**CH302 Spring 2009 Practice Quiz 3 Answer Key—The TA Version**

1. Which of the following pairs of solutions would result in a buffer upon mixing?
   1. 25 mL of 4 M HCl & 15 mL of 4 M $HNO_2$
   2. 200 mL of 0.5 M LiOH & 100 mL of 0.5 M $H_2SO_4$
   3. 100 mL of 1 M $NH_3$ & 10 mL of 10 M $HNO_3$
   4. 150 mL of 3 M $Ba(OH)_2$ & 200 mL of 2 M HClO
   5. 100 mL of 1 M $CH_3COOH$ & 50 mL of 1 M NaOH **Correct**

Explanation: 100 mL of 1 M $CH_3COOH$ & 50 mL of NaOH, would equate to 0.1 mol of a weak acid and 0.05 mol of a strong base. Upon neutralization, the resulting solution would contain 0.05 mol each of acetic acid and its conjugate base, acetate - resulting in a buffered system.

2. What would be the pH of a solution prepared from 2 L of $H_2O$, 85 g of $NH_3$ and 98 g of $NH_4Br$? Assume the $K_b$ of ammonia is $2x10^{-5}$.
   1. 4
   2. 5.4
   3. 10 **Correct**
   4. 8.6
   5. 7

Explanation: 85 g of $NH_3$ x 1 mol/17 g = 5 mol $NH_3$

5 mol $NH_3$ / 2 L $H_2O$ = 2.5 M $NH_3$

98 g of $NH_4Br$ x 1 mol/98 g = 1 mol $NH_4Br$

1 mol $NH_4Br$ / 2 L $H_2O$ = 0.5 M $NH_4Br$

$[OH^-] = K_b(C_b \backslash C_a) = 2x10^{-5}(2.5\ M/0.5\ M) = 10^{-4}$

pH = 10

3. Two liters of a buffer containing 0.6 M $CH_3NH_2$ and 0.8 M $CH_3NH_3Cl$ has 102.4 g of HI added to it. What is the new pH? Assume the $K_b$ of $CH_3NH_3$ is $6x10^{-4}$.
   1. 6
   2. 3
   3. 11
   4. 4
   5. 10 **Correct**
   6. 8

Explanation: 102.4 g of HI x 1 mol/128 g = 0.8 mol HI

$[OH^-] = K_b(C_b \backslash C_a) = 6x10^{-4}(0.2\ M/1.2\ M) = 10^{-4}$

pH = 10

4. A 0.08 M $CH_3NH_2$ solution is titrated against a 0.08 M HCl solution. Assuming the $K_b$ of $CH_3NH_2$ is $4x10^{-10}$, what is the pH at the equivalence point?
   1. 3 **Correct**
   2. 7
   3. 9
   4. 5
   5. not enough information

Explanation: Because the titrant and analyte are equimolar, the volume of the system at the equivalance point will be double its initial value and the concentration of the conjugate acid will be half the initial concentration of the base.

$V_{total} = 2 \times V_{initial}$

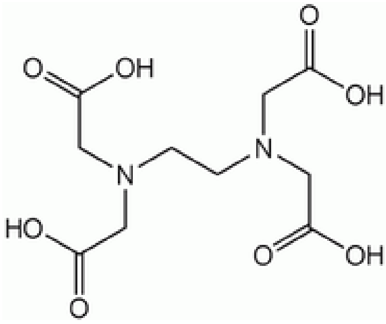
$C_a = 0.04\ M\ CH_3NH_3^+$

$K_a = K_w / K_b = 10^{-14} / 4x10^{-10} = 2.5x10^{-5}$

$[H^+] = (K_a \cdot C_a)^{1/2} = (2.5x10^{-5} \cdot 0.04)^{1/2} = (10^{-6})^{1/2} = 10^{-3}$

pH = 3

5. Consider the molecule ethylenediaminetetraacetic acid (EDTA):



As drawn above, how many $K_a$ would be needed to describe the complete deprotonation of EDTA?

1. 4 **Correct**
2. 6
3. 3
4. 5

Explanation: As drawn, EDTA has 4 ionizable protons and would thus require 4 $K_a$ to express each deprotonation. In actuality, the nitrogen moieites are also ionizable, but as drawn, are already deprotonated.

6. What would be the difference in pH of a 1 M solution of $NaH_2AsO_4$ and a 1 M solution of $Na_2HAsO_4$? Assume $H_3AsO_4$ has a $pK_{a1}$ of 2 and a $pK_{a2}$ of 7 and a $pK_{a3}$ of 12.

1. 7
2. 4.5
3. 9.5
4. 5 **Correct**
5. 2.5
6. 1.5

Explanation: For a solution composed of a single amphoteric species ($H_2AsO_4^-$), pH = $0.5(pK_{a1} + pK_{a2}) = 0.5(2 + 7) = 4.5$

For a solution composed of a single amphoteric species ($HAsO_4^{2-}$), pH = $0.5(pK_{a2} + pK_{a3}) = 0.5(7 + 12) = 9.5$

7. A student erroneously calculated that a solution consisting solely of a weak base dissolved in water had a pH of 6. Which two of the following might have been true?

I. $K_b < 10^{-11}$

II. $K_b > 10^{-3}$

III. $C_b > 10^{-1}$

IV. $C_b < 10^{-4}$

1. I and IV only **Correct**
2. II and III only
3. I and III only
4. II and IV only

Explanation: Having erroneously calculated a pH of 6 (pOH of 8) for a weak base solution suggests that student probably used the equation $[OH^-] = (K_b \cdot C_b)^{1/2}$ and failed to notice that both the value of $K_b$ and $C_b$ were too small to satisfy the assumptions made when using $[OH^-] = (K_b \cdot C_b)^{1/2}$.

8. An aqueous system with $Na_2CO_3$, NaCl and $NH_4Cl$ dissolved in it would require how many equations to find all the unknown equilibrium concentrations?

1. 3
2. 7 **Correct**
3. 4
4. 6
5. 9

Explanation: An aqueous system with $Na_2CO_3$, NaCl and $NH_4Cl$ dissolved in it would have an unknown value for $[H^+]$, $[OH^-]$, $[CO_3^{2-}]$, $[HCO_3^-]$, $[H_2CO_3]$, $[NH_4^+]$ and $[NH_3]$.