CHAPTER 7

Basics of Chemistry

Chapter Outline

- Why Study Chemistry?
- Chemistry
- Matter
- Potential Hydrogen (pH)
- Chemical Reactions
- Chemistry as Applied to Cosmetics

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Learning Objectives

After completing this chapter, you will be able to:

- ☑ **L01** Define chemistry and its branches: organic and inorganic chemistry.
- ☑ **L02** Explain matter and its structure.
- ☑ **L03** Discuss the properties of matter and how matter changes.
- ☑ **L04** Understand how acid, alkaline, and pH affect the skin.
- ☑ **L05** Explain pH and the pH scale.
- ☑ **L06** Explain the difference among solutions, suspensions, and emulsions.

Key Terms

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As an esthetician, you will be working with chemistry every day. As you will see, chemistry (one of the physical sciences), along with chemicals and chemical changes, makes life on earth possible. The daily functioning of our bodies is based on chemical reactions. The skin is made of chemicals. Creams, lotions, masks, and makeup—whether they come from natural sources such as plant extracts or from ingredients manufactured in a laboratory—are made from chemicals (**Figure 7–1**).

The effects of cosmetics and skin care products are based on how the skin reacts to chemicals. To understand how different chemicals affect the skin, and to choose the correct products and cosmetics for each client's skin type, estheticians must have a basic knowledge of chemistry.

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▲ **Figure 7–1**
All skin care products are made of chemicals.

Why Study Chemistry?

Estheticians need to understand basic chemistry as it is crucial in performing services safely, effectively, and with the best results for clients.

- Without an understanding of basic chemistry, you would not be able to use professional products effectively and safely.
- Every product used in the salon and spa and in skin care services contains some type of chemical.
- With an understanding of chemistry, you will learn how to layer products in services and know how the skin may react with products and services.
- With an understanding of chemistry, you will be able to troubleshoot and solve common problems you may encounter with esthetic services.

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Chemistry

Chemistry is the science that deals with the composition, structure, and properties of matter and how matter changes under different conditions. There are two branches of chemistry—organic and inorganic.

Organic chemistry is the study of substances that contain the element carbon. All living things, whether they are plants or animals, contain carbon. Although the term *organic* is often used to mean safe or *natural* because of its association with living things, the term also applies to anything that has ever been alive. Gasoline, plastics, synthetic fabrics, pesticides, and fertilizers are all organic substances. These products are manufactured from natural gas and oil, which are the remains of plants and animals that died millions of years ago. Organic compounds are flammable and will burn.

Inorganic chemistry is the branch of chemistry dealing with compounds that do not contain the element carbon, but may contain the element hydrogen. Inorganic substances are not flammable and will not burn because they do not contain carbon. Inorganic substances are not, and never were, alive. Metals, minerals, glass, pure water, and air are examples of inorganic substances. ☑ L01

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Matter

Matter is any substance that occupies space and has mass (weight). All matter has physical and chemical properties and exists in the form of a solid, liquid, or gas. Since matter is made from chemicals, everything made out of matter is a chemical.

Although matter has physical properties that we can touch, taste, smell, or see, not everything that we can see is matter. For instance, we can see visible light and electric sparks, but these are forms of energy, and energy is not matter. Everything known to exist in the universe is either made of matter or energy. There are no exceptions to this rule.

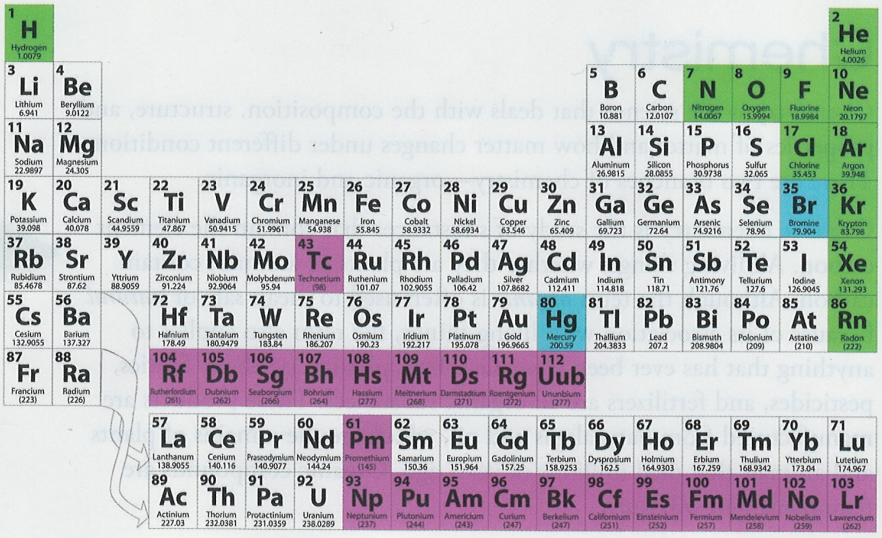
Energy does not occupy space or have physical properties, such as mass (weight). Energy is discussed in Chapter 8, Basics of Electricity.

Elements

An **element** is the simplest form of chemical matter. It cannot be broken down into a simpler substance without a loss of identity. There are about 90 naturally occurring elements, each with its own distinctive physical and chemical properties. All matter in the universe is made up of one or more of these 90 different elements.

Each element is identified by a letter symbol, such as O for oxygen, C for carbon, H for hydrogen, N for nitrogen, and S for sulfur (**Figure 7–2**).

▶ **Figure 7–2**
The periodic table of elements.



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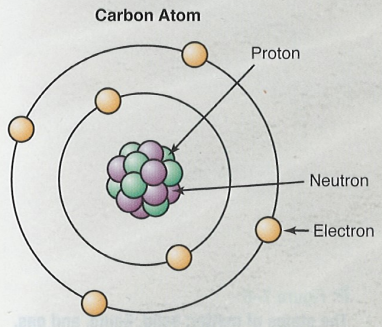
Atoms

Atoms are the particles from which all matter is composed. An atom is the smallest particle of an element that still retains the properties of that element.

The atoms of each element are different in structure from the atoms of all other elements. The structural differences of the 90 different atoms account for the 90 different elements and their distinct properties. All the atoms of the same element are identical. Atoms cannot be divided into simpler substances by ordinary chemical means. Atoms consist of smaller particles; protons, which have a positive electrical charge; neutrons, with a neutral charge; and electrons, with a negative charge (**Figure 7–3**). The number of protons in an atom equals the number of electrons.

