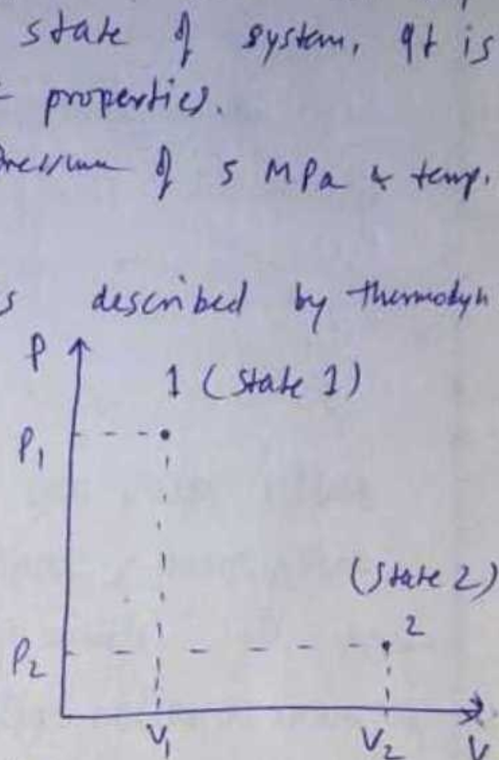
ॐ गणेशाय नमः

Thermodynamic State, Path, Process & Cycle:

The physical condition of a thermodynamic system at any time is known as thermodynamic state of system. It is described by a set of thermodynamic properties.

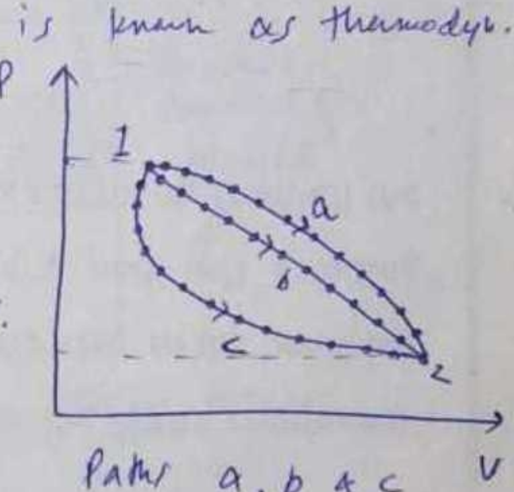
Ex: 5 kg of gas is kept at a pressure of 5 MPa & temp. of 350 K.

The state of the system is described by thermodyn. co-ordinates on property diagram.



Any operation; in which at least one of the properties of system changes is known as change of state.

The locus of the infinite intermediate states, during a change of state is known as thermodyn. Path.

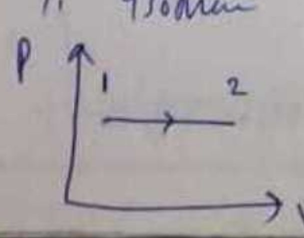


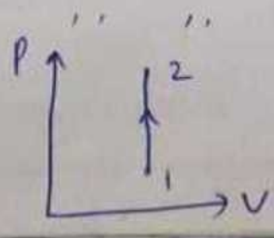
Paths a, b & c

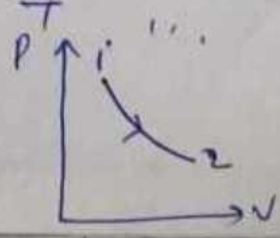
If during a change of state; the path is completely specified; it is known as a thermodynamic Process.

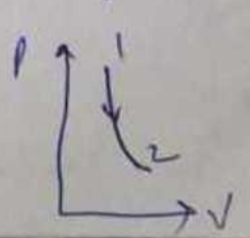
Ex: Process 1a2
" 1b2
" 1c2

An Isobaric Process is a const. P Process.
" Isochoric " " " " V ".
" Adiabatic " is " " Heat ". (No heat flow)
" Isotherm " " " " T ".

