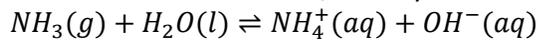


16.1: Brønsted-Lowry Concept of Acids and Bases

Arrhenius & Brønsted Acid/Bases

16.1.1. In the reaction, identify the acid and base.



16.1.2. What is the conjugated acid of NH_3 ?

16.1.3. What is the conjugated base of OH^- ?

16.1.4. What is the conjugated acid of NaHSO_3 ?

16.1.5. What is the conjugated base of NaHSO_3 ?

16.1.6. It is known that the hydride ion H^- is a stronger base than OH^- , what is(are) the product(s) of the reaction: $\text{H}^-(aq) + \text{H}_2\text{O}(l) \rightarrow$

16.2: Water and the pH Scale

pH and Strong Acid/Base

16.2.1. In a sample of lemon juice, $[\text{H}^+]$ is 6.2×10^{-4} M. What is the pH?

16.2.2. A sample of detergent has a pH of 8.20. What is the $[\text{H}^+]$?

16.2.3. What is $[\text{OH}^-]$ of the detergent in Q 16.2.2?

16.2.4. What is the pH of 0.055M of HCl?

16.2.5. What is the pH of 0.001M of $\text{Ca}(\text{OH})_2$?

16.2.6. What is the pOH of the solution in Q 16.2.5?

16.2.7. If 0.56g of CaO is dissolved in the water to make 1.0L solution. What is the pH of the solution?

16: Acids and Bases

16.3: Equilibrium Constants for Acids and Bases

Weak Acids

16.3.1. What is the pH of 0.20M aqueous HF? $K_a = 6.8 \times 10^{-4}$

16.3.2. What is the pH of 0.0050M aqueous HF? $K_a = 6.8 \times 10^{-4}$

16.3.3. Which one is more acidic, 0.2M HF or 0.02M HCl?

16.3.4. What is the pH of 0.04M of NH_4Cl ? $K_a = 5.6 \times 10^{-10}$

16.3.5. A 0.10M solution of lactic acid ($\text{HC}_3\text{H}_5\text{O}_3$, one acidic hydrogen) has a pH of 2.45. What is the K_a for lactic acid?

Weak Base

16.3.6. What is the concentration of OH^- in 0.10M of ethylamine ($\text{C}_2\text{H}_5\text{NH}_2$)? $K_b = 6.4 \times 10^{-4}$

16.3.7. What is the concentration of OH^- in 0.005M of ethylamine ($\text{C}_2\text{H}_5\text{NH}_2$)?

16.3.8. Which solution is more basic, 0.10M of ethylamine or 0.01M of NaOH?

16.3.9. A solution of NH_3 has a pH of 10.25. What is the concentration of the solution? $K_b = 1.8 \times 10^{-5}$

16.3.10. If 1.06g of Na_2CO_3 is dissolved in plenty of water to make 1.0L of solution, what is the pH of the solution? $K_b = 1.8 \times 10^{-4}$

Polyprotic Acids

16.3.11. What is the pH of a 0.002M solution of H_2CO_3 ? $K_{a1} = 4.3 \times 10^{-7}$, $K_{a2} = 5.6 \times 10^{-11}$

16.3.12. What is the concentration of CO_3^{2-} ion in the solution in Q16.3.11?

16: Acids and Bases

16.3.13. What is the pH of a 0.05M of sulfurous acid (H_2SO_3)? $K_{a1}=1.7 \times 10^{-2}$, $K_{a2}=6.4 \times 10^{-8}$

16.3.14. What is the concentration of SO_3^{2-} ion in the solution in Q16.3.13?

16.3.15. What is the concentration of a sample solution of H_2CO_3 that has a pH = 4.50?

16.4: Acid-Base Properties of Salts

Percent Ionization

16.4.1. What is the percent ionization of 0.25 aqueous HF? $K_a = 6.8 \times 10^{-4}$

16.4.2. What is the percent ionization of 0.0055 aqueous HF? $K_a = 6.8 \times 10^{-4}$

16.4.3. What is the percent ionization of 0.05M of NH_4Cl ? $K_a=5.6 \times 10^{-10}$

16.4.4. What is the percent ionization of a 0.002M solution of H_2CO_3 ? $K_{a1}=4.3 \times 10^{-7}$, $K_{a2} = 5.6 \times 10^{-11}$

