

Chemical satire and theory, 1868

William B Jensen

Scientific intercourse in the mid-19th century ranged from cheerful bonhomie to spiteful attack. There was ample scope for satire and re-primination in this period, when the basic theories and nomenclature of chemistry were being evolved by independently-minded scientists.

On 30 March 1916, the Chemical Society met for its annual general meeting and to celebrate its 75th anniversary. The president, Alexander Scott, used the occasion to reminisce on the origins and progress of the Society.¹ Among its illustrious predecessors Scott mentioned Section B of the British Association for the Advancement of Science, which had been founded in 1831. Section B specialised in chemistry and mineralogy, and its meetings eventually led to the organisation of a special 'chemical society' or social-dinner club known as the B Club or the Hive of Bs. Its membership was restricted to 20 chemists and it took as its symbol, not surprisingly, the honey bee. The club dined together once a month during the Association's session and organised country excursions during the summer.

These get-togethers were often the occasion for the presentation of humorous poems, drawings, and songs; and Scott, in his presidential address, preserved some of them for posterity. They are not only gems of chemical humour, but, when properly annotated, give a microhistory of the chemical theory and speculation of the period. Two of the more outstanding pieces date from a meeting held in March 1868: a satirical drawing of 'graphic formulae' (shown in Fig. 1) and a poem by John Cargill Brough entitled 'Modern chemistry' (see facing page).

The terms 'monads', 'diads', 'pentads', and 'triads' mentioned in the second verse were the then current British equivalents for what we would today call monovalent elements, bivalent elements etc. The terms were suggested by the French chemist August Laurent and were originally used to indicate the number of atoms in a molecule rather than their valencies. They were intro-

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duced into English by the chemist William Odling, who had translated Laurent's *Chemical method*, and were largely popularised, in their new sense, by Edward Frankland's textbook *Lecture notes for chemical students*, published in 1866.² The corresponding British term for valency was atomicity (first used by Kekulé in 1861). Our present word valency was introduced by the chemist August W. Hofmann in 1865. (He actually employed the term quantivalence, the prefix later being dropped.)³

The reference to 'Frankland's notation' in the third verse has to do with the 'symbolic' formulae which Frankland had used in 'great profusion' in his *Lecture notes for chemical students*. Some examples are shown in Fig. 2. Thick type or augmented letters were used to represent the multivalent element to which all of the other atoms were directly united or, in Frankland's words, 'the atom occupying the

prominent position' in the compound. The use of large and small 'O's distinguished those oxygens in which both valence lines were united to a single atom from those in which they were united to two separate atoms. Dashes or Roman numerals in the upper right or left hand corners indicated the valency. Sometimes both notations were employed, one to indicate the absolute valency and the other to indicate the active valency. Brackets were also used to indicate connections between atoms or, more often, between groups of atoms or radicals.

The 'bonds of atomic connection' in the fourth verse refer to the 'graphic' formulae introduced by Crum Brown in 1864 (see Fig. 2).⁴ Minus the circle around each atomic symbol, they are the direct ancestor of our modern structural formulae. They were also used extensively by Frankland in his book. The small curve emanating from some of the symbols represents two valence lines mutually saturating one another and was used to rationalise the fact that variable valency usually occurred in steps of two (eg, PCl_3 , PCl_5). This is not far removed from our current

Below, left: Edward Frankland (1825–1899); right: Alexander Williamson (1824–1904). Facing page, top: William Odling (1829–1921), photo from Russell;³ centre: Benjamin Brodie (1817–1880), photo from Brock;⁹ bottom: Alexander Crum Brown (1838–1922). All photos (except where otherwise stated) Edgar Fahs Smith collection.



