apart (Bridges 1921). In the first experiment ultra bar (B^u), an allelomorph of bar described by Zeleny (1920) was used. Zeleny has shown that homozygous ultra-bar stocks give rise to reversions to wild-type with about the same frequency as do homozygous bar stocks. In the present case females of the constitution $\frac{B}{f\,B^u\,fu}$ were tested. Three reverted offspring were produced in about 6,500 flies, thus indicating a reversion frequency for the heterozygote that is of about the same order as the frequency in homozygous bar or homozygous ultra-bar. All three of these reverted individuals arose from crossing over between forked and fused: one was forked not-fused and the other two were not-forked fused. In the second experiment ultra-bar was not used and forked and fused were in opposite chromosomes, *i.e.*, the females tested were of the constitution $\frac{B\,fu}{f\,B}$. Three reversions have so far appeared—two wild-type males and one forked fused male. Thus all six reversions in these experiments were accompanied by crossing over between forked and fused; yet such crossovers include only about three per cent. of the total number of individuals examined. It follows that *reversion of bar to normal is associated with crossing over at or near the bar locus.*

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THE ABSOLUTE VALUES OF THE ELECTRICAL MOMENTS OF ATOMS AND MOLECULES

SINCE an atom consists of a number of electrons distributed around a positive nucleus, its effect at an external point at a distance which is large in comparison with the diameter of the atom, is equivalent to an electrical doublet. The nature of the interaction of atoms or molecules in a gas or liquid must, therefore, largely correspond to that of electrical doublets. The writer has pointed out[1] that, since the doublets would tend to set themselves with respect to each other so that the potential energy is a minimum, attraction would be the outstanding force between the molecular doublets, and if repulsion occurs, it would be as small as possible. This is a different view than that taken by Debeye[2], who supposes that attraction is brought about by contractions and expansions of the molecular doublets on approaching and receding from each other, in such a manner that attraction is the outstanding force. But such changes, though probably occurring to a certain extent, need not necessarily exist in order that attraction may be the outstanding force. In any case, the determination of the absolute value of the average electrical moment associated with the atoms or molecules during their interaction in a substance is of outstanding importance.

In dealing with this problem the main difficulty is that the molecular collisions interfere with, or act in opposition to, the tendency of the molecular doublets to set themselves so that the potential energy is a minimum. The extent of this effect can not be calculated without introducing a number of assumptions. It is thus practically impossible to determine the moment of a molecule from data on the internal heat of evaporation of a liquid, the quantity most directly connected with the molecular moments. But this difficulty largely ceases to exist on considering the internal heat of evaporation at the absolute zero of temperature.[3] The average attraction between two molecular doublets in a substance in that case can be shown to be approximately given by

$$4\,\frac{M^2}{r^4},$$

where M denotes the moment of each doublet and r their distance of separation. The values of the internal heat of evaporation at the absolute zero can be exterpolated by means of the empirical latent heat equation

$$L = (\rho_1{}^2 - \rho_2{}^2)\ k$$

which is particularly well adapted for this purpose, where ρ_1 and ρ_2 denote the densities of the liquid and vapor respectively, and k a con-

1 *Phys. Review,* xviii, 4, p. 303, 1921.

2 *Phys. Zeit.* 21, p. 178.

3 The details of these deductions are given in a paper in the course of publication in the *Journal of the Franklin Institute.*

stant which depends only on the nature of the liquid. It is a fairly straightforward process now to show that

$$L_0 = 8.42 \frac{\rho_0}{m_a^2} M^2$$

where L_0 denotes the internal heat of evaporation[4] at the absolute zero, m_a the absolute molecular weight of a molecule, and ρ_0 the density at the absolute zero, which has been exterpolated for a large number of substances by means of Cailletet and Mathias' linear diameter law. Using this equation, the writer has determined the electrical moments of the molecules of a number of substances and found that they were approximately given by

$$M = 10^{-19} \Sigma N^{2/3},$$

where N denotes the atomic number of an atom. It appears, therefore, that the moment of a molecule is equal to the sum of the moments of its atoms, and that the moment of an atom is proportional to the two thirds power of its atomic number which is equal to the number of elementary electrical charges of one sign the atom contains. This result may be taken as good evidence that the molecules of a substance largely interact as if they consisted of electrical doublets.

If x denotes the distance between the charges of the representative doublet of an atom, we have

$$x N e = M$$

or

$$x = 2.09 \times 10^{-10} N^{-1/3} \, cm.$$

Thus the value of x decreases as the atomic weight increases, which is probably owing to the fact that the larger the number of electrons in an atom, the more symmetrically they may be distributed around the positive nucleus. Moreover, x is also always less than the diameter of the atom, as we might expect. The value 2.09×10^{-10} c.m. of x for the hydrogen atom is much smaller than the value of $.53 \times 10^{-8}$ c.m. of the radius of the circle the moving electron describes around the positive nucleus according to Bohr's theory. Thus in order that the atom may behave as an electrical doublet it is necessary that the nucleus does not occupy the center of the circular path of the electron, but a distance of about 2.09×10^{-10} c.m. from the center at right angles to the plane of motion. Strictly the system will not be in equilibrium by itself under these conditions, but may be when associated with another system. If the electron describes an ellipse with the nucleus at one of the foci, the atom may behave on the whole as a doublet when isolated. The doublet effect of more complicated atoms may be produced along similar lines.

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[4] In ergs per gram.

SIMPLE MILK FORMULAE[1]

Certain formulæ[2] obtain in milk analysis. Among these are:

Fleischmann's:

The mean specific gravity of the milk solids =

$$\frac{T}{T - \dfrac{100G - 100}{G}}$$

where T = per cent. of total solids.
G = specific gravity of the milk.

Babcock's (Hehner & Richmond's):

The per cent. of total solids $= 0.25L + 1.2F$,
where L = lactometer reading $= 10(100G - 100)$
F = per cent. of fat.

Bialon's:

The specific gravity of the fat-free milk =

$$\frac{100G - F}{100 - \dfrac{F}{0.933}}$$

Certain numerical limits in these formulæ are generally recognized: the mean specific gravity of the milk solids does not exceed 1.34 in herd milks above suspicion of skimming,[3] and the

[1] Abstracted from a paper read before the Delaware County Institute of Science, Media, Pennsylvania, May 9, 1921.

[2] More or less adequate discussion of one or more of these milk formulæ are to be found in Bulletin 134, U. S. Dept. Agriculture, Bur. Animal Industry (by Shaw and Eckles) and in books relating to milk control, such as those of Leffmann, Ernst-Mohler-Eichhorn, Barthel, Van Slyke, Race, Jensen-Pearson, Heineman, and particularly in that of Richmond. Books on food analysis, such as those of Leach, Woodman and Allen, also take up milk formulæ more or less completely.