

attained without introducing seriously objectionable distortion. Signals resulting from $N^{16}H_3$ lines can readily be observed without introducing serious distortion. If signal size for the 66 line of $N^{16}H_3$ was maximized, the signal-to-noise ratio could be made as large as sixty, but under these conditions the observed signal showed little resemblance to true line shape.

One serious objection to the use of the present double modulation method is that all irregularities in power received by the crystal are amplified in the same manner as the spectral lines. Hence, the beginning and end of the "mode" will always give large signals. Any sharp reflection peaks existing in the transmission line will also give rise to unwanted signals. For short wave guides the reflections are usually much broader than spectral lines observed at low pressure, and hence may be distinguished from lines visually or by means of low frequency rejection filters.⁴ However, as the absorption sections are made longer the observed reflection peaks become sharper and hence more difficult to distinguish from spectral lines. Hence, there are definite limitations in the length of "absorption cell" which can be used in this method of detection; these limitations are the same as those for any method involving "sharpness" as a criterion of the recognizability of absorption lines.

We wish to thank Professor E. B. Wilson and Dr. C. H. Townes for helpful discussions last spring during the early stages of our experiments, to thank Professor Walter Gordy for telling us of his work prior to publication of his recent note, and to express our appreciation to Dr. W. D. Hersberger for sending us information concerning his more recent work on the subject.

* This work was done in connection with Contract No. W28-099ac-179 between Watson Laboratories of the Air Materiel Command, Red Bank, New Jersey, and the Ohio State University Research Foundation.

¹ W. Gordy and M. Kessler, Phys. Rev. 72, 644 (1947).

² E. B. Wilson, unpublished report: Progress Report 3, N5ori-76 Harvard.

³ W. D. Hersberger, paper before Symposium on Molecular Spectra and Molecular Structure, Ohio State University, June 1947.

** Note: For low modulation frequencies, the modulation products are proportional to the "sharpness" of the absorption lines.

⁴ The use of low frequency rejection filters obviously introduces distortion of line shapes, since the rejected frequencies make a definite contribution to true line shapes. However, it is possible that properly designed filters can be used without introducing objectionable distortion. Gordy and Kessler report that the use of filters can actually result in an apparent gain in resolution. (Phys. Rev. 71, 640 (1947).) Hersberger, who has used filters in his work for some time, reports definite distortion of line shape but has used filters quite successfully.

On the Pressure-Volume and Pressure-Compressibility Relation of Metals

P. GOMBÁS

Physical Institute of the University for Technical and Economic Sciences, Budapest, Hungary

October 1, 1947

IT has been shown in a previous work¹ of the author that, by further development of the statistical theory of the atom, it is possible to develop a statistical metal theory² which enables us to give a full account of the metallic bond of the alkali and alkaline earth metals and, further, to compute the constants of these metals as well as several relations between them, without the help of empiric or semi-empiric parameters. The lattice energy U per metal

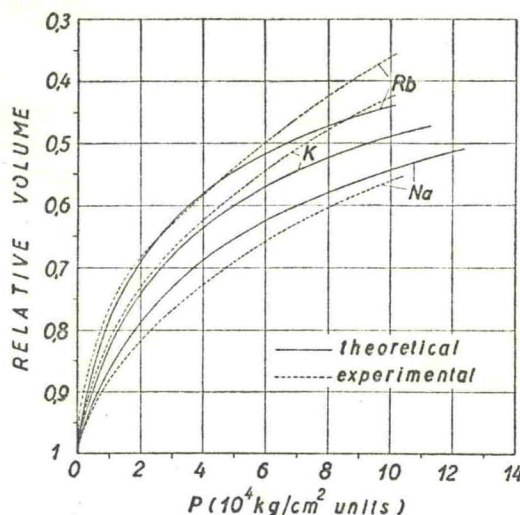


FIG. 1. Comparisons of theoretical and experimental values of pressure-volume relations.

atom—from which all further conclusions can be derived in a simple way—can be expressed as follows:

$$U = A_0 + \frac{A_1}{R} + \frac{A_2}{R^2} + \frac{A_3}{R^3} + \frac{A_4}{R^4} \quad (1)$$

where R denotes the radius of the elementary sphere containing one metal atom and the coefficients A_i are constants, their value being determined only by the distribution of the electrons and the potential within the ions, and the number of the metal electrons per atom. The constants A_i can be easily calculated.

