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then be obtained as a function of pressure from equations of the type

$$C(p) = C(1 \text{ atm})(\delta_1/\delta_p)^2 s(p), \tag{6}$$

where δ_1 and δ_p are the transit times corresponding to 1 atm and to a pressure p. In general, the calculation of $s(p)$ requires a knowledge of the isothermal compressibility as a function of pressure. However, an excellent approximation to $s(p)$ can be calculated directly from our present adiabatic velocity data[18] since the difference between the isothermal and adiabatic compressibilities is very small except in the immediate vicinity of the lambda point. [At 300°K and 1 atm, $(\beta^T - \beta^S)/\beta^S$ is only 0.007.] Since $s(p)$ values vary only between 1.00 and 1.02 for the pressure range 0 to 12 kbar, small uncertainties in the $s(p)$ variation do not cause significant errors in the elastic constant values (which depend mostly on δ_1/δ_p).

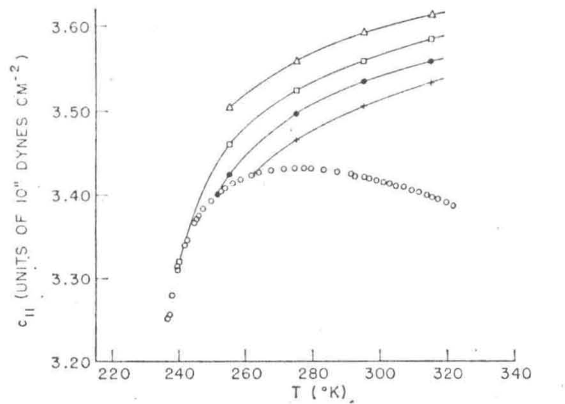

FIG. 3. Variation of c_{11} with temperature. Open circles represent data at 1 atm; for a definition of the symbols used for values at various constant volumes, see the legend of Fig. 5.

For measurements made at 1 atm, the quartz transducers were cemented to the sample with Dow resin 276-V9 as the seal material for all runs between 215° and 320°K. Below 215°K, these seals broke and Nonaq stopcock grease was used in a few runs despite the fact that it seemed to dissolve the sample slowly. Since the Dow resin was soluble in the hydraulic pressure fluid, it was necessary to find a new seal material for the high-pressure work. A polymer of phthalic anhydride and glycerin was found suitable[12] and was used for all the pressure runs.

The Dow resin and Nonaq seals were all very thin. Thus the phase shifts γ were small (between $-5°$ and $-8°$) at all temperatures, and the corrections to the transit times[12] due to phase shifts amounted to only 0.01% at 1 atm. Since all high-pressure measurements were carried out at a frequency equal to the resonance frequency of the transducer at 1 atm, there were appreciable changes in the phase shifts γ as a function of pressure. This effect of pressure on the behavior of

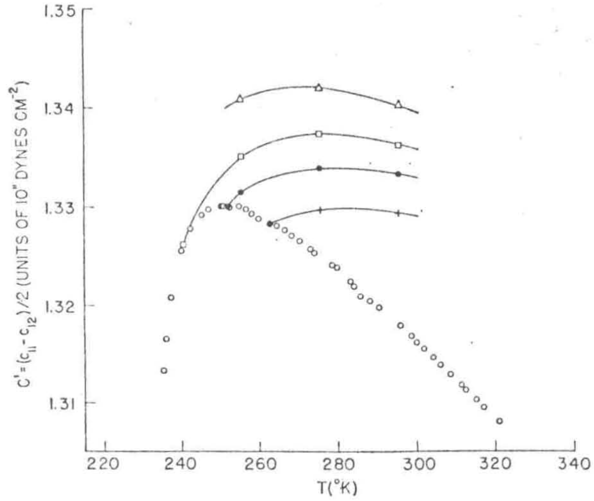

FIG. 4. Variation of C' with temperature. Open circles represent data at 1 atm; for a definition of the symbols used for values at various constant volumes, see the legend of Fig. 5.

the transducers is known[14] and was corrected for. The effect of pressure on the seal is not known and has been neglected.

RESULTS

Constant-Pressure Data

The open-circle points shown in Figs. 3–5 are experimental data points for the elastic constants c_{11}, c_{44}, and C' as functions of temperature at 1 atm. Smooth-curve values of these directly measured quantities are presented in Table I together with the adiabatic bulk modulus $1/\beta^S$, which can be calculated from

$$1/\beta^S = c_{11} - 4C'/3. \tag{7}$$

Since the temperatures in Table I are all above the lambda point, all entries pertain to the disordered cubic phase of NH_4Br.

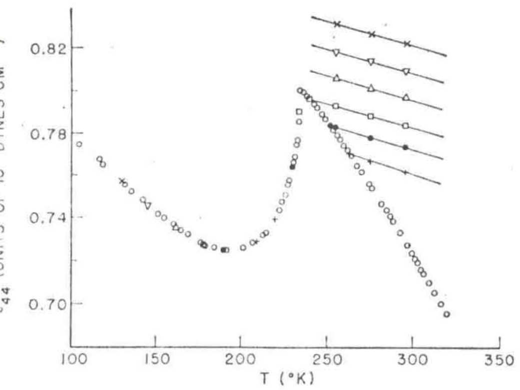

FIG. 5. Variation of c_{44} with temperature. Open circles represent data at 1 atm. Values at various constant volumes are distinguished by the symbols: $X \cdots V_{12}$ (a_{12}=4.040 Å); $\nabla \cdots V_{13}$ (a_{13}=4.0425 Å); $\triangle \cdots V_{14}$ (a_{14}=4.045 Å); $\square \cdots V_{15}$ (a_{15}=4.0476 Å); ● $\cdots V_{16}$ (a_{16}=4.0496 Å); $+ \cdots V_{17}$ (a_{17}=4.0517 Å).