TRANSPORT COEFFICIENTS OF AIR IN THE REGION OF TEMPERATURES FROM 3000 TO 25,000°K AND PRESSURES OF 0.1, 1, 10, AND 100 ATM

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In the article a calculation is made of the transport properties of air in the region of temperatures from 3000 to 25,000°K and pressures of 0.1, 1, 10, and 100 atm. The calculations are made within the framework of molecular-kinetic theory in a first approximation of the distribution function by the Chapman–Enskog method, taking account of the first four terms of a series expansion by Sonin polynomials. The collision integrals $\Omega_{ij}^{l,s}$ of the air components (N_2–N_2, O_2–O_2, NO–NO, N_2–O_2, N_2–NO, O_2–NO, N_2–N, N_2–O, O_2–N, O_2–O, N–NO, O–NO, N–N, O–O, O–N, e–N, e–O, e–N_2, e–O_2, e–NO, N–N^+, O–O^+, N–O^+, O–N^+, electron–ion, ion–ion, electron–electron) of the orders $l=1,\ldots,4$ and $s=l,\ldots,(8-l)$ are calculated. As far as possible the collision integrals presented are calculated on the basis of experimentally measured interaction potentials obtained through the "direct" scattering of atomic and molecular beams on gas targets or other beams. The missing information on interaction potentials is borrowed from works on spectroscopic analysis. The scattering of an electron on an oxygen atom is calculated in the framework of a quantum-mechanical analysis. The collision integrals presented for charged components of the air were calculated numerically for the Debye–Hückel screening potential. The collision integral moments obtained in the work can be used to calculate the kinetic coefficients for an arbitrary mixture of nitrogen and oxygen, including the case of a variable elementary composition.

1. Recently attention has been turned to the transport properties of partially and fully ionized air both in the areas of theoretical [1-6] and experimental studies [7-9]. There are two main reasons for the significant disagreement among the data of theoretical works. As a rule, the approximate equations of molecular-kinetic theory developed by Chapman and Cowling [10, 11] are used in calculations of the transport coefficients in the region of partial and total ionization of a gas. In this case the rules verified for neutral mixtures are formally applied to the region of ionized gases. Agreement with the asymptotic equations of Spitzer [12] is not observed with such an approach to the calculation of the transport properties of ionized gases.

On the other hand, data of reduced collision integrals obtained by approximate calculations are used even with a stricter theoretical examination of this question. A comparison of the results of individual reports is connected with important difficulties, since in addition to simplification of the theoretical expressions for the kinetic coefficients and approximate means of calculating the collision integrals there is a large arbitrariness in the choice of the potential functions of the interaction of the air components. In a number of works [1, 2] interatomic potentials, the force constants of which are obtained from experiments on the transport properties at low temperatures, are used in the calculation of the reduced collision integrals. Potentials obtained by polyempirical calculations from spectroscopic data are sometimes used [2, 6]. In calculations of transport properties preference must be given to measurements from "direct" scattering of beams, since the potentials derived from these experiments are "purer" in comparison with potentials obtained from the kinetic properties at low temperatures or from quantum-mechanical calculations based on spectroscopic data.

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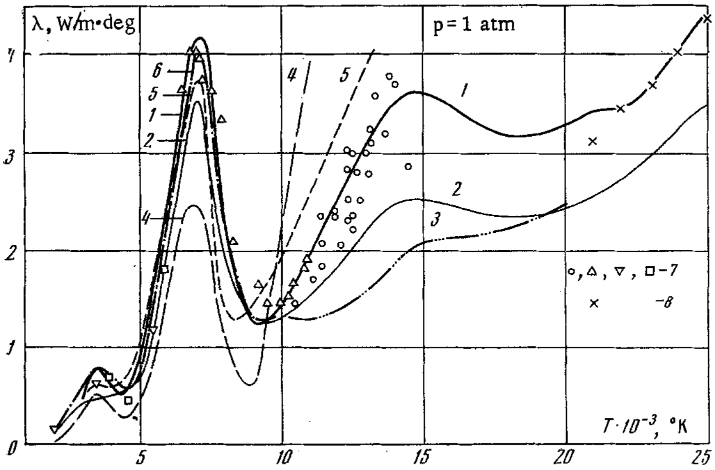

