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REVISION BIBLIOGRAFICA

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Hans Heinrich Landolt (1831-1910) - el gran químico alemán de la segunda mitad del siglo XIX y la primera década del siglo XX (Al 190 aniversario de su nacimiento)

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ABSTRACT

Hans Landolt (1831-1910) was one of the important chemists of the second half of the XIX century and the first decade of the XX century. The purpose of this paper is to familiarize readers with the important events in the life of Landolt and his writing activities, in particular with his chemistry books. In addition, his research activities is briefly described, and especially the chemical reaction named after him.

Keywords: H. Landolt, Physical chemistry, Landolt Reaction, "Landolt-Börnstein" Tables, Germany – XIX –XX centuries.

RESUMEN

Hans Landolt (1831-1910) fue uno de los químicos importantes de la segunda mitad del siglo XIX y la primera década del siglo XX. El propósito de este artículo es familiarizar a los lectores con los eventos importantes en la vida de Landolt y sus actividades de escritura, en particular con sus libros de química. Además, se describen brevemente sus actividades de investigación, y especialmente la reacción química que lleva su nombre.

Palabras claves: H. Landolt, Química física, Reacción de Landolt, Tablas "Landolt-Börnstein", Alemania - siglos XIX-XX.

INTRODUCTION

The important events in the Landolt's life

One hundred and eleven years have passed since the death of Hans Heinrich Landolt, known simply as Hans Landolt, but in that time very little has appeared in the literature about this very interesting man. He went down in the history of chemistry as a pioneer of physical chemistry as well as he was known for his chemistry books published in Germany, Great Britain and U.S.A.

Landolt (Figure 1) was born in Zurich (Switzerland) on December 4, 1831 (Landolt, 1853, p. 41), and he was the son of Johann Heinrich Landolt (1792-1847) and his wife Henriette, née Rahn (1807-1851) (Lendorf, 1904, p. 249; Priesner, 1982).

He attended the *Cantonsschule* (Canton School) for 6 years (Landolt, 1853, p. 41). In 1850, at the age of nineteen, he entered the University of Zurich and studied for three years under Carl Löwig (1803-1890), professor of chemistry (H. T. C., 1911, p. 1654; Oesper, 1945, p. 158). In the spring of 1853, Löwig succeeded Robert Bunsen (1811-1899) in Breslau in Silesia in the Kingdom of Prussia (now, Wrocław, Poland). Landolt went with him and became his assistant at the *Chemischen Laboratorium* (Chemical Laboratory) at the *Chemische Institut* (Institute of Chemistry) at the *Königliche Universität zu Breslau* (Royal University of Breslau). He continued his studies at the university. He attended lectures on physics by Moriz Frankenheim (1801-1869) and mineralogy by Ernst Glocker (1793-1858) (Landolt, 1853, p. 41).

Fig. 1. *H. Landolt (1831-1910) ("Hans Heinrich Landolt", 1880).*

On November 30, 1853, he defended his doctoral dissertation entitled *Untersuchungen über die Arsenäthyle* (Investigations on the Arsenic Ethyls) and received his Ph.D in

Breslau (Landolt, 1853; Landolt, 1854; Pribram, 1911, p. 3341). Figure 2 shows the title page of his dissertation (Landolt, 1853).

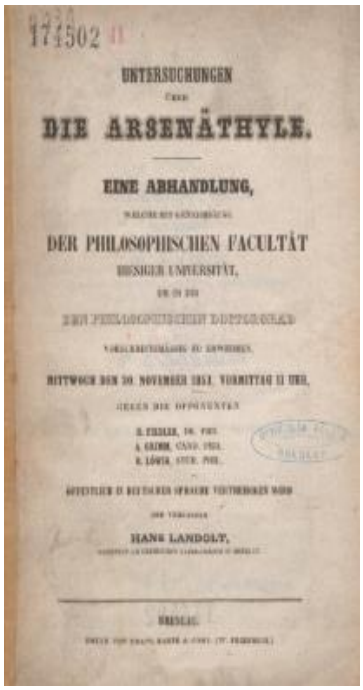

Fig. 2. *Title page of H. Landolt's doctoral dissertation (Breslau: Druck von Grass, Barth & Comp. (W. Friedrich.), 1853).*

