

- The number of microstates and, therefore, the entropy tends to increase with increases in
 - Temperature.
 - Volume.
 - The number of independently moving molecules

3. Entropy changes in Chemical Reactions

→ Entropy and Physical States (the effect of states on entropy)

- Entropy increases with the freedom of motion of molecules. Therefore, $S(g) > S(l) > S(s)$
- Generally, when a solid is dissolved in a solvent, entropy increases.
- In general, entropy increases when
 - Gases are formed from liquids and solids;
 - Liquids or solutions are formed from solids;
 - The number of gas molecules increases;
 - The number of moles increases (see point 1).
- **Third Law of Thermodynamics:** The entropy of a pure crystalline substance at absolute zero is zero.
- Standard entropies (molar entropy values of substances in their standard states) tend to increase with increasing molar masses (again, see point 1)
- Entropy changes for a reaction can be estimated in a manner analogous to that by which ΔH is estimated:

$$\Delta S^\circ = \sum n \Delta S^\circ(\text{products}) - \sum m \Delta S^\circ(\text{reactants})$$
 where n and m are the coefficients in the balanced chemical equation.
- Heat that flows into or out of the system changes the entropy of the surroundings.
For an isothermal process: $\Delta S_{\text{surr}} = \frac{-q_{\text{sys}}}{T}$

- At constant pressure, q_{sys} is simply ΔH° for the system.

- Since $\Delta S_{\text{surroundings}} = -q_{\text{system}} / T$
and $q_{\text{system}} = \Delta H_{\text{system}}$
This becomes:
$$\Delta S_{\text{universe}} = \Delta S_{\text{system}} + -\Delta H_{\text{system}} / T$$

Multiplying both sides by $-T$, we get

$$-T\Delta S_{\text{universe}} = \Delta H_{\text{system}} - T\Delta S_{\text{system}}$$

→ Gibb's Free Energy:

- $-T\Delta S_{\text{universe}}$ is defined as the Gibbs free energy, ΔG .
When $\Delta S_{\text{universe}}$ is positive, ΔG is negative.
- Therefore, when ΔG is negative, a process is spontaneous
- 1. If ΔG is negative, the forward reaction is spontaneous.