the ring protons and the concomitant gradual increased shielding of the β-protons may conceivably indicate a progressively increasing radial expansion in the size of the d-orbital(s) responsible for the shielding, proceeding from the iron to the ruthenium to the osmium derivatives.[8] The effects observed and the interpretation advanced can be compared with the information obtained from the comparative chemistry of these metallocenes.[9] Since the proton shifts indicate selective shielding or deshielding in certain regions of the molecule, any comparison of the chemistry of these compounds must also be made between equivalent regions only. If done accordingly, the deductions drawn from chemical shifts appear to parallel many of the conclusions concerning relative electron densities derived from the chemistry of this metallocene triad.

We are pursuing the implications of these findings in order to understand better the "topography" of metal d-orbitals and specific metal effects in metallocene chemistry. The results of such a study might also prove useful in clarification of the bonding in metallocenes, since this topic is presently the subject of some controversy.[10]

---

[8] There is conceivably a parallelism between the plots of Fig. 1 and similar plots using either the covalent radii (1.165, 1.241, and 1.255 Å.) or the atomic volumes (7.10, 8.18, or 8.38 cc.) of iron, ruthenium, and osmium, respectively. The values are from T. Moeller, "Inorganic Chemistry," John Wiley and Sons, New York, N. Y., 1952, pp. 870–872.

[9] For a review, see M. D. Rausch, *Can. J. Chem.*, **41**, 1298 (1963).

[10] G. Wilkinson and F. A. Cotton, *Progr. Inorg. Chem.*, **1**, 1 (1959); J. P. Dahl and C. J. Ballhausen, *Kgl. Danske Videnskab. Selskab Mat.-fys. Medd.*, **33**, 5, 111 (1961); E. M. Shustorovich and M. E. Dyatkina, *Zh. Strukt. Khim.*, **3**, 345 (1962).

RESEARCH CENTER V. MARK
HOOKER CHEMICAL CORPORATION
NIAGARA FALLS, NEW YORK
DEPARTMENT OF CHEMISTRY M. D. RAUSCH
UNIVERSITY OF MASSACHUSETTS
AMHERST, MASSACHUSETTS

RECEIVED JANUARY 13, 1964

Book Reviews

Teaching Chemistry with Models. By R. T. SANDERSON. D. Van Nostrand and Co., Princeton, N. J. 1962. 175 pp. 15 × 23 cm. Price, $5.75.

Models of organic and inorganic molecules and of various crystal types have been available commercially for many years now. However, due mainly to their size, the small models are not satisfactory for lecture demonstrations. Consequently, there have been numerous articles discussing "do it yourself" methods of constructing larger models using styrofoam or other suitable materials. Articles by J. A. Campbell: "Structural Molecular Models," *J. Chem. Educ.*, **25**, 200 (1948), and "Some Simple Solid State Models," *ibid.*, **34**, 210 (1957), have been particularly useful among some 40 papers on this subject.

In this book R. T. Sanderson, of the State University of Iowa, summarizes some methods of making and using models. He has developed his own scale of electronegativities and shows this for each element by using a color-coded scale from blue to green to yellow to orange to red for the atoms from fluorine to cesium. The atomic models also show the relative size of atoms (using covalent radii only), the distribution of electrons, and the valence orbitals.

The molecular models show the geometric structure, the multiplicity of bonding, and the charge distribution. Sanderson uses tangent spheres with the appropriate covalent radii, rather than using both van der Waals and covalent radii as used in most models such as the Fisher–Hirschfelder type which are preferred by most chemists. His rationalization of his personal preference, on p. 21 of the book, was not particularly convincing to this reviewer, who has constructed over 300 atomic, molecular, and solid state models using both radii without any of the difficulties mentioned in this book.

In addition to the one chapter of model construction, there are nine chapters on possible uses of the models to explain the properties of various substances. There is a useful bibliography of articles on model building from the *Journal of Chemical Education* and 55 pages of tables giving the dimensions and other data necessary for the construction of the Sanderson type models. The book also contains 16 pages of black and white photographs and a like number of pages of color plates which probably contributed to the relatively high cost of this small volume.

It is the hope of this reviewer that teachers who use the Sanderson and other types of models will stress the many limitation and dangers of over-emphasizing the use of models in teaching so that their students will not be carried away by the glib accounts of their usefulness that characterize many of the articles written by model building enthusiasts.

DEPARTMENT OF CHEMISTRY LLOYD E. MALM
UNIVERSITY OF UTAH
SALT LAKE CITY, UTAH

Mathematical Crystallography and the Theory of Groups of Movements. By HAROLD HILTON. Dover Publications, Inc., 180 Varick St., New York 14, N. Y. 1963. xii + 262 pp. 13.7 × 21.6 cm. Price, $2.00.

A review of this book was originally published in the *Philosophical Magazine*, **7**, 605 (1904), and some of the reviewer's comments are still appropriate today.

"Crystallography is a science which in its practical aspect concerns the mineralogist and the chemist; but very few of those who are familiar with the forms and classifications of crystals will find Mr. Hilton's pages easy reading."

"The book is . . . . a treatise on the theory of a set of finite groups of a special type, involving certain operations of translation, reflexon, and rotation."

"The argument is frequently very condensed, and every line demands the closest attention on the part of the reader if he really wishes to follow the demonstration. . . . There is a steady strain upon the geometrical and kinematical imagination, a strain which comparatively few of those who are practically interested in crystallographic questions will care to undergo."

The listing of point groups, space groups, and their subgroups and equivalent points are, of course, more adequately presented in the modern "International Tables for X-Ray Crystallography." There are also a number of modern books presenting the applications of symmetry groups to crystallography which should be preferred by a student of crystallography. Another style of presentation is always valuable for deeper insight, however, and a modern reader may be intrigued by the extent of the development of the symmetry concepts before von Laue's discovery of the X-ray diffraction phenomenon and the present