Name _____

Last 5 digits of Student Number: XXX – X ___ – ___ ___ ___ ___

Chem 116
Sample Examination #3

This exam consists of eight (8) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one.

Copies of the "Periodic Table" and the "Table of Acids and Bases and K_a Values" are attached at the back of the exam. You may remove these and use the back sides of these tables as scratch paper. No work on scratch paper will be graded or collected.

The following information may be useful:

Constants of nature

$K_w = 1.0 \times 10^{-14}$ at 25 ºC

Equations

$pH = -\log [H_3O^+]$

DO NOT WRITE BELOW THIS LINE

Part I:

Questions 1-6 _____ (maximum 24)

Question 7 _____ (maximum 4)

Question 8 _____ (maximum 6)

Question 9 _____ (maximum 10)

Part II:

Question 1 _____ (maximum 20)

Question 2 _____ (maximum 20)

Part III:

Lab question _____ (maximum 16)

Ext

Total (

Disclaimer:
This is a copy of a typical Exam 3 given in Chem 116 during the academic year. Your test will be different. This test is being posted to give you a sense of the format, style, scope and level of a typical test on this material. This test may have questions on topics that may not be covered on your exam. Moreover, your test may have questions on topics not covered in this practice exam. Posting this test in no way limits the format, style, scope and level of the test that you will take. Do not limit your preparation to the material in this practice exam.

Part I. Multiple-Choice or Short Response

Points possible on each question are indicated in curly braces {…}. This part of the exam (Part I) is worth 44% of the exam grade.

1. {4 pts} When the polyprotic acid, oxalic acid ($H_2C_2O_4$), is added to water, it undergoes the following two-step dissociation process:

$$H_2C_2O_4 + H_2O \leftrightarrows HC_2O_4^- + H_3O^+ \qquad K_{a1} = 5.90 \times 10^{-2}$$
$$HC_2O_4^- + H_2O \leftrightarrows C_2O_4^{2-} + H_3O^+ \qquad K_{a2} = 6.40 \times 10^{-5}$$

The majority of the hydronium ion concentration, $[H_3O^+]$, is produced in

A) The first dissociation step
B) The second dissociation step
C) The amount that was present in the pure water prior to adding the oxalic acid
D) There is not enough information to tell

2. {4 pts} A sample of 0.0200 moles of propanoic acid is added to 1.00 L of water. When the acid is fully dissolved and the solution comes to equilibrium, the solution is found to have a pH of 3.30. What is the value of K_a for propanoic acid?
A) 5.0×10^{-4}
B) 1.3×10^{-5}
C) 2.0×10^{-2}
D) 3.3×10^{1}
E) There is not enough information to tell

3. {4 pts} Which of the following salts, if added to water in equal molar quantities, would produce the most acidic solution?
A) KCl
B) Na_2SO_4
C) NH_4ClO_4
D) $ZnBr_2$
E) $Cu(NO_3)_2$

4. {4 pts} A student has set up the following I-C-E table to aid in solving this problem
"What is the pH of a 0.0010 M solution of a weak acid with $K_a = 3.4 \times 10^{-4}$? "

	HA (*aq*) +	H_2O (*l*) ⇆	A^- (*aq*)	H_3O^+ (*aq*)
Initial	0.0010 M		0 M	1.0×10^{-7} M
Change	$-x$		$-x$	$-x$
Equilibrium	$0.0010 - x$		x	$(1.0 \times 10^{-7}) + x$

The student considers the following approximations:

I. $x << 0.0010$, so $(0.0010 - x)$ is approximately equal to 0.0010
II. $x >> 1.0 \times 10^{-7}$, so $[(1.0 \times 10^{-7}) + x]$ is approximately equal to x

Which of these answers lists <u>all</u> the approximations that are valid for the student to make?

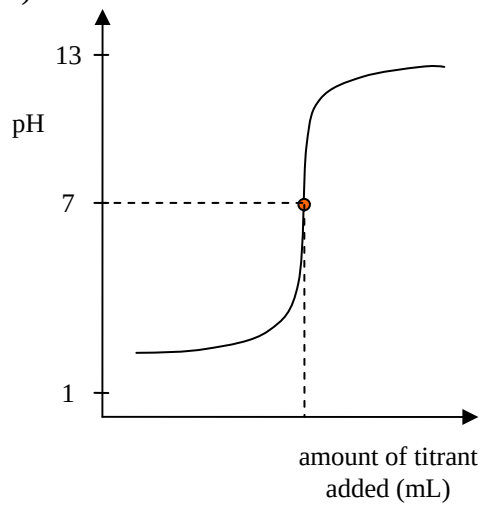
A) I only
B) II only
C) I and II both
D) neither I nor II

