

main body of the work concerning the variations in the volumes of the atoms, more particularly in the cases of oxygen, sulphur, nitrogen, and chlorine. He traces the effect of constitutive influences, *e.g.*, the influence of the homologous increment, unsaturation, and ring structure; valency, and groups; and lastly he discusses the special conception embodied in molecular volume and its relation to other physical properties, such as boiling point, surface tension, and viscosity.

The book is by no means easy reading, but it bears on every page the evidence of thoughtful, critical insight, and may be unreservedly commended as a faithful and accurate digest of the state of present knowledge upon what is confessedly a complicated and intricate subject.

T. E. THORPE.

THE PARTITIONS OF NUMBERS.

Combinatory Analysis. By Major Percy A. MacMahon. Vol. i., pp. 300. (Cambridge: At the University Press.) Price 15s. net.

THOSE who, like the present writer, have been privileged to hear Major MacMahon give an account of his methods of solving the problems of which the well-known Latin Square is typical—problems of interest to many who are not professed mathematicians—have been waiting for this treatise with eagerness. Volume i. has now appeared, and it amply fulfils the expectations which have been formed. If we may quote from the preface, the object of the work is to present to mathematicians an account of theorems in combinatory analysis which are of a perfectly general character, and to show their connection as parts of a general doctrine. The modesty of the author forbids him to mention that the greater part of the work is his own, as well as most of the important theorems which are treated. It is fair to say that Major MacMahon has developed a new line of mathematical work, and that many of the main theorems, rescued here for the first time from the author's papers in scientific periodicals, must form an essential part of text-books on higher algebra in the future.

The author enters a justifiable protest against the relegation of combinatory analysis to a part of the theory of numbers, for the theory is algebraical up to the point of determining the enumerating generating functions. He traces his method back to Laplace, who used these functions for the theory of probability, but he has greatly simplified Laplace's method by the extended use of symmetric functions.

The work is divided into six sections, each subdivided into a series of chapters. As a detail

of arrangement, it would surely have been more convenient for a reader to find the chapters numbered consecutively throughout, instead of beginning again with each section. Section i. contains the theory of symmetric functions, and of distributions into parcels and groups in general, and it is especially notable in its clear account of the uses of Hammond's operators. The theory of separations is taken up in section ii., where an important generalisation of Girard's well-known formula is obtained. Permutations are taken up in section iii., where is proved what the author has ventured to call the "master theorem." This theorem really deserves such a title in a subject of this nature, and this section is, in fact, one of the most interesting in the book. The applications of the theorem to such problems as the sum of the n th powers of binomial coefficients are very elegant, and the chapter on lattice permutations is a very valuable piece of work. The theory of the compositions of numbers appears in section iv., and further applications of the master theorem are developed in this connection. Simon Newcomb's celebrated problem suggested by a game of "patience" is treated in a very attractive manner. Section v. takes up the question of distributions on a chess board, preceded by a discussion of the perfect partitions of numbers. This section will completely displace any other account of such problems, and shows the power of the analytical method very strongly. The sixth and last section is concerned with the enumeration of the partitions of multipartite numbers.

These brief references will serve to indicate the main outlines of the work, but they necessarily miss many of its characteristic features. The book is interesting even when the analysis becomes somewhat cumbersome, which the author allows it to do as little as possible. It is published by the Cambridge University Press, and maintains the tradition of excellence of this series. While congratulating the author, we hope that the second volume will not be long delayed.

THE TINTOMETER.

Light and Colour Theories and their Relation to Light and Colour Standardisation. By J. W. Lovibond. Pp. xii+90. (London: E. and F. N. Spon, Ltd., 1915.) Price 6s. net.

MR. J. LOVIBOND is known as the inventor of the tintometer. He has written no preface to the present book in the ordinary acceptance of the word, but commences with a chapter on "Purpose," which is largely devoted to enumerating the awards he has received from international juries and various scientific socie-