A NEW CHEMICAL SYSTEM?

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SUMMARY: It is argued that Ouahes' proposal to replace the current symbols of the chemical elements by periodic meaningful ones should not be adopted. If such a chemical revolution would prove to be necessary, then the new symbols must be related to the atomic numbers, by which the elements are characterized. Using numerical roots, introduced by IUPAC, such a set of retinol symbols, with matching names, can easily be devised.

Key Words: Symbols of the chemical elements, periodic system.

INTRODUCTION

In about 1790 Lavoisier gave chemistry a face-lift. He insisted on using well-defined concepts and accurate measurements, and he was instrumental in devising a nomenclature for the elements and their compounds. But the symbols, still in use today, are mainly due to Berzelius.

Recently, Ouahes (1) proposed new symbols for the elements. The reason for doing so is the fact that the current symbols do not relate in any way to the properties of the elements, and that chemical education might profit from a simple set of symbols that is easier to memorize. In his opinion, each symbol should be rational and convey information about the electron distribution of the free atom.

Ouahes' rationale amounts to the idea that the new symbols should contain as many straight lines as the rank of the valence shell of the appropriate atom. To denote Main Group elements consisting of atoms with valence electrons in the first, second, third, or fourth shell, Ouahes chose the Roman capitals I, L, N, and M respectively. Indeed, the number of strokes needed to write down each of these letters, is equal to the rank of the shell in question. The problem arising from the fact that the Roman alphabet has no five-stroke capitals was solved by chosing O to represent the fifth shell. Now, by adding strokes again, Ouahes found the symbols P and R to represent the sixth and seventh shell, respectively. To facilitate comparison with other representations, Ouahes' shell-indicators have been summarized as Set 2 of Table 1. Unfortunately, Ouahes did not give a symbol for the eight shell, for it would be interesting to learn how he would have solved the second next-stroke problem.

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Seven symbols are not nearly enough to mark each of the hundred odd elements. Therefore, Ouahes differentiated between Main Group elements, of which the atoms have the same valence shell, by adding a superscript (denoting the total number of valence electrons) to the right of the appropriate Roman capital. Thus, the new symbol of Li is L^1, and Ne becomes L^8. The problem of the transition and inner transition elements was cleverly solved by adding one small capital (denoting the inner shell) to the large capital for the outer shell. Now the new symbol of Mn becomes MN^7, and U is changed to Ro^6.

In Table 5 of his article, which is a Periodic Table, Ouahes (1) arranged the new symbols of the elements, up to and including element 109. This table has the usual format, with a separate f-block (2), and one may wonder, why Ouahes did not use Mills' version (3), in favor of which he gave many arguments, and which he recommends so ardently (4-6).

Reviewing his work as an advocatus diabolic, Ouahes nevertheless comes to the conclusion that his "new 'ALPHABET' of chemistry .... could be a universal tool for a better learning all over the world". Our conclusion, to be substantiated in the next sections, is not that positive.

THE LETTERS

Before choosing his set of letters, Ouahes considered using the numerical roots, introduced by IUPAC (to create provisional names for elements with z > 103 (7)). This possibility was rejected, because "We still need to know Latin or Greek roots to deduce the meaning of the symbols, and nowadays most scientists ignore Latin and Greek languages". This statement is preposterous. Modern science (especially the medical science) is riddled with terms of Greek or Latin origin. Glacing through the index of a general chemistry text yielded: atom, barometer, catalyst, detergent, element, formula, gas, helix, ion, ..., zymase. Even the names of modern chemical concepts, such as hybridization and the nephelauxetic effect, are often derived from the classical languages. Evidently, Latin, once the European language of science, still exercises influence from the grave.

From the moment Ouahes decided to use Roman capitals, it was clear that he could not pursue his rationale to the end. So he chose O to represent the fifth shell. If his reference to Indian digits ("the number 5 is represented by a loop") is meant to be taken seriously, then he could have defended the choice D (instead of O) just as well. Not only can D be associated with the Roman number 500 (which reduces to 5 if the zero's, signifying nought anyway, are neglected), but his next symbol, P, can be obtained by adding a stroke to D, but not by adding one to O.

A real problem arises when Ouahes' symbols are

Table 1: Sets of symbols for the electron shells.

