HENRY LOUIS LE CHATELIER

Henry Le Chatelier was born on October 8, 1850 in Paris, France. He received his early training in mathematics and chemistry from his father, Louis Le Chatelier, an accomplished engineer. He assisted his father who helped to create the aluminum industry in France, gaining information about metallurgy. His mother was a rigid disciplinarian and a devout Catholic whose love of poetry gave him an appreciation of art and letters, which was evident throughout his life. He received a B. Lett in 1867 and a B. S. in 1868 from the College Rollin. He served as an army lieutenant in the Franco-Prussian War of 1870-71. He completed his studies as a mining engineer at the Ecole Polytechnique in 1872. In 1874, he was licensed to practice physical sciences. After two years in the Corps des Mines at Besancon, he was offered the position of professor of chemistry at the Ecole des Mines in 1877. He lectured at the Ecole Polytechnique in 1882, was made a professor at the College de France in 1883 and later at the Sorbonne. He received the degree of Doctor of Physical and Chemical Sciences in 1887, the same year he became Professor of Industrial Chemistry and Metallurgy at the Ecole des Mines. His thesis was entitled *Recherches expérimentales sur la constitution des mortiers hydrauliques* (Experiments in the composition of hydraulic mortars). He was a consulting engineer for a cement company, the *Société des chaux et ciments Pavin de Lafarge*. In 1889, he returned to the College de France where he remained until 1908 as Professor of Inorganic Chemistry. After working for the French government during World War I, he retired in 1919.

His first research was in the chemistry of cements when he discovered that good plaster of Paris consists of the hemihydrate of calcium sulfate, which he identified, and not the anhydride as was previously believed. These investigations led him to a theory of the setting of cements in which when cement comes into contact with water, a supersaturated solution is formed that deposits a less soluble hydrated material. This process of solution and solidification results in the production of an interlaced, coherent mass of minute crystals. He modified, or in some cases actually invented the instruments needed to carry on his researches. In his work with cements, for example, he chose a method of thermal analysis devised by Regnault but little known at the time. Methods known at the time for determining high temperatures, such as the use of gas thermometers and of thermocouples, soon proved inaccurate for his work with cements, as Regnault himself had predicted. In 1887, for the determination of high temperatures he designed the first successful platinum-rhodium thermocouple. Another major area of research was in the combustion and explosion of gaseous mixtures. The specific problem that directed his attention into this area was a series of coalmine disasters in France. To solve the problem, he initiated a study of the combustion of methane. Together with Mallard, a professor at the Ecole des Mines, he determined the temperature of ignition, the explosive ratio of air and methane, the speed of propagation in explosions, the explosive pressure, etc. With the development of new techniques, they extended the study to the combustion of hydrogen, carbon monoxide, acetylene, and cyanogen. He also developed devices for detecting and determining small quantities of marsh gas. They devised explosives and mine safety devices. For his research, he invented a differential dilatometer that allowed him to follow the transformations by observing the expansion rates of a given specimen relative to the refractory material on which it rested. He also studied the thermal expansion of glasses, he complex reactions that take place in the production of ceramics, and properties of alloys: their thermal expansion, electrical conductivity, thermoelectric potentials, cooling and heating characteristics, tempering, and annealing. In this latter work, he greatly improved the techniques of microscopic metallography. His improved microscope revealed the formation of compounds between iron and carbon in steel and proved the value of heat treatment in steel. This empirical data, coupled with his theoretical application of the phase rule to the allotropic transformations of a wide variety of alloys, proved to be of enormous value to the world of industry.

He applied thermodynamics to problems such as his study of cements, the solubility of salts and their reaction with water. The result of these investigations was that he discovered the law of reaction governing the effect of pressure and temperature on equilibrium and the displacement of equilibria (Le Chatelier's Principle) with which every beginner in the study of chemistry is familiar. By applying the Le Chatelier's principle, he accomplished the synthesis of ammonia in 1901, anticipating Fritz Haber. Without his equilibrium principle, it is possible that the practical applications of the phase rule and phase law diagrams would have remained hidden for quite some time. His results on chemical equilibrium were published in *Comptes Rendus* **99**, 786-789 (1884).

He published over five hundred journal articles and books including works in chemistry and ceramics, numerous biographies, and articles on social welfare, the scientific management of industries ("Taylorism"), the interrelationship between pure and applied science, and the relation of science to economics. In 1904, he started La revue de métallurgie" (The Metallurgy Review).and was the editor for the next ten years. Besides his many scientific papers, he wrote books on metal alloys, steel, clays and ceramics and acted as an industrial consultant in the manufacture of steel, cement and synthetic ammonia. Throughout his life, he was a leader in progressive movements, giving much of his time and effort to causes that he believed worthwhile. In particular, he wrote and spoke extensively on educational reform, taking the lead through the example of his own highly respected career as a teacher. At the Sorbonne, where he was made professor in 1887, he directed the work of over one hundred graduate students during the period from 1908-1922.

He received many honors. One of which was that his name is included among the seventy-two names of French scientists, engineers and some other notable people that are engraved on the Eiffel Tower in Paris in recognition of their contributions by Gustave Eiffel. Other honors include membership in the French Academy Sciences, 1907, which awarded him the Jerome Ponti and

Lacaze Prizes. Since 1886, he was a Chevalier of the Legion of Honor of France became an Officer in 1908, a Commander in 1919, and in 1927, a Grand Officer. He received five honorary degrees as well as many prizes at International Expositions.

He died at his country estate, Miribel-les-Echelles, in Isėre, France on September 17, 1936. He married Genièvre Nicolas, and they had four daughters and three sons.

Le Chatelier's Principle

In the introduction to Linus Pauling's chapter on chemical equilibrium, he gives the student the following advice:

> *The student (or the scientist) would be wise to refrain from using the mathematical equation unless he understands the theory that it represents, and can make a statement about the theory that does not consist just in reading the equation. It is fortunate that there is a general qualitative principle, called Le Chatelier's principle, that relates to all the applications of the principles of chemical equilibrium. When you have obtained a grasp of Le Chatelier's principle, you will be able to think about any problem of chemical equilibrium that arises, and, by use of a simple argument, to make a qualitative statement about it....*
> *Some years after you have finished your college work, you may (unless you become a chemist or work in some closely related field) have forgotten all the mathematical equations relating to chemical equilibrium. I hope, however, that you will not have forgotten Le Chatelier's principle.* L. Pauling, *College Chemistry*, 3rd ed., Freeman, San Francisco, CA, 1964, pp. 437-438.

S.S. Henri Le Chatelier

The S.S. Henri Le Chatelier (a concrete ship) was built by McCloskey and Company in Tampa, Florida and launched January 30, 1944. She was operated by A.H.Bull and Co. operated for trading sugar and, later, by the US Army as a store ship in the South Pacific. In 1948, the ship was purchased by the Powell River Company to be used in their floating breakwater. It is still afloat as part of a breakwater on the Powell River in British Columbia, Canada.

http://www.concreteships.org/ships/ww2/chateliere/

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