Fig. 1

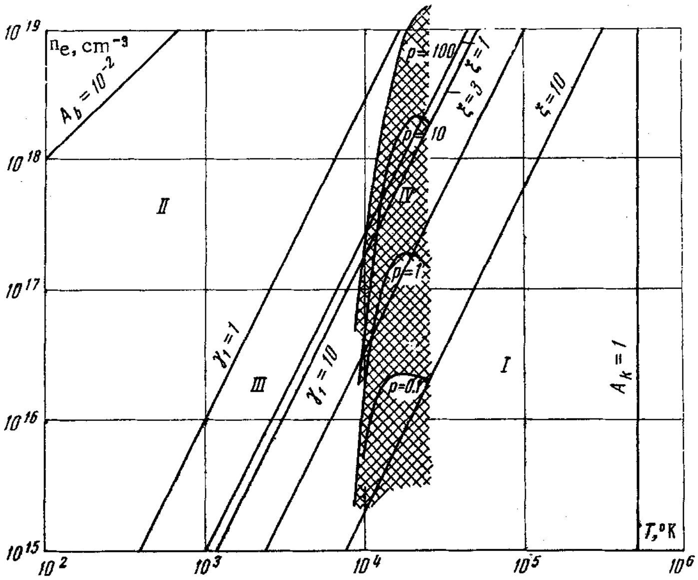

Fig. 2

Moreover, the choice of the air composition affects the magnitude of the transport coefficients.

Thermal conductivity coefficients from the data of [1-6] are presented in Fig. 1. The experimental points of [7] are plotted for comparison with the theoretical calculations. The number 1 marks the results of the calculation conducted in the present report, the number 2 those in [6], 3, [5]; 4, [1]; 5, [2]; 6, [4]; 7, [7]; and 8, [12]. There is no good agreement either among the data of individual articles or with the experiments.

In the present report the calculation of the transport properties of air is conducted according to a single principle. All the necessary collision integrals $\Omega_{ij}^{l,s}$ of the order $l = 1, \ldots, 4$ and $s = l, \ldots, (8 - l)$ are calculated on the basis of existing experimental data on the interaction potentials of the air components. Data on direct scattering of molecular and atomic beams on gas targets were used wherever possible, as well as data of a spectroscopic analysis. Quantum-mechanical calculations of the scattering cross sections of an electron on an oxygen atom and exact numerical calculations of the scattering cross sections of charged particles were conducted. The transport coefficients and coefficients of multicomponent diffusion, thermal conductivity, and electrical conductivity are calculated within the framework of molecular-kinetic theory by the Chapman–Enskog method in a first approximation of the distribution function taking account of four terms in the expansion by Sonin polynomials. The air composition is taken from the tables of [13] for temperatures of T < 12,000°K and from [14] for T = 12,000-25,000°K.

