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**P-V-T and Sound Velocity Data for
Fluid n -D₂ in the Range 75-300 K and 2-20 kbar**

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P-V-T AND SOUND VELOCITY DATA FOR FLUID
 $n\text{-D}_2$ IN THE RANGE 75-300 K AND 2-20 kbar

by

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ABSTRACT

Simultaneous static measurements of pressure, volume, temperature, and sound velocity are reported in deuterium fluid in the range $75 \leq T \leq 300\text{K}$ and $2 \leq P \leq 20\text{ kbar}$ [$0.2 - 2.0\text{ GPa}$]. The 1340 sets of data points along the 33 different isotherms are presented so that they may be available for use in equation-of-state development. The equipment description, a discussion of accuracy and precision, and presentation of an equation of state are to be published in J. Chem. Phys.

INTRODUCTION

A series of static measurements of the pressure, volume, temperature, and sound velocity in molecular deuterium fluid is reported. The pressure range was from 2 kbar to 20 kbar (or the freezing pressure), and the temperature range was from 75 to 300 K. In this range, deuterium is above the critical temperature and pressure.

The measurements were obtained in a piston-cylinder high pressure apparatus as described by Mills, Liebenberg, and Bronson.¹ A sequence of measurements was obtained along an isotherm, and a fixed-path sound cell in the high pressure fluid provided sound velocity $v_s = V[-M(\partial V/\partial P)_S]^{-1/2}$ as an independent simultaneous measurement with P, V, and T. Details of the experimental techniques are given in Ref. 1.

The data in the table on the microfiche in the back of this report are organized in a quasi-chronological order of experimental runs along an

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isotherm. In each table a line of four entries consists of the temperature [Kelvin], pressure [kbar], sound velocity [km s^{-1}], and volume [$\text{cm}^3 \text{ mole}^{-1}$]. Preserving the quasi-chronological order also provides the increasing and decreasing pressure segments that have been corrected for the hysteresis loop commonly obtained with this type of apparatus.²

Uncertainties in the measurements are discussed fully in Ref. 1. Pressures were determined with an uncertainty estimated to be a few tenths of 1% at the lowest pressures and 0.5% at the highest pressure. Volumes were estimated to be known to 0.4%, although at the lowest temperature or highest pressure an individual molar volume could stray by over 1%. Temperatures were estimated to be within ± 0.5 K of the value given, although at the lowest temperatures and at room temperature the error would be an order of magnitude less. Sound velocities were determined with an average deviation of $\pm 0.5\%$ from a smooth power law fit along each isotherm.

The 1340 sets of data in the table are those for which all four variables were measured. In some runs, a gas leak prevented accurate volume measurements, although P , T , and v_s could be obtained accurately. Other runs were made without the ultrasonic cell so that accurate P - V - T measurements were obtained. These data are not included here since the isotherms were generally repeated to obtain a full set of P - V - T - v_s data.

A full comparison of these data with those from earlier investigations is given in Ref. 1. No other data of molar volumes above 3-kbar pressure were available. There were no previous sound velocity measurements in fluid deuterium at $3 < P < 20$ kbar and $75 < T < 30$ K, so only a smooth extrapolation of our data to lower pressure could be checked.

The development of an equation of state (EOS) in the pressure and temperature range of the present data is described in Ref. 1. With this EOS, the volume and sound velocity data can be obtained to nearly within the data point uncertainties. A double-process least squares fit was used to treat the full set of P , V , T , and v_s data simultaneously. The derivative, $(\partial V / \partial P)_S$, obtained from sound velocity measurements provides a stringent condition on the form of an EOS. The derivation of other thermodynamic variables such as the volume expansivity, specific heats, and isothermal compressibility is expected to be correspondingly improved as was discussed in Ref. 1. A tabular output of these thermodynamic data and the entropy is available.³

REFERENCES

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