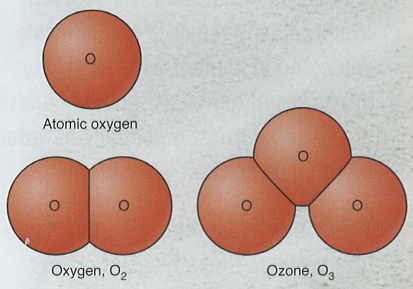


▲ **Figure 7–3**
An atom consists of negatively charged electrons, positively charged protons, neutral neutrons, and electrons orbiting the unit.

Molecules

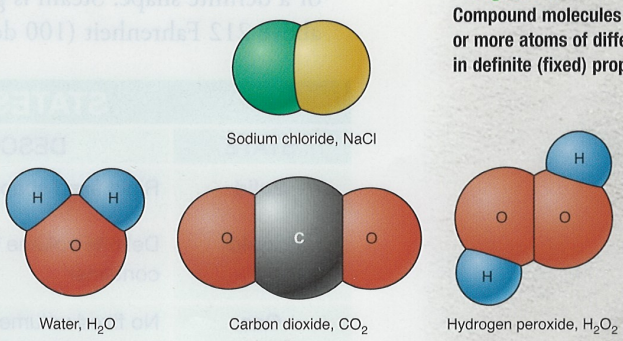
A **molecule** (MAHL-uh-kyool) is formed by joining two or more atoms chemically. For example, water is made from hydrogen atoms and oxygen atoms. Carbon dioxide is made from carbon atoms and oxygen atoms. There are two types of molecules.

- **Elemental molecules** (el-uh-MEN-tuhl MAHL-uuh-kyools) contain two or more atoms of the same element that are united chemically (**Figure 7–4**). When all the atoms that form a molecule are the same, the molecule is made of the same element, and the molecule is called an elemental molecule. Atmospheric oxygen, in the air we breathe, is the elemental molecule O_2. In the atmosphere, the ozone that protects us from ultraviolet radiation is the elemental molecule O_3.
- **Compound molecules** ((KAHM-pownd MAHL-uh-kyools), also known as **compounds**, are chemical combinations of two or more atoms of different elements that are united chemically. An example would be sodium chloride (NaCl) which is common table salt. It is a chemical compound that contains one atom of the element sodium (Na) and one atom of the element chlorine (Cl) (**Figure 7–5**). ☑ **L02**



▲ **Figure 7–4**
Elemental molecules contain two or more atoms of the same element in definite (fixed) proportions.

◀ **Figure 7–5**
Compound molecules contain two or more atoms of different elements in definite (fixed) proportions.



States of Matter

All matter exists in one of three different physical forms:

- Solid
- Liquid
- Gas

The difference in these physical forms depends on temperature. These

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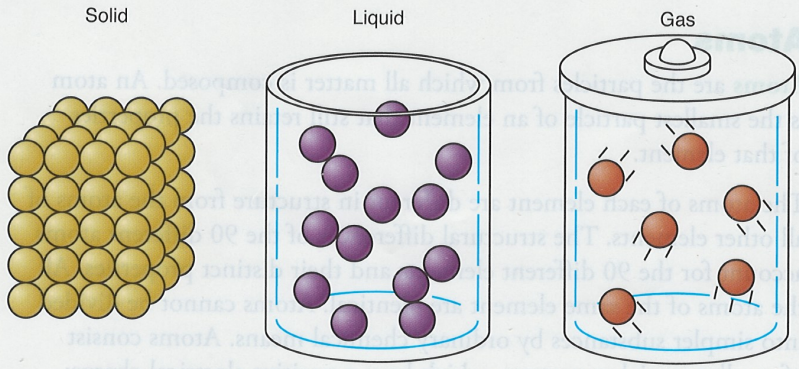

▶ Figure 7–6
The states of matter: solid, liquid, and gas.

Did You Know?

Everything except light and electricity is a chemical. Water is a *chemical*. Using the word chemical to describe something does not mean it is dangerous or harmful. The vast and overwhelming majority of chemicals you come in contact with every day are safe and harmless. Manufacturers are required to list potentially harmful ingredients on their labels.

There is no such thing as a chemical-free product, these types of claims are misleading. Even your body is completely composed of chemicals.

three different physical forms of matter—solid, liquid, gas—are called **states of matter** (**Figure 7–6**).

Like most other substances, water (H_2O) can exist in all three states of matter, depending on its temperature. Ice turns to water as it melts, and water turns to steam as it boils. The form of water is different due to a change of state, but it is still water (H_2O). It is not a different chemical. It is the same chemical in a different physical form. This is called a physical change.

The three different states of matter have the following distinct characteristics (**Table 7–1**):

- **Solids** have a definite size (volume) and a definite shape. Ice is an example of a solid. Ice has a definite size and shape. Ice is solid water (H_2O) at a temperature of less than 32 degrees Fahrenheit (0 degrees Celsius).
- **Liquids** have a definite size (volume) but not a definite shape. Liquids take on the shape of the container they are in. Water is an example of a liquid. Water has a definite size, but it does not have a definite shape. Water is a liquid (H_2O) at a temperature between 32 degrees Fahrenheit (0 degrees Celsius) and 211 degrees Fahrenheit (100 degrees Celsius).
- **Gases** do not have a definite size (volume) or a definite shape. Steam is an example of a gas. Steam does not have a definite size or a definite shape. Steam is gaseous water (H_2O) at a temperature above 212 Fahrenheit (100 degrees Celsius).

STATES OF MATTER

STATE	DESCRIPTION	EXAMPLES
Solid	Rigid fixed shape and volume	Ice, brushes, chair
Liquid	Definite volume but takes shape of container	Water, cleansers, serums
Gas	No fixed volume or shape; takes shape and volume of container	Steams/vapor, propane, ozone

▲ Table 7–1 States of Matter.

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Physical and Chemical Properties of Matter

Every substance has unique physical and chemical properties that allow us to identify it.