Then he entered the University of Berlin, where he attended lectures of Alexander Mitscherlich (1836-1918), Heinrich Rose (1795-1864), Johannes Müller (1801-1858), and Félix Henri DuBois-Reymond (1782-1865) (H. T. C., 1911, p. 1654; van't Hoff, 1910, p. 4).

In 1855, he began worked under Bunsen in Heidelberg. Figure 3 is a photograph taken during this stay. Landolt is second from the left in the front row; to his left are Ludwig Carius (1829-1875), August Kekulé (1829-1896) and Leopold Pebal (1826-1887). To his right is Johann Bahr (1815-1875). From left to right, in the second row are Ernest Gaupillat, Agostino Frapolli (1824-1903), Adolph Wagner (1835-1917), Henry Roscoe (1833-1915), Lothar Meyer (1830-1895), Angelo Pavesi (1830-1896) and Friedrich Beilstein (1838-1906) ("Ficheiro: AK Bunsen", 1857; (Anschütz, 1929, p. 64; Roscoe, 1906, pp. 414-415).

Beilstein in a congratulatory letter, dated April 22, 1904, sent to Roscoe (1906) on the occasion of his Graduation Jubilee, reminded him of this photo. He wrote:

In April 1856, when I returned to Heidelberg from Munich, where I had listened to Liebig and worked with Jolly, you and I were colleagues in the new Laboratory, then just finished, and where later on you were a frequent and welcome guest. In June 1856, we—the senior pupils in Bunsen's laboratory—were photographed together. In this picture, which lies before me, I see the forms of many dear old friends who are now no more. Yes, most of them —Bahr, Carius, Kekulé, Lothar Meyer, Pebal—have gone. Besides we two, our excellent and honoured comrade Landolt is the only one remaining"(pp. 414-415).