Shell	1	2	3	4	5	6	7	8
Set								
1	K	L	M	N	O	P	Q	R
2	I	L	N	M	O	P	R	?
3	I							
4	A	B	C	D	E	F	G	H

compared with the current ones, given in Set 1 of Table 1. Amazingly, Ouahes seems to be rather pleased when he notices "only three slight differences". But if his proposal is adopted, then it has to be taught, presumably by a chemistry teacher who is familiar with the current representation. This teacher is seeking that some symbols are unchanged, some are changed, and some are interchanged. In short, he observes the ingredients of utter confusion. Clearly, Ouahes paid to the maxim: if you want change, then change drastically.

It is possible to construct a set of shell-indicators that is in full agreement with Ouahes' rationale. One can even impose the condition that each symbol must be *derived* from the previous one by adding one stroke, just as an electron shell can be built from the previous one by adding one (appropriate) sub-shell. At first symbol we take a vertical stroke. In its end-point a similar stroke is drown perpendicular to the original one. First the strokes are added in a counter-clockwise manner, but each time when a closed figure is obtained, this procedure is reversed. To ensure that the symbols are all of the same size, the square (that represents the fourth shell) is halved in the vertical direction, before a fifth stroke is added. The result of this procedure is Set 3 of Table 1. The first four symbols can be regarded as (sometimes styled) Greek or Roman capitals. The sixth symbols looks like a Cyrillic letter, and the next two resemble Chinese ideograms. This international aspect might prove favorable for world-wide acceptance. Comparing Set 3 with Set 1, it is seen that only the symbols for the second shell happen to be identical. If this is felt to be undesirable, then each symbol of Set 3 could be replaced by its mirror image.

To Table 1 we have added Set 4, consisting of the first capital letters of the Roman alphabet. The correspondence is now so clear, that it can be grasped by a child.

Unlike Ouahes' Set 2, Our Sets 3 and 4 are completely rational and liable to extension to higher shells. Possible confusion with whatever element of Set 1 is essentially nonexistent. It seems that now the intended change is sufficiently drastic.

THE SUPERSCRIPTS

Ouahes' superscript takes the place that is currently used for noting down the ionic charge. His solution of this problem ("Fe^{3+} is written either $(M\textsc{n}^{8})^{3+}$ or $M_N{}^{8+++}$") leads to cumbersome symbols. Not so in Ouahes' opinion, "since we are used to several right superscripts especially in chemical thermodynamics". But the unfortunate fact that cumbersome, if not downright clumsy, symbols are still being used in some fields of chemistry cannot be a valid argument for the introduction of cumbersome symbols in a field where none such existed before. Besides, the cumbersome symbols of chemical thermodynamics would become even more cumbersome.

How chemical formulae would look like, if Ouahes' proposal were adopted, can be illustrated by a simple example. The current formulae of lithium cyanate and lithium fulminate are LiOCN and LiCNO, respectively. The difference between the two is seen at a glance. The new formulae would be L^1 L^6 L^4 L^5 and L^1 L^4 L^5 L^6, respectively. One has to look very carefully now, in order to distinguish between the small printed superscripts. In fact, each time one wishes to consult the chemical literature, one (especially the older chemist) had better a magnifying glass at hand. As the new system would probably be prone to typographical errors, proofreading would become a punishment.

Instead of furthering chemical progress, adoption of Ouahes' proposal seems to be taking a step backwards.

A THEORETICAL OBJECTION

The new symbols are said to be meaningful, because they "refer to the building-up principle", and thus contain "the full information needed to predict chemical facts". However, Madelung's rules (8) are a consequence of the *assumption* that the electron cloud of an atom can be divided into shells and sub-shells. Much experimental evidence supports this shell model. Consequently, it is a good description of the electron distribution, but it is an *approximation* just the same. Perhaps this can be appreciated best by considering its theoretical foundation.

If we assume that the wave function of an atom can be built from orbitals only, then the simplest quantum mechanical treatment (known as the Hartree-Fock approximation) of the atom results in the shell structure of its electron distribution. The Hartree-Fock treatment of the ground state of the helium atom yields about 98.5 per cent of its total energy, but to find the exact non-relativistic value, the orbital picture (and thereby the shell model) has to be abandoned. For larger atoms the Hartree-Fock description becomes less accurate, because then relativistic effects cannot be neglected any more.

The notion that the electron population of the valence shell(s) of an atom determines its chemical behavior, is only true to some extent. According to Laing (9) "the electron configuration route is fraught with detours and dead ends". Even if one can deduce from the symbol M_N^7 that the other shell electron configuration is $3d^5$ $4s^2$, then this information is hardly helpful to understand the complex chemistry of manganese.

