The balance of advantages seems to lie with the selection of either Esperanto or Ido or some modification of them recommended by experts on language. The vital requirement is that the auxiliary language should be kept auxiliary, the vehicle of formal statement. If it should become a language of common speech, of emotion, or of literature it will at once fail of its purpose and be only an additional linguistic burden.—London *Times.*

SPECIAL ARTICLES

ATOMIC STRUCTURE

THERE has been considerable discussion in the literature, during the past few months, of the Lewis theory of atomic structure[1] and Langmuir's extension of it to the heavy elements.[2] In 1919 and 1920 the writer worked out a somewhat different extension of this theory. For various reasons its publication has been delayed, but in a few months a paper describing it in some detail is to appear. Because of this delay, a short outline of the theory may not be out of place here.

The *number* of electrons in each shell of the lighter atoms is the same as in the original Lewis theory. It is assumed, however, that the fifth, sixth, seventh and eighth electrons in the second and third shells pair off with the first four, the distance between the electrons in each of these pairs; and also in each pair formed by bonding between atoms, being much less than the distance between pairs. These shells are therefore tetrahedra of pairs instead of cubes of single electrons.[3] The electrons in each shell (after the second) tend to be placed opposite the centers of the faces of the imaginary polyhedron formed by the electron groups in the underlying shell. If a certain shell is a tetrahedron, the next shell out will also be a tetrahedron; if the inner shell is a cube, the outer shell will be an octahedron (six points, eight faces); and if the smaller shell is an octahedron, it will be surrounded by a tetrahedron—four of its eight faces then being occupied—or by a cube.

When the nuclear charge becomes sufficiently great, the same forces which cause pairing of electrons in nitrogen result in the formation of triplets in the inner shells of the heavier atoms. The type of force between electrons necessary to account for these phenomena is discussed in my longer paper and will not be considered here. As one after another of the outer electrons are drawn into an inner shell to form triplets, the remaining pairs are pushed further and further from the nucleus. This may result in rearrangement of the kernel structure, as indicated in the examples of atomic structure given below. Often, in different environments, different kernel structures are stable, some having more valence electrons and fewer triplets than others, etc.

The structures resulting from the application of the foregoing ideas I shall represent by means of formulæ, in which the first parenthesis represents the nucleus and indicates its charge, the remaining parentheses each representing a shell of electrons, in order from the nucleus out. The number of electron-groups and the number of electrons in each group are indicated for every shell, except (in some cases) the valence shell. Formulæ for atoms and ions of some of the elements follow:

H	$(+1)(1)$
He	$(+2)(2x1)$
C	$(+6)(2x1)(4)$
Ne	$(+10)(2x1)(4x2)$
Cl$^-$	$[(+17)(2x1)(4x2)(4x2)]^-$ or
	$[(+17)(2x1)(8x2)]^-$
A	$(+18)(2x1)(4x2)(4x2)$ or
	$(+18)(2x1)(8x2)$
Co^{+++}	$[(+27)(2x1)(6x3+2x2)]^{+++}$
Cu^{++}	$[(+29)(2x1)(5x3+1x2)(4x2)]^{++}$
Cu$^+$	$[(+29)(2x1)(6x3)(4x2)]^+$
Zn^{++}	$[(+30)(2x1)(6x3)(4x2)]^{++}$
Br$^-$	$[(+35)(2x1)(6x3)(8x2)]^-$
Kr	$(+36)(2x1)(6x3)(8x2)$
Ag$^+$	$[(+47)(2x1)(8x3)(6x2)(4x2)]^+$
Sn	$(+50)(2x1)(8x3)(6x2)(4x2)(4)$ and
	$(+50)(2x1)(6x3)(8x2)(6x2)(2)$
I$^-$	$[(+53)(2x1)(8x3)(6x2)(8x2)]^-$
Xe	$(+54)(2x1)(8x3)(6x2)(8x2)$
Ce	$(+58)(2x1)(8x3)(6x2)(8x2)(4)$ and
	$(+58)(2x1)(8x3)(1x3+5x2)(8x2)(3)$
Lu	$(+71)(2x1)(8x3)(6x3)(8x3)(3)$
Ta	$(+73)(2x1)(8x3)(6x3)(8x3)(5)$
Au$^+$	$[(+79)(2x1)(8x3)(6x3)(8x2)(6x3)]^+$

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[1] *J. Am. Chem. Soc.,* 38: 762 (1916).

