Chapter 16 Acid-Base Equilibria and Solubility Equilibria

Student: ____

NOTE: A table of ionization constants and K_a's is required to work some of the problems in this chapter.

1. In which one of the following solutions will acetic acid have the greatest percent ionization?

   A. 0.1 M CH_3COOH
   B. 0.1 M CH_3COOH dissolved in 1.0 M HCl
   C. 0.1 M CH_3COOH plus 0.1 M CH_3COONa
   D. 0.1 M CH_3COOH plus 0.2 M CH_3COONa

2. Which one of the following is a buffer solution?

   A. 0.40 M HCN and 0.10 KCN
   B. 0.20 M CH_3COOH
   C. 1.0 M HNO_3 and 1.0 M $NaNO_3$
   D. 0.10 M KCN
   E. 0.50 M HCl and 0.10 NaCl

3. Which one of the following combinations cannot function as a buffer solution?

   A. HCN and KCN
   B. NH_3 and $(NH_4)_2SO_4$
   C. HNO_3 and $NaNO_3$
   D. HF and NaF
   E. HNO_2 and $NaNO_2$

4. Which of the following is the most acidic solution?

   A. 0.10 M CH_3COOH and 0.10 M CH_3COONa
   B. 0.10 M CH_3COOH
   C. 0.10 M HNO_2
   D. 0.10 M HNO_2 and 0.10 M $NaNO_2$
   E. 0.10 M CH_3COONa

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5. Calculate the pH of a buffer solution that contains 0.25 M benzoic acid ($C_6H_5CO_2H$) and 0.15 M sodium benzoate (C_6H_5COONa). [$K_a = 6.5 \times 10^{-5}$ for benzoic acid]

A. 3.97
B. 4.83
C. 4.19
D. 3.40
E. 4.41

6. A solution is prepared by mixing 500. mL of 0.10 M NaOCl and 500. mL of 0.20 M HOCl. What is the pH of this solution? [$K_a(HOCl) = 3.2 \times 10^{-8}$]

A. 4.10
B. 7.00
C. 7.19
D. 7.49
E. 7.80

7. Calculate the pH of a buffer solution prepared by dissolving 0.20 mole of cyanic acid (HCNO) and 0.80 mole of sodium cyanate (NaCNO) in enough water to make 1.0 liter of solution. [$K_a(HCNO) = 2.0 \times 10^{-4}$]

A. 0.97
B. 3.10
C. 4.40
D. 3.70
E. 4.30

8. Calculate the pH of a solution that is 0.410 M in HOCl and 0.050 M in NaOCl. [$K_a(HOCl) = 3.2 \times 10^{-8}$]

A. 0.39
B. 3.94
C. 6.58
D. 7.49
E. 8.40

9. Calculate the pH of a buffer solution prepared by dissolving 0.20 mole of sodium cyanate (NaCNO) and 1.0 mole of cyanic acid (HCNO) in enough water to make 1.0 liter of solution. [$K_a(HCNO) = 2.0 \times 10^{-4}$]

A. 0
B. 3.0
C. 3.7
D. 4.4
E. 5.0

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10. You are asked to go into the lab and prepare an acetic acid - sodium acetate buffer solution with a pH of 4.00 ± 0.02. What molar ratio of CH_3COOH to CH_3COONa should be used?

    A. 0.18
    B. 0.84
    C. 1.19
    D. 5.50
    E. 0.10

11. What is the *net ionic equation* for the reaction that occurs when small amounts of hydrochloric acid are added to a HOCl/NaOCl buffer solution?

    A. $H^+ + H_2O \rightarrow H_3O^+$
    B. $H^+ + OCl^- \rightarrow HOCl$
    C. $HOCl \rightarrow H^+ + OCl^-$
    D. $H^+ + HOCl \rightarrow H_2OCl^+$
    E. $HCl + HOCl \rightarrow H_2O + Cl_2$

12. Consider a buffer solution prepared from HOCl and NaOCl. Which is the net ionic equation for the reaction that occurs when NaOH is added to this buffer?

    A. $OH^- + HOCl \rightarrow H_2O + OCl^-$
    B. $OH^- + OCl^- \rightarrow HOCl + O^{2-}$
    C. $Na^+ + HOCl \rightarrow NaCl + OH^-$
    D. $H^+ + HOCl \rightarrow H_2 + OCl^-$
    E. $NaOH + HOCl \rightarrow H_2O + NaCl$

13. Over what range of pH is a HOCl - NaOCl buffer effective?

    A. pH 2.0 - pH 4.0
    B. pH 7.5 - pH 9.5
    C. pH 6.5 - pH 8.5
    D. pH 6.5 - pH 9.5
    E. pH 1.0 - pH 14.0

14. Assuming equal concentrations of conjugate base and acid, which one of the following mixtures is suitable for making a buffer solution with an optimum pH of 9.2-9.3?

    A. CH_3COONa/CH_3COOH ($K_a = 1.8 \times 10^{-5}$)
    B. NH_3/NH_4Cl ($K_a = 5.6 \times 10^{-10}$)
    C. $NaOCl/HOCl$ ($K_a = 3.2 \times 10^{-8}$)
    D. $NaNO_2/HNO_2$ ($K_a = 4.5 \times 10^{-4}$)
    E. NaCl/HCl

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15. Assuming equal concentrations of conjugate base and acid, which one of the following mixtures is suitable for making a buffer solution with an optimum pH of 4.6-4.8?

    A. CH_3COO_2Na/CH_3COOH ($K_a = 1.8 \times 10^{-5}$)
    B. NH_3/NH_4Cl ($K_a = 5.6 \times 10^{-10}$)
    C. $NaOCl/HOCl$ ($K_a = 3.2 \times 10^{-8}$)
    D. $NaNO_2/HNO_2$ ($K_a = 4.5 \times 10^{-4}$)
    E. NaCl/HCl

16. You have 500.0 mL of a buffer solution containing 0.20 M acetic acid (CH_3COOH) and 0.30 M sodium acetate (CH_3COONa). What will the pH of this solution be after the addition of 20.0 mL of 1.00 M NaOH solution? [$K_a = 1.8 \times 10^{-5}$]

    A. 4.41
    B. 4.74
    C. 4.56
    D. 4.92
    E. 5.07

17. You have 500.0 mL of a buffer solution containing 0.30 M acetic acid (CH_3COOH) and 0.20 M sodium acetate (CH_3COONa). What will the pH of this solution be after the addition of 20.0 mL of 1.00 M NaOH solution? [$K_a = 1.8 \times 10^{-5}$]

    A. 4.65
    B. 4.71
    C. 4.56
    D. 4.84
    E. 5.07

18. Calculate the percent ionization of cyanic acid, $K_a = 2.0 \times 10^{-4}$, in a buffer solution that is 0.50 M HCNO and 0.10 M NaCNO.

    A. 0.02%
    B. 0.10%
    C. 0.20%
    D. 2.0%
    E. 20%

19. In which one of the following solutions will acetic acid have the greatest percent ionization?

    A. 0.1 M CH_3COOH
    B. 0.1 M CH_3COOH dissolved in 0.1 M HCl
    C. 0.1 M CH_3COOH dissolved in 0.2 M HCl
    D. 0.1 M CH_3COOH plus 0.1 M CH_3COONa
    E. 0.1 M CH_3COOH plus 0.2 M CH_3COONa

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20. On the basis of the information below, a buffer with a pH = 9 can best be made by using

Acid	K_a
H_3PO_4	7×10^{-3}
$H_2PO_4^-$	8×10^{-8}
HPO_4^{2-}	5×10^{-13}

A. pure $NaH_2PO_4^-$.
B. $H_2PO_4^- + PO_4^{3-}$.
C. $H_2PO_4^- + HPO_4^{2-}$.
D. $HPO_4^{2-} + PO_4^{3-}$.

21. The pH at the equivalence point of a titration may differ from 7.0 due to

A. the initial concentration of the standard solution.
B. the indicator used.
C. the self-ionization of H_2O.
D. the initial pH of the unknown.
E. hydrolysis of the salt formed.

22. For which type of titration will the pH be basic at the equivalence point?

A. Strong acid vs. strong base.
B. Strong acid vs. weak base.
C. Weak acid vs. strong base.
D. all of the these
E. none of these

23. 50.00 mL of 0.10 M HNO_2 (nitrous acid, $K_a = 4.5 \times 10^{-4}$) is titrated with a 0.10 M KOH solution. After 25.00 mL of the KOH solution is added, the pH in the titration flask will be

A. 2.17
B. 3.35
C. 2.41
D. 1.48
E. 7.00

24. A titration of an acid and base to the equivalence point results in a noticeably acidic solution. It is likely this titration involves

A. a strong acid and a weak base.
B. a weak acid and a strong base.
C. a weak acid and a weak base (where K_a equals K_b).
D. a strong acid and a strong base.

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25. Calculate the pH at the equivalence point for the titration of 0.20 M HCl with 0.20 M NH_3 ($K_b = 1.8 \times 10^{-5}$).

A. 2.87
B. 4.98
C. 5.12
D. 7.00
E. 11.12

26. What is the pH at the equivalence point in the titration of 100 mL of 0.10 M HCl with 0.10 M NaOH?

A. 1.0
B. 6.0
C. 7.0
D. 8.0
E. 13.0

27. What is the pH at the equivalence point in the titration of 100 mL of 0.10 M HCN ($K_a = 4.9 \times 10^{-10}$) with 0.10 M NaOH?

