Chem 1515
Problem Set #7
Fall 2001

Name_____

TA Name _____

Lab Section #_____

ALL work must be shown to receive full credit. **Due at the beginning of lecture on Wednesday, October 24, 2001.**

PS7.1. Given the reaction

$$3O_{2(g)} + 4NH_{3(g)} \rightleftarrows 6H_2O_{(g)} + 2N_{2(g)}$$

Initially (before any reaction occurs) a 1.00 liter reaction vessel at some temperature contains 0.502 moles of O_2 and 0.791 moles of NH_3 and no water or nitrogen. Consider the following:

a) If 0.245 moles of O_2 react, how many moles of NH_3 must react and how many moles of H_2O and N_2 are formed? How many moles of O_2, NH_3, H_2O and N_2 remain after completion of the reaction?

b) If 0..304 moles of NH_3 react, how many moles of O_2 must react and how many moles of H_2O and N_2 are formed? How many moles of O_2, NH_3, H_2O and N_2 remain after completion of the reaction?

c) If '**3x**' moles of O_2 react, how many moles of NH_3 must react and how many moles of H_2O and N_2 are formed(in terms of '**x**')? How many moles of O_2, NH_3, H_2O and N_2 remain after completion of the reaction?

d) If 0.503 moles of H_2O are formed, how many moles of N_2 are formed and how many moles of O_2 and NH_3 must react? How many moles of O_2, NH_3, H_2O and N_2 remain after completion of the reaction?

PS7.2. Write the equilibrium expression for each of the following chemical equations;

a) $N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)}$

b) $2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)}$

c) $N_{2(g)} + 2O_{2(g)} \rightleftarrows 2NO_{2(g)}$

d) $2N_2O_{(g)} + O_{2(g)} \rightleftarrows 4NO_{(g)}$

PS7.3. In each of the following you are given the equation for an equilibrium system and the magnitude of the equilibrium constant. Calculate the new equilibrium constant for the reaction in the alternative form;

	Equilibrium reaction	Equilibrium constant	Alternative reaction
a)	$N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)}$	4.7×10^{-31}	$\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftarrows NO_{(g)}$
b)	$CO_{2(g)} + H_{2(g)} \rightleftarrows CO_{(g)} + H_2O_{(g)}$	1.4	$CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)}$
c)	$6ClO_3F_{(g)} \rightleftarrows 2ClF_{(g)} + 4ClO_{(g)} + 7O_{2(g)} + 2F_{2(g)}$	32.6	$\frac{1}{3}ClF_{(g)} + \frac{2}{3}ClO_{(g)} + \frac{7}{6}O_{2(g)} + \frac{1}{3}F_{2(g)} \rightleftarrows ClO_3F_{(g)}$

PS7.4. Equilibrium constants for the following reactions have been determined at 298 K:

$N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)}$ $\quad K_1 = 4.7 \times 10^{-31}$

$2NO_{2(g)} \rightleftarrows 2NO_{(g)} + O_{2(g)}$ $\quad K_2 = 4.35 \times 10^{-13}$

Calculate K (at the same temperature) for the reaction

$\frac{1}{2}N_{2(g)} + O_{2(g)} \rightleftarrows NO_{2(aq)}$ $\quad K_3 = ?$

PS7.5. The reaction

$$NOBr_{(g)} \rightleftarrows NO_{(g)} + \frac{1}{2} Br_{2(g)}$$

has been carefully studied at 350 ˚C and the K_c is 0.079. Calculate Q and determine which direction (left-to-right or right-to-left) will the reaction proceed to establish equilibrium under each of the following initial conditions?

a) $[NOBr]_o = 0.100$ M : $[NO]_o = 0$: $[Br_2]_o = 0$

b) $[NOBr]_o = 0$: $[NO]_o = 0.100$ M : $[Br_2]_o = 0.100$ M

c) $[NOBr]_o = 0.100$ M : $[NO]_o = 0$: $[Br_2]_o = 0.100$ M

d) $[NOBr]_o = 0.100$ M : $[NO]_o = 0.100$ M : $[Br_2]_o = 0.100$ M

e) $[NOBr]_o = 0.200$ M : $[NO]_o = 0.0500$ M : $[Br_2]_o = 0.100$ M

PS7.6. Consider the reaction

$$2H_2S_{(g)} + 3O_{2(g)} \rightleftarrows 2H_2O_{(g)} + 2SO_{2(g)}$$

for which $\Delta H_{rxn} = -1036$ kJ. Predict how the $[H_2O]$ will change when the equilibrium is disturbed by;

a) Addition of O_2

b) Addition of SO_2

c) Addition of a catalyst

d) Decrease in temperature

e) Decrease in the volume of the reaction container

PS7.7. In the manufacture of ammonia from its elements hydrogen must be produced on site. An important source of hydrogen is the reforming of methane at high temperature. The reaction which describes the reforming of methane is;

$$CH_{4(g)} + 2H_2O_{(g)} \rightleftarrows CO_{2(g)} + 4H_{2(g)}$$

a) A mixture of 1.00 mol of methane and 1.00 mol of water are heated to 1000 K in a 10.0 L flask. The mixture was allowed to reach equilibrium. The amount of unreacted methane was found to be 11.2 g. Calculate the amount of hydrogen at equilibrium.

b) Calculate the magnitude of the equilibrium constant for the reaction at 1000 K.

c) Calculate ΔH° for the reaction

d) Describe the effect on the equilibrium amount of H_2 produced by each of the following actions;

i) add a catalyst

ii) add CH_4

iii) remove CO_2

iv) increase T to 1200 K

v) transfer mixture to a 15.0 L flask