



**ELECTRICAL-AND-THERMOELECTRIC LAWS, RELATIONS, AND
COEFFICIENTS IN n(p)-TYPE DEGENERATE GaSb(1-x) Te(x)-
CRYSTALLINE ALLOY, ENHANCED BY OUR STATIC DIELECTRIC
CONSTANT LAW AND ELECTRICAL CONDUCTIVITY (V)**

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ABSTRACT

In the $n^+(p^+) - p(n)$ $\text{GaSb}_{1-x}\text{Te}_x$ - crystalline alloy, $0 \leq x \leq 1$, the electrical-and-thermoelectric laws, relations, and various coefficients, enhanced by our static dielectric constant law given in Equations (1a, 1b) and new electrical conductivity in Eq. (14), and by our accurate Fermi energy given in Eq. (11), are now investigated, by basing on the same physical model and mathematical treatment method, as those used in our recent works (Van Cong, 2024, 2025). It should be noted here that, for $x=0$, these obtained numerical results may be reduced to those given in n(p)-type degenerate GaSb-crystal. Then, some remarkable results could be cited in the following. In Tables 5n(5p) given Appendix 1, for a given impurity density N and with increasing temperature T , and then in Tables 6n(6p) given Appendix 1, for a given T and with decreasing N , the reduced Fermi-energy $\xi_{n(p)}$

decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows by: (increase: ↗, decrease: ↘). Further, one notes in these Tables that with increasing T (or with decreasing N) one obtains: (i) for $\xi_{n(p)} \simeq 1.8138$, while the numerical results of the Seebeck coefficient S present a same minimum $(S)_{\min.} (\simeq -1.563 \times 10^{-4} \frac{V}{K})$, those of the figure of merit ZT show a same maximum $(ZT)_{\max.} = 1$, (ii) for $\xi_{n(p)} = 1$, the numerical

results of S , ZT , the Mott figure of merit $(ZT)_{\text{Mott}}$, the first Van-Cong coefficient $VC1$, and the Thomson coefficient Ts , present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715, 3.290, $1.105 \times 10^{-4} \frac{V}{K}$, and $1.657 \times 10^{-4} \frac{V}{K}$, respectively, and finally (iii) for $\xi_n \simeq 1.8138$, $(ZT)_{\text{Mott}} = 1$. It seems that these same results could represent a new law in the thermoelectric properties, obtained in the degenerate case.

KEYWORDS: Electrical conductivity, Seebeck coefficient (S), Figure of merit (ZT), First Van-Cong coefficient ($VC1$), Second Van-Cong coefficient ($VC2$), Thomson coefficient (Ts), Peltier coefficient (Pt)

INTRODUCTION

In the $n^+(p^+) - p(n) X(x) \equiv \text{GaSb}_{1-x}\text{Te}_x$ - crystalline alloy, $0 \leq x \leq 1$, the electrical-and-thermoelectric laws, relations, and various coefficients, enhanced by our static dielectric constant law, $\epsilon(r_{d(a)}, x)$, $r_{d(a)}$ being the donor (acceptor) $d(a)$ -radius, given in Equations (1a, 1b) and new electrical conductivity, in Eq. (14), and also by our accurate Fermi energy, $E_{Fn(Fp)}$, given in Eq. (11), are now investigated, by basing on the same physical model and mathematical treatment method, as those used in our recent works (Van Cong, 2024, 2025). It should be noted here that for $x=0$, these obtained numerical results may be reduced to those given in the $n(p)$ -type degenerate GaSb-crystal (Van Cong, and Van Cong et al., 1980-2023; Hyun et al. 1998; Kim et al., 2015). Then, some remarkable results could be noted in the following.

(1) The generalized Mott criterium in the metal-insulator transition (**MIT**) is expressed in Equations (3, 5, 6), stating that the critical impurity density $N_{\text{CDn(CDp)}}$ is just the density of electrons (holes), localized in the exponential conduction (valence)-band tail (**EBT**), $N_{\text{CDn(CDp)}}^{\text{EBT}}$, obtained with a precision of the order of 2.87×10^{-7} , as given in our recent work (Van Cong, 2024), and the effective electron (hole)-density can be defined by: $N^* \equiv N - N_{\text{CDn(CDp)}} \simeq N - N_{\text{CDn(CDp)}}^{\text{EBT}}$, N being the total impurity density, as that observed in the compensated crystals.

(2) The ratio of the inverse effective screening length $k_{sn(sp)}$ to Fermi wave number $k_{Fn(kp)}$ at 0 K, $R_{sn(sp)}(N^*)$, defined in Eq. (7), is valid at any N^* .

(3) The Fermi energy for any N and T, $E_{Fn(Fp)}$, determined in Eq. (11) with a precision of the order of 2.11×10^{-4} (Van Cong and Debiais, 1993), and it is present in all the expressions of electrical-and-thermoelectric coefficients.

(4) Our expressions for the electrical conductivity, σ , and for the Seebeck coefficient, S, determined respectively in Equations (14, 19) are the basic expressions, used to determine all the following electrical-and-thermoelectric coefficients.

(5) In Tables 5n(5p) given Appendix 1, for a given impurity density N and with increasing temperature T, and further in Tables 6n(6p) given Appendix 1, for a given T and with decreasing N, the reduced Fermi-energy $\xi_{n(p)}$ decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows by: (increase: ↗, decrease: ↘). Furthermore, one notes in these Tables that with increasing T (or with decreasing N) one obtains: (i) for $\xi_{n(p)} \simeq 1.8138$, while the numerical results of the Seebeck coefficient S present a same minimum $(S)_{min.} (\simeq -1.563 \times 10^{-4} \frac{V}{K})$, those of the figure of merit ZT show a same maximum $(ZT)_{max.} = 1$, (ii) for $\xi_{n(p)} = 1$, the numerical results of S, ZT, the Mott figure of merit $(ZT)_{Mott}$, the first Van-Cong coefficient VC1, and the Thomson coefficient Ts, present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715, 3.290, $1.105 \times 10^{-4} \frac{V}{K}$, and $1.657 \times 10^{-4} \frac{V}{K}$, respectively, and finally (iii) for $\xi_n \simeq 1.8138$, $(ZT)_{Mott} = 1$. It seems that these same results could represent a new law in the thermoelectric properties, obtained in the degenerate case.

OUR STATIC DIELECTRIC CONSTANT LAW AND GENERALIZED MOTT CRITERIUM IN THE METAL-INSULATOR TRANSITION

First of all, in the $n^+(p^+) - p(n) X(x)$ - crystalline alloy at T=0 K, we denote the donor (acceptor) d(a)-radius by $r_{d(a)}$, the corresponding intrinsic one by: $r_{do(ao)} = r_{sb(Ga)}$, the unperturbed relative effective electron (hole) mass in conduction (valence) bands by: $m_{c(v)}(x)/m_o$, the unperturbed relative static dielectric constant by: $\epsilon_o(x)$, and the intrinsic band gap by: $E_{go}(x)$. Then, their values are reported in Table 1 in Appendix 1.

Therefore, we can define the effective donor (acceptor)-ionization energy in absolute values as:

$$E_{do(ao)}(x) = \frac{13600 \times [m_{c(v)}(x)/m_o]}{[\epsilon_o(x)]^2} \text{ meV} , \text{ and then, the isothermal bulk modulus, by:}$$

$$B_{do(ao)}(x) \equiv \frac{E_{do(ao)}(x)}{(\frac{4\pi}{3}) \times (r_{do(ao)})^3} .$$

Our Static Dielectric Constant Law

Here, the changes in all the energy-band-structure parameters, expressed in terms of the effective relative dielectric constant $\epsilon(r_{d(a)}, \mathbf{x})$, developed as follows.

At $r_{d(a)} = r_{do(ao)}$, the needed boundary conditions are found to be, for the impurity-atom volume $V = (4\pi/3) \times (r_{d(a)})^3$, $V_{do(ao)} = (4\pi/3) \times (r_{do(ao)})^3$, for the pressure p , $p_o = 0$, and for the deformation potential energy (or the strain energy) α , $\alpha_o = 0$. Further, the two important equations, used to determine the α -variation, $\Delta \alpha \equiv \alpha - \alpha_o = \alpha$, are defined by:

$\frac{dp}{dV} = -\frac{B}{V}$ and $p = -\frac{d\alpha}{dV}$, giving rise to: $\frac{d}{dV}(\frac{d\alpha}{dV}) = \frac{B}{V}$. Then, by an integration, one gets:

$$[\Delta\alpha(r_{d(a)}, \mathbf{x})]_{n(p)} = B_{do(ao)}(\mathbf{x}) \times (V - V_{do(ao)}) \times \ln\left(\frac{V}{V_{do(ao)}}\right) = E_{do(ao)}(\mathbf{x}) \times \left[\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 - 1\right] \times \ln\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 \geq 0$$

Furthermore, we also showed that, as $r_{d(a)} > r_{do(ao)}$ ($r_{d(a)} < r_{do(ao)}$), the compression (dilatation) gives rise to the increase (the decrease) in the energy gap $E_{gn(gp)}(r_{d(a)}, \mathbf{x})$, and the effective donor (acceptor)-ionization energy $E_{d(a)}(r_{d(a)}, \mathbf{x})$ in absolute values, obtained in the effective Bohr model, which is represented respectively by: $\pm [\Delta\alpha(r_{d(a)}, \mathbf{x})]_{n(p)}$,

$$E_{gno(gp)}(r_{d(a)}, \mathbf{x}) - E_{go}(\mathbf{x}) = E_{d(a)}(r_{d(a)}, \mathbf{x}) - E_{do(ao)}(\mathbf{x}) = E_{do(ao)}(\mathbf{x}) \times \left[\left(\frac{\epsilon_o(\mathbf{x})}{\epsilon(r_{d(a)})}\right)^2 - 1\right] + [\Delta\alpha(r_{d(a)}, \mathbf{x})]_{n(p)}$$

for $r_{d(a)} \geq r_{do(ao)}$, and for $r_{d(a)} \leq r_{do(ao)}$,

$$E_{gno(gp)}(r_{d(a)}, \mathbf{x}) - E_{go}(\mathbf{x}) = E_{d(a)}(r_{d(a)}, \mathbf{x}) - E_{do(ao)}(\mathbf{x}) = E_{do(ao)}(\mathbf{x}) \times \left[\left(\frac{\epsilon_o(\mathbf{x})}{\epsilon(r_{d(a)})}\right)^2 - 1\right] - [\Delta\alpha(r_{d(a)}, \mathbf{x})]_{n(p)}$$

Therefore, one obtains the expressions for relative dielectric constant $\epsilon(r_{d(a)}, \mathbf{x})$ and energy band gap $E_{gn(gp)}(r_{d(a)}, \mathbf{x})$, as:

(i)-for $r_{d(a)} \geq r_{do(ao)}$, since $\epsilon(r_{d(a)}, \mathbf{x}) = \frac{\epsilon_o(\mathbf{x})}{\sqrt{1 + \left[\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 - 1\right] \times \ln\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3}} \leq \epsilon_o(\mathbf{x})$, being a **new**

$\epsilon(r_{d(a)}, \mathbf{x})$ -law,

$$E_{gno(gp)}(r_{d(a)}, \mathbf{x}) - E_{go}(\mathbf{x}) = E_{d(a)}(r_{d(a)}, \mathbf{x}) - E_{do(ao)}(\mathbf{x}) = E_{do(ao)}(\mathbf{x}) \times \left[\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 - 1\right] \times \ln\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 \geq 0, \tag{1a}$$

according to the increase in both $E_{gn(gp)}(r_{d(a)}, x)$ and $E_{d(a)}(r_{d(a)}, x)$, with increasing $r_{d(a)}$ and for a given x , and

(ii)-for $r_{d(a)} \leq r_{do(ao)}$, since $\varepsilon(r_{d(a)}, x) = \frac{\varepsilon_o(x)}{\sqrt{1 - \left[\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 - 1\right] \times \ln\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3}} \geq \varepsilon_o(x)$, with a condition,

given by: $\left[\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 - 1\right] \times \ln\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 < 1$, being a **new $\varepsilon(r_{d(a)}, x)$ -law**,

$$E_{gno(gp)}(r_{d(a)}, x) - E_{go}(x) = E_{d(a)}(r_{d(a)}, x) - E_{do(ao)}(x) = -E_{do(ao)}(x) \times \left[\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 - 1\right] \times \ln\left(\frac{r_{d(a)}}{r_{do(ao)}}\right)^3 \leq 0, \tag{1b}$$

corresponding to the decrease in both $E_{gno(gp)}(r_{d(a)}, x)$ and $E_{d(a)}(r_{d(a)}, x)$, with decreasing $r_{d(a)}$ and for a given x .

It should be noted that, in the following, all the electrical-and-thermoelectric properties strongly depend on this **new $\varepsilon(r_{d(a)}, x)$ -law**.

Furthermore, the effective Bohr radius $a_{Bn(Bp)}(r_{d(a)}, x)$ is defined by:

$$a_{Bn(Bp)}(r_{d(a)}, x) \equiv \frac{\varepsilon(r_{d(a)}, x) \times \hbar^2}{m_{c(v)}(x) \times m_o \times q^2} = 0.53 \times 10^{-8} \text{ cm} \times \frac{\varepsilon(r_{d(a)}, x)}{m_{c(v)}(x)}. \tag{2}$$

Generalized Mott Criterium in the MIT

Now, it is interesting to remark that the critical total donor (acceptor)-density in the MIT at $T=0$ K, $N_{CDn(NDp)}(r_{d(a)}, x)$, was given by the Mott’s criterium, with an empirical parameter, $M_{n(p)}$, as:

$$N_{CDn(CDp)}(r_{d(a)}, x)^{1/3} \times a_{Bn(Bp)}(r_{d(a)}, x) = M_{n(p)}, \quad M_{n(p)} = 0.25, \tag{3}$$

depending thus on our **new $\varepsilon(r_{d(a)}, x)$ -law**.

This excellent one can be explained from the definition of the reduced effective Wigner-Seitz (WS) radius $r_{sn(sp)}$, characteristic of interactions, by:

$$r_{sn(sp)}(N, r_{d(a)}, x) \equiv \left(\frac{3}{4\pi N}\right)^{1/3} \times \frac{1}{a_{Bn(Bp)}(r_{d(a)}, x)} = 1.1723 \times 10^8 \times \left(\frac{1}{N}\right)^{1/3} \times \frac{m_{c(v)}(x) \times m_o}{\varepsilon(r_{d(a)}, x)}, \tag{4}$$

being equal to, in particular, at $N=N_{CDn(CDP)}(\Gamma_{d(a)}, \mathbf{x})$: $\Gamma_{sn(sp)}(N_{CDn(CDP)}(\Gamma_{d(a)}, \mathbf{x}), \Gamma_{d(a)}, \mathbf{x})=2.4813963$, for any $(\Gamma_{d(a)}, \mathbf{x})$ -values. Then, from Eq. (4), one also has :

$$N_{CDn(CDP)}(\Gamma_{d(a)}, \mathbf{x})^{1/3} \times a_{Bn(Bp)}(\Gamma_{d(a)}, \mathbf{x}) = \left(\frac{3}{4\pi}\right)^{1/3} \times \frac{1}{2.4813963} = 0.25 = (WS)_{n(p)} = M_{n(p)}, \quad (5)$$

explaining thus the existence of the Mott's criterium.