A. 3.0
B. 6.0
C. 7.0
D. 11.0
E. 12.0

28. Calculate the pH of the solution resulting from the addition of 10.0 mL of 0.10 M NaOH to 50.0 mL of 0.10 M HCN ($K_a = 4.9 \times 10^{-10}$) solution.

A. 5.15
B. 8.71
C. 5.85
D. 9.91
E. 13.0

29. Methyl red is a common acid-base indicator. It has a K_a equal to 6.3×10^{-6}. Its un-ionized form is red and its anionic form is yellow. What color would a methyl red solution have at pH = 7.8?

A. green
B. red
C. blue
D. yellow
E. violet

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30. What mass of sodium fluoride must be added to 250. mL of a 0.100 M HF solution to give a buffer solution having a pH of 3.50? (K_a(HF) = 7.1×10^{-4})

A. 0.49 g
B. 1.5g
C. 3.4g
D. 2.3g
E. 0.75 g

31. What mass of ammonium nitrate must be added to 350. mL of a 0.150 M solution of ammonia to give a buffer having a pH of 9.00? ($K_b(NH_3)$ = 1.8×10^{-5})

A. 7.6 g
B. 2.4g
C. 5.4g
D. 11g
E. 3.3g

32. 40.0 ml of an acetic acid of unknown concentration is titrated with 0.100 M NaOH. After 20.0 mL of the base solution has been added, the pH in the titration flask is 5.10. What was the concentration of the original acetic acid solution? ($K_a(CH_3COOH)$ = 1.8×10^{-5})

A. 0.11 M
B. 0.022 M
C. 0.072 M
D. 0.050 M
E. 0.015 M

33. 25.0 mL of a hydrofluoric acid solution of unknown concentration is titrated with 0.200 M NaOH. After 20.0 mL of the base solution has been added, the pH in the titration flask is 3.00. What was the concentration of the original hydrofluoric acid solution. (K_a(HF) = 7.1×10^{-4})

A. 0.39 M
B. 0.27 M
C. 0.16 M
D. 2.4M
E. 0.23 M

34. For $PbCl_2$ (K_{sp} = 2.4×10^{-4}), will a precipitate of $PbCl_2$ form when 0.10 L of 3.0×10^{-2} M $Pb(NO_3)_2$ is added to 400 mL of 9.0×10^{-2} M NaCl?

A. Yes, because Q > $K_{sp.}$
B. No, because Q < $K_{sp.}$
C. No, because Q = $K_{sp.}$
D. Yes, because Q < $K_{sp.}$

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35. The solubility of lead(II) iodide is 0.064 g/100 mL at 20°C. What is the solubility product for lead(II) iodide?

A. 1.1×10^{-8}
B. 3.9×10^{-6}
C. 1.1×10^{-11}
D. 2.7×10^{-12}
E. 1.4×10^{-3}

36. The molar solubility of magnesium carbonate is 1.8×10^{-4} mol/L. What is K_{sp} for this compound?

A. 1.8×10^{-4}
B. 3.6×10^{-4}
C. 1.3×10^{-7}
D. 3.2×10^{-8}
E. 2.8×10^{-14}

37. The molar solubility of manganese(II) carbonate is 4.2×10^{-6} M. What is K_{sp} for this compound?

A. 4.2×10^{-6}
B. 8.4×10^{-6}
C. 3.0×10^{-16}
D. 1.8×10^{-11}
E. 2.0×10^{-3}

38. The molar solubility of tin(II) iodide is 1.28×10^{-2} mol/L. What is K_{sp} for this compound?

A. 8.4×10^{-6}
B. 1.28×10^{-2}
C. 4.2×10^{-6}
D. 1.6×10^{-4}
E. 2.1×10^{-6}

39. The solubility of strontium carbonate is 0.0011 g/100 mL at 20°C. Calculate the K_{sp} value for this compound.

A. 7.5×10^{-5}
B. 1.5×10^{-4}
C. 5.6×10^{-9}
D. 7.5×10^{-6}
E. 1.5×10^{-3}

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40. The molar solubility of lead(II) iodate in water is 4.0×10^{-5} mol/L. Calculate K_{sp} for lead(II) iodate.

A. 1.6×10^{-9}
B. 6.4×10^{-14}
C. 2.6×10^{-13}
D. 4.0×10^{-5}
E. 4.0×10^{-15}

41. The solubility product for chromium(III) fluoride is $K_{sp} = 6.6 \times 10^{-11}$. What is the molar solubility of chromium(III) fluoride?

