Version A

CHEM 1423 - Exam 3 – March 30, 2017

Name Solutions

(76) **PART I. MULTIPLE CHOICE (Circle the ONE correct answer)**

1. What is the approximate pH of a solution containing 0.07 grams of the strong base, potassium hydroxide, KOH (M = 56.1 g/mol) , dissolved in 50 L of aqueous solution?

   (A) 4.3 (B) 4.6 (C) 9.7 (D) 9.4

2. Which of the following aqueous solutions is/are acidic?

   ✓(i) Ammonium Bromide (NH_4Br)
   ✗(ii) Potassium Bromide (KBr)
   ✓(iii) Anilinium Chloride (AnilHCl)
   ✗(iv) Sodium Lactate (NaLac)

   (A) iv only (B) i & iii (C) i & ii & iv (D) i & ii & iii

3. What is the Base Equilibrium Constant of the weak base, Hydroxylamine, if a 0.05 M hydroxylamine solution has a pH = 9.4?

   (A) 1.3×10^{-8} (B) 3.2×10^{-18} (C) 5.0×10^{-4} (D) 4.8×10^{-6}

For #4 - #5: Consider the weak base, Morphine (Morp). Its base equilibrium constant is 1.6×10^{-6} .

4. What is the approximate **percent protonation** in a 0.07 M solution of Morphine?

   (A) 3.4×10^{-2} % (B) 4.8×10^{-3} % (C) 3.4×10^{-4} % (D) 0.48%

5. What is the approximate pH of a 0.04 M solution of Morphinium Chloride, (MorpHCl) ?

   (A) 4.8 (B) 3.6 (C) 5.3 (D) 9.2

6. Benzoic Acid (HBenz) is a weak acid with an acid dissociation constant of 6.3×10^{-5}. What is the approximate pH of a 0.20 M solution of Sodium Benzoate (NaBenz)?

   (A) 2.4 (B) 5.2 (C) 8.8 (D) 11.6

7. Sulfurous Acid, H_2SO_3, is a diprotic acid with acid dissociation constants, $K_a' = 1.2\times10^{-2}$, and $K_a'' = 6.6\times10^{-8}$. What is the approximate pH of a 0.10 M solution of sodium sulfite, Na_2SO_3 ?

   (A) 3.9 (B) 10.1 (C) 9.9 (D) 4.1

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8. Arsenous Acid, $HAsO_2$, has an acid dissociation constant, $K_a = 8.0x10^{-10}$. What is the approximate percent dissociation of a 0.03 M solution of $HAsO_2$?

(A) $4.9x10^{-4}$ % (B) $1.6x10^{-2}$ % (C) 9.9 (D) $1.6x10^{-4}$ %

9. If added to 2 L of 0.50 M NaOH, which one of the following would form a buffer?

(A) 2. L of 0.40 M Nitric Acid (HNO_3)

(B) 2. L of 0.40 M Potassium Acetate (KAc)

(C) 2. L of 0.60 M Lactic Acid (HLac)

(D) 2. L of 0.40 M Acetic Acid (HAc)

10. The base equilibrium constant for aniline (Anil) is $4.3x10^{-10}$. What is the approximate pH of a solution containing 0.30 M Aniline and 0.50 M Anilinium Bromide (AnilHBr)?

(A) 9.60 (B) 4.85 (C) 4.41 (D) 9.15

11. The acid dissociation constant of Propanoic Acid (HProp) is $1.5x10^{-5}$. What is the approximate pH after 0.40 mol of NaOH is added to a solution initially containing 2.0 L of 0.50 M HProp ?

(A) 4.65 (B) 5.00 (C) 4.42 (D) 5.22

For #12 - #14: Consider the amino acid, Glutamic Acid (Glu). The most positive form of Glutamic Acid is Glu^{1+} and the most negative form is Glu^{2-}. The three pKa's of Glutamic Acid are: $pK_a' = 2.1$, $pK_a'' = 4.1$, and $pK_a''' = 9.5$.

