

YAKEEN NEET 2.0

2026

(One Shot)

Thermodynamics and Thermochemistry

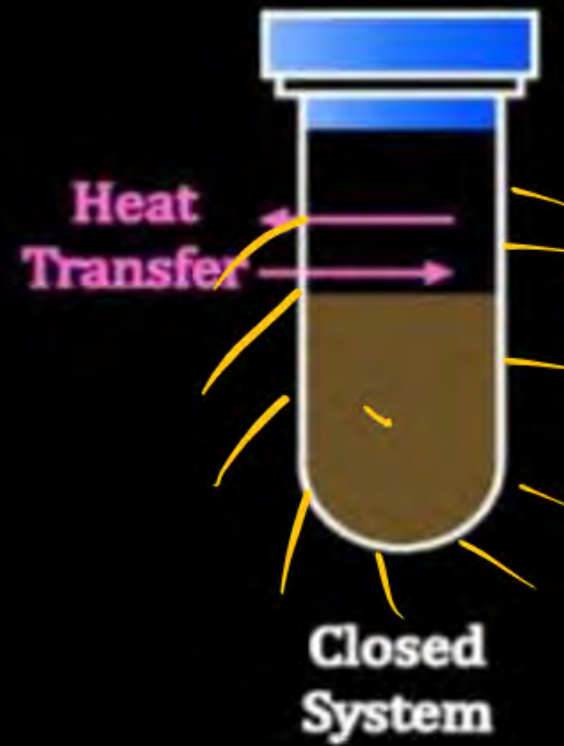
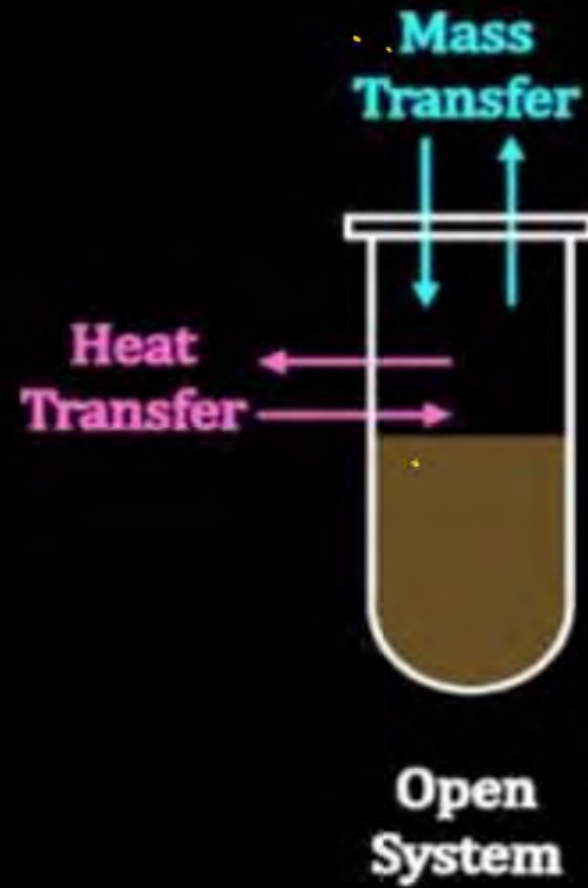
Physical Chemistry Summary Lecture

By- Amit Mahajan Sir





Types of System



Note:-

System + Surrounding = Universe



Function of a System

State fⁿ :-

- State:- Depend on initial and final state

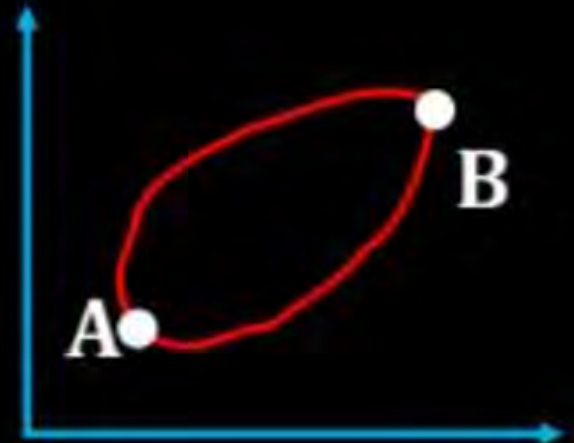
$$P_1 V_1 T_1 \rightarrow P_2 V_2 T_2$$

Ex.: U, H, G, S, T, etc

Path fⁿ :-

- Path:- Depend on path

Ex.: w, q, etc





Properties of a System

| Intensive (Independent of mass of the system) | Extensive (Depends on mass of the system) |
|--|--|
| 1. Pressure | 1. Mass |
| 2. Temperature | 2. Volume |
| 3. Density | 3. Internal energy |
| 4. Concentration | 4. Heat capacity |
| 5. Melting point | 5. Enthalpy |
| 6. Boiling point | 6. Entropy |
| 7. Surface tension | 7. Gibbs energy, etc |
| 8. Viscosity, etc | |

If x & y are two extensive Prop.

$x + y$
 or
 $x - y$
 or
 xy

→ extensive Prop.

