"OR"

Statement:-

"The energy can niether be created nor be destroyed but can be converted from one form to the other".

Mathematically:-

df

Q = heat supplied

U = Internal energy

W = Work done.

Then

$$Q = U + W$$

Methods Of Heating & Expanding Gases & Vapours:-

There are several different ways in which gas or vapour may be heated or expanded which are also known as thermodynamic processes.

1) Constant Volume.
2) Constant Pressure.
3) Constant temperature.
4) Hyperbolic expansion.
5) Polytropic Process (General law).
6) Adiabatic Process
7) Free expansion.
8) Throttling.

1) Isochoric (Constant Volume) Process:-

A gas or vapour heated in a fixed enclosed space will remain at constant volume. The heating will be accompanied by a rise in pressure.

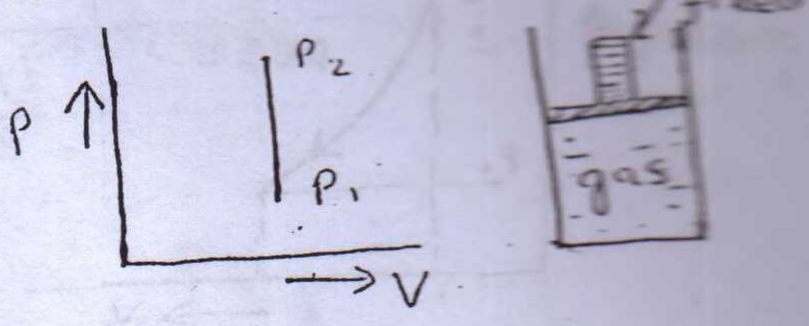
As, Volume remains constant.

So $\Delta V = 0$

As

$W = P \Delta V$

$W = 0$

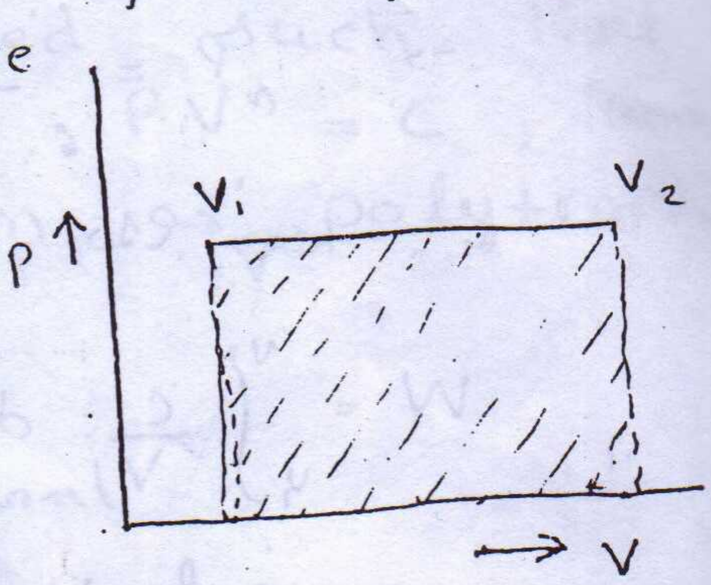


So work done is zero. Hence whole of the heat supplied will be stored in the gas in the form of internal energy.

Const Vol → Pressure Increase

2) Isobaric (Const. Pressure) Process:-

The heating of a gas under constant pressure causes an increase of Volume & temperature. External work is done owing to the increase in Volume.



