Topic Page: [Chemistry]

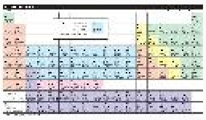

Image from: **Chemical elements are arranged according to their...** in *Philip's Encyclopedia*

Summary Article: **chemistry**
From *The Columbia Encyclopedia*

branch of science concerned with the properties, composition, and structure of substances and the changes they undergo when they combine or react under specified conditions.

Branches of Chemistry

Chemistry can be divided into branches according to either the substances studied or the types of study conducted. The primary division of the first type is between inorganic chemistry and organic chemistry. Divisions of the second type are physical chemistry and analytical chemistry.

The original distinction between organic and inorganic chemistry arose as chemists gradually realized that compounds of biological origin were quite different in their general properties from those of mineral origin; organic chemistry was defined as the study of substances produced by living organisms. However, when it was discovered in the 19th cent. that organic molecules can be produced artificially in the laboratory, this definition had to be abandoned. **Organic chemistry** is most simply defined as the study of the compounds of carbon. **Inorganic chemistry** is the study of chemical elements and their compounds (with the exception of carbon compounds).

is concerned with the physical properties of materials, such as their electrical and magnetic behavior and their interaction with electromagnetic fields. Subcategories within physical chemistry are thermochemistry, electrochemistry, and chemical kinetics. Thermochemistry is the investigation of the changes in energy and entropy that occur during chemical reactions and phase transformations (see states of matter). Electrochemistry concerns the effects of electricity on chemical changes and interconversions of electric and chemical energy such as that in a voltaic cell. Chemical kinetics is concerned with the details of chemical reactions and of how equilibrium is reached between the products and reactants.

is a collection of techniques that allows exact laboratory determination of the composition of a given sample of material. In qualitative analysis all the atoms and molecules present are identified, with particular attention to trace elements. In quantitative analysis the exact weight of each constituent is obtained as well. Stoichiometry is the branch of chemistry concerned with the weights of the chemicals participating in chemical reactions. See also chemical analysis.

History of Chemistry

The earliest practical knowledge of chemistry was concerned with metallurgy, pottery, and dyes; these crafts were developed with considerable skill, but with no understanding of the principles involved, as early as 3500 B.C. in Egypt and Mesopotamia. The basic ideas of element and compound were first formulated by the Greek philosophers during the period from 500 to 300 B.C. Opinion varied, but it was generally believed that four elements (fire, air, water, and earth) combined to form all things. Aristotle's definition of a simple body as “one into which other bodies can be decomposed and which itself is not capable of being divided” is close to the modern definition of element.

About the beginning of the Christian era in Alexandria, the ancient Egyptian industrial arts and Greek philosophical speculations were fused into a new science. The beginnings of chemistry, or alchemy, as it was first known, are mingled with occultism and magic. Interests of the period were the transmutation of base metals into gold, the imitation of precious gems, and the search for the elixir of life, thought to grant immortality. Muslim conquests in the 7th cent. A.D. diffused the remains of Hellenistic civilization to the Arab world. The first chemical treatises to become well known in Europe were Latin translations of Arabic works, made in Spain c.A.D. 1100; hence it is often erroneously supposed that chemistry originated among the Arabs. Alchemy developed extensively during the Middle Ages, cultivated largely by itinerant scholars who wandered over Europe looking for patrons.

Evolution of Modern Chemistry

In the hands of the “Oxford Chemists” (Robert Boyle, Robert Hooke, and John Mayow) chemistry began to emerge as distinct from the pseudoscience of alchemy. Boyle (1627–91) is often called the founder of modern chemistry (an honor sometimes also given Antoine Lavoisier, 1743–94). He performed experiments under reduced pressure, using an air pump, and discovered that volume and pressure are inversely related in gases (see gas laws). Hooke gave the first rational explanation of combustion—as combination with air—while Mayow studied animal respiration. Even as the English chemists were moving toward the correct theory of combustion, two Germans, J. J. Becher and G. E. Stahl, introduced the false phlogiston theory of combustion, which held that the substance phlogiston is contained in all combustible bodies and escapes when the bodies burn.

The discovery of various gases and the analysis of air as a mixture of gases occurred during the phlogiston period. Carbon dioxide, first described by J. B. van Helmont and rediscovered by Joseph Black in 1754, was originally called fixed air. Hydrogen, discovered by Boyle and carefully studied by Henry Cavendish, was called inflammable air and was sometimes identified with phlogiston itself. Cavendish also showed that the explosion of hydrogen and oxygen produces water. C. W. Scheele found that air is composed of two fluids, only one of which supports combustion. He was the first to obtain pure oxygen (1771–73), although he did not recognize it as an element. Joseph Priestley independently discovered oxygen by heating the red oxide of mercury with a burning glass; he was the last great defender of the phlogiston theory.

