Dougherty Valley HS Chemistry - AP
Equilibrium – Keq Constant

Worksheet #1

Name: **Period:** **Seat#:**

Directions: Show all work in a way that would earn you credit on the AP Test! This is always the rule! Some answers are provided at the end in italics and underlined. If you need more space, use binder paper and staple to your worksheet.

Note: All [ ] are expressed in molarities. All [ ] symbols have been omitted. An alternate symbol for K_{eq} is K_c.

1) Write the expression for the equilibrium constant for each of the following reactions.

a) $H_2 + Cl_2 \leftrightarrow 2HCl$	**b)** $2\ SO_2 + O_2 \leftrightarrow 2SO_3$	**c)** $N_2 + 3H_2 \leftrightarrow 2NH_3$
d) $2\ CO + O_2 \leftrightarrow 2CO_2$	**e)** $N_2 + ½\ O_2 \leftrightarrow N_2O$	**f)** $HCN \leftrightarrow H^+ + CN^-$
g) $H_2SO_4 \leftrightarrow H^+ + HSO_4^-$	**h)** $NO + ½\ O_2 \leftrightarrow NO_2$	**i)** $PbF_2 \leftrightarrow Pb^{2+} + 2F^-$

2) From the data provided below, calculate the value of the equilibrium constant or the missing concentration for the reactions listed in problem #1 above.

a)	$[H_2] = [Cl_2] = 1.0E^{-2}$	$[HCl] = 1.0E^{-4}$		Kc = *0.0001*
b)	$[SO_2] = 1.0E^{-3}$	$[O_2] = 2.0E^{-3}$	$[SO_3] = 3.0E^{-3}$	Kc = *4500*
c)	$[N_2] = 4.4E^{-2}$	$[H_2] = 1.2E^{-1}$	$[NH_3] = 3.4E^{-3}$	Kc = *0.152*
d)	$[CO] = 2.5E^{-3}$	$[O_2] = 1.6E^{-3}$	$[CO_2] = 3.2E^{-2}$	Kc = *1.02×10^5*
e)	**$[O_2]$ =** *4.94×10^{-4}*	$[N_2] = 1.00$	$[N_2O] = 1.00$	Kc = 45.0
f)	$[HCN] = 0.25$	$[H^+] = 0.10$	$[CN^-] = 0.010$	Kc = *4.0×10^{-3}*
g)	$[H_2SO_4] = 0.0039$	$[H^+] = 0.0039$	$[HSO_4^-] = 0.0039$	Kc = *3.9×10^{-3}*
h)	**[NO] =** *6.32×10^{-2}*	$[O_2] = 0.100$	$[NO_2] = 0.200$	Kc = 10.0
i)	$[PbF_2] = 0.37$	$[Pb^{2+}] = 0.00078$	$[F^-] = 0.00156$	Kc = *5.13×10^{-9}*

3) For the reaction, $2\ NO_2 \leftrightarrow N_2O_4$, the equilibrium concentrations are: $[NO_2] = 3.1E^{-2}$ and $[N_2O_4] = 4.5E^{-3}$. From these data, calculate Kc for the reaction at this temperature. *4.68*

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Equilibrium Calculations Using the Quadratic Equation (and some maybe not)

4) Nitric oxide, NO, is formed in automobile exhaust by the reaction of the N_2 and O_2 in air. At 2127 °C Kc is 0.0125. Initially a mixture contains 0.850 mol of each N_2 and O_2 in a 15 liter vessel. Find the concentration of all species when equilibrium is reached at 2127 °C. *N_2 0.054, O_2 0.054, NO 6.04 x 10^{-3}*

5) Suppose the equilibrium mixture is disturbed by adding 0.0500 mol of N_2 with no temperature change. What will the new equilibrium concentrations become? (Use scratch paper if you need more space for the algebra on this one!) *N_2 0.0572, O_2 0.0539, NO 0.00627*

6) 0.500 mol of N_2 and O_2 are introduced into a 5.00 liter reaction flask at 2127 °C. What are the concentrations after equilibrium has been established? *N_2 0.947, O_2 0.947, NO 0.0106*

7) Phosgene, $COCl_2$, is prepared from CO and Cl_2 according to the following equation: $CO + Cl_2 \leftrightarrow COCl_2$. Kc at 395°C is 1.23E^3. If 2.00 mol of CO and 3.50 mol of Cl_2 are added to a 5.00 liter reaction vessel at 395°C, what would the equilibrium concentrations be for all species? *CO 0.001, Cl_2 0.301, $COCl_2$ 0.399*

8) Hydrogen fluoride decomposes according to the following equation: $2HF \leftrightarrow H_2 + F_2$
The value of Kc at room temperature is $1.0E^{-95}$. From the value of the equilibrium constant do you think the decomposition occurs to any great extent at room temperature? *no*

9) If an equilibrium mixture at room temperature in a 1.0 liter vessel contains 1.0 mol of HF, what is the concentration of H_2? Does this result agree with your prediction about the decomposition? *3.16×10^{-48}, yes*

10) The equilibrium constant, Kc for the reaction $PCl_3 + Cl_2 \leftrightarrow PCl_5$ is 49 at 230 °C. If 0.500 mol each of phosphorus trichloride and chlorine are added to a 5.0 liter reaction vessel. What is the equilibrium composition of the mixture at 230 °C? *PCl_3 0.0361, Cl_2 0.0361, PCl_5 0.0639*

11) Iodine and bromine react to give iodine monobromide: $I_2 + Br_2 \leftrightarrow 2IBr$. At a temperature of 150 °C. a 5.0 liter reaction vessel initially contained 0.0015 mol each of iodine and bromine. At equilibrium if IBr was found at a concentration of 5.1×10^{-4} M what is the value of Kc? *128*

A few Le Chatelier's Problems on the next page!

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12) What will happen to the equilibrium $N_2 + 3H_2 \leftrightarrow 2NH_3 + heat$ under the following conditions? Explain WHY also!

a) The pressure is increased
b) More nitrogen is introduced
c) The temperature is increased

13) $2NO_2 \leftrightarrow N_2O_4 + heat$ How is the quantity of N_2O_4 affected by: Explain WHY also!

a) Increasing the temperature.
b) Increasing the pressure.

14) In aqueous solution the following equilibrium takes place. $NH_4OH \leftrightarrow NH_4^+ + OH^-$ what will happen to the concentration of unionized NH_4OH by addition of the following substances. Explain your answers.

a) NH_4Cl
b) NaCl
c) HCl
d) NaOH
e) Pure water

15) Explain what happens when concentrated hydrochloric acid (HCl) is added to a saturated solution of potassium chloride (KCl).