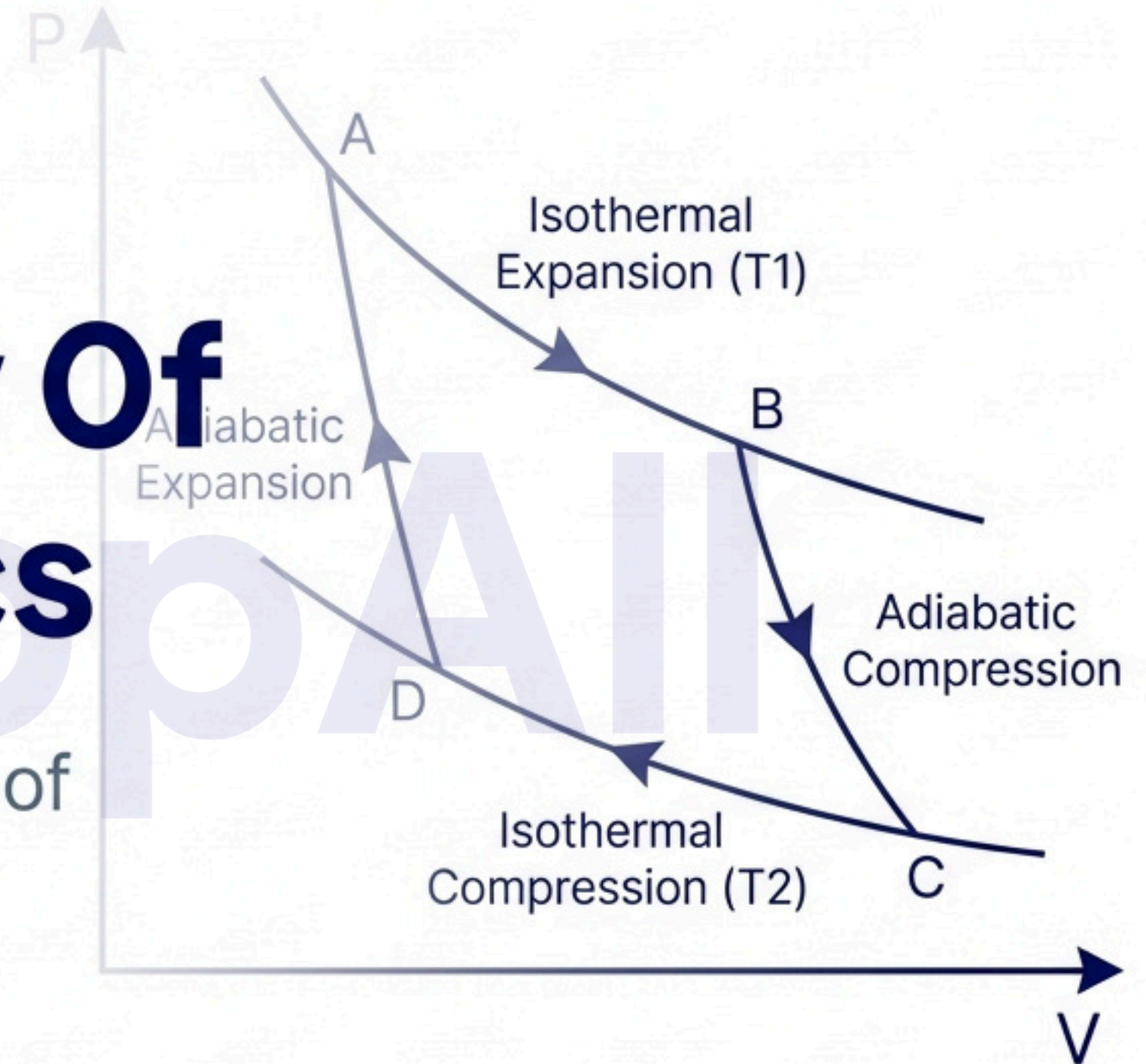


CLASS 11 PHYSICS • CHAPTER 11

The Second Law Of Thermodynamics

Understanding the fundamental limits of heat, work, and nature's direction.



CONCEPT CHECK

The Limitation Of The First Law

The First Law dictates that energy is conserved ($\Delta Q = \Delta U + \Delta W$). However, it tells us nothing about the direction in which a process can naturally occur.

- ✓ Many processes perfectly obey energy conservation but are never observed in nature.
- ✓ A new principle is required to explain the spontaneous direction of heat and work.

Conservation of Energy



Perfectly Balanced

Direction of Process



The Missing Piece

The Jumping Book Paradox

Imagine a book resting on a table. What if the table spontaneously cooled down, transferring its internal thermal energy into mechanical potential energy to make the book jump?