$\frac{x}{y}$ or $\frac{dx}{dy}$ = Intensive

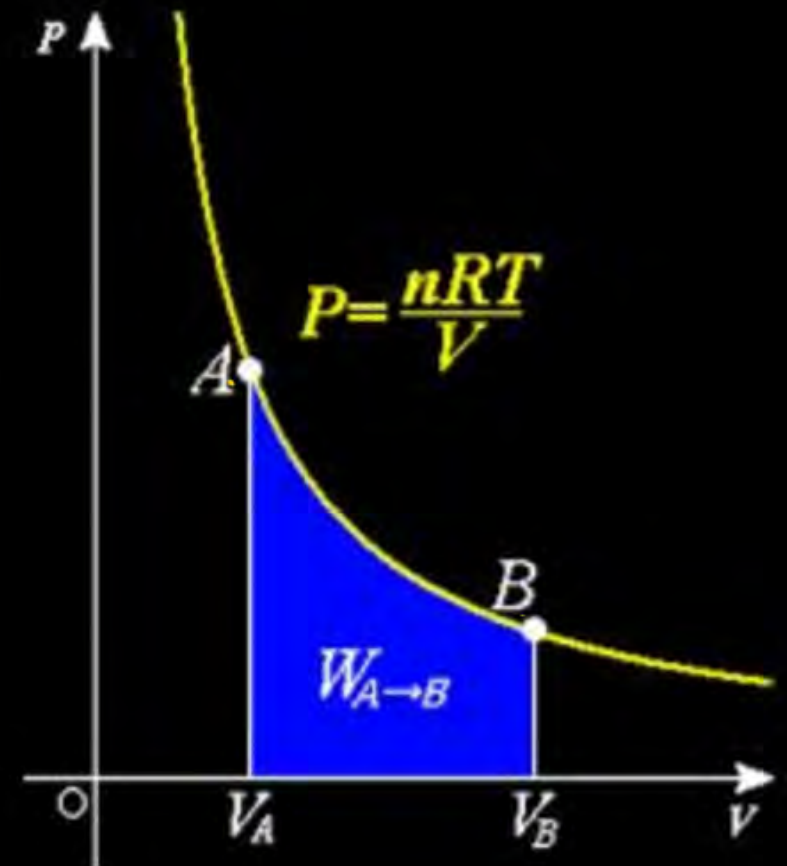


Types of Thermodynamics Process

➤ Iso-thermal Process:-

$T \rightarrow \text{Constant}$

$$\Delta T = 0$$



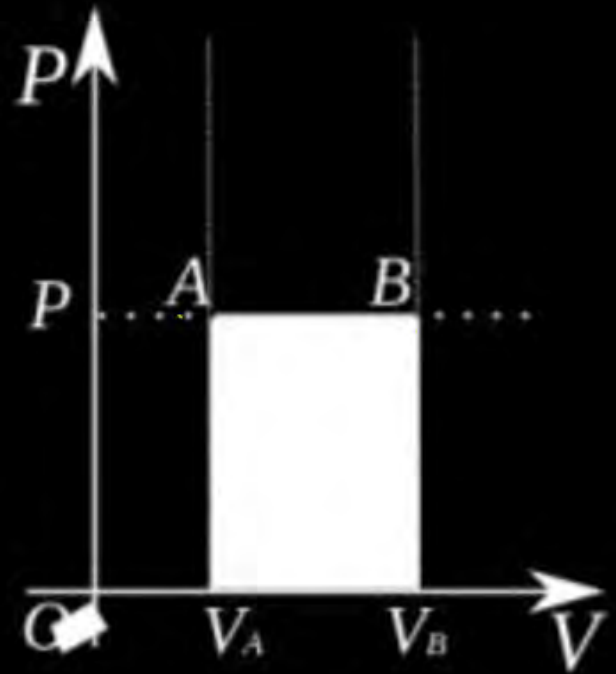


Types of Thermodynamics Process

➤ Iso-baric Process

$P \rightarrow \text{Constant}$

$$\Delta P = 0$$



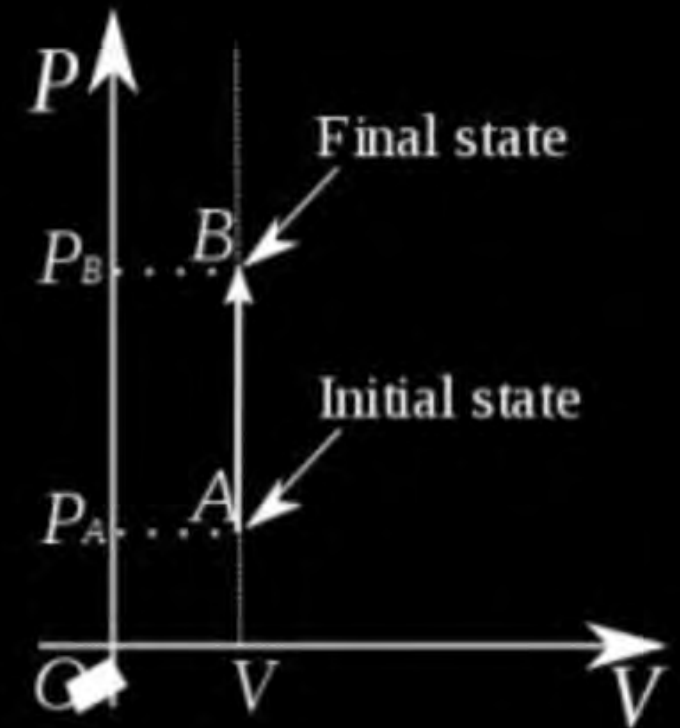


Types of Thermodynamics Process

➤ Iso-choric Process

$V \rightarrow \text{Constant}$

$$\Delta V = 0$$





Types of Thermodynamics Process

➤ Adiabatic Process:-

Transfer of heat is 0

i.e., $q = 0$

$$P V^{\gamma} = K$$

$$T V^{\gamma-1} = K$$

$$T P^{\frac{1-\gamma}{\gamma}} = K$$

→ Rev. Adi. Process.

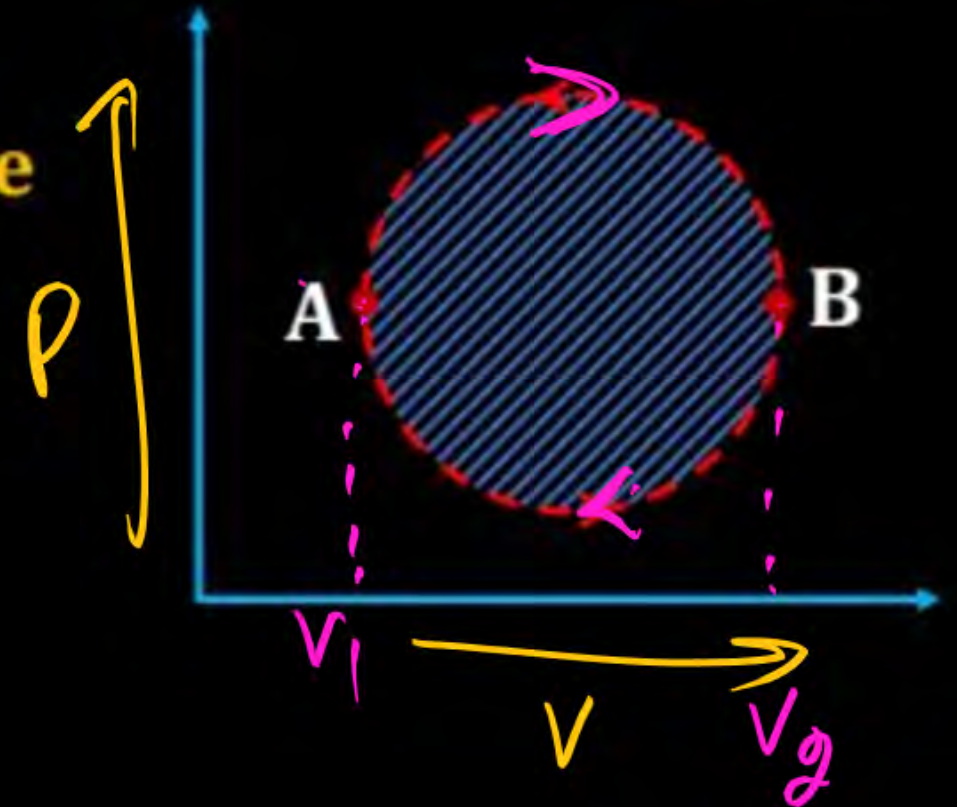


Types of Thermodynamics Process

➤ Cyclic Process:

Process in which initial and final point is same
i.e., for cyclic process

$$\Delta P = 0, \Delta V = 0, \Delta U = 0, \Delta S = 0, \Delta H = 0$$



Note:- Clockwise $\Rightarrow \Delta V = +ve \Rightarrow W = -ve$ process
Anticlock process $\Rightarrow \Delta V = -ve \Rightarrow W = +ve$



Internal Energy (U)

