significant differences. The similarity is shown by the low values at the beginning and end of each period; and by the major and the minor maxima and the minimum, near group VIIA, group IVB, and group IIIB, respectively. The major difference is that for most properties the values for the elements of the sixth period are larger than those of the fifth, which are larger than those of the fourth. For the Debye temperatures (Fig. 21) the reverse is generally observed. Other differences are that a maximum occurs near group IVA, and that the broad maximum near group VIIA, seen for other properties, splits up into two maxima and a minimum.

The $\theta_0{}^S$ values for the rare earths are shown in Fig. 22a. The data seem to lie on two different curves. The upper curve connects the experimental values obtained for lanthanum, terbium, dysprosium, and lutetium and
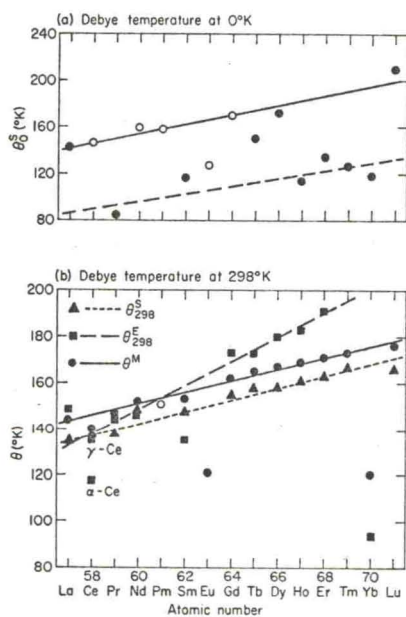

Fig. 22. (a) Debye temperature at 0°K, as determined from specific heat data of the rare-earth metals. (b) Debye temperature at 298°K of the rare-earth metals, as determined from the specific heat, $\theta_{298}{}^S$, from elastic constants, $\theta_{298}{}^E$, and from the Lindemann Equation, θ^M. Open points are estimated values.

the estimated values of cerium, neodymium, promethium, and gadolinium. The values for europium and ytterbium lie below this curve because they are divalent.[13] Unfortunately these two values (Eu and Yb) lie near the lower curve, and it should be pointed out that they are not related to it. The lower curve connects the values of praseodymium, samarium, holmium, erbium, and thulium. As noted earlier (Sections 13 and 15), the electronic contribution to the specific heat is anomalously high and is probably incorrect for praseodymium, holmium, and thulium. Because of this it is quite possible that the lattice contribution is also incorrect. The lattice and electronic contributions to the specific heat of these three metals and also samarium and erbium is difficult to evaluate, especially at low temperatures, because of the magnetic and nuclear contributions. Thus it appears that $\theta_0{}^S$ is also too low for samarium and erbium.

Titanium. The value of $\theta_0{}^S$ given by Estermann, *et al.*[100] for titanium (280°) is not included in the average (426 ±5°) since it is significantly smaller than the other values given in the literature.

Chromium. Since the value of $\theta_0{}^S$ given by Estermann *et al.*[100] for chromium (418°) is significantly smaller than the other literature values (598 ±32°), it is not included in the average.

Copper. The value of $\theta_0{}^S$ was found in general to decrease with increasing total number of impurities in copper, if the purity was less than 99.99%. Therefore, only $\theta_0{}^S$ values for copper specimens which had a purity of 99.99% or greater are considered here. The value given by Franck *et al.*[101] (327°) is not considered in the average, since it is smaller than the seven other values given in literature (343° ±2°K).

Tungsten. The values given by Daunt and co-workers[83,84] for $\theta_0{}^S$ (250° and 169°) are much smaller than those given by others (388° ±17°) and therefore are not included in the average.

Estimated Data. The estimated $\theta_0{}^S$ values were calculated using the Lindemann equation and the constant 145.1 (the choice of this constant and further details are described in Section 17). The $\theta_0{}^S$ values were estimated for white and red phosphorus, monoclinic sulfur, arsenic, technetium, antimony, γ-cerium, neodymium, promethium, europium, gadolinium, polonium, francium, radium, actinium, protactinium, and neptunium.

Debye Temperature at 298°K. The Debye temperatures at 298°K, $\theta_{298}{}^S$ are also given in Table XV. They were evaluated from $C_v{}^l$ (Table XIV) by using the tables of $C_v{}^l$ versus θ^S/T given by Lewis *et al.*[57] For a few elements the values of $\theta_{298}{}^S$ obtained in this manner were quite unreasonable, primarily because $C_v{}^l$ was too large. These $\theta_{298}{}^S$ values were discarded and replaced by more reasonable values of $\theta_T{}^S$, where T refers

[100] I. Estermann, S. A. Friedberg, and J. E. Goldman, *Phys. Rev.* **87**, 582 (1952).
[101] J. P. Franck, F. D. Manchester, and D. L. Martin, *Proc. Roy. Soc.* **A263**, 494 (1961).