# The chemical atomic theory in Ramón Torres Muñoz de Luna's textbooks (1848 – 1885)

**Inés Pellón; Ana Bilbao-Goyoaga•**

**Abstract**

After being formulated by John Dalton (1766-1844) in 1803, and published in his *New System* (1808), the chemical atomic theory was further developed by Jöns J. Berzelius (1779-1848) in the 1830s, exerting great influence on contemporary scientists. Based on a series of experimental facts, some chemists opted for the theory of equivalents, which they deemed to be more trustworthy. By mid-19th century, the confusion in this regard was so rampant that the chemists felt the need to meet and clear up the differences between both theories. That meeting took place in Karlsruhe, Germany, in September 1860, and as a result, the concepts of molecule and atom were clarified. Ramón Torres Muñoz de Luna (1822-1890) was the only Spanish representative at that meeting. The main aims of the present article were to describe some features of Torres' biography and publications, analyse his participation in the Karlsruhe Congress, and discuss the influence that the latter and the atomic theory had on Torres'most relevant works.

**Keywords:**

History of chemistry; Chemical atomic theory; Chemistry textbooks; 19th century chemistry in Spain; Ramón Torres Muñoz de Luna

**Teoria atómica química nos textos de Ramón Torres Muñoz de Luna (1848 – 1885)**

Depois de formulada por John Dalton (1766-1844) em 1803 e publicada em *New System* (1808), a teoria atómica química foi desenvolvida por Jöns J. Berzelius (1779-1848) na década de 1830, exercendo grande influência nos cientistas da época. Mais tarde e baseados numa série de fatos experimentais, alguns químicos optaram pela teoria dos equivalentes, que consideravam ser mais fidedigna. Por volta da metade do século XIX, a confusão acerca dessa temática era tal, que os químicos sentiram a necessidade de se reunir para esclarecer as diferenças entre essas duas teorias. A reunião foi realizada em Karlsruhe, Alemanha, em setembro de 1860 e como resultado, os conceitos de molécula e átomo foram elucidados. Ramón Torres Muñoz de Luna (1822-1890) foi o único representante espanhol nesse encontro. O objetivo do presente estudo é descrever alguns aspectos da biografia e publicações de Torres, analisar a sua participação no congresso de Karlsruhe e discutir a influência desse e a teoria atómica nas obras principais de Torres.

**Palavras-chave**

História da química; Teoria atómica química; Manuais químicos; Química na España no século XIX; Ramón Torres Muñoz de Luna

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**Introduction**

In 1868, Angus Smith, president of the Literary and Philosophical Society of Manchester, wrote an article on the composition of the atmosphere, in which he mentioned the results obtained by a Spanish chemist about the composition of the air in Madrid.[1] In addition, that article also made reference to the methodology applied to obtain those results, and mentioned one of the books published by the Spanish author. That chemist was Ramón Torres, whose works were also mentioned in the *Comptes rendus* of the French Académie des Sciences,[2] *The Anthropological Review*,[3] and a number of German journals.[4] Adolphe Bobierre (1823-1881) dedicated his *Études chimiques* to Torres,[5] and mentioned his works all along the book. Torres' books are currently found in the British Library and the Bibliothèque Nationale de France, among other European libraries.

In our study of Torres' life and works, in addition to secondary literature, we also analysed documents deposited in different archives, journal *Gaceta de Madrid*, and writings by Torres, many of which are still unpublished. More specifically, we focused on the expression of the atomic theory in Torres' works, and discussed it within the framework of the ideas held at that time in the rest of Europe.

In the second half of the 19th century, there was a group of scientists who admitted and taught innovative knowledge, which thus might be described as a *modernity range*. According to M. Hormigón,[6] universal scientific paradigms are deemed to embody the core knowledge of a specific historical period, and are accepted as a reference by the contemporary scientific community. They play a crucial role in the subsistence, spreading, and advancement of the scientific field to which they belong. However, as some time is needed for new ideas to become universally accepted paradigms, Hormigón suggested the notion of *modernity range*.[7]

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[1] Angus Smith, "On the Composition of the Atmosphere," *Memoirs of the Literary and Philosophical Society of Manchester* (London: H. Baillière, 1868), 3rd series, vol. 3, 1-55.

[2] "Correspondance," and "Bulletin bibliographique," *Comptes rendus hebdomadaires des séances de l'Académie des Sciences*, 51 (1860): 327-36; "Mémoires et communications," 59, no. 270 (1864): 1123; "Bulletin bibliographique," 61 (1865): 60.

[3] "Spanish Anthropological Society," *The Anthropological Review*, 4 (1866): 260.

[4] *Chemisches Central-Blatt für 1866*, 143 (1866): 191; *Sitzungsberichte der königl. Bayer. Akademie der Wissenschaften zu München* (München: Akademische Buchdruckerei von F. Straub, 1868), 490.

[5] Adolphe Bobierre, *Études chimiques sur le phosphate de chaux et son emploi en agriculture* (Paris: Librairie agricole, 1861).

[6] Mariano Hormigón, "Paradigmas y matemáticas: un modelo teórico para la investigación en la historia de las matemáticas," *Cuadernos de Historia de la Ciencia*, 8 (1995) <http:www.oei.es/salactsi/zaragoza4.htm> accessed March 11, 2013.

[7] See also, Hormigón, *Las matemáticas en el siglo XIX* (Madrid: Ediciones AKAL, 1992), 50. This notion has also been used by José M. Sánchez Ron, *Ciencia y sociedad en España: de la Ilustración a la Guerra Civil* (Madrid: El Arquero – CSIC, 1988), 281; Itsaso Ibáñez, & José Llombart, "La comparación de textos en historia de la ciencia: una propuesta metodológica," *Llull* 24 (2001): 131-48; Mario H. Otero, "Ideología de las matemáticas uruguayas," <http://galileo.fcien.edu.uy/texto_de_m_h_otero_sobre .htm> accessed March 11 2013, and "¿Una medalla de chocolate? Sobre cierta difundida ideología interviniente en la historiografía de las matemáticas y en muchos otros discursos no triviales," *Yupana* 5 (2010): 69-76.

In the case of the chemical atomic theory, we might identify one such modernity range starting in the mid 1850s with the so-called "quiet revolution"[8], and finishing in the last decade of the 19th century. It encompassed scientists who believed in the atomic theory and their publications on it, such as André-Marie Ampère (1775-1836), Amedeo Avogadro (1776-1856), Jean-Baptiste-André Dumas (1800-1884), Charles Frédéric Gerhardt (1816-1856), Friedrich August Kekulé von Stradonitz (1829-1896), Auguste Laurent (1807-1853), Justus von Liebig (1803-1873), and Charles Adolphe Würtz (1817-1884), among others.