➤ Sum of all the components of energy due to internal factor of the system,

i.e., $U = \text{K.E.} + \text{P.E.} + \dots\dots\dots$

$$\Delta U = \sum U_P - \sum U_R$$

if $\sum U_P > \sum U_R = \Delta U = (+)\text{ve} \Rightarrow \Delta U \text{ inc.}$

~~~~~  $<$  ~~~~~  $= (+)\text{ve} \Rightarrow \Delta U \text{ dec.}$

Ideal gas



$$\text{P.E.} = 0$$

$$\text{K.E.} = \frac{3}{2} nRT$$

$$U = f(T)$$

∴ If gas is ideal

$$U = f(T, V)$$

# Work

- Mode of transfer of energy between system and surrounding.
- Mathematical expression: (If  $P_{\text{ext}} = \text{Constant}$ )

$$\underline{W} = -P_{\text{ext}} (\underline{V_2 - V_1})$$

**Note:-** Work done in any process is equal to area under PV diagram.

**Note:-**

**SIGN CONVENTION**

**For expansion  $\Rightarrow \Delta V = +ve$**

**$\therefore W = -ve$  {Work is done by the system}**

**For compression  $\Rightarrow \Delta V = -ve$**

**$\therefore W = +ve$  {Work is done on the system}**



Heat (q) =

$$q = m \Delta T$$

$$= C \Delta T$$

$$C = m \Delta$$



# First law of Thermodynamics

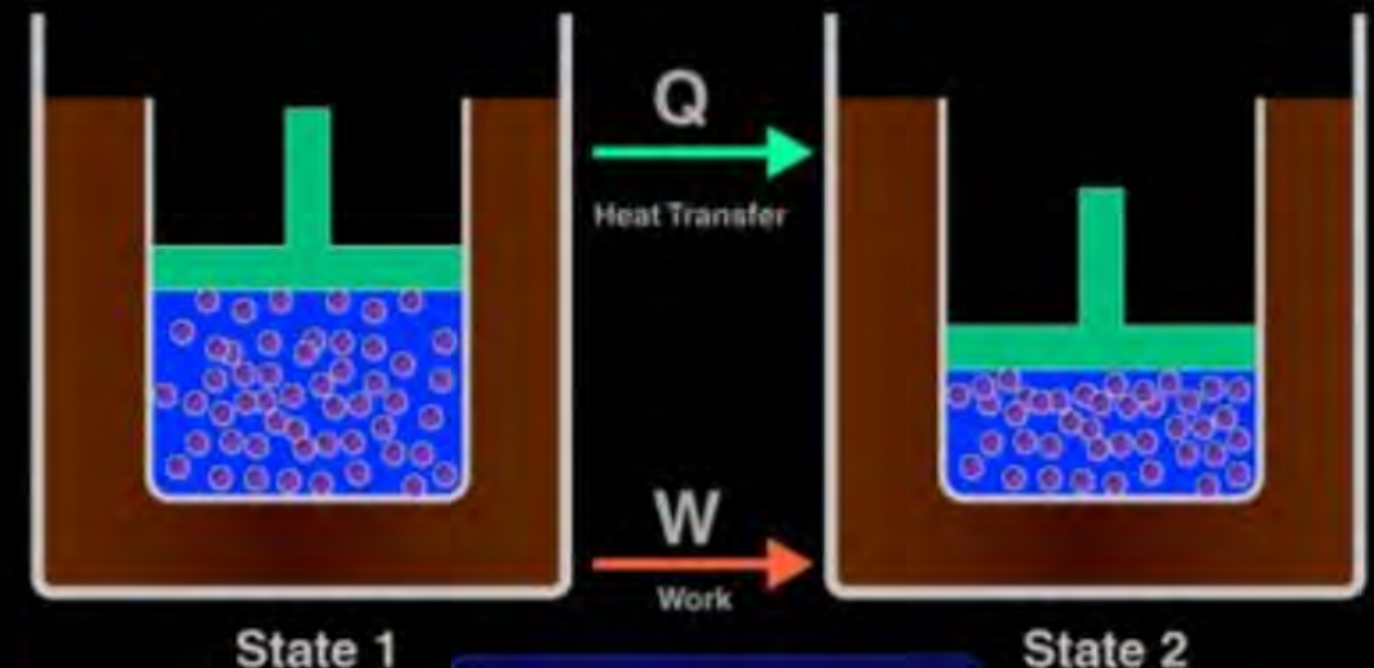
- Based on 'Conservation of Energy' principle.
- Mathematical expression:

$$\Delta U = q + w$$

① Isothermal process  $\Rightarrow \Delta T = 0 \Rightarrow \Delta U = 0$   
 or  
 Cyclic process  $q = -w$

② Adiabatic process  $\Rightarrow q = 0$   
 $\Delta U = w$

③ Isochoric process  $\Rightarrow \Delta V = 0 \Rightarrow w = 0$  | ④ Isobaric process  
 $\Delta U = q_v$   $\Delta U = q_p + w$



E = Internal energy  
 $E_2 - E_1 = Q - W$





## Work Done for Different Processes

➤ Iso-choric  $\Rightarrow W = 0$

➤ Iso-baric  $\Rightarrow W = -P_{\text{ext}} (V_2 - V_1)$

➤ Iso-thermal  $\Rightarrow W_{\text{rev}} = -2.303 nRT \log \frac{V_2}{V_1} = -2.303 nRT \log \frac{P_1}{P_2} = -nRT \ln \frac{V_2}{V_1} = -nRT \ln \frac{P_1}{P_2}$

