

"OR"

Statement

"The energy can neither be created nor be destroyed but can be converted from one form to the other".

Mathematically:

If

 $Q =$  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.

(5)



## 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.

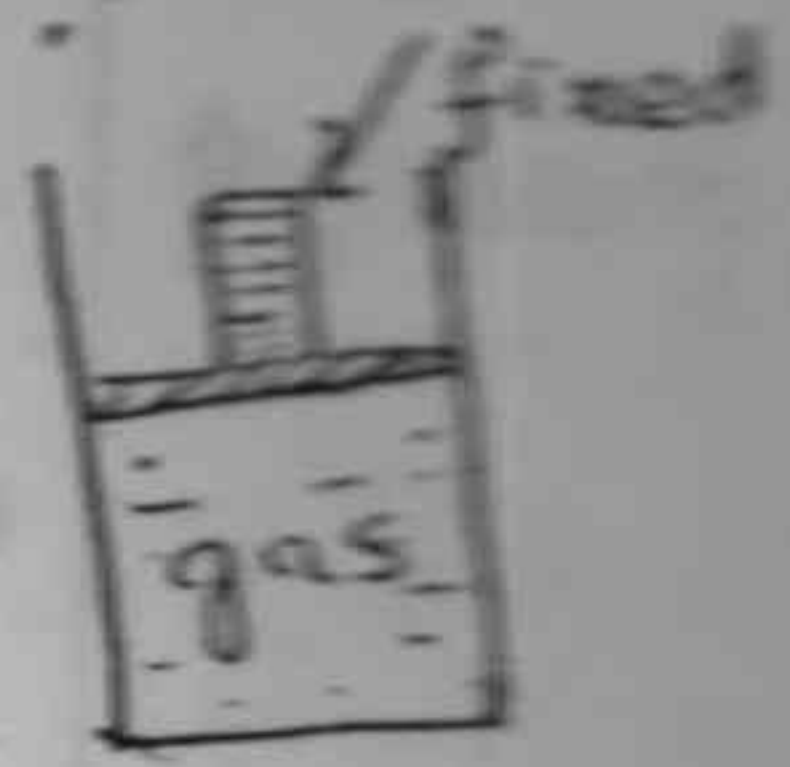
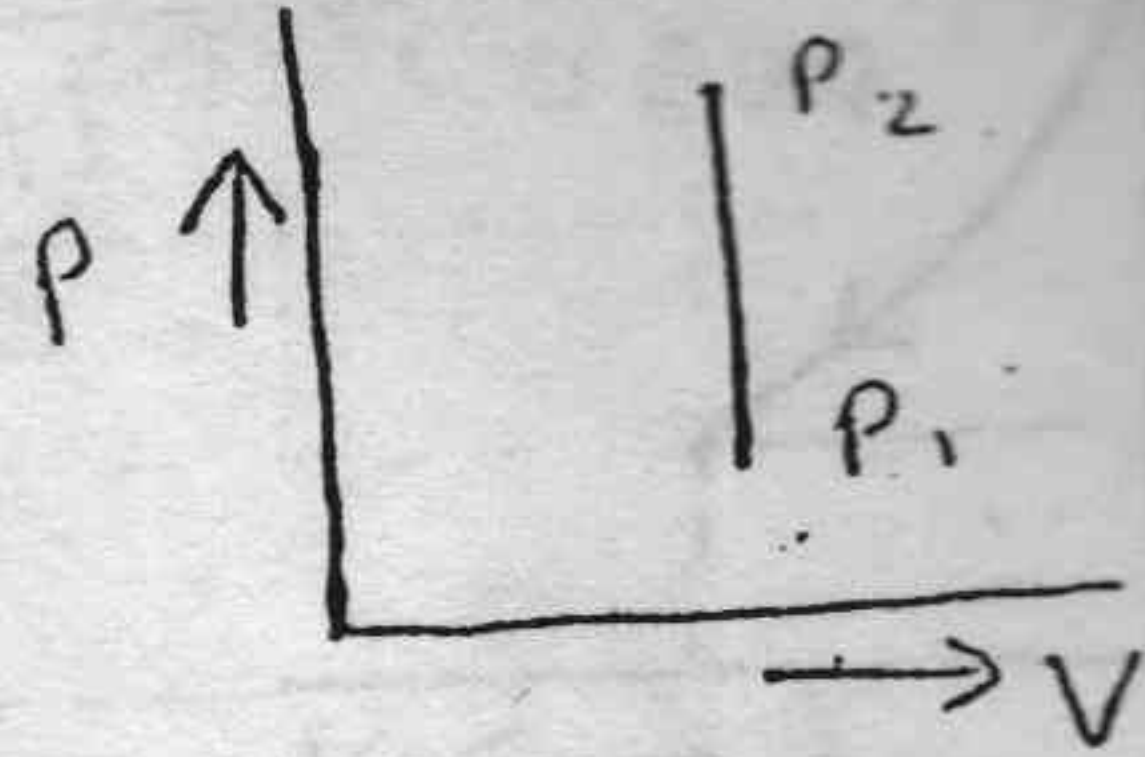
$$\text{So } \Delta V = 0$$

