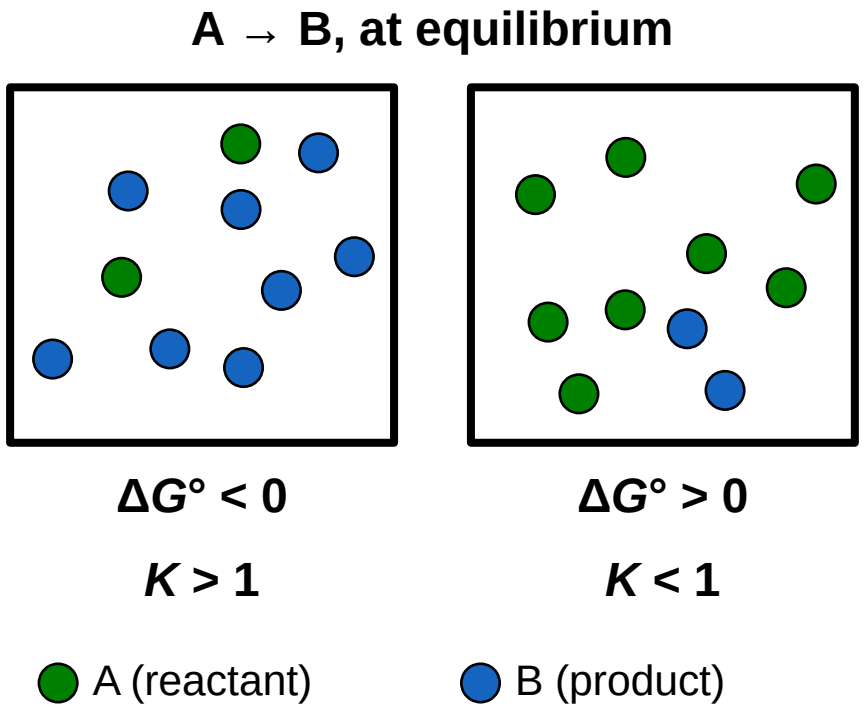
Essential Question

How is ΔG° related to the equilibrium constant?

Favored Means Products Win

- $\Delta G° < 0 \rightarrow$ products favored, $K > 1$
- $\Delta G° > 0 \rightarrow$ reactants favored, $K < 1$



Connecting ΔG° and K

$$\Delta G^\circ = -RT \ln K$$

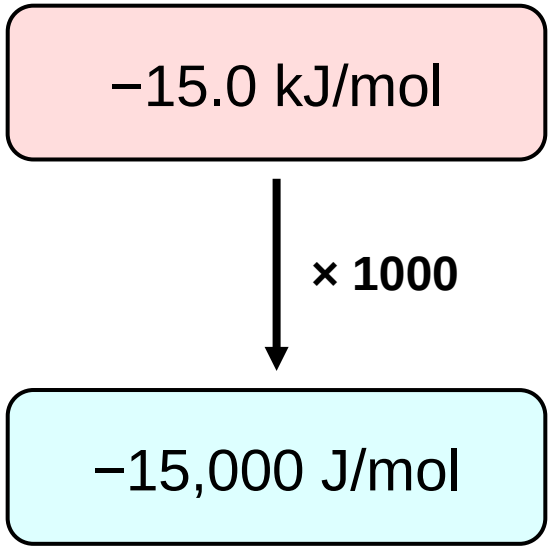
$$K = e^{-\Delta G^\circ / RT}$$

R = 8.314 J/(mol·K)

T in kelvins (K)

Watch Your Units!

