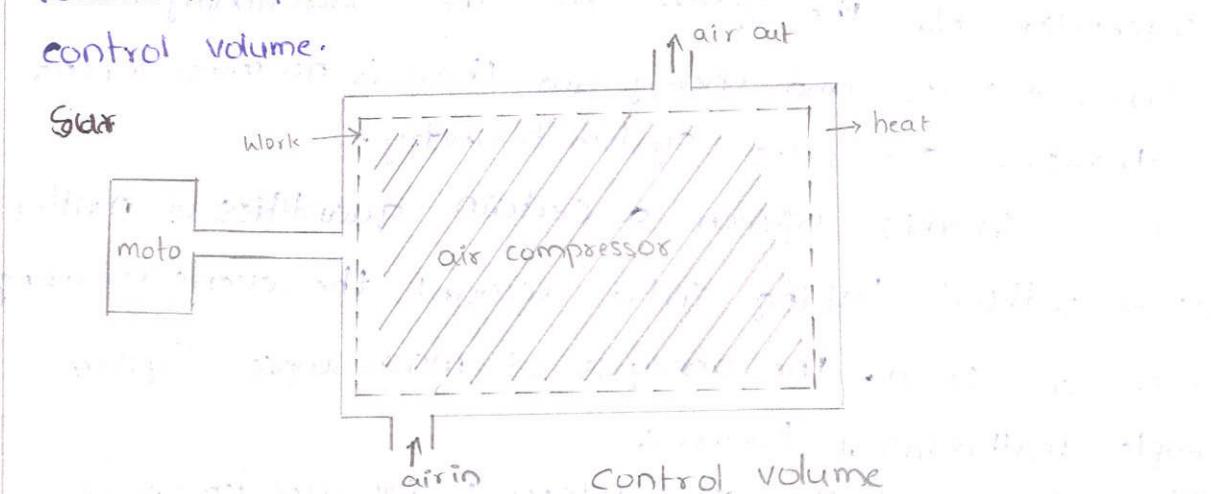


# unit-1 Thermodynamics

## Basic concepts

System:- System is defined as a quantity of matter (or) region in space upon which attention is concentrated in the analysis of a problem.

Control volume:- Thermodynamic analysis of an open system such as an air compressor attention is focused on a certain volume in space surrounding the compressor is known as control volume.



Surrounding:- everything external to the system is called environment (or) surroundings.

Boundary:- The system is separated from the surroundings by the system boundary.

The boundary may be either fixed (or) moving.

Types of systems:- System is classified into 3 types

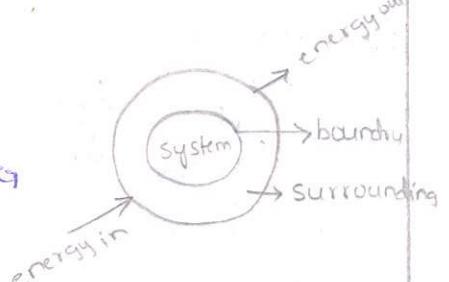
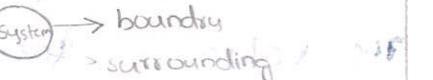
(i) closed system

(ii) open system

(iii) isolated system

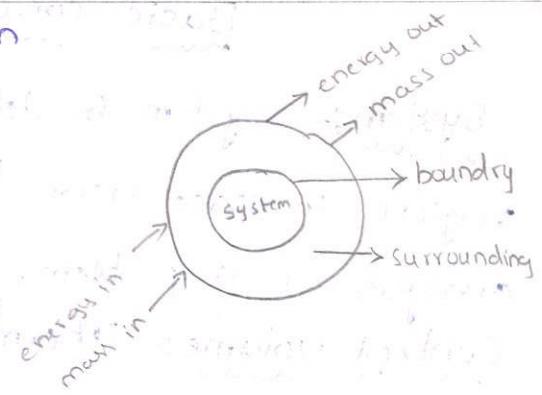
(i) closed system:-

The closed system is a system of fixed mass there is no mass transfer across the boundary. There may be energy transfer into or out of system. Certain quantity of fluid in a cylinder boundary by a piston consists of a closed system.



open system:- The open system is one in which matter crosses the boundary of the system. There may be energy transfer also.

