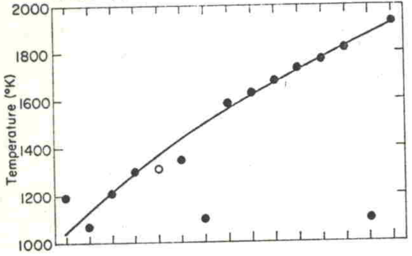
(a) Melting point



(b) Heat of fusion

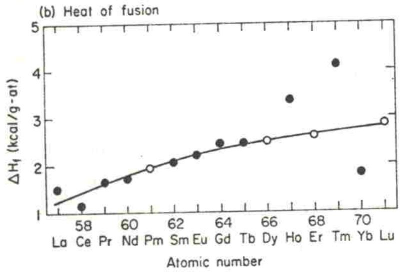


FIG. 13. (a) Melting point of the rare-earth metals. (b) Heat of fusion of the rare-earth metals. Open points are estimated values.

samarium, and for the estimated value of promethium. The large departures from this curve for europium and ytterbium again confirm the divalent nature of these two metals.[13]

The melting points are found to range from 234.28°K (−38.87°C) for mercury to 4100°K (3827°C) for carbon (graphite). The three estimated values fall well within this range. Of the true metallic elements tungsten has the highest melting point, 3653°K (3380°C). The melting points for graphite, red phosphorus, and arsenic all lie above their respective sublimation points at 1 atm pressure.

Estimated Data. The melting points of promethium, francium, and protactinium are estimated values. The estimated value for promethium is taken from Gschneidner's review.[49] He estimated the melting point of promethium by assuming that it lies about midway between those of neodymium and samarium, the immediate neighbors of promethium. The melting point of francium was estimated from a plot of the melting points versus the atomic numbers of the alkali metals and extrapolation to the atomic number of francium. In this manner a value of 297°K (24°C) was obtained, which compares favorably to the estimated value of 300°K (27°C) given by Lyman.[50] In a similar manner the melting point of protactinium was obtained by interpolation from a plot of the melting points versus atomic numbers of thorium, uranium, and neptunium. This gives a value of 1698°K (1425°C), which is larger than the estimated values given by Lyman[50] (1503°K or 1230°C) and Hansen[51] (1573°K or 1300°C).

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[49] K. A. Gschneidner, Jr., "Rare Earth Alloys," p. 24. Van Nostrand, Princeton, New Jersey, 1961.

9. HEAT OF FUSION

The heat of fusion, which is given in Table X, is one of the lesser known properties of the elements. This area, which also includes high-temperature specific heat data, will require considerably more experimental work before we have a reasonably complete set of reliable data.

In 1936 Kelley[52] thoroughly reviewed the existing heats of fusion as determined from direct measurements, phase diagrams, and vapor pressure data. Since that time, many of these data have been redetermined and are summarized in the reviews by Stull and Sinke[53] and Kelley.[54] If no better value has been determined since Kelley's 1936 review,[52] this paper is cited as the reference rather than later reviews of Stull and Sinke[53] and Kelley.[54] More recent experimental data (published since 1960) which have come to the reviewer's attention, are also included in Table X.

The variation of the heat of fusion of the elements of the fourth, fifth, and sixth periods of the Periodic Table as a function of atomic number is shown in Fig. 14. This plot is very similar to those seen earlier. Low values for the heats of fusion are found for the alkali metals and for most of the group IIB, IIIB, IVB, and VIB elements. The maximum value occurs at approximately the s^2d^4 configuration, and the minimum near the end of each period occurs at approximately the $s^2p^1d^{10}$ configuration. The large value for germanium as compared with those of tin and lead is probably related to germanium's diamond structure, while tin and lead are more nearly metallic elements. The large value for arsenic may be incorrect; Kelley[52] also questioned its large magnitude. It should be noted

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[50] T. Lyman, ed., "Metals Handbook," 8th ed., Vol. 1. Am. Soc. for Metals, Metals Park, Ohio, 1961.

[51] M. Hansen, "Constitution of Binary Alloys." McGraw-Hill, New York, 1957.

[52] K. K. Kelley, *U.S. Bur. Mines, Bull.* **393,** (1936).

[53] D. R. Stull and G. C. Sinke, "Thermodynamic Properties of the Elements in Their Standard State." Am. Chem. Soc., Washington, D.C., 1956.

[54] K. K. Kelly, *U.S. Bur. Mines, Bull.* **584,** (1960).