Section 19.1 Acids and Bases: An Introduction

In your textbook, read about the properties of acids and bases.

For each description below, write **acid** if it tells about a property of an acid or **base** if it tells about a property of a base. If the property does not apply to either an acid or a base, write **neither**. If it applies to both an acid and a base, write **both**.

1. Can turn litmus paper a different color
2. Reacts with certain metals
3. Contains more hydrogen ions than hydroxide ions
4. Feels slippery
5. Reacts with carbonates
6. Feels rough
7. Contains equal numbers of hydrogen and hydroxide ions
8. Tastes bitter
9. Tastes sour

In your textbook, read about the different models of acids and bases.

Use the terms below to complete the passage. You may use each term more than once.

<table>
<thead>
<tr>
<th>Arrhenius</th>
<th>Bronsted-Lowry</th>
<th>conjugate acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>conjugate base</td>
<td>hydrogen</td>
<td>hydroxide</td>
</tr>
</tbody>
</table>

The **(10)____________** model of acids and bases states that an acid contains the element **(11)____________** and forms ions of this element when it is dissolved in water. A base contains the **(12)____________** group and dissociates to produce **(13)____________** ions in aqueous solution.

According to the **(14)____________** model, an acid donates **(15)____________** ions, and a base accepts **(16)____________** ions.

According to this model, in an acid-base reaction, each acid has a **(17)____________**, and each base has a **(18)____________**.
Section 19.4 Neutralization

In your textbook, read about neutralization and titration.

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A chemical dye that changes color based on the pH of a solution</td>
<td>a. acid-base indicator</td>
</tr>
<tr>
<td>2. A method for using a neutralization reaction to determine the concentration of a solution</td>
<td>b. end point</td>
</tr>
<tr>
<td>3. A reaction in which an acid and a base react to produce a salt and water</td>
<td>c. equivalence point</td>
</tr>
<tr>
<td>4. A solution of known concentration</td>
<td>d. neutralization</td>
</tr>
<tr>
<td>5. An ionic product of an acid-base reaction</td>
<td>e. salt</td>
</tr>
<tr>
<td>6. The point in a titration in which an indicator changes color</td>
<td>f. standard solution</td>
</tr>
<tr>
<td>7. The stoichiometric point of a titration</td>
<td>g. titration</td>
</tr>
</tbody>
</table>

Complete the following table, indicating the formula and name of the salt formed by a neutralization reaction between the listed acid and base.

<table>
<thead>
<tr>
<th>Acids</th>
<th>Bases</th>
<th>Salt formula</th>
<th>Salt names</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. HCl</td>
<td>KOH</td>
<td>KCl</td>
<td>potassium chloride</td>
</tr>
<tr>
<td>9. $\text{H}_2\text{SO}_4$</td>
<td>Mg(OH)$_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. $\text{H}_3\text{PO}_4$</td>
<td>NaOH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. $\text{HNO}_3$</td>
<td>Fe(OH)$_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. $\text{H}_3\text{PO}_4$</td>
<td>Ca(OH)$_2$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the space at the left, write 1 through 4 to show the correct sequence of the steps in performing a titration using a pH meter. Then, write 5 through 8 to sequence the steps used to calculate the concentration of the unknown solution.

Sequence of Steps

13. Continue adding the standard solution to the solution of unknown concentration until the equivalence point is reached.

14. Fill a buret with the standard solution.

15. Start adding the standard solution slowly, with mixing, to the solution of unknown concentration, reading the pH at regular intervals.
Acids and Bases

Write balanced chemical equations for each of the following reactions that involve acids and bases.

1. aluminum and hydrochloric acid
2. nitric acid and sodium carbonate
3. potassium hydroxide and sulfuric acid

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

4. H₂CO₃
5. H₃BO₃

A solution has a [H⁺] of 1.0 × 10⁻⁵ M.

6. What is its [OH⁻]?  
7. What is its pH?  
8. What is its pOH?

A solution has a [OH⁻] of 3.6 × 10⁻⁷ M.

9. What is its [H⁺]?  
10. What is its pH?  
11. What is its pOH?

A solution has a [H⁺] of 5.6 × 10⁻⁶ M.