As

$$W = P \Delta V$$

$$W = 0$$

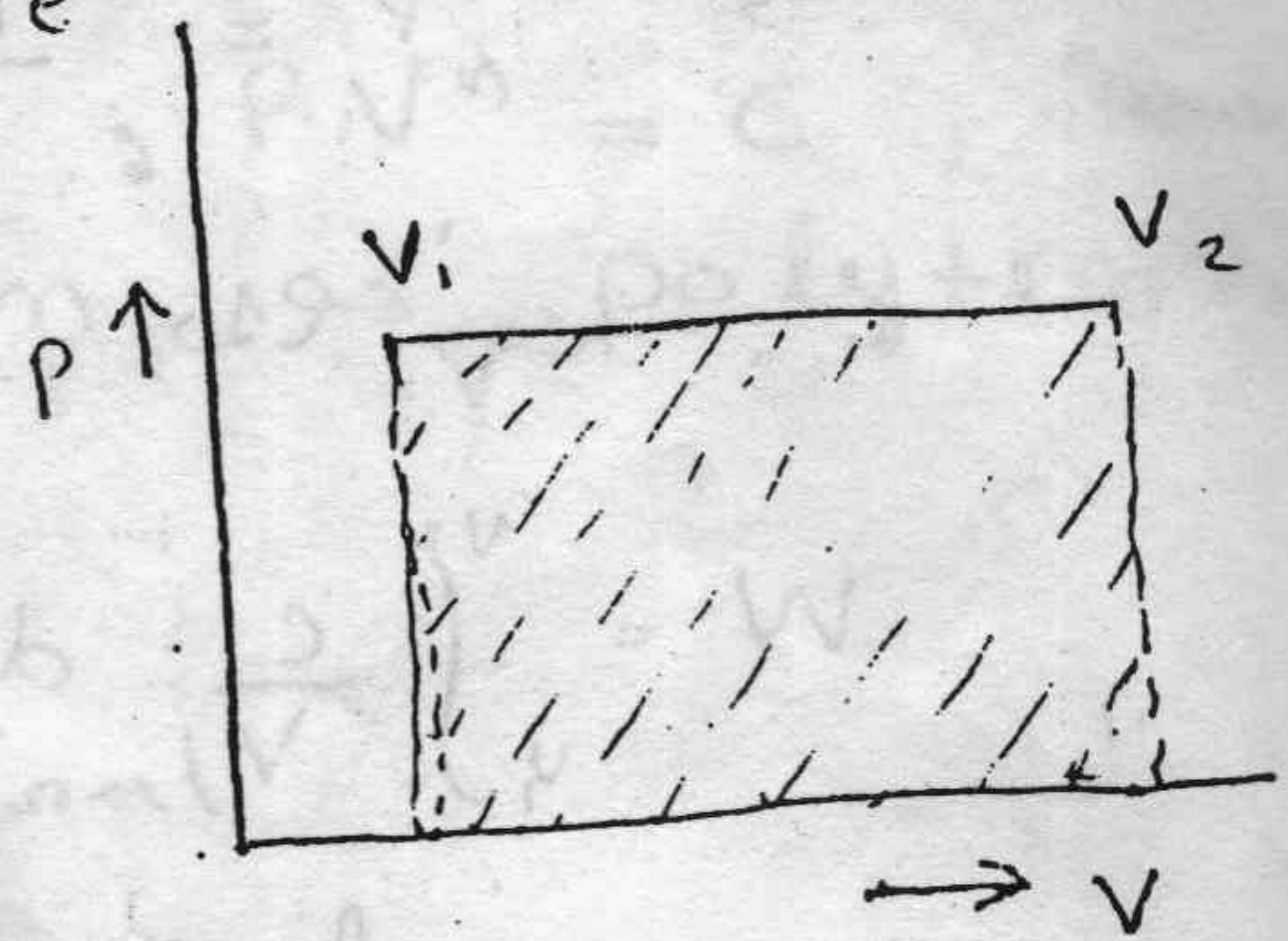
So work done is zero. Hence whole of the heat supplied will be stored in the gas in the form of internal energy.



