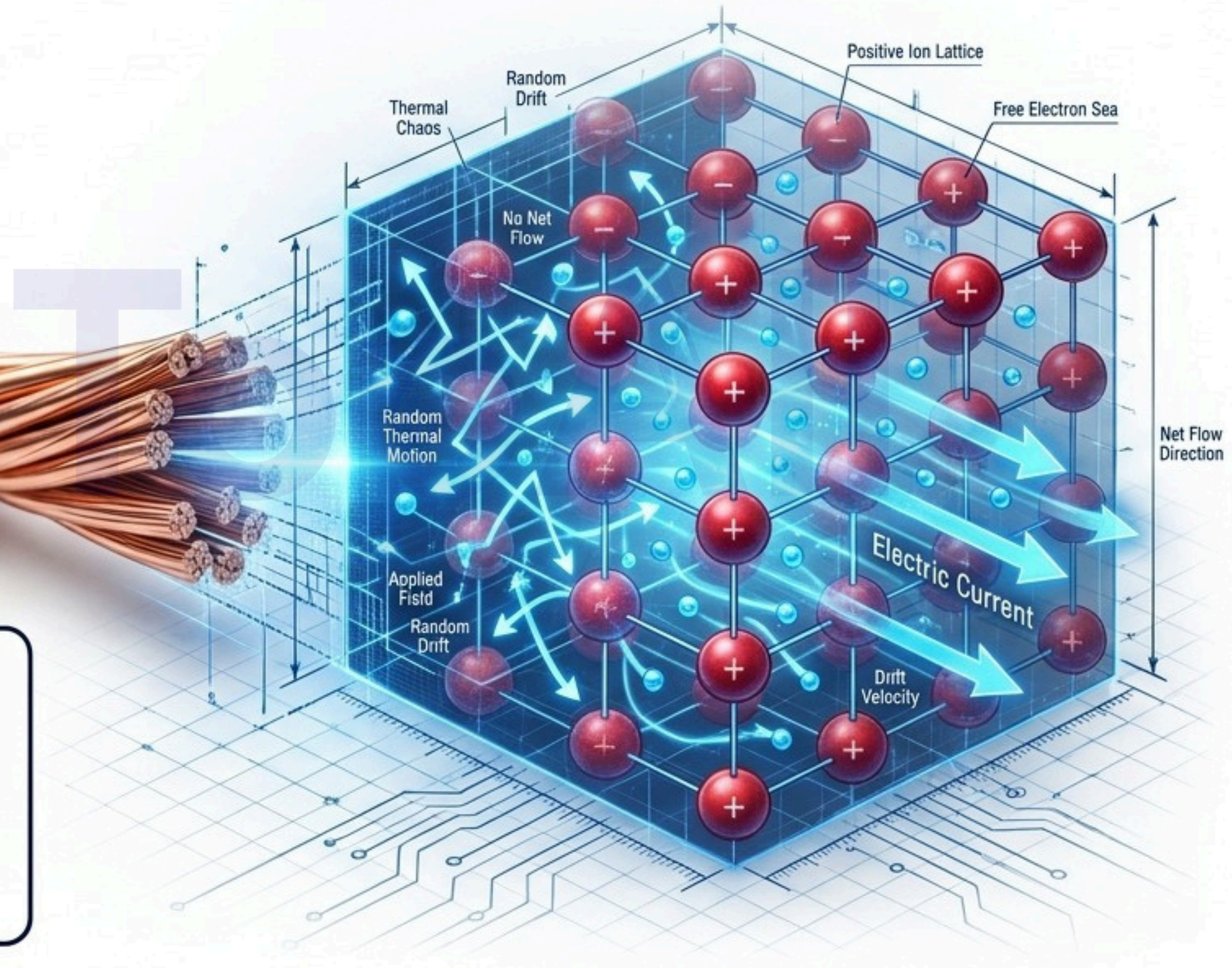


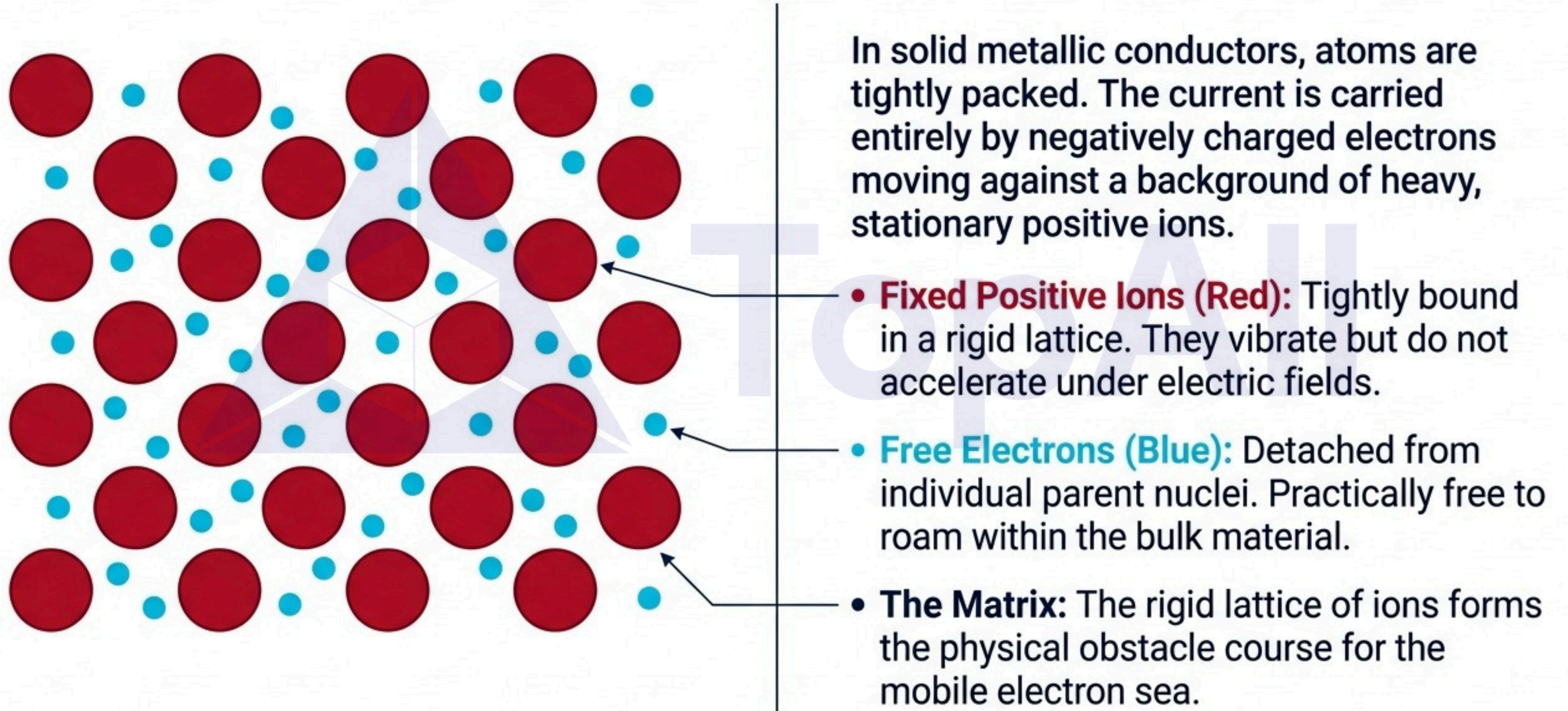
# Why Random Electrons Give Zero Current

[SUBHEADING] Mastering Electric Currents in Solid Conductors: From Thermal Chaos to Steady Drift.

Charges in motion constitute an **electric current**. But in a standard metal, millions of electrons are moving right now at incredible speeds—so why don't you get shocked when you touch it?