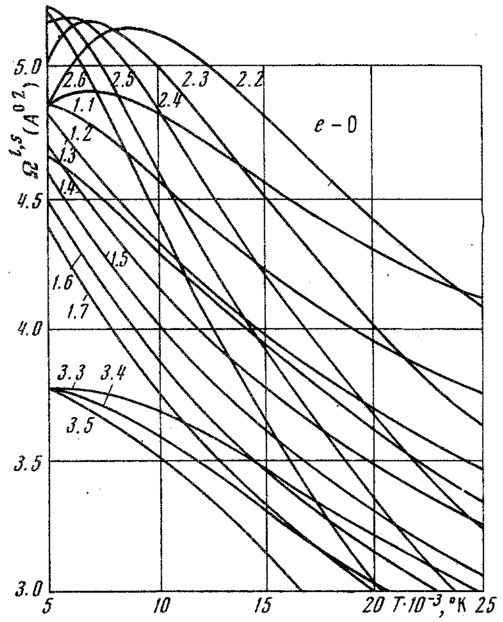

Fig. 3

2. In calculating the transport coefficients of an ionized gas in an expansion of the distribution function by Sonin polynomials, it is necessary to retain at least three to four terms instead of one to two, as usually done in the calculation of neutral mixtures. The generalization of the Chapman–Enskog method to the region of partial ionization is studied in Devoto's articles [15, 16]. The convergence of a series expansion of the distribution function by Sonin polynomials depends on the form of the potential functions of the interaction between the particles and is best for hard repulsion potentials [11]. For an interaction of the Coulomb type convergence of the transport coefficients is determined by three to four terms. For such a choice of the number of terms in the expansion, upon the transition to the region of total ionization the coefficients of thermal conductivity and electrical conductivity coincide with the limiting values of Spitzer's theory [12], while in the transition to the region of a neutral gas agreement with the lower approximations of the molecular-kinetic theory is automatically achieved.

The following assumptions are made in calculating the transport coefficients of air:

1) the gas is nondegenerate

$$A_b = \frac{nh^3}{(2\pi mkT)^{3/2}} \ll 1 \tag{2.1}$$

2) the plasma is in thermal equilibrium ($T_e = T_i = T_a$) and is quasineutral;

3) the plasma is ideal

$$\Gamma = e^2 n_e^{1/3}/kT \ll 1 \tag{2.2}$$

4) the classical approximation

$$A_k = \lambda/r_0 \ll 1 \; (\lambda = \sqrt{h^2/2mkT}, \;\; r_0 = e^2/kT) \tag{2.3}$$

where λ is the de Broglie wavelength, is assumed to be applicable for a description of the Coulomb interactions;

5) it is assumed that the theory of binary collisions is applicable to all types of particles.

An n_e–T diagram [17] on which lines of $\gamma_1 = 1/\Gamma$ = const ($\gamma_1 = 10$, $\gamma_1 = 1$), lines of ξ = const (ξ is the number of particles in a Debye sphere), the line A_b = const ($A_b = 10^{-2}$), and the line $A_k = 1$ are plotted in a logarithmic scale is presented in Fig. 2. Region I corresponds to the region of applicability of the classical description of an ideal plasma. Region II, which lies above the line $\gamma_1 = 1$, corresponds to the condition where the potential energy of the interaction of the charged particles becomes greater than the average kinetic energy. Region III, lying between the lines $\gamma_1 = 1$ and $\xi = 1$, corresponds to the region of plasma parameters for which the deviation from the ideal state becomes significant. Region IV is the region of air parameters being considered.

The deviation from the conditions of an ideal state of an air plasma in the region of high pressures (10, 100 atm) leads to a disturbance in the condition of applicability of the binary collision theory for charged particles. As shown in [18, 19], the phenomenological theory of fluctuations and the binary collision theory applicable to an equilibrium ideal plasma supplement one another and give practically identical results. The theory of the screening of the Coulomb field, lying at the basis of the creation of methods of calculating the kinetic parameters of a plasma, to which Spitzer's theory [12] and the theory of Kihara and Aono [19] belong, is strictly applicable to an ideal plasma. The upper limit of these theories is indeterminate. Upon a disturbance in the conditions of an ideal state, the interactions of charged particles can be described in the framework of the screening theory and, as experiments in a cesium plasma show [20], a correction must be introduced into the screening constant which takes into account the nonideal nature. There are no experiments in the region of a nonideal plasma for air.

