

The "New Look" for THE PERIODIC SYSTEM

PAUL A. GIGUERE, F.C.I.C.,
Université Laval, Québec, Qué.

Devising new forms of the periodic classification of the elements has been a favorite pastime with chemists ever since Mendelée⁽¹⁾ discovered the Periodic Law nearly 100 years ago. Here is yet another one, based primarily on the electronic structure of the atoms, and featuring the use of color and the third dimension for a more lively and meaningful presentation.

Every chemist worth his sodium chloride has, or at least had at one time, his favorite form of the periodic system of the elements. Quite a few, unsatisfied with any in the innumerable variety available, go on to invent their own. In point of fact this is often assigned as a profitable exercise to chemistry students. In his extensive, yet admittedly incomplete, monograph on the subject Mazurs⁽²⁾ quotes no less than 600 individual references and reproduces one hundred or so tables. A look at the current *Chemical Abstracts* index will confirm that the topic is far from exhausted. The fact that the ideal representation of the periodic system has not been found is considered by some as a challenge, even if it be sheer utopia.

Long ago Rudorf⁽³⁾ admonished that "everyone who intends to derive a new form of the table should first take the trouble to examine the earlier literature in order to avoid unnecessary repetitions . . ." Having satisfied myself that the model I have imagined had not been reported before, at least not in the "open" literature, I can proceed with a clear conscience to describe it hereafter. Let me say at the outset that it involves no new principle; its novelty rests mainly in the physical presentation. Like all the other modern versions it is based mainly on the electronic structure of the elements. This, as we know, is the all-powerful principle, firmly grounded in both theory (quantum mechanics) and experiment (atomic spectroscopy), which has finally made the whole subject rational and intelligible by lifting it above the level of mere empiricism*. Therefore, it is only logical that electronic corre-

lations be emphasized, and prevail over chemical or physical analogies whenever there is uncertainty or conflict.

Contrary to the great majority of previous efforts the present one is not a table but a three-dimensional model (Fig. 1). Now, a number of such models have been proposed before in the guise of spheres, helices, cones, prisms, etc. In general they have been considered impractical, being difficult to reproduce and carry about; whereas a table is so readily printed and slipped into a book. Another serious objection is that the whole periodic classification cannot be seen at a glance in a three-dimensional model. On the other hand, it certainly makes the presentation a lot more vivid and striking; a great advantage in the art of teaching. A new dimension is added, not only physically but also psychologically.

The model proposed here partakes of these qualities and defects. However, being composed in the main of two interlocking planes, made from sheets of transparent plastic, it is fairly easy to construct, and can be readily dismantled for storing flat. Fundamentally its great advantage is that it allows a clear-cut separation of the four main groups of elements according to the type of atomic orbitals being filled; viz. *s*, *p*, *d*, and *f*. Previously this essential separation had been achieved only at the expense of continuity; for instance by breaking up and separating widely the short periods, as in the so-called long form of the table, or by reversing occasionally the natural sequence of the elements, or again by placing on different lines various groups of elements of the same period. As for the poor lanthanides and actinides, they were invariably relegated to the bottom, as in a footnote, to avoid making the table uncomfortably long.

In the new arrangement the unbroken sequence of the elements follows from left to right, turning around corners or at the end of a row. Passage

from one period to the next is clearly marked by a curving of the horizontal lines at the junction of planes *p* and *s*. To help in identifying the various atomic orbitals the principal quantum number is shown on a triangular marker at the end of each row. Thus the complete electronic configuration is shown in detail, and in the correct order energywise, for any element . . . save a few exceptions. Indeed, nature is not simple, unfortunately, and in a dozen or so cases, the "normal" order of filling up the electronic orbitals, after the "Aufbauprinzip", is not followed strictly. For instance, because of the extra repulsion between electrons with parallel spins (Hund's rule) the actual ground state configuration for chromium is [Ar 3d⁵ 4s¹] instead of the expected [Ar 3d⁴ 4s²]. These few exceptions are usually overlooked to avoid disrupting the basic regularity of the periodic system. At any rate their importance is rather academic since the ground state of the free atoms can be achieved only under exceptional conditions. Besides, in a number of cases, especially among the heavier elements, the true ground state configuration is not yet known with certainty. If necessary these few exceptions may be singled out, for instance, by means of a dot in the upper right-hand corner of the "box".

