이항정리 식들과 비-이항정리식들을 사용한 금속들의 정용 열 용량

김대겸*, 하백현[1]
삼일약국, [1]한양대학교
(dkkim9744@hanmail.net*)

Heat Capacity of Metals at the Constant Volume by using Binomial Equations and Non-Binomial Equations

Dea kyoum kim*, Baik-Hyon Ha[1]
Samil Pharmacy, [1]Hanyang University
(dkkim9744@hanmail.net*)

I. INTRODUCTION

In part 1 of this series[Kim et al. 2005] a statistical thermo-dynamical model was derived for explaining the heat capacity of metals at constant volume as a function of the temperatures by multiplying the binomial equations by the energy levels. The member of a set making a harmonic vibration are an electron, its proton and its neutron. And it is stressed that the number of the energy levels composed of metals is five. In the derivation of the heat capacity equation the only two excitation energies, the excitation energy of the lowest energy level, D_{l1} and the excitation energy of the higher energy levels, D_h are used. In the similar way by using non-binomial theory the same types of the heat capacity equations are derived.

As a further test, the model was applied to more metals as possible. The line spectra are looked over and the atomic models are figured out. During counting the line spectra of lithium metal, we could figure out the atomic models of ${}^{6}_{3}Li$ and ${}^{7}_{3}Li$ in order to make their metals. Hence the explanation about the atomic model of a metal in Fig. 1 of the reference[Kim et al. 2005] is embodied. And Plank's constant of lithium and boron metals are calculated and the quantum numbers are explained.

II. STATISTICAL MODELING

a. By multiplying binomial equations

The heat capacity equation of the lowest energy level of a metal at the constant volume by multiplying the binomial equations by energy levels is obtained as follows

$$C_{l1} = \frac{3R\left(\frac{z-z^n}{1-z}+\frac{z^n}{g}\right)}{\beta_1+\left(\frac{z-z^n}{1-z}+\frac{z^n}{g}\right)} \qquad n=2,\ 3,\ 4,\ \cdots \tag{1}$$

where

$$\beta_1 = \frac{W_h}{W_{l1}} \exp \frac{-(D_h - D_{l1})}{k_B T_s} \frac{(1 - W_{l1} \exp \frac{-D_{l1}}{k_B T_s})}{(1 - W_h \exp \frac{-D_h}{k_B T_s})} \qquad (1)\text{-}1$$

$$g = 1 - W_h \exp \frac{-D_h}{k_B T_s} = 1 - \exp \frac{-D_h}{k_B T_s} \quad \text{for} \quad W_h = 1 \qquad (1)\text{-}2$$

$$z = c_{s1} g x \quad (1)\text{-}3 \quad x = \frac{T}{T_s} \quad (1)\text{-}3\text{-}1 \quad c_{s1} = \frac{N_{ns}}{N_{n-1s} - N_{ns}} \quad (1)\text{-}3\text{-}1$$

In Eq. (1) R is the universal gas constant and in Eq. (1)-1 W_{l1} the rotational(decay constant) energy of the lowest energy level and W_h the rotational(decay constant) energy of the higher energy levels. And in the above equations k_B is Boltzmann constant, T_s the saturation temperature and T the temperature of the sample metal. And more in Eq. (1)-3-1 c_{s1} which is obtained at T_s is called the saturation temperature factor.

So we apply the heat capacity equations of the more higher energy level isotherms. For the higher energy level isotherms we derive the following equations

$$C_{l2} = 3R\left(\frac{z_n}{\beta_1 + z_n} - \frac{z}{\beta_1 + z_n}\right) \qquad n = 2,\ 3,\ 4 \cdots \qquad (2)\text{-}1$$

$$C_{l3} = 3R\left(\frac{z_n - z - z^2}{\beta_1 + z_n}\right) \qquad n = 3,\ 4 \cdots \qquad (2)\text{-}2$$

$$C_{l4} = 3R\left(\frac{z_n - z - z^2 - z^3}{\beta_1 + z_n}\right) \qquad n = 4,\ 5 \cdots \qquad (2)\text{-}3$$

$$C_{l5} = 3R\left(\frac{z_n - z - z^2 - z^3 - z^4}{\beta_1 + z_n}\right) \qquad n = 5,\ 6 \cdots \qquad (2)\text{-}4$$

$$C_{l6} = 3R\left(\frac{z_n - z - z^2 - z^3 - z^4 - z^5}{\beta_1 + z_n}\right) \qquad n = 6,\ 7 \cdots \qquad (2)\text{-}5$$

where

$$z_n = \frac{z - z^n}{1 - z} + \frac{z^n}{g} \qquad (2)\text{-}1\text{-}1$$

Since irrespective of the energy levels each excited quantum set is furnished with the same amount of energy(the same temperature), the total quantum excitation(internal) energy, U, of all excited sets becomes

$$U = \frac{D_{l1} N_1}{m} + D_h\left(N - \frac{N_1}{m}\right) \fallingdotseq u_1 N \qquad (3)$$

In Eq. (15) u_1 is the average quantum excitation energy of a set and m the degeneracy of the sets. It is considered that there is no additivity according to the energy levels in the heat capacity. C_{l1}, C_{l2}, C_{l3} and etc. are the multiplicative thermodynamic probability functions of levels 1, 2 and 3. And so we take the geometric mean heat capacities of the above two - five equations according to the energy levels of the same kind of the sets of the metal. So here they become

