17.2: Controlling pH: Buffer Solutions

Buffer Solutions

17.2.1. The Henderson-Hasselbalch equation is

a. $[H^+] = K_a + \frac{[base]}{[acid]}$

b. $pH = pK_a - \log\frac{[base]}{[acid]}$

c. $pH = pK_a + \log\frac{[base]}{[acid]}$

d. $pH = pK_a + \log\frac{[acid]}{[base]}$

e. $pH = \log\frac{[acid]}{[base]}$

17.2.2. What is the pH of a solution formed by adding 0.20mol HF and 0.20mol of NaF to enough water to make 1.0L of solution? K_a=6.8x10^{-4}

17.2.3. What is the pH of a solution formed by 0.3M HF and 0.1M HCl?

17.2.4. What is the pH of the solution if 0.020mol of NaOH is added to the 1.0L solution formed by adding 0.200mol of HF and 0.200mol of NaF?

17.2.5. What is the ratio of HCO_3^- to H_2CO_3 in our blood that has a pH=7.4? Ka_1=4.3x10^{-7}

17.2.6. How many grams of NH_4Cl must be added to 1.00L of 0.10M NH_3 to form a buffer that has a pH=9.0? K_b=1.8x10^{-5} (Regardless the volume change.)

17.2.7. Which one of the following pairs cannot be mixed to form a buffer solution?

a. H_3PO_4, KH_2PO_4

b. KOH, HF

c. $NaC_2H_3O_2$, HCl

d. NH_3, NH_4Cl

e. RbOH, HBr

17.2.8. Consider a solution containing 0.100M fluoride ion and 0.126M hydrogen fluoride. The concentration of hydrogen fluoride after addition of 5.00mL if 0.0100M HCl to 25.0mL of this solution is _____.

17.2.9. Of the following, which solution has the greatest buffering capacity?

a. 0.821 M HF and 0.217 M NaF
b. 0.821 M HF and 0.909 M NaF
c. 0.100 M HF and 0.217 M NaF
d. 0.121 M HF and 0.667 M NaF
e. They are all buffer solutions and would all have the same capacity.

17.2.10. The K_a of acetic acid is $1.7*10^{-5}$. What is the pH of a buffer prepared by combining 50.0mL of 1.00M potassium acetate and 50.0mL of 1.00M acetic acid?

17.2.11. The K_b of ammonia is $1.8*10^{-5}$. What is the pH of a buffer prepared by combining 50.0mL of 1.00M ammonia and 50.0mL of 1.00M ammonium nitrate?

17.2.12. Calculate the pH of a solution prepared by dissolving 0.25 mol of benzoic acid ($C_7H_5O_2H$) and 0.15 mol of sodium benzoate ($NaC_7H_5O_2$) in 1.00L of solution. $K_a = 6.5*10^{-5}$ for benzoic acid.

17.2.13. Determine the pH of a solution prepared by adding 0.45 mol of solid KOAc to 1.00L of 2.00M HOAc. $K_a = 1.8*10^{-5}$ of HOAc.

17.2.14. The pH of a solution is prepared by dissolving 0.35 mol of solid CH_3NH_3Cl (methylamine hydrochloride) in 1.00L of 1.1 M CH_3NH_2 (methylamine) is _____. The K_b for methylamine is $4.4*10^{-4}$.

17.2.15. Which of the following substances, when added to a solution of hydrofluoric acid, could be used to prepare a buffer solution?

a. HCl
b. $NaNO_3$
c. NaF
d. NaCl
e. NaBr

17.2.16. Which of the following could not be added to a solution of sodium acetate to prepare a buffer?

a. ammonium acetate
b. acetic acid
c. hydrochloric acid
d. nitric acid
e. more than one of these answers is correct

17.2.17. The primary buffer system that controls the pH of the blood is the _____ buffer system.

a. carbon dioxide, carbonate
b. carbonate, bicarbonate
c. carbonic acid, carbon dioxide
d. carbonate, carbonic acid
e. carbonic acid, bicarbonate

17.3: Acid-Base Titrations

Acid-Base Titrations

17.3.1. How many milliliters of 0.0750M NaOH are required to titrate 50.0ml of 0.025M HCl?

17.3.2. How many milliliters of the same NaOH are needed to titrate 25.0ml of HCl solution that has 1.85g of HCl per liter?