The most of the engineering devices are generally open system.



Isolated System:- The isolated system is one in which there is no interaction b/w the system and the surroundings.  $\rightarrow$  it is fixed masses and energy and there is no mass (or) no energy transfer across the system boundary.

Macroscopic:- in this approach a certain quantities of matter is consider without taking into account the events occurring at molecular level. The analysis of macroscopic system uses simple mathematical formula.

$\rightarrow$  The values of properties of system is pressure, temperature.

Microscopic:- The approach consider that system is made up of very large number of discrete particles known as molecules. These molecules have different velocities and energies.

The values of these energies are constantly changing with time.

$\rightarrow$  The behaviour of the system is found by using statistical methods as the no. of molecules is very large.

$\rightarrow$  The properties velocity, moment, impulse, kinetic energy, force etc.

Concept of continuum:- The behaviour of individual molecules matter is here treated as continuous let us consider the mass ( $\delta m$ ) in a volume ( $\delta V$ )

Surrounding the point p, that the ratio,

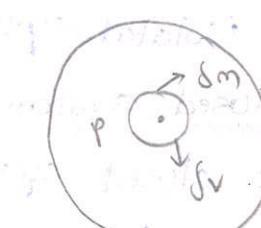
is  $\frac{\Delta m}{\Delta V}$ .

$$\int = \lim_{\Delta r \rightarrow 0} \frac{\Delta m}{\Delta V}$$

Thermodynamic equilibrium:-

System is set to exist in a state of thermodynamic equilibrium.  $\rightarrow$  when no change in any macroscopic property if the system is isolated from its surroundings.

$\rightarrow$  Thermodynamic equilibrium classified into 3 types.



Quasi state.

(i) mechanical (ii) chemical (iii) Thermal

Mechanical:- in the absence of any unbalanced force with in the system it self and also b/w the system and surrounding the system is said to be a mechanical equilibrium.

Chemical:- if there is no chemical reaction or transfer of matter from one part of the system to another system such as diffusion or solution. The system is said to be chemical equilibrium.

Thermal:- when the system existing in mechanical and chemical equilibrium separated from its boundary by a dia-thermic wall (which allows heat to flow) and if there is no spontaneous change in any property of the system. the system is said to be thermal equilibrium.

State:- state is defined as the state of passed through during change of path is called the path of the changing state.

Properties:- Thermodynamic properties are classified into 2 types

(i) intensive and (ii) extensive

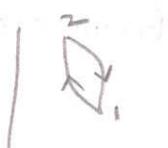
(i) Intensive:- The intensive property is defined as intensive property is known as independent of mass of the system.

Ex:- pressure, temperature.

(ii) Extensive:- Extensive Property is known as dependent of mass of the system

Ex:- volume, energy

→ mass is increased to the values of the extensive properties is increased



process:- A process occurs when the system undergoes a change in a state or energy transfer of a steady state.

→ a process may be non flow in which a fixed mass with in the defined boundary is undergoing a change of state.

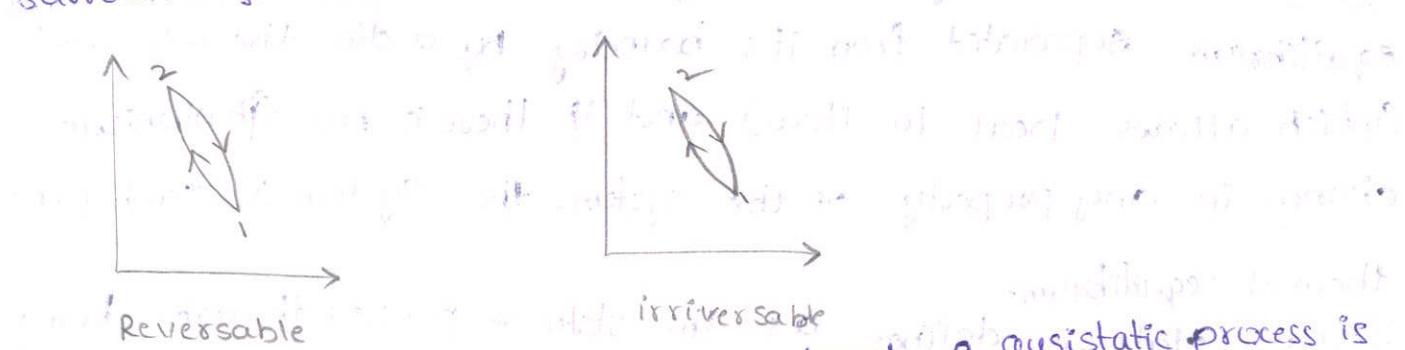
Ex:- closed system.

