

authoritative accounts of the theory of resonance, is a misconception which should be abandoned. Actually the strength of a bond depends on the interaction between the resonating structures [DEWAR, M. J. S., AND H. C. LONGUET-HIGGINS, *Proc. Roy. Soc.*, **A-214**, 482 (1952)].

Because of the many advantages of the molecular orbital theory over the resonance theory it is very likely that the former will eventually supplant the latter even in elementary courses. Why not begin the change now, following the path opened by C. R. Noller in his "Chemistry of organic compounds" (also *THIS JOURNAL*, **27**, 504 (1950))?

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*To the Editor:*

I appreciate Dr. de Carvalho Ferreira's interest in the paper on "Aspects of isomerism and mesomerism," and will attempt to answer each point raised in order.

(1) The author is, of course, painfully aware of the inadequacy of a qualitative (and brief) treatment of a highly mathematical subject, but unfortunately many of the mathematical ideas involved have not yet been translated into simple language.

My remarks concerning the hydrogen molecule were not intended to be interpreted as implying an oscillation between different electronic structures. After bond formation, the two electrons are, of course, in motion about both nuclei but the motion is not uniform so that a "piling up" of negative charge occurs between the two positive nuclei, resulting in a strong electrostatic attraction between opposite charges and in a stable molecule. Presumably such a "time-averaged" picture can be regarded as the "intermediate" electronic state (see KETELAAR, J. A. A., "Chemical Constitution," pp. 143 ff., for a recent discussion of the problem).

(2) Perhaps it should have been worded differently, as follows:

If, for example, the extreme covalent structure has the same bond-energy value as the extreme ionic struc-

ture then the two structures can be regarded as contributing equally to the "intermediate" electronic state of the molecule. The actual bond energy of such a molecule is greater than the bond energy for either structure alone, the gain being called the resonance energy of interaction. In such cases the resonance interaction will be at a maximum because if either of the extreme structures had a greater or smaller bond energy value than the other, the resonance energy of interaction would be smaller (see PAULING, L., "Nature of the Chemical Bond," p. 35).

(3) The conventional treatment of the subject was followed. While no theoretical significance was intended, it does appear that the concept of the resonance energy depending upon the number of contributing structures (of reasonable stability) is a useful rule of thumb.

I agree with Dr. Ferreira that the molecular orbital theory offers a number of advantages and that it should be incorporated into even elementary courses and texts. Nevertheless, I am convinced that the convenience and great simplicity of the resonance theory "language" is such that it will not readily be abandoned (even though it has often been misused in the past). Coulson, who has made noteworthy contributions to molecular orbital theory, has this to say in the preface of his recent book, "Valence":

"... a serious attempt has been made to use both of the two main competing theories, usually known as the molecular-orbital and valence-bond methods. Both are approximations, whose range of validity is now sufficiently understood for us to recognize the folly of trusting to either alone."

Dr. J. Figueras, of these Laboratories, has pointed out in connection with Part III that the author was a little hasty in stating that no optically active compounds were known which involved a type of asymmetry brought about by deuterium alone. Thus, compounds such as  $\alpha$ -deuteroethylbenzene and 3-deutero-*trans*-*p*-menthane have been shown to be optically active (see *J. Am. Chem. Soc.*, **72**, 3796 (1950) and references given there).

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