Const Vol  $\rightarrow$  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:

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

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

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

$\therefore$  eq (1) becomes:

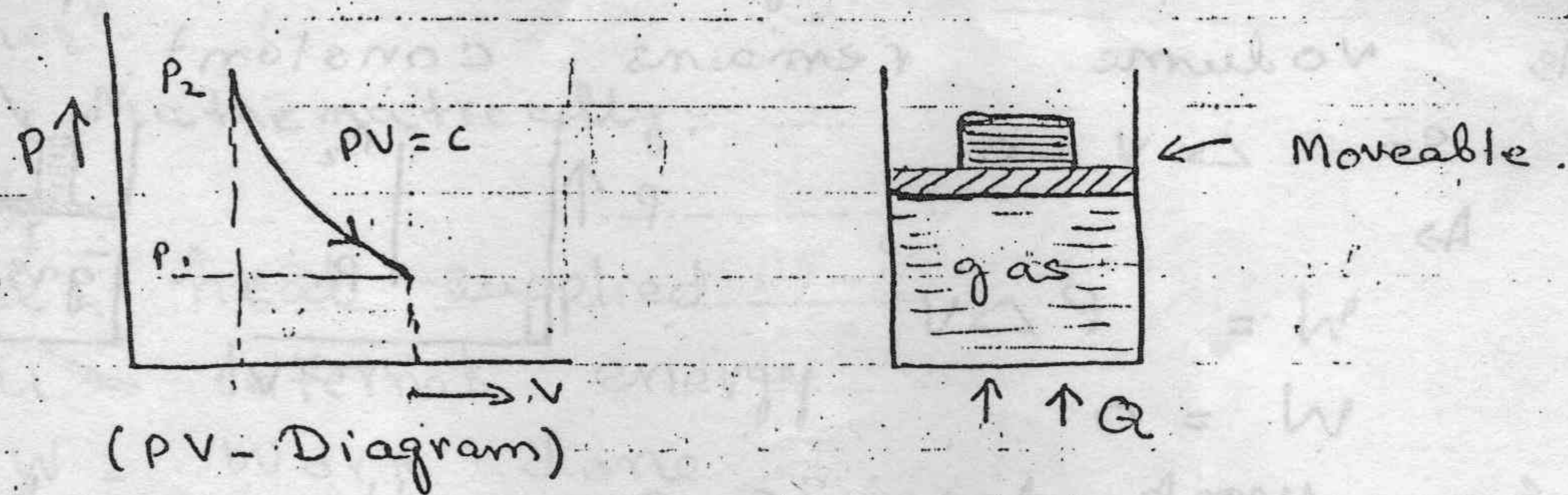
$$Q = P(V_2 - V_1) + U$$

Energy can neither be created nor destroyed but transferred from one form to another



### 3) Isothermal (Constant temperature) Process:-

In this case the gas will expand doing, ~~do~~ external work equal to the amount of heat supplied.



