CORRELATION AND PREDICTION OF DIFFUSION COEFFICIENTS IN BINARY GAS SYSTEMS

BY

RAYMOND GERALD BAILEY

For Dr. Chen
Ch.E.

A THESIS
PRESENTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE
OF
MASTER OF SCIENCE IN CHEMICAL ENGINEERING
AT
NEWARK COLLEGE OF ENGINEERING

Newark, New Jersey
1970

ABSTRACT

A correlation was developed for estimating binary gas diffusion coefficients by the reference substance method, in this case using the viscosity of air and subsequently its corresponding temperature. The derivation was made by the linear least square analysis of 65 different binary systems comprising 161 separate data points at temperatures ranging from 193°K. to 1200°K. At any given temperature only the critical molal volume and the molecular weights of the two gases of interest are required to calculate the diffusion coefficient. The correlation based on the viscosity of air had an average error of 7.67%. The correlation using temperature had an average error of 6.89%. Also developed were equations to predict the diffusion coefficient at any temperature when the coefficient is known at 298°K., and to predict the coefficient of any system when the coefficient is known for any other system containing one component of the desired pair.

APPROVAL OF THESIS

CORRELATION AND PREDICTION OF DIFFUSION COEFFICIENTS IN BINARY GAS SYSTEMS

BY

RAYMOND GERALD BAILEY

FOR

DEPARTMENT OF CHEMICAL ENGINEERING

NEWARK COLLEGE OF ENGINEERING

BY

FACULTY COMMITTEE

APPROVED: ______________________

____

____

NEWARK, NEW JERSEY

JUNE, 1970

PREFACE

The work reported in this thesis is concerned with the development of a mathematical correlation for estimating binary gas phase diffusion coefficients as a function of temperature, molecular weight, and critical volume.

ACKNOWLEDGMENTS

The writer extends special thanks to Dr. H.T. Chen for his assistance and guidance without which this work would not have been possible.

Thanks are due also to my wife Sue Bailey for her assistance with the manuscript.

TABLE OF CONTENTS

	Page
I. Introduction	1
A. Object	1
B. Scope	1
II. Theory	2
A. Fick's Laws of Diffusion	2
B. Kinetic Theory of Diffusion	3
C. Pressure-Temperature Effects	5
D. Existing Correlations	5
1. Arnold	5
2. Gilliland	7
3. Chen and Othmer	9
4. Othmer and Chen	11
5. Fuller, Schettler, and Giddings	14
III. Investigational Procedure	17
A. Selection of Experimental Diffusion Data	17
B. Method of Calculation	18
C. Determination of Temperature Dependence	18
1. Diffusion Coefficients as a Function of Temperature	18
2. Diffusion Coefficients as Correlated with the Viscosity of Air	19
D. Analysis of Othmer and Chen Correlation	25

TABLE OF CONTENTS (CONT'D)

Page

1. Varying Exponents of Inverse of Molecular Weight Term 25
2. Varying Exponent of Critical Volume Term 26
3. Final Correlation Selection 29

IV. Derivation of Formal Diffusion Coefficient Equation 31

A. Mathematical Derivation of Equation Based on Viscosity of Air 31
B. Comparision of Derived Viscosity-Type Equation with Theoretical Developement 32
C. Development of Reference Plot for Diffusion-Temperature Relation 35
D. Derivation of Final Equation Based on Temperature Relation 36
E. Multicomponent Relationship 39

V. Results 42

VI. Comparison of Resulting Correlation with Experimental Data and Other Correlations 44

VII. Conclusions 47

VIII. Recommendations 49

TABLE OF CONTENTS (CONT'D)

Page

IX. Appendix 50

A. Index to Appendix 51

B. List of Tables 52

X. References 157

XI. Vita 160

LIST OF TABLES

Page

I. Diffusion Coefficients as a Function of Temperature 21

II. Diffusion Coefficients as Correlated with the Viscosity of Air 23

III. Othmer-Chen Correlation: Effect of Various Exponents for Molecular Weight Term 27

IV. Comparison of Diffusion Coefficients by this Work; Fuller, Schettler, and Giddings; and Othmer-Chen 46

LIST OF FIGURES

Page

I. DP vs. T for CO_2-N_2 System 20

II. DP vs. μ air for CO_2-N_2 System 24

III. Diffusion Coefficients - Temperature Relation:
DP/DP_{298} vs. T/T_{298} 37

IV. Multicomponent Relationship:
DP_{AB}/DP_{AC} vs. $\alpha_{AB}^{1.096}/\alpha_{AC}^{1.096}$
(where α is MW, V_c function) 40

