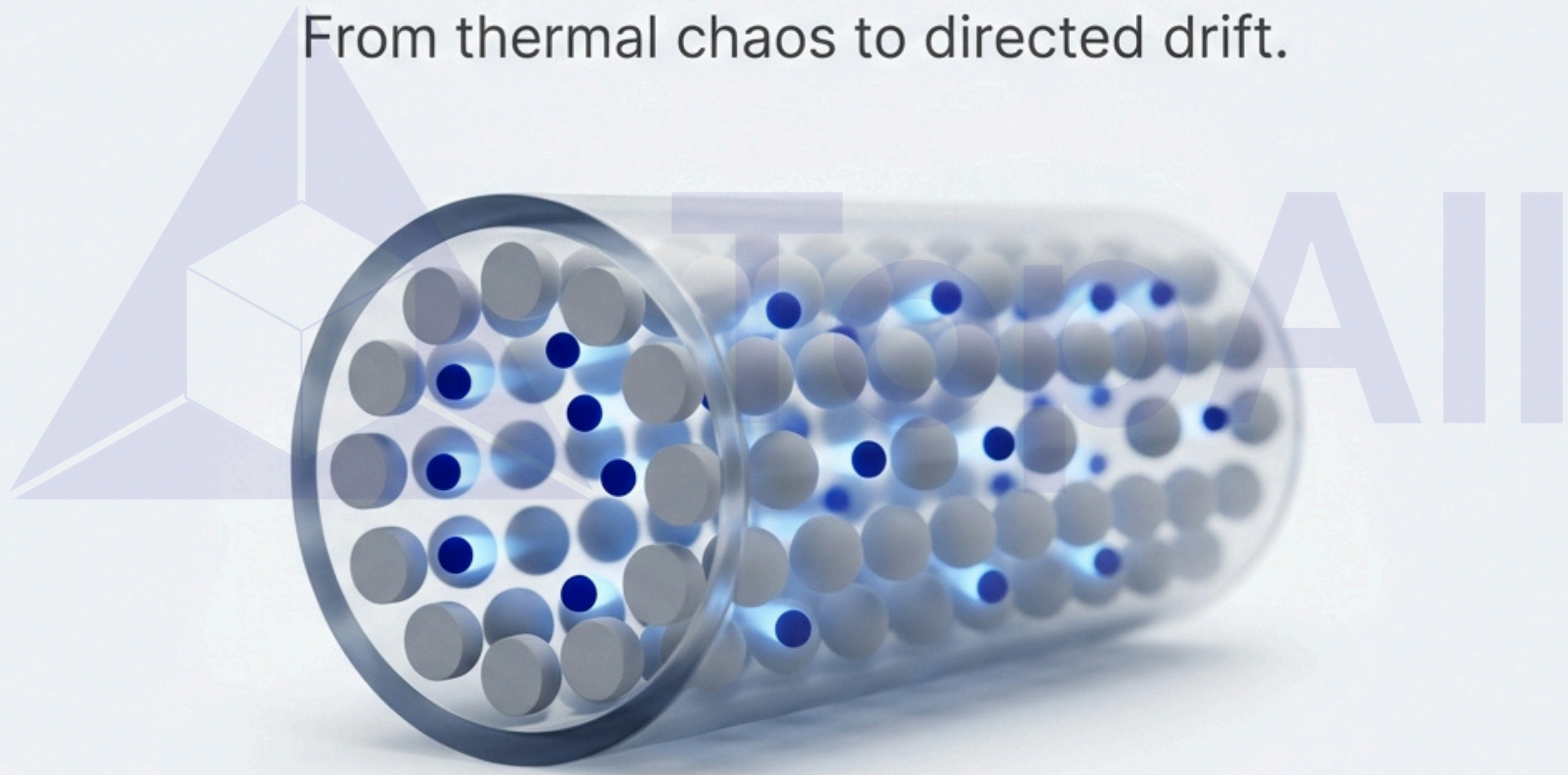