Torres clearly belonged with this modernity range, not only because he wrote and published during this period, but also because he described the atomic theory in all the texts we analysed, although he supported the theory of equivalents, as it is shown below.

Torres travelled throughout Europe to visit the main centres of knowledge, took part in the Karlsruhe Congress of 1860, and brought all the scientific innovations he had learnt abroad back to Spain. Thanks to his many contacts among the most prominent scientists, European chemistry entered Spain. However, it should be observed that the chemical atomic theory was introduced in Spain by José R. Fernández de Luanco (1805-1925).

Despite the relevance of Torres for the history of chemistry in Spain, his name was misspelt in the Congress minutes, and thus for a long time he was not identified as one of the attendants. However, he was there when Stanislao Cannizzaro (1826-1910) presented his conclusions, and in 1861 published a textbook, in which he described both the atomic theory, and the theory of equivalents.[9] The Spanish government acknowledged the importance of Torres' work and the news he had brought from other parts in Europe, and made that book one of the official textbooks of general chemistry used at the School of Exact Physical and Natural Sciences.

## Historical context

We should not pass over the fact that Torres' life was indelibly marked by the historical conditions proper to the time when he was born, and the economic, political, and social circumstances under which he had to live. In Spain, the 18th century revival of science was hindered by King Charles III's son Charles IV, and more especially by his grandson Ferdinand VII, who led the country to a general crisis. The reign of

[8] Alan J. Rocke, *The Quiet Revolution: Hermann Kolbe and the Science of Organic Chemistry* (Berkeley: University of California Press, 1993).

[9] Ramón Torres, *Lecciones elementales de química general para uso de los alumnos de medicina, ciencias, farmacia, ingenieros industriales, agrónomos, de minas, etc*. This book had five editions (1861, 1864, 1872, 1877, and 1885); the title changed in the 4th edition to *Elementos de química general para uso de los alumnos de medicina, ciencias, farmacia, ingenieros industriales, agrónomos, de minas, etc*., and to *Tratado de química general para uso de los alumnos de medicina, ciencias, farmacia, ingenieros industriales, agrónomos, de minas, etc.* in the 5th.

Ferdinand VII (1813-1833) is known as a "catastrophic period"[10], because all that had been achieved during the Enlightenment collapsed, and the doors opened for Spain to earn a place on the European stage were closed. In addition, the colonial crisis and economic bankruptcy resulting from the Independence War against Napoleon (1808-1814) and the Carlist Wars, which intermittently kept the country in conflict from 1833 to 1876, slowed progress down, and hindered any institutional interest in the development of science.

Moreover, as no scientific societies were created in Spain, there were no journals where to publish and share the scarce scientific knowledge produced within its boundaries. As an example, in the last quarter of the 18th century, 331 works on chemistry were published in Spain, but only 115 in the first quarter of the 19th century.[11] According to the law of exponential growth in science,[12] the production in that period should have soared.[13] Together with the continuous governmental changes that characterised the Spanish socio-political context, also the educational plans were constantly changed.

When Ferdinand VII died in 1833, his daughter Isabella II (1830-1904) rose to the throne, although she was only three years old. Absolutist conservative groups supported Ferdinand's brother Charles, which resulted in the Carlist Wars. Isabella won all three wars, and her model of constitutional monarchy lasted until 1868, when the Glorious Revolution took place, and the Queen was deposed and forced to exile. During this "intermediate stage", Spanish science slowly developed towards the levels achieved in other parts of Europe.[14]

After a troubled period (brief reign of Amadeo I of Savoy, and short-lasting First Spanish Republic), the Bourbon dynasty was restored in 1874, when Isabella's II son Alphonse XII rose to the throne. The constitutional monarchy was ensured by the alternation of liberals and moderates, both of which were capitalist, monarchic and parliamentarist.

Although slowly, the average scientific level boosted, and some original lines of research were started. Science recovered slowly, and the country could at last catch up with the remainder of Europe.

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[10] The existence of a "catastrophic period" in 19th century Spanish science was proposed by José M. López Piñero (ed.), *La ciencia en la España del siglo XIX* (Madrid: Marcial Pons, 1992), 200-1.

[11] Eugenio Portela, & Amparo Soler, *Bibliographia Chemica Hispanica*, *1482-1950,* vol. I (Valencia: Instituto de Estudios Documentales e Históricos sobre la Ciencia, 1987).

[12] This law is valid when representative populations are observed over a long period of time, see Derek Solla Price, *Little Science, Big Science* (New York-London: Columbia University Press, 1963).

[13] Eugenio Portela, *Historia de la química en España durante el siglo XIX* (Madrid: Akal, 1998), 52.

[14] The historical contextual data in the present article were taken from López Piñero, 201 et seq.

**Ramón Torres: a life in times of change**

Those were the hectic times in which Ramón Torres Muñoz de Luna lived (b. Madrid, November 8 1822; d. Malaga, November 10 1890). He earned doctorates in pharmacy, and physical and mathematical science, but devoted his life to teaching and research in chemistry.[15]

Few data are available relative to Torres' family background: his father was a renowned theatre actor known as "Garcia Luna", and his father's aunt a classical theatre actress known as "Rita Luna" (1770-1832). Ramón Torres added the surname "de Luna" to his original name to honour his great-aunt, a woman he loved and appreciated, as shown by a poem he dedicated to her.

On May 27 1846, Ramón Torres married Maria Iglesias y Caudete, and had a son, Ramón Torres Iglesias, who died young; this fact affected Torres deeply. He married at least once again, and had at least three daughters called Carmen, Maria, and Rita with Carolina Jauregui Zuzen, to wit, the woman who appears as his widow, and who claimed the widow and orphans' pension after his death.

In the course of his 68 years of life Torres suffered various illnesses, which compelled him to "take the waters" often at the thermal springs of Vichy, as it was the custom at the time. In the summer of 1863, he exhibited a "liver attack", and later on a "nervous affection of the stomach" was diagnosed. He died on November 10 1890.[16]

As it was mentioned above, the educational plans changed several times along the 19th century, resulting in the gradual modernisation of university studies in Spain, and that encompassed several degrees. As of 1857, chemical subjects were taught in the courses on pharmacy, medicine, engineering, philosophy, and science.[17] Torres had attended school at *Reales Estudios de San Isidro* in Madrid from 1835 to 1840, and then studied pharmacy also in Madrid, earning a BSc in 1844, and a PhD two years later, when he was only 23 years old.