I. INTRODUCTION

A. Object

The object of this thesis was to develop a correlation for the estimation of gas phase diffusion coefficients. A number of correlations have been derived by other workers with various arrangements of physical parameters such as molecular weight, temperature, critical volume, and potential energy. For this work the correlation of D.F. Othmer and H.T. Chen was chosen as the basic equation from which further modifications could be developed.

B. Scope

Available diffusion data from the literature was used to analyze the basic equation and to examine the effect of variable temperature. An equation of improved reliability was sought. The work reported herein was conducted over the period from September, 1968 to April, 1970.

II. THEORY

A. Fick's Laws of Diffusion

Diffusion in a gas is the transport of mass across a concentration gradient. The diffusion coefficient D is the number of molecules per second crossing unit area under unit concentration gradient.

The principles of diffusion are expressed most generally and ideally by equations known as Fick's first and second laws. The first law, when applied to a binary system at steady state, states that the diffusive fluxes of the two components of the mixture are equal and opposite and that these fluxes are directly proportional to the concentration gradients in the direction of diffusion. Simply, that is the diffusion of component A in a binary system composed of A and B takes place because of a concentration gradient of A. The first law expression is written below:

$$J_A = -J_B = -cD_{AB} \frac{dx_A}{dr} \qquad (1)$$

where J_A and J_B are the molar fluxes of components A and B in moles per unit area per unit time, c is the molar density of the system in moles per unit volume, D_{AB} is the binary diffusion coefficient in area per unit time, and dx_A/dr expresses the change in mole fraction of A along a differential distance perpendicular to the plane of diffusion.

The basic expression used to formulate more general diffusion equations is

$$J_A = -cD_{AB} \nabla x_A \tag{2}$$

and

$$\frac{\partial x_A}{\partial t} = D_{AB} \nabla^2 x_A \tag{3}$$

For an one dimensional diffusion, Equation (3) may be reduced to

$$\frac{\partial x_A}{\partial t} = D_{AB} \frac{\partial^2 x_A}{\partial r^2} \tag{4}$$

This is the so-called Fick's second law.

B. Kinetic Theory of Diffusion

The kinetic theory developments for a pure gas (molecules of the same size, shape, and mass) of the rigid sphere model at low density, with negligible effects of temperature, pressure and velocity, have been expressed as

$$\text{mean molecular speed} = \bar{u} = \sqrt{\frac{8kT}{\pi m}} \tag{5}$$

wall collision frequency $= Z = \frac{1}{4} n\bar{u}$ (6)

mean free path $= \frac{1}{\sqrt{2}\, \pi d^2 n}$ (7)

where k is the Boltzmann constant, m is mass, n is molecules per unit volume, and d is molecular diameter. On the average the molecules reaching a plane had their last collision at a distance a from the plane so that

$$a = 2/3\,\lambda \tag{8}$$

From these relations one may consider the molar flux N_{Ay} of species A across any plane of constant y in both positive and negative directions under a concentration gradient dx_A/dy. This leads to an expression, for species A and A*, of:

$$N_{Ay} = x_A(N_{Ay} + N_{A^*y}) - \frac{1}{3} c\, \bar{u}\, \lambda \, \frac{dx_A}{dy} \tag{9}$$

Reference is made to Bird, Stewart, and Lightfoot (2), pages 509-510, for the detailed procedure for arriving at Equation (9). Of interest here is that the above equation can be reduced to a form of Fick's law for the y-component if for D_{AB} we use:

$$D_{AB} = \frac{1}{3} \bar{u}\, \lambda \tag{10}$$

Bird, Stewart, and Lightfoot go further and use the ideal gas law to represent the diffusion coefficient as follows:

$$D_{AA*} = \frac{2}{3}\left(\frac{k^3}{\pi^3 m_A}\right)^{\frac{1}{2}} \frac{T^{3/2}}{p d_A^{\,2}} \qquad (11)$$

In the following sections of this discussion of theory it will be noted how Equation (11) was variously expressed by the workers in this field in developing the basic correlations for estimating diffusion coefficients.