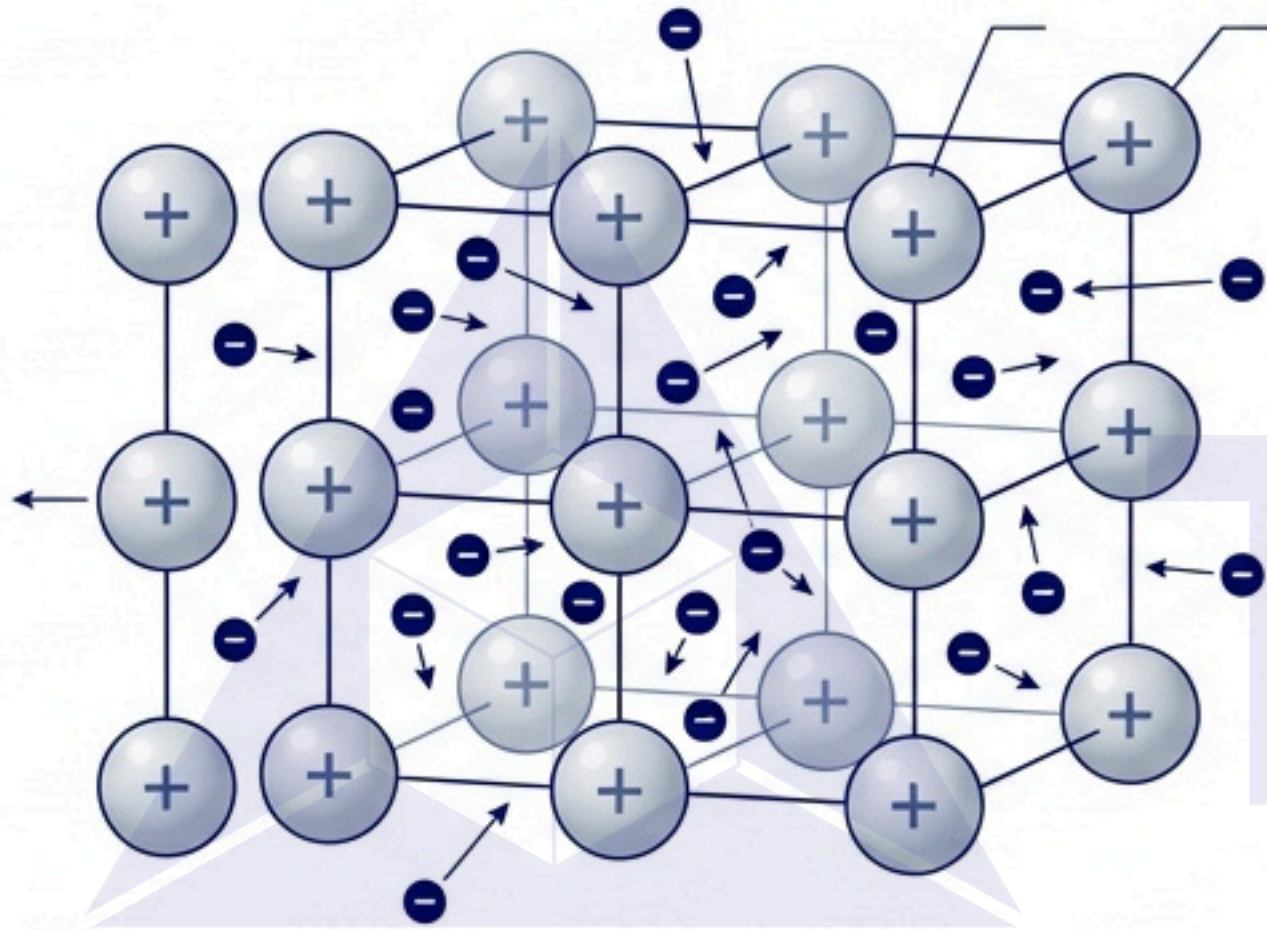