Torres' academic career started when the "catastrophic period" (1809–1833) had already finished, and the country was in the "intermediate stage" (1834-1860) along which Spain slowly approached the level of science of the remainder of Europe. To achieve that goal, the government authorised degree courses on pharmacy and medicine to be taught in Madrid and Barcelona, which lasted five academic years. The course of pharmacy included teaching of inorganic chemistry and inorganic chemical-

[15] All the biographical data on Torres were collected from Archivo General de la Administración, Sección Educación (AGAE), box 16,846, and Archivo Histórico Nacional, Universidades (AHNU), 1163, Exp. 63; Luis Ballesteros, *Diccionario biográfico matritense* (Madrid: Imprenta Municipal, 1912), 626; Ramón Torres, *El álbum de mis hijos* (Madrid: Peñuelas, 1864); newspaper *ABC,* from August 30t 1919, 5; *La Vanguardia,* November 17 1923, 14; AGA, Hacienda, box 20,382. .

[16] AGAE, box 16,846.

[17] Royal Order of September 17 1845, *Gaceta de Madrid* of September 25 1845; Royal Order of July 08 1847, *Gaceta de Madrid* of July 12 1847; Royal Order of August 28 1850, *Gaceta de Madrid* of September 3 and 4 1850.

surgical pharmacy in the third year, and of organic chemistry and organic chemical-surgical pharmacy in the fourth.[18]

The reign of Isabella II (1833-1868) boosted the study of scientific subjects through several legal dispositions, and the modification of the structure of the faculty of philosophy, which until then had served as preparation for other degrees only. Organic and inorganic chemistry were taught for the first time in the faculty of philosophy in 1843 and 1847, respectively.[19]

While the organisation of studies in Spain was fostered by Isabella II's government, in his last year of studies (1843-1844), Torres began collaborating with University of Madrid as Assistant Professor of medical physics and chemistry. In 1844, he was hired as Associate Lecturer in the department of pharmacy of the school of medical science of Cadiz. As that position was suppressed soon after, Torres moved to the school of pharmacy of University of Madrid. In 1847 he moved to the faculty of philosophy, and in 1848 he took the exam to fill in the first chair of organic chemistry created in that faculty, at a time when this subject was not taught in any Spanish university. Although Torres passed the exam, the judges considered that no candidate exhibited enough qualifications for the position, and the chair was declared void. Torres was thus sent to Paris to study chemistry for two or three years, and become qualified to teach it at University of Madrid. As a result, he stayed in Paris and other foreign centres two years and a half (1849-1851). Along that period he attended courses taught by Antoine-Jérôme Balard (1802-1876), César-Mansuète Despretz (1791-1863), Dumas, Mateo José Buenaventura Orfila (1787-1853), Anselme Payen (1795-1871), Eugène-Melchior Péligot (1811-1890), Théophile-Jules Pelouze (1807-1867), Claude Servais Mathias Pouillet (1791-1868) and Wurtz, and in March 1851, he went to Giessen to learn from Liebig. Indeed, when Torres turned up at Liebig's office on May 25 1851, they had not met before, and the only reference Liebig had on Torres was "a little scientific piece of work carried out in Paris" he had written. Torres said they communicated "half in German, half in French", and that he had been offered warm hospitality.[20] He was 29 years old then, and the influence of the German teacher on him was enormous.

While Torres was travelling across Europe, the educational plan of 1850 upgraded the scientific sections of the Spanish universities by establishing a larger number of chairs. As the century advanced, the study of chemistry improved both in quality and depth of specialization. The educational plan also regulated the contents and textbooks used in the faculty of philosophy.[21]

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[18] Royal Order of September 17 1845, *Gaceta de Madrid,* September 25 1845.

[19] Royal Decree of July 8 1847, *Gaceta de Madrid,* July 12 1847.

[20] Justus Liebig, *Nuevas cartas sobre la química, consideradas en sus aplicaciones a la industria, a la fisiología y a la agricultura* (Madrid: Imprenta de Don Agustín Espinosa y Compañía, 1853), Prologue.

[21] Royal Order of September 10 1850, Education Plan of August 28 1850, *Gaceta de Madrid,* September 12-16 1850.

Upon returning to Spain in 1851, Torres took up a lectureship of chemical analysis at University of Madrid. In 1852, the various sections of the faculty of philosophy merged, giving rise to divisions "physical-mathematical and chemical sciences" and "natural sciences". Subjects such as general chemistry, inorganic chemistry extension, organic chemistry extension, and chemical analysis were taught at University of Madrid.[22]

Torres travelled abroad often to learn from the most important chemists of his time, as well as to participate in international exhibitions and scientific meetings. During his summer vacations, he used to make short travels, during which he met the most outstanding European chemists. Thus, he was an apprentice and assistant to Orfila, from Mahon, but based in Paris, who was an expert chemist, toxicologist, and medical jurist, in addition to the dean of the Paris school of medicine. He devoted another vacation to work with Louis René Le Canu (1800-1871) in Licerasse, whom he considered to be a friend. Together they performed chemical-experimental studies, and Torres translated one of Le Canu's textbooks on chemistry into Spanish.[23]

In 1869, Torres went to Germany for one year with the purpose of learn how to develop the industrial and agricultural wealth of Spain swiftly and effectively. In addition, he was a member of the Spanish commissions to the World Fairs held in Paris in 1855, 1867 and 1883, in which he acted as a judge. He was also a judge in the exhibition held in Vienna in 1873, and attended the International Exhibition of Philadelphia in 1875. Three years later he went abroad once again for one month, devoting one fortnight to the study of methods to fight phylloxera, and the other to visit the World Fair held in Paris seeking additional innovations against that pest. In 1881 he attended the International Congress of Directors of Agronomical Stations and Agricultural Laboratories held in Versailles, was appointed representative of the Ministry of Public Works, and was the Spanish representative at the International Congress on Phylloxera held in Bordeaux.

Ever since graduation in 1844, Torres held different positions at University of Madrid, and at the end of his life was Head Professor of organic chemistry and professor in the school of science.

In 1857 a new Public Instruction Act split the older faculty of philosophy in school of philosophy and arts, and school of exact, physical and natural sciences. For that reason, 1857 is remembered as the year when science schools were first created in Spain. The latter was then divided in three sections: school of physical and mathematical science, school of chemical science, and school of natural science.[24]

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[22] Royal Order of September 09 1857, *Gaceta de Madrid* of 5eptember 10, 1857.

[23] Louis René Le Canu, *Cours complet de pharmacie* (París: Baillière, 1842); *Curso completo de Farmacia por L.R. Le-Canu* (Madrid: Imprenta de Don José María Alonso, 1848-9). The life and work of Le Canu have been studied by Antonio García Belmar, & José R. Bertomeu-Sánchez "Louis Jacques Thenard's Chemistry Courses at the Collège de France, 1804-1835." *Ambix*, 57 (2010): 48-63.

[24] AGAE, box 16,846.

