THE RESULT OF PLOTTING THE SEPARATION OF HOMOLOGOUS PAIRS AGAINST ATOMIC NUMBERS INSTEAD OF ATOMIC WEIGHTS.

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THE relationship between the characteristic spectra of the chemical elements and their atomic weights and chemical properties has been the subject of considerable study. Ramage,[1] Runge and Precht,[2] Watts[3] and Rudorf[4] may be mentioned among those who have sought for and established more or less definite connections between the frequencies of spectrum lines and atomic weights. In every case however there have been exceptions and discrepancies of such character as to indicate that while there is undoubtedly a real connection the true relationship has not been found.

Perhaps the most interesting contribution to this problem was furnished by Runge and Precht, in their attempt to determine the atomic weight of radium from spectroscopic evidence. They stated the following law: "In each group of chemically related elements the atomic weight varies as some power of the distance apart of the two lines of a pair," so that "the logarithms of the atomic weights and those of the distances when plotted as coördinates lie on a straight line for a chemically related group of elements." They are careful to apply this law only to "homologous" pairs of lines; homologous lines being characterized by similar behavior in the magnetic field.

Having established the generality of this law Runge and Precht applied it to the group of elements, magnesium, calcium, strontium, barium, radium. Extrapolating for the latter element they obtained a value of 257.8, which disagreed by 13 per cent. from the value obtained by Mme. Curie by chemical methods. Runge and Precht point out that the Curie value may be expected to be too low by reason of the effect of impurities. Nevertheless the high value obtained by them is generally considered incompatible with the place of radium in the periodic system and the spectroscopic method is to some extent discredited.

[1] Proc. Royal Society, LXX., p. 3, 1901.
[2] Phil. Mag. (5), 476, 1903.
[3] Phil. Mag., July 1903, August, 1904.
[4] Zeits. Phys. Chemie, 50, p. 100, 1904.

The spectroscopic value would probably be entitled to more consideration were it not for the fact that other exceptions than radium were found to the law. The existence of exceptions of course detracts seriously from the applicability of any rule for purposes of prophesy. Thus boron and potassium were noted by Runge and Precht. With regard to boron they remark that it had not been examined in a magnetic field so that their choice of lines might be at fault. In regard to potassium the following highly significant remark is made: "It appears to us interesting that the straight line law is appreciably departed from precisely in the case of the element whose atomic weight in the periodic system points to an unknown disturbing cause, which produces the inversion of the positions of argon and potassium."

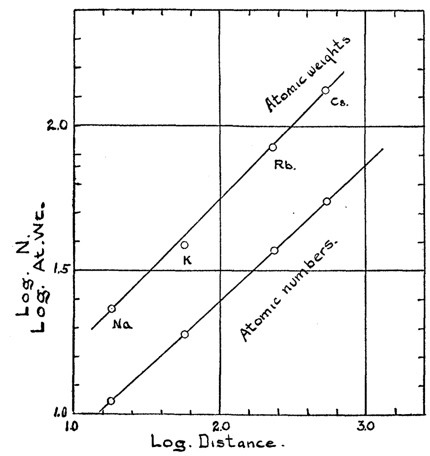

Fig. 1.

Within the past year it has been strikingly demonstrated by the work of Mosely[1] that the most characteristic figure connected with a chemical element is not its atomic weight, but its *atomic number*, which is identified with the charge on the positive nucleus of the Rutherford atom. Not only are these atomic numbers whole numbers but the various elements follow each other in the order of their chemical properties without the inversions found in the cases of nickel and cobalt, argon and potassium, tellurium and iodine, when atomic weights are considered. The periodic system should apparently be built around atomic numbers, not atomic weights.

It occurred to us that the problem of the relation between chemical properties and spectroscopic phenomena might be assisted by recourse

[1] Phil. Mag., *27*, p. 703, 1914.

to the newer reference frame. We have therefore re-plotted the figures used by Runge and Precht, with interesting results.

In Fig. 1 we have plotted the series sodium, potassium, rubidium, cæsium, both in terms of atomic weights and atomic numbers. It is at once clear that the "unknown disturbing cause" is the use of the non-significant atomic weight, for on the atomic number plot potassium is no longer an exception to the straight-line relationship.

In Fig. 2 is shown the series in which boron occurs. It too falls in line.