$$W_{\text{irr.}} = -P_{\text{ext}} \left\{ \frac{nRT}{P_2} - \frac{nRT}{P_1} \right\} \quad (P_{\text{ext}} = P_2)$$

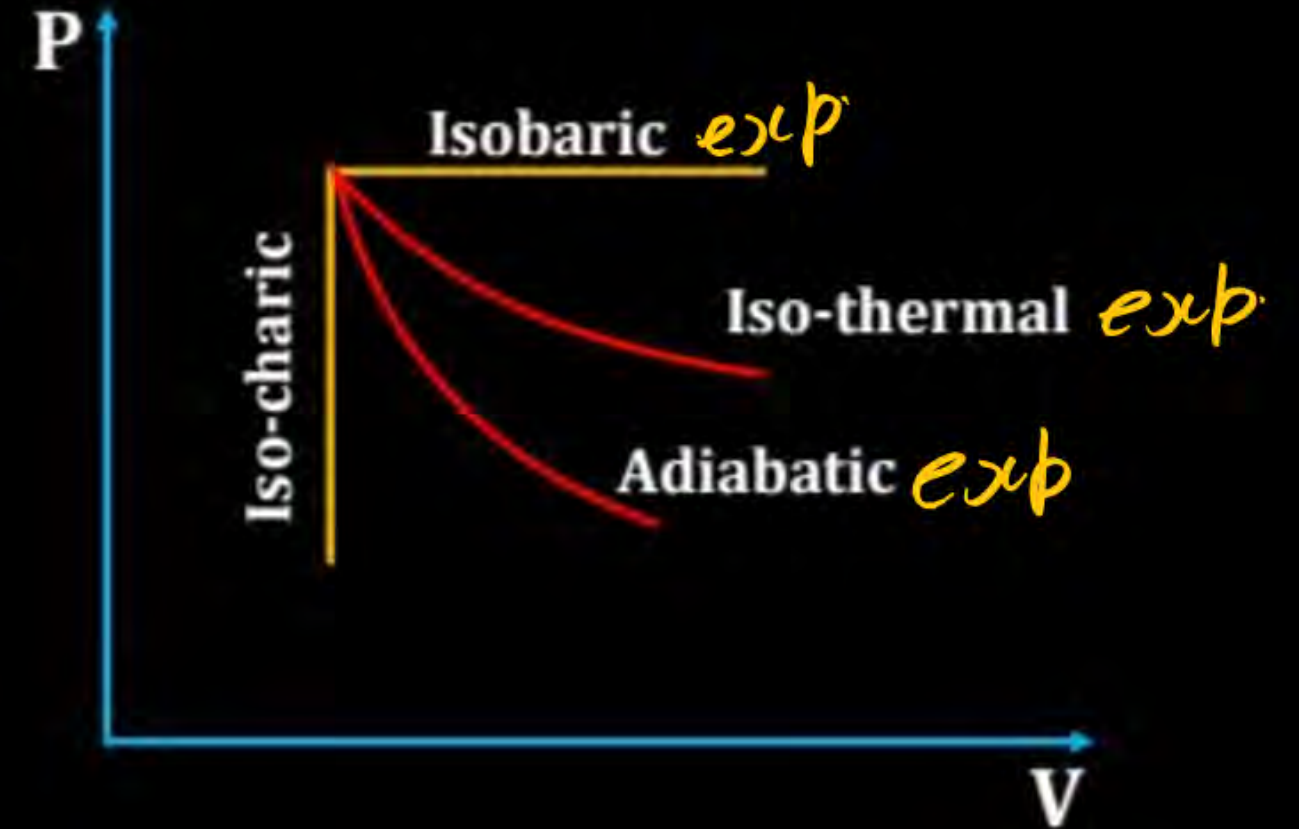
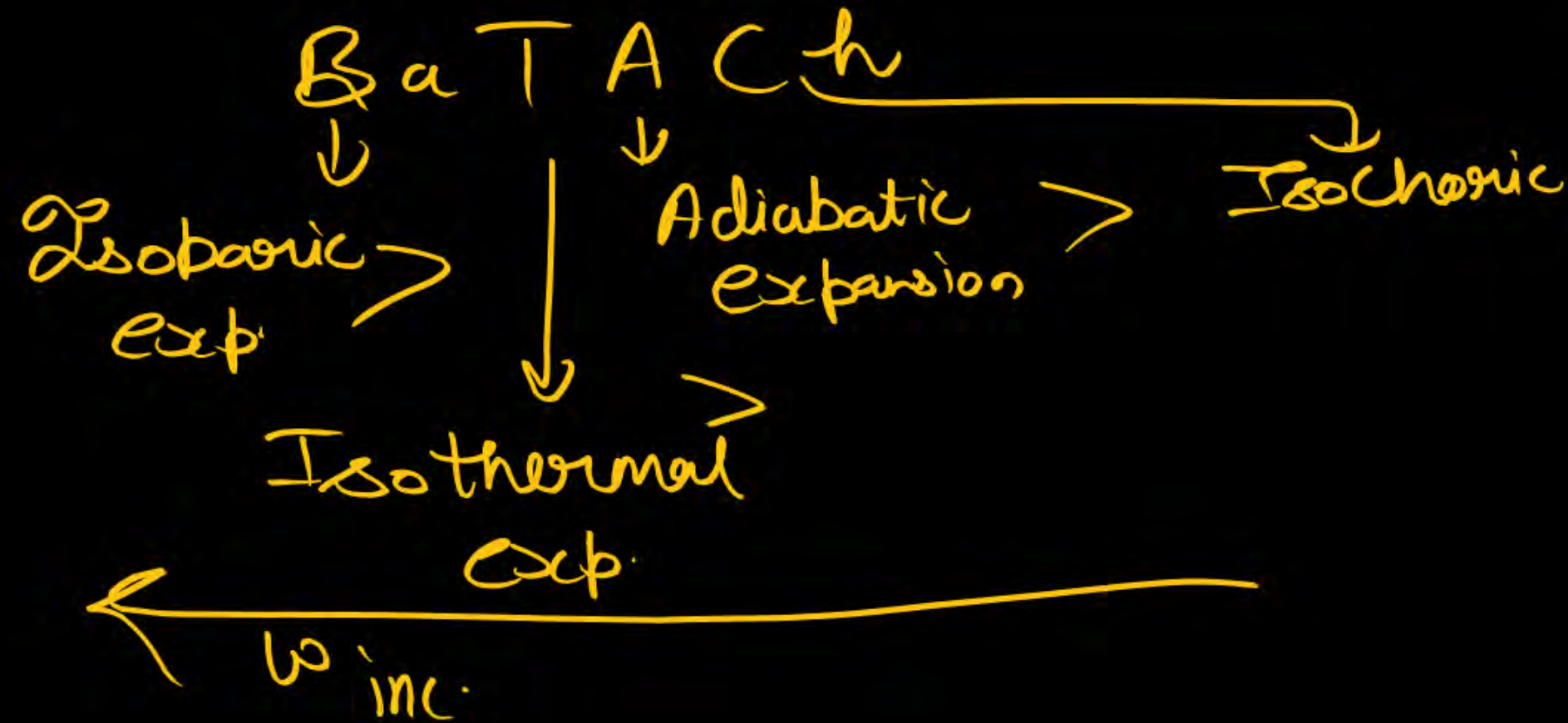
➤ Adiabatic  $\Rightarrow W_{\text{rev}} = \frac{P_2 V_2 - P_1 V_1}{\gamma - 1} = \frac{nR}{\gamma - 1} \Delta T = nC_{V,m} \Delta T$

$$W_{\text{irr.}} = -P_{\text{ext}} \left( \frac{nRT_2}{P_2} - \frac{nRT_1}{P_1} \right) = \frac{nR}{\gamma - 1} \Delta T = nC_{V,m} \Delta T$$





# Work Done in Various Processes (Graph)





## Enthalpy (H)

- It represents the net heat content of the system.
- Mathematical expression:

$$H = U + PV$$

Ex.: for a reaction,  $aA + bB \longrightarrow cC + dD$

$$\Delta H = \Delta U + \Delta n_g RT$$

Where  $\Delta n_g = \underbrace{(c + d)}_{n_p(g)} - \underbrace{(a + b)}_{n_r(g)}$

$$\Delta U = \check{q}_p + w$$

$$q_p = \Delta U - w$$

$$\Delta H = \Delta U + P\Delta V$$

or  
 $nR\Delta T$   
or  
 $\Delta n_g RT$





## Endothermic & Exothermic Process

$$\Delta H = H_P - H_R$$

| Exothermic Process   | Endothermic Process  |
|----------------------|----------------------|
| ✓ $\Delta H < 0$     | ✓ $\Delta H > 0$     |
| ✓ $\Delta H = -ve$   | ✓ $\Delta H = +ve$   |
| ✓ Energy of released | ✓ Energy is absorbed |





## Heat Capacity (C)

- It is the amount of heat required to raise the temperature of a system by  $1^{\circ}\text{C}$ .

- Mathematical Expression:

$$C = \frac{q}{\Delta T} \quad q = m \cdot c \cdot \Delta T$$

; Units =  $\text{J}/^{\circ}\text{C}$  or  $\text{J}/\text{K}$

- Extensive property



## Type of Heat Capacity

| Specific Heat Capacity ( $s$ )                                  | Molar Heat Capacity ( $C_m$ )                                     |
