of flow must then be the much smaller metal ion, i.e., the atom free of its valence electrons.
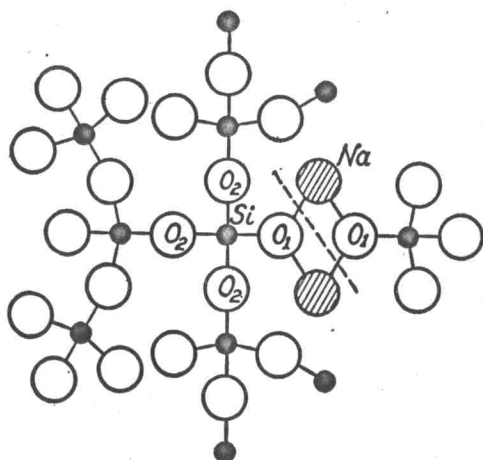

FIG. 9. Schematic representation of the structure of a soda-silica glass.§

On this hypothesis the activation energy of flow would be

$$\Delta E_{vis} = \frac{\Delta E_{vap}}{3} \times \frac{\text{volume of ion}}{\text{volume of atom}}$$

$$= \frac{\Delta E_{vap}}{3} \times \left(\frac{\text{radius of ion}}{\text{radius of atom}}\right)^3$$

or $\quad \dfrac{\Delta E_{vap}}{\Delta E_{vis}} \times \left(\dfrac{\text{radius of ion}}{\text{radius of atom}}\right)^3 = 3.$

A test of this relation for nine liquid metals showed it to be true within the experimental error of the quantities involved. While this result is interesting and suggestive, the hypothesis is undoubtedly too simplified and should not be taken too literally. The qualitative concept of the metal ions flowing free of their valence electrons is, of course, quite in harmony with modern ideas on the structure of metals.

(b) *Liquid sulfur*. As is well known, liquid sulfur is a fluid yellow liquid between the melting point and about 160° and also in the supercooled liquid region below the melting point. Above 160° the viscosity increases rapidly with rising temperature, increasing several thousand-fold between 160° and 190°, and thereafter the viscosity

§ After B. E. Warren and A. D. Loring, J. Am. Cer. Soc. **18**, 272 (1935).

decreases in a normal way. It is thought that below 160° the liquid is composed of S_8 rings (S_λ), and at higher temperatures of S_n chains (S_μ), at least in part. The plot of log η *vs.* $1/T$ gives two linear portions, one below 160° and one above 250°, whose slopes give ΔE_{vis} equal to 7.04 and 18.35 kcal., respectively. A comparison of these values with the known heat of vaporization led to a confirmation of the S_8 ring structure in the lower temperature range and to an S_{36} chain formula at higher temperatures. The exact interpretation of the figure S_{36} is not certain; the liquid may be an equilibrium mixture of S_8 rings and chain molecules of different lengths, or of the chain molecules only, so as to give an average of S_{36} as deduced from the experimental value of ΔE_{vis}.

(c) *Long chain hydrocarbon*. It has previously been shown that linear molecules require less than $\frac{1}{3}$ the energy of vaporization for activation of the flow process. If the molecules in a series such as the normal paraffins all flowed in the extended form, it would seem that they would require a smaller and smaller fraction of the energy of vaporization as the length of the chain increased. The data showed that $\Delta E_{vap}/\Delta E_{vis}$ was constant at 4 for all the normal paraffins from C_5H_{12} to $C_{18}H_{38}$, and this led to the conclusion that all these hydrocarbons were curled into a ball shape during the flow process. Such a concept is in harmony with Langmuir's conclusion that molecules are curled in this way in the vapor state, since flow can be thought of as vaporization in one degree of freedom This suggests that the liquid hydrocarbon contains both extended and curled molecules, and the activated molecules which are responsible for flow, diffusion and vaporization of the liquid are of the curled type. For further details the reader is referred to the original paper.

General Remarks on the Application of the Theory to Other Than Normal Liquids

From the point of view of viscous behavior and of most other physical properties, liquids may be classified as follows:

I. Intermolecular forces are exclusively undirected forces (van der Waals, dipole and repulsive forces)

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      ace
(b) Very
   E.g.,

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(a) Hydr
   E.g.,

(b) Coval
   E.g.,

III. Metalli
IV. Ionic li

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