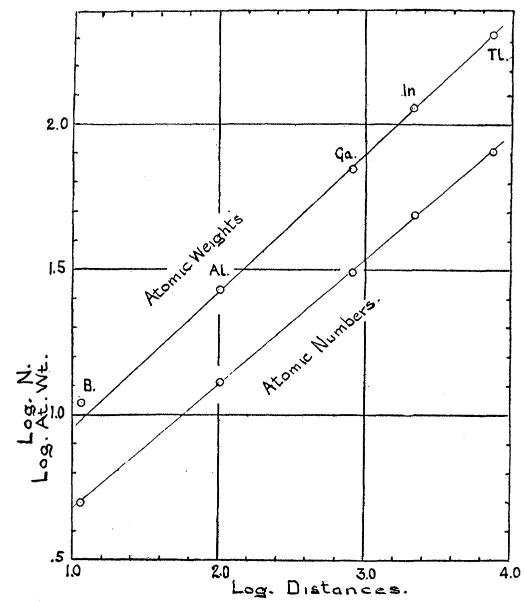

Fig. 2.

The data of these two figures were taken from the paper by Runge and Precht, and apply to lines which fulfill their criterion as to homologous character. Another exception to the law is pointed out by Rudorf, in the series zinc, cadmium, mercury. Upon plotting his data,[1] as we have done in Fig. 3, it appears probable that the reason for this exception is again the choice of atomic weights instead of atomic numbers, for the atomic number points fall on a straight line.

What happens when we attempt to obtain the atomic number of radium by this revised law? Fig. 4 shows the series from magnesium to radium, using again the data of Runge and Precht. Calcium, barium and strontium fall on a straight line, but magnesium falls slightly off. (The atomic number 13 would fit the case better than the number 12

[1] Rudorf, loc. cit., p. 101.

which has been ascribed to this element.) Continuing the line through the calcium, barium, strontium group we obtain for radium the number 96. The atomic number ascribed to radium is actually 88.

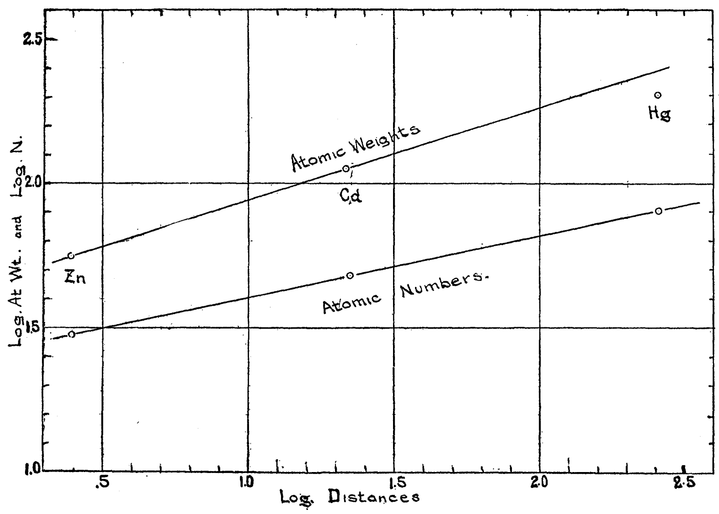

Fig. 3.

It appears, therefore, that while the exceptions which previously cast doubt on this relationship have been eliminated by the new method of

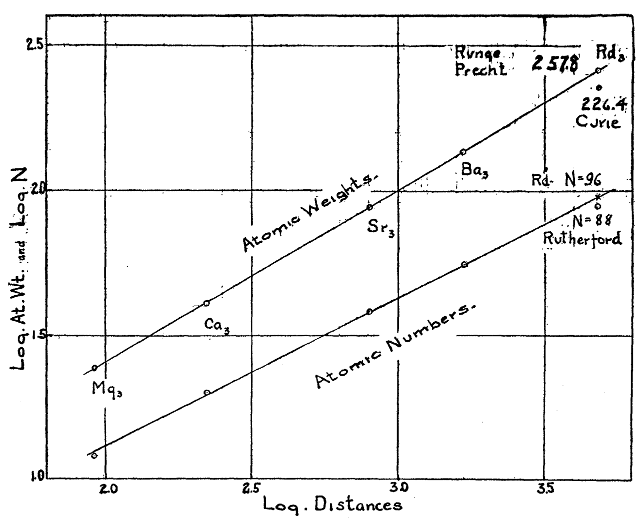

Fig. 4.

plotting, the best it can do for radium is to reduce the discrepancy from 13 to 8 per cent., at the same time getting into trouble with magnesium.

Against this, however, may be set the fact that the atomic number of radium has been derived only indirectly through its relationship to lead, and that of magnesium has not been experimentally determined. At any rate the relationship between line separation and atomic number is so very satisfactory in the case of the other groups of elements as to suggest the desirability of going over anew the experimental work on which the data depend in the magnesium-radium group.

It is of course obvious that this entirely empirical relationship must be, if true, a necessary consequence of the complete mathematical description of the structure of the atom. The fact that it is apparently a function of atomic numbers, on which the most recent picture of the atom is built, gives, we believe, some slight additional support to the idea of the nucleus atom. At the same time it suggests that a review of outstanding difficulties both in the periodic system and in series relations in spectra, might be undertaken with atomic numbers as a basis, with profitable results.

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