In regard to the governmental efforts to come close to the European scientific standards, the reform of the educational plans and updating of the university environment were performed gradually by means of measures such as the centralisation and control of the textbooks to prevent the use of obsolete and superseded works. The lecturers were compelled to follow the official syllabuses in all the university disciplines, and to use up to six books in their classes selected from a periodically revised list published by the government.[25]

Paradoxically, when those reforms started the most reactionary parties advocated the right of the professors to select freely the textbooks they preferred. The reason was that the professors were known to hold extremely conservative and traditional views. However, that initiative was not successful.[26]

At that time, Torres was professor of physical and mathematical sciences at the faculty of philosophy of Madrid. When the school of science was created, he was assigned to the section on physical science, where he taught inorganic chemistry to the BSc candidates throughout the academic year of 1859-60 using a textbook written by himself, and that had made the government's list. However, only two students enrolled in that course, whereas 263 students had enrolled in chemistry, which should be taken by all the students attending the science school. Also few students attended the courses on organic chemistry (five) and chemical analysis (three).[27]

As the lecturers whose books made the government's list earned a percentage of the sales, naturally all of them expected to teach courses with a large number of students, and Torres, indeed, applied to move from inorganic to general chemistry. He was successful, and started teaching general chemistry in 1861, when the number of students was 335, to increasingly grow to 388 in 1862-63, and 650 in 1866-67.[28] He was also appointed assistant to the Royal Cabinet of Physics at the Royal Palace, a position he held until 1875, following the First Republic and the Restoration.

Apparently, Torres was a good lecturer, who tried to teach as much and the best of an eminently practical discipline. His interest in the progress made by his students is illustrated, for instance, by the request he made in 1867 to the University Chancellor to allow his best students repeat the experiments he carried out as a demonstrator. For that purpose, the students would have to pay for the materials, and the experiments would take place after the regular class schedule under Torres'

[25] On textbooks in Spain during the first half of the 19th century, see José R. Bertomeu-Sánchez, & Antonio García-Belmar, "Spanish Chemical Textbooks (1788-1845): A Sketch of the Audience for Chemistry in Early Nineteenth-Century Spain," in *Communicating Chemistry: Textbooks and their Audiences, 1789-1939*, ed. Bernadette Bensaude-Vincent (Canton: History of Science Publications, 2000), 57-91. For a wider discussion on the European chemical textbooks, see José R. Bertomeu-Sánchez, et al., ed., "Textbooks in the Scientific Periphery," *Science & Education*, Special Issue, 15, no. 7/8 (2006).

[26] Royal Decree of September 23 1857, *Gaceta de Madrid* of September 24 1857.

[27] Anonymous, *Memoria acerca del estado de la enseñanza en la Universidad Central y en los establecimientos de su distrito, en el curso de 1859 a 1860. Anuario de 1860 a 61.* (Madrid: Jose M. Ducazcal, 1861).

[28] Anonymous, *Memoria acerca del estado de la enseñanza en la Universidad Central y en los establecimientos de su distrito, en el curso de 1866 a 1867. Anuario de 1867 a 68* (Madrid: José M. Ducazcal, 1868).

supervision. The Chancellor, however, refused permission on the grounds of the extra cost associated with the use of equipment. [29]

The fact that the number of students enrolled in Torres' classes increased continuously did not threaten the quality of teaching, as the following review shows:

> "His course has the largest number of students, with an average of 700 per academic year. In addition, his classes are known for being a model of order and discipline, even when they have not been subdivided, as many others with fewer students were. This lecturer has a total number of alumni of more than 10,000."[30]

The academic structure described here survived the various political swings of the second half of the 19th century because all the governments ensured its continuity. [31]

Textbooks are valuable tools in education, and also indicate the pedagogic system prevalent at the time when they were written, thus they are reliable witnesses of the changes in educational programs.[32] In the particular case of research, the publication of a textbook is the last step for a theory to be consolidated and accepted by other experts. Textbooks influence the educational and scientific practice, even though their content might not be entirely accepted. Consequently, the research experience of Ramón Torres is evident in his publications, including articles in national and international journals and books.

Torres' 1842 translation of Le Canu's book was designated as official textbook in the school of pharmacy from academic year 1850-1851 to 1867-1868, which was the last time when the list of official textbooks was published.[33] His *Lecciones elementales de química general* (Elementary lessons of general chemistry) was listed as official textbook of general chemistry, which he taught at the school of exact physical and natural sciences from academic year 1860-1861 also to 1867-1868.[34] The large number of students enrolled in Torres' courses ensured the diffusion of the content of those books.

Torres's professional career continued soaring until 1882, when he was appointed professor at the new school of science of University of Madrid.

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[29] AGAE, box 16,846.

[30] AGAE, box 16,846.

[31] Royal Decree of September 11 1858, *Gaceta de Madrid,* September 14 1858.

[32] J. N. Cornejo, "El análisis de manuales escolares y la historia de la enseñanza de la ciencia como recurso en la formación docente," *La Revista Iberoamericana de Educación* 38, no. 6 (2006) <http://www.rieoei.org/experiencias122.htm> accessed November 29 2010.

[33] The last list of official textbooks (academic year 1867-1868) was published by *Gaceta de Madrid* on September 24 1867.

[34] *Gaceta de Madrid,* September 28 1850; October 27 1861; September 3 1864; and September 24 1867; see also Inés Pellón, *La recepción de la teoría atómica química* (Bilbao: Universidad del País Basco, 1998), 344-63.

**Torres' research experience**

Torres was not only a committed professor, but also a renowned researcher. He was a member of several Spanish and European scientific associations, among which the Society of Chemistry of Paris, the Academy of Science of Nantes, the Academy of Medicine of Madrid, and all the Spanish societies and professional associations of pharmacy. In addition, he was unanimously selected to be a correspondent member of the Royal Society of Pharmacy of Paris, and of the Royal Academy of Science of Munich, following the nomination made by Liebig.

Torres designed a number of useful inventions, and published articles in international journals. He was a prolific author, whose extensive production (60 pieces are known at least) has not yet been studied in depth.

Torres' works on applied chemistry dealt with a wide range of topics, including chemical analysis,[35] nitrification,[36] and the uses and recovery of phosphates.[37] However, his main interest was the application of chemistry to agriculture,[38] very likely due to Liebig's influence.

In 1860 he conducted several studies on the extraction of urea from urine based on the new method formulated by Liebig.[39] In addition, he studied ozone and its production from oxygen based on the reaction of sulphuric acid with potassium hydroxide in the presence of oxygen (Figure 1).

[35] Ramón Torres, *Guía del químico práctico o compendio de análisis químico* (Madrid: Aguado, 1852).

