## FURTHER LIGHT UPON THE NATURE OF THE BENZENE NUCLEUS.

AN important memoir, containing an admirable compendium of the data now accumulated bearing upon the much-discussed question of the nature of the fundamental hydrocarbon of the aromatic compounds, together with the results of new spectrometric observations of great value, is contributed to the current issue of the *Journal für praktische Chemie*, by Prof. J. W. Brühl, of Heidelberg. The main question now at issue is whether benzene is best represented by the well-known structural formula of Kekulé,
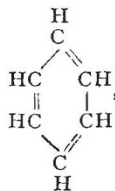


in which the carbon atoms are linked together by alternate double and single linkages, or by a formula in which there are no double linkages, and each carbon atom is attached to three others, the three extra linkages being diagonal,
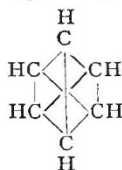


a view which has latterly received some support at the hands of Prof. von Baeyer. A full discussion of the valuable experimental work of the latter chemist is given, together with the thermochemical work of Thomsen, Dieffenbach, Horstmann and Stohmann.

Prof. Brühl has recently determined the specific gravities and optical constants of the three compounds benzene dihydride $C_6H_8$, benzene tetrahydride $C_6H_{10}$, and benzene hexahydride $C_6H_{12}$, the two former of which were prepared some time ago by Prof. von Baeyer, together with those of hexylene. There have now been fully investigated as regards the spectrometric constants eight compounds which are so closely related as to enable most important deductions to be derived from their comparison. These compounds are : benzene itself $C_6H_6$, benzene dihydride $C_6H_8$, benzene tetrahydride $C_6H_{10}$, benzene hexahydride $C_6H_{12}$, hexane $C_6H_{14}$, hexylene $C_6H_{12}$, diallyl $C_6H_{10}$, and dipropargyl $C_6H_6$. The second, third, and fourth are the graduated products of the addition of hydrogen to benzene, two atoms at a time ; the fifth, hexane, is the open chain six carbon paraffin, hexylene the six carbon olefine with one double linkage, diallyl the six carbon fatty compound containing two double linkages, and dipropargyl the six carbon compound containing two acetylene triple linkages.

Upon comparing the specific gravities at 20° of these eight compounds it is observed that the density steadily decreases from benzene to benzene hexahydride ; there is then a sudden large fall upon the disruption of the ring and formation of the open chain compound hexane. The density then slightly increases through hexylene and diallyl, and again a sudden break of continuity, a large rise, occurs upon the passage to the acetylene derivative dipropargyl. Still more striking are the changes exhibited by the molecular volumes. There is an exceptionally large rise of twenty-three units between benzene hexahydride and hexane, and a similar large decrease between diallyl and dipropargyl. Passing to the molecular refraction, it is observed that upon the graduated addition of hydrogen to benzene, this constant becomes gradually larger as far as the hexahydride, then there is a great leap upon the breaking of the ring and production of hexane. Similarly as the hydrogen is again removed step by step a continuous decrease occurs until diallyl is reached, when upon removal of $2H_2$ and formation of dipropargyl, the two ethylene groups being changed into acetylene radicles, the molecular refraction falls precipitately.

The whole of these physical properties thus exhibit a break of continuity on passing from benzene hexahydride to hexane, that is upon the opening of the ring into a straight

chain, and also when the ethylene derivatives are converted into derivatives of acetylene. Moreover, if the isomers among these eight compounds are compared, benzene with dipropargyl, benzene tetrahydride with diallyl, and benzene hexahydride with hexylene, it is found that the physical constants differ very materially. From these considerations Prof. Brühl concludes that the Kekulé structural formula is most in accordance with the facts.

In addition to the above new observations, the spectrometric constants of the ethyl ester of phthalic acid have been determined. Prof. von Baeyer considered that he had proved that phthalic acid cannot be constituted according to Kekulé's conception of the aromatic nucleus, but that a nucleus with three diagonal single linkages must be present. Upon comparing, however, the observed molecular refraction and dispersion of the ethyl ester with the values for these constants calculated upon the assumptions of the two hypotheses, they are found to correspond closely with those demanded by the Kekulé structural formula, and are very far removed from those calculated upon the basis of three diagonal linkages.

Prof. Brühl considers it to be well founded that in benzene tetrahydride and in hexylene there is one ethylenic double linkage, and that in benzene dihydride and in diallyl there are two such linkages. Now the continuity in the entire physical properties as hydrogen is removed step by step from hexane to diallyl on the one hand, and from benzene hexahydride to benzene itself upon the other, points conclusively to a continuity in the nature of the alteration of the constitution in both series. Benzene must therefore, according to Prof. Brühl, likewise contain ethylenic double linkages, three in number, if benzene dihydride contains two such linkages and the tetrahydride one. The view that three effective diagonal linkages, or, as has recently been surmised by certain chemists, three central potential linkages, can bring about in benzene the same physical action as three ethylenic bonds, appears to Prof. Brühl to be out of the question. He shows, moreover, that the values for the whole of the eight substances agree most remarkably with the numbers calculated upon the basis of the Kekulé formula, and further, that the thermodynamical data all point to the same conclusion.

The relation of the atoms to one another in the benzene nucleus is not, however, ideally expressed by Kekulé's structural formula. This can only be achieved by a spacial representation. The happiest conception of the spacial configuration of benzene, according to Prof. Brühl, is that of Sachse. This model is constructed by taking a cardboard octahedron, removing two parallel sides, and upon each of the six remaining ones placing a regular tetrahedron. The six tetrahedra represent the six carbon atoms, and the hydrogen atoms are supposed to be attached at the six apices. The six carbon atoms then lie in two parallel planes, as do likewise the six hydrogen atoms. The properties of such an arrangement would be such as accord with the observed facts. The gradual addition of hydrogen would cause a regular and continuous movement of the tetrahedra, corresponding with the observed continuity in physical properties. The best representation of this model in one plane is the structural formula of Kekulé.

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## THE FACE OF THE EARTH.[1]

AT the present time we all acknowledge the value of the accepted classification of the relief-forms of the earth's surface in continents and islands, mountain chains, plateaus, plains, &c. ; into ocean-basins, seas, lakes, and the like. But few of us ask ourselves the very natural questions, "What is the fundamental unit among all these morphological individuals, great and small ? Is there any surface unit existent among them which, like the species of the biologist, once identified, will not only be found to group its individuals rank over rank into the genera, the families, the orders, and the kingdoms of the surface world ; but the study of whose life-history and necessary interactions with its fellow-species will eventually afford us some clue to the relationships and the natural classification of the whole?"

This aspect of the subject perhaps excepted, there is probably no theory possible upon the matter of the grouping of the forms of the earth's surface which has not, either as a whole or in part,