Thermal Conductivity of Liquid Ammonia

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Interest has been expressed recently in transport properties of polar liquids (*1*, *8*). We report here values of thermal conductivity for liquid ammonia between the freezing point and the normal boiling point.

MEASUREMENTS were taken using a standard "thermal potentiometer" technique (*7*). Heat was supplied to one end of a cylindrical sample which was isolated except at the end opposite the heater. If heat, H, conducted through the sample produces a temperature difference, ΔT, then the thermal conductivity, K, is given by $(H/\Delta T)(l/A)$, where l and A are the sample length and cross sectional area respectively. The ammonia was contained in a Pyrex glass cell, heated and filled at the top. The use of guard heaters reduced heat loss up the filling tubes. Heat supplied to the top was lost by radiation and glass conduction as well as conduction through the liquid. Corrections were applied using the known emissivity (*5*) and conductivity (*6*) of glass; the correction term was checked on an empty cell as well as by measurements on mercury. Conducted heat was finally delivered to a bath of Freon at the bottom of the cell. The temperature gradient in the cell was measured by thermocouples attached to the sides. The combination of systematic errors due to the correction factors and the usual random errors produces the scatter in the data. The scatter, less than 10% of the average value, is used as a precision index.

Our data are shown in Figure 1 and in Table I; in the figure comparisons are also made with values computed from two models. The dashed curve is based on an old kinetic theory equation (*2*), due originally to Bridgman; the dotted line to a recent law of corresponding states approach due to Thodos. The horizontal solid line is the average value reported by Kardos (*3*).

The Bridgman equation,

$$K_m = 2.80\, k(N/V)^{2/3} v \gamma^{-1/2}$$

where k is Boltzman's constant, (N/V) the molecular density, v the speed of sound, and γ the heat capacity ratio (also the ratio of isothermal to adiabatic compressibilities), was originally derived by assuming the liquid to be a disordered solid. Subsequent modifications, some empirical, lead to the equation above which is quite successful with most liquids (*2*). We used density and compressibility data from Gmelin and sound velocity data from Maybury (*4*) to obtain the dashed curve of Figure 1. The agreement is quite satisfactory; Maybury's data does not extend above the normal boiling point.

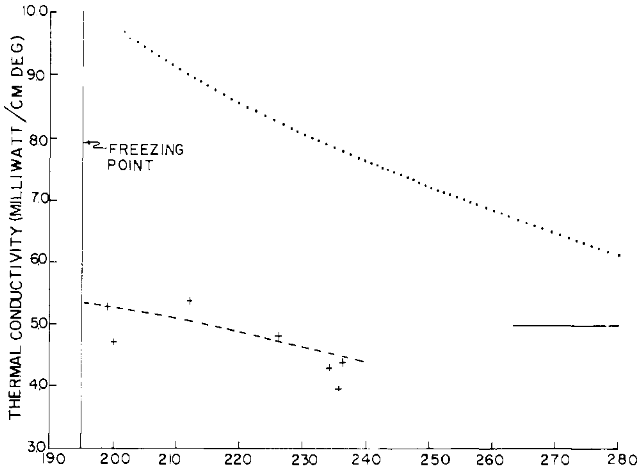

Figure 1. The thermal conductivity of liquid ammonia.

Table I. Thermal Conductivity of Ammonia

T° K.	K(Milliwatt/ Cm.°)	T° K.	K(Milliwatt/ Cm.°)
199	5.28	234	4.27
200.5	4.71	235.6	3.95
212.3	5.37	236	4.37
226	4.81		

The Thodos approach is through the law of corresponding states which has also been used for transport properties of less complex (and non-polar) fluids. His predictions are quiet satisfactory in the low density portion of the phase diagram for ammonia. As can be seen from the dotted curve, taken from Figure 7 (*1*), the prediction for the liquid is almost a factor of two high. This is perhaps not surprising in view of the extreme differences between the fluid at the critical point and the liquid below the normal boiling point.

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