

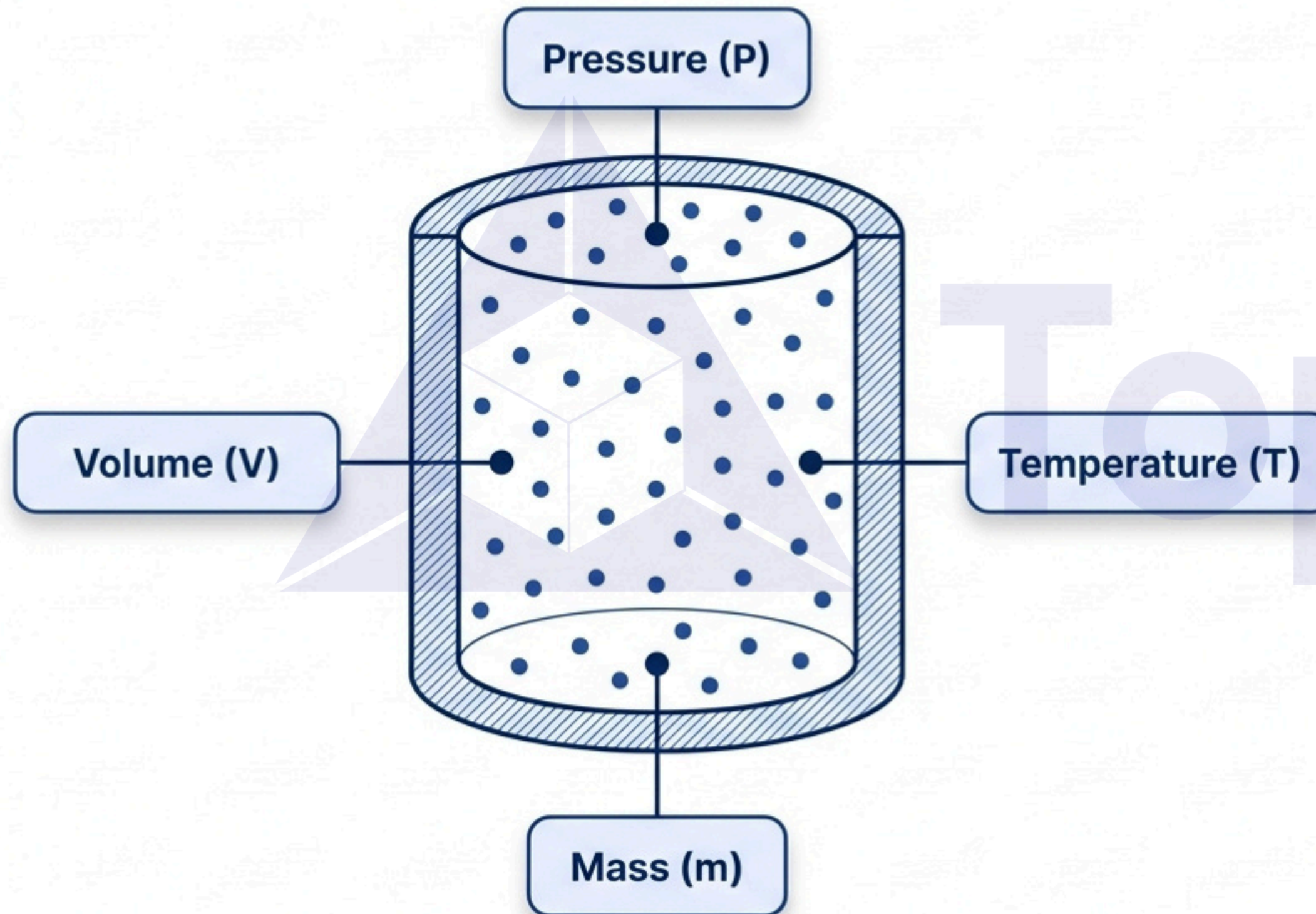
CLASS 11 PHYSICS

SECTION 11.7

Thermodynamic State Variables & The Equation of State

A visual blueprint guide to equilibrium states, ideal gases, and system variables.

Defining the Equilibrium State



What is it?

A state where the macroscopic variables characterizing a system do not change in time.

State Variables:

Specific, measurable values (P , V , T , mass, composition) that completely describe this stable condition.

