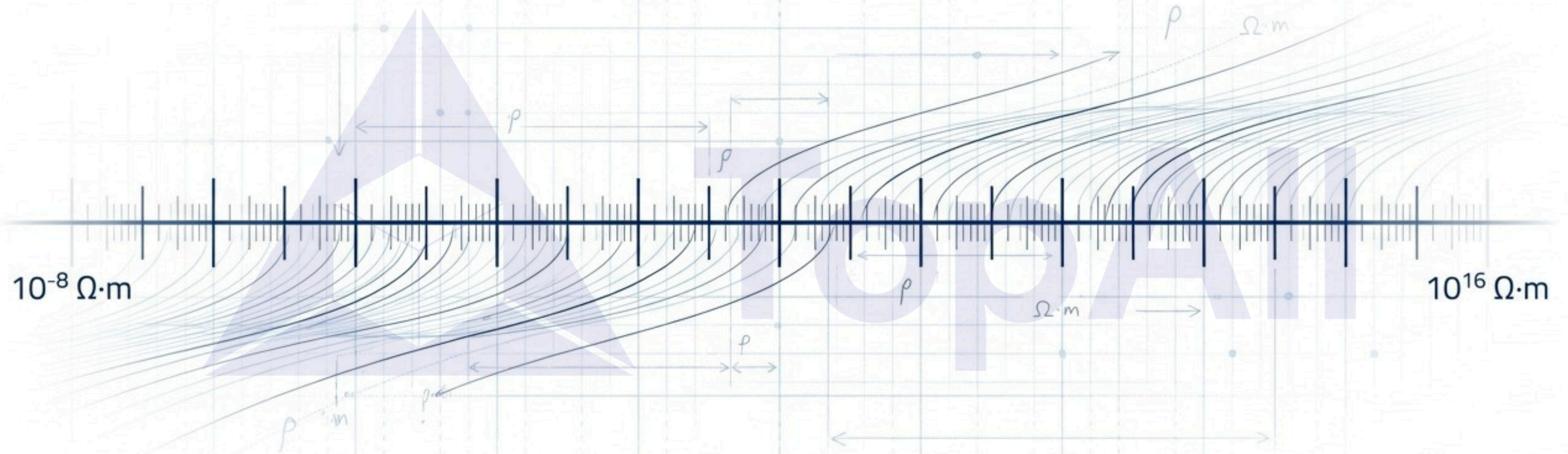


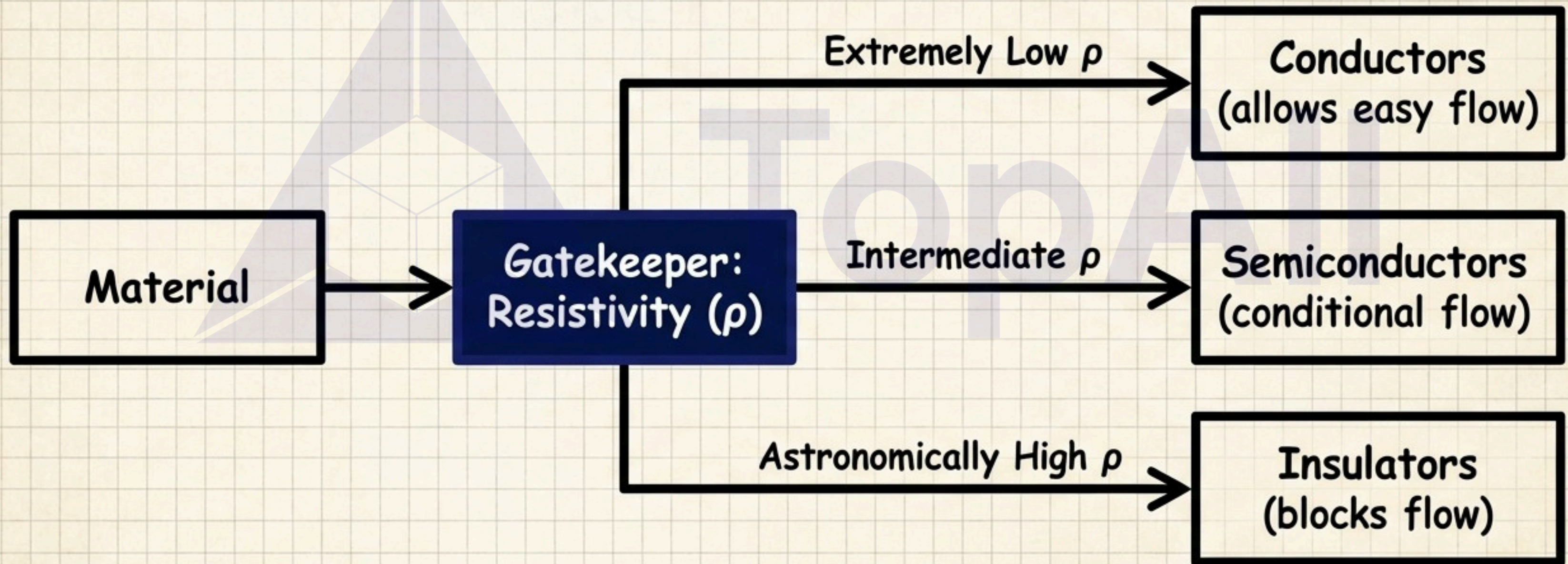
Conductors, Semiconductors and Insulators

