Gibbs free Energy

It is the thermodynamic state function related to enthalpy & entropy

$$G = H - TS$$

The free energy (G) of system is a measure of available energy for doing useful work.

Energy available for useful work = Total energy available − Non available form of energy

$$\Rightarrow \Delta G = \Delta H - \Delta(TS)$$
$$= \Delta H - \Delta T \cdot S - T\Delta S$$

At constant temperature, $(\Delta T = 0)$

$$\therefore \Delta G = \Delta H - T\Delta S$$

But, $\boxed{\Delta H = \Delta E + P\Delta V}$ → Enthalpy formula (at const pressure)

$$\therefore \Delta G = \Delta E + P\Delta V - T\Delta S$$

(At constant pressure & temperature)

- ΔE → internal energy
- $P\Delta V$ → work done on/by system
- $T\Delta S$ → Non available Energy

General form :- $\Delta G = \pm\Delta H \pm T\Delta S$

Here, $+\Delta H$ → endothermic
$-\Delta H$ → exothermic

$+T\Delta S$ → entropy decrease (System contraction)
$-T\Delta S$ → entropy increase (System expansion)

$+p\Delta V$ → System expansion
$-p\Delta V$ → System contraction

Derivation (in terms of $\Delta A = -W_{max}$)

$$G = H - TS$$

$$\Rightarrow \Delta G = \Delta H - T\Delta S \quad \text{(const temperature)}$$

Here, $\Delta S = \frac{q_{rev}}{T} \Rightarrow \boxed{T\Delta S = q_{rev}}$

and $\boxed{\Delta H = \Delta E + p\Delta V}$ (const pressure)

$$\therefore \Delta G = \Delta E + p\Delta V - q_{rev}$$

But, $\Delta A = \Delta E - T\Delta S$

$$\Rightarrow \Delta E = \Delta A + T\Delta S$$

$$\therefore \Delta G = \Delta A + T\Delta S + p\Delta V - q_{rev}$$

$$= \Delta A + T\Delta S + p\Delta V - T\Delta S$$

$$\Rightarrow \Delta G = \Delta A + p\Delta V$$

But, $\Delta A = -W_{max}$ (helmholtz eqⁿ)

$$\therefore \Delta G = -W_{max} + p\Delta V$$

$$\Rightarrow -\Delta G = W_{max} - p\Delta V$$

∴ When ΔG is -ve, Maximum work is done

When ΔG is +ve, Minimum work is done