(P-V Diagram)

Mathematically:

$$Q = W + U \quad \text{---(1)}$$

where $W = \int_{V_1}^{V_2} P \, dV$

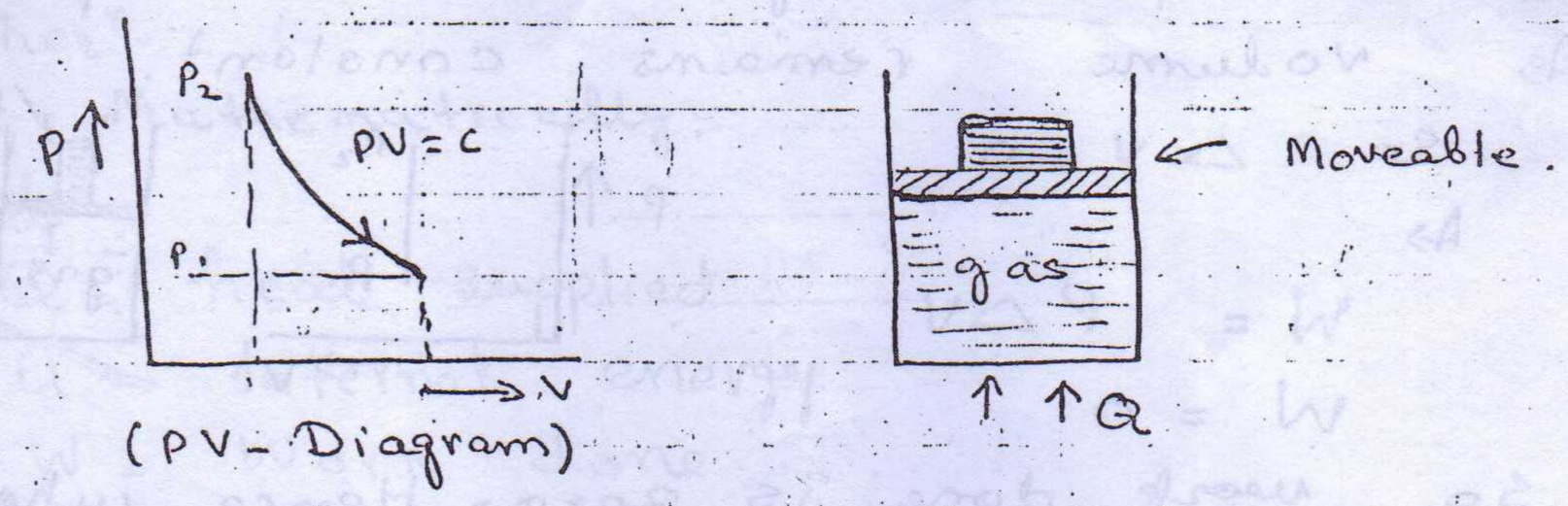
$$W = P(V_2 - V_1)$$

$\therefore$ eq (1) becomes:

$$\boxed{Q = P(V_2 - V_1) + U}$$

Energy can neither be created not destroyed but transferred from one form to another

3) Isothermal (Constant temperature) Process:-
In this case the gas will expand doing, ~~doing~~ external work equal to the amount of heat supplied.



Mathematically:

$$W = \int_{V_1}^{V_2} P\,dV \quad \text{---- (1)}$$

As,

$$P_1V_1 = P_2V_2 = PV = C \quad \text{--- (a)}$$

$$\Rightarrow P = \frac{C}{V}$$

$\therefore$ eqⁿ (1) becomes:

