
# Chapter 10

## Summary of Terms

**Acid** A substance that donates hydrogen ions.

**Acidic** Said of a solution in which the hydronium ion concentration is higher than the hydroxide ion concentration.

**Amphoteric** A description of a substance that can behave as either an acid or a base.

**Base** A substance that accepts hydrogen ions.

**Basic** Said of a solution in which the hydroxide ion concentration is higher than the hydronium ion concentration. Also sometimes called alkaline.

**Buffer solution** A solution that resists large changes in pH, made from either a weak acid and one of its salts or a weak base and one of its salts.

**Hydronium ion** A polyatomic ion made by adding a proton (hydrogen ion) to a water molecule.

**Hydroxide ion** A polyatomic ion made by removing a proton (hydrogen ion) from a water molecule.

**Neutral** Said of a solution in which the hydronium ion concentration is equal to the hydroxide ion concentration.

**Neutralization** A reaction between an acid and a base.

**pH** A measure of the acidity of a solution, equal to the negative logarithm of the hydronium ion concentration.

**Salt** An ionic compound commonly formed from the reaction between an acid and a base.

## Review Questions

### 10.1 Exchanging Protons

1. What are the Brønsted–Lowry definitions of acid and base?

2. When an acid is dissolved in water, what ion does the water form?

3. When a chemical loses a hydrogen ion, is it behaving as an acid or a base?

### 10.2 Acid and Base Strength

4. What does it mean to say that an acid is strong in aqueous solution?

5. Why does a solution of a strong acid conduct electricity better than a solution of a weak acid having the same concentration?

6. When can a solution of a weak base be more corrosive than a solution of a strong base?

### 10.3 Acidic, Basic, or Neutral

7. Is water a strong acid or a weak acid?

8. What is true about the relative concentrations of hydronium and hydroxide ions in an acidic solution? How about a basic solution? A neutral solution?

9. What does the pH of a solution indicate?

10. As the hydronium ion concentration of a solution increases, does the pH of the solution increase or decrease?

### 10.4 Buffers Resist pH Changes

11. What is a buffer solution?

12. A strong acid quickly drops the pH when added to water. Not so when added to a buffer solution. Why?

13. Why is it so important that the pH of our blood be maintained within a narrow range of values?

### 10.5 Rainwater Is Acidic

14. What is the product of the reaction between carbon dioxide and water?

15. What does sulfur dioxide have to do with acid rain?

16. How do humans generate the air pollutant sulfur dioxide?

## Quantitative Questions

17. Show that the hydroxide ion concentration in an aqueous solution is $1 \times 10^{-4}$ M when the hydronium ion concentration is $1 \times 10^{-10}$ M? Recall that $10^a \times 10^b = 10^{(a+b)}$.

18. When the hydronium ion concentration of a solution is $1 \times 10^{-10}$ M, what is the pH of the solution? Is the solution acidic or basic?

19. When the hydronium ion concentration of a solution is $1 \times 10^{-4}$ M, what is the pH of the solution? Is the solution acidic or basic?

20. Show that an aqueous solution having a pH of 5 has a hydroxide ion concentration of $1 \times 10^{-9}$ M.

21. When the pH of a solution is 1, the concentration of hydronium ions is $10^{-1}$ M = 0.1 M. Assume that the volume of this solution is 500 mL. What is the pH after 500 mL of water is added? You will need a calculator with a logarithm function to answer this question.

22. Show that the pH of a solution is –0.301 when its hydronium ion concentration equals 2 moles per liter. Is the solution acidic or basic?

23. Rank the following solutions in order of increasing concentration of hydronium ions, $H_3O+$.

    a) Hydrogen Chloride, HCl (concentration = 2 M)

    b) Acetic Acid, $CH_3COOH$ (concentration = 2 M)

    c) Ammonia, $NH_3$ (concentration = 2 M)

## Solutions (Odd-Numbered)

1. The Brønsted-Lowry definition of an acid and base says that an acid is any chemical that donates a hydrogen ion and a base is any chemical that accepts a hydrogen ion.

3. A chemical that loses a hydrogen ion is behaving as an acid.

5. A solution of a strong acid has more ions in solution, which means it can conduct electricity better than a weak acid.

7. Water is a weak acid.

9. The pH of a solution indicates the acidity of the solution as judged by the concentration of hydronium ions.

11. A buffer solution is any solution that resists changes in pH.

13. A pH of blood that is too high or too low can be lethal.

15. Sulfur dioxide combines with oxygen and water in the air to make sulfuric acid.

17. The product of the hydroxide ion and hydronium ion concentration is always equal to $1 \times 10^{-14}$. So, if the hydroxide ion concentration equals $1 \times 10^{-4}$ M, then the hydronium ion concentration must be equal to $1 \times 10^{-10}$ M, because these two values multiply together to equal $1 \times 10^{-14}$.

19. The pH is of this solution is 4 and it is acidic.

21. The concentration of hydronium ions in the pH = 1 solution is 0.1M. Doubling the volume of solution with pure water means that its concentration is cut in half. The new concentration of hydronium ions after the addition of 500 mL of water, therefore, is 0.05 M. To calculate for pH:

$$pH = -\log [H_3O+] = -\log (0.05) = -(-1.3) = 1.3$$

23. All of these solutions have the same concentration. The difference between them is their acid strength. As discussed in the text, hydrogen chloride is a strong acid, which means nearly all of the hydrogen chloride molecules donate hydrogen ions to form hydronium ions. Acetic acid is a weak acid, which means only a few of the acetic acid molecules in solution donate hydrogen ions to form hydronium ions. The ammonia behaves better as a base than an acid, which means that it contributes very, very few hydrogen ions. The ammonia solution, therefore, has the lowest concentration of hydronium ions. The acetic acid solution has more hydronium ions, but not as many as are found in the hydrogen chloride solution.

### Solutions to Chapter 10
### Calculation Corner
### Logarithms and pH

1. 5 (This is the exponent to which 10 is raised)

2. 5 (This is the number of zeros)

3. The pH is 9. This is a basic solution.