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19 ACIDS, BASES, AND SALTS

SECTION 19.1 ACID–BASE THEORIES (pages 587–593)

This section compares and contrasts acids and bases as defined by the theories of Arrhenius, Brønsted-Lowry, and Lewis. It also identifies conjugate acid–base pairs in acid–base reactions.

▶ Properties of Acids and Bases (pages 587–588)

1. Circle the letters of all the terms that complete the sentence correctly. The properties of acids include _____ .

a. reacting with metals to produce oxygen

b. giving foods a sour taste

c. forming solutions that conduct electricity

d. causing indicators to change color

2. Bases are compounds that react with acids to form _____ and a(n) _____ .

3. Circle the letters of all the terms that complete the sentence correctly. The properties of bases include _____ .

a. tasting bitter

b. feeling slippery

c. changing the color of an indicator

d. always acting as a strong electrolyte

▶ Arrhenius Acids and Bases (pages 588–590)

4. Match the number of ionizable hydrogens with the type of acid.

_____ one	**a.** diprotic
_____ two	**b.** triprotic
_____ three	**c.** monoprotic

5. Is the following sentence true or false? Only the hydrogens in weak polar bonds are ionizable. _____

6. Hydrogen is joined to a very _____ element in a very polar bond.

7. Alkali metals react with water to produce _____ solutions.

CHAPTER 19, Acids, Bases, and Salts *(continued)*

8. How do concentrated basic solutions differ from other basic solutions?

_____

▶ Brønsted-Lowry Acids and Bases (pages 590–592)

9. How does the Brønsted-Lowry theory define acids and bases?

_____

_____

10. Is the following sentence true or false? Some of the acids and bases included in the Arrhenius theory are not acids and bases according to the Brønsted-Lowry theory. _____

11. Is the following sentence true or false? A conjugate acid is the particle formed when a base gains a hydrogen ion. _____

12. A conjugate _____ is the particle that remains when an acid has donated a hydrogen ion.

13. What is a conjugate acid–base pair?_____

_____

14. A substance that can act as both an acid and a base is said to be

_____ .

15. In a reaction with HCl, is water an acid or a base?

_____

▶ Lewis Acids and Bases (pages 592–593)

16. What is a Lewis acid? _____

_____

17. A Lewis base is a substance that can _____ a pair of electrons to form a covalent bond.

18. Is the following sentence true or false? All the acids and bases included in the Brønsted-Lowry theory are also acids and bases according to the Lewis theory.

_____

19. Complete this table of acid-base definitions.

Acid–Base Definitions		
Type	**Acid**	**Base**
Brønsted-Lowry		H^+ acceptor
	electron-pair acceptor	
	H^+ producer	

SECTION 19.2 HYDROGEN IONS AND ACIDITY (pages 594–604)

This section classifies solutions as neutral, acidic, or basic, given the hydrogen-ion or hydroxide-ion concentration. It explains how to convert hydrogen-ion concentrations into pH values and hydroxide-ion concentrations into pOH values.

▶ Hydrogen Ions from Water (pages 594-595)

1. What does a water molecule that loses a hydrogen ion become?

_____

2. What does a water molecule that gains a hydrogen ion become?

_____

3. The reaction in which water molecules produce ions is called the _____ of water.

4. In water or aqueous solution, _____ are always joined to _____ as hydronium ions (H_3O^+).

5. Is the following sentence true or false? Any aqueous solution in which $[H^+]$ and $[OH^-]$ are equal is described as a neutral solution. _____

▶ Ion Product Constant for Water (pages 595–596)

6. What is the ion-product constant for water (K_w)? Give the definition, the expression, and the value. _____

_____

_____

CHAPTER 19, Acids, Bases, and Salts *(continued)*

7. A(n) _____ solution is one in which $[H^+]$ is greater than $[OH^-]$.

A(n) _____ solution is one in which $[H^+]$ is less than $[OH^-]$.

8. Match the type of solution with its hydrogen-ion concentration.

_____ acidic	**a.** less than $1.0 \times 10^{-7} M$
_____ neutral	**b.** greater than $1.0 \times 10^{-7} M$
_____ basic	**c.** $1.0 \times 10^{-7} M$

▶ The pH Concept (pages 596–600)