A. 1.6×10^{-3} M
B. 1.2×10^{-3} M
C. 6.6×10^{-11} M
D. 2.2×10^{-3} M
E. 1.6×10^{-6} M

42. The solubility product for barium sulfate is 1.1×10^{-10}. Calculate the molar solubility of barium sulfate.

A. 5.5×10^{-11} mol/L
B. 1.1×10^{-5} mol/L
C. 2.1×10^{-5} mol/L
D. 1.1×10^{-10} mol/L
E. 2.2×10^{-10} mol/L

43. The K_{sp} for silver(I) phosphate is 1.8×10^{-18}. Calculate the molar solubility of silver(I) phosphate.

A. 1.6×10^{-5} M
B. 2.1×10^{-5} M
C. 3.7×10^{-5} M
D. 7.2×10^{-1} M
E. 1.8×10^{-1} M

44. The solubility product for calcium phosphate is $K_{sp} = 1.3 \times 10^{-26}$. What is the molar solubility of calcium phosphate?

A. 1.3×10^{-26} M
B. 1.5×10^{-7} M
C. 2.6×10^{-6} M
D. 4.6×10^{-6} M
E. 6.6×10^{-6} M

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45. The K_{sp} value for lead(II) chloride is 2.4×10^{-4}. What is the molar solubility of lead(II) chloride?

A. 2.4×10^{-4} mol/L
B. 6.2×10^{-2} mol/L
C. 7.7×10^{-3} mol/L
D. 3.9×10^{-2} mol/L
E. 6.0×10^{-5} mol/L

46. Calculate the silver ion concentration in a saturated solution of silver(I) carbonate ($K_{sp} = 8.1 \times 10^{-12}$).

A. 5.0×10^{-5} M
B. 2.5×10^{-4} M
C. 1.3×10^{-4} M
D. 2.0×10^{-4} M
E. 8.1×10^{-4} M

47. The K_{sp} for silver(I) phosphate is 1.8×10^{-18}. Determine the silver ion concentration in a saturated solution of silver(I) phosphate.

A. 1.6×10^{-5} M
B. 2.1×10^{-5} M
C. 3.7×10^{-5} M
D. 1.1×10^{-13} M
E. 4.8×10^{-5} M

48. Calculate the silver ion concentration in a saturated solution of silver(I) sulfate ($K_{sp} = 1.4 \times 10^{-5}$).

A. 1.5×10^{-2} M
B. 2.4×10^{-2} M
C. 3.0×10^{-2} M
D. 1.4×10^{-5} M
E. none of these

49. Calculate the concentration of chloride ions in a saturated lead(II) chloride ($K_{sp} = 2.4 \times 10^{-4}$) solution.

A. 2.4×10^{-4} M
B. 4.8×10^{-4} M
C. 3.9×10^{-2} M
D. 1.2×10^{-1} M
E. 7.8×10^{-2} M

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50. Calculate the concentration of fluoride ions in a saturated barium fluoride ($K_{sp} = 1.7 \times 10^{-6}$) solution.

A. 7.6×10^{-3} M
B. 1.5×10^{-2} M
C. 3.4×10^{-5} M
D. 1.7×10^{-6} M
E. 3.4×10^{-6} M

51. Which of the following would decrease the K_{sp} for PbI_2?

A. Lowering the pH of the solution
B. Adding a solution of $Pb(NO_3)_2$
C. Adding a solution of KI
D. None of these—the K_{sp} of a compound is constant at constant temperature.

52. Calculate the minimum concentration of Mg^{2+} that must be added to 0.10 M NaF in order to initiate a precipitate of magnesium fluoride. (For MgF_2, $K_{sp} = 6.9 \times 10^{-9}$.)

A. 1.4×10^{7} M
B. 6.9×10^{-9} M
C. 6.9×10^{-8} M
D. 1.7×10^{-7} M
E. 6.9×10^{-7} M

53. Calculate the minimum concentration of Cr^{3+} that must be added to 0.095 M NaF in order to initiate a precipitate of chromium(III) fluoride. (For CrF_3, $K_{sp} = 6.6 \times 10^{-11}$.)

A. 0.023 M
B. 0.032 M
C. 7.7×10^{-8} M
D. 2.9×10^{-9} M
E. 6.9×10^{-10} M

54. Will a precipitate form (*yes* or *no*) when 50.0 mL of 1.2×10^{-3} M $Pb(NO_3)_2$ are added to 50.0 mL of 2.0×10^{-4} M Na_2S? If so, identify the precipitate.

A. Yes, the precipitate is PbS.
B. Yes, the precipitate is $NaNO_3$.
C. Yes, the precipitate is Na_2S.
D. Yes, the precipitate is $Pb(NO_3)_2$.
E. No, a precipitate will not form.