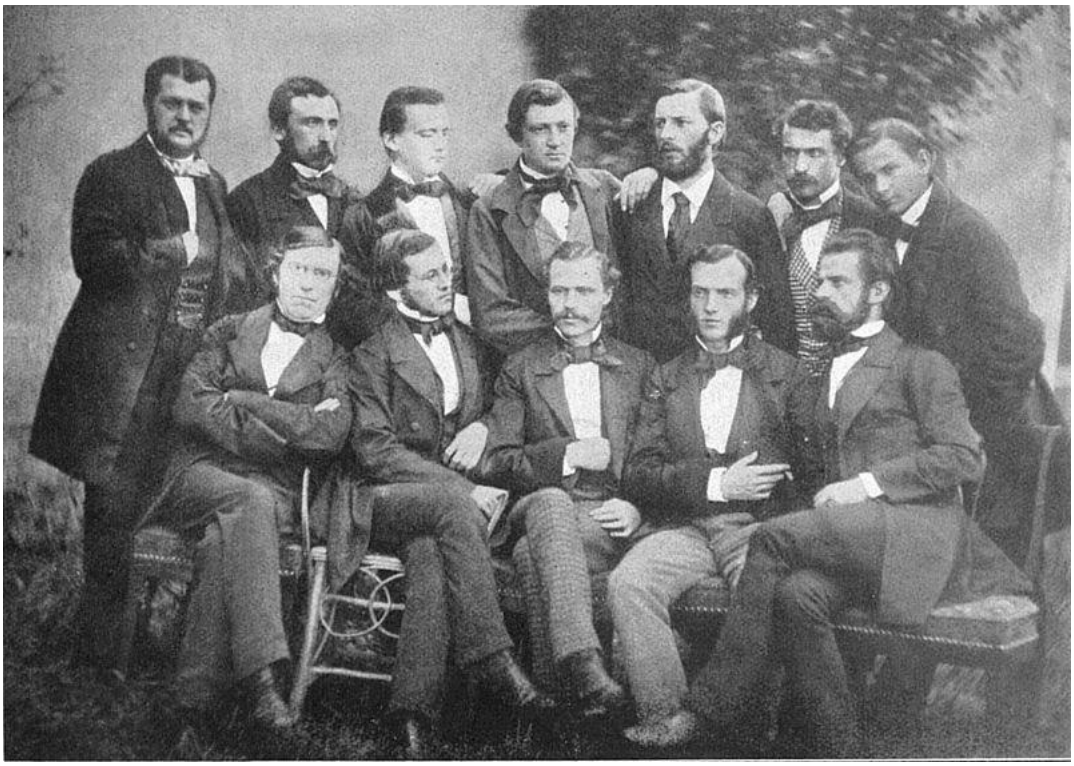

***Fig 3**. Landolt with the group of young chemists from the Bunsen laboratory in Heidelberg ("Ficheiro: AK Bunsen", 1857).*

The German chemist Richard Anschütz (1852-1937), professor of chemistry at the University of Bonn, in the first volume of his biographical book on Kekulé, also included a group photo of young researchers from Bunsen's laboratory in Heidelberg (Anschütz, 1929, p. 64).

Then, at the invitation of Löwig, Landolt returned to Breslau and on October 30, 1856, at the age of 25, he habilitated as *Privatdozent* in Chemistry and Technology (Ladenburg & Buchner, 1911, p. 454; Oesper, 1945, p. 158) with a habilitation thesis entitled *Die chemischen Vorgänge in der Flamme des Leuchtgases* (The Chemical Processes in the Flame of Illuminating Gas) (Landolt, 1856).

In 1857, he received an appointment as Extraordinary Professor at the University of Bonn (Schenk, 1911, p. 28). Two years later, he married Emilie (Milla), neé Schallenberg (1839-1914). The spouses had two children: son Robert (1865-1914), who became an ophthalmologist and professor of medicine in Strasbourg, and a daughter, Maria (1860-?), who became the wife of the German pharmacologist Oskar Liebreich (1839-1908) in Berlin (Lendorf, 1904, p. 249; Preisner, 1982).

In 1860, he attended the first ever International Congress of Chemists held in Karlsruhe (Germany) on 3-5 September. In addition to Landolt, 54 German chemists participated in the Congress ("Charles-Adolphe Wurtz", n.d.).

In 1869, he was appointed Professor of Inorganic and Organic chemistry at the *Rheinisch-Westfälischen Technische Hochschule* (Rhenish-Westphalian Technical University) at Aachen. In 1880, he took up a professorship at the newly founded *Landwirtschaftliche Hochschule zu Berlin* (Agricultural University in Berlin). Since then, he has worked continuously in Berlin.

In December 1882, the Baltic-German chemist Wilhelm Ostwald (1853-1932), later a Nobel Laureate in Chemistry in 1909, visited Berlin. He wrote about his stay in this city and his meeting with Landolt in his autobiography (Scholz & Jack, 2017) as follows:

Nevertheless, after a long day's journey I arrived with a pounding heart in Berlin, where I took a room at the Central Hotel, … which at that time was the biggest in the city, and set off to admire the metropolis. Because of the New Year holidays I had time to first of all visit the museums and other places of interest. The first chemist I met was Hans Landolt who held a professorship at the agricultural university. He welcomed me with great kindness and showed me his labs. I learned a lot of things which would be useful in teaching courses and this was the start of a long and deep friendship which remained unshaken even in difficult times and continued until his death (p. 98).