12. What is its [OH⁻]?

13. What is its pH?  
14. What is its pOH?

A solution has a pH of 5.79.

15. What is its pOH?  
16. What is its [H⁺]?

17. What is its [OH⁻]?

18. What is the pH of a 0.50 M solution of HCl, a strong acid?

19. What is the pH of a 1.5 × 10⁻³ M solution of NaOH, a strong base?

20. What is the molarity of a KOH solution if 25.0 mL of it is neutralized by 31.7 mL of a 0.100 M nitric acid solution?

21. During a titration, 0.200 M HCl is added to a NaOH solution of unknown concentration. What is the concentration of the NaOH solution if 20.0 mL of it is neutralized by 30.7 mL of the standard solution?

22. A 25.0-mL sample of H₂SO₄ is neutralized by 27.4 mL of 1.00 M KOH. What is the concentration of the acid?

23. A 50.0-mL sample of 0.0100 M Ca(OH)₂ is neutralized by 45.6 mL of HBr. What is the molarity of the acid?
Directions: Complete the concept map using the terms in the list below.

**Terms:**
- salt
- base
- hydrogen ions
- positive
- negative
- acid

The strength of an acid or base depends on how completely an an produces a in solution which are hydroxide atoms in solution which are and combine to form a

1. 
2. 
3. 
4. 
5. 
6.
Directions: For each of the following, write the letter of the term that best completes the sentence.

1. A substance that produces hydrogen ions in solution is a(n) ______.
   a. acid  b. base

2. The familiar sour taste of citrus fruits is caused by the presence of _____ in these foods.
   a. acid  b. base

3. An acid that ionizes almost completely in solution is a ______.
   a. strong acid  b. weak acid

4. The strength of a base is determined by
   a. the concentration of a solution  b. how completely it separates into ions in solution

5. A substance that produces hydroxide ions in solution is a(n) ______.
   a. acid  b. base

6. A hydrogen ion is indicated by ______.
   a. H⁺  b. OH⁻

7. The pH of a substance can be determined by using a device called ______.
   a. an acid meter  b. a pH meter

8. The term *dilute* is used to refer to the _____ of an acid or a base.
   a. strength  b. concentration

9. A hydroxide ion is indicated by ______.
   a. OH⁻  b. OH⁻

10. An organic compound that changes color in an acid or a base is an _____.
    a. indicator  b. alcohol

11. The acidity of a solution can be indicated by its ______.
    a. pH  b. concentration

12. On the pH scale, a solution with pH 7 is ______.
    a. acidic  b. neutral

13. When an acid is dissolved in water, H⁺ ions form ______.
    a. hydrogen molecules  b. hydronium ions

14. The formula for a hydronium ion is ______.
    a. H₃O⁺  b. OH⁻

15. On the pH scale, a solution with pH 3 is ______.
    a. acidic  b. basic
Across
4. A solution that contains ions that react with acids or bases to minimize their effects
5. A compound formed when the negative ions from an acid combine with the positive ions from a base
7. An acid that ionizes almost completely in water
8. The chemical reaction between an acid and a base that takes place in a water solution
10. Organic salts that have a nonpolar end that mixes with oily dirt and a polar end that helps the dirt dissolve in water

Down
1. Organic compound that changes color in an acid or a base
2. Salts of organic acids that can be used in hard water
3. Ions formed when an acid is dissolved in water
4. A substance that forms hydroxide ions in solutions
6. A process in which a solution of known concentration is used to determine the concentration of another solution
9. A substance that produces hydrogen ions in solution
11. A measure of hydronium ions in solution. It measures how acidic or basic a solution is.
Directions: Decide whether each term listed below refers to an acid, a base, or both an acid and a base. Write your answer in the space provided using the letters in the key.

KEY: A = acid    B = base    AB = acid and base

1. sour taste
2. bitter taste
3. produces hydrogen ions in solution
4. is often corrosive
5. is slippery
6. can cause severe burns and tissue damage
7. exists as a crystalline solid in an undissolved state
8. produces hydroxide ions in solution
9. reacts with a predictable indicator to produce a color change
10. Soaps are an example.
11. may be used to make fertilizer
12. gastric juice in stomach
13. produces hydronium ions
14. Most compounds that produce this in aqueous solution are ionic.
15. a solution that contains more H₃O⁺ ions than OH⁻ ions.
16. HCl is an example.
17. Ammonia is a common example.

