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Science Chemistry chemical compound, any substance composed of identical molecules consisting of atoms of two or more chemical elements.water moleculeA water molecule is made up of two hydrogen atoms and one oxygen atom. A single oxygen atom contains six electrons in its outer shell, which can hold a total of eight electrons. When two hydrogen atoms are bound to an oxygen atom, the outer electron shell of oxygen is filled.All the matter in the universe is composed of the atoms of more than 100 different chemical elements, which are found both in pure form and combined in chemical compounds. A sample of any given pure element is composed only of the atoms characteristic of that element, and the atoms of each element are unique. For example, the atoms that constitute carbon are different from those that make up iron, which are in turn different from those of gold. Every element is designated by a unique symbol consisting of one, two, or three letters arising from either the current element name or its original (often Latin) name. For example, the symbols for carbon, hydrogen, and oxygen are simply C, H, and O, respectively. The symbol for iron is Fe, from its original Latin name ferrum. The fundamental principle of the science of chemistry is that the atoms of different elements can combine with one another to form chemical compounds. Methane, for example, which is formed from the elements carbon and hydrogen in the ratio four hydrogen atoms for each carbon atom, is known to contain distinct CH4 molecules. The formula of a compound—such as CH4—indicates the types of atoms present, with subscripts representing the relative numbers of atoms (although the numeral 1 is never written).Water, which is a chemical compound of hydrogen and oxygen in the ratio two hydrogen atoms for every oxygen atom, contains H2O molecules. Sodium chloride is a chemical compound formed from sodium (Na) and chlorine (Cl) in a 1:1 ratio. Although the formula for sodium chloride is NaCl, the compound does not contain actual NaCl molecules. Rather, it contains equal numbers of sodium ions with a charge of positive one (Na+) and chloride ions with a charge of negative one (Cl−). (See below Trends in the chemical properties of the elements for a discussion of the process for changing uncharged atoms to ions [i.e., species with a positive or negative net charge].) The substances mentioned above exemplify the two basic types of chemical compounds: molecular (covalent) and ionic. Methane and water are composed of molecules; that is, they are molecular compounds. Sodium chloride, on the other hand, contains ions; it is an ionic compound.The atoms of the various chemical elements can be likened to the letters of the alphabet: just as the letters of the alphabet are combined to form thousands of words, the atoms of the elements can combine in various ways to form a myriad of compounds. In fact, there are millions of chemical compounds known, and many more millions are possible but have not yet been discovered or synthesized. Most substances found in nature—such as wood, soil, and rocks—are mixtures of chemical compounds. These substances can be separated into their constituent compounds by physical methods, which are methods that do not change the way in which atoms are aggregated within the compounds. Compounds can be broken down into their constituent elements by chemical changes. A chemical change (that is, a chemical reaction) is one in which the organization of the atoms is altered. An example of a chemical reaction is the burning of methane in the presence of molecular oxygen (O2) to form carbon dioxide (CO2) and water. CH4 + 2O2 → CO2 + 2H2O In this reaction, which is an example of a combustion reaction, changes occur in the way that the carbon, hydrogen, and oxygen atoms are bound together in the compounds.mercury (Hg)Mercury (chemical symbol: Hg) is the only metal element that is liquid at room temperature.Chemical compounds show a bewildering array of characteristics. At ordinary temperatures and pressures, some are solids, some are liquids, and some are gases. The colours of the various compounds span those of the rainbow. Some compounds are highly toxic to humans, whereas others are essential for life. Substitution of only a single atom within a compound may be responsible for changing the colour, odour, or toxicity of a substance. So that some sense can be made out of this great diversity, classification systems have been developed. An example cited above classifies compounds as molecular or ionic. Compounds are also classified as organic or inorganic. Organic compounds (see below Organic compounds), so called because many of them were originally isolated from living organisms, typically contain chains or rings of carbon atoms. Because of the great variety of ways that carbon can bond with itself and other elements, there are more than nine million organic compounds. The compounds that are not considered to be organic are called inorganic compounds (see below Inorganic compounds). Facts You Should Know: The Periodic Table Quiz Within the broad classifications of organic and inorganic are many subclasses, mainly based on the specific elements or groups of elements that are present. For example, among the inorganic compounds, oxides contain O2− ions or oxygen atoms, hydrides contain H− ions or hydrogen atoms, sulfides contain S2− ions, and so forth. Subclasses of organic compounds include alcohols (which contain the —OH group), carboxylic acids (characterized by the —COOH group), amines (which have an —NH2 