Name _____ Date _____

Acids and Bases

Before You Read

Review Vocabulary *Define the following terms.*

chemical equilibrium

a state in which forward and reverse reactions balance each other because they occur at equal rates

Chapter 9

Write *the equation for hydrogen chloride dissolving in water to form hydrogen ions and chloride ions.*

$HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$

Explain *what type of compound hydrogen chloride is since it produces hydrogen ions in aqueous solution.*

The compound is an acid.

Chapter 16

Identify *five factors that influence reaction rate.*

1. **the reactive nature of the reactants**
2. **the concentrations of the reacting particles**
3. **surface area**
4. **temperature**
5. **adding a catalyst**

Name _____ Date _____

Acids and Bases

Section 1 Introduction to Acids and Bases

Main Idea — **Details**

Skim *Section 1 of your text. Write two questions that come to mind from reading the headings and the illustration captions.*

1. **Accept all reasonable responses.**

2. _____

New Vocabulary *Use your text to define each term.*

acidic solution
a solution that contains more hydrogen ions than hydroxide ions

basic solution
a solution that contains more hydroxide ions that hydrogen ions

Arrhenius model
an acid-base model that states that an acid is a substance that contains hydrogen and ionizes to produce hydrogen ions in aqueous solution, and that a base is a substance that contains a hydroxide group and dissociates to produce a hydroxide ion in aqueous solution

Brønsted-Lowry model
an acid-base model in which an acid is a hydrogen-ion donor and a base is a hydrogen-ion acceptor

conjugate acid
the species produced when a base accepts a hydrogen ion from an acid

conjugate base
the species that results when an acid donates a hydrogen ion to a base

conjugate acid-base pair
two substances related to each other by the donating and accepting of a single hydrogen ion

amphoteric
substances that can act as both acids and bases

Lewis model
an acid-base model in which a Lewis acid is an electron-pair acceptor and a Lewis base is an electron-pair donor

Name _____ Date _____

Section 1 Introduction to Acids and Bases (continued)

Main Idea — **Details**

Properties of Acids and Bases

Use with pages 634–636.

Compare and contrast *the properties of an acid and a base by placing an X in the Acid column if the property applies to an acid and in the Base column if the property applies to a base.*

Acid	Properties	Base
X	tastes sour	
	tastes bitter	X
	feels slippery	X
X	affects color	X
X	reacts with metal	
X	conducts electricity	X
X	has more hydrogen ions than hydroxide ions	
	has more hydroxide ions than hydrogen ions	X

Write *the chemical equation for the self-ionization of water.*

$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

The Arrhenius and Brønsted-Lowry Models

Use with pages 637–639.

Analyze *why the Arrhenius model ofacids and bases does NOT include ammonia (NH_3) in solution as a base.*

Because ammonia does not include OH^- (a hydroxide ion), ammonia does not fit the Arrhenius definition of a base, which says that a base contains a hydroxide group.

Identify *which of the following statements describes the Arrhenius model and which describes the Brønsted-Lowry model by filling in the blanks.*

The **Arrhenius** model is based on the dissociation of compounds, while the **Brønsted-Lowry** model is based on the donation and acceptance of hydrogen ions. Conjugate acid-base pairs are a component of the **Brønsted-Lowry** model and are NOT a component of the **Arrhenius** model.

Name _____ Date _____

Section 1 Introduction to Acids and Bases (continued)

Main Idea — **Details**

Describe *what happens in the forward and reverse reactions when ammonia is dissolved in water. Identify the conjugate acid, the conjugate base, and the two conjugate acid-base pairs.*

In the forward reaction, water is a Brønsted–Lowry acid because it gives up a H^+ ion. Ammonia is a Brønsted-Lowry base because the NH3 molecule accepts a H^+ ion to form the ammonium ion NH_4^+. In the reverse reaction, the ammonium ion gives up a H^+ ion to form the molecule ammonia and acts as a Brønsted-Lowry acid, and the hydroxide ion donated by the water is a Brønsted-Lowry base because it accepts a H^+ ion to form a water molecule. The ammonium ion is the conjugate acid of the base ammonia. The ammonia and the ammonium ion are a conjugate acid-base pair. The hydroxide ion is the conjugate base of the acid water. The water and the hydroxide ion are a conjugate acid-base pair.

