

Spontaneity, Entropy, and Free Energy Part II

1) If the conditions are STANDARD CONDITIONS, this means 1 atm of pressure (or an equivalent), 298 K for temperature, and 1 M concentration.

2) If the system is at standard state use the equation:

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

“K” can be ANY K we have used.

3) If the system is not at standard state. We must look at “Q,” not “K.”

$$\Delta G = \Delta G^\circ + RT \ln Q$$

Regardless of the equation used, “K” and “Q” represent product concentration over reactant concentration. We can also apply Le Châtelier’s Principle here by comparing “K” and “Q.”

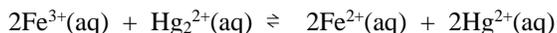
1) If $K < Q$, then reaction must shift left. $\Delta G > 0$.

2) If $K > Q$, then the reaction must shift right. $\Delta G < 0$

3) If $K = Q$, then the system is at equilibrium and $\Delta G = 0$.

Notice that the free energy used above is the nonstandard conditions free energy. You must recognize the difference between ΔG° and ΔG !

1. The equilibrium constant for the reaction



is $K_c = 9.1 \times 10^{-6}$ at 298 K.

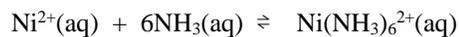
(a) What is ΔG° at this temperature?

(b) If standard-state conditions of reactants and products were mixed, in which direction would the reaction proceed? Justify your answer.

(c) Calculate ΔG at 298 K when $[\text{Fe}^{3+}] = 0.20 \text{ M}$, $[\text{Hg}_2^{2+}] = 0.010 \text{ M}$, $[\text{Fe}^{2+}] = 0.010 \text{ M}$, and $[\text{Hg}^{2+}] = 0.025 \text{ M}$. In which direction will the reaction proceed to achieve equilibrium?

Spontaneity, Entropy, and Free Energy Part II

2. The formation constant for the reaction



is $K_f = 5.6 \times 10^8$ at 25 °C.

- What is ΔG° at this temperature?
- If standard-state conditions of the reactants and products were mixed, in which direction would the reaction proceed?
- Determine ΔG when $[\text{Ni}(\text{NH}_3)_6^{2+}] = 0.010 \text{ M}$, $[\text{Ni}^{2+}] = 0.0010 \text{ M}$, and $[\text{NH}_3] = 0.0050 \text{ M}$. In which direction will the reaction proceed to achieve equilibrium?

Spontaneity, Entropy, and Free Energy Part II

3. The excessive production of ozone (O_3) gas in the lower atmosphere causes rubber to deteriorate, green plants to brown, and persons with respiratory disease to have difficult breathing.

	ΔH°_f kJ/mol	ΔG°_f kJ/mol	S° J/mol
O_2	0	0	205
O_3	143	163	239

- (a) Is the formation of O_3 from O_2 favored at all temperatures, no temperatures, high temperatures or low temperatures (HINT: determine $\Delta H^\circ_{\text{rxn}}$ and ΔS° to determine the sign of ΔG°).
- (b) Calculate the value of ΔG° .
- (c) Calculate ΔG at 298 K for this reaction in urban smog where $[\text{O}_2] = 0.21 \text{ M}$ and $[\text{O}_3] = 5.0 \times 10^{-7} \text{ M}$.