

**Exam 2 Chm 205 (Dr Mattson) 2 March 2015**

**Academic Integrity Pledge:** In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.

Signature: \_\_\_\_\_

Name: \_\_\_\_\_

Circle your section: **Section A or Section C**

Circle your Folder group:

H He Li Be B C N O F Ne Na Mg Al Si

**Instructions:** Show all work whenever a calculation box is provided! Write legibly. Include units whenever appropriate. You will receive credit for **how** you worked each problem as well as for the correct answer. If you need more space, you may use the back of the data sheet provided — Write: "See Data Sheet" in the answer box and then submit data sheet with your exam. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks and bags must be closed and on the floor under the table. Cell phones must be OFF and placed in your backpack/bag – not in your pocket.

1. The following reaction is called the **water-gas shift reaction** and is an important part of a process used to produce hydrogen gas. This reaction takes place at very high temperatures and all species are gases.

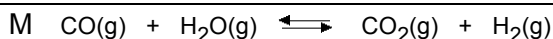


- 1a. (4 pts) Write the equilibrium constants,  $K_c$  and  $K_p$  for this reaction in terms of concentrations,  $[\text{CO}]$ , etc. or pressures,  $P_{\text{CO}}$ , etc.

$K_c =$  \_\_\_\_\_

$K_p =$  \_\_\_\_\_

- 1b. (4 pts) Suppose 0.0500 mol  $\text{CO(g)}$  and 0.0300 mol  $\text{H}_2\text{O(g)}$  were placed in a 1.00 L vessel and heated to 600 K. At equilibrium, the  $[\text{CO}]_E$  was found to be 0.0214 M. What is  $K_c$ ?



I  
C  
E

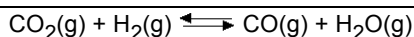
Answer: \_\_\_\_\_

- 1c. (4 pts) At 800 K,  $K_c = 4.11$ . If 0.0400 mol  $\text{CO(g)}$  and 0.0400 mol  $\text{H}_2\text{O(g)}$  were placed in a 1.00 L vessel and heated to 800 K, what is the equilibrium concentration of carbon dioxide,  $[\text{CO}_2]_E$ ? **Hint: Quadratic not necessary.**



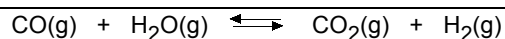
Answer with units: \_\_\_\_\_

- 1d. (2 pts) What is the numerical value of  $K_c$  at 800 K for this equilibrium?



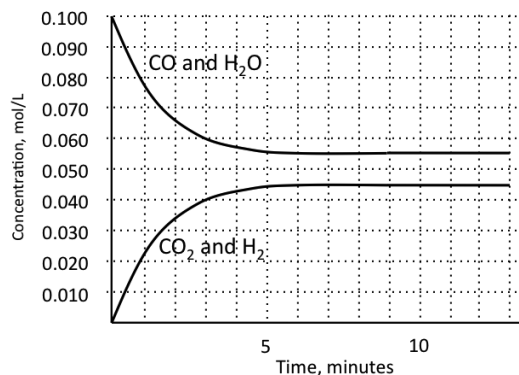
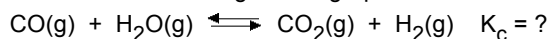
Answer: \_\_\_\_\_

- 1e. (3 pts) Suppose all four gases were present in the following amounts at 800 K:  $[\text{CO}]_i = [\text{H}_2\text{O}]_i = 0.045 \text{ M}$ ; and  $[\text{CO}_2]_i = [\text{H}_2]_i = 0.075 \text{ M}$ . Is the system at equilibrium? If not, in which direction will it shift?

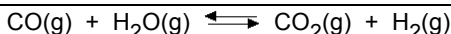


Answer: **Yes** OR **No, must shift Left** OR **No, must shift Right**

- Questions 1f – 1j refer to the graph below. At 1000 K the reaction concentrations give this graph:



- 1f. (3 pts) Estimate  $K_c$  for the reaction using data from the graph. **Hint: Read the graph carefully!**



- 1g. (5 pts) True or False

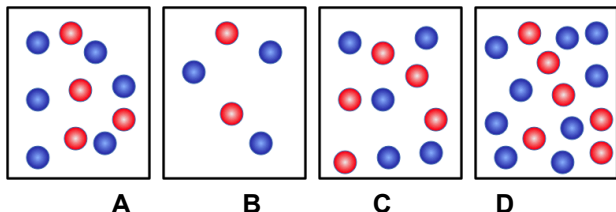
- T F The value for  $\text{rate}_{\text{fwd}} = \text{rate}_{\text{rev}}$  after about 6 min.  
 T F The value for  $K_c = K_p$  for this reaction.  
 T F If a catalyst were added, it would take less time to establish equilibrium.  
 T F The equilibrium concentrations of the product gases would increase if a catalyst were added.  
 T F The value for  $k_{\text{fwd}} > k_{\text{rev}}$  at equilibrium.

- 1h. (2 pts) What would happen if more CO were added after 15 minutes?

- i. Reaction would shift... **Right** **Left** **Not shift**  
 ii.  $K_c$  would... **Increase** **Decrease** **Remain the same**

- 1i. (2 pts) What would happen if the volume was doubled in size after 15 minutes?
- Reaction would shift... **Right Left Not shift**
  - $K_c$  would... **Increase Decrease Remain the same**
- 1j. (2 pts) Given the reaction is exothermic, what would happen if the temperature were raised after 15 minutes?
- Reaction would shift... **Right Left Not shift**
  - $K_c$  would... **Increase Decrease Remain the same**

2. Vessel A is at equilibrium.



2a. (3 pts) Which other vessels are also at equilibrium? **Circle all that apply. Circle: Vessel B Vessel C Vessel D**

2b. (3 pts) What is the equilibrium constant for Blue  $\rightleftharpoons$  Red?

