

CH 223 Problem Set #3

Covering: **Chapter Seventeen Part I** (up to the solubility section) and **Chapter Guide Three**

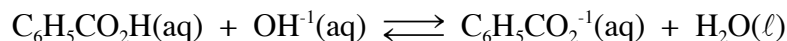
Important Tables and/or Constants: **Appendix D Table D-1** (page 1115), "**Titration Guide**" (Handout), "**Buffers and Henderson-Hasselbalch**" (Handout) and the **Table of Acids and Bases for CH 223** (from Problem Set #2.)

- Calculate the hydronium ion concentration and the pH when 50.0 mL of 0.40 M NH_3 is mixed with 50.0 mL of 0.40 M HCl.
- For each of the following cases, decide whether the pH is less than 7, equal to 7 or greater than 7.
 - 25 mL of 0.45 M H_2SO_4 is mixed with 25 mL of 0.90 M NaOH
 - 15 mL of 0.050 M formic acid, HCO_2H , is mixed with 15 mL of 0.050 M NaOH
 - 150 mL of 0.20 M HNO_3 is mixed with 75 mL of 0.40 M NaOH
- Does the pH of the solution increase, decrease or stay the same when you:
 - Add solid sodium oxalate, $\text{Na}_2\text{C}_2\text{O}_4$, to 50.0 mL of 0.015 M oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$?
 - Add solid ammonium chloride to 75 mL of 0.016 M HCl?
 - Add 20.0 g of NaCl to 1.0 L of 0.10 M sodium acetate, NaCH_3CO_2 ?
- For each of the following cases, decide whether the pH is less than 7, greater than 7 or equal to 7.
 - equal volumes of 0.10 M acetic acid, $\text{CH}_3\text{CO}_2\text{H}$, and 0.10 M KOH are mixed
 - 25 mL of 0.015 M NH_3 is mixed with 12 mL of 0.015 M HCl
 - 150 mL of 0.20 M HNO_3 is mixed with 75 mL of 0.40 M NaOH
- What is the pH of 100. mL of 0.15 M acetic acid to which 1.56 g of sodium acetate, NaCH_3CO_2 , has been added?
- What is the pH of the solution that results from adding 25.0 mL of 0.12 M HCl to 25.0 mL of 0.43 M NH_3 ?
- Lactic acid, $\text{CH}_3\text{CHOHCO}_2\text{H}$, is found in sour milk, in sauerkraut, and in muscles after activity. K_a for lactic acid = 1.4×10^{-4} .
 - If 2.75 g of $\text{NaCH}_3\text{CHOHCO}_2$, sodium lactate, is added to 5.00×10^2 mL of 0.100 M lactic acid, what is the pH of the resulting buffer solution?
 - Is the final pH lower or higher than the pH of the lactic acid solution?
- What mass of ammonium chloride, NH_4Cl , must be added to exactly 5.00×10^2 mL of 0.10 M NH_3 to give a solution with a pH of 9.00?
- Calculate the pH of a solution that has an ammonium chloride concentration of 0.050 M and an ammonia concentration of 0.045 M.
- A buffer solution is composed of 1.360 g of KH_2PO_4 and 5.677 g of Na_2HPO_4 .
 - What is the pH of the buffer solution?
 - What mass of KH_2PO_4 must be added to decrease the buffer solution pH by 0.5 units?
- Which of the following combinations would be the best choice to buffer the pH of a solution at approximately 7?
 - H_3PO_4 and NaH_2PO_4
 - NaH_2PO_4 and Na_2HPO_4
 - Na_2HPO_4 and Na_3PO_4

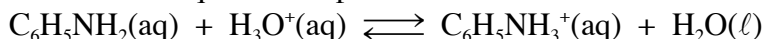
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12. You dissolve 0.425 g of NaOH in 2.00 L of a buffer solution that has $[\text{H}_2\text{PO}_4^-] = [\text{HPO}_4^{2-}] = 0.132 \text{ M}$. What is the pH of the solution before adding the NaOH? After adding the NaOH?
13. What will be the pH change when 20.0 mL of 0.100 M NaOH is added to 80.0 mL of a buffer solution consisting of 0.169 M NH_3 and 0.183 M NH_4Cl ?
14. Assume you dissolve 0.235 g of the weak acid benzoic acid, $\text{C}_6\text{H}_5\text{CO}_2\text{H}$, in enough water to make $1.00 \times 10^2 \text{ mL}$ of solution and then titrate the solution with 0.108 M NaOH.

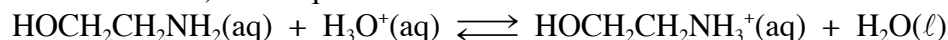


- What is the pH of the original benzoic acid solution?
 - What are the concentrations of the following ions at the equivalence point? Na^+ , H_3O^+ , OH^- , and $\text{C}_6\text{H}_5\text{CO}_2^-$?
 - What is the pH of the solution at the equivalence point?
15. A solution of the weak base aniline, $\text{C}_6\text{H}_5\text{NH}_2$, $K_b = 4.0 \times 10^{-10}$, in 25.0 mL of water requires 25.67 mL of 0.175 M HCl to reach the equivalence point.

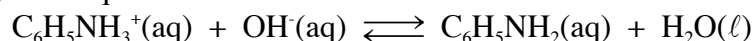


- What was the concentration of the aniline in the original solution?
 - What are the concentrations of H_3O^+ , OH^- and $\text{C}_6\text{H}_5\text{NH}_3^+$ at the equivalence point?
 - What is the pH of the solution at the equivalence point?
16. Construct a rough plot of pH versus volume of base for the titration of 25.0 mL of 0.050 M HCN ($K_a = 4.0 \times 10^{-10}$) with 0.075 M NaOH.
- What is the pH before any NaOH is added?
 - What is the pH at the half-equivalence point of the titration?
 - What is the pH when 15.8 mL of NaOH have been added?
 - What volume of base (in mL) is required to reach the equivalence point?
 - What is the pH at the equivalence point?
 - What is the pH when 19.0 mL of NaOH have been added?

17. The weak base ethanolamine, $\text{HOCH}_2\text{CH}_2\text{NH}_2$, can be titrated with HCl. Assume you have 25.0 mL of a 0.010 M solution of ethanolamine and titrate it with 0.0095 M HCl (K_b for ethanolamine is 3.2×10^{-5} .) The equation:



- What is the pH of the ethanolamine solution before the titration begins?
 - What is the pH at the equivalence point?
 - What is the pH at the half-equivalence point?
 - Calculate the pH of the solution after adding 5.00, 10.0, 20.0 and 30.0 mL of acid.
 - Combine the above information and create an approximate titration curve.
18. Aniline hydrochloride, $(\text{C}_6\text{H}_5\text{NH}_3)\text{Cl}$, is a weak acid with a conjugate base aniline ($\text{C}_6\text{H}_5\text{NH}_2$). The acid can be titrated with a strong base such as NaOH. Assume 50.0 mL of 0.100 M aniline hydrochloride is titrated with 0.185 M NaOH (K_a for aniline hydrochloride is 2.4×10^{-5} .) The equation:



- What is the pH of the $(\text{C}_6\text{H}_5\text{NH}_3)\text{Cl}$ solution before the titration begins?
- What is the pH at the equivalence point?
- What is the pH at the half-equivalence point?
- Calculate the pH of the solution after adding 10.0, 20.0 and 30.0 mL of base.
- Combine the above information to create an approximate titration curve.