THERMO DYNAMICS

1. **System:**
A particular portion of matter is called a system

2. **Surroundings:**
Every thing outside of the system that may have a direct influence on the system is referred as the surroundings.

3. **Types of systems:**
There are 3 types of systems

a. Open system:
A system which exchanges both energy and matter with its surroundings is called as open system

b. Closed system:
A system which can exchange energy only and not matter with surrounding is known as closed system.

c. Isolated system:
A system which can exchange neither energy nor matter with the surroundings is called isolated system.
Examples: hot box, thermo flask

4. **Thermo dynamics co-ordinates (or) variables:**
The parameters like presure, volume, temperature entropy, internal energy, work, etc characterising. The state of the system are called thermo dynamic variables

5. **Thermo dynamic system:**
A system that can be described in terms of the thermo dynamic co-ordinates is called thermo dynamic system:

6. **Heat:**
Heat is a form of energy which transfer from a body at heigher temperature to a body at lower temperature.
Units: Unit of heat in SI - Joule
Unit of heat in C. G. S - Calorie

1 Cal = 4.2 J

7. **Thermal equillibrium:**
Two bodies are said to be in thermal equilibrium if there is no exchange of heat energy between them when conected thermally with each other.

8. **Zeroth law of thermo dynamics:**
If two systems A and B are in thermal equilibrium with third system C seperately then they (A, B) must be in thermal equilibrium with each other. Mathematical representation

$$f_A(P_AV_A) = f_B(P_BV_B) = f_C(P_CV_C) = T$$

(or)

$$f(P,V,T) = 0$$

9. **Calorie:**
The quantity of heat required to rise the temperature of 1gm of water through 1^0C is called 1 calorie.

10. **Standand Calorie:**
The quantity of heat required to rise the temperature of 1gm of water from 14.5^0C to 15.5^0C is called standrad calorie

11. **External work:**
When the force is exerted by the ststem on its surroundings produces a displacement the work done by the system is called external work.

(or)

When the force is exerted by the surroundings on the system produces a displacement the work done by the surroundings is called external work.

a. The work done by the system on the surroundings is taken as '+ve'
b. The work done by the surroundings on the system is taken as '– ve'

12. **Internal work:**
When the work done by one part of the system on another part of the same system is called internal work.

13. **Internal energy:**
Internal energy of a thermo dynamic system is defined as the energy possessed by the system by virtue of its molecular constitution and the position of the molecules

a. In a gas the molecules are in the state of random motion hence they posses kinetic energy.
b. Due to molecular forces of attraction among the molecules they posses potential energy.
c. The sum of potential energy and kinetic energy of individual molecules in the system is called internal energy.
Internal energy $U = P.E. + K.E$
$\therefore$ change in internal energy
$dU = U_f - U_i$
where U_f is final internal energy
U_i is initial internal energy
d. Internal energy of a system increases with temperature.

14. **Heat capacity (or) thermal capacity**
The quantity of heat required to rise the temperature of a substance through 1^0C is called heat capacity it is represented by 'H'

$$\therefore H = \frac{\text{Change in heat energy}}{\text{rise in temperature}}$$

$$H = \frac{dQ}{dT}$$

Units: J/k in S.I.

$Cal/{}^0C$ in C. G. S

dimensional formula. $ML^2T^{-2}K^{-1}$

15. Specific heat:

The quantity of heat required to rise the temperature of unit mas of a substance through 1^0C is called its specific heat it is represented by 'c'

$\therefore$ specific heat =

$$\frac{1}{\text{mass}}\times\frac{\text{change in heat energy}}{\text{rise in temperature}}$$

$$\therefore\ c=\frac{1}{m}.\frac{dQ}{dt}$$

Units: $J/kg\,k$ in S.I.

$Cal/gm\ {}^0C$ in C. G. S

dimensional formula: $\frac{L^2T^{-2}}{M\times K}=L^2T^{-2}K^{-1}$

16. Relation between heat capacity and specific heat:

Specific heat of a substance is given by

$$c=\frac{1}{m}.\frac{dQ}{dt}$$

But $\frac{dQ}{dT}=H$ heat capacity

$$c=\frac{H}{m}$$

$$\therefore H=mc$$

17. Water equivalent:

The mass of water in grams which would require the same amount of heat to raise in temperature through 1^0C as the body when heated through the same temperature is called water equaivalent

a. In C.G. S system, thermal capacity and water equivalent are numerically equal. water equivalent = thermal capacity = mc = $\frac{dQ}{dT}$

b. Of all the solids and liquids water has highest specific heat so that water is used in radiators of motor vehicles