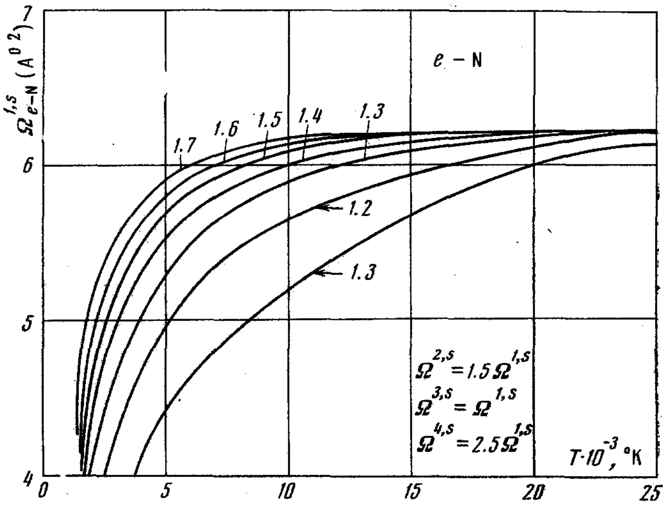

Fig. 4

TABLE 1

Type of interaction	A^sB^s	s							
		1	2	3	4	5	6	7	C
N—N⁺	A^s	51.8	50.9	50.2	49.6	49.1	48.7	48.4	0.207
	B^s	6.55	6.49	6.44	6.41	6.38	6.35	6.33	
O—O⁺	A^s	53.8	52.7	51.9	51.7	50.9	50.5	50.1	0.226
	B^s	6.96	6.90	6.85	6.81	6.78	6.75	6.72	

3. The reduced integrals $\Omega^{l,s}_{ij}$(T) have the form [15]

$$\Omega^{l,s}_{ij}(T) = \frac{4(l+1)}{(s+1)!\,[2l-1-(-1)]^{l}} \int_0^\infty \exp(-\gamma^2)\,\gamma^{2s+3} Q^l(g)\,d\gamma \tag{3.1}$$

$$Q^l(g) = 2\pi \int_0^\infty [1-\cos^l \chi(g)]\, b\,db \tag{3.2}$$

$$\chi(g) = \pi - 2b \int_{2_m}^{\infty} \frac{dr/r^2}{(1-b^2/r^2-\varphi(r)/\gamma^2 kT)^{1/2}} \qquad (\gamma = g(\mu/2kT)^{1/2}) \tag{3.3}$$

where Q^l(g) are the effective transport cross sections, χ(g) is the angle of deviation of the two colliding particles, φ(r) is the interaction potential of the two repelling particles, and γ is the reduced relative velocity of the two particles at infinity.

The reduced collision integrals for the charged air components are calculated for a Coulomb screening potential of attraction and repulsion. The results of the numerical calculations are presented in [21]. Logarithmic divergence as H/E → 0 is not observed in an exact numerical calculation of the cross sections Q^l_* and the integrals $\Omega^{l,s}_*$

$$\mp Q_*{}^l = \mp Q^l/\pi E^2, \quad H = \sqrt{kT/4\pi n_e e^2(1+\bar{z})}, \quad E = e^2 z_i z_j/kT$$

where H is the Debye screening radius. The condition H/E → 0 is analogous to the condition of the nonideal nature of the plasma if the average potential energy of the interaction of the charged particles is determined at the distance of the Debye radius. In this case H/E and γ_1 are the same. The analytical equations for the Coulomb cross sections and collision integral moments obtained in Devoto's work [15] are valid in the limit of large H/E values.