Furthermore, by using $M_{n(p)} = 0.25$, according to the empirical Heisenberg parameter $\mathcal{H}_{n(p)} = 0.47137$, as those given in our previous work (Van Cong, 2024), we have also showed that $N_{CDn(CDP)}$ is just **the density of electrons (holes) localized in the exponential conduction (valence)-band tail, $N_{CDn(CDP)}^{EBT}$** , with a precision of the order of 2.87×10^{-7} .

It should be noted that the values of $M_{n(p)}$ and $\mathcal{H}_{n(p)}$ could be chosen so that those of $N_{CDn(CDP)}$ and $N_{CDn(CDP)}^{EBT}$ are found to be in good agreement with their experimental results.

Therefore, the density of electrons (holes) given in parabolic conduction (valence) bands can be defined, as that given in compensated materials:

$$N^*(N, \Gamma_{d(a)}, \mathbf{x}) \equiv N - N_{CDn(NDp)}(\Gamma_{d(a)}, \mathbf{x}) = N^*, \text{ for a presentation simplicity.} \quad (6)$$

In summary, as observed in Table 4 of our previous paper (Van Cong, 2024), one remarks that, for a given x and an increasing $\Gamma_{d(a)}$, $\varepsilon(\Gamma_{d(a)}, \mathbf{x})$ decreases, while $E_{gno(gpo)}(\Gamma_{d(a)}, \mathbf{x})$, $N_{CDn(NDp)}(\Gamma_{d(a)}, \mathbf{x})$ and $N_{CDn(CDP)}^{EBT}(\Gamma_{d(a)}, \mathbf{x})$ increase, affecting strongly all electrical-and-thermoelectric properties, as those observed in following Sections.

PHYSICAL MODEL

In the $n^+(p^+) - p(n) \mathbf{X}(\mathbf{x})$ - crystalline alloy, if denoting the Fermi wave number by:

$k_{Fn(Fp)}(N^*) \equiv \left(\frac{3\pi^2 N^*}{\varepsilon_c(v)}\right)^{1/3}$, the reduced effective Wigner-Seitz (WS) radius $\Gamma_{sn(sp)}$, characteristic of interactions, being given in Eq. (4), in which N is replaced by N^* , is now defined by:

$$\gamma \times \Gamma_{sn(sp)}(N^*) \equiv \frac{k_{Fn(Fp)}^{-1}}{a_{Bn(Bp)}} < 1,$$

being proportional to $N^{*-1/3}$. Here, $\gamma = (4/9\pi)^{1/3}$, $k_{Fn(Fp)}^{-1}$ means the averaged distance between ionized donors (acceptors), and $a_{Bn(Bp)}(\Gamma_{d(a)}, \mathbf{x})$ is determined in Eq. (2).

Then, the ratio of the inverse effective screening length $k_{sn(sp)}$ to Fermi wave number $k_{Fn(kp)}$ at 0 K is defined by:

$$R_{sn(sp)}(N^*) \equiv \frac{k_{sn(sp)}}{k_{Fn(Fp)}} = \frac{k_{Fn(Fp)}^{-1}}{k_{sn(sp)}^{-1}} = R_{snWS(spWS)} + [R_{snTF(spTF)} - R_{snWS(spWS)}]e^{-r_{sn(sp)}} < 1, \quad (7)$$

being valid at any N^* .

Here, these ratios, $R_{snTF(spTF)}$ and $R_{snWS(spWS)}$, can be determined as follows.

First, for $N \gg N_{CDn(NDp)}(r_{d(a)}, X)$, according to the **Thomas-Fermi (TF)-approximation**, the ratio $R_{snTF(spTF)}(N^*)$ is reduced to

$$R_{snTF(spTF)}(N^*) \equiv \frac{k_{snTF(spTF)}}{k_{Fn(Fp)}} = \frac{k_{Fn(Fp)}^{-1}}{k_{snTF(spTF)}^{-1}} = \sqrt{\frac{4\gamma r_{sn(sp)}}{\pi}} \ll 1, \quad (8)$$

being proportional to $N^{*-1/6}$.

Secondly, for $N \ll N_{CDn(NDp)}(r_{d(a)})$, according to the **Wigner-Seitz (WS)-approximation**, the ratio $R_{snWS(spWS)}$ is respectively reduced to

$$R_{sn(sp)WS}(N^*) \equiv \frac{k_{sn(sp)WS}}{k_{Fn}} = 0.5 \times \left(\frac{s}{2\pi} - \gamma \frac{d[r_{sn(sp)}^2 \times E_{CE}(N^*)]}{dr_{sn(sp)}} \right), \quad (9)$$

where $E_{CE}(N^*)$ is the majority-carrier correlation energy (CE), being determined by:

$$E_{CE}(N^*) = \frac{-0.87553}{0.0908 + r_{sn(sp)}} + \frac{\frac{0.87553}{0.0908 + r_{sn(sp)}} + \left(\frac{2[1 - \ln(2)]}{\pi^2}\right) \times \ln(r_{sn(sp)}) - 0.093288}{1 + 0.03847728 \times r_{sn(sp)}^{1.67378876}}.$$

Furthermore, in the highly degenerate case, the physical conditions are found to be given by:

$$\frac{k_{Fn(Fp)}^{-1}}{a_{Bn(Bp)}} < \frac{\eta_{n(p)}}{E_{Fno(Fpo)}} \equiv \frac{1}{A_{n(p)}} < \frac{k_{Fn(Fp)}^{-1}}{k_{sn(sp)}^{-1}} \equiv R_{sn(sp)} < 1, \quad \eta_{n(p)}(N^*) \equiv \frac{\sqrt{2\pi N^*}}{s(r_{d(a)})} \times q^2 k_{sn(sp)}^{-1/2}, \quad (10)$$

which gives: $A_{n(p)}(N^*) = \frac{E_{Fno(Fpo)}(N^*)}{\eta_{n(p)}(N^*)}$.

FERMI ENERGY AND FERMI-DIRAC DISTRIBUTION FUNCTION

Fermi Energy and generalized Einstein relation

Here, for a presentation simplicity, we change all the sign of various parameters, given in the $p^+ - X(x)$ - crystalline alloy in order to obtain the same one, as given in the $n^+ - X(x)$ - crystalline alloy, according to the reduced Fermi energy, $\xi_{n(p)}(N, r_{d(a)}, X, T) \equiv \frac{E_{Fn(Fp)}(N, r_{d(a)}, X, T)}{k_B T} > 0 (< 0)$, obtained respectively in the degenerate (non-degenerate) case.

For any $(N, r_{d(a)}, x, T)$, the reduced Fermi energy $\xi_{n(p)}(N, r_{d(a)}, x, T)$ or the Fermi energy $E_{Fn(Fp)}(N, r_{d(a)}, x, T)$, obtained in our previous paper (Van Cong, Debiais, and Doan Khanh, 1991- 1993), obtained with a precision of the order of 2.11×10^{-4} , is found to be given by:

$$\xi_{n(p)}(u) \equiv \frac{E_{Fn(Fp)}(u)}{k_B T} = \frac{G(u) + Au^B F(u)}{1 + Au^B} \equiv \frac{V(u)}{W(u)}, \quad A = 0.0005372 \text{ and } B = 4.82842262, \quad (11)$$

where u is the reduced electron density, $u(N, r_{d(a)}, x, T) \equiv \frac{N^*}{N_{c(v)}(T, x)}$,

$$N_{c(v)}(T, x) = 2g_{c(v)} \times \left(\frac{m_{c(v)}(x) \times m_0 \times k_B T}{2\pi \hbar^2} \right)^{\frac{3}{2}} \quad (\text{cm}^{-3}), \quad g_{c(v)} = 1,$$

$$F(u) = au^{\frac{2}{3}} \left(1 + bu^{-\frac{4}{3}} + cu^{-\frac{8}{3}} \right)^{-\frac{2}{3}}, \quad a = [3\sqrt{\pi}/4]^{2/3}, \quad b = \frac{1}{8} \left(\frac{\pi}{a} \right)^2, \quad c = \frac{62.3739855}{1920} \left(\frac{\pi}{a} \right)^4, \quad \text{and}$$

$$G(u) \simeq \text{Ln}(u) + 2^{-\frac{3}{2}} \times u \times e^{-du}; \quad d = 2^{3/2} \left[\frac{1}{\sqrt{27}} - \frac{3}{16} \right] > 0.$$

So, in the non-degenerate case ($u \ll 1$), one has: $E_{Fn(Fp)}(u) = k_B T \times G(u) \simeq k_B T \times \text{Ln}(u)$ as $u \rightarrow 0$, **the limiting non-degenerate condition**, and in the very degenerate case ($u \gg 1$),

$$\text{one gets: } E_{Fn(Fp)}(u \gg 1) = k_B T \times F(u) = k_B T \times au^{\frac{2}{3}} \left(1 + bu^{-\frac{4}{3}} + cu^{-\frac{8}{3}} \right)^{-\frac{2}{3}} \simeq \frac{\hbar^2 \times k_{Fn(Fp)}^2(N^*)}{2 \times m_{c(v)}(x) \times m_0}$$

as $u \rightarrow \infty$, **the limiting degenerate condition**. In other words, $\xi_{n(p)} \equiv \frac{E_{Fn(Fp)}}{k_B T}$ is accurate, and it also verifies the correct limiting conditions.

In particular, at $T=0K$, since $u^{-1} = 0$, Eq. (11) is reduced to: $E_{Fno(Fpo)}(N^*) \equiv \frac{\hbar^2 \times k_{Fn(Fp)}^2(N^*)}{2 \times m_{c(v)}(x) \times m_0}$, being proportional to $(N^*)^{2/3}$, and also equal to 0 at $N^* = 0$, according to the MIT.

In the following, it should be noted that all the electrical-and-thermoelectric properties strongly depend on such the accurate expression of $\xi_{n(p)}(N, r_{d(a)}, x, T)$.

Fermi-Dirac Distribution Function (FDDF)

The Fermi-Dirac distribution function (FDDF) is given by: $f(E) \equiv (1 + e^\gamma)^{-1}$, $\gamma \equiv (E - E_{Fn(Fp)})/(k_B T)$.

So, the average of E^p , calculated using the FDDF-method, as developed in our previous work (Van Cong, 2018, 2025) is found to be given by:

$$\langle E^p \rangle_{FDDF} \equiv G_p(E_{Fn(Fp)}) \times E_{Fn(Fp)}^p \equiv \int_{-\infty}^{\infty} E^p \times \left(-\frac{\partial f}{\partial E} \right) dE, \quad -\frac{\partial f}{\partial E} = \frac{1}{k_B T} \times \frac{e^\gamma}{(1+e^\gamma)^2}.$$

Further, one notes that, at 0 K, $-\frac{\partial f}{\partial E} = \delta(E - E_{F_{no}(F_{po})}), \delta(E - E_{F_{no}(F_{po})})$ being the Dirac delta (δ)-function. Therefore, $G_p(E_{F_{no}(F_{po})}) = 1$.

Then, at low T, by a variable change $\gamma \equiv (E - E_{F_n(F_p)})/(k_B T)$, one has:

$$G_p(E_{F_n(F_p)}) \equiv 1 + E_{F_n(F_p)}^{-p} \times \int_{-\infty}^{\infty} \frac{e^{\gamma}}{(1+e^{\gamma})^2} \times (k_B T \gamma + E_{F_n(F_p)})^p d\gamma = 1 + \sum_{\mu=1,2,\dots}^p C_p^{\beta} \times (k_B T)^{\beta} \times E_{F_n(F_p)}^{-\beta} \times I_{\beta}$$

where $C_p^{\beta} \equiv p(p-1) \dots (p-\beta+1)/\beta!$ and the integral I_{β} is given by:

$I_{\beta} = \int_{-\infty}^{\infty} \frac{\gamma^{\beta} \times e^{\gamma}}{(1+e^{\gamma})^2} d\gamma = \int_{-\infty}^{\infty} \frac{\gamma^{\beta}}{(e^{\gamma/2} + e^{-\gamma/2})^2} d\gamma$, vanishing for odd values of β . Then, for even values of $\beta = 2n$, with $n=1, 2, \dots$, one obtains:

$$I_{2n} = 2 \int_0^{\infty} \frac{\gamma^{2n} \times e^{\gamma}}{(1+e^{\gamma})^2} d\gamma .$$

Now, using an identity $(1 + e^{\gamma})^{-2} \equiv \sum_{s=1}^{\infty} (-1)^{s+1} s \times e^{\gamma(s-1)}$, a variable change: $s\gamma = -t$, the Gamma function: $\int_0^{\infty} t^{2n} e^{-t} dt \equiv \Gamma(2n + 1) = (2n)!$, and also the definition of the Riemann's zeta function: $\zeta(2n) \equiv 2^{2n-1} \pi^{2n} |B_{2n}| / (2n)!$, B_{2n} being the Bernoulli numbers, one finally gets: $I_{2n} = (2^{2n} - 2) \times \pi^{2n} \times |B_{2n}|$. So, from above Eq. of $\langle E^p \rangle_{FDDF}$, we get in the degenerate case the following ratio:

$$G_p(E_{F_n(F_p)}) \equiv \frac{\langle E^p \rangle_{FDDF}}{E_{F_n(F_p)}^p} = 1 + \sum_{n=1}^p \frac{p(p-1)\dots(p-2n+1)}{(2n)!} \times (2^{2n} - 2) \times |B_{2n}| \times y^{2n} \equiv G_{p \geq 1}(y), \quad (12)$$

where $y \equiv \frac{\pi}{\xi_n(p)(N^*, T)} = \frac{\pi k_B T}{E_{F_n(F_p)}(N^*, T)}$.

Then, some usual results of $G_{p \geq 1}(y)$ are given in Table 2 in Appendix 1, being needed to determine all the following electrical-and-thermoelectric properties.

ELECTRICAL-AND-THERMOELECTRIC PROPERTIES

Here, if denoting, for majority electrons (holes), the electrical conductivity by $\sigma(N, r_{d(a)}, x, T)$ expressed in $\text{ohm}^{-1} \times \text{cm}^{-1}$, the thermal conductivity by $\kappa(N, r_{d(a)}, x, T)$ in $\frac{W}{\text{cm} \times K}$, and the

Lorenz number L defined by:

$$L = \frac{\pi^2}{3} \times \left(\frac{k_B}{q}\right)^2 = 2.4429637 \left(\frac{W \times \text{ohm}}{K^2}\right) = 2.4429637 \times 10^{-8} (V^2 \times K^{-2}),$$

then the well-known Wiedemann-Frank law states that the ratio, $\frac{\kappa}{\sigma}$, is proportional to the temperature T(K), as:

$$\frac{\kappa(N, r_{d(a)}, x, T)}{\sigma(N, r_{d(a)}, x, T)} = L \times T. \tag{13}$$

We now determine the general form of σ in the following.

First of all, it is expressed in terms of the kinetic energy of the electron (hole),

$$E_k \equiv \frac{\hbar^2 \times k^2}{2 \times m_{Cn(Cp)} \times m_0}, \text{ or the wave number } k, \text{ as:}$$

$$\sigma(k) \equiv \frac{q^2 \times k}{\pi \times \hbar} \times \frac{k}{k_{sn(sp)}} \times [k \times a_{Bn(Bp)}] \times \left(\frac{E_k}{\eta_{n(p)}} \right)^{1/2},$$

which is thus proportional to E_k^2 .