→ a system may be flow process in which mass is entering and leaving through to the boundary of an open system.

Cycle:- cycle is any process or series of processes whose states are identically thermal in a cycle.

Reversible process:- it is one which both the system and surroundings are return to their original system states which is not so, in the original system case of irreversible process in all actual process are irreversible.

Irreversible process:- In this type of process, the system and surroundings are will not return to their original state.



Quasi-static process:- quasi means almost a quasi-static process is called reversible process, this process is a succession of equilibrium state and infinite slowness is its characteristic feature.

Work:- work is one of the basic modes of energy transfer.

→ The work is done by a force as it acts upon a body moving in the direction of the force.

→ in thermodynamic work transfer is considered as occurring b/w the system and surrounding. When work is done by a system, it is arbitrarily taken to positive.

→ When work done on the system is negative

→ when work done by the system is positive

Displacement work:- when the piston moves out from piston

1 to 2 with the volume change in  $v_1$  to  $v_2$

→ The amount of work done by a system will be

$$dW = pdV$$

$$dW_{1-2} = dW_2 - dW_1$$

$$= P V_2 - P V_1$$

$$\therefore \Delta W = P(V_2 - V_1)$$

$$dW = pdV$$

Total Work = displacement work + shear work + electric work + stirring work

$$W_{\text{total}} = W_{\text{dis}} + W_{\text{shear}} + W_{\text{electrical}} + W_{\text{stirring}}$$

Heat:- Heat is defined as a form of energy that is transfer across the boundary by virtue of a temperature difference.

→ Heat on the system is positive

→ Heat by the system is negative

→ a process in which no heat crosses the boundary of the system is called adiabatic process.

→ Heat transfer a path function.  $dq = \int_T^x dx$

Path function:- There are certain quantities which can't be located on a graph by a point but the area on the graph. in that case the area on the graph pertaining of a particle.

→ Process is a function of Path of the process, such quantities are called Path function.

Ex:- heat, work etc.

it is the property of the system when two

Point function:- If properties locate a point on the graph (Co-ordinate axis) then these properties are called as point function.

Ex:- Pressure, volume, temperature

$$\int dv = V_2 - V_1 \text{, an exact differential.}$$

Zeroth law:- Zeroth law states that if two systems are each equal in thermally equilibrium to a third system there are equal in thermally equilibrium to each other.

