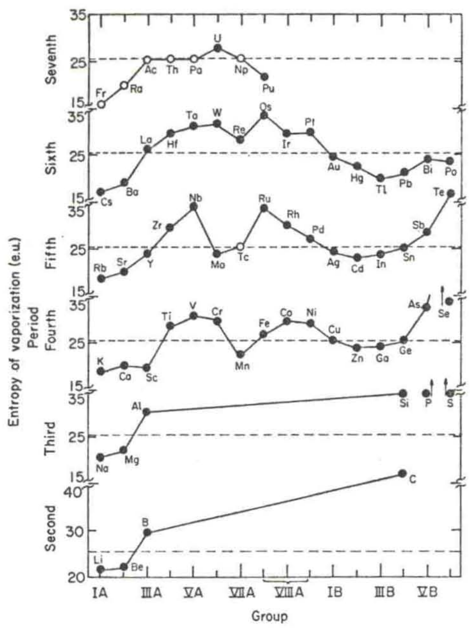

FIG. 31. Entropy of vaporization of all of the elements considered in this review with the exception of the rare-earth metals. The horizontal dashed line represents the mean value. Open points are estimated data.

in a plot of ΔS_v versus the period. The mean value of ΔS_v of the alkaline-earth metals was assumed to be the value for radium.

28. Grüneisen Constant

Grüneisen[116] showed that a quantity γ_G, which is defined as

$$\gamma_G = \frac{\alpha_v V}{\chi C_v{}^l}, \tag{28.1}$$

is a constant of a material, and that it is about equal to 1.8 for most sub-

[116] E. Grüneisen, *in* "Handbuch der Physik" (H. Geiger and K. Scheel, eds.), Vol. 10, p. 1. Springer, Berlin, 1926; *NASA (Natl. Aeron. Space Admin.), Rept. (Engl. Transl.)* NASA-RE-2-18-59W.

stances. In Eq. (28.1) γ_G is now known as the Grüneisen constant, α_v is the volume coefficient of thermal expansion and is equal to 3α (α is the linear coefficient of thermal expansion in Table VI), V is the atomic volume (Table VII), χ is the compressibility (Table V), and $C_v{}^l$ is the lattice contribution to the heat capacity at constant volume (Table XIV). In most of the previous calculations the total heat capacity at constant volume $C_v = C_v{}^l + C_v{}^e$, was used in the denominator of Eq. (28.1). For most substances the inclusion of $C_v{}^e$ makes only a small difference in γ_G. For a few materials, however, $C_v{}^e$ is large enough to have a significant effect on γ_G. Since most of the literature values are based on C_v, these values have also been included in Table XXIV for convenience in comparing the value calculated herein with those previously given in the literature. The values calculated from Eq. (28.1) (that is, by using $C_v{}^l$) are also given in Table XXIV.

Slater[17] has shown that the Grüneisen constant may be given also by the compressibility constants a and b (see Table IV). The constant is given by the symbol γ_S and is defined as

$$\gamma_S = b/a^2 - \tfrac{2}{3}. \tag{28.2}$$

According to Slater, γ_G should equal γ_S; however, he found that a large discrepancy existed between these values for manganese, molybdenum, tantalum, and gold. Gilvarry,[117] by using Bridgman's more recent data, found that γ_G and γ_S are in good agreement for gold, in fair to poor agreement for molybdenum, and in very poor agreement for tantalum. The results were inconclusive for manganese. Since much more information is presently available for the compressibility constants, the analysis of Slater and Gilvarry was extended to all of the elements for which data exist. The γ_S values are also shown in Table XXIV.

The Grüneisen constant can also be calculated from shock wave data.[26] Since these data are somewhat limited, the reader is referred to the review by Rice *et al.*[26] concerning the details of this method for obtaining the Grüneisen constant. The Grüneisen constant obtained from shock wave data is represented by the symbol γ_{SW}, and values thus obtained for this constant are listed in Table XXIV.

Grüneisen Constant γ_G. The mean value of γ_G (as calculated from $C_v{}^l$) is 1.57 ±0.72 excluding the value for plutonium. The error ±0.72 corresponds to a percentage error of 45.8. The values of γ_G vary from a minimum of 0.25 for graphite to a maximum of 6.76 for plutonium. The estimated data also lie within this range.

The variation of γ_G for the elements is shown in Fig. 32, and the dependency of that constant on an element's position in the Periodic Table is

[117] J. J. Gilvarry, *J. Chem. Phys.* **23**, 1925 (1955).