$$W = \int_{V_1}^{V_2} \frac{C}{V}\,dV$$

$$= C \ln V \Big|_{V_1}^{V_2}$$

$$W = C \ln\left(\frac{V_2}{V_1}\right)$$

As $PV = C$

So

$$\boxed{W = P_1 V_1 \ln\left(\frac{V_2}{V_1}\right)}$$

4) Hyperbolic Process :-

Def :-

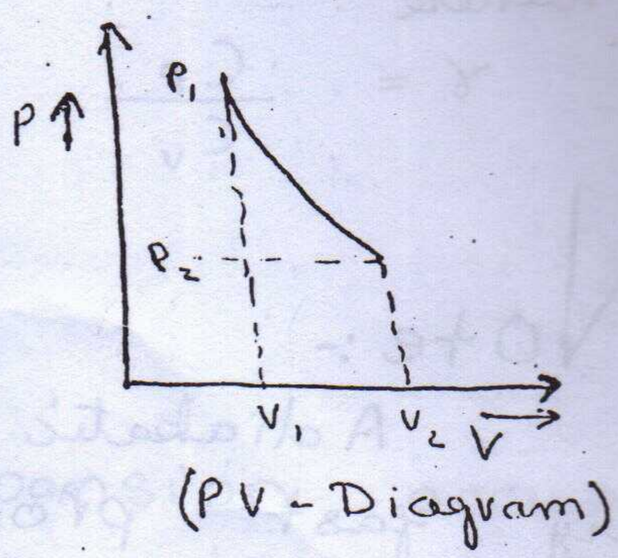
"If a gas is heated in such a way that the product of its pressure & Volume is always a constant, then the process is known as hyperbolic process".

Mathematically;

Pressure * Volume = Constant

i.e

$$PV = C$$



(PV - Diagram)

5) General Law "OR" Polytropic Process :-

Def :-

"If a gas is heated such that it follows the law $PV^n = C$, than the process is known as polytropic process".

Mathematically;

$$PV^n = \text{a Constant}$$

when

n = index of expansion or compression & actually denoting the slope of the curve ~~for~~ formed from the above equation.

6) Reversible Adiabatic Expansion :-

Def :-

"When a gas or vapour expands doing external work, in such a manner that no heat ~~or~~ is supplied or rejected

during the expansion, the expansion is called reversible adiabatic."

Mathematically;

$$PV^{\gamma} = \text{Constant}$$

where

$$\gamma = \frac{C_p}{C_v}$$

Note:-

Adiabatic process is a very very fast process. As distances of process are small & very fast, so heat is not allowed to enter.

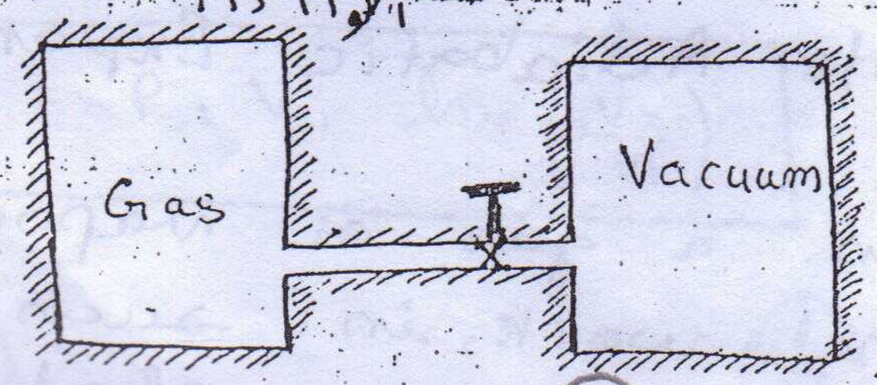
7) Free Expansion:-

Def#1:-

"If a gas is allowed to expand freely without offering resistance to the gas, the expansion is known as free expansion".

Def#2:-

"Free expansion occurs when a fluid is allowed to expand suddenly into a vacuum chamber through an orifice of large dimensions.



Mathematically;

As; $\overset{\circ}{Q} = \overset{\circ}{W} + U$

=>

$U = 0$

As $U = f(T)$

=>

$$\boxed{T_2 = T_1}$$

8) Throttling :-

Def :-

"This type of expansion occurs when a gas or vapour is expanded through an aperture of minute dimensions such as a narrow throat or a slightly opened valve".

Explanation :-

It should be noted that frictional resistance of a fluid in passing through a pipe, varies inversly with the fifth power of the pipes diameter. i.e.

$$\boxed{\text{Velocity} \propto \frac{1}{d^5}}$$

During a throttling process no heat is supplied or rejected, no external work is done, and in the case of a perfect gas, there is no alteration in the temperature. Hence, throttling is an expansion under conditions of constant total energy.