SPONTANEITY AND FREE ENERGY

NAME _____ SECTION _____

1. Summarize the signs (+ or −) of $\Delta H°_{rxn}$ and ΔS_{rxn} for each of the following reactions (refer to the previous activities).

	$\Delta H°_{rxn}$	$\Delta S°_{rxn}$	$\Delta G°_{rxn}$

a. $H_2O(l) \rightarrow H_2O(g)$ @25 °C

b. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

c. $Ba(OH)_2 \bullet 8H_2O(s) + 2NH_4Cl(s) \rightarrow BaCl_2(aq) + 10H_2O(l) + 2NH_3(aq)$

d. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ or (g)

e. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

f. $Al(s) + \frac{3}{2}Br_2(l) \rightarrow AlBr_3(s)$

2. Circle which driving forces account for the spontaneity of each of the previous reactions.

3. In which reactions do the driving forces oppose each other?

4. The net driving force for a chemical reaction is called the free energy ($\Delta G°$) for the reaction. It is the energy that is free to drive the reaction rather than oppose another driving force. It can be calculated from free energies of formation ($\Delta G°_f$) in the same way as enthalpies of formation. Calculate $\Delta G°_{rxn}$ for the reactions in question 1.

5. Another way to calculate the free energy is to combine the two driving forces of enthalpy and entropy to recognize the contribution of each and to compensate for any way they oppose each other. The equation for doing this (called the Gibbs free energy equation) is: $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$. Calculate the free energy of the equations in question 1 using this equation, and compare your results with the values you determined from free energies of formation.

6. Use your data from question 1 to complete the blank cells for ΔG°_{rxn} when the driving forces drive in the same direction. What does the sign for ΔG°_{rxn} signify for the spontaneity of the reaction?

Sign of ΔH°_{rxn} (25 °C)	Sign of ΔS°_{rxn} (25 °C)	Sign of ΔG°_{rxn} (25 °C)	Sign of ΔG°_{rxn} at high temperature	Sign of ΔG°_{rxn} at low temperature
–	+			
+	–			
–	–			
+	+			

7. How does ΔG° change with increasing temperature for each of the following reactions?

   a. $Al(s) + \frac{3}{2} Br_2(l) \rightarrow AlBr_3(s)$

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

   c. $CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$

8. Use the Gibbs free energy equation to predict how the sign of ΔG° changes with temperature. Complete the cells in the previous table.

9. Calculate the temperature at which ΔG° is zero for the reaction.

$$HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$$