Exam 2 Chm 205 (Dr Mattson) 21 February 2018

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:

Chemistry Student Number: _____

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 – then write your name on the data sheet. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and purse-like items must be stored on the tables in the back of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

1. The molecule NO_2Cl reacts according in a way that is consistent with this mechanism:

Step 1. $NO_2Cl(g) \rightarrow NO_2(g) + Cl(g)$ (slow)

Step 2. $Cl(g) + NO_2Cl(g) \rightarrow NO_2(g) + Cl_2(g)$

1a. (2 pts) What is the overall reaction?

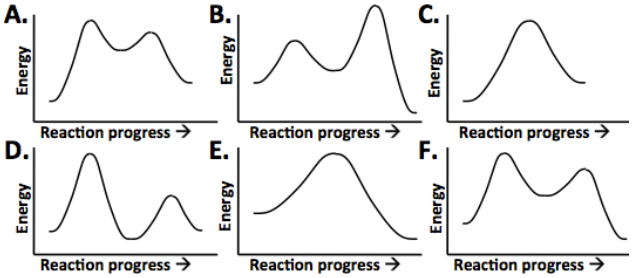
1b. (2 pts) What is the molecularity of each of the two elementary steps? Circle your choice for each step.

Step 1 unimolecular bimolecular termolecular

Step 2 unimolecular bimolecular termolecular

1c. (3 pts) What is the rate expression (rate law)?

1d. (4 pts) Consider these reaction profile diagrams.



i. Which diagram best describes the proposed mechanism for this endothermic reaction? **Circle: A B C D E F**

ii. Which diagram describes a 1-step endothermic mechanism? **Circle: A B C D E F**

iii. Which diagram features a thermodynamically stable intermediate? **Circle: A B C D E F**

iv. Which best describes a 2-step mechanism with a slow second step? **Circle: A B C D E F**

1e. (5 pts) T/F regarding the mechanism

T F The mechanism includes a catalyst.

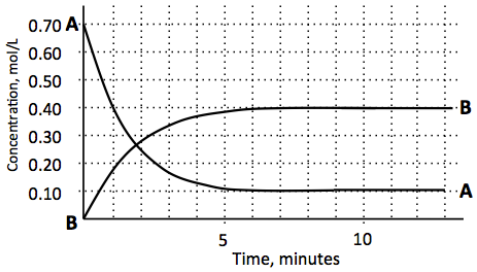
T F The mechanism includes an intermediate.

T F Most collisions between the reactants in either step will be effective in producing products.

T F Orientation of reactants is probably a bigger factor for Step 2 than for Step 1.

T F E_{act}^{fwd} for Step 1 is larger than E_{act}^{fwd} for Step 2.

2. **Carefully** calculate the changes in concentration for both A and B as depicted in this diagram.



2a. (2 pts) What is the **change** in [A] by the time the reaction reaches equilibrium?

2b. (2 pts) What is the **change** in [B] by the time the reaction reaches equilibrium?

2c. (4 pts) Balance the equation for this reaction using the smallest whole numbers.

_____ A → _____ B

2d. (4 pts) Create a MICE table with the info from 2a – 2c.

M →
I
C
E

2e. (5 pts) Write the equilibrium constant in terms of [A] and [B] **and** solve for its numerical value.

2f. (2 pts) How many minutes does it take for the reaction to reach equilibrium?

2g. (2 pts) If A were added to an equilibrium mixture, how would the reaction shift in order to return to equilibrium?
Circle your choice: **Shift left** **Shift right** **No Shift**

2h. (2 pts) Suppose the volume were decreased. How would the reaction shift to return to equilibrium?
Circle your choice: **Shift left** **Shift right** **No Shift**

2i. (2 pts) The reaction is exothermic and the temperature is increased. What shift occurs to return equilibrium?
Circle your choice: **Shift left** **Shift right** **No Shift**

2j. (2 pts) If a catalyst were added, how would K_c change?
Circle your choice: **Increase** **Decrease** **No change**

2k. (2 pts) Is $K_c = K_p$ for this reaction? Circle: **Yes** **No**

3a. (4 pts) Consider the following equilibrium. Suppose $[NO]_I = 0.100$ M. What is $[N_2]_E$?