- R uses joules, so $\Delta G°$ must be in J/mol
- kJ × 1000 = J



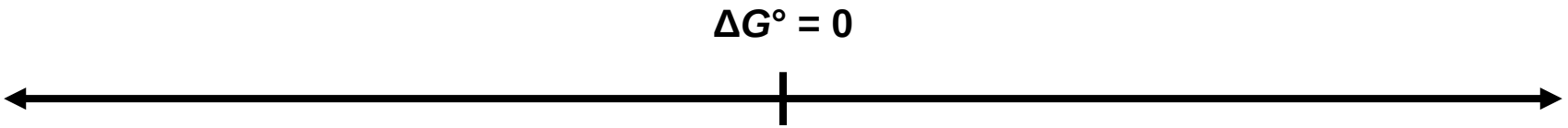
Sign of ΔG° and Size of K

$\Delta G°$	ln K	K	At equilibrium
< 0	+	> 1	products favored
0	0	1	neither favored
> 0	−	< 1	reactants favored

ln K always has the opposite sign of $\Delta G°$

Estimating K from ΔG°

- ΔG° near 0 → K near 1
- ΔG° much bigger than RT (+ or −) → K far from 1



ΔG° very negative K far above 1	ΔG° ≈ 0 K ≈ 1	ΔG° very positive K far below 1

At 298 K, RT ≈ 2.5 kJ/mol

A Little ΔG° Goes a Long Way

- At 298 K, every 5.7 kJ/mol changes *K* by a factor of 10
- Small Δ*G*° change → huge *K* change

Δ*G*° (kJ/mol)	*K* at 298 K
−40	1.0×10^{7}
−20	3.2×10^{3}
−10	57
0	1
+10	0.018
+20	3.1×10^{-4}
+40	9.7×10^{-8}

Temperature Connects It All

- Use $\Delta G°$ and K at the same temperature
- Change $T \rightarrow \Delta G°$ changes $\rightarrow K$ changes

$\Delta H°, \Delta S°, T$

↓

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

↓

$$K = e^{-\Delta G°/RT}$$

Example: Finding K from ΔG°

For the reaction below, $\Delta G°$ = −32.9 kJ/mol$_{rxn}$ at 298 K. Calculate the value of *K*.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Example: Finding ΔG° from K

At 298 K, K_a for acetic acid is 1.8×10^{-5}. Calculate $\Delta G°$ for this reaction.

$$HC_2H_3O_2(aq) + H_2O(l) \rightarrow C_2H_3O_2^-(aq) + H_3O^+(aq)$$

Example: From ΔH° and ΔS° to K

Use the data to calculate *K* for this reaction at 298 K.

$$2NO_2(g) \rightarrow N_2O_4(g)$$

$\Delta H° = -57.2$ kJ/mol	$\Delta S° = -175.9$ J/(mol·K)	$T = 298$ K

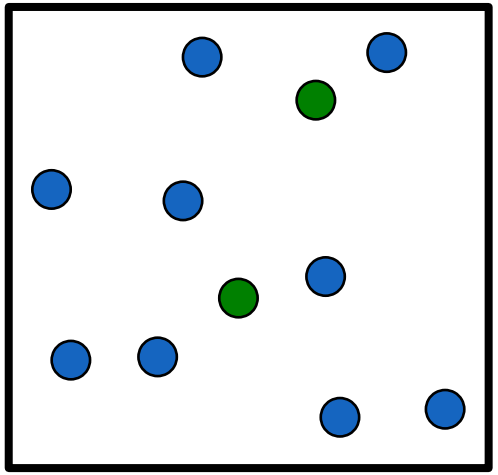
Example: Is K Big or Small?

At 298 K, $\Delta G°$ = +173.2 kJ/mol$_{rxn}$ for the reaction below. Without calculating, is *K* greater than or less than 1? Is it close to 1? Justify your answer.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

Big Ideas

- $\Delta G° < 0$ means products favored, $K > 1$
- $\Delta G° = -RT \ln K$, with $\Delta G°$ in J/mol
- $\Delta G°$ near 0 $\rightarrow$ K near 1
- $|\Delta G°|$ much bigger than RT $\rightarrow$ K far from 1



$\Delta G° < 0$, $K > 1$