16.4.5. What is the percent ionization of 0.04M of hydrazoic acid (HN_3)? $K_a=1.9 \times 10^{-5}$

pH of various salts

16.4.6. What is the pH of 0.05M of NH_4Cl ? $K_a=5.6 \times 10^{-10}$

16.4.7. What is the pH of 0.05M of NaClO ? $K_b=3.3 \times 10^{-7}$

16.4.8. What is the pH of 0.05M of NaHCO_3 ? $K_b=2.3 \times 10^{-8}$

16.4.9. What is the pH of 0.05M of KF ? $K_b=1.5 \times 10^{-11}$

16.4.10. How many grams of NaHCO_3 will be used to make a 1.0L solution that has a pH = 9.0?

16.5: Acid-Base Equilibrium Calculations

Acid anhydrides

- 16.5.1. What is the pH of the solution if 0.05mol of SO_3 is dissolved in the water to make 1.0L solution? (SO_3 is very soluble.)
- 16.5.2. How many grams of SO_3 is needed to make a 1.0L solution that has a pH=1.0?
- 16.5.3. What is the pH of the solution if 0.002mol of CO_2 is dissolved in the water to make 1.0L solution at 25°C and 0.1atm? (The solubility of CO_2 in pure water at 25°C and 0.1atm is 0.0037M.) $K_{a1}=4.3 \times 10^{-7}$, $K_{a2} = 5.6 \times 10^{-11}$
- 16.5.4. What is the concentration of CO_3^{2-} ion in the solution in Q4?
- 16.5.5. How many grams of CO_2 is needed at 25°C and 0.1atm to make a 1.0L solution that has a pH=4.50?

Basic Anhydrides

- 16.5.6. What is the pH of the solution that is prepared by dissolving 0.62g of Na_2O in enough water to make 1.0L?
- 16.5.7. How many grams of Na_2O is needed to make a 1.0L solution that has a pH=13.0?
- 16.5.8. What is the pH of the solution that is prepared by dissolving 0.56g of CaO in the water to make 1.0L?
- 16.5.9. How many grams of CaO is needed to make a 1.0L solution that has a pH = 13.0?
- 16.5.10. If 100.0ml of the solution in Q4 is transferred to a 500.0ml container, and plenty water was added to fill it up, what is the pH of the solution?

16: Acids and Bases

Polyprotic Acid Calculations

Consider 0.50M of H_2SeO_3 for the following questions.

$$K_{a1}=2.7 \times 10^{-5}$$

$$K_{a2}=2.5 \times 10^{-9}$$

16.5.11. What is the pH of H_2SeO_3 ?

16.5.12. What is the concentration of H^+ ?

16.5.13. What is the concentration of HSeO_3^- ?

16.5.14. What is the concentration of H_2SeO_3 ?

16.5.15. What is the concentration of OH^- ?

16.5.16. What is the concentration of SeO_3^{2-} ?

16.7: Lewis Concept of Acids and Bases

16.7.1. CO can form complexes with metals, eg. $\text{Fe}(\text{CO})_5$, $\text{Ni}(\text{CO})_4$. Is CO a Lewis acid or a Lewis base?

16.7.2. In Q 16.6.1, Is the metal, such as Fe(II), a Lewis acid or a Lewis base?

16.7.3. In the reaction, $\text{Zn}(\text{OH})_2(\text{s}) + 2\text{OH}^- \rightleftharpoons \text{Zn}(\text{OH})_4^{2-}(\text{aq})$, Which one is the Lewis acid?

16.7.4. In the reaction, $\text{CO}_2 + \text{O}^{2-} \rightarrow \text{CO}_3^{2-}$, Which one is the Lewis acid or base?

16.7.5. Can CH_3NH_2 be a Lewis acid or a Lewis base?

16.7.6. Trimethylamine $(\text{CH}_3)_3\text{N}$ can react with diborane B_2H_6 after its dissociation to form $(\text{CH}_3)_3\text{N}-\text{BH}_3$. Which one is the Lewis acid? Which one is the Lewis base?

16.7.7. In the reaction, $\text{H}_2\text{NOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow [\text{H}_3\text{NOH}]\text{Cl}(\text{aq})$, which one is the Lewis base?

16: Acids and Bases

16.7.8. In the reaction, $SO_2(g) + BF_3(g) \rightarrow O_2S - BF_3(s)$, which one is the lewis acid? and the lewis base?

General Questions

16.1. Which of the following would be considered a base according to the Bronsted-Lowry definition but not by the Arrhenius definition?

- a. $Ba(OH)_2$ (aq)
- b. HBr (g)
- c. HF (g)
- d. KOH (aq)
- e. NH_3 (g)

16.2. Which of the following is a Bronsted-Lowry acid?

- a. $(CH_3)_3NH^+$
- b. CH_3COOH
- c. HF
- d. HNO_2
- e. all of these

16.3. Which one is more acidic, HNO_2 or HNO_3 ?

16.4. Which one is more acidic H_3AsO_3 or H_3AsO_4 ?

16.5. List the acids in order of increasing acid strength: $HClO_2$, $HBrO_2$, HIO_2

16.6. List the compounds in order of increasing acid strength: AsH_3 , HBr, NaH, H_2O

16.7. List the compounds in order of increasing acid strength: H_2TeO_3 , H_2TeO_4 , H_2O

16.8. What is the conjugate acid of NH_3 ?

16.9. What is the conjugate base of OH^- ?

16.10. The following acids are listed in order of increasing strength. List their conjugate bases in order of increasing strength. HCN, CH_3COOH , HF, $HClO_4$:

16.11. The hydride ion, (H^-), is a stronger base than the hydroxide ion, (OH^-). The products of the reaction $H^-(aq) + H_2O(l) \rightarrow$ products are _____.

