Gilbert Newton Lewis
1875-1946

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Lewis, Gilbert Newton (b. 23 October 1875, Weymouth, MA, d. 23 March 1946, Berkeley, CA), American physical chemist best known for his contributions to chemical thermodynamics, the electron-pair model of the covalent bond, the electronic theory of acids and bases, the separation and study of deuterium and its compounds, and his work on phosphorescence and the triplet state.

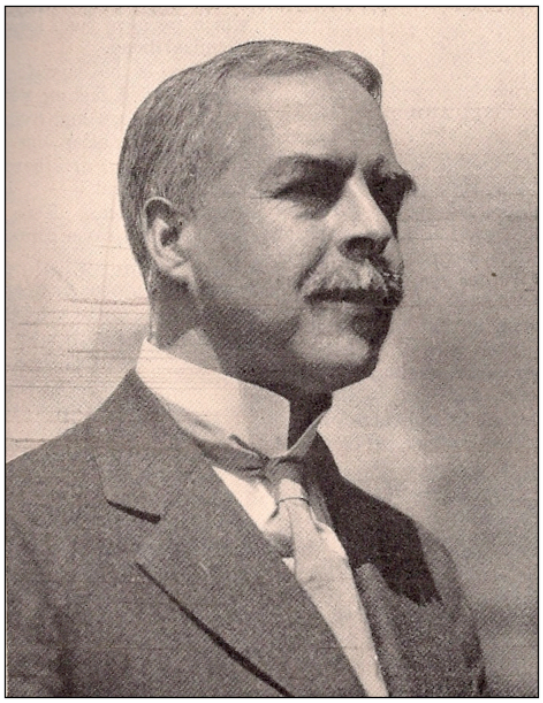
Education and Career

Though born in Massachusetts, Lewis spent his youth in Lincoln, Nebraska. Initially educated at home by his parents, he entered the preparatory school of the University of Nebraska at age 13. Continuing on at the university through his sophomore year, Lewis transferred to Harvard in 1893, from which he received his B.S. in chemistry in 1896. After a year of teaching at the Phillips Academy, he returned to Harvard to complete his M.S. in 1898, followed by his Ph.D. the next year for work done under the supervision of Theodore Richards on the electrochemistry of zinc and cadmium amalgams.

After graduation, Lewis remained at Harvard for a year as an instructor. This was followed by a year of postgraduate work in Europe in the laboratories of Wilhelm Ostwald and Walther Nemst, another three years as an instructor at Harvard, and a year in the Philippine Islands as Superintendent of Weights and Measures. In 1905 Lewis joined the faculty of the Massachusetts Institute of Technology and in 1912 he was appointed permanent Dean of the College of Chemistry and Chair of the Department of Chemistry at the University of California-Berkeley, where he remained until his death at age 70 of an apparent heart attack while working in his laboratory. During his 34-year tenure at Berkeley, Lewis succeeded in molding its chemistry department into one of the best in the United States.

Personality and Private Life

About 5' 7" in height, Lewis sported a full beard in his youth, but switched to wearing a moustache in his early 40s. Though his appointment as Chair at Berkeley relieved him of all class room teaching duties, he was well known for his insightful and often witty comments during student and staff seminars. A brilliant conversationalist with an almost unlimited supply of jokes and bon mots, Lewis was also addicted to the use of limericks and puns. He preferred to write his books and papers by dictating them to his assistants and collaborators, having fully composed his carefully crafted sentences in his head. When dictating, he would pace up and down the room while simultaneously smoking an imported cigar – a habit picked up during his stay in the Philippines.



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In 1912 Lewis married Mary Hinckley Sheldon by whom he had three children – a daughter (Margery) and two sons (Richard and Edward). Because of the lateness of his marriage, the children were only in their

late 20s at the time of Lewis' death. Like their father, both sons became chemists.

Chemical Thermodynamics

Lewis' major area of research was the field of chemical thermodynamics. In 1899 there was still a large gap between thermodynamic theory and practice. On the one hand, there was a complete theory of chemical equilibria developed 24 years earlier by the American physicist Josiah Willard Gibbs, which showed that chemical equilibrium was determined by the free energies of the reacting substances, and, on the other, there was a vast collection of data on the enthalpies of formation and reaction of chemical substances as measured by such chemists as Julius Thomsen and Marcellin Berthelot earlier in the century, as well as a series of empirical laws dealing with the behavior of ideal gases and dilute solutions which formed the substance of the newer physical chemistry championed by such European chemists as Wilhelm Ostwald, Svante Arrhenius, Jacobus van't Hoff, and Walther Nernst. Lewis set himself the task of closing this gap. This required that he either directly measure the missing free-energy values for chemical substances or supplement the existing enthalpy data with entropy values, which would allow their calculation. It was also necessary to find some way of extending the empirical laws to include the behavior of real gases and concentrated solutions.