group), and so on. periodic tableThe periodic table of the elements.The different abilities of the various atoms to combine to form compounds can best be understood in terms of the periodic table. The periodic table was originally constructed to represent the patterns observed in the chemical properties of the elements (see chemical bonding). That is to say, as the science of chemistry developed, it was observed that elements could be grouped according to their chemical reactivity. Elements with similar properties are listed in vertical columns of the periodic table and are called groups. As the details of the atomic structure were revealed, it became clear that the position of an element in the periodic table correlates with the arrangement of the electrons possessed by the atoms of that element (see atom). In particular, it was observed that the electrons that determine the chemical behaviour of an atom are those in its outermost shell. Such electrons are called valence electrons. For example, the atoms of the elements in Group 1 of the periodic table all have one valence electron, the atoms of the elements in Group 2 have two valence electrons, and so on, until Group 18, whose elements contain eight valence electrons, is reached. The simplest and most important rule for predicting how atoms form compounds is that atoms tend to combine in ways that allow them either to empty their valence shell or to complete it (i.e., fill it up), in most cases with a total of eight electrons. Elements on the left side of the periodic table tend to lose their valence electrons in chemical reactions. Sodium (in Group 1), for example, tends to lose its lone valence electron to form an ion with a charge of +1. Each sodium atom has 11 electrons (e−), each with a charge of −1, to just balance the +11 charge on its nucleus. Losing one electron leaves it with 10 negative charges and 11 positive charges to give a net +1 charge: Na → Na+ + e−. Potassium, located directly beneath sodium in Group 1, also forms +1 ions (K+) in its reactions, as do the remaining members of Group 1: rubidium (Rb), cesium (Cs), and francium (Fr). The atoms of the elements toward the right end of the periodic table tend to undergo reactions such that they gain (or share) enough electrons to complete their valence shell. For example, oxygen in Group 16 has six valence electrons and thus needs two more electrons to complete its outermost shell. Oxygen achieves this arrangement by reacting with elements that can lose or share electrons. An oxygen atom, for instance, can react with a magnesium (Mg) atom (in Group 2) by taking magnesium’s two valence electrons, producing Mg2+ and O2− ions. (When a neutral magnesium atom loses two electrons, it forms the Mg2+ ion, and, when a neutral oxygen atom gains two electrons, it forms the O2− ion.) The resulting Mg2+ and O2− then combine in a 1:1 ratio to give the ionic compound MgO (magnesium oxide). (Although the compound magnesium oxide contains charged species, it has no net charge, because it contains equal numbers of Mg2+ and O2− ions.) Likewise, oxygen reacts with calcium (just below magnesium in Group 2) to form CaO (calcium oxide). Oxygen reacts in a similar way with beryllium (Be), strontium (Sr), barium (Ba), and radium (Ra), the remaining elements in Group 2. The key point is that, because all the elements in a given group have the same number of valence electrons, they form similar compounds. The chemical elements can be classified in many different ways. The most fundamental division of the elements is into metals, which constitute the majority of the elements, and nonmetals. The typical physical properties of metals are lustrous appearance, malleability (the ability to be pounded into a thin sheet), ductility (the ability to be drawn into a wire), and efficient thermal and electrical conductivity. The most important chemical property of metals is the tendency to give up electrons to form positive ions. Copper (Cu), for example, is a typical metal. It is lustrous but easily tarnishes; it is an excellent conductor of electricity and is commonly used for electrical wires; and it is readily formed into products of various shapes, such as pipes for water systems. Copper is found in many ionic compounds in the form of either the Cu+ or the Cu2+ ion. The metallic elements are found on the left side and in the centre of the periodic table. The metals of Groups 1 and 2 are called the representative metals; those in the centre of the periodic table are called the transition metals. The lanthanoids and actinoids shown below the periodic table are special classes of transition metals. The nonmetals, which are relatively few in number, are found in the upper right-hand corner of the periodic table—except for hydrogen, the only nonmetallic member of Group 1. The physical properties characteristic of metals are absent in nonmetals. In chemical reactions with metals, nonmetals gain electrons to form negative ions. Nonmetallic elements also react with other nonmetals, in this case forming molecular compounds. Chlorine is a typical nonmetal. At ordinary temperatures, elemental chlorine contains Cl2 molecules and reacts with other nonmetals to form molecules such as HCl, CCl4, and PCl3. Chlorine reacts with metals to form ionic compounds containing Cl− ions. The division of the elements into metals and nonmetals is only approximate. A few elements along the dividing line exhibit both metallic and nonmetallic properties and are called metalloids, or semimetals. Science Chemistry chemistry, the science that deals with the properties, composition, and