Thermodynamics chapter- 1

Thermodynamics -

The heat is defined as the energy transferred, without transfer mass, across the boundry of a System because of a temperature difference betn the system and the Surrounding, It is usually represented by Q and is expressed in joule(J) or Kilo - Joule (KJ).

Work -

Work is defined as the product of force (F) and the distance moved(X) ~~in S.I. system of units.~~
~~Mathematically, Work done, W=F×X.~~

~~The unit of work depends upon the unit of force and the distance moved~~ In the direction the force.
Mathematically, Work done, $W = F \times X$.

The unit of the work depends upon the unit of force and the distance moved. In S.I. System of units, the partical units of work is Newton- metre (N-m). The work of 1N-m is known as joule such that $1 N\text{-}m = 1 J$.

1st law of thermodynamics -

The heat and mechanical work are mutually Convertible. According to this law, When a closed system undergoes a thermodynamic cycle, the net heat transfer is equal to the net work transfer. In other works, the cyclic integral of heat transf is equal to the cyclic integral of work transfers.
Mathematically, $\oint \delta Q = \oint \delta W$
phi

Where symbol $\oint$ Stands for cyclic integral and δQ, δW represent infinitesimal elements of heat and Work transfer respectively.

* The energy can neither be created nor destroyed through it can be transferred from one form to another. According to this law, when a system undergoes a change of state, then both heat transfer and work transfer takes place. The net energy transfer is stored within the system and is known as stored energy or total energy of the system.

Mathematically $\delta Q - \delta W = dE$

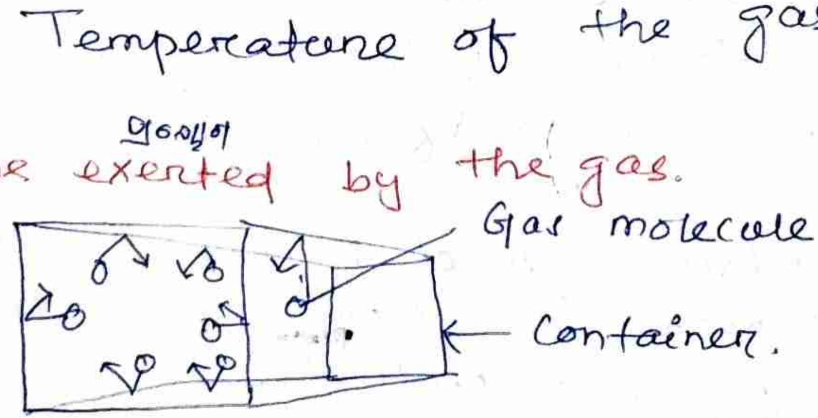
The symbol δ is used for a quantity which is inexact differential and symbol d is used for a quantity which is an exact differential. The quantity E is an extensive property and represents the total energy of the system at a particular state.

→ State Laws of perfect gas.

The physical properties of a gas are controlled by the following three variables.

1. Pressure exerted by the gas.
2. Volume occupied by the gas.
3. Temperature of the gas.

* Pressure exerted by the gas.



The pressure exerted by the gas is due to the continous collision of the molecules against walls of the container. Due to this continuous collision, the wall experience a continous force which is equal to the total momentum imparted to the walls per second.

The behaviour of a perfect gas, undergoing any change in the above mentioned variables, is governed by the following laws which have been established from experimental results.

1. Boyle's Law
2. Charle's Law
3. Gay-Lussac Law.

1. Boyle's Law

This law was formulated by Robert Boyle in 1662. It states, " The absolute pressure of a given mass of a perfect gas varies inversely as its volume, when temperature remain constant". (Pressure increase volume decre

Mathematically, $P \propto \frac{1}{V}$ or $PV =$ Constant.

2. Charles's Law

This law was formulated by a frenchman A.C. Charles in about 1787. It may be stated in the following two different forms. (Temperature increase ~~[illegible]~~ Pressure increase

(i) The volume of a given mass of a perfect varies directly as its absolute temperature, when the absolute pressure remain constant".

Mathematically, $V \propto T$ or $\frac{V}{T} =$ Constant.

3. Gray-Lussac Law

This law states, " The absolute pressure of a given mass of a perfect gas varies directly as its absolute ~~pressure remains constant~~ temperature when the volume remains constant."