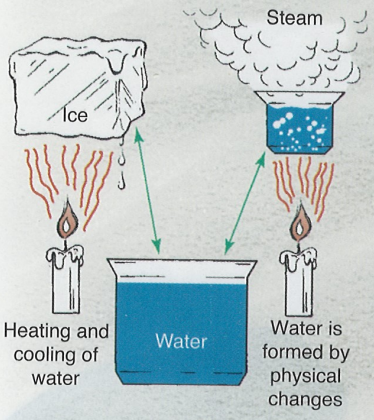
Physical properties are characteristics that can be determined without a chemical reaction and that do not cause a chemical change in the identity of the substance. Physical properties include color, odor, weight, density, specific gravity, melting point, boiling point, and hardness.

Chemical properties are characteristics that can be determined only with a chemical reaction and that cause a chemical change in the identity of the substance. Rusting iron and burning wood are examples of a change in chemical properties. In both of these examples, the chemical reaction known as **oxidation**, the addition of oxygen or the loss of hydrogen, creates a chemical change in the identity of the substance. The iron is chemically changed to rust, and the wood is chemically changed to ash.

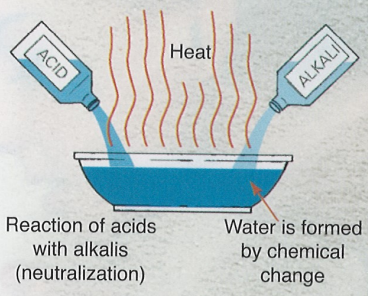
Physical and Chemical Changes

Matter can be changed in two different ways: physically and chemically.

- A **physical change** is a change in the form or physical properties of a substance without the formation of a new substance. There is no chemical reaction involved, and no new chemicals are formed. A change in the state of matter is an example of a physical change. Solid ice undergoes a physical change when it melts into liquid water (**Figure 7–7**).
- A **chemical change** is a change in the chemical composition of a substance, in which a new substance or substances are formed having properties different from the original. It is the result of a chemical reaction (**Figure 7–8**). As previously described (iron into rust, wood into ash), oxidation is an example of a chemical reaction that causes a chemical change. ☑ L03



▲ **Figure 7–7**
Physical changes.



▲ **Figure 7–8**
Chemical changes.

Properties of Common Elements, Chemical Compounds, and Physical Mixtures

A familiarity with the properties of some of the most common elements, chemical compounds, and physical mixtures can help you understand why certain cosmetic products act the way they do. **Chemical compounds** are a combination of two or more atoms of different elements united chemically with a fixed chemical composition, definite proportions, and distinct properties. **Physical mixtures** are a combination of two or more substances that are united physically, in any proportions with combined properties.

Hydrogen (H) is a colorless, odorless, tasteless gas and is the lightest element known. It is found in chemical combination with oxygen in water and with other elements in most organic substances. Elemental hydrogen is flammable and explosive when mixed with air.

Oxygen (O), the most abundant element found on earth, is a colorless, odorless, tasteless gas. It comprises about half of the Earth's crust, half of the

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rock, one-fifth of the air, and 90 percent of the water. It combines with most other elements to form an infinite variety of compounds, called oxides. One of the chief chemical characteristics of this element is its ability to support combustion.

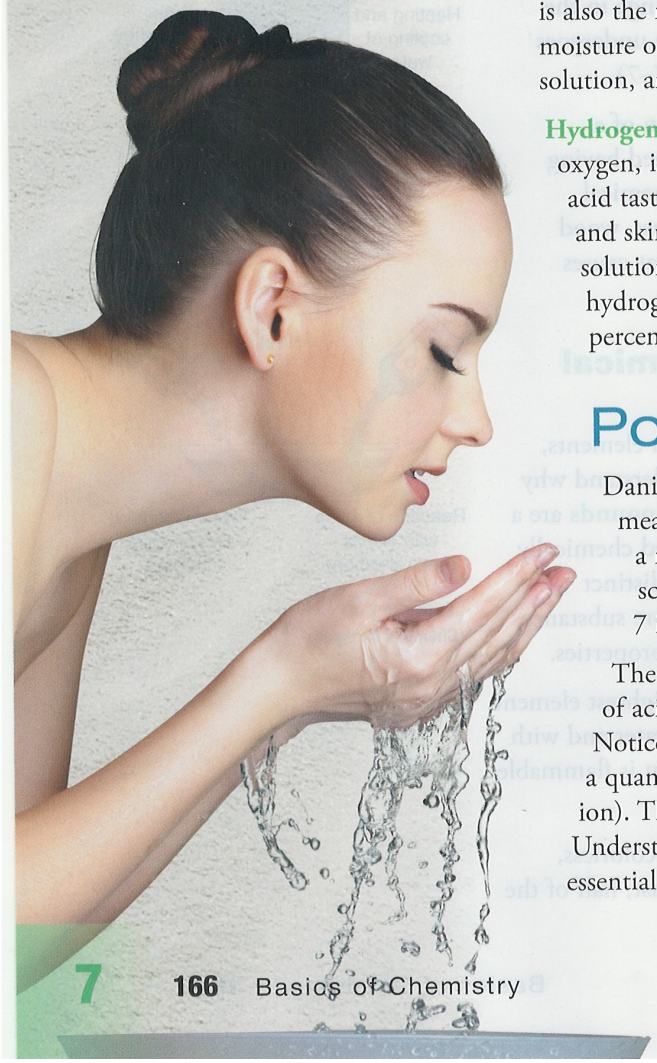
Nitrogen (N) is a colorless, gaseous element. It makes up about four-fifths of the air in our atmosphere and is found chiefly in the form of ammonia and nitrates.

Air is the gaseous mixture that makes up the Earth's atmosphere. It is odorless, colorless, and generally consists of about 1 part oxygen and 4 parts nitrogen by volume. It also contains a small amount of carbon dioxide, ammonia, and organic matter, which are all essential to plant and animal life.

Water (H_2O) is the most abundant of all substances, comprising about 75 percent of the Earth's surface and about 65 percent of the human body. Water is seldom pure. Natural spring water contains dissolved minerals, bacteria, and other substances.

Water makes up a large part of the skin. All cells require water to live, and even dying cells in the upper layer of the skin contain water. Water is also the most commonly used cosmetic ingredient. It replenishes moisture on the surface of the skin, helps keep other ingredients in solution, and helps spread products across the skin.

Hydrogen peroxide (H_2O_2), a chemical compound of hydrogen and oxygen, is a colorless liquid with a characteristic odor and a slightly acid taste. There are many uses for hydrogen peroxide in spas, salons, and skin care clinics. In haircoloring developers, for example, the solution known as a 20-volume peroxide is a solution of 6 percent hydrogen peroxide; and 10-volume peroxide is a solution of 3 percent hydrogen peroxide and can be used as an antiseptic.