12. What is the isoelectric point (pI) of Glutamic Acid?

(A) 3.1 (B) 6.8 (C) 2.1 (D) 4.1

13. At what pH does one have 50% Glu^0 (neutral) and 50% Glu^{1-} ?

(A) 3.1 (B) 9.5 (C) 6.8 (D) 4.1

14. What is the average charge on the Glutamic Acid molecule at pH = 6.8 ?

(A) -1.5 (B) -0.5 (C) -1.0 (D) -2.0

Vers. A

15. 240 mL of 0.40 M NaOH(aq) is needed to completely neutralize 120 mL of an aqueous H_3PO_4(aq) solution? What is the Molarity of the H_3PO_4(aq) solution?

(A) 0.27 M (B) 0.47 M (C) 0.80 M (D) 0.21 M

For #16 - #19: Arsenous acid, H_3AsO_3, is a triprotic acid with acid dissociation constants, $K_a' = 5.6 \times 10^{-3}$, $K_a'' = 1.7 \times 10^{-7}$, and $K_a''' = 2.5 \times 10^{-12}$

16. Which one of the solutions below would be best to prepare a buffer with pH = 7.2?

(A) K_2HAsO_3/Na_3AsO_3 (B) Na_2HAsO_3

(C) KH_2AsO_3/Na_2HAsO_3 (D) KH_2AsO_3/Na_3AsO_3

17. What is the approximate pH of a solution containing pure K_2HAsO_3?

(A) 6.8 (B) 9.2 (C) 11.6

(D) The pH depends upon the K_2HAsO_3 concentration.

18. What is the approximate pH of a solution prepared by adding 0.30 mol of NaOH to 2.0 L of 0.40 M KH_2AsO_3?

(A) 7.20 (B) 7.00 (C) 6.34 (D) 6.55

19. Approximately what ratio of $[H_3AsO_3]/[H_2AsO_3^-]$ will give a solution with pH = 2.9 ?

(A) 0.2 (B) 0.6 (C) 5.6 (D) 4.5

PART II. TWO (2) PROBLEMS BELOW: REMEMBER TO SHOW WORK FOR CREDIT

$H_2TeO_3 \rightleftharpoons HTeO_3^- \rightleftharpoons TeO_3^{2-}$ Ans A

$pK_a' = 2.52$ $pK_a'' = 7.70$

(16) 1. Tellurous acid, H_2TeO_3, is a diprotic acid with acid dissociation constants, $K_a' = 3.0\times10^{-3}$ and $K_a'' = 2.0\times10^{-8}$

-1.2 ✓.

(6) (a) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M K_2TeO_3 with 1.0 L of 0.70 M HCl.

0.7 ✓.

	TeO_3^{2-}	$+H^+$	$\rightarrow HTeO_3^-$
init	1.2	0.7	0
chg.	-0.7	-0.7	+0.7
Fin.	0.50 mol	0	0.70 mol.

Can also by V(3.0L) to get conc. if wrk

$$pH = pK_a'' + \log\frac{[TeO_3^{2-}]}{[HTeO_3^-]}$$

$$= 7.70 + \log\left(\frac{0.50}{0.70}\right)$$

$$= \boxed{7.55}$$

1.2 ✓.

(6) (b) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M H_2TeO_3 with 2.0 L of 0.80 M NaOH.

1.6 ✓.

Step 1

	H_2TeO_3	$+OH^-$	$\rightarrow HTeO_3^-$	$+H_2O$
in	1.2	1.6	0	
chg.	-1.2	-1.2	+1.2	
Fin	0	0.40	1.20	

Step 2

	$HTeO_3^-$	$+OH^-$	$\rightarrow TeO_3^{2-}$	$+H_2O$
Init	1.2	0.4	0	
chg.	-0.4	-0.4	+0.4	
	0.80		0.40	

$$pH = pK_a'' + \log\frac{[TeO_3^{2-}]}{[HTeO_3^-]}$$

$$= 7.70 + \log\left(\frac{0.40}{0.80}\right)$$

$$= \boxed{7.40}$$

(Part C on next Page)

$H_2TeO_3 \rightleftharpoons HTeO_3^- \rightleftharpoons TeO_3^{2-}$ Vus. A

$pK_a' = 2.52$

(16) 1. **(Continued)** Tellurous acid, H_2TeO_3, is a diprotic acid with acid dissociation constants, $K_a' = 3.0\times10^{-3}$ and $K_a'' = 2.0\times10^{-8}$

(4) (c) Calculate the ratio, $[HTeO_3^-]/[H_2TeO_3]$, needed to prepare a buffer solution with pH = 3.20