Monoprotic and Polyprotic Acids

Use with pages 640–641.

Explain *what a polyprotic acid is.*

A polyprotic acid is any acid that has more than one ionizable hydrogen atom.

Sequence *the following equations in the steps of the ionization of phosphoric acid in the correct order.*

3 $HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + PO_4^{3-}(aq)$

1 $H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + H_2PO_4^{2-}(aq)$

2 $H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HPO_4^-(aq)$

The Lewis Model

Use with pages 641–643.

Define and give examples of an anhydride, distinguishing between those that produce an acid and those that produce a base.

An anhydride is an oxide that can become an acid or base by adding the elements contained in water. Oxides of nonmetallic elements, such as carbon, sulfur, and nitrogen, produce an acid in aqueous solution. Oxides of metallic elements, such as calcium oxide, usually form basic solutions.

Name _____ Date _____

Acids and Bases

Section 2 Strengths of Acids and Bases

Main Idea — **Details**

Skim *Section 2 of your text Focus on the headings, subheadings, boldfaced words, and the main ideas. Write three questions about strengths of acids and basis based on what you have read.*

1. **Accept all reasonable responses.**
2. _____
3. _____

New Vocabulary *Use your text to define each term.*

strong acid	**an acid that ionizes completely**
weak acid	**an acid that ionizes only partially in dilute aqueous solution**
acid ionization constant	**the value of the equilibrium constant expression for the ionization of a weak acid**
strong base	**a base that dissociates entirely into metal ions and hydroxide ions**
weak base	**a base that ionizes only partially in dilute aqueous solution to form the conjugate acid of the base and hydroxide ion**
base ionization constant	**the value of the equilibrium constant expression for the ionization of a base**

Name _____ Date _____

Section 2 Strengths of Acids and Bases (continued)

Main Idea — **Details**

Strengths of Acids

Use with pages 644–647.

Explain *why all acids are not equal in strength.*

Some acids ionize completely, which makes them strong, and other acids do not ionize completely, which makes them weak.

Identify *the acids in the following table as strong or weak.*

Acid	Strong or Weak	Acid	Strong or Weak
acetic	**weak**	hydroiodic	**strong**
carbonic	**weak**	hydrosulfuric	**weak**
		hypochlorous	**weak**
hydrochloric	**strong**	nitric	**strong**
hydrofluoric	**weak**	sulfuric	**strong**

Describe *the difference in conductivity between strong and weak acids.*

Because ions carry electricity through a solution, strong acids produce the maximum number of ions, and they are good conductors of electricity. Weak acids have fewer ions and, as a result, do not conduct electricity as well as strong acids do.

Analyze *equilibrium constant expressions by completing the following statements.*

The concentration of liquid water in the denominator of an equilibrium constant expression is considered to be **constant** in dilute aqueous solutions. Therefore, liquid water can be **combined with** K_{eq} to give a new equilibrium constant, K_a. For weak acids, the equilibrium **concentration** of the **products** in the numerator tends to be small compared to the equilibrium **concentration** of the **reactants** in the denominator. The weakest acids have the **smallest** K_a values because their solutions have the highest concentrations of **un-ionized** acid molecules.

