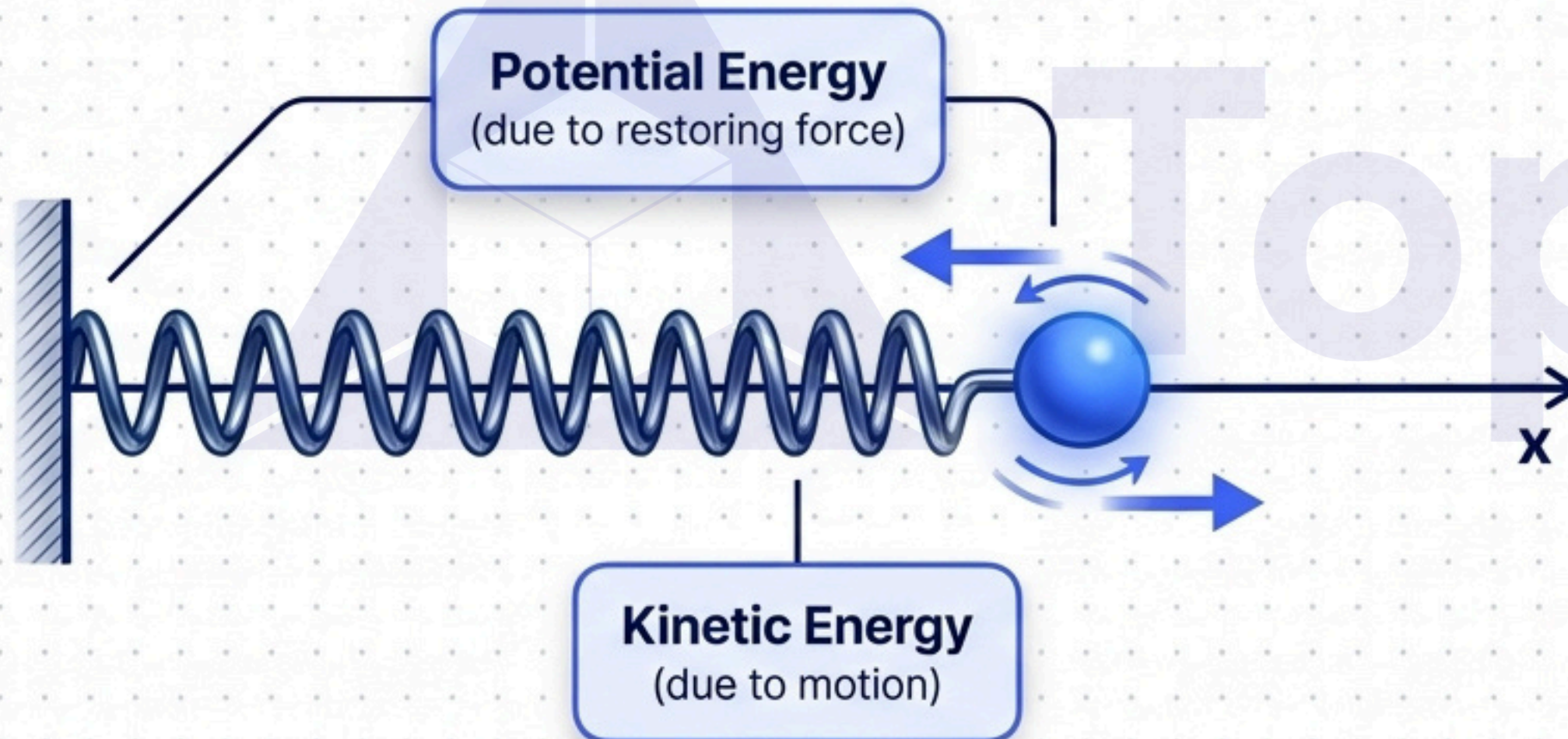
In a solid, atoms are tightly packed and cannot move freely like in a gas.

However, they possess thermal energy and continuously **vibrate about their mean positions.**

This microscopic vibration is the key to understanding a solid's internal energy.

The 1D Oscillator Model

If we look at an atom vibrating in just one dimension (like a mass on a spring), it has two forms of energy:



Equipartition Law

Plus Jakarta Sans
Each energy mode
contributes $1/2 k_B T$

$$\begin{aligned}\text{Total 1D Energy} &= 2 \times (1/2 k_B T) \\ &= k_B T\end{aligned}$$



