Name: Key ☺ Pd: ____

Equilibrium Constant (K_{eq}) - Chemistry

1. **Write the equilibrium constant (K_{eq}) expressions for the following homogeneous equilibria.**

   a. $C_2H_4O\ (g) \leftrightarrow CH_4\ (g) + CO\ (g)$

   $K_{eq} = \frac{[CH_4][CO]}{[C_2H_4O]}$

   b. $3O_2\ (g) \leftrightarrow 2O_3\ (g)$

   $K_{eq} = \frac{[O_3]^2}{[O_2]^3}$

   c. $2N_2O\ (g) + O_2\ (g) \leftrightarrow 4NO\ (g)$

   $K_{eq} = \frac{[NO]^4}{[N_2O]^2[O_2]}$

   d. $4NH_3\ (g) + 3O_2\ (g) \leftrightarrow 2N_2\ (g) + 6H_2O\ (g)$

   $K_{eq} = \frac{[N_2]^2[H_2O]^6}{[NH_3]^4[O_2]^3}$

   e. $4HCl\ (g) + O_2\ (g) \leftrightarrow 2Cl_2\ (g) + 2H_2O\ (g)$

   $K_{eq} = \frac{[Cl_2]^2[H_2O]^2}{[HCl]^4[O_2]}$

   f. $PCl_5\ (g) \leftrightarrow PCl_3\ (g) + Cl_2\ (g)$

   $K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]}$

2. **Write the equilibrium constant (K_{eq}) expressions for the following heterogeneous equilibria.**

   a. $C_4H_{10}\ (l) \leftrightarrow C_4H_{10}\ (g)$

   $K_{eq} = [C_4H_{10}]$

   b. $NH_4HS\ (s) \leftrightarrow NH_3\ (g) + H_2S\ (g)$

   $K_{eq} = [NH_3][H_2S]$

   c. $CO\ (g) + Fe_3O_4\ (s) \leftrightarrow CO_2\ (g) + 3FeO\ (s)$

   $K_{eq} = \frac{[CO_2]}{[CO]}$

   d. $(NH_4)_2CO_3(s) \leftrightarrow 2NH_3(g) + CO_2(g)+H_2O(g)$

   $K_{eq} = [NH_3]^2[CO_2][H_2O]$

For the following problems, show *all* of your work including set-up (with K_{eq} expression) and answer with units if needed.

3. At 773 K, the reaction **$2NO\ (g) + O_2\ (g) \leftrightarrow 2NO_2\ (g)$** produces the following concentrations: [NO] = 3.49×10^{-4} M; $[O_2]$ = 0.80 M; $[NO_2]$ = 0.25 M. Calculate the equilibrium constant (K_{eq}) for this reaction.

   $K_{eq} = \frac{[NO_2]^2}{[NO]^2[O_2]}$ $K_{eq} = \frac{(.25)^2}{(3.49 \times 10^{-4})^2(.80)} = \boxed{6.41 \times 10^5}$

   products favored b/c $K_{eq} > 1$

4. The chemical equation for the decomposition of formamide is: **$HCONH_2\ (g) \leftrightarrow NH_3\ (g) + CO\ (g)$** Calculate K_{eq} using the following equilibrium data: $[HCONH_2]$ = 0.0637 M, $[NH_3]$ = 0.518 M and [CO] = 0.518 M.

   $K_{eq} = \frac{[NH_3][CO]}{[HCONH_2]}$ $K_{eq} = \frac{.518 \cdot .518}{.0637} = \boxed{4.21}$ products favored b/c $K_{eq}>$

5. Calculate K_{eq} for the reaction for iron and water if the equilibrium concentrations are as follows: $[H_2O]$ = 1.00 M & $[H_2]$ = 4.50 M. **$2Fe\ (s) + 3H_2O\ (g) \leftrightarrow Fe_2O_3\ (s) + 3H_2\ (g)$**

   $K_{eq} = \frac{[H_2]^3}{[H_2O]^3}$ $K_{eq} = \frac{(4.5)^3}{(1.00)^3}$ $\boxed{K_{eq} = 91.1}$

   products favored b/c $K_{eq} > 1$

6. At 793 K, the equilibrium constant for the reaction NCl_3 (g) + Cl_2 (g) ↔ NCl_5 (g) is 39.3.

a. Do the products or the reactants dominate in this equilibrium? Explain your answer in complete sentences.

products because the Keq = 39.3 and that is greater than 1

b. If the equilibrium constant for this reaction were less than 1, would the reactants or products be dominant? Explain your answer in complete sentences.

reactants b/c Keq is less than 1

7. The equilibrium constant is $\boxed{9.36}$ for the following reaction: **A (g) + 3B (g) ↔ 2C (g).** The table below provides concentration data for two different reaction mixtures of these gases.

	A (mol/L)	B (mol/L)	C (mol/L)
Mixture 1	0.716	0.208	0.425
Mixture 2	0.562	0.491	0.789

a. Calculate the K_{eq} for each mixture. Use the back of the sheet to show your work.

$K_{eq} = \frac{[C]^2}{[A][B]^3}$

Mixture 1: $K_{eq} = \frac{(.425)^2}{(.716)(.208)^3}$

$K_{eq} = 28.0$

Mixture 2: $K_{eq} = \frac{(.789)^2}{(.562)(.491)^3}$

$K_{eq} = 9.36$

b. Are both reactions at equilibrium? Explain your answer in complete sentences.

No, only mixture 2 is at equilibrium because it has a Keq value of 9.36.