

Chemistry 1A, Fall 2007

Midterm Exam #2

October 16, 2007

(90 min, closed book)

Name: _____

SID: _____

GSI Name: _____

- The test consists of 6 short answer questions and a page of multiple choice questions.
- Put your written answers in the boxes provided. Answers outside the boxes may not be considered in grading.
- Show your work to receive the maximum credit possible.
- Write your name on every page of the exam.

Question	Page	Points	Score
Question 1	2	10	
Question 2	3	6	
Question 3	3	8	
Question 4abc	4	12	
Question 4def	5	10	
Question 5	5	8	
Question 6	7	14	
Multiple Choice	8	12	
Total		80	

Useful Equations and Constants:

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$\text{pX} = -\log X$$

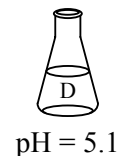
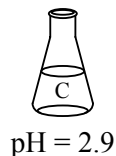
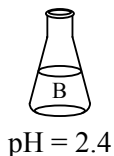
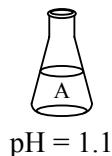
$$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

Strong acids and bases:

HCl	LiOH
HNO ₃	NaOH
H ₂ SO ₄	KOH
HClO ₄	
HBr	
HI	

Acid-base chemistry (10 points)

1. A group of students measures and records the pH of each of the 0.10 M aqueous acid solutions shown below:



- a) List the four acids in order of increasing dissociation.

_____ < _____ < _____ < _____

- b) Based on this information, Marco states that "The solution of pH 1.1 will require the most base to titrate it to the equivalence point since it is the strongest acid and its pH is the farthest away from 7."

Jovan disagrees: "I think that all four solutions will require the same amount of base to reach the equivalence point because they all contain the same concentration of acid."

Katrina does not agree with either of these statements: "Since we don't know the identity of the acids, we can't determine which one will require the most base to titrate it to the equivalence point."

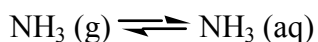
Which student do you agree with?

- _____ I agree with Marco.
_____ I agree with Jovan.
_____ I agree with Katrina.
_____ I don't agree with any of them.

- c) Explain your reasoning.

Two-phase equilibria (6 points)

2. Suppose that you establish an equilibrium between NH_3 (g) and NH_3 (aq) in a closed 2.0 L container at 25°C.



For each of the following, circle the correct answer:

- a) If the pressure of NH_3 (g) is increased, the molar concentration of NH_3 (aq) will:

increase stay the same decrease

- b) If the temperature is increased from 25°C to 80°C, the molar concentration of NH_3 (aq) will:

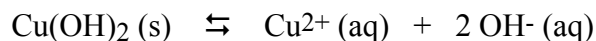
increase stay the same decrease

- c) If the total pressure is increased by adding air, the molar concentration of NH_3 (aq) will:

increase stay the same decrease

Solubility equilibria (8 points)

3. Consider the solubility of $\text{Cu}(\text{OH})_2$.



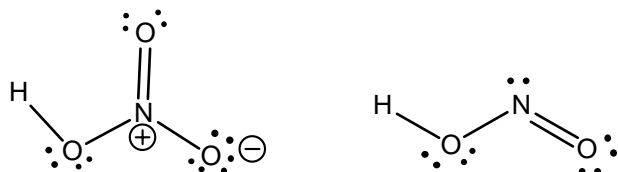
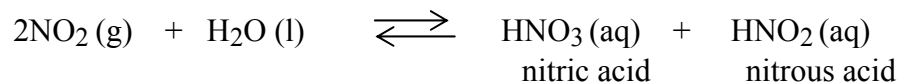
- a) The pH of a solution of 1 mole $\text{Cu}(\text{OH})_2$ (s) dissolved in 1.0 L of water is 7.66. Does all the $\text{Cu}(\text{OH})_2$ dissolve?

yes no not enough information

- b) Determine the solubility of $\text{Cu}(\text{OH})_2$ in 1.0 M NaOH (aq). The K_{sp} is 4.8×10^{-20} .