Then, for $E \geq 0$, we obtain: $\langle E^2 \rangle_{FDDF} \equiv G_2(y = \frac{\pi k_B T}{E_{Fn(Fp)}}) \times E_{Fn(Fp)}^2$, and

$$G_2(y) = \left(1 + \frac{y^2}{3} \right) \equiv G_2(N, r_{d(a)}, x, T), \text{ with } y \equiv \frac{\pi}{\xi_{n(p)}}, \xi_{n(p)} = \xi_{n(p)}(N, r_{d(a)}, x, T) \text{ for a}$$

presentation simplicity. Therefore, one obtains (Van Cong, 2025):

$$\sigma(N, r_{d(a)}, x, T) \equiv \left[\frac{q^2}{\pi \times \hbar} \times \frac{k_{Fn(Fp)}(N^*)}{R_{sn(sp)}(N^*)} \times [k_{Fn(Fp)}(N^*) \times a_{Bn(Bp)}(r_{d(a)})] \times \sqrt{A_{n(p)}(N^*)} \right] \times \left[G_2(N, r_{d(a)}, x, T) \times \left(\frac{E_{Fn(Fp)}(N, r_{d(a)}, x, T)}{E_{Fno(Fpo)}(N^*)} \right)^2 \right] \left(\frac{1}{\text{ohm} \times \text{cm}} \right),$$

$$\frac{q^2}{\pi \times \hbar} = 7.7480735 \times 10^{-5} \text{ ohm}^{-1}, A_{n(p)}(N^*) = \frac{E_{Fno(Fpo)}(N^*)}{\eta_{n(p)}(N^*)}, R_{sn(sp)}(N^*) \equiv \frac{k_{sn(sp)}}{k_{Fn(Fp)}}, \tag{14}$$

which can be used to define the resistivity as: $\rho(N, r_{d(a)}, x, T) \equiv 1/\sigma(N, r_{d(a)}, x, T)$, noting again that $N^* \equiv N - N_{CDn(NDp)}(r_{d(a)}, x)$. This $\sigma(N, r_{d(a)}, x, T)$ -result is an essential one in this paper, being used to determine other electrical-and-thermoelectric properties.

In Eq. (14), one notes that at $T=0$ K, $\sigma(N, r_{d(a)}, x, T=0K)$ is proportional to $E_{Fno(Fpo)}^2$, or to $(N^*)^{\frac{4}{3}}$. Thus, $\sigma(N = N_{CDn(NDp)}, r_{d(a)}, x, T=0K) = 0$ at $N^* = 0$, at which the metal-insulator transition (MIT) occurs.

Electrical Coefficients

The relaxation time τ is related to σ by (Van Cong, 2025):

$$\tau(N, r_{d(a)}, x, T) \equiv \sigma(N, r_{d(a)}, x, T) \times \frac{m_{c(v)}(x) \times m_0}{q^2 \times N^*}. \text{ Therefore, the mobility } \mu \text{ is given by:}$$

$$\mu(N, r_{d(a)}, x, T) \equiv \mu(N^*, r_{d(a)}, T) = \frac{q \times \tau(N, r_{d(a)}, x, T)}{m_{c(v)}(x) \times m_0} = \frac{\sigma(N, r_{d(a)}, x, T)}{q \times N^*} \left(\frac{\text{cm}^2}{\text{V} \times \text{s}} \right). \tag{15}$$

Here, at $T=0K$, $\mu(N^*, r_{d(a)}, T)$ is thus proportional to $(N^*)^{1/3}$, since $\sigma(N^*, r_{d(a)}, T=0K)$ is proportional to $(N^*)^{4/3}$. Thus, $\mu(N^*=0, r_{d(a)}, T=0K) = 0$ at $N^*=0$, at which the metal-insulator transition (MIT) occurs.

Then, since τ and σ are both proportional to $E_{Fn(Fp)}(N^*, T)^2$, as given above, the Hall factor is defined by:

$$r_H(N, r_{d(a)}, x, T) \equiv \frac{(\tau^2)_{FDDF}}{[(\tau)_{FDDF}]^2} = \frac{G_4(y)}{[G_2(y)]^2}, y \equiv \frac{\pi}{\xi_{n(p)}(N, r_{d(a)}, x, T)} = \frac{\pi k_B T}{E_{Fn(Fp)}(N, r_{d(a)}, x, T)},$$

and therefore, the Hall mobility yields:

$$\mu_H(N, r_{d(a)}, x, T) \equiv \mu(N, r_{d(a)}, x, T) \times r_H(N^*, T) \left(\frac{cm^2}{V \times s}\right), \tag{16}$$

noting that, at $T=0K$, since $r_H(N, r_{d(a)}, x, T) = 1$, one then gets: $\mu_H(N, r_{d(a)}, x, T) \equiv \mu(N, r_{d(a)}, x, T)$.

Finally, our **generalized Einstein relation** is found to be defined as:

$$\frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} \equiv \frac{N^*}{q} \times \frac{dE_{Fn(Fp)}}{dN^*} \equiv \frac{k_B \times T}{q} \times \left(u \frac{d\xi_{n(p)}(u)}{du}\right) = \sqrt{\frac{3 \times L}{\pi^2}} \times T \times \left(u \frac{d\xi_{n(p)}(u)}{du}\right), \frac{k_B}{q} = \sqrt{\frac{3 \times L}{\pi^2}} \tag{17}$$

where $D(N, r_{d(a)}, x, T)$ is the diffusion coefficient, $\xi_{n(p)}(u)$ is defined in Eq. (11), and the mobility $\mu(N, r_{d(a)}, x, T)$ is determined in Eq. (15). Then, by differentiating this function $\xi_{n(p)}(u)$ with respect to u , one thus obtains $\frac{d\xi_{n(p)}(u)}{du}$. Therefore, Eq. (17) can also be rewritten as:

$$\frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} = \frac{k_B \times T}{q} \times u \frac{V'(u) \times W(u) - V(u) \times W'(u)}{W^2(u)},$$

where $W'(u) = ABu^{B-1}$ and $V'(u) = u^{-1} + 2^{-\frac{3}{2}} e^{-du} (1 - du) + \frac{2}{3} Au^{B-1} F(u) \left[\left(1 + \frac{3B}{2}\right) + \frac{4}{3} \times \frac{bu^{-\frac{4}{3} + 2cu^{-\frac{8}{3}}}}{1 + bu^{-\frac{4}{3}} + cu^{-\frac{8}{3}}}\right]$. One remarks

that: (i) as $u \rightarrow 0$, one has: $W^2 \simeq 1$ and $u[V' \times W - V \times W'] \simeq 1$, and therefore:

$$\frac{D_{n(p)}(u)}{\mu} \simeq \frac{k_B \times T}{q}, \text{ and (ii) as } u \rightarrow \infty, \text{ one has: } W^2 \approx A^2 u^{2B} \text{ and}$$

$$u[V' \times W - V \times W'] \approx \frac{2}{3} au^{2/3} A^2 u^{2B},$$

and therefore, in this **highly degenerate case** and at $T=0K$, the **above generalized Einstein relation** is reduced to the **usual Einstein one**:

$$\frac{D(N, r_{d(a)}, x, T=0K)}{\mu(N, r_{d(a)}, x, T=0K)} \approx \frac{2}{3} E_{Fn(Fp)}(N^*)/q.$$

In other words, **Eq. (17) verifies the correct limiting conditions.**

Furthermore, in the present degenerate case ($u \gg 1$), Eq. (17) gives:

$$\frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} \approx \frac{2}{3} \times \frac{E_{Fno}(F_{po})(u)}{q} \times \left[1 + \frac{4}{3} \times \frac{\left(bu^{-\frac{4}{3}} + 2cu^{-\frac{8}{3}} \right)}{\left(1 + bu^{-\frac{4}{3}} + cu^{-\frac{8}{3}} \right)} \right], \quad (18)$$

where $a = [3\sqrt{\pi}/4]^{2/3}$, $b = \frac{1}{8} \left(\frac{\pi}{a}\right)^2$ and $c = \frac{62.3739855}{1920} \left(\frac{\pi}{a}\right)^4$.

In Tables 3n(3p) given in Appendix 1, for given x , $N > N_{CDn}$ and $T(=4.2 \text{ K and } 77 \text{ K})$, and from Equations (14, 15, 16, 17), the numerical results of the coefficients: σ , μ , μ_H and D are found to be decreased with increasing $r_{d(a)}$, respectively.

Thermoelectric Coefficients

First of all, from Eq. (14), obtained for $\sigma(N, r_{d(a)}, x, T)$, the well-known Mott definition for the thermoelectric power or for the Seebeck coefficient, S , is found to be given by:

$$S(N, r_{d(a)}, x, T) \equiv \frac{-\pi^2}{3} \times \frac{k_B}{q} \times k_B T \times \left. \frac{\partial \ln \sigma(E)}{\partial E} \right]_{E=E_{Fn}(F_p)} = \frac{-\pi^2}{3} \times \frac{k_B}{q} \times \frac{\partial \ln \sigma(\xi_{n(p)})}{\partial \xi_{n(p)}}.$$

Then, using Eq. (11), for the degenerate case, $\xi_{n(p)}(N, r_{d(a)}, x, T) \gtrsim 1$, one gets, by putting

$$F_S(N, r_{d(a)}, x, T) \equiv \left[1 - \frac{y^2}{3 \times G_2 \left(y = \frac{\pi}{\xi_{n(p)}} \right)} \right],$$

$$S(N, r_{d(a)}, x, T) \equiv \frac{-\pi^2}{3} \times \frac{k_B}{q} \times \frac{2F_{Sb}(N, T)}{\xi_{n(p)}} = -\sqrt{\frac{3 \times L}{\pi^2}} \times \frac{2 \times \xi_{n(p)}}{\left(1 + \frac{3 \times \xi_{n(p)}^2}{\pi^2} \right)} = -2\sqrt{L} \times \frac{\sqrt{(ZT)_{Mott}}}{1 + (ZT)_{Mott}} \left(\frac{V}{K} \right) <$$

$$0, \quad (ZT)_{Mott} = \frac{\pi^2}{3 \times \xi_{n(p)}^2} \quad , \quad (19)$$

for the present degenerate case, giving here: (i) at $\xi_{n(p)} = \sqrt{\frac{\pi^2}{3}} \simeq 1.8138$, one thus gets:

$S = -\sqrt{L} \simeq -1.563 \times 10^{-4} \left(\frac{V}{K} \right)$, and (ii) at $\xi_{n(p)} = 1$ one obtains: $S \simeq -1.322 \times 10^{-4} \left(\frac{V}{K} \right)$.

Further, the figure of merit, ZT , is found to be defined by:

$$ZT(N, r_{d(a)}, x, T) \equiv \frac{s^2 \times \sigma \times T}{\kappa} = \frac{s^2}{L} = \frac{4 \times (ZT)_{Mott}}{[1 + (ZT)_{Mott}]^2}, \quad (20)$$

giving rise to: (i) at $\xi_{n(p)} = \sqrt{\frac{\pi^2}{3}} \simeq 1.8138$, one gets: $ZT = 1$ and $(ZT)_{Mott} = 1$, and (ii) at

$\xi_{n(p)} = 1$, one obtains: $ZT \simeq 0.715$ and $(ZT)_{Mott} = \frac{\pi^2}{3} \simeq 3.290$.

Furthermore, from Eq. (19), one gets:

$$\frac{\partial S}{\partial \xi_{n(p)}} = \sqrt{\frac{3 \times L}{\pi^2}} \times 2 \times \frac{\frac{3 \times \xi_{n(p)}^2}{\pi^2} - 1}{\left(1 + \frac{3 \times \xi_{n(p)}^2}{\pi^2}\right)^2} = \sqrt{\frac{3 \times L}{\pi^2}} \times 2 \times \frac{(ZT)_{Mott} \times [1 - (ZT)_{Mott}]}{[1 + (ZT)_{Mott}]^2}, \quad (ZT)_{Mott} = \frac{\pi^2}{3 \times \xi_{n(p)}^2}. \quad (21)$$

Finally, the first Van-Cong coefficient, VC1, can be defined by:

$$VC1(N, r_{d(a)}, x, T) \equiv -N^* \times \frac{dS}{dN^*} \left(\frac{V}{K}\right) = N^* \times \frac{\partial S}{\partial \xi_{n(p)}} \times -\frac{\partial \xi_{n(p)}}{\partial N^*}, \text{ being equal to } 0 \text{ for } \xi_{n(p)} = \sqrt{\frac{\pi^2}{3}} \quad (22)$$

and the second Van-Cong coefficient, VC2, as:

$$VC2(N, r_{d(a)}, x, T) \equiv T \times VC1(V), \quad (23)$$

the Thomson coefficient, Ts, by:

$$Ts(N, r_{d(a)}, x, T) \equiv T \times \frac{dS}{dT} \left(\frac{V}{K}\right) = T \times \frac{\partial S}{\partial \xi_{n(p)}} \times \frac{\partial \xi_{n(p)}}{\partial T}, \text{ being equal to } 0 \text{ for } \xi_{n(p)} = \sqrt{\frac{\pi^2}{3}}, \quad (24)$$

and the Peltier coefficient, Pt, as:

$$Pt(N, r_{d(a)}, x, T) \equiv T \times S(V). \quad (25)$$

One notes here that in next Tables 5n(p) and 6n(p) given in Appendix 1, obtained with such given physical conditions N(or T) for the decreasing $\xi_{n(p)}$, since $VC1(N, r_{d(a)}, x, T)$ and

$Ts(N, r_{d(a)}, x, T)$ are expressed in terms of $\frac{-dS}{dN^*}$ and $\frac{dS}{dT}$, one has: $[VC1, Ts] < 0$ for $\xi_{n(p)} > \sqrt{\frac{\pi^2}{3}}$

, $[VC1, Ts] = 0$ for $\xi_{n(p)} = \sqrt{\frac{\pi^2}{3}}$, and $[VC1, Ts] > 0$ for $\xi_{n(p)} < \sqrt{\frac{\pi^2}{3}}$, stating well that for

$$\xi_{n(p)} = \sqrt{\frac{\pi^2}{3}}:$$

(i) S, determined in Eq. (19), thus presents a **same minimum**

$$(S)_{min.} = -\sqrt{L} \simeq -1.563 \times 10^{-4} \left(\frac{V}{K}\right),$$

(ii) ZT, determined in Eq. (20), therefore presents a **same maximum**: $(ZT)_{max.} = 1$, since the variations of ZT are expressed in terms of $[VC1, Ts] \times S, S < 0$.

Furthermore, it is interesting to remark that the (VC2)-coefficient is related to our generalized Einstein relation (17) by:

$$\frac{k_B}{q} \times VC2(N, r_{d(a)}, x, T) \equiv -\frac{\partial S}{\partial \xi_{n(p)}} \times \frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} \left(\frac{V^2}{K}\right), \quad \frac{k_B}{q} = \sqrt{\frac{3 \times L}{\pi^2}}, \quad (26)$$

according, in this work, with the use of our Eq. (21), to:

$$VC2(N, r_{d(a)}, x, T) \equiv -\frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} \times 2 \times \frac{(ZT)_{Mott} \times [1 - (ZT)_{Mott}]}{[1 + (ZT)_{Mott}]^2} \quad (V).$$

Of course, our relation (26) is reduced to: $\frac{D}{\mu}$, VC1 and VC2, being determined respectively by Equations (17, 22, 23).

Now, in the lightly degenerate n(p)-type $X(x)$ – alloy, and for $N > N_{CDn(CDp)}$, and for $T=3K$ (80K), the numerical results of various thermoelectric coefficients are reported in Tables 4n(4p) in Appendix 1, noting that their variations with increasing $r_{d(a)}$ are represented by the arrows: ↗ (increase), and ↘ (decrease), respectively.

