

## 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.

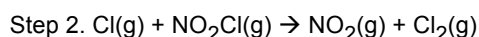
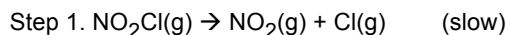
Signature: \_\_\_\_\_

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  $\text{NO}_2\text{Cl}$  reacts according in a way that is consistent with this mechanism:



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

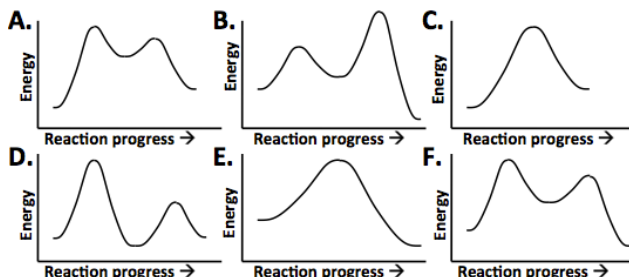
- 1b. (2 pts) What is the molecularity of each of the two elementary steps? Circle your choice for each step.

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.

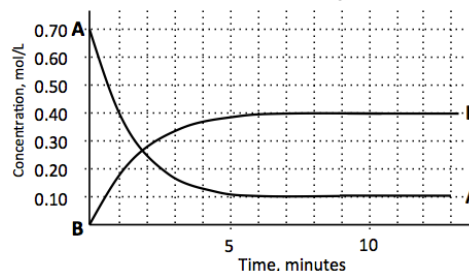


- Which diagram best describes the proposed mechanism for this endothermic reaction? Circle: **A B C D E F**
- Which diagram describes a 1-step endothermic mechanism? Circle: **A B C D E F**
- Which diagram features a thermodynamically stable intermediate? Circle: **A B C D E F**
- Which best describes a 2-step mechanism with a slow second step? Circle: **A B C D E F**

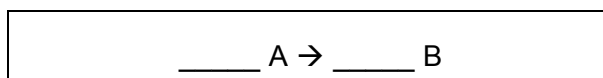
- 1e. (5 pts) T/F regarding the mechanism

- 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**  $E_{\text{act}}^{\text{fwd}}$  for Step 1 is larger than  $E_{\text{act}}^{\text{fwd}}$  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.



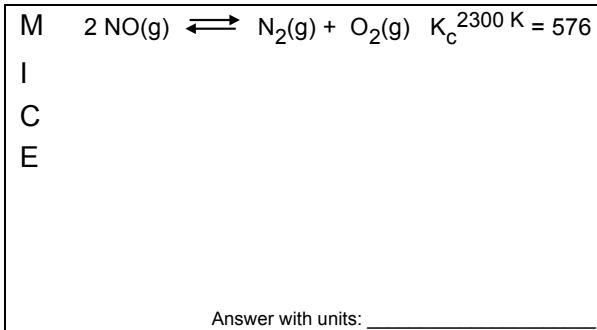
- 2d. (4 pts) Create a MICE table with the info from 2a – 2c.

M	$\rightarrow$
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  $[\text{NO}]_i = 0.100 \text{ M}$ . What is  $[\text{N}_2]_E$ ?



- 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  $\text{N}_2(\text{g})$  to an equilibrium mixture increase  $K_c$ ? Circle: **Yes No**
- 3f. (2 pts) Would adding  $\text{N}_2(\text{g})$  to an equilibrium mixture cause the reaction to shift right? Circle: **Yes No**

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

- a.  $\text{HNO}_2(\text{aq})$ ,  $\text{HNO}_3(\text{aq})$ ,  $\text{KNO}_3(\text{aq})$
- b.  $\text{HClO}_2(\text{aq})$ ,  $\text{HClO}_3(\text{aq})$ ,  $\text{HClO}_4(\text{aq})$
- c.  $\text{NH}_3(\text{aq})$ ,  $\text{KClO}(\text{aq})$ ,  $\text{HI}(\text{aq})$

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

a. $\text{HC}_2\text{H}_3\text{O}_2$	b. $\text{HF}$	c. $\text{H}_2\text{SO}_3$	d. $\text{H}_3\text{PO}_4$
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6. (4 pts) Write the conjugate acid for each weak base.

a. $\text{NO}_2^-$	b. $\text{NH}_3$	c. $\text{HCO}_3^-$	d. $\text{HPO}_4^{2-}$
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7. (3 pts) Which member of each pair is the most acidic?

