The experimental data from 0·3 to 1·5 °K due to Heltemes & Swenson (1962) do not, however, confirm these expectations. According to their measurements, the specific heats of both isotopes tend to be higher than those corresponding to the dashed lines in figures 7 and 8; in fact Heltemes & Swenson conclude that there is, in addition to the term in $(T/\theta)^3$, an additional contribution to the specific heat approximately proportional to T. This contribution does not change much with volume and is of similar magnitude in both ^{3}He and ^{4}He. On the plot of θ_D against T this would show as a maximum in the curve for a particular density followed by a rather rapid fall in θ_D at the lowest temperatures. In the preliminary account of their experiments, Heltemes & Swenson (1961) assumed that this linear term was spurious and due to some unexplained peculiarity of the apparatus. Since, however, they were subsequently unable to find anything wrong with the apparatus, it is not

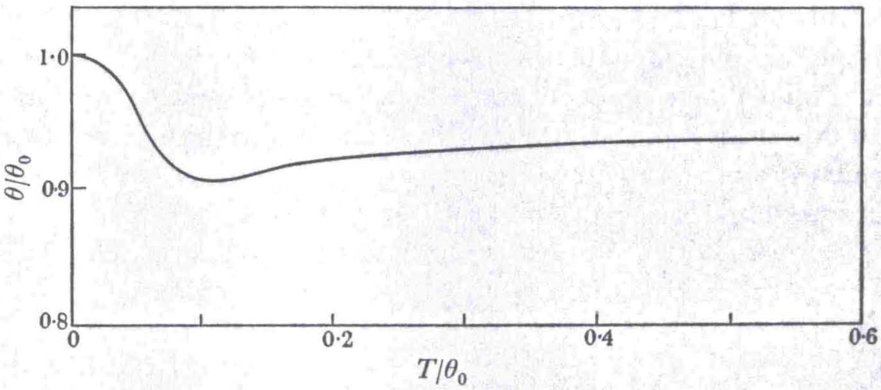

FIGURE 14. The dependence of θ_D on temperature as calculated for an f.c.c. lattice (after Leighton 1948). The precise form of the curve depends on the force constants chosen.

at present clear whether this contribution to the specific heat is a genuine effect or not. The situation clearly calls for better data, especially in the range 1 to 4 °K, to obtain more reliable information on the temperature variation of θ_D in this range. This uncertainty means that we cannot convincingly extrapolate the θ_D curves to 0 °K. Although this is unfortunate in that we cannot then evaluate θ_0, it does not appreciably affect the calculations of the entropy and internal energy of the solid already described, since the contribution to these quantities from this small term in the specific heat is negligible.†

Since reliable values of the Debye temperature at 0 °K cannot be obtained at present, we base the following discussion of the volume dependence of θ_D on a comparison at constant reduced temperature (i.e. at constant T/θ_D). The lowest reduced temperature for which experimental values of θ_D were obtained is $T/\theta_D = \frac{1}{18}$. In figure 15 we have plotted θ_D as function of molar volume for $T/\theta_D = \frac{1}{18}$. From these curves we can derive a value for the Gruneisen constant γ

$$\gamma = -\partial \ln \theta / \partial \ln V. \tag{12}$$

We find for both isotopes almost independent of molar volume $\gamma = 2{\cdot}4$.

† [*Note added in proof*, 10 *June* 1964.] Recent measurements (Franck, to be published) from 1·3 to 4 °K on solid ^{4}He for molar volumes between 10·85 and 16·30 cm^3/mole have shown an anomalous linear term in the specific heat similar to that found by Heltemes & Swenson. The extrapolated Debye temperature at 0 °K agrees with the data reported by Heltemes & Swenson if the anomalous linear term is neglected in both sets of measurements. The nature of the anomaly is not clear at present. There are indications, however, that the anomaly is much reduced (to roughly 1/3) in well-annealed samples.