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Joachim Telle

BOER, JAN HENDRIK DE (*b.* Ruinen, Netherlands, 19 March 1899; *d.* The Hague, Netherlands, 26 April 1971), *inorganic chemistry, physical chemistry, industrial chemistry, catalysis, nuclear energy.*

De Boer was a prominent industrial chemist who combined a career in the management of industrial research, with scientific research of a high academic level. During the first half of the twentieth century he was considered one of the leading Dutch physical chemists. Together with Irving Langmuir of General Electric, de Boer belonged to a small group of chemists who contributed significantly both to solid state chemistry and to heterogeneous catalysis. As an all-round materials scientist he also became an important advisor to the Dutch government in the field of nuclear energy.

De Boer's most significant contributions to science are the development of a process for the separation and purification of transition metals such as hafnium, zirconium, and titanium (the so-called Van Arkel–de Boer process), the formulation of a theory (the de Boer–Mott model) on the so-called color centers (F-centers) in semiconductors, and the development of an improved method for the determination of the surface area and pore distribution of catalysts (the de Boer-t-curve). Together with Anton E. van Arkel, de Boer wrote an influential theoretical treatise on the structure of molecules and crystals, based on Walther Kossel's electrostatic theory. His theoretical work on Van der Waals–London forces and the role of electric "double layers" in colloids prepared the road for the DLVO theory (Derjaguin, Landau, Verwey, Overbeek) on the stability of colloids.

De Boer's scientific work stands out as a result of his ability to construct relatively simple theoretical models—often grounded in more advanced theories—with a great heuristic value for industrial and academic research. As research leader at three multinational corporations—Philips, Unilever, and DSM (Dutch State Mines)—de Boer contributed creatively to such diverse fields as solid state electronics, food research, and the ammonia synthesis for fertilizer production. "I have never met an investigator," Philips' research director Evert Verwey wrote in 1970, "who found his way so easily between experimental facts and simple theoretical concepts in his attempts to open new roads in science and technology. In the five years that I worked with him I was repeatedly struck by his flexible mind. No discouraging experiment could defeat him; on the contrary, an unexpected result or a new theoretical concept was always immediately incorporated in his arsenal and used successfully. He showed continually that he combined the typical traits of an inventor and of a scientist, a mixture rarely met in such high concentration, in a single person" (Verwey, 1970, p. xvi). De Boer published about 300 scientific papers and filed more than 150 original patents.

Childhood and Education. Jan Hendrik de Boer was born in Ruinen near Assen, in the northern part of the Netherlands, on 19 March 1899, the son of Jan de Boer, head of a primary school, and Jantina de Boer (née Somer). From 1912 to 1917 he went to the Hogere Burgerschool (a modern secondary school) in Assen. De Boer studied chemistry at the University of Groningen from 1917 to 1922. A year later, on 25 April 1923, he obtained the doctorate at Groningen with a dissertation on the synthesis and separation of the optical isomers of alpha-sulfobutyric acid.

De Boer from 1919 to 1921 became the assistant of Frans M. Jaeger, the professor of inorganic and physical chemistry at Groningen, who engaged him in the recovery of the metal ruthenium from waste products. De Boer also worked as a teacher of chemistry at a modern secondary school at Hoogezand, near Groningen. From 1921 to 1923 he was assistant to Hilmar J. Backer, the professor of organic chemistry at Groningen. He developed a keen interest in physical chemistry. Although his dissertation was on organic chemistry, it had a strong physical-chemical orientation. In November 1923 de Boer married Grietje Hilbrands. They had two daughters.

Research Chemist at Philips. In June 1923 de Boer was engaged as research chemist at the Natuurkundig Laboratorium (Physics Laboratory) of the N. V. Philips' Gloeilampenfabrieken (Philips' Incandescent Lamps Factories) at Eindhoven. This research laboratory, founded in 1914, was led by the physicist Gilles Holst. In 1922, just before de Boer's arrival, the Nat Lab, as the laboratory was commonly called, was still a modest research laboratory, with thirty-three employees, of which twelve were academics. In the following years, however, the laboratory expanded considerably. By 1940 there were 174 academic scientists among a total staff of 516.