The notion that an atom of a Main Group element tends to react in such a way that its electron configuration changes to one with closed (i.e., completely filled) shells or sub-shells, leads to the well-known octet rule. On this basis, Main Group metals can form positive ions only, and noble gases cannot react at all. Indeed, such was chemical theory some 30 years ago. But in 1962 Bartlett (10) mixed equal volumes of platinum hexafluoride vapor and xenon gas. At *room temperature* a reaction took place, yielding solid $XePtF_6$, the first genuine compound of a noble gas. In 1974 Dye et al (11,12) synthesized solid $Na_2C_{18}H_{36}N_2O_6$. Its structure can, simplified and be written as NaC^+. Na^-, in which NaC^+ represents a cage complex containing a trapped sodium cation. As far as is known, this was the first time that a compound with a metal *anion* was formed.

These two examples suffice to show that the theory founded on the electron population of outer shells was *incapable* to predict recent discoveries. It may even have hampered chemical progress. The future development of quantum chemistry might eventually provide a detailed picture of atomic structure, and expose the shell model as only its first approximation. But this means that Ouahes has based his symbols on a theory that may become obsolete. In that case, the current symbols are to be preferred, if only because they do not depend on pictures of the electron structures of the atoms.

AN EDUCATIONAL OBJECTION

About the *names* of the elements Ouahes only remarks that "Naturally there is no more link between the name and the symbol ....". Clearly, he intends to retain the current names of the elements and to change their symbols only. This half-revolution causes educational problems. For example, to recognize $M^2L^7_2$ as the formula of calcium fluoride, the student must at least know that M^2 is named calcium and that L^7 is the symbol of fluorine. But how should these correspondences be taught? A teacher can choose between the meaningless way of learning them by heart, and the meaningful way based upon a Periodic Table of suitable format.

If the first method is adopted, then a student's capability to memorize would be much more stressed than at present. This follows immediately from a comparison of assignments such as "Learn by hearth: I^1 is named hydrogen; I^2 is named helium; L^1 is named lithium; and so on", and "Learn by heart: H is named hydrogen; He is named helium; Li is named lithium; and so on". A few weeks after some 40 elements have been treated in this way, the student starts to forget. If he now tries to remember the symbol of nitrogen, say, he may waver between N and Ni, and he has equal chances of picking the right chance of choosing L^5.

If a Periodic Table is used, then families like the halogens and the noble gases could be memorized in the right order and associated with their numbers of valence electrons. But now a detailed knowledge of the structure of the Periodic Table is a necessity, so that quite a bit of physics needs to be known beforehand. For an elementary course in chemistry this might prove too heavy a burden.

Whatever method is used, the student would need some frame of reference, being the Periodic Table in this case. Instead of making this table redundant ("using the new symbols we do not any more need to refer to the periodic table of the elements"), it seems that Ouahes' proposal would make it indispensable more than ever.

This section could have been omitted, if Ouahes had only complemented his proposal with a concise new nomenclature. As it stands now, it is doubtful whether his symbols "will make learning chemistry more attractive...".

A PRACTICAL SOLUTION

A chemical element can not be defined on the basis of the electron structure of its atoms. For example: Na^+ has the same electron configuration as Ne, but this does not make Na^+ a particle of the element neon. Conversely: Na^-, Na and Na^+ have different electron configurations, but all are particles of the element sodium. We submit that the *only* property, by which a chemical element can be characterized, is the atomic number of its constituent particles.

If one *really* wishes to replace the current symbols of the elements by meaningful ones, then the new symbols must be related to the atomic numbers. Since IUPAC published numerical roots (7), such a system with a *matching nomenclature* can be introduced at once. Thus, hydrogen becomes unium (U), sodium becomes ununium (Uu), the brand-new element 111 becomes unununium (Uuu), and so on. But this Great Change would involve peculiar transmutations, such as

H --> U, a late homage to Prout, and

Tm --> He --> B --> Up.

The current rules for naming compounds (possibly adapted a little) can readily be applied. For example: barium sulfide, barium sulfite, and barium sulfate now become penthexium unhexide, penthexium unhexite, and penthexium unhexate, respectively. The alkanes are now named unane, biane, triane, quadane, pentane, hexane, septane, octane, ennane, unnilane, etc. The alkenes and alkynes can be treated similarly. As names like iron, fer, Eisen, Wörn, and so on, are all replaced by bihexium, the new nomenclature is essentially the same in any language.

The New Chemical System is astonishingly simple. One could not afford letting this chemical egg of Columbus go to waste, and one should applaud Scott (13) for demanding its immediate introduction. Whatever the costs.

But would *you* want to trade tasty sodium chloride for sterile ununium unseptide?

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