16: Acids and Bases

- 16.12. The magnitude of K_w indicated that
- a. water autoionizes very slowly
 - b. water autoionizes very quickly
 - c. water autoionizes only to a very small extent
 - d. the autoionization of water is exothermic
 - e. the autoionization of water is endothermic
- 16.13. What is the concentration of water in pure water?
- a. 18 M
 - b. 100 M
 - c. 55 M
 - d. 0.100 M
 - e. 83 M
- 16.14. What is the pH of a solution in which the molar concentration of HCl is 1.3×10^{-11} ?
- 16.15. What is the pH of a 0.015 M solution of barium hydroxide?
- 16.16. What is the pH of an aqueous solution at 25°C in which $[H^+]$ is 0.0025 M?
- 16.17. What is the pH of a solution that contains 3.98×10^{-9} M hydronium ion at 25°C?
- 16.18. Calculate the pOH of a solution at 25°C that contains 1.94×10^{-10} M hydronium ions.
- 16.19. Which solution below has the highest concentration of hydroxide ions?
- a. pH = 3.21
 - b. pH = 12.59
 - c. pH = 7.93
 - d. pH = 9.82
 - e. pH = 7.00
- 16.20. What is the $[H^+]$ of an aqueous solution whose pH is 8.11?
- 16.21. What is the concentration of H^+ in a solution at 25°C with a pH of 7.35?
- 16.22. What is the $[OH^-]$ and pH of a 0.035M KOH solution at 25°C?
- 16.23. The pH of a 0.011 M NaOH solution at 25°C is _____.

16: Acids and Bases

- 16.24. Which of the following possesses the greatest concentration of hydroxide ion?
- a solution with a pH of 3.0
 - a 1×10^{-4} M solution of HNO_3
 - a solution with a pOH of 12.0
 - pure water
 - a 1×10^{-3} M solution of NH_4Cl

16.25. What is the pH of a 0.053 M solution of $\text{Ca}(\text{OH})_2$?

16.26. The pH of a 0.030 M HCl solution at 25°C is _____.

16.27. What is the $[\text{H}^+]$ and pH of a 0.0037 M HBr solution at 25°C ?

16.28. What is the conjugate base of HSO_4^- . Conjugate acid?

- 16.29. Which of the following acids is not a strong acid?
- H_2CO_3
 - H_2SO_4
 - HNO_3
 - HClO_4
 - HCl

16.30. What molar concentration of aqueous barium hydroxide would have pH = 12.25?

16.31. What molar concentration of aqueous hydrochloric acid would have a pH = 9.50? It is not possible for a solution of hydrochloric acid to have a pH = 9.50

- 16.32. Which one of the following is the weakest acid?
- HF ($K_a = 6.8 \times 10^{-4}$)
 - HClO ($K_a = 3.0 \times 10^{-8}$)
 - HNO_2 ($K_a = 4.5 \times 10^{-4}$)
 - HCN ($K_a = 4.9 \times 10^{-10}$)
 - Acetic Acid ($K_a = 1.8 \times 10^{-5}$)

16.33. Using the table below, which is the strongest acid?

Acid	K_a
HOAc	1.8×10^{-5}
HCHO ₂	1.8×10^{-4}
HClO	3.0×10^{-8}
HF	6.8×10^{-4}

16.34. What is the percent ionization of hypochlorous acid (HClO) in a 0.015 M aqueous solution of HClO at 25°C ? ($K_a = 3.0 \times 10^{-8}$)

16: Acids and Bases

16.35. A 0.15M aqueous solution of the weak acid HA at 25°C has a pH of 5.35. What is the value of K_a for HA?

16.36. The K_a of HClO is 3.0×10^{-8} . What is the pH at 25°C of an aqueous solution that is 0.020M in HClO?

16.37. The K_a of HF is 6.8×10^{-4} . What is the pH of a 0.35M solution of HF?

16.38. A 0.25M solution of the weak acid HX has a pH of 4.15. What is the value of K_a for HX?

16.39. A 0.0035M aqueous solution of a compound has a pH=2.46. The compound is

- a. a weak base
- b. a weak acid
- c. a strong acid
- d. a strong base
- e. a salt

