

Letters to the Editor.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

Theories of Atomic Structure.

IN a letter to NATURE (March 11, p. 41) S. C. Bradford stated: "The great objection to Langmuir's theory of atomic structure is the difficulty of accepting his hypothesis of stationary electrons." The cases cited are all discussed in G. N. Lewis's paper, "The Atom and the Molecule" (Journ. Amer. Chem. Soc., xxxviii., p. 762, April, 1916), so it is scarcely fair to Lewis to refer to the theory as "Langmuir's theory."

Although Lewis frankly implied that the electrons in atoms are stationary, his theory of valency did not depend upon such an assumption. The chemical data give information in regard to the geometry of atoms, and, in particular, tell us of the kinds of symmetry which they possess. From the chemical point of view it is at present a matter of comparative indifference what the motions of the electrons may be so long as they conform to the required conditions of symmetry. For this reason I was careful to state in my first paper (Journ. Franklin Inst., clxxxvii., p. 359, March, 1919, and Journ. Amer. Chem. Soc., xli., p. 932, 1919) that "the electrons in atoms are either stationary or rotate, revolve, or oscillate about definite positions in the atom." It was, perhaps, not sufficiently emphasised that the positions of the electrons shown in the diagrams may be regarded as the centres of their orbits.

It is sometimes thought that the success of Bohr's theory furnishes reason for believing that all the electrons in atoms are rotating in coplanar orbits about the nucleus. There is little justification for this opinion. The remarkable results yielded by Bohr's theory, particularly in the hands of Sommerfeld, for the case of the hydrogen atom and the helium ion seem to prove beyond question that in an atom containing only one electron this electron actually revolves in a circular or elliptical orbit about the nucleus. Although Bohr's theory has had some applications to other atoms, these are, for the most part, of a very general nature, such as those which relate to the combination principle. The theory does not give a satisfactory model even for such simple structures as the hydrogen molecule or helium atom (see, for example, Sommerfeld's recent book, "Atombau und Spectrallinien").

From the chemical point of view Bohr's theory is wholly unsatisfactory when applied to atoms containing more than one electron. Thus, according to Bohr's calculations (*Phil. Mag.*, xxvi., p. 492, 1913), a lithium nucleus surrounded by three equidistant electrons should have less potential energy (and, therefore, greater stability) than one in which one electron is further from the nucleus than the other two. Bohr's theory thus gives no reason for the contrast between the properties of lithium and helium.

The two theories are not mutually incompatible if we consider that, in general, the electrons do not revolve about the nucleus, but about definite positions symmetrically distributed in three dimensions with respect to the nucleus. It is interesting to note that Born and Landé (*Verh. deut. physik. Ges.*, xx., pp. 210, 230, 1918), starting out from Bohr's theory and without knowledge of Lewis's work, were led to the theory of the cubical atom by a study of the compressibilities of the alkali halides. They conclude that the electron orbits do not lie in a plane, but are arranged in space with cubic symmetry. Sommerfeld

in his book suggests that this conception may help to solve some of the outstanding difficulties, and evidently does not consider it inconsistent with Bohr's theory.

In the case of atoms which do not share electrons with other atoms, it is logical to assume that each electron in the outer shell has its own orbit. Thus the atoms Ne, Na⁺, Mg⁺⁺, F⁻, and the S atom in SF₆ should have cubic symmetry, the eight outer electrons revolving about positions located at the corners of a cube. But where a pair of electrons is held in common between two atoms, the chemical evidence indicates that the pair acts as a unit. When an atom shares four pairs of electrons with its neighbours, it thus has tetrahedral rather than cubic symmetry. So far as the chemical evidence is concerned, it would be satisfactory to adopt Bohr's model for the hydrogen molecule to represent the pair of electrons which constitutes the chemical bond. We may thus picture the chemical bond as a pair of electrons revolving in a single orbit about the line connecting the centres of the two atoms.

Bohr in his 1913 paper (*Phil. Mag.*, xxvi., p. 874) states: "The configuration suggested by the theory for a molecule of CH₄ is of the ordinary tetrahedron type; the carbon nucleus surrounded by a very small ring of two electrons being situated in the centre, and a hydrogen nucleus in every corner. The chemical bonds are represented by four rings of two electrons each rotating round the lines connecting the centre and the corners." This structure is quite consistent with the octet theory. Bohr did not, in general, identify a pair of electrons with a valency bond.

When we consider, however, that Bohr's theory in its present form does not furnish an explanation of the stability of the pair of electrons in the helium atom and in the bond between atoms, it is evident that the model described above can scarcely be regarded as satisfactory. It seems as though some factor of vital importance is still missing in Bohr's theory. The chemical data suggest that the ultimate theory will be extremely simple, but perhaps more radical than anything yet proposed.

I am in full agreement with the views put forward by Dr. H. S. Allen in NATURE for March 18, p. 71.

IRVING LANGMUIR.

Research Laboratory, General Electric Co.,
Schenectady, New York, April 12.

Decimal Coinage.

IN NATURE of April 1, p. 145, reference is made to the unfavourable report of the Royal Commission appointed to inquire into the above subject. It would appear from a close study of the findings of the Commission that the failure to solve this century-old problem was due more to differences between the advocates than to opposition to the principle.

Although fifteen of the twenty Commissioners would prefer to decimalise the existing £ sterling rather than to create a new monetary unit equal to 100 halfpence, it is significant that only four of them could agree that the advantages to be secured by the decimalisation of the £ would outweigh the inconvenience arising from the change. This is tantamount to an admission that the method of dealing with the penny difficulty as proposed in Lord Southwark's Bill (£—mil) was unduly complicated. (No exact equivalent of the penny was provided, the choice of a 4-mil and 5-mil piece being alternatively offered.)

Retaining the £ as the unit, there are three possible values for the penny, viz.:

- 4 mils = the present penny less 4 per cent.
- 5 mils = the present penny plus 20 per cent.
- 4½ mils = the present penny exactly.

The claims of these denominations may be summed up as follows: