CH 223 Practice Problem Set #3

*This is a **practice problem set** and not the actual graded problem set that you will turn in for credit. Answers to each problem can be found at the end of this assignment.*

Covering: **Chapter Fourteen Part II** *and* **Chapter Guide Three**

Important Tables and/or Constants: "**Titration Guide**" *(Handout),* "**Buffers and Henderson-Hasselbalch Guide**" *(Handout)* and the **Table of Acids and Bases for CH 223** *(in problem set #3),* $\mathbf{K_w = 1.00 \times 10^{-14}}$ at 25 °C

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1. Calculate the hydronium ion concentration and pH of the solution that results when 22.0 mL of 0.15 M acetic acid, CH_3CO_2H, is mixed with 22.0 mL of 0.15 M NaOH.
2. For each of the following cases, decide whether the pH is less than 7, equal to 7, or greater than 7.
   a. equal volumes of 0.10 M acetic acid, CH_3CO_2H, and 0.10 M KOH are mixed
   b. 25 mL of 0.015 M NH_3 is mixed with 25 mL of 0.015 M HCl
   c. 150 mL of 0.20 M HNO_3 is mixed with 75 mL of 0.40 M NaOH
3. Does the pH of the solution increase, decrease, or stay the same when you
   a. Add solid ammonium chloride to a dilute aqueous solution of NH_3?
   b. Add solid sodium acetate to a dilute aqueous solution of acetic acid?
   c. Add solid NaCl to a dilute aqueous solution of NaOH?
4. What is the pH of a solution that consists of 0.20 M ammonia, NH_3, and 0.20 M ammonium chloride, NH_4Cl?
5. What is the pH of the solution that results from adding 30.0 mL of 0.015 M KOH to 50.0 mL of 0.015 M benzoic acid?
6. What mass of sodium acetate, $NaCH_3CO_2$, must be added to 1.00 L of 0.10 M acetic acid to give a solution with a pH of 4.50?
7. What is the pH of the buffer solution that contains 2.2 g of NH_4Cl in 250 mL of 0.12 M NH_3? Is the final pH lower or higher than the pH of the original ammonia solution?
8. A buffer is composed of formic acid and its conjugate base, the formate ion.
   a. What is the pH of a solution that has a formic acid concentration of 0.050 M and a sodium formate concentration of 0.035 M?
   b. What must the ratio of acid to conjugate base be to increase the pH by 0.5 unit?
9. Calculate the pH of a solution that has an acetic acid concentration of 0.050 M and a sodium acetate concentration of 0.075 M.
10. Which of the following combinations would be the best to buffer the pH of a solution at approximately 9?
    a. HCl and NaCl
    b. NH_3 and NH_4Cl
    c. CH_3CO_2H and $NaCH_3CO_2$
11. Describe how to prepare a buffer solution from NaH_2PO_4 and Na_2HPO_4 to have a pH of 7.5.
12. A buffer solution was prepared by adding 4.95 g of sodium acetate, $NaCH_3CO_2$, to 2.50×10^2 mL of 0.150 M acetic acid, CH_3CO_2H.
    a. What is the pH of the buffer?
    b. What is the pH of 1.00×10^2 mL of the buffer solution if you add 82 mg of NaOH to the solution?

13. A buffer solution is prepared by adding 0.125 mol of ammonium chloride to 5.00 x 102 mL of 0.500 M solution of ammonia.
    a. What is the pH of the buffer?
    b. If 0.0100 mol of HCl gas is bubbled into 5.00 x 10^2 mL of the buffer, what is the new pH of the solution?
14. Phenol, C_6H_5OH, is a weak organic acid. Suppose 0.515 g of the compound is dissolved in exactly 125 mL of water. The resulting solution is titrated with 0.123 M NaOH.