Mathematically

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

As,

$$P_1 V_1 = P_2 V_2 = PV = C \quad \text{--- (a)}$$

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

$\therefore$  eq (1) becomes:

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

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

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

$$\text{As } PV = C$$

So

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



## 4) Hyperbolic Process:-

Def:-

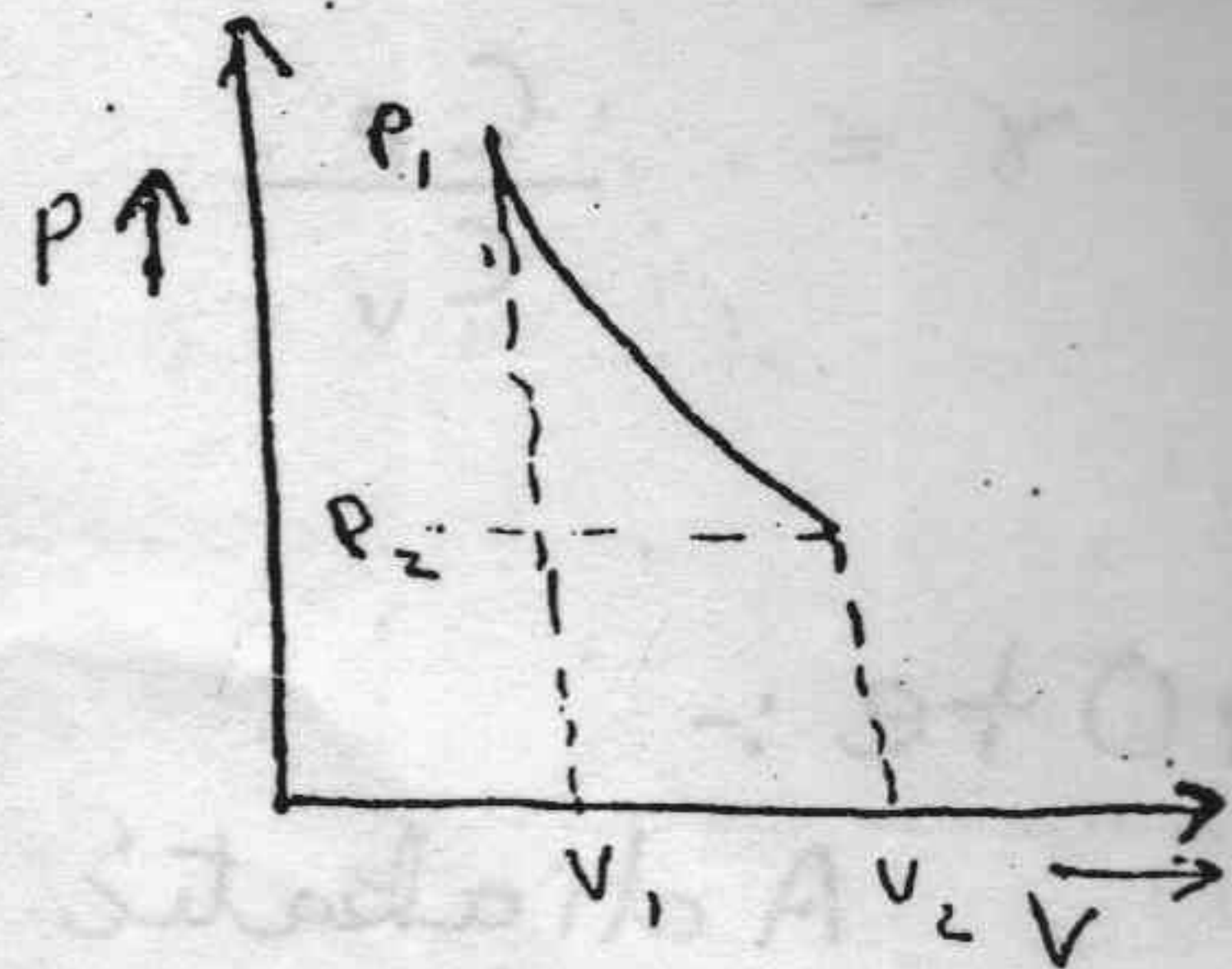
"If a gas is heated in such a way that the product of its pressure & volume is always a constant, then the process is known as hyperbolic process".

Mathematically;

Pressure  $\times$  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  $PV^n = C$ , then 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 ~~is~~ 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.

