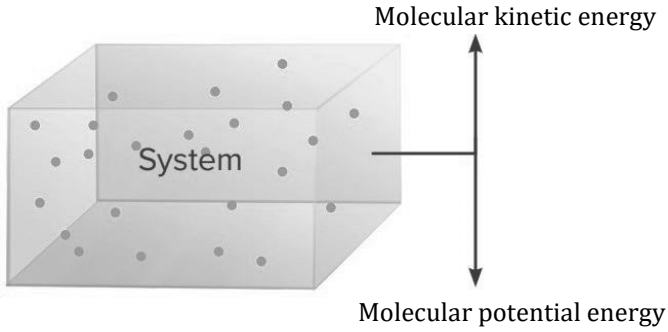
THERMODYNAMICS

HEAT, INTERNAL ENERGY AND WORK

INTERNAL ENERGY

Internal energy is the energy that molecules have from their movement and arrangement. Think of it as the total energy of all the molecules in the system's perspective. Here are a couple of things to know about internal energy:

- It is solely dependent on temperature, $U = f(T)$ *or,* $\Delta U = f(T)$.
- It's a "state function," which means it doesn't matter how you got there. The change in internal energy only depends on the starting and ending temperatures, not how you got from one temperature to another.



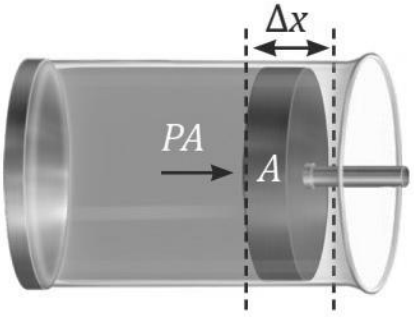
Note: Molecular kinetic energy (due to the motion of the molecules within the system)

Molecular potential energy (due to the configuration of the molecules like electromagnetic and chemical energies)

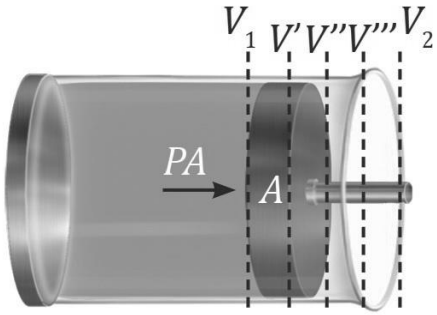
WORK DONE BY A GAS

Imagine a piston, like a plug, in a container. It's getting pushed by gas inside. We'll assume the gas pressure (P) stays the same while we move the piston a certain distance (Δx).

Work done by the gas, $W = PA\Delta x$



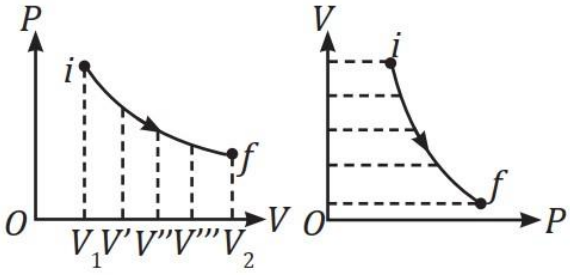
A times Δx can be described as the change in volume (ΔV) of the gas. So, the work that the gas does when it pushes the piston with a constant pressure of P is, $W = P\Delta V$.



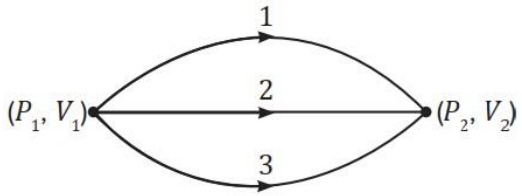
But, if the pressure P changes as we go along, we can break the whole process into really tiny parts, like (Pi, Vi). To find the work done by the gas, we calculate the area under the P-V graph, which is outlined by the V-axis in the picture. Here's how you express the work done by the gas:

$$W = \int_{V_2}^{V_1} PdV$$

The amount of work done relies on the way the system goes (the path it takes), so work is what we call a "path function."



Imagine a system going from one set of conditions (P_1, V_1) to another (P_2, V_2) through three different ways. The change in internal energy ΔU will be the same no matter which way it goes, because it's a "state function." But the work done W won't be the same for all three paths, because it's a "path function."



$\Delta U_1 = \Delta U_2 = U_3$

$W_1 \neq W_2 \neq W_3$

Sign convention

Let me explain how we indicate whether heat is entering or leaving a system and if work is being done on or by the system during a thermodynamic process:

Sign	Heat (Q)	Work (W)
Positive	Heat gained by the system	Work done by the system (Expansion)
Negative	Heat lost by the system	Work done on the system (Compression)