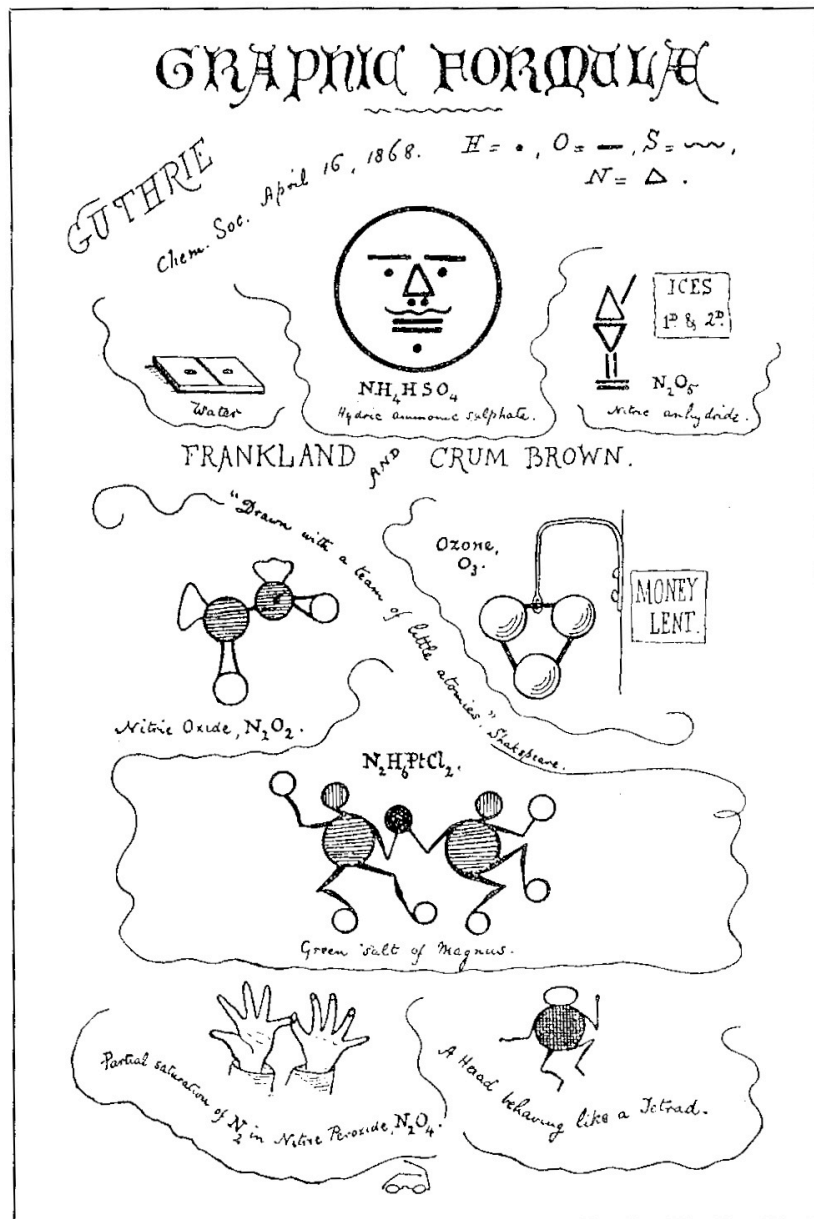


Fig. 1. Anonymous satirical drawing, probably by Odling.

explanation which associates valency with the number of unpaired electrons on an atom. Pairing two of the electrons to create a lone pair reduces the valency by two.

The graphic formulae of Crum Brown and Frankland are also satirised in the bottom half of Fig. 1. Further discussions of the development of valence nomenclature and symbolism can be found in the books by Russell³ and Crosland.⁵

'Mr Kay Shuttleworth', in verse three, refers to Sir James Kay-Shuttleworth, first Secretary to the Committee of the Privy Council for Education, who had apparently praised the didactic virtues

of using pictorial materials in teaching. However, if the educators were pleased with the graphic formulae, many chemists decidedly were not. Sir Benjamin Brodie, in verse five, had called them 'scribbled pictures' and, when he saw an advertisement for a set of atomic models made of wooden balls and wire, he referred to them as 'a thoroughly materialistic bit of joiner's work' which showed that chemical theory was turning into a 'bathos'.⁶

Brodie was a positivist who believed that the atomic theory was an unnecessary, if not dangerously misleading, hypothesis. In 1866 he read to the Royal

Society an abstract of his *Calculus of chemical operations* which he felt to be an acceptable alternative basis for chemical theory, and one founded solely on experimental fact.⁷ Basically, it was an attempt to symbolise chemical composition and reaction equations in the form of a self-consistent operational algebra, much as George Boole had done with the laws of logic.