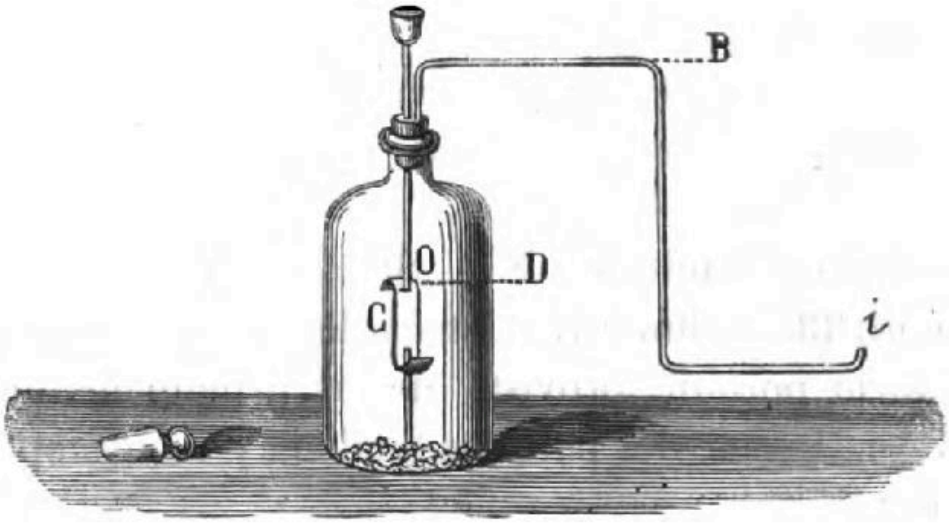
[36] Ramón Torres, "Demostrar con experimentos el fenómeno de la nitrificación en general y causas más influyentes en la misma, exponiendo al propio tiempo los medios más ventajosos de favorecer la nitrificación natural de nuestro país," in *Memorias de la Real Academia de Ciencias Exactas, Físicas y Naturales* (Madrid: RACEFyN, 1862), I, 2nd series, part 3. This work was awarded a RACEFyN gold medal in 1862.

[37] Ramón Torres, "Influencia de los fosfatos térreos en la vegetación para utilizarlos en la producción de cereales en la Península"; "Es preciso devolver a los campos el fosfato de cal que bajo la forma de huesos humanos queda depositado en los sepulcros," in *Memorias de la RACEFyN* (Madrid: Eusebio Aguado, 1864). This report was awarded a RACEFyN commendation in academic year 1862–63.

[38] Ramón Torres, *La química en sus principales aplicaciones a la agricultura* (Madrid: Félix de Bona, 1856).

[39] Ramón Torres, *Urinometría: Nuevo método normal para analizar la orina, descubierto por el célebre químico Justo Liebig* (Madrid: M. Rivadeneyra, 1853).

**Figure 1.** Ozone production according to Torres.[40]




As mentioned at the beginning of this article, Torres' work on the chemical analysis of the quality of atmospheric air in Madrid was worth high praise from Angus Smith, the president of the *Literary and Philosophical Society of Manchester*.[41] That study was also read by Dumas at the Academy of Sciences of Paris in 1860,[42] several parts of Torres' book were published in various journals, and the whole work was eventually translated into French.[43]

Concerned with the use of chemical products in medicine, he devised a technique based on the use of "hyponitric gas" to disinfect hospitals and houses during epidemics, which was very much appreciated at that time.[44] He also created a "chemical bag" that served to diagnose a number of diseases, and that was presented by Wurtz and Le Canu at the Imperial Academy of Medicine of Paris in 1863.

Torres also designed a spirometer (Figure 2) to measure the lung capacity of patients. This device enjoyed great popularity in Spain, because Torres pretended it had been patented in England, thus increasing its value. Apparently, Torres did not

[40] Mentioned in Ramón Torres, *Memoria relativa a la Exposición Universal de Londres* (1863), 26-8.

[41] Ramón Torres, *Estudios químicos sobre el aire atmosférico de Madrid* (Madrid: Manuel Álvarez, 1860); Angus Smith, "On the composition of the atmosphere," *Memoirs of the Literary and Philosophical Society of Manchester,* (London: H. Baillière, 1868), 3rd series, vol. III, 1-55.

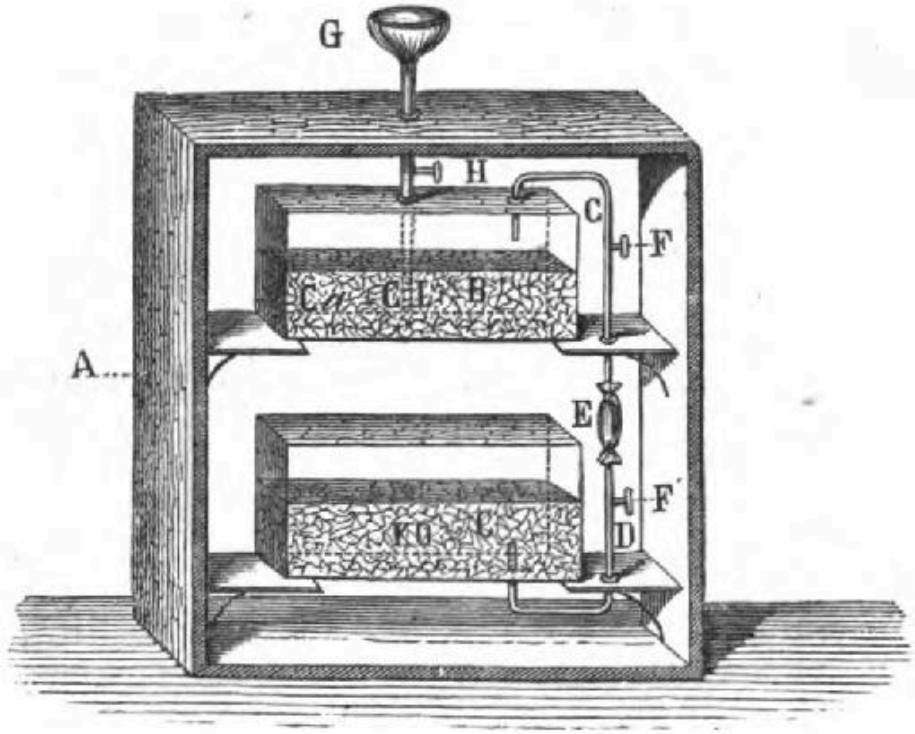
[42] J. B. A. Dumas, "Études chimiques et physiques sur l'air atmosphérique de Madrid" *Comptes rendus hebdomadaires des séances de l'Académie des Sciences* (París: Mallet-Bachelier, 1860), on 327.

[43] M.H. Gaultier de Claubry, *Etudes chimiques sur l'air atmosphérique de Madrid, par Ramón Torres Muñoz de Luna* (París: J. B. Baillière et fils, 1861).