Name _____ Date _____

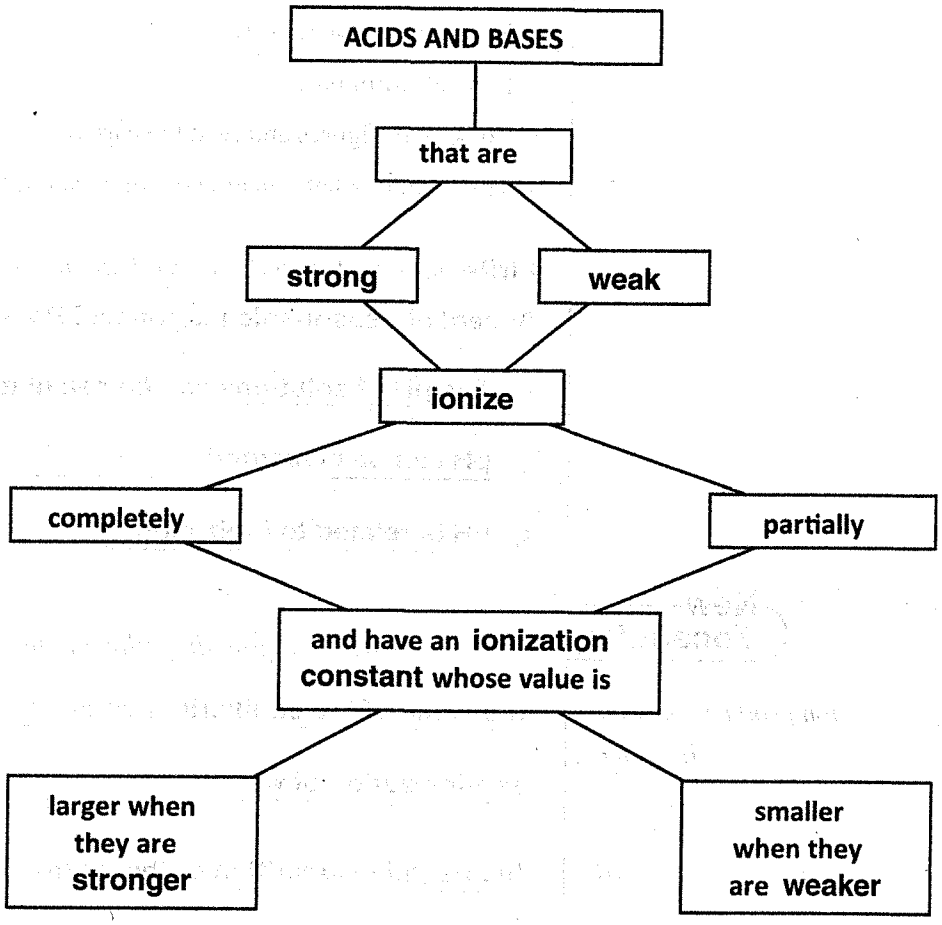
Section 2 Strengths of Acids and Bases (continued)

Main Idea — **Details**

Strengths of Bases

Use with pages 648–649.

Compare and contrast *the strengths of acids and bases by completing this concept map using the terms ionize, ionization constant, strong, stronger, weak, and weaker.*



Describe *the differences between the strength and the concentration of acids and bases by completing the following statements.*

The number of the acid or base molecules dissolved is described by the terms **dilute** and **concentrated**. The degree to which an acid or base separates into ions is described by the terms **weak** and **strong**. A strong acid can be a **dilute** solution and a **weak** acid can be a concentrated solution.

Name _____ Date _____

Acids and Bases

Section 3 Hydrogen Ions and pH

Main Idea — **Details**

Scan *Section 3 of your text. Use the checklist below as a guide.*

- Read all section titles.
- Read all boldfaced words.
- Read all formulas.
- Look at all figures and read the captions.
- Think about what you already know about hydrogen ions and pH

Write *three facts you discovered about pH as you scanned the section.*

Accept all reasonable responses. Possible answers:

1. **The pH of solutions can be calculated.**
2. **pH can be measured.**
3. **pH is related to ionization.**

New Vocabulary

Use your text to define the following terms.

ion product constant for water — **the value of the equilibrium constant expression for the self-ionization of water**

pH — **the negative logarithm of the hydrogen ion concentration**

pOH — **the negative logarithm of the hydroxide ion concentration**

Name _____ Date _____

Section 3 Hydrogen Ions and pH (continued)

Main Idea — **Details**

Ion Product Constant for Water

Use with pages 650–651.

Describe *how the ion product constant for water is derived from the self-ionization equation.*

$H_2O(l) \rightleftharpoons$ **$H^+(aq) + OH^-(aq)$**

$K_{eq} =$ **$[H^+][OH^-] / [H_2O]$**

$K_{eq}[H_2O] =$ **$K_w = [H^+][OH^-]$**

$K_w = [H^+][OH^-] =$ **$(1.0 \times 10^{-7})(1.0 \times 10^{-7}) = 1.0 \times 10^{-14}$**

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

Use with Example Problem 1, page 651.

Summarize *Fill in the blanks to help you take notes while you read Example Problem 1.*

Problem

Calculate $[OH^-]$ using **K_w** and the concentration of **$[H^+]$**, and determine if the solution is acidic, basic, or neutral.

