Exam Two CHM 205 (Dr. Mattson) 21 February 2012	***Print your name:*** ***Signature:***	***Circle your section:*** ***8:30 9:30***

Instructions: Show all work whenever a calculation is required! 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 your periodic table — Write: "See PT" in box and then attach the periodic table. BOX YOUR ANSWERS! Write legibly.

1. Consider the following reaction mechanism:

Step 1. A + A → B fast

Step 2. B → C slow

Step 3. C → D + A fast

(a) (2 pts) What is the overall reaction?

(b) (1 pt) Which step determines the rate of the reaction? Circle: Step 1 Step 2 Step 3

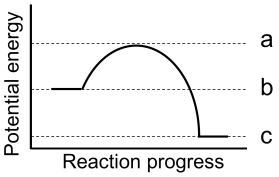
(c) (1 pt) Which step has the largest E_{act}?
Circle: Step 1 Step 2 Step 3

(d) (2 pts) Circle the intermediate(s): A B C D

(e) (4 pts) Write the rate law for this mechanism.

Show all work!

2. (a-d: 1 pt ea) The reaction profile for L → R is:



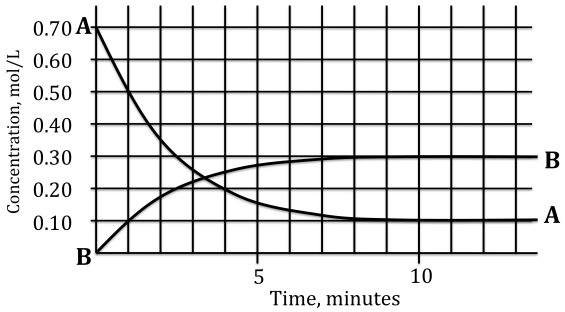
2a. Is the reaction exothermic? Circle: Yes or No

2b. Identify ΔH. Circle your choice. Watch sign (+/-)!
a - b a - c b - c b - a c - a c - b

2c. Identify E_{act}^{fwd}. Circle your choice:
a - b a - c b - c b - a c - a c - b

2d. Identify E_{act}^{rev}. Circle your choice:
a - b a - c b - c b - a c - a c - b

2e. (4 pts) At equilibrium, circle all that apply:
A. $k_{fwd} = k_{rev}$ B. $k_{fwd} > k_{rev}$
C. $K_c = k_{fwd} / k_{rev}$ D. $rate_{fwd} = rate_{rev}$



3a. (3 pts) Use the graph above to create a MICE table for the reaction. Start by identifying changes (x values for the Change line) from the graph.

M	A(g)	→	B(g)	(unbalanced)
I				
C				
E				

3b. (2 pts) Now write the balanced reaction.

3c. (3 pts) Write the K_c expression and determine a numerical value for K_c.

3d. (2 pts) How long does it take for the reaction to come to equilibrium?

3e. (1 pt) Does $K_p = K_c$ for this reaction? YES or NO

3f. (4 pts) The reaction is exothermic in the forward direction. What would happen if you raised the temperature? Circle:

$[A]_{eq}$ increases, decreases or stays the same

$[B]_{eq}$ increases, decreases or stays the same

K_c increases, decreases or stays the same

k_{fwd} increases, decreases or stays the same

3g. (4 pts) What would happen if the volume of the container decreased? Circle:

$[B]_{eq}$ increases, decreases or stays the same

K_c increases, decreases or stays the same

k_{fwd} increases, decreases or stays the same

k_{rev} increases, decreases or stays the same

4. Consider the reaction (all gases):

$$CO + H_2O \rightleftharpoons CO_2 + H_2 \quad K_c^{800\ K} = 4.92$$

4a. (2 pts) Write the equilibrium expression for K_c.

4b. (4 pts) Suppose a 1.00 L vessel was filled with 0.270 mol of CO(g) and 0.270 mol H_2O(g). Calculate the equilibrium concentrations for CO and CO_2. (It is not necessary to use quadratic!)