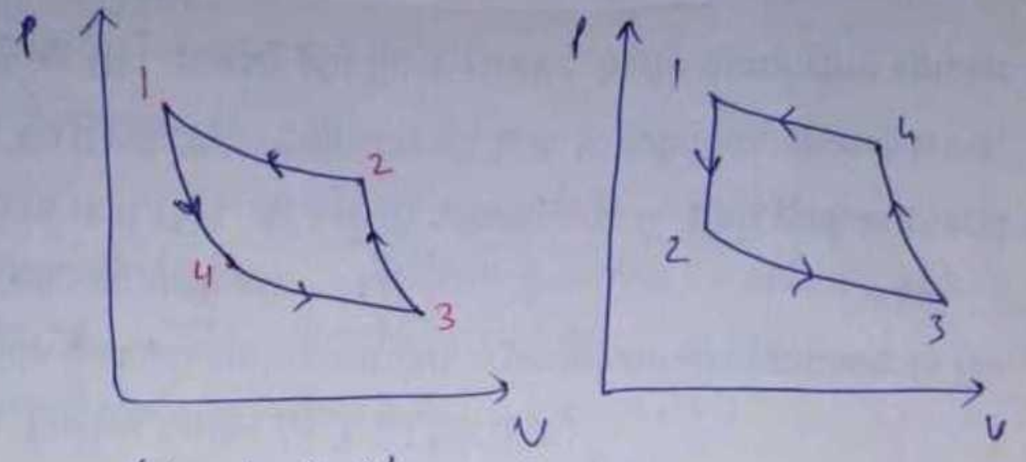








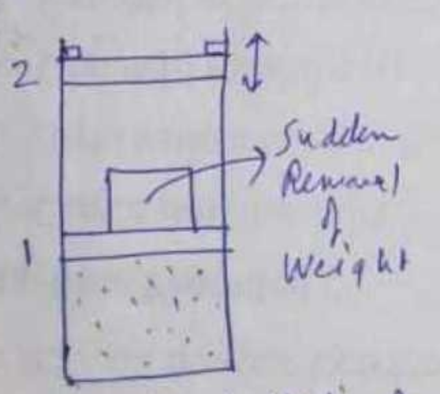
A thermodynamic cycle is a series of thermodyn processes such that the final state is coinciding with the initial state.



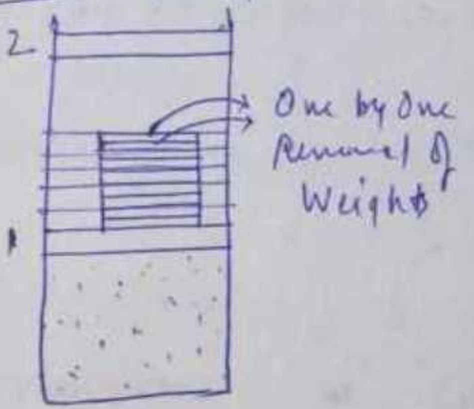
Carnot cycle

QUASI-STATIC PROCESS: An infinitely slow process is known as a Quasi-static Process.