Its value $1Cal/gm\ {}^0C$ or $4180\ J/kg.k$

c. Specific heat of a substance during its change of state is infinity during change of state dT = 0

$$\therefore c=\frac{1}{m}.\frac{dQ}{0}$$

$$c=\propto$$

18. External work done by an ideal gas during expansion

$$dw=PdV$$

19. First law of thermo dynamics:

A quantity of heat energy is supplied to a system is equal to sum of the external work done by the system and increase in its internal energy this is called first law of thermo dynamics

(or)

When certain amount of heat is given to a system a part of it is used to increase the internal energy and the remaining part is used in doing external work. This is known as first law of thermo dynamics.

a. This law is particular form of the law of conservation of energy.

b. $\mathrm{dQ}=\mathrm{dU}+\mathrm{dw}$

where dQ amount of heat

dU in crease in internal energy

dw = PdV work done

c. $\mathrm{dQ}=\mathrm{dU}+\mathrm{PdV}$

20. Significance:

a. Heat is a form of energy in transit

b. Energy is conserved in thrmo dynamic system

c. Every thermo dynamic system in equilibrium state possesses internal energy.

21. Specific heats of gases: Every gas has two specific heats

a. Specific heat of gas at constant volume

b. Specific heat of gas at constant pressure.

22. Specific heat of gas at constnat volume:

It is defined as the amount of heat required to rise the temperature of unit mass of gas through 1^0C at constant volume

$$C_V=\frac{1}{m}.\frac{dQ}{dT}$$

23. Specifi heat of gas at constant pressure.

It is defined as the amount of heat required to rise the temperature of unit mass of gas through 1^0C at constant pressure.

$$C_P=\frac{1}{m}.\frac{dQ}{dT}$$

24. Molar specific heat at constant volume

a. It is defined as the amount of heat required to rise the temprature of one mole of gas through 1^0C at constant volume.

$$C_V = \frac{1}{n}.\frac{dQ}{dT}$$

b. at constant volume the system uses given heat energy to increase internal energy only and dw = 0

$$\therefore dQ = dU + dw$$

$$dU = dQ$$

$$dU = nC_V.dT$$

25. Molar specific heat at constant pressure.

a. It is defined as the amount of heat required to rise the temperature of one mole of gas through 1^0C at constant pressure.

$$C_P = \frac{1}{n}.\frac{dQ}{dT}$$

b. When system is at constant pressure which uses the given heat energy for the system in two ways a part of it used to increase internal energy remaining part used for doing external work

$$\therefore dQ = dU + dw$$

$$C_P = \frac{1}{n}.\frac{d\theta}{dT}$$

$$dQ = nC_P.dT$$

$$nC_PdT = dU + PdV$$

26. Relation between C_P and C_V

a. to increase internal energy of a system to same level at constant volume and at constnat pressure, the system required more heat energy at constant pressure.

$$\therefore C_P > C_V$$

b. $C_P - C_V = R$

c. The ratio of C_P and C_V is a constant

i.e. $\frac{C_P}{C_V} = \gamma$

27. Law of method of mixtures:

When there is no loss of heat energy to the surroundings the heat lost by the hot body will be equal to the heat gained by the cold body when they are mixed together is called law of method of mixtures.

heat lost by the hot bodies = heat gained by the cold bodies

a. Two substances of masses m_1 and m_2 specific heats c_1 and c_2 are at temperatures θ_1 and θ_2 are mixed then final temperature of mixture is

$$\theta = \frac{m_1c_1\theta_1 + m_2c_2\theta_2}{m_1c_1 + m_2c_2}$$

b. If $c_1 = c_2$ i.e. substances are made of same material then

$$\theta = \frac{m_1\theta_1 + m_2\theta_2}{m_1 + m_2}$$

c. If $m_1 = m_2$, then $\theta = \frac{m(\theta_1 + \theta_2)}{2m}$

$$\theta = \frac{\theta_1 + \theta_2}{2}$$

28. Mechanical equivalent of heat (or) Joules law:

The amount of work performed is directly proportional to the amount of heat generated

$$w \alpha Q$$

$$w = JQ$$

where

J = Joules constant (or) mechanical equivalent of heat

Units: S.I. units of J is unity J = 4.2 J/Cal

29. Isothermal process:

a. The changes in volume and pressure of a gas taking place at constant temperature is called isothermal process

b. Isothermal process obeys boyles law i.e PV = constant

c. In this process the system is enclosed with perfect heat conducting walls

d. Due to exchange of heat from system to surroundings (or) vice versa through heat conducting walls so that temperature of the system is constant.

