FIRST LAW OF THERMODYNAMICS

The initial law of thermodynamics is grounded in the principle of energy conservation, which states that the total energy of the universe remains constant.

Let us consider a system whose internal energy is U_1. If the system is supplied with heat q, the internal energy of the system increases to $U_1 + q$.

If work (w) is now done on the system, the internal energy in the final state of the system, U_2 is given by

$$U_2 = U_1 + q + w$$

or $$U_2 - U_1 = q + w$$

$$\Delta U = q + w,$$

According to IUPAC, heat, added to the system and work done on the system are assigned positive values as both these Modes increase the internal energy of the system.

Sign Convention

1. The presence of a positive q value signifies that the system undergoes heat absorption.
2. Conversely, a negative q value signifies that heat is released from the system.
3. When external work is applied to the system, the resulting work value is positive (W = +).
4. In contrast, when the system performs work on its surroundings, the associated work value is negative (W = –).

Special cases of first law of thermodynamics

1. In a cyclic process where the change in internal energy (dE) is zero, the heat transfer (dq) equals the negative of the work done (dW): dq = -dW.
2. For an adiabatic process characterized by zero heat transfer (dq = 0), the change in internal energy (dE) is equal to the work done (dW): dE = dW.
3. In an isochoric process where no work is done (dW = 0), the heat transfer (dq) is equivalent to the change in internal energy (dE): dq = dE.

Ex. A system expands from 5L to 10L against a constant external pressure of 2 atom. If it absorbs 800J of energy in the process. Calculate the change in its internal energy.

Sol.

$$\Delta u = q + w$$

$$W = -(v_2 - v)$$

$$= -2(10 - 5)$$

$$= -10 \text{ atm -L} \times 101.3\text{J} = -1013\text{J}$$

$$\Delta U = -213\text{J}$$