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JOSEPH EDWARD MAYER

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A Biographical Memoir by

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Joseph E Mayer

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JOSEPH EDWARD MAYER was a distinguished scientist who could be called either a physical chemist or a chemical physicist, and whose main contributions to science came from two distinct lines of work. The first, the thermodynamics of ionic crystals, involved both theoretical calculations and the development of ingenious experimental techniques; the second, for which he was particularly well known, was in the statistical mechanical theory of imperfect gases and solutions, including ionic solutions. In his professional career, he was successively a member of the chemistry departments of Johns Hopkins (1930–39), Columbia (1939–45), Chicago (1946–60), and the University of California at San Diego (UCSD) (1960–72), UCSD emeritus 1972–83.

Mayer wrote an interesting autobiographical sketch of the first part of his life entitled, "The Way It Was," [*Annual Review of Physical Chemistry,* 33(1982):1–23]. Much of the following material is taken from it.

Joseph E. Mayer was born on February 5, 1904, in New York City. His father, also named Joseph Mayer, was an expatriate Austrian from the small town of Schruns in western Austria, and trained in applied mathematics at the Sorbonne. He was employed as a civil engineer, but according to his son he considered himself a scientist who practiced civil engineering to obtain income and who read Darwin, Huxley, and Freud for relaxation. The younger Joseph's mother was Catherine Proescher, an American-born New York City school teacher. Joseph E. reports that he himself developed an early interest in mechanical construction, stimulated by his father's designing of bridges, and also by a "Mechano" set of toy girders, nuts and bolts, wheels and shafts, given him by a young visiting German engineer.

Encouraged by his home background and also by an excellent teacher in Hollywood High School in California, the younger Joseph studied quantitative chemical analysis in high school and was employed during two summers as an analyst in sugar mills. In 1921 he entered the California Institute of Technology to study chemistry.

At Cal Tech he was in contact with R. C. Tolman, A. A. Noyes, and R. Dickinson of the chemistry faculty, who were all first-class scientists, and with graduate students Paul Emmett and Linus Pauling, soon to become famous as scientists themselves. Mayer worked for Dickinson as an undergraduate assistant while Pauling was starting his graduate work there; one of Mayer's first tasks was to put up chicken wire to keep Pauling's hair out of the high-voltage line from the transformer to the x-ray tube. He received his B.S. degree in 1924, and moved on to Berkeley for graduate work in chemistry under Gilbert Newton Lewis, who was one of the most important chemists of the first half of this century.

To describe his Berkeley period, we can quote from his own sketch: "I can imagine no milieu more beneficial to the development of a graduate student than that department at that time. The atmosphere was that of unravelling the intricacies of nature in one of its important aspects. Pure knowledge of an assortment of unconnected facts was seldom emphasized, but a deep understanding of principles and originality in interpretation were most admired. I was never aware of jealousy or friction between faculty members and in four years I grew to know most of them very well."

In view of his later reputation as a theorist, it is interesting that Mayer's first research was experimental; actually a purely theoretical thesis would have been most unusual in a chemistry department at that time. The 1927 publication from his thesis with G. N. Lewis was titled, "A Disproof of the Radiation Theory of Chemical Activation," which was followed by a longer paper by Mayer alone in the *Journal of the American Chemical Society*. This work was relevant to a hypothesis, popular at the time, that excitation of molecules by infra-red radiation was an important cause of chemical reaction. Mayer's experiment exposed a beam of pinene molecules in vacuum to an intense bath of infra-red, but found no evidence of the expected reaction, racemization of the pinene. Settling this question was important for the development of a correct theory of chemical reactions.

However, it was at Berkeley that Mayer's first work on chemical theory was done; this was a postdoctoral effort in collaboration with G. N. Lewis on the relation between quantum statistical mechanics and thermodynamics. In his own words: "I had no knowledge of statistical mechanics and Lewis had never worked in the field either. He had become interested in the discovery that had just been made of the difference between quantum mechanical statistical mechanics and the classical. . . . During the day I tried to learn statistical mechanics using Tolman's two books . . . Gilbert and I spent the evenings together, usually at about eight o'clock, sometimes until about midnight." One is struck by the image of two of the outstanding physical chemists of this century, Lewis at the peak of an illustrious career, Mayer at the beginning of his, struggling to assimilate and apply to chemistry the new ideas of quantum physics that had just revolutionized our picture of the fundamentals of the physical world. On a recent rereading of these papers, I was impressed by the clarity with which the fundamental ideas of quantum-based statistical mechanics are developed and presented. The statistical-mechanics textbook by Mayer and Mayer, referred to below, most probably had its genesis in these papers.

In 1929 Mayer was awarded a Rockefeller Fellowship and went to Göttingen, Germany, to work in the institute of James Franck, Nobel Laureate in Physics in 1925. Göttingen then was known as the source of the new quantum theory, developed there by W. Heisenberg, E. Schrödinger, and M. Born. While at Göttingen Mayer worked with Born on the theory of ionic crystals, a field in which Born was very prominent. The collaboration was interrupted for a year while he returned to the United States to take up a position in the Chemistry Department at Johns Hopkins. This work was the beginning of a series of studies on the thermodynamics of ionic crystals, a series that continued for about fifteen years.