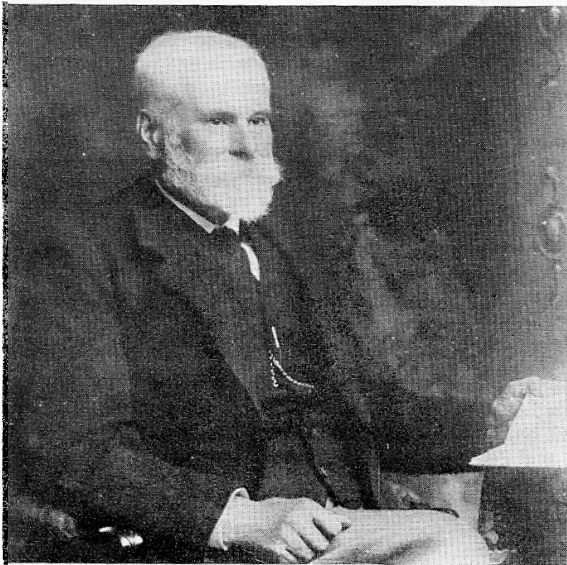
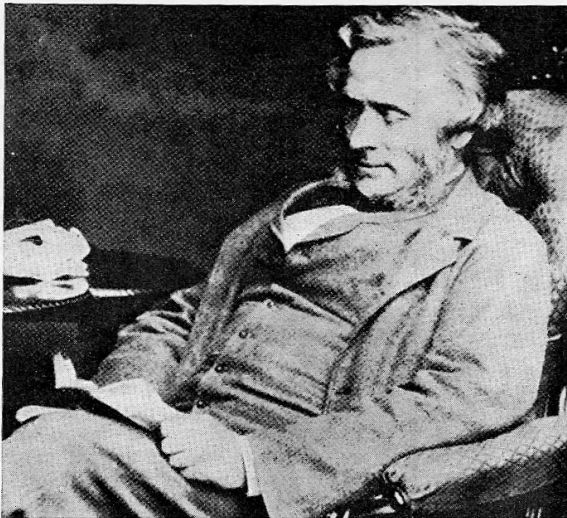
A unit of space was represented by the number 1 and the act of operating on that unit to generate a standard unit weight of different elements by various Greek letters. Substitution into experimentally determined chemical equations, and the use of a set of self-consistent algebraic operations, allowed one to derive operator symbols for other elements and compounds. One result of this was that certain elements came out as composite symbols, such as $\alpha\chi^2$ in the case of chlorine (see verse five of Brough's poem). In the 18th century, Lavoisier, in order to maintain his oxygen theory of acidity, had speculated that chlorine was actually an oxide of a hypothetical element he called the muriatic radical (or muriaticum). Despite the work of Davy on the elemental nature of chlorine, this suggestion continued to lurk in the chemical subconscious and Brodie's result served to reawaken interest in the idea that certain elements might actually be compound in nature.

Brodie's calculus had no lasting impact on chemistry. However, it did stimulate a good deal of discussion and forced chemists to reconsider their assumptions in using the atomic theory. Brodie's calculus, and the debates surrounding it, have been the subject of numerous papers³ and at least two books.^{6,9}

Attacks on graphic formulae

Odling was also outspoken on the subject of atoms and graphic formulae. On the evening of 16 April 1868, Dr Frederick Guthrie signed the statute book and was formally admitted as a fellow of the Chemical Society. The same evening he read a paper before the society in which he proposed his own set of graphic formulae. Each element was represented by a geometric form, the number of sides of which gave its atomicity or valency. Thus monads were represented by various shaped points, diads by lines, triads by triangles etc. Some examples of Guthrie's formulae are shown in Fig. 2, and they are satirised in the top half of Fig. 1. Odling apparently used the question and answer period which followed to do a stand-up comedy routine at Guthrie's expense. The *Chemical News* reported that:

'Dr Odling regretted the absence of Dr Frankland, who was so warm an advocate



Modern chemistry

I'm all in a flutter; I scarcely dare utter
The words I have set to a jingle;
For I see at this table philosophers able,
Whose ears at my verses will tingle.
Still, I don't mind confessing, I'm fond of expressing
My notions and thoughts, in defiance
Of every great gun who can't see the fun
Of winnowing chaff out of science.