Electric Currents in Conductors

From thermal chaos to directed drift.



What Makes a Conductor Conduct?



FIXED POSITIVE IONS

Heavy, immobile, and tightly bound to each other in a crystalline structure.

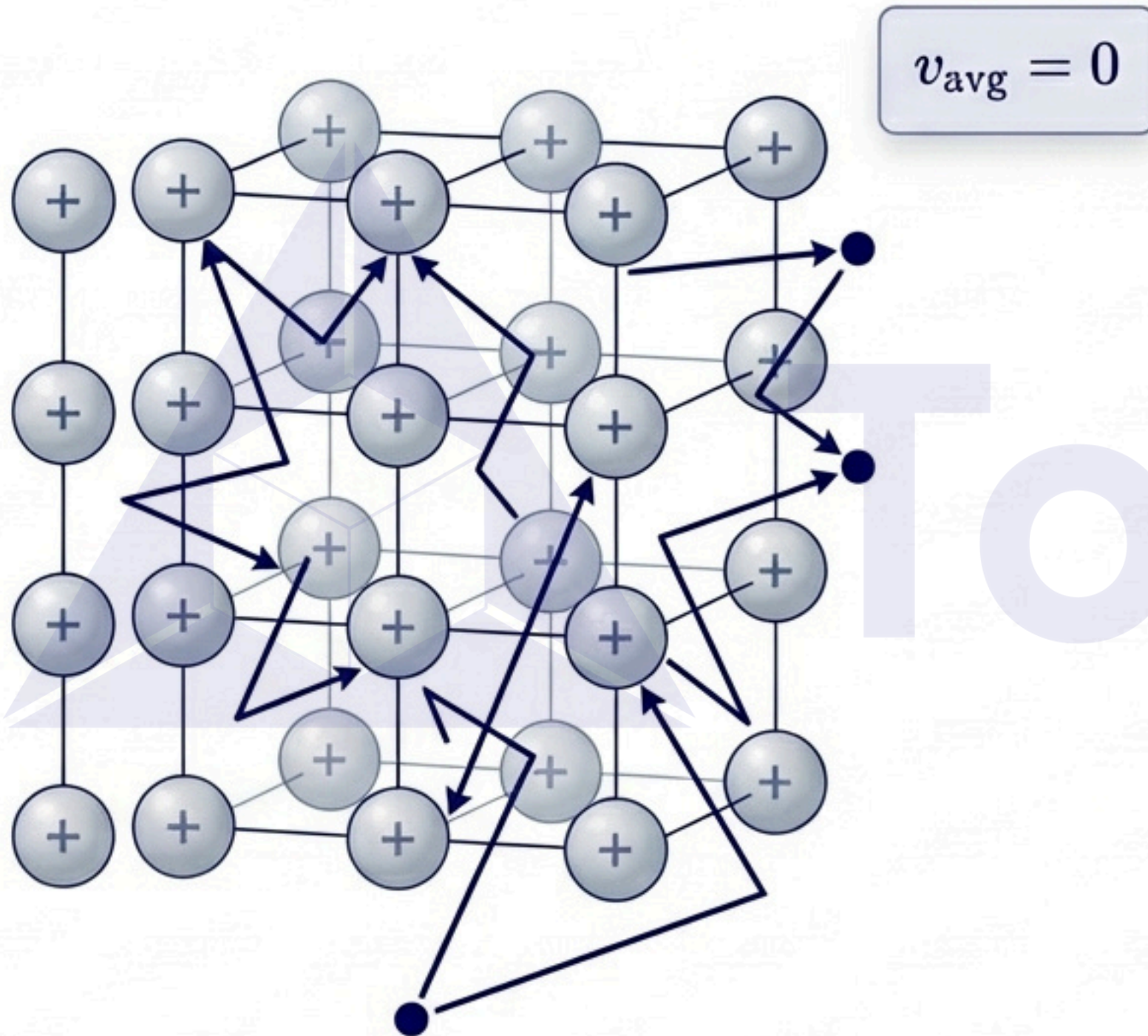
FREE ELECTRONS

Detached from individual nuclei, forming a highly mobile 'sea' or 'gas' within the bulk material.

