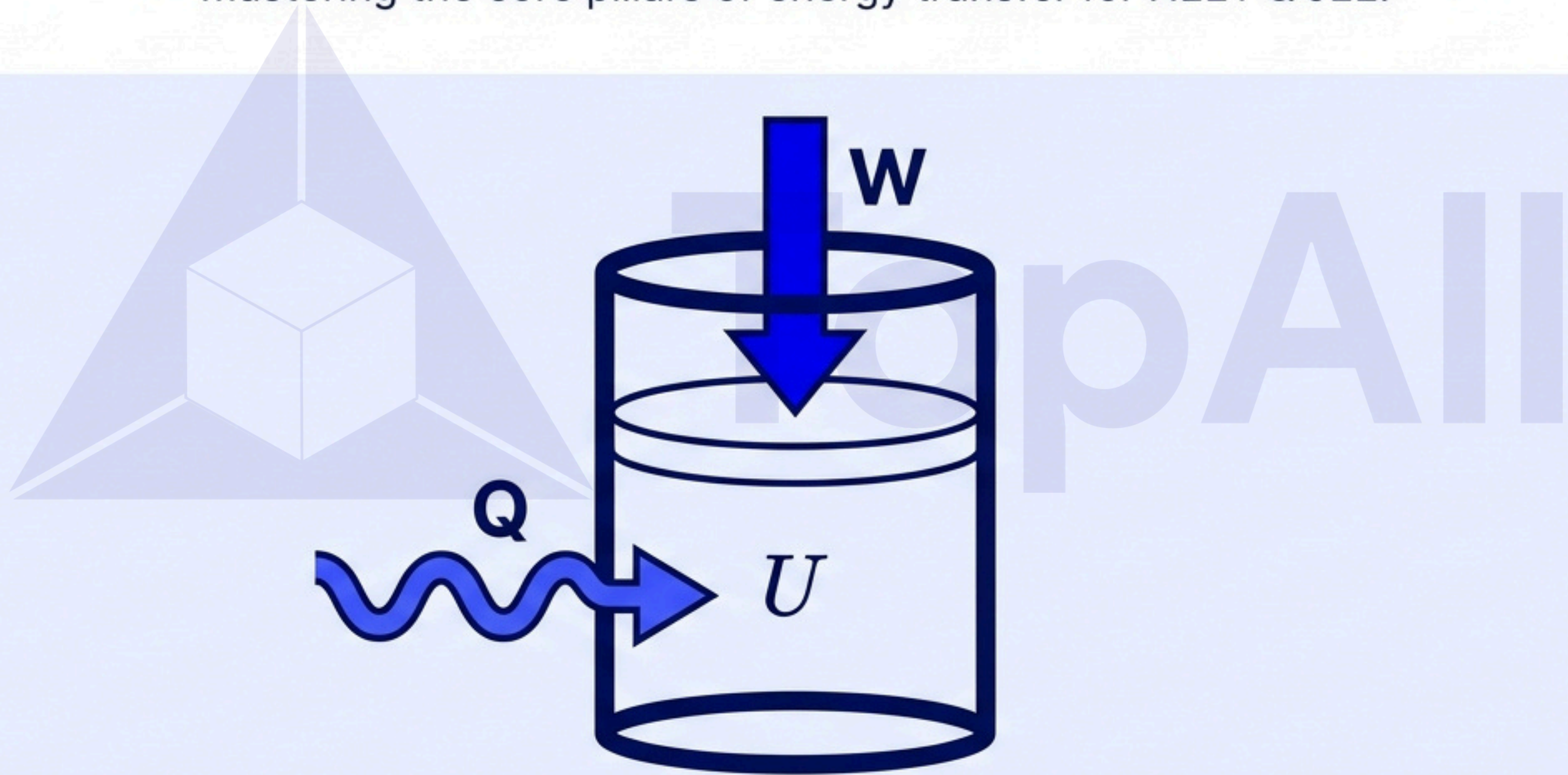


Heat, Internal Energy, and Work

Mastering the core pillars of energy transfer for NEET & JEE.



