ISSN 0036-0244, Russian Journal of Physical Chemistry A, 2007, Vol. 81, No. 8, pp. 1352–1354. © Pleiades Publishing, Ltd., 2007.
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CHRONICLE

Anatolii Fedorovich Kapustinskii (On His Centenary)

DOI: 10.1134/S0036024407080328

December 29, 2006 marked centenary since the birth of Anatolii Fedorovich Kapustinskii, an outstanding chemist, corresponding member of the USSR Academy of Sciences (1939), head of the Department of General and Inorganic Chemistry at the Mendeleev Institute (nowadays University) of Chemical Technology (1943–1957), the author of numerous works in the fields of physical, inorganic, and theoretical chemistry, chemical technology, thermochemistry, and the history of science.

Kapustinskii was born on December 29, 1906, in Zhitomir, Volynskaya gubernia, studied at Zhitomir, Warsaw, and Moscow gymnasia. While still a boy, at 15, he began to work at the VKhUTEMAS (Higher Art and Technical Studios) dye factory as a worker. Mixing mineral salts, observing marvelous play of colors and astonishing transformations of compounds, Kapustinskii gradually took great interest in studying the chemical process underlying these transformations and decided to dedicate himself to chemistry. Sixteen years old, he entered the Faculty of Chemistry of Moscow State University and was lucky to be taught by many prominent chemists and to have as supervisors of his scientific work famous academicians E.V. Britske and I.A. Kablukov.

After graduating from the university, he was offered a job, on Britske's recommendation, at the Thermal Laboratory of the Institute of Applied Mineralogy (later reorganized into the All-Union Institute of Mineral Resources), where he advanced from 1929 till 1941 in rank from graduate student, senior research associate, to head of a laboratory and a department.

In 1930, Kapustinskii began his teaching career as an assistant at the Moscow Higher Technical School, where he taught a special course on chemical thermodynamics.

In 1934, Kapustinskii became a professor and head of the Department of Physical Chemistry at the Faculty of Chemistry of Gor'kii (Nizhni Novgorod) State University.

In 1935, the young professor took a leave of absence to visit the California University to study at the famous laboratory headed by G.N. Lewis, the author of the theory of covalent bonding (1916), a new theory of acids and bases (1926), and a method of producing heavy water (1933). Unfortunately, little is known about this period of his life and scientific activity—in all his autobiographies, he painstakingly omitted all what concerned his trip to the United States and West European countries. The times were inauspicious to be proud of cooperation and friendship with prominent scientists from the "hostile capitalist camp."

In 1937, the All-Union Committee for Higher Education of the Council of People's Commissars awarded Kapustinskii the degree of doctor of sciences in chemistry; in the same year, he was elected head of a department at Moscow Institute of Steel. In 1939, Kapustinskii was elected a corresponding member at the Department of Mathematics and Natural Sciences (in inorganic and physical chemistry) of the USSR Academy of Sciences. In 1940, he became head of the editorial board of *Izvestiya Akademii Nauk SSSR, Seriya*

Khimicheskaya (Bulletin of the USSR Academy of Sciences, Division of Chemical Science) and a deputy editor-in-chief of this journal. In 1941, he was offered the position of head of the Laboratory of Thermochemistry at the Institute of General and Inorganic Chemistry of the USSR Academy of Sciences. During the period of evacuation, 1941–1943, Kapustinskii was head of the Department of Physical Chemistry at the Faculty of Chemistry of Kazan State University.

From 1943 to the end of his life, he was head of the Department of General and Inorganic Chemistry at Mendeleev Institute of Chemical Technology, concurrently teaching special courses "Theoretical Foundations of Modern Inorganic Chemistry" and "Chemistry of Isotopes" for students of Moscow State University.

Kapustinskii was a scientist of encyclopedic knowledge—he was interested in the problems of thermochemistry and thermodynamics, left fundamental works in crystal chemistry and structural chemistry. His theoretical studies intimately combined with works in chemical technology and metallurgy. A special place in his creative work was occupied by the history of science, especially chemistry. But the main focus of his studies was on the energy characteristics of inorganic chemical reactions.