One of the fields of expansion initiated by Holst was materials research. In 1921 Van Arkel had become the first chemist engaged by Holst for that purpose. Van Arkel tackled the purification of tungsten, the crucial metal in lamp filaments, and in 1923 discovered a process in which tungsten was purified via a (cyclical) sublimation process of tungsten hexachloride (WCl_6), followed by deposition of tungsten on a glowing tungsten wire. This followed research done by Irving Langmuir at General Electric and by F. Koref at Osram.

In 1923 the element hafnium was discovered in zirconium ores in the Copenhagen laboratory of Niels Bohr by the Hungarian chemist Georg (György) von Hevesy and the Dutch physicist Dirk Coster. Holst immediately decided to investigate the possibilities of zirconium and hafnium as filaments in incandescent lamps, instead of tungsten. At the advice of Wander J. de Haas, professor of physics at Groningen, who knew Holst from their student days in Leiden, Holst engaged de Boer for that purpose. De Haas had been on de Boer's dissertation committee and was impressed by the ingenuity of the latter to separate the optical isomers of alpha-sulfobutyric acid. Although this separation was very different from the problem of separating hafnium and zirconium, de Boer, together with Van Arkel, in 1924 developed a complicated, multistep, fractional crystallization process for the separation of the two metals.

The next target was their purification. De Boer first tried a process similar to the one invented by Van Arkel for the purification of tungsten, but the route via the chlorides did not work. De Boer then had the idea to try the tetra-iodides, in an autoclave at temperatures of about 800 centigrade, and that worked very well (Van Arkel and de Boer, 1925). Between 1926 and 1930, together with his research assistant Johan D. Fast, he successfully developed a large-scale, cyclical thermal process for the production of very pure, and ductile, hafnium, zirconium, titanium, thorium, vanadium, and other metals. Later, this so-called "Van Arkel–de Boer" process proved to be of great significance for the production of pure transition metals for the electronic industries, the aircraft industry, and the nuclear power industry.

During this same period, Holst and the theoretical physicist Paul Ehrenfest, who was research advisor to the Nat Lab, encouraged De Boer and Van Arkel to write a synthetic monograph on the chemical research on the structure of atoms, molecules, and crystals, thereby using the electrostatic theory developed by Kossel in 1916. The monograph *Chemische binding als electrostatisch verschijnsel* (Chemical Bonding as an Electrostatic Phenomenon), published by these two industrial chemists in 1930, had a long-lasting influence on academic inorganic and physical chemistry, both in the Netherlands and abroad. A German edition came out in 1931, and a French one in 1936. It showed the inorganic chemists that their field was more than a disparate collection of facts. Van Arkel and de Boer presented a theoretical framework that could make sense of a great number of chemical properties. And it showed the physical chemists that their work—then dominated in the Netherlands by thermodynamics and the phase rule —could be understood fruitfully in terms of intermolecular forces.

During the next decade the electrostatic theory showed its great power and heuristic value in the research at the Nat Lab. De Boer incorporated the ideas on crystal defects, formulated around 1930 by Adolph Smekal ("Locker-stellen"), Walter Schottky (vacancies), and Yakov Frenkel (interstitials), into the crystal models that Van Arkel and he had formulated. That helped him, together with Verwey, in 1936 to understand the electrical and magnetic properties of spinel type oxides, such as Fe_3O_4, Co_3O_4, and Mn_3O_4. These insights played a role in the research on magnetic ferrites at Philips, which proved of crucial strategic importance after World War II, when Philips exchanged its patent portfolio on ferrites with the transistor patents of Bell Labs. Building on the notion of crystal defects, de Boer also developed a model for understanding the luminescence of so-called light-emitting "phosphors" such as potassium chloride, which found application in the production of x-ray screens and television screens. In 1937 Schottky's ideas helped de Boer in the formulation of his theory on color centers in semiconductors, which the next year was put into a more sophisticated form by the English physicist Nevill F. Mott. De Boer thus laid the foundations for a whole new area of research—"defect chemistry"—at Philips, which after World War II was developed successfully by chemists such as F.A. Kröger and Henny Vink.

