Thermodynamic Variables and equation of state

The thermodynamic state or macroscopic state of a system is determined by various observable properties These are pressure (P), volume (V), concentration (n) and temperature (T).

$P, V, T, n \rightarrow$ state variables

For a system,

$$f(P, V, T) = 0$$

Therefore, the pressure, volume and temperature are not independent variables.

For example; The ideal gas equation

$$PV = RT$$

For a vander waal's equation

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

Classes of system

There are three types of system:-

1) open system: A system which can exchange matter and energy with the surrounding is called an open system.

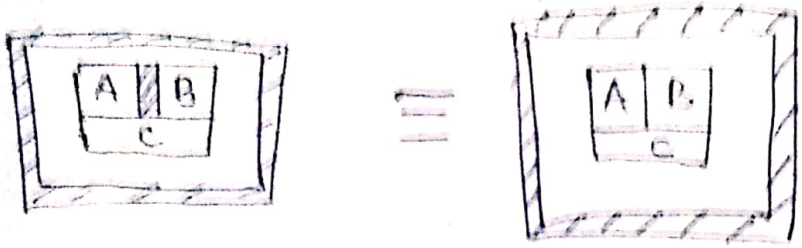
2) closed system: A system which can exchange only energy with the surroundings is called a closed system.

3) Isolated system: A system which is thermally insulated and has no communication of heat or work with the surroundings is called isolated system.

Law of thermodynamics

1) Zeroth law of thermodynamics

Statement:- The zeroth law of thermodynamic state that if two bodies A and B are each separately in thermal equilibrium with third body C, then A and B are also in thermal equilibrium.



Consider three fluids A, B and C.
Let P_A, V_A & P_B, V_B & $P_C V_C$ be the Pressure and Volume associated with them.

If A & B in equilibrium i,e thermal equilibrium

$$\phi_1(P_A, V_A) = \phi_2(P_B, V_B)$$

$$F_1(P_A, V_A, P_B, V_B) = 0 \quad \text{— (1)}$$

similarly If B and C are in equilibrium, then

$$\phi_2(P_B, V_B) = \phi_3(P_C, V_C)$$

$$F_2(P_B, V_B, P_C, V_C) = 0 \quad \text{— (2)}$$

from (1) & (2)

$$P_B = f_1(P_A, V_A, V_B) \quad \text{— (3)}$$

$$P_B = f_2(V_B, P_C, V_C) \quad \text{— (4)}$$

If A and C are in thermal equilibrium

$$F_3(P_A, V_A, P_C, V_C) = 0 \quad \text{— (5)}$$

from zeroth law, eq (5) does not have V_B and P_B;

$$\phi_1(P_A, V_A) = \phi_3(P_C, V_C)$$

In general

$$\phi_1(P_A, V_A) = \phi_2(P_B, V_B) = \phi_3(P_C, V_C)$$

Then

$$\phi(P, V) = T$$

This is known as equation of state in fluid. The term, T can be defined as temperature of a system. It is property that determine whether or not the body is in thermal equilibrium with the neighbouring systems.