Temperature:- it is defined as ~~a factor~~ changes the thermal

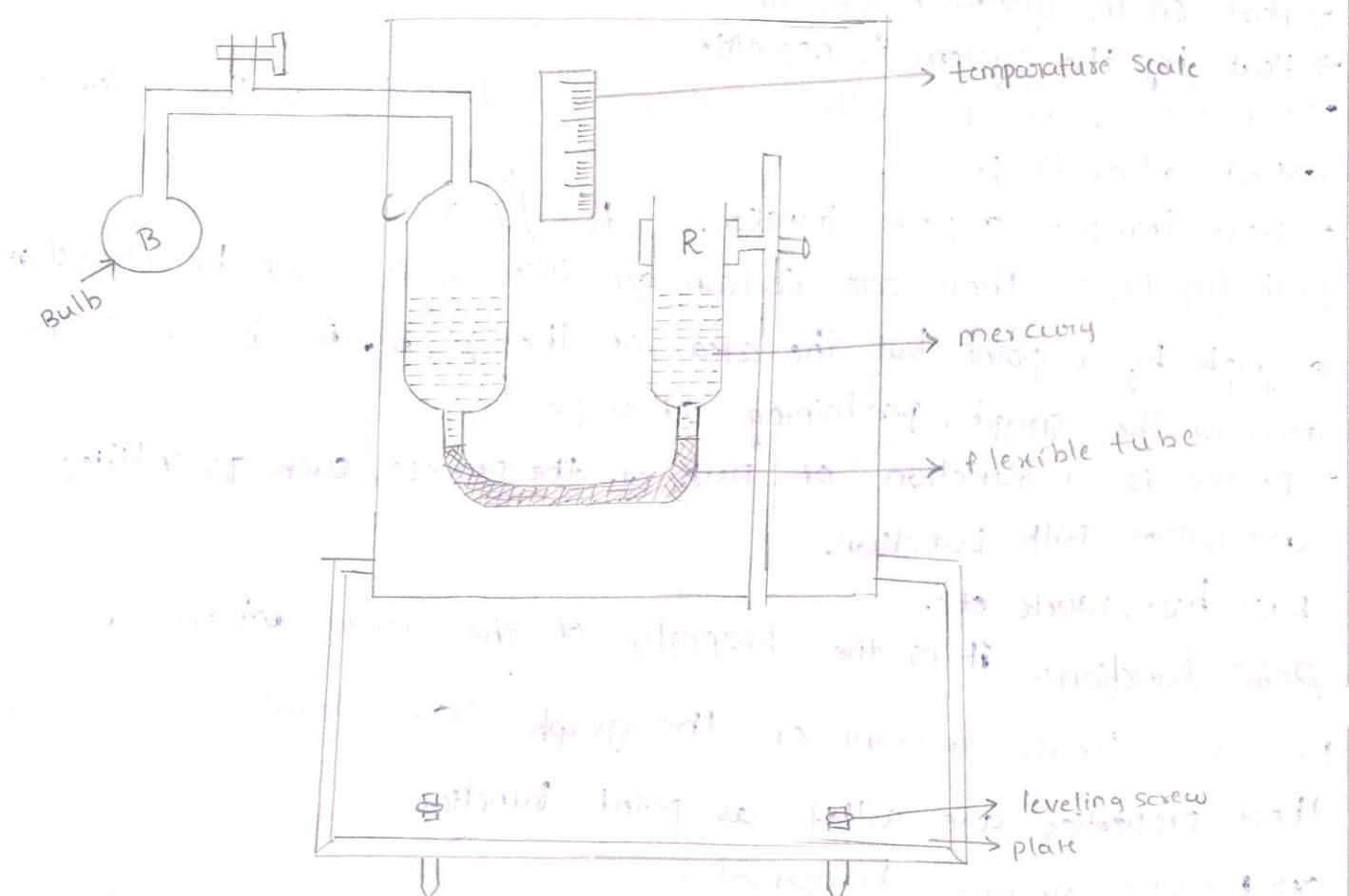
state and it changes from hot body to cold body.

The temperature of a system is a property

Reference points:- The temperature of a system is in thermal equilibrium with other system. if a body is at say  $70^\circ C$ , it will be  $70^\circ C$  whether measured by a mercury in glass

thermometry resistance thermometer or constant volume gas thermometer.

constant volume gas thermometer:- It is a device used to measure temperature by observing the change in pressure of a gas at constant volume.