Step 1



Book on Cooling Table

Step 2



Book Spontaneously Jumps

1st Law

Allows this! Total energy is perfectly conserved.

Reality

This never happens. Heat cannot spontaneously convert entirely into targeted mechanical work.



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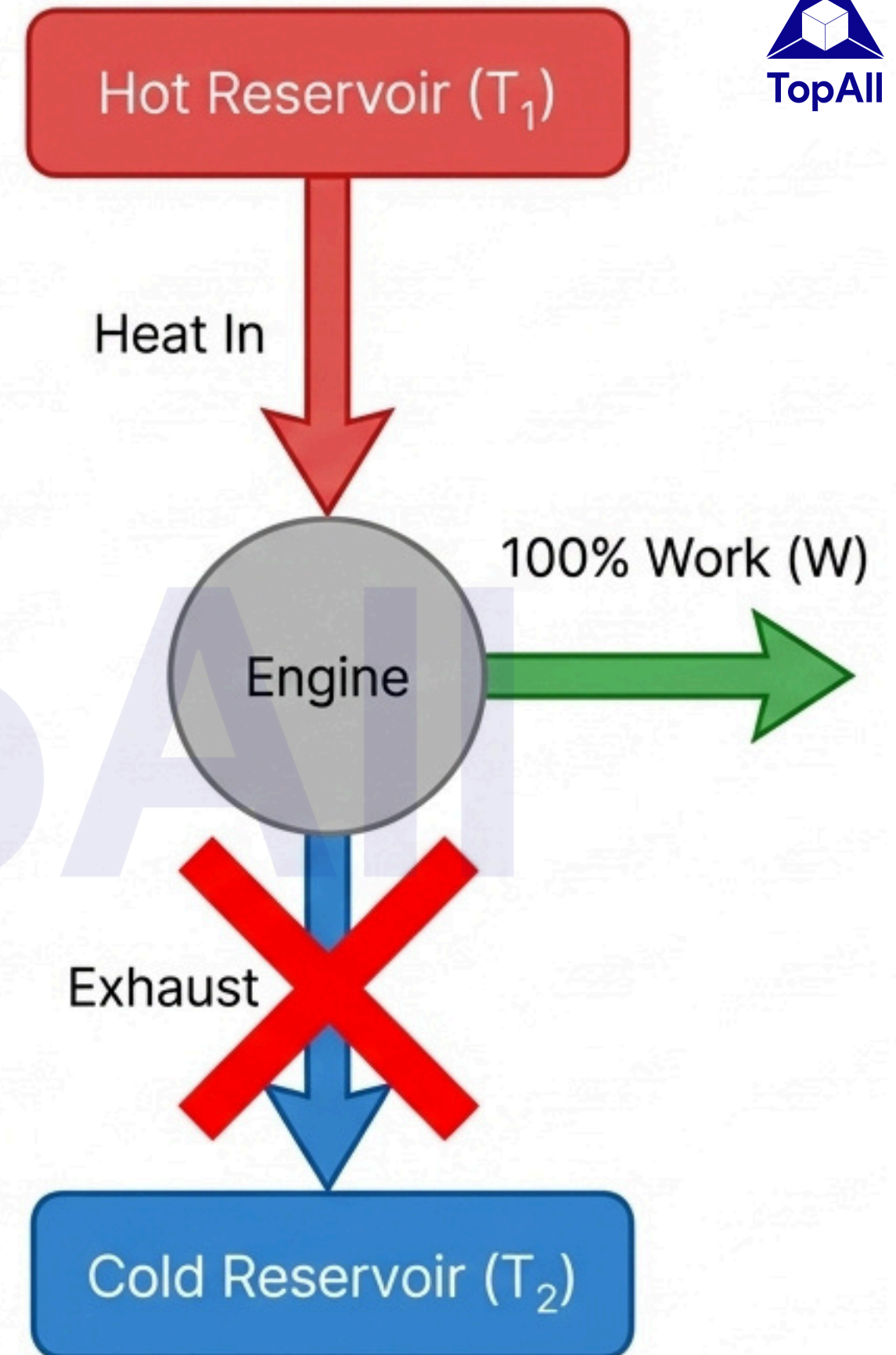


The Kelvin-Planck Statement

Law Card

No process is possible whose sole result is the absorption of heat from a reservoir and the complete conversion of the heat into work.

- You cannot build a perfectly efficient heat engine.
- Some heat must always be rejected to a colder sink.