|-----------------------------------------------------------------|-------------------------------------------------------------------|
| ✓ Raise temperature of 1 kg of substance by $1^\circ\text{C}$ . | ✓ Raise temperature of 1 mole of substance by $1^\circ\text{C}$ . |
| ✓ $s = \frac{q}{m\Delta T}$                                     | ✓ $C_m = \frac{q}{n\Delta T}$                                     |
| ✓ Intensive property                                            | ✓ Intensive property                                              |





## Molar Heat Capacity ( $C_m$ )

➤ At constant volume ( $C_v$ )

$$q_v = \Delta U = nC_{v,m}\Delta T$$

➤ At constant pressure ( $C_p$ )

$$q_p = \Delta H = nC_{p,m}\Delta T$$

gas Triatomic or Polyatomic

$$C_{v,m} = 3R$$

$$C_{p,m} = 4R$$

$$\gamma = 1.33$$

$$C_{p,m} = C_{v,m} + R$$

gas monoatomic  $\sqrt[3]{\frac{5}{2}}$

$$C_{v,m} = \frac{3}{2}R$$

$$C_{p,m} = \frac{5}{2}R$$

$$\gamma = \frac{C_{p,m}}{C_{v,m}} = 1.66$$

gas Diatomic

$$C_{v,m} = \frac{5}{2}R$$

$$C_{p,m} = \frac{7}{2}R$$

$$\gamma = 1.4$$







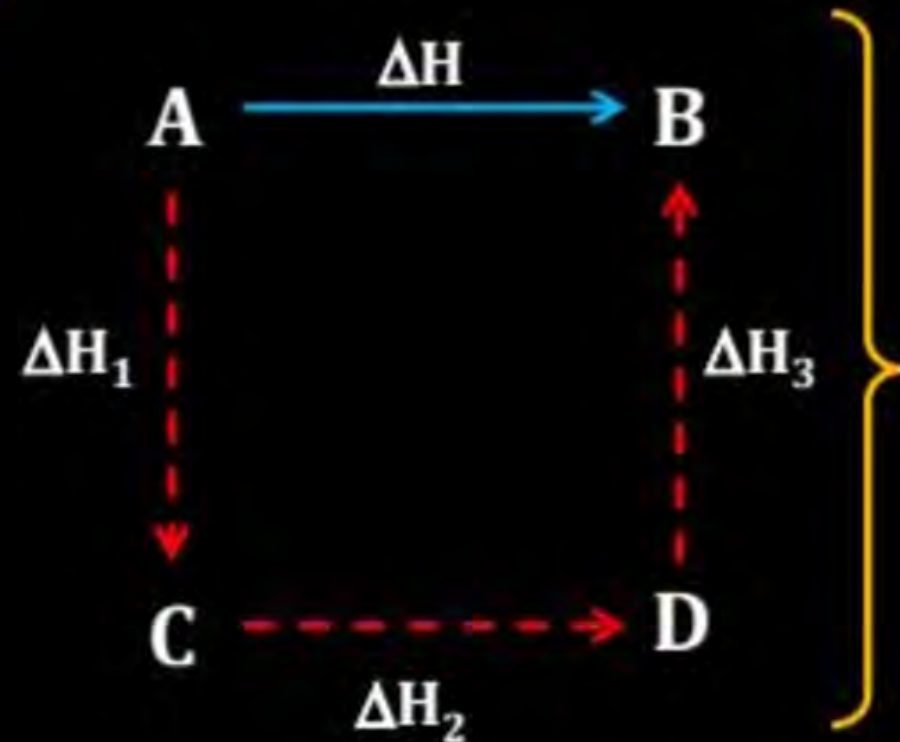
## Relation Between $C_p$ & $C_v$

- $C_{p,m} - C_{v,m} = R$  (Gas constant)
- $\frac{C_{p,m}}{C_{v,m}} = \gamma$  (Poisson's ratio)
- ❖ For monoatomic  $\Rightarrow \gamma = 1.66$
- ❖ For diatomic  $\Rightarrow \gamma = 1.4$
- ❖ For triatomic  $\Rightarrow \gamma = 1.33$

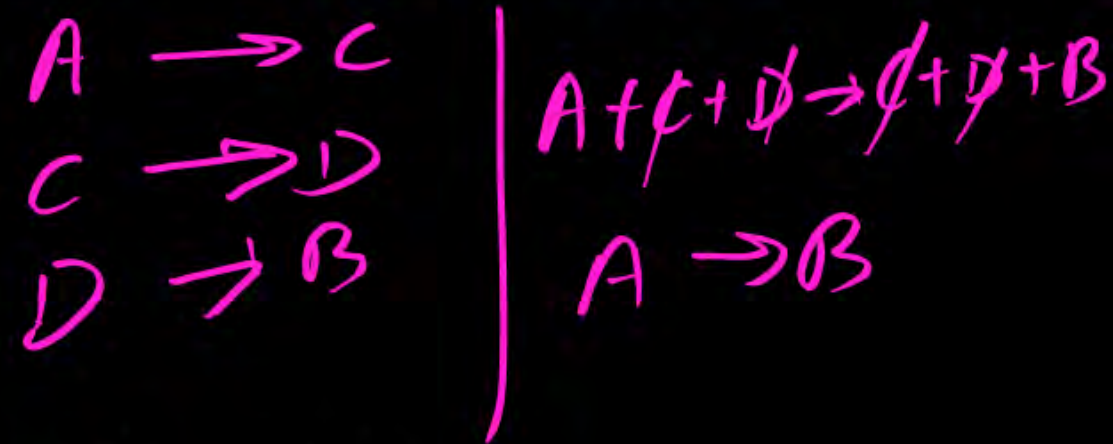


## Hess's Law

- The overall enthalpy change of a chemical process is independent of the path taken



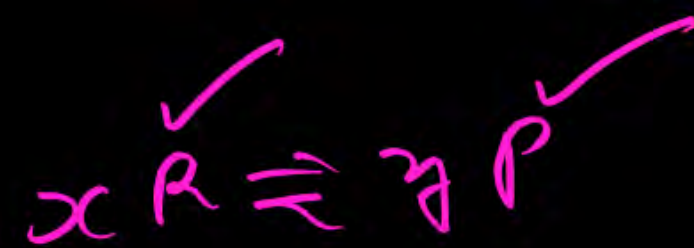
$$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$$



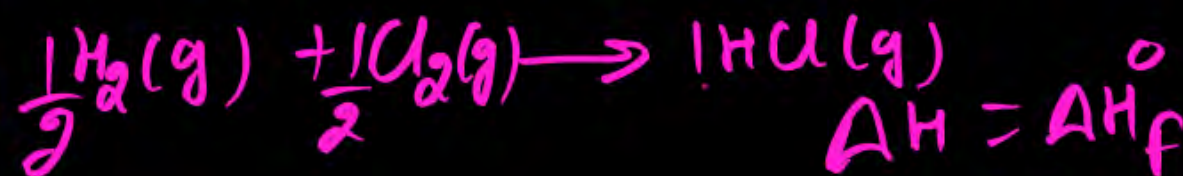




## Different Type of Enthalpies

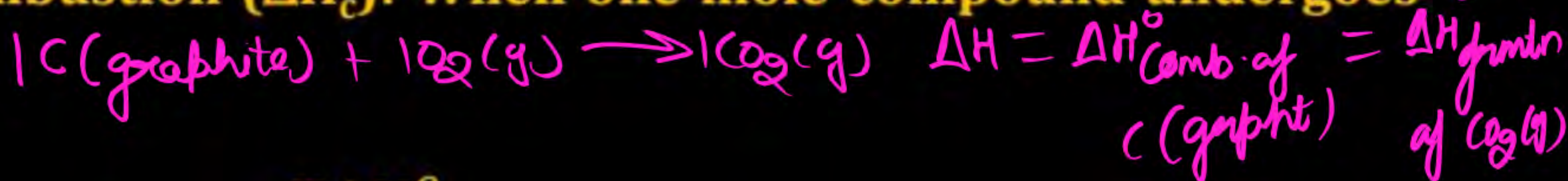


