Exercise 13.4
Equilibrium Basics

Name: ______________________

Date:________________ Per:________

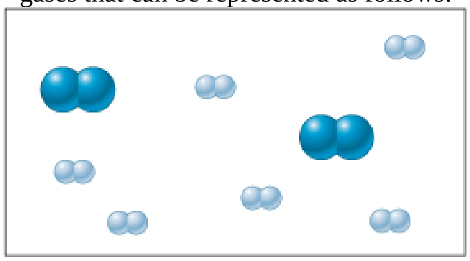
The equilibrium constant (K) is the ratio of the equilibrium concentration (or pressure) of product(s) to the equilibrium concentration (or pressure) of reactant(s).

$$2NO_2(g) + 7H_2(g) \rightleftarrows 2NH_3(g) + 4H_2O(l)$$

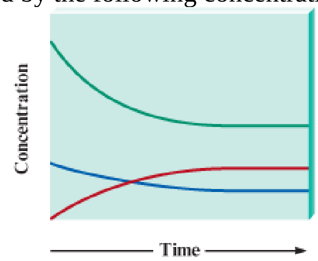
$$K_C = \frac{[NH_3]^2_{(eq)}}{[NO_2]^2_{(eq)}[H_2]^7_{(eq)}} \quad \textit{equilibrium concentrations} \qquad K_P = \frac{(pNH_3)^2_{(eq)}}{(pNO_2)^2_{(eq)}(pH_2)^7_{(eq)}} \quad \textit{equilibrium pressures}$$

The coefficients from the balanced equation become exponents. Liquids and solids never appear in the expressions, because their concentrations (or pressures) do not change throughout the reaction.

1. Consider an initial mixture of N_2 and H_2 gases that can be represented as follows:



The gases react to form ammonia gas (NH_3) as represented by the following concentration profile:



   a. Label each plot of the graph as N_2, H_2, or NH_3, and explain your answers: ______________________________

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   b. Explain the relative shapes of the plots: ______________________________

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   c. When is equilibrium reached? How do you know? ______________________________

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2. Suppose a reaction has the equilibrium constant $K = 1.3 \times 10^8$. What does the magnitude of this constant tell you about the relative concentrations of products and reactants that will be present once equilibrium is reached? Is this reaction likely to be a good source of the products?

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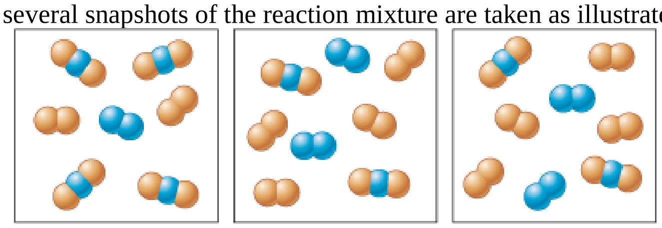
3. Consider the following generic reaction: $2A_2B(g) \rightleftarrows 2A_2(g) + B_2(g)$. Some molecules of A_2B are placed in a 1.0 L container. As time passes, several snapshots of the reaction mixture are taken as illustrated below.



   a. Which illustration is the first to represent an equilibrium mixture? Explain. ______________________________

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   b. How many molecules of A_2B reacted initially? ______________________________

Answers: 4) 1.7×10^{-5} 5a) 3.8×10^4 5b) $Q = 1.21 \times 10^3$, No 6) 4.7×10^3 7) d. 8) 8.0×10^9

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4. At a particular temperature, a 3.0 L flask contains 2.4 moles of Cl_2, 1.0 mole of NOCl, and 4.5×10^{-3} mole of NO. Calculate *K* at this temperature for the following reaction: $2NOCl(g) \rightleftarrows 2NO(g) + Cl_2(g)$

5. The following equilibrium pressures at a certain temperature were observed for the reaction, $N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$.

   $P_{NH3} = 3.1 \times 10^{-2}$ atm; $P_{N2} = 8.5 \times 10^{-1}$ atm; $P_{H2} = 3.1 \times 10^{-3}$ atm

   a. Calculate the value of the equilibrium constant K_p at this temperature.

   b. If $P_{N2} = 0.525$ atm, $P_{NH3} = 0.0167$ atm, and $P_{H2} = 0.00761$ atm, does this represent a system at equilibrium?

6. At 327° C, the equilibrium concentrations are $[CH_3OH] = 0.15$ M, $[CO] = 0.24$ M, $[H_2] = 1.1$ M for the reaction:

   $$CH_3OH(g) \rightleftarrows CO(g) + 2H_2(g)$$

   Calculate K_p at this temperature.

7. For which of the reactions below does K_p equal to *K*?

   a. $2NH_3(g) + CO_2(g) \rightleftarrows N_2CH_4O(s) + H_2O(g)$

   b. $2NBr_3(s) \rightleftarrows N_2(g) + 3Br_2(g)$

   c. $2KClO_3(s) \rightleftarrows 2KCl(s) + 3O_2(g)$

   d. $CuO(s) + H_2(g) \rightleftarrows Cu(s) + H_2O(g)$

8. Consider the following reaction at a certain temperature:

   $$4Fe(s) + 3O_2(g) \rightleftarrows 2Fe_2O_3(s)$$

   An equilibrium mixture contains 1.0 mole of Fe, 1.0×10^{-3} mole of O_2, and 2.0 mole of Fe_2O_3 all in a 2.0 L container. Calculate the value of *K* for this reaction.

Answers: 4) 1.7×10^{-5} 5a) 3.8×10^{4} 5b) $Q = 1.21 \times 10^{3}$, No 6) 4.7×10^{3} 7) d. 8) 8.0×10^{9}