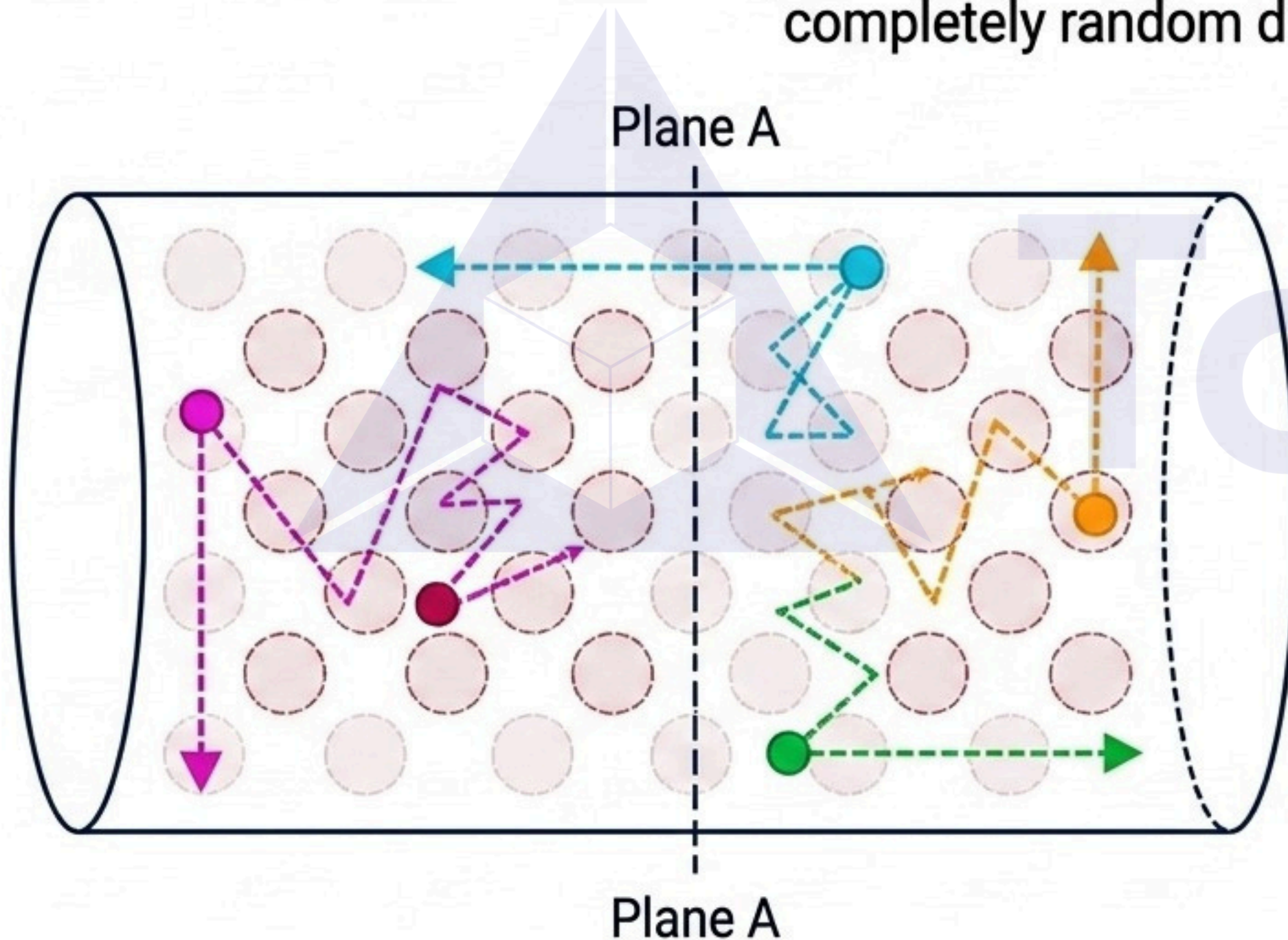


# Core Concept: The Anatomy of a Conductor



# Main Diagram: Thermal Motion & Zero Net Flow

Without an external electric field, free electrons move purely due to thermal energy. They collide constantly with fixed ions, emerging with the same speed but in completely random directions.



- **No Preferential Direction:** For every electron moving right across the plane, another moves left.
- **Mathematical Cancellation:** Net positive charge flow ( $q_+$ ) minus net negative charge flow ( $q_-$ ) across any area strictly equals zero.
- **Result:** Net Electric Current ( $I$ ) = 0.



