

Entropy and Free Energy

STUDY LIST From Paul Groves

I can...

The Driving Forces

- State the two driving forces for reactions, Enthalpy (ΔH) and Entropy (ΔS).
- State that Enthalpy (ΔH) tends toward a minimum and this means
 - ΔH is negative
 - ΔH is < 0
 - heat is on the right (products)
 - PE curve is downhill
- State that Entropy (ΔS) tends toward a maximum and this means
 - ΔS is positive
 - ΔS is > 0
 - the products are more disordered (spread out) than reactants
 - the entropy curve is uphill
- Calculate ΔH using Hess's Law or $q=mc\Delta T$ and moles of reactant.

Entropy

- Define entropy (ΔS) as the randomness, disorder, or "spreadioutiness" of a system.
- Calculate entropy (ΔS) using Hess's Law with these differences:
 - **elements** have values for entropy
 - units for entropy are $\text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$ rather than $\text{kJ}\cdot\text{mol}^{-1}$... (a conversion is usually needed).
- Recognize changes in entropy.

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

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

Spontaneity (Product-Favored)

- Look at a reaction and state whether it is exothermic or endothermic.
- State whether a reaction will be product-favored depending on ΔH , ΔS , and absolute temperature.

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

- Explain that 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 15)... we are discussing whether a reaction **CAN OCCUR** which is **Thermodynamics** (Ch 6 and Ch 20).*

- Combine the effects of ΔH , ΔS , and Temperature to form ΔG , the Gibbs Free Energy: $\Delta G = \Delta H - T\Delta S$

Note watch your units for ΔH & ΔS

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

- Use the special case of **equilibrium** (e.g. boiling point or temperature when a reaction becomes spontaneous) to use the modified equation: $\Delta H = T\Delta S$

Link with Other Chapters

- Convert between K , ΔG , and E° using equations given on the AP Exam.