

FROM CHEMICAL THEORY TO INDUSTRIAL CHEMISTRY: THE ECLECTIC CAREER OF GEOFFREY MARTIN

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Geoffrey Martin (Figure 1) was born on 29 January 1881 in Dover, England, one of several children of William and Grace (née Etheridge) Martin (1). At some point the family moved to Wales, where the father, a retired artillery officer who had served in India, began to develop mental problems that necessitated his confinement to the Joint Counties Lunatic Asylum in Carmarthen. The rest of the family then moved to nearby Haverfordwest, where Geoffrey received his secondary education at the local grammar school, followed in 1897 by his enrollment, at age 16, as a student at the Merchant Venturers' Technical College in Bristol.

By 1901 Martin had completed his undergraduate work at Bristol, which entitled him to a B.Sc. in chemistry with first class honors from the University of London, since at this time Merchant Venturers was not empowered to grant independent degrees of its own. This was followed by a four-year sojourn in Germany, where he spent the summer of 1902 at the University of Berlin attending the lectures of Warburg, Stark, Fock and Jahn. In the winter of 1902-1903 Martin transferred to the University of Kiel, where he attended the lectures of Martius, Stäckel, Pochhammer and Lenard, and where he met and married a German girl by the name of Anna Wentritt, by whom he would have two sons (2). Fol-

lowing a brief interlude at Leipzig, he finally landed at Rostock, where he remained until 1906, having received his Ph.D. in chemistry there in December of 1905 (3).



Figure 1. Geoffrey Martin (1881-1966).

By 1907 Martin was back in England working as a Lecturer and Demonstrator at University College, Nottingham, and conducting research with Frederic Stanley Kipping on organosilicon chemistry. In 1910, after receiving a M.Sc. degree at Bristol, he moved to London, where he served as a Lecturer in Chemistry at Birkbeck College while simultaneously working on a D.Sc. degree at the University of London. This, his second doctoral degree, was granted in 1915, as well as yet a third, presumably external, doctorate from the University of Bristol the same year based on his published papers (4).

From this point on, Martin, at age 34, ceased to be associated with academia and instead embarked upon a bewilderingly diverse career as an industrial chemist—at least if we are to believe the numerous affiliations listed in his various books and papers and in his various entries in Poggendorff (5). Between 1915 and 1917, his list of industrial positions included Research Chemist with United Kingdom Chemical Products Co.; Managing Director of Abbey Chemical and Medical Supply Co. Ltd.; Research Chemist with Stockton-on-Trees Chemical Co., and Research Chemist with the Chemical Supply Co. in Barking. It is unclear whether all of these positions were held simultaneously or in rapid succession.



Figure 2. The original home the C.W.S. in Manchester as it looks today.

In 1917 Martin became Director of Research for The Co-operative Wholesale Society or C.W.S. Ltd., of Manchester (Figure 2) (6, 7). This was one of several such societies born of the wholesale cooperative movement of the mid-19th century whose purpose was to obtain wholesale prices for food and other commodities for their members either by buying in bulk or establishing and

running their own factories and farms (8). Martin was the first director of the C.W.S.'s newly established research and quality control laboratory that would eventually employ twenty-three university trained chemists and chemical engineers, and whose function was to ensure the quality of the co-operative's products and the purity of the raw materials used in their manufacture, as well as to develop new and improved methods of production. In a 1921 article describing the laboratory's operations, Martin reported that it was analyzing roughly 3000 samples per year and had issued an average of three patents per month on newly developed or improved techniques (9).

However, by late 1921 Martin was on the move once more and was now listing his employment as Director of Research for the British Portland Cement Association, followed in 1925 by Director of Research for Martin and Taylor Ltd. and Asheham Cement and Lime Co., as well as Technical Director for Hinde and Hardy Ltd, Silk, Dyers, Weavers, etc. in Norwich. Again it is not known whether these positions were held simultaneously or in rapid succession. However, the listing for Martin and Taylor Ltd. suggests that by the mid 1920s Martin may have gained some degree of stability by becoming part owner of his own business.

There is no entry for Martin in Poggendorff after 1938 and no listing of publications after 1931. This may simply be the result of a large lag time between submission of biographical data (1931) and actual publication (1938), coupled with the disruptions caused by the Second World War. The next volume of Poggendorff that would have contained Martin's name was not published until 1958 and by then Martin had almost certainly retired (he would have been 70 in 1951), though he did not die until 1966 at age 85 in his home borough of Brent in north London, having been predeceased by his wife the previous year.

Given the above barebones biography, why is Martin deserving of more historical attention than the average industrial chemist? The answer is that he was not only a prolific writer of papers and articles (Poggendorff lists at least 99 by 1931), he was also a prolific writer of books, of which he would author, coauthor, or edit at least 21. In addition, he also held well over 20 patents. As such, he is part of an almost uniquely 20th-century British tradition of prolific writers of chemical textbooks, monographs and reference works that includes such names as Joseph William Mellor (1869-1938), James Riddick Partington (1886-1965), Samuel Glasstone (1897-1986) and, more recently, Peter Atkins. And it is to his various books and more interesting papers that we must now turn.

Chemical Affinity and the Periodic Table

Soon after his arrival in Germany in the summer of 1902, Martin must have begun an extensive reading program in the chemical literature, as he was soon generating a steady stream of publications dealing with such diverse topics as the theory of solubility and osmotic pressure, the periodic table, the nature of valence, and the measurement of chemical affinity and its relation to other chemical and physical properties. Most of these appeared as short notes in the *Chemical News*, though a few longer contributions were also sent to the *Journal of Physical Chemistry*. Curiously the list (see previous section) of German professors given at the end of his first doctoral thesis, whose lectures he had attended during his years in Germany, did not include a single chemist, but rather only the names of various mathematicians and a few physicists, so the program for theoretical chemistry which he now began to formulate must have been largely the product of self tuition and his extensive reading.

Two of these papers were of particular importance to Martin's final program. The first of these, entitled "On a Method of Representing the Properties of Elements Graphically by Means of Characteristic Surfaces," appeared in the 7 October 1904 issue of the *Chemical News* (10). Here Martin proposed that, instead of plotting the properties of the elements as a function of their atomic weights so as to produce a two-dimensional periodic curve like the famous plot of atomic [i.e. molar] volume versus atomic weight first given by Lothar Meyer in 1870 (11), one should instead employ the short form of the periodic table as a grid lying in the xy plane and plot the corresponding property for each element along the z axis directly above its position in the periodic table. The result would then be a characteristic three-dimensional surface, rather than a two-dimensional curve, for the property in question.

Moreover, Martin proposed that these plots be used, not for just any chemical or physical property of the elements, but rather to display the chemical affinity of a given element towards all of other elements in the periodic table as measured by the heat of formation per equivalent of its compounds with each of these elements (12). In other words, there would be a separate plot, and hence a separate characteristic affinity surface for, say Li versus F, each simultaneously displaying its respective chemical affinities for all other elements in the periodic table. Martin believed that the affinity relations of an element, as displayed in such a plot, would ultimately be found to also determine all of its other properties as well,

such as the solubilities and volatility of its compounds, their thermal stability, etc.

The basic premise of Martin's program was that chemically similar elements should have similarly shaped affinity surfaces (Figure 3) and that, consequently, such surfaces could be used to measure the degree of chemical relatedness of various elements within the periodic table. He was also aware that, since most elements displayed a range of possible valence values (or oxidation states in modern parlance) and affinity varied with valence, complete characterization of an element would ultimately require the construction of a separate affinity surface for each possible valence state. He also recognized that the affinity surface of an element would be both temperature and pressure dependent, and speculated that, by manipulating these parameters, it should be possible to equalize the properties of any two elements that were initially found to be dissimilar under ambient conditions, thus creating a chemical version of "corresponding states."