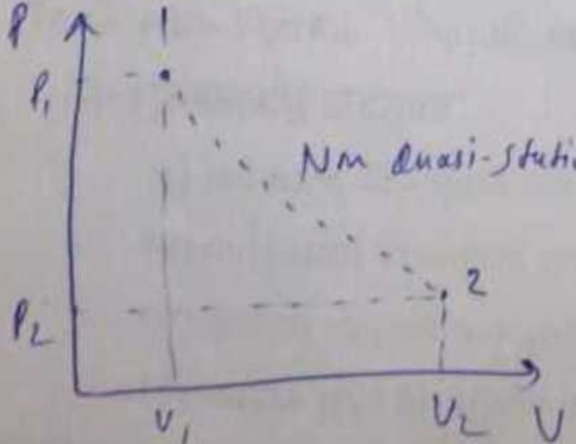
QUASI: Almost   Static: Fixed

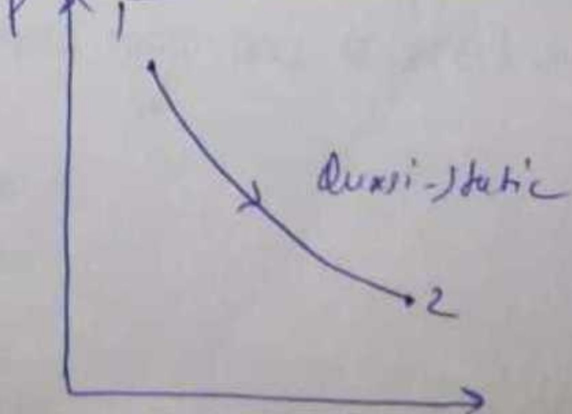


Non Quasi-static Process



Quasi-static Process



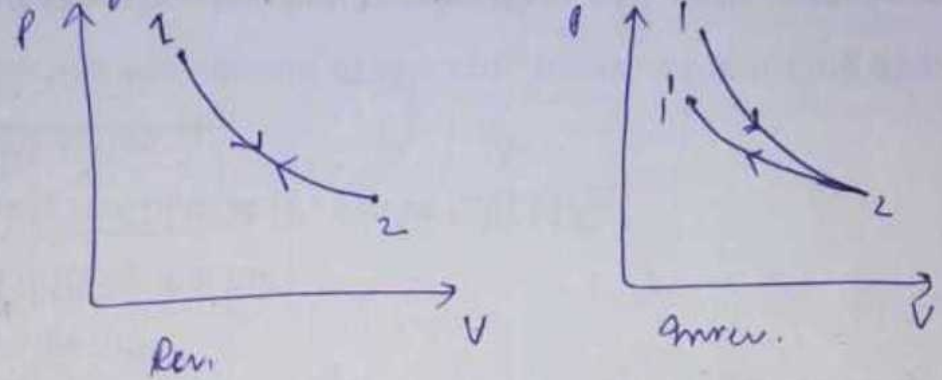


Infinitely Slow V
Expn (All interm states are clear)

A Quasi-Static process is represented by a continuous line on property diagrams & non-quasi-static by a dashed line.

Reversible & Irreversible processes:

A Process is said to be reversible; if it can be reversed in direction; following the same path; without leaving any change in the system as well as surroundings, otherwise irreversible.

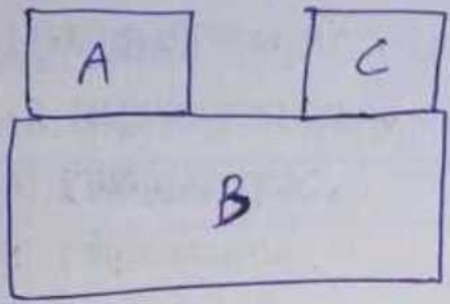


Ex: • A frictionless Quasi-static Expansion or Compression of a gas is a rev. process.

• Ideal flow through a nozzle, turbine etc. Irrevers.

Zeroth Law of Thermodynamics :

If a body A is in thermal equilibrium with body B & body B is in thermal equilibrium with body C ; then Body A & Body C will be in thermal Equilibrium, without even in direct contact



$$T_A = T_B$$
$$T_B = T_C$$
$$\Rightarrow \boxed{T_A = T_C}$$

Zeroth law is the basis of Thermometry i.e. the science of temp. measurement.

- R.H. Fowler Gave Zeroth Law in 1931. (VERY NEW)

Temperature Measurement (Thermometry) :

Temperature difference is the driving potential; which causes the Heat transfer.

It (T) is generally also said as the degree of hotness or coldness of any body.

Temperature is the measure of the mean K.E. of the molecules of any ~~object~~, system,

Unlike Other properties like Mass, Volume, length etc. of the system ; temperature is not directly seen or measured. But temperature is measured in the form of some physical characteristic of the material, which varies with temperature in a predictable & repeatable way. Now the change in this property is taken as an indication of the change in temperature.

The device, which is used to measure temp., is known as a thermometer; the physical property; which changes with r. t. temp. in a predictable & repeatable way, is known as <u>thermometric property</u> & the material is known as <u>thermometric material.</u>

<u>Ex:</u> ① In Mercury in Glass Thermometer; Hg is thermo. material; expansion in the length of Hg column is used as the thermometric property.

② In case of Thermistor (Resistence Thermometer); A metal like Pt etc. is thermo material & Resistence acts as a thermometric Property.

$$\boxed{R_t = R_0(1+\alpha \cdot t)}$$

R_0 = Resist. at $0°C$; α = const. (dependent on Metal)
R_t = " " $t°C$

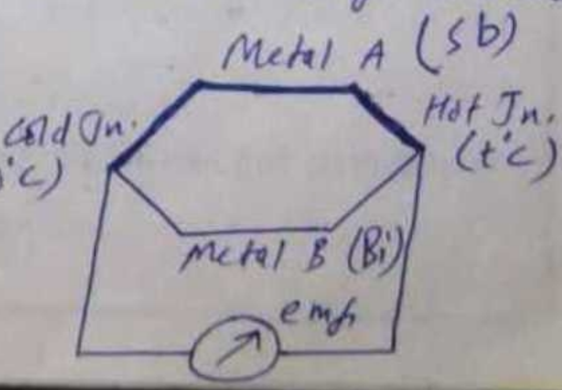
③ In case of a thermocouple; Bimettalic joint acts as thermometric material + the emf induced is the the property.

$\boxed{emf \propto t}$

when $t = 0°C$

$\boxed{emf = 0}$

$\boxed{Pt-Rh}$



After 1954: Only single Reference Point i.e. triple point of water (273.16 K) is used for calibration of the thermometer.