The reduced collision integrals for the neutral components of the air are calculated on the basis of experimental data on the interaction potentials obtained by the direct scattering method in [22]. For a potential function of the form

$$\varphi(r) = c/r^\delta \tag{3.4}$$

the reduced collision integrals are expressed in the form of semianalytical functions

$$\Omega_{ij}^{l,s}(T) = \frac{4(l+1)}{(s+1)!\,[2l-1-(-1)^l]}\Gamma\left(\frac{s+2-2}{\delta}\right)A^l(\delta)\left(\frac{c\delta}{kT}\right)^{2/\delta}$$
$$A^l(\delta) = \int_0^\infty [1-\cos^l\chi(\beta)]\,\beta d\beta, \quad \beta = b\left[\frac{\mu g^2}{2\delta c}\right]^{1/\delta} \tag{3.5}$$

The calculated values of the integrals $\Omega_{ij}^{l,s}(T)$ for all the neutral components are presented in [23].

The calculation of the reduced collision integrals of electrons with neutral atoms is based on quantum-mechanical methods of calculating the cross sections $Q^l(g)$, for which it is necessary to determine the set of scattering phases. For the description of the scattering of an electron on an oxygen atom the parameters of the spherically symmetrical potential are selected in such a way that in the numerical solution of Schrödinger's equation the value of the null phase coincides with the value obtained by the more exact quantum-mechanical calculation of [24], while the set of all the remaining phases gives good agreement with the values of the total cross section from the data of [24] at low energies and the data of [25] at high energies. The scattering phases calculated in this approximation are used to determine the cross sections $Q^l(g)$ and all the collision integrals, whose values are presented in Fig. 3. The substitution of the total value Q for the values Q^l in the calculation of $\Omega^{l,s}(T)$ leads to an error of up to 30%.

The absence of reliable theoretical calculations for the scattering of an electron on a nitrogen atom prohibits the conducting of calculations analogous to e−0 scattering. Therefore, the total scattering cross section [26] in best agreement with experiment [27] was taken for the calculation of the reduced collision integrals. In the calculation of the interaction potential of an electron with a nitrogen atom only with respect to the total cross section the error in the scattering phases leads to an error of ~30% in the cross section calculation, i.e., on the same order as the error given by the average of the total cross section in place of the cross section Q^l. The calculated collision integrals are presented in Fig. 4.

The calculation of the integral moments for the scattering of an electron on molecules of nitrogen and oxygen was conducted on the basis of data on the total scattering cross sections [18, 29]. Since the simultaneous occurrence of molecules and electrons in an air plasma is low, the error resulting from such a substitution is acceptable.

In calculating the collision integrals of atoms with free ions the resonance nature of the charge exchange must be kept in mind. Using spectroscopic data and a calculation of the exchange scattering cross sections [30] for the $N-N^+$ and $O-O^+$ interactions, all the collision integral moments are calculated. The results have the following temperature dependence:

$$\Omega^{l,s}(T) = 2\,[A^s - B^s\log_{10}(T) + C\log_{10}^2(T)] \tag{3.7}$$

The constants A^S, B^S, and C are presented in Table 1. Interaction potentials of the work of Peng et al. [2] were used to calculate the collision integrals of unlike atoms and ions.

4. The transport coefficients obtained by kinetic theory methods, in a series expansion of the distribution function by Sonin polynomials in which four terms are retained, which were obtained in [15] have the form:

diffusion coefficients of a multicomponent mixture

$$[\mathbf{D}_{ij}]_4 = \frac{3\rho n_i}{2nm_j|\mathbf{q}|}\left(\frac{2\pi kT}{m_i}\right)^{1/2}\begin{vmatrix} q_{hk}^{00} & q_{hk}^{01} & q_{hk}^{02} & q_{hk}^{03} & \delta_{hj}-\delta_{hi} \\ q_{hk}^{10} & q_{hk}^{11} & q_{hk}^{12} & q_{hk}^{13} & 0 \\ q_{hk}^{20} & q_{hk}^{21} & q_{hk}^{22} & q_{hk}^{23} & 0 \\ q_{hk}^{30} & q_{hk}^{31} & q_{hk}^{32} & q_{hk}^{33} & 0 \\ \delta_{ki} & 0 & 0 & 0 & 0. \end{vmatrix} \tag{4.1}$$