Then, in Tables 5n(5p) given Appendix 1 for a given N and with increasing T , and in Tables 6n(6p) given Appendix 1 for a given T and with decreasing N , the reduced Fermi-energy $\xi_{n(p)}$ decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows as: (increase: ↗, decrease: ↘).

CONCLUDING REMARKS

Here, some concluding remarks can be given as follows.

(1) In the $n^+(p^+) - p(n) X(x) \equiv GaSb_{1-x}Te_x$ - crystalline alloy, $0 \leq x \leq 1$, the electrical-and-thermoelectric laws, relations, and various coefficients are found to be enhanced by our static dielectric constant law, $\epsilon(r_{d(a)}, x)$, being decreased with increasing $r_{d(a)}$, as given in Equations (1a, 1b) and also in Table 5 of our recent work (2024), by our new electrical conductivity, as given in Eq. (14), and also by our accurate Fermi energy, $E_{Fn(Fp)}$, as given in Eq. (11).

(2) The generalized Mott criterium in the MIT is expressed in Equations (3, 5, 6), stating that the critical impurity density $N_{CDn(CDp)}$ is just the density of electrons (holes), localized in the exponential conduction (valence)-band tail, $N_{CDn(CDp)}^{EBT}$, obtained with a precision of the order of 2.87×10^{-7} , as given in our previous work (2024), and the effective electron (hole)-density can be defined by: $N^* \equiv N - N_{CDn(CDp)} \simeq N - N_{CDn(CDp)}^{EBT}$, as that observed in the compensated crystals.

(3) The ratio of the inverse effective screening length $k_{sn(sp)}$ to Fermi wave number $k_{Fn(kp)}$ at 0 K, $R_{sn(sp)}(N^*)$, defined in Eq. (7), is valid at any density N^* .

(4) In Tables 5n(5p) given Appendix 1, for a given impurity density N and with increasing temperature T , and then in Tables 6n(6p) given Appendix 1, for a given T and with decreasing N , the reduced Fermi-energy $\xi_{n(p)}$ decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows by: (increase: ↗, decrease: ↘). One remarks in these Tables that with increasing T (or with decreasing N) one obtains: (i) for $\xi_{n(p)} \simeq 1.8138$, while the numerical results of the Seebeck coefficient S present a same minimum $(S)_{min.} = -\sqrt{L} \simeq -1.563 \times 10^{-4} \left(\frac{V}{K}\right)$, those of the figure of merit ZT show a same maximum $(ZT)_{max.} = 1$, (ii) for $\xi_{n(p)} = 1$, the numerical results of S , ZT , the Mott figure of merit $(ZT)_{Mott}$, the Van-Cong coefficient $VC1$, and the Thomson coefficient Ts , present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715, 3.290, $1.105 \times 10^{-4} \frac{V}{K}$, and $1.657 \times 10^{-4} \frac{V}{K}$, respectively, and finally (iii) for $\xi_n \simeq 1.8138$, $(ZT)_{Mott} = 1$. **It seems that these same results could represent a new law in the thermoelectric properties, obtained in the degenerate case.**

(5) Finally, our electrical-and-thermoelectric relation is given in Eq. (26) by:

$$\frac{k_B}{q} \times VC2(N, r_{d(a)}, x, T) \equiv -\frac{\partial S}{\partial \xi_{n(p)}} \times \frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} \left(\frac{V^2}{K}\right), \frac{k_B}{q} = \sqrt{\frac{3 \times L}{\pi^2}}, \text{ according, in this work,}$$

to:

$$VC2(N, r_{d(a)}, x, T) \equiv -\frac{D(N, r_{d(a)}, x, T)}{\mu(N, r_{d(a)}, x, T)} \times 2 \times \frac{(ZT)_{Mott} \times [1 - (ZT)_{Mott}]}{[1 + (ZT)_{Mott}]^2} (V), \text{ being reduced to: } \frac{D}{\mu},$$

$VC1$ and $VC2$, determined respectively in Equations (17, 22, 23). This should be a **new result**.

REFERENCES

1. Van Cong, H. Electrical-and-Thermoelectric Properties, Obtained in n(p)-type Degenerate InSb(1-x)As(x)-Crystalline Alloy (I). WJERT, 2025; 11(2): 42-76. Van Cong, H. Electrical-and-Thermoelectric Laws Given in n(p)-type Degenerate InSb(1-x)P(x)-Crystalline Alloy, Due to Our Static Dielectric Constant Law and Electrical Conductivity Formula (II). WJERT, 2025; 11(2): 90-119.
2. Van Cong, H. New critical impurity density in MIT, obtained in various n(p)-type Degenerate $InSb_{1-x}P_x(As_x)$, $GaSb_{1-x}P_x(As_x, Te_x)$, $CdSe_{1-x}S_x(Te_x)$ – crystalline alloys,

being just that of carriers localized in exponential band tails (III). WJERT, 2024; 10(4): 191-220.

3. Van Cong, H. New critical impurity density in Metal-Insulator Transition, obtained in n(p)-type Degenerate $\text{InP}_{1-x}\text{As}_x(\text{Sb}_x), \text{GaAs}_{1-x}\text{Te}_x(\text{Sb}_x, \text{P}_x), \text{CdS}_{1-x}\text{Te}_x(\text{Se}_x)$ –crystalline alloys (II). EJASET, 2024; 2(2): 186-211.

Van Cong, H. Maximal Efficiencies in $\text{GaP}_{1-x}\text{Sb}_x$ -Alloy Junction Solar Cells at 300 K, According to Highest Hot Reservoir Temperatures, Obtained from Carnot-Efficiency Theorem. EJASET, 2024; 2(3): 33-49.

4. Van Cong, H. Effects of donor size and heavy doping on optical, electrical and thermoelectric properties of various degenerate donor-silicon systems at low temperatures. American Journal of Modern Physics, 2018; 7(4): 136-165.

Van Cong, H. et al. Size effect on different impurity levels in semiconductors. Solid State Communications, 1984; 49: 697-699.

Van Cong, H. Diffusion coefficient in degenerate semiconductors. Phys. Stat. Sol. (b), 1984; 101: K27.

5. Van Cong, H. Same Maximal Figure of Merit $ZT(=1)$, Due to the Effect of Impurity Size, Obtained in the n(p)-Type Degenerate GaSb-Crystal ($\xi_{n(p)} \geq 1$), at Same Reduced Fermi Energy $\xi_{n(p)} (= 1.814)$, Same Minimum Seebeck Coefficient $S (= -1.563 \times 10^{-4} \frac{\text{V}}{\text{K}})$, and Same $(ZT)_{\text{Mott}} (= \frac{\pi^2}{3\xi_{n(p)}^2} = 1)$. SCIREA Journal of Physics, 2023; 8(4): 358-382.

6. Kim, H. S. et al. Characterization of Lorenz number with Seebeck coefficient measurement. APL Materials, 2015; 3(4): 041506.

7. Hyun, B. D. et al. Electrical-and-Thermoelectric Properties of $90\%\text{Bi}_2\text{Te}_3 - 5\%\text{Sb}_2\text{Te}_3 - 5\%\text{Sb}_2\text{Se}_3$ Single Crystals Doped with SbI_3 . Scripta Materialia, 1998; 40(1): 49-56.

8. Van Cong, H. and Debiais, G. A simple accurate expression of the reduced Fermi energy for any reduced carrier density. J. Appl. Phys., 1993; 73: 1545-1546.

Van Cong, H. and Doan Khanh, B. Simple accurate general expression of the Fermi-Dirac integral $F_j(a)$ and for $j > -1$. Solid-State Electron., 1992; 35(7): 949-951.

Van Cong, H. New series representation of Fermi-Dirac integral $F_j(-\infty < a < \infty)$ for arbitrary $j > -1$, and its effect on $F_j(a \geq 0_+)$ for integer $j \geq 0$. Solid-State Electron., 1991; 34(5): 489-492.

APPENDIX 1: Tables

Table 1: The values of energy-band-structure parameters are given in the following.

In the $X(x) \equiv GaSb_{1-x}Te_x$ -crystalline alloy, in which $r_{do(ao)} = r_{sb(Ga)} = 0.136$ nm (0.126 nm), we have:
 $g_{c(v)}(x) = 1 \times x + 1 \times (1 - x)$, $m_{c(v)}(x)/m_o = 0.209 (0.4) \times x + 0.047 (0.3) \times (1 - x)$,
 $\epsilon_o(x) = 12.3 \times x + 15.69 \times (1 - x)$, $E_{go}(x) = 1.796 \times x + 0.81 \times (1 - x)$.

Table 2: Expressions for $G_{p \geq 1}(y \equiv \frac{\pi}{\xi_{n(p)}})$, due to the Fermi-Dirac distribution function, noting that $G_{p=1}(y \equiv \frac{\pi k_B T}{E_{Fn(PP)}} = \frac{\pi}{\xi_{n(p)}}) = 1$, used to determine the electrical-and-thermoelectric coefficients.

$G_{3/2}(y)$	$G_2(y)$	$G_{5/2}(y)$	$G_3(y)$	$G_{7/2}(y)$	$G_4(y)$	$G_{9/2}(y)$
$(1 + \frac{y^2}{8} + \frac{7y^4}{640})$	$(1 + \frac{y^2}{3})$	$(1 + \frac{5y^2}{8} - \frac{7y^4}{384})$	$(1 + y^2)$	$(1 + \frac{35y^2}{24} + \frac{49y^4}{384})$	$(1 + 2y^2 + \frac{7y^4}{15})$	$(1 + \frac{21y^2}{8} + \frac{147y^4}{128})$

Table 3n: Here, one notes that, for given x, $N > N_{CDn}$ and $T(=4.2$ K and 77 K), the functions: σ, μ, μ_H, D , expressed respectively in $(\frac{10^3}{ohm \times cm}, \frac{10^3 \times cm^2}{V \times s}, \frac{10^3 \times cm^2}{V \times s}, \frac{10 \times cm^2}{s})$, decrease with increasing r_d .

Donor	P	As	Sb	Sn
r_d (nm)	↗ 0.110	0.118	0.136	0.140

For x=0, the values of (σ, μ, μ_H, D) at 4.2K

N (10^{19} cm^{-3})

3	2.25, 4.694, 4.695, 5.05	1.98, 4.129, 4.130, 4.44	1.79, 3.724, 3.724, 4.00	1.78, 3.705, 3.705, 3.98
10	5.82, 3.632, 3.632, 8.72	5.07, 3.165, 3.165, 7.59	4.54, 2.835, 2.835, 6.80	4.52, 2.820, 2.820, 6.77
40	18.3, 2.864, 2.864, 17.3	15.8, 2.462, 2.462, 14.9	13.9, 2.181, 2.181, 13.2	13.9, 2.168, 2.168, 13.1
70	29.7, 2.648, 2.648, 23.2	25.4, 2.264, 2.264, 19.9	22.4, 1.998, 1.998, 17.5	22.3, 1.986, 1.986, 17.4

For x=0.5, the values of (σ, μ, μ_H, D) at 4.2K

N (10^{19} cm^{-3})

3	1.06, 2.240, 2.242, 8.76	0.93, 1.976, 1.977, 7.69	0.83, 1.784, 1.785, 6.92	0.83, 1.775, 1.776, 6.88
10	2.70, 1.695, 1.695, 14.9	2.37, 1.487, 1.487, 13.0	2.13, 1.339, 1.339, 11.7	2.12, 1.332, 1.332, 11.7
40	8.28, 1.293, 1.293, 28.7	7.16, 1.120, 1.120, 24.8	6.38, 0.998, 0.998, 22.1	6.34, 0.992, 0.992, 22.0
70	13.2, 1.181, 1.181, 38.1	11.4, 1.017, 1.017, 32.8	10.1, 0.902, 0.902, 29.1	10.0, 0.897, 0.897, 28.9

For x=1, the values of (σ, μ, μ_H, D) at 4.

N (10^{19} cm^{-3})

40	4.84, 0.760, 0.760, 10.3	4.21, 0.663, 0.663, 8.96	3.76, 0.594, 0.594, 8.02	3.74, 0.591, 0.591, 7.97
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70	7.65, 0.685, 0.685, 13.5	6.62, 0.594, 0.594, 11.7	5.90, 0.530, 0.530, 10.4	5.87, 0.527, 0.527, 10.3
90	9.42, 0.656, 0.656, 15.3	8.14, 0.567, 0.567, 13.2	7.24, 0.505, 0.505, 11.7	7.20, 0.502, 0.502, 11.68
100	10.3, 0.644, 0.644, 16.1	8.88, 0.557, 0.557, 13.9	7.89, 0.495, 0.495, 12.4	7.85, 0.492, 0.492, 12.3

For x=0, the values of (σ, μ, μ_H, D) at 77 K

N (10¹⁸ cm⁻³)

3	2.28, 4.740, 4.844, 5.08	2.00, 4.170, 4.262, 4.47	1.80, 3.760, 3.842, 4.03	1.79, 3.741, 3.823, 4.01
10	5.83, 3.639, 3.655, 8.73	5.08, 3.171, 3.185, 7.61	4.55, 2.841, 2.853, 6.81	4.52, 2.826, 2.838, 6.78
40	18.3, 2.865, 2.867, 17.3	15.8, 2.462, 2.464, 14.9	14.0, 2.182, 2.183, 13.2	13.9, 2.169, 2.170, 13.1
70	29.7, 2.648, 2.649, 23.2	25.4, 2.265, 2.266, 19.9	22.4, 1.998, 1.999, 17.5	22.3, 1.986, 1.987, 17.4

For x=0.5, the values of (σ, μ, μ_H, D) at 77 K

N (10¹⁸ cm⁻³)

3	1.14, 2.408, 2.782, 9.25	1.00, 2.125, 2.458, 8.13	0.90, 1.919, 2.222, 7.32	0.89, 1.910, 2.211, 7.28
10	2.74, 1.720, 1.776, 15.1	2.40, 1.509, 1.558, 13.2	2.16, 1.358, 1.403, 11.9	2.15, 1.351, 1.396, 11.8
40	8.30, 1.296, 1.303, 28.7	7.18, 1.122, 1.128, 24.9	6.39, 1.000, 1.005, 22.2	6.36, 0.994, 0.999, 22.0
70	13.2, 1.182, 1.185, 38.1	11.4, 1.018, 1.020, 32.8	10.1, 0.903, 0.905, 29.1	10.0, 0.898, 1.000, 28.9

For x=1, the values of (σ, μ, μ_H, D) at 77 K

N (10¹⁸ cm⁻³)

40	4.87, 0.765, 0.776, 10.3	4.23, 0.667, 0.676, 9.00	3.78, 0.598, 0.607, 8.05	3.76, 0.595, 0.603, 8.01
70	7.67, 0.687, 0.691, 13.5	6.64, 0.595, 0.599, 11.7	5.92, 0.531, 0.535, 10.4	5.88, 0.528, 0.532, 10.3
90	9.44, 0.657, 0.660, 15.3	8.16, 0.568, 0.571, 13.2	7.25, 0.506, 0.508, 11.8	7.21, 0.503, 0.505, 11.7
100	10.3, 0.645, 0.648, 16.1	8.90, 0.558, 0.560, 13.9	7.91, 0.496, 0.498, 12.4	7.86, 0.493, 0.495, 12.3

Table 3p: Here, one notes that, for given x, N > N_{CDP} and T(=4.2 K and 77 K), the functions: σ, μ, μ_H, D, expressed respectively in $(\frac{10^8}{\text{ohm}\times\text{cm}}, \frac{10^8 \times \text{cm}^2}{\text{V}\times\text{s}}, \frac{10^8 \times \text{cm}^2}{\text{V}\times\text{s}}, \frac{10 \times \text{cm}^2}{\text{s}})$, decrease with increasing r_a.

