NAME:

CHM 2046 **Practice Quiz 1**

Answer all questions. Give your final answer with the correct units, if any, and to the correct sig. figs. **Useful Information**: 0 °C ≈ 273 K, R = 0.0820 L. atm/mol. K

1. a) (3 points each) Balance the following reactions, if necessary, and write down their mass-action expression, Q_c

$$2\,NO(g) + 2\,H_2(g) \rightleftharpoons N_2(g) + 2\,H_2O(g)$$

$$2\,KCl(s) \rightleftharpoons 2\,K(g) + Cl_2(g)$$

$$Q_c = \frac{[N_2][H_2O]^2}{[NO]^2[H_2]^2}$$

$$Q_c = [K]^2[Cl_2]$$

b) (5 points) At 100 °C, K_p = 60.6 for the reaction

$$2\,NOBr(g) \rightleftharpoons NO(g) + Br_2(g)$$

In a particular experiment, 0.35 atm (atmospheres) of NOBr, 4.0 atm of NO, and 2.0 atm of Br_2 are placed in a vessel. Is the reaction at equilibrium? Explain.

Balance first! $2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$

$$Q_p = \frac{P_{NO}^2 P_{Br_2}}{P_{NOBr}^2} = \frac{(4.0)^2(2.0)}{(0.35)^2} = 2.6 \times 10^2$$

NOT at equilibrium because $Q_p \neq K_p$

If not, in which direction will it proceed? Explain.

reaction proceeds right → left because $Q_p > K_p$ (and Q_p must become smaller).

2 a) (4 points) Gaseous ammonia (NH_3) was introduced into a sealed container and heated to a certain temperature

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$$

At equilibrium, $[NH_3]$ = 0.0250M, $[N_2]$ = 0.124M, and $[H_2]$ = 0.322M. Calculate K_c for this reaction at this temperature.

$$K_c = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{(0.124)(0.322)^3}{(0.0250)^2} = 6.62$$

b) (1 point) What will happen to the $[NH_3]$ if more N_2 is now added to the container?

Reaction shifts R → L ∴ $[NH_3]$ ↑

c) (4 points) For the following reaction, $K_p = 8.5 \times 10^4$ at a particular temperature.

$$2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$$

At equilibrium, p_{NO} = 0.35 atm and p_{Cl2} = 0.10 atm. What is the partial pressure of NOCl(g) (p_{NOCl}) at equilibrium?

$$K_p = 8.5 \times 10^4 = \frac{P_{NOCl}^2}{P_{NO}^2 P_{Cl2}} = \frac{P_{NOCl}^2}{(0.35)^2(0.10)} \quad \therefore P_{NOCl}^2 = 1041.2$$

∴ P_{NOCl} = 32 atm

d) (1 point) What will happen to the pNO if N_2 is now added to the container?

N_2 does not appear in the equation ∴ no change to P_{NO}.

3 (3 points each)

The reaction below has K_c = 4.4 at 300 K. Use this to answer a) and b).

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

a) What is K_c for the reaction below. Explain your answer.

$$\tfrac{1}{2}CO(g) + \tfrac{1}{2}H_2O(g) \rightleftharpoons \tfrac{1}{2}CO_2(g) + \tfrac{1}{2}H_2(g)$$

New $K_c = \sqrt{(\text{old } K_c)}$ **K_c = 2.1**

b) What is K_c for the reaction below? Explain your answer.

$$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$$

New $K_c = \dfrac{1}{\text{old } K_c}$ **K_c = 0.23**

c) K_c = 122 for the reaction below at 300 K? What is K_p?

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

Change in moles of gas (Δn) = -1 $\therefore$ $K_p = K_c(RT)^{-1} = K_c/RT = 4.96$ **K_p = 4.96**

4 (10 points) Consider the following reaction at a particular temperature:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

A 2.00 L flask is filled with 0.320 mol of HI and allowed to reach equilibrium. At equilibrium, [HI] = 0.098 M. Calculate K_c.

	2HI (g)	=	H_2 (g)	+	I_2 (g)
n(init)	0.320 mol		0		0
[init]	0.160 M		0		0
[change]	-2x		+x		+x
[equil]	(0.160-2x)		x		x

Since [HI] = (0.160-2x) = 0.098M, x = $\left(\dfrac{0.160-0.098}{2}\right)$ = 0.031M

$$\therefore K_c = \frac{[H_2][I_2]}{[HI]^2} = \frac{(0.031)^2}{(0.098)^2} = 0.10$$

5 (10 points) At a particular temperature, the reaction below has K_c = 0.680

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

In a 20.0 L vessel, 1.00 mol of CO and 1.00 mol of H_2O are allowed to reach equilibrium. Calculate the concentrations of all four species at equilibrium.

	CO (g)	+	H_2O (g)	≡	CO_2 (g)	+	H_2 (g)
n(init)	1.00 mol		1.00 mol		0		0
[init]	0.0500		0.0500		0		0
[change]	-x		-x		+x		+x
[equil]	(0.0500-x)		(0.0500-x)		x		x

$$K_c = 0.680 = \frac{x^2}{(0.0500-x)^2} \quad \text{square-rooting: } \pm 0.8246 = \frac{x}{(0.0500-x)}$$

$\therefore$ x = 0.0226 (or -0.235) $\therefore$ x = 0.0226M

$\therefore$ **$[CO_2]$ = $[H_2]$ = 0.0226M**

[CO] = $[H_2O]$ = 0.0274M