The Rule:

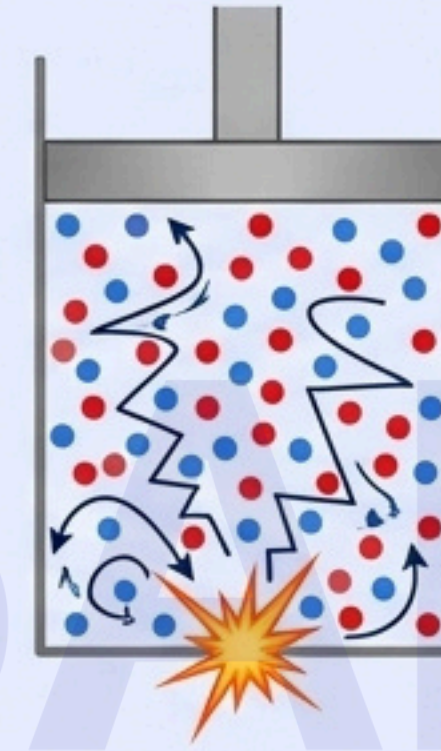
State variables only describe systems in equilibrium.

When State Variables Fail: Non-Equilibrium



Free Expansion

Partition suddenly removed into a vacuum.



Explosive Reaction

Ignited mixture of petrol vapor and air.

- State variables cannot describe these systems because Pressure and Temperature are not uniform throughout.
- *Note: Eventually, both systems will settle and attain a uniform temperature and pressure, returning to a measurable equilibrium state.*



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$$E=mc^2$$



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The Equation of State: Ideal Gas

An Equation of State is the mathematical connection between a system's state variables.

P = Pressure

V = Volume

$$PV = \mu RT$$

μ = Number of moles
(Amount of gas)

R = Universal Gas
Constant

T = Temperature

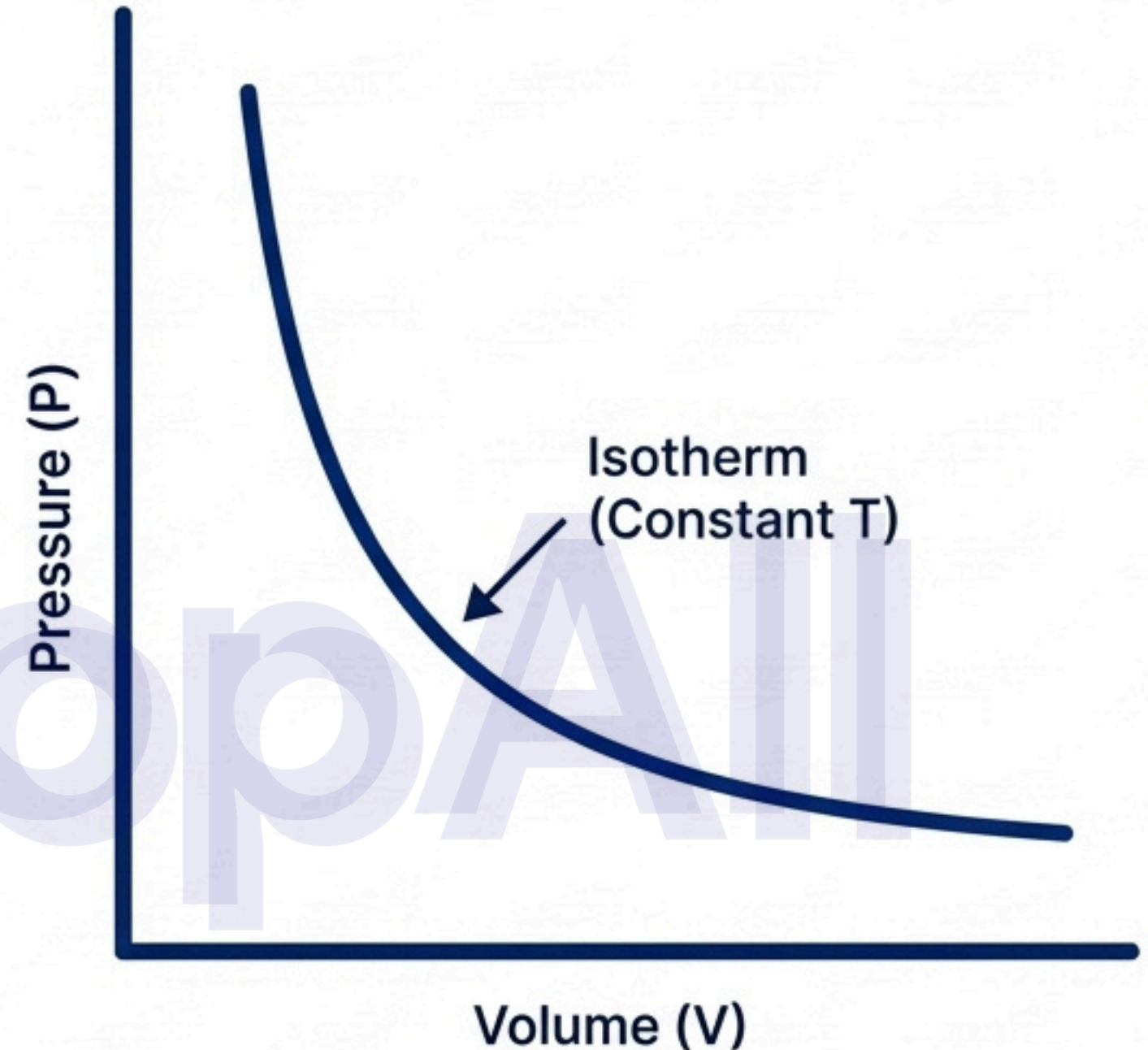
Independent Variables & The Isotherm

Independent Variables:

For a **fixed amount** of gas (μ), there are only two independent variables (e.g., P and V , or T and V). Fixing two automatically determines the third.

The Isotherm:

A pressure-volume curve plotted for a system at a fixed temperature.



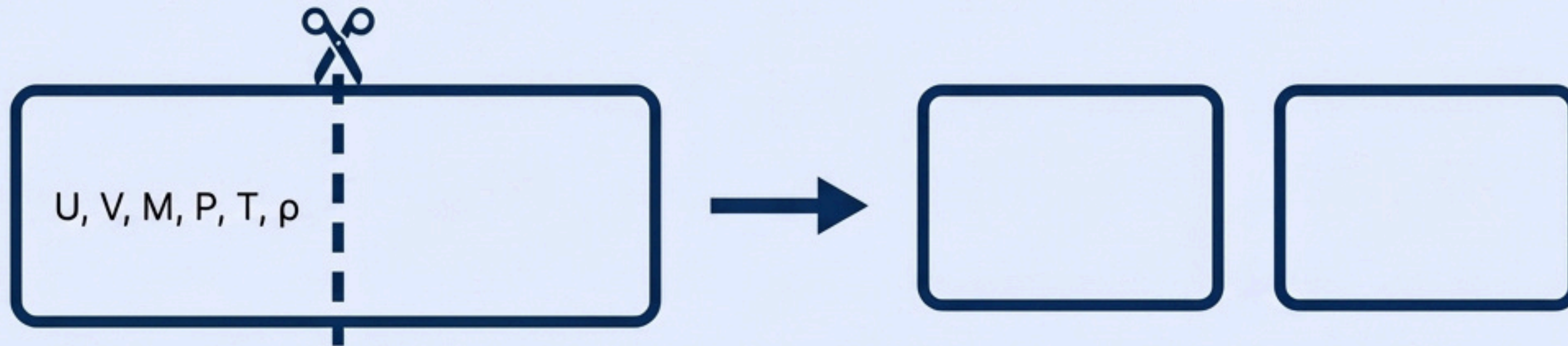
Following $PV = \mu RT$, if T is constant, Pressure varies inversely with Volume.

EXAM TIP

Use this classification to check the consistency of thermodynamic equations!

Categorizing Variables: Intensive vs. Extensive

The Halving Test: Imagine dividing an equilibrium system in two equal parts.



Intensive

Definition: Independent of the size of the system (remains unchanged when halved).

Examples: Pressure (P), Temperature (T), Density (ρ).

Extensive

Definition: Indicates the size of the system (value gets halved in each part).

Examples: Internal Energy (U), Volume (V), Total Mass (M).

KEY TAKEAWAYS

Section Synthesis

- ✓ State Variables (P , V , T , m) completely describe a system, but only when it is in a stable equilibrium state.
- ✓ The Equation of State mathematically connects these variables (e.g., $PV = \mu RT$ for ideal gases).
- ✓ Variables are either Extensive (change with system size, like Volume) or Intensive (independent of size, like Temperature).

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