IONIC EQUILIBRIA IN AQUEOUS SYSTEMS

Chapter 19 Outline

Text Problems: # 12, 15, 16, 18, 19, 42(C), 50, 56(also calculate S in pure water)
+ Supplementary Questions (attached)

Text Sample Problems: The text has a number of excellent sample problems (solved in detail) in each section. I would recommend that you study these problems + the "follow up" problems, which have brief solutions at the end of the chapter.

Sect.	Title and Comments	Required?
1.	Equilibria of Acid-Base Buffers We will also add a section on amino acids/buffers	YES
2.	Acid-Base Titration Curves	YES
3.	Equilibria of Slightly Soluble Ionic Compounds	YES
4.	Equilibria Involving Complex Ions	NO

Chapter 19

Supplementary Homework Questions

Buffers

S1. In a buffer solution, if $[A^-] > [HA]$, which of the following must be true?
a. $pH < pK_a$
b. $pH = pK_a$
c. $pH > pK_a$
d. pH < 7.00
e. pH > 7.00

S2. A buffer solution is 0.080 M in lactic acid ($K_a = 1.8 \times 10^{-4}$) and 0.070 M in sodium lactate. The pH of the solution is
a. 2.86.
b. 3.68.
c. 3.80.
d. 4.18.
e. 4.62.

S3. Which acid, in combination with its conjugate base, would be the best choice to make a buffer of pH = 4.35?
a. acetic acid ($K_a = 1.8 \times 10^{-5}$)
b. benzoic acid ($K_a = 6.3 x 10^{-5}$)
c. formic acid ($K_a = 1.8 \times 10^{-4}$)
d. hydrofluoric ($K_a = 7.2 \times 10^{-4}$)
e. nitrous acid ($K_a = 4.5 \times 10^{-4}$)

S4. If a buffer is made up using 1.00 mole of a weak acid ($pK_a = 5.00$) and 0.90 mole of its conjugate base, which of the following must be true?
a. pH < 5.00
b. pH = 5.00
c. pH > 5.00
d. pH = 7.00
e. pH > 7.00

S5. For each of the solutions below, indicate whether the solution would be a buffer.

a) A solution prepared by adding 1 L of 0.50 M NaOH to 1 L of 2 L of 0.5 M HAc (acetic acid)

b) A solution prepared by adding 1 L of 1.0 M HCl to 2 L of 0.80 M NaAc (sodium acetate)

c) A solution prepared by adding 1 L of 0.50 M H_2CO_3 to 1 L of 0.50 M K_2CO_3

d) A solution prepared by adding 1 L of 0.50 M HCl to 2 L of 0.50 M K_2CO_3

e) A solution prepared by adding 3 L of 0.50 M HCl to 2 L of 0.50 M K_2CO_3

f) A solution prepared by adding 5 L of 0.50 N HCl to 2 L of 0.50 M K_2CO_3

g) A solution prepared by adding 1 L of 0.25 M HNO_3 to 1 L of 0.50 M K_2Prop (potassium propanoate)

h) A solution prepared by adding 1 L of 0.25 M NaOH to 1 L of 0.50 M K_2Prop (potassium propanoate)

S6. The following **independent** questions are on pH calculations in solutions of Arsenic Acid (H_3AsO_4) and its various anions. H_3AsO_4 is a triprotic acid with Acid Dissociation Constants:
$K_a' = 6.0x10^{-3}$, $K_a'' = 1.0x10^{-7}$, $K_a''' = 3.2x10^{-12}$

a) Calculate the pH of a solution prepared by mixing 3.0 L of 0.40 M H_3AsO_4 with 1.0 L of 0.80 M KOH.

b) Calculate the pH of a solution prepared by mixing 3.0 L of 0.40 M H_3AsO_4 with 2.0 L of 0.80 M KOH.

c) Calculate the pH of a solution prepared by mixing 3.0 L of 0.40 M H_3AsO_4 with 4.0 L of 0.80 M KOH.

d) Calculate the pH of a solution prepared by mixing 3.0 L of 0.40 M Na_3AsO_4 with 1.0 L of 0.80 M HNO_3.

e) Calculate the pH of a solution prepared by mixing 3.0 L of 0.40 M Na_3AsO_4 with 2.0 L of 0.80 M HNO_3.

f) Calculate the pH of a solution prepared by mixing 3.0 L of 0.40 M Na_3AsO_4 with 4.0 L of 0.80 M HNO_3.

g) What will be the pH of a buffer solution containing $[H_2AsO_4^-] = 0.40$ M and $[HAsO_4^{2-}] = 0.60$ M?

h) What will be the pH of a buffer solution containing $[HAsO_4^{2-}]$ = 0.40 M and $[AsO_4^{3-}]$ = 0.15 M?

i) What value of the ratio, $[H_2AsO_4^-]/[H_3AsO_4]$, is required to prepare a buffer with pH = 2.60?

j) What value of the ratio, $[HAsO_4^{2-}]/[AsO_4^{3-}]$, is required to prepare a buffer with pH = 10.90?

