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.

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

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

$K_c =$ $K_p =$

1b. (4 pts) Suppose 0.0500 mol CO(g) and 0.0300 mol $H_2O(g)$ were placed in a 1.00 L vessel and heated to 600 K. At equilibrium, the $[CO]_E$ was found to be 0.0214 M. What is K_c?

	$CO(g)$ +	$H_2O(g)$ $\rightleftharpoons$	$CO_2(g)$ +	$H_2(g)$
M				
I				
C				
E				

Answer: _____

1c. (4 pts) At 800 K, $K_c = 4.11$. If 0.0400 mol CO(g) and 0.0400 mol $H_2O(g)$ were placed in a 1.00 L vessel and heated to 800 K, what is the equilibrium concentration of carbon dioxide, $[CO_2]_E$? Hint: Quadratic not necessary.

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

Answer with units: _____

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

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

Answer: _____

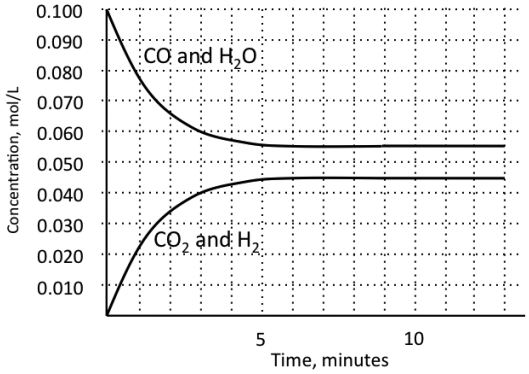
1e. (3 pts) Suppose all four gases were present in the following amounts at 800 K: $[CO]_I = [H_2O]_I = 0.045$ M; and $[CO_2]_I = [H_2]_I = 0.075$ M. Is the system at equilibrium? If not, in which direction will it shift?

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

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:

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



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

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

1g. (5 pts) True or False

T F The value for $rate_{fwd} = rate_{rev}$ 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 $k_{fwd} > k_{rev}$ 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?

i. Reaction would shift… Right Left Not shift

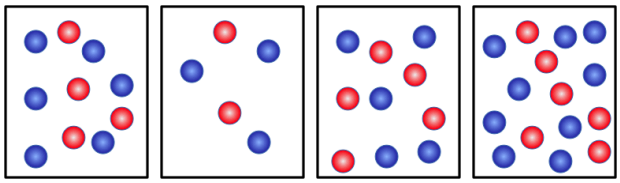
ii. K_c would… Increase Decrease Remain the same

1j. (2 pts) Given the reaction is exothermic, what would happen if the temperature were raised after 15 minutes?

i. Reaction would shift… Right Left Not shift

ii. K_c would… Increase Decrease Remain the same

2. Vessel A is at equilibrium.



A **B** **C** **D**

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 pH = -log($[H_3O^+]$)

T F $[H_3O^+] \times [OH^-] = 1 \times 10^{14}$ at 25 °C

T F pH + pOH = 14.0 at 25 °C

T F $[H_3O^+] = 10^{-pH}$

T F $pK_a^{wa} + pK_b^{wb} = 14.0$ at 25 °C

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

A. pH = 8.0 OR pOH = 8.0

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

C. pOH = 2.0 OR $[H_3O^+] = 4 \times 10^{-4}$

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

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

Answer: _____

7. (3 pts) Write the equilibrium expression (with appropriate arrows) and the K_a expression for $HBrO_2$.

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 pK_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.	Na_2HPO_4	SA	WA	N	WB	SB	NMI
G.	NH_4NO_3	SA	WA	N	WB	SB	NMI
H.	NH_4F	SA	WA	N	WB	SB	NMI

Exam Subtotal: _____ Folder (20 max): _____ Total: _____

A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60

Answers

1a. $K_c = [CO_2][H_2]/[CO][H_2O]$ $K_p = P_{CO2} \times P_{H2} / P_{CO} \times P_{H2O}$

1b. $K_c = 27.3$

1c. $[CO_2]_E = 0.0268$ M

1d. $K_c = 0.243$

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

1f. $K_c = [CO_2][H_2]/[CO][H_2O] \sim 0.45 \times 0.45 / 0.55 \times 0.55 = 0.67$

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? $K_c = [Red]/[Blue] = 0.67$

3. x = 0.39

4. T F T T T

5. A. pOH = 8.0; B. $[OH^-] = 1 \times 10^{-12}$; C. $[H_3O^+] = 4 \times 10^{-4}$; D. pH = 6.0

6. pH = 10.70

7. $HBrO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + BrO_2^-(aq)$ $K_a = [H_3O^+][BrO_2^-]/[HBrO_2]$

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

9a. 3.93

9b. (i) OCl^- (ii) $pK_b = 6.54$

9c. $ClO^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + HClO(aq)$ $K_b = [OH^-][HClO] / [ClO^-]$

10. A. KOH, SB; B. HBr, SA; C. HF, WA; D. NaF, WB; E. KBr, N; F. Na_2HPO_4, NMI; G. NH_4NO_3, WA; H. NH_4F, NMI