TABLE 13. COMPARISON OF THE DEBYE TEMPERATURES OF SOLID ^{3}He AND ^{4}He

AS A FUNCTION OF VOLUME

V (cm^3/mole)	$(m_3/m_4)^{\frac{1}{2}} \theta_3/\theta_4$
12·5	1·028
13	1·030
14	1·035
15	1·040
16	1·058
16·5	1·074

4·3. *The fluid helium isotopes*

Only a few experimental determinations of the specific heat of fluid helium at high density are reported. Eucken (1916) measured C_v at fairly low densities over the temperature range 16 to 32 °K. A few observations were reported by Keesom & Keesom (1936) and by Dugdale & Simon (1953). Hill & Lounasmaa (1960) covered the range up to a pressure of 100 Kg/cm^2, corresponding to $V = 19·4$ cm^3/mole from 1·2 to 4 °K. The results of Hill & Lounasmaa do not overlap with the present set of measurements; they seem, however, to form a reasonable extrapolation.

The characteristic result of the present set of measurements is that C_v at the high temperature limit tends towards the value $\frac{3}{2}R$ (or slightly above this value) independent of the molar volume. At low temperatures C_v decreases in a monotonic way until the solidification point is reached. A close similarity exists between the behaviour of both isotopes and, in the range of densities and temperatures investigated, there seems to be no detectable influence of the different particle statistics.

The fall in C_v with falling temperature is thus *not* attributable to simple ideal gas degeneracy: it seems more probable that the fall-off is due to localized vibrations of the atoms of the fluid. Let us suppose that each atom is imprisoned in a cell formed by neighbouring atoms. At low energies, the energy levels available to the atoms will be discrete so that when kT falls to a value comparable with the energy difference between these levels, C_v will begin to diminish. At higher energies, the energy levels will be more like those of a free particle in a box. This model of a fluid, which was developed by Eucken and his co-workers (Eucken & Seekamp 1928; Bartholomé & Eucken 1937) and more recently by Levelt & Hurst (1960) has been applied with some success to the explanation of the temperature dependence of C_v in other simple fluids such as the hydrogen isotopes and the heavier inert gases. The model implies that C_v may rise above $\frac{3}{2}R$ (indeed in the extreme limit it may reach $3R$) before falling again at higher temperatures to the classical limit of $\frac{3}{2}R$, characteristic of monatomic gases. The actual temperature dependence of C_v is, of course, determined by the detailed form of the potential which is assumed to exist within the cell. Here, however, we wish only to point out that a model of this kind will explain not only the decrease of C_v at lower temperatures in the fluid helium isotopes but also why, in these fluids, C_v appears to rise above $\frac{3}{2}R$ at higher temperatures, as indicated in figures 5 and 6.

CONCLUSIONS

The behaviour of the specific heats of the solid helium isotopes at very low temperatures is still obscure. (But see the note added in proof on p. 22.) Until this has been convincingly established and understood, conclusions about their behaviour at higher temperatures must ·