- ✓ Enthalpy of formation ( $\Delta H_f$ ) : When one mole of compound is formed from its elements in elementary state.



$$\Delta H = \sum \Delta H_f^\circ(\text{products}) - \sum \Delta H_f^\circ(\text{reactants})$$

- ✓ Enthalpy of combustion ( $\Delta H_c$ ): When one mole compound undergoes combustion.



$$\Delta H = \sum \Delta H_c^\circ(\text{reactants}) - \sum \Delta H_c^\circ(\text{products})$$

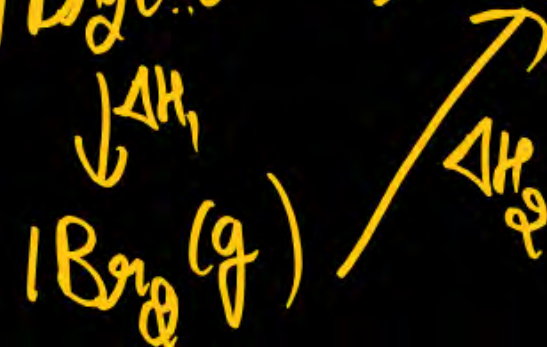
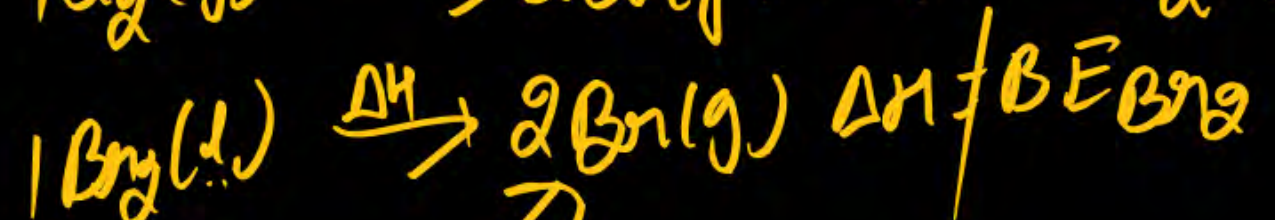
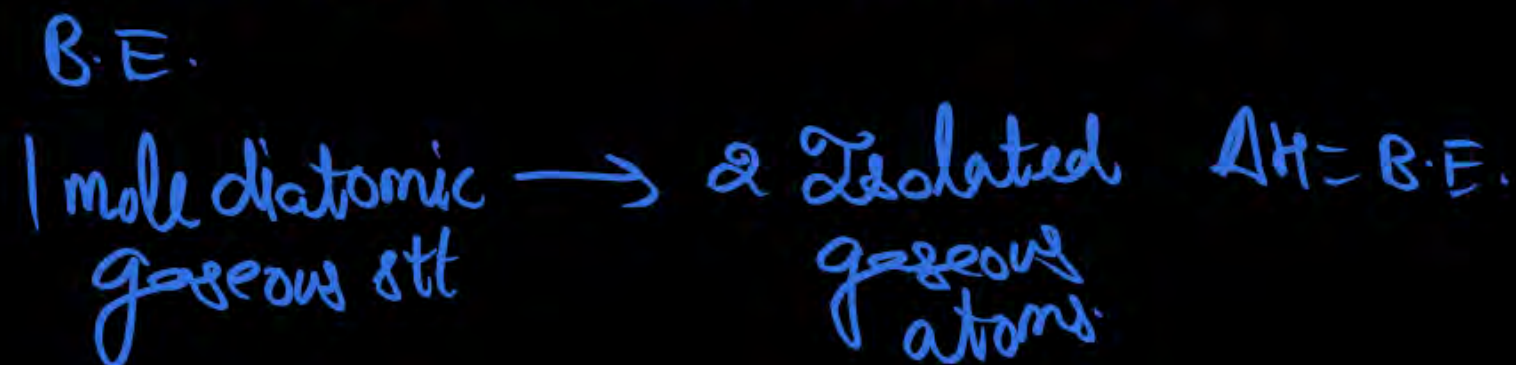


➤ **Enthalpy of Hydrogenation:-** When one mole of unsaturated compound converts into saturated compound.

➤ **Enthalpy of Hydration:** When one mole of anhydrous salt converts into hydrated salts.



➤ **Bond Dissociation Enthalpy:** Energy needed to break one mole of the bond to give separated atoms





## Calculation of Enthalpy



$$\Delta H = \sum \Delta H_{\text{(product)}} - \sum \Delta H_{\text{(reactant)}}$$

Always use this formula, except

**R**  
↓  
Reactants

**C**  
↓  
Enthalpy  
of Combustion

**B** ↓  
B.E.

$$\Delta H = \sum \alpha B.E._{(R)} - \sum \gamma B.E._{(P)}$$





## Bomb Calorimeter

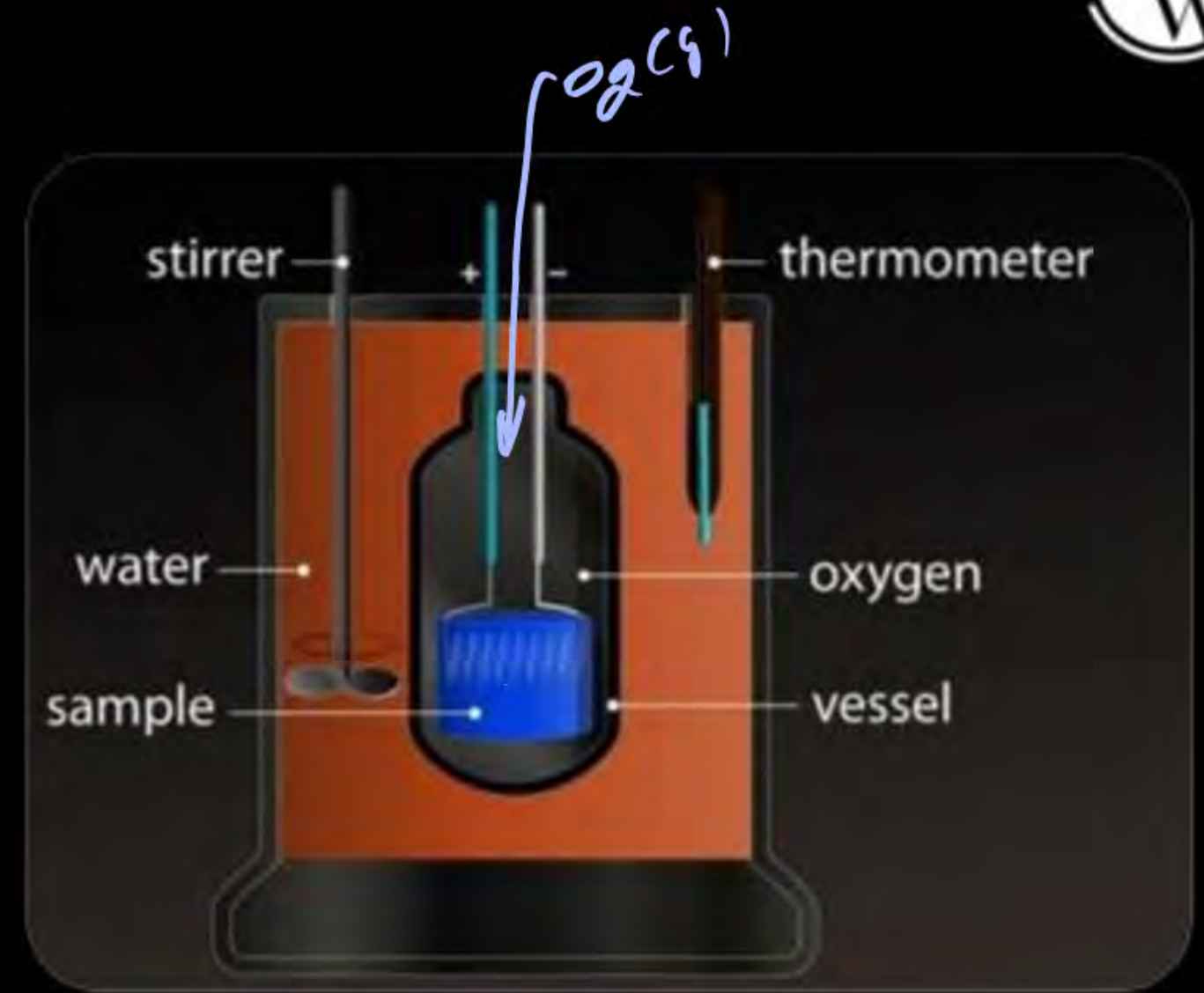
➤ In Bomb Calorimeter,

we measure  $q_v = \Delta U$

$q_v = \Delta U$  = (Heat absorbed by Bomb Calorimeter + Heat absorbed by Water)

$$\Delta U = (m_{\text{Bomb Calorimeter}} \times S_{\text{Bomb Calorimeter}} \times \Delta T + m_{\text{water}} \times S_{\text{water}} \times \Delta T)$$

$$\Delta U = \frac{(\text{Heat Cap. of B.C.} + m_{\text{water}} \times S_{\text{water}}) \Delta T}{\text{moles of sample}} \quad \text{J/mole.}$$





$$\Delta H = \Delta \overset{\checkmark}{U} + \Delta \overset{\checkmark}{n_g} R T$$



$$\Delta n_g = 1 - (1 + 2) = -2$$