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55. Will a precipitate of magnesium fluoride form when 300. mL of 1.1×10^{-3} M $MgCl_2$ are added to 500. mL of 1.2×10^{-3} M NaF? (K_{sp} (MgF_2) = 6.9×10^{-9})

A. Yes, Q > K_{sp}
B. No, Q < K_{sp}
C. No, Q = K_{sp}
D. Yes, Q < K_{sp}

56. Will a precipitate of magnesium fluoride form when 200. mL of 1.9×10^{-3} M $MgCl_2$ are added to 300. mL of 1.4×10^{-2} M NaF? (K_{sp} (MgF_2) = 6.9×10^{-9})

A. Yes, Q > K_{sp}
B. No, Q < K_{sp}
C. No, Q = K_{sp}
D. Yes, Q < K_{sp}

57. Will a precipitate (ppt) form when 300. mL of 5.0×10^{-5} M $AgNO_3$ are added to 200. mL of 2.5×10^{-7} M NaBr? Answer *yes* or *no*, and identify the precipitate if there is one.

A. Yes, the ppt is $AgNO_3$(s).
B. Yes, the ppt is AgBr(s).
C. Yes, the ppt is NaBr(s).
D. Yes, the ppt is $NaNO_3$(s).
E. No, a precipitate will not form.

58. Will a precipitate (ppt) form when 20.0 mL of 1.1×10^{-3} M $Ba(NO_3)_2$ are added to 80.0 mL of 8.4×10^{-4} M Na_2CO_3?

A. Yes, the ppt is $Ba(NO_3)_2$.
B. Yes, the ppt is $NaNO_3$.
C. Yes, the ppt is $BaCO_3$.
D. Yes, the ppt is Na_2CO_3.
E. No, a precipitate will not form.

59. Will a precipitate (ppt) form when 300. mL of 2.0×10^{-5} M $AgNO_3$ are added to 200. mL of 2.5×10^{-9} M NaI? Answer *yes* or *no*, and identify the precipitate if there is one.

A. Yes, the ppt is $AgNO_3$(s).
B. Yes, the ppt is $NaNO_3$(s).
C. Yes, the ppt is NaI(s).
D. Yes, the ppt is AgI(s).
E. No, a precipitate will not form.

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60. Which response has *both* answers correct? Will a precipitate form when 250 mL of 0.33 M Na_2CrO_4 are added to 250 mL of 0.12 M $AgNO_3$? ($K_{sp}(Ag_2CrO_4) = 1.1 \times 10^{-12}$) What is the concentration of the silver ion *remaining* in solution?

A. Yes, $[Ag^+] = 2.9 \times 10^{-6}$ M.
B. Yes, $[Ag^+] = 0.060$ M.
C. Yes, $[Ag^+] = 1.3 \times 10^{-4}$ M.
D. No, $[Ag^+] = 0.060$ M.
E. No, $[Ag^+] = 0.105$ M.

61. To 1.00 L of a 0.100 M aqueous solution of benzoic acid (C_6H_5COOH) is added 1.00 mL of 12.0 M HCl. What is the percentage ionization of the benzoic acid in the resulting solution? [Given: $K_a(C_6H_5COOH) = 6.5 \times 10^{-5}$]

A. 3.3%
B. 12%
C. 1.3%
D. 0.52%
E. 0.065%

62. To 1.00 L of a 0.100 M aqueous solution of the week base pyridine (C_5H_5N) is added 1.00 mL of 14.0 M NaOH. What fraction of the pyridine molecules in the resulting solution react with water to release hydroxide ions? [Given: $K_b(C_5H_5N) = 1.7 \times 10^{-9}$]

A. 1.2×10^{-7}
B. 4.1×10^{-5}
C. 0.14
D. 2.4×10^{-10}
E. 1.3×10^{-5}

63. Find the concentration of Pb^{2+} ions in a solution made by adding 5.00 g of lead(II) iodide to 500. mL of 0.150 M KI. [For PbI_2, $K_{sp} = 1.39 \times 10^{-8}$.]

A. 3.04×10^{-4} M
B. 1.54×10^{-7} M
C. 6.18×10^{-7} M
D. 1.52×10^{-4} M
E. 9.27×10^{-8} M

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64. Find the concentration of calcium ions in a solution made by adding 3.50 g of calcium fluoride to 750. mL of 0.125 M NaF. [For CaF_2, $K_{sp} = 3.95 \times 10^{-11}$.]