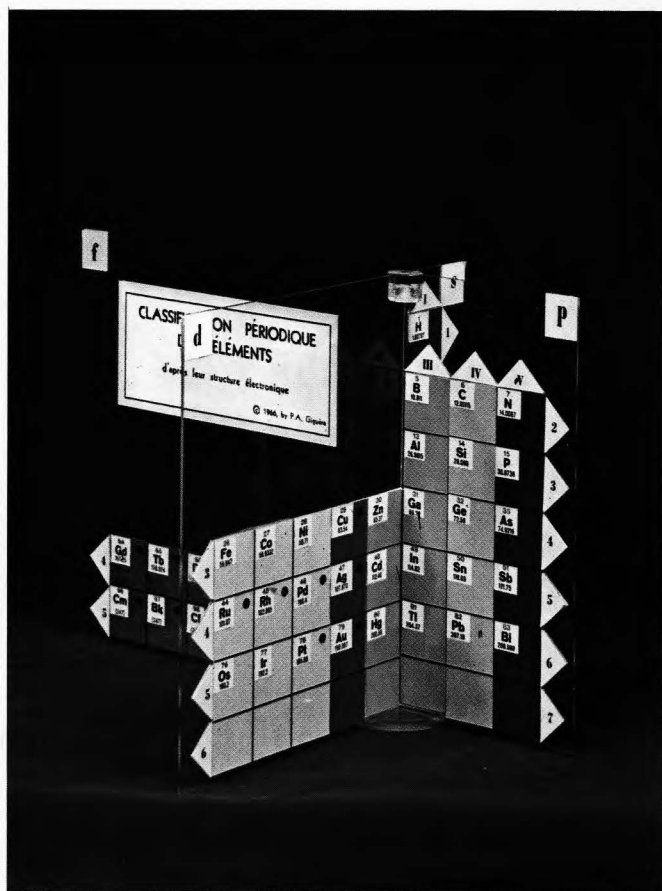
Incidentally, by following the electronic configuration as a clue one finds at last the answer to that perennial—and still debated⁽⁴⁻⁶⁾—riddle of the position of hydrogen in the periodic classification; clearly an impossible assignment from the viewpoint of chemical or physical relationships alone. By the same token helium must be located in the *s* plane above beryllium. The dissimilarity between the two is hardly worse than between hydrogen and lithium. As explained below the membership of helium in the rare gas family is indicated by means of the color scheme.

* * *

Malgré la prépondérance indéniable des relations de structures électroniques sur les ressemblances physiques et chimiques, celles-ci n'en conservent pas moins une importance capitale dans l'arrangement des éléments. Non seulement dans l'ordre historique mais encore dans la pratique, puisque l'un

*It is amusing to recall here that Mendelée⁽¹⁾ himself had no use for theoretical speculations. He once said, in his Faraday lecture before the Chemical Society of London (1889):

"The Periodic Law, based as it is on the solid and wholesome ground of experimental research, has been evolved independently of any conception as to the nature of the elements; it does not in the least originate in the idea of a unique matter; and it has no historical connection with that relic of the torments of classical thoughts."
A nice sample of Dialectic Materialism!



des buts principaux de la classification périodique est justement de souligner ces ressemblances. Dans notre modèle nous utilisons à cette fin une combinaison de couleurs en plus de l'arrangement traditionnel par colonnes des éléments de chaque groupe. Une dizaine de couleurs différentes sont nécessaires; soit une pour chacun des huit groupes majeurs, plus une neuvième pour le triple sous-groupe désigné jusqu'ici par le chiffre VIII, et une dernière pour les lanthanides et les actinides. Il est clair que cet artifice, tout comme la troisième dimension, ajoute beaucoup de vivacité à l'ensemble; plus important encore il permet de trancher certaines questions épineuses restées jusqu'ici sans solution satisfaisante.

En effet, il n'est plus nécessaire de désigner chaque colonne par un chiffre romain suivi de la lettre A ou B, comme on en avait l'habitude, pour différencier groupes et sous-groupes. Sur ce dernier point l'absence d'uniformité a conduit à la regrettable confusion que l'on sait, plusieurs auteurs appelant A les groupes majeurs (éléments s et p) et B les groupes de transition (éléments d), ce qui semble assez logique, tandis que d'autres, presque aussi nombreux, préféraient continuer la série A à travers les éléments de transition jusqu'au sous-groupe VIII pour débiter ensuite la série B avec le groupe du cuivre. Toutes ces indications deviennent superflues avec notre modèle. Pour ceux qui trouveraient trop brusque cette rupture avec la tradition on peut imaginer la solution intermédiaire que voici: les groupes majeurs portent en tête la suite des chiffres romains jusqu'à *et y compris*, VIII pour les gaz rares (ce qui ne s'était jamais fait jusqu'ici, on se demande pourquoi). Quant aux groupes de transition, ils portent aussi en tête le chiffre romain approprié, mais en prime, en commençant par III' pour le scandium. Enfin le triple sous-groupe des métaux ferreux, et ceux de la mine du platine, peut être désigné soit par l'en-tête commun VIII' vu que les relations chimiques et autres deviennent horizontales au lieu de verticales, ou encore séparément par les chiffres VIII', IX' et X', pour le fer, le cobalt et le nickel, suivant le nombre total d'électrons s et d dans la couche externe. Mais ce sont là des solutions de compromis, nettement moins élégantes et logiques que le schéma de couleurs.

