

Table 2. Atomic radii of the alkali metals calculated from compressibility data and knowledge of the crystal form (bcc)
Pressure = 1 kg/cm², T = 300°K, N₀ = 6.02283 x 10²³

Metal	r(A) ^a	r(A) ^b	r(A) ^c
Lithium	1.437	1.45	1.50
Sodium	1.752	1.80	1.77
Potassium	2.099	2.20	2.07
Rubidium	2.295	2.35	2.25
Cesium	2.541	2.60	2.37

(low pressure form)

^a Ginell and Quigley, ref. 12 from compressibility and knowledge of crystal form.

^b J. C. Slater, *J. Chem. Phys.*, **41**, 3199, (1964), from X-ray measurements.

^c W. L. Bragg, *Phil. Mag.*, **40**, 169 (1920), from X-ray measurements.

assumption made in this calculation was that α was the average size of the liquid cluster rather than the minimum size. This we feel is a good assumption since the range of sizes in the liquid α -mers is probably small.

Second: We have shown that the equation of state (Equation 3) can be converted exactly into the Tait-Tamann Law for the isothermal compressibility of liquids (7). This law is

$$-\left(\frac{\partial v}{\partial P}\right)_T = \frac{J}{L + P} \quad (8)$$

where J and L are constants. This law has been found to hold well for most liquids. For example, it holds for methyl, ethyl, propyl, isobutyl, and amyl alcohols, acetone, ethyl ether, ethyl chloride, bromide, and iodide, benzene, chloro-, bromo-, nitro-benzene, aniline, carbon disulfide, phosphorus trichloride, and helium I and II (8). It also holds for solutions such as: ethylene glycol/water and concentrated aqueous sodium chloride and bromide. It has even been shown to hold for solids such as the alkali metals: lithium, sodium, potassium, rubidium, and cesium (9).

The integrated form of this equation

$$(P + L)e^{v/J} = H \quad (9)$$

where H is a constant of integration, gives excellent fit to the P - v curves of many liquids (10) and of the alkali metals (9).

Third: From the Tait-Tamann Law there can be obtained the relationship (11) at the critical point

$$P_c = -L \quad (10)$$

The data necessary to examine this equation are rather sparse. Long extrapolations are necessary; however, in the case of He - 4, a least-squares extrapolation over half the liquid range gives

$$P_c = 2.26 \text{ atm (experimental)}$$

$$P_c = 2.258 \text{ (calculated)}$$

Calculations with other liquids (e.g., ethyl ether) for which the extrapolation is more difficult and for which the data are very scant give results agreeing to about 1/2%.

Fourth: We have calculated the atomic radii of the alkali metals (12). The results of this calculation are shown in Table 2. As can be seen the results that are calculated from compressibility data (P - v) and a knowledge of crystal form (bcc) agree very well with the results from

direct measurement by X-rays. In order to make this calculation we assumed that the free volume was negligible.

Fifth: As mentioned previously the equation of state (Equation 3) can be expanded directly without approximations into the virial equation of state and yields the composition of the various virial coefficients. Hence this equation of state is the closed form of the virial equation of state.

Sixth: A plausible theory of nucleation has been presented (2). Using this theory Brown and Ginell (13) have derived an equation describing the rate of growth of crystals from a glass. Since many of the parameters in the theory are thus far unknown, the equation has been treated as if it were an empirical equation and it was fitted to the available data. In the paper (13) four sets of data were fitted and the fit was excellent. One set of data contained not only values for the rate of crystallization but also for the rate of decrystallization (change from devitrified to vitrified). Even here the fit is excellent.

Conclusion: Like all theory this one is not completely developed. Problems remain to be solved and more comparisons with experimental data need to be made. However at this point I feel that association theory is a logical comprehensive picture of the states of matters and the nature of the transitions from state to state. Further work is in progress to develop this point of view.

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