A. 3.16×10^{-10} M
B. 2.53×10^{-9} M
C. 4.29×10^{-4} M
D. 6.32×10^{-10} M
E. 2.15×10^{-4} M

65. A saturated sodium carbonate solution at 0°C contains 7.1 g of dissolved sodium carbonate per 100. mL of solution. The solubility product constant for sodium carbonate at this temperature is

A. 1.2.
B. 0.30.
C. 3.0×10^{-4}.
D. 0.90.
E. 1.2×10^{-3}.

66. A saturated sodium carbonate solution at 100°C contains 45.5 g of dissolved sodium carbonate per 100. mL of solution. The solubility product constant for sodium carbonate at this temperature is

A. 79.0.
B. 0.316.
C. 0.0790.
D. 36.8.
E. 316.

67. What volume of 0.0500 M sodium hydroxide should be added to 250. mL of 0.100 M HCOOH to obtain a solution with a pH of 4.50? [$K_a(HCOOH) = 1.7 \times 10^{-4}$]

A. 540 mL
B. 420 mL
C. 80. mL
D. 340 mL
E. 500. mL

68. What volume of 0.200 M potassium hydroxide should be added to 300. mL of 0.150 M propanoic acid (C_2H_5COOH) to obtain a solution with a pH of 5.25? [$K_a(C_2H_5COOH) = 1.34 \times 10^{-5}$]

A. 32 mL
B. 210mL
C. 160mL
D. 65mL
E. 13mL

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69. What is the effective pH range for a sodium acetate/acetic acid buffer? (For CH_3COOH, $K_a = 1.8 \times 10^{-5}$)

70. Calculate the pH of a solution that is 0.15 M CH_3COOH and 0.75 M CH_3COONa.

71. What is the optimum pH of a sodium formate/formic acid buffer? (For formic acid, $K_a = 1.7 \times 10^{-4}$)

72. Describe how to make a sodium formate (HCOONa)/formic acid (HCOOH) buffer that has a pH of 4.77.

73. Write an equation showing the net reaction that occurs when a strong acid is added to a CO_3^{2-}/HCO_3^- buffer solution (for carbonic acid, $K_{a1} = 4.2 \times 10^{-7}$, $K_{a2} = 2.4 \times 10^{-8}$).

74. Write an equation showing the net reaction that occurs when a strong base is added to a CO_3^{2-}/HCO_3^- buffer solution (for carbonic acid, $K_{a1} = 4.2 \times 10^{-7}$, $K_{a2} = 2.4 \times 10^{-8}$).

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75. Calculate the percent ionization of formic acid in a 0.010 M HCOOH solution. ($K_a = 1.7 \times 10^{-4}$)

76. Calculate the percent ionization of formic acid in a solution that is 0.010 M HCOOH and 0.005 M HCOONa and compare your answer to the percent ionization you would calculate if the sodium formate were not present. Explain the difference, if any. ($K_a = 1.7 \times 10^{-4}$)

77. Calculate the percent ionization of formic acid in a solution that is 0.010 M HCOOH and 0.050 M HCOONa. ($K_a = 1.7 \times 10^{-4}$)

78. What molar ratio of benzoate ion to benzoic acid would be required to prepare a buffer with a pH of 5.20? ($K_a(C_6H_5COOH) = 6.5 \times 10^{-5}$)

79. Write a net ionic equation for the reaction that occurs when a small amount of hydrochloric acid is added to a buffer solution containing NH_4Cl and NH_3 .

80. Write a net ionic equation for the reaction occurring when a small amount of sodium hydroxide solution is added to a buffer solution containing NH_4Cl and NH_3.

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81. Write a net ionic equation for the reaction that occurs when a small amount of nitric acid is added to a $NaNO_2/HNO_2$ buffer.

82. Write a net ionic equation for the reaction occurring when a small amount of sodium hydroxide is added to a $NaNO_2/HNO_2$ buffer.

83. Calculate the pH at the equivalence point for the titration of 0.25 M CH_3COOH with 0.25 M NaOH. (For CH_3COOH, $K_a= 1.8 \times 10^{-5}$)

84. Calculate the pH at the equivalence point for the titration of 0.22 M HCN with 0.22 M NaOH. ($K_a = 4.9 \times 10^{-10}$ for HCN.)

85. Bromothymol blue is a common acid-base indicator. It has a K_a equal to 1.6×10^{-7}. Its un-ionized form is yellow and its conjugate base is blue. What color would a solution have at pH = 5.8?

86. Describe how to prepare 500. mL of a cyanic acid (HCNO)/sodium cyanate (NaCNO) buffer having a pH of 4.80. (K_a(HCNO) = 2.0×10^{-4})

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87. Solid sodium iodide is slowly added to a solution that is 0.0050 M Pb^{2+} and 0.0050 M Ag^{+}. (K_{sp} (PbI_2) = 1.4×10^{-8}; K_{sp} (AgI) = 8.3×10^{-17})

What compound will precipitate first?

88. Solid sodium iodide is slowly added to a solution that is 0.0050 M Pb^{2+} and 0.0050 M Ag^{+}. (K_{sp} (PbI_2) = 1.4×10^{-8}; K_{sp} (AgI) = 8.3×10^{-17})

Calculate the Ag^{+} concentration when PbI_2 just begins to precipitate.