$pH = pK_a' + \log\frac{[HTeO_3^-]}{[H_2TeO_3]}$

$3.2 = 2.52 + \log\frac{[HTeO_3^-]}{[H_2TeO_3]}$

$\log\frac{[HTeO_3^-]}{[H_2TeO_3]} = 3.2 - 2.52 = 0.68$

$\frac{[HTeO_3^-]}{[H_2TeO_3]} = 10^{0.68} = 4.79 \approx \boxed{4.8}$

(08) 2. Hypobromous Acid, HBrO, has an Acid Dissociation Constant, $K_a = 2.0\times10^{-9}$. Calculate the pH of a solution of Sodium Hypobromite, NaBrO (M = 118.9 g/mol) that is 3.0% NaBrO by weight.

Note: Assume that the density of the solution is 1.0 g/mL

Calc of $[NaBrO] = [BrO^-]$

Assume $1\,L = 1000\,mL = 1000\,g$.

$m_{NaBrO} = \frac{3.0}{100}\times1000 = 30\,g$.

$n_{NaBrO} = 30\,g \times \frac{1\,mol}{118.9\,g}$

$= 0.252\,mol$

$[NaBrO] = [BrO^-] = 0.252\,M$

(Since $V = 1.0\,L$)

Calc of pH

$K_b(BrO^-) = \frac{10^{-14}}{K_a(HBrO)}$

$= \frac{10^{-14}}{2\times10^{-9}}$

$= 5.0\times10^{-6}$

$BrO^- + H_2O \rightleftharpoons HBrO + OH^-$

$0.252 \quad x \quad x$

$K_b = \frac{[NaBrO][OH^-]}{[BrO^-]} = \frac{x^2}{0.252} = 5\times10^{-6}$

$x^2 = 1.26\times10^{-6}$

$x = [OH^-] = 1.12\times10^{-3}\,M$

$pOH = -\log(1.12\times10^{-3}) = 2.95$

$pH = 14 - 2.95 = 11.05$

$\approx \boxed{11.0 \text{ or } 11.1}$

Ver. B

CHEM 1423 - Exam 3 – March 30, 2017 - Version B

Name Solutions

(76) **PART I. MULTIPLE CHOICE (Circle the ONE correct answer)**

1. Which of the following aqueous solutions is/are acidic?

   (i) Ammonium Bromide (NH_4Br)
   (ii) Potassium Bromide (KBr)
   (iii) Anilinium Chloride (AnilHCl)
   (iv) Sodium Lactate (NaLac)

   (A) iv only (B) i & ii & iii (C) i & ii & iv (D) i & iii

For #2 - #3: Consider the weak base, Morphine (Morp). Its base equilibrium constant is 1.6×10^{-6} .

2. What is the approximate **percent protonation** in a 0.07 M solution of Morphine?

   (A) 3.3×10^{-2} % (B) 0.48% (C) 3.3×10^{-4} % (D) 4.8×10^{-3} %

3. What is the approximate pH of a 0.04 M solution of Morphinium Chloride, (MorpHCl) ?

   (A) 3.6 (B) 4.8 (C) 5.3 (D) 9.2

4. What is the approximate pH of a solution containing 0.07 grams of the strong base, potassium hydroxide, KOH (M = 56.1 g/mol) , dissolved in 50 L of aqueous solution?

   (A) 9.4 (B) 4.6 (C) 9.7 (D) 4.3

5. What is the Base Equilibrium Constant of the weak base, Hydroxylamine, if a 0.05 M hydroxylamine solution has a pH = 9.4?

   (A) 5.0×10^{-4} (B) 3.2×10^{-18} (C) 1.3×10^{-8} (D) 4.8×10^{-6}

6. Sulfurous Acid, H_2SO_3, is a diprotic acid with acid dissociation constants, $K_a' = 1.2 \times 10^{-2}$, and $K_a'' = 6.6 \times 10^{-8}$. What is the approximate pH of a 0.10 M solution of sodium sulfite, Na_2SO_3 ?

   (A) 3.9 (B) 10.1 (C) 9.9 (D) 4.1

7. Benzoic Acid (HBenz) is a weak acid with an acid dissociation constant of 6.3×10^{-5}. What is the approximate pH of a 0.20 M solution of Sodium Benzoate (NaBenz)?