Mathematically, $P \propto T$ or $\frac{P}{T} = \text{Constant}$

Specific heat of a gas - Specific heat - C

The specific heat of a gas substance may be broadly defined as the amount of heat required to raise the temperature of its units of mass through one degree. All the liquids and solids have one specific heat only. But a gas can have any number of specific heat (lying between zero and infinity) depending upon the conditions, under which it is ~~reach~~ heated. The following two types of heats of a gas are important from the subject point of view

1. Specific heat at constant volume.
2. Specific heat at constant pressure.

1. Specific heat at constant volume. (cv)

It is the amount of heat required one to raise the temperature of a unit mass of gas through one degree when it is heated at a constant volume. It is generally denoted by C_v.

fixed

Heat being supplied at constant volume.

Consider a gas contained in a container with a fixed lid as shown in the figure. Now, if this gas is heated, it will increase the temperature and pressure of the gas in the container. Since the lid of the container is fixed, therefore the volume of gas remains unchanged.

Let m = Mass of the gas

T_1 = Initial temperature of the gas

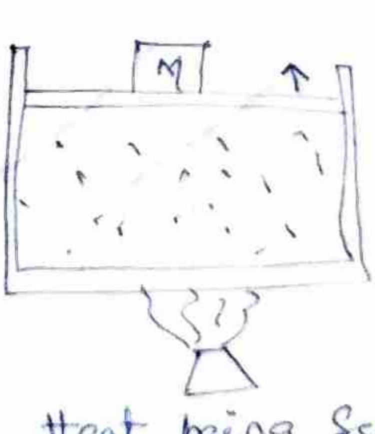
T_2 = Final temperature of the gas.

Total heat supplied to the gas at constant volume Q_{1-2} = mass × supplied heat at constant volume × Rise in temperature = $mC_v(T_2-T_1)$

It may be noted that whenever a gas is heated at constant volume, no work is done by the gas. The whole heat energy is utilised in increasing the temperature and pressure of the gas.

Specific heat at constant Pressure -

It is the amount of heat required to raise the temperature of a unit mass of a gas through one degree, when it is heated at constant pressure. it is generally denoted by C_p.



Heat being supplied at constant pressure

Consider a gas contained in a container with a movable lid as shown in figure. Now if this gas is heated, it will increase the temperature and pressure of the gas in container. Since the lid of the container is movable, therefore it will move upwards in order to counter balance the tendency for pressure to rise.

Let, m = mass of the gas

T_1 = Initial temperature of the gas.

V_1 = Initial volume of the gas.

T_2, V_2 = Corresponding values for the final condition of the gas.

Q_{1-2} = Mass × Specific heat at constant pressure × rise in temperature.

$= m C_p (T_2 - T_1)$

Relationship between Specific heats.

Consider a gas enclosed in a container and being heated, at a constant pressure, from the initial State 1 to the final stange 2.

m = Mass of the gass

T_1 = Initial temperature of the gas.

T_2 = final temperature of the gas.

v_1 = Initial volume of the gas.

v_2 = final volume of the gas.

C_p = Specific heat at constant pressure.

C_v = Specific heat at constant volume.

P = constant pressure.

We know that heat supplied to the gas at constant pressure,

$$Q_{1-2} = m C_p (T_2 - T_1)$$

A part of this heat utilised in doing the external work, and the rest remains within the gas and is used in increasing the internal energy of the gas.

∴ Heat utilised for external work $W_{1-2} =$

$$P(V_2 - V_1) \text{ —— (i)}$$

And increase the internal energy

$$dU = m C_v (T_2 - T_1) \text{ —— (ii)}$$

We Know that $Q_{1-2} = W_{1-2} + dU$ —— (iii)

$\therefore mC_p(T_2 - T_1) = P(V_2 - V_1) + mC_V(T_2 - T_1)$ —— (iv)

$PV_1 = mRT_1$ —— (for initial condition)

$PV_2 = mRT_2$ —— (for final condition)

$\therefore P(V_2 - V_1) = mRT(T_2 - T_1)$

Now substituting the value of $P(V_2 - V_1)$ in equation —— (v)

$mC_p(T_2 - T_1) = mR(T_2 - T_1) + mC_V(T_2 - T_1)$ —— (vi)

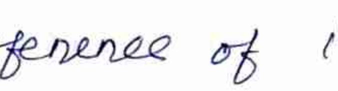
The above equation may be rewritten as

$C_p - C_V = R$ or $C_V(\gamma - 1) = R$ — $\left[\gamma = \frac{C_p}{C_V}\right]$

$C_V = \frac{R}{\gamma - 1}$ —— (vii)

The equation (v) given as an impontant nesult as it proves that charasticas constant of a gas (R) is equal to the diffenence of its two specific heats. $(C_p - C_V)$.

Sensible heat = exchange of heat changes the temperature of the body.



Latent heat = energ needed or heat needed to phase change.

enthapy - measurement of energy in a thermodynam system. total heat content of a system