

CHAPTER 11 | THERMODYNAMICS

Reversible & Irreversible Processes

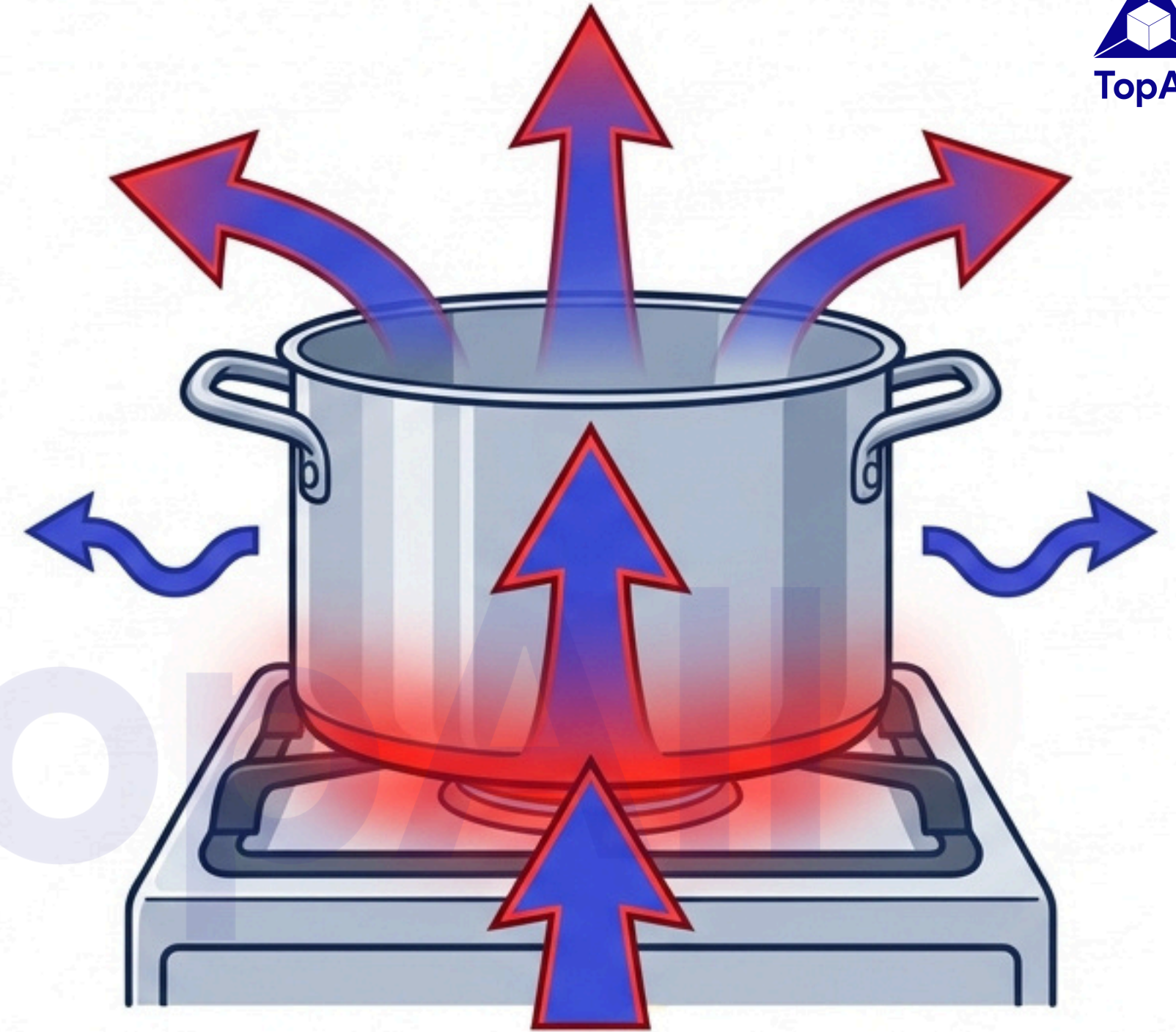
Understanding the Direction of Time
in Thermodynamics

Class 11 Physics • Target: NEET / JEE

Can Nature Run Backward?

THE SECOND LAW OF THERMODYNAMICS (Forbids exact reversal)

- Most processes in nature are spontaneous and only go in one direction.
- A process is irreversible if it cannot be turned back to exactly restore both the system and the surroundings to their original states.



Heat flows from a hot vessel to the surroundings. It will never spontaneously reverse to cool the surroundings and heat the vessel.

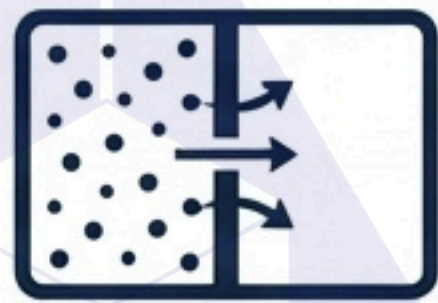
Everyday Examples of Irreversibility

Irreversibility is the rule, not the exception in nature.



Hot Vessel

Heat equalizing
across a vessel
base



Free Expansion

Gas expanding
into a vacuum



Combustion

Petrol-air mixture
ignited by a
spark



Diffusion

Cooking gas
leaking and
spreading in a
room



Stirring

Mechanical work
turning into heat
in a liquid



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$$E=mc^2$$



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The Two Causes of Irreversibility

EXAM TIP: Irreversibility arises from non-equilibrium and dissipation.