Demystifying Internal Energy (U)

- U is the sum of the kinetic and potential energies of all molecules in a bulk system.
- Calculated in a frame of reference where the center of mass is at rest.
- Ignores the macroscopic kinetic energy of the entire system moving as a whole.

EXAM TIP: STATE VARIABLE

- Internal Energy (U) is a State Variable.
- Its value depends only on the current state of the system (P, V, T).
- It does not depend on the path or history taken to reach that state.

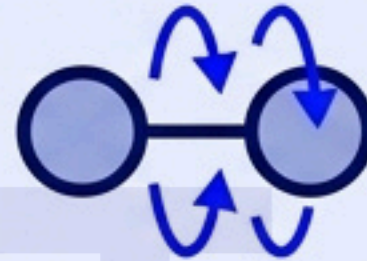
The Microscopic View of U

Translational



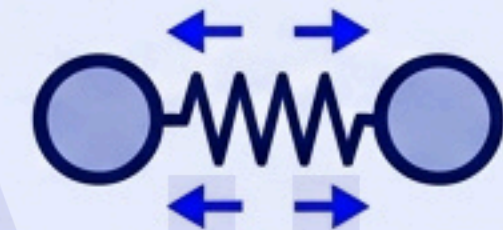
Motion from one point to another in the volume.

Rotational

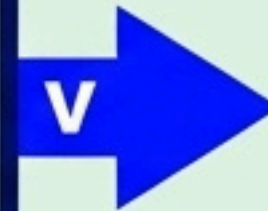
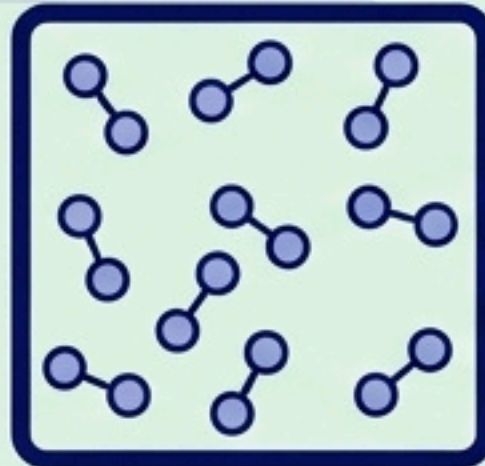
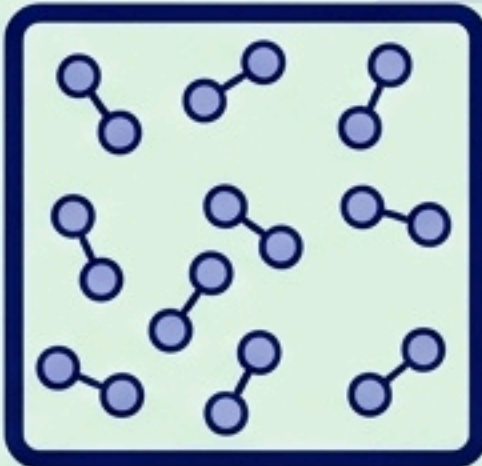


Spinning of molecules around their axes.

Vibrational



Oscillation of atoms within the molecule.



Rule of Thumb: If the container moves as a whole, that kinetic energy does not count towards U. U is purely disordered, internal energy!