5. Which of the following acids is strongest? _____
{4 points. No partial credit will be awarded on this question. However, it may help you to draw the molecular structures, so I've left room here to do that.}

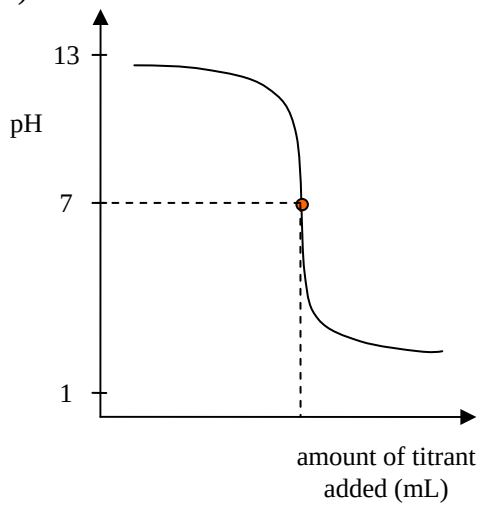
CH_3COOH $CH_2BrCOOH$ $CHBr_2COOH$ CBr_3COOH

6. {4 pts} Which of the following graphs represents the titration of a strong acid (located in the burette) into a weak base (located in the Erlenmeyer flask below)? The equivalence point is marked on all the graphs.

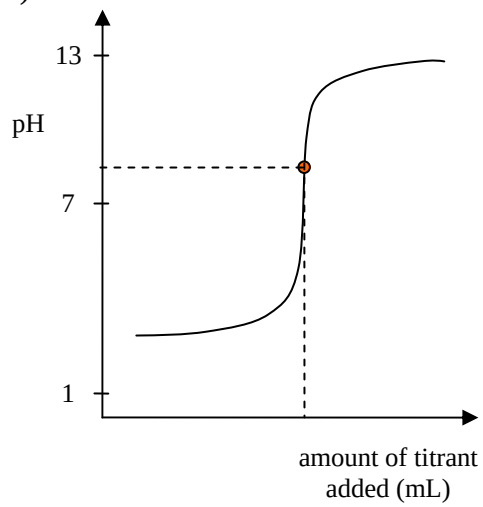
A)



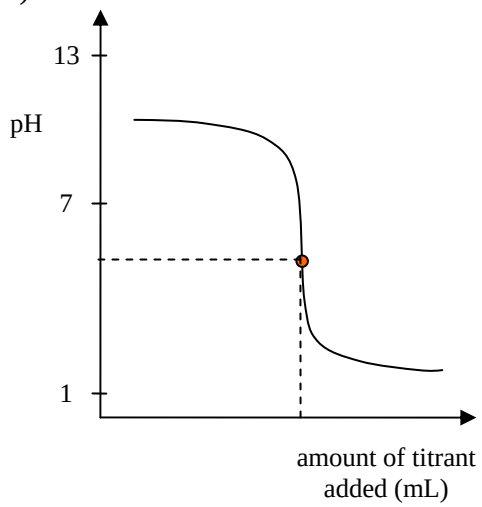
B)



C)



D)



7. {4 pts} For the following reaction, indicate which reactant is a <u>Lewis acid</u> and which reactant is a <u>Lewis base</u>.

$$Ag^{+}\,(aq) \quad + \quad 3\,N_2H_4\,(aq) \quad \leftrightarrows \quad [Ag(N_2H_4)_3]^{+}\,(aq)$$

_____ _____

8. Is the following reaction reactant-favored or product-favored? _____
{6 points, with partial credit possible for written part}

$HCrO_4^-$ (*aq*) +	$C_6H_6COO^-$ (*aq*) ⇆	C_6H_6COOH (*aq*) +	CrO_4^{2-} (*aq*)
hydrogen chromate ion	benzoate ion	benzoic acid	chromate ion

Justify your answer:

9. Quick calculations. Be sure to attend to significant digits.
{2 points for each answer, no partial credit}

a) The pH of a solution is 10.36. What are the hydronium ion and hydroxide ion concentrations?

$[H_3O^+]$ = _____

$[OH^-]$ = _____

b) What is the value of pK_a for hydrogen sulfide (H_2S)? pK_a = _____

c) For the weak base, CH_3NH_2, the value of K_b is 4.4×10^{-4}. Answer the following two questions based on this information.