With the help of (1) the pressure P at the absolute zero point of temperature can be expressed as follows:

$$P = -\frac{dU}{d\Omega} = -\frac{1}{4\pi R^3} \frac{dU}{dR} = \frac{1}{4\pi R^3} \times (A_1 R^3 + 2A_2 R^2 + 3A_3 R + 4A_4), \quad (2)$$

where $\Omega = 4\pi R^3/3$ denotes the volume of the elementary sphere. Substituting the expression $(3\Omega/4\pi)^{1/3}$ for R , the equation yields the pressure-volume relation of the metal.

In the above mentioned work I calculated this relation for the metals Na, K, Rb, and Cs up to pressures of about $4 \cdot 10^4$ kg/cm², and I compared the results with those of Bridgman corrected for the absolute zero point of temperature. Recently, the measurements of Bridgman were extended³ to the alkali metals Na, K, Rb, and to several other elements up to pressures of 10^5 kg/cm² at the temperature $T = 296^\circ K$ and this induced me to extend theoretical investigations to high pressures of the same order and compare my results with those of Bridgman.

It appears—supposing a constant density distribution of the metal electrons throughout—that the theory is applicable even to these high pressures without change. As long as we apply to the metal ions the statistical model corrected by the electron exchange, the so-called Thomas-Fermi-Dirac model, even at these high pressures there is no overlapping of the electron clouds of neighboring ions. And even calculating the electron distribution of the metal

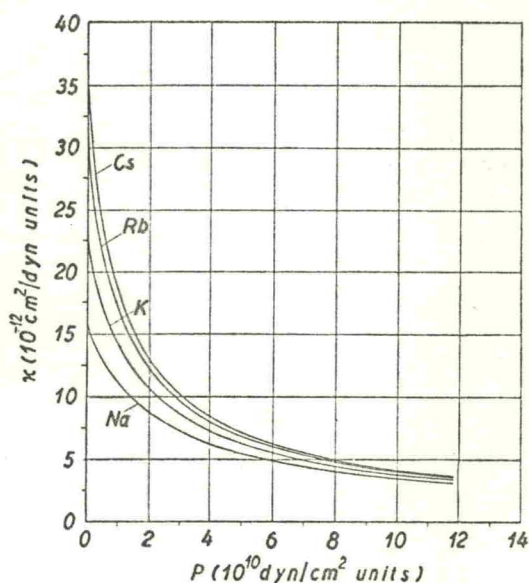


FIG. 2. Pressure-compressibility relations for Cs, Rb, and K.

ions from the more accurate self-consistent field, in the case of alkali and alkaline earth metals, the overlapping of the electron clouds of neighboring ions is negligibly small. It follows, therefore, that the formulae (1) and (2) are applicable even to these high pressures.

For the sake of comparison with the recent experimental results of Bridgman, I calculated the pressure-volume relation for the alkali metals Na, K, and Rb. Since the theory refers to the absolute zero point of temperature, for the purpose of comparison, the theoretical results had to be corrected for the temperature $T=296^\circ\text{K}$ with Bardeen's formula.⁴ Theoretical results as well as those obtained experimentally by Bridgman are graphically recorded in Fig. 1.

The agreement between the theoretical and experimental curves is quite satisfactory, especially if we consider that neither empirical nor semi-empirical parameters were applied in the theory.