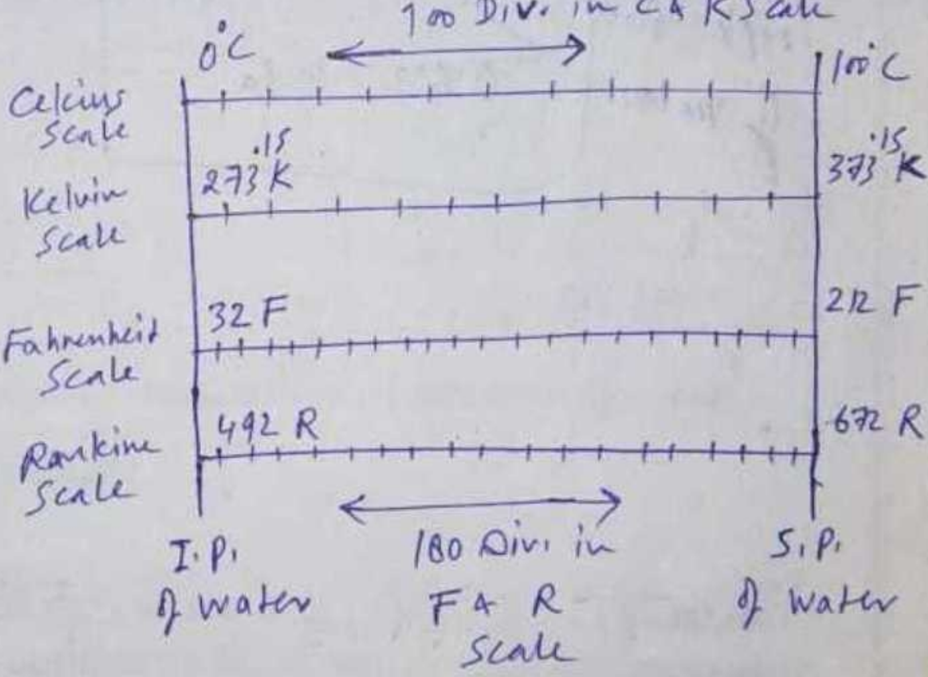
Triple Point: At which; all the 3 phases, viz.: solid, liquid & gas co-exist in equilibrium.

e.g.: for water (0.01°C or 273.16 K)

$$\Rightarrow T_{tp} = \alpha \cdot x_{tp} \Rightarrow \alpha = \frac{T_{tp}}{x_{tp}}$$

$$\text{Now } T = \alpha \cdot x \Rightarrow \boxed{T = \frac{T_{tp}}{x_{tp}} \cdot x}$$

Temperature Scales:



From the eqn $\boxed{\frac{T - T_i}{T_s - T_i} = c}$

$$\frac{C - 0}{100 - 0} = \frac{K - 273.15}{373.15 - 273.15} = \frac{F - 32}{212 - 32} = \frac{R - 492}{672 - 492}$$

$$\boxed{\frac{C}{5} = \frac{K - 273.15}{5} = \frac{F - 32}{9} = \frac{R - 492}{9}}$$

Note: All the thermometers will give the same reading at the calibration points i.e. reference points (T.P. & S.P. of water); but it is not necessary that they will give the same reading in between these reference points; thats why temp. scales are said to be ARBITRARY in nature.

Prob! A new temp. scale in °N is desired with F.P. at 100°N & B.P. at 400°N; Establish a correlation between °C & °N.

Sol! °C: $100 = a \cdot x_s + b$; $0 = a \cdot x_i + b$
$\Rightarrow b = -a \cdot x_i$

$$\boxed{100 = a \cdot x_s - a \cdot x_i}$$

$$a = \frac{100}{(x_s - x_i)} \; ; \; b = -\frac{100 \cdot x_i}{(x_s - x_i)}$$

°N: $400 = a \cdot x_s + b$; $100 = a \cdot x_i + b$

$$\boxed{T_C = \frac{100 \cdot x}{(x_s - x_i)} - \frac{100 x_i}{(x_s - x_i)} = \frac{100 (x - x_i)}{(x_s - x_i)}} \quad (1)$$

$$a (x_s - x_i) = 300 \Rightarrow a = \frac{300}{(x_s - x_i)}$$

$$b = 100 - \frac{300 \cdot x_i}{(x_s - x_i)} = \frac{100 x_s - 100 x_i - 300 x_i}{(x_s - x_i)}$$

$$b = \frac{100 x_s - 400 x_i}{(x_s - x_i)}$$

$$T_N = \frac{300 \cdot x}{(x_s - x_i)} + \frac{100 x_s - 400 \cdot x_i}{(x_s - x_i)}$$

$$T_N = \frac{300 (x - x_i)}{(x_s - x_i)} + 100$$

from eq. (1) ; $\boxed{T_N = 3 T_C + 100}$ Ans