## Limitation of 1<sup>st</sup> Law of Thermodynamics

- No information about direction in which flow of energy takes place
- It does not differentiate between spontaneous and nonspontaneous process



## Spontaneous and Non-spontaneous Process

Factors affecting spontaneity

① Tendency for minimum energy:  $\Delta H = (-)ve$

② Tendency for maximum randomness

↓  
 $\Delta S = (+)ve$





## Entropy (S)

- measurement of disorder or randomness.



$$\Delta S = \sum S_{(\text{product})} - \sum S_{(\text{reactant})}$$

- **Mathematical Expression:**

$$\Delta S = \frac{q_{\text{rev}}}{T} \quad ; \text{Unit} = \text{J/K}$$

- ✓ **Extensive property**
- **State function**

➤ **Important Points:-**

**$S \propto \text{Temperature}$ ,**

**But**

$$\Delta S \propto \frac{1}{\text{Temperature}}$$

$\Delta S_{\text{Universe}} \Rightarrow \Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surrounding}}$



## 2<sup>nd</sup> Law of Thermodynamics

- For a spontaneous change:

$$\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surrounding}} > 0$$

- In a reversible process the entropy of the Universe remains constant,

i.e.,  $\Delta S_{\text{total}} = 0$

$$\Delta S_{\text{system}} = -\Delta S_{\text{surroundings}}$$





## Entropy Change for an Ideal Gas

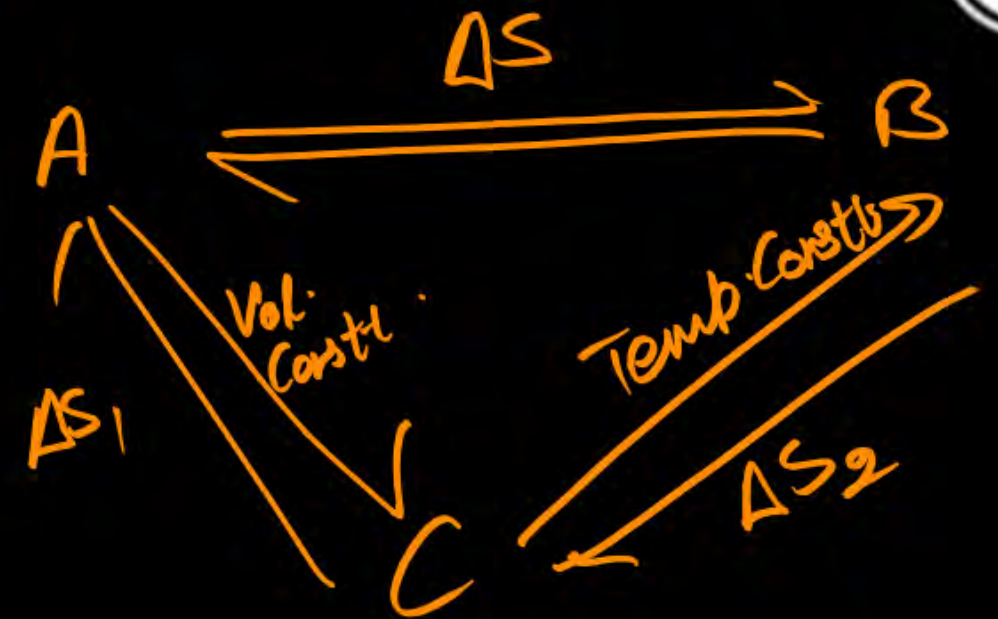
- General expression:  $\Delta S = nC_{v,m} \ln \frac{T_2}{T_1} + nR \ln \frac{V_2}{V_1}$   
for Heating or Cooling.

$$= nC_{p,m} \ln \frac{T_2}{T_1} + nR \ln \frac{P_1}{P_2}$$

- Iso-thermal process:  $\Delta S_{system} = nR \ln \frac{V_2}{V_1} = nR \ln \frac{P_1}{P_2}$

- Iso-baric process:  $\Delta S_{system} = n C_{p,m} \ln \left( \frac{T_2}{T_1} \right)$

- Iso-choric process:  $\Delta S_{system} = n C_{v,m} \ln \left( \frac{T_2}{T_1} \right)$