Step 1: Analyze the Problem

Known: Unknown:

$[H^+] =$ **$1.0 \times 10^{-5} M$** $[OH^-] =$? mol/L

$K_w =$ **1.0×10^{-14}**

Write what you can predict about $[OH^-]$:

$[OH^-]$ will be less than 1.0×10^{-7}

Step 2: Solve for the Unknown

Write the ion product constant expression

$K_w =$ **$[H^+][OH^-] = 1.0 \times 10^{-14}$**

Solve for $[OH^-]$ by **dividing both sides of the equation by $[H^+]$**

$[OH^-] =$ **$K_w/[H^+]$**

$[OH^-] =$ **$(1.0 \times 10^{-14})/(1.0 \times 10^{-5}) = 1.0 \times 10^{-9}$ mol/L**

Since $[H^+] > [OH^-]$, **the solution is acidic**

Name _____ Date _____

Section 3 Hydrogen Ions and pH (continued)

Main Idea — **Details**

pH and pOH

Use with pages 652–658.

Step 3: Evaluate the Answer

The answer is correctly stated with **two** significant figures because $[H^+]$ and $[OH^-]$ each have two. The hydroxide ion concentration **matched** the prediction.

Compare and contrast *pH and pOH by completing the following table.*

Solution Type	Scale Measure	Relationship (Equation)
acid	pH	**$pH = -\log[H^+]$**
base	**pOH**	**$pOH = -\log[OH^-]$**
acid and base	**pH + pOH**	**$pH + pOH = 14.00$**

Analyze *the process of calculating pH and pOH from the hydroxide concentration.*

Calculate the pOH from concentration of the hydroxide. This is done by calculating the negative log of the concentration. Then subtract the pOH value from 14 to find the pH value.

Describe *the process of calculating the hydrogen ion and hydroxide ion concentrations from pH.*

First find the concentration of the hydrogen ion by calculating the antilog of the negative pH. Then subtract the pH value from 14 to find the pOH value.

Describe *the process of calculating* K_a *from pH for a 0.100M weak acid.*

Set up the acid ionization constant expression for this acid. Then use pH to find the hydrogen ion concentration. We know that the number of hydrogen ions must be equal to the conjugate base concentration in an ionization reaction. Therefore, the weak acid concentration must equal the 0.100 molar concentration minus the hydrogen ion concentration. Last, substitute the concentrations in the K_a expression and solve.

Name _____ Date _____

Acids and Bases

Section 4 Neutralization

Main Idea — **Details**

Skim *Section 4 of your text. Focus on the headings, subheadings, boldfaced words, and the main ideas. Write three questions about strengths of acids and bases based on what you have read.*

1. **Accept all reasonable responses.**
2. _____
3. _____

New Vocabulary *Define the following term.*

neutralization reaction — **reaction in which an acid and a base in aqueous solution react to produce a salt and water; it is a double-replacement reaction**

salt — **an ionic compound made up of a cation from a base and an anion from an acid**

titration — **a stoichiometric method for determining the concentration of a solution by reacting a known volume of the solution with a solution of known concentration**

titrant — **a titrating solution of known concentration, called the standard solution**

equivalence point — **point at which moles of hydrogen ions from the acid equal moles of the hydroxide ions from the base; the stoichiometric ratio is equivalent**

acid-base indicator — **chemical dyes whose colors are affected by acidic and basic solutions**

end point — **the point at which the indicator used in a titration changes color because the equivalence point is reached**

salt hydrolysis — **process in which anions of the dissociated salt accept hydrogen ions from water or the cations of the dissociated salt donate hydrogen ions to water**

buffer — **solution that resists changes in pH when limited amounts of acid or base are added**

buffer capacity — **the amount of acid or base a buffer solution can absorb without a significant change in pH**

Name _____ Date _____

Section 4 Neutralization (continued)

Main Idea

Reactions Between Acids and Bases

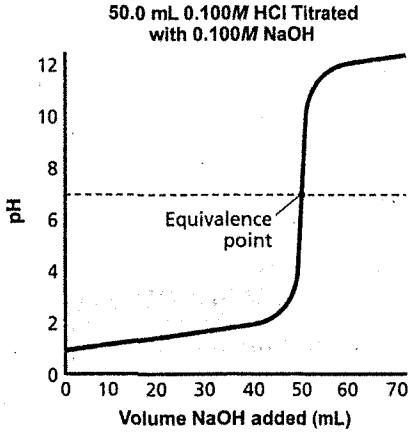
Use with pages 659–664.

