**Enthalpy (H) :-** Enthalpy is defined as the total heat content of a system.

$$H = U + PV$$

It is a state function and an extensive property.

Suppose a system containing ideal gas has enthalpy $H_1$ and after changing it's volume from $V_1$ to $V_2$ the enthalpy becomes $H_2$.

Initially $H_1 = U_1 + PV_1$

Finally $H_2 = U_2 + PV_2$

$$H_2 - H_1 = U_2 - U_1 + P(V_2 - V_1)$$

$$\boxed{\Delta H = \Delta U + P\Delta V}$$

For an ideal gas, $PV = nRT$

$$\Delta H = \Delta U + \Delta n RT \qquad (\because P\Delta V = \Delta n RT)$$

From first law $\Delta U = Q - P\Delta V$

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

$$\Delta H = Q - P\Delta V + P\Delta V$$

$$\Delta H = (Q)_p \qquad \text{(at constant pressure)}$$

If $\Delta H$ = -ve the reaction is exothermic

If $\Delta H$ = +ve the reaction is endothermic.

Heat capacity at constant volume ($C_V$) and constant pressure ($C_p$) :->

$$C_V = \frac{q_V}{\Delta T}$$

From first law of thermodynamics

$$\Delta U = q - P\Delta V$$

at constant volume $\Delta V = 0$

$$\Delta U = q_V$$

$$\boxed{C_V = \frac{\Delta U}{\Delta T}}$$

for $n$ moles, $\boxed{\Delta U = n \bar{C}_V \Delta T}$

$\bar{C}_V \rightarrow$ molar heat capacity at constant volume.

$$C_p = \frac{q_p}{\Delta T} = \frac{\Delta H}{\Delta T}$$

$$\boxed{\Delta H = n \bar{C}_p \Delta T}$$

Relation between $C_p$ and $C_V$ :->

$$C_p - C_V = \left(\frac{\delta H}{\delta T}\right)_p - \left(\frac{\delta U}{\delta T}\right)_V$$

$$= \left\{\frac{\delta (U+PV)}{\delta T}\right\}_p - \left(\frac{\delta U}{\partial T}\right)_V$$

$$= \left(\frac{\delta U}{\partial T}\right)_p + P\left(\frac{\delta V}{\partial T}\right)_p - \left(\frac{\partial U}{\partial T}\right)_V$$

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

Then $$dU = \left(\frac{\delta U}{\partial V}\right)_T dV + \left(\frac{\delta U}{\delta T}\right)_V dT$$

dividing by $\delta T$ at constant pressure (P).

$$\left(\frac{\delta U}{\delta T}\right)_P = \left(\frac{\delta U}{\delta V}\right)_T \left(\frac{\delta V}{\delta T}\right)_P + \left(\frac{\delta U}{\delta T}\right)_V$$

$$C_p - C_V = \left(\frac{\delta U}{\delta T}\right)_P + P\left(\frac{\delta V}{\delta T}\right)_P - \left(\frac{\delta U}{\delta T}\right)_V$$

$$C_p - C_V = \left(\frac{\delta U}{\delta V}\right)_T \left(\frac{\delta V}{\delta T}\right)_P + \cancel{\left(\frac{\delta U}{\delta T}\right)_V} + P\left(\frac{\delta V}{\delta T}\right)_P - \cancel{\left(\frac{\delta U}{\delta T}\right)_V}$$

$$C_p - C_V = \left[\left(\frac{\delta U}{\delta V}\right)_T + P\right]\left(\frac{\delta V}{\delta T}\right)_P$$

for an ideal gas

$$\left(\frac{\delta U}{\delta V}\right)_T = 0$$

$$\left(\frac{\delta H}{\delta P}\right)_T = 0$$

$$C_p - C_V = P\left(\frac{\delta V}{\delta T}\right)_P$$

$$PV = nRT$$

$$\left(\frac{\delta V}{\delta T}\right)_P = \frac{nR}{P}$$

$$C_p - C_V = \cancel{P} \times \frac{nR}{\cancel{P}}$$

$$C_p - C_V = nR$$

for 1 mole i.e $n = 1$

$$\boxed{C_p - C_V = R}$$

$$C_p > C_V$$