Non-Equilibrium States

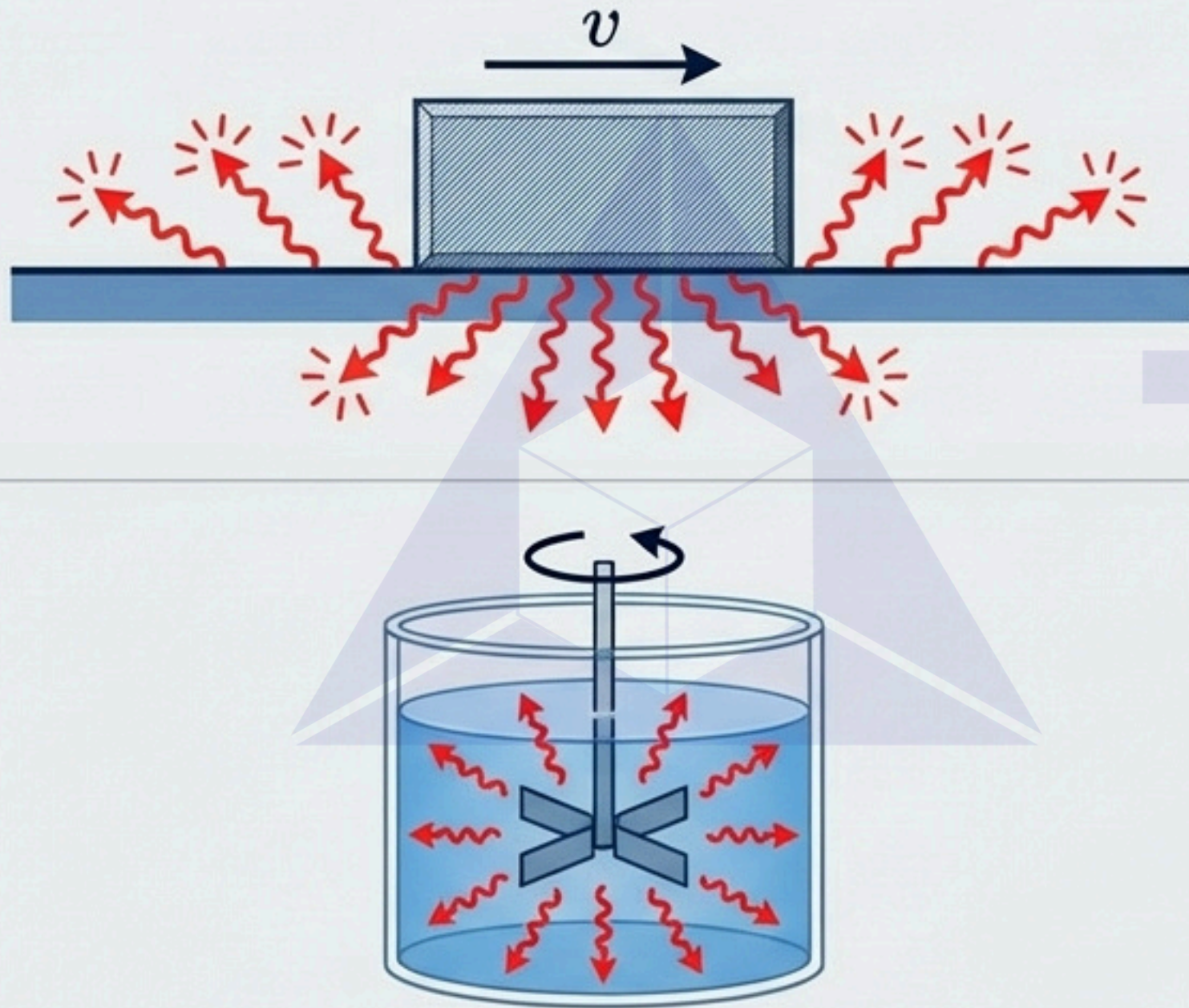
- Rapid changes (like free expansion or explosions) do not allow the system to settle.
- Pressure and temperature become non-uniform.
- The system loses its well-defined thermodynamic state variables.

Dissipative Effects

- Friction, viscosity, and resistance are always present.
- Mechanical energy is permanently lost as heat to the surroundings.

Zooming In On Dissipative Effects

Why mechanical energy gets “lost”



Example A: Friction

A moving body comes to a stop on a floor. Mechanical energy is lost as heat to the floor and the body.

Example B: Viscosity

A rotating blade in a liquid eventually stops. Mechanical energy increases the internal energy (heat) of the liquid.

KEY INSIGHT: Dissipative effects can be minimized, but never fully eliminated in reality.

The Ideal: Reversible Processes



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Reversible Process =
Quasi-Static (Infinitely slow) + **Non-Dissipative** (No friction)

Feature	Reversible	Irreversible
Nature	Idealized & hypothetical	Real & spontaneous
Speed	Infinitely slow (Quasi-static)	Fast / finite time
Energy Loss	Zero (Non-dissipative)	Always present (Friction/viscosity)
Equilibrium	Maintained at every stage	Lost during the process

Chapter 11.10 Mastered!

KEY TAKEAWAYS

- **Spontaneity:** Natural processes only proceed in one direction (Irreversible).
- **Causes:** Irreversibility is driven by non-equilibrium states and dissipative forces.
- **The Ideal Condition:** A reversible process is an idealized concept requiring quasi-static execution and zero dissipation.

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