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# Note on the Calculation of Transport Properties of Gas Mixtures*

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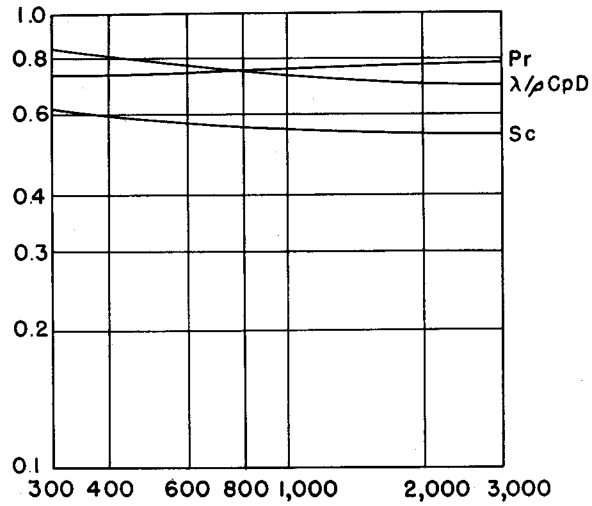
As a result of recent theoretical studies on transport properties of gases by Hirschfelder, et al.,[1] and others,[2] the dynamic viscosity ($\mu$), the thermal conductivity ($\lambda$), and the mechanical diffusivity ($D$), as well as the dimensionless ratios Prandtl Number ($Pr = C_p \mu/\lambda$, where $C_p$ = specific heat at constant pressure), Schmidt Number ($Sc = \mu/\rho D$, where $\rho$ = density), and $\lambda/\rho C_p D$† may now be calculated rapidly and with a reasonable degree of accuracy both for pure gases and for mixtures of gases, provided that the temperature of the gases is not too low. This happy state of affairs does not seem to be realized by aeronautical engineers, and it is the purpose of the present note to call attention to it.

The greatest error in these calculations arises in the determination of $\lambda$, where the Eucken approximation is used. This approximation involves the assumption that thermal equilibrium is established between the translational and internal degrees of freedom of colliding molecules, an assumption that describes physical facts most closely at elevated temperatures. However, even at moderate temperatures, the calculated values of $\lambda$ are not in error, in most cases, by more than 2 per cent according to reference 1.

As an illustration, calculations have been made for $Pr$ of dry air (80 per cent nitrogen and 20 per cent oxygen) and for $Sc$ and $\lambda/\rho C_p D$ for water diffusing into air, assuming that $C_p$ (see reference 4), $\mu$, $\rho$, and $\lambda$ are those of dry air and that no diffusion by temperature gradient occurs. The results of these calculations are presented in Fig. 1. It is expected that the methods of calculation to which attention has been called in this communication will be of value, for example, to engineers interested in boundary-layer calculations or the determination of transport coefficients in combustion chambers.



Pr, Sc, & $\lambda/\rho C_p D$ VS. TEMP. FOR WATER DIFFUSING INTO AIR

FIG 1.

* The calculations required for Fig. 1 were made with the assistance of E. Zukoski, G. McLeod, F. Hartwig, and J. Schroeder.

† Although a Klinkenberg and H. H. Mooy have given the name "Lewis Number" to $\lambda/\rho C_p D$ in reference 3, this nomenclature is not generally used in the present literature.

## REFERENCES

[1] Hirschfelder, J. O., Bird, R. B., and Spotz, Ellen L., *Viscosity and Other Physical Properties of Gases and Gas Mixtures*, Trans. A.S.M.E., November, 1949.

[2] Bromley, L. A., and Wilke, C. R., *Viscosity Behavior of Gases*, Ind. & Eng. Chem., July, 1951.

[3] Klinkenberg, A., and Mooy, H. H., *Dimensionless Groups in Fluid Friction, Heat, and Material Transfer*, Chemical Engineering Progress, January, 1948.

[4] For values of $C_p$, see, for example, National Bureau of Standards, "Tables of Selected Values of Chemical Thermodynamic Properties," Series III, Vol. I, March 31, 1947, to June 30, 1949.