   (A) 2.4 (B) 5.2 (C) 11.6 (D) 8.8

Vers. B

For #8 - #10: Consider the amino acid, Glutamic Acid (Glu). The most positive form of Glutamic Acid is Glu^{1+} and the most negative form is Glu^{2-}. The three pKa's of Glutamic Acid are: $pK_a' = 2.1$, $pK_a'' = 4.1$, and $pK_a''' = 9.5$.

8. At what pH does one have 50% Glu^0 (neutral) and 50% Glu^{1-} ?

   (A) 3.1 (B) 9.5 (C) 4.1 (D) 6.8

9. What is the isoelectric point (pI) of Glutamic Acid?

   (A) 4.1 (B) 3.1 (C) 6.8 (D) 4.1

10. What is the average charge on the Glutamic Acid molecule at pH = 6.8 ?

    (A) -1.0 (B) -0.5 (C) -1.5 (D) -2.0

11. If added to 2 L of 0.50 M NaOH, which one of the following would form a buffer?

    (A) 2. L of 0.40 M Nitric Acid (HNO_3)

    (B) 2. L of 0.40 M Potassium Acetate (KAc)

    (C) 2. L of 0.40 M Acetic Acid (HAc)

    (D) 2. L of 0.60 M Lactic Acid (HLac)

12. Arsenous Acid, $HAsO_2$, has an acid dissociation constant, $K_a = 8.0 \times 10^{-10}$. What is the approximate percent dissociation of a 0.03 M solution of $HAsO_2$?

    (A) 1.6×10^{-2} % (B) 4.9×10^{-4} % (C) 9.9 (D) 1.6×10^{-4} %

13. The acid dissociation constant of Propanoic Acid (HProp) is 1.5×10^{-5}. What is the approximate pH after 0.40 mol of NaOH is added to a solution initially containing 2.0 L of 0.50 M HProp ?

    (A) 4.42 (B) 5.00 (C) 4.65 (D) 5.22

14. The base equilibrium constant for aniline (Anil) is 4.3×10^{-10}. What is the approximate pH of a solution containing 0.30 M Aniline and 0.50 M Anilinium Bromide (AnilHBr)?

    (A) 9.60 (B) 4.41 (C) 4.85 (D) 9.15

Vers B

For #15 - #18: Arsenous acid, H_3AsO_3, is a triprotic acid with acid dissociation constants, $K_a' = 5.6 \times 10^{-3}$, $K_a'' = 1.7 \times 10^{-7}$, and $K_a''' = 2.5 \times 10^{-12}$

15. What is the approximate pH of a solution containing pure K_2HAsO_3?

(A) 9.2 (B) 11.6 (C) 6.8

(D) The pH depends upon the K_2HAsO_3 concentration.

16. Which one of the solutions below would be best to prepare a buffer with pH = 7.2?

(A) K_2HAsO_3/Na_3AsO_3 (B) Na_2HAsO_3

(C) KH_2AsO_3/Na_3AsO_3 (D) KH_2AsO_3/Na_2HAsO_3

17. What is the approximate pH of a solution prepared by adding 0.30 mol of NaOH to 2.0 L of 0.40 M KH_2AsO_3?

(A) 6.55 (B) 7.00 (C) 6.34 (D) 7.20

18. Approximately what ratio of $[H_3AsO_3]/[H_2AsO_3^-]$ will give a solution with pH = 2.9 ?

(A) 2.5 (B) 0.6 (C) 5.6 (D) 0.2

19. 240 mL of 0.40 M NaOH(aq) is needed to completely neutralize 120 mL of an aqueous H_3PO_4(aq) solution? What is the Molarity of the H_3PO_4(aq) solution?

(A) 0.47 M (B) 0.80 M (C) 0.27 M (D) 0.21 M

PART II. TWO (2) PROBLEMS BELOW: REMEMBER TO SHOW WORK FOR CREDIT

$H_2TeO_3 \rightleftharpoons HTeO_3^- \rightleftharpoons TeO_3^{2-}$ Vers. B

$pK_a' = 2.52$ $pK_a'' = 7.70$

(16) 1. Tellurous acid, H_2TeO_3, is a diprotic acid with acid dissociation constants, $K_a' = 3.0\times10^{-3}$ and $K_a'' = 2.0\times10^{-8}$ -1.2 pl.