EXAM FOCUS CALLOUT

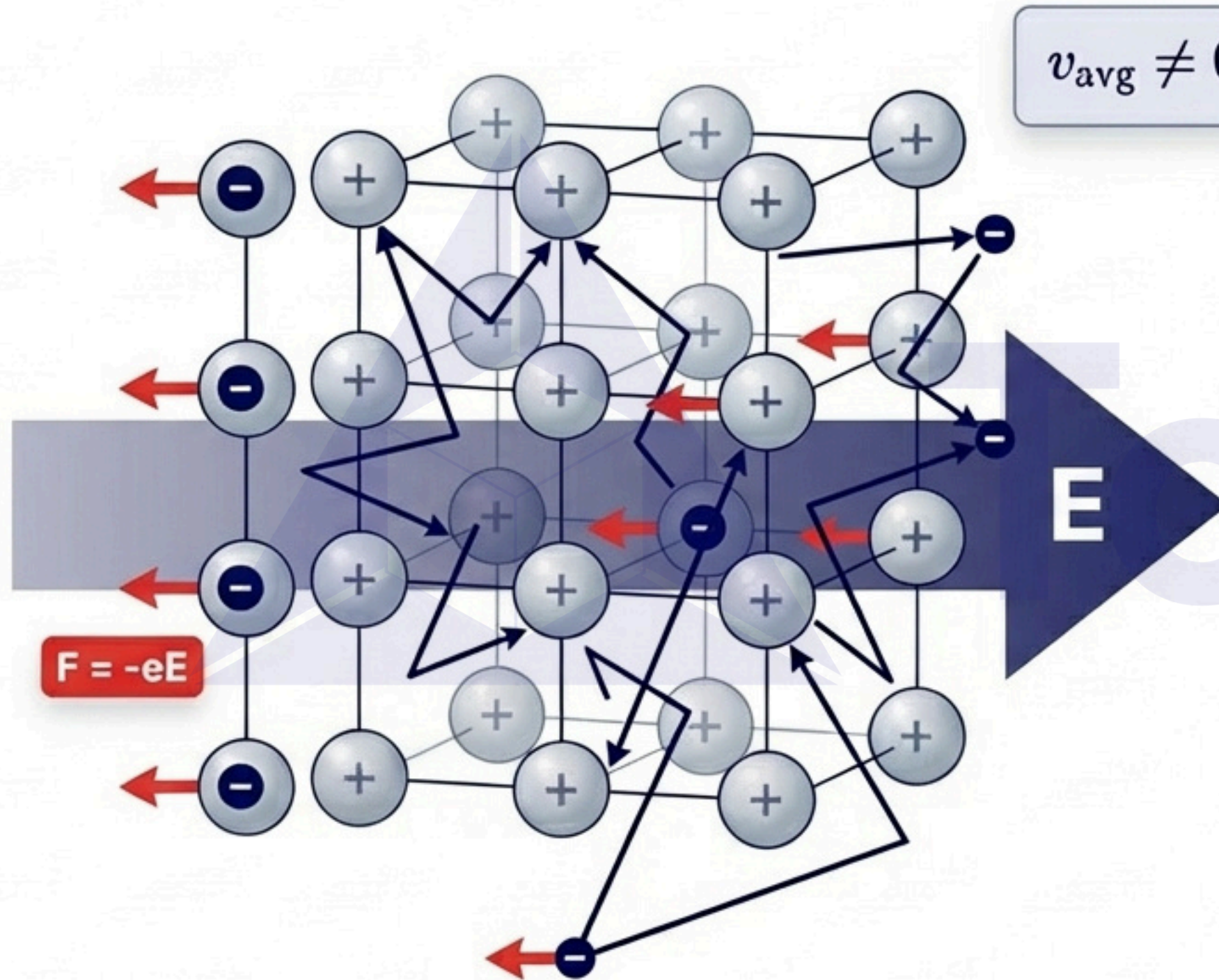
Crucial Distinction: In solid conductors (unlike electrolytic solutions), electric current is carried solely by negatively charged electrons.