# You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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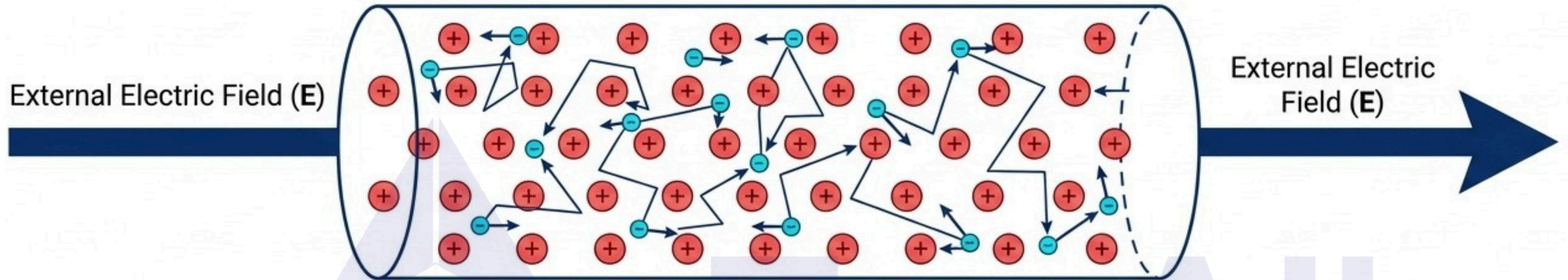
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# Formula & Rule Bank: Introducing the Electric Field



// Current across an area in forward direction:

$$I = q / t$$

Where  $q = q_+ - q_-$  (net charge flowing across area)

// Limit definition for non-steady current:

$$I(t) = \lim(\Delta t \rightarrow 0) (\Delta Q / \Delta t)$$

*The Rule of Drift:* An applied electric field (E) forces free electrons to accelerate. Because they carry a negative charge (-e), they experience a force and drift in the exact opposite direction of the electric field to neutralize charges.

# JEE Trap Alert

Thermal Speed



Drift Speed



**TRAP:** High electron speed means a high electric current.

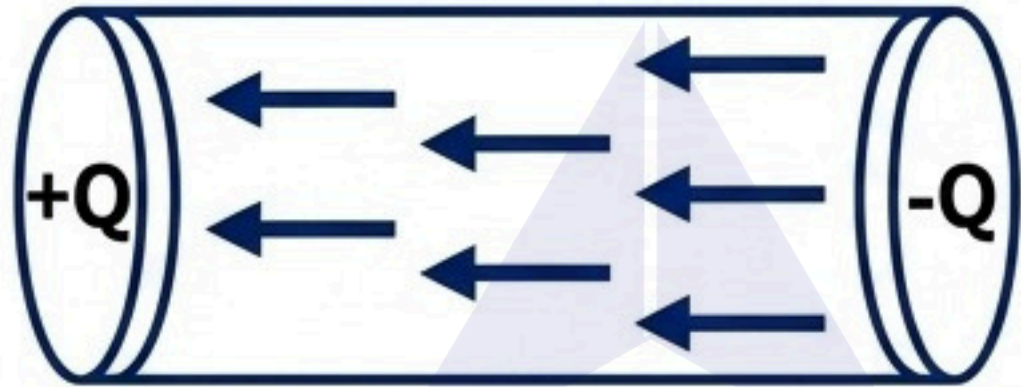
**REALITY:** Do not confuse Thermal Speed with Drift Speed.

- **Thermal Speed:** Electrons vibrate randomly at massive speeds (approx.  $10^5 \text{ m/s}$  at room temp). Net current contribution = 0.
- **Drift Speed:** The electric field causes a tiny, slow unified drift (approx.  $10^{-3} \text{ m/s}$ ). Net current contribution = 100%.

**Exam Takeaway:** Current is defined by the net transport of charge across a cross-section over time. High-speed microscopic chaos alone does not equal net current.