Acceptor	Ga	Mg	In	Cd
r _a (nm)	↗ 0.126	0.140	0.144	0.148

For x=0, the values of (σ, μ, μ_H, D) at 4.2K

N (10¹⁹ cm⁻³)

3	5.72, 1.219, 1.219, 9.38	5.22, 1.119, 1.120, 8.59	4.94, 1.062, 1.062, 8.13	4.63, 0.999, 0.999, 7.62
5	8.94, 1.333, 1.333, 12.3	8.17, 1.037, 1.038, 11.3	7.72, 0.983, 0.983, 10.7	7.22, 0.922, 0.922, 9.99
8	13.5, 1.067, 1.067, 15.9	12.3, 0.975, 0.975, 14.5	11.7, 0.922, 0.922, 13.7	10.9, 0.863, 0.863, 12.9
10	16.5, 1.039, 1.039, 18.0	15.1, 0.948, 0.948, 16.4	14.2, 0.896, 0.896, 15.5	13.3, 0.838, 0.838, 14.5

For x=0.5, the values of (σ, μ, μ_H, D) at 4.2K

N (10^{19} cm^{-3})				
3	3.71, 0.816, 0.816, 5.27	3.39, 0.754, 0.754, 4.83	3.20, 0.718, 0.718, 4.58	2.99, 0.678, 0.678, 4.30
5	5.78, 0.746, 0.746, 6.88	5.29, 0.687, 0.687, 6.30	5.00, 0.652, 0.652, 5.97	4.68, 0.614, 0.614, 5.60
8	8.72, 0.694, 0.694, 8.83	7.96, 0.637, 0.637, 8.08	7.53, 0.604, 0.604, 7.64	7.05, 0.567, 0.567, 7.16
10	10.6, 0.673, 0.673, 9.95	9.68, 0.616, 0.616, 9.10	9.15, 0.584, 0.584, 8.61	8.56, 0.548, 0.548, 8.06

For x=1, the values of (σ, μ, μ_H, D) at 4.2K

N (10^{19} cm^{-3})				
3	2.40, 0.568, 0.568, 3.06	2.18, 0.529, 0.529, 2.80	2.05, 0.507, 0.507, 2.65	1.90, 0.482, 0.482, 2.48
5	3.78, 0.509, 0.509, 3.99	3.45, 0.471, 0.471, 3.66	3.26, 0.450, 0.450, 3.47	3.04, 0.426, 0.426, 3.25
8	5.70, 0.466, 0.466, 5.10	5.21, 0.430, 0.430, 4.67	4.93, 0.409, 0.409, 4.43	4.61, 0.386, 0.386, 4.15
10	6.92, 0.448, 0.448, 5.73	6.33, 0.413, 0.413, 5.25	5.99, 0.392, 0.392, 4.97	5.61, 0.370, 0.370, 4.66

For x=0, the values of (σ, μ, μ_H, D) at 77K

N (10^{19} cm^{-3})				
3	5.82, 1.242, 1.295, 9.52	5.33, 1.141, 1.190, 8.71	5.04, 1.083, 1.129, 8.25	4.72, 1.018, 1.062, 7.74
5	9.03, 1.144, 1.168, 12.4	8.24, 1.047, 1.070, 11.4	7.79, 0.992, 1.013, 10.7	7.29, 0.930, 0.951, 10.1
8	13.6, 1.072, 1.085, 16.0	12.4, 0.979, 0.990, 14.6	11.7, 0.926, 0.937, 13.8	11.0, 0.867, 0.877, 12.9
10	16.6, 1.043, 1.052, 18.1	15.1, 0.951, 0.960, 16.5	14.3, 0.900, 0.907, 15.6	13.3, 0.842, 0.849, 14.6

For x=0.5, the values of (σ, μ, μ_H, D) at 77K

N (10^{19} cm^{-3})				
3	3.81, 0.838, 0.888, 5.38	3.48, 0.774, 0.821, 4.93	3.29, 0.738, 0.783, 4.68	3.08, 0.697, 0.740, 4.39
5	5.86, 0.756, 0.779, 6.95	5.36, 0.696, 0.717, 6.37	5.07, 0.661, 0.681, 6.03	4.75, 0.623, 0.642, 5.66
8	8.78, 0.699, 0.710, 8.88	8.02, 0.641, 0.651, 8.12	7.58, 0.608, 0.618, 7.69	7.10, 0.571, 0.580, 7.20
10	10.6, 0.676, 0.684, 9.99	9.73, 0.619, 0.627, 9.14	9.20, 0.587, 0.594, 8.64	8.61, 0.551, 0.557, 8.10

For x=1, the values of (σ, μ, μ_H, D) at 77K

N (10^{19} cm^{-3})				
3	2.50, 0.590, 0.641, 3.15	2.27, 0.550, 0.599, 2.89	2.14, 0.528, 0.575, 2.73	1.98, 0.503, 0.549, 2.56
5	3.85, 0.518, 0.539, 4.05	3.52, 0.480, 0.500, 3.71	3.32, 0.458, 0.477, 3.52	3.10, 0.434, 0.452, 3.30
8	5.76, 0.470, 0.480, 5.13	5.26, 0.434, 0.443, 4.71	4.98, 0.413, 0.422, 4.46	4.66, 0.389, 0.398, 4.19
10	6.97, 0.451, 0.458, 5.76	6.38, 0.416, 0.422, 5.28	6.03, 0.395, 0.401, 5.00	5.65, 0.372, 0.378, 4.69

Table 4n: In the lightly degenerate n-type X(x) – alloy, and for T=3K and 80K, the numerical results of various thermoelectric coefficients are reported. Further, their variations with increasing $r_{d(a)}$ are represented by the arrows: ↗ (increase), and ↘ (decrease).

Donor	P	As	Sb	Sn
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For $x=0$ and $N=5 \times 10^{17} \text{ cm}^{-3}$,

$\xi_n(T=3K)$	↘	188.604	188.461	188.309	188.301
$\xi_n(T=80K)$	↘	7.253	7.248	7.242	7.242
$\kappa_{(T=3K)} \left(\frac{10^{-5} \times W}{\text{cm} \times K} \right)$	↘	4.169	3.647	3.262	3.244
$\kappa_{(T=80K)} \left(\frac{10^{-3} \times W}{\text{cm} \times K} \right)$	↘	1.242	1.087	0.972	0.967
$-S_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	3.006	3.008	3.010	3.0108
$-S_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	7.357	7.362	7.366	7.367
$-VC1_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	2.003	2.005	2.006	2.0067
$-VC1_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	4.109	4.111	4.112	4.1125
$-VC2_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	6.010	6.015	6.020	6.0201
$-VC2_{(T=80K)} \left(\frac{10^{-3} \times V}{K} \right)$	↘	3.287	3.289	3.290	3.2901
$-Ts_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	3.005	3.007	3.009	3.010
$-Ts_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	6.164	6.166	6.168	6.1688
$-Pt_{(T=3K)}(10^{-6} \times V)$	↘	9.018	9.024	9.032	9.0325
$-Pt_{(T=80K)}(10^{-3} \times V)$	↘	5.886	5.889	5.893	5.8936
$ZT_{(T=3K)}(10^{-4})$	↗	3.699	3.704	3.710	3.7107
$ZT_{(T=80K)}(10^{-1})$	↗	2.217	2.218	2.221	2.2216

For $x=0.5$ and $N=10^{18} \text{ cm}^{-3}$,

$\xi_n(T=3K)$	↘	106.699	105.492	104.204	104.132
$\xi_n(T=80K)$	↘	4.2112	4.1599	4.1044	4.1012
$\kappa_{(T=3K)} \left(\frac{10^{-5} \times W}{\text{cm} \times K} \right)$	↘	3.2564	2.8114	2.4790	2.4633
$\kappa_{(T=80K)} \left(\frac{10^{-3} \times W}{\text{cm} \times K} \right)$	↘	1.1400	0.9863	0.8715	0.8660
$-S_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	5.3124	5.3731	5.4395	5.4433
$-S_{(T=80K)} \left(\frac{10^{-4} \times V}{K} \right)$	↘	1.1357	1.1453	1.1557	1.1563
$-VC1_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	3.5388	3.5792	3.6233	3.6258
$-VC1_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	5.5689	5.6366	5.7116	5.7158
$-VC2_{(T=3K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	1.0616	1.0737	1.0870	1.0877
$-VC2_{(T=80K)} \left(\frac{10^{-3} \times V}{K} \right)$	↘	4.4552	4.5093	4.5693	4.5727
$-Ts_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	5.3082	5.3688	5.4350	5.4388
$-Ts_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	8.3534	8.4550	8.5674	8.5737
$-Pt_{(T=3K)}(10^{-5} \times V)$	↘	1.5937	1.6119	1.6319	1.6330

$-Pt_{(T=80K)}(10^{-3} \times V)$	↘	9.0856	9.1621	9.2458	9.2506
$ZT_{(T=3K)}(10^{-3})$	↗	1.1552	1.1818	1.2112	1.2128
$ZT_{(T=80K)}(10^{-1})$	↗	5.2797	5.3690	5.4676	5.473

For $x=1$ and $N=3 \times 10^{18} \text{ cm}^{-3}$,

$\xi_n(T=3K)$	↘	130.784	127.422	123.803	123.600
$\xi_n(T=80K)$	↘	5.1479	5.0232	4.8877	4.8801
$\kappa_{(T=3K)}\left(\frac{10^{-5} \times W}{\text{cm} \times K}\right)$	↘	4.4123	3.7568	3.2580	3.2342
$\kappa_{(T=80K)}\left(\frac{10^{-3} \times W}{\text{cm} \times K}\right)$	↘	1.4570	1.2512	1.0953	1.0879
$-S_{(T=3K)}\left(\frac{10^{-6} \times V}{K}\right)$	↘	4.3345	4.4488	4.5788	4.5863
$-S_{(T=80K)}\left(\frac{10^{-4} \times V}{K}\right)$	↘	0.9798	0.9985	1.0196	1.0208
$-VC1_{(T=3K)}\left(\frac{10^{-6} \times V}{K}\right)$	↘	2.8881	2.9642	3.0507	3.0557
$-VC1_{(T=80K)}\left(\frac{10^{-5} \times V}{K}\right)$	↘	4.7741	4.8361	4.9149	4.9197
$-VC2_{(T=3K)}\left(\frac{10^{-5} \times V}{K}\right)$	↘	0.8664	0.8892	0.9152	0.9167
$-VC2_{(T=80K)}\left(\frac{10^{-3} \times V}{K}\right)$	↘	3.8193	3.8689	3.9319	3.9358
$-TS_{(T=3K)}\left(\frac{10^{-6} \times V}{K}\right)$	↘	4.3322	4.4464	4.5761	4.5836
$-TS_{(T=80K)}\left(\frac{10^{-5} \times V}{K}\right)$	↘	7.1612	7.2542	7.3723	7.3796
$-Pt_{(T=3K)}(10^{-5} \times V)$	↘	1.3003	1.3346	1.3736	1.3759
$-Pt_{(T=80K)}(10^{-3} \times V)$	↘	7.8382	7.9884	8.1569	8.1666
$ZT_{(T=3K)}(10^{-3})$	↗	0.7691	0.8102	0.8582	0.8910
$ZT_{(T=80K)}(10^{-1})$	↗	3.9395	4.0815	4.2556	4.2657

Table 4p: In the lightly degenerate p-type $X(x)$ – alloy, in which $N=3 \times 10^{19} \text{ cm}^{-3}$, and for $T=3K$ and $80K$, the numerical results of various thermoelectric coefficients are reported. Further, their variations with increasing $r_{d(a)}$ are represented by the arrows: ↗ (increase), and ↘ (decrease).

Acceptor		Ga	Mg	In	Cd
For $x=0$,					
$\xi_n(T=3K)$	↘	446.416	445.062	444.099	442.816
$\xi_n(T=80K)$	↘	16.815	16.764	16.728	16.680
$\kappa_{(T=3K)}\left(\frac{10^{-4} \times W}{\text{cm} \times K}\right)$	↘	4.190	3.830	3.622	3.390
$\kappa_{(T=80K)}\left(\frac{10^{-2} \times W}{\text{cm} \times K}\right)$	↘	1.140	1.042	0.986	0.923
$-S_{(T=3K)}\left(\frac{10^{-6} \times V}{K}\right)$	↘	1.270	1.274	1.277	1.280
$-S_{(T=80K)}\left(\frac{10^{-5} \times V}{K}\right)$	↘	3.333	3.343	3.350	3.359

$-VC1_{(T=3K)} \left(\frac{10^{-7} \times V}{K} \right) \searrow$	8.447	8.492	8.511	8.536
$-VC1_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right) \searrow$	2.152	2.157	2.162	2.167
$-VC2_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right) \searrow$	2.540	2.548	2.553	2.561
$-VC2_{(T=80K)} \left(\frac{10^{-3} \times V}{K} \right) \searrow$	1.721	1.726	1.729	1.734
$-Ts_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right) \searrow$	1.270	1.274	1.277	1.280
$-Ts_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right) \searrow$	3.227	3.236	3.243	3.251
$-Pt_{(T=3K)} (10^{-6} \times V) \searrow$	3.810	3.822	3.830	3.841
$-Pt_{(T=80K)} (10^{-3} \times V) \searrow$	2.666	2.674	2.680	2.687
$ZT_{(T=3K)} (10^{-5}) \nearrow$	6.603	6.643	6.672	6.711
$ZT_{(T=80K)} (10^{-3}) \nearrow$	4.548	4.575	4.594	4.620

For $x=0.5$,

$\xi_n(T=3K) \searrow$	374.687	372.061	370.188	367.691
$\xi_n(T=80K) \searrow$	14.139	14.042	13.972	13.879
$\kappa_{(T=3K)} \left(\frac{10^{-4} \times W}{cm \times K} \right) \searrow$	2.717	2.483	2.347	2.195
$\kappa_{(T=80K)} \left(\frac{10^{-2} \times W}{cm \times K} \right) \searrow$	0.746	0.682	0.645	0.603
$-S_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right) \searrow$	1.513	1.524	1.531	1.542
$-S_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right) \searrow$	3.945	3.972	3.991	4.017
$-VC1_{(T=3K)} \left(\frac{10^{-7} \times V}{K} \right) \searrow$	10.087	10.159	10.210	10.279
$-VC1_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right) \searrow$	2.512	2.528	2.539	2.554
$-VC2_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right) \searrow$	3.026	3.047	3.063	3.084
$-VC2_{(T=80K)} \left(\frac{10^{-3} \times V}{K} \right) \searrow$	2.010	2.022	2.031	2.043
$-Ts_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right) \searrow$	1.513	1.524	1.531	1.542
$-Ts_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right) \searrow$	3.769	3.792	3.808	3.830
$-Pt_{(T=3K)} (10^{-6} \times V) \searrow$	4.540	4.572	4.595	4.626
$-Pt_{(T=80K)} (10^{-3} \times V) \searrow$	3.156	3.177	3.193	3.213
$ZT_{(T=3K)} (10^{-5}) \nearrow$	9.373	9.506	9.602	9.733
$ZT_{(T=80K)} (10^{-3}) \nearrow$	6.371	6.457	6.519	6.604

For $x=1$,

$\xi_n(T=3K) \searrow$	312.504	307.315	303.600	298.626
$\xi_n(T=80K) \searrow$	11.826	11.633	11.495	11.310
$\kappa_{(T=3K)} \left(\frac{10^{-4} \times W}{cm \times K} \right) \searrow$	1.761	1.599	1.503	1.395