From Photochemistry to Catalysis. In the meantime, de Boer's attention shifted increasingly to surface phenomena and colloid chemistry. Among the nine research groups at the Nat Lab in 1931, there were two groups on chemistry: Chemistry A, headed by Van Arkel, on solid state chemistry, and Chemistry B, headed by de Boer, on photochemistry. After Van Arkel left Philips in 1934 to become professor of inorganic and physical chemistry at Leiden, de Boer became the head of all the chemistry research at Philips. Although his work on photochemistry also included the emission of electrons and photons from inside the crystals (see above: phosphors; F-centers), many effects took place at the surface, or in layers of substances adsorbed at crystal surfaces. When the British surface chemist and catalysis expert Eric Rideal visited the Philips Nat Lab in March 1933, he invited de Boer to write a monograph for his *Cambridge Series on Physical Chemistry*, which would show how new insights on adsorption could be gained from the study of electron emission. Two years later de Boer's book *Electron Emission and Adsorption Phenomena* was published. It was a wide-ranging book with great relevance to the electronic industries, but also to parts of the chemical industries. It was soon translated into German, with a preface by Schottky of Siemens, and also into Russian. De Boer, by again using the electrostatic theory, was among the first to show how adsorption could be understood with the help of the same interatomic and intermolecular forces that were crucial to understanding the structures of crystals and molecules. With the help of potential energy diagrams, de Boer succeeded in giving insight into a great number of surface phenomena. Although the word *catalysis* does not appear in the index of the book, the theoretical insights on adsorption developed by de Boer had a relevance for that emerging field, and led in time to the setting up of the "Dutch School of Catalysis."

De Boer's work thus constituted a unique link between research within the electronic industries and research done by companies in the process industries. The same is true for several other of his pre-war contributions to surface chemistry and colloid science: theoretical work, together with H. C. Hamaker, on the non-isotropic nature of Van der Waals–London forces, and the electrical double layers of colloids (1936; 1937); the organization of a symposium (1936) on natural and artificial rubber, for which he cooperated with Dutch rubber scientists such as Johan R. Katz and Roel Houwink; the organization of a symposium on the dynamics of hydrophobic suspensions and emulsions (1937); and the organization of a symposium on proteins (1939).

At the eve of World War II, de Boer was the undisputed leader of chemical research at Philips and one of the leading physical chemists of the country. During his years at the Nat Lab he had published more than 140 scientific books and papers, and filed about 150 patents, by far the majority of those he would ever file. In 1940 he was elected an ordinary member of the Royal Netherlands Academy of Sciences. Moreover, he was the intended successor to Gilles Holst, as the leader of all research at Philips. Then, in September 1939, the war broke out and de Boer's careertook a completely different turn.

War Years in London and Brussels. Because of the threat of war, the Dutch government in 1939 decided to create the function of "officer-chemist" and to establish a Central Laboratory of the Supreme Command of the Army and the Navy, based inside the inorganic and organic laboratories of the University of Leiden. Jan de Boer was asked to become its director. He stayed in the employ of Philips, but was detached to the defense organization, with the rank of captain. In 1939 he set up a research team of "officer chemists" at Leiden who started research on the protection against chemical war gases by means of adsorption to active carbon and other materials.

On 10 May 1940 German forces crossed the Dutch border, and the Netherlands entered the war. After Rotterdam had been destroyed by the German Luftwaffe on 14 May, Queen Wilhelmina and the Dutch government left the country and went to London. The next day the Dutch commander in chief capitulated. On the same day, 15 May 1940, de Boer managed to escape with a fishing boat to England, together with one of his collaborators, J. van Ormondt, carrying all the technical papers and documents of the Central Laboratory.