In 1891, he changed his position at the Agricultural University for a professorship at the *zweiten chemischen Instituts* (Second Chemical Institute) at the University of Berlin (Marckwald, 1910, p. 195). He became the successor of Karl Rammelsberg (1813-1899) (Partington, 1964, p. 759; van't Hoff, 1910, p. 9). In 1905, he resigned from the professorship, but worked until his death in the laboratory reserved for him at the *Physikalisch-Technische Reichsanstalt* (Priesner, 1982). In early April 1905, he handed over his laboratory to his successor Walther Nernst (1864-1941), but he still had lectures on inorganic chemistry in the summer semester (Pribram, 1911, p. 3382).

"On the night of March 15", 1910, Landolt died at Berlin at the age of 79 "after a short but serious illness" (Marckwald, 1910, p. 194). He was buried in the old cemetery at Bonn (Oesper, 1945, p. 161). "In him science loses a loyal worker, an extremely hardworking and conscientious researcher, who was privileged to be scientifically active for no less than 58 years" (Schönrock, 1910, p. 93). The German chemist Willy Marckward (1864-1942) wrote about him in Landolt's obituary (1910) as follows:

"In spite of his old age, he continued to develop until his death he took an active interest in his science and thus served it faithfully for two generations and with the greatest success … Landolt possessed gifts in his straightforward, open manner, his kind humor and an unusual pedagogical talent, which made him outstandingly qualified as an academic teacher. All of his students therefore clung to their master with the greatest admiration and remained loyal to him through the years of study. ... The consciousness of the faithful fulfillment of his duty together with a happy family life and a devoted circle of friends made the happiness of his life" (pp. 194-195).

Landolt's participation in the scientific celebrations

On January 3, 1898, he attended the meeting on the occasion of the opening of the *Physikalisch-Chemisch Institut* (Institute of Physical Chemistry) in Leipzig. Among the invited guests were, among others the Dutch chemist Jacobus Henricus van't Hoff (1852-1911), who won the Nobel Prize in Chemistry in 1901 ("Jacobus H. van't", 2021), the Swedish chemist Svante August Arrhenius (1859-1927), who received the Nobel Prize in Chemistry in 1903, Walther Nernst, who was awarded the Nobel Prize in Chemistry in 1920, the German chemist Ernst Beckmann (1853-1923), the German chemist Gustav Wiedemann (1826-1899) and the German chemist Johannes Wislicenus (1835-1902). A photo taken at this meeting was included by Ostwald in his autobiography first published in German in 1926/1927 (Scholz & Jack, 2017). He wrote:

To publically mention all these things I arranged a special inauguration celebration to which the minister of culture, the rector of the university, the dean of the faculty and a number of friends and colleagues from near and far were kind enough to attend. A photograph of the meeting is attached to this volume. I look at the people with a mixture of happiness and sadness. Happiness, that I was able to interact with so many splendid men, sadness because the majority of them are now dead (p. 288).

Gerhard Ertl in his article (2009, p. 6602) also included the same photo. He also wrote about the lecture delivered by Ostwald as follows: "During his lecture on this occasion Ostwald experimented with liquid air, the production of which had been carried out shortly before by [the German engineer] Carl von Linde [(1842-1934)] (Ertl, 2009, p. 6602).

In 1900, Landolt took part in the Berlin conference devoted to the 200th Anniversary of the *Königlich Preußischen Akademie der Wissenschaften* (Royal Prussian Academy of Sciences). Figure 4 is a photography made during this celebration ("200th Anniversary of Berlin", 1900). The American biochemists Benjamin Harrow (1888-1970) inserted this photo on the one of first pages of his book entitled *Eminent Chemists of Our Time.* He also wrote that it "showing several eminent chemists was taken at one of the international scientific gatherings" (Harrow, 1920, p. 8).