M	$2\,NO(g) \rightleftharpoons N_2(g) + O_2(g)$	$K_c^{2300\ K} = 576$
I		
C		
E		

Answer with units: _____

3b. (2 pts) The reaction is exothermic. Would increasing the temperature increase K_c? Circle: **Yes** **No**

3c. (2 pts) Would decreasing the volume increase K_c? Circle: **Yes** **No**

3d. (2 pts) Would decreasing the volume shift the reaction right? Circle: **Yes** **No**

3e. (2 pts) Would adding some $N_2(g)$ to an equilibrium mixture increase K_c? Circle: **Yes** **No**

3f. (2 pts) Would adding $N_2(g)$ to an equilibrium mixture cause the reaction to shift right? Circle: **Yes** **No**

4. (3 pts) Circle the strong acid in each set.

a. $HNO_2(aq)$, $HNO_3(aq)$, $KNO_3(aq)$

b. $HClO_2(aq)$, $HClO_3(aq)$, $HClO_4(aq)$

c. $NH_3(aq)$, $KClO(aq)$, $HI(aq)$

5. (4 pts) Write the conjugate base for each weak acid.

a. $HC_2H_3O_2$	b. HF	c. H_2SO_3	d. H_3PO_4

6. (4 pts) Write the conjugate acid for each weak base.

a. NO_2^-	b. NH_3	c. HCO_3^-	d. HPO_4^{2-}

7. (3 pts) Which member of each pair is the most acidic?

a. pH = 4.2 or $[OH^-] = 3.5 \times 10^{-9}$

b. $[H_3O^+] = 5.1 \times 10^{-2}$ or $[OH^-] = 9.8 \times 10^{-4}$

c. pOH = 8.20 or pH = 9.40

8. (3 pts) What is the pH of a 0.045 M HBr(aq) solution?

Answer with correct significant figures: _____

9. (3 pts) What is the $[H_3O^+]$ of a 2.4×10^{-4} M NaOH(aq) solution?

Answer with correct significant figures: _____

10. (4 pts) What is the pH of a 0.150 M weak acid solution with the $K_a = 2.6 \times 10^{-6}$?

Answer with correct significant figures: _____

11. (4 pts) What is the K_a of a 0.200 M solution that exhibits a pH of 2.94?

Answer: _____

12. (3 pts) What is the K_b for a weak base that has a conjugate weak acid with a $pK_a = 3.90$?

Answer: _____

13. (5 pts) What is the pH of a 0.300 M solution of NaCN, given that the K_a for HCN is 4.9×10^{-10}?

Answer with units: _____

14. (5 pts) Which if these salts are acidic, basic, or neutral? Circle your choice.

a. LiBr **Acidic** **Basic** **Neutral**

b. $NaBrO_2$ **Acidic** **Basic** **Neutral**

c. NH_4Cl **Acidic** **Basic** **Neutral**

d. Na_2SO_3 **Acidic** **Basic** **Neutral**

e. KI **Acidic** **Basic** **Neutral**

Total score (out of 100): _____

A+ ≥ 95% A ≥ 90% B+ ≥ 85% B ≥ 80% C+ ≥ 75% C ≥ 70% D ≥ 60%

Answers:

1a. $2\ NO_2Cl(g) \rightarrow 2\ NO_2(g) + Cl_2(g)$

1b. Step 1 is unimolecular; Step 2 is bimolecular

1c. rate = $k[NO_2Cl]$

1d. i. A; ii. C; iii. D; iv. B

1e. F, T, F, T, T

2a. 0.6 mol/L

2b. 0.4 mol/L

2c. 3 A → 2 B

2d.

M	3 A → 2 B		
I	0.7	0	
C	-3x	+2x	x = 0.2
E	0.1	0.4	

2e. $K = [B]^2/[A]^3 = [0.4]^2/[0.1]^3 = 160$

2f. 6 min; 2g. Shift right; 2h. Shift right; 2i. Shift left; 2j. No change; 2k. No

3a. $[N_2]_E = 0.049$; 3b. No; 3c. No; 3d. No; 3e. No; 3f. No

4. a. $HNO_3(aq)$; b. $HClO_4(aq)$; c. HI(aq)

5. (4 pts) Write the conjugate base for each weak acid.

a. $HC_2H_3O_2$	b. HF	c. H_2SO_3	d. H_3PO_4
$C_2H_3O_2^-$	F^-	HSO_3^-	$H_2PO_4^-$

6. (4 pts) Write the conjugate acid for each weak base.

a. NO_2^-	b. NH_3	c. HCO_3^-	d. HPO_4^{2-}
HNO_2	NH_4^+	H_2CO_3	$H_2PO_4^-$

7. a. pH = 4.2; b. $[H_3O^+] = 5.1 \times 10^{-2}$; c. pOH = 8.20

8. 1.35

9. 4.2×10^{-11} M

10. 3.20?

11. 6.6×10^{-6}

12. 7.9×10^{-11}

13. 11.39

14.

a. LiBr	Neutral
b. $NaBrO_2$	Basic
c. NH_4Cl	Acidic
d. Na_2SO_3	Basic
e. KI	Neutral