16.40. In which of the following aqueous solution does the weak acid exhibit the highest percentage ionization?

- f. 0.01M $\text{HC}_2\text{H}_2\text{C}_2$ ($K_a = 3.0 \times 10^{-8}$)
- g. 0.01M HNO_2 ($K_a = 4.5 \times 10^{-4}$)
- h. 0.01M HF ($K_a = 6.8 \times 10^{-4}$)
- i. 0.01M HClO ($K_a = 3.0 \times 10^{-8}$)
- j. These will all exhibit the same percentage ionization

16.41. An aqueous solution of phosphoric acid has a concentration of 2.5M. ($K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, $K_{a3} = 4.2 \times 10^{-13}$)

- a. What is the pH?
- b. What is the molar concentration of phosphate ion?

16.42. Which species from the following list would be the strongest Bronsted-Lowry base?

- a. Cl^-
- b. Br^-
- c. NO_3^-
- d. F^-
- e. ClO^-

16: Acids and Bases

16.43. Which of the following ions will act as a weak base in water?

- a. OH^-
- b. Cl^-
- c. NO_3^-
- d. ClO^-
- e. None of these will act as a weak base in water

16.44. The pH of a 0.10M solution of a weak base is 9.82. What is the K_b for this base?

16.45. Given that the K_a for gallic acid, ($\text{HC}_7\text{H}_5\text{O}_5$) is 4.57×10^{-3} , what is the K_b for the gallate ion ($\text{NaC}_7\text{H}_5\text{O}_5$)? $T = 25^\circ\text{C}$

16.46. K_b for $\text{C}_5\text{H}_5\text{N}$ is 1.4×10^{-9} . K_a for $\text{C}_5\text{H}_5\text{NH}^+$ is _____. $T = 25^\circ\text{C}$

16.47. K_a for HF is 7.0×10^{-4} . K_b for the fluoride ion is _____.

16.48. Calculate the pOH of a 0.0827M aqueous sodium cyanide solution at 25°C (for CN^- , $K_b = 4.9 \times 10^{-10}$).

16.49. Determine the pH of a 0.15M solution of KF. For hydrofluoric acid, $K_a = 7.0 \times 10^{-4}$.

16.50. Calculate the pH of 0.726M anilinium hydrochloride, ($\text{C}_6\text{H}_5\text{NH}_3\text{Cl}$) solution in water given that K_b for aniline is 3.83×10^{-4} .

16.51. The K_a for formic acid (HCHO_2) is 1.8×10^{-4} . What is the pH of a 0.35M solution of sodium formate (NaCHO_2)?

16.52. A 0.1M aqueous solution of _____ will have the highest pH.

- a. KCN, K_a of HCN = 4.0×10^{-10}
- b. NH_2NO_3 , K_b of $\text{NH}_3 = 1.8 \times 10^{-5}$
- c. NaOAc, K_a of HOAc = 1.8×10^{-5}
- d. NaClO, K_a of HClO = 3.2×10^{-8}
- e. NaHS, K_b of $\text{HS}^- = 1.8 \times 10^{-7}$

16: Acids and Bases

16.53. A 0.1M solution of _____ has a pH of 7.0.

- a. Na_2S
- b. KF
- c. NaNO_3
- d. NH_3Cl
- e. NaF

16.54. K_a of HX is 7.5×10^{-12} . What is the pH of a 0.15M solution of NaX ?

16.55. Of the following, which is the strongest acid?

- a. HIO
- b. HIO_4
- c. HIO_2
- d. HIO_3
- e. The acid strength of all these is nearly the same.

16.56. Of the following, the acid strength of _____ is the greatest.

- a. CH_3COOH
- b. ClCH_2COOH
- c. Cl_2CHCOOH
- d. Cl_3CCOOH
- e. BrCH_2COOH

16.57. Of the following, _____ is the strongest acid.

- a. $\text{Cl}_3\text{C-COOH}$
- b. $\text{H}_3\text{C-COOH}$
- c. $\text{Br}_2\text{C-COOH}$
- d. $\text{F}_3\text{C-COOH}$
- e. $\text{Br}_2\text{ClC-COOH}$

16.58. Which of the following acids will be the strongest?

- a. H_2SO_4
- b. HSO_4^-
- c. H_2SO_3
- d. H_2SeO_4
- e. HSO_3^-

16.59. The more electronegative X is, the _____ polar will be the H-X bond and the _____ easily the H-X bond is broken, making HX more _____ acidic.

- a. more, less, weakly
- b. more, more, weakly
- c. more, more, strongly
- d. more, less, strongly
- e. less, less, strongly

16: Acids and Bases

16.60. Which one of the following cannot act as a Lewis base?

- a. Cl^-
- b. NH_3
- c. BF_3
- d. CN^-
- e. H_2O