De toute façon il est certain que le présent modèle ne saurait satisfaire toutes les exigences, et les chimistes vont continuer à rechercher la perfection, là comme ailleurs.

References

- (1) Mendeléev, D. (or Mendeléeff, Mendeleyev, Mendelejev, Mendéléiev, etc.) Zhur. Russ. Khim. Obshchestva. 1, 60 (1869).
- (2) Mazurs, E. G., "Types of Graphic Representation of the Periodic System of Chemical Elements". Published by the author, La Grange, Ill., U.S.A.
- (3) Rudorf, G., "Das periodische System . . ." Voss, Hamburg u. Leipzig, 1904.
- (4) Dash, H. H., Nature. 202, 1001 (1964).
- (5) Hawes, L., Nature. 206, 188 (1965).
- (6) Bankowski, Z., Nature. 209, 71 (1966).

1967 CONGRESS OF CANADIAN ENGINEERS PROGRAM

Eleven major engineering societies in Canada including The Canadian Society for Chemical Engineering, are meeting together next year as the 1967 Congress of Canadian Engineers.

The emphasis of the program is on new rather than the already-known, and will comprise four parallel sessions.

The first session covers the major engineering challenges in Canada during the next decade; the second focuses on the techniques and trends needed to handle these challenges; the third deals with people, the engineer himself and his situation in the Seventies. The fourth (and possibly fifth) sessions include the more specialized papers on new engineering developments and research.

Session I is dominated by the question, what will be through technology the new limits of Canada's four frontiers—space, Arctic, Oceans, Earth? Effective control and optimization of our greatest natural resource—water—is clearly a must; agriculture and transportation must expand but how far? Communication systems will be substantially bigger—more of the same or different? and the utilization of energy from fissionable atoms will be significantly greater and more varied.

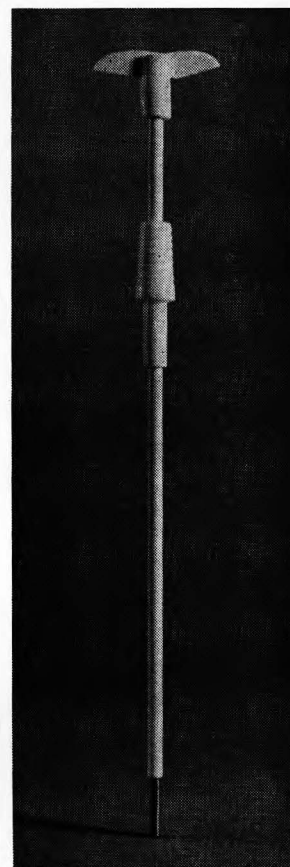
These needs constitute "super-problems" since they involve more than one jurisdiction under Canadian conditions. Their solution through systems engineering (adapted to suit the multi-jurisdictional Canadian scene) forms the core of Session II. Growth in population will require more products made from less material at lower unit cost, and trends in materials and processes to achieve this will also be studied.

The focus of Session III is on man, man the engineer. Will we have enough engineers and of the right kinds? How should engineers be trained for the Seventies initially and subsequently? A new age of bigger, better, and more remote machines will create an increasingly clearly defined interface between man and machines. What kind of society are we therefore creating, and will we as engineers and human beings like the society we are creating? And whatever problems we face in Canada, many nations face more serious ones. What are Canadian engineers and engineering doing for other peoples.

Where new ideas and solutions are already being developed, will be presented in more detail in Sessions IV and V for specialist papers.

Program chairman is W. H. C. Simmonds, C-I-L, Montreal. □

UNBREAKABLE!



How many lab stirrers have you broken lately?

Our Teflon and stainless steel unit will solve your problem

It's — self lubricating

— 24/40 Standard Taper

— \$29.50

SAVI PRODUCTS

74 Villa Crescent

Ottawa 5, Canada