1. Consider the Gibbs free energy relationship

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

Determine the temperature at which the following reaction conditions would be spontaneous:

Reaction	ΔS	ΔH	Spontaneous ($\Delta G < 0$) at …			
A)	positive	negative	all Temps	high Temps	low Temps	no Temps
B)	positive	positive	all Temps	high Temps	low Temps	no Temps
C)	negative	positive	all Temps	high Temps	low Temps	no Temps
D)	negative	negative	all Temps	high Temps	low Temps	no Temps

2. Ammonia (NH_3) is a weak base in water with a $K_b = 1.8 \times 10^{-5}$.

A) Calculate the Gibbs free energy ($\Delta G°$) of the ammonia dissociation in water from the table of thermodynamic properties at 298.15 K.

	NH_3 (aq)	NH_4^+ (aq)	H_2O (l)	OH^- (aq)
$\Delta H° \left(\frac{\text{kJ}}{\text{mol}}\right)$	−80.3	−132.5	−285.8	−230.0
$\Delta S° \left(\frac{\text{J}}{\text{mol} \cdot \text{K}}\right)$	111.3	113.4	69.9	−10.8

B) Is the dissociation of NH_3 in water spontaneous or nonspontaneous?

C) Calculate the equilibrium constant (K_b) for NH_3 based on its $\Delta G°$ from part A. Recall that:

$$\Delta G° = -RT \ln K \qquad K = e^{-\Delta G°/RT} \qquad R = 8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

D) The phrases "spontaneous" and "nonspontaneous" may mislead you into believing that certain reactions will or will not take place. This is a misconception though.

What does the magnitude and sign of the $\Delta G°$ value tell us about the reaction?

Hint: Consider the relationship between $\Delta G°$ and K in part C.

3. For each reaction, predict the sign of the entropy change.

A) $Ag^+ (aq) + Cl^- (aq) \rightarrow AgCl (s)$

B) $2\ C_6H_6 (l) + 15\ O_2 (g) \rightarrow 6\ CO_2 (g) + 3\ H_2O (l)$

4. What is the free energy change (ΔG) for the process shown under the specified conditions?

$$2\ NH_3 (g) \rightleftharpoons N_2 (g) + 3\ H_2 (g) \qquad \Delta G° = 33.0\ \text{kJ/mol}$$

$T = 25\ °\text{C}$ $\qquad P_{NH_3} = 12.9\ \text{atm}$ $\qquad P_{N_2} = 0.870\ \text{atm}$ $\qquad P_{H_2} = 0.250\ \text{atm}$