The work of Priestley, Black, and Cavendish was radically reinterpreted by Lavoisier, who did for chemistry what Newton had done for physics a century before. He made no important new discoveries of his own; rather, he was a theoretician. He recognized the true nature of combustion, introduced a new chemical nomenclature, and wrote the first modern chemistry textbook. He erroneously believed that all acids contain oxygen.

Impact of the Atomic Theory

The assumption that compounds were of definite composition was implicit in 18th-century chemistry. J. L. Proust formally stated the law of constant proportions in 1797. C. L. Berthollet opposed this law, holding that composition depended on the method of preparation. The issue was resolved in favor of Proust by John Dalton's atomic theory (1808). The atomic theory goes back to the Greeks, but it did not prove fruitful in chemistry until Dalton ascribed relative weights to the atoms of chemical elements. Electrochemical theories of chemical combinations were developed by Humphry Davy and J. J. Berzelius. Davy discovered the alkali metals by passing an electric current through their molten oxides. Michael Faraday discovered that a definite quantity of charge must flow in order to deposit a given weight of material in solution. Amedeo Avogadro introduced the hypothesis that equal volumes of gases at the same pressure and temperature contain the same number of molecules.

William Prout suggested that as all elements seemed to have atomic weights that were multiples of the atomic weight of hydrogen, they could all be in some way different combinations of hydrogen atoms. This contributed to the concept of the periodic table of the elements, the culmination of a long effort to find regular, systematic properties among the elements. Periodic laws were put forward almost simultaneously and independently by J. L. Meyer in Germany and D. I. Mendeleev in Russia (1869). An early triumph of the new theory was the discovery of new elements that fit the empty spaces in the table. William Ramsay's discovery, in collaboration with Lord Rayleigh, of argon and other inert gases in the atmosphere extended the periodic table

Organic Chemistry and the Modern Era

Organic chemistry developed extensively in the 19th cent., prompted in part by Friedrich Wohler's synthesis of urea (1828), which disproved the belief that only living organisms could produce organic molecules. Other important organic chemists include Justus von Liebig, C. A. Wurtz, and J. B. Dumas. In 1852 Edward Frankland introduced the idea of valency (see valence), and in 1858 F. A. Kekule showed that carbon atoms are tetravalent and are linked together in chains. Kekule's ring structure for benzene opened the way to modern theories of organic chemistry. Henri Louis Le Châtelier, J. H. van't Hoff, and Wilhelm Ostwald pioneered the application of thermodynamics to chemistry. Further contributions were the phase rule of J. W. Gibbs, the ionization equilibrium theory of S. A. Arrhenius, and the heat theorem of Walther Nernst. Ernst Fischer's work on the amino acids marks the beginning of molecular biology.

At the end of the 19th cent., the discovery of the electron by J. J. Thomson and of radioactivity by A. E. Becquerel revealed the close connection between chemistry and physics. The work of Ernest Rutherford, H. G. J. Moseley, and Niels Bohr on atomic structure (see atom) was applied to molecular structures. G. N. Lewis, Irving Langmuir, and Linus Pauling developed the electronic theory of chemical bonds, directed valency, and molecular orbitals (see molecular orbital theory). Transmutation of the elements, first achieved by Rutherford, has led to the creation of elements not found in nature; in work pioneered by Glenn Seaborg elements heavier than uranium have been produced. With the rapid development of polymer chemistry after World War II a host of new synthetic fibers and materials have been added to the market. A fuller understanding of the relation between the structure of molecules and their properties has allowed chemists to tailor predictively new materials to meet specific needs.

Bibliography

See Asimov, I. , A Short History of Chemistry (1965);.
D. A. McQuarrie; P. A. Rock, General Chemistry (1984);.
Pauling, L. , General Chemistry (3d ed. 1991);.
Weast, R. C. , ed., CRC Handbook of Chemistry and Physics (published annually).

chemistry. (2018). In P. Lagasse, & Columbia University, *The Columbia encyclopedia* (8th ed.). New York, NY: Columbia University Press. Retrieved from https://search.credoreference.com/content/topic/chemistry

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chemistry. (2018). In P. Lagasse, & Columbia University, *The Columbia encyclopedia* (8th ed.). New York, NY: Columbia University Press. Retrieved from https://search.credoreference.com/content/topic/chemistry

Chicago

"chemistry." In *The Columbia Encyclopedia*, by Paul Lagasse, and Columbia University. 8th ed. Columbia University Press, 2018. https://search.credoreference.com/content/topic/chemistry

Harvard

chemistry. (2018). In P. Lagasse & Columbia University, *The Columbia encyclopedia*. (8th ed.). [Online]. New York: Columbia University Press. Available from: https://search.credoreference.com/content/topic/chemistry [Accessed 21 November 2019].

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"chemistry." *The Columbia Encyclopedia*, Paul Lagasse, and Columbia University, Columbia University Press, 8th edition, 2018. *Credo Reference*, https://search.credoreference.com/content/topic/chemistry. Accessed 21 Nov. 2019.