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MADE EASY

MECHANICAL ENGINEERING

Thermodyanamics

By-Amrinder Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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Thermodynamics

Gate – (4-6) marks (8-10) Q's
ESE → Prelims
→ Mains (40-60) marks

Book → Theory :- Cengel and Boles
→ Q's :- P.K. Nag

(1) Class discussion
(2) Class work book
(3) Theory book Q's
(4) Test

Sub = Class Notes + Work Book + GATE P/Q + ESE P/Q + Test

16-04-20

Thermodynamic

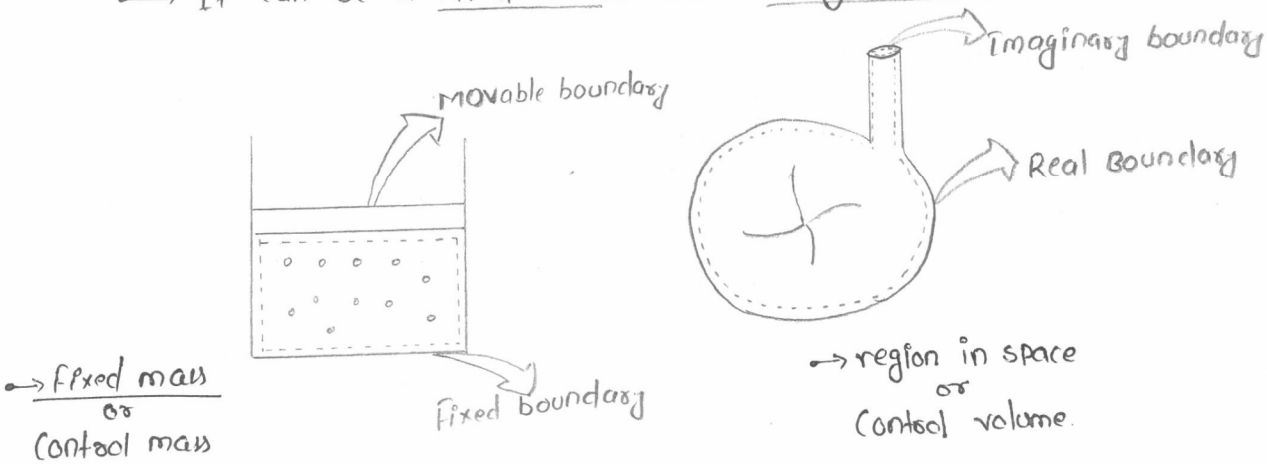
Thermodynamic :- It is a branch of science which deals with energy interaction and its effect on system and surroundings

Therm = Heat
+
Dynamic = Power - work/time

Energy :- It can be understood as the ability to cause changes.

System :- It can be defined as the part of the Existence which is under observation.

→ It can be a fixed mass or a reagon in space



Surrounding :- Everything Except the system become's surrounding

→ The part of the surrounding which directly get effected by the system is called immidiate surrounding.

Boundary :- It is a real or imaginary surface which saparate the system from the surrounding

→ Boundary can be fixed or movable

NOTE :- An Ideal Boundary is of zero thickness

# Type of system	mass	Energy	work	Example
1. Closed system	×	✓		Piston Cylinder without valves
2. Open system	✓	✓		Piston Cylinder with valves
3. Isolated system	×	×		UNIVERSE → Hot tea in a perfectly insulated

Properties of the System

→ Any characteristic of the system is called properties of the system.

→ These properties can be classified as

(a) Intrinsic (Intensive) :- Independent of mass of system under consideration. [कैसा है (How)]

Ex:- pressure, Temp, density, Thermal conductivity, young's modulus, velocity.

(b) Extrinsic [Extensive] :- The property which dependent on the system under consideration [कितना (How much)]

Ex:- volume, Internal Energy, Entropy, Enthalpy etc.

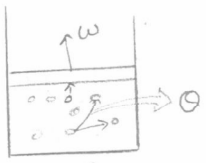
NOTE:- All specific properties are Intensive properties

Ex:- Specific volume, specific Entropy, Specific Internal Energy, Specific Heat, specific Enthalpy. etc

→ If we devide the system into two Half's the property which does not change is intensive.