structure of substances (defined as elements and compounds), the transformations they undergo, and the energy that is released or absorbed during these processes. Every substance, whether naturally occurring or artificially produced, consists of one or more of the hundred-odd species of atoms that have been identified as elements. Although these atoms, in turn, are composed of more elementary particles, they are the basic building blocks of chemical substances; there is no quantity of oxygen, mercury, or gold, for example, smaller than an atom of that substance. Chemistry, therefore, is concerned not with the subatomic domain but with the properties of atoms and the laws governing their combinations and how the knowledge of these properties can be used to achieve specific purposes.The great challenge in chemistry is the development of a coherent explanation of the complex behaviour of materials, why they appear as they do, what gives them their enduring properties, and how interactions among different substances can bring about the formation of new substances and the destruction of old ones. From the earliest attempts to understand the material world in rational terms, chemists have struggled to develop theories of matter that satisfactorily explain both permanence and change. The ordered assembly of indestructible atoms into small and large molecules, or extended networks of intermingled atoms, is generally accepted as the basis of permanence, while the reorganization of atoms or molecules into different arrangements lies behind theories of change. This chemistry involves the study of the atomic composition and structural architecture of substances, as well as the varied interactions among substances that can lead to sudden, often violent reactions.Chemistry also is concerned with the utilization of natural substances and the creation of artificial ones. Cooking, fermentation, glass-making, and metallurgy are all chemical processes that date from the beginnings of civilization. Today, vinyl, Teflon, liquid crystals, semiconductors, and superconductors represent the fruits of chemical technology. The 20th century saw dramatic advances in the comprehension of the marvelous and complex chemistry of living organisms, and a molecular interpretation of health and disease holds great promise. Modern chemistry, aided by increasingly sophisticated instruments, studies materials as small as single atoms and as large and complex as DNA (deoxyribonucleic acid), which contains millions of atoms. New substances can even be designed to bear desired characteristics and then synthesized. The rate at which chemical knowledge continues to accumulate is remarkable. Over time more than 8,000,000 different chemical substances, both natural and artificial, have been characterized and produced. The number was less than 500,000 as recently as 1965.Intimately interconnected with the intellectual challenges of chemistry are those associated with industry. In the mid-19th century the German chemist Justus von Liebig commented that the wealth of a nation could be gauged by the amount of sulfuric acid it produced. This acid, essential to many manufacturing processes, remains today the leading chemical product of industrialized countries. As Liebig recognized, a country that produces large amounts of sulfuric acid is one with a strong chemical industry and a strong economy as a whole. The production, distribution, and utilization of a wide range of chemical products is common to all highly developed nations. In fact, one can say that the “iron age” of civilization is being replaced by a “polymer age,” for in some countries the total volume of polymers now produced exceeds that of iron. The days are long past when one person could hope to have a detailed knowledge of all areas of chemistry. Those pursuing their interests into specific areas of chemistry communicate with others who share the same interests. Over time a group of chemists with specialized research interests became the founding members of an area of specialization. The areas of specialization that emerged early in the history of chemistry, such as organic, inorganic, physical, analytical, and industrial chemistry, along with biochemistry, remain of greatest general interest. There has been, however, much growth in the areas of polymer, environmental, and medicinal chemistry during the 20th century. Moreover, new specialties continue to appear, as, for example, pesticide, forensic, and computer chemistry. Facts You Should Know: The Periodic Table Quiz chemical formula, any of several kinds of expressions of the composition or structure of chemical compounds. The forms commonly encountered are empirical, molecular, structural, and projection formulas.An empirical formula consists of symbols representing elements in a compound, such as Na for sodium and Cl for chlorine, and subscripts indicating the relative number of atoms of each constituent element. (A subscript is not used, however, unless the number is more than one.) Thus, benzene is represented by the empirical formula CH, which indicates that a typical sample of the compound contains one atom of carbon (C) to one atom of hydrogen (H). Water is represented by the empirical formula H2O, denoting that the substance contains two atoms of hydrogen (H2) for every atom of oxygen (O).A general formula is a type of empirical formula that represents the composition of any member of an entire class of compounds. Every member of the class of paraffin hydrocarbons is, for example, composed of hydrogen and carbon, the number of hydrogen atoms always being two or