Numerical answer: \_\_\_\_\_

3. (4 pts) Solve for x. No partial credit.

$$\frac{(0.75 + x)}{(0.93 - x)} = 2.11$$

Answer: \_\_\_\_\_

**All of the following questions refer to aqueous solutions.**

4. (5 pt) True or False.

T F  $\text{pH} = -\log([\text{H}_3\text{O}^+])$

T F  $[\text{H}_3\text{O}^+] \times [\text{OH}^-] = 1 \times 10^{14}$  at 25 °C

T F  $\text{pH} + \text{pOH} = 14.0$  at 25 °C

T F  $[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$

T F  $\text{p}K_a^{\text{wa}} + \text{p}K_b^{\text{wb}} = 14.0$  at 25 °C

5. (4 pts) Which solution of each pair is the more acidic?

A.  $\text{pH} = 8.0$  OR  $\text{pOH} = 8.0$

B.  $\text{pH} = 5.5$  OR  $[\text{OH}^-] = 1 \times 10^{-12}$

C.  $\text{pOH} = 2.0$  OR  $[\text{H}_3\text{O}^+] = 4 \times 10^{-4}$

D.  $[\text{OH}^-] = 1 \times 10^{-5}$  OR  $\text{pH} = 6.0$

6. (4 pts) What is the pH of a  $5.0 \times 10^{-4}$  M KOH solution?

Answer: \_\_\_\_\_

7. (3 pts) Write the equilibrium expression (with appropriate arrows) and the  $K_a$  expression for  $\text{HBrO}_2$ .

8. (4 pts) A 0.500 M solution of a weak acid has pH of 4.77. What is the  $K_a$  for this weak acid?

Answer: \_\_\_\_\_

9a. (4 pts) What is the pH of a 0.40 M solution of HOCl?  
Given:  $K_a = 3.5 \times 10^{-8}$

Answer: \_\_\_\_\_

9b. (4 pts) Given  $K_a$  for HOCl in the previous problem, (i) what is the conjugate base and (ii) what is its  $\text{p}K_b$ ?

Answers: (i) \_\_\_\_\_ (ii) \_\_\_\_\_

9c. (3 pts) Write the equilibrium expression (with appropriate arrows) and the  $K_b$  expression for the conjugate base of HOCl.

10. (8 pts) Identify each of these as a strong acid (SA), weak acid (WA), neutral (N), weak base (WB), strong base (SB), or more information needed (NMI)

- |                              |                   |
|------------------------------|-------------------|
| A. KOH                       | SA WA N WB SB NMI |
| B. HBr                       | SA WA N WB SB NMI |
| C. HF                        | SA WA N WB SB NMI |
| D. NaF                       | SA WA N WB SB NMI |
| E. KBr                       | SA WA N WB SB NMI |
| F. $\text{Na}_2\text{HPO}_4$ | SA WA N WB SB NMI |
| G. $\text{NH}_4\text{NO}_3$  | SA WA N WB SB NMI |
| H. $\text{NH}_4\text{F}$     | SA WA N WB SB NMI |

Exam Subtotal: \_\_\_\_\_ Folder (20 max): \_\_\_\_\_ Total: \_\_\_\_\_

**A  $\geq$  90; B  $\geq$  85; B  $\geq$  80; C  $\geq$  75; C  $\geq$  70; D  $\geq$  60**

## Answers

1a.  $K_c = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]}$

$$K_p = \frac{P_{\text{CO}_2} \times P_{\text{H}_2}}{P_{\text{CO}} \times P_{\text{H}_2\text{O}}}$$

1b.  $K_c = 27.3$

1c.  $[\text{CO}_2]_E = 0.0268 \text{ M}$

1d.  $K_c = 0.243$

1e.  $Q_c = 2.78$ , therefore it shifts to the RIGHT

1f.  $K_c = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]} \sim \frac{0.45 \times 0.45}{0.55 \times 0.55} = 0.67$

1g. T T T F T

1h. i. Right; ii. Remain the same

1i. i. Not shift; ii. Remain the same

1j. i. Left; ii. Decrease

2a. **Vessel B Vessel D**

2b. Blue  $\rightleftharpoons$  Red?  $K_c = \frac{[\text{Red}]}{[\text{Blue}]} = 0.67$

3.  $x = 0.39$

4. T F T T T

5. A.  $\text{pOH} = 8.0$ ; B.  $[\text{OH}^-] = 1 \times 10^{-12}$ ; C.  $[\text{H}_3\text{O}^+] = 4 \times 10^{-4}$ ; D.  $\text{pH} = 6.0$

6.  $\text{pH} = 10.70$



8.  $K_a = 5.8 \times 10^{-10}$

9a. 3.93

9b. (i)  $\text{OCl}^-$  (ii)  $\text{p}K_b = 6.54$



10. A. KOH, SB; B. HBr, SA; C. HF, WA; D. NaF, WB; E. KBr, N; F.  $\text{Na}_2\text{HPO}_4$ , NMI; G.  $\text{NH}_4\text{NO}_3$ , WA; H.  $\text{NH}_4\text{F}$ , NMI