$$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$$

$$\Delta S_{surr} = \frac{-q_{sys}}{T} = \frac{-\Delta H_{sys}}{T}$$

$$\boxed{\Delta S_{univ} = \Delta S_{sys} - \frac{\Delta H_{sys}}{T}} > 0 \text{ for spontaneity}$$

$$\underbrace{-T\Delta S_{univ}}_{\downarrow} = -T\Delta S_{sys} + \Delta H_{sys} < 0$$

$$\boxed{\begin{aligned} \Delta G_{sys} &= \Delta H_{sys} - T\Delta S_{sys} \\ \Delta G &= \Delta H - T\Delta S \end{aligned}} < 0 \text{ for spontaneity}$$

ΔG - Gibbs free energy

↳ energy available to do useful work

$$\Delta H = \underbrace{\Delta G}_{\text{energy that can go into work}} + \underbrace{T\Delta S}_{\text{energy that goes into entropy}}$$

Spontaneous?

$\Delta G < 0 \Rightarrow \Delta S_{univ} > 0 \Rightarrow$ Spontaneous

$\Delta G > 0 \Rightarrow \Delta S_{univ} < 0 \Rightarrow$ non-spontaneous $\Rightarrow$ reverse process is spontaneous

$\Delta G = 0 \Rightarrow \Delta S_{univ} = 0 \Rightarrow$ at equilibrium

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ for Std. conditions (1 atm, 25°C)