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Department of Physics

Subject:- Heat and Thermodynamics

1.Fundamentals of Thermodynamics

- ## Thermodynamic state:-

a thermodynamic state of a system is its condition at a specific time; that is, fully identified by values of a suitable set of parameters known as state variables, state parameters or thermodynamic variables.

- ## State functions:-

The Thermo dynamical system is characterized by further quantities called **state functions**, which are also called state variables, thermodynamic variables, state quantities, or functions of state.

Examples are internal energy, enthalpy, Helmholtz free energy, Gibbs free energy, thermodynamic temperature, and entropy.

Van der Waals equation of state

- The Van der Waals equation of state is an equation of state which extends the ideal gas law to include the effects of interaction between molecules of a gas, as well as accounting for the finite size of the molecules.
- The ideal gas law states that the volume V occupied by n moles of any gas has a pressure P at temperature T given by the following relationship,
- PV=nRT

where R is the gas constant

- To account for the volume occupied by real gas molecules, the Van der Waals equation replaces V/n in the ideal gas law with (Vm−b), where Vm is the molar volume of the gas and b is the volume occupied by the molecules of one mole.

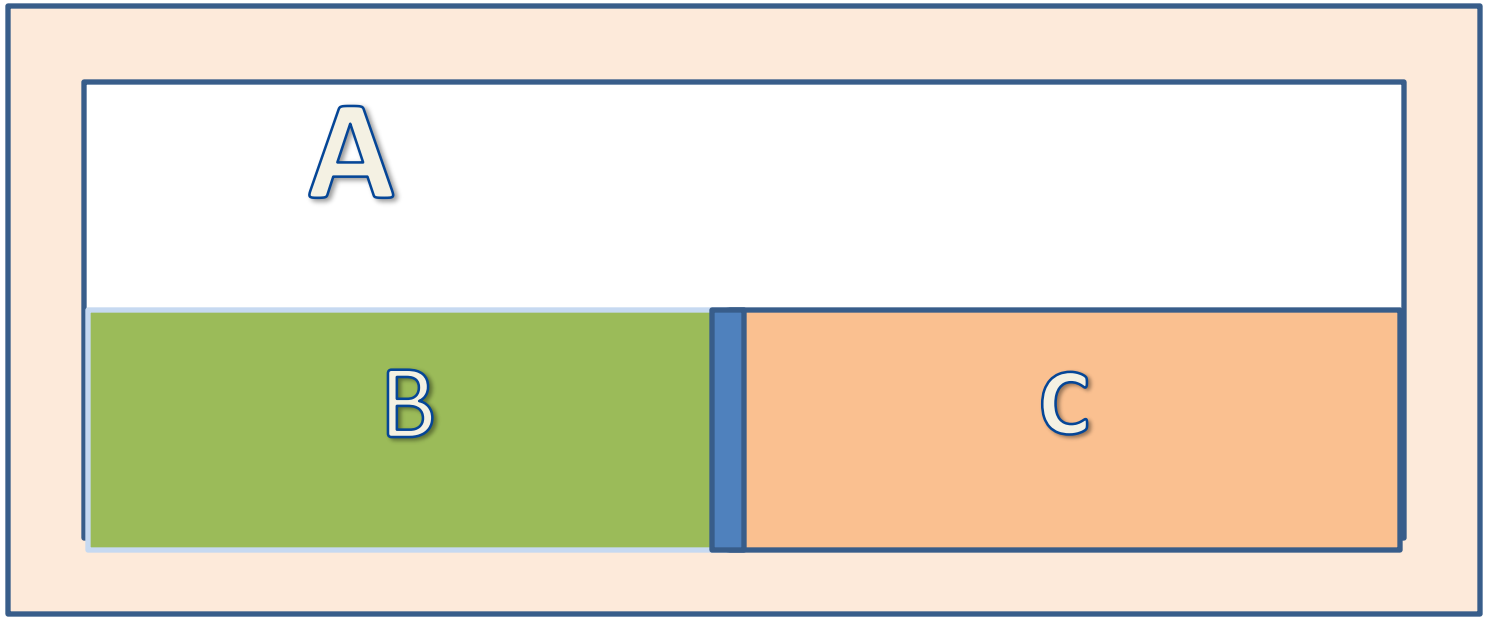
$$P(V_m - b) = RT$$

The second modification made to the ideal gas law accounts for interaction between molecules of the gas. The Van der Waals equation includes intermolecular interaction by adding to the observed pressure P in the equation of state a term of the form a/Vm2, where a is a constant whose value depends on the gas.

