CHEM 1474  
Test #3  
Fall 2010 (Buckley)

Multiple Choice. Each is worth 2 points.

1. Which of the following is the conjugate base of HPO₄²⁻?
   a. PO₄³⁻  b. H₂PO₄⁻  c. H₃PO₄  d. OH⁻

2. Kₛ for phenol, H₅C₆H₅O, is 1.3 x 10⁻¹⁰. What is the expression that will give the value of Kₛ for the phenolate ion, C₆H₅O⁻?
   a. (1.3×10⁻¹⁰)×(1.0×10⁻¹⁴)  b. 1.3×10⁻¹⁰  c. 1.0×10⁻¹⁴  d. 1.0×10⁻¹⁴ / (1.3×10⁻¹⁰)²

For questions 3-5 consider the following compounds and their associated numbers.

I. Ba(C₂H₅O₂)₂  II. NH₄NO₃  III. SrCl₂  IV. AlCl₃  V. Ca(NO₂)₂

3. Solutions of which of the compounds above, I through V, would form acidic solutions?
   a. I only  b. III and IV only  c. I and V only  d. II and IV only  e. II only

4. Solutions of which of the compounds above, I through V, would form neutral solutions?
   a. I only  b. III and IV only  c. III only  d. II, III, and IV only  e. V only

5. Solutions of which of the compounds above, I through V, would form basic solutions?
   a. I only  b. III and IV only  c. I and V only  d. II and IV only  e. V only
6. Which of the following compounds would you expect to be the most acidic?

   a. \[ \text{F} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{Cl} \quad \text{O} \quad \text{H} \]
   
   b. \[ 
   \text{H} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{H} \]
   
   c. \[ 
   \text{C} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{H} \]

    d. \[ 
   \text{C} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{H} \]

    e. \[ 
   \text{C} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{H} \]

7. Which of the following could act as a Lewis acid? *NEEDS A PLACE TO ACCEPT ELECTRONS*

   a. \[ \text{AlCl}_{4}^{-} \]
   
   b. \[ \text{NH}_{3} \]
   
   c. \[ \text{NH}_{4}^{+} \]
   
   d. \[ \text{Cl}^{-} \]
   
   e. \[ \text{AlCl}_{3} \]

8. The titration of which of the following will have a pH of 7 at the equivalence point?

   a. a weak acid with a strong base
   
   b. a weak base with a strong acid
   
   c. a weak base with a weak acid
   
   d. a strong acid with a strong base

9. Which of the following combinations could **NOT** be used to form a buffer solution?

   a. \[ \text{NH}_{3} \text{ and } \text{NH}_{4}^{+} \text{Cl} \]
   
   b. \[ \text{Ba(ClO}_{4} \text{)}_{2} \text{ and } \text{HClO}_{4} \]
   
   c. \[ \text{KNO}_{2} \text{ and } \text{HNO}_{2} \]
   
   d. \[ \text{HC}_{2}\text{H}_{3}\text{O}_{2} \text{ and } \text{Ca(C}_{2}\text{H}_{3}\text{O}_{2})_{2} \]
   
   e. \[ \text{CH}_{3}\text{NH}_{2} \text{ and } \text{CH}_{3}\text{NH}_{3}\text{Br} \]

10. At the equivalence point of a weak base-strong acid titration the pH will be:

    a. equal to 7
    
    b. greater than 7
    
    c. less than 7
    
    d. impossible to tell without further information
Problems. Point totals are indicated in parentheses to the right of the problem number. Show your work to receive full credit.

11. (5 points) Find the pH, pOH, [H⁺], and [OH⁻] for a 0.15 M solution of NH₄NO₃.

\[ NH₄⁺(aq) \rightleftharpoons NH₃(aq) + H^+(aq) \]

\[ K_a \text{ for } NH₄⁺ = \frac{[NH₃][H^+]}{[NH₄⁺]} \]

\[ 5.56 \times 10^{-10} = \frac{(x)(x)}{0.15-x} \quad \text{ASSUME } 0.15 - x \ll 0.15 \]

\[ x^2 = (0.15)(5.56 \times 10^{-10}) = 8.33 \times 10^{-11} \]

\[ x = 9.13 \times 10^{-6} \]

\[ [H^+] = 9.13 \times 10^{-6} \]

\[ pH = 5.94 \]

\[ pOH = 8.06 \]

\[ [OH^-] = 1.0 \times 10^{-9} \]