#

Heat / work	properties
1. Path function	1. Point function
2. Dependent on past history	2. Independent of past history
3. Inexact differential $\int_1^2 \delta W = W$ (not $W_2 - W_1$) or $\int dW$ (small)	3. Exact differential $\int_1^2 dE = E_2 - E_1$ (small change)



Thermodynamic Equilibrium

→ A system is said to be in thermodynamic equilibrium If it satisfied the following Equilibrium conditions.

① Thermal equilibrium :- Equality of temp

② Mechanical equilibrium :- Equality of force

③ Chemical equilibrium :- Equality of No chemical reaction potential

④ phase equilibrium :- mass of each phase remains constant with time.

State of the system and processes

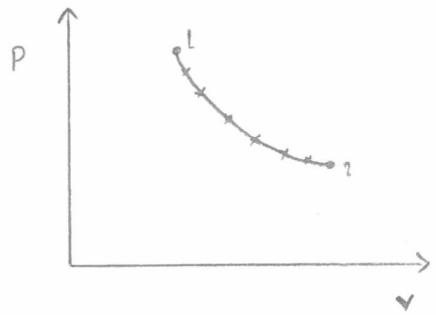
→ Any Equilibrium condition of the system is called state of the system.

→ The state of the system is specified by the properties of the system.

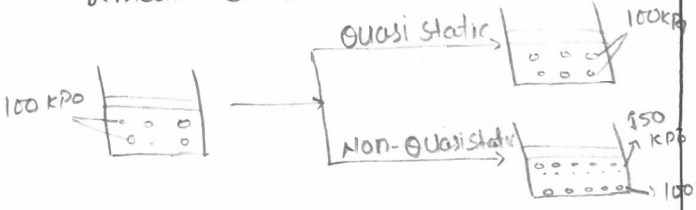
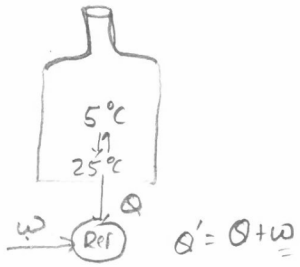
→ If any one of the propertie changes, the state of the system changes.

→ The change in state is called processes

→ The infinite states through which the system passes while moving from initial state to final state. is called processes path.



Processes can be classified

Quasi-state (Quasi-equilibrium) or Non-Quasistate	Reversible or Irreversible
→ A process is quasi static if it occurs infinitly slowy else process is Non-Quasistatic → In quasistatic process gradient (different) tendes to zero → In quasistatic process properties remain uniform 	→ A process is said to be reversible it can be reversed, following the same path without leaving any change in system and surrounding. 

NOTE :- A Frictionless quasi-static process become reversible.

Microscopic and Macroscopic Approch

① Macroscopic Approch :- In this approch the avg molicular behaviour is considered an individual molicular behaviour is neglected.

→ for macroscopic Approch to be valid the ~~Continuum~~ Continuum concept is valid

Continuum → In continuum concept the matter is treated as continously distributed without any gap between the molecules

→ The continuum concept is applicable if the mean free path [MFP] is much less then the system dimensions.

Mean free path [MFP] :- It is the avg distance traveled by a molecules between two sucessive collision

Microscopic Approach :- In this approach the individual molecular behaviours is considered because the matter becomes very Rare very rare (↓↓ low density)

→ Rarified gas flow theory is used.
→ microscopic Approach is used in Space exploration

pure substance :- A substance is said to be a pure substance if it is of homogenous Chemical Composition throughout.

Ex :-

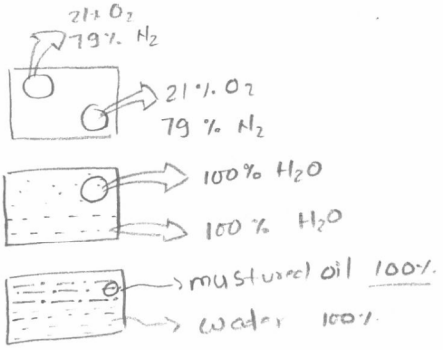
① Gaseous mix of O_2 and N_2 ✓

② water + water vapour ✓

③ mustard oil + water ✗

④ Ethyl Alcohol + water ✓
(C_2H_5OH)

⑤ Liquid air + Gaseous air ✗



Gibb's Phase rule :-

$P + F = C + 2$ → Pressure, Temperature } Both as variable

P = No of phases that can exist at the given condition.