Details

Write *the full equation of the neutralization reaction for magnesium hydroxide and hydrochloric acid.*

$$Mg(OH)_2(aq) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

Draw *the titration curve for 50.0 mL 0.100M HCl titrated with 0.100M NaOH. Label the pH and volume vectors, as well as the equivalence point.*



Describe *the indicator that matches each of the following pH levels. Use Figure 24 as a guide.*

pH	Indicator
7.2	**phenol red**
4.2	**methyl orange**
1.8	**cresol red**
1–12	**universal indicator**

Explain *the process for calculating the molarity of an unknown HCOOH solution by completing the equations below.*

Balanced equation:
$HCOOH(aq) + NaOH(aq) \rightarrow HCOONa(aq) + H_2O(l)$

18.28 mL NaOH × **1 L NaOH/1000 mL NaOH** = **0.01828** L NaOH

0.01828 L NaOH × **0.1000 mol NaOH/1 L NaOH**

= **1.828×10^{-3}** mol NaOH

1.828×10^{-3} mol NaOH × **1 mol HCOOH /1 mol NaOH**

= **1.828×10^{-3}** mol HCOOH

1.828×10^{-3} mol HCOOH / **0.02500 L HCOOH**

= **7.312×10^{-2}** *M* HCOOH

Name _____ Date _____

Section 4 Neutralization (continued)

Main Idea — **Details**

Salt Hydrolysis

Use with page 665.

Describe *salt hydrolysis by completing the following statements.*

Some aqueous salt solutions are neutral, some are basic, and some are **acidic**. The reason for this is a process known as **salt hydrolysis**. In this process, the anions of the dissociated salt donate **hydrogen ions** to water. Salts that will hydrolyze have a weak acid and a **strong base** or a strong acid and a **weak base**. A salt formed from a strong acid and a weak base will form an **acidic solution**. A salt formed from a strong base and a weak acid will form a **basic solution**. Salts formed from weak acids and bases or from strong acids and bases will not hydrolyze and form **neutral solutions**.

Buffered Solutions

Use with pages 666–667.

Explain *how a buffer works by completing the table below.*

The equation at equilibrium	**$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$**	
Δ Condition	**Equilibrium Shift**	**The Process**
add acid	left	The H^+ ions react with F^- ions to form **additional HF molecules.**
add base	right	The OH^- ions react with H^+ ions to form water. This decreases the concentration of the H^+ ions so that **more H^+ ions need to be made.**
A greater **concentration** of the buffering molecules and ions in the solution leads to a **greater buffering capacity** of the solution.		
A buffer has **equal quantities** of an acid and its **conjugate base** or a base with its **conjugate acid.**		

Name _____ Date _____

Acids and Bases Chapter Wrap-Up

Now that you have read the chapter, review what you have learned; write out three key equations and relationships.

Accept all reasonable responses. Possible answers:

1. **A strong acid has a weak conjugate base, and a weak acid has a strong conjugate base.**
2. **$K_w = 1.0 \times 10^{-14}$**
3. **pH + pOH = 14.00**

Review

Use this checklist to help you study.

- ☐ Study your Science Notebook for this chapter.
- ☐ Study the definitions of vocabulary words.
- ☐ Review daily homework assignments.
- ☐ Reread the chapter and review the tables, graphs, and illustrations.
- ☐ Answer the Section Review questions at the end of each section.
- ☐ Look over the Study Guide at the end of the chapter.

Real-World Connection

Suppose you are on the bench for your school's soccer team when one of the players comes out of the game with a cramp. A teammate suggests that she start breathing into a paper bag to recover sooner. Explain whether or not this is good advice.

It is not good advice, as the cramping may be caused by acidosis, or a lowering of pH in the blood due to excessive acid levels. Breathing into a paper bag will cause the soccer player to inhale more CO_2 which could further lower pH levels, making the condition worse.