Material classification through the lens of electrical resistivity (ρ).

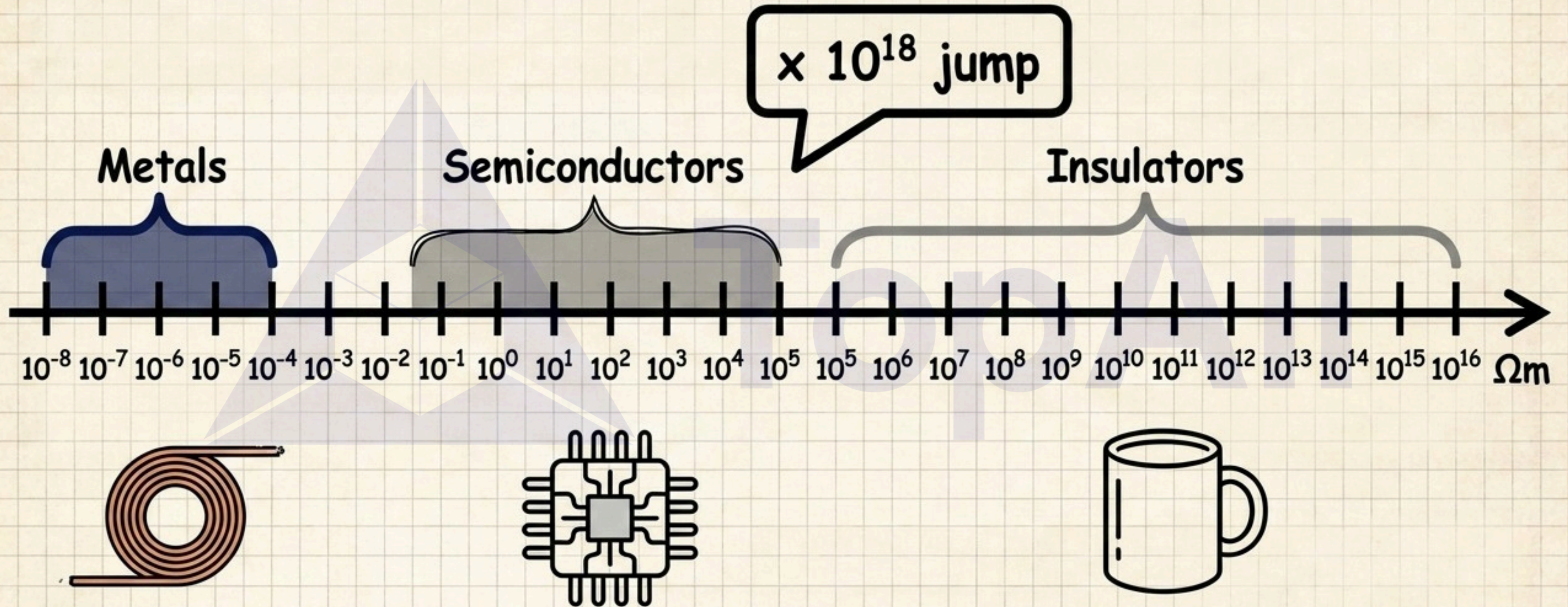


Classification by Resistivity

Materials are classified into three distinct categories based on their inherent opposition to current flow, sorted in increasing order of their resistivity values.