Free Electron Motion (State 0)



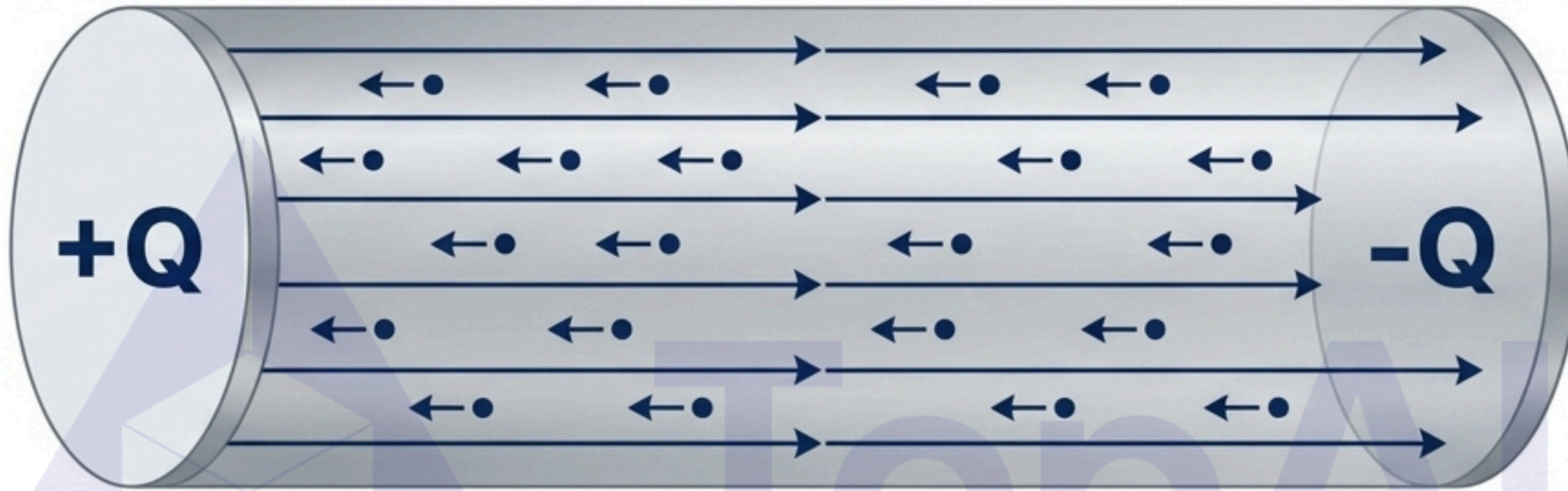
- **Thermal Motion:** Electrons move at high speeds due to temperature.
- **Random Collisions:** Electrons collide with fixed ions; emergence velocity is the same, but direction is completely randomized.
- **Zero Net Flow:** Because there is no preferential direction, the average velocity of all electrons at any given time is zero. No electric current exists.

The Applied Field (Directed Motion Begins)



- **THE DISRUPTING FORCE:**
An applied electric field (E) exerts a uniform force on every free electron.
- **SUPERIMPOSED DRIFT:**
Electrons still collide randomly, but they acquire a slow, directed velocity (drift) opposite to the electric field.
- **NET FLOW:** This directed migration constitutes an electric current.

The Metallic Cylinder Model



STEP 1

Attach $+Q$ and $-Q$ dielectric discs to the cylinder ends.

STEP 2

An internal Electric Field (E) is instantly created from $+Q$ to $-Q$.

STEP 3

Free electrons accelerate toward the $+Q$ end to neutralize the charges.

STEP 4

Once neutralized, the field vanishes and the transient current stops.

Continuous Flow Note: To make this current steady, a continuous charge supply mechanism (like a battery) is required.

Key Takeaways

- ✓ **[The Actors]:** In solid metallic conductors, current is exclusively carried by free electrons moving through a lattice of fixed positive ions.
- ✓ **[Thermal Equilibrium]:** Without an external field, electron motion is chaotic and random. Net current is exactly zero ($I = 0$).
- ✓ **[Directed Drift]:** Applying an electric field forces electrons to drift opposite to the field lines, transforming random chaos into a measurable electric current ($I > 0$).