Titration

S7. 138. mL of 0.105 M KOH was required to completely titrate a 25.00 mL sample of H_3PO_4. Determine the Molarity of the H_3PO_4 sample.

S8. Consider the weak base, pyridine [$C_5H_5N \equiv$ Pyr], which has $K_b = 1.7x10^{-9}$. Titration of pyridine with a strong acid causes formation of the pyridinium ion [$C_5H_5NH^+ \equiv PyrH^+$].

(a) Calculate the pH of a solution formed by adding 30.00 mL of 0.20 M HNO_3 to 50.00 mL of 0.20 M pyridine.

(b) Calculate the pH of a solution formed by adding 50.00 mL of 0.20 M HNO_3 to 50.00 mL of 0.20 M pyridine.

S9. Vitamin C ($C_6H_8O_6$, M = 176.) is a monoprotic acid. To analyze a Vitamin C capsule weighing 0.64 grams by titration, 23.6 mL of 0.120 M NaOH was required. Calculate the mass percent of Vitamin C in the capsule.

S10. When 6.00 grams of a sample of impure Strontium Hydroxide [$Sr(OH)_2$, M = 121.6] is titrated with 0.340 M HNO_3, it takes 224. mL of the strong acid to completely titrate the base. Calculate the mass percent of impurity in the Strontium Hydroxide sample.

Solubility Product

S11. The solubility product of the slightly soluble salt, Ag_2CO_3, is K_{sp}= $6.2x10^{-12}$.

a) What is the solubility and the $[Ag^+]$ and $[CO_3^{2-}]$ concentrations in pure water?

b) What is the solubility in a solution containing Ag_2CO_3 and 0.20 M $AgNO_3$?

c) What is the concentration of silver ions, $[Ag^+]$ in a solution containing Ag_2CO_3 and 0.10 M K_2CO_3?

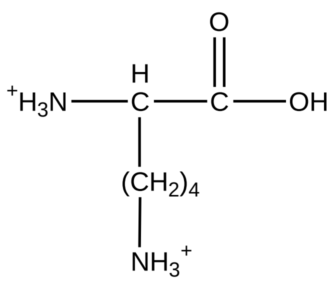
S12. The solubility products of two sparingly soluble Bromide (Br^-) salts are:
AgBr - $K_{sp} = 5.4x10^{-13}$, $HgBr_2$ - $K_{sp} = 6.2x10^{-20}$
Consider a solution which initially contains $5.0x10^{-5}$ M Ag^+(aq) and $5.0x10^{-5}$ M Hg^{2+}(aq). KBr (a strong electrolyte) is added until $[Br^-] = 2.0x10^{-8}$ M. Which of the above salts (AgBr and $HgBr_2$) will precipitate?

S13. Mercury(I) Sulfate, Hg_2SO_4 , is a sparingly soluble salt with $K_{sp} = 6.5x10^{-7}$.

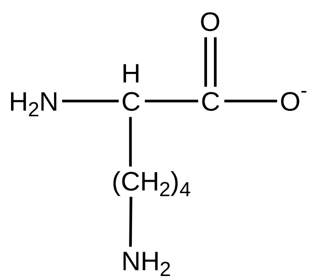
If 1200 mL of 0.010 M K_2SO_4(aq) is mixed with 800 mL of 0.020 M $HgNO_3$(aq), calculate the concentrations of [Hg^+] and [SO_4^{2-}] in the resulting solution and **determine whether or not** Hg_2SO_4(s) will precipitate.

Amino Acids

S14. Consider the amino acid, Lysine. The most positive and most negative forms are shown below:



Lys^{2+}



Lys$^-$

The three pKa's are: pKa'(α-COOH) = 2.18 pKa''(α-NH_3^+) = 8.95 pKa'''(ε-NH_3^+) = 10.53

a) What is the isoelectric point?

b) At what pH does one have 100% Lys$^+$.

c) At what pH does one have 50% Lys and 50% Lys$^-$

d) What is the composition of the solution at pH = 2.18

Answers to the Supplementary Homework Questions are posted on the course web site.
Questions about these Problems will be answered in Recitation