In pursuit of the first of these goals, Lewis initiated a vigorous experimental program designed to measure the missing free-energy and entropy values and, in pursuit of the second, he successively introduced the concepts of fugacity (1901), activity (1907) and ionic strength (1921). These efforts culminated in 1923 in the publication of the book, *Thermodynamics and the Free Energy of Chemical Substances*, written in collaboration with his personal assistant, Merle Randall. A revised second edition of this book was published in 1961, 15 years after Lewis' death.

Theory of the Chemical Bond

A second important thread in Lewis' research centered on his speculations on the role of the newly discovered electron in chemical bonding. Though his first attempts in this area date as early as 1902, he did not publish on the subject until 1913 and then only to critically comment on attempts of others to formulate similar theories. Not until 1916 did Lewis publish his own model, which equated the classical chemical bond with the sharing of a pair of electrons between the two bonded atoms. Most students know of Lewis today because of the electron-dot diagrams which he introduced in this paper to symbolize the electronic structures of atoms and molecules. Now known as "Lewis structures," they are discussed in virtually every introductory chemistry book.

Shortly after publication of his 1916 paper, Lewis became involved war work and did not return to the subject of chemical bonding until 1923, when he masterfully summarized his model in a short monograph entitled *Valence and the Structure of Atoms and Molecules*. His renewal of interest in this subject was largely stimulated by the activities of the American chemist, Irving Langmuir, who between 1919 and 1922 popularized and elaborated Lewis' model. Many of our current terms relating to the chemical bond, such as covalent, octet rule, etc., were actually introduced by Langmuir rather than Lewis.

The 1920s saw a rapid adoption and application of Lewis' model of the electron-pair bond in the fields of organic and coordination chemistry. In organic chemistry this was primarily due to the efforts of the British chemists Arthur Lapworth, Robert Robinson, Thomas Lowry, and Christopher Ingold and, in coordination chemistry, to the efforts of the American chemist Maurice Huggins and the British chemist Nevil Sidgwick. Though Lewis occasionally published on his bonding model throughout the 1920s, he stopped writing on the subject after 1933 and left the task of reconciling the model with the newer quantum mechanics of Erwin Schrödinger and Werner Heisenberg in hands of the American chemist, Linus Pauling. Pauling transformed it into the "valence bond model" and made it the subject of his classic book, *The Nature of the Chemical Bond*, first published in 1939.

Deuterium, Acid-Base Theory, Triplet State

Between 1933 and 1934 Lewis published more than 26 papers dealing with the separation and study of the properties of deuterium and its compounds. This was followed by a brief period of interest in neutron refraction (1936-1937) and by his classic work on the electronic theory of acids and bases (1938-1943). Now universally known as the electronic or Lewis acid-base definitions, these concepts define an acid as an electron-pair acceptor and a base as an electron-pair donor. First proposed, almost as a passing thought, in his 1923 monograph on chemical bonding, discussions of Lewis acids and bases are now found in most introductory chemistry textbooks. Almost simultaneous with his work on acid-base theory, Lewis also began his classic research on the triplet state and its role in determining the nature of the fluorescence, phosphorescence, and colors of organic dyes, which continued until his death in 1946.

Speculations

In addition to the above, throughout his career Lewis occasionally published speculative papers dealing with fundamental problems in theoretical physics. While still a student at Harvard he had postulated that light could exert a pressure on dilute matter in outer space and he later introduced the term "photon" to describe the particulate nature of electromagnetic radiation. In 1909 he published the first American paper to deal with Einstein's recently proposed theory of relativity. Later papers dealt with vector analysis, rational units, quantum theory, statistical mechanics, and the thermodynamics of glacier formation. Some of these speculations were discussed in his third and final book, *The Anatomy of Science*, first published in 1926 and based on his Silliman lectures given at Yale the previous year.

One of the great puzzles of Lewis' career is the absence of a Nobel Prize. It has been suggested that he should have shared the 1934 Nobel Prize in Chemistry with Harold Urey for his contributions to the separation and study of deuterium and its compounds and that, had he lived longer, he most certainly should have shared the 1954 Nobel Prize in Chemistry with Linus Pauling for his contributions to the theory of the chemical bond.

Select Annotated Bibliography

* Joel H. Hildebrand, "Gilbert N. Lewis," *Biographical Memoirs, National Academy of Sciences*, **1958**, *31*, 209-235. Still the best overall summary of Lewis' life and career. Contains a complete bibliography of Lewis' publications.

* Arthur Lachmann. *Borderland of the Unknown: The Life Story of Gilbert Newton Lewis*, Pageant: New York, NY, 1955. A popular, but largely outdated, account of Lewis' life for the general reader.

* Edward S. Lewis, *A Biography of Distinguished Scientist Gilbert Newton Lewis*, Mellen: Lewiston, NY, 1998. A recent biographical memoir by Lewis' son. Weak on his science but contains details of his family life and a good collection of photographs.

* Anthony N. Stranges, *Electrons and Valence: Development of the Theory, 1900-1925*, Texas A&M University: College Station, TX. 1982. A detailed history of the early electronic theory of the chemical bond with a heavy emphasis on the importance of Lewis' work. Contains an excellent bibliography of other papers dealing with the same subject.

Publication History

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