Potential Hydrogen (pH)

Danish biochemist Soren Sorensen invented the pH scale for measuring the acidity of a substance in 1909. The **pH scale** is a measure of the acidity and alkalinity of a substance; the pH scale has a range of 0 to 14, with 7 being neutral. A pH below 7 is an acidic solution; a pH above 7 is an alkaline solution.

The **pH** (potential hydrogen) of a substance is its relative degree of acidity or alkalinity and is measured on a scale of 0 to 14. Notice that the term pH is written with a small p (which represents a quantity) and a capital H (which represents the hydrogen ion). The symbol pH represents the quantity of hydrogen ions. Understanding pH and how it affects the hair, skin, and nails is essential to understanding all salon and spa services.

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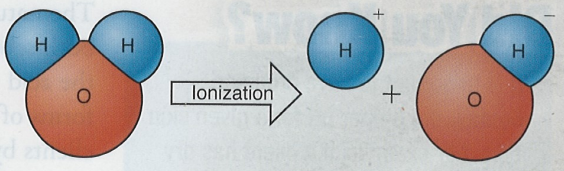
Water and pH

Understanding pH requires that we learn the term *ion*. An **ion** (EYE-on) is an atom or molecule that carries an electrical charge. **Ionization** (eye-on-ih-ZAY-shun) causes an atom or molecule to split in two, creating a pair of ions with opposite electrical charges. An ion with a negative electrical charge is an **anion** (AN-eye-on). An ion with a positive electrical charge is a **cation** (KAT-eye-on).



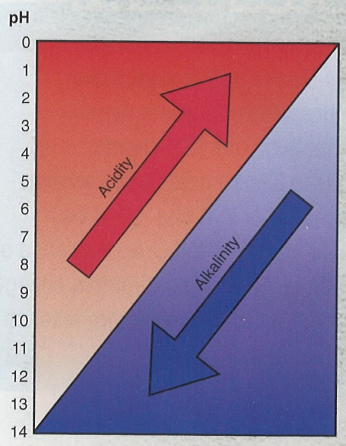
▲ Figure 7–9
Ionization.

In water, some of the water (H_2O) molecules naturally ionize into hydrogen ions and **hydroxide** ions, which is an anion with one oxygen and one hydrogen atom. The pH scale measures ions (**Figure 7–9**). The hydrogen ion (H^+) is acidic. The more hydrogen ions there are in a substance, the more acidic it will be. The hydroxide ion (OH^-) is alkaline. The more hydroxide ions there are in a substance, the more alkaline it will be. pH is only possible because of this ionization of water. Only products that contain water can have a pH.

CAUTION!

As estheticians, we must safeguard our hands while using various chemicals, peels, and products with varying pH levels. Make certain to wear gloves and follow manufacturer's recommendations for using products both for treatments and services, and for disinfecting.

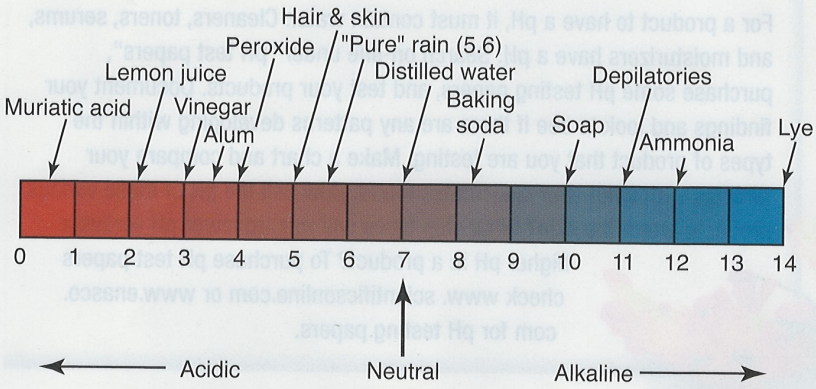
In pure (distilled) water, each water molecule that ionizes produces one hydrogen ion and one hydroxide ion. Pure water has a neutral pH because it contains the same number of hydrogen ions as hydroxide ions. It is an equal balance of 50 percent acid and 50 percent alkaline. The pH of any substance is always a balance of both acidity and alkalinity. As acidity increases, alkalinity decreases. The opposite is also true; as alkalinity increases, acidity decreases (**Figure 7–10**). Even the strongest acid also contains some alkalinity.



▲ Figure 7–10
Each step in the pH scale represents a tenfold change in pH.

Acids and Alkalis

Acids are substances that have a pH below 7.0, taste sour, and turn litmus paper from blue to red. The lower the pH number, the greater the degree of acidity. **Alkalis**, also known as **bases**, have a pH above 7.0, taste bitter, and turn litmus paper from red to blue. The higher the pH number, the greater the degree of alkalinity (**Figure 7–11**). A pH of 7 is a neutral solution.



◀ Figure 7–11
The pH scale.

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Did You Know?

It is important to have products contain the proper pH for a given skin type. For example, if a client has dry dehydrated skin, giving that client a product that is too acidic could further dry and irritate their skin. Conversely, if a client has an oily skin type, a product that is slightly alkaline may contribute to oil and sebum buildup and possibly create acne. This client may need a more acidic pH to their product.

Did You Know?

The pH scale is a **logarithmic scale**. This means that in a pH scale, a change of one whole number represents a tenfold change in pH. A pH of 8 is 10 times more alkaline than a pH of 7. A change of two whole numbers indicates a change of 10 times 10, or a hundredfold change. A pH of 9 is 100 times more alkaline than a pH of 7.

The natural pH of the skin is slightly acidic at 5.5. The skin produces both sebum and sweat to create a barrier on the skin's surface known as the acid mantle. The **acid mantle** is a protective barrier against certain forms of bacteria and other microorganisms. We can influence our clients by selecting and using products that are developed for their skin type and condition.

pH and Skin Care Products

When the skin is exposed to extremes in pH levels, dryness, dehydration, inflammation, and even bacteria can grow if the product is incorrect for a given skin type. It is important to give a client with an oily skin type a product that will help reduce oil and bacteria, rather than have them use the same product as their friend who may have very dry skin, for instance. The pH will be slightly different in these two products. It is important to note that while many estheticians cross over in product lines, using a cleanser from one line and a serum from another, it may not be beneficial to the skin as pH values can differ from line to line and might have different delivery systems within the ingredients. Additionally, it is important to layer products from the lowest viscosity to the highest. For example, the following products would be applied in this order: a light serum or ampoule, a lotion, then a cream. Products that are heavier, such as creams, may have larger molecules, varying pH values, and could potentially block a product from penetrating into the skin and therefore should be applied last.