[44] James R. Partington, *A History of Chemistry* (London: Macmillan & Co., 1964-1970), vol. IV, 81. This was the name given at the time to "nitrous acid". Nowadays it is called nitrogen(IV) oxide, $NO_2$.

trust the Spanish scientific community would accept inventions devised by a Spanish chemist.[45]

**Figure 2.** Spirometer designed by Torres[46]




Torres published a number of original articles in foreign journals dealing with chemical analysis, production of volatile alkaloids,[47] manufacturing of artificial soda,[48] the salt deposits at the lakes in the province of Toledo,[49] an innovative method to manufacture hydrochloric acid, which was awarded a commendation at the World Fair held in Paris in 1855, and the use of magnesium sulphate as a substitute of sulphuric acid in the preparation of various compounds.[50]

[45] J. Vernet, *Historia de la ciencia española* (Madrid: Instituto de España, Cátedra Alfonso X el Sabio, 1976).

[46] Ramón Torres, *Memoria relativa a la Exposición Universal de Londres* (1863), 26-8.

[47] Ramón Torres, "Obtention des alcaloides volátiles," *Comptes rendus de l'Academie des Sciences de Paris* (1859): 802.

[48] Ramón Torres, "Fabrication de la soude artificielle", *Journal de Pharmacie* 730: 119.

[49] Ramón Torres, "Des dépôts salins des lacs de la province de Tolède (Espagne)," *Journal de Pharmacie* 26 (1854): 125–127.

[50] Ramón de Luna, "De la substitution du sulfate de magnésie naturel à l'acide sulfurique dans la fabrication de l'acide chlorhydrique, du sulfate du soude, de l'acide azotique et du chlore," *Annales de Chimie* 45 (1855): 341-3; Ramón de Luna, "Emploi du sulfate de magnésie comme succédané de l'acide sulfurique dans la préparation de certains corps," *Journal de Pharmacie et de Chimie*, 29 (1856): 285-6; Ramón de Luna "De la substitution du sulfate de magnésie naturel à l'acide sulfurique dans la fabrication de l'acide chlorhydrique, du sulfate du soude, de l'acide azotique et du chlore," *Journal de Pharmacie* 29 (1856): 49–50 and 30 (1856): 115-

Torres translated the 3rd edition of *Essai de statique chimique des êtres organisés*,[51] by Dumas and Jean-Baptiste Joseph Dieudonné Boussingault (1802-1887) and other writings by Liebig and Le Canu. [52]

In the agricultural exhibition of 1858, Torres was awarded a prize for his method to extract sugar and oil from tiger-nut (*Cyperus sculentus* L.)[53] In addition, Torres was awarded a number of prizes by the *Real Academia de Ciencias Exactas, Físicas y Naturales de Madrid* (RACEFNM), including the Academy's gold medal. Moreover, the Academy published his work[54] in the first volume of its *Memorias* for that year.[55]

**The Karlsruhe Congress and the atomic theory in Torres' work**

A large number of books on chemistry were published in Spanish in the 19th century, especially from 1850 onwards. As those texts were the main vehicle of propagation of the new ideas, they reflect the reception of scientific theories, and how they evolved until becoming paradigms.[56]

Many studies have been conducted about the situation of chemistry in Spain in the 19th century, but none addressed the stance took by the Spanish chemists relative to the atomic theory, nor analysed its development comparatively to the theory of equivalents.[57]

The first written record of the atomic theory in Spain was made by Orfila, who mentioned it in the 2nd edition of *Elementos de Química* (1822).[58] Later on, pharmacist Joaquín Olmedilla y Garrido (1799-1875) read the first part of "Memoria sobre los

6; Ramón de Luna, "Ùber die Anwendung der natürlich vorkommenden schwefelsauren Magnesia and der Stelle der Schwefelsäure bei der Fabrikation der Salzsäure, des schwefelsauren Natrons, der Salpetersäure und des Chlors," *Annalen der Chemie und Pharmacie*, 96 (1855): 104-6 and 47 (1856): 176-8.

[51] Jean B. A. Dumas, & Jean-B. J. D. Boussingault, *Essai de statique chimique des êtres organisés* (Paris: Fortin, Masson et cie, 1844); *Ensayo de estática química de los seres organizados*. 3rd edition (Madrid: Corrales y Compañía, 1846).

[52] Ramón Torres, *Noticia de los trabajos científicos de Mr. Lecanu, precedida de un juicio crítico sobre su discurso titulado "Recuerdos de Mr. Thenard"* (Madrid: Manuel Álvarez, 1858).

[53] José M. López Piñero, *Diccionario Histórico*, vol. II, does not indicate where or when this exhibition took place, or what the title of Torres' work was. It may have been the *Exposición Agrícola, Industrial y Artística* held in Seville in 1858.

[54] R. Torres Muñoz de Luna, "Demostrar con experimentos el fenómeno de la nitrificación en general y causas más influyentes en la misma, exponiendo al propio tiempo los medios más ventajosos de favorecer la nitrificación natural de nuestro país," *Memorias de la Real Academia de Ciencias Exactas, Físicas y Naturales*, I, 3rd part of the 2nd series, vol. 6, 1863): 349-412. Gold medal of RACEFNM in 1862.

[55] Mariano Lorente, *Resumen de las actas de la Real Academia de Ciencias Exactas, Físicas y Naturales de Madrid en el año académico de 1859 a 1860* (Madrid: Eusebio Aguado, 1862).

[56] Helge Kragh, *Introducción a la historia de la ciencia* (Barcelona: Editorial Crítica, 1989); Ana M. Alfonso-Goldfarb, *Da Alquimia à Química: Um Estudo sobre a Passagem do PensamentoMágico-vitalista ao Mecanicismo* (São Paulo: Landy, 2001).

[57] The latter was approached by Inés Pellón, *Recepción de la teoría atómica*, which also summarises a large part of the literature on the subject published until 1998.

[58] Mateo Orfila, *Elementos de Química Aplicada a la Medicina, Farmacia y Artes* 2nd ed. (Madrid: Cosme Martínez, 1822): 11-5.

átomos" (Memoir on the atoms) at the Academy of Natural Science of Madrid on February 18 1839, and the second part on March 18.[59]

The success of Berzelius' system of atomic weights followed the same path in Spain as in the rest of Europe, however, with a delay of several years. Most of the books on chemistry written in Spanish reflect this fact.[60] However, the 1860s were disastrous for the diffusion of the atomic theory in Spain, as Leopold Gmelin's (1748-1804) *Handbook*, which popularised the use of equivalents, and discredited Berzelius' atomic weights was at the peak of its success. Nevertheless, something changed in the Spanish scientific scene in the 1870s, because the number of works that rated the atomic theory more relevant than the one of equivalents increased, and this trend continued to grow in the last third of the century.[61]

As mentioned earlier, Torres had made many contacts in his trips abroad to attend courses and learn the theories formulated by some of the most relevant European scientists of his time. Within that context, he was quite interested in attending the first gathering of European chemists, to wit, the Karlsruhe Congress, to contact other men of science, and clarify the fuzzy theories that were the major topics of interest among the European chemists.