In the Johns Hopkins and Columbia years Mayer ran an experimental program measuring various thermodynamic properties of alkali halide crystals and vapors as a complement to accompanying theoretical work. This program occupied a series of graduate students, of whom Lindsay Helmholz was the first, and Paul Doty and the author among the last. As part of this program Mayer developed an ingenious method for measuring the electron affinity of the halogen gases, which is one of the fundamental quantities involved in the thermodynamics of formation of halide salts, and is not otherwise directly measurable. This method consists of observing "the ratio of electrons to ions coming off a hot filament in an atmosphere of very low pressure of chlorine or any other halogen. The electrons could be deflected by a relatively small magnetic field parallel to the length of the filament; they curled themselves up and did not go to a positively charged plate of a centimeter diameter." Several students used this method in their thesis work. With the move to Chicago in 1945, however, he found setting up a laboratory again to be too much of an investment of time and energy, and he terminated the experimental work.

At Johns Hopkins he wrote, in collaboration with three students, Philip Ackermann, Sally Harrison, and Sally Streeter, an epoch-making series of papers on the equilibrium statistical mechanics of imperfect gases. These introduced methods based on graphs, now known as Mayer graphs, for evaluating the highly complex coefficients of the virial series for the various thermodynamic properties. The step that caused a sensation at the time was the bold extension of these series to the condensation of the gas to liquid, a point that was identified with the divergence of the series. Continuing this work at Columbia first with Elliott Montroll and then with graduate student W. G. McMillan, Jr., he extended the methods to liquid solutions; the resulting McMillan-Mayer solution theory has served as the rigorous basis for much later work by other people. At Chicago he extended the methods further to ionic solutions, where the long-ranged Coulomb interaction potentials forced a regrouping of the terms of the various series. This paper created the first thoroughly rigorous foundation of the ionic-solution theory originally put forward by Debye and Hückel in the 1920s, and in addition showed how to make practically useful extensions into the difficult but important range of concentrated salt solutions, extensions that have been extensively used by other workers. This paper is remarkable also in that it represents a coming together of the two previously separate threads of

Mayer's research interests, ionic interactions and statistical mechanics.

These cited items are only the most prominent of his many research activities. In his Chicago and UCSD periods his work became increasingly directed toward attempts to find a rigorous basis for a complete statistical mechanical theory of both the static and dynamic aspects of the liquid phase, an activity that he sometimes referred to as "my hobby." This was very difficult work that progressed very slowly, and which was never effectively completed.

In addition to his research and teaching career, Joe Mayer was active in public service. He was a consultant during World War II at the Ballistics Research Laboratories, Aberdeen Proving Ground, of the U. S. Army. In this connection he was at the front lines in Okinawa during the battle there. Afterwards he was for many years a member of the Scientific Advisory Committee of the Laboratories. He was editor of the *Journal of Chemical Physics* from 1941 to 1952. He was chairman of the Commission of Statistical Mechanics and Thermodynamics of the International Union of Pure and Applied Chemistry from 1955 to 1967. He was a member of the Scientific Council of the Solvay Foundation of Brussels from 1961 on. He was vice-president of the American Physical Society in 1972–73, becoming president for 1973–74.

At Göttingen Joe met Maria Göppert, a student of Born's. They were married in 1930, just before going to America. The Mayers had two children, Maria (called Marianna) and Peter Conrad. At Johns Hopkins they collaborated on a textbook of statistical mechanics, published in 1940, which has been known to generations of graduate students simply as "Mayer and Mayer." Much later Maria G. Mayer received the Nobel Prize in Physics for the development of the shell theory of the atomic nucleus, which she had done in the late 1940s at Chicago. Maria G. Mayer died in 1972. After Maria's death Joe married Margaret (Peg) Gannon Griffen.

In 1960 the Mayers left Chicago and came to help build the new general campus at UCSD, where Maria had for the first time a full professorship in the newly formed Physics Department. This move was encouraged by Harold Urey, their old colleague from Columbia and Chicago, who was already there.

At UCSD Joe was chairman of the Chemistry Department from 1963 to 1966, at which time the department, first formed only three years before, was in a critical early stage of growth.

Among many awards and honors, he received the G. N. Lewis Medal (1958), the Peter Debye Award (1967), and the James Flack Norris Award (1969) from the American Chemical Society, the Chandler Medal (1966) from Columbia University, and the J. G. Kirkwood Medal from Yale (1967). He was elected to membership in the National Academy of Sciences in 1946. He received an honorary Sc.D. from Brussels in 1962.

Outside of working hours Joe Mayer was a gregarious person who much enjoyed serious conversation, giving and taking opinions with marked but friendly intensity. He and Maria had many friends in the worldwide physics and chemistry communities, and frequently entertained some of these as house guests. He belonged to the generation of Americans who measured their accomplishments as hosts by the temperature and dryness of the Martinis they served, and his Martinis were among the coldest and driest.

In personal qualities most significant in scientific relationships was probably his ability to listen intently to others. Consequently, he was much sought after for advice and analysis. The same intensity was manifest in classroom lectures on statistical mechanics, which he was wont to present with exemplary clarity and enthusiasm, chalk in one hand and lighted cigarette in the other, never confusing the two, always starting at the upper left of the blackboard and carefully filling it with precise symbols. It was these qualities of clarity and enthusiasm that earned him the Norris Award from the American Chemical Society, an award that is specifically designed to recognize outstanding teaching.

IN ADDITION TO Mayer's own account, referred to above, and a set of biographical data that he prepared in 1982, much useful biographical material is given by Harold J. Raveché, *International Journal of Quantum Chemistry Symposium,* 16(1982):1–13, "Dedication to Joseph E. Mayer." I am also indebted to my colleague, Professor Leigh B. Clark, for help in preparing a preliminary version of this memoir.

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