After his arrival in London, de Boer succeeded in obtaining laboratory space in Imperial College in South Kensington. He led a small research team of Dutch chemists, which grew gradually during the war. They did chemical work for the Dutch government in exile, translated technical military papers into English, and did research for the British Ministry of Supply. Although a foreigner, de Boer was asked to become a member of the Chemical Warfare Board of the Ministry of Supply.

From 1942 onward he also was a member of the Buitengewone Raad van Advies (the Extraordinary Advisory Council) to the Dutch government in exile, which was set up as a kind of small parliament, under the pressure of industrialists such as Paul Rijkens, member of the board of Unilever. As a lieutenant-colonel, later colonel, de Boer in 1944 became head of the section on repatriation of the so-called Militair Gezag (Military Authority), a body created to govern the liberated parts of the Netherlands during the military operations in the country. It had the task of preparing the transition of the country from German occupation to a free democracy. In September 1944 de Boer arrived on the continent and was attached to the headquarters of the Military Authority in Brussels. He returned to London after German capitulation in May 1945, and stayed in the service of the military until 1946. In England, de Boer also met his second wife, Evangeline A. Malcolm Swanson, whom he married in March 1946, after a divorce from his first wife earlier that year. The second marriage was childless.

Research Leader at Unilever. In 1946 Gilles Holst retired as leader of the Nat Lab and of all corporate research and development at Philips. He was succeeded by a triumvirate: Henk Casimir (physics), Evert Verwey (chemistry), and Herre Rinia (electronics), but not by de Boer, who had decided for personal reasons, related to his divorce and second marriage, not to return to Eindhoven (report of a phone call of DSM director Jan van Aken with Gilles Holst, on 21 January 1950. Personal papers de Boer, DSM Archives; cf. de Boer, 1969, pp. 8–9). With the help of Unilever director Paul Rijkens, whom he knew well from their joint meetings within the Buitengewone Raad van Advies, de Boer succeeded in obtaining a leading research position at the British-Dutch multinational Unilever.

In 1946 de Boer started as manager of scientific research at the Unilever research laboratory at Port Sunlight, near Liverpool, with the specific task of setting up a Food Research Department for the company. This second British research center of Unilever was established in 1947 in Colworth House (Bedfordshire). De Boer had expected to become the director of the new research institute, but as a result of a conflict between the Dutch and the British members of the board of Unilever, he was not appointed. De Boer's views on industrial research played a crucial role in this conflict. He wanted to set up a research organization similar to the one created by Holst at Philips: with a true academic atmosphere, in which work of high scientific value was done, and in which publication in scientific journals was encouraged. This approach was unacceptable to the British board members, who preferred a greater degree of secrecy (report of a phone call of J. L. Poelhekke of DSM with Professor Hein Waterman of Delft, on 17 September 1949. Personal papers de Boer, DSM Archives).

As a result, de Boer decided to leave Unilever. He stayed in Colworth House from 1948 until 1950, and wrote a textbook on adsorption during this period (see below). In the meantime, he tried to secure a new research position elsewhere. With the help of his friend and colleague Hein Waterman, professor of chemical technology at Delft, de Boer succeeded in finding a new job at Staatsmijnen (DSM; Dutch State Mines) in March 1950.

Professor of Catalysis at Delft. In 1946 Waterman had already offered de Boer a part-time professorship of chemical technology at the Technological University at Delft. After consultation with Unilever, de Boer accepted the offer. As a result, he traveled every month for two days to Delft, acted the next day as an advisor of the Unilever research laboratory at Zwijndrecht, near Rotterdam, and went on Saturday to the monthly meeting of the Royal Netherlands Academy of Sciences, at Amsterdam.

De Boer decided to focus his research and teaching at Delft on catalysis, a field that was not represented at any of the Dutch universities. In his inaugural lecture of 23 May 1946 on *Monomoleculaire lagen in de chemische industrie* (Monomolecular layers in the chemical industry) he presented a broad picture of the role of surface phenomena in industry: in separation processes; in mixing and adhesion; and in chemical processes, such as photochemical and catalytic processes. Adsorption and Van der Waals forces were the focus of this lecture, and their investigation would occupy de Boer during the next twenty-three years as a part-time professor at Delft.

