Equilibrium Constant (K_{eq}) - Chemistry Name: KEY Pd: ____

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

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

$$Keq = \frac{[CH_4][CO]}{[C_2H_4O]}$$

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

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

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

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

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

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

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

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

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

$$Keq = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

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

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

$$Keq = [C_4H_{10}]$$

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

$$Keq = [NH_3][H_2S]$$

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

$$Keq = \frac{[CO_2]}{[CO]}$$

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

$$Keq = [NH_3]^2[CO_2][H_2O]$$

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: $[NO] = 3.49 \times 10^{-4}$ M; $[O_2] = 0.80$ M; $[NO_2] = 0.25$ M. Calculate the equilibrium constant (K_{eq}) for this reaction.

$$Keq = \frac{[NO_2]^2}{[NO]^2[O_2]} = \frac{[0.25]^2}{[3.49 \times 10^{-4}]^2[.80]} \boxed{= 6.41 \times 10^5}$$

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.

$$Keq = \frac{[NH_3][CO]}{[HCONH_2]} = \frac{[.518][.518]}{[.0637]} \boxed{= 4.21}$$

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. **$2Fe\ (s) + 3H_2O\ (g) \leftrightarrow Fe_2O_3\ (s) + 3H_2\ (g)$**

$$Keq = \frac{[H_2]^3}{[H_2O]^3} = \frac{[4.50]^3}{[1.00]^3} \boxed{= \cancel{0.0411}} \boxed{91.1}$$

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

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

   $$Keq = \frac{[NCl_5]}{[NCl_3][Cl_2]} = 39.3$$

   products, Keq > 1 is favored by the products, products are numerator

   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, reactants go on the denominator so greater denominator gives a # < 1

7. The equilibrium constant is 9.36 for the following reaction: **A (g) + 3B (g) $\leftrightarrow$ 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.

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

   mix#1 $\frac{[.425]^2}{[.716][.208]^3} = 28.0$

   mix#2 $\frac{[.789]^2}{[.562][.491]^3} = 9.36$

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

   No, only mixture #2 b/c the calculated Keq is equal to the Keq