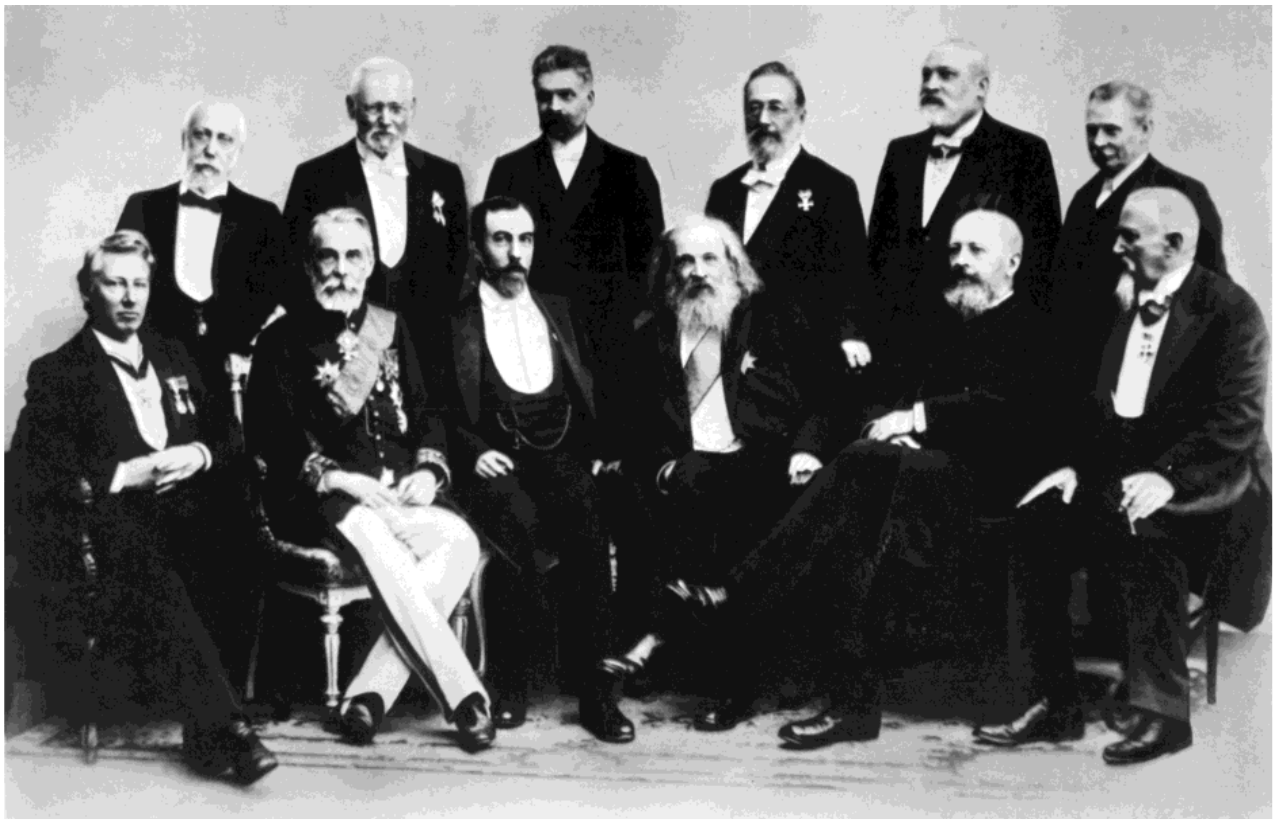

Fig. 4*. Landolt* with the group of the prominent chemists ("200th Anniversary of Berlin", 1900).

Photograph was published by Harrow thanks to the kindness of the Dutch chemist Ernst Julius Cohen (1869-1944) (Donnan, 1948). Landolt is standing third from the right; to his left are the German chemist Clemens Alexander Winkler (1838-1904), who discovered germanium in 1886 (Volke, 2004), and the British chemist and

