Exam Two
CHM 205 (Dr. Mattson)
16 February 2007

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

Signature:

Instructions: Show all work whenever a calculation is required. You will receive credit for <u>how</u> you worked each problem as well as for the correct answer. This exam is worth 100 points. <u>Box your answers.</u>

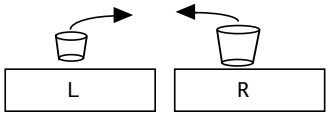
1. (a) (4 pts) Write the K_c and K_p expression for:

$2\ H_2S(g) + SO_2(g) \rightleftharpoons 2\ H_2O(g) + 3\ S(s)$ $K_c = 0.188$

(b) (2 pts) What is the numerical value of K_c for:

$2\ H_2O(g) + 3\ S(s) \rightleftharpoons 2\ H_2S(g) + SO_2(g)$ $K_c = ?$

2. (2 pts each) In class, I used two shoeboxes, one filled with green-colored water, and two cups to demonstrate how a reaction proceeds first through the kinetics region and on to the equilibrium region. In the demonstrations, I transferred water from the left shoebox to the right shoebox with the small cup and simultaneously transferred water from right to left with the large cup. I did this demo twice, once starting with all the water in the left shoebox and once starting will all the water in the right shoebox.



(a) What did the two cups represent?

(b) Which of the two experiments reached equilibrium?

i. The experiment where the water started on the left.
ii. The experiment where the water started on the right.
iii. Both demos reached equilibrium.
iv. Neither demo reached equilibrium.

(c) When did we know we had reached equilibrium?

(d) Sketch the relative levels of water at equilibrium in the shoeboxes <u>and</u> (e) write the equation that shows how Kc is related to the forward and reverse rate constants.

3. (2 pts ea) Draw the appropriate arrows between the brackets, { }, from these choices for these equilibria:

$\longleftarrow \quad \rightleftharpoons \quad \longrightarrow$

$A(g) + B(g)$ { } $C(g) + D(s)$ $K_c = 4.2 \times 10^{12}$

$E(s) + F(g)$ { } $G(l) + H(g)$ $K_c = 0.88$

$I(g) + J(g)$ { } $K(g) + L(g)$ $K_p = 1.2 \times 10^{-7}$

4. (6 pts) Suppose that 1.40 mol F_2 were placed in a 10.0 L container and heated to 1200 K. At that temperature the concentration of F atoms was measured to be 0.138 M. Calculate the value for K_c for the equilibrium $F_2 \rightleftharpoons 2\ F$ at 1200 K.

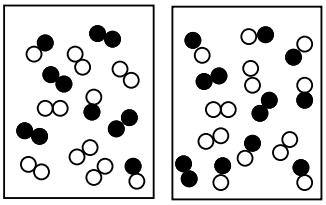
5. (6 pts) Consider the equilibrium

$Br_2 + Cl_2 \rightleftharpoons 2\ BrCl$ $K_c = 377$ at 300 K

If 60.0 mol of each Br_2 and Cl_2 were placed in a 100.0 L reactor and allowed to come to equilibrium, what is the expected concentration of BrCl?

(b) (3 pts) Given that $K_c = 32$ at 500 K, is the reaction exothermic or endothermic? Explain your answer.

6. The container on the left is at equilibrium. The spheres are ○ for O and ● for F.



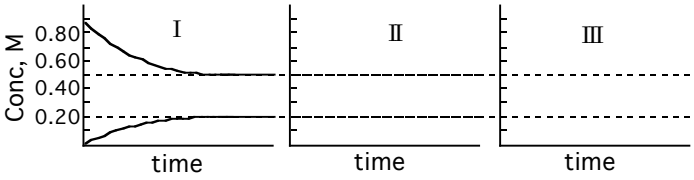
$O_2 + F_2 \rightleftharpoons 2\ OF$

(a) (3 pts) What is K_c for this equilibrium?

(b) (3 pts) The container on the right represents the same system. Is it at equilibrium? If it is not, determine which way it must shift in order to establish equilibrium.

7(a) (2 pts) Consider Graph I shown at left below. Given only these choices, which of the following reactions does this graph show?

A → B A → 2 B 2 A → B



(b) (2 pts) Estimate the equilibrium constant, K_c, for the reaction you selected in Part (a) above.

(c) (1 pts) On Graph I, sketch a vertical line that shows where kinetics gives way to equilibrium.

(d) (2 pts) On Graph II, sketch what occurs if a catalyst is added.

(e) (2 pts) On Graph III, sketch what occurs if the temperature is increased and the forward reaction is known to be endothermic.

8. (4 pts) In each case, circle the most acidic species.

A. pH = 4 or pH = 9 B. pOH = 8 or pH = 8

C. $[H_3O^+] = 1.0 \times 10^{-5}$ or $[OH^-] = 1.0 \times 10^{-4}$

D. pH = 13 or $[OH^-] = 1.0 \times 10^{-10}$

9. (5 pts) What is the pH of a 0.00478 M HCl solution?

