

teenth century was much more nearly correct than the later quantitative explanation of the ultra-phlogistonists, which ascribed negative gravity to phlogiston in order to explain many of the same facts. The latter explanation appeared to be at least consistent from a quantitative point of view, but was very ill-founded as regards its fundamental premises. Not only in this matter of crystalline form, but in many other physico-chemical problems, it seems to me highly desirable that the fundamental premises or original assumptions should be reasonable, and in accordance with as wide a variety of facts as possible, even if the resulting system appears to us now to be too complex to receive complete mathematical treatment.

Besides, the fact should be emphasized that my views concerning the significance of changing atomic volume by no means rest upon a mere qualitative basis; they are supported by many observations of a highly quantitative nature.

To sum up the situation, it seems to me that the immediately preceding paper under discussion has not attempted to answer some of the most important objections to the deductive theory; that the authors have misunderstood others; that they adopt a mathematical treatment which tends often to make disagreeing results more harmonious, and then find crystallographic confirmations of their deductive tenets which do not seem to me to be cogent; that here as before they seem to have essentially overlooked the very large internal pressures which must exist in solids, and have not heeded the arguments from which the existence and effects of these pressures are inferred; that the paper gives evidence of an illusory security sometimes felt by those who put their trust in a complex mathematical superstructure rather than in a firm foundation of sound assumptions, and that no argument has been advanced to show that my fundamental assumptions are not sounder than those of the joint authors. On the other hand, the various papers on the significance of atomic volume have brought forward so many evidences in favor of atomic compressibility as to put the burden of proof on any contrary hypothesis.

In conclusion it gives me much pleasure to express once more my appreciation of the real service which Mr. Barlow and Professor Pope have done by collating a great quantity of crystallographic data; and to this expression I must add my regret that I have found their fundamental doctrine of valency volume irreconcilable with a broader view of the nature of solids and liquids and the mechanism of chemical change.

HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Additional Note by William Barlow and William Jackson Pope.

The perusal of the two foregoing communications will probably convince the reader that little of public utility will result from the further

continuance of the discussion in THIS JOURNAL. This reason alone would lead us to decline further controversy on the subject for the present after having had the opportunity of putting our case forward in these pages; another and weightier reason seems now, however, to render further immediate discussion superfluous. During the last year or two a method for the practical determination of crystal structure has been developed by Laue and by W. H. and W. L. Bragg, which gives every promise of ultimately leading to very precise information concerning the arrangement of the atoms in a crystalline structure. While we greatly appreciate the frank and courteous manner in which Professor Richards has dealt with our crystallographic work we think that further discussion on the lines laid down in the preceding two papers may well be postponed until the important developments which are promised have had time to mature.

CAMBRIDGE, ENGLAND.

THE MIXED CRYSTALS OF AMMONIUM CHLORIDE WITH MANGANESE CHLORIDE.

BY H. W. FOOTE AND BLAIR SAXTON.

Received June 15, 1914.

The products which form when mixed solutions of ammonium and manganese chlorides are allowed to crystallize, have been investigated repeatedly and a number of double salts have been described by different investigators.¹ In the early work, the possibility of mixed-crystal formation was not taken into account, so that any material which appeared homogeneous was considered a chemical compound and at least four double salts were described which undoubtedly do not exist. Lehman² first recognized that ammonium chloride was capable of forming a curious type of mixed crystal or solid solution with manganese chloride, as well as with a number of chlorides of other metals such as nickel and ferrous and ferric iron, and he and also Johnsen³ investigated them, chiefly from a crystallographic standpoint. The most complete investigation on the double salts of the chlorides of ammonium and manganese was carried out by Saunders.⁴ He repeated the work of some of the previous investigators, following their directions so far as practicable and concluded that only one double salt forms, which has the formula $2\text{NH}_4\text{Cl} \cdot \text{MnCl}_2 \cdot 2\text{H}_2\text{O}$. He analyzed a number of products which did not give rational formulas, and concluded that these were mechanical mixtures; but he did not consider the possibility of true mixed-crystal formation. Lehman's work, which appeared nine years previously, was apparently un-

¹ A summary of the literature on the subject will be found in Abegg's "Handb. der anorg. Chem.," 7th Group, p. 705.

² *Z. Kryst.*, 8, 438 (1883).

³ *N. Jahrb. Min.*, 2, 93 (1903).

⁴ *Am. Chem. J.*, 14, 127 (1892).