[CO] = _____ M and [CO_2] = _____ M

4c. (3 pts) Suppose instead, one started with [CO] = 0.20 M, [H_2O] = 0.20 M, [CO_2] = 0.50 M, [H_2] = 0.50 M. Which direction would the reaction have to shift in order to attain equilibrium? Show work!

5a. (2 pts) Write the acid dissociation reaction (with appropriate arrows) for HOCl in water (e.g. A → B).

5b. (1 pt) Circle the conjugate base in 5a.

5c. (2 pts) Write the K_a expression for HOCl(aq).

5d. (4 pts) The value of K_a for HOCl(aq) is 3.5×10^{-8}. Calculate the pH of a 0.205 M HOCl(aq) solution.

5e. (2 pts) Is HOCl a stronger acid than HCN, K_a = 3.5×10^{-10}? Circle: Yes or No

5f. (3 pts) What is the percent dissociation in the 0.205 M HOCl(aq) solution?

6. (4 pts) Complete the following chart of conjugate acid and base pairs.

Weak acid	Weak base
HNO_2	
HOCl	
NH_4^+	
	F^-

7. (1 pt) Which of these solutions is the most acidic?

A. pH = 4.25 B. [H_3O^+] = 1.0×10^{-5} C. pH = 9.22

8. (4 pts) An acid solution, known to be 0.500 M has a pH = 3.55. What is the K_a for the acid?

9a. (3 pts) Write the weak base equilibrium expression for OCl^-(aq). (Use long/short arrows.)

9b. (3 pts) Given K_a for HOCl (See 5d), what is the numerical value of K_b for OCl^-(aq)?

9c. (4 pts) What is the pH of 0.0725 M NaOCl(aq)?

9d. (1 pt) Is HOCl a better weak acid than OCl^- is a weak base? Circle Yes or No

Answers

1. (a) A → D

(b) Step 2

(c) Step

(d) B C

(e) Starting with slow step, rate = $k_2[B]$. However, B is an intermediate, so we must substitute in actual reactants, products or the catalyst. From step 1, we know that $rate_{fwd} = rate_{rev}$. Therefore, $k_1[A]^2 = k_{-1}[B]$ (or you could write $K_c = [B]/[A]^2$. Then solve for [B]:

$$[B] = k_1/k_{-1}[A]^2$$

or $$[B] = K_c [A]^2$$

Then, substitute in for [B] in rate = $k_2[B]$:

$$rate = k_2 k_1/k_{-1}[A]^2 \text{ OR}$$

$$rate = k_2 K_c [A]^2$$

Either way, we gather the various k values into one k:

$$rate = k [A]^2$$

2. (a-d: 1 pt ea) The reaction profile for L → R is:

2a. Yes, exothermic

2b. c - b

2c. a - b

2d. a - c

2e. B, C, D

3a.

M	2 A(g)	→	B(g) (balanced)
I	0.7		0
C	-2x		+x
E	0.7 – 2x = 0.1		x = 0.3

3b. 2 A → B

3c. $K_c = [B]/[A]^2 = 0.3/0.1^2 = 30$

3d. 8 min

3e. No

3f.

$[A]_{eq}$ increases

$[B]_{eq}$ decreases

K_c decreases

k_{fwd} increases

3g.

$[B]_{eq}$ increases

K_c stays the same

k_{fwd} stays the same

k_{rev} stays the same

4a. $K_c = [CO_2][H_2]/[CO][H_2O] = 4.92$

4b. [CO] = 0.084 M and $[CO_2]$ = 0.186 M

4c. $Q_c = 6.25$, therefore the reaction mixture shifts left in order to establish equilibrium

5a. $HOCl(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OCl^-(aq)$

5b. $OCl^-(aq)$

5c. $K_a = [H_3O^+][OCl^-]/[HOCl]$

5d. 4.07

5e. Yes

5f. 0.041%

6.

Weak acid	Weak base
HNO_2	NO_2^-
HOCl	OCl^-
NH_4^+	NH_3
HF	F^-

7. A

8. $K_a = 1.59 \times 10^{-7}$

9a. $OCl^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + HOCl(aq)$

9b. $K_b = 2.86 \times 10^{-7}$

9c. pH = 10.16

9d. No