L04

Even at levels that are not nearly as severe, extreme variations in pH can damage the skin's barrier function and cause irritation. Buffering agents are frequently added to skin care products to maintain the pH at the correct level to produce the desired effect while keeping the product safe and nonirritating to the skin. This is why it is important for estheticians to understand the chemistry of products and to make selections based on the skin type and condition being treated.

ACTIVITY

For a product to have a pH, it must contain water. Cleaners, toners, serums, and moisturizers have a pH. Search on-line under "pH test papers", purchase some pH testing papers, and test your products. Document your findings and look to see if there are any patterns developing within the types of product that you are testing. Make a chart and compare your findings with what your classmates found. How will the pH of these various products affect the skin? What skin types will require lower pH versus a higher pH in a product? To purchase pH test papers check www. scientificsonline.com or www.enasco. com for pH testing papers.

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pH WORKSHEET FORM				
NORMAL	DRY	OILY	COMBINATION	SENSITIVE
Product name & pH level	Product name & pH level	Product name & pH level	Product name & pH level	Product name & pH level
NORMAL	DRY	OILY	COMBINATION	SENSITIVE
Product name & pH level	Product name & pH level	Product name & pH level	Product name & pH level	Product name & pH level

Table 7–2 pH Worksheet Form.

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Testing pH in Products

As an esthetician, it is helpful to learn to test the pH in products regularly when you are considering what to buy for your salon, spa, clinic, or for research. This is a great habit to begin as a student. Refer to Table 7–2 as a sample worksheet to chart your findings. Look for patterns in the pH of products for various skin types, and then test how they perform. Begin testing products with your classmates, and then continue that practice once you have clients of your own. Ask yourself: Is the product well tolerated by my client? Is the product made for oily skin more acidic? Is the product made for dry skin more alkaline? Document your findings. ☑ L05

Chemical Reactions

Two types of chemical reactions are of importance to estheticians because they explain how skin care products work. They are acid-alkali neutralization reactions and oxidation-reduction reactions.

Acid-alkali neutralization reactions occur when an acid is mixed with an alkali, also called a base, in equal proportions to neutralize each other

Did You Know?

When you see a rusty nail, tarnish on a silver spoon, or corrosion on metal, you are observing oxidation.

and form water (H_2O) and a salt. For example, hydrochloric acid (HCl) reacts with sodium hydroxide (NaOH) to form sodium chloride (NaCl) which is common table salt, and water (H_2O). These are examples of acid-alkali neutralization reactions.

Oxidation-reduction, also known as **redox**, is a chemical reaction in which the oxidizing agent is reduced and the reducing agent is oxidized. An *oxidizing agent* is a substance that releases oxygen. Hydrogen peroxide (H_2O_2) is an example of an oxidizing agent. Hydrogen peroxide can be thought of as water with an extra atom of oxygen. When hydrogen peroxide is mixed with haircolor, facial bleaching cream, or brow tint, oxygen is added to the preparation and thus it becomes oxidized. At the same time, oxygen is subtracted from the hydrogen peroxide and the hydrogen peroxide is reduced. In this example, the haircolor, the facial bleach, or the brow tint is a reducing agent. Redox reactions are always an exchange. When a substance is oxidized, the oxidizer is always reduced. A **reduction** is the subtraction of oxygen or the addition of hydrogen. The chemical reaction is called a **redox reaction**.

Web Resources

For some fun with chemistry, check out these Web sites:

www.chem4kids.com (This is not just for kids!)

www.ehow.com

www.scienceclarified.com

www.answers.com

www.wisegeek.com

www.kangenwaterreport.com

Oxidation reactions can take place without oxygen. Oxidation also can occur when hydrogen is subtracted from a substance. Thus, oxidation is the result of either the addition of oxygen, or the subtraction of hydrogen. Reduction can also occur when hydrogen is added to a substance. Consequently, reduction is the result of either the loss of oxygen or the addition of hydrogen. The desired chemical changes created by processing of haircolors, facial bleaching creams, or brow tinting products would not be possible without oxidation–reduction (redox) reactions.

Combustion is the rapid oxidation of a substance, accompanied by the production of heat and light. Lighting a match is an example of rapid oxidation. You cannot have a fire without oxygen.

As estheticians, we learn about the process of oxidation by using antioxidants in skin care products. **Antioxidants** are used to stabilize skin care products by preventing oxidation that would otherwise cause a product to turn rancid and decompose. They are vitamins such as A, C, and E, which can be applied topically in products or taken internally to increase healthy body functions.

Did You Know?

The sugar in grapes is chemically converted into ethyl alcohol by certain types of yeast when wine is fermented in a wooden vat. This is an example of a chemical reaction.

Antioxidants prevent oxidation by neutralizing **free radicals**. Free radicals are *super* oxidizers that cause an oxidation reaction and produce a new free radical in the process. Because they are created by highly reactive atoms or molecules (often oxygen), free radicals are unstable. If left alone they will create inflammation, damage DNA, and eventually cause disease and death. One free radical can **oxidize** (combine or cause a substance to combine with oxygen) millions of other substances. Antioxidants are free radical scavengers that stop the oxidation reaction from continuing.

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SOLUTIONS, SUSPENSIONS, AND EMULSIONS		
SOLUTIONS	SUSPENSIONS	EMULSIONS
Miscible	Slightly miscible	Immiscible
No surfactant	No surfactant	Surfactant
Small particles	Larger particles	Largest particles
Usually clear	Usually cloudy	Usually a solid color
Stable mixture	Unstable mixture	Limited stability through an emulsifier
Example: solution of hydrogen peroxide	Example: calamine lotion	Example: shampoos and conditioners

Table 7–3 Solutions, Suspensions, and Emulsions.

Chemistry as Applied to Cosmetics

To better serve their clients, estheticians should have an understanding of the chemical composition, preparation, and uses of cosmetics that are intended to cleanse and beautify the skin. Most of the products an esthetician uses are solutions, suspensions, and emulsions.