Principle :- From Avogadro's law, WKT at constant volume the temp of the gas is directly proportional to pressure of the gas.  
→ Thus when the gas is heated by keeping the volume is constant, its pressure increased and when we cool the gas its pressure is decreased.  
Working :- By adjusting the leveling tools the apparatus is adjusted exactly parallel to the surface of the table. The mercury present in bulb is made to attain the temperature of ice at which the mercury level becomes stationary. which is obtained by keeping the bulb B in an ice bath for some times the difference b/w the mercury level given as  $a_0$ . if  $P_0$  is the pressure exerted by the air in the bulb.

$$P_0 = P + a_0$$

Scales of temperature :-

$t$  is the thermodynamic property

A, B are arbitrary constants

Ice point  $t_I = 0^\circ\text{C}$

Steam point  $t_s = 100^\circ\text{C}$

$$t^o C = A L_S + B$$

$$100 = A L_S + B \rightarrow ①$$

$$0 = A L_I + B \rightarrow ②$$

$$100 = A (L_S - L_I)$$

$$A = \frac{100}{L_S - L_I}$$

Sub A in ① ; we get

$$100 = \left( \frac{100}{L_S - L_I} \right) L_S + B$$

$$100 - \left( \frac{100}{L_S - L_I} \right) L_S = B$$

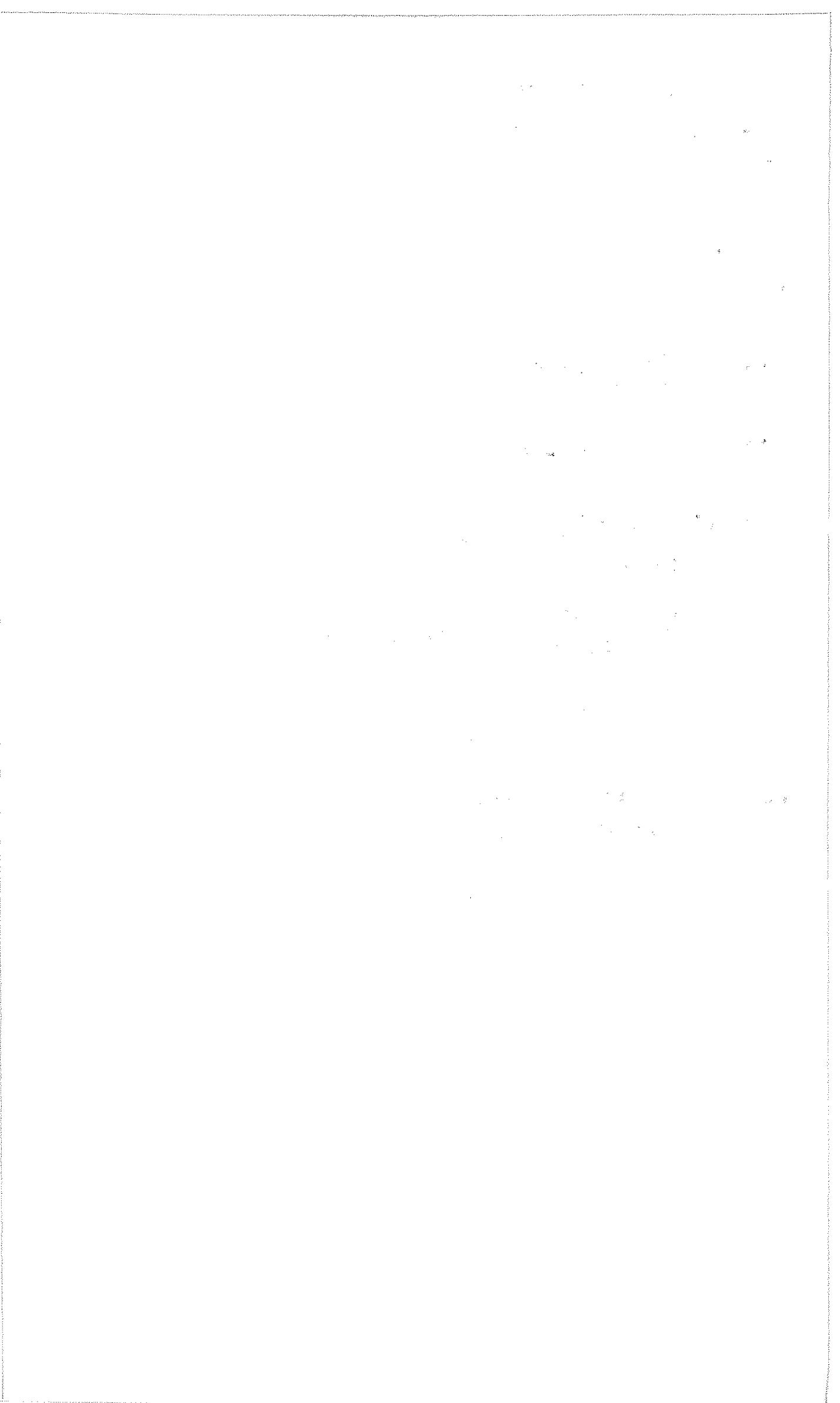
$$\frac{100 L_S - 100 L_I - 100 L_S}{L_S - L_I} = B$$

