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

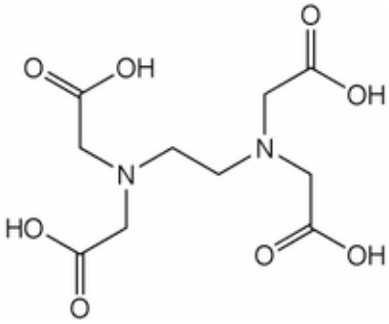
Explanation: 85 g of NH_3 x 1 mol/17 g = 5 mol NH_3
5 mol NH_3 / 2 L H_2O = 2.5 M NH_3
98 g of NH_4Br x 1 mol/98 g = 1 mol NH_4Br
1 mol NH_4Br / 2 L H_2O = 0.5 M NH_4Br
$[OH^-] = K_b(C_b\backslash C_a) = 2x10^{-5}(2.5\ M/0.5\ M) = 10^{-4}$
pH = 10

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



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 for a full solution?

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 $[NH_3]$.