I've read till I'm weary books weighty and dreary
In which certain chemists seem aiming
To prove to outsiders they're excellent riders
Of hobbies in theory and naming.
With 'monads' and 'diads', and 'pentads' and 'triads',
My brain has been addled completely;
And what's really meant by 'something-valent',
Is a question I give up discreetly.

Though Frankland's notation commands admiration,
As something exceedingly clever,
And Mr Kay Shuttleworth praises its subtle worth,
I give it up sadly for ever:
Its brackets and braces, and dashes and spaces,
And letters decreased and augmented
Are grimly suggestive of lutes to make restive
A chemical printer demented.

I've tried hard, but vainly, to realise plainly
Those bonds of atomic connection,
Which Crum Brown's clear vision discerns with
precision
Projecting in every direction.
In fine, I'm confounded with doctrines expounded
By writers on chemical statics,
Whom jokers unruly may designate truly
As modern atomic fanatics.

I turn for instruction to Brodie's production,
But stick at the famous equations
Which make chlorine fare as 'alpha ki square',
Or the product of three operations.
It may be the case that the 'unit of space'
Requires symbolic expression;
But I cannot extract any notions exact
From Sir Benjamin's daring aggression.

For years I received the doctrines believed
About acids with much satisfaction,
And constantly swore H_2SO_4
Was an acid above all detraction;
But Williamson's views my notions confuse,
And make me once more undecided
Whether old SO_3 the acid should be,
Or merely a fragment divided.

When Odling with unction dilates on a function,
I sink out of sheer inanition;
For I find his 'aplones' and 'diamerones'
Indigestible mental nutrition.
In fact, I am dazed with the systems upraised
By each master of chemical knowledge,
Who seems to suppose that truth only grows
In the shadow of one little college.

John Cargill Brough

of the policy of introducing these pictorial methods of representation. For his own part, he looked upon them much in the light of 'picture alphabets' and applicable only to those who, like juveniles, could not be brought to book without such fascinating aid'.¹⁰

Guthrie felt compelled to reply to Odling's remarks several weeks later in a letter to the *Chemical News* with some one-liners of his own:

"The vivacious onslaught committed by Dr Odling on graphic formulae in general, and on Dr Brown's especially, and of which a judiciously subdued account appears in your report, I would willingly leave for reply to Dr Brown. But as the "humorous remarks" were called forth by my modification of Dr Brown's scheme, I may be allowed a few words of reply.

"In support of the use of graphic formulae, I am fortunately able to cite an authority of whom I have no doubt Dr Odling entertains a very high opinion. This authority is Dr Odling himself.

"In his "humorous remarks" Dr Odling appeared shocked at the idea of an atom of nitrogen supporting three "sticks", one in each hand, and one on its head. Strange objection from one who years ago trained his atom of nitrogen to the much more difficult acrobatic feat of balancing simultaneously three sticks on the tip of its nose—N".

"Or would not our Secretary rather liken his accents to an advertisement on the part of the element? "Willing to adopt, three hydrogen babies, or an oxygen boy and a hydrogen baby, or a full-grown phosphorus adult. Apply to N., care of Dr O." etc., etc?"

"In seriousness, I am far from wishing to depreciate the system of accents introduced by our humorous Secretary. But as the formulae constructed with them are to all intents graphic formulae, I am at a loss to understand why the graphic formulae introduced by Dr Brown should have so terrified our Secretary that he has sought refuge from Dr Brown's "sticks" even beneath the once detested "buckle" of Kolbe....

"... I refrain from following Dr Odling in his connubial illustrations, which combined great humour with considerable pathos".¹¹

The 'buckle of Kolbe' probably refers to the extensive use of the curly bracket made by the German chemist in his famous *Ausführliches lehrbuch der organischen chemie*, published in 1854.¹² The author of the satirical drawing in *Fig. 1* was not given by Scott. However, Odling's name appears among the members of the B Club and one strongly suspects he is the guilty party.