Solutions, Suspensions, and Emulsions

Solutions, suspensions, and emulsions are all physical mixtures of two or more different substances (Table 7–3). The distinction between solutions, suspensions, and emulsions depends on the size of the particles and the solubility of the components.

Solutions

Solutions (soh-LOO-shuns) a uniform mixture of two or more mutually miscible substances. A **solute** (SOL-yoot) is any substance that is dissolved by a solvent to form a solution. A **solvent** (SOL-vent) is any substance that dissolves the solute to form a solution.

Miscible (MIS-eh-bel) liquids are mutually soluble. Water and alcohol are examples of miscible (mixable) liquids. **Immiscible** liquids are not mutually soluble (Figure 7–12). Water and oil are examples of immiscible (nonmixable) liquids. You have probably heard the saying, "oil and water don't mix."

Solutions contain particles the size of a small molecule that are invisible to the naked eye. Solutions are usually transparent, although they may be colored. Solutions do not separate on

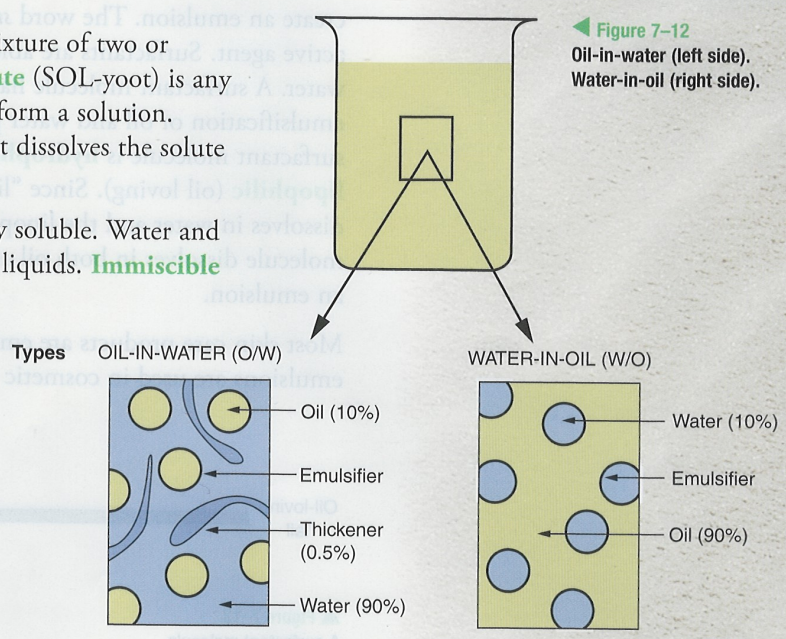

Figure 7–12 Oil-in-water (left side). Water-in-oil (right side).

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standing. Salt water is a solution of a solid dissolved in a liquid. Water is the solvent that dissolves the salt and holds it in solution. Air, salt water, and hydrogen peroxide are examples of solutions.

Suspensions

Suspensions unstable mixtures of two or more immiscible substances. Suspensions differ from solutions due to the size of the particles. Suspensions contain larger particles than solutions do. The particles in a suspension are large enough to be visible to the naked eye. Suspensions are not usually transparent and may be colored. Suspensions have a tendency to separate over time.

Oil and vinegar salad dressing is an example of a suspension with oil suspended in vinegar. Salad dressing will separate on standing and should be shaken well before use. Salad dressing, paint, and aerosol hair spray are examples of suspensions.

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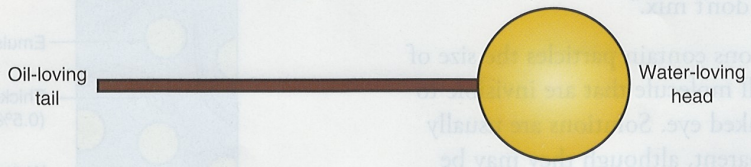
Emulsions

Emulsions (ee-MUL-shuns) are mixtures of two or more immiscible substances united with the aid of an emulsifier. The term *emulsify* means "to form an emulsion," with one liquid dispersed in another. Although emulsions tend to separate over time, a properly formulated emulsion, when stored correctly, should be stable for at least 3 years. Without adequate dispersion, emulsions can become unstable over time and break (separate) into two insoluble layers. Once this occurs, the emulsion should usually be discarded. ☑ L06

Surfactants

Surfactants (sur-FAK-tants) are used to emulsify oil and water to create an emulsion. The word *surfactant* is an acronym for surface active agent. Surfactants are able to wet the skin and emulsify oil and water. A surfactant molecule has two distinct parts that make the emulsification of oil and water possible (**Figure 7–13**). One end of the surfactant molecule is **hydrophilic** (water loving), and the other end is **lipophilic** (oil loving). Since "like dissolves like," the hydrophilic end dissolves in water and the lipophilic end dissolves in oil, so, a surfactant molecule dissolves in both oil and water and joins them together to form an emulsion.

Most skin care products are emulsions of oil and water. Two types of emulsions are used in cosmetic preparations: oil-in-water (O/W) and



▲ **Figure 7–13**
A surfactant molecule.

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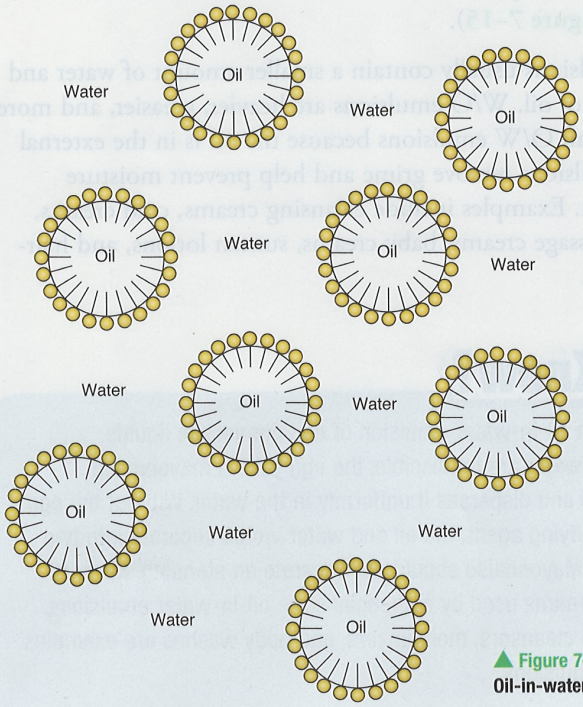
water-in-oil (W/O). As a skin moisturizer, the purpose of an emulsion is to apply a uniform layer of the emulsion's oil phase evenly on the skin. Once contact is made with the skin, the oil phase is deposited on the surface. The oil phase acts as an external lubricant to smooth and protect the surface of the epidermis. The water phase restores the natural moisture content of the epidermis, making the skin soft and smooth. Thus, the water in the emulsion acts as an internal lubricant. One advantage of O/W emulsions is that they are easily rinsed away with water. An O/W cleansing lotion, for example, can be removed easily with wet cotton pads or sponges.