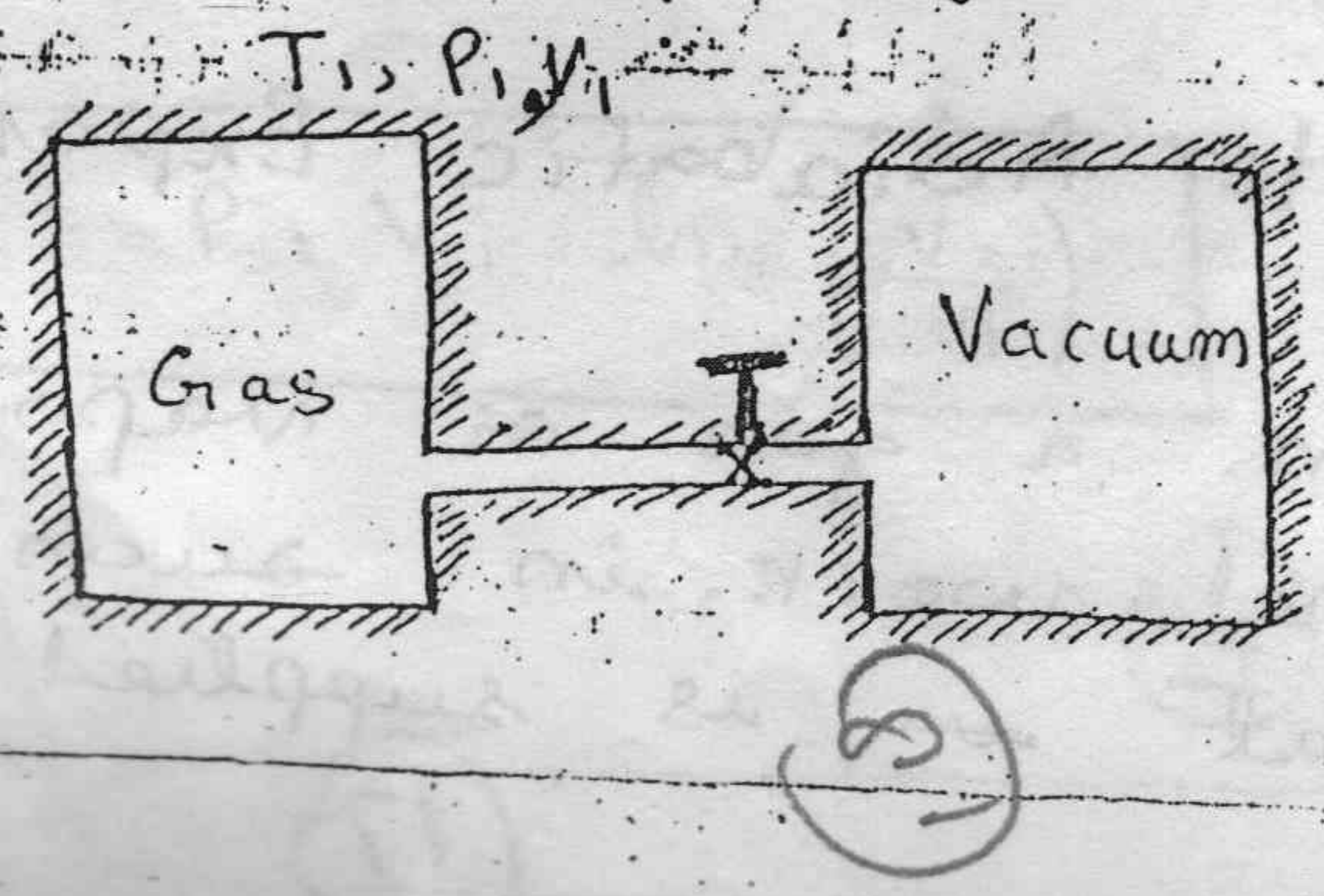
T) Free Expansion:-

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."



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Mathematically;

$$\text{As: } Q = W + U$$

$\Rightarrow$

$$U = 0$$

$$\text{As } U = f(T)$$

$\Rightarrow$

$$T_2 = T_1$$

### 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 inversely with the fifth power of the pipe's diameter. i.e.

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

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. (19)