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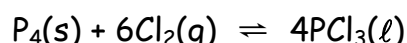
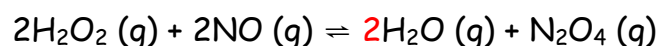
CHM 2046

Quiz 1B

Spring, 2017

Answer all questions. Give your final answer with correct units, if any, and to the correct sig. figs. Useful Information:  $0\text{ }^{\circ}\text{C} \approx 273\text{ K}$ ,  $R = 0.0820\text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$

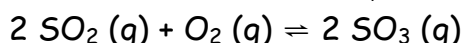
- 1) a) (3 points each) For the following equilibria, write down their mass-action expression,  $Q_c$



$$Q_c = \frac{[\text{N}_2\text{O}_4][\text{H}_2\text{O}]^2}{[\text{NO}]^2[\text{H}_2\text{O}_2]^2}$$

$$Q_c = 1/[\text{Cl}_2]^6$$

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



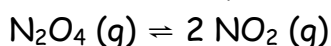
In a particular reaction carried out, the pressures of the gases at a particular time are 0.12 atm (atmospheres) of  $\text{SO}_2$ , 1.2 atm of  $\text{O}_2$ , and 2.4 atm of  $\text{SO}_3$ . Has the reaction reached equilibrium yet? Explain.

$$Q_p = \frac{p(\text{SO}_3)^2}{p(\text{SO}_2)^2 p(\text{O}_2)} = \frac{(2.4)^2}{(0.12)^2(1.2)} = 333 \quad \therefore Q_p \neq K_p \quad \therefore \text{not at equilibrium}$$

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

$$Q_p > K_p \quad \therefore \text{reaction proceeding to the left.}$$

- c) (4 points)  $\text{N}_2\text{O}_4(\text{g})$  was introduced into a 2.00 L flask and allowed to reach equilibrium at  $100\text{ }^{\circ}\text{C}$ . At equilibrium, the flask contained 0.38 mol

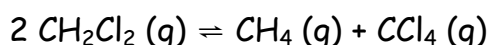


of  $\text{N}_2\text{O}_4$  and 0.40 mol of  $\text{NO}_2$ . What is  $K_c$  for this reaction at  $100\text{ }^{\circ}\text{C}$ ?

$$K_c = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.20)^2}{0.19} = 0.21$$

- 2). (6 points total)

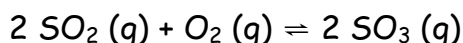
- a) At 350 K, the reaction below has  $K_c = 1.05$ . What is  $K_p$ ? Explain.



$$K_p = K_c$$

$$K_p = 1.05$$

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



$\Delta n = -1$  therefore

$$K_p = \frac{K_c}{RT} = \frac{279}{(0.082)(300)} = 11.3$$

$$K_p = 11.3$$

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



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

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



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

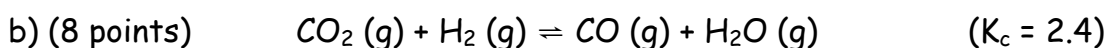
	$2 \text{ HBr}$	$\rightleftharpoons$	$\text{H}_2$	$+$	$\text{Br}_2$
I	0.150 M		0		0
C	-2x		+x		+x
E	(0.150-2x)		x		x

$$(0.150-2x) = 0.104$$

$$\therefore x = 0.023$$

$$K_c = \frac{[\text{H}_2][\text{Br}_2]}{[\text{HBr}]^2} = \frac{x^2}{(0.15-2x)^2} = \frac{(0.023)^2}{(0.104)^2}$$

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



0.500 mol each of  $\text{CO}_2$  and  $\text{H}_2$  are placed in a 10.0 L flask and allowed to reach equilibrium at some temperature. Calculate the equilibrium concentrations of all species.

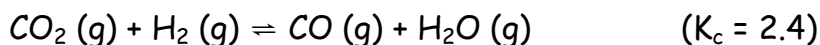
	$\text{CO}_2$	$+$	$\text{H}_2$	$\rightleftharpoons$	$\text{CO}$	$+$	$\text{H}_2\text{O}$
I	0.0500		0.0500		0		0
C	-x		-x		+x		+x
E	(0.0500-x)		(0.0500-x)		x		x

$$K_c = 2.4 = \frac{x^2}{(0.0500-x)^2} \quad \therefore \pm 1.549 = \frac{x}{0.0500-x} \quad \therefore x = 0.030$$

$$\pm 1.549x + 0.077 = x \quad \therefore [\text{CO}_2] = [\text{H}_2] = 0.020$$

$$\therefore 2.549x = 0.077 \quad [\text{CO}] = [\text{H}_2\text{O}] = 0.030$$

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



This time 0.500 mol of  $\text{CO}_2$  and 1.00 mol of  $\text{H}_2$  are placed in a 10.0 L flask and allowed to reach equilibrium at some temperature. Calculate the equilibrium concentrations of all species.

	$\text{CO}_2$	$+$	$\text{H}_2$	$\rightleftharpoons$	$\text{CO}$	$+$	$\text{H}_2\text{O}$
I	0.0500		0.100		0		0
C	-x		-x		+x		+x
E	(0.0500-x)		(0.100-x)		x		x

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

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

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

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

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

We choose  $x = 0.039$

$$\therefore [\text{CO}_2] = 0.011\text{M}$$

$$[\text{H}_2] = 0.061\text{M}$$

$$[\text{CO}] = [\text{H}_2\text{O}] = 0.039\text{M}$$