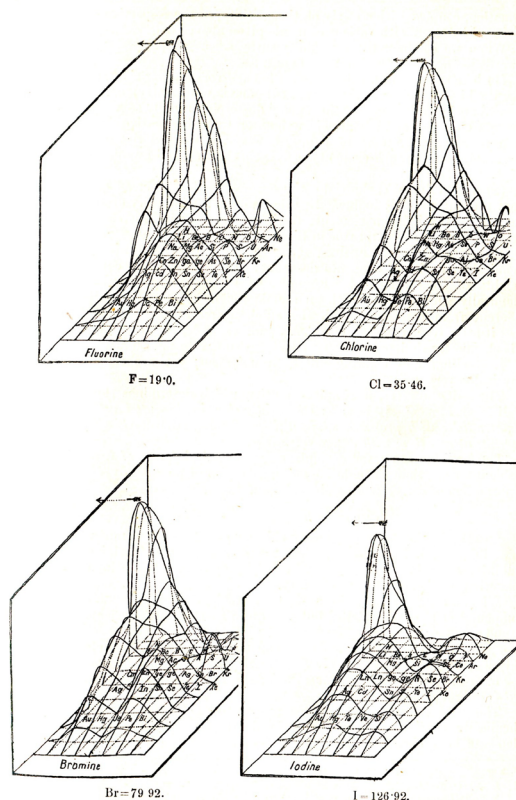


Figure 3. Martin's characteristic affinity surfaces for the halogens F, Cl, Br, and I showing their similarity as members of the same group of the periodic table (13, p 17).

The second paper, published in 1905 in the *Journal of Physical Chemistry*, was entitled "On the Condition

which Determines the Chemical Similarity of Elements and Radicals” and proposed a more quantitative way of ascertaining how similar two elements were that went beyond a mere qualitative visual comparison of the shapes of their corresponding affinity surfaces (14). This involved calculating the ratio ($K_i = f_i/f'_i$) of their corresponding affinities values (f_i and f'_i) towards a given third element i . If the two elements being compared really had identically shaped affinity surfaces, this ratio should be constant for the corresponding compounds of the two elements as one varied i . Thus, for example, if we wish to calculate how similar Cl and Br are, we would calculate the affinity ratios (K_i) for the formation of the chlorides and bromides of such metals as Ag, Li, Na, Hg, Sb, etc. If this ratio was approximately the same for all of the various metals, then the overall affinity surfaces of Cl and Br must also be approximately the same and the two elements rated as being chemically similar in their properties, whereas if the ratios varied widely in value then one must infer that the corresponding affinity surfaces have different shapes and that the two elements in question are chemically dissimilar.

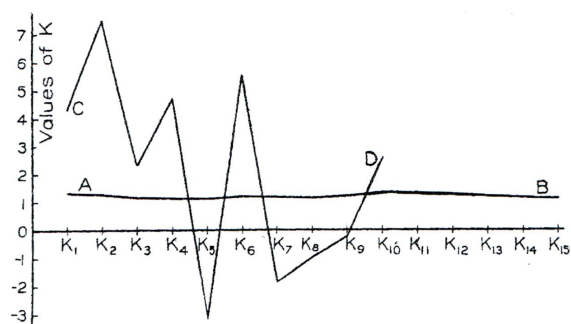


Figure 4. Plots of the K ratios for various compounds of Cl and H (line CD) and for various compounds of Cl and Br (line AB) (14). The zigzag nature of the line for Cl and H indicates a lack of chemical similarity for these two elements whereas the nearly horizontal line for Cl and Br indicates a significant degree of chemical similarity.

Martin illustrated this procedure using the graph in Figure 4 which shows a plot (CD) of the ratios obtained for various compounds of H and Cl versus the plot (AB) obtained for various compounds of Cl and Br. The widely varying values of K_i in the H/Cl plot show that these two elements are chemically dissimilar whereas the nearly constant values of K_i for the Cl/Br plot show that these two elements are chemically similar.

At the end of 1905 Martin expanded the results of these two papers, as well as several more minor points

dealt with in some of his other notes to the *Chemical News*, into a 287-page book entitled *Researches on the Affinities of the Elements and on the Causes of the Chemical Similarity or Dissimilarity of Elements and Compounds* (15). In addition, in early 1906 he also submitted a brief summary of the book as his doctoral thesis at Rostock under the title of *Ueber das Affinitätsgesetz in dem periodischen System* (3). For lack of the necessary thermochemical data, Martin was able to construct the affinity surfaces under ambient conditions for only 34 elements. These he displayed in the form of a huge foldout chart tucked into a pocket inside the back cover of the book. In addition, many data points were missing even for the elements described, thus requiring some creative interpolation of the corresponding affinity surfaces.

Nevertheless, Martin's results, as may be seen from the affinity surfaces for the halogens in Figure 3, were truly impressive and allowed him to make some significant, and mostly correct, conclusions concerning the subject of chemical periodicity, which he summarized as follows:

1. The affinity surfaces of chemically similar elements are of a similar shape, and those of unlike elements of a dissimilar shape.
2. The form of the affinity surface of a metal is diametrically opposite that of a nonmetal.
3. The chemical inactivity of nitrogen is to a great extent only an apparent effect.
4. The affinity surface of hydrogen shows that it belongs to the alkali metals and not to the chlorine group of elements.
5. The point of maximum affinity shifts from F to Li as we pass from Li to F.
6. The chemical affinities of the heavy elements are in general much feebler than those of lighter elements.

Points 5 and 6 were based on Martin's observation that the maximum in the surfaces for the halogens occurred on the far left of the periodic table above the alkali metals, whereas that for the alkali metals occurred on the far right above the halogens. In the case of elements lying between the alkali metals and the halogens, the maximum gradually moved from left to right across a each period of the table and progressively decreased in magnitude as one move from the top to the bottom of the table (Figure 5). Since the plots looked like a rolling wave, Martin called this result the "wave law of affinity in the periodic table."

Most textbooks of the period characterized nitrogen as having little chemical affinity for other elements, but Martin's plots revealed that this was not the case. While true that it had little affinity for the elements on the far left and right of the table, the plots showed that it had a significant affinity for elements near the center of the table, such as B and P, whence point 3 in the above list.

Reception of the book varied widely. The reviews in the *Chemical News* and in the *Journal of Physical Chemistry* were noncommittal and simply summarized the book's contents (16, 17). On the other hand, a rather lengthy review in the *Zeitschrift für physikalische Chemie*, by none other than Wilhelm Ostwald himself, was quite favorable (18):

We are here dealing with a research which deserves the most serious attention and encouragement ... One

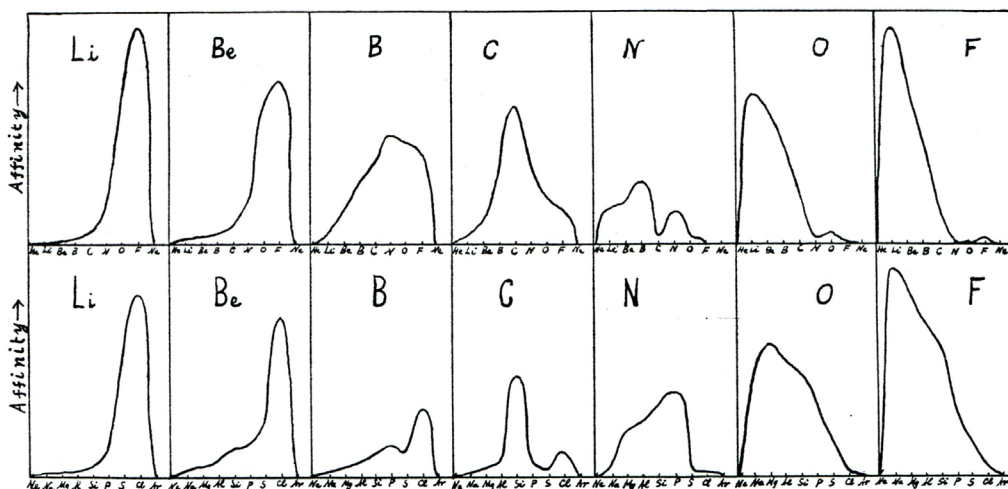


Figure 5. Hand-drawn cross-sections through the affinity surfaces of the period 2 elements as shown in Martin's doctoral thesis of 1906 (3) showing their affinities for the other elements of period 2 and for the elements of period 3 and intended to illustrate Martin's wave law of chemical affinity.

must recognize that here a quite unusual scientific imagination, taking the word in its best sense, has been at work, which leads one to look for far greater achievements in the future.