The Resistivity Spectrum





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$$E=mc^2$$



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Formula / Rule Bank

METALS:

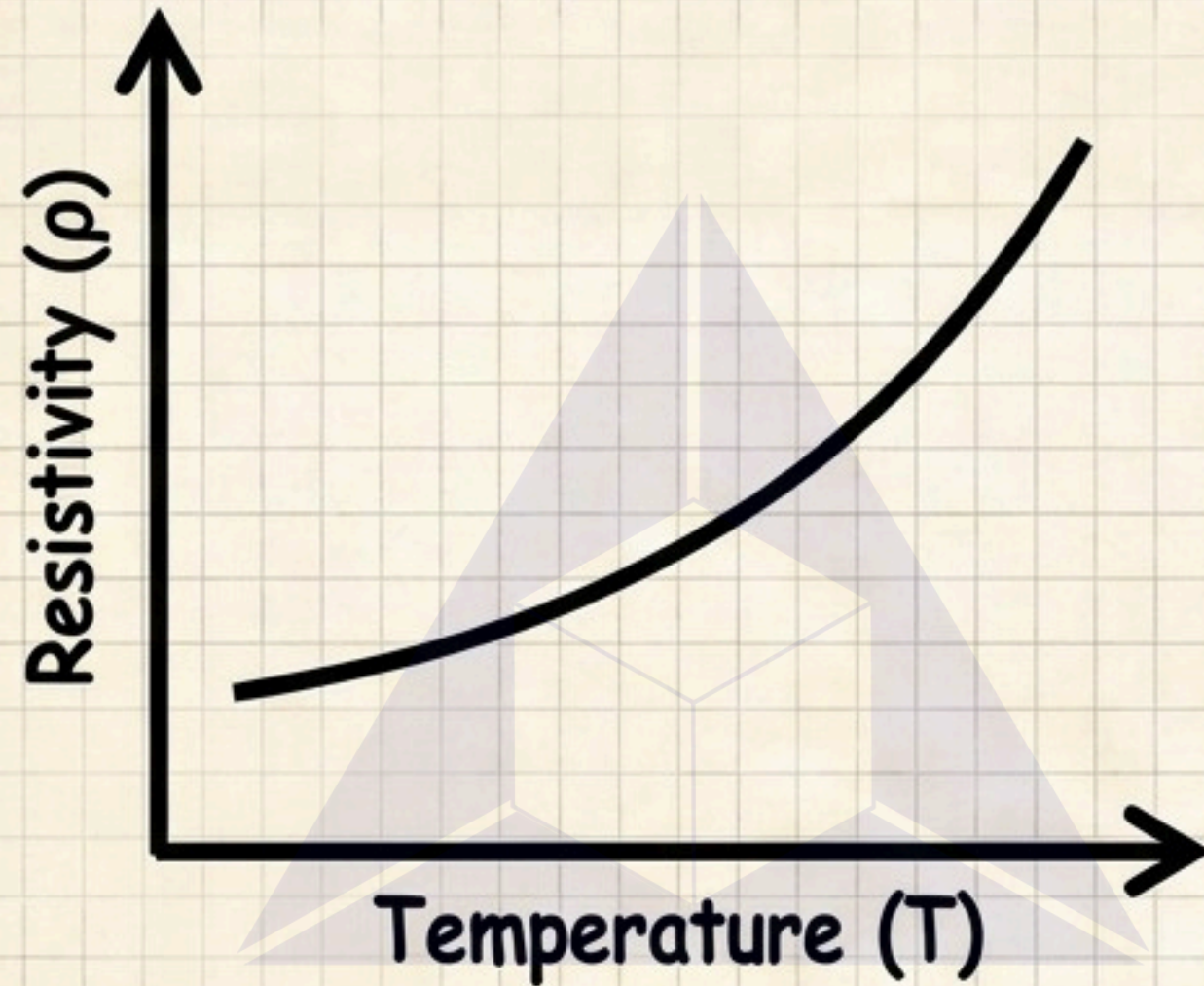
ρ range of $10^{-8} \Omega\text{m}$ to $10^{-6} \Omega\text{m}$
(Extremely low resistivity)

SEMICONDUCTORS: ρ sits in the middle range.
Examples: Silicon (Si), Germanium (Ge).
Note: Resistivity can be actively decreased by adding impurities.