10. (5 pts) What is the pH of a 0.0513 M KOH solution?

11. (5 pts) What is the K_a of a 0.143 M weak acid that exhibits a pH = 3.97?

Use this table to answer all of the following questions.

Table of Acid Dissociation Constants

HA $K_a = 3.6 \times 10^{-5}$	H_3D	$pK_{a1} = 3.5$
HB $K_a = 2.7 \times 10^{-6}$		$pK_{a2} = 8.7$
HC $K_a = 1.2 \times 10^{-7}$		$pK_{a3} = 11.2$

12. (5 pts) What is the pH of a 0.100 M HB solution?

13. (2 pts) Which of the monoprotic acids, HA, HB or HC would give the solution with the lowest pH among solutions of equal concentration? *Circle:* **HA HB HC**

14. (5 pts) What is the pH of a 0.80 M solution of NaA?

15. (2 pts) Which of the salts, NaA, NaB or NaC is the strongest of the weak bases? *Circle*: **NaA NaB NaC**

16. (a) (3 pts) Write the chemical equilibrium that is associated with K_{a3} for H_3D.

(b) (2 pts) Which of the following species would give the solution with the highest pH among solutions of equal concentration?

Circle: **H_3D NaH_2D Na_2HD Na_3D**

17. (8 pts) Classify the acid/base properties of each of these substances when dissolved in water. SA = strong acid, WA = weak acid, N = neutral, WB = weak base and SB = strong base.

HBr	SA	WA	N	WB	SB
RbOH	SA	WA	N	WB	SB
$NaClO_4$	SA	WA	N	WB	SB
$NaClO_3$	SA	WA	N	WB	SB
NH_4NO_3	SA	WA	N	WB	SB
$HC_2H_3O_2$	SA	WA	N	WB	SB
NH_3	SA	WA	N	WB	SB
KF	SA	WA	N	WB	SB

18. (2 pts) Which situation would most likely require the use of the quadratic in order to solve for pH?

0.0010 M HA 0.0100 M HB 0.100 M HC

19. (2 pt) Sign the Academic Integrity pledge (on the front) *and* print your name here:

Your exam score (100 possible): _____

Answers:

1. (a)

$K_c = [H_2O]^2/[H_2S]^2[SO_2]$

$K_p = P(H_2O)^2/P(H_2S)^2P(SO_2)$

(b) $K_c = 5.32$

2. (a) the rate constants, k_{fwd} and k_{rev}.

(b) vii. Both demos reached equilibrium.

(c) when the amount of water being transferred back and forth is equal in volume.

(d) level in left shoebox should be higher

(e) $K_c = k_{fwd} / k_{rev}$

3.

$A(g) + B(g) \rightleftharpoons C(g) + D(s)$ $K_c = 4.2 \times 10^{12}$

$E(s) + F(g) \rightleftharpoons G(l) + H(g)$ $K_c = 0.88$

$I(g) + J(g) \rightleftharpoons K(g) + L(g)$ $K_p = 1.2 \times 10^{-7}$

4. ICE table problem: $K_c = 0.268$

5. ICE table problem: [BrCl] = 1.09 mol/L

(b) The reaction is exothermic because increasing the temperature always favors the endothermic direction and here increasing the temperature resulted in a decrease for K_c, thus the reaction can only be exothermic.

6. $K_c = 3^2/(6 \times 4) = 0.375$; $Q_c = 5^2/(4 \times 3) = 2.08$
Conclusion: $Q_c > K_c$ so it must shift LEFT to go to equilibrium

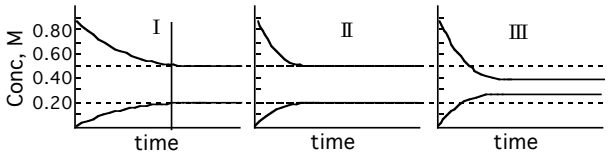
7(a) 2 A → B

(b) $K_c = 0.2/0.5^2 = 0.8$

(c) see diagram below

(d) see diagram below

(e) see diagram below



8.

A. pH = 4 or

B. pOH = 8

C. $[H_3O^+] = 1.0 \times 10^{-5}$

D. $[OH^-] = 1.0 \times 10^{-10}$

9. 2.32

10. 12.71

11. 8.0×10^{-8}

12. 3.28

13. **HA**

14. 9.17

15. **NaC**

16. $HD^{-2} + H_2O \rightleftharpoons H_3O^+ + D^{-3}$

(b) **Na_3D**

17.

HBr	SA
RbOH	SB
$NaClO_4$	N
$NaClO_3$	WB
NH_4NO_3	WA
$HC_2H_3O_2$	WA
NH_3	WB
KF	WB

18. 0.0010 M HA