Acid-Base Equilibria (12 points)

4. NO_2 gas can dissolve in water and react to make acids. This pollutant is one of the causes of acid rain



- a) Write the chemical reaction for the reaction of nitric acid with water. Circle the conjugate base of HNO_3 .
- b) Write the chemical reaction for the reaction of nitrous acid with water. Circle the conjugate base of HNO_2 .
- c) Based on the relative stabilities of the conjugate bases produced, which acid is stronger? Circle one and explain your reasoning.
- nitric acid nitrous acid

#4) Continued (10 points)

- d) A buffer solution is made by mixing HNO_2 and NaNO_2 . What is the pH of a 1.00 L buffer solution that is 0.100 M HNO_2 and 0.150 M NaNO_2 ?
($K_a = 4.3 \times 10^{-4}$)

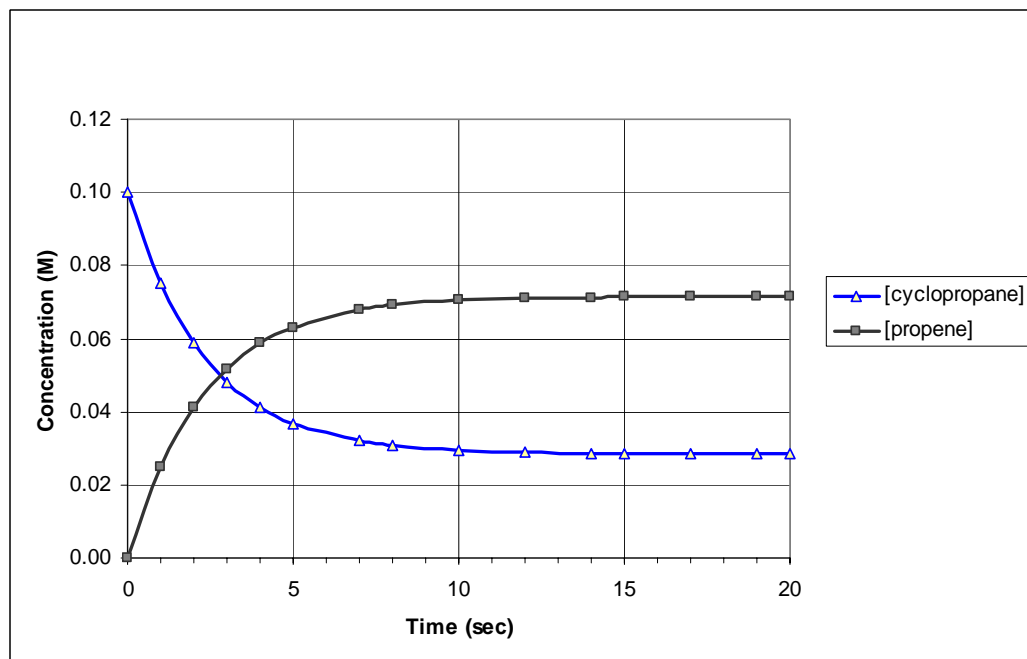
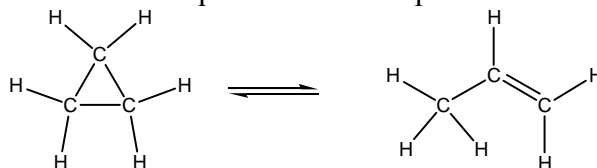
- e) Consider adding a strong base to a buffer. Write the chemical reaction that occurs when the strong base NaOH reacts with the buffer solution from part 4d.

- f) If you add 20.00 mL of 1.00 M NaOH to the solution, estimate the resulting pH.
(circle one)

1 2 3 4 5 6 7 8 9

Equilibrium (8 points)

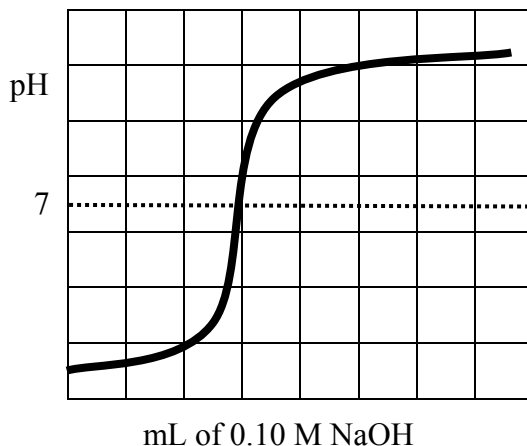
5. Cyclopropane can convert to propene. Given the reaction and data below, answer the following questions. Assume that pressure and temperature are constant.



- a) Which is true for the reaction at 2 seconds? (circle one)
 $Q < K$ $Q = K$ $Q > K$
- b) Which is true for the reaction at 17 seconds? (circle one)
 $Q < K$ $Q = K$ $Q > K$
- c) What is the value of the equilibrium constant for the reaction?

Titration Curves (14 points)

6. The titration curve of 30 mL 0.10 M HCl with 0.10 M NaOH is shown for your reference in the graph below. The dotted line indicates pH of 7.



