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## Chapter 7

### *Equilibria for Multiple Component Systems*

7.2. With only a single component and phase, if only  $\text{Fe}_2(\text{SO}_4)_3$  were present in our system, we would have  $C - P + 2 = 1 - 1 + 2 = 2$  degrees of freedom.

7.4. For a single-component system, there will never be negative degrees of freedom. The maximum number of phases that can exist in equilibrium is three, so the Gibbs phase rule would yield  $1 - 3 + 2 = 0$  degrees of freedom (like might occur at the triple point). For a two-component system, the maximum number of phases that can exist in equilibrium is four. There will never be negative degrees of freedom.

7.6. In this reaction, there are only three independent components (the amount of the fourth can be determined from the equilibrium constant) and 3 phases, two solids and a gas mixture. Therefore, there are  $3 - 3 + 2 = 2$  degrees of freedom.

7.8. For water:  $n = \frac{PV}{RT} = \frac{(23.76 \text{ torr})(5.00 \text{ L})}{(0.08205 \text{ L} \cdot \text{atm/mol} \cdot \text{K})(298.15 \text{ K})} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 6.39 \times 10^{-3}$  mol of water is needed to ensure that there is a liquid and gas phase. This equals 0.115 grams.  
For methanol:  
$$n = \frac{PV}{RT} = \frac{(125.0 \text{ torr})(5.00 \text{ L})}{(0.08205 \text{ L} \cdot \text{atm/mol} \cdot \text{K})(298.15 \text{ K})} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 3.36 \times 10^{-3}$$
 mol of methanol is needed to ensure that there is a liquid and gas phase. This equals 1.08 grams.

7.10. Since, according to equation 7.11,  $\alpha_i = \frac{P_i}{P_{i^*}}$ , and since  $P_{i^*} = 760 \text{ torr}$ , we can calculate  $\alpha_i$ :

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