- What is the formula of the conjugate acid? _____
- What is the value of K_a for the conjugate acid? _____

Part II. Problems

Each problem is worth 20 points. Points possible per part are indicated in curly braces {…}.

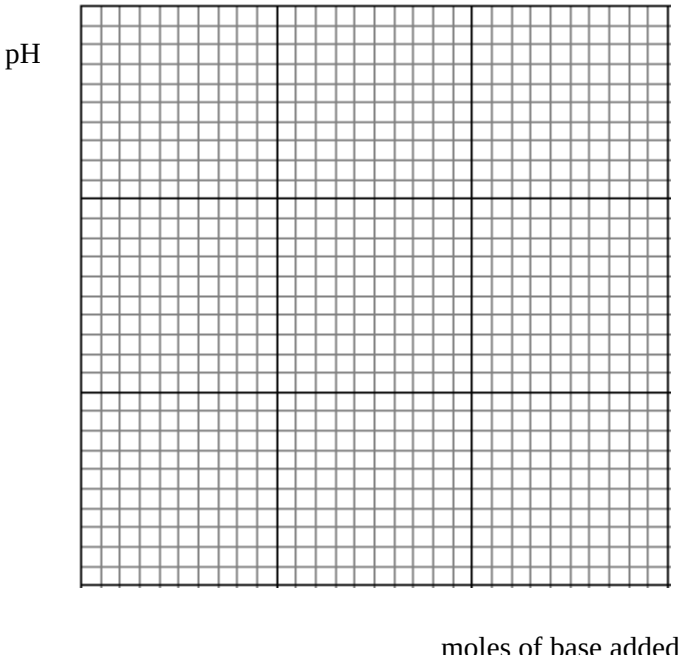
1. Cyanic acid (HOCN) is a weak acid and has $K_a = 3.5 \times 10^{-4}$. The titration is begun with 0.0400 moles of HOCN (*aq*) in 1.00 L of solution in an Erlenmeyer flask below a burette holding KOH (*aq*). Gradually KOH (*aq*) in the burette is added to the acid to titrate it. Assume that the base concentration is high enough that it contributes a negligible volume to the titration mixture.

   a) What is the pH of the initial 0.0400 M solution of cyanic acid? {5 pts}

   b) What is the pH after 0.0200 moles of KOH have been added to the solution? {5 pts}

   c) What is the pH after 0.0400 moles of KOH have been added to the solution? {5 pts}

   d) On the graph at the right, sketch the titration curve. Label the equivalence point. {5 pts}



2. Calculate the pH of each solution. Show your work. Be mindful of significant digits.
{10 pts for each part}

a) A 0.0100 M solution of NaOH
(show your work)

b) A solution made by adding 0.020 moles of HCl to 1.00 L of a 0.040 M ammonia solution (NH_3, $K_b = 1.76 \times 10^{-5}$)
(show your work)

Part III. Laboratory

This part is worth 16 points. Points possible per part are indicated in curly braces {…}.

For a particular laboratory assay, you require a buffer that maintains a pH of 4.25. On your shelf, you have the following chemicals available:

Solutions	Solids
hypochlorous acid, HOCl (*aq*), 1.00 M solution	sodium hypochlorite, NaOCl (*s*), crystals
formic acid, HCOOH (*aq*), 1.00 M solution	benzoic acid, C_6H_5COOH (*s*), crystals
	sodium benzoate, $Na(C_6H_5COO)$ (*s*), crystals
	sodium formate, NaHCOO (*s*), crystals
	sodium bicarbonate, $NaHCO_3$ (*s*), crystals
	sodium carbonate, Na_2CO_3 (*s*), crystals

a) Identify the four conjugate acid-base pairs among the chemicals available. You can write either the name or the formula. If the acid or base is an ion you can identify either the compound or the ion. If you identify an ion by formula you must get the charge correct. {8 pts}

Conjugate acid	Conjugate base partner
1.	
2.	
3.	
4.	

b) Which two chemicals should you use to prepare the buffer solution? Explain. {4 pts}

c) What ratio of conjugate base [A^-] to weak acid [HA] (*i.e.*, the ratio [A^-]/[HA]) should you use to prepare the buffer solution? Show your work. {4 pts}

Bonus: If you want the buffer to be able to withstand the addition of 0.0010 moles of strong acid or strong base and maintain the pH, what amounts of the two chemicals should you use? (Show your work. You may continue your work on the back of this page.) {up to 4 pts possible}