(6) (a) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M K_2TeO_3 with 1.0 L of 0.70 M HCl. → 0.7 pl.

	TeO_3^{2-}	$+H^+$	$\rightarrow HTeO_3^-$
Init	1.2	0.7	0
Chg	-0.7	-0.7	+0.7
Fin	0.50 pl	0	0.70 pl.

Can divide by V(3.0L) to get conc. if wish

$$pH = pK_a'' + \log\frac{[TeO_3^{2-}]}{[HTeO_3^-]}$$

$$= 7.70 + \log\left(\frac{0.50}{0.70}\right)$$

$$= \boxed{7.55}$$

1.2 pl.

(6) (b) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M H_2TeO_3 with 2.0 L of 0.80 M NaOH. 1.6 pl.

Step 1

$H_2TeO_3 + OH^- \rightarrow HTeO_3^- + H_2O$

	H_2TeO_3	OH^-	$HTeO_3^-$	H_2O
In	1.2	1.6	0	
Chg	-1.2	-1.2	+1.2	
Fin	0	0.40	1.20	

Step 2

$HTeO_3^- + OH^- \rightarrow TeO_3^{2-} + H_2O$

	$HTeO_3^-$	OH^-	TeO_3^{2-}
Init	1.2	0.4	0
Chg	-0.4	-0.4	+0.4
	0.80		0.40

$$pH = pK_a'' + \log\frac{[TeO_3^{2-}]}{[HTeO_3^-]}$$

$$= 7.70 + \log\left(\frac{0.40}{0.80}\right)$$

$$= \boxed{7.40}$$

(Part C on next Page)

$H_2TeO_3 \rightleftharpoons HTeO_3^- \rightleftharpoons TeO_3^{2-}$ Vers. B

$pK_a = 2.52$

(16) 1. **(Continued)** Tellurous acid, H_2TeO_3, is a diprotic acid with acid dissociation constants, $K_a' = 3.0\times10^{-3}$ and $K_a'' = 2.0\times10^{-8}$

(4) (c) Calculate the ratio, $[HTeO_3^-]/[H_2TeO_3]$, needed to prepare a buffer solution with pH = 3.20

$pH = pK_a' + \log\frac{[HTeO_3^-]}{[H_2TeO_3]}$

$3.2 = 2.52 + \log\frac{[HTeO_3^-]}{[H_2TeO_3]}$

$\log\frac{[HTeO_3^-]}{[H_2TeO_3]} = 3.2 - 2.52 = 0.68$

$\frac{[HTeO_3^-]}{[H_2TeO_3]} = 10^{0.68} = 4.79 \approx \boxed{4.8}$

(08) 2. Hypobromous Acid, HBrO, has an Acid Dissociation Constant, $K_a = 2.0\times10^{-9}$. Calculate the pH of a solution of Sodium Hypobromite, NaBrO (M = 118.9 g/mol) that is 3.0% NaBrO by weight.

Note: Assume that the density of the solution is 1.0 g/mL

Calc of $[NaBrO] = [BrO^-]$

Assume 1 L = 1000 mL = 1000 g.

$m_{NaBrO} = \frac{3.0}{100}\times1000 = 30\text{ g}$

$n_{NaBrO} = 30\text{ g}\times\frac{1\text{ mol}}{118.9\text{ g}}$

$= 0.252\text{ mol}$

$[NaBrO] = [BrO^-] = 0.252\text{ M}$

(Since V = 1.0 L)

Calc of pH

$K_b(BrO^-) = \frac{10^{-14}}{K_a(HBrO)}$

$= \frac{10^{-14}}{2\times10^{-9}}$

$= 5.0\times10^{-6}$

$BrO^- + H_2O \rightleftharpoons HBrO + OH^-$

0.252 — x — x

$K_b = \frac{[NaBrO][OH^-]}{[BrO^-]} = \frac{x^2}{0.252} = 5.0\times10^{-6}$

$x^2 = 1.26\times10^{-6}$

$x = [OH^-] = 1.12\times10^{-3}\text{ M}$

$pOH = -\log(1.12\times10^{-3}) = 2.95$

$pH = 14 - 2.95 = 11.05$

$\approx \boxed{11.0 \text{ or } 11.1}$