EXAM TWO **CHM 205 (Dr. Mattson)** **15 FEBRUARY 2008**	***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. If you need more space, you may use the back of your periodic table — Write: "See PT" in box and then attach the periodic table. BOX YOUR ANSWERS! Write legibly.

CHAPTER 12. KINETICS

1. Consider the following mechanism:

Step 1 $H_2(g) + FCl(g) \rightarrow HF(g) + HCl(g)$ slow

Step 2 $HF(g) + FCl(g) \rightleftharpoons HCl(g) + F_2(g)$ fast

(a) (3 pts) What is the overall reaction?

(b) (3 pts) What is the rate law for this mechanism?

(c) (5 pts) Sketch a reaction profile for this reaction given that the overall reaction is exothermic.

Add labels: E_{act}(Step 1), E_{act}(Step 2), ΔH_{rxn}

(d) (6 pts) Circle the catalyst(s) and intermediate(s):

Catalyst(s)	H_2	F_2	HF	HCl	FCl	None
Intermediate(s)	H_2	F_2	HF	HCl	FCl	None

(e) (4 pts) True-False questions about the role of temperature, T:

T F Increasing T increases the rate determining step, as well as the rate of the fast step.

T F All rate constants increase when T increases.

T F Increasing T does not change E_{act}.

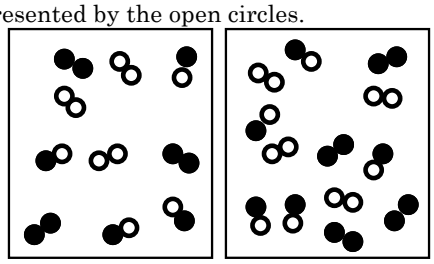
T F Increasing T causes ΔH_{rxn} to decrease.

CHAPTER 13. EQUILIBRIUM

2. (6 pts) Write the K_c and K_p expressions for:

$$Fe_3O_4(s) + 4\ H_2(g) \rightleftharpoons 3\ Fe(s) + 4\ H_2O(g)$$

3. The vessel at left shows an equilibrium mixture $A_2(g) + B_2(g) \rightleftharpoons 2\ AB(g)$, where A is represented by the open circles.



3(a) (4 pts) Determine the numerical value of the equilibrium constant, K_c. Because the balanced equation has an equal number of moles of gas on each side, knowing the volume is not necessary,

3(b) (4 pts) Determine if the mixture at right is at equilibrium. If it is not, which direction must it shift in order to attain equilibrium?

4. (6 pts) Suppose 4.0 mol $H_2(g)$ were placed in a 9.0 L vessel containing excess S(s) and allowed to come to equilibrium. What are $[H_2]$ and $[H_2S]$ at equilibrium?

$$H_2(g) + S(s) \rightleftharpoons H_2S(g)\ K_c = 4.2$$

5. (5 pts) Check each equilibrium where $K_p = K_c$.

- ❑ $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$
- ❑ $2\ NO_2Cl(g) \rightleftharpoons 2\ NO_2(g) + Cl_2(g)$
- ❑ $Fe_3O_4(s) + 4\ H_2(g) \rightleftharpoons 3\ Fe(s) + 4\ H_2O(g)$
- ❑ $H_2(g) + S(s) \rightleftharpoons H_2S(g)$
- ❑ $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$

6. (6 pts) The equilibrium given below is used in the process to make sulfuric acid. Suppose some $SO_3(g)$ were placed in an empty vessel. If $[SO_3]_i$ = 0.445 M and $[SO_3]_e$ = 0.208 M, what is the numerical value of K_c?

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

7. (6 pts) Carbon monoxide and carbon dioxide exist in equilibrium as shown here:

$$2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g)\ \Delta H = -111\ kJ$$

T F Adding carbon dioxide to an equilibrium mixture will cause the reaction to shift right in order to regain equilibrium.

T F Increasing the volume of the vessel would cause the reaction to shift right in order to regain equilibrium.

T F Increasing the temperature of the vessel would cause the reaction to shift right in order to regain equilibrium.

T F Adding a catalyst to the vessel would cause the equilibrium constant to increase.

T F Increasing the temperature would cause the equilibrium constant to decrease.