The monthly lectures that he gave during the first years of his professorship "were very popular as they gave lucid and vivid explanations of the fundamentals, avoiding unneeded bookishness, instead using straightforward models and examples" (Steggerda, 1994, p. 84). They resulted in a review paper on "Atomic Forces and Adsorption" for *Advances in Colloid Science* (1950), and a textbook called *The Dynamical Character of Adsorption* which was written during de Boer's stay at Unilever but published in 1953. That book shows de Boer's didactic qualities at their best: It is lucidly written, well structured, and clear. With the help of the kinetic theory of gases, de Boer succeeded in creating "a picture of adsorption" that would stay in the minds of his students. He visualized the phenomena as an imaginary "gas of super bees," and structured the content of his book in terms of a small number of crucial parameters: the number of molecules striking a unit area of surface in a unit time; the time of adsorption; and the amount of adsorbed molecules per unit area (de Boer, 1953, pp. v, 1–3).

After his return to Holland in 1950, de Boer started to build a research team at Delft. He supervised at least twenty-six doctoral dissertations. Several of his students later became university professors themselves: Piet Mars, Jacques Coenen, John Geus, and Jos Scholten in catalysis, Jan Steggerda in inorganic chemistry, and Jan Fortuin in chemical engineering. Others, such as Hans Linsen of Unilever, became research leaders in industry. Before 1960 the research was somewhat hampered by the poor equipment of the Delft laboratory, but even though de Boer visited the laboratory only a few days a months, and left his PhD students finding their own way most of the time, he succeeded in creating a true research spirit in which new results on adsorption on, especially, alumina, silica, and Ni-silica catalysts could be obtained with simple means.

The trademark of the Dutch School of Catalysis, as shaped by de Boer, was its focus on the investigation of the structure and texture of catalysts. Together with his students, and partly in his other roles, described below, de Boer again published about 150 scientific papers between 1946 and his untimely death in 1971. The phase transitions of alumina were studied, which were important for the understanding of the activation process of alumina supported catalysts. The research done on nitrogen adsorption isotherms that were used for the determination of the surface areas of catalysts was also important. De Boer succeeded in finding a better alternative for the popular BET-equation (Brunauer, Emmett, and Teller), and with the help of theoretical studies on the two-dimensional Van der Waals equation, on two-dimensional phase transitions, and on the entropy of adsorption, he developed the so-called t-method that is still used in the early twenty-first century. In this way, he offered a theoretical foundation to the experimental result—studied in detail by his students Ben Lippens and Hans Linsen between 1961 and 1964—that the volume of adsorbed nitrogen plotted as a function of the relative pressure follows a common t-curve for a great variety of adsorbents and catalysts. In the course of the 1960s, de Boer and his students Hans Broekhoff and Linsen succeeded in developing this t-curve method not only for the determination of the surface areas, but also for the pore size distribution of catalysts. This gave a better understanding of the chemical activity of catalysts.

De Boer had a large network of international contacts, and he organized several national and international conferences, such as the symposium on "The Mechanism of Heterogeneous Catalysis" in 1959, and one on "Reactivity of Solids" in 1960. In 1956 he received an honorary doctorate from the Technological University of Hannover.

Scientific Advisor at DSM. When de Boer started to work for Staatsmijnen (DSM), on 1 March 1950, the Central Laboratory of that company had a staff of 420 persons, with about fifty academics among them. The day-to-day research work was supervised by Dick van Krevelen, who created an academic atmosphere in the laboratory, following the example of the Philips Nat Lab. The overall supervision of all research and development at DSM was in the hands of Gé Berkhoff. Therefore, there was no clear position available for de Boer within the hierarchy of the DSM research organization, and it was decided to give him an independent role as scientific advisor to board member Jan van Aken, who was responsible for the chemical division of the company, as well as for research.