Attendance to that Congress left a definite hallmark on the books Torres wrote thereafter, which might be identified in the many mentions he made of the Congress in his texts, especially in the textbooks he used for teaching at the University, which as it was mentioned before, were mandatory for all students of chemistry.

An overall analysis of all the known writings by Torres' has been performed in this article aiming at understanding how he dealt with the atomic theory. Those writings include several mentions to the Karlsruhe Congress. Torres is mentioned in the Congress minutes as one of the attendants to the opening session (September 3 1860),[62] but his name was spelt "R. de Suna" and "Ramón de Luna" instead of "Ramón Torres Muñoz de Luna". For that reason it was difficult to establish it was the same person. Although he was the only Spanish chemist to attend the Congress, this fact has not been known until now. The first person to mention Ramón Torres' attendance to the Congress was himself. After reading his books, Juan Vernet mentioned that fact,[63] although this explicit mention did not leak out to the scientific community.

There are two possible and complementary explanations for the earlier confusion and belated identification.

First, Spanish women keep their maiden surnames eve after marriage, and people use the surnames of both parents (first the father's followed by the mother's) all

[59] These lectures are announced in *Actas de la Academia de Ciencias Naturales* 2 (1839): 9, no further publication could be located.
[60] Pellón, 197-328.
[61] Ibid.
[62] Mary J. Nye, *The Question of the Atom: From the Karlsruhe Congress to the First Solvay Conference, 1860-1911: A Compilation of Primary Sources selected and introduced by Nye* (San Francisco: Tomash Publishers, 1986), 8; 634.
[63] Vernet, *Historia de la ciencia española*.

throughout their lives. When the first surname is rather common, it is customary to call oneself by the second surname, provided it is less common, and sometimes this custom is transmitted from parents to children along several generations. Therefore, the real and correct name of Torres was "Ramón Torres Muñoz", and thus it appears in all Spanish documents, although he preserved his father's second surname "de Luna" or "y Luna" to facilitate his identification (Muñoz is a common surname in Spain) and honour his great-aunt, Rita Luna. To summarise, a custom quite common and well known to Spaniards, but less known abroad explains why Torres kept the surname "Luna", and used it as main surname for the purpose of identification to the point of signing R. Luna plainly.

Alternatively, upon arriving to the Congress, he might have written or dictated his full name (Ramón Torres Muñoz de Luna) to the employee charged of registration, who, unaware of the Spanish custom, entered "R. de Luna" in the Congress minutes.

Why *Suna* instead of *Luna*? The explanation is quite obvious, when we remember how capital letter L was handwritten in the 19th century, and the flourishes used to embellish writing. This is to say, letter L could have very easily been mistaken for an S, as Figure 3 shows.

**Figure 3:** Spanish calligraphy of the 19th century[64]

[64] Letraherido, "Elementos de la caligrafía" <http://www.letraherido.com/160202elementoscaligrafia.htm> accessed June 14 2013.

**The influence of the Karlsruhe Congress on Torres' work**

Torres took part in the second session of the Congress, which was presided by Boussingault, and also included Kekulé, Jacob Natansen (?), Adolph Strecker (1822-1871), J. Nicklès (?), and Antoine Béchamp (1816-1908), among others. Unfortunately, there is no record of the contribution of the Spanish chemist to the debate. For that reason, one needs to look into the introductions and footnotes of Torres' writings and translations to learn about his own ideas about a number of chemical topics.

The most representative example from the period before 1860 is the translation of Le Canu's *Cours complet de pharmacie.* Torres did not follow the order of the original book, but started with chemical pharmacy instead of Galenic pharmacy, and added five extra units on general chemistry in the introduction, which he worked out "taking the works of the most popular scientific authors into account"[65]. Those five units were not present in Le Canu's original text. According to Torres, that textbook was intended for the students at the school of pharmacy attending the third, fourth and fifth academic years, as it complied with the corresponding official syllabuses. Torres also added his own "Introduction", in which he explained the atomic theory and the theory of equivalents, and compared them, before declaring his support to the latter.

It is worth to observe that Torres explained Ampère's hypothesis on the structure of particles in that book. Although it is usually believed that most contemporary chemists only started mentioning that hypothesis following the Karlsruhe Congress, analysis of writings by Dumas, Alexandre Edouard Baudrimont (1806-1880), Marc Antoine Gaudin (1804-1880), William Prout (1785-1850) and Laurent shows that Ampère's theory was known, accepted, and discussed as early as 1850.[66]

*Lecciones* (1861) was one of the first publications of Torres following the Karlsruhe Congress, which is mentioned in two footnotes. In this book Torres does not only describe the atomic theory, but also the theory of equivalent,s and the latter provides the context for the first mention of the Karlsruhe Congress:

> "During the congress on chemistry held last September in Karlsruhe, most professors agreed to the proposal made by the permanent commission for the ratio of the weights of simple or compound bodies, which are reciprocally exchangeable in different ways in chemical reactions, to be considered equivalent."[67]

The section devoted to the atomic theory starts exactly the same as the translation of Le Canu's *Curso completo de Farmacia,* and provides the occasion for the second mention of the Karlsruhe Congress. Following the definition of "atom", Torres comments that "In

[65] Torres, *Curso completo de Farmacia,* prologue.
[66] Alan J. Rocke, *Chemical Atomism in the Nineteenth Century: From Dalton to Cannizzaro* (Columbus: Ohio State University Press, 1984), 106; and *Quiet Revolution*.
[67] Torres, *Lecciones* (1861), 86.

the Congress of Karlsruhe, the attendants agreed to consider the atoms as chemical and indivisible entities of simple or compound bodies"[68] .

Upon comparing the contending theories, Torres declared himself "an expert, even an enthusiast" of the atomic theory, which he qualified as a "philosophical merit". Nevertheless, he explained that in the book he had resource to the equivalents, because "they are the pure and simple expression of facts"[69]. Those words reflect Torres' attitude towards both theories: he explained that although he was fully acquainted with the atomic theory, and supported it as an entelechy, as an eminently pragmatic chemist he used the theory of equivalents in actual practice.