$\kappa_{(T=80K)} \left(\frac{10^{-2} \times W}{cm \times K} \right)$	↘	0.489	0.445	0.419	0.389
$-S_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	1.814	1.845	1.867	1.899
$-S_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	4.684	4.758	4.813	4.887
$-VC1_{(T=3K)} \left(\frac{10^{-7} \times V}{K} \right)$	↘	12.094	12.298	12.449	12.656
$-VC1_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	2.924	2.964	2.993	3.032
$-VC2_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	3.628	3.689	3.735	3.797
$-VC2_{(T=80K)} \left(\frac{10^{-3} \times V}{K} \right)$	↘	2.340	2.371	2.394	2.426
$-T_s_{(T=3K)} \left(\frac{10^{-6} \times V}{K} \right)$	↘	1.814	1.845	1.867	1.898
$-T_s_{(T=80K)} \left(\frac{10^{-5} \times V}{K} \right)$	↘	4.387	4.446	4.489	4.549
$-Pt_{(T=3K)} (10^{-6} \times V)$	↘	5.443	5.535	5.602	5.696
$-Pt_{(T=80K)} (10^{-3} \times V)$	↘	3.747	3.807	3.850	3.910
$ZT_{(T=3K)} (10^{-5})$	↗	13.474	13.933	14.276	14.755
$ZT_{(T=80K)} (10^{-3})$	↗	8.982	9.268	9.481	9.777

Table 5n: Here, for a given N and with increasing T , the reduced Fermi-energy ξ_n decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows as: (increase: ↗, decrease: ↘). One notes here that with increasing T : (i) for $\xi_n \simeq 1.8138$, while the numerical results of S present a same minimum $(S)_{min.} (\simeq -1.563 \times 10^{-4} \frac{V}{K})$, those of ZT show a same maximum $(ZT)_{max} = 1$, (ii) for $\xi_n = 1$, those of S , ZT , $(ZT)_{Mott}$, $VC1$, and T_s present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715 , 3.290 , $1.105 \times 10^{-4} \frac{V}{K}$, and $1.657 \times 10^{-4} \frac{V}{K}$ respectively, and (iii) for $\xi_n \simeq 1.8138$, $(ZT)_{Mott} = 1$.

For $x=0$,

In the degenerate P- $X(x)$ – alloy, for $N = 2 \times N_{CDn}(\Gamma_P)$, one gets:

$T(K)$	↗	5	5.6729	6	7.719467	7.720
ξ_n	↘	2.225	1.8138	1.649	1	0.9998
$S \left(10^{-4} \frac{V}{K} \right)$		-1.531	↘ -1.563 ↗	-1.556	↗ -1.322 ↗	-1.321
ZT		0.959	↗ 1 ↘	0.991	↘ 0.715 ↘	0.7149
$(ZT)_{Mott}$	↗	0.664	1	1.210	3.290	3.291
$VC1 \left(10^{-4} \frac{V}{K} \right)$	-0.324	↗	0 ↗	0.171	↗ 1.105 ↗	1.1052
$VC2 \left(10^{-4} \frac{V}{K} \right)$	-1.622	↗	0 ↗	1.024	↗ 8.529 ↗	8.532
$T_s \left(10^{-4} \frac{V}{K} \right)$	-0.487	↗	0 ↗	0.256	↗ 1.657 ↗	1.6578
$Pt (10^{-3} V)$	-0.765	↘	-0.887	↘ -0.933	↘ -1.02028	↗ -1.02027

In the degenerate As- $X(x)$ – alloy, for $N = 2 \times N_{CDn}(\Gamma_{As})$, one gets:

$T(K)$	↗	6.8	6.90423	7	9.3950696	9.4
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ξ_n	↘	1.860	1.8138	1.772	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.321
ZT		0.999	↗ 1 ↘	0.999	↘ 0.715 ↘	0.714
$(ZT)_{Mott}$	↗	0.951	1	1.047	3.290	3.298
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.043	↗ 0 ↗	0.040	↗ 1.105 ↗	1.107
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-0.296	↗ 0 ↗	0.283	↗ 8.529 ↗	10.406
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.065	↗ 0 ↗	0.061	↗ 1.657 ↗	1.660
Pt ($10^{-3}V$)		-1.062	↘ -1.079 ↘	-1.094	↘ -1.242 ↗	-1.241

In the degenerate Sb- X(x) – alloy, for $N = 2 \times N_{CDn}(r_{Sb})$, one gets:

T(K)	↗	7.95	8.1009	8.3	11.023411	11.05
ξ_n	↘	1.871	1.8138	1.741	1	0.994
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.318
ZT		0.999	↗ 1 ↘	0.998	↘ 0.715 ↘	0.711
$(ZT)_{Mott}$	↗	0.939	1	1.085	3.290	3.327
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.054	↗ 0 ↗	0.072	↗ 1.105 ↗	1.114
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-0.426	↗ 0 ↗	0.597	↗ 12.180 ↗	12.316
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.080	↗ 0 ↗	0.108	↗ 1.657 ↗	1.672
Pt ($10^{-3}V$)		-1.242	↘ -1.266 ↘	-1.296	↘ -1.457 ↗	-1.456

In the degenerate Sn- X(x) – alloy, for $N = 2 \times N_{CDn}(r_{Sn})$, one gets:

T(K)	↗	7.95	8.16501	8.3	11.110508	11.12
ξ_n	↘	1.896	1.8138	1.764	1	0.998
$S \left(10^{-4} \frac{V}{K}\right)$		-1.561	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.320
ZT		0.998	↗ 1 ↘	0.999	↘ 0.715 ↘	0.713
$(ZT)_{Mott}$	↗	0.915	1	1.056	3.290	3.303
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.075	↗ 0 ↗	0.048	↗ 1.105 ↗	1.108
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-0.600	↗ 0 ↗	0.401	↗ 12.276 ↗	12.325
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.113	↗ 0 ↗	0.072	↗ 1.657 ↗	1.662
Pt ($10^{-3}V$)		-1.241	↘ -1.276 ↘	-1.297	↘ -1.4685 ↗	-1.46816

For x=0.5,

In the degenerate P- X(x) – alloy, for $N = 2 \times N_{CDn}(r_P)$, one gets:

T(K)	↗	19	19.41857	19.85	26.424058	26.45
ξ_n	↘	1.880	1.8138	1.748	1	0.998
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.320
ZT		0.999	↗ 1 ↘	0.999	↘ 0.715 ↘	0.713

$(ZT)_{Mott}$	↗	0.930		1		1.077		3.290		3.305
$VC1 \left(10^{-4} \frac{V}{K}\right)$	↗	-0.062	↗	0	↗	0.065	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$	↗	-1.178	↗	0	↗	1.290	↗	29.197	↗	29.330
$T_s \left(10^{-4} \frac{V}{K}\right)$	↗	-0.093	↗	0	↗	0.097	↗	1.657	↗	1.663
$Pt (10^{-3}V)$	↘	-2.968	↘	-3.035	↘	-3.100	↘	-3.4925	↗	-3.491

In the degenerate As- $X(x)$ – alloy, for $N = 2 \times N_{CDn}(r_{As})$, one gets:

T(K)	↗	23.13		23.6336		24.14		32.159715		32.19
ξ_n	↘	1.880		1.8138		1.750		1		0.998
$S \left(10^{-4} \frac{V}{K}\right)$	↘	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.320
ZT	↗	0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗	0.931		1		1.074		3.290		3.304
$VC1 \left(10^{-4} \frac{V}{K}\right)$	↗	-0.061	↗	0	↗	0.063	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$	↗	-1.417	↗	0	↗	1.512	↗	35.535	↗	35.689
$T_s \left(10^{-4} \frac{V}{K}\right)$	↗	-0.092	↗	0	↗	0.094	↗	1.657	↗	1.663
$Pt (10^{-3}V)$	↘	-3.613	↘	-3.694	↘	-3.771	↘	-4.250	↗	-4.2495

In the degenerate Sb- $X(x)$ – alloy, for $N = 2 \times N_{CDn}(r_{Sb})$, one gets:

T(K)	↗	27.14		27.7298		28.32		37.733596		37.77
ξ_n	↘	1.880		1.8138		1.751		1		0.998
$S \left(10^{-4} \frac{V}{K}\right)$	↘	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.320
ZT	↗	0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗	0.931		1		1.073		3.290		3.305
$VC1 \left(10^{-4} \frac{V}{K}\right)$	↗	-0.061	↗	0	↗	0.062	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$	↗	-1.660	↗	0	↗	1.763	↗	41.693	↗	41.880
$T_s \left(10^{-4} \frac{V}{K}\right)$	↗	-0.092	↗	0	↗	0.093	↗	1.657	↗	1.663
$Pt (10^{-3}V)$	↘	-4.239	↘	-4.334	↘	-4.424	↘	-4.987	↗	-4.986

In the degenerate Sn- $X(x)$ – alloy, for $N = 2 \times N_{CDn}(r_{Sn})$, one gets:

T(K)	↗	27.35		27.94884		28.55		38.031732		38.07
ξ_n	↘	1.880		1.8138		1.750		1		0.998
$S \left(10^{-4} \frac{V}{K}\right)$	↘	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.320
ZT	↗	0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗	0.931		1		1.074		3.290		3.305
$VC1 \left(10^{-4} \frac{V}{K}\right)$	↗	-0.062	↗	0	↗	0.063	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$	↗	-1.685	↗	0	↗	1.796	↗	42.023	↗	42.219

$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.092	↗	0	↗	0.094	↗	1.657	↗	1.663
Pt ($10^{-3}V$)	-4.272	↘	-4.368	↘	-4.459	↘	-5.027	↗	-5.025

For x=1,

In the degenerate P- X(x) – alloy, for $N = 2 \times N_{CDn}(r_P)$, one gets:

T(K)	↗	40.17		41.0477		41.93		55.856203		55.91
ξ_n	↘	1.880		1.8138		1.750		1		0.998
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.320
ZT		0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗	0.931		1		1.074		3.290		3.305
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.061	↗	0	↗	0.063	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-2.470	↗	0	↗	2.635	↗	61.718	↗	61.993
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.092	↗	0	↗	0.094	↗	1.657	↗	1.663
Pt ($10^{-3}V$)		-6.274	↘	-6.416	↘	-6.549	↘	-7.3825	↗	-7.3807

In the degenerate As- X(x) – alloy, for $N = 2 \times N_{CDn}(r_{As})$, one gets:

T(K)	↗	48.89		49.95763		51.01		67.98046		68.05
ξ_n	↘	1.880		1.8138		1.751		1		0.997
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.320
ZT		0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗	0.931		1		1.072		3.290		3.306
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.061	↗	0	↗	0.061	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-3.005	↗	0	↗	3.142	↗	75.115	↗	75.470
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.092	↗	0	↗	0.092	↗	1.657	↗	1.663
Pt ($10^{-3}V$)		-7.636	↘	-7.808	↘	-7.968	↘	-8.9850	↗	-8.9826

In the degenerate Sb- X(x) – alloy, for $N = 2 \times N_{CDn}(r_{Sb})$, one gets:

T(K)	↗	57.36		58.6162		59.87		79.762746		79.84
ξ_n	↘	1.880		1.8138		1.750		1		0.998
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.320
ZT		0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗	0.931		1		1.074		3.290		3.305
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.062	↗	0	↗	0.062	↗	1.105	↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-3.535	↗	0	↗	3.745	↗	88.133	↗	88.528
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.092	↗	0	↗	0.094	↗	1.657	↗	1.663
Pt ($10^{-3}V$)		-8.959	↘	-9.162	↘	-9.352	↘	-10.5423	↗	-10.5396

In the degenerate Sn- $X(x)$ – alloy, for $N = 2 \times N_{CDn}(\Gamma_{Sn})$, one gets:

T(K)	↗	57.82	59.0793	60.35	80.392957	80.48
ξ_p	↘	1.880	1.8138	1.750	1	0.997
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.320
ZT		0.999	↗ 1 ↘	0.999	↘ 0.715 ↘	0.713
$(ZT)_{Mott}$	↗	0.931	1	1.074	3.290	3.307
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.061	↗ 0 ↗	0.063	↗ 1.105 ↗	1.109
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-3.545	↗ 0 ↗	3.796	↗ 88.830 ↗	89.275
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.092	↗ 0 ↗	0.094	↗ 1.657 ↗	1.664
Pt ($10^{-3}V$)		-9.031	↘ -9.234 ↘	-9.427	↘ -10.6255 ↗	-10.6226

Table 5p: Here, for a given N and with increasing T , the reduced Fermi-energy ξ_p decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows as: (increase: ↗, decrease: ↘). One notes here that with increasing T : (i) for $\xi_p \simeq 1.8138$, while the numerical results of S present a same minimum $(S)_{min.} (\simeq -1.563 \times 10^{-4} \frac{V}{K})$, those of ZT show a same maximum $(ZT)_{max} = 1$, (ii) for $\xi_p = 1$, those of S , ZT , $(ZT)_{Mott}$, $VC1$, and T_s present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715 , 3.290 , $1.105 \times 10^{-4} \frac{V}{K}$, and $1.657 \times 10^{-4} \frac{V}{K}$, respectively, and (iii) for $\xi_p \simeq 1.8138$, $(ZT)_{Mott} = 1$.