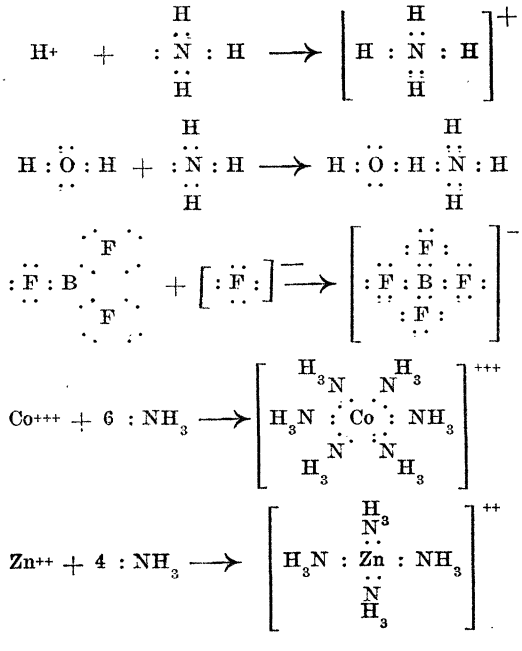
[2] *Ibid.,* 41: 868 (1919).

[3] *Cf.* Lewis, *loc. cit.,* p. 779.

Hg (+80)(2x1)(8x3)(6x3)(8x2)(6x3)(2)
and (+80)(2x1)(8x3)(6x3)(8x3)(6x2)
Nt (+86)(2x1)(8x3)(6x3)(8x3)(6x3) or
(+86)(2x1)(8x3)(6x3)(8x2)(6x3)(4x2)

These and similar formulæ for the other elements express very satisfactorily their known chemical, physical and crystallographic properties. By applying this theory to crystal structures, it has been found possible to determine the arrangements of electrons in nearly all crystals for which the arrangements of atomic centers were already known, and also the atomic and electronic structures *in many cases in which even the atomic marshalling was previously unknown.* These structures furnish incontrovertible proof that this theory of atomic structure, fundamentally and in many of its details, is correct.

An important part of the theory is the idea that a single bond may be formed not only by the attraction between two atoms, each of which contains an unpaired electron in its valence shell, the two single electrons forming a pair, but also by the attraction of an atom containing a "lone electronpair"—one not acting as a bond—for another capable of holding on to this lone pair. The following are typical reactions of this type:



$$H^+ + :\overset{H}{\underset{H}{\ddot{N}}}:H \longrightarrow \left[H:\overset{H}{\underset{H}{\ddot{N}}}:H\right]^+$$

$$H:\ddot{O}:H + :\overset{H}{\underset{H}{\ddot{N}}}:H \longrightarrow H:\ddot{O}:H:\overset{H}{\underset{H}{\ddot{N}}}:H$$

$$:\ddot{F}:B\genfrac{}{}{0pt}{}{:\ddot{F}:}{:\ddot{F}:} + \left[:\ddot{F}:\right]^- \longrightarrow \left[:\ddot{F}:\overset{:\ddot{F}:}{\underset{:\ddot{F}:}{B}}:\ddot{F}:\right]^-$$

$$Co^{+++} + 6\ :NH_3 \longrightarrow \left[\begin{matrix} & H_3N \quad NH_3 & \\ H_3N & :Co: & NH_3 \\ & NH_3 \quad NH_3 & \end{matrix}\right]^{+++}$$

$$Zn^{++} + 4\ :NH_3 \longrightarrow \left[H_3N:\overset{NH_3}{\underset{NH_3}{Zn}}:NH_3\right]^{++}$$

In the last two cases the lone pairs of the nitrogen atoms become bond pairs, assuming positions at octahedron corners opposite the six faces of the distorted cube of the cobalt kernel and at tetrahedron corners opposite the four previously unoccupied faces of the zinc kernel octahedron (or, what is the same thing, opposite the four faces of the zinc kernel tetrahedron). We thus have an entirely satisfactory picture of Werner's "auxiliary valencies" and "coordination numbers." In some cases (*e. g.*, in $Ag(NH_3)_2^+$) all the faces of the kernel polyhedron are not occupied. (In the silver iodide crystal, each silver kernel is surrounded by four electronpairs at tetrahedron corners, showing its true coordination number to be *four.*)

This theory has not yet been applied to the explanation of spectra; nor is it possible to give the *exact* positions of the electrons in each atom. These positions may in fact be merely the centers or foci of electronic orbits. In these and other respects the theory is still incomplete.

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A SIMPLE BUBBLING HYDROGEN ELECTRODE

THE electrode described in this paper is the result of an attempt by the writer to combine the principles of the bubbling type of electrode with simplicity of construction and the necessity for only a small amount of solution. That this has been accomplished, seems to be apparent from a study of the accompanying diagram and the behavior of the electrode in numerous tests.

Four models similar to the one shown in the diagram were constructed by the writer and compared with each other and a Bailey electrode. Various standard buffer solutions were tested and it was found that all electrodes gave results that agreed within .3 of a millivolt, which was the limit of accuracy of the galvanometer in the set up.

While the models constructed by the writer require only about 1.5 c.c. of solution, there seems to be no good reason why, with proper