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

$$E=mc^2$$



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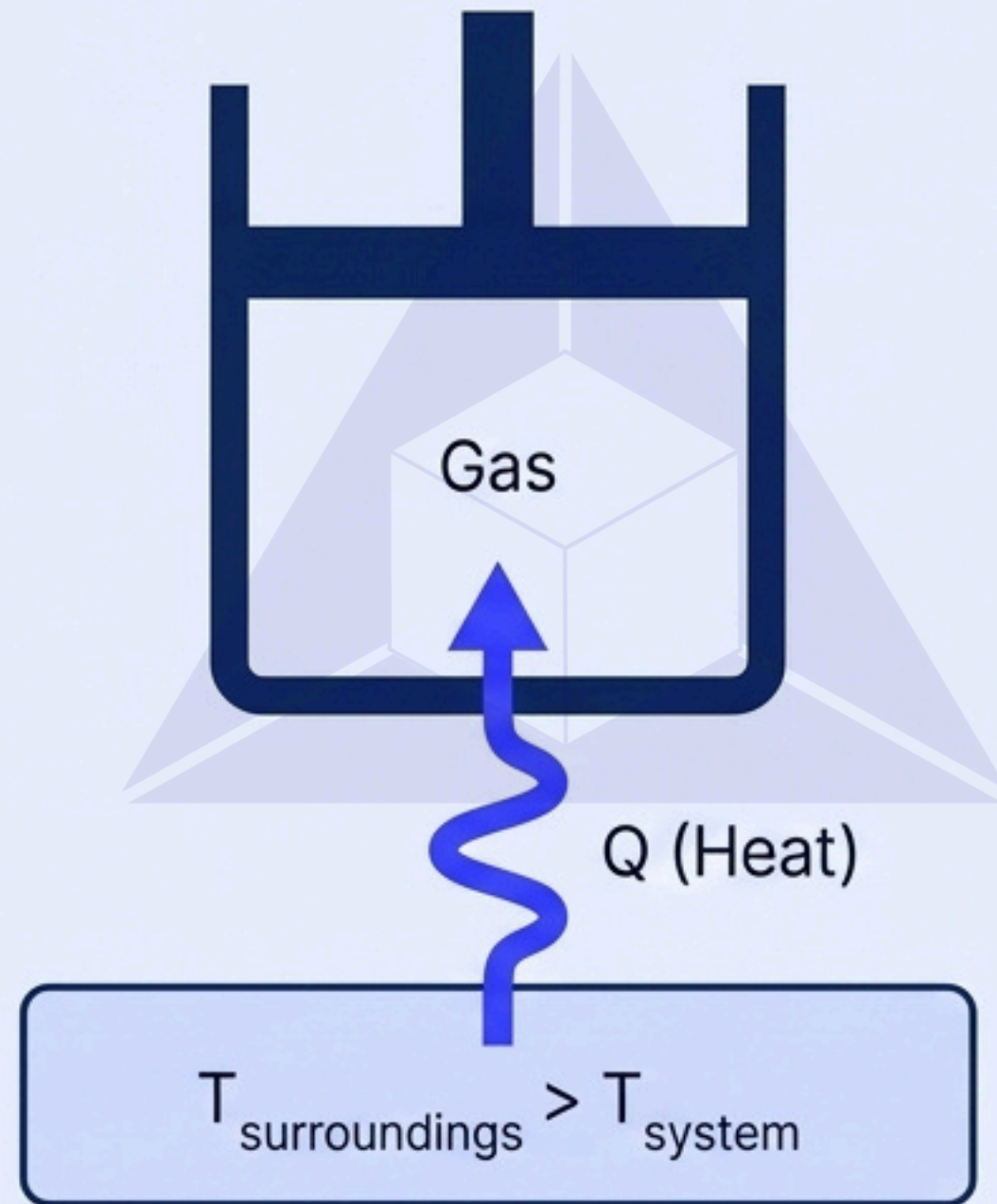
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Heat (Q): Energy via Temperature Difference

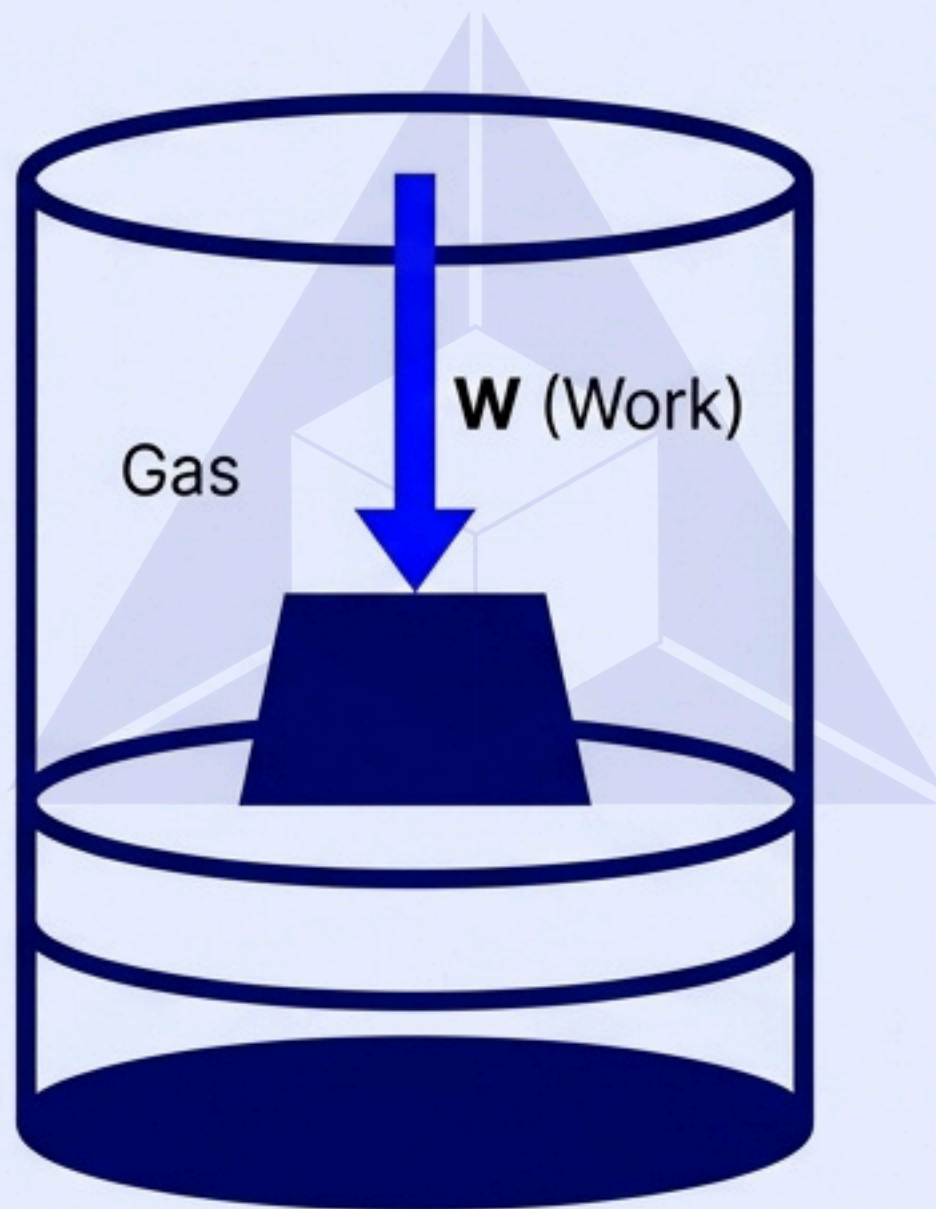


- **What it is:** Energy transferred from a hotter body to a colder body.
- **The Trigger:** Driven purely by a difference in temperature.
- **The Result:** Increases the internal energy (U) of the gas.

⚠ NOT A STATE VARIABLE

“A gas has a certain amount of heat” is a meaningless statement. Heat is exclusively energy in transit.

Work (W): Energy via Mechanical Means



- **What it is:** Energy transfer brought about by macroscopic forces.
- **The Mechanism:** E.g., compressing a gas by pushing a piston down.
- **The Result:** Also increases the internal energy (U) of the gas.

⚠ NOT A STATE VARIABLE

Work, exactly like heat, is a mode of altering a system, not a property the system "contains".

The Thermodynamic Triad

	Internal Energy (U)	Heat (Q)	Work (W)
DEFINITION:	Sum of random molecular KE & PE.	Energy transfer due to temperature difference.	Energy transfer via mechanical means.
NATURE OF VARIABLE:	State Variable (Path-independent).	Path Variable (Energy in transit).	Path Variable (Energy in transit).
VALID STATEMENTS:	"The gas has U." (Valid)	"Heat was supplied to the gas." (Valid)	"Work was done on the gas." (Valid)

Chapter 11.4 Summary

- ✓ **U defines the state:** Internal energy is a macroscopic state variable derived from microscopic molecular motion.
- ✓ **Q & W are the changers:** Heat and Work are the only two ways to alter the internal energy of a system.
- ✓ **Transit vs. Possession:** A system possesses Internal Energy, but it never possesses Heat or Work.

[Try Chapter MCQs Next →]



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