O/W emulsions are often milky, free-flowing liquids, although thickeners may be added to form gels or thick creams. O/W emulsions include moisturizing and cleansing lotions.

Oil-in-Water (O/W) Emulsions

In an **oil-in-water (O/W) emulsion**, droplets of oil are dispersed in water. The droplets of oil (micelles) are surrounded by surfactants with their "tails" (lipophilic ends) pointing in and their "heads" (hydrophilic ends) pointing out, which keeps the oil dispersed in water. In O/W emulsions, the water is the continuous or external phase and the oil is the discontinuous or internal phase (**Figure 7–14**). O/W emulsions usually contain a small amount of oil and a greater amount of water. Salons and spas primarily use O/W emulsions.



▲ **Figure 7–14**
Oil-in-water emulsion.

Did You Know?

Soaps were the first synthetic surfactants. Soaps were made more than 5,000 years ago by boiling oil or animal fat with wood ashes. Modern soaps are made from animal, vegetable, or synthetic fats or oils by a process called *saponification*. Traditional bar soaps are highly alkaline and combine with the minerals in hard water to form an insoluble film that coats skin and can cause hands to feel dry, itchy, and irritated. Modern synthetic surfactants have overcome these disadvantages and are superior to soaps; many are milder on the skin than soaps used in the past.

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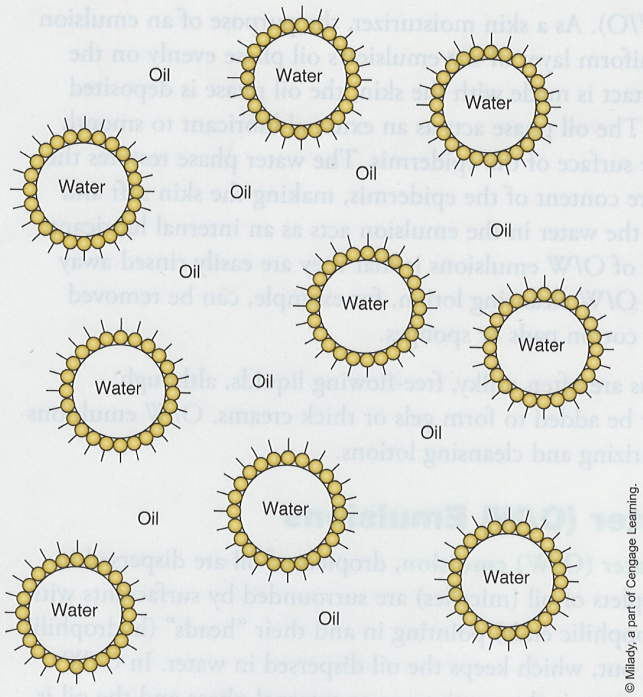
▶ Figure 7–15
Water-in-oil emulsion.



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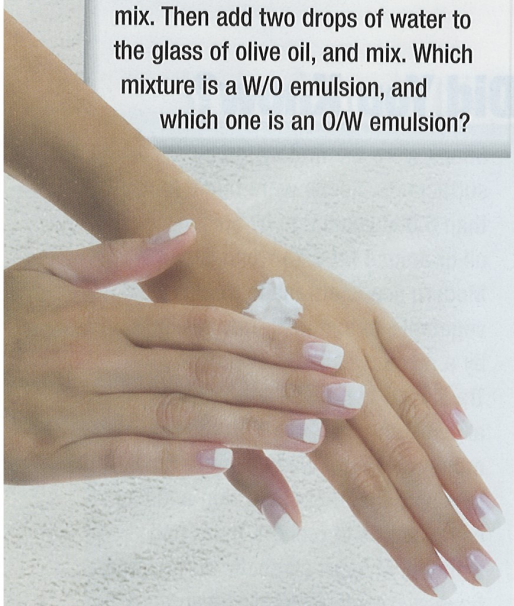
ACTIVITY

Experiment: Water-in-oil emulsion, Oil-in-water emulsion

Pour water into one glass, and olive oil into another glass. Put two drops olive oil into the water glass, and mix. Then add two drops of water to the glass of olive oil, and mix. Which mixture is a W/O emulsion, and which one is an O/W emulsion?



Water-in-Oil (W/O) Emulsions

In a **water-in-oil (W/O) emulsion**, droplets of water are dispersed in oil. The droplets of water (inverse micelles) are surrounded by surfactants with their "heads" (hydrophilic ends) pointing in and their "tails" (lipophilic ends) pointing out. In W/O emulsions, the oil is the continuous or external phase and the water is the discontinuous, or internal phase (**Figure 7–15**).

Water-in-oil emulsions usually contain a smaller amount of water and a greater amount of oil. W/O emulsions are heavier, greasier, and more water resistant than O/W emulsions because the oil is in the external phase. These emulsions remove grime and help prevent moisture loss from the skin. Examples include cleansing creams, cold creams, night creams, massage creams, baby creams, suntan lotions, and hair-grooming creams.

Did You Know?

Mayonnaise is an oil-in-water emulsion of two immiscible liquids. Although oil and water are immiscible, the egg yolk in mayonnaise emulsifies the oil and disperses it uniformly in the water. Without the egg yolk as an emulsifying agent, the oil and water would separate into two insoluble layers. Mayonnaise should not separate on standing. Many of the lotions and creams used by estheticians are oil-in-water emulsions. Mayonnaise, skin cleansers, moisturizers, and body washes are examples of oil-in-water emulsions.