T F Increasing the temperature of the vessel would cause the reverse rate constant to increase, but not the forward rate constant.

CHAPTER 14. AQUEOUS EQUILIBRIA: ACIDS & BASES

8. (8 pts) Write the equilibrium expression for each of the following in aqueous solution. Use appropriate arrows ($\xrightarrow{100\%}$, $\rightleftharpoons$, or $\rightleftharpoons$).

HCl
$HC_2H_3O_2$
NaOH
NH_3

9. (5 pts) In each case, circle the solution that is most acidic (has a lower pH).

	Solution A	Solution B
(a)	pH = 9.5	pH = 5.2
(b)	pH = 2.5	pOH = 10.5
(c)	$[H_3O^+] = 3.0 \times 10^{-5}$	pH = 4.0
(d)	$[H_3O^+] = 5.3 \times 10^{-9}$	$[OH^-] = 1.0 \times 10^{-9}$
(e)	pOH = 5.5	$[OH^-] = 5.0 \times 10^{-3}$

10. (5 pts) What is the pH of a 0.0042 M solution of hydrochloric acid?

11. (6 pts) What is the pH of a 0.70 M solution of benzoic acid, given its $K_a = 6.5 \times 10^{-5}$?

12. (4 pts) What is the $[OH^-]$ of the benzoic acid solution from the previous problem?

13. (6 pts) In order to determine a K_a value for boric acid, a 0.12 M solution was prepared that gave pH of 5.11. What is the K_a of boric acid?

14. (5 pts) Hydrazine, N_2H_4 is a weak base with a $K_b = 8.9 \times 10^{-7}$. What is the pH of a 0.50 M solution of hydrazine?

15. (1 pts) What is the conjugate acid of hydrazine?

(2 pts) Print your name here and sign Academic Integrity Statement on other side.

Your exam score (100 possible): _____

Determine your grade:
A+ ≥ 95; A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60

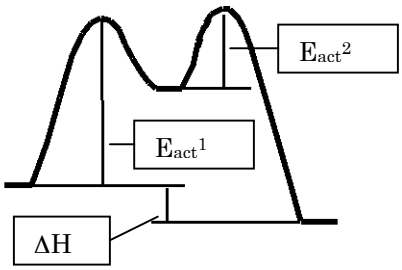
ANSWERS

1.

(a) $H_2(g) + 2\ FCl(g) \rightarrow 2\ HCl(g) + F_2(g)$

(b) rate = $k[H_2][FCl]$

(c)



(d) Catalyst(s): None
Intermediate(s): HF

(e) T T T F

2. (6 pts) Write the $K_c = [H_2O(g)]^4/[H_2(g)]^4$ and $K_p = P_{H_2O(g)}{}^4/ P_{H_2(g)}{}^4$

3.

3(a) $K_c = 1.78$

3(b) $Q_c = 1.56$ so the reaction must shift RIGHT in order to reestablish equilibrium.

4. $[H_2] = 0.084$ M and $[H_2S] = 0.36$ M

5.

$Fe_3O_4(s) + 4\ H_2(g) \rightleftharpoons 3\ Fe(s) + 4\ H_2O(g)$

$H_2(g) + S(s) \rightleftharpoons H_2S(g)$

6. $K_c = 6.50$

7. F F F F T F

CHAPTER 14. AQUEOUS EQUILIBRIA: ACIDS & BASES

8.

$HCl(aq) + H_2O(l) \xrightarrow{100\%} H_3O^+(aq) + Cl^-(aq)$

$HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$

$NaOH(aq) \xrightarrow{100\%} OH^-(aq) + Na^+(aq)$

$NH_3(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + NH_4^+(aq)$

9.

	Solution A	Solution B
(a)		pH = 5.2
(b)	pH = 2.5	
(c)		pH = 4.0
(d)		$[OH^-] = 1.0 \times 10^{-9}$
(e)	pOH = 5.5	

10. pH = 2.38

11. pH = 2.17

12. $[OH^-] = 1.48 \times 10^{-12}$

13. $K_a = 5.02 \times 10^{-10}$

14. pH = 10.82

15. $N_2H_5^+$ or $HN_2H_4^+$