

# The Laws of Thermodynamics

## Thermodynamic Process

A *thermodynamic process* is one in which heat is added to or taken away from a system.  $\Delta Q = \text{change in heat}$

## Zeroth Law of Thermodynamics

**Zeroth** : *Two systems are at thermal equilibrium if they have the same temperature.*

The significant consequence of the Zeroth Law is that, when a hotter object and a colder object are placed in contact with one another, heat will flow from the hotter object to the colder object until they are in thermal equilibrium.



## First Law of Thermodynamics

**First** : also known as Law of Conservation of Energy, states that energy can not be created or destroyed; it can only be redistributed or changed from one form to another.

$$\Delta U = Q + W$$

$\Delta U$  is the change in internal energy of the system,  $Q$  is the heat added to the system, and  $W$  is the work added to the system

$Q$  is positive when it is added to the system and negative if it is taken out of the system.

*Output Work (done on other systems) is negative*

*Input Work (done on the system) is positive*

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## Sign Convention

$$\Delta U = Q + W$$

- ❖ +Q when **heat is added** to the system.
- ❖ - Q when **heat is lost** from the system.
- ❖ +W when **work is done on the system** .
- ❖ - W when **work is done by the system** .

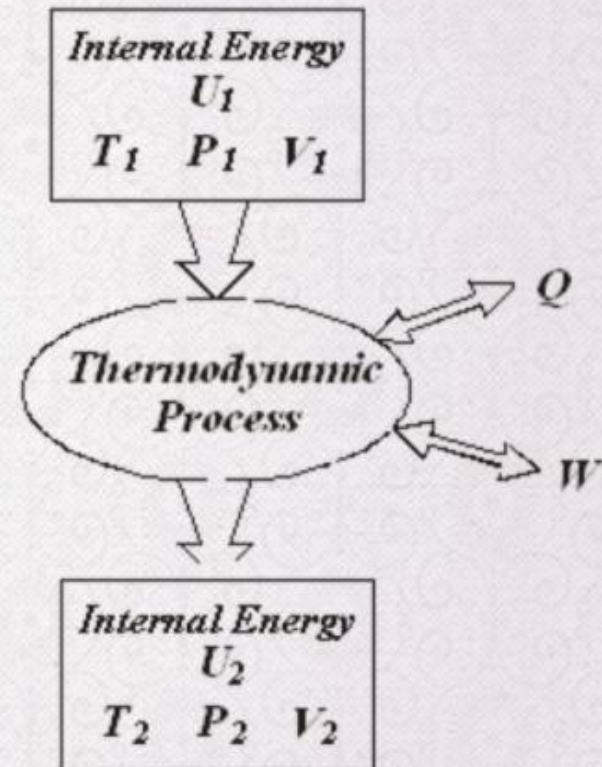
## First Law in a “Nutshell”

*Here is a diagram of a generic thermodynamic process.*

A system has an initial internal energy.

Heat (Q): *can be added to the system, or taken away from the system or there may be no heat transfer.*

Work (W): *may be done on the system or the system may do work or there may be no work involved at all.*





## First Law Question

In a thermodynamic process, a system absorbs 450 kJ of heat and does 87 kJ of work on its surroundings. By what amount did the system's internal energy change?

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$$\Delta U = 450 \text{ kJ} - 87 \text{ kJ} = \boxed{360 \text{ kJ}}$$

*Note that the work done by the system ON the surroundings is negative.*

## Second Law of Thermodynamics

**Second**: The entropy of a closed system never decreases as time goes by. Reversible processes do not change the entropy of a system, while irreversible processes increase a system's entropy.

$$S \geq 0$$

**S = Entropy of a System**

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