more than twice the number of carbon atoms. Given that n stands for “any number,” the general formula of this class is therefore CnH2n + 2. Facts You Should Know: The Periodic Table Quiz Empirical formulas are normally used to represent substances with undetermined molecular structures or substances not made up of normal molecular entities—e.g., sodium chloride (table salt), which is composed of ions. To express the chemical composition of the individual molecules of a substance—the molecule being the smallest particle in which the substance retains its chemical properties—a molecular formula is employed. For example, the molecular formulas C2H4 and C3H6 for ethylene and propylene, respectively, state the number and kind of every atom present in a molecule of each substance. In contrast, both ethylene and propylene have the same empirical formula, CH2, because they are both composed of carbon and hydrogen atoms in a ratio of 1 to 2. In some cases, such as water, the empirical and molecular formulas of a substance may be identical.Structural formulas identify the location of chemical bonds between the atoms of a molecule. A structural formula consists of symbols for the atoms connected by short lines that represent chemical bonds—one, two, or three lines standing for single, double, or triple bonds, respectively. For example, the structural formula of ethane signifying that the compound consists of two carbon atoms each linked to the other and to three hydrogen atoms by single bonds. Structural formulas are particularly useful for showing how compounds with the identical kind and number of atoms differ. A projection formula is a two-dimensional representation of what is actually a three-dimensional molecule. Such a formula resembles the structural type in that it consists of symbols representing atoms of the constituent elements connected to each other by dashes or curves that stand for chemical bonds. Thus, the methane molecule, characterized by a tetrahedral disposition of four chemical bonds around a carbon atom, is conveniently represented by the projection formulaProjection formulas are widely used in the study of stereoisomers—compounds that have the same composition but that differ in the spatial arrangement of the atoms comprising their molecules. Certain conventions for drawing projection formulas have been adopted so that stereoisomers can be distinguished from one another by means of appropriate differences in their formulas. Science Chemistry Ask the Chatbot a Question chemical reaction, a process in which one or more substances, the reactants, are converted to one or more different substances, the products. Substances are either chemical elements or compounds. A chemical reaction rearranges the constituent atoms of the reactants to create different substances as products.Chemical reactions are an integral part of technology, of culture, and indeed of life itself. Burning fuels, smelting iron, making glass and pottery, brewing beer, and making wine and cheese are among many examples of activities incorporating chemical reactions that have been known and used for thousands of years. Chemical reactions abound in the geology of Earth, in the atmosphere and oceans, and in a vast array of complicated processes that occur in all living systems, including iceMelting ice, Lower Purgatory Falls, on a tributary of the Souhegan River between Mont Vernon and Lyndeborough, New Hampshire. Ice melting is a physical change and not a chemical reaction.Chemical reactions must be distinguished from physical changes. Physical changes include changes of state, such as ice melting to water and water evaporating to vapor. If a physical change occurs, the physical properties of a substance will change, but its chemical identity will remain the same. No matter what its physical state, water (H2O) is the same compound, with each molecule composed of two atoms of hydrogen and one atom of oxygen. However, if water, as ice, liquid, or vapor, encounters sodium metal (Na), the atoms will be redistributed to give the new substances molecular hydrogen (H2) and sodium hydroxide (NaOH). By this, we know that a chemical change or reaction has occurred. The concept of a chemical reaction dates back about 250 years. It had its origins in early experiments that classified substances as elements and compounds and in theories that explained these processes. Development of the concept of a chemical reaction had a primary role in defining the science of chemistry as it is known today. The first substantive studies in this area were on gases. The identification of oxygen in the 18th century by Swedish chemist Carl Wilhelm Scheele and English clergyman Joseph Priestley had particular significance. The influence of French chemist Antoine-Laurent Lavoisier was especially notable, in that his insights confirmed the importance of quantitative measurements of chemical processes. In his book *Traité élémentaire de chimie* (1789, *Elementary Treatise on Chemistry*), Lavoisier identified 33 “elements”—substances not broken down into simpler entities. Among his many discoveries, Lavoisier accurately measured the weight gained when elements were oxidized, and he ascribed the result to the combining of the element with oxygen. The concept of chemical reactions involving the combination of elements clearly emerged from his writing, and his approach led others to pursue experimental chemistry as a quantitative science. 