

THERMODYNAMICS

Thermodynamics is the branch of Physics which deals with the study of flow or transformation of heat or any other form of energy.

Thermodynamic state :- The state of thermodynamic system is determined in terms of four variables which are the thermodynamic variables.

- (1) mass (m)
- (2) Pressure (P)
- (3) Volume (V)
- (4) Temperature (T)

A set of particular values of $m, P, V, & T$ define a particular state of the system.

thermodynamic process.

(1) Isothermal process :- In this process ΔT or $dT = 0$ (T is constant)

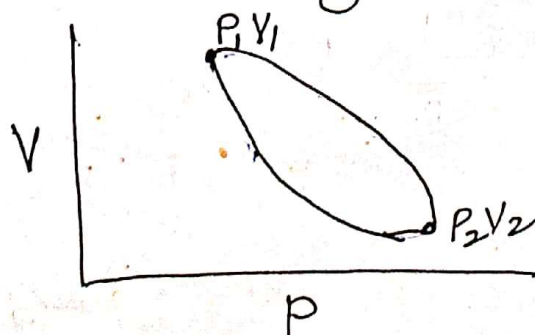
(2) Isochoric process :- In this process volume is constant i.e. ΔV or $dV = 0$

(3) Isobaric process :- In this process pressure P is constant i.e. ΔP or $dP = 0$

(4) Adiabatic process :- No exchange of energy between system & surrounding.

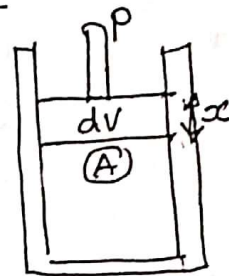
$P, V, T \rightarrow$ all variable & entropy constant

(5) cyclic process :- If the initial and the final state of a system are same then the process is called cyclic.



Work done in thermodynamic Process.

Let us consider a gas in a cylinder of Area 'A' & volume V at Press P. The Workdone for displacement of Piston P



$$W = F \cdot dx$$
$$= P \cdot A \cdot dx$$
$$= P \cdot dV$$

$$P = F/A$$
$$F = PA$$

[A] Work done in Isochoric Process:- In Isochoric Process the volume of the gas is ~~equal~~ constant

$$\therefore dV = 0$$

$$\therefore W = 0$$

[B] Workdone in Isobaric Process:- In Isobaric Process the Pressure is constant.

If the volume of the gas is changed from V_1 to V_2 then

$$W = P \int_{V_1}^{V_2} dV = P \cdot [V_2 - V_1]$$

[C] Workdone in Isothermal process:- In this process the temp (T) is constant. there is an exchange of heat between system & surrounding.

Using gas law, $PV = nRT$

$$P = \frac{nRT}{V}$$

If the volume of the gas is changed from V_1 to V_2 then Pressure changes from P_1 to P_2

$$W = \int_{V_1}^{V_2} P dV = \int_{V_1}^{V_2} \frac{nRT \cdot dV}{V}$$
$$= nRT \left[\log \right]_{V_1}^{V_2}$$

$$W = nRT \log \frac{V_2}{V_1}$$

$$\therefore \frac{V_2}{V_1} = \frac{P_1}{P_2} \Rightarrow W = nRT \log \frac{P_1}{P_2}$$

③

(4) Adiabatic change: It is a fast process in which Pressure P, volume V & temp (T) all are variable. In this system entropy is constant

In adiabatic Process.

$$PV^\gamma = \text{constant}; \gamma = C_p/C_v$$

$$\text{or, } P = KV^{-\gamma}$$

= Adiabatic exponent

work done in a adiabatic Process.

$$W = \int_{V_1}^{V_2} P dV = \int_{V_1}^{V_2} KV^{-\gamma} dV$$

$$= \frac{K}{1-\gamma} \left[V_1^{1-\gamma} - V_2^{1-\gamma} \right]$$

$$= \frac{KV_1^{-\gamma} \cdot V_1 - KV_2^{-\gamma} \cdot V_2}{1-\gamma}$$



$$W = \frac{P_1 V_1 - P_2 V_2}{1-\gamma}$$

Inters of Temperature

$$W = \frac{nR(T_1 - T_2)}{1-\gamma}$$

(5) Work done in a cyclic Process:-

Let us consider a cyclic Process abcd.