$$\therefore dT = 0$$

e. In this process the change in internal energy of the system is zero
dU = 0

f. This process is slow process

g. Molar specific heat is infinity in this process

$$C = \frac{1}{n}.\frac{d\theta}{dT} = \frac{1}{n}.\frac{d\theta}{0}$$

h. Work done in isothemal process is

$$w = 2.302\ nRT\ \log_{10}\left(\frac{P_1}{P_2}\right)$$

30. Adiabatic process

a. The changes in pressure, volume of a

gas taking place at constant heat energy is called adiabatic process

b. This process do not obey any gas laws but it obeys piossions law

$PV^{\gamma} = \text{constant}\cdot$

c. In this proces the system is enlclosed with bad conductor of heat

d. In this process there will not be any exchange of heat from system to surroundings & vice versa through bad conductor of head so that heat energy remains constant.

e. Change in heat energy in this process is zero
i.e. $dQ = 0$

f. Molar specific heat is zero i.e.

$$C = \frac{1}{n}.\frac{dQ}{dT}$$

$C = 0$

$(\because dQ = 0)$

g. It is quick and sudden process
Ex: When cycle tube bursts suddenly pressure, volume, temperature of the gas changes but heat energy remains same.

h. Work done in adiabatic process is

$$w = \frac{R}{1-\gamma}\left[T_2 - T_1\right]$$

31.Relation between P, V

Relation between P, V is given by PV^{γ} = constant

a Relation between V, T is given by $V^{\gamma-1}T$ = constant

b Relation between P, T is given by $P^{1-\gamma}T^{\gamma}$ = constant

32. Latent heat:

The amount of heat absorbed (or) released by unit mass of a substance during its change of state at constant temperature is called latent heat it is denoted by ‘L’

$$\therefore \text{ Latent Heat} = \frac{\text{heat energy}}{\text{mass}}$$

$$L = \frac{Q}{m}$$

Units: J/Kg in S.I.
Cal/ gm in C. G. S

The amount of heat required for a substance of mass m to change its state is

$$Q = mL$$

33. Latent heat of ice:

The quantity of heat required to change the state of 1gm of ice into water at 0^0C is called latent heat of ice

in C.G.S $L_{ice} = 80Cal/gm$

in.SI. $L_{ice} = 0.336\times10^6 J/Kg$

34. Latent heat of steam:

The quantity of heat required to change the state of 1gm of water into steam at 100^0C is called latent heat of steam.

in C. G. S

$L_{steam} = 540cal/gm$

S.I.

$L_{steam} = 2.268\times10^6 J/Kg$

Note: Liquids with low latent heat of steam are called volatile liquids
Ex: Petrol, either, Perfumes

35. Sublimation of heat:

The amount of heat is required to change unit mass of solid into steam directly at given temperatures is called heat of sublimation
Ex: camphor, iodine

36. Triple point:

The pressure and temperature at which the given substance can exists in 3 states (liquid, solid and gas) simultaneously is known as triple point pressure and temperatures of triple point of water are 610.13 Pa and 273.16k

37. Second law of thermo dynamics:

a.Clausius statement

It is impossible for a self acting machine unaided by any external agency to transfer heat from a body at lower temperature to a body at higher temperature

(or)

Heat cannot by it self flow from a colder body to hotter body.

b.Kelvin Flank statement:

It is impossible to construct a heat engine operating in a cycle to convert the heat energy completely into work with out any change of working system.

38. Heat engine is a device used to convert energy into work or mechanical enerty. Its efficiency

$$\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1}$$

Principle of refrigerator (or heat pump)

A refrigerator, as we all know, is a device used for cooling Things. It is also called a heat pump.

Note that water and other food stuff to be cooled in the refrigerator serve as sink at loser temperature. The source in this case is the atmosphere or surrounding air at room temperature T_1.

$$W = Q_1 - Q_2$$

$$\beta = \frac{Q_2}{w} \quad \beta = \frac{Q_2}{Q_1 - Q_2}$$

$$\beta = \frac{T_2}{T_1 - T_2}$$

$$\beta = \frac{1-\eta}{\eta}$$

$$\beta = \frac{1-\eta}{\eta}$$

Second law of thermodynamics

This, principle which disallows certain phenomena consistent with the first law of thermodynamics is know as the second law of thermodynamics.