historian of chemistry Sir Thomas Edward Thorpe (1845-1925) (Tutton, 1925). To his right are the Finnish chemist and historian of chemistry Edvard Hjelt (1855-1921) (Kauffman & NiiNistö, 1998), the Danish chemist Sophus Mads Jørgensen (1837-1914) (Kauffman, 1992) and the German chemist and historian of chemistry Albert Ladenburg (1842-1911) (Sztejnberg, 2021b). Seated from the left to right in the front row are van't Hoff, the Russian - German chemist Friedrich Konrad Beilstein (1838-1906) (Sztejnberg, 2021a), the British chemist Sir William Ramsay (1852-1916), who found neon, argon, krypton, and xenon in air and was awarded the Nobel Prize in Chemistry in 1904 (Tilden, 1918), the Russian chemist Dmitri Ivanovich Mendeleev, who discovered the Periodic Law in 1871 (Boeck & Zott, 2007; Sztejnberg, 2018), the German chemist Adolf von Baeyer (1835-1917), who received the Nobel Prize in Chemistry in 1905 (Baeyer, Villiger, Hottenroth, & Hallensleben, 1905), and the Italian chemist Alfonso Cossa (1833-1902) (Kauffman & Molayem, 1990).

Landolt's works

The list of Landolt's works includes seventy-six papers that appeared in print for fifty-nine years from 1851 to 1910 (Pribram, 1911, pp. 3387-3391). His articles presenting the results of his experimental studies were published mainly in *Berichte der deutschen chemischen Gesellschaft* and *Sitzungsberichte Der Königlich Preussischen Akademie der Wissenschaften zu Berlin*. His experimental studies were carried out in chemical laboratories in Zurich (1851-1852), Breslau and Heidelberg (1853-1856), Bonn (1857-1869), Aachen (1869-1880), and Berlin (1880-1910).

His first works were articles on the chemistry of antimony and arsenic compounds. His experimental studies in Zurich focused on antimony methyl $Sb(CH_3)_4$ and its compounds (Landolt, 1851a; Landolt, 1851b; Landolt, 1852a; Landolt, 1852b; Landolt, 1852c). He also continued research on antimony methyl compounds in the University Laboratory in Bonn (Landolt, 1861). In Breslau, he dealt with some new compounds of the arsenic ethyls (Landolt, 1853; Landolt, 1854).

In 1882, he published the results of his studies of molecular refraction of liquid organic compounds (Landolt, 1882). In one of the articles published in 1885, he described some laboratory devices, incl. apparatus for concentrating the obtained very dilute solutions; and a device for sublimation (Landolt, 1885a).

In the history of chemistry, Landolt's name was written in the name of one reaction. He was the discoverer of the chemical "clock" reaction, also known as the *Landolt Reaction*. It is a reaction between iodic acid (HIO_3) and sulfurous acid (H_2SO_3). It was investigated by him in 1885 (Landolt, 1885b, p. 249; Landolt, 1886, p. 1317). According to K. J. Morgan, during the course of Landolt's clock reaction, there are three reactions involved:

"(i) $IO_3^- + 3HSO_3^- = I^- + 3HSO_4^-$

(ii) $IO_3^- + 6H^+ + 5I^- = 3I_2 + 3H_2O$

(iii) $I_2 + HSO_3^- + H_2O = 2I^- + HSO_4^- + 2H^+$"(Morgan, 1954, p. 139).

G. Svehla (1969) described the course of Landolt reactions as follows:

The application of Landolt reactions provides a new, simple sort of indication for chronometric procedures. Landolt … himself examined the reaction that takes place between sulphite and iodate ions in acidic medium. If the initial concentrations are such that iodate is in excess after mixing the reactants (iodate and sulphite) no visible change takes place for a while, but after the lapse of an incubation period, the colour of iodine appears. This latter process is immediate and is easily visible. The

phenomenon is often termed the "Landolt effect," … The length of this incubation period, hereafter called reaction time, can be measured with a stop-watch (p. 514).

In 1908, an article by Landolt entitled *The Development of Mineral Chemistry* was published in Polish. It was his lecture, translated from German, which was delivered on November 11, 1907 at a solemn Meeting in Honor of the Fortieth Anniversary of the German Chemical Society (Landolt, 1908a).