The 2nd edition of *Lecciones* (1864) is identical to the first one. One year later, he published a shorter work entitled *Prontuario de Química General* (Compendium of general chemistry),[70] in which he described the "rudiments of chemical science", and linked them to practical applications. In this book he explained the theory of equivalents and the atomic theory as questions and answers. In the 3rd edition of *Lecciones* (1872), he mentioned Jules Henri Debray (1827-1888), Alfred Joseph Naquet (1834-1916), G. Brèlaz (?) and "above all, our dear friend and lecturer A. Wurtz's chemical philosophy" as sources, as well as the Karlsruhe Congress with a sentence that shows he attended it until the end:

> "As Dumas appropriately told us upon closing the scientific debates at the memorable Chemical Congress of Karlsruhe: 'A new Lavoisier hasn't yet been born, [i.e.] a man capable of linking both chemistries, the glorious traditional one of dualism, and the unitary modern one born from it'". [71]

In the 3rd edition of *Lecciones*, Torres described the theory of chemical equivalents, as well as different methods used to determine them. In addition, the progression of the atomic theory over time is more clearly exposed here than in his previous works. He quotes Gerhardt's ideas on the atomic theory and the right values of atomic weights, and recommends the *Introduction to Modern Chemistry* by G. Brélaz as a textbook, in the version translated by the professor of general chemistry at University of Barcelona, José R. Fernández de Luanco, a committed atomist. He also recommended the *Lessons of Chemical Philosophy* by Wurtz, and the *Treatise on Chemistry*, by Naquet. In short, all the recommended books had been written by overt atomists. In addition, further evidence on the greater significance he attached to atomic theory compared to the equivalents is provided by the larger number of pages devoted to the former.[72]

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[68] Torres, *Lecciones* (1861), 101.
[69] Ibid.
[70] Ramón Torres, *Prontuario de Química General para complemento de la instrucción preparatoria en los Institutos de 2ª enseñanza, Seminarios y Colegios* (Madrid: Librería de Sánchez, 1865).
[71] Torres, *Lecciones* (1872), 39-40.
[72] Torres, Ibid, equivalents on 542-4, 550-7; atomic theory on 573-89.

Both the 4th and the 5th editions of *Lecciones* are entirely different from the three previous ones, as Torres explains in the prologue, and Table 1 shows.

| CONCEPTS | BOOKS | | | | | |
|---|---|---|---|---|---|---|
| | *Curso* (1848) | *Prontuario* (1865) | *Lecciones* (1861; 1864) | *Lecciones* (1872) | *Elementos* (1877) | *Tratado* (1885) |
| Higgins | Yes | No | Yes | No | No | No |
| Dalton: LMP<br>AT | Yes<br>Yes | Yes<br>Yes | Yes<br>Yes | Yes<br>Yes | Yes<br>Yes | Yes<br>Yes |
| Prout | Yes (Eq.) | Yes (Eq.) | Yes (Eq.) | Yes (Eq.) | Yes (Eq.) | Yes (Eq.) |
| Gay-Lussac | Yes | Yes (Eq.) | Yes (Eq. and AT) | Yes (Eq. and AT) | Yes (AT) | Yes (AT) |
| Avogadro<br>Ampère | Yes<br>Yes | No<br>No | No<br>No | No<br>Yes | Yes<br>Yes | Yes<br>Yes |
| Karlsruhe | No | No | Yes | Yes | No | No |
| Dulong and Petit | Yes (AT) | Yes (Eq.) | Yes (Eq. and AT) | Yes (Eq. and AT) | Yes (AT) | Yes (AT) |
| Mitscherlich | Yes (AT) | Yes (Eq.) | Yes (Eq. and AT) | Yes (Eq. and AT) | No | Yes (Eq. and AT) |
| Gerhardt | No | No | No | Yes | Yes | Yes |
| Table of atomic weights | Yes (p. 86-7) | No | No | No | Yes (p. 97) | Yes (p. 37) |
| Reference to atomic weight | Oxygen 100 | None | None | No | Hydrogen = 1 | Hydrogen = 1 |
| Supporter of | Equivalents | Not specified | Equivalents | Not specified | Equivalents | Not specified |

**Table 1:** Progression of some ideas in different texts by Torres.
Eq.: equivalents; AT: atomic theory; LMP: law of multiple proportions

Table 1 shows that Torres mentioned the atomic theory in all his books, as well as Prout's hypothesis on the calculation of equivalents. He also made reference to William Higgins' (1763-1825) ideas in his books published in 1848, 1861 and 1864, and Joseph-Louis Gay-Lussac's (1778-1860) law appears in all of them. Avogadro-Ampère's law is mentioned in the books published in 1848, 1872, 1877 and 1885, and the Karlsruhe Congress in the ones from 1861, 1864 and 1872. The law of Pierre Louis Dulong (1785-1838) and Alexis Thérèse Petit (1791-1820) appears in all the books, but in the ones from 1848, 1877 and 1885 only for the calculation of atomic weights, while in the remainder it is applied to the deduction of equivalents (1865), or to the calculation of both atomic weights and equivalents (1861, 1864, 1872). In the book published in 1848, the law proposed by Eilhard Mitscherlich (1794-1863) is applied to the calculation of atomic weights only, in the one from 1865 to calculate equivalents only, in 1877 it is not mentioned, and in the remainder of editions (1861, 1864, 1872, and 1885) it is used to calculate both. Gerhardt's hypothesis is mentioned in the last three books (1872, 1877, and 1885), while the editions of 1848, 1877, and 1885 include tables of atomic weights.

Apparently, Torres developed a preference for the atomic theory, which is especially evident in the edition of *Lecciones* from 1872. However, as Table 1 shows, he supported the theory of equivalents both before and after that date.

The reason for this paradox seems to be that although atomism provided an excellent explanation for the structure of matter, and as a chemist, Torres appreciated its theoretical value, he considered the theory of equivalents to be much more helpful and functional for practical purposes, and therefore recommended its use.

## Conclusions

In the present study, we showed that chemical research was still in its childhood in 19$^{th}$ century Spain. The first book in Spanish to explain the atomic theory was published by Orfila in 1822, however, the number of works discussing it exhibited continuous increase from that moment onwards. Torres made a major contribution to the diffusion of the state of the art among the Spanish chemists not only by means of his translations, but also by writing on what he had learnt abroad. For instance, in his translation of Le Canu's *Cours complet de Pharmacie* (1848-9), Torres described Ampère's hypothesis. That is to say, Torres entered the modernity range as a function of his knowledge and acceptance of the ideas of many of the most relevant chemists of his time. As a consequence, he belonged with a group of university lecturers, who wrote high-quality textbooks, and thus raised the average educational level, in addition to contributing to the institutionalization of chemistry in Spain.

Ramón Torres was the only Spanish representative at the Karlsruhe Congress. In his writings, he described the two conflicting theories formulated at that time to account

for the structure of matter, and of chemical combinations. Torres mentioned both in all his works, but the proportion of attention he devoted to the atomic theory increased gradually, due to the influence of atomists Wurtz and Fernández de Luanco.

The many acknowledgements and prizes he was awarded along his life evidence the relevance and value that authorities attached to Torres' research and writings not only in Spain, but also internationally. Torres was not only devoted to travelling, learning and writing, but also to teaching his students the latest innovations in science, particularly in chemistry.

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