$$B = \frac{-100 L_I}{L_S - L_I}$$

Sub B in ① ; we get

$$100 = \frac{100}{L_S - L_I} \cdot L_S - \frac{100 L_I}{L_S - L_I}$$

$$100 = \frac{100 L_S}{L_S - L_I} - \frac{100 L_I}{L_S - L_I}$$



- \* PMM-I (perpetual motion machine) :-  
 Work is produced when we supply energy to a device in a some form.  
 → A pmm-I is the devise which continuously produces work without any other interaction with the environment which is highly not possible for developed such a kind of machine.
- \* First law of thermodynamics:-  
 First law of based on the principle of conservation of energy and forms the basic of the various forms of energy transformation → from experimental observations the 1st law of thermodynamics states that energy can neither be created or destroyed but 1 form of energy can be changed to other form.

$$\Delta E = Q + W$$

where  $\Delta E$  = total change in energy

for closed system  $\Delta E = Q - W$

for cyclic process initial and final states are identified.

$$\Delta E = E_2 - E_1 = 0 \therefore Q = W$$

Corollaries of 1<sup>st</sup> law:-

PMM-I (perpetual motion machine) :-

Work is produced when we supply energy to a device in a some form.

→ A pmm-I is the devise which continuously produces work without any other interaction with the environment which is highly not possible for developed such a kind of machine.

Internal energy:-

Energy stored in a system which is neither heat nor work is called a internal energy.

→ when a gas in a system is applied with heat then the gas expands in this process, it will developed work but

the total work developed is not equal to the heat supply and the difference of heat added and work developed is not equal to the heat supply and the diff of heat added and work developed is not equal to the heat supply and the system.

thus energy in storage is neither lost nor work & is called as internal energy.

consider a closed system which changes from state 1 to state 2 as shown in fig. the system initially changes from path P and returns to the Q & R.

from path P  $Q_p = \Delta E_{p\text{th}}$

from path Q  $Q_q = \Delta E_{q\text{th}}$

→ Using the first law of TP

1-P-2-Q-1

→ for path P;  $Q_p = \Delta E_{p\text{th}} + W_p \rightarrow (1)$

for path Q;  $Q_q = \Delta E_{q\text{th}} + W_q \rightarrow (2)$

P & Q processes constitute a cycle for which net heat transfer is equal to the net work done by the system.