Similar positive comments occurred in the review in the *Philosophical Magazine* (19)

This original and interesting work should strongly appeal to all interested in the wider generalizations of modern chemistry.

and in *The Oxford Magazine* (19)

Chemists cannot fail to profit by reading it ... The great value of the book is that it puts things in a new way, and may help to change the textbook atmosphere

which results in chemists seeing things, not as they are, but as they expect to find them.

Unhappily these favorable impressions were not shared by the book's anonymous reviewer for *Nature*, whose comments carried the suggestive title of "Mathematics' Applied to Chemistry." The reasons for this title choice were spelled out in the first paragraph of the review which proceeded to attack Martin's preoccupation with mathematical formalisms (20):

The word "mathematics" has been placed in the title of the review in inverted commas because, although the mathematical formulae employed appear formally correct, the application of mathematical formulae to the data in Mr. Martin's work appears to this reviewer to be unjustified.

After first summarizing Martin's mathematical analysis of the number of characteristic surfaces required to completely deal with all of the possible valence states of all of the known elements, the reviewer zeroed in on his primary objection (20):

We have italicized the words "imagine a curved surface to be drawn through these points" because there lies the crux of Mr. Martin's attempt. Does he imagine that the interspaces are filled by an infinity of elements of all conceivable atomic weights between the

known limits of 1 and 240? If not, then the whole system is discontinuous, and the characteristic surface is nonexistent.

Interestingly this mathematical objection is identical to that raised by Mendeleev 20 years earlier with respect to early attempts to reduce the periodic law to a mathematical function, as well as attempts to represent it using two-dimensional property-atomic weight plots like those of Lothar Meyer and later of Thomas Carnelley (21). It is, in many ways, spurious, since in most cases the purpose of the curves and surfaces connecting the discrete data points is merely to serve as a visual aid which allows the viewer to more easily see the variations in the actual data points. Even in cases where the

authors attempted to represent this visual aid by means of an explicit continuous mathematical function (which Martin never did—his discussion of the curves is in very general mathematical terms and is largely concerned with the number of independent variables that would be necessary), the required “quantization,” so to speak, comes not from the nature of the mathematical function itself, but rather from restrictions on the values of the independent variables that one is allowed to substitute into the function—a point which Martin also made in a brief answer to the review published the next month (22).

But this was not all. Following his criticism of Martin’s overuse of mathematics, the reviewer proceeded to attack his use of heats of formation per equivalent as a measure of chemical affinity, and then concluded by criticizing the book’s physical layout (20):

A word in conclusion as to the “get up” of the book. The reviewer, in reading it, felt that he must act as a proof-reader. There is hardly a page on which a misprint does not occur; and such lapses as “The only data available is the following,” the use of “uni-” and “tetra-valent” in one line, “to completely picture;” and the printing of almost every sentence as a paragraph, make the reader’s task an ungrateful one.

Martin had no doubt rushed the book into print for fear he would be scooped by others, and having, at age 24, no colleagues or students of his own to burden with proof-reading the galleys, had done so himself—a procedure which every author soon discovers is fraught with danger, since one often sees what one intended to say rather than what is actually printed on the page.

Martin would later refer to this youthful work only once, in the introductory chapter of the volume on the chemistry of the halogens which he and Ernest Dancaster wrote in 1915 for the multivolume textbook of inorganic chemistry edited by J. Newton Friend (13). Here the affinity surfaces of the four nonradioactive halogens, shown earlier in Figure 3, were put to good use to provide a very insightful overview of the comparative chemistry of these elements. Beyond this, however, Martin’s book and program for reformatting the descriptive inorganic chemistry of the elements seems to have almost immediately dropped out of sight. Since much of it concerned the use and extension of the periodic table, one would have thought that it would have at least been referenced in works on this subject. Unfortunately, though Martin referred to the periodic table in the title of his German doctoral thesis, no reference to it appears in the title of his book and thus no reference to it appears in either the 1909 monograph on the periodic table by Garrett (23) or the

1930 monograph by Rabinowitsch and Thilo (24). Nor does it appear in more modern histories of the periodic table, like that by van Spronsen (25).

The Rule of Eight

In May of 1902, while still at the University of Berlin, Martin published a short note in *The Chemical News* entitled “Note of the Mathematical Expression of the Valency Law of the Periodic Table, and the Necessity for Assuming that the Elements of its First Three Groups Are Polyvalent,” in which he presented the graph in Figure 6 showing a plot of an element’s highest (v_1) and lowest (v_2) valence values as a function of its group number (n) (26). All of the points on this graph were based on known valence values except those of the upper branch for groups 1-3 which are therefore distinguished using a dashed, rather than a solid line. Assuming that the predicted missing valence values on the dashed line segment would eventually be found to exist among the intermetallic compounds, Martin then derived a rather complex algebraic expression for the graph which he eventually reduced to the condition:

$$v_1 + v_2 = 8$$

and which he interpreted as implying that (26):

... the sum of the highest and lowest degrees of valence with which an element acts towards other elements is a constant whose value is 8.

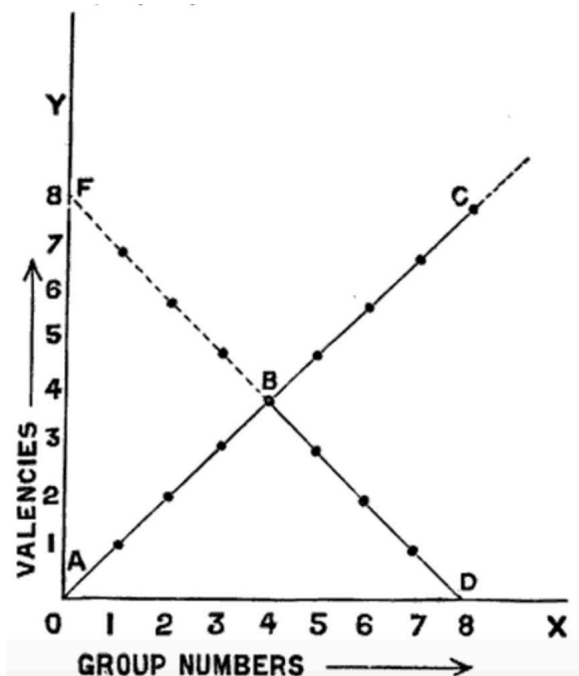


Figure 6. Martin’s plot of the highest versus the lowest

valence values of the elements in groups 1-8 of the periodic table (26). Those on line segment FB are hypothetical.

He then further elaborated on the significance of this result (26):

This is a very remarkable relationship. It includes Mendeleev's observation that the total valency of an element both towards hydrogen and oxygen is 8. And for this reason: An element tends to act towards radicals of like electrical sign with its highest valence but towards radicals of opposite electrical sign with its lowest valence. Now hydrogen is electropositive and oxygen is electronegative. Therefore by observing the valence exhibited by any one element towards each of these two standard elements, we obtain at the same time the measure of its highest and lowest valence. Hence Mendeleev's law.

This is, of course, the well-known "Rule of Eight" usually attributed to the German chemist, Richard Abegg, who also first stated it in 1902 (27) and in much greater detail in 1904 (28). For many years the rule was a standard feature of inorganic textbooks, where it was always credited to Abegg alone, without any acknowledgement of Martin's presumably independent contribution (29, 30).