17.3.3. How many milliliters of the same NaOH are needed to titrate 20.0ml of 0.050M HBr?

17.3.4. Calculate the pH of the solution formed when 20.0ml of 0.100M NaOH is added to 40.0ml of 0.100M of $HC_2H_3O_2$. Ka=$1.8x10^{-5}$

17.3.5. Calculate the pH at the equivalence point in the titration of 50.0ml of 0.20M $HC_2H_3O_2$ with 0.05M NaOH. Ka=$1.8x10^{-5}$

17.3.6. Determine the pH when 50.0ml of 0.010M NaOH is added to 40.0ml of 0.010M $HC_2H_3O_2$.

17.3.7. Consider the titration of 25.0mL of 0.723M $HClO_4$ with 0.273M KOH.

a. What is the H_3O^+ concentration before any KOH is added?

b. What is the H_3O^+ concentration after addition of 10.0mL of KOH?

c. What is the H_3O^+ concentration after addition of 66.2mL of KOH?

d. What is the H_3O^+ concentration after addition of 80.0mL of KOH?

17.3.8. A _____ yields a titration curve with an initial pH of 1.00, an equivalence point at pH 7.00, and a relatively long, nearly vertical middle section.

a. strong acid titrated by a strong base
b. strong base titrated by a strong acid
c. weak acid titrated by a strong base
d. weak base titrated by a strong acid
e. weak base titrated by a weak acid

17.3.9. An initial pH of 13.00, an equivalence point at pH 7.00 and a relatively long, nearly vertical middle section corresponds to a titration curve for _____.

a. strong acid titrated by a strong base
b. strong base titrated by strong acid
c. weak acid titrated by strong acid
d. weak base titrated by strong acid
e. weak base titrated by weak acid

17.3.10. The pH of a solution prepared by mixing 45mL of 0.183M KOH with a 65mL of 0 .145M HCl is_____?

Titration of Weak Acid by Strong Base

Use the following information to answer questions 17.3.11-17.3.16:

25mL of 0.15M CH_3COOH $K_a = 1.8*10^{-5}$

titrated with 0.15M NaOH

17.3.11. What is the pH at V_B (volume of base) = 0?

17.3.12. What is the pH at V_B = 10mL?

17.3.13. What is the pH at V_B at half equivalence (12.5mL)?

17.3.14. What is the pH at V_B = 15mL?

17.3.15. What is the pH at V_B at equivalence (25mL)?

17.3.16. What is the pH at V_B = 30mL (excess base)?

17.3.17. What is the molarity of an HOAc solution if 25.5mL of this solution required 37.5mL of 0.175M NaOH to reach the equivalence point?

17.3.18. Consider an experiment where 35.0mL of 0.175M HOAc is titrated when 0.25M in NaOH. What is the pH at equivalence point for this titration? The Ka for HOAc is $1.8 * 10^{-5}$.

17.3.19. 50.50mL of 0.116 M HF is titrated with 0.1200 M NaOH. (Ka for HF is $6.8 * 10^{-4}$)

a. How many mL of the base are required to reach the equivalence point?

b. What is the pH after 50.50ML of base has been added?

17.3.20. 65.50mL of 0.161 M HF is titrated where 0.1200 M NaOH. What is the pH at the equivalence point? (Ka for HF is $6.8 * 10^{-4}$)

Titration of Weak Base with Strong Acid

Use the following information to answer questions 17.3.21 – 17.3.26:

25mL of 0.15M NH_3 $K_b = 1.8*10^{-5}$

titrated with 0.15M HCl

17.3.21. What is the pH at V_A (volume of acid) = 0?

17.3.22. What is the pH at V_A = 10mL?

17.3.23. What is the pH at V_A at half equivalence (12.5mL)?

17.3.24. What is the pH at V_A = 15mL?

17.3.25. What is the pH at V_A = 25mL?

17.3.26. What is the pH at V_A = 30mL (excess acid)?

17.4: Solubility of Salts

17.4.1. In which of the following aqueous solutions would you expect AgCl to have the lowest solubility?

a. pure water
b. 0.020 M $BaCl_2$
c. 0.015 M NaCl
d. 0.020 M $AgNO_3$
e. 0.020 M KCl

