Le Chatelier Practice Problems

1. How will the position of equilibrium in this equation be affected by the following changes? Heat + CH_4 (g) + 2 H_2S (g) $\rightarrow$ CS_2 (g) + $4H_2$ (g)
   - Adding CH_4 (g)
   - Adding H_2 (g)
   - Removing CS_2 (g)
   - Decreasing the volume of the container
   - Increasing the temperature

   a. Solving changes a, b, and c requires definition of ke. $Ke = \dfrac{[CS_2\,(g)][H_2]^4}{[CH_4\,(g)][\,H_2S\,(g)]^2}$

   Ke must not change. If CH_4 is added, ke will be smaller if nothing else changes. By increasing the numerator, ke will remain the same. Therefore, the reaction must move towards the right, producing more product.

   Another way to understand is to assign mathematical concentrations to each item in the equation. e.g. $CS_2 = 2$ $CH_4 = 2$ $H_2 = 2$ $H_2S = 2$ $ke = \dfrac{[2][2]^4}{[2][2]^2} = 4$

   If CH_4 is doubled to 4 and no other changes occur: $ke = \dfrac{[2][2]^4}{[2]^2[2]^2} = 2$ (Cannot occur, ke must remain 4)

   Must equally increase the numerator or produce more product.

   $Ke = \dfrac{[2]^2[2]^4}{[2]^2[2]^2} = 4$ (ke remains unchanged)

b. Applying the same approach results in the production of more material in the denominator to offset the larger potential ke which must remain constant. Therefore, the reaction must move toward the left.

c. If CS_2 is removed, ke will be smaller, unless the denominator is reduced or more CS_2 is added. Reducing the denominator means that the equilibrium must move to the right to produce more CS_2.

d. Reducing the volume causes <u>the position of equilibrium to shift in the direction</u> that produces the fewest molecules, <u>to the left</u>.

e. If heat is treated as a concentration, the ke equation will become $ke = \dfrac{[CS_2]_g[H_2]^4}{[CH_4]_g[H_2S]^2_g[heat]}$

For the ke to remain the same (an assumption), increase the numerator and the equilibration position will go to the right.

2. Consider the equation

$$N_2O\ (g) + NO_2\ (g) \rightarrow 3NO\ (g) \qquad \Delta H = +155.7\ kJ$$

In which direction will the equilibrium shift with the following changes?

a. Add N_2O
b. Remove NO_2
c. Add NO
d. Increase temperature
e. add helium gas to mixture
f. decrease volume of container

$$ke = \frac{\text{products}}{\text{reactants}} = \frac{[NO]^3}{[N_2O][NO_2]}$$

Solutions:

a. Adding N_2O requires increasing the numerator to keep the same ke. Have the reaction move to the right by increasing NO to achieve this.

b. Adding NO requires increasing the denominator. Have the reaction move to the left to achieve this.

c. Removing NO_2 requires reducing the numerator. The reaction must move to the left to produce less NO.

d. If the temperature is increased, rewrite the ke so that heat is added as a component. Since ΔH is +, reaction is endothermic. The heat component is located on the reactant side of the equation.

$$ke = \frac{[NO]^3}{[\Delta H][N_2O][NO_2]}$$

To compensate for increasing the temp which makes the denominator larger, the numerator must also be made larger to keep the ke constant. The equilibrium must move to the right. <u>Note:</u> This assumes the heat change does not affect ke.

e. An inert gas has no effect on the equilibrium.

f. Decreasing volume will cause the reaction to proceed in the direction that produces the fewest molecules. Equilibrium will move to the left.