13 True-or-False Questions from Britannica’s Easiest Science Quizzes The other occurrence of historical significance concerning chemical reactions was the development of atomic theory. For this, much credit goes to English chemist John Dalton, who postulated his atomic theory early in the 19th century. Dalton maintained that matter is composed of small, indivisible particles, that the particles, or atoms, of each element were unique, and that chemical reactions were involved in rearranging atoms to form new substances. This view of chemical reactions accurately defines the current subject. Dalton’s theory provided a basis for understanding the results of earlier experimentalists, including the law of conservation of matter (matter is neither created nor destroyed) and the law of constant composition (all samples of a substance have identical elemental compositions). Thus, experiment and theory, the two cornerstones of chemical science in the modern world, together defined the concept of chemical reactions. Today experimental chemistry provides innumerable examples, and theoretical chemistry allows an understanding of their meaning. When making a new substance from other substances, chemists say either that they carry out a synthesis or that they synthesize the new material. Reactants are converted to products, and the process is symbolized by a chemical equation. For example, iron (Fe) and sulfur (S) combine to form iron sulfide (FeS). Fe(s) + S(s) → FeS(s) The plus sign indicates that iron reacts with sulfur. The arrow signifies that the reaction “forms” or “yields” iron sulfide, the product. The state of matter of reactants and products is designated with the symbols (s) for solids, (l) for liquids, and (g) for gases. Science Chemistry chemical element, any substance that cannot be decomposed into simpler substances by ordinary chemical processes. Elements are the fundamental materials of which all matter is composed.This article considers the origin of the elements and their abundances throughout the universe. The geochemical distribution of these elementary substances in the Earth’s crust and interior is treated in some detail, as is their occurrence in the hydrosphere and atmosphere. The article also discusses the periodic law and the tabular arrangement of the elements based on it. For detailed information about the compounds of the elements, see chemical compound. The Editors of Encyclopaedia Britannica At present there are 118 known chemical elements. About 20 percent of them do not exist in nature (or are present only in trace amounts) and are known only because they have been synthetically prepared in the laboratory. Of the known elements, 11 (hydrogen, nitrogen, oxygen, fluorine, chlorine, and the six noble gases) are gases under ordinary conditions, two (bromine and mercury) are liquids (two more, cesium and gallium, melt at about or just above room temperature), and the rest are solids. Elements can combine with one another to form a wide variety of more complex substances called compounds. The number of possible compounds is almost infinite; perhaps a million are known, and more are being discovered every day. When two or more elements combine to form a compound, they lose their separate identities, and the product has characteristics quite different from those of the constituent elements. The gaseous elements hydrogen and oxygen, for example, with quite different properties, can combine to form the compound water, which has altogether different properties from either oxygen or hydrogen. Water clearly is not an element because it consists of, and actually can be decomposed chemically into, the two substances hydrogen and oxygen; these two substances, however, are elements because they cannot be decomposed into simpler substances by any known chemical process. Most samples of naturally occurring matter are physical mixtures of compounds. Seawater, for example, is a mixture of water and a large number of other compounds, the most common of which is sodium chloride, or table salt. Mixtures differ from compounds in that they can be separated into their component parts by physical processes; for example, the simple process of evaporation separates water from the other compounds in seawater. The modern concept of an element is unambiguous, depending as it does on the use of chemical and physical processes as a means of discriminating elements from compounds and mixtures. The existence of fundamental substances from which all matter is made, however, has been the basis of much theoretical speculation since the dawn of history. The ancient Greek philosophers Thales, Anaximenes, and Heraclitus each suggested that all matter is composed of one essential principle—or element. Thales believed this element to be water; Anaximenes suggested air; and Heraclitius, fire. Another Greek philosopher, Empedocles, expressed a different belief—that all substances are composed of four elements: air, earth, fire, and water. Aristotle agreed and emphasized that these four elements are bearers of fundamental properties, dryness and heat being associated with fire, heat and moisture with air, moisture and cold with water, and cold and dryness with earth. In the thinking of these philosophers all other substances were supposed to be combinations of the four elements, and the properties of substances were thought to reflect their elemental compositions. Thus, Greek thought encompassed the idea that all matter could be understood in terms of elemental qualities; in this sense, the elements themselves were thought of as nonmaterial. The Greek concept of an element, which was accepted for nearly 2,000 years, contained only one aspect of the modern definition—namely, that elements have characteristic properties. In