Landolt's last work from 1910 (158 pages) entitled *Über die Erhaltung der Masse bei chemischen Umsetzungen* (On the Conservation of Mass in Chemical Reactions) was published after his death. It was presented by the German physicist Heinrich Rubens (1865-1922) at the General Meeting of the Prussian Academy of Science on May 26, 1910. It was submitted for printing on the same day, and published on October 13, 1910. Prof. Willy Marckwald (1864-1942) wrote in his introductory remarks:

"When the author [Landolt] died, most of the manuscript of this treatise was found ready for printing. Chapters I, II, IV and Parts A and D of Chapter III required only peer review and minor editorial changes. The undersigned [Marckwald] made additions, as far as possible, in accordance with the notes left by the author and his previous publications [Landolt, 1893; Landolt, 1906a; Landolt, 1908b]" (p. 3).

Landolt's other works on chemistry

The first German edition of his *Das Optische Drehungsvermögen Organischer Substanzen Und Die Praktische Anwendungen Desselben. Für Chemiker, Physiker und Zuckertechniker* was published in 1879 in Braunschweig (Landolt, 1879), and the second, in 1898 (Landolt, 1898).

The first English edition of this book entitled *Handbook Of The Polariscope And Its Pracitcal Applications* was published in 1882 in London. The translators were D. C. Robb and V. H. Veley (Landolt, 1882b). The second American edition under the title *The Optical Rotating Power Of Organic Substances And Its Practical Applications* appeared in 1902 in Easton. The translator was John Harper Long (1856-1918) (Landolt, 1902). In his preface to this book written in January 1902 in Chicago, he wrote: "The two editions of this work which appeared in Germany in 1879 and 1898 enjoyed there a great and well-deserved popularity. A translation of the first edition was brought out in England in 1882, under the title: "Handbook of the Polariscope and Its Practical Applications," and contributed not a little to the advance of methods of optical analysis in that country and the United States. Both the original edition and this translation have been, however, long out of print.The scope of the second edition, a translation of which I have the honor of presenting to American and English readers, is much wider than that of the first; the main points of difference are made plain in the author's preface, but attention may be called to the fact that the detailed discussions in Sections IV and V of Part I on the relations between the rotating power and the chemical constitution of carbon compounds, along with the full numerical data on constants of rotation, etc., render the work of the highest value to investigators in many fields of pure organic chemistry" (p. IX).

In 1883, the first German edition of Landolt's and Richard Börnstein's (1852-1913) the *Physikalisch-Chemische Tabellen* (Physico-Chemical Tables) was published in Berlin (Landolt & Börnstein, 1883). In the preface to this book written in July 1883 in Berlin, they wrote:

"The publication of the present book was initially caused by a small number of tables which one of us had put in print for students for use in physico-chemical work. The

idea of expanding this collection and transforming it into a more or less complete one was all the more obvious since the literature, as far as we know, has no work of the form we had in mind. Our intention was to provide, in addition to the tables required for reduction calculations, a compilation of physical constants, with an indication of the source for each number given. Little or no consideration has been given to this point of view in the physical and chemical tables published in the "Annuaire du Bureau des Longitudes", the "Sammlung von Tabellen, Zahlen und Formeln für Chemiker von Hoffmann-Schädler" [Collection of Tables, Figures and Formulas for Chemists by Hoffmann-Schädler], the "Chemikerkalender von R. Biedermann" [Chemist's Calendar by R. Biedermann] and others. Only the "Constants of nature von F. W. Clarke "[Constants of Nature by F. W. Clarke] contain references to literature, but these only go up to the year 1875; besides, the work extends only to a few physical characteristics and has a different character altogether. Furthermore, since there are no more recent tables of special physics than those by E. L. Schubarth, the last edition of which dates from 1841, a book of the kind mentioned seemed to us to meet an existing need" (p. V).