For $x=0$,

In the degenerate Ga- $X(x)$ – alloy, for $N = 2 \times N_{CDp}(\Gamma_{Ga})$, one gets:

T(K)	↗	50.5	51.708	53	70.3622	70.5
ξ_p	↘	1.886	1.8138	1.740	1	0.995
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.318
ZT		0.998	↗ 1 ↘	0.998	↘ 0.715 ↘	0.711
$(ZT)_{Mott}$	↗	0.925	1	1.086	3.290	3.320
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.067	↗ 0 ↗	0.073	↗ 1.105 ↗	1.113
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-3.390	↗ 0 ↗	3.878	↗ 77.746 ↗	78.451
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.101	↗ 0 ↗	0.110	↗ 1.657 ↗	1.669
Pt ($10^{-3}V$)		-7.887	↘ -8.082 ↘	-8.2768	↘ -9.2998 ↗	-9.295

In the degenerate Mg- $X(x)$ – alloy, for $N = 2 \times N_{CDp}(\Gamma_{Mg})$, one gets

T(K)	↗	56.5	57.78394	59	78.629815	78.7
ξ_p	↘	1.883	1.8138	1.751	1	0.998
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.320
ZT		0.999	↗ 1 ↘	0.999	↘ 0.715 ↘	0.713
$(ZT)_{Mott}$	↗	0.928	1	1.072	3.290	3.304

$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.064 ↗	0 ↗	0.061 ↗	1.105 ↗	1.108
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-3.608 ↗	0 ↗	3.631 ↗	86.881 ↗	87.240
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.096 ↗	0 ↗	0.092 ↗	1.657 ↗	1.663
Pt ($10^{-3}V$)	-8.825 ↘	-9.032 ↘	-9.216 ↘	-10.3925 ↗	-10.390

In the degenerate In- X(x) – alloy, for $N = 2 \times N_{CDP}(\Gamma_{In})$, one gets:

T(K) ↗	60.5	61.914	63.3	84.2501	84.3
ξ_p ↘	1.884	1.8138	1.747	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.998 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$ ↗	0.926	1	1.077	3.290	3.300
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.066 ↗	0 ↗	0.065 ↗	1.105 ↗	1.107
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-3.971 ↗	0 ↗	4.145 ↗	93.092 ↗	93.347
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.098 ↗	0 ↗	0.098 ↗	1.657 ↗	1.661
Pt ($10^{-3}V$)	-9.449 ↘	-9.677 ↘	-9.887 ↘	-11.1353 ↗	-11.134

In the degenerate Cd- X(x) – alloy, for $N = 2 \times N_{CDP}(\Gamma_{Cd})$, one gets:

T(K) ↗	66	67.2	68.7	91.44384	91.5
ξ_p ↘	1.869	1.8138	1.748	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$ ↗	0.942	1	1.077	3.290	3.299
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.051 ↗	0 ↗	0.065 ↗	1.105 ↗	1.107
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-3.396 ↗	0 ↗	4.484 ↗	101.040 ↗	101.327
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.077 ↗	0 ↗	0.098 ↗	1.657 ↗	1.661
Pt ($10^{-3}V$)	-10.311 ↘	-10.503 ↘	-10.730 ↘	-12.086 ↗	-12.084

For x=0.5,

In the degenerate Ga- X(x) – alloy, for $N = 2 \times N_{CDP}(\Gamma_{Ga})$, one gets:

T(K) ↗	74.2	75.8235	77.45	103.177805	103.22
ξ_p ↘	1.880	1.8138	1.750	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$ ↗	0.931	1	1.074	3.290	3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061 ↗	0 ↗	0.063 ↗	1.105 ↗	1.106
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-4.569 ↗	0 ↗	4.858 ↗	114.006 ↗	114.221

$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.092 ↗	0 ↗	0.094 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-11.590 ↘	-11.851 ↘	-12.098 ↘	-13.637 ↗	-13.636

In the degenerate Mg- X(x) – alloy, for $N = 2 \times N_{CDP}(\Gamma_{Mg})$, one gets

T(K) ↗	82.93	84.73286	86.55	115.30128	115.35
ξ_p ↘	1.880	1.8138	1.750	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$ ↗	0.931	1	1.074	3.290	3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061 ↗	0 ↗	0.063 ↗	1.105 ↗	1.107
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-5.075 ↗	0 ↗	5.428 ↗	127.401 ↗	127.651
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.092 ↗	0 ↗	0.094 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-12.954 ↘	-13.244 ↘	-13.519 ↘	-15.239 ↗	-15.238

In the degenerate In- X(x) – alloy, for $N = 2 \times N_{CDP}(\Gamma_{In})$, one gets:

T(K) ↗	88.85	90.78935	92.74	123.54276	123.6
ξ_p ↘	1.880	1.8138	1.750	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$ ↗	0.931	1	1.074	3.290	3.297
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061 ↗	0 ↗	0.063 ↗	1.105 ↗	1.107
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-5.458 ↗	0 ↗	5.827 ↗	136.508 ↗	136.801
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.092 ↗	0 ↗	0.094 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-13.878 ↘	-14.190 ↘	-14.486 ↘	-16.3287 ↗	-16.3267

In the degenerate Cd- X(x) – alloy, for $N = 2 \times N_{CDP}(\Gamma_{Cd})$, one gets:

T(K) ↗	96.45	98.54147	100.65	134.09152	134.145
ξ_p ↘	1.879	1.8138	1.750	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$ ↗	0.931	1	1.074	3.290	3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061 ↗	0 ↗	0.062 ↗	1.105 ↗	1.106
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-5.887 ↗	0 ↗	6.298 ↗	148.164 ↗	148.437
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.091 ↗	0 ↗	0.094 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-15.065 ↘	-15.402 ↘	-15.722 ↘	-17.7229 ↗	-17.7211

For x=1,

In the degenerate Ga- $X(x)$ – alloy, for $N = 2 \times N_{CDP}(\Gamma_{Ga})$, one gets:

T(K)	↗	109.8		112.184162		114.6		152.655978		152.72
ξ_p	↘	1.879		1.8138		1.750		1		0.999
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.321
ZT		0.999	↗	1	↘	0.999	↘	0.715	↘	0.714
$(ZT)_{Mott}$	↗	0.931		1		1.074		3.290		3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.061	↗	0	↗	0.063	↗	1.105	↗	1.107
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-6.711	↗	0	↗	7.217	↗	168.676	↗	169.004
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.092	↗	0	↗	0.094	↗	1.657	↗	1.660
Pt ($10^{-3}V$)		-17.151	↘	-17.534	↘	-17.900	↘	-20.1766	↗	-20.1744

In the degenerate Mg- $X(x)$ – alloy, for $N = 2 \times N_{CDP}(\Gamma_{Mg})$, one gets:

T(K)	↗	122.7		125.365892		128		170.59318		170.66
ξ_p	↘	1.880		1.8138		1.751		1		0.999
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.321
ZT		0.999	↗	1	↘	0.999	↘	0.715	↘	0.714
$(ZT)_{Mott}$	↗	0.931		1		1.072		3.290		3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.061	↗	0	↗	0.061	↗	1.105	↗	1.106
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-7.504	↗	0	↗	7.863	↗	188.496	↗	188.838
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.092	↗	0	↗	0.092	↗	1.657	↗	1.660
Pt ($10^{-3}V$)		-19.166	↘	-19.595	↘	-19.994	↘	-22.547	↗	-22.545

In the degenerate In- $X(x)$ – alloy, for $N = 2 \times N_{CDP}(\Gamma_{In})$, one gets:

T(K)	↗	131.5		134.32677		137.2		182.7868		182.86
ξ_p	↘	1.879		1.8138		1.750		1		0.999
$S \left(10^{-4} \frac{V}{K}\right)$		-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.321
ZT		0.999	↗	1	↘	0.999	↘	0.715	↘	0.714
$(ZT)_{Mott}$	↗	0.932		1		1.074		3.290		3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$		-0.060	↗	0	↗	0.062	↗	1.105	↗	1.106
$VC2 \left(10^{-4} \frac{V}{K}\right)$		-7.959	↗	0	↗	8.581	↗	201.969	↗	202.343
$T_s \left(10^{-4} \frac{V}{K}\right)$		-0.091	↗	0	↗	0.094	↗	1.657	↗	1.660
Pt ($10^{-3}V$)		-20.541	↘	-20.995	↘	-21.431	↘	-24.159	↗	-24.156

In the degenerate Cd- $X(x)$ – alloy, for $N = 2 \times N_{CDP}(\Gamma_{In})$, one gets:

T(K)	↗	142.7		145.79633		148.92		198.39414		198.47
ξ_p	↘	1.879		1.8138		1.750		1		0.999

$S \left(10^{-4} \frac{V}{K}\right)$	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.321
ZT	0.999	↗	1	↘	0.999	↘	0.715	↘	0.714
$(ZT)_{Mott}$	↗ 0.931		1		1.074		3.290		3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061	↗	0	↗	0.063	↗	1.105	↗	1.106
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-8.716	↗	0	↗	9.330	↗	219.214	↗	219.602
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.092	↗	0	↗	0.094	↗	1.657	↗	1.660
Pt ($10^{-3}V$)	-22.290	↘	-22.788	↘	-23.261	↘	-26.222	↗	-26.219

Table 6n: Here, for a given T and with decreasing N, the reduced Fermi-energy ξ_n decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows as: (increase: ↗, decrease: ↘). One notes here that with increasing T: (i) for $\xi_n \approx 1.8138$, while the numerical results of S present a same minimum $(S)_{min.} (\approx -1.563 \times 10^{-4} \frac{V}{K})$, those of ZT show a same maximum $(ZT)_{max} = 1$, (ii) for $\xi_n = 1$, those of S, ZT, $(ZT)_{Mott}$, VC1, and T_s present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715, 3.290, $-1.105 \times 10^{-4} \frac{V}{K}$ and $1.657 \times 10^{-4} \frac{V}{K}$ respectively, and (iii) for $\xi_n \approx 1.8138$, $(ZT)_{Mott} = 1$.

For x=0, BON

In the degenerate P- X(x) – alloy, for T= 5.6729 K, one gets:

$N(10^{15}cm^{-3})$	↘ 3.4		3.3064128		3.25		2.69469323		2.69
ξ_n	↘ 1.927		1.8138		1.745		1		0.993
$S \left(10^{-4} \frac{V}{K}\right)$	-1.560	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.317
ZT	0.996	↗	1	↘	0.998	↘	0.715	↘	0.710
$(ZT)_{Mott}$	↗ 0.886		1		1.081		3.290		3.337
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.103	↗	0	↗	0.068	↗	1.105	↗	1.117
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-0.584	↗	0	↗	0.389	↗	6.268	↗	6.337
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.154	↗	0	↗	0.103	↗	1.657	↗	1.675
Pt ($10^{-3}V$)	-0.885	↘	-0.887	↗	-0.886	↗	-0.750	↗	-0.747

In the degenerate As- X(x) – alloy, for T= 6.90423 K, one gets:

$N(10^{15}cm^{-3})$	↘ 4.5		4.4394186		4.38		3.6180693		3.615
ξ_n	↘ 1.869		1.8138		1.759		1		0.996
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.319
ZT	0.999	↗	1	↘	0.999	↘	0.715	↘	0.712
$(ZT)_{Mott}$	↗ 0.942		1		1.062		3.290		3.313
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.051	↗	0	↗	0.053	↗	1.105	↗	1.111
$VC2 \left(10^{-4} \frac{V}{K}\right)$	-0.354	↗	0	↗	0.368	↗	7.629	↗	7.669
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.077	↗	0	↗	0.080	↗	1.657	↗	1.666

Pt ($10^{-3}V$) -1.0786 ↘ -1.07913 ↗ -1.0786 ↗ -0.912 ↗ -0.911

In the degenerate Sb- X(x) – alloy, for T= **8.1009 K**, one gets:

$N(10^{15}cm^{-3})$	↘	5.75	5.6422212	5.55	4.5983503	4.595
ξ_n	↘	1.890	1.8138	1.747	1	0.997
$S(10^{-4}\frac{V}{K})$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.320
ZT		0.998	↗ 1 ↘	0.998	↘ 0.715 ↘	0.713
$(ZT)_{Mott}$	↗	0.920	1	1.077	3.290	3.309
$VC1(10^{-4}\frac{V}{K})$		-0.071	↗ 0 ↗	0.065	↗ 1.105 ↗	1.110
$VC2(10^{-4}\frac{V}{K})$		-0.574	↗ 0 ↗	0.531	↗ 8.951	↗ 8.992
$T_s(10^{-4}\frac{V}{K})$		-0.106	↗ 0 ↗	0.098	↗ 1.657 ↗	1.665
Pt ($10^{-3}V$)		-1.265	↘ -1.266	↗ -1.265	↗ -1.071	↗ -1.069

In the degenerate Sn- X(x) – alloy, for T=**8.16501**, one gets:

$N(10^{15}cm^{-3})$	↘	5.78	5.7092226	5.6	4.6529901	4.65
ξ_n	↘	1.864	1.8138	1.736	1	0.997
$S(10^{-4}\frac{V}{K})$		-1.562	↘ -1.563 ↗	-1.561	↗ -1.322 ↗	-1.320
ZT		0.999	↗ 1 ↘	0.998	↘ 0.715 ↘	0.713
$(ZT)_{Mott}$	↗	0.947	1	1.091	3.290	3.307
$VC1(10^{-4}\frac{V}{K})$		-0.047	↗ 0 ↗	0.077	↗ 1.105 ↗	1.10
$VC2(10^{-4}\frac{V}{K})$		-0.381	↗ 0 ↗	0.630	↗ 9.022	↗ 9.058
$T_s(10^{-4}\frac{V}{K})$		-0.070	↗ 0 ↗	0.116	↗ 1.657 ↗	1.664
Pt ($10^{-3}V$)		-1.2757	↘ -1.276	↗ -1.275	↗ -1.079	↗ -1.078

For x=0.5,

In the degenerate P- X(x) – alloy, for T=**19.41857 K**, one gets:

$N(10^{16}cm^{-3})$	↘	9.565	9.4111682	9.264	7.6700068	7.666
ξ_n	↘	1.879	1.8138	1.750	1	0.998
$S(10^{-4}\frac{V}{K})$		-1.562	↘ -1.563 ↗	-1.562	↗ -1.322 ↗	-1.320
ZT		0.999	↗ 1 ↘	0.999	↘ 0.715 ↘	0.713
$(ZT)_{Mott}$	↗	0.931	1	1.074	3.290	3.304
$VC1(10^{-4}\frac{V}{K})$		-0.061	↗ 0 ↗	0.063	↗ 1.105 ↗	1.108
$VC2(10^{-4}\frac{V}{K})$		-1.185	↗ 0 ↗	1.216	↗ 21.456	↗ 21.527
$T_s(10^{-4}\frac{V}{K})$		-0.091	↗ 0 ↗	0.094	↗ 1.657 ↗	1.663
Pt ($10^{-3}V$)		-3.033	↘ -3.035	↗ -3.033	↗ -2.566	↗ -2.564

In the degenerate As- X(x) – alloy, for T= **23.6336 K**, one gets:

$N(10^{17} \text{ cm}^{-3})$	↘ 1.284	1.2636086	1.244	1.02982812	1.0296
ξ_n	↘ 1.879	1.8138	1.751	1	0.999
$S(10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.932	1	1.073	3.290	3.296
$VC1(10^{-4} \frac{V}{K})$	-0.060 ↗	0 ↗	0.062 ↗	1.105 ↗	1.106
$VC2(10^{-4} \frac{V}{K})$	-1.424 ↗	0 ↗	1.468 ↗	26.114 ↗	26.150
$T_s(10^{-4} \frac{V}{K})$	-0.090 ↗	0 ↗	0.093 ↗	1.657 ↗	1.660
$Pt(10^{-3} V)$	-3.692 ↘	-3.694 ↗	-3.692 ↗	-3.124 ↗	-3.122

In the degenerate Sb- X(x) – alloy, for T=27.7298, one gets:

$N(10^{17} \text{ cm}^{-3})$	↘ 1.632	1.6059668	1.581	1.3088481	1.3085
ξ_n	↘ 1.879	1.8138	1.751	1	0.999
$S(10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.932	1	1.073	3.290	3.297
$VC1(10^{-4} \frac{V}{K})$	-0.060 ↗	0 ↗	0.062 ↗	1.105 ↗	1.107
$VC2(10^{-4} \frac{V}{K})$	-1.678 ↗	0 ↗	1.726 ↗	30.640 ↗	30.691
$T_s(10^{-4} \frac{V}{K})$	-0.090 ↗	0 ↗	0.093 ↗	1.657 ↗	1.660
$Pt(10^{-3} V)$	-4.331 ↘	-4.334 ↗	-4.331 ↗	-3.665 ↗	-3.663

In the degenerate Sn- X(x) – alloy, for T=27.94884 one gets:

$N(10^{17} \text{ cm}^{-3})$	↘ 1.651	1.6250376	1.60	1.32438914	1.3241
ξ_n	↘ 1.878	1.8138	1.751	1	0.999
$S(10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.933	1	1.072	3.290	3.296
$VC1(10^{-4} \frac{V}{K})$	-0.060 ↗	0 ↗	0.062 ↗	1.105 ↗	1.106
$VC2(10^{-4} \frac{V}{K})$	-1.668 ↗	0 ↗	1.723 ↗	30.882 ↗	30.924
$T_s(10^{-4} \frac{V}{K})$	-0.089 ↗	0 ↗	0.092 ↗	1.657 ↗	1.660
$Pt(10^{-3} V)$	-4.366 ↘	-4.368 ↗	-4.366 ↗	-3.6940 ↗	-3.6922