the latter part of the Middle Ages, as alchemists became more sophisticated in their knowledge of chemical processes, the Greek concepts of the composition of matter became less satisfactory. Additional elemental qualities were introduced to accommodate newly discovered chemical transformations. Thus, sulfur came to represent the quality of combustibility, mercury that of volatility or fluidity, and salt that of fixity in fire (or incombustibility). These three alchemical elements, or principles, also represented abstractions of properties reflecting the nature of matter, not physical substances. Facts You Should Know: The Periodic Table Quiz The important difference between a mixture and a chemical compound eventually was understood, and in 1661 the English chemist Robert Boyle recognized the fundamental nature of a chemical element. He argued that the four Greek elements could not be the real chemical elements because they cannot combine to form other substances nor can they be extracted from other substances. Boyle stressed the physical nature of elements and related them to the compounds they formed in the modern operational way. In 1789 the French chemist Antoine-Laurent Lavoisier published what might be considered the first list of elemental substances based on Boyle’s definition. Lavoisier’s list of elements was established on the basis of a careful, quantitative study of decomposition and recombination reactions. Because he could not devise experiments to decompose certain substances, or to form them from known elements, Lavoisier included in his list of elements such substances as lime, alumina, and silica, which now are known to be very stable compounds. That Lavoisier still retained a measure of influence from the ancient Greek concept of the elements is indicated by his inclusion of light and heat (caloric) among the elements. Seven substances recognized today as elements—gold, silver, copper, iron, lead, tin, and mercury—were known to the ancients because they occur in nature in relatively pure form. They are mentioned in the Bible and in an early Hindu medical treatise, the Caraka-samhita. Sixteen other elements were discovered in the second half of the 18th century, when methods of separating elements from their compounds became better understood. Eighty-two more followed after the introduction of quantitative analytical methods, chemical synthesis, the construction of complex chemical compounds from simpler ones. It is the process by which many substances important to daily life are obtained. It is applied to all types of chemical compounds, but most syntheses are of organic molecules.Chemists synthesize chemical compounds that occur in nature in order to gain a better understanding of their structures. Synthesis also enables chemists to produce compounds that do not form naturally for research purposes. In industry, synthesis is used to make products in large quantity.Chemical compounds are made up of atoms of different elements, joined together by chemical bonds. A chemical synthesis usually involves the breaking of existing bonds and the formation of new ones. Synthesis of a complex molecule may involve a considerable number of individual reactions leading in sequence from available starting materials to the desired end product. Each step usually involves reaction at only one chemical bond in the molecule. Types of Chemical Reactions In planning the route of chemical synthesis, chemists usually visualize the end product and work backward toward increasingly simpler compounds. For many compounds, it is possible to establish alternative synthetic routes. The ones actually used depend on many factors, such as cost and availability of starting materials, the amount of energy needed to make the reaction proceed at a satisfactory rate, and the cost of separating and purifying the end products. Moreover, knowledge of the reaction mechanism and the function of the chemical structure (or behaviour of the functional groups) helps to accurately determine the most-favoured pathway that leads to the desired reaction product.A goal in planning a chemical synthesis is to find reactions that will affect only one part of the molecule, leaving other parts unchanged. Another goal is to produce high yields of the desired product in as short a time as possible. Often, reactions in a synthesis compete, reducing the yield of a desired product. Competition can also lead to the formation of side products which can be difficult to separate from the main one. In some industrial syntheses, by-product formation can be welcome if the by-products are commercially useful. Diethyl ether, for example, is a by-product of the large-scale synthesis of ethanol (ethyl alcohol) from ethylene. Both the alcohol and ether are valuable and can be separated easily.The reactions involved in chemical syntheses usually, but not always, involve at least two different substances. Some molecules will change into others solely under the effect of heat, for example, while others react on exposure to radiation (e.g., ultraviolet light) or to electric current. However, where two or more different substances interact, they need to be brought into close proximity with one another. This is usually done by carrying out the syntheses with the elements or compounds in their liquid or gaseous states. Where the reactants are involatile solids, reaction is often carried out in solution.The rate of a chemical reaction generally increases with temperature; chemical syntheses are thus often carried out at elevated temperatures. The industrial synthesis of nitric acid from ammonia