Odling was not without sin himself, as shown in the final verse of Brough's poem. 'Aplones' and 'diamerones' are again terms introduced by Laurent and used by Odling in his own text, *A manual of chemistry*, published in 1861.¹³ Molecules containing two distinct complex groups or radicals, each capable of being replaced in a substitution reaction, were diamerones. Those containing only one radical, and in which, therefore, only individual atoms could be substituted, were aplones. The phrase 'dilates on a function' probably refers to the fact that Odling was known for

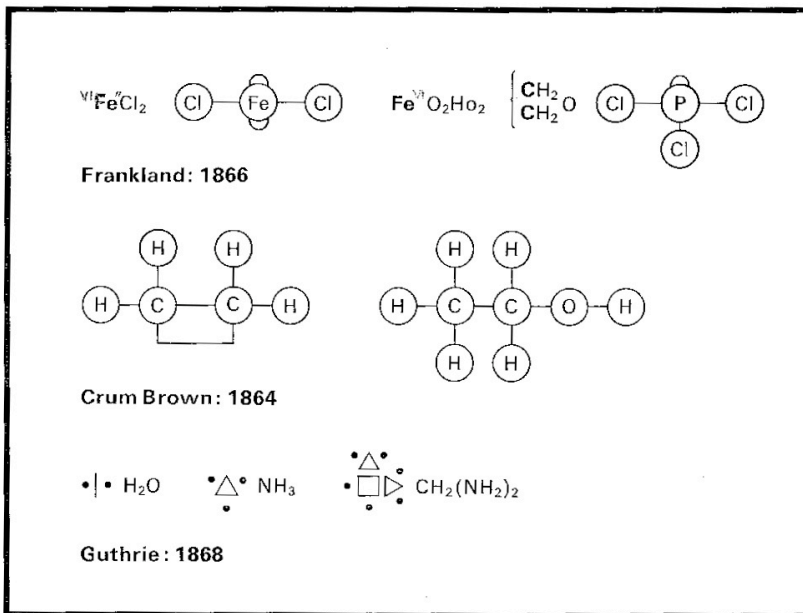


Fig. 2. Some examples of chemical notations of the period.

his tendency to develop elaborate, and often purely formal, classification schemes—a practice he shared in common with Laurent and Gerhardt, the two French chemists whose work he admired, and one which led him to within a hair's breath of discovering the periodic law.¹⁴ He divided the elements into the classes of artiads and perissads (even and odd valency), and in his text he talked about the interrelation of organic functions using Gerhardt's homologous, isologous, and heterologous series, and about acidulous, chlorous, and basyous functions.

Acid-base theory

In 1864 the Chemical Society appointed a committee to report on the state of chemical nomenclature. Later that year the chemist Alexander Williamson published a paper offering his criticisms and recommendations for nomenclature reform.¹⁵ These criticisms included suggestions for the use of the words acid and base, and are the subject of verse six of the poem.

Largely through the work of Liebig, Gerhardt, and Laurent, the words acid and base had been transferred from the oxides (eg SO_3 , CO_2 , and Na_2O) to the corresponding 'hydrated' compounds (eg H_2SO_4 , H_2CO_3 , and NaOH). Williamson pointed out that the experimental evidence showed that such species as H_2SO_4 and HCl were actually hydrogen salts and completely analogous to such metal salts as Na_2SO_4 and NaCl . They should, therefore, be given the salt-like names of hydric sulphate, hydric chloride etc, rather than names using the special terminology of acid or base.

The terms acid and base originally referred to highly unsaturated species, of opposite character, which neutralised one another to give saturated salts:



Acids and bases were typified by addition reactions; salts by substitution reactions. Hence, Williamson recommended that the terms acid and base be transferred back to the anhydrides. The situation is similar to that existing today between the Brønsted and Lewis definitions. The Lewis definitions regard H_2SO_4 as an acid-base adduct and reactions (1) and (2) as neutralisation reactions. The Brønsted definitions regard H_2SO_4 as an acid and ignore the existence of reactions (1) and (2).

The closing lines of Brough's poem are good advice. They apply not only to the debates of his day but to those which came before and have come after. The debates in the 1830s and 1840s which led to the demise of the dualistic theory and the triumph of the type theory were so bitter that Laurent, one of the major participants, could say before his death in 1853, 'I was an imposter, the worthy associate of a brigand etc, etc, and all of this for an atom of chlorine put in the place of an atom of hydrogen, for the simple correction of a chemical formula'.¹⁶ In the 1930s we can cite the debates between the Robinson and Ingold schools of organic chemistry and, more recently, between those advocating different approaches to the use of orbital symmetry in predicting chemical reactivity.

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