

Name: \_\_\_\_\_

Chem 2113

Test 2

Spring 2005

Questions are worth 25 points each. OMIT ONE QUESTION by clearly writing OMIT in the space provided for your work. If you fail to mark OMIT on a question I will omit the last question of the test. Show your work and circle your answers for full credit.

1. Calculate the pH of the following solutions:

$2.74 \times 10^{-3} \text{ M LiClO}_4$

7.00

15.0 mL of 0.0124 M NaOH mixed with 20.0 mL of 0.0108 M HCl

3.07

20.0 mL of 0.150 M HNO<sub>2</sub> mixed with 30.0 mL of 0.100 M NaNO<sub>2</sub>

3.29

0.215 M NaHS

10.98

0.025 M H<sub>2</sub>SO<sub>4</sub>

1.50

2. Consider the titration of 25.0 mL of 0.10 M sodium carbonate with 0.10 M HCl. Calculate the pH of the solution at the following points along the titration curve:

a) Before any titrant is added;

11.66

b) After 12.5 mL of titrant is added;

10.32

c) After 25.0 mL of titrant is added;

8.34

d) After 37.5 mL of titrant is added;

6.37

e) After 50.0 mL of titrant is added.

3.92

3. Consider the titration of 25.0 mL of 0.10 M boric acid with 0.050 M NaOH. Calculate the pH of the solution at the following points along the titration curve:

a) Before any titrant is added;

5.10

b) After 25.0 mL of titrant is added;

9.19

c) After 40.0 mL of titrant is added;

9.80

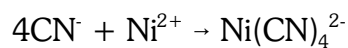
d) After 50.0 mL of titrant is added;

10.86

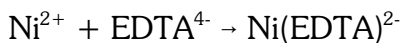
e) After 60.0 mL of titrant is added.

11.77

4. A cyanide solution with a volume of 13.72 mL was treated with 25.00 mL of  $\text{Ni}^{2+}$  solution (which contained an excess of Ni(II) ions) to convert the cyanide to the complex ion tetracyanonickelate(II):



The excess  $\text{Ni}^{2+}$  was then titrated with 10.15 mL of 0.01307 M EDTA. One mole of this reagent reacts with one mole of Ni(II) as follows:



$\text{Ni}(\text{CN})_4^{2-}$  does not react with EDTA. If 39.35 mL of EDTA was required to react with 30.10 mL of the original  $\text{Ni}^{2+}$  solution, calculate the molarity of  $\text{CN}^-$  in the 13.72 mL cyanide sample.

0.08586 M  $\text{CN}^-$

5. One of the assumptions that we make when dealing with polyprotic acids is that “all of the first proton reacts before any of the second proton” and so forth. In reality, there will be at least some of all of the forms of the acid present at any point in the reaction - a more correct statement would be that no *significant* amount of the second proton reacts before essentially all of the first proton reacts, and so forth. Determine the validity of this assumption for a 0.050 M solution of sulfurous acid at a pH of 4.593 (which corresponds to the pH of the first equivalence point in the titration of this diprotic acid) by calculating the fractional amount of  $\text{H}_2\text{SO}_3$ ,  $\text{HSO}_3^-$ , and  $\text{SO}_3^{2-}$  that are present at this pH.

$$\alpha_0 = 0.002 \text{ (fractional amount of } \text{H}_2\text{SO}_3\text{)}$$