89. Solid sodium iodide is slowly added to a solution that is 0.0050 M Pb^{2+} and 0.0050 M Ag^{+}. (K_{sp} (PbI_2) = 1.4×10^{-8}; K_{sp} (AgI) = 8.3×10^{-17})

What percent of Ag^{+} remains in solution at this point?

90. The K_{sp} of CaF_2 is 4×10^{-11}. What is the maximum concentration of Ca^{2+} possible in a 0.10 M NaF solution?

91. 5.0 mL of 12 M NH_3 is added to 500. mL of 0.050 M $AgNO_3$. What concentration of silver ion will exist after equilibrium is established? (K_f for $Ag(NH_3)_2^{+}$ = 1.5×10^{7})

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92. Will a precipitate of AgCl form when 0.050 mol NaCl(s) and 0.050 mol $AgNO_3$(s) are dissolved in 500. mL of 3.0 M NH_3? (K_f for $Ag(NH_3)_2^+ = 1.5 \times 10^7$; $K_{sp}(AgCl) = 1.6 \times 10^{-10}$)

93. Will $Fe(OH)_3$ precipitate from a buffer solution that is 0.60 M CH_3COOH and 0.10 M CH_3COONa, if the solution is also made to be 0.001 M in Fe^{3+}? (For $Fe(OH)_3$, $K_{sp} = 6.8 \times 10^{-36}$.)

94. The concentration of Mg^{2+} in seawater is 5.0×10^{-2} M. What hydroxide concentration is needed to remove 90% of the Mg^{2+} by precipitation? (For $Mg(OH)_2$, $K_{sp} = 1.2 \times 10^{-11}$.)

95. Ammonium chloride solutions are slightly acidic, so they are better solvents than water for insoluble substances such as $Ca(OH)_2$. Identify two reactions that, added together, give the overall reaction below. Then determine K_c for the overall reaction.
(K_{sp} for $Ca(OH)_2$ is 4.0×10^{-8}; K_b for NH_3 is 1.8×10^{-5}.)

$$Ca(OH)_2(s) + 2NH_4^+(aq) \rightleftharpoons Ca^{2+}(aq) + 2NH_3(aq) + 2H_2O$$

96. Calculate the equilibrium constant K_c for the following overall reaction.
(For AgCl, $K_{sp} = 1.6 \times 10^{-10}$; for $Ag(CN)_2^-$, $K_f = 1.0 \times 10^{21}$)

$$AgCl(s) + 2CN^-(aq) \rightleftharpoons Ag(CN)_2^-(aq) + Cl^-(aq)$$

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97. Calculate the equilibrium constant K_c for the net reaction shown below.
(For AgI, $K_{sp} = 8.3 \times 10^{-17}$; for $Ag(NH_3)_2^+$, $K_f = 1.5 \times 10^7$.)

$$AgI(s) + 2NH_3(aq) \leftrightharpoons Ag(NH_3)_2^+(aq) + I^-(aq)$$

98. The solubility of $Ba(NO_3)_2$ is 130.5 g/L at 0^oC. How many moles of dissolved salt are present in 4.0 L of a saturated solution of $Ba(NO_3)_2$ at 0^oC?

99. A sample of rainwater collected near a lead smelter is analyzed for acid content. Experiments show that a 100. mL sample of the rainwater is neutralized by 22.4 milliliters of 0.0122 M NaOH. Assuming that the acid present is sulfurous acid, which resulted from the reaction of SO_2 with water, what is the molarity of acid in the rainwater?

100. A wildlife biologist is interested in testing the pH of the water in a lake. He obtains a 200. mL sample of the water and titrates this sample with a .050 M NaOH solution. Neutralization of the lake water requires 40. mL of the NaOH solution.

Estimate the pH of the lake.

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101. A wildlife biologist is interested in testing the pH of the water in a lake. He obtains a 200. mL sample of the water and titrates this sample with a .050 M NaOH solution. Neutralization of the lake water requires 40. mL of the NaOH solution.

Is the lake acidic, basic, or neutral?

102. A wildlife biologist is interested in testing the pH of the water in a lake. He obtains a 200. mL sample of the water and titrates this sample with a .050 M NaOH solution. Neutralization of the lake water requires 40. mL of the NaOH solution?

If the size of the lake can be described as 1.1 km long by 2.3 km wide, and has a depth of 10. m, estimate how many moles of acid are present in the lake water.

103. NaCl is added slowly to a solution that is 0.010 M each in Cu^+, Ag^+, and Au^+. The K_{sp}'s for CuCl, AgCl, and AuCl are 1.9×10^{-7}, 1.8×10^{-10}, and 2.0×10^{-13}, respectively. Which compound will precipitate first?