Continuing the direction of his diploma work, which was guided by his renowned teachers, Academicians Britske and Kablukov, at the Thermal Laboratory of the Institute of Applied Mineralogy, Kapustinskii undertook a study of the thermodynamic characteristics (heat of formation and free energy) of sulfides and oxides of metals. Experiments were performed over a wide temperature range (from 20 to 1500°C) with the use of a wide variety of methods. As a result, the first series of works devoted to a systematic study of the thermodynamics of crystalline inorganic substances and to theoretical aspects of metallurgical processes appeared. The results obtained offered methods for optimizing the extraction of metals from ores and, therefore, were of considerable importance for the metallurgical industry.

In these first works, along with thermochemical problems, Kapustinskii examined crystal chemical aspects. In 1933, he suggested an important generalization: the energy of a crystal and properties dependent on it are determined by the number of ions and their polarization characteristics. This principle stemmed from the discovery he made that the Madelung constant is directly proportional to the number of ions in the salt's molecule and to the ratio of the empirical interionic distance to the sum of the ionic radii (in the Goldschmidt system). Based on this concept, the author derived a simple equation for the crystal lattice energy based on a few parameters, such as Goldschmidt's ionic radii and charges of ions. Using this equation, without preliminary XRD analysis, Kapustinskii calculated crystal lattice energy for many ionic compounds and offered an approach to determining the crystal lattice energy for unknown or not yet synthesized compounds provided that the chemical formula and the radii of the constituent ions were known. In addition, he proposed how to solve the inverse problem, i.e., calculate the ionic radii from data on the crystal lattice energy, which, in turn, was determined from experimental thermochemical data with the help of the Born–Haber cycle. This method of calculating ionic radii, known as thermochemical, became a valuables supplement to the XRD method of determining interionic distances; it has been widely used in works of Russian and foreign researchers.

Owing to experimental studies of Kapustinskii and his pupils, a vast body of data on the thermochemical properties of inorganic compounds of various classes was accumulated, which were systematized and generalized in the fundamental monograph "Thermal Constant of Inorganic Substances" (1949).

In the mid-1930s, Kapustinskii began studies on the thermochemical characteristics of reactions involving isotopes. Conducting spectroscopic studies of crystalline lithium hydride and deuteride (1937), Kapustinskii and his coworkers revealed that the energy of a crystal depended on its isotopic composition, one of the first few works on the chemistry of isotopes. In the late 1940s, he taught a special course, "Chemistry of Isotopes," at the Faculty of Chemistry of Moscow State University.

In his studies, Kapustinskii relied on the Periodic Table law. For example, in 1944, he demonstrated that the entropy of ions in solution is a periodic function of their atomic numbers and discovered a relation between the heats of formation of various substances and the atomic numbers of the constituent elements. He revealed the periodicity of variation of the crystal chemical electronegativity, a quantity that characterizes the electron affinity of the ions in the crystal lattice (this notion was introduced by Kapustinskii in 1949).

A further analysis of periodicity led him to the concept of the cyclic structure of the Periodic Table. He identified in it four cycles associated with the specificity of the formation of the electron configurations of atoms with increasing atomic number. Based on the theory of numbers and physicochemical analysis, Kapustinskii introduced the notion of zeroth cycle and clearly identified secondary periodicity, innovations that allowed him to develop a consistent concept of the periodic system.

Of special interest are Kapustinskii's works on the history of natural science. Largely due to Kapustinskii's good services, a series of papers by G.I. Gess, one of the founders of thermochemistry, was first published in 1958, confirming the priority of Russian science in a

number of fields of thermochemistry. He published the biographies of many prominent chemists, notably, D.I. Mendeleev, M.V. Lomonosov, G.I. Gess, D.P. Konovalov, N.S. Kurnakov, I.A. Kablukov, A.E. Fersman, E.V. Britske, G.N. Lewis, L.J. Proust, A. Avogadro, W. Ramsay and some others.

Kapustinskii successfully combined his scientific work with teaching. His lectures were extremely popular with students, captivated by a brilliant, unpredictably minded teacher of enormous charm.

Kapustinskii died suddenly on August 26, 1960, several days before the start of the new semester at the Mendeleev Institute, aged only 53. His life was short but extraordinary intense and vivid—he left us a wealth of ideas, concepts, and manuscripts. Even now, almost half a century after his death, the citation index of his works is rather high, his books are in demand at libraries and second-hand bookshops, while his concepts continue to be developed by present-day physical chemists.