Nature (London) **109** 138–139 (1922)

Molecular structure of amorphous solids

A question of fundamental importance in the theory of the solid state is the nature of the arrangement of the ultimate particles in amorphous or vitreous bodies, of which glass is the most familiar example. Is it to be supposed that the molecules are packed together at more or less uniform distances apart, as in crystals, the orientation of individual molecules or of groups of molecules being, however, arbitrary? Or, on the other hand, is the spacing of the molecules itself irregular, the solid exhibiting in a more or less *permanent form* local fluctuations of density similar to those that arise *transitorily* in liquids owing to the movement of the molecules? The physical properties of amorphous solids, notably their softening and viscous flow below the temperature of complete fusion, would tend to support the latter view, but the possibility of a closer approximation to the crystalline state should not entirely be ruled out, especially in view of the very interesting recent work of Lord Rayleigh on the feeble double refraction exhibited by fused silica (*Proc. R. Soc. London*, 1920, p. 284). A good deal might be expected to depend on the nature of the material, its mode of preparation, and heat treatment. A material formed by simple fusion and resolidification of comparatively simple molecules, such as silicon dioxide, might stand on a different footing from a material such as ordinary glass built up by chemical action and formation of complex silicates.

If the arrangement of molecules in a vitreous body were irregular, the local fluctuations of optical density would result in a strong scattering of a beam of light passing through it, the intensity of such scattering being comparable with that occurring in the liquid state at the temperature of fusion of the material (see note by the present writer in *Nature* of November 24 last, p. 402). On the other hand, if the arrangement of the molecules approximated to the crystalline state the scattering of light would be merely that due to the thermal movements of the molecules and would be much smaller. As a matter of fact, glasses exhibit a very strong scattering of light, some 300 to 500 times as strong as in dust-free air, the Tyndall cone being of a beautiful skyblue colour and nearly, but not quite, completely polarised when viewed in a transverse direction. (Some glasses exhibit a green, yellow, or pink fluorescence when a beam of sunlight is focussed within them, and cannot be used for the present purpose; the fluorescence, even when very feeble, can be detected by the difference in colour of the two images of the Tyndall cone seen through a double-image prism.) Rayleigh, who observed the light-scattering in glass, attributed it to inclusions, some of which he assumed

p. 476). The closest scrutiny through the microscope under powerful dark-ground illumination fails, however, to indicate the presence of any such inclusions, and it seems more reasonable to assume, in view of the foregoing remarks, that the scattering is really molecular. Its magnitude is of the order that might be expected on the basis of a non-uniform distribution of the molecules.

Further observations with specially prepared glasses and with fused silica would be of great interest to investigate the influence of the chemical constitution and heat treatment on the molecular *texture* of the solid.

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29 December