THE THERMODYNAMIC PROPERTIES OF SOLID AND FLUID HELIUM-3 AND HELIUM-4 ABOVE 3 °K AT HIGH DENSITIES

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Measurements have been made of the specific heat at constant volume of solid ^{3}He from 3 °K up to the melting point at a number of different densities corresponding to pressures up to 2000 atm. The measurements have been extended through the melting region at constant volume up to 29 °K in the fluid phase. For comparison similar measurements have been made on ^{4}He at four different densities.

By combining these data with the p-V-T data of Mills & Grilly (1955) and Grilly & Mills (1959), the complete thermodynamic properties of the solids have been derived in the relevant pressure and temperature range. The results can be understood semi-quantitatively in terms of the zero-point energy of the solids and a quasi-harmonic model of the lattice vibrations. A brief discussion of the specific heat of the fluid phase is also given.

1. Introduction

Simon (1934) first drew attention to the importance of zero-point energy in interpreting the properties of solid and liquid helium. If helium behaved classically, it would exist as a solid in equilibrium with its vapour at the lowest temperatures with a molar volume of about 10 cm^3 and a latent heat of sublimation of about 150 cal/mole; all this can be readily deduced from the properties of the gas phase at higher temperatures. In fact experiment shows that solid ^{4}He is *not* in equilibrium with the vapour phase at *any* temperature and that at the lowest temperatures it exists in equilibrium with the liquid under a pressure of about 25 atm. Its molar volume under these conditions is more than 20 cm^3 and its internal energy

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