Electron Repulsion and Molecular Shape

The following year, after his move to Kiel, Martin published yet another note in the *Chemical News* with the rather cumbersome title of "Some Additional Remarks on the Connection Between Metals and Nonmetals and Its Bearing on the Valence Theory of Helmholtz and on Stereochemistry" (31). In his famous Faraday Lecture of 1881, Hermann von Helmholtz had proposed an electrical model of the atom in which valence was explained in terms of an excess of either mobile positive or mobile negative electrical particles (32). Though J. J. Thomson had characterized the electron in 1897, the Rutherford nuclear atom was still eight years away in 1903 and there continued to be much speculation as to where the necessary compensating positive charge resided in the atom. In short, what were essentially particulate versions of the older debate between the two-fluid versus the one-fluid theories of electricity were still going strong. Thus, as late as 1911, no less a luminary than Walther Nernst would opt, like Helmholtz before him, for the use of both positive and negative mobile electrons in his famous textbook on theoretical chemistry (33).

In this note Martin presented numerous arguments based on the transition between metals and nonmetals in

support of the conclusion that only mobile negative electrons were involved in valence interactions and that the compensating positive charge had to reside somewhere in the interior of the atom and was itself nonmobile (31).

We thus arrive at the conclusion that one, and only one, kind of electron causes the phenomenon of chemical valence. The electrons can cause an atom to appear either as electropositive [i.e. metallic] or electronegative [i.e. nonmetallic] in nature according as they are feebly or firmly held by the atom.

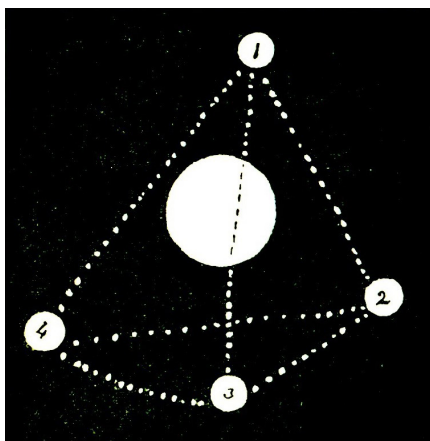
But what is of most interest is the manner in which Martin then used this conclusion to make some rather striking suggestions concerning the stereochemistry of various elements (31):

This places us in a position to define the law of the special arrangement of the valence bonds on the surface of the atom. For electrons, being equally charged particles of like sign, repel each other with the same force. Therefore, in the case of a polyvalent spherical atom whereon several electrons are condensed by the attractive force of the material out of which the atom is composed, the mutual repulsions between the electrons will cause them to take up a position of equilibrium on the surface of the sphere such that each is as far removed as possible from its neighbor and, if possible, in a symmetrical position.

Therefore the manner in which the electrons (and, consequently, valency bonds) distribute themselves over the surface of an atom depends only on the number of electrons and not at all on the nature of the material of which the atom is composed. The problem, therefore, of determining the shape of an atom of valency n is reduced to the problem of distributing n points as symmetrically as possible over the surface of a sphere.

Though Martin did not include an illustration of his model in his note, he did include a drawing (Figure 7) of what the model implied about the carbon atom in one of his later books (34).

Martin was neither the first nor the last to propose a repulsion model of molecular geometry (35), and in many ways his proposal was premature, since, at the time of his writing, only the inferred structures of organic chemistry, based on the van't Hoff tetrahedral carbon atom, and a few inferred octahedral and square-planar metal complexes, based on Werner's coordination theory, available for testing it. X-ray crystallography was still nearly a decade away and electron diffraction studies of discrete gas-phase molecules even further.



were

Figure 7. Martin's electron-repulsion model of the tetrahedral carbon atom (34, 1st ed., p 26).

In addition, Martin had no idea of how many electrons were in a given atom, but was rather working backwards from classical valence values by inferring one electron per valence. This means he would have been unaware of the stereochemical consequences of nonbonding valence electrons so central to the final form of the successful Valence-Shell Electron-Pair Repulsion (VSEPR) model of molecular geometry finally proposed by Nyholm and Gillespie in 1957 (36).

Silicon as an Analog of Carbon

As noted earlier, Martin spent the first seven years (1907-1914) of his career in academia as a lecturer in introductory chemistry, first at University College, Nottingham and then at Birkbeck College in London, and during this time he published at least ten experimental papers on the chemistry of silicon in both the *Berichte* and in the *Journal of the Chemical Society* (37). Martin's interest in this subject actually went back to 1900 and his junior year as an undergraduate at Merchant Venturers' Technical College, when he had published a series of five articles in a popular journal called *Science Gossip* under the title of "Life Under Other Conditions" in which he speculated on the possibility of silicon life forms and which he reproduced as one of the appendices to his monograph of 1905 (38, 39).

As we have seen, one of the major premises of Martin's monograph was that the pattern of properties for the elements in the periodic table was pressure and temperature dependent and that it was possible to "equalize" the properties of two elements, especially if they were in the same group, by comparing them under

widely different physical conditions. In particular, Martin postulated a "critical temperature and pressure" for each element's chemical compounds. This corresponded to an upper limit on their stabilities and represented the conditions under which they displayed a maximum in their reactivity. After first observing that carbon-based life was limited to a small temperature-pressure range, Martin wrote (38):

I suggest that the temperature range of animal life is probably nothing more or less than the range of the critical temperature of decomposition of a series of certain very complex carbon compounds which are grouped together under the name "protoplasm," the external pressure of the atmosphere coinciding roughly with their critical pressures of decomposition.

Given this assumption, the next step was obvious (38):

We are therefore justified in asking whether there is any other element which at some other temperature could play the part now played by carbon at ordinary temperatures in living organic matter?

as was Martin's answer to his rhetorical question (38):

Silicon is such an element ... There probably exists for silicon, as well as for carbon, a transition or critical temperature range whereat a large number of unstable silicon compounds are capable of momentary existence, a higher temperature rendering their existence impossible, while a lower temperature would make the compounds stable. At this transitional temperature the complex compounds would be capable of a continual metathesis, and thus give rise to the phenomenon of life; only in this case all forms of life would have as the determining element not carbon, but silicon. Seeing that in the case of carbon this temperature occurs when many of its compounds are in a semi-fluid condition, and near their decomposing point, we should expect the corresponding temperature for silicon compounds to occur when they, too, are in a pasty or semi-fluid condition.

Last, but not least, Martin connected his speculations with the geological history of the earth, which he assumed had been formed via the gradual cooling of an originally molten mass (38):

Have we any evidence which supports the view that living matter did not start originally with carbon, hydrogen, oxygen, and nitrogen as its fundamental elements, but started with elements of far higher atomic weights, such as silicon, phosphorus, and sulphur, of which only vestiges now remain in the protoplasm? It must be remembered that our evidence could only be indirect; such life could have thrived to an enormous extent in the white hot molten siliceous matter which covered the earth's surface in by-gone ages, and yet

have left no traces of its existence behind; for when such forms of life died, their bodies would but blend again into the molten rock, in the same way that a jelly-fish dies and blends into the ocean of salt water without leaving a vestige behind ...

In light of this interest, it is hardly surprising that Martin chose to move to University College, Nottingham, after his return from Germany in order to work with the British expert on silicon chemistry, Frederic Stanley Kipping (Figure 8). As early as 1899 Kipping had begun an intensive study of organosilicon compounds that would eventually span nearly four decades. Perhaps the most important contribution to come out of this work was Kipping's discovery of a new class of organosilicon oxygen derivatives known as the "silicones." Like his predecessors, Kipping, in his early work, naively assumed that analogous stoichiometry automatically implied analogous structure. Consequently, when he prepared a class of compounds having the general formula R_2SiO , he naturally thought that he had discovered the alkyl silane analogs of the ketones R_2SiO —whence his use of the name "silicones"—a term equaled in the annals of chemical nomenclature for its misleading implications only by Lavoisier's equally naive assumption that the composition of sugars and starches implied that they were literally hydrates of carbon.



