Unit 9

NMSI Super Problem: General Equilibrium

$$2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$$

A 5.00 mol sample of sulfur trioxide, SO_3 is placed into a 5.00 L reaction vessel and allowed to decompose at 400 K according the reaction above. Once equilibrium is established, 3.00 mol of sulfur dioxide, SO_2, is present.

a. Write the expression for the equilibrium constant, K_c, for the reaction above.

b. Calculate

   i. the initial molar concentration of SO_3

   ii. the equilibrium concentrations of O_2, SO_2, and SO_3

c. Calculate the equilibrium constant, K_c for this reaction.

d. Calculate the equilibrium constant, K_p for this reaction.

The reaction vessel above is cooled from 400 K to 298 K. The mixture reestablishes equilibrium with fewer moles of sulfur dioxide and oxygen gas at the new temperature.

e. Is the forward reaction endothermic or exothermic? Justify your answer.

skip f. Predict the sign of the standard entropy change, $\Delta S°$, for the reaction. Explain.

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g. The value of the standard free energy change, $\Delta G°$, for the reaction is +141.8 kJ mol^{-1}. Calculate the value of the equilibrium constant, K, at 298 K.

h. Determine whether the number of moles of SO_3 will increase, decrease, or stay the same after each of the following disturbances. Justify each response.

i. The temperature of the equilibrium mixture is decreased.

ii. The volume of the reaction container is increased.

In a different experiment, sulfur dioxide and oxygen gases were added to a reaction vessel at 400 K and the following reaction occurred and equilibrium was established.

$$SO_2(g) + \frac{1}{2} O_2(g) \rightleftharpoons SO_3(g)$$

i. Calculate the equilibrium constant, K_c for this reaction at 400. K.