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# PROPERTIES OF HYDROGEN : NITROGEN AND HYDROGEN : CARBON-DIOXIDE MIXTURES

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## NOMENCLATURE

$C_p$, specific heat at constant pressure [cal/g °K];
$D_{12}$, diffusion coefficient [cm²/s];
$k$, thermal conductivity [cal/cm s °K];
$K$, Boltzmann constant;
$M$, molecular weight;
$P$, pressure, 1 atm;
$R$, gas constant;
$T$, absolute temperature [°K];
$W$, mass fraction of injected gas;
$\epsilon$, potential function parameter, [$\epsilon/K$ in °K];
$\mu$, coefficient of dynamic viscosity [g/cm s];
$\rho$, density [g/cm³];
$\sigma$, collision diameter [Å];
$\Omega$, parameter defined in reference [2].

Subscripts

1, injected gas;
2, main stream gas.

## INTRODUCTION

As PART OF a program investigating transpiration cooling in atmospheres other than air, the transport properties of the gas mixtures $H_2:N_2$ and $H_2:CO_2$ have been calculated.

It is the purpose of this note to indicate the methods used and the availability of the results at the American Documentation Institute in Washington. Selected results are depicted in graphical form (Figs. 1 and 2).

## RANGE OF PARAMETERS

All properties are calculated for a pressure of one atmosphere and for the temperature range 100°K to 5000°K in steps of 50°K. The mass fraction of hydrogen varies from 0·0 to 0·1 in steps of 0·01 and from 0·1 to 1·0 in steps of 0·1.

## ANALYSIS

The following assumptions are made:

(a) Perfect gas behavior.
(b) No dissociation or ionization.

The density and specific heat of a gas mixture are obtained from the perfect gas relationships,

$$\rho = \frac{M_2 P}{\{1 + [(M_2/M_1) - 1]\, W\}\, RT}$$

and $C_p = WC_{p_1} + (1 - W)C_{p_2}$

The specific heats of the pure components are taken from reference [1].

The viscosity of the pure gas is determined from reference [2] using

$$\mu \times 10^7 = 266{\cdot}93 \frac{\sqrt{(MT)}}{\sigma^2 \Omega^{(2,\,2)}}$$

The thermal conductivity is determined from reference [3] including the improved Eucken correction to allow for the additional degrees of freedom in the polyatomic molecule.

$$k \times 10^7 = \frac{1989{\cdot}1 \sqrt{(T/M)}}{\sigma^2 \Omega^{(2,\,2)}} \left[0{\cdot}354 \frac{C_p}{R} + 0{\cdot}115\right]$$

The coefficient of ordinary diffusion is calculated from reference [2] using

$$D_{12} = 0{\cdot}002628 \frac{\sqrt{[T^3(M_1 + M_2)/2M_1M_2]}}{\sigma_{12}{}^2 \Omega_{12}{}^{(2,\,2)}}$$

Other mixture properties are calculated using the empirical mixture rules of reference [2].

Values of the force constants required in these expressions are taken from reference [4], and are tabulated below.

| | $\mu$ and $D_{12}$ | | $k$ | |
|---|---|---|---|---|
| | $\sigma$ | $\epsilon/K$ | $\sigma$ | $\epsilon/K$ |
| $H_2$ | 2·968 | 33·3 | 2·605 | 123 |
| $N_2$ | 3·749 | 79·8 | 3·767 | 93 |
| $CO_2$ | 3·897 | 213 | 3·721 | 309 |

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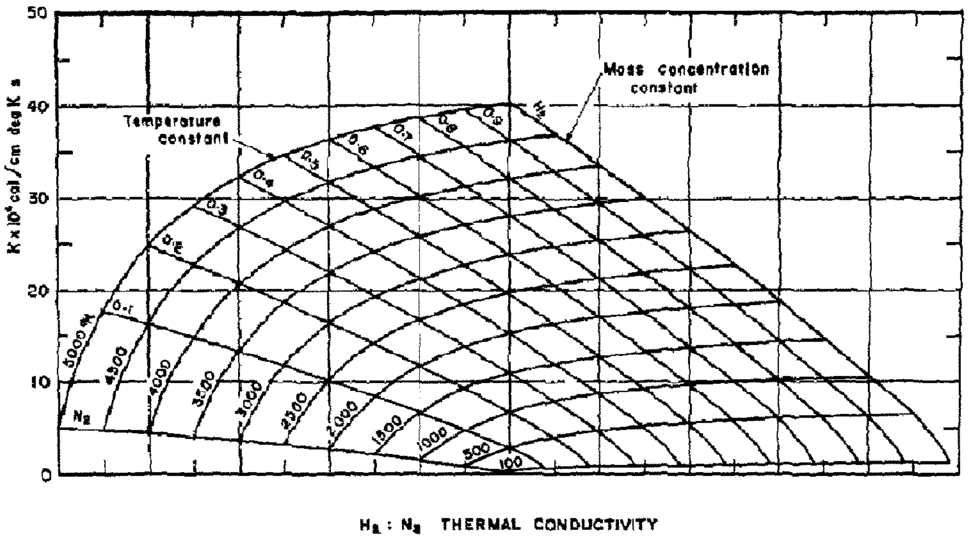
K x 10⁴ cal/cm deg K s
Mass concentration constant
Temperature constant
H₂ : N₂ THERMAL CONDUCTIVITY

FIG. 1.

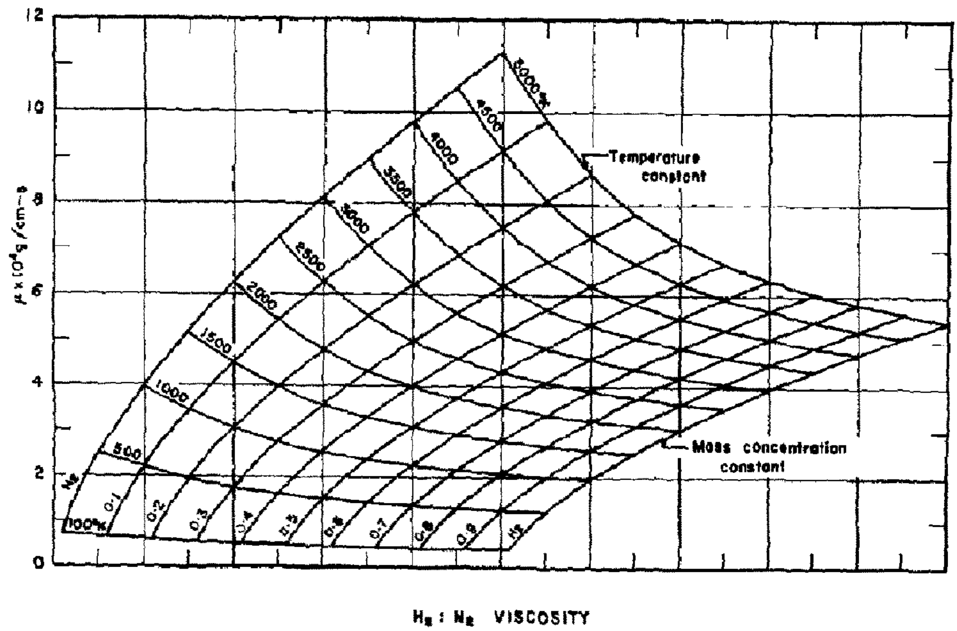
Temperature constant
Mass concentration constant
H₂ : N₂ VISCOSITY

FIG. 2.

of Delaware for their cooperation in carrying out the numerical calculations.

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