$$C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^{-1}(aq) + H_2O(l)$$

    a. What is the pH of the original solution of phenol?
    b. What are the concentrations of all of the following ions at the equivalence point: Na^+, H_3O^+, OH^-, and $C_6H_5O^{-1}$?
    c. What is the pH of the solution at the equivalence point?
15. You require 36.78 mL of 0.0105 M HCl to reach the equivalence point in the titration of 25.0 mL of aqueous ammonia.
    a. What was the concentration of NH_3 in the original ammonia solution?
    b. What are the concentrations of H_3O^+, OH^{-1}, and NH_4^+ at the equivalence point?
    c. What is the pH of the solution at the equivalence point?
16. For the titration of 50.0 mL of 0.150 M ethylamine, $C_2H_5NH_2$, with 0.100 M HCl, find the pH at each of the following points and then use that information to sketch the titration curve and decide on an appropriate indicator.
    a. at the beginning, before HCl is added
    b. at the halfway point in the titration
    c. when 75% of the required acid has been added
    d. at the equivalence point
    e. when 10.0 mL more HCl has been added than is required
    f. Sketch the titration curve.
    g. Suggest an appropriate indicator for this titration.
17. You titrate 25.0 mL of 0.10 M NH3 with 0.10 M HCl.
    a. What is the pH of the NH3 solution before the titration begins?
    b. What is the pH at the equivalence point?
    c. What is the pH at the halfway point of the titration?
    d. What indicator in Figure 18.10 could be used to detect the equivalence point?
    e. Calculate the pH of the solution after adding 5.00, 15.0, 20.0, 22.0, and 30.0 mL of the acid. Combine this information with that in parts (a)–(c) and plot the titration curve.
18. Aniline hydrochloride, $(C_6H_5NH_3)Cl$, is a weak acid with a conjugate base aniline ($C_6H_5NH_2$). 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 x 10^{-5}.) The equation: $C_6H_5NH_3^+(aq) + OH^-(aq) \rightleftharpoons C_6H_5NH_2(aq) + H_2O(\ell)$
    a. What is the pH of the $(C_6H_5NH_3)Cl$ solution before the titration begins?
    b. What is the pH at the equivalence point?
    c. What is the pH at the half-equivalence point?
    d. Calculate the pH of the solution after adding 10.0, 20.0 and 30.0 mL of base.

Answers to the Practice Problem Set:

1. $[H_3O^+] = 1.5 \times 10^{-9}$ M; pH = 8.81
2. a. > 7 b. < 7 c. = 7
3. a. decreases b. increases c. no change
4. 9.25
5. 4.38
6. 4.7 g
7. pH = 9.11; lower pH than original solution
8. a. 3.59 b. 0.45
9. 4.92
10. answer (b)
11. 2 mol of base for every 1 mol of acid to some amount of water
12. a. 4.95 b. 5.05
13. a. 9.55 b. 9.50
14. a. pH = 5.62 b. $[Na^+] = 0.0323$ M, $[H_3O^+] = 6.5 \times 10^{-12}$ M, $[OH^-] = 0.0015$ M, $[C_6H_5O^-] = 0.0307$ M c. pH = 11.19
15. a. $[NH_3] = 0.0154$ M b. $[H_3O^+] = 1.9 \times 10^{-6}$ M, $[OH^-] = 5.3 \times 10^{-9}$ M, $[NH_4^+] = 0.00625$ M c. pH = 5.73
16. a. pH = 11.89 b. pH = 10.63 c. pH = 10.15 d. pH = 5.93 e. pH = 2.13 f. WB + SA curve (see titration lab) g. Alizarin or bromcresol purple (two possible examples)
17. a. pH = 11.13 b. pH = 5.28 c. pH = 9.25 d. methyl red (one possible answer) e. at 5.00 mL, pH = 9.85; at 15.00 mL, pH = 9.08; at 20.00 mL, pH = 8.65; at 22.00 mL, pH = 8.39; at 30.00 mL, pH = 2.04; graph = WB + SA curve (see titration lab)
18. a. pH = 2.81 b. pH = 8.72 c. pH = 4.62 d. at 10.00 mL, pH = 4.39; at 20.00 mL, pH = 5.07; at 30.00 mL, pH = 11.84