

## 20 • Entropy and Free Energy

### BLUFFER'S GUIDE

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

minimum **Enthalpy**,  $\Delta H$  (heat energy)

$\Delta H -$ ,  $\Delta H < 0$ , downhill

maximum **Entropy**,  $\Delta S$  (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  $\Delta H$ ,  $\Delta S$ , and absolute Temp

$\Delta H$	$\Delta S$	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 15)... we are discussing whether a reaction CAN OCCUR which is Thermodynamics (Ch 6 and Ch 20).

5. Gibbs Free Energy,  $\Delta G$ , puts the effects of  $\Delta H$ ,  $\Delta S$ , 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  $\Delta H$  is usually in kJ/mol

$\Delta S$  is usually in J/mol·K

*Acknowledgement:* This page is adapted from a similar document from South Pasadena • AP Chemistry