NAME:

CHM 2046 **Quiz 1B** **Spring, 2017**

Answer all questions. Give your final answer with 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) For the following equilibria, write down their mass-action expression, Q_c

$2H_2O_2\ (g) + 2NO\ (g) \rightleftharpoons 2H_2O\ (g) + N_2O_4\ (g)$

$$Q_c = \frac{[N_2O_4][H_2O]^2}{[NO]^2[H_2O_2]^2}$$

$P_4(s) + 6Cl_2(g) \rightleftharpoons 4PCl_3(\ell)$

$$Q_c = 1/[Cl_2]^6$$

b) (5 points) At a particular temperature, K_p = 313 for the reaction

$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$

In a particular reaction carried out, the pressures of the gases at a particular time are 0.12 atm (atmospheres) of SO_2, 1.2 atm of O_2, and 2.4 atm of SO_3. Has the reaction reached equilibrium yet? Explain.

$$Q_p = \frac{p(SO_3)^2}{p(SO_2)^2 p(O_2)} = \frac{(2.4)^2}{(0.12)^2(1.2)} = 333 \quad \therefore Q_p \neq K_p \quad \therefore \text{not at equilibrium}$$

If not, in which direction is it proceeding? Explain.

$Q_p > K_p$ ∴ reaction proceeding to the left.

c) (4 points) N_2O_4 (g) was introduced into a 2.00 L flask and allowed to reach equilibrium at 100 °C. At equilibrium, the flask contained 0.38 mol

$N_2O_4\ (g) \rightleftharpoons 2\ NO_2\ (g)$

of N_2O_4 and 0.40 mol of NO_2. What is K_c for this reaction at 100 °C?

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.20)^2}{0.19} = 0.21$$

2). (6 points total)

a) At 350 K, the reaction below has K_c = 1.05. What is K_p? Explain.

$2\ CH_2Cl_2\ (g) \rightleftharpoons CH_4\ (g) + CCl_4\ (g)$

$K_p = K_c$

K_p = 1.05

b) At 300 K, the reaction below has K_c = 279. What is K_p? Explain.

$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$

Δn = -1 therefore

$$Kp = \frac{Kc}{RT} = \frac{279}{(0.082)(300)} = 11.3$$

K_p = 11.3

c) At 300 K, what is K_c for the reaction below? Explain.

$4\ SO_3\ (g) \rightleftharpoons 4\ SO_2\ (g) + 2\ O_2\ (g)$

This is the reaction of part b) reversed and multiplied by 2

$$\therefore \text{new } K_c = \frac{1}{K_c^2} = \frac{1}{279^2} = 0.0000128 = 1.28 \times 10^{-5}$$

4. a) (6 points) $2HBr\,(g) \rightleftharpoons H_2\,(g) + Br_2\,(g)$

A 2.00 L flask is filled with 0.300 mol of HBr and allowed to reach equilibrium at a particular temperature. At equilibrium, [HBr] = 0.104 M. Calculate K_c at this temperature.

	2 HBr	⇌	H_2	+	Br_2
I	0.150 M		0		0
C	-2x		+x		+x
E	(0.150-2x)		x		x

(0.150-2x) = 0.104

$\therefore$ x = 0.023

$$K_c = \frac{[H_2][Br_2]}{[HBr]^2} = \frac{x^2}{(0.15-2x)^2} = \frac{(0.023)^2}{(0.104)^2}$$

$$\therefore K_c = 4.89 \times 10^{-2}$$

b) (8 points) $CO_2\,(g) + H_2\,(g) \rightleftharpoons CO\,(g) + H_2O\,(g)$ (K_c = 2.4)

0.500 mol each of CO_2 and H_2 are placed in a 10.0 L flask and allowed to reach equilibrium at some temperature. Calculate the equilibrium concentrations of all species.

	CO_2	+	H_2	⇌	CO	+	H_2O
I	0.0500		0.0500		0		0
C	-x		-x		+x		+x
E	(0.0500-x)		(0.0500-x)		x		x

$$K_c = 2.4 = \frac{x^2}{(0.0500-x)^2}$$

$$\therefore \pm\ 1.549 = \frac{x}{0.0500-x}$$

$$\pm 1.549x + 0.077 = x$$

$$\therefore 2.549x = 0.077$$

$$\therefore x = 0.030$$

$$\therefore [CO_2] = [H_2] = 0.020$$

$$[CO] = [H_2O] = 0.030$$

5. (14 points) Consider the reaction in Question 4b again.

$CO_2\,(g) + H_2\,(g) \rightleftharpoons CO\,(g) + H_2O\,(g)$ (K_c = 2.4)

This time 0.500 mol of CO_2 and 1.00 mol of H_2 are placed in a 10.0 L flask and allowed to reach equilibrium at some temperature. Calculate the equilibrium concentrations of all species.

	CO_2	+	H_2	⇌	CO	+	H_2O
I	0.0500		0.100		0		0
C	-x		-x		+x		+x
E	(0.0500-x)		(0.100-x)		x		x

$$K_c = 2.4 = \frac{x^2}{(0.0500-x)(0.100-x)} = \frac{x^2}{(0.005-0.15x+x^2)} = 2.4$$

$\therefore$ $2.4x^2 - 0.36\,x + 0.012 = x^2$

$\therefore$ $1.4\,x^2 - 0.36\,x + 0.012 = 0$

$$x = \frac{0.36 \pm \sqrt{0.1296 - 4(1.4)(0.012)}}{2.8} = \frac{0.36 \pm \sqrt{0.0624}}{2.8}$$

$$x = \frac{0.36 \pm 0.250}{2.8} = 0.039 \text{ or } 0.218$$

We choose x = 0.039

$\therefore$ $[CO_2]$ = 0.011M

$[H_2]$ = 0.061M

$[CO] = [H_2O]$ = 0.039M