12. (5 points) Find the pH, pOH, [H⁺], and [OH⁻] for a 0.25 M solution of Ba(BrO₃)₂.

\[ Ba(O_3Br)^-(aq) \rightleftharpoons OH^-(aq) + BrO^-(aq) \]

\[ K_b \text{ for } BrO^- = 4 \times 10^{-6} \]

\[ \frac{4 \times 10^{-6}}{5.0-x} = \frac{x^2}{0.25-x} \quad \text{ASSUME } 0.25 - x \approx 0.25 \]

\[ x = \sqrt{4.12 \times 10^{-6}} = 2.0 \times 10^{-3} \]

\[ [OH^-] = 7.08 \times 10^{-12} \]

\[ pOH = 11.15 \]

13. (5 points) Find the pH of a solution containing 0.00500 M NaClO and 0.0125 M HClO.

\[ [ClO^-] = 0.00500 \text{ M} \quad [NaClO] = 0.0125 \text{ M} \]

\[ K_a \text{ for } HClO = 2.3 \times 10^{-11} \]

\[ pH = pK_a + \log \frac{[ClO^-]}{[NaClO]} = 10.64 + \log \frac{0.00500}{0.0125} = 10.64 - 0.40 = 10.24 \]
14. (8 points) A flask contains 35.00-mL of 0.125 M HCN. The flask is titrated with a 0.175 M solution of KOH. Find the pH in the flask at the following points in the titration. Show your work.

\[ K_a \text{ for HCN} = 4.9 \times 10^{-10} \]
\[ pK_a = 9.910 \]

a. Before the titration starts: WEAK ACID

\[ [HCN] \rightarrow [H^+] + [CN^-] \]
\[ 4.9 \times 10^{-10} \}

\[ x^2 \]

\[ x = 7.83 \times 10^{-6} \text{ M} = [CN^-] \]
\[ pCN = 5.180 \]

b. After the addition of 15.00-mL of the KOH solution.

\[ \text{mmol OH}^- \text{ added} = 15.00 \times 0.175 = 2.625 \text{ mmol OH}^- \]
\[ \text{mmol} \text{ HCN} = 3.50 \times 0.125 = 0.4375 \text{ mmol HCN} \]
\[ \text{CN}^- + \text{OH}^- \rightarrow \text{CN}^- + \text{H}_2\text{O} \]
\[ x = 2.625 \]
\[ \text{pH} = pK_a + \log \frac{[CN^-]}{[HCN]} = 9.310 + \log \frac{2.625}{7.83} = 9.310 + 0.176 = 9.486 \]

\[ [CN^-] = \frac{4.375 \text{ mmol}}{35.00 + 25.00} = 7.27 \times 10^{-5} \]

\[ \text{At the equivalence point} \]
\[ \text{AT THE EQUIVALENCE HAVE DELIVERED 4.375 mmol OH}^- \text{ TO MATCH THE STARTING 4.375 mmol HCN} \]
\[ \text{PRODUCED 4.375 mmol CN}^- \text{ NOW IT'S A WEAK BASE PROBLEM.} \]

\[ \text{Volume KOH = 25 mL} \]
\[ K_f \frac{14 \times 10^{-10}}{4.9 \times 10^{-10}} = 2.81 \times 10^{-5} \]

\[ \text{At the equivalence point} \]
\[ \text{CN}^- (aq) + \text{OH}^- (aq) \rightarrow \text{CN}^- (aq) + \text{H}_2\text{O} \]
\[ x = 1.22 \times 10^{-3} \]
\[ \text{pH} = 11.056 \]

\[ \text{After 10.00-mL of the KOH solution have been added past the equivalence point.} \]

\[ \text{Excess OH}^-: \text{ HAVE ADDED 25 mL + 5 mL = 35 mL OF KOH} \]
\[ \text{mmol OH}^- = 35 \times 0.125 = 4.375 \text{ mmol OH}^- \]
\[ \text{mmol of OH}^- \text{ used to react with -4.375} \]
\[ \text{CN}^- \]
\[ \text{Total volume} = 35 \text{ mL HCN} + 75 \text{ mL KOH} = 110 \text{ mL} \]
\[ \text{0.125 M OH}^- \]
\[ \text{pH} = 12.39 \]