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Review Questions

1. Define chemistry.
2. What is the difference between organic and inorganic chemistry?
3. Define matter.
4. What are the differences between solids, liquids, and gases?
5. Define element.
6. What are atoms?
7. Define molecule.
8. What is the difference between a chemical compound and a physical mixture?
9. What are physical properties? How are they different from chemical properties?
10. How can matter be changed? Give an example of each kind of change.
11. Describe hydrogen, oxygen, and nitrogen.
12. How is water important in skin care?
13. Define pH. Why do you need to know the pH of products you work with?
14. Define oxidation and reduction.
15. Explain the differences between solutions, suspensions, and emulsions.
16. Explain the structure of the two types of emulsion products used in skin care.
17. What types of products are made with oil-in-water (O/W) emulsions? With water-in-oil (W/O) emulsions?

Glossary

acid mantle	Protective barrier of lipids and secretions on the surface of the skin.
acid-alkali neutralization reactions	When an acid is mixed with an alkali in equal proportions to neutralize each other and form water (H_2O) and a salt.
acids	Substances that have a pH below 7.0, taste sour, and turn litmus paper from blue to red.
air	The gaseous mixture that makes up the Earth's atmosphere. It is odorless, colorless, and generally consists of about 1 part oxygen and 4 parts nitrogen by volume.
alkalis	Also known as *bases*; compounds that react with acids to form salts; have a pH above 7.0 (neutral), taste bitter, and turn litmus paper from red to blue.
anion	An ion with a negative electrical charge.
antioxidants	Used to stabilize skin care products by preventing oxidation that would otherwise cause a product to turn rancid and decompose. They are vitamins such as A, C, and E, which can be applied topically in products or taken internally to increase healthy body functions.
atoms	The smallest chemical components (often called particles) of an element that still retains the properties of that element.
cation	Ion with a positive electrical charge.
chemical change	Change in the chemical properties of a substance that is the result of a chemical reaction in which a new substance or substances are formed that have properties different from the original.

Glossary

chemical compounds	Combinations of two or more atoms of different elements united chemically with a fixed chemical composition, definite proportions, and distinct properties.
chemical properties	Those characteristics that can only be determined by a chemical reaction and a chemical change in the identity of the substance.
chemistry	Science that deals with the composition, structures, and properties of matter and how matter changes under different conditions.
combustion	Rapid oxidation of any substance, accompanied by the production of heat and light.
compound molecules	Also known as *compounds*; a chemical combination of two or more atoms of different elements in definite (fixed) proportions.
element	The simplest form of matter; cannot be broken down into a simpler substance without loss of identity.
elemental molecules	Molecule containing two or more atoms of the same element in definite (fixed) proportions.
emulsions	An unstable physical mixture of two or more immiscible substances (substances that normally will not stay blended) plus a special ingredient called an emulsifier.
free radicals	Unstable molecules that cause inflammation, disease, and biochemical aging in the body, especially wrinkling and sagging of the skin. Free radicals are super oxidizers that cause an oxidation reaction and produce a new free radical in the process that are created by highly reactive atoms or molecules (often oxygen).
gases	Matter without a definite shape or size. No fixed volume or shape; takes the shape of its container.
hydrogen	Colorless, odorless, tasteless gas; the lightest element known.
hydrogen peroxide	Chemical compound of hydrogen and oxygen; a colorless liquid with a characteristic odor and a slightly acid taste.
hydrophilic	Easily absorbs moisture; in chemistry terms, capable of combining with or attracting water (water-loving).
hydroxide	An anion (an ion with a negative electrical charge) with one oxygen and one hydrogen atom.
immiscible	Liquids that are not capable of being mixed together to form stable solutions.
inorganic chemistry	The study of substances that do not contain the element carbon, but may contain the element hydrogen.
ion	An atom or molecule that carries an electrical charge.
ionization	The separation of an atom or molecule into positive or negative ions.
lipophilic	Having an affinity for or an attraction to fat and oils (oil-loving).
liquids	Matter that has volume, no definite shape and will take shape of its container, such as water.
logarithmic scale	A method of displaying data in multiples of 10.
matter	Any substance that occupies space and has mass (weight).
miscible	Capable of being mixed; liquids that are mutually soluble, meaning that they can be mixed together to form stable solutions.

Glossary

molecule	A chemical combination of two or more atoms.
nitrogen	A colorless gaseous element that makes up about four-fifths of the air in our atmosphere and is found chiefly in ammonia and nitrates.
oil-in-water (O/W) emulsion	Oil droplets dispersed in a water with the aid of an emulsifying agent.
organic chemistry	Study of substances that contain carbon.
oxidation	Either the addition of oxygen or the loss of hydrogen; a chemical reaction that combines a substance with oxygen to produce an oxide.
oxidation-reduction	Also known as *redox*; chemical reaction in which the oxidizing agent is reduced and the reducing agent is oxidized.
oxidize	To combine or cause a substance to combine with oxygen.
oxygen	The most abundant element on Earth.
pH	The abbreviation used for potential hydrogen; relative degree of acidity and alkalinity of a substance. pH represents the quantity of hydrogen ions.
pH scale	A measure of the acidity and alkalinity of a substance; the pH scale has a range of 0 to 14, with 7 being a neutral. A pH below 7 is an acidic solution; a pH above 7 is an alkaline solution.
physical change	Change in the form or physical properties of a substance without a chemical reaction or the formation of a new substance.
physical mixtures	Combination of two or more substances united physically, not chemically, without a fixed composition and in any proportions.
physical properties	Characteristics that can be determined without a chemical reaction and that do not cause a chemical change in the identity of the substance.
redox reactions	Chemical reaction in which the oxidizing agent is reduced and the reducing agent is oxidized.
reduction	The process through which oxygen is subtracted from or hydrogen is added to a substance through a chemical reaction.
solids	A state of matter that is rigid with a definite size and shape, such as ice.
solute	A substance that dissolves the solute to form a solution.
solutions	A uniform mixture of two or more mutually miscible substances.
solvent	A substance that dissolves another substance to form a solution.
states of matter	The three different physical forms of matter: solid, liquid, and gas.
surfactants	Acronym for *surface active agent*; reduce surface tension between the skin and the product to increase product spreadability; allow oil and water to mix, or emulsify.
suspensions	Unstable mixtures of two or more immiscible substances.
water	Most abundant of all substances, comprising about 75 percent of the Earth's surface and about 65 percent of the human body.
water-in-oil (W/O) emulsion	Droplets of water dispersed in an oil.