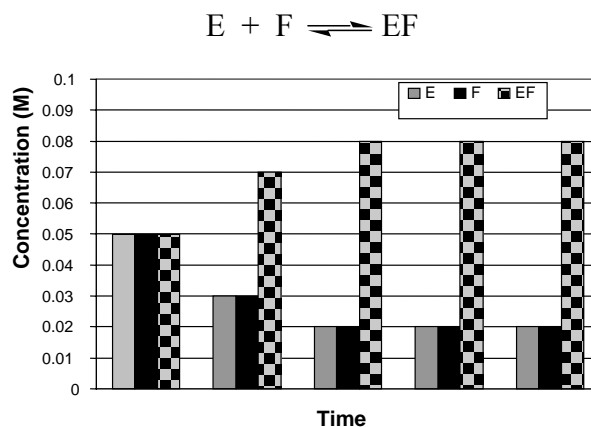
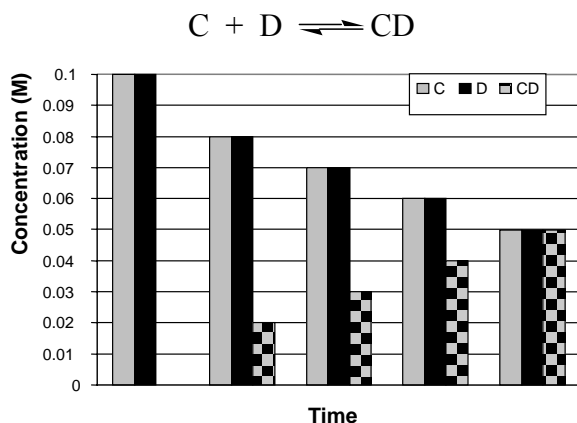
- a) Roughly sketch a second titration curve on the graph above for 60 mL of 0.10 M formic acid, HCOOH , ($K_a = 1.8 \times 10^{-4}$) that is titrated with 0.10 M NaOH.
- b) Explain your choice for initial pH. Rigorous calculations are not needed.

- c) Mark the equivalence point on the curve you drew with an “x”.
- d) Explain your choice for the pH at equivalence.

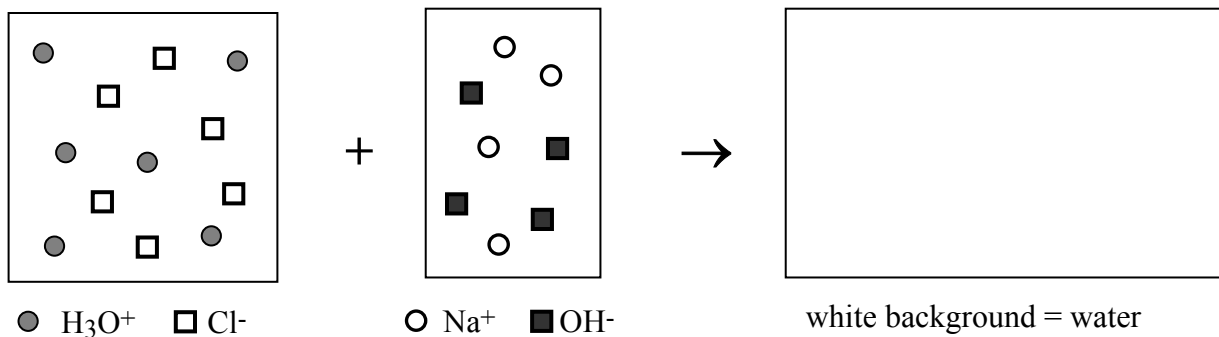
- e) Explain your choice for the equivalence volume.

Multiple Choice, Fill in the Blank (12 points)

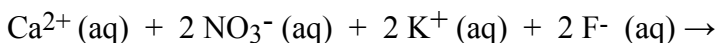
7. Which acid is the strongest? A. BrOH B. CH₃OH C. KOH
8. Which mixture is most resistant to changes in pH:
 A. HCl and NaCl B. NH₄Cl and NH₃ C. HBr and NaBr
9. The two sets of graphs below show how the concentrations of the species in two different chemical reactions change over time. Circle the reaction that is at equilibrium.



10. Sketch the product of the reaction in the box provided.



11. Predict the products of the reaction below. Be sure to balance the equation.



$$K_{\text{sp}} [\text{Ca}(\text{NO}_3)_2] = 1.6 \times 10^{-3}$$

$$K_{\text{sp}} [\text{CaF}_2] = 3.5 \times 10^{-11}$$

$$K_{\text{sp}} [\text{KNO}_3] = 1.3 \times 10^{-6}$$

$$K_{\text{sp}} [\text{KF}] = 8.7 \times 10^{-5}$$