Figure 8. Frederic Stanley Kipping (1863-1949).

However, by the time Kipping delivered his 1936 Bakerian Lecture on "Organic Derivatives of Silicon," summarizing his life's work, time and experience had

considerably dampened his earlier enthusiasm for the possibility of a silicon-modified organic chemistry (40):

Even after a very short experience, it was evident that corresponding derivatives of the two elements in question showed very considerable differences in their chemical properties; it may now be said that the principal, if not the only, case in which they exhibit a really close resemblance is that of the paraffins and those particular silicohydrocarbons containing a silicon atom directly united to four alkyl radicals. But of far greater importance in any general comparison of carbon compounds with the organic derivatives of silicon is the fact that many, if not most, of the more important types of the former are not represented among the latter. Apparently this is not merely a consequence of the insufficient experimental investigation of silicon derivatives but is due to the fundamental differences in the properties of the atoms of silicon and carbon ...

In other words, after 40 years of research, Kipping had come to the conclusion that even the weak form of the carbon-silicon analogy was defective, and subsequent work would soon show that his pessimism was fully justified.

Whether Martin experienced a similar sense of disillusionment is not known. In any case, his three-year sojourn with Kipping resulted in only one joint publication (41), as well as two authored by Martin alone, with the majority of Martin's work in this area being done after his move to London. There it served as the basis of his 1915 doctoral thesis at the University of London on *The Preparation of Silicon Tetrachloride and Disilicon Hexachloride* (4).

Textbooks and Popularizations

In addition to the numerous research papers mentioned in the previous section, Martin's brief sojourn in academia also led to the publication of four books between 1907 and 1915 dealing with various aspects of chemical education. The first of these, published in 1907 while he was at Nottingham, was a conventional laboratory manual entitled *Practical Chemistry for Army and Matriculation Candidates and for Use in Schools*. Its overly descriptive title no doubt reflected the kinds of students Martin was dealing with and, indeed, his introduction indicates that he did not think very highly of some of them (42):

The average army candidate does not seem to possess the slightest idea of the necessity of care in carrying out experiments. He works in a mess and with a complete disregard of all the precautions necessary to ensure accuracy.

This was followed in 1914 by a short monograph on teaching aids entitled *Modern Chemical Lecture Diagrams* (43) showing the various lecture charts Martin had developed for use in his introductory chemistry course at Birkbeck.

Interspersed among these publications were two thick books of more than 350 pages each that attempted to popularize recent advances in chemistry for the general public: *Triumphs and Wonders of Modern Chemistry*, which appeared in 1911 (34), and *Modern Chemistry and Its Wonders*, which appeared in 1915 (44). During the first two decades of the 20th century chemistry was experiencing a veritable revolution, due in large part to the advent of the electronic theory of matter and all that it implied for the theory of valence and chemical bonding. It was the excitement of this revolution that Martin hoped to share with his lay audience (34):

It has been my lot while lecturing on chemistry to have come into frequent contact with many thoughtful men and women, boys and girls, who have felt much interest in this new chemistry, which has arisen out of the old, and who have wished to know something more of the grand questions of the day touching the ultimate nature and constitution of the universe in which they live, and of the matter which surrounds them on every side in untold millions of tons, but who have neither the leisure nor the inclination to master the technicalities and enter into the minutiae of the regular textbooks of chemistry where such things are discussed.

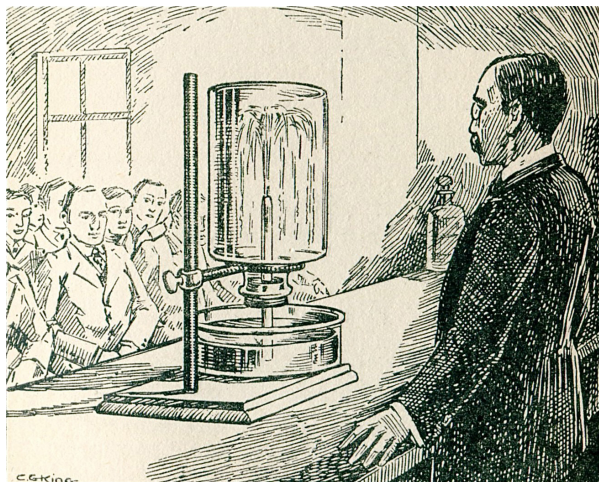


Figure 9. An illustration from *Modern Chemistry and Its Wonders* (44) showing what is assumed to be Martin demonstrating the ammonia fountain to his class at Birkbeck College.

The fact that this statement of intent was then followed by a trenchant criticism of the way in which chemistry was taught in Great Britain, suggests that Martin had found his years as a lecturer less than satisfying and may well explain his reasons for soon abandoning academia altogether (34):

These textbooks, moreover, labor under the disadvantage that they are written for candidates for one or another of the innumerable examinations in which our university authorities take such keen delight, and which, combined with a complete lack of educational freedom, make an English university student's life a perfect nightmare to him (in sad contrast to that of a German or American student), and destroy rapidly and effectively any genuine interest in science he may have possessed at his entrance to the university, besides exercising a paralyzing effect on the university lecturers themselves, and diminishing greatly the output of research work in this country, to its incalculable material and moral harm.

In short, these two popular books apparently represented what Martin would have liked to tell his students but which he was unable to tell them in either his earlier laboratory manual or in his lectures, since he found himself trapped in a rigid system that reduced him to a mere drudge whose sole purpose was to cram enough predetermined rote information into his students to allow them to pass their qualifying examinations.

Both books were moderately successful. They were reprinted in the United States, translated into several foreign languages, and, via second editions, remained in print well into the 1920s. Both were also heavily illustrated with photographs and original line drawings, and several of the latter are still of interest to the historian. In the case of *Triumphs and Wonders*, these drawings include several speculative views of pre-Bohr and pre-Lewis atoms and molecules, of which the earlier drawing of the tetrahedral carbon atom (recall Figure 7) is an example, though most depicted flat solar system molecules with rotating swarms of peripheral atoms. In the case of *Modern Chemistry*, the drawings include several of a chemical lecturer performing various chemical demonstrations of which Figures 9 and 10 are typical examples. They all appear to depict the same lecture hall and a lecturer not unlike Martin in appearance, leading one to speculate whether the book's illustrator, C. G. King, might not have sat in on several of Martin's lectures in the old Brems building in Fetter Lane in order to make preliminary sketches for the book.

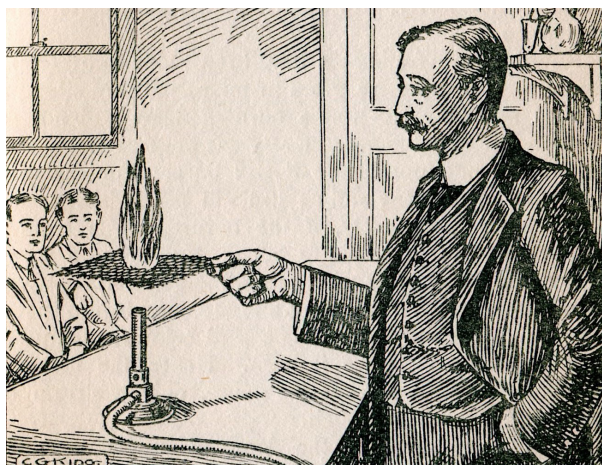


Figure 10. An illustration from *Modern Chemistry and Its Wonders* (44) showing what is assumed to be Martin demonstrating the principle of the Davy safety lamp to his class at Birkbeck College.