- a.  $\text{pH} = 4.2$  or  $[\text{OH}^-] = 3.5 \times 10^{-9}$
- b.  $[\text{H}_3\text{O}^+] = 5.1 \times 10^{-2}$  or  $[\text{OH}^-] = 9.8 \times 10^{-4}$
- c.  $\text{pOH} = 8.20$  or  $\text{pH} = 9.40$

8. (3 pts) What is the pH of a 0.045 M  $\text{HBr}(\text{aq})$  solution?

Answer with correct significant figures: \_\_\_\_\_

9. (3 pts) What is the  $[\text{H}_3\text{O}^+]$  of a  $2.4 \times 10^{-4} \text{ M}$   $\text{NaOH}(\text{aq})$  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  $\text{p}K_a = 3.90$ ?

Answer: \_\_\_\_\_

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

Answer with units: \_\_\_\_\_

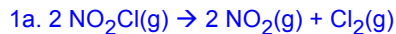
14. (5 pts) Which if these salts are acidic, basic, or neutral? Circle your choice.

- a.  $\text{LiBr}$                       **Acidic Basic Neutral**
- b.  $\text{NaBrO}_2$                   **Acidic Basic Neutral**
- c.  $\text{NH}_4\text{Cl}$                     **Acidic Basic Neutral**
- d.  $\text{Na}_2\text{SO}_3$                   **Acidic Basic Neutral**
- e.  $\text{KI}$                             **Acidic Basic Neutral**

Total score (out of 100): \_\_\_\_\_

A+  $\geq$  95% A  $\geq$  90% B+  $\geq$  85% B  $\geq$  80% C+  $\geq$  75% C  $\geq$  70% D  $\geq$  60%

## Answers:



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

1c.  $\text{rate} = k[\text{NO}_2\text{Cl}]$

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.  $3 \text{A} \rightarrow 2 \text{B}$

2d.

M	$3 \text{A} \rightarrow 2 \text{B}$		
I	0.7	0	
C	-3x	+2x	$x = 0.2$
E	0.1	0.4	

2e.  $K = [\text{B}]^3/[\text{A}]^2 = [0.4]^3/[0.1]^2 = 6.4$

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

3a.  $[\text{N}_2]_{\text{E}} = 0.096$ ; 3b. No; 3c. No; 3d. No; 3e. No; 3f. No

4. a.  $\text{HNO}_3(\text{aq})$ ; b.  $\text{HClO}_4(\text{aq})$ ; c.  $\text{HI}(\text{aq})$

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

a. $\text{HC}_2\text{H}_3\text{O}_2$	b. $\text{HF}$	c. $\text{H}_2\text{SO}_3$	d. $\text{H}_3\text{PO}_4$
$\text{C}_2\text{H}_3\text{O}_2^-$	$\text{F}^-$	$\text{HSO}_3^-$	$\text{H}_2\text{PO}_4^-$

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

a. $\text{NO}_2^-$	b. $\text{NH}_3$	c. $\text{HCO}_3^-$	d. $\text{HPO}_4^{2-}$
$\text{HNO}_2$	$\text{NH}_4^+$	$\text{H}_2\text{CO}_3$	$\text{H}_2\text{PO}_4^-$

7. a.  $\text{pH} = 4.2$ ; b.  $[\text{H}_3\text{O}^+] = 5.1 \times 10^{-2}$ ; c.  $\text{pOH} = 8.20$

8. 1.35

9.  $4.2 \times 10^{-11} \text{ M}$

10. 3.20?

11.  $6.6 \times 10^{-6}$

12.  $7.9 \times 10^{-11}$

13. 11.39

14.

- |                             |         |
|-----------------------------|---------|
| a. LiBr                     | Neutral |
| b. $\text{NaBrO}_2$         | Basic   |
| c. $\text{NH}_4\text{Cl}$   | Acidic  |
| d. $\text{Na}_2\text{SO}_3$ | Basic   |
| e. KI                       | Neutral |