

absorption at constant humidity, as Pidgeon and Maass would appear to expect on theoretical considerations, but has the opposite effect.

From the purely scientific aspect, the absolute values of the absorption may appear of less importance, as any errors of technique affecting all measurements would not necessarily invalidate conclusions drawn from the comparative behavior of different materials. Absolute values of the moisture absorption of cotton are, however, of the highest commercial and technical importance, since cotton is bought and sold on an agreed average moisture content, which can be defined from the absorption isotherm when the average conditions with respect to humidity and temperature are known. From this point of view alone it seems advisable to place on record the fact that the low figures of Pidgeon and Maass at high humidities—which will certainly surprise many technical workers experienced in the cotton processing industries—are much below those of other workers who have also devoted themselves to a long and critical examination of the subject.

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### THE SUPERPOSITION OF ELECTRON CHARGES IN MOLECULES AND $\alpha$ -PARTICLES

*Sir:*

In their paper on the hydrogen molecule, Heitler and London<sup>1</sup> went to great length to stress the fact that the valence forces were not the ordinary coulomb forces, but were due to an exchange phenomenon involving the pair of electrons. Recent work by Slater,<sup>2</sup> Zener,<sup>3</sup> Bartlett<sup>4</sup> and others, raises the question as to whether Heitler and London have not over-emphasized the importance of the exchange phenomenon. When we consider the exchange phenomenon we find that it has little objective significance; it may be described as a resonance effect in wave functions. On the other hand, the work of Slater and the others referred to above makes it clear that the bonding force between atoms is due to the overlapping or superposition of electron charge, the electron charge being treated as a distributed charge, whose density is proportion to  $\psi\bar{\psi}$ . In atoms with more than one valence electron, where the charge distribution is not spherically symmetrical, there is the possibility of a considerable

<sup>1</sup> Heitler and London, *Z. Physik*, **44**, 455 (1927).

<sup>2</sup> Slater, *Phys. Rev.*, **36**, 57 (1930).

<sup>3</sup> Zener, *ibid.*, **36**, 51 (1930).

<sup>4</sup> Bartlett, *ibid.*, **36**, 1096 (1930).

bonding force, without the exchange phenomenon. When the exchange phenomenon is taken into account, a redistribution of charge is obtained with an increase in bonding energy, but this increase is in some cases a small fraction of the total energy. It seems entirely probable that the "residual affinity" which has been invented to explain compounds such as  $B_2H_6$  may be a result of overlapping of charge, without the exchange phenomenon.

It is perhaps not realized by chemists how revolutionary the idea of superposition of electron charges is, and how completely it removes the old difficulties with electrical charges and coulomb forces. The combination of two protons and two electrons in a stable arrangement is an impossibility; if the two electrons are superposed the repulsive forces between electrons disappear and a stable configuration is possible.

Of course, the complete superposition of charge does not occur ordinarily but one may wonder if it is not approached in the  $\alpha$ -particle. The idea of the tetrahedral structure of the  $\alpha$ -particle has suggested itself to many, and Latimer<sup>5</sup> has recently developed the idea in formulating a lattice structure for the nucleus. It is evident that a pair of electrons surrounded by four protons is subject to extraordinary forces and the superposition of the two electron charges might be nearly complete. The solution of this problem seems to lie within the present possibilities of wave mechanics, and the result would be of great interest.

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### ZIRCONIUM. III. THE REACTION BETWEEN AMMONIA AND METHYL ALCOHOLIC SOLUTIONS OF ZIRCONIUM SULFATE

*Sir:*

The fact that solutions of zirconium salts yield, upon the addition of ammonium hydroxide, a white gelatinous precipitate of zirconium hydroxide quite insoluble in water or in an excess of the precipitant has been known since the days of Berzelius. The results of recent work in this Laboratory tend to show, however, that under special conditions a compound other than the hydroxide may be precipitated by ammonium hydroxide if the zirconium sulfate be dissolved in methyl alcohol.

A methyl alcoholic solution of zirconium sulfate was treated with ammonium hydroxide or ammonia gas. Under ordinary conditions only the hydroxide would have been precipitated. If the solution be quite fresh, that is, if it has been prepared for only a matter of two or three minutes,

<sup>5</sup> Latimer, *THIS JOURNAL*, **53**, 981 (1931).