Industrial Chemistry and Manufacturing Chemistry: Organic

In 1913, while he was still at Birkbeck, Martin's career as an author changed drastically when he published *Industrial and Manufacturing Chemistry. Organic. A Practical Treatise* with Crosby Lockwood & Co. of London, a massive tome of some 726 pages (45). This was only the beginning of a vast series of volumes relating to industrial chemistry. The inorganic volume of *Industrial and Manufacturing Chemistry* appeared belatedly in 1917 and both volumes went through several editions until the early 1950s. At the same time Crosby Lockwood produced a series of "Manuals of Chemical Technology" which would eventually run to nine volumes, eight of which were either authored or coauthored by Martin. This was not a stepwise process, fuelled by the success of the first volume, as it appears (as shown below) that the volumes were conceived at more or less the same time although their appearance was delayed mainly because of the First World War. While Martin was editor of these volumes, he also wrote much of the content as we will see, so their publication must have been a massive task.

How did this transformation in Martin's publications come about? Much depends on whether the initiative came from Martin or the publisher and without archival evidence we cannot be sure. However we can make an educated guess that the idea came from the publisher. The original firm had been founded by Mark Lockwood in the early nineteenth century and his son Crosby Lockwood

took over the firm after his death in the 1850s (46). It published scientific and technical books ranging from advice for the general public to dense (and thick) engineering tomes. Martin's practical chemistry fitted well into the publisher's range. However in the first decade of the twentieth century, Crosby Lockwood was not publishing many chemistry books; only six appear in the online catalogue COPAC under the keyword "chemistry" between 1901 and 1910.

Given the time needed to produce the first volume of *Industrial and Manufacturing Chemistry*, the origins of the monograph and its associated series must have begun early in Martin's career at Birkbeck and may have even been precipitated by his newly found geographical proximity to the publisher in Ludgate Hill, only five minutes' walk from Fetter Lane. Furthermore most of the teaching at Birkbeck College was in the evening, leaving Martin free to visit the publisher and do research—possibly in the Patent Office Library off Chancery Lane, which would have been another five minute walk—and write.

In the preface to the first volume of *Industrial and Manufacturing Chemistry*, dealing with organic chemistry, Martin makes no reference to its gestation, but states (45):

This book is a treatise on the applications of Organic Chemistry to the arts and manufactures. It embraces both British and American practice, and affords, so far as is ascertainable in view of the many secret processes employed, thoroughly up-to-date information regarding the various branches of chemical industry and of manufactures having a chemical basis.

As far as the intended audience, Martin aimed to cast his net as wide as possible (45):

... the book will serve either as a text-book or as a work of reference; it is intended to meet the requirements of all business and practical men interested in chemical processes, of manufacturers, consulting chemists, chemical engineers, patent workers, inventors, technical lawyers, students in technical institutions, lecturers on technology, fire insurance inspectors, and others.

In the preface for the seventh edition in 1954, the new editor, Edward Cooke, tried to cast the net even further, "this book is thoroughly recommended to sixth-form and university students deciding on their future career, and to all who wish to know more of British Industry." In practice, the main market was probably libraries and larger chemical works. Students of industrial chemistry would have more likely have used a shorter book such as Frank Hall Thorp's *Outlines of Industrial Chemistry*

(47) which first appeared in 1898, although they would have probably consulted Martin's volume in the college library for additional details.

The organic chemical industry, as we understand it today, hardly existed in 1913 and most of the industrial sectors covered in this volume would hardly be considered to be organic chemicals nowadays. One finds not only aliphatic chemicals, coal tar chemicals, synthetic dyes, synthetic drugs and photographic chemicals, but also milk and cheese, sugar, wine and beer, paint and ink, and explosives. The text is entirely descriptive with an emphasis on the details of processes accompanied by drawings of the equipment used. There is no attempt to draw general principles from these processes or to teach industrial chemistry in a systematic way.

However there is a clear intention to be up-to-date as possible and an interesting example of this is the section of synthetic rubber. It was written by Martin himself and was clearly a late addition as the pagination for this segment is 366, then 366a-336h. The publishers obviously wished to capitalize on the upsurge of interest in synthetic rubber in 1912 following the work of Strange & Graham (collaborating with William Henry Perkin Jr and Chaim Weizmann), Fritz Hofmann at Bayer (collaborating with Carl Harries) and Ivan Kondakov in Russia (48).

Given the length of the volume (624 pages of text) and his lack of any direct experience of the chemical industry, one might have thought that Martin would have simply been the editor, but in fact he wrote much of it himself. He wrote 34% on his own and a further 29% with co-authors. The segments he wrote are rather random and one strongly suspects that he wrote those segments for which he could not find an expert author. This impression is reinforced by the fact that many of his segments are short, whereas the co-authored segments (and the segments by other authors) are usually longer. The average lengths of the 26 segments written solely by Martin is 8.1 pages, whereas the 15 segments written by others are an average of 15.3 pages long. The 13 segments co-authored by Martin are similar with an average of 13.9 pages.

How did Martin write his segments given his lack of industrial experience? He relied heavily on the published literature and his expert advisors, notably W. H. Stephens (49). Stephens was about the same age as Martin and a graduate of the Royal College of Science in 1903 (which became part of Imperial College four years later). He was a patent agent and Martin may have met him at the Patent Office Library. One thus gains the impression that much of the volume was based on the published literature rather than practical experience. It is striking that when Martin

did not have an expert to fall back on or an established literature, his segments were very short, for example three pages for synthetic perfumes.

The main rival to the organic chemistry volume when it was published was Samuel Sadtler's *Industrial Organic Chemistry*, first published by J. B. Lippincott in 1892 with a fourth edition in 1912 (50). Sadtler was a leading consulting chemist in Philadelphia and a former professor of organic and industrial chemistry at the University of Pennsylvania (51). The two books are a similar size (559 pages of text compared with 624 for Martin) and discuss many of the same topics, such as fats, sugar, milk, textiles and dyes. Sadtler does not cover paint and ink or explosives and gives scant attention to rubber. More surprisingly he does not include synthetic drugs or photographic chemicals. By contrast, only the subject of "bread" is missing from Martin.

Industrial Organic Chemicals has a very regular structure in that every chapter deals with processes, products and analysis in turn. The addition of analysis would have made Sadtler's tome more useful to industrial chemists but the division of processes and products seems guaranteed to generate repetition. In their details and style, the two books are very similar. They are both aimed at the manufacturer and for reference rather than teaching.

Another competitor to Martin's book was *Industrial Chemistry: A Manual*, first published by van Nostrand in 1912 (52). Edited by Allen Rogers of the Pratt Institute, Brooklyn, and Alfred Aubert of the University of Maine, it had a large cast of authors, who in contrast to Martin, wrote most of the chapters. Once again, its coverage and style were very similar to Martin. The general structure of the chapters is in fact very close to *Industrial and Manufacturing Chemistry*, being a string of topics rather than Sadtler's more systematic approach. Like Martin, Rogers and Aubert cover explosives (but not drugs and photographic chemicals), but their treatment of inorganic chemicals is not as good. They do not devote a chapter to alkali manufacture for example (it is covered in "Commercial Chemicals"), but there are two chapters on white lead which is only covered by Martin briefly under pigments (in the organic volume no less!). Both books deal with construction materials and metallurgy. The most striking aspect is the wealth of illustrations which exceeds even the large number in Martin's volumes, whereas Sadtler's volume is relatively restrained in its use of illustrations.

The outbreak of the First World War in early August of 1914 soon showed the importance of the organic chemical industry and the dangerous reliance of the Allied countries on imports from Germany. This gave heightened importance to the development of the industry in Britain and it is perhaps not surprising that Crosby Lockwood quickly produced a second edition of the organic volume, although the inorganic volumes were yet to appear (53). The preface to the second edition, dated May 1915, curiously made no reference to the war and its impact on organic chemicals, but highlighted various improvements including a new section on rubber analysis (3 pages) by Martin's near namesake Gerald Martin, and a list of synthetic drugs and photographic developers. The section on rubber analysis was a new departure for *Industrial and Manufacturing Chemistry* which, in contrast to Sadtler, had hitherto not covered analysis.