$$\left(P + a\frac{1}{V_m^2}\right)(V_m - b) = RT$$

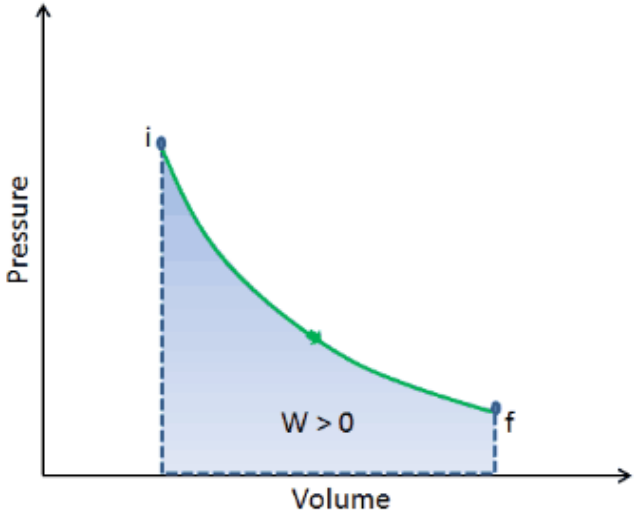
Zeroth Law of Thermodynamics:

Zeroth's Law of Thermodynamic states that when body ‘A’ is in thermal equilibrium with body ‘B’ and also separately with body ‘C’ then B and C will be in thermal equilibrium with each other.



Thermodynamic Processes

- A thermodynamic process is defined as a change from one equilibrium macrostate to another macrostate.
  The initial and final states are the defining elements of the process.



- During such a process, a system starts from initial state i, described by a pressure pi, a volume Vi and a temperature Ti, passes through various quasi-static states to a final state f, described by a pressure pf, a volume Vf, and a temperature Tf. In this process, energy may be transferred from or into the system and can be done by or on the system.

Isobaric Process

An isobaric process is a thermodynamic process in which the pressure of the system remains constant (p = const). The heat transfer into or out of the system does work but also changes the internal energy of the system.

Since there are changes in internal energy (dU) and changes in system volume (ΔV), engineers often use the enthalpy of the system, which is defined as:

$H = U + pV$

In many thermodynamic analyses, it is convenient to use enthalpy instead of internal energy, especially in the first law of thermodynamics.

- Isochoric Process

An isochoric process is a thermodynamic process in which the volume of the closed system remains constant (V = const). It describes the behavior of gas inside the container that cannot be deformed. Since the volume remains constant, the heat transfer into or out of the system does not the $p\Delta V$ work but only changes the system's internal energy (the temperature).

- Reversible Process
- In thermodynamics, a reversible process is defined as a process that can be reversed by inducing infinitesimal changes to some property of the system. In so doing, it leaves no change in either the system or surroundings.During the reversible process, the system’s entropy does not increase, and the system is in thermodynamic equilibrium with its surroundings.

Irreversible Process

- In thermodynamics, an irreversible process is defined as a process that cannot be reversed, which cannot return both the system and the surroundings to their original conditions.
- During irreversible process the entropy of the system increases.

- Cyclic Process

  A process that eventually returns a system to its initial state is called a cyclic process. After a cycle, all the properties have the same value they had at the beginning. For such a process, the final state is the same as the initial state, so the total internal energy change must be zero.

Adiabatic Process

An adiabatic process is a thermodynamic process in which there is no heat transfer into or out of the system ($Q = 0$). The system can be considered to be perfectly insulated. In an adiabatic process, energy is transferred only as work. The assumption of no heat transfer is very important since we can use the adiabatic approximation only in very rapid processes. There is not enough time for the transfer of energy as heat to take place to or from the system in these rapid processes.

- Isothermal Process

An isothermal process is a thermodynamic process in which the system's temperature remains constant (T = const). The heat transfer into or out of the system typically must happen at such a slow rate to continually adjust to the temperature of the reservoir through heat exchange. In each of these states, the thermal equilibrium is maintained.