18.1 Introduction to Acids and Bases

1. Name the following compounds as acids:

_____a. H_2SO_4 _____d. $HClO_4$

_____b. H_2SO_3 _____e. HCN

_____c. H_2S

2. Which (if any) of the acids mentioned in item **1** are binary acids?

3. Write formulas for the following acids:

_____a. nitrous acid _____d. acetic acid

_____b. hydrobromic acid _____e. hypochlorous acid

_____c. phosphoric acid

5. Identify the Brønsted-Lowry acid and the Brønsted-Lowry base on the reactant side of each of the following equations for reactions that occur in aqueous solution. Explain your answers.

a. $H_2O(l) + HNO_3(aq) \rightarrow H_3O^+(aq) + NO_3^-(aq)$

_____

_____

b. $HF(aq) + HS^-(aq) \rightarrow H_2S(aq) + F^-(aq)$

_____

_____

Example Problem 1

Identifying Conjugate Acid-Base Pairs

Identify the conjugate acid-base pairs in this reaction.

$$HClO_2(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + ClO_2^-(aq)$$

6. Identify the conjugate acid-base pairs in the following reactions.

a. $H_2SO_3(aq) + H_2O(l) \leftrightarrow HSO_3^-(aq) + H_3O^+(aq)$

b. $HPO_4^{2-}(aq) + H_2O(l) \leftrightarrow H_2PO_4^-(aq) + OH^-(aq)$

c. $HSeO_3^-(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + SeO_3^{2-}(aq)$

7. Write the steps in the complete ionization of the following polyprotic acids.

a. carbonic acid (H_2CO_3)

b. chromic acid (H_2CrO_4)

8. Answer the following questions according to the Brønsted-Lowry definitions of acids and bases:

_____ a. What is the conjugate base of H_2SO_3?

_____ b. What is the conjugate base of NH_4^+?

_____ c. What is the conjugate base of H_2O?

_____ d. What is the conjugate acid of H_2O?

_____ e. What is the conjugate acid of $HAsO_4^{2-}$?

18.2 Strengths of Acids and Bases

Strong Acid: _____

Strong Base: _____

List the strong acids: _____

List the strong bases: _____

18. Write the formula for the salt formed in each of the following neutralization reactions, and identify if the salt is acidic, basic, or neutral:

_____ a. potassium hydroxide combined with phosphoric acid

_____ b. calcium hydroxide combined with nitrous acid

_____ c. hydrobromic acid combined with barium hydroxide

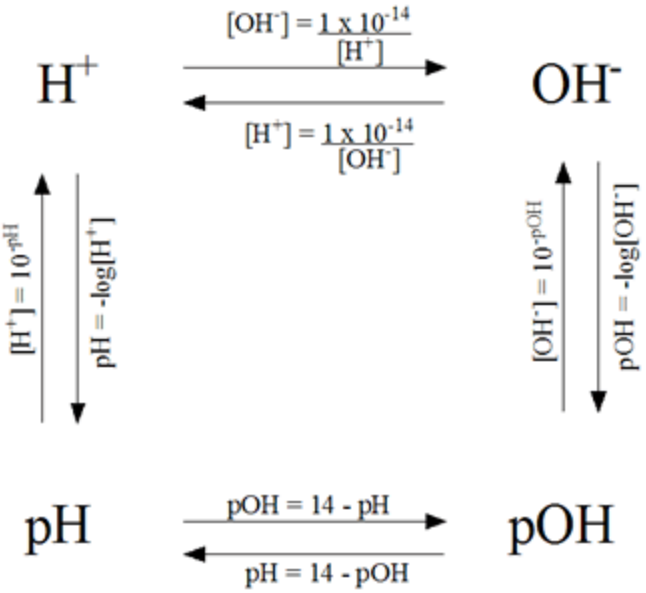
_____ d. lithium hydroxide combined with sulfuric acid

18.3 Hydrogen Ions and pH

Example Problem 2

Using K_w to Calculate $[H^+]$ and $[OH^-]$

At 298 K, the OH^- ion concentration of an aqueous solution is $1.0x10^{-11}M$. Find the H^+ ion concentration in the solution and determine whether the solution is acidic, basic, or neutral.



20. Given the concentration of either hydrogen ion or hydroxide ion, calculate the concentration of the other ion at 298 K and state whether the solution is acidic, basic, or neutral.

