Chapter 3

Principles of Thermodynamics and the First Law of thermodynamics

5.1 The first law of thermodynamics

Is the law of conservation of energy, which states that:

'Energy cannot be created or destroyed, but it can be converted from one form to another.'

It expresses the relationship between work, heat, and internal energy in any thermodynamic system.

If we assume that we have a thermodynamic system, and work is done within the system such that heat is absorbed from the surroundings, there will be a change in the internal energy of the system.

$$E_2 = E_1 + q + w$$
$$\Delta E = E_2 - E_1 = q + w$$
$$\Delta E = q + w$$

From this law, we conclude that it is the sum of two values, and we can calculate the amount of change in internal energy, not its absolute value.

Where ($\Delta E = E_2 - E_1$) represents the difference in the internal energy of the system and is equal to the difference between the added heat energy and the work done.

(q) represents the heat energy or (amount of heat),

(w +) represents the work done on the system by the environment. The formula given in the above equation is one of the ways in which the first law of closed systems is expressed. The work sign can be negative if the work is done by the system, in which case the first law formula becomes as follows:

$$\Delta E = q - w$$

5.1.1 The relationship between the first law and systems, process

1- Isothermal system: This is a closed system (the temperature remains constant in this system) and therefore there is no change in internal energy

$(\Delta E = 0)$

$$q = - w$$

Any system that performs work on its surroundings must absorb heat.

$w = - ve$
$q = + ve$

Conversely, when work is done on the system from the surroundings, heat must be emitted.

$w = + ve$
$q = - ve$

2- The adiabatic system: This is an isolated system (no heat loss). That is:

$$q = 0$$

Where all work is converted into internal energy

$$\Delta E = W$$

3- System that does not perform work:

$$W = 0$$

since the amount of heat is converted into internal energy.

$$\Delta E = q$$

4- Isobaric process: This is a process that takes place under constant pressure (expansion under constant pressure). It is more common than processes that take place under constant volume, such as a steam engine.

$$\Delta E = q - w$$
$$\Delta E = q_p - P(V_2 - V_1)$$
$$\Delta E = E_2 - E_1$$
$$E_2 - E_1 = q_p - P(V_2 - V_1)$$
$$q_p = (E_2 + PV_2) - (E_1 + PV_1),$$

$$\because \; E + PV = H$$
$$\therefore \; q_p = H_2 - H_1 = \Delta H$$

Where (ΔH) represents the heat content (enthalpy).

Since ($H = E + PV$)

and (E, V) have state function properties, (H) also has state function properties, i.e. it depends on the initial state and the final state.

5- Isochoric process: This is a process that occurs at a constant volume, such as ignition and explosion in internal combustion engines (car engines).

Since the volume is constant:

$$\Delta E = q + w$$
$$\because w = P\,\Delta V$$
$$\because \Delta V = 0 \Rightarrow \quad w = 0$$
$$\Delta E = q_V + P\,\Delta V$$
$$\therefore \Delta E = q_V + 0$$
$$\Delta E = q_V$$

The equation ($\Delta E = q_V$) represents the heat content when the volume is constant. That is, all heat is converted into internal energy.

6- Cyclic (circular) processes: These are processes that start at one point and return to the same point, i.e. the system goes through a series of steps that ultimately return it to its initial conditions. The internal energy of the system is the same at the end of the process, and the algebraic sum of the energy is equal to zero, i.e. for every circular, triangular or square process, (there is no change in energy because it returns to the same point).