thermodiffusion coefficient

$$[\mathbf{D}_i^T]_4 = \frac{15n_i(2\pi m_i kT)^{1/2}}{4|\mathbf{q}|}\begin{vmatrix} q_{hk}^{00} & q_{hk}^{01} & q_{hk}^{02} & q_{hk}^{03} & 0 \\ q_{hk}^{10} & q_{hk}^{11} & q_{hk}^{12} & q_{hk}^{13} & n_k \\ q_{hk}^{20} & q_{hk}^{21} & q_{hk}^{22} & q_{hk}^{23} & 0 \\ q_{hk}^{30} & q_{hk}^{31} & q_{hk}^{32} & q_{hk}^{33} & 0 \\ \delta_{ki} & 0 & 0 & 0 & 0 \end{vmatrix} \tag{4.2}$$

thermal conductivity coefficient

$$\lambda = \lambda' + \lambda_1 \tag{4.3}$$

$$[\lambda']_4 = -\frac{75}{8}\frac{(2\pi kT)^{1/2}}{|\mathbf{q}|}\begin{vmatrix} \mathbf{q}_{ij}^{00} & \mathbf{q}_{ij}^{01} & \mathbf{q}_{ij}^{02} & \mathbf{q}_{ij}^{03} & 0 \\ \mathbf{q}_{ij}^{10} & \mathbf{q}_{ij}^{11} & \mathbf{q}_{ij}^{12} & \mathbf{q}_{ij}^{13} & n_i \\ \mathbf{q}_{ij}^{20} & \mathbf{q}_{ij}^{21} & \mathbf{q}_{ij}^{22} & \mathbf{q}_{ij}^{23} & 0 \\ \mathbf{q}_{ij}^{30} & \mathbf{q}_{ij}^{31} & \mathbf{q}_{ij}^{32} & \mathbf{q}_{ij}^{33} & 0 \\ 0 & n_j / m_j^{1/2} & 0 & 0 & 0 \end{vmatrix} \tag{4.4}$$

$$\lambda_1 = \frac{\rho k}{n}\sum_{i,\,j=1}^{\nu}\frac{\mathbf{E}_{ij}\mathbf{D}_i{}^T\mathbf{D}_j{}^T}{n_i m_i m_j} \tag{4.5}$$

viscosity coefficient

$$[\eta]_2 = -\frac{5}{2}\frac{(2\pi kT)^{1/2}}{|\mathbf{q}|}\begin{vmatrix} \bar{\mathbf{q}}_{ij}^{00} & \bar{\mathbf{q}}_{ij}^{01} & n_i m_i^{1/2} \\ \bar{\mathbf{q}}_{ij}^{10} & \bar{\mathbf{q}}_{ij}^{11} & 0 \\ n_j & 0 & 0 \end{vmatrix} \tag{4.6}$$

electrical conductivity coefficient

$$\sigma = \frac{e^2 n}{\rho kT}\sum_{j=2}^{I}\left(n_j m_j z_j \mathbf{D}_{1j} - z_j \sum_{i=1}^{I} n_i m_i z_j \mathbf{D}_{ij}\right) \tag{4.7}$$

where $\mathbf{E}_{ij}$ are the elements of an inverse matrix made up of the elements $\mathbf{D}_{ij} \times m_j$, $|\mathbf{q}|$ is the determinant of a matrix in which the last row and last column are discarded, m_i is the particle mass, n_i is the number of particles per unit volume, ρ is the density, ν the number of particles in the mixture, e the electron charge, $z_i e$ the ion charge, ζ the number of charged particles, and q_{ij}^{mp} and $\bar{q}_{ij}^{mp}$ are matrices whose elements are expressed through the collision integral moments $\Omega_{ij}^{l,s}$ [15].