Work done in the Process.

$$W = \frac{P_1 V_1 - P_2 V_2}{1-\gamma} - \frac{P_2 V_2 - P_1 V_1}{1-\gamma}$$

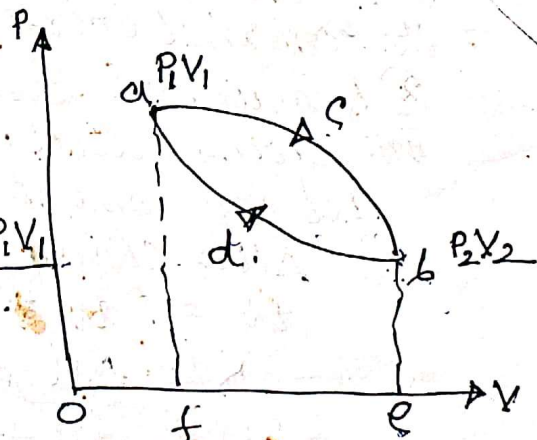
$$= \text{Area (acbefa)}$$

$$= \text{Area (adbefa)}$$

$$= \text{Area (actda)}$$

W → +ve for clockwise cycle.

W → -ve for anticlockwise cycle.



INTERNAL ENERGY

The energy of a gas system due to the constituents & its configuration is called internal energy.

$$\text{Internal energy } U = \text{Internal K.E} + \text{Internal P.E} + \text{Rest mass energy.}$$

$$U = K_i + V_i + m_0 c^2$$

For ideal gas, $V_i = 0$

$$\therefore U = K_i + m_0 c^2$$

At the moles of ideal gas in equilibrium.

$$U = \frac{3}{2} nRT$$

Hence the internal energy depends upon its temp. If the temp is changed by T_1 to T_2 then the change in energy

$$\Delta U = \frac{3}{2} nR(T_2 - T_1).$$

FIRST LAW OF THERMODYNAMICS

According to first law of thermodynamics, 'HEAT Energy' given to a system is transformed almost in two forms.

- ① A first part of energy is used to increase the internal energy of the system.
- ② Remaining part of the energy is used in doing work.

Let $Q =$ Amount of heat given to a system

$\Delta U =$ change in internal energy.

$W = PdV =$ Work done in this process.

$$Q = \Delta U + W.$$

$$\Rightarrow \boxed{dQ = du + PdV}$$

① In isochoric process, $dv=0$

$$\therefore \boxed{du = dQ}$$

$$\text{or, } \boxed{du = n c_v dT}$$

where c_v = Specific heat at constant volume.

② Isothermal Process; - In this process the temp of system remains constant i.e there is no change in ~~int~~ internal energy.

$$(dQ)_T = dW$$

If state of system in isothermal change, changes from $P_1 V_1$ to $P_2 V_2$.

Heat absorbs by the system

$$\boxed{(dQ)_T = nRT \log \frac{V_2}{V_1}}$$

$$= nRT \log P_1/P_2$$

③ Adiabatic change; - In adiabatic process the system neither absorbs energy nor ejects energy
So $dQ = 0 = du + dW$

$$\therefore \boxed{du = -dW}$$

④ Isobaric Process; - In this process pressure of the system remains constant
1st law of thermodynamics is

$$(dQ)_P = du + PdV$$

$$\text{or, } n c_p dT = n c_v dT + PdV$$

$$n dT (c_p - c_v) = n R dT$$

$$\Rightarrow \boxed{c_p - c_v = R}$$