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Thermal conductivity of polyatomic gaseous mixtures at elevated temperatures

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Abstract. A recent expression of Saksena and Sharma for the thermal conductivity of polyatomic gas mixtures has been presented in a well known form after Wassiljewa. The utility of the modified form has been tested by calculating the thermal conductivity of dry air, considered as a binary mixture, and comparing the values with experimental results.

Although based on a rigorous theory, the recent expression of Saksena and Sharma (1969) for the thermal conductivity of polyatomic gaseous mixtures has the disadvantage of involving very cumbersome computations. However, following Saksena and Saxena (1967), it is amenable to transformation into a well known form after Wassiljewa (1904) which, while maintaining its mathematical rigour, reduces the amount of computation involved. This can be done by rearranging the expression so that it appears in a form involving certain correction terms in the equation due to Mason and Saxena (1958). The different terms are then reduced to a common denominator. This ultimately leads to an equation analogous to the one given by Wilke (1950) for the viscosity of the mixture. Thus, in the notations of Saksena and Sharma (1969), the final expression may be written as

$$\lambda_{\mathrm{mix}} = \sum_{i=1} \frac{(\lambda_{\mathrm{eff}})_i}{1+\sum\limits_{j\neq i} \phi_{ij}(x_j/x_i)} \tag{1}$$

where

$$(\lambda_{\mathrm{eff}})_i = \left\{\lambda_i + \left(\frac{5n}{3}D_{ii} - \frac{\lambda_i^0}{C_{\mathrm{vtr}}}\right)\sum_{k=1} x_k C_{\mathrm{rot}k}\frac{\mathrm{d}T_{\mathrm{rot}k}}{\mathrm{d}T} - nD_{ii}C_{\mathrm{rot}i}\frac{\mathrm{d}T_{\mathrm{rot}i}}{\mathrm{d}T}\right\}. \tag{2}$$

Here ϕ_{ij} is seen to have the same expression for the two transport properties.

Table 1. Thermal conductivity of air ($\lambda \times 10^5$ cal cm^{-1} s^{-1} K^{-1})

Temperature (K)	Experiment[1]	Calculated according to Authors' expression		Lindsay-Bromley's equation[2]		Empirical formula[3]	
		Calc.	% deviation	Calc.	% deviation	Calc.	% deviation
600	10·74	10·59	−1·40	10·77	0·29	10·73	−0·93
800	13·51	13·68	1·26	13·65	1·04	13·74	1·70
1000	16·01	16·23	1·37	15·99	−1·28	16·17	1·00
1300	18·38	18·01	−2·01	18·35	−0·16	18·61	1·25

[1] Bromley (1952).
[2] Lindsay and Bromley (1950).
[3] Hirschfelder *et al.* (1954).

The theoretical values of the thermal conductivity of air, treated as a binary mixture of oxygen and nitrogen—the major constituents—were calculated with the help of equation (1) at different temperatures. On comparison (table 1) with the results of other theoretical and experimental studies, these values are found to be in good agreement in the temperature range 600–1300 K. However, the general usefulness of equation (1) can be determined only when reliable experimental data on some more mixtures and their components are available.

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