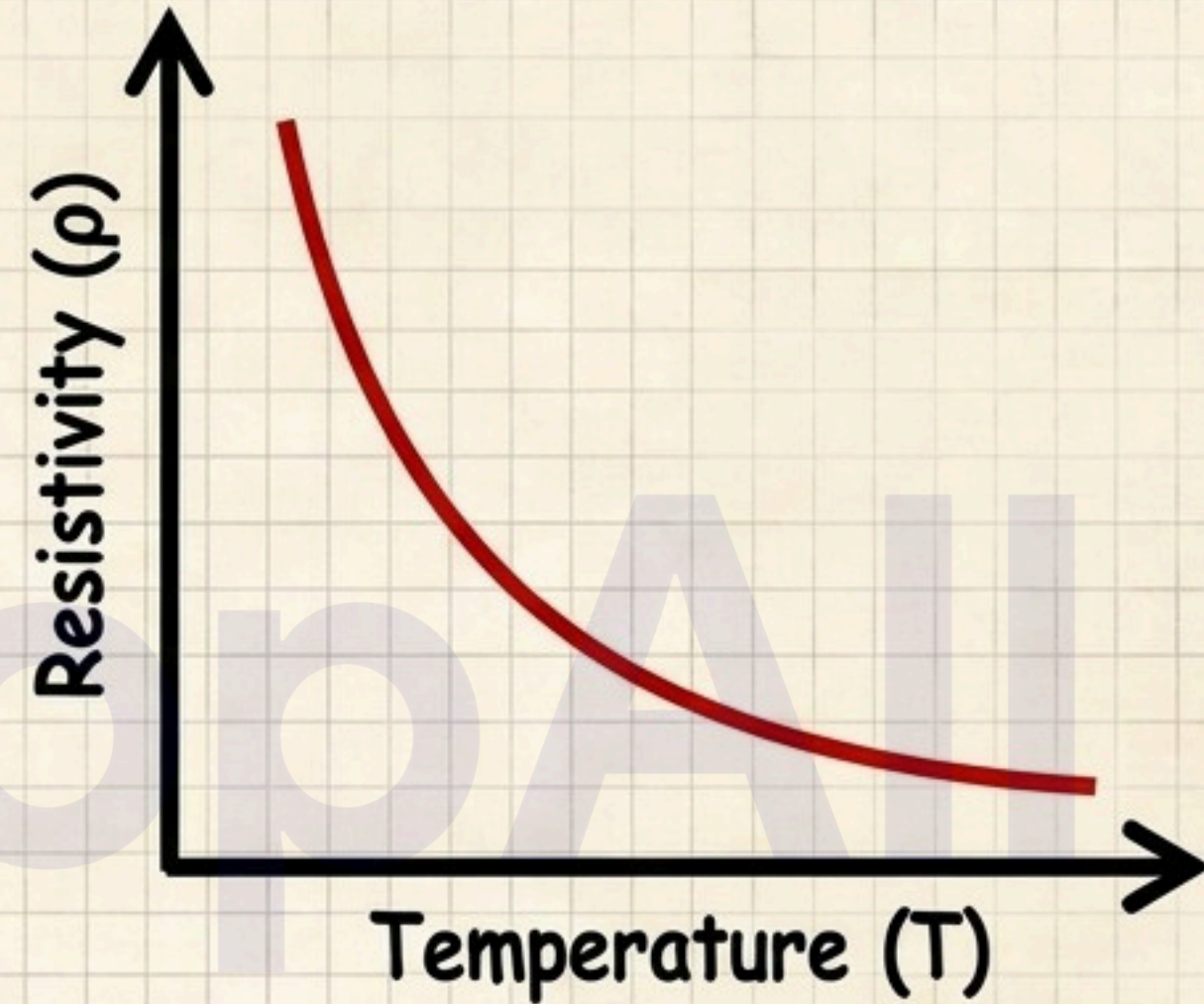
INSULATORS:

ρ values 10^{18} times greater than metals.
Examples: Ceramic, rubber, plastics.