9. The _____ of a solution is the negative logarithm of the hydrogen-ion concentration.

10. Match the type of solution with its pH.

_____ acidic	**a.** pH $>$ 7.0
_____ neutral	**b.** pH $=$ 7.0
_____ basic	**c.** pH $<$ 7.0

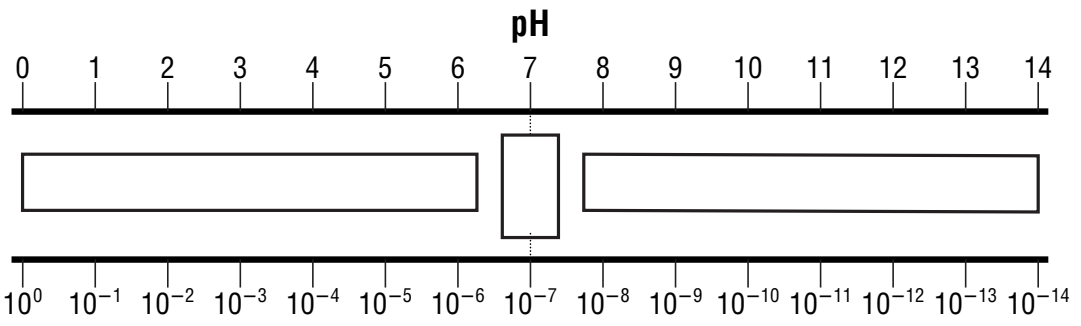
11. Look at Table 19.5 on page 598. What is the approximate $[H^+]$, the $[OH^-]$, and the pH of washing soda? _____

12. The pOH of a solution is the negative logarithm of the _____ concentration.

13. What is the pOH of a neutral solution? _____

14. For pH calculations, in what form should you express the hydrogen-ion concentration? _____

15. Look at the pH scale below. Label where you would find acids, bases, and neutral solutions.



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16. Is the following sentence true or false? Most pH values are whole numbers.

_____

17. If $[H^+]$ is written in scientific notation but its coefficient is not 1, what do you need to calculate pH? _____

_____

18. Is the following sentence true or false? You can calculate the hydrogen-ion concentration of a solution if you know the pH. _____

▶ Measuring pH (pages 600–603)

19. When do you use indicators and when do you use a pH meter to measure pH?

_____

_____

20. Why is an indicator a valuable tool for measuring pH?

_____

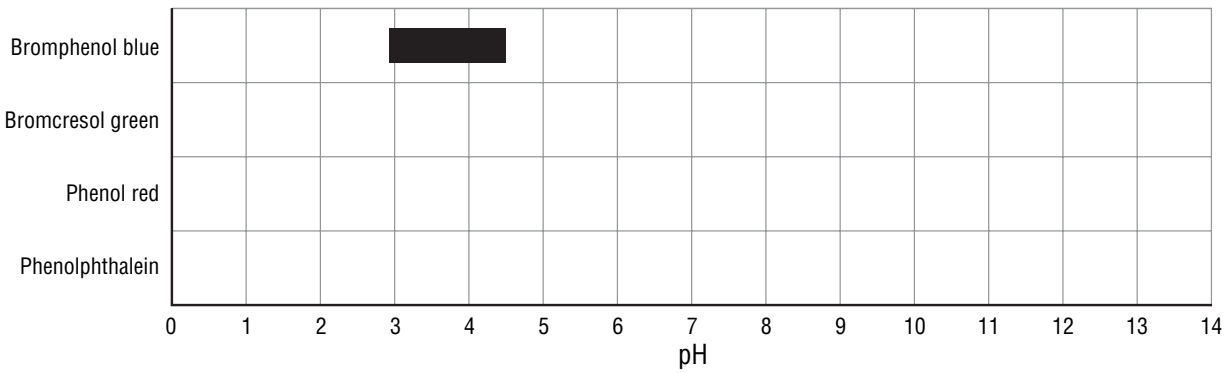
_____

21. Why do you need many different indicators to span the entire pH spectrum?

_____

_____

22. Look at the figure below. Fill in the missing pH color change ranges for the indicators.



23. List three characteristics that limit the usefulness of indicators.

a. _____

b. _____

c. _____

24. How accurate are measurements of pH obtained with a pH meter?

_____

25. What is the pH of each of the following solutions?

a. water _____

b. vinegar _____

c. milk of magnesia _____

26. Is the following sentence true or false? Measurements of pH obtained with a pH meter are typically accurate to within 0.001 pH unit of the true pH.

_____

SECTION 19.3 STRENGTHS OF ACIDS AND BASES (pages 605–611)

This section defines strong acids and weak acids, and then explains how to calculate an acid dissociation constant. It describes how acids and bases are arranged by strength according to their dissociation constants (K_a) and (K_b).

▶ Strong and Weak Acids and Bases (pages 605–609)

1. What factor is used to classify acids as strong or weak?

_____

2. Strong acids are _____ ionized in aqueous solution; weak acids ionize _____ in aqueous solution.

3. Look at Table 19.6 on page 605. Which acid is the weakest acid in the table? Which base is the weakest base?

_____

4. What do you use to write the equilibrium-constant expression?

_____

5. An acid dissociation constant (K_a) is the ratio of the concentration of the _____ form of an acid to the concentration of the _____ form.

6. What is another name for dissociation constants?

_____

7. Is the following sentence true or false? The stronger an acid is, the smaller its K_a value. _____

8. A diprotic acid has _____ dissociation constants.

9. Look at Table 19.7 on page 607. What is the second dissociation constant for the triprotic phosphoric acid? _____

10. Weak bases react with water to form the hydroxide ion and the _____ of the base.

11. A base dissociation constant (K_b) is the ratio of the concentration of the _____ times the concentration of the hydroxide ion to the concentration of the _____ .

