

Dougherty Valley HS • AP Chemistry
Entropy and Free Energy Bluffer Guide

REFERENCE SHEET

1. There are two driving forces for reactions.
Reactions tend toward:

minimum **Enthalpy**, ΔH (heat energy)
 $\Delta H -$, $\Delta H < 0$, downhill maximum
Entropy, ΔS (randomness)
 $\Delta S +$, $\Delta S > 0$, uphill

2. Recognize whether $\Delta S > 0$ or < 0

Entropy increases, $\Delta S +$, $\Delta S > 0$:

- from solid to liquid to gas
- fewer moles (g) to more moles (g)
- simpler molecules to more complex molecules
- smaller molecules to longer molecules
- ionic solids with strong attractions to ionic solids with weaker attractions
- separate solute & solvent to solutions
- gas dissolved in water to escaped gas

3. Product or Reactant favored reactions
depend on ΔH , ΔS , and absolute Temp

| ΔH | ΔS | Product-Favored... |
|------------|------------|--|
| + | + | at higher temperatures |
| - | - | at lower temperatures |
| - | + | at all temperatures |
| + | - | never (reactant-favored at all temps) |

4. Many books use the term “spontaneous” for “product-favored.”

A spontaneous reaction does not necessarily mean a fast reaction.
The SPEED of a reaction is Kinetics (Ch 12)... we are discussing whether a reaction CAN OCCUR which is Thermodynamics (Ch 6 and Ch 18).

5. Gibbs Free Energy, ΔG , puts the effects of ΔH , ΔS , and Temperature together.

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

$\Delta G < 0$, $\Delta G -$, product-favored reaction
 $\Delta G > 0$, $\Delta G +$, reactant-favored reaction
 $\Delta G = 0$, reaction is at equilibrium

Note that ΔH is usually in kJ/mol
 ΔS is usually in J/mol·K

| | $\Delta H < 0$ | $\Delta H > 0$ |
|----------------|---|--|
| $\Delta S > 0$ | Spontaneous at all T ($\Delta G < 0$) | Spontaneous at high T (when $T\Delta S$ is large) |
| $\Delta S < 0$ | Spontaneous at low T (when $T\Delta S$ is small) | Non-spontaneous at all T ($\Delta G > 0$) |

| $\Delta H_{\text{sys}} - T\Delta S_{\text{sys}} = \Delta G_{\text{sys}}$ | | | |
|--|------------|--------------------|-----------|
| ΔH | ΔS | ΔG | At... |
| - exothermic | + | - ALWAYS spont. | Any temp |
| + | - | + | Any temp |
| - exothermic | - | - spont. | Low Temp |
| - exothermic | - | + | High Temp |
| + | + | - spont. | High Temp |
| + | + | + | Low Temp |