For x=1,

In the degenerate P- X(x) – alloy, for T=41.0477 K, one gets:

$N(10^{17} \text{ cm}^{-3})$	↘ 6.133	6.0347024	5.94	4.9182193	4.917
ξ_n	↘ 1.879	1.8138	1.750	1	0.999
$S(10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321

ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
(ZT) _{Mott}	↗ 0.931	1	1.074	3.290	3.296
VC1 (10 ⁻⁴ $\frac{V}{K}$)	-0.061 ↗	0 ↗	0.063 ↗	1.105 ↗	1.107
VC2 (10 ⁻⁴ $\frac{V}{K}$)	-2.496 ↗	0 ↗	2.579 ↗	45.355 ↗	45.426
T _s (10 ⁻⁴ $\frac{V}{K}$)	-0.091 ↗	0 ↗	0.094 ↗	1.657 ↗	1.660
Pt (10 ⁻³ V)	-6.412 ↘	-6.416 ↗	-6.412 ↗	-5.4253 ↗	-5.4224

In the degenerate As- X(x) – alloy, for T=49.95763 K, one gets:

N(10 ¹⁷ cm ⁻³)	↘ 8.23	8.102609	7.98	6.6035443	6.602
ξ _n	↘ 1.877	1.8138	1.752	1	0.999
S (10 ⁻⁴ $\frac{V}{K}$)	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
(ZT) _{Mott}	↗ 0.934	1	1.071	3.290	3.296
VC1 (10 ⁻⁴ $\frac{V}{K}$)	-0.059 ↗	0 ↗	0.060 ↗	1.105 ↗	1.106
VC2 (10 ⁻⁴ $\frac{V}{K}$)	-2.936 ↗	0 ↗	3.023 ↗	55.200 ↗	55.281
T _s (10 ⁻⁴ $\frac{V}{K}$)	-0.088 ↗	0 ↗	0.091 ↗	1.657 ↗	1.660
Pt (10 ⁻³ V)	-7.804 ↘	-7.808 ↗	-7.804 ↗	-6.6029 ↗	-6.5996

In the degenerate Sb- X(x) – alloy, for T=58.6162 K, one gets:

N(10 ¹⁸ cm ⁻³)	↘ 1.046	1.0297905	1.014	0.83926868	0.8389
ξ _n	↘ 1.877	1.8138	1.752	1	0.998
S (10 ⁻⁴ $\frac{V}{K}$)	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.320
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
(ZT) _{Mott}	↗ 0.934	1	1.072	3.290	3.302
VC1 (10 ⁻⁴ $\frac{V}{K}$)	-0.059 ↗	0 ↗	0.061 ↗	1.105 ↗	1.108
VC2 (10 ⁻⁴ $\frac{V}{K}$)	-3.449 ↗	0 ↗	3.596 ↗	64.768 ↗	64.946
T _s (10 ⁻⁴ $\frac{V}{K}$)	-0.088 ↗	0 ↗	0.092 ↗	1.657 ↗	1.662
Pt (10 ⁻³ V)	-9.156 ↘	-9.162 ↗	-9.156 ↗	-7.7473 ↗	-7.7399

In the degenerate Sn- X(x) – alloy, for T=59.0793 K, one gets:

N(10 ¹⁸ cm ⁻³)	↘ 1.059	1.0420193	1.026	0.84923472	0.849
ξ _n	↘ 1.879	1.8138	1.751	1	0.999
S (10 ⁻⁴ $\frac{V}{K}$)	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
(ZT) _{Mott}	↗ 0.931	1	1.072	3.290	3.297
VC1 (10 ⁻⁴ $\frac{V}{K}$)	-0.061 ↗	0 ↗	0.061 ↗	1.105 ↗	1.107
VC2 (10 ⁻⁴ $\frac{V}{K}$)	-3.595 ↗	0 ↗	3.634 ↗	65.279 ↗	65.392

$T_s (10^{-4} \frac{V}{K})$	-0.091 ↗	0 ↗	0.092 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-9.228 ↘	-9.234 ↗	-9.228 ↗	-7.8085 ↗	-7.8038

Table 6p: Here, for a given T and with decreasing N, the reduced Fermi-energy ξ_p decreases, and other thermoelectric coefficients are in variations, as indicated by the arrows as: (increase: ↗, decrease: ↘). One notes here that with increasing T: (i) for $\xi_p \approx 1.8138$, while the numerical results of S present a same minimum $(S)_{min.} (\approx -1.563 \times 10^{-4} \frac{V}{K})$, those of ZT show a same maximum $(ZT)_{max} = 1$, (ii) for $\xi_p = 1$, those of S, ZT, $(ZT)_{Mott}$ VC1, and T_s present the same results: $-1.322 \times 10^{-4} \frac{V}{K}$, 0.715, 3.290, $-1.105 \times 10^{-4} \frac{V}{K}$ and $1.657 \times 10^{-4} \frac{V}{K}$ respectively, and (iii) for $\xi_p \approx 1.8138$, $(ZT)_{Mott} = 1$.

For x=0,

In the degenerate Ga- X(x) – alloy, for T=51.708K, one gets:

$N(10^{18}cm^{-3})$	↘ 1.492	1.4673047	1.445	1.19583942	1.1952
ξ_p	↘ 1.881	1.8138	1.752	1	0.998
$S (10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.320
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.713
$(ZT)_{Mott}$	↗ 0.929	1	1.071	3.290	3.304
$VC1 (10^{-4} \frac{V}{K})$	-0.063 ↗	0 ↗	0.061 ↗	1.105 ↗	1.109
$VC2(10^{-3}V)$	-0.324 ↗	0 ↗	0.314 ↗	5.713 ↗	5.732
$T_s (10^{-4} \frac{V}{K})$	-0.094 ↗	0 ↗	0.091 ↗	1.657 ↗	1.663
Pt ($10^{-3}V$)	-8.076 ↘	-8.082 ↗	-8.077 ↗	-6.834 ↗	-6.826

In the degenerate Mg- X(x) – alloy, for T= 57.78394 K, one gets:

$N(10^{18}cm^{-3})$	↘ 1.763	1.7333732	1.705	1.4126857	1.412
ξ_p	↘ 1.882	1.8138	1.747	1	0.998
$S (10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.320
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.713
$(ZT)_{Mott}$	↗ 0.928	1	1.077	3.290	3.303
$VC1 (10^{-4} \frac{V}{K})$	-0.064 ↗	0 ↗	0.066 ↗	1.105 ↗	1.108
$VC2(10^{-3}V)$	-0.368 ↗	0 ↗	0.379 ↗	6.385 ↗	6.404
$T_s (10^{-4} \frac{V}{K})$	-0.095 ↗	0 ↗	0.098 ↗	1.657 ↗	1.662
Pt ($10^{-3}V$)	-9.025 ↘	-9.032 ↗	-9.025 ↗	-7.637 ↗	-7.629

In the degenerate In- X(x) – alloy, for T=61.914 K, one gets:

$N(10^{18}cm^{-3})$	↘ 1.955	1.9225022	1.9	1.56682126	1.566
ξ_p	↘ 1.882	1.8138	1.766	1	0.998
$S (10^{-4} \frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.320

ZT	0.999	↗	1	↘	0.999	↘	0.715	↘	0.713
$(ZT)_{Mott}$	↗ 0.928		1		1.054		3.290		3.303
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.063	↗	0	↗	0.046	↗	1.105	↗	1.108
$VC2(10^{-3}V)$	-0.390	↗	0	↗	0.288	↗	6.841	↗	6.864
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.094	↗	0	↗	0.070	↗	1.657	↗	1.663
$Pt(10^{-3}V)$	-9.671	↘	-9.677	↗	-9.674	↗	-8.183	↗	-8.174

In the degenerate Cd- X(x) – alloy, for T=67.2 K, one gets:

$N(10^{18}cm^{-3})$	↘ 2.2		2.1739166		2.15		1.77171312		1.770
ξ_p	↘ 1.862		1.8138		1.769		1		0.996
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.319
ZT	0.999	↗	1	↘	0.999	↘	0.715	↘	0.712
$(ZT)_{Mott}$	↗ 0.949		1		1.051		3.290		3.316
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.045	↗	0	↗	0.043	↗	1.105	↗	1.112
$VC2(10^{-3}V)$	-0.304	↗	0	↗	0.293	↗	7.425	↗	7.470
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.068	↗	0	↗	0.065	↗	1.657	↗	1.667
$Pt(10^{-3}V)$	-10.500	↘	-10.503	↗	-10.500	↗	-8.882	↗	-8.863

For x=0.5,

In the degenerate Ga- X(x) – alloy, for T=75.8235 K, one gets:

$N(10^{18}cm^{-3})$	↘ 3.335		3.2833018		3.232		2.6758571		2.6752
ξ_p	↘ 1.877		1.8138		1.750		1		0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.321
ZT	0.999	↗	1	↘	0.999	↘	0.715	↘	0.714
$(ZT)_{Mott}$	↗ 0.934		1		1.074		3.290		3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.060	↗	0	↗	0.062	↗	1.105	↗	1.107
$VC2(10^{-3}V)$	-4.463	↗	0	↗	4.743	↗	83.781	↗	83.909
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.088	↗	0	↗	0.094	↗	1.657	↗	1.660
$Pt(10^{-3}V)$	-11.844	↘	-11.851	↗	-11.844	↗	-10.0216	↗	-10.0163

In the degenerate Mg- X(x) – alloy, for T=84.73286 K, one gets:

$N(10^{18}cm^{-3})$	↘ 3.942		3.8786676		3.818		3.1610749		3.16
ξ_p	↘ 1.879		1.8138		1.750		1		0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562	↘	-1.563	↗	-1.562	↗	-1.322	↗	-1.321
ZT	0.999	↗	1	↘	0.999	↘	0.715	↘	0.714
$(ZT)_{Mott}$	↗ 0.931		1		1.074		3.290		3.299
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061	↗	0	↗	0.063	↗	1.105	↗	1.107
$VC2(10^{-3}V)$	-5.165	↗	0	↗	5.306	↗	93.625	↗	93.824

$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.091 ↗	0 ↗	0.094 ↗	1.657 ↗	1.661
Pt ($10^{-3}V$)	-13.235 ↘	-13.244 ↗	-13.235 ↗	-11.1992 ↗	-11.1909

In the degenerate In- X(x) – alloy, for T=90.78935 K, one gets:

$N(10^{18}cm^{-3})$	↘ 4.37	4.3018704	4.235	3.5059803	3.505
ξ_p	↘ 1.877	1.8138	1.751	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.933	1	1.073	3.290	3.297
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.059 ↗	0 ↗	0.062 ↗	1.105 ↗	1.107
$VC2(10^{-3}V)$	-5.374 ↗	0 ↗	5.649 ↗	100.317 ↗	100.493
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.089 ↗	0 ↗	0.093 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-14.182 ↘	-14.190 ↗	-14.181 ↗	-11.9996 ↗	-11.9924

In the degenerate Cd- X(x) – alloy, for T=98.54147 K, one gets:

$N(10^{18}cm^{-3})$	↘ 4.944	4.8644456	4.79	3.9644739	3.9635
ξ_p	↘ 1.879	1.8138	1.752	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.931	1	1.072	3.290	3.296
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.061 ↗	0 ↗	0.061 ↗	1.105 ↗	1.107
$VC2(10^{-3}V)$	-6.016 ↗	0 ↗	6.033 ↗	108.883 ↗	109.050
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.091 ↗	0 ↗	0.092 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-15.392 ↘	-15.402 ↗	-15.393 ↗	-13.0242 ↗	-13.0173

For x=1,

In the degenerate Ga- X(x) – alloy, for T=112.184162 K, one gets:

$N(10^{18}cm^{-3})$	↘ 7.335	7.2192156	7.11	5.8835877	5.882
ξ_p	↘ 1.878	1.8138	1.752	1	0.999
$S \left(10^{-4} \frac{V}{K}\right)$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.932	1	1.071	3.290	3.297
$VC1 \left(10^{-4} \frac{V}{K}\right)$	-0.060 ↗	0 ↗	0.060 ↗	1.105 ↗	1.107
$VC2(10^{-3}V)$	-6.721 ↗	0 ↗	6.787 ↗	123.957 ↗	124.167
$T_s \left(10^{-4} \frac{V}{K}\right)$	-0.090 ↗	0 ↗	0.091 ↗	1.657 ↗	1.660
Pt ($10^{-3}V$)	-17.524 ↘	-17.534 ↗	-17.524 ↗	-14.8274 ↗	-14.8187

In the degenerate Mg- X(x) – alloy, for T=125.365892 K, one gets:

$N(10^{18}\text{cm}^{-3})$	↘ 8.665	8.5282866	8.4	6.9504673	6.949
ξ_p	↘ 1.878	1.8138	1.753	1	0.999
$S(10^{-4}\frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.932	1	1.071	3.290	3.295
$VC1(10^{-4}\frac{V}{K})$	-0.060 ↗	0 ↗	0.060 ↗	1.105 ↗	1.106
$VC2(10^{-3}V)$	-7.508 ↗	0 ↗	7.540 ↗	138.522 ↗	138.705
$T_s(10^{-4}\frac{V}{K})$	-0.090 ↗	0 ↗	0.090 ↗	1.657 ↗	1.660
$Pt(10^{-3}V)$	-19.583 ↘	-19.595 ↗	-19.583 ↗	-16.5696 ↗	-16.5621

In the degenerate In- X(x) – alloy, for T=134.32677 K, one gets:

$N(10^{18}\text{cm}^{-3})$	↘ 9.61	9.458811	9.31	7.7088353	7.707
ξ_p	↘ 1.878	1.8138	1.750	1	0.999
$S(10^{-4}\frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.321
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.714
$(ZT)_{Mott}$	↗ 0.933	1	1.074	3.290	3.296
$VC1(10^{-4}\frac{V}{K})$	-0.060 ↗	0 ↗	0.063 ↗	1.105 ↗	1.106
$VC2(10^{-3}V)$	-8.022 ↗	0 ↗	8.462 ↗	148.424 ↗	148.645
$T_s(10^{-4}\frac{V}{K})$	-0.089 ↗	0 ↗	0.094 ↗	1.657 ↗	1.660
$Pt(10^{-3}V)$	-20.982 ↘	-20.995 ↗	-20.982 ↗	-17.754 ↗	-17.745

In the degenerate Cd- X(x) – alloy, for T=145.79633 K, one gets:

$N(10^{19}\text{cm}^{-3})$	↘ 1.088	1.0695783	1.053	0.87169548	0.8712
ξ_p	↘ 1.883	1.8138	1.751	1	0.998
$S(10^{-4}\frac{V}{K})$	-1.562 ↘	-1.563 ↗	-1.562 ↗	-1.322 ↗	-1.320
ZT	0.999 ↗	1 ↘	0.999 ↘	0.715 ↘	0.713
$(ZT)_{Mott}$	↗ 0.928	1	1.073	3.290	3.305
$VC1(10^{-4}\frac{V}{K})$	-0.064 ↗	0 ↗	0.062 ↗	1.105 ↗	1.109
$VC2(10^{-3}V)$	-9.357 ↗	0 ↗	9.044 ↗	161.097 ↗	161.670
$T_s(10^{-4}\frac{V}{K})$	-0.096 ↗	0 ↗	0.093 ↗	1.657 ↗	1.663
$Pt(10^{-3}V)$	-22.772 ↘	-22.788 ↗	-22.774 ↗	-19.2699 ↗	-19.2462