17.4.2. Given the following table K_{sp} values, determine which compound listed has the greatest solubility.

Compound	K_{sp}
$CdCO_3$	$5.2*10^{-12}$
$Cd(OH)_2$	$2.5*10^{-14}$
AgI	$8.3*10^{-17}$
$Fe(OH)_3$	$4.0*10^{-38}$
$ZnCO_3$	$1.4*10^{-11}$

a. $CdCO_3$
b. $Cd(OH)_2$
c. AgI
d. $Fe(OH)_3$
e. $ZnCO_3$

17.4.3. The solubility of which one of the following will not be affected by the pH of the solution?

a. Na_3PO_4
b. NaF
c. KNO_3
d. $AlCl_3$
e. MnS

17.4.4. Write the expression relating solubility to K_{sp} for silver sulfide.

17.4.5. In which aqueous system is PbI_2 least soluble?

a. H_2O
b. 0.5 M HI
c. 0.2 M HI
d. 1.0 M HNO_3
e. 0.8 M KI

17.4.6. Of the substances below, _____ will <u>decrease</u> the solubility of $Pb(OH)_2$ in a saturated solution.

a. $NaNO_3$
b. H_2O_2
c. HNO_3
d. $Pb(NO_3)_2$
e. NaCl

Solubility Calculations

17.4.7. What is the Pb^{+2} concentration for a saturated solution of $PbSO_4$? $K_{sp}=6.3x10^{-7}$

17.4.8. What is the Pb^{+2} concentration if 0.10mol of Na_2SO_4 is added to 1L of a saturated solution of $PbSO_4$?

17.4.9. What is the solubility of $Ca_3(PO_4)_2$? $K_{sp}=2.0x10^{-29}$

17.4.10. What is the Ca^{2+} concentration for a saturated solution of $Ca_3(PO_4)_2$?

17.4.11. What is the PO_4^{3-} concentration for a saturated solution of $Ca_3(PO_4)_2$?

17.4.12. What is the K_{sp} for MgF_2 if F^-=0.00236M?

17.4.13. If the molar solubility of CaF_2 at 25°C is $1.25x10^{-3}$mol/L, what is the K_{sp} at this temperature?

17.4.14. A saturated solution of NaF contains 4.0 g of salt in 100.0ml of water at 15°C, what is the solubility product for NaF?

17.4.15. The K_{sp} for AgBr is $5.0x10^{-13}$ at 25°C, what is the molar solubility of AgBr?

17.4.16. Calculate the molar solubility of AgBr in 0.10M NaBr solution?

17.4.17. Calculate the solubility of $Mn(OH)_2$ in grams per liter when buffered at pH = 9.50? K_{sp}= $5.0x10^{-13}$

17.4.18. Calculate the concentration of Cu^{2+} at equilibrium when NH_3 is added to a 0.010M $CuCl_2$ solution to produce an equilibrium concentration of $[NH_3]$ = 0.02M. Neglect the volume change when the ammonia is added. $K_f=5x10^{12}$

17.4.19. What is the molar solubility of MgC_2O_4? (K_{sp} for MgC_2O_4 is $8.6*10^{-5}$)

17.4.20. Calculate the concentration (in M) of iodine ions in a saturated solution of lead (II) iodine ($K_{sp} = 1.39*10^{-8}$)

17.4.21. Calculate the molar solubility of silver carbonate ($K_{sp} = 6.15*10^{-12}$)

17.4.22. The concentration (in M) of bromide ions in a saturated solutions of mercury (II) bromide. $K_{sp} = 8.0*10^{-20}$, is _____ M.

17.4.23. The solubility of $AuCl_3$ (as Au^{3+} and Cl^-) in water at 298K is $3.3*10^{-7}$ M. K_{sp} for $AuCl_3$ is _____.

17.4.24. What is the molar solubility of PbS? (K_{sp} (PbS) = $8.0*10^{-28}$)

17.4.25. Calculate the maximum concentration (in M) of sulfide ions in a solution containing 0.181M of lead ions. The K_{sp} for lead sulfide is $3.4*10^{-28}$.

General Questions

17.1. What is the pH of 10-9M HCl (a very dilute strong acid)?

17.2. What is the pH of 6.0M HCl (super strong acid)?

17.3. What is the pH of 10-9M NaOH (very dilute strong base)?

17.4. What is the pH of 6.0M NaOH (very concentrated strong base)?

17: Aqueous Equilibria

17.5. What is the pH of 10-6M HCl (dilute strong acid)?

17.6. What is the pH of 6.0M CH3COOH (concentrated weak acid)?

17.7. Calculate the fluoride ion concentration (in M) in a 1.0L aqueous solution containing 0.40 mol of HF and 0.10 mol of HCl. (K_a for HF = $6.8*10^{-4}$).

17.8. Calculate the pH of 1.0L aqueous solution containing 0.30mol of HF and 0.10mol of HCl. (K_a for HF = $6.8*10^{-4}$)