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$$E=mc^2$$



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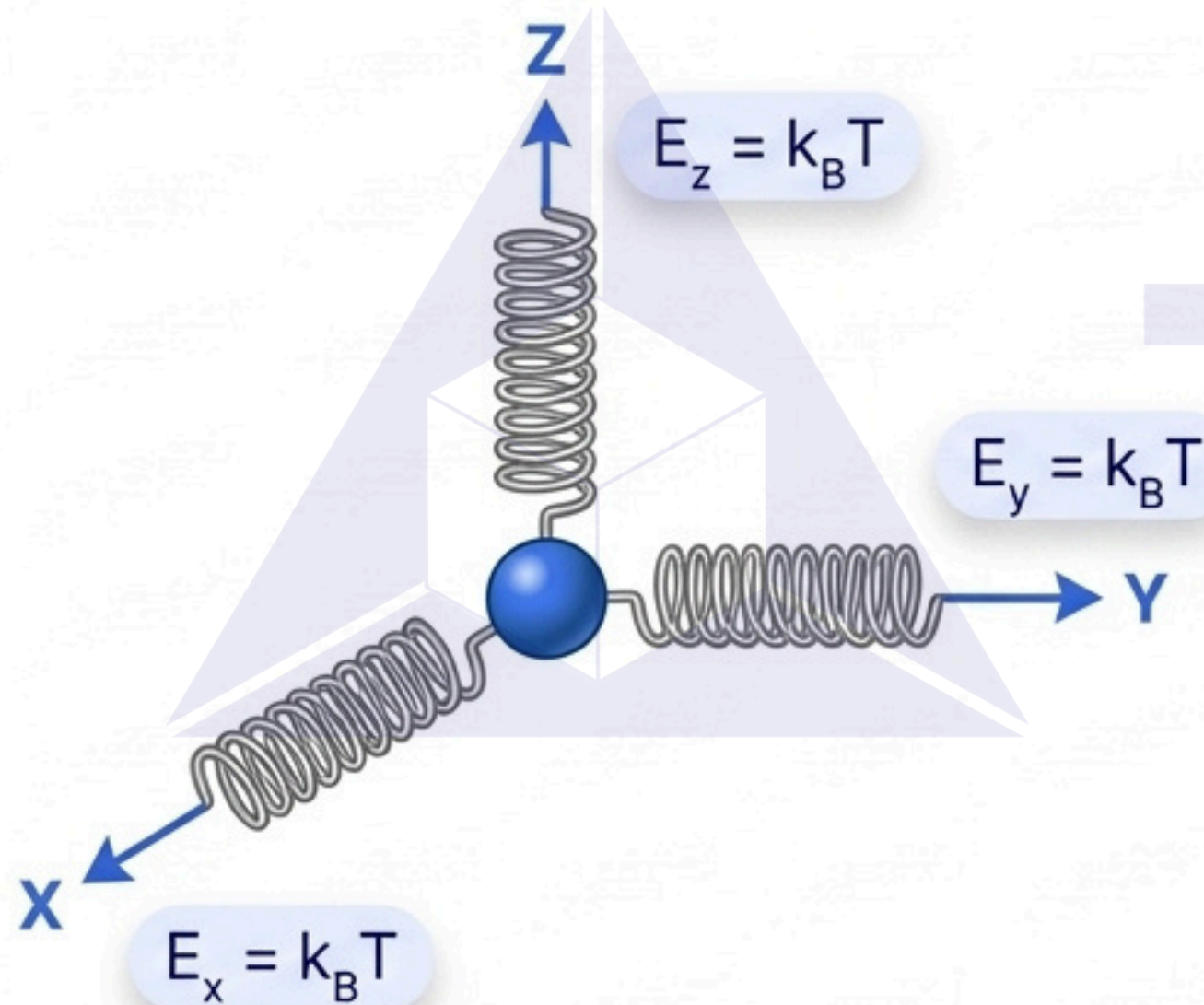
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Expanding to Three Dimensions



Atoms in a real crystal lattice are free to vibrate in three independent directions (x, y, and z).

Since a 1D oscillation has an average energy of $k_B T$...

Average energy of a 3D atom
 $= 3 \times k_B T = 3 k_B T$

H2: Calculating Molar Specific Heat

Single Atom

$$\text{Energy} = 3 k_B T$$

1. Internal Energy (U) for 1 mole

Multiply by Avogadro's number (N_A).

$$U = 3N_A k_B T = 3RT$$

(Eq. 12.37)

2. Molar Specific Heat (C)

At constant pressure, change in V is negligible, so change in Q = change in U.

$$C = \frac{\Delta Q}{\Delta T} = \frac{\Delta U}{\Delta T} = 3R$$

Theory vs. Reality: Does $C = 3R$ actually work?

Since $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$, the predicted specific heat is **$3R \approx 24.9 \text{ J mol}^{-1} \text{ K}^{-1}$** .

Table 12.3 Data

Element	Predicted C (3R)	Measured C
Aluminum (Al)	24.9	24.4
Copper (Cu)	24.9	24.5
Silver (Ag)	24.9	23.6
Lead (Pb)	24.9	26.5



[EXAM TIP] The theory agrees well with experiment at ordinary temperatures. (Note: The model fails at very low temperatures, and Carbon is a notable exception).

KEY TAKEAWAYS

Chapter 12: Solid Specific Heat

Microscopic Motion

Atoms in a solid vibrate in 3D around fixed mean positions.

Energy Modes

Each 3D atom has an average energy of $3 k_B T$ (Kinetic + Potential modes).

Molar Energy

For one mole, Internal Energy is $U = 3 R T$.

Specific Heat

The molar specific heat capacity for solids is $C = 3R$ (approx $24.9 \text{ J mol}^{-1} \text{ K}^{-1}$).

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