THE DENSITIES OF MAGNESIUM AT ITS MELTING POINT.

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Introduction. Most of the well-defined properties of elements change periodically when they are arranged in order of their atomic weight, for example, atomic volume, specific gravity, melting point, magnetic susceptibility, electric and thermal conductivities, compressibility, arc spectra etc.

When the numerical values are plotted against the atomic weights, the curve obtained is broken up into periods, the shape of period varying according to the property tabulated.

The present writer(1) also stated the periodicity of the change of volume of elements on melting to their atomic weights as illustrated in Fig. 1.

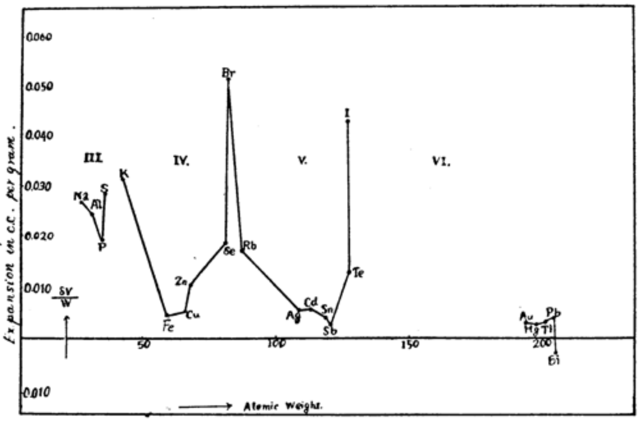

Fig. 1.

The first period in the curve corresponds to the third series of the Mendelejeff's periodic table. A complete short period contains eight elements and a complete long period, eighteen, which are made up of series connected by a transition groups of three elements. Within any one period, whether short or long, there is no sudden change in chemical and physical properties in general as we pass from one element to the next in order. But when we pass from one period to the next, there is a sudden change in the properties of consecutive elements. These sudden changes in the properties correspond in Fig. 1 to sudden change in the direction of the curves. In the Mendelejeff's table, the elements which are located near one another have general resemblance in their properties. From Fig. 1, therefore, it is highly probable that the amount of volume change on melting per unit mass of magnesium will intermediate between those of sodium and aluminium. The volume change on melting per one gram of sodium is 0.0243 c.c. and that of aluminium 0.0267 c.c., hence that of magnesium will be about 0.0255 c.c.

The value of volume change can be obtained if we were able to measure the densities of magnesium at its melting point both in the solid and the liquid states. But the density of magnesium at high temperature has not

(1) H. Endo: *Sci. Rep. Tohoku Imp. Univ.*, **13** (1924), 193; The eighty-eighth report of the Research Institute for Iron, Steel and Other Metals.

yet been determined. So the author has calculated the densities of magnesium at its melting point under the assumption that the above value of the volume change is reasonable.

Experimental. The density of solid at its melting point might easily be calculated from the mean coefficient of cubical expansion of magnesium from room temperature to the vicinity of its melting point. The mean coefficient of linear expansion of the metal has been measured accurately with the dilatometer constantly used in our Institute.[1] The measurement was always made in a vacuum high enough to avoid the oxidation of the specimen. The rate of heating was slow, the whole time required for heating the specimen from room temperature to 600°C. extending over three hours. From the observed data, the elongation $\delta l/l$ of the specimen, whose length is l, was calculated. The mean coefficients of linear expansion of magnesium at various temperatures measured with the apparatus are illustrated in Fig. 2.

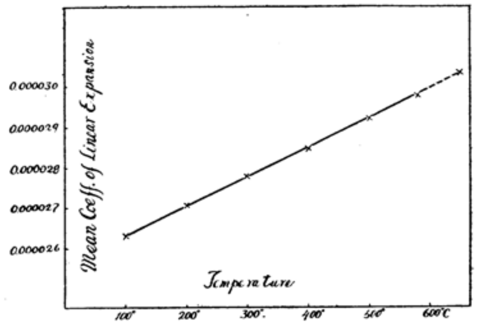

Fig. 2.

The melting point of the metal is 650°C. and, therefore, the mean coefficient of expansion between 20°C. and 650°C. can be deduced by extraporation, thus it has been known to be 0.00003025. Then the mean coefficient of cubical expansion will be calculated as follows:—

$$\beta = 3\alpha = 0.00003025 \times 3 = 0.00009075.$$

The specific volume of the solid state of magnesium at its melting point is 0.60724 c.c. that is:

$$V_s = V_{20}(1+\beta t) = 0.5744(1+0.00009075 \times 630) = 0.60724$$

where V_{20} is the specific volume of the metal at 20°C. The density of the solid state at the melting point is reciprocal of the specific volume that is:—

$$\rho_s = \frac{1}{V_s} = \frac{1}{0.60724} = 1.6468$$

The Density of Magnesium in Liquid State at its Melting Point. The density of the liquid state of the metal at its melting point can easily be calculated from the density of solid state and the amount of the change of volume per unit mass on melting which described above. The writer published the results of measurements of the change of volume in several

(1) *Sci. Rep. Tohoku Imp. Univ.*, 6 (1917), 203.

metals and alloys during solidification with a thermo-balance.[1] The result was that, with the exception of bismuth and antimony, all of the metals and alloys studied show the contraction during solidification. Therefore it may reasonably be assumed that the magnesium also expands during melting, and the amount of it is 0.0255 c.c. per gr. which was derived from the periodic curve described above.

Then the specific volume of the liquid state of magnesium at its melting point is,

$$V_l = 0.60724 + 0.0255 = 0.63274 \text{ c.c.}$$

And the density of the liquid magnesium at its melting point is,

$$\rho_l = \frac{1}{V_l} = \frac{1}{0.63274} = 1.5804.$$

The mean coefficients of linear expansions at several temperatures which have been obtained by measurements are tabulated in the following table.

Temp. C.	Mean linear exp. coeff.	Temp. C.	Mean linear exp. coeff.
20~100	0.0000263	20~500	0.0000292
20~200	0.0000271	20~580	0.0000299
20~300	0.0000278	20~650	0.0000303
20~400	0.0000284		

Density of solid magnesium at 20°C = 1.7410
Density of solid at melting point = 1.6468
Density of liquid at melting point = 1.5804.

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(1) K. Honda, *Sci. Rep. Tohoku Imp. Univ.*, **4** (1915), 97.