$C_{v1}=\sqrt{C_{l1}C_{l2}}$ (4) $C_{v2}=\sqrt[3]{C_{l1}C_{l2}C_{l3}}$ (5) $C_{v3}=\sqrt[4]{C_{l1}C_{l2}C_{l3}C_{l4}}$ (6)

$C_{v4}=\sqrt[5]{C_{l1}C_{l2}C_{l3}C_{l4}C_{l5}}$ (7) $C_{v5}=\sqrt[5]{C_{l1}C_{l2}C_{l3}C_{l4}C_{l5}C_{l6}}$ (8)

b. By using non-binomial equations

As we explained in the previous paper[Kim et ad., 2005], Eq. (1) could not be fitted to the experimental heat capacity data at all since it draw Langmuir type line for itself. But if we omit the effect of non-excited probability functions of $1-W_{l1}\exp(-D_{l1}/k_BT_s)$ and $1-W_h\exp(-D_h/k_BT_s)$ as we did with similar method in the reference[Kim, 2000], then the derived heat capacity equation of the lowest energy level draws the sigmoid line which can be fitted to the experimental heat capacity in a certain extent, even if it is incomplete mathematically. This derivation is helpful in explaining the continuum theory. Hence the heat capacity equation of the lowest energy level at the constant volume becomes

$$C_{l10}=C_{v10}=\frac{3R(\frac{z_0-z_0^n}{1-z_0}+z_0^n g_0)}{\beta_{10}+(\frac{z_0-z_0^n}{1-z_0}+z_0^n g_0)} \quad n=2,\ 3,\ 4,\ \cdot\cdot\cdot \qquad (9)$$

where

$\beta_{10}=\frac{W_h}{W_{l1}}\exp\{-(D_h-D_{l1})/k_BT_s\}$ (9)-1 $z_0=\frac{c_{s1}x}{g_0}$ (9)-2 and

$g_0=\exp\{-q/(mk_BT_s)\}$ (9)-3

In Eq. (9)-3 q is the additional subtraction energy in nth level. So we apply the heat capacity equations of the more higher energy level isotherms. For the higher energy level isotherms we derive the following equations

$$C_{l20}=3R(\frac{z_{0n}}{\beta_{10}+z_{0n}}-\frac{z_0}{\beta_{10}+z_{0n}}) \qquad n=2,\ 3,\ 4\cdot\cdot\cdot \qquad (10)$$

$$C_{l30}=3R(\frac{z_{0n}-z_0-z_0^2}{\beta_{10}+z_{0n}}) \qquad n=3,\ 4\cdot\cdot\cdot \qquad (11)$$

where

$$z_{0n}=\frac{z_0-z_0^n}{1-z_0}+z_0^n g_0 \qquad (10)\text{-}1$$

And so we take the geometric mean heat capacities of the above two and three equations according to the energy levels of the same kind of the sets of the metal. So here they become

$C_{v20}=\sqrt{C_{l10}C_{l20}}$ (12) $C_{v30}=\sqrt[3]{C_{l10}C_{l20}C_{l30}}$ (13)

III. RESULTS AND DISCUSSION

The semi-experimental heat capacity data of metal at the constant volume are fitted to the multiplication binomial equations much better than the non-binomial equation. We may predict the propagating direction of the photon as $\cos\alpha^2 + \cos\beta^2 + \cos\gamma^2 = 1$.

IV. CONCLUSION

The most promising heat capacity equation at the constant volume among the above derived equations is $C_{t5} = \sqrt[5]{C_{l1}C_{l2}C_{l3}C_{l4}C_{l5}}$. In order to meat this equation we suggest that the four energy levels are $\leftarrow\Leftarrow$, $\rightarrow\Leftarrow$, $\leftarrow\Rightarrow$ and $\rightarrow\Rightarrow$. And we had better agree the existence of a core set composed of free neutrons, if we do not have the other way to approve the five energy levels, such as by accepting the existence of some another atomic model, quarklike model etc. The number of the diagonal energy levels which go toward 4 or 5 grossly show the smallest standard error. We think that the empirical equation, $C_p - C_v = AT\,C_p^2$, the Dulong-Petit law, the experimental heat capacity data at the constant pressure and the above derived equations make the good combination and are promising. 1. k_B is defined as the specific heat of an average level of the metal atom in one dimension. The members of a level become sets. The members of a set of a harmonic oscillation are an electron, its proton and its neutron.
2. The number of the energy levels of each experimented metal is 4 and they represent the sets of an inward electron spin with its outward proton(+neutron) spin($\rightarrow\Leftarrow$), an inward electron spin with its inward proton(+neutron) spin($\rightarrow\Rightarrow$), an outward electron spin with its outward proton(+neutron) spin($\leftarrow\Leftarrow$) and an outward electron spin with its inward proton(+neutron) spin($\leftarrow\Rightarrow$). Each thermal energy level has the same number of the sets of harmonic oscillators. 3. We can clarify the difference of ${}^{6}_{3}Li$ and its isotope ${}^{7}_{3}Li$ by the spin alignments of the sets, 4. We can count the number of the line spectra of atoms by the spin alignments of sets or their interferences. Then we can discern metals, non-metal and semi-metal. Hund's rule is not applied in our study.

V. REFERENCE

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