Directions: Answer the questions on the lines provided.

18. Use the information above to identify four properties that acids and bases have in common.

19. Identify three facts about acids that are NOT true of bases.

20. Identify three facts about bases that are NOT true of acids.
The pH values of several common substances are listed below. Place each item from the list on the pH scale in its proper location. The first one has been done for you.

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>pure water</td>
<td>7.0</td>
</tr>
<tr>
<td>ocean water</td>
<td>8.5</td>
</tr>
<tr>
<td>tomatoes</td>
<td>4.0</td>
</tr>
<tr>
<td>lye</td>
<td>13.8</td>
</tr>
<tr>
<td>stomach acid</td>
<td>1.0</td>
</tr>
<tr>
<td>lemons</td>
<td>2.5</td>
</tr>
<tr>
<td>shampoo</td>
<td>5.8</td>
</tr>
<tr>
<td>bananas</td>
<td>5.2</td>
</tr>
<tr>
<td>blood</td>
<td>7.2</td>
</tr>
<tr>
<td>milk of magnesia</td>
<td>10.5</td>
</tr>
<tr>
<td>ammonia</td>
<td>11.5</td>
</tr>
<tr>
<td>eggs</td>
<td>7.8</td>
</tr>
<tr>
<td>soap</td>
<td>10.0</td>
</tr>
<tr>
<td>vinegar</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Complete the table below by writing the name of each of the substances above under the proper heading. Place substances with a pH lower than 3.0 in the strong acids column. Place substances with a pH higher than 10.0 in the strong bases column.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Answer the following questions on the lines provided.

5. Is pure water an acidic, basic, or neutral substance? __________

6. Is the pH of a strong acid higher or lower than the pH of a weak acid of the same concentration? __________

7. Is the pH of a strong base higher or lower than the pH of a weak base of the same concentration? __________

8. On the pH scale, what are the values of acids and what are the values of bases? __________
White Gloves

The “white glove treatment” is an expression that’s long been associated with extreme cleanliness. It refers to something being so clean that even a white-gloved fingertip or hand can’t detect any dirt. Hotels and cleaning services, for example, boast about giving customers the “white glove treatment.” In reality, however, the white glove treatment has little to do with finding dirt and everything to do with acids.

Don’t Touch!

Acids are caustic, meaning they can eat away at or cause deterioration of something. That’s why museums post signs asking patrons not to touch objects on display. You may, in fact, see museum staff members wearing white cotton gloves. That’s so they can handle an art object or artifact without damaging it. Over time, an object or artifact can wear down. This is due, in part, to what’s on the human hand—acidic oils.

Sweat Damage

The human hand is full of sweat glands. In fact, of the 2 million to 5 million sweat glands found on the average human body, they’re most numerous on the palms and soles. Sweat glands on the palms and soles keep those surfaces damp so we can grip and feel things. The secretion from a sweat gland is 99 percent water. However, the hidden danger is in the remaining 1 percent—potassium, urea, lactic acid, ammonia, and salts. This can cause irreversible damage to a wide variety of materials, including paper, metals, fabric, photographs, wood, and paintings. Most metals suffer from excessive (and sometimes just occasional) contact with human hands.

No Bare Hands Allowed

However, this knowledge about acidic secretions from the human hand is not new. Records dating back to 14th century Japan show that prized samurai swords were always handled with rice paper—and never touched with bare hands. Women, if even allowed to touch the sword, had to use the sleeves of their kimonos (robes) to carry them. In fact, that’s a tradition that continues today. One of the protocols or customs for looking at and handling a samurai sword in modern-day Japan is that the blade never be touched by bare hands or fingers. It should be supported with either a piece of cloth or rice paper, or the person looking at the sword should wear white gloves; otherwise, the acidic natural oils of the human hand can cause the blade to rust or tarnish.

1. How much of our sweat is actually water?

2. Name three things that can be damaged by the acids from our hands.

3. Can paper materials, such as old documents or antique books, escape harm through use of the “white glove treatment”? Explain.