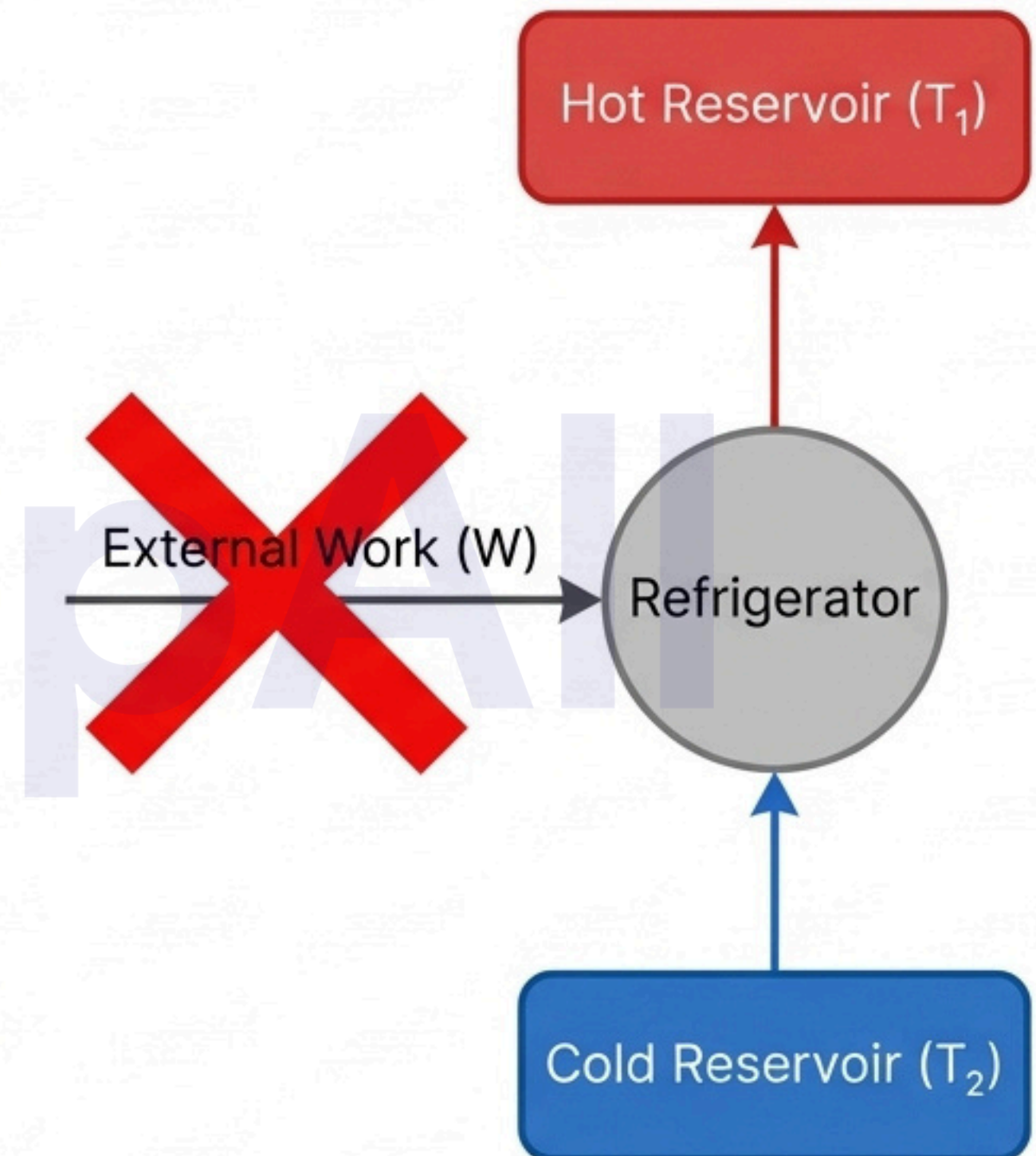


The Clausius Statement

Law Card

No process is possible whose sole result is the transfer of heat from a colder object to a hotter object.

- Heat naturally flows from hot to cold.
- To force heat from cold to hot (like in a fridge), external work must be done on the system.



The Impossibility Of Perfection

Both statements of the Second Law are completely equivalent. They establish fundamental boundaries on thermodynamic devices.

Kelvin-Planck

Device: Heat Engine

Limitation: Efficiency can never be 1 (or 100%).

$$\eta \neq 1$$

Clausius

Device: Refrigerator

Limitation: Co-efficient of performance can never be infinite.

$$\alpha \neq \infty$$

Chapter 11.9 Summary

Key Takeaways

- ✓ **The Missing Link:** The First Law allows energy conservation; the Second Law dictates the direction of natural processes.
- ✓ **Kelvin-Planck:** Denies the possibility of a perfect heat engine (Efficiency $\eta < 1$).
- ✓ **Clausius:** Denies the possibility of a perfect refrigerator (External work is always required).

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