C = No of Chemical Components

F = D.O.F

① O_2 and N_2 gaseous mixture :-



$P + F = C + 2$
$1 + F = 2 + 2$
$F = 3$

Partial pressure total = $P_{O_2} + P_N$
(P_t)

② water + water vapour :-

$P + F = C + 2$
$2 + F = 1 + 2$
$F = 1$

③ Triple point of water

$P + F = C + 2$
$3 + F = 1 + 2$
$F = 0$

$P_{tp} = 0.61$ kPa → pressure at triple point

$T_{tp} = 273.16$ K $= 0.01°C$ ← For H_2O. → Temp at triple point.

NOTES:-

(1) Gibbs phase rule dose't include compositional voliable.

(2) If total variable is required to fix the state in wet region. $|_{L+V}^{x}$
is two (?)

(3) The D.O.F and the total variable required for Saturated Liquid of saturated vapour is one

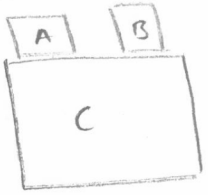
(4) According to state postulate for a simple compressible system the number of variables required to fixed the state of system is two = 2

17-Oct-26

Zeroth Law of thermodynamic

→ Fowler – 1931

→ According to zeroth law if Body 'A' and 'C' is in thermal equilibrium and also Body 'B' and 'C' is in thermal equilibrium saperatly, Then Body 'A' and 'B' must be in thermal equilibrium with each other.



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

→ In zeroth law body 'C' act's as a thermometre
→ zeroth law help's us in temperature measurment
→ Hotness or coldness is the measure of heat transfer rate and temp is one of the variable effecting it.

Type's of thermometre

→ thermometre are based on the measurement of ~~thermomatric~~ thermomatric properties.

→ A thermomatric propertie is a properties which help's in measuring the temprature.

Ex:- volume or Length in mercury thermometre

(1) Resistance thermometer

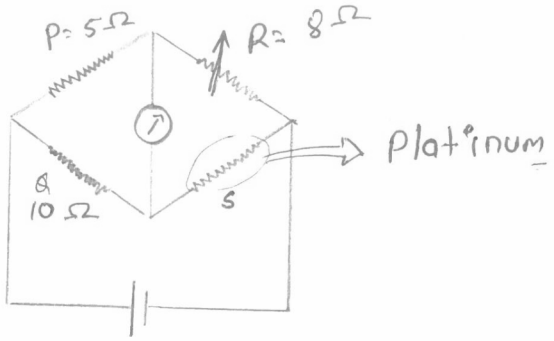
→ wheat stone bridge

to be balanced

$$\frac{P}{Q} = \frac{R}{S}$$

$$\frac{5}{10} = \frac{8}{S}$$

$$\boxed{S = 16}$$



⇒ $\boxed{S = \alpha t^2 + \beta t + \gamma}$ → constant

(Find = Temp)

→ Resestance bear is the thermomatoic propesty

② Thermocouple

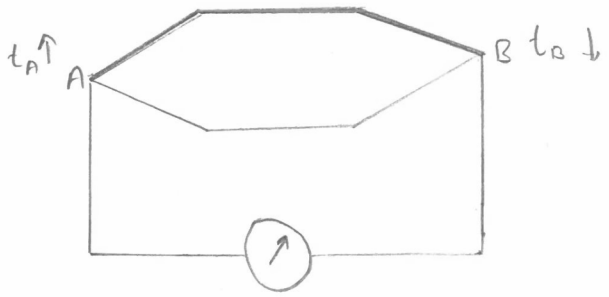
→ It is based on see back effect

→ According to see back effect If diff^n metlers are joined together to form two diff^n junction's and these junction are maintained at diff^n temp then an EMF is generated which is directly poopertional to the themp diff^n.

→ By measuring the EMF the temp diff^n and hence the unknown teme can be found.

See beck effect

$|EMF \propto \Delta T|$



NOTE :— Peltier effect

→ Peltier effect is the opposite of See beck effect and is used for thermo electric seperagation

→ In thermo couple EMF or voltage is the thermometric propesty