De Boer must have felt at home in the academic atmosphere of the laboratory, which he had helped to shape himself in the 1930s, when DSM board member F. K. Th. van Iterson had visited him frequently at home on Sunday mornings to get advice on the creation of a research laboratory at DSM (de Boer, 1969, pp. 9–10). He encouraged fundamental research on the mechanism of the ammonia synthesis at DSM, within the physical chemistry group, headed by Henk de Bruijn, and later by Cor van Heerden. The catalyst used for that process was made by the reduction of the iron oxide Fe_3O_4 (magnetite), a material that de Boer knew very well from his research at Philips. At the first Dutch conference on catalysis, organized by de Boer in 1951, he gave an opening lecture on theoretical ideas on the mechanism of the catalytic synthesis of ammonia. Four years later his collaborators wrote an extensive review article on the "Research on Ammonia Synthesis since 1940." In 1959 three of his coworkers again reviewed the mechanism of the ammonia synthesis (Mars, Scholten, and Zwietering, in de Boer, 1960, pp. 66–89).

Apart from this fundamental research on catalysis, de Boer mainly acted as a go-between for academia and industry. He liaised with the external academic advisors to DSM, and was a member of numerous advisory bodies and committees. From 1953 to 1955 he was president of the Koninklijke Nederlandse Chemische Vereniging (Royal Dutch Chemical Society), and from that position he founded the Dutch research organization for fundamental chemical research, Scheikundig Onderzoek Nederland (SON), which acted as a national funding agency from 1956 onward. In September 1961 the Dutch government asked de Boer to become the chairman of the newly established Wetenschappelijke Raad voor de Kernenergie (WRK; Scientific Council for Nuclear Energy). This was an almost full-time position. De Boer left DSM, and until his retirement in 1969 he chaired this important advisory body.

Nuclear Energy. De Boer's involvement with nuclear energy had started in 1950, almost immediately after his return to his home country. Already on 17 March, his friend and successor at Philips Nat Lab, Evert Verwey, asked his advice about the technical purification of a large stock of uranium oxide, bought by Dutch government in 1939 on the advice of Wander J. de Haas, and hidden from the Germans during World War II. Later that year The Netherlands and Norway agreed to collaborate in building a nuclear research reactor at Kjeller, Norway. Together, both countries had the essential ingredients: Holland had its stock of uranium, and Norway was in the possession of heavy water. A Joint Committee was coordinating the effort, and de Boer became one of its deputy members. At the end of 1950 the national physics research organization, Fundamenteel Onderzoek der Materie (FOM; Fundamental Research of Matter), established a Reactor Committee, of which de Boer became a member. His knowledge of materials science, of metals especially, was of great value to the Dutch-Norwegian project. He solved several problems, and also send de Bruijn and other DSM chemists to Norway to investigate radiochemical issues that played a role during the construction of the reactor.

In 1955 the Dutch government decided to build a nuclear research reactor in the Netherlands and founded the Reactor-Centrum Nederland (RCN). The same year, de Boer became chairman of the Wetenschappelijke Advies Raad (WAR; Scientific Advisory Council) of RCN, and from then on he played a key role in science policy with respect to nuclear research. Between 1955 and 1969 he was involved in almost all major decisions about nuclear energy, cooperating closely with the research leaders of Shell, Philips, Werkspoor, and the other companies that were participating in the Dutch nuclear energy effort. Already during the 1950s, together with his collaborators de Bruijn and Jan Houtman, he had cooperated closely with scientists of KEMA, the research organization of the Dutch electricity companies, in the construction of a so-called suspension reactor. He also encouraged the initiative to develop on an industrial scale the ideas of the physicist Jaap Kistemaker on uranium enrichment by ultracentrifuges. This ultimately led, in 1971, to the founding of the Dutch-German-British company Urenco (Uranium Enrichment Corporation) in 1971, which has produced enriched uranium in the Netherlands since 1976.