$$\int \delta w = \int f \delta q$$

$$W_p + W_q = Q_p + Q_q$$

$$W_p - Q_p = Q_q - W_q$$

$$\therefore (Q_p - W_p) = (Q_q - W_q)$$

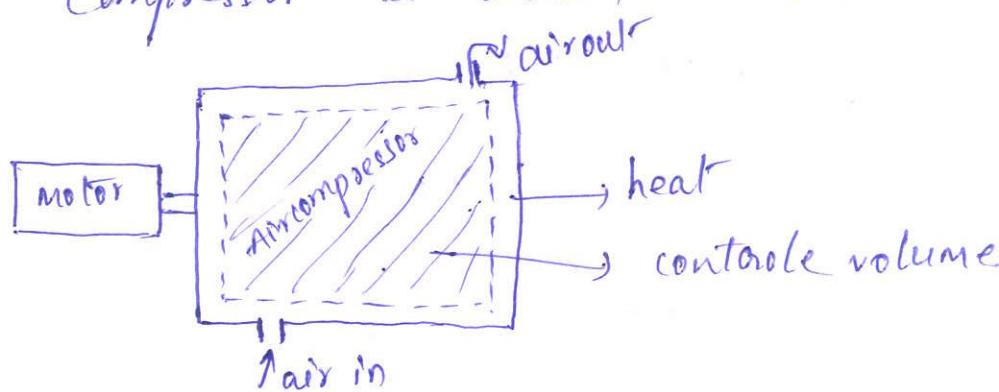
$$\therefore \Delta E_p = \Delta E_q$$

the most of the engineering devices are generally open system.

### ③ Isolated system:-

Isolated system is one in which there is no interaction between system and surroundings & it is fixed mass & energy transfer across the boundaries

Controlled volume :- Thermo dynamic analyses of a open system such as an air compressor attention is focused on certain volume in space surrounding the compressor is known as controlled volume



State :- State is defined as the state of passed through during change of state is called the path of change state.

### Thermo dynamic properties:-

Thermo dynamic properties are classified into two types.

1. Intensive property.
2. Extensive property.

1. Intensive property :- The properties are defined as independent of mass of the system

Ex:- pressure, temperature.

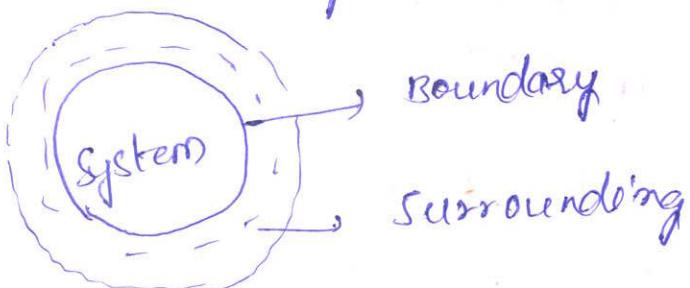
2. Extensive property :- dependent of mass of the system

Ex:- volume, energy.

System :- System <sup>UNIT - I</sup> is defined as the quantity of matter or region in space upon which attention is concentrated analyses of problem.

Surrounding:- Everything External to the system is known as surrounding or Environment.

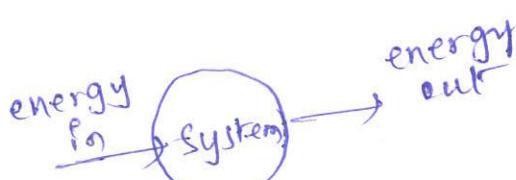
Boundary:- The system is separated from the surrounding by the system boundary. The boundary may be fixed or moving.



system is classified into three types

- ① closed system ② open system ③ isolated system

① closed system :-



closed system is the system of fixed mass. There is no mass transfer across the boundary. There may be energy transfer into across the boundary or out to the system.

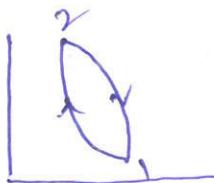
Certain quantity of a fluid in a cylinder bounded by a piston constitute a closed ~~loop~~ system.

② Open system :- Open system is one in which matter crosses the boundary of the system. There may be energy transfer also.

Thermal equilibrium :- When the system existing in mechanical and chemical equilibrium is separated from its boundary by a thermic wall (which allows heat to flow). If there is no spontaneous change in any property of the system then system is said to be Thermal equilibrium.

mass is increased to the values of the Extensive properties is increased.

process cycle :-



1-2-1 → path  
1-2 → cycle

Thermo dynamic equilibrium :-

System is said to exist in a state of thermo dynamic equilibrium when no change in any microscopic property. If its system is Isolated from its surroundings.

Thermo dynamic equilibrium classified into three types

- ① mechanical equilibrium
- ② chemical equilibrium
- ③ Thermal equilibrium

① mechanical equilibrium :- In the absence of unbalanced force within the system it self and also between the system and surrounding system that is said to be a state mechanical equilibrium.

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