4. Name two acidic compounds found in sweat glands.

Meeting Individual Needs

1. How much of our sweat is actually water?

2. Name three things that can be damaged by the acids from our hands.

3. Can paper materials, such as old documents or antique books, escape harm through use of the “white glove treatment”? Explain.

4. Name two acidic compounds found in sweat glands.
Most people have heard of acid rain and the damage it causes to forests. Acid rain is formed when certain chemicals, including sulfur and nitrogen oxides, react with water in the atmosphere. These chemicals are mostly produced by cars and electrical power plants. When these chemicals get into the atmosphere, they can combine with water to form strong acids. When the water finally gathers as rain and falls to the ground, the acid can damage or kill life forms.

A Soil Problem

Much of the damage to plants from acid rain is a result of damage that acid rain causes to the soil. Acid rain drains many of the nutrients out of the soil and can cause toxic substances to increase. Remember that, in an acid, the hydrogen ion is reactive. Chemical reactions involving hydrogen ions can cause changes in compounds in the soil. Examples of ions required by plants are potassium (K⁺), calcium (Ca²⁺), and sodium (Na⁺). These ions might be washed out of the soil if rainwater becomes too acidic.

The acidity can also cause aluminum ions, which are toxic to many plants, to increase in concentration.

A Soil Solution

However, some good news is being discovered. Soils with the salt calcium carbonate (CaCO₃) are very good at neutralizing the acids. Rocks composed of this salt are called limestone. In Brazil, the atmosphere contains much acid rain. However, in the region of Belo Horizonte, a large amount of limestone is found. The limestone is mined to use as a building material. The dust from digging up the limestone can reach high concentrations in the air. In the atmosphere it can neutralize the acid in the rain. The neutralized rain is better for plant life in the region.

Farmers can use powdered limestone or lime (calcium oxide) to help neutralize the effects of acid rain. This is a case where a common salt can be used to combat acid rain. Reducing air pollution is still the best way to prevent acid rain.

1. What are the main sources of acid rain?

2. What can happen to soil if the hydrogen ion concentration increases?

3. Which common salt is good for neutralizing acid rain?

4. Where can this salt be found in nature?
I. Testing Concepts

Directions: In the blank at the left, write the letter of the term or phrase that best completes each statement or answers each question.

1. In a titration, the point where the indicator changes color and stays that way is the _____.
   a. pH point    b. endpoint    c. acid point    d. standard point

2. In a titration, the solution for which the concentration is known is called the _____.
   a. indicator    b. hydrate    c. normal solution    d. standard solution

3. H₃O⁺ units are called _____.
   a. hydroxide ions    b. hydronium ions    c. hydroxyl groups    d. hydrogen ions

4. In an equation describing the ionization of an acid, double arrows pointing in opposite directions indicate the acid is _____.
   a. negative    b. strong    c. neutral    d. weak

5. A substance that produces H⁺ ions in solution is a(n) _____.
   a. acid    b. salt    c. base    d. soap

6. A substance that produces OH⁻ ions in solution is a(n) ____.  
   a. acid    b. salt    c. base    d. alcohol

7. Our blood contains ______, which allow small amounts of acids or bases to be absorbed without harmful effects.
   a. salts    b. esters    c. buffers    d. indicators

8. Organic substances that change color in the presence of an acid or a base are called _____.
   a. soaps    b. glycerins    c. hydrates    d. indicators

9. A compound formed in solution from the negative ion of an acid and the positive ion of a base is a _____.
   a. salt    b. soap    c. glycerin    d. detergent

10. Which of the following substances will react to form an ester?
    a. ethyl alcohol and sodium hydroxide    c. sodium chloride and ethyl alcohol
    b. acetic acid and sodium chloride    d. acetic acid and ethyl alcohol

11. Which of the following is NOT a characteristic shared by soaps and detergents?
    a. has long carbon chains
    b. reacts with minerals to form insoluble substances often called scum
    c. may be classified as an organic salt
    d. is used for cleaning

12. Which of the following is the best indicator of the number of hydronium ions in a solution?
    a. the pH of the solution
    b. the mass of the solution
    c. the color of the solution in the presence of an indicator
    d. the amount of water in the solution
13. Antacids work because they _____ excess stomach acid.
   a. neutralize   b. contain   c. acidify   d. titrate