However most of the changes were minor. For example, a new article on acetylene by Frank Gatehouse (54), the editor of journal *Acetylene Lighting and Welding*, was only a page longer than the section on acetylene in the previous edition and had little more to say about the burgeoning use of acetylene in the wartime chemical industry—in fact a prescient reference to the use of acetylene in synthetic rubber manufacture was dropped. The changes are so small in fact that the publisher did not change the pagination from the previous edition, using letters for new pages (e.g. 365a for a new half-page on rubber statistics). This slow evolution—amounting to little more than the updating of statistics and correction of errors—was to be an enduring feature of the later editions of *Industrial and Manufacturing Chemistry*.

Industrial Chemistry and Manufacturing Chemistry: Inorganic

It is a puzzling feature of *Industrial and Manufacturing Chemistry* that the less important branch of the industry was covered first, even if the subsequent war showed its importance. It was probably originally intended that the volume on the inorganic chemical industry be published at the same time as organic or at least shortly afterwards. For whatever reason the appearance of the inorganic volume was delayed and the outbreak of the war was a further complication as explained in the preface of December 1916 (55):

The work which has been carried out on the lines of the previous treatise, has been written under very formidable difficulties, for not only have several years been spent in its compilation, but before its completion the great War broke out and dispersed many of

the contributors in the fighting ranks throughout the world, one at least, the late Major L. Foucar, having been killed in action before his article could be completed. It is a great satisfaction to the Editor that he has been able to bring his task to a conclusion in spite of these obstacles.

Major Louis Foucar was killed in the Second Battle of Ypres on 8 May 1915 at the age of 32 but has no known grave; he is commemorated on the Menin Gate (56). This battle is of course best known for the first use of chlorine as a chemical weapon by the Germans under the direction of Fritz Haber (57). Ironically, liquid chlorine is the subject of one of the chapters in this volume, although it was written by Martin. Foucar wrote the sections about sulphur, sulphuric acid and sulphur dioxide (which were completed by Martin).

The inorganic section finally appeared in 1917 in two volumes (55). It covers a remarkably wide range of material, far beyond what we would consider to be the inorganic chemical industry today, but as we have seen this was true of other books on the chemical industry in this period. Hence it covers fuels, furnaces, building materials (including lutes), ceramics, glass, asbestos and matches. A particular feature of the second volume is the material on minor elements such as zirconium, tantalum and the radioactive elements, which were also hived off as one of the manuals of chemical technology under the editorship of Sydney Johnstone. Of course all the standard branches of the inorganic chemical industry were covered, such as the major acids, alkalis, industrial gases, chlorine, ammonia and nitrates, and industrial fertilizers. It is interesting to note that antiseptics and disinfectants are covered in the second inorganic volume despite the fact that many of them were organic. Martin apologized for this mismatch, noting that “the removal of them [i.e. organic antiseptics] from such sections would largely destroy their value.” One suspects, however, that antiseptics and disinfectants were added once the war had demonstrated their importance. Insecticides and fungicides are also in this volume but they were almost solely inorganic compounds in this period. Needless to say, the style is identical to the organic volume, namely a series of well-illustrated descriptions of processes and products.

Manuals of Chemical Technology

The manuals of chemical technology began to appear in 1915, two years before the inorganic volumes of *Industrial and Manufacturing Chemistry* were published (58). It might be thought that they were produced to

capitalize on the sudden interest in chemical technology as a result of the First World War breaking out. Certainly some of the titles seem to address that interest, namely dyestuffs, nitrogen products and industrial gases, even one on chlorine. The preface to the dyestuffs volume said that (58a):

The lack of an English book on the subject, the sudden stoppage of the supply of German fine chemicals, and the preparations of the British Government for the establishment on a large scale of the synthetic dye industry in this country, all combine to provide opportunity and justification for the appearance of the present volume.

However publications take time to be produced and the series was probably conceived at the same time as the main volumes and the reason why they first appeared in 1915 was the delayed publication of the inorganic volume of the main work.

These manuals were not additions to the main book but extracts from it. Clearly the publisher aimed to sell the expensive and large *Industrial and Manufacturing Chemistry* to libraries and the larger manufacturers while producing the shorter manuals for smaller more specialized firms and individual chemists. The title page of the dyestuffs volume refers to “additions” which seem to be entirely restricted, as far as we can determine, to an updating of the figures for synthetic indigo production from 1910 to 1913. The reason for this is simple. If any significant updating or expansion of the text had taken place, the publisher would not have been able to use the same plates (as clearly they did) and this would have made the spin-offs uneconomic. Most of the manuals follow the same order as the original source, but the chapters were moved round in the dyestuffs volume (to its improvement, it has to be said) and the segment on saccharine (one page!) slotted in on page 116A, seemingly as an afterthought.

A Change of Career

The publications of these volumes also reflect a major change in Martin’s career from 1915 onwards, as already mentioned in our earlier biographical summary. It is striking that in the organic volume, published when he was still at Birkbeck, he describes himself on the title page, first and foremost, as an “Industrial Chemist and Chemical Patent Expert” despite the fact that, at this point in his career, he had never worked in industry nor trained as a patent agent. One suspects that the latter title simply refers to his use of the Patent Office Library. By early 1917 (even before his move to C.W.S.), Martin was calling himself a

“technological chemist and chemical engineer,” perhaps reflecting his personal shift from academia and the Patent Office Library to the chemical industry and the general shift from industrial chemistry to chemical engineering which had been accelerated by the First World War. However his qualifications as a chemical engineer appear to be as equally tenuous as his claim to be a patent expert. Certainly his personal transformation into a chemical engineer is not reflected in any change of approach in *Industrial and Manufacturing Chemistry*.

It is interesting to reflect on whether his departure from academia was a consequence of his work on *Industrial and Manufacturing Chemistry* or his work on these volumes a reflection of his desire to leave academia. It is perhaps suggestive that Martin comments in his preface to the organic volume (45):

Matters calling for industrial research have been specially emphasized by the editor; for he has recognised that the subject of chemical industry is not only one which is full of problems whose solution demands the highest technical skill, but also one that holds out prizes of very great value for the scientific worker.

Either way, his editorship of a major work on industrial chemistry would have strengthened his ability to find a post in industry. The urgent need to start producing chemicals formerly imported from Germany after the outbreak of war in August 1914 would have increased the value of his expertise (albeit mostly obtained from books) to chemical firms.

The Modern Soap and Detergent Industry

Martin’s books written after the publication of *Industrial and Manufacturing Chemistry* were closely allied to his work and were authored solely by himself rather than being co-authored by experts on specific topics. Soap manufacture was a major activity for the Co-operative Wholesale Society as it made its own soap in order to undercut the oligopolistic commercial soap producers, and especially Lever Brothers. So intense was the competition between the Co-op and Levers, that Lever Brothers took the alkali firm of Brunner Mond to court in 1924 for fraudulently selling alkali more cheaply to the Co-op (59). As a result, Brunner Mond had to pay Lever Brothers heavy damages and Roscoe Brunner, the disgraced chairman of Brunner Mond, committed suicide. Against this dramatic background, Martin published a three volume work on *The Modern Soap and Detergent Industry including Glycerol Manufacture* between 1924 and 1926 (60). In the preface, Martin noted that “[a]t the present time no complete work exists dealing with

the soap and detergent industry in all its branches” and the book appears to have been popular as a second edition appeared in 1931, but curiously the third volume (on glycerol) was not republished and a revised version did not appear until 1956.