With the help of the theoretical explanations given above, the pressure-compressibility relation at the absolute

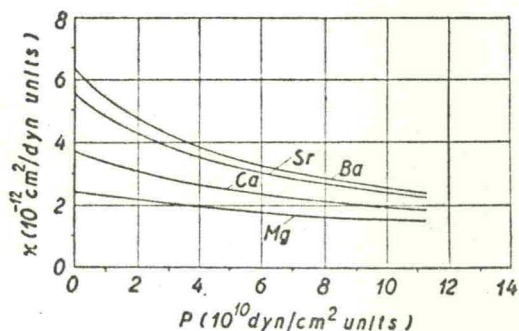


FIG. 3. Pressure-compressibility relations for Ba, Sr, Ca, and Mg.

zero point of temperature can be calculated too. The definition of the compressibility κ is as follows:

$$\frac{1}{\kappa} = \frac{1}{12\pi R} \frac{d^2U}{dR^2}$$

By inserting expression (1) of the lattice energy in this formula, κ appears as the function of R . Connecting that with the expression (2) which gives the relation between R and P , we get the pressure-compressibility relation. That has been calculated for the alkali metals Na, K, Rb, and Cs as well as for the alkaline earths Mg, Ca, Sr, and Ba. The results are graphically recorded in Figs. 2 and 3.

I wish to thank Dr. A. Kónya for performing the calculations.

¹ P. Gombás, *Nature* 157, 668 (1946).

² A detailed presentation of this theory is given in the author's monography, "Die statistische Theorie des Atoms und ihre Anwendungen," *Hungarica Acta Physica* 1, No. 2 (in print); also in book form (Julius Springer Verlag, Vienna, in press).

³ P. W. Bridgman, *Phys. Rev.* 60, 351 (1941). These results of Bridgman are somewhat divergent from his earlier ones and—because of war conditions—became known here only a year ago.

⁴ J. Bardeen, *J. Chem. Phys.* 6, 372 (1938).

The β -Radiations of Antimony¹²⁴, Tantalum¹⁸², Tungsten¹⁸⁵, and Iridium¹⁹²

SWAMI JNANANANDA

The Harrison M. Randall Laboratory of Physics,
University of Michigan, Ann Arbor, Michigan

October 22, 1947

AN investigation of the distribution with momentum of the β -rays of ⁵¹Sb¹²⁴, ⁷³Ta¹⁸², ⁷⁴W¹⁸⁵, and ⁷⁷Ir¹⁹² has been made by analyzing them with a magnetic-lens spectrometer. The results were obtained by an electrical counter with automatic registration in the range between $B\rho=560$ and $B\rho=3750$ gauss-centimeters, the lower value being limited by the window of the detecting device.

The spectrometer used in these experiments is based on the selective focusing action of a magnetic lens on β -rays of heterogeneous velocity. The design admits a transmission factor which corresponds to 0.7 percent of 4π in solid angle of β -particles from the source into the field of selective focusing action. From the size of the solid angle used, the chosen focal length, and the magnitude of the linear spread of the focus along the axis, it can be seen that the resolving power $R=\Delta B\rho/B\rho=\pm 0.37$ percent. This resolution value, however, is influenced by the form, size, thickness, and the percental inactive isotopic content of the source.

An electrical counter of the self-quenching type, with Neher-Pickering circuit, is used to detect the β -spectrum. The detecting device is further provided with an amplifier, a scale of 64, and an electronic operated mechanical recorder for registration of the impulse frequency.

The spectrometer lens being air-core type, the relation between magnetizing current and $B\rho$ gauss-centimeters is linear. Because of this unique linear relation, the magnetizing current is calibrated once for all in terms of the $B\rho$ -value of the well-known and accurately measured F -line of thorium B. ($B\rho=1385.8$ gauss-centimeters¹.)

Z
51
73
74
77

Isotop
Antimo
Tantal
Tungste
Iridium

For
again
repre
They
from
radio
tribut
correc
The m
energy
measu
with v
ence a

The
spectr
0.654
being
be see
point
portec
not pu
of ⁷⁷Ir
The
bomb
was st
takes
James
sugge

¹ C.
² Iso
³ Wa
⁴ K.
⁵ Pa

I N
th
tions
of the