The second (1894) much enlarged edition of this book was published by Julius Springer in Berlin. Among the co-authors were the names of 15 scientists who participated in the creation of this work (Landolt & Börnstein, 1894). The third edition under the title *Landolt-Börnstein Physikalisch-Chemische Tabellen* was published in 1905 under the editorship of Börnstein and Wilhelm Meyerhoffer (1864-1906) (Börnstein & Meyerhoffer, 1905). The fourth edition, revised and expanded, appeared in 1912, two years after Landolt's death. Its editors were Börnstein and Walther Adolf Roth (1873-1950) (Börnstein & Roth, 1912). The name of the book *Landolt-Börnstein Physikalisch-Chemische Tabellen* was also kept by the editors of the fifth, two-volume edition (Roth & Scheel, 1923a; Roth & Scheel, 1923b).

Currently, on the Landolt-Börnstein online shelf there are seven groups of books published by the Springer, including Physical Chemistry (Group IV) (Poerschke, n.d.; "Springer Materials. Landolt", n.d.).

In 2008, a book edited by Otfried Madelung and Rainer Poerschke, entitled *Der Landolt-Börnstein. Erfolgsgeschichte einer wissenschaftlichen Datensammlung im Springer-Verlag* (The Landolt-Börnstein. Success Story of a Scientific Data Collection at Springer-Verlag) was published. Appendix No. 1 contains a list of all volumes of the *Landolt-Börnstein Physikalisch-Chemische Tabellen* that appeared from 1883 to 2007 (Madelung & Poerschke, 2008, pp. 105-139).

Landolt is the author of Chapter VIII in the book under the title *Graham – Otto's Ausführliches Lehrbuch Der Chemie* (Horstmann, Landolt, & Winkelmann, 1898). The English edition of this Chapter entitled *Optical Activity and Chemical Composition* appeared in 1899 in London. The translator was John McCrae (Landolt, 1899a).

CONCLUSION

Hans Heinrich Landolt (1831-1910) was one of the important chemists of the second half of the XIX century and the first decade of the XX century. In the years 1831-1853 he lived in Zurich, and then for 57 years in Germany. He achieved tremendous success in his life. He was one of the founders of physical chemistry. On August 15, 1881, he was elected an ordinary member of the *Königlich Preussischen Akademie der Wissenschaften* (Royal Prussian Academy of Sciences) in Berlin ("Sitzungsberichte

Der Königlich", 1882). He became a corresponding member of *the Imperial Academy of Sciences in St. Petersburg* on December 7, 1896 ("Landol't Gans Genrikh", 2007). On February 2, 1888, he was elected a foreign member of *the Chemical Society of London* ("List of the", 1909, p. 9). After Landolt, not only his papers and books survived. In addition, several of his portraits were produced. His portrait can be found in a book written by the American chemist Henry Monmouth Smith (1868-1950) (Smith, 1949, p. 143). Two his photographs are from the Edgar Fahs Smith Chemistry Collection ("Landolt, H. (Hans)", n.d.a; "Landolt, H. (Hans)", n.d.b). His photos were also posted by some authors of articles describing his life and scientific achievements, for instance by H.C.T. (1911, p. 1653) and Richard Pribram (1911, p. 3337). Landolt was the author of obituaries on the chemists of his time. He wrote the obituaries of August Kekulé (Landolt, 1896a), Eugen Sell, 1842-1896 (Landolt, 1896b), Hermann Wilhelm Vogel, 1834-1898 (Landolt, 1899b), Robert Wilhelm Bunsen (Landolt, 1899c), Hans Jahn, 1853-1906 (Landolt, 1906b), and Carl Rammelsberg (Landolt, 1909). In 1875, he wrote the obituary of the German entrepreneur in the chemical industry Friedrich Wilhelm Hasenclever (1809-1874) (Landolt, 1875). Landolt, as one of the outstanding masters of physical chemistry, went down in the history of chemistry, and his name was written in it forewer. This was made possible thanks to his great scientific achievements, his clasical book on the optical rotation of organic compounds and his Physico-Chemical Tables, his clock reaction and "fastidious testing of the law of conservation of mass during chemical reactions as one of the finest quantitative studies in the whole history of chemistry" (Oesper, 1945, p. 158).

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