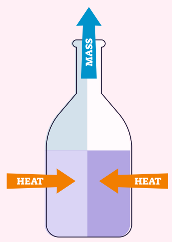
11. THERMODYNAMICS

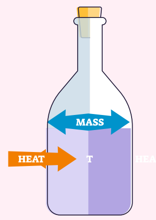
Branch of Physics that deals with concepts of heat and temperature including inter – conversion of heat to another form.

System



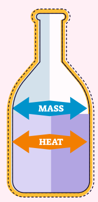
OPEN

Energy and mass can be exchanged



CLOSED

Only energy can be exchanged



ISOLATED

Nothing is exchanged

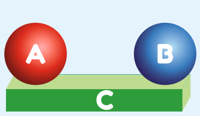
A body of matter or radiation confined in spaced walls with definite permeabilities separated from surrounding.

Equilibrium in Thermodynamics

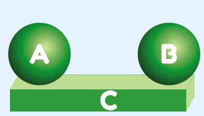
(1) When the temperature difference between two bodies becomes zero then they are said to be in thermal Equilibrium.
(2) When all mechanical forces within the system are balanced to have zero acceleration, system is in mechanical equilibrium.
(3) When no chemical reaction occur within reactants of system, then it is in chemical equilibrium.
(4) System is in thermodynamic equilibrium if all three equilibrium are attained.

ZEROTH LAW OF THERMODYNAMICS

Before Thermal Equilibrium



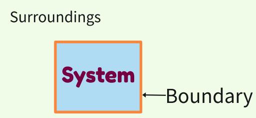
After Thermal Equilibrium



Body A Temperature = Body C Temperature = Body B Temperature

If two bodies A and B are individually in thermal equilibrium with third body C, then A and B will also be in thermal equilibrium with each other.

Surrounding



Everything external to the system is known as Surrounding.

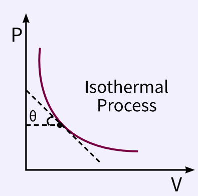
Types of Systems

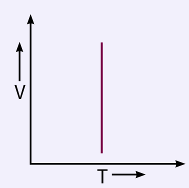
(1) In closed system, only energy transfer is possible rather than mass.
(2) In open system, both energy and mass transfer is possible.
(3) In isolated systems, both energy and mass transfer is not possible.

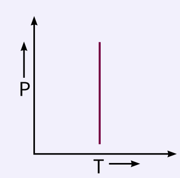
THERMODYNAMIC PROCESS

It is a process in which the thermodynamic state of a system is changed

Isothermal Process







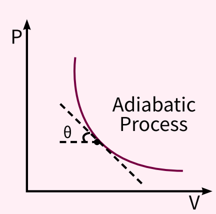
Temperature, T = constant

(1) $W = nRT\ln\left(\frac{V_2}{V_1}\right) = nRT\ln\left(\frac{P_1}{P_2}\right)$

(2) $W = 2.303\ nRT\log\left(\frac{V_2}{V_1}\right) = 2.303\ nRT\log\left(\frac{P_1}{P_2}\right)$

(3) For isothermal process, $\Delta U = 0$, So, $\Delta Q = \Delta W$

Adiabatic Process



(1) $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$

γ – adiabatic constant

(2) $\Delta Q = 0$ for this process

(3) $\pm\ \Delta w = \mp\Delta U$

FIRST LAW OF THERMODYNAMICS

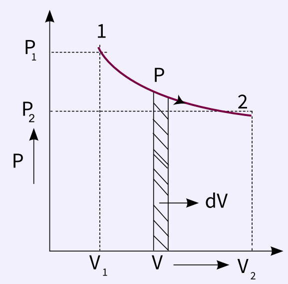
If the energy (ΔQ) supplied to System goes in partly to increase the internal energy of system (ΔU) and rest in work done (ΔW).

ΔQ = ΔU + ΔW to the system

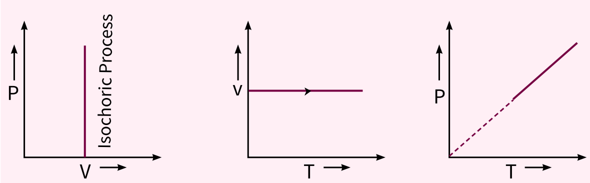
(1) Heat (Q) – Energy transfer from a thermodynamic system = nCΔT

(2) ΔU – Energy associated with internal configuration = $nC_v\Delta T$ environment. ΔQ = ΔU + ΔW

(3) Area under P – V graph gives work done $W = \int_1^2 P.dv$



Isochoric Process

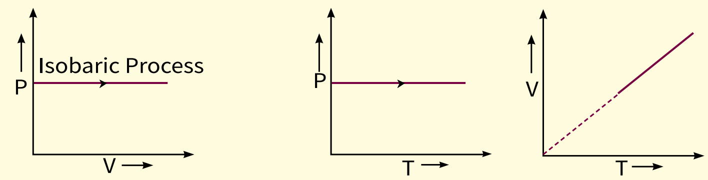


(1) Volume, V = Constant
(2) Work done, ΔW = 0
(3) ΔQ = ΔU + ΔW so, ΔQ = ΔU

Point function and state function

(I) Function whose value depends on initial and final state of system is point function.
(ii) Function whose value depends on thermodynamic process is called state Function.

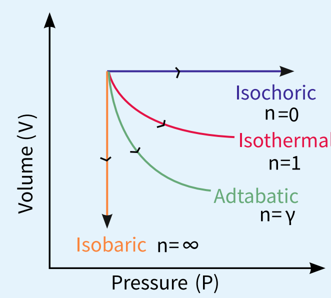
Isobaric Process



(1) W = nRΔT = PΔV
(2) ΔQ = ΔU + ΔW
(3) Pressure P = Constant.

Polytropic Process

(1) PV^n = Const ;
n = polytropic index
(2) If n = o, isobaric process
(3) If n = 1, isothermal process
(4) If n = γ, Adiabatic process
(5) If n = ∞, isochoric process



SECOND LAW OF THERMODYNAMICS

Kelvin – Planck's statement:
"No process is possible, whose sole result is absorption of heat from reservoir and the complete conversion of heat into work"

Clausius Statement:
"No process is possible , whose sole result is the transfer of heat from a colder object to hotter object"