G N Lewis (1875–1946)*

The Quintessential Physical Chemist

Gilbert Newton Lewis was born in 1875 and was raised in Weymouth, Massachusetts and Lincoln, Nebraska in the United States. Although he started his undergraduate studies at the University of Nebraska, he completed it in Harvard University in 1896. He received his PhD degree under the guidance of Theodore William Richards (Nobel Laureate (NL), 1914) in 1899. After spending a year as an instructor at Harvard, he went to Germany to work with Ostwald (NL, 1909) and Nernst (NL, 1920). Unfortunately, the relation between Lewis and Nernst was strained and perhaps came in the way of Lewis getting the Nobel Prize in later years, even though he was nominated 35 times. Although he returned to Harvard in 1902, Lewis moved to MIT in 1905 and then to the Univerity of California, Berkeley in 1912, where he stayed till his death in 1946.

G N Lewis built the chemistry department at Berkeley to be the leading one in the world, and it stays so even today. There, he trained illustrious graduate students, some of whom became Nobel Laureates: H C Urey (NL, 1934) and Glenn T. Seaborg (NL, 1951).

Lewis was responsible for reviving thermodynamics after Gibbs. He introduced the concept of activity and fugacity and devoted considerable time to measure the free energy of substances. His book on *Thermodynamics* [1], co-authored by Randall became a classic. He also introduced the concept of ionic strength of strong electrolytes. The famous work of Lewis acid and Lewis base was the subject of the PhD thesis of his student Seaborg.

Lewis made several fundamental contributions, the most important being the definition of a chemical bond arising from the sharing of a pair of electrons between two atoms. He could see that helium was stable with two electrons. For all other rare gases, he attributed their stability to a kernel of eight electrons (which would later be termed as the 'octet') distributed in the corners of a cube. He envisaged the formation of a single bond between two atoms by sharing of an edge between two cubes and sharing of a face to form a double bond. Although he was aware of the formation of a triple bond in acetylene, for example, he was at a loss to explain it on the basis of the cubic arrangement of electrons in an atom. He used the double dot structure (:) to represent a bond and advocated its location to reflect the unequal sharing of the electrons by atoms from different elements in the periodic table. His classic paper, 'The Atom and the Molecule', was published in the *Journal of American Chemical Society* in 1916

*DOI: https://doi.org/10.1007/s12045-019-0833-1

[2], much before quantum mechanics was discovered. This paper was unique in many ways (see the Classics section in this issue). It could explain the difference between a polar and nonpolar molecule, and Lewis anticipated the breaking of a bond between two atoms resulting in 'odd' molecules in that paper. He could explain on the basis of the frequencies associated with the electronic motion why most of the compounds were colourless and how most of the 'odd' molecules known at that time (with the exception of NO) were coloured. He found experimental evidence for the existence of O_4 and its diamagnetic property, in contrast to the paramagnetic property of O_2. Lewis prepared heavy water in sufficient quantities to study its thermodynamic properties and effects on biological systems. Along with his (last) student Kasha, he explained the formation of the triplet state and phosphorescence.

Lewis was an introvert and not a great speaker. Langmuir amplified Lewis's ideas and gave him due credit in his paper [3]. When Langmuir got the Nobel Prize for his work on surfaces, Lewis could not accept it. He seems to have believed that he deserved the Prize. He believed that his discovery of Lewis acid and Lewis base also deserved a Nobel Prize. He couldn't take it when the Nobel Prize for the discovery of heavy hydrogen went to his student Urey, as he (Lewis) had prepared the heavy water. Therefore, at least on three counts, Lewis thought that he deserved the Nobel Prize and he was prevented from getting it presumably because of an insider in the Nobel committee sabotaging it each time.

Lewis did not like to travel. He became a Fellow of the National Academy of Sciences (USA) in 1913, but he resigned from it in 1934, without stating any reason.

Lewis was known to work hard, late into the night talking to his students and dictating papers. He worked with his own hands. This was evident in his working with liquid hydrogen cyanide himself in the lab when the students were out for lunch. Unfortunately, on their return, the students found him dead.

In the year 1926, he coined the term 'photon' for 'light particles'. Lewis wrote papers on special relativity, giving an alternative view to time dilation and related aspects (see the article by R Nityananda in this issue). His idea of a chemical equilibrium approach to wave-particle duality was not taken kindly by the community. But, when it came to physical chemistry, he was unparalleled. Elsewhere in this issue, the great chemist of India, Professor C N R Rao declares Lewis as one of his heroes. But, the successful physical chemist died an unhappy man. It appears that he had lunch with Langmuir before he came back to the lab on that fateful day.

Acknowledgement

This article relies heavily on the book of Coffey [4], a copy of which was gifted to me by Professor V Ramamurthy of the University of Miami.

Suggested Reading

[1] G N Lewis and M Randall, *Thermodynamics and the Free Energies of Chemical Substances*, McGraw-Hill, 1923.
[2] G N Lewis, The Atom and the Molecule, *J. Am. Chem. Soc*., 38, 762, 1916.
[3] I Langmuir, The Arrangement of Electrons in Atoms and Molecules, *J. Am. Chem. Soc*., Vol.41, No.6, pp.868–934, 1919.
[4] P Coffey, *Cathedrals of Science: The Personalities and Rivalries That Made Modern Chemistry*, Oxford Univ. Press, New York, 2008.

N. Sathyamurthy
Email: nsathyamurthy@gmail.com