The estimate of the heat transport due to chemical reactions of dissociation and the ionization reaction is determined by the Brokaw correction [31]

$$\lambda_R = -\frac{1}{RT^2}\begin{vmatrix} 0 & \Delta H_1 \ldots \Delta H_\alpha \\ \Delta H_1 & A_{11} \ldots A_{1\alpha} \\ \vdots & \vdots \\ \Delta H_\alpha & A_{\alpha 1} \ldots A_{\alpha\alpha} \end{vmatrix} : \begin{vmatrix} A_{11} \ldots A_{1\alpha} \\ \vdots \\ A_{\alpha 1} \ldots A_{\alpha\alpha} \end{vmatrix} \tag{4.8}$$

where α is the number of simultaneously occurring reactions and ΔH_i is the heat of the reaction.

The estimate of the heat transport due to the excited degrees of freedom of the molecules at low temperatures is determined by a modified Eucken correction [32]

$$\lambda_b{}^i = \frac{\eta_i}{M_i} f \qquad \left(f = \left[\frac{6}{5} A^* (1 + c_{vr}) - \frac{2}{\pi}\left(1 + \frac{c_{vr}}{z_r}\right)\left(\frac{5}{2} - \frac{6}{5} A^*\right)^2\right]\right)$$

$$c_{vr} = \left(\frac{h\nu_i}{kT}\right)^2 \frac{\exp h\nu_i / kT}{\exp h\nu_i / (kT-1)^2} \tag{4.9}$$

$$Z_r = Z_0{}^i\left[1 + \frac{\pi^{3/2}}{2}\left(\frac{\varepsilon_0{}^i}{T}\right)^{1/2} + \left(\pi + \frac{\pi^2}{4}\right)\left(\frac{\varepsilon_0{}^i}{T}\right)\right]^{-1} \qquad \left(A^* = \frac{\Omega^{22}}{\Omega^{11}}\right) \tag{4.10}$$

c_{vr} is the heat capacity of the rotational degrees of freedom.

Since $\lambda_b{}^i$ is a correction to the thermal conductivity coefficient, in calculating λ_b for gas mixtures an approximate rule obtained in [33] is used:

$$\lambda_b = \sum_{i=1}^{\nu} \lambda_b{}^i \left[1 + \sum_{\substack{k=1 \\ k \neq i}}^{\nu} \frac{D_{ii}}{D_{ik}} \frac{x_k}{x_i}\right]^{-1} \tag{4.11}$$

5. The calculated values of the transport coefficients are presented in Table 2 for temperatures from 3000 to 25,000°K and pressures of 0.1, 1, 10, and 100 atm. A comparison of the thermal conductivity coefficient with the calculations of other authors shows good agreement in the region of dissociation of air with

