Gibbs Free Energies

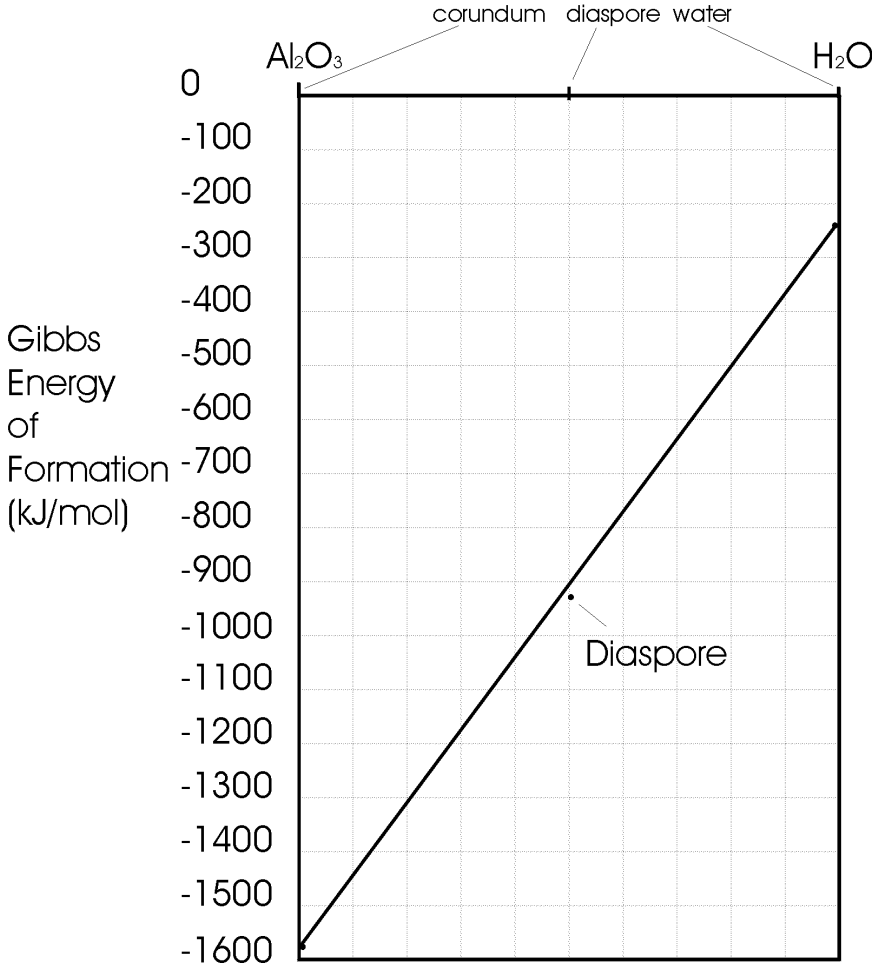
C:\Courses\320\in-class\04-GibbsEanswer.wpd; August 23, 2003 (11:20am)

formula	mineral/phase	ΔG^o_f kJ/mol
O_2	oxygen	0
Al	aluminum	0
H_2O	water	-237.141
Al_2O_3	corundum	-1582.228
AlO(OH)	diaspore	-918.4
$Al(OH)_3$	gibbsite	-1154.889

The graph below provides a convenient way to compare some Gibbs Free Energies in the chemical system Al_2O_3 - H_2O.

1. Put tic marks on the top line where the compositions of corundum, diaspore and water plot. Then move down and put dots (clearly labeled) to show the ΔG^o_f for each phase. Be sure to plot very carefully!

2. Draw a line from corundum to water. If diaspore plots below this line, it means that diaspore is more stable than separate water and corundum. Is it? (Note that we cannot do the same graphical analysis for the stability of gibbsite because the reaction of corundum+water to gibbsite does not have the same number of moles on each side.) Diaspore is just barely more stable.



3. Another way to compare relative stabilities is to consider the Gibbs energies of reactions. Consider the reactions:

corundum + water = diaspore (1)
corundum + water = gibbsite (2)

Balance these reactions and use the Gibbs energy values from the table to calculate ΔG^{o}_{rxn} at STP (standard temperature and pressure). Do these values come out to be less than 0? If so, diaspore and gibbsite are more stable than separate corundum + water at STP.

corundum + water = 2 diaspore ΔG = -17.431 J/mol

corundum + 3 water = 2 gibbsite ΔG = -16.127 J/mol

So, both reactions proceed to the right. Diaspore and gibbsite are more stable than assemblages of corundum + water.

4. In the Al_2O_3-H_2O system, there are two other possible chemical reactions involving three phases. List and balance them. Calculate ΔG^{o}_{rxn} for each. For each, which is the stable side of the reaction at STP?

diaspore + water = gibbsite ΔG = 0.652 J/mol, so Di + water is slightly more stable.

gibbsite + corundum = 3 diaspore ΔG=-18.083 J/mol, so Di is more stable.

5. If a rock that is 100% Al_2O_3, then (considering only the Al_2O_3-H_2O system) it must contain 100% corundum. (There is no combination involving diaspore, gibbsite or water that equals 100% Al_2O_3.)

Suppose, however, you have a rock that is 50% Al_2O_3 and 50% H_2O. You could have any of the following three assemblages: (1) only diaspore, (2) gibbsite + corundum, (3) water + corundum.

Which of these assemblages is most stable at STP? Explain how you concluded this?

From question #3, we know that diaspore is more stable than water+corundum, and from question #4, we know that diaspore is more stable than gibbsite+corundum. So diaspore is the answer.