$$\alpha_1 = 0.995 \text{ (fractional amount of } \text{HSO}_3^-\text{)}$$

$$\alpha_2 = 0.003 \text{ (fractional amount of } \text{SO}_3^{2-}\text{)}$$

## Acid Dissociation Constants

NAME	FORMULA	$K_1$	$K_2$	$K_3$
Acetic	$\text{HC}_2\text{H}_3\text{O}_2$	$1.75 \times 10^{-5}$		
Alanine	$\text{CH}_3\text{CH}(\text{NH}_2)\text{COOH}$	$4.5 \times 10^{-3}$	$1.3 \times 10^{-10}$	
Arsenic	$\text{H}_3\text{AsO}_4$	$6.0 \times 10^{-3}$	$1.0 \times 10^{-7}$	$3.0 \times 10^{-12}$
Arsenious	$\text{H}_3\text{AsO}_3$	$6.0 \times 10^{-10}$	$3.0 \times 10^{-14}$	
Benzoic	$\text{C}_6\text{H}_5\text{COOH}$	$6.3 \times 10^{-5}$		
Boric	$\text{H}_3\text{BO}_3$	$6.4 \times 10^{-10}$		
Carbonic	$\text{H}_2\text{CO}_3$	$4.3 \times 10^{-7}$	$4.8 \times 10^{-11}$	
Chloroacetic	$\text{ClCH}_2\text{COOH}$	$1.51 \times 10^{-3}$		
Citric	$\text{HOOC}(\text{OH})\text{C}(\text{CH}_2\text{COOH})_2$	$7.4 \times 10^{-4}$	$1.7 \times 10^{-5}$	$4.0 \times 10^{-7}$
Formic	$\text{HCOOH}$	$1.76 \times 10^{-4}$		
Glycine	$\text{H}_2\text{NCH}_2\text{COOH}$	$4.5 \times 10^{-3}$	$1.7 \times 10^{-10}$	
Hydrocyanic	$\text{HCN}$	$7.2 \times 10^{-10}$		
Hydrofluoric	$\text{HF}$	$6.7 \times 10^{-4}$		
Hydrogen sulfide	$\text{H}_2\text{S}$	$9.1 \times 10^{-8}$	$1.2 \times 10^{-15}$	
Hypochlorous	$\text{HOCl}$	$3.0 \times 10^{-8}$		
Iodic	$\text{HIO}_3$	$2. \times 10^{-1}$		
Lactic	$\text{CH}_3\text{CHOHCOOH}$	$1.4 \times 10^{-4}$		
Leucine	$(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{NH}_2)\text{COOH}$	$4.7 \times 10^{-3}$	$1.8 \times 10^{-10}$	
Maleic	$\text{cis-HOOCCH:CHCOOH}$	$1.5 \times 10^{-2}$	$2.6 \times 10^{-7}$	
Malic	$\text{HOOCCHOHCH}_2\text{COOH}$	$4.0 \times 10^{-4}$	$8.9 \times 10^{-6}$	
Nitrous	$\text{HNO}_2$	$5.1 \times 10^{-4}$		
Oxalic	$\text{HOOC-COOH}$	$6.5 \times 10^{-2}$	$6.1 \times 10^{-5}$	
Phenol	$\text{C}_6\text{H}_5\text{OH}$	$1.1 \times 10^{-10}$		
Phosphoric	$\text{H}_3\text{PO}_4$	$1.1 \times 10^{-2}$	$7.5 \times 10^{-8}$	$4.8 \times 10^{-13}$
Phosphorous	$\text{H}_3\text{PO}_3$	$5. \times 10^{-2}$	$2.6 \times 10^{-7}$	
o-Phthalic	$\text{C}_6\text{H}_4(\text{COOH})_2$	$1.2 \times 10^{-3}$	$3.9 \times 10^{-6}$	
Picric	$(\text{NO}_2)_3\text{C}_6\text{H}_5\text{OH}$	$4.2 \times 10^{-1}$		
Propanoic	$\text{CH}_3\text{CH}_2\text{COOH}$	$1.3 \times 10^{-5}$		
Salicylic	$\text{C}_6\text{H}_4(\text{OH})\text{COOH}$	$1.0 \times 10^{-3}$		
Sulfamic	$\text{NH}_2\text{SO}_3\text{H}$	$1.0 \times 10^{-1}$		
Sulfuric	$\text{H}_2\text{SO}_4$	$>>1$	$1.2 \times 10^{-2}$	
Sulfurous	$\text{H}_2\text{SO}_3$	$1.23 \times 10^{-2}$	$6.6 \times 10^{-8}$	
Trichloroacetic	$\text{HC}_2\text{Cl}_3\text{O}_2$	$1.29 \times 10^{-1}$		

## Base Dissociation Constants

NAME	FORMULA	$K_1$	$K_2$
Ammonia	$\text{NH}_3$	$1.75 \times 10^{-5}$	
Aniline	$\text{C}_6\text{H}_5\text{NH}_2$	$4.0 \times 10^{-10}$	
1-Butylamine	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{NH}_2$	$4.1 \times 10^{-4}$	
Diethylamine	$(\text{CH}_3\text{CH}_2)_2\text{NH}$	$8.5 \times 10^{-4}$	
Dimethylamine	$(\text{CH}_3)_2\text{NH}$	$5.9 \times 10^{-4}$	
Ethanolamine	$\text{HOC}_2\text{H}_4\text{NH}_2$	$3.2 \times 10^{-5}$	
Ethylamine	$\text{CH}_3\text{CH}_2\text{NH}_2$	$4.3 \times 10^{-4}$	
Ethylenediamine	$\text{NH}_2\text{C}_2\text{H}_4\text{NH}_2$	$8.5 \times 10^{-5}$	$7.1 \times 10^{-8}$
Glycine	$\text{HOOCCH}_2\text{NH}_2$	$2.3 \times 10^{-12}$	
Hydrazine	$\text{H}_2\text{NNH}_2$	$1.3 \times 10^{-6}$	
Hydroxylamine	$\text{HONH}_2$	$9.1 \times 10^{-9}$	
Methylamine	$\text{CH}_3\text{NH}_2$	$4.8 \times 10^{-4}$	
Piperidine	$\text{C}_5\text{H}_{11}\text{N}$	$1.3 \times 10^{-3}$	
Pyridine	$\text{C}_6\text{H}_5\text{N}$	$1.7 \times 10^{-9}$	
Triethylamine	$(\text{CH}_3\text{CH}_2)_3\text{N}$	$5.3 \times 10^{-4}$	
Trimethylamine	$(\text{CH}_3)_3\text{N}$	$6.3 \times 10^{-5}$	
Tris(hydroxymethyl)aminomethane (TRIS, THAM)	$(\text{HOCH}_2)_3\text{CNH}_2$	$1.2 \times 10^{-6}$	
Zinc Hydroxide	$\text{Zn}(\text{OH})_2$	$4.4 \times 10^{-5}$	