$$\begin{aligned} \Delta S &= \Delta S_1 + \Delta S_2 \\ &= nC_{v,m} \ln \frac{T_2}{T_1} + nR \ln \frac{V_2}{V_1} \end{aligned}$$



## Entropy Change in Various Physical Process

### ➤ During phase transformation

$$\Rightarrow \Delta S_{\text{Fusion}} = \frac{\Delta H_{\text{Fusion}}}{T_m}$$

$$\Rightarrow \Delta S_{\text{Vapourisation}} = \frac{\Delta H_{\text{Vapourisation}}}{T_B}$$

$$\Rightarrow \Delta S_{\text{Sublimation}} = \frac{\Delta H_{\text{Sublimation}}}{T_s}$$

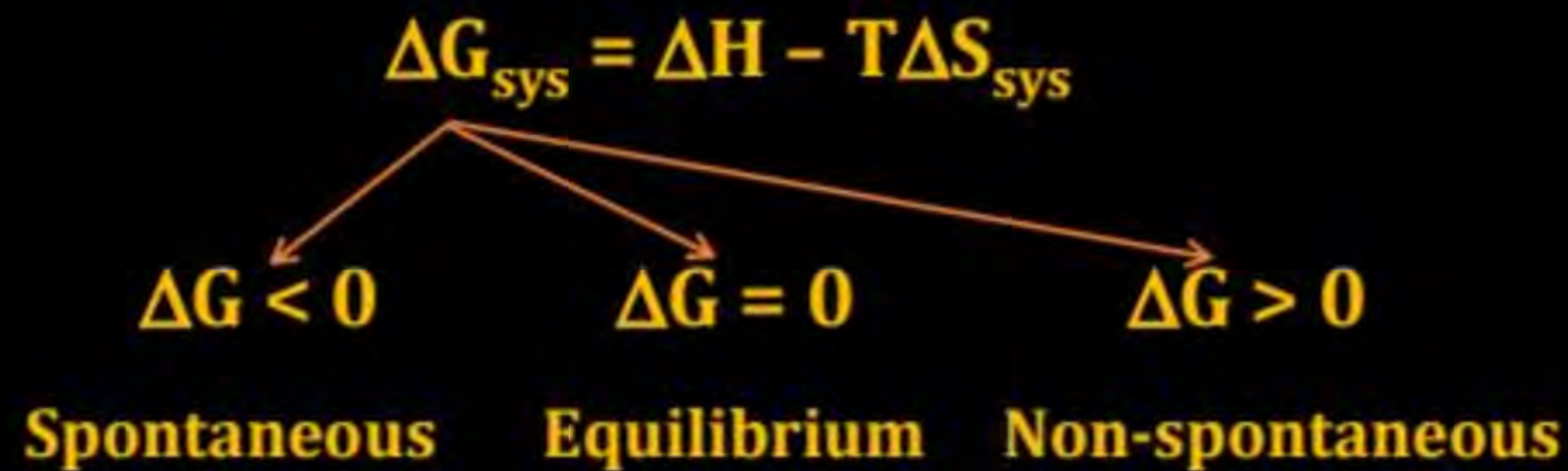
$\Delta S_{\text{vap}} = 88 \text{ J K}^{-1} \text{ mol}^{-1}$   
except for H-Bond  
liquid and metallic Bond.





## Gibbs Free Energy

➤ At constant temperature:



- \* Unit  $\Rightarrow$  Joule
- \* State function
- \* Extensive property



## Important Table

|                | $\Delta H < 0$                            | $\Delta H > 0$                              |
|----------------|-------------------------------------------|---------------------------------------------|
| $\Delta S > 0$ | Spontaneous at all temp<br>$\Delta G < 0$ | Spont. at high $T \Rightarrow \Delta G < 0$ |
| $\Delta S < 0$ | Spont. at low $T \Delta G < 0$            | Non-spont at all temp<br>$\Delta G > 0$     |



## 3<sup>rd</sup> Law of Thermodynamics

➤ For a perfectly crystalline solid, entropy is 0 at 0 K (absolute zero)

➤ Mathematically,

$$\lim_{T \rightarrow 0K} S = 0$$





## Curve Between Entropy v/s Temperature

$$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3 + \Delta S_4 + \Delta S_5$$

$$\Delta S_1 = n C_{p,m} \ln \frac{T_2}{T_1}$$

(s)

$$\Delta S_2 = \frac{\Delta H_{\text{fusion}}}{T_2}$$

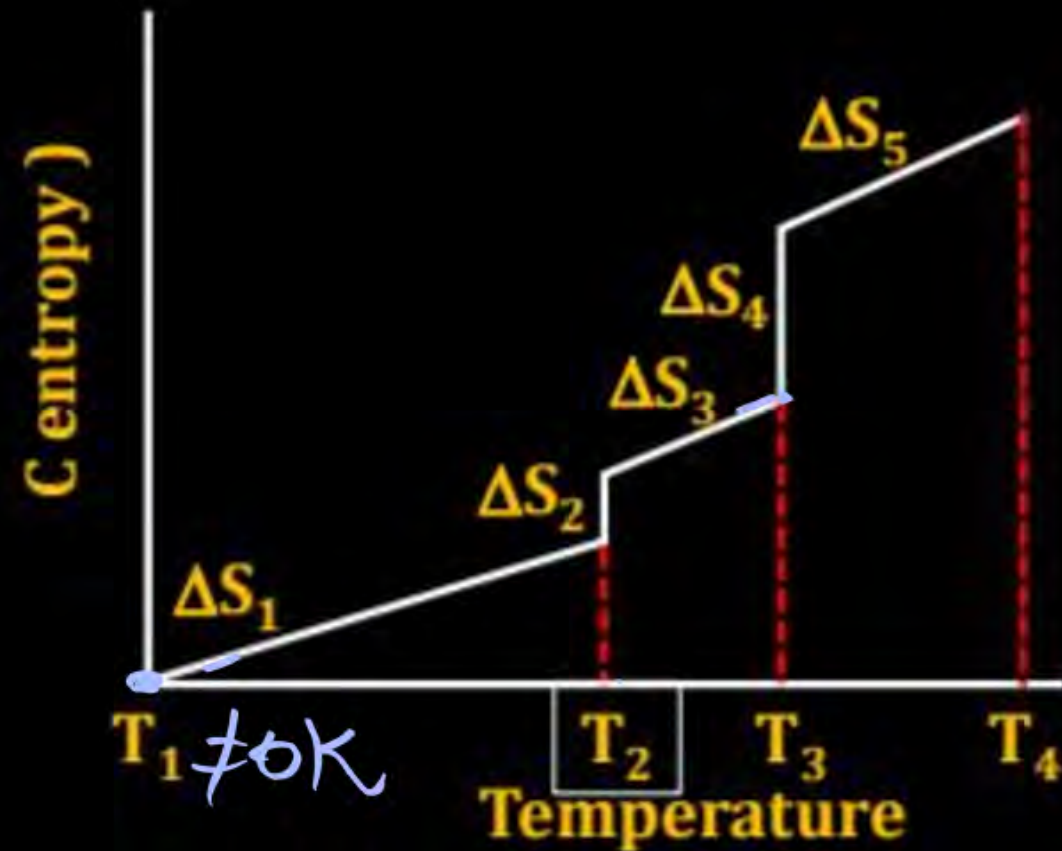
$$\Delta S_3 = n C_{p,m} \ln \frac{T_3}{T_2}$$

(l)

$$\Delta S_4 = \frac{\Delta H_{\text{vap.}}}{T_3}$$

$$\Delta S_5 = n C_{p,m} \ln \frac{T_4}{T_3}$$

(g)





**Thank** *You*