- **a.** $[OH^-] = 1.0x10^{-6}M$
- **b.** $[H^+] = 1.0x10^{-7}M$
- **c.** $[H^+] = 8.1x10^{-3}M$

Example Problem 3

Calculating pH and pOH from $[H^+]$

If a certain carbonated soft drink has a hydrogen ion concentration of $7.3x10^{-4}M$, what are the pH and pOH of the soft drink?

21. Calculate the pH and pOH of aqueous solutions having the following ion concentrations.

- **a.** $[H^+] = 1.0x10^{-14}M$
- **b.** $[OH^-] = 5.6x10^{-8}M$
- **c.** $[H^+] = 2.7x10^{-3}M$
- **d.** $[OH^-] = 0.061M$

Example Problem 4

Calculating $[H^+]$ and $[OH^-]$ from pH

What are $[H^+]$ and $[OH^-]$ in an antacid solution with a pH of 9.70?

Use pH to find $[H^+]$.

22. The pH or pOH is given for three solutions. Calculate $[H^+]$ and $[OH^-]$ in each solution.

- **a.** pH = 2.80
- **b.** pH = 13.19
- **c.** pOH = 8.76

23. Calculate the pH of the following strong acid or strong base solutions.

- **a.** $0.015M$ HCl
- **b.** $0.65M$ KOH
- **c.** $2.5x10^{-4}M$ HNO_3
- **d.** $4.0x10^{-3}M$ $Ca(OH)_2$

25. Calculate the following values

_____a. The [H3O+] is 1 x 10-6 M in a solution. Calculate the [OH-].
_____b. The [H3O+] is 1 x 10-9 M in a solution. Calculate the [OH-].
_____c. The [OH-] is 1 x 10-12 M in a solution. Calculate the [H3O+].
_____d. The [OH-] in part c is reduced by half, to 0.5 x 10-12 M. Calculate the [H3O+].
_____e. The [H3O+] and [OH-] are ____ (directly, inversely, or not) proportional in any system involving water.

26. Calculate the following values

_____a. The pH of a solution is 2.0. Calculate the pOH.
_____b. The pOH of a solution is 4.73. Calculate the pH.
_____c. The [H3O+] in a solution is 1 x 10-3 M. Calculate the pH.
_____d. The pOH of a solution is 5.0. Calculate the [OH-].
_____e. The pH of a solution is 1.0. Calculate the [OH-].

27. Calculate the following values.

_____a. The $[H_3O+]$ is 2.34×10^{-5} M in a solution. Calculate the pH.
_____b. The pOH of a solution is 3.5. Calculate the [OH-].
_____c. The $[H_3O+]$ is 4.6×10^{-8} M in a solution. Calculate the [OH-].

28. $[H_3O+]$ in an aqueous solution = 2.3×10^{-3} M.

_____a. Calculate [OH-] in this solution.
_____b. Calculate the pH of this solution.
_____c. Calculate the pOH of this solution.
_____d. Is the solution acidic, basic, or neutral? Explain your answer.

29. Consider a dilute solution of 0.025 M Ba(OH)2 in answering the following questions.

_____a. What is the [OH-] in this solution? Explain your answer.
_____b. What is the pH of this solution?

Example Problem 6

Calculating Concentration from Titration Data

In a titration, 53.7 mL 0.100*M* HCl solution is needed to neutralize 80.0 mL of KOH solution. What is the molarity of the KOH solution?

Practice Problems

31. A 45.0-mL sample of nitric acid solution is neutralized by 119.4 mL 0.200*M* NaOH solution. What is the molarity of the nitric acid solution?

32. What is the molarity of a CsOH solution if 29.61 mL 0.2500*M* HCl is needed to neutralize 60.00 mL solution?

33. A 70.0-mL sample of nitric acid solution is neutralized by 256.3 mL 0.100*M* NaOH solution. What is the molarity of the nitric acid solution?

Chapter 18 Concept Review

39. How does the pH of an aqueous solution change when there is a decrease in the concentration of hydroxide ions? Explain your answer.

40. Solution A has a pH of 9.0, and solution B has a pOH of 3.0. State whether each solution is acidic, basic, or neutral. Which solution has a higher concentration of hydrogen ions?

41. What is the molarity of a solution of HCl if the pH of the solution is 2.00?

42. How can you detect the equivalence point of an acid-base titration?

43. A chemist prepares a buffer solution by dissolving sodium formate (NaHCOO) and another substance in water. What is the other substance likely to be? Explain your answer.