JEE Trap Alert: The Temperature Paradox



Metals: Heating INCREASES ρ

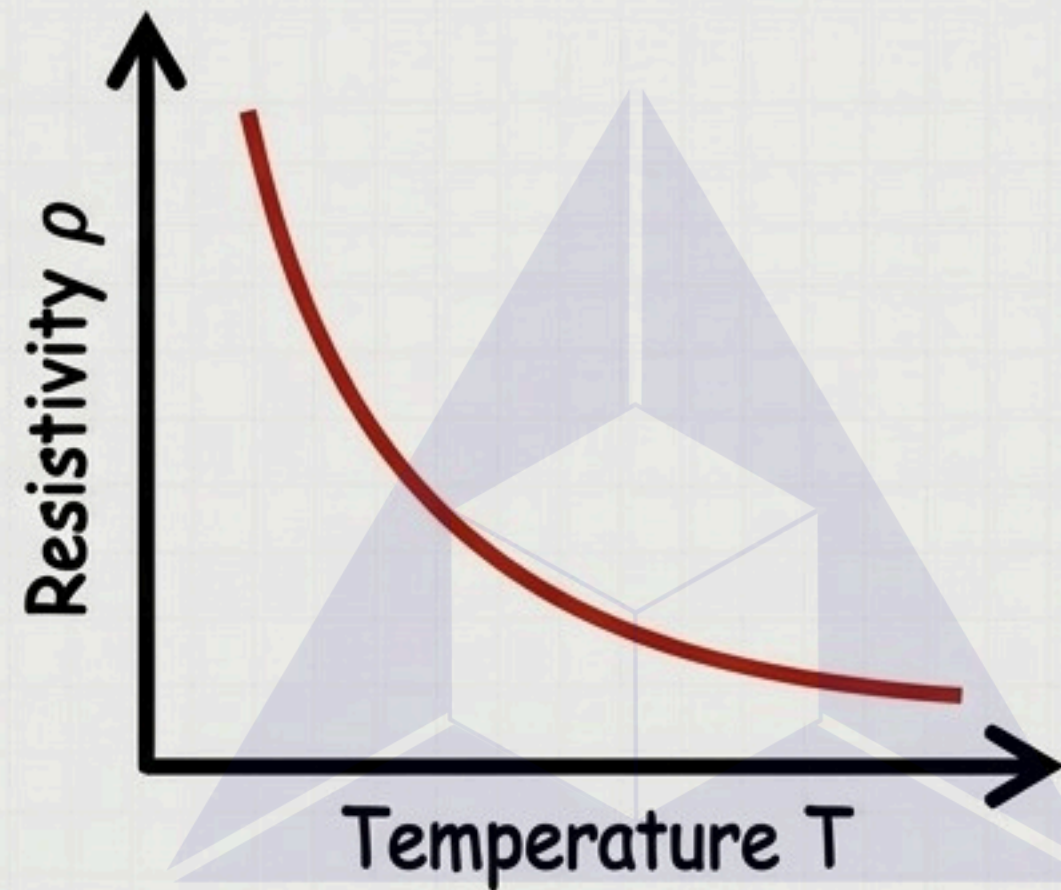


Semiconductors: Heating DECREASES ρ

$$\rho = \frac{m}{ne^2\tau}$$

Trap: In semiconductors, raising T causes carrier density (n) to explode. This massive increase in n more than compensates for the decrease in relaxation time (τ), causing overall resistivity to drop.

Mini Application: Pattern Recognition



Question: A material exhibits the ρ - T profile shown above. Classify this material and state what happens to its carrier density (n) as T increases.

Step 1:
 ρ decreases with $T \rightarrow$ Negative temperature coefficient.

Step 2:
Conclusion $\rightarrow$ Material is a Semiconductor.

Step 3:
Microscopic reason $\rightarrow$ Carrier density (n) increases exponentially with temperature, dominating the ρ equation.

Revision Card: The Master Matrix



	Conductors	Semiconductors	Insulators
Resistivity (ρ) Range	Low (10^{-8} to $10^{-6} \Omega\text{m}$)	Medium	Ultra-High ($>10^{18}$ x metals)
Temperature Effect (as $T \uparrow$)	ρ Increases (α is positive)	ρ Decreases	N/A (remains blocking)
Primary Charge Carriers	Electrons	Electrons & Holes	None (bound)
Key Examples	Copper, Silver	Silicon, Germanium	Ceramic, Rubber

Rule of Thumb: The scale differentiates them; the temperature defines them.



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