14. A solution with a bitter taste and a slippery feel is most likely _____.
   a. an acid   b. a base   c. salt   d. an ester

15. HCl is the formula for _____.
   a. the hydronium ion   c. hydrogen peroxide
   b. hydrochloric acid   d. sodium hydroxide

16. When you wash your hands with soap, you are using a(n) _____.
   a. buffer   b. acid   c. base   d. indicator

17. The terms dilute and concentrated refer to the _____.
   a. concentration   b. strength   c. pH   d. acidity

18. The strength of a base that only partly ionizes in solution would be described as _____.
   a. dilute   b. concentrated   c. weak   d. strong

19. A solution that is basic contains _____.
   a. fewer OH\(^-\) ions than   c. more OH\(^-\) ions than
   b. an equal amount of OH\(^-\) ions and   d. no

20. A reaction between an acid and a base that produces a salt and water is a(n) _____.
   a. neutralization   b. synthesis   c. decomposition   d. endpoint

II. Understanding Concepts

Skill: Comparing and Contrasting

Directions: Answer the following questions on the lines provided.

1. How does the charge of the ions produced by an acid in solution differ from the charge of the ions produced by a base in solution?

2. List three characteristics that acids and bases have in common.
1. Which of these decreases as the pH of a solution increases?
   A. The basicity of a solution
   B. Number of hydrogen ions
   C. The value of $K_w$
   D. Number of hydroxide ions

2. Acid rain is extremely harmful to the environment. All of the following are ways that acid rain affects the environment EXCEPT —
   A. eroding buildings
   B. promoting hydroxide deposits
   C. leaching mineral ions from the soil
   D. altering biological molecules necessary for aquatic life

3. A Brønsted-Lowry base is to a hydrogen-ion acceptor as a Brønsted-Lowry acid is to —
   A. a hydroxide-ion producer
   B. a hydroxide-ion donor
   C. an electron-pair donor
   D. a hydrogen-ion donor

4. Strong acids or bases make the best electrolytes because they —
   A. do not ionize in solution
   B. react in an equilibrating manner
   C. ionize completely in solution
   D. have extremely small ionization constants

5. The neutralization of a strong acid by a strong base always involves the products —
   A. water and a salt
   B. an anion and a salt
   C. water and an ion
   D. a weak acid and a strong base

6. Black coffee has a pH of approximately 5.0. What is the pOH of black coffee?
   A. 7.0
   B. 19.0
   C. 3.0
   D. 9.0
Use the table below to answer question 7.

<table>
<thead>
<tr>
<th>pH of Various Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solution</strong></td>
</tr>
<tr>
<td>Gastric Juice</td>
</tr>
<tr>
<td>Vinegar</td>
</tr>
<tr>
<td>Human Blood</td>
</tr>
<tr>
<td>Baking Soda</td>
</tr>
</tbody>
</table>

7 The pH scale is used to rank the hydronium ion concentration of a given substance. Which of the following sequences shows these solutions from least acidic to most acidic?

A  Gastric juice, vinegar, human blood, baking soda
B  Baking soda, human blood, vinegar, gastric juice
C  Baking soda, vinegar, human blood, gastric juice
D  Gastric juice, human blood, vinegar, baking soda

8 Buffers in your body are constantly working to prevent harmful increases or decreases in the pH of your blood, urine, and other fluids. In order to resist such changes, a buffer is composed of —

A  a strong acid and a strong base
B  a weak acid and its conjugate base, or a weak base and its conjugate acid
C  a strong base and a weak acid
D  a strong acid and a weak base

9 According to this chemical equation, which of the following represents a conjugate acid–base pair?

\[ \text{HBr(aq)} + \text{NH}_3(aq) \leftrightarrow \text{NH}_4^+(aq) + \text{Br}^-(aq) \]

A  NH_4^+(aq) and Br^- (aq)
B  HBr(aq) and NH_4^+(aq)
C  NH_3(aq) and HBr(aq)
D  HBr(aq) and Br^- (aq)

10 Which of the following does NOT represent a balanced equation for an acid–base neutralization reaction?

A  HCl + NaOH \rightarrow NaCl + H_2O
B  CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O
C  2HBr + Ca(OH)_2 \rightarrow 2H_2O + CaBr_2
D  Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O