Cement Chemistry

In 1928, Martin published *A Treatise on Chemical Engineering*, but this was not directly an attempt to capitalize on the increasingly important discipline of chemical engineering as one might expect. In the preface, Martin writes (61):

When in 1921 the author was appointed Director of Research to the British Portland Cement Research Association he found an almost unbelievable state of technical inefficiency in the cement industry, owing to the fact that much of the plant had been designed in ignorance of the laws regulating the flow of fluids. ... It is the object of this work to remedy this state of affairs by providing the chemical and mechanical engineer and works chemist with scientific means for calculating the flow of fluids of all kinds, and practical methods for estimating their speeds and volumes, with a view to more efficient plant design.

On the title page of this book Martin no longer refers to himself as an industrial chemist or a Fellow of the Chemical Society (as he did only three years earlier), but as a Consulting Chemical Engineer and Works Contractor and a Fellow of the Physical Society. Two tables in this volume were spun out in the now customary manner as the monograph, *Volume and Weights of Industrial Gases*, in 1930 (which was republished in a revised and enlarged edition by Wilfred Francis in 1953) (62). Martin also published a more specialized volume on *Chemical Engineering and Thermodynamics Applied to The Cement Rotary Kiln* in 1932 which also clearly arose out of his earlier work at the British Portland Cement Research Association (63).

Later Reprints and Revisions

Having produced (or revised) a volume on industrial chemistry every few years from 1913 onwards, Martin did not publish any further books after 1932 and one must wonder why—though no obvious reason (apart from possible ill health) presents itself. The Technical Press (which we assume was a subsidiary of Crosby, Lockwood, as the latter existed until 1972) produced a seventh edition of the organic volume of *Industrial and Manufacturing Chemistry* in 1952 (64). This was edited by Edward Ingram Cooke, a chemist who appears to

have been a writer and editor who also updated William Gardner's *Chemical Synonyms* from 1948 onwards (65). It is stated in the preface that the fuel-related sections had been updated, but the chapter on synthetic rubber, for example, barely reflected the development of the industry in the Second World War. Similarly the chapter on aliphatic chemicals was only updated with “slight additions.” A sixth edition of the inorganic volume followed two years later, edited by Wilfrid Francis (66). Again the changes were largely a minor updating of the chapters.

This minimalist approach to updating is in sharp contrast to the radical revision of the sixth edition of Allen Rogers' *Industrial Chemistry* in 1942 by Clifford Cook Furnas of Yale University (67), who was a chemical engineer, as well as an Olympic athlete and a future Assistant Secretary of Defense under Eisenhower. The key to his revision was a complete new slate of authors for the chapters rather than the piecemeal tinkering of the Martin volumes. Seemingly lacking the resources or will for this scale of revision and facing competition from more modern American works such as the new version of Rogers, Emil Raymond Riegel's *Industrial Chemistry* which was first published in 1928 and completely updated in 1962 (68), and the *Kirk-Othmer Encyclopedia of Chemical Technology*, which first appeared in fifteen volumes between 1947 and 1956 (69), Crosby Lockwood never produced another edition of either part.

The last book to appear under Martin's name was *Glycerol*, published as a single volume in 1956 (70) rather than as part of *The Modern Soap and Detergents Industry* (the other two volumes had been republished under the editorship of Edward Cooke in 1950-1951) (71). Once again, the revision (even after a gap of thirty years) is only a modest updating of the chapters with no change to the structure of the book. In common with the other volumes published in the 1950s, the preface makes no mention of Martin, which is curious as Martin would have been 75 in 1956 and he lived for another ten years. Even if he was not able (or willing) to edit any volumes in the 1950s, it would have been customary to pay tribute to the founder of the series. This makes us wonder if there might have been a falling out between Martin and The Technical Press.

Some Conclusions

In reviewing the life and career of Geoffrey Martin, one is left with the impression that, despite his prolific publication record, he remained something of an outsider with regard to the early 20th-century chemical commu-

nity. Aside from his brief association with Kipping at Nottingham, he seems to have had no academic mentors. His thesis at Rostock was based on his book on affinity surfaces and lists no doctoral advisor. Likewise no advisor is given for his doctoral degree from the University of London and his doctoral degree from Bristol, as already noted, was external and was based on his published papers. In short, all three degrees were based on his own independent ideas and research. Even his brief foray into silicon chemistry seems to have been driven more by his interest as an undergraduate in the possibility of silicon life forms than by an admiration for Kipping's work.

This apparent absence of influential contacts within the academic community doubtlessly played a role in condemning Martin to a series of low-paying, temporary, academic positions that eventually forced him to eke out a living as an industrial chemist. Both the fact that his major conceptual contribution to chemistry—the affinity surface—failed to attract any substantive interest among his fellow chemists, and the fact that by 1913 he also had a wife and two children to support, almost certainly contributed to his decision to change careers as well.

As for his many books and published papers, it is difficult to believe that the former were a source of any significant income and, with the exception of the volumes on industrial chemistry, most fell still-born from the press. In lieu of any significant social contacts, Martin appears to have instead used writing as his preferred medium for interacting with his fellow chemists. And here Martin's instincts were, in a sense, sound, for if he can be said to have left a chemical legacy, it is to be found in the form of his many books, and especially in those dealing with industrial chemistry.

In the final analysis, Martin's life and career illustrate many of the trials and tribulations facing an early 20th century chemist in Great Britain and are certainly worthy of being recorded for posterity.

A Personal Tribute

One of the authors (PM) has an emotional attachment to Martin's *Industrial and Manufacturing Chemistry*. His school had a policy of awarding some of its annual prizes by an essay competition and one year, when Morris was fifteen (hence 1971), the topic of the chemistry essay was an industrial chemistry one. He duly visited his local public reference library (which was still well stocked in these days of long ago), and in the basement he found a copy of *Industrial and Manufacturing Chemistry* (probably several editions as he recalls a run of several feet)

which had clearly not been used for some considerable time. In amazement he read detailed accounts of bygone processes complete with numerous line drawings. The memory has always remained strong and is one of the motivations for this paper. Sadly, recent enquiries have (unsurprisingly) revealed that the volumes were probably thrown out a couple of decades ago at least.

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3. G. Martin, *Ueber das Affinitätsgesetz in dem periodischen System*, Jebens: Kiel, 1906. Surprisingly, this thesis is not listed in P. R. Jones, *Bibliographie der Dissertationen amerikanischer und britischer Chemiker an deutschen Universitäten, 1840-1914*, Deutschen Museums, München, 1983, though we have since located a printed copy. This was based on the book in Ref. 15 and was apparently an external degree as no doctoral advisor is listed.
4. Poggendorff (Ref. 5) lists the title of the doctoral thesis at University of London as *The Preparation of Silicon Tetrachloride and Disilicon Hexachloride*. The thesis at University of Bristol was entitled "A Contribution to the Theory of Solutions and Other Papers," from which we infer that it was probably an external degree based on Martin's published papers. Our thanks to Michael Richardson, Special Collections Librarian of the University of Bristol, and Richard Temple, Archivist for the Senate House Library of the University of London, for their assistance in unraveling Martin's various degrees.
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17. "Review of *Researches on the Affinities of the Elements*," *Chem. News.*, **1905**, 92, 224.
18. W. Ostwald, "Review of *Researches on the Affinities of the Elements*," *Z. phys. Chem.*, **1906**, 55, 761-762.
19. Quoted in an advertisement for the book.
20. "'Mathematics' Applied to Chemistry, Review of *Researches on the Affinities of the Elements*," *Nature*, **1905**, 73, 49-50.
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 - i. G. Martin, *Manuals of Chemical Technology X: Perfumes, Essential Oils, and Fruit Essences Used for Soap and Other Toilet Articles*, Lockwood, London, 1921.Volume VIII of the series was apparently never published. According to ads for the projected series it was to be authored by S. J. Johnstone and titled *The Minor Elements: Their Occurrence and Industrial Uses*. Our thanks to Gregory Girolami for this information.
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