

Thermodynamic Equilibrium - when state variable in a system do not change with time
(constant)

Types of process:-

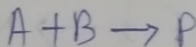
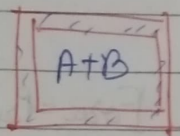
(1) Isothermal :- No change in temperature ($\Delta T = 0$)
same temperature

(2) Isochoric :- No change in pressure ($\Delta P = 0$)
same pressure Unit of pressure - bar

(3) Isochoric :- No change in volume ($\Delta V = 0$)
same volume

(*) (4) Adiabatic process :- (possible only in isolated system)

In isolated system, the system is isolated from environment. It means no external influence can affect this system.



In this process, no heat can flow in and out of the system

(*) (5) Cyclic process :- (possible in both open & closed system)

In open/closed system, there is exchange of heat with environment

In this process, when the initial and final state of the system are same, the system undergoes various stages and returns back to its initial state

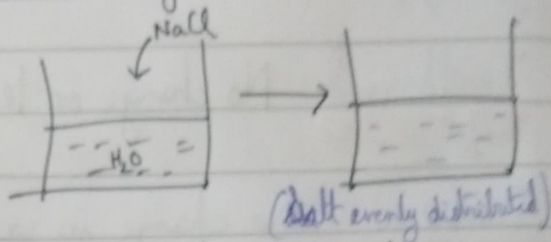
(6) Irreversible Process :- If the driving force and opposing force in a reaction differs by large amount

(7) Reversible Process :- If the driving force and opposing force in a reaction differs by small amount.

Based on the processes, we have two types of systems:-

1) Homogeneous system:- When the system is uniform throughout. It is made up of one phase only.

Eg:- Salt in water
Mixture of gas

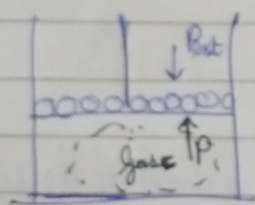


2) Heterogeneous system:- When the system is non-uniform throughout. It consists of 2 or more phases.

Eg:- Water & benzene
Ice & water

$H_2O \rightarrow$ polar
 $C_6H_6 \rightarrow$ non-polar } They do not mix well

P-V type of work done



$$W = F \times d \rightarrow Nm$$

$$P = \frac{F}{A} \Rightarrow F = P \times A$$

$$\therefore \frac{Nm}{m} = Nm$$

\therefore PV is a type of work done

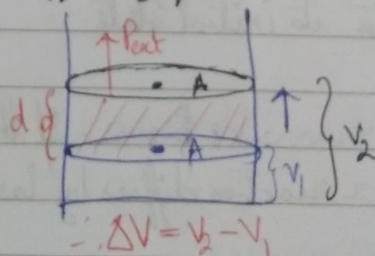
In ideal gas eqⁿ:- $PV = nRT$
 $n \rightarrow$ no. of moles of gas
 $R \rightarrow 0.082 \text{ L-atm/K-mol}$
 8.314 J/K-mol

This work ~~done~~ is ~~done~~ against opposing force

$$\therefore W = -Pd$$

$$= -P_{ext} \cdot A \cdot d$$

$$\Rightarrow W = -P_{ext} \cdot \Delta V$$



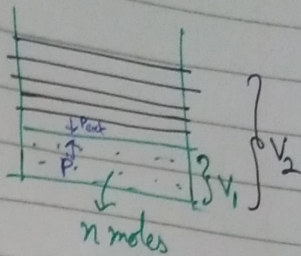
$W \rightarrow -ve$ when system expands (Expansion)
 $W \rightarrow +ve$ when system contracts (Contraction)

Max work done :- (W_{max})

Small work done in each segment till V_2 :-

$$dp = P - P_{ext}$$

Small volume change in each segment dV



$$\therefore dW = -P_{ext} dV$$

$$= -(P - dp) dV$$

$$\Rightarrow dW = -P dV + \underline{dp dV}$$

$$\therefore \boxed{dW = -P \cdot dV} \quad \rightarrow \text{negligible value}$$

for getting max work done, we integrate :-

$$\int_0^W dW = \int_{V_1}^{V_2} -P dV$$

We know, $PV = nRT$

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

$$\therefore \int_0^{W_{max}} dW = - \int_{V_1}^{V_2} \frac{nRT}{V} \cdot dV$$

$$\Rightarrow W_{max} = -nRT \int_{V_1}^{V_2} \frac{1}{V} dV$$

$$= -nRT [\ln(V)]_{V_1}^{V_2} \left[\because \frac{d}{dx}(\ln x) = \frac{1}{x} \quad \therefore \int \frac{1}{x} dx = \ln x \right]$$

$$= -nRT [\ln V_2 - \ln V_1]$$

$$\Rightarrow \boxed{W_{max} = -nRT \ln \frac{V_2}{V_1}}$$

We know,

$$\ln = 2.303 \log_{10}$$

Here,

$$R = 0.082 \text{ L-atm/K-mol}$$

$$= 8.314 \text{ J/K-mol}$$

$$\therefore W_{max} = -2.303 nRT \log_{10} \left(\frac{V_2}{V_1} \right)$$