and oxygen, for instance, is carried out at about 900 °C (1,650 °F). Frequently, heating will increase the rate of a reaction insufficiently or the instability of one or more reactants prevents application. In such cases catalysts—substances that speed up or slow down a reaction—are used. Most industrial processes involve the use of catalysts. Some substances react so rapidly and violently that only careful control of the conditions will lead to the desired product. When ethylene gas is synthesized to polyethylene, one of the most common plastics, a large amount of heat is released. If this release is not controlled in some way—e.g., by cooling the reactor vessel—the ethylene molecules decompose to carbon and hydrogen.Many techniques have been developed to separate the products of chemical synthesis. These often involve a phase change. For example, the product of a synthetic reaction may not dissolve in a particular solvent, while the starting materials do. In this case, the product will precipitate out as a solid and can be separated from the mixture by filtration. Alternatively, if both starting materials and products are volatile, it may be possible to separate them by distillation.Certain chemical syntheses lend themselves readily to the use of automated techniques. Automatic DNA (deoxyribonucleic acid) synthesizers, for example, are widely used to produce specific protein sequences. Science Chemistry salt (NaCl), mineral substance of great importance to human and animal health, as well as to industry. The mineral form halite, or rock salt, is sometimes called common salt to distinguish it from a class of chemical compounds called salts.Properties of common salt are shown in the Click Here to see full-size table/salt. Salt is essential to the health of both people and animals. Table salt, used universally as a seasoning, is fine-grained and of high purity. To ensure that this hygroscopic (i.e., water-attracting) substance will remain free-flowing when exposed to the atmosphere, small quantities of sodium aluminosilicate, tricalcium phosphate, or magnesium silicate are added. Iodized salt—that is, salt to which small quantities of potassium iodide have been added—is widely used in areas where iodine is lacking from the diet, a deficiency that can cause swelling of the thyroid gland, commonly called goitre. Livestock also require salt; it is often made available in solid blocks.The meat-packing, sausage-making, fish-curing, and food-processing industries use salt as a preservative or seasoning or both. It is employed for curing and preserving hides and as a brine for refrigeration.In the chemical industry, salt is required in the manufacture of sodium bicarbonate (baking soda), sodium hydroxide (caustic soda), hydrochloric acid, chlorine, and many other chemicals. Salt is also employed in soap, glaze, and porcelain manufacture and enters into metallurgical processes as a flux (a substance promoting fusing of metals) when applied to snow or ice, salt lowers the melting point of the mixture. Thus, large amounts are used in northern climates to help rid thoroughfares of accumulated snow and ice. Salt is used in water-softening equipment that removes calcium and magnesium compounds from water. In some parts of the Western Hemisphere and in India, the use of salt was introduced by Europeans, but in parts of central Africa it is still a luxury available only to the rich. Where people live mainly on milk and raw or roasted meat (so that its natural salts are not lost), sodium chloride supplements are unnecessary; nomads with their flocks of sheep or herds of cattle, for example, never eat salt with their food. On the other hand, people who live mostly on cereal, vegetable, or boiled meat diets require supplements of salt. The habitual use of salt is intimately connected with the advance from nomadic to agricultural life, a step in civilization that profoundly influenced the rituals and cults of almost all ancient nations. The gods were worshipped as the givers of the kindly fruits of the earth, and salt was usually included in sacrificial offerings consisting wholly or partly of cereal elements. Such offerings were prevalent among the Greeks and Romans and among a number of the Semic peoples. Covenants were ordinarily made over a sacrificial meal, in which salt was a necessary element. The preservative qualities of salt made it a peculiarly fitting symbol of an enduring compact, sealing it with an obligation to fidelity. The word salt thus acquired connotations of high esteem and honour in ancient and modern languages. Examples include the Arab avowal “There is salt between us,” the Hebrew expression “to eat the salt of the palace,” and the modern Persian phrase namak harām, “untrue to salt” (i.e., disloyal or ungrateful). In English the term “salt of the earth” describes a person held in high esteem. Salt contributes greatly to our knowledge of the ancient highways of commerce. One of the oldest roads in Italy is the Via Salaria (Salt Route) over which Roman salt from Ostia was carried into other parts of Italy. Herodotus tells of a caravan route that united the salt oases of the Libyan Desert. The ancient trade between the Aegean and the Black Sea coast of southern Russia was largely dependent on the salt pans (ponds for evaporating seawater to obtain salt) at the mouth of the Dnieper River and on the salt fish brought from this district. China, the United States, India, Germany, Canada, and Australia are the world’s largest salt producers in the early 21st century. Frank Osborne Wood

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