12. What does the magnitude of the base dissociation constant (K_b) indicate?

_____

_____

13. The words *concentrated* and *dilute* indicate how much acid or base is _____ in solution.

14. Is the following sentence true or false? The words strong or weak refer to the extent of ionization or dissociation of an acid or base. _____

▶ Calculating Dissociation Constants (pages 609–610)

15. Is the following sentence true or false? You can calculate the acid dissociation constant (K_a) of a weak acid from experimental data. _____

16. To measure the equilibrium concentrations of all substances present at equilibrium for a weak acid, what two conditions must you know?

_____

_____

Reading Skill Practice

By looking carefully at photographs and drawings in textbooks, you can better understand what you have read. Look carefully at Figure 19.16 on page 606. What important idea does this drawing communicate? Do your work on a separate sheet of paper.

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SECTION 19.4 NEUTRALIZATION REACTIONS (pages 612–616)

This section explains how acid–base titration is used to calculate the concentration of an acid or a base. It also explains the concept of equivalence in neutralization reactions.

▶ Acid–Base Reactions (pages 612–613)

1. Is the following sentence true or false? Acids react with compounds containing hydroxide ions to form water and a salt. _____

2. What does the reaction of an acid with a base produce?

_____

3. In general, reactions in which an acid and a base react in an aqueous solution to produce a salt and water are called _____ reactions.

4. Look at Table 19.9 on page 613. Circle the letter of the salt that is used for photographic emulsions.

a. calcium chloride **c.** silver bromide

b. potassium chloride **d.** sodium chloride

5. Salts are compounds consisting of a(n) _____ from an acid and a(n) _____ from a base.

▶ Titration (pages 613–616)

6. How can you determine the concentration of an acid or base in a solution?

_____

7. Complete the flow chart below showing the steps of a neutralization reaction.

A measured volume of an acid solution of _____ concentration is added to a flask.

↓

Several drops of the _____ are added to the solution while the flask is gently swirled.

↓

Measured volumes of a base of _____ concentration are mixed into the acid until the indicator changes _____ .

8. The process of adding a known amount of solution of known concentration to determine the concentration of another solution is called _____ .

9. What is the solution of known concentration called?

_____

SECTION 19.5 SALTS IN SOLUTION (pages 618–622)

This section demonstrates with equations how buffers resist changes in pH. It also explains how to calculate the solubility product constant of a slightly soluble salt.

▶ Salt Hydrolysis (pages 618–620)

1. What is salt hydrolysis? _____

_____

2. Complete this table of the rules for hydrolysis of a salt.

Reactants	Products
_____ acid + _____ base	Neutral solution
Strong acid + Weak base	_____ solution
_____ acid + _____ base	Basic solution

▶ Buffers (pages 620–622)

3. What are buffers? _____

_____

4. A buffer is a solution of a _____ acid and one of its salts, or a solution of a _____ base and one of its salts.

5. Is the following sentence true or false? The buffer capacity is the amount of acid or base that can be added to a buffer solution before a significant change in pH occurs. _____

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GUIDED PRACTICE PROBLEMS

EXTRA PRACTICE PROBLEM (similar to Practice Problem 13, page 600)

13. Find the value of $[OH^-]$ for a solution with a pH of 8.00.

GUIDED PRACTICE PROBLEM 16b (page 601)

16b. Calculate the pH of this solution: $[H^+] = 8.3 \times 10^{-10}\,M$.

Step 1. Identify the known and unknown values.	**Known** $[H^+] = \boxed{} \times 10^{-10}\,M$	**Unknown** pH = ?
Step 2. Substitute values into the pH equation.	$pH = -\log [H^+]$ $= -\log (8.3 \times \boxed{})$	
Step 3. The logarithm of a product equals the sum of the logs of its factors.	$= -(\log \boxed{} + \log \boxed{})$	
Step 4. Evaluate log 8.3 by using a calculator. Evaluate $\log 10^{-10}$ by using the definition of logarithm.	$= -(0.919 + \boxed{})$	
Step 5. Add and simplify. Write your answer with two significant figures to the right of the decimal point.	$= -(-9.081) = \boxed{}$	

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GUIDED PRACTICE PROBLEM 22 (page 610)

22. For a solution of methanoic acid exactly 0.1 *M*, $[H^+] = 4.2 \times 10^{-3} M$. Calculate the K_a of methanoic acid.

Analyze

Step 1. What is known about the acid?

_____

_____

Step 2. What is the unknown? ____

Step 3. What is the expression for the K_a of methanoic acid? $K_a =$

Solve

Step 4. What expression can you write to find the equilibrium concentration of HCOOH? _____

Step 5. Substitute values into the formula for K_a and solve.

_____

Analyze

Step 6. Look at Table 19.7 on page 607. Explain why your answer is reasonable.

_____