In 1958 he chaired the Dutch delegation at the Second International United Nations Conference on the Peaceful Applications of Nuclear Energy in Geneva. Given his multiple roles in this field, his appointment to chairman of the WRK was no surprise. Between 1962 and 1969 de Boer and his Council wrote about 135 advisory reports on all aspects related to nuclear research, from medical applications to radioactive waste. From 1963 to 1969 he also chaired the Centrale Raad voor de Kernenergie (Central Advisory Council on Nuclear Energy), which coordinated the industrial and scientific efforts. Although undoubtedly *the* spider in the Dutch nuclear web of the 1960s, his multiple roles also caused problems. After a conflict with the board of directors of RCN, he resigned as chairman of the WAR in 1967.

On 26 April 1971, Jan de Boer suddenly passed away. Those who knew him were impressed by his flexible mind, which had involved him in so many different fields, although sometimes the critique was voiced that, without being pedantic, de Boer was too often a “schoolmaster.” Clearly his father’s profession had left its stamp on him.

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BOGOLUBOV, NIKOLAI NIKOLAEVICH (*b.* Nizhny Novgorod, Russia, 21 [old style 8] August 1909; *d.* Moscow, Russia, 13 February 1992), *mathematics, theoretical physics.*

Bogolubov (the name can also be spelled Bogolyubov or Bogoliubov) was a prominent Russian and Ukrainian mathematician and mathematical physicist, one of the founders of non-linear mechanics and the quantum theory of many-body systems. Bogolubov also developed fundamental mathematical methods in kinetic theory, quantum statistics, quantum field theory, and the theories of superfluidity and superconductivity.

In Lieu of Education. Bogolubov descended from a family line of Russian Orthodox priests. His father, Nikolai Mikhailovich, taught philosophy and theology at a seminary in Nizhny Novgorod, and later at Kiev University; his mother, Olga Nikolayevna, gave music lessons. Nikolai was the oldest of the family's three sons, all of whom eventually became prominent scientists. The boy's childhood coincided with the turbulent period of the Russian revolution. He was mainly self-taught and received little formal education, other than a certificate from a seven-year secondary school in a Ukrainian village, where the family survived during the years of the Civil War, 1919–1921, and where his father served as a parish priest after his university chair of theology was closed by revolutionary authorities. During those village years, family friends and relatives aroused Nikolai's interest in mathematics and noticed his exceptional aptitude for the subject.

In 1921 the Bogolubov family returned to Kiev, where the father accepted another parish. With the help of old faculty acquaintances, he obtained permission for his thirteen-year-old son to start attending an advanced university seminar in mathematics. There Nikolai's talents came to the attention of a senior mathematician, Nikolai Mitrofanovich Krylov (1879-1955), who held the chair of mathematical physics at the recently organized Ukrainian Academy of Sciences. Krylov took the boy under his informal patronage and tutelage, and also offered him room and board at his house in 1925, after the rest of the Bogolubov family left Kiev and returned to Nizhny Novgorod following the father's new church appointment. The same year Krylov obtained for Nikolai status at the Academy of Sciences as an *aspirant*, which was a junior academic position similar to that of graduate student. Because of Bogolubov's "phenomenal talents" and advanced knowledge of mathematics, an exception was made to his minor age and lack of university courses. The Soviet educational system, in general, allowed much flexibility in the early post-revolutionary period: It was undergoing many different reforms and often permitted young students to skip certain formal stages and degrees in their scientific education.

At the age of fifteen Bogolubov published his first research paper. Many of his early works were authored together with Krylov in the latter's fields of specialization: variational calculus, differential equations, approximate solutions. Sometimes they published their important results only in Ukrainian, sometimes in Russian, English, or French. Some papers appeared in established international journals with wide circulation, others in small and rare local publications. In 1930 the Bologna Academy of Sciences recognized one of Bogolubov's early accomplishments with its special prize. Earlier that year the twenty-one-year-old completed his graduate studies and received from the Ukrainian Academy of Sciences the degree of Doctor of Mathematics. He continued working under Krylov's supervision as research associate at the Academy.