TABLE 2

$P = 0.1$ atm				$P = 1$ atm			
$T \cdot 10^{-3}$, °K	λ, W/m · deg	$\eta \cdot 10^3$, g/cm · sec	σ, 1/ohm·cm	$T \cdot 10^{-3}$, °K	λ, W/m · deg	$\eta \cdot 10^3$, g/cm · sec	σ, 1/ohm·cm
3	0.7943	0.9722	—	3	0.4534	1.034	—
4	0.3425	1.304	—	4	0.5907	1.286	—
5	1.490	1.582	—	5	0.9670	1.575	—
6	4.504	1.858	1.547	6	2.401	1.852	0.8264
7	2.266	2.056	6.101	7	4.175	2.112	2.892
8	1.001	2.280	12.06	8	2.355	2.326	8.834
9	1.286	2.401	20.80	9	1.267	2.546	16.83
10	2.087	2.259	31.65	10	1.442	2.685	27.10
11	3.174	1.798	39.47	11	2.014	2.662	40.44
12	4.309	1.085	47.38	12	2.512	2.303	52.55
13	2.704	0.5952	54.24	13	3.100	1.710	63.91
14	2.716	0.3147	59.67	14	3.549	1.177	74.08
15	2.266	0.1820	65.05	15	3.616	0.8786	83.12
16	1.982	0.1261	69.92	16	3.474	0.4911	90.69
17	1.774	0.1053	74.50	17	3.280	0.3331	97.41
18	1.869	0.1003	79.14	18	3.176	0.2488	103.6
19	2.037	0.1003	84.35	19	3.184	0.2072	109.6
20	2.188	0.1005	87.84	20	3.288	0.1896	115.6
21	2.417	0.1026	90.76	21	3.461	0.1854	121.4
22	2.654	0.0999	91.62	22	3.467	0.1891	126.2
23	2.894	0.0901	91.66	23	3.783	0.1810	130.4
24	3.127	0.0763	90.39	24	4.112	0.1729	133.4
25	3.753	0.0624	89.40	25	4.453	0.1692	135.5
$P = 10$ atm				$P = 100$ atm			
3	0.2797	0.9425	—	3	2.019	0.9735	—
4	0.6671	1.245	—	4	2.118	1.219	—
5	0.5756	1.556	—	5	2.163	1.515	—
6	1.174	1.780	0.4529	6	1.540	1.801	0.2258
7	2.756	2.062	1.445	7	3.273	2.070	0.7500
8	3.865	2.358	4.131	8	5.701	2.349	1.923
9	2.845	2.600	10.97	9	3.369	2.623	4.595
10	1.718	2.836	21.06	10	3.334	2.877	10.70
11	1.368	3.048	36.09	11	2.627	3.121	22.20
12	1.834	3.185	53.71	12	2.165	3.261	43.85
13	2.456	2.844	70.06	13	2.259	3.380	63.97
14	3.063	2.492	86.24	14	2.694	3.373	86.26
15	3.659	1.997	101.1	15	3.452	3.211	109.6
16	4.201	1.559	115.6	16	4.185	2.908	132.8
17	4.578	1.168	128.2	17	5.009	2.521	155.2
18	4.785	0.8706	139.5	18	5.753	2.112	175.6
19	4.890	0.6664	149.6	19	6.599	1.760	194.6
20	4.984	0.5331	158.8	20	7.281	1.469	211.1
21	5.150	0.4502	166.1	21	7.891	1.241	226.6
22	5.347	0.4021	174.0	22	8.431	1.072	240.4
23	5.632	0.3775	181.4	23	8.926	0.9518	253.3
24	6.003	0.3677	188.6	24	9.416	0.8723	265.6
25	6.198	0.3692	194.1	25	9.858	0.8201	280.6

the work of Zdunkevich et al. [4] and of Peng and Pindroh [2]. In the region of the ionization of air the data of the present calculation lie above the curves of P. P. Kulik and N. V. Ermokhin [5] and of Yos et al. [6]. Good agreement with the experimental results of É. I. Asinovskii et al. [7] is observed in all the temperature regions. The data of the present calculation of the thermal conductivity coefficient at p = 1 atm and for comparison the data of the other works are presented in Fig. 1. The low values of the data of [5] are explained mainly by the choice of an exchange scattering cross section for atoms and ions of the same kind. In the region of total ionization of air at 1 atm and T ⩾ 20,000°K the calculated values of the thermal conductivity coefficient coincide with the results of Spitzer's theory (these points are marked by crosses in Fig. 1).

A comparison of the calculated values of the electrical conductivity coefficient with the data of the experimental works of É. I. Asinovskii [7] and of Lamb and Lin [8] shows good agreement within the limits of the experimental accuracy. In the region of total ionization of air the data of the present calculation coincide with the values calculated from Spitzer's theory.

A comparison of the coefficient of viscosity with experiment is difficult. Of the well-known experimental work on viscosity, the experiment for air in the region of high temperatures was conducted in a carbon arc [9], where carbon composed up to 30% of the air. The agreement of the calculated values of the coefficient of viscosity in the present article with the data of [5] and [6] is good.

All the numerical calculations were conducted with an accuracy of ~ 1%.

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