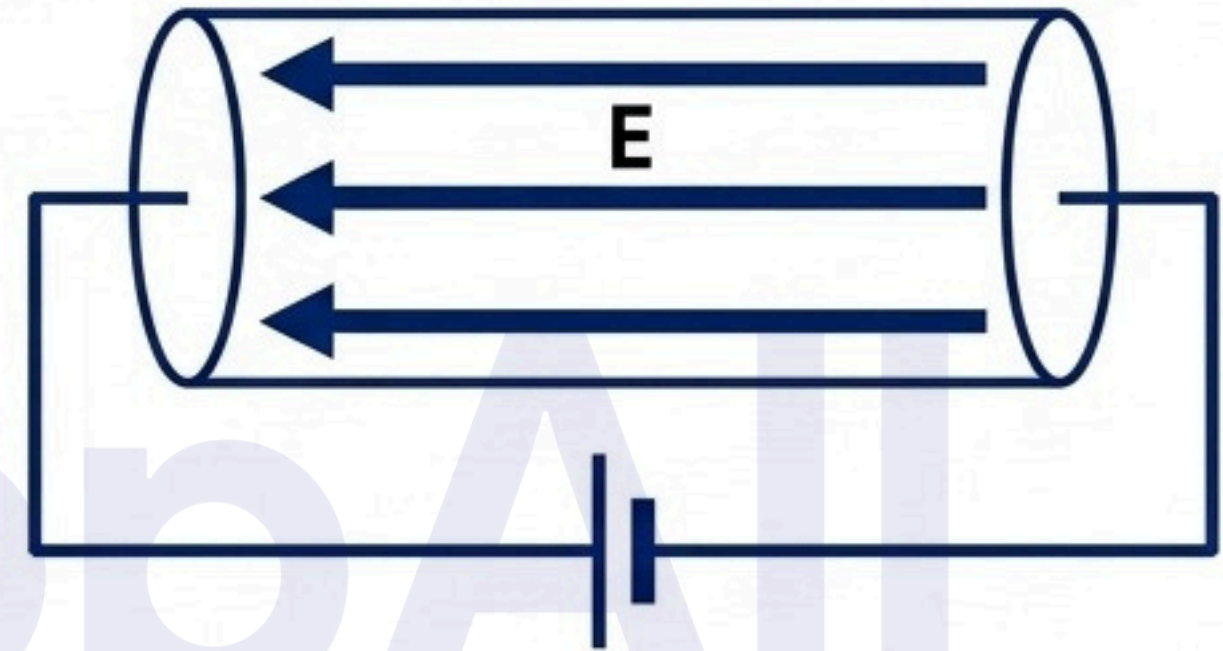
# Mini Application: Temporary vs. Maintained Current

What happens when an electric field is applied? The duration of the current depends on the source.



## Panel A: Temporary Current (Dielectric Discs)

- **Setup:** Cylinder with +Q disc on left, -Q disc on right.
- **Action:** Electric field (E) is created. Electrons drift towards +Q to neutralize it.
- **Result:** Current flows for a fraction of a second, then stops once charges are neutralized. E drops to 0.



## Panel B: Steady Current (Battery)

- **Setup:** Cylinder connected to a cell/battery.
- **Action:** The battery continuously replenishes fresh charges to the ends of the cylinder.
- **Result:** A steady Electric field (E) is maintained in the body. Electrons continuously flow. Current is steady.

# Revision Card

## The Logic of Conductor Currents

### 1. NO FIELD (Equilibrium):

Random Thermal Motion → Frequent Collisions → Zero Net Velocity → **ZERO CURRENT.**

### 2. STATIC FIELD (Discharge):

Electric Field Applied → Electrons Drift Opposite to  $E$  → Neutralize End Charges →  
→ **TEMPORARY CURRENT.**

### 3. MAINTAINED FIELD (Circuit):

Battery attached → Continuous Potential Difference Maintained → Constant E-Field & Drift  
→ **STEADY CURRENT.**

**Remember:** Steady electric currents flow in everyday devices exactly like water flowing smoothly in a river—they require a continuous pump (battery/cell) to maintain the flow against the resistance of the fixed positive ions.



# You've Learned the Theory.

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