104. A 50.0 mL sample of 2.0×10^{-4} M $CuNO_3$ is added to 50.0 mL of 4.0 M NaCN. The formation constant of the complex ion $Cu(CN)_3^{2-}$ is 1.0×10^{9}. What is the copper(I) ion concentration in this system at equilibrium?

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105. How many moles of NaF must be dissolved in 1.00 liter of a saturated solution of PbF_2 at 25°C to reduce the $[Pb^{2+}]$ to 1.0×10^{-6} M? (K_{sp} of PbF_2 at 25 °C = 4.0×10^{-8})

106. At 25°C, the base ionization constant for NH_3 is 1.8×10^{-5}. Determine the hydroxide ion concentration in a 0.150 M solution of ammonia at 25°C.

107. At 25°C, the base ionization constant for NH_3 is 1.8×10^{-5}. Determine the pH of a solution prepared by adding 0.0500 mol of solid ammonium chloride to 100. mL of 0.150 M ammonia.

108. At 25°C, the base ionization constant for NH_3 is 1.8×10^{-5}. Determine the percentage ionization of a 0.150 M solution of ammonia at 25°C.

109. At 25°C, the base ionization constant for NH_3 is 1.8×10^{-5}. If 0.0800 mole of solid magnesium chloride is dissolved in a solution prepared by adding 0.0500 mol of solid ammonium chloride to 100. mL of 0.150 M ammonia, will a precipitate of magnesium hydroxide form? [Assume the volume of the solution is unchanged. The solubility product constant for magnesium hydroxide is 1.5×10^{-11}.]

110. The percent ionization of a weak acid HA is greater in a solution containing the salt NaA than it is in a solution of the weak acid only.

True False

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111. A mixture made from 10 mL of 1 M HCl and 20 mL of 1 M CH_3COONa would be classified as a buffer solution.

True False

112. All indicators are weak acids that are one color in acidic solution and another color in basic solution.

True False

113. For any conjugate acid-base pair, it is true that $K_b = K_aK_w$.

True False

114. The pH of a solution that is 0.20 M CH_3COOH and 0.20 M CH_3COONa should be *higher* than the pH of a 0.20 M CH_3COOH solution.

True False

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Chapter 16 Acid-Base Equilibria and Solubility Equilibria Key

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1.A

2.A

3.C

4.C

5.A

6.C

7.E

8.C

9.B

10.D

11.B

12.A

13.C

14.B

15.A

16.E

17.B

18.C

19.A

20.C

21.E

22.C

23.B

24.A

25.C

26.C

27.D

28.B

29.D

30.D

31.A

32.C

33.A

34.B

35.A

36.D

37.D

38.A

39.C

40.C

41.B

42.B

43.A

44.C

45.D

46.B

47.E

48.C

49.E

50.B

51.D

52.E

53.C

54.A

55.B

56.A

57.B

58.C

59.D

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60.A

61.D

62.A

63.C

64.B

65.A

66.E

67.B

68.C

69.3.7-5.7

70.5.44

71.3.77

72.Prepare a solution having a molar ratio of 10.0 mol HCOONa to 1.0 mol HCOOH.

73.CO_3^{2-} + H^+ $\rightarrow$ HCO_3^- and HCO_3^- + H^+ $\rightarrow$ H_2CO_3

74.HCO_3^- + OH^- $\rightarrow$ CO_3^{2-} + H_2O

75.13%

76.3.4%; the addition of formate suppresses the ionization of formic acid by shifting the ionization equilibrium towards the un-ionized acid.

77.0.34%

78.10.3

79.H^+ + NH_3 $\rightarrow$ NH_4^+

80.OH^- + NH_4^+ $\rightarrow$ NH_3 + H_2O

81.H^+ + NO_2^- $\rightarrow$ HNO_2

82.OH^- + HNO_2 $\rightarrow$ NO_2^- + H_2O

83.8.92

84.11.18

85.Yellow

86.Dissolve amounts of the two compounds equal to a molar ratio of 12.6 mol NaCNO to 1.0 mol HCNO in enough water to yield 500. mL of solution.

87.AgI

88.5.0×10^{-14} M

89.1.0×10^{-9} %

90.4×10^{-9} M

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91.8.4×10^{-6} M

92.Yes

93.Yes

94.4.9×10^{-5} M

95. $Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$
$2NH_4^+(aq) + 2OH^-(aq) \rightleftharpoons 2NH_3(aq) + 2H_2O$
$K_c = 120$

96. 1.6×10^{11}

97. 1.2×10^{-9}

98.2.0 moles

99.1.37×10^{-3} M

100.2

101.acidic

102.2.5×10^{8} mol

103.AuCl

104.1.3×10^{-14} M

105.0.20 mol

106.1.6×10^{-3} M

107.8.73

108.1.1%

109.Yes

110.FALSE

111.TRUE

112.FALSE

113.FALSE

114.TRUE

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