C. Pressure - Temperature Effects

Diffusion coefficients of gases at low pressure increase with temperature (approximately as $T^{1.8}$ as will be shown in this work), vary inversely with pressure, and there is little effect from composition. In the discussions that follow on other correlations the temperature factor will appear as a definite point for some difference in results, whereas most work has been conducted at atmospheric pressure when obtaining experimental values. However, the correlations developed are generally expressed as a function of DP where P is pressure in atmospheres so as to obtain results at various pressure levels.

D. Existing Correlations

1. Arnold (1). The Arnold correlation for the calculation of diffusion constants in gaseous systems at any temperature is based on the theoretical investigations made

by Stefan (22), Maxwell (15), and Sutherland (23). Arnold accepted the general form of the equation developed by these workers and studied that equation with available experimental diffusion data to arrive at a reliable set of particular constants for evaluating the equation.

The Arnold equation utilizes the molecular weights, the molecular volumes V at the boiling point, the temperature and the Sutherland constant to calculate the diffusion coefficient (cm.^{2}/sec.) as follows:

$$D = \frac{0.00837 \sqrt{\frac{1}{M_1} + \frac{1}{M_2}}}{\left(V_1^{1/3} + V_2^{1/3}\right)^2} \left(\frac{T^{5/2}}{T + C}\right) \qquad (12)$$

where V = cc./g.mole at boiling point
T = diffusing temperature, °K.
C = Sutherland constant

To apply the above equation Arnold uses calculated values of C from the expression

$$C = 1.47 \quad F \sqrt{T_{B_1} \; T_{B_2}} \qquad (13)$$

where T_B is the absolute boiling temperature and F is given as a function of the molal volumes at the boiling point. Note thère are these exceptions: experimental values are used for hydrogen (72) and helium (78).

As discussed above, Arnold worked from the general equation

$$D = \frac{B \sqrt{\frac{1}{M_1} + \frac{1}{M_2}}}{S^2} \quad \frac{T^{5/2}}{T + C} \qquad (14)$$

The calculation of C was fixed, and M and T values had only to be substituted. A value for the constant B had to be developed, as well as for the S^2 term which is the molecular volume parameter.

The expression for S was

$$S = V_1^{1/3} + V_2^{1/3} \qquad (15)$$

which had V related to Kopp's law (molal volume is an additive function of the atomic volumes of the constituents of a molecule) and V can be found by the values developed for atomic volumes by LeBas (14). For reference it is noted that these values are given in Perry's Handbook (19), page 538.

To evaluate the constant B, Arnold investigated the diffusion relationships of Chapman (4) and Jeans (11). The value of 0.00837 was from Jeans and was finally chosen as it gave the better agreement between observed D and calculated D by Arnold's equation.

<u>2. Gilliland (8).</u> Gilliland recognized the fundamental equations of Maxwell (15) and Stefan (22) just as Arnold did. However, Arnold refined the earlier representations by the use of Sutherland's constant, but Gilliland concluded in his work that this Sutherland modification was not necessary. These findings were based on the evaluation of considerable experimental data accumulated by Gilliland

versus calculated results.

To be consistent in presenting the equations by various workers as originally published, it is appropriate to show Maxwell's equation below in the form from which Gilliland worked:

$$D = \frac{AT^{3/2}\sqrt{\frac{1}{M_A} + \frac{1}{M_B}}}{S^2P} \qquad (16)$$

where M_A, M_B = molecular weights

P = total pressure
S = distance between the centers of the two unlike molecules at collision
D = diffusion coefficient
T = absolute temperature
A = a constant

Equation (16) can be compared to Equation (14) discussed previously. The difference being in Arnold's incorporation of the Sutherland constant term.

Furthermore, Gilliland continued to follow Arnold's development by using the relationship that molal volume of a liquid at its normal boiling point is proportional to the cube of the radius of the molecule, and thus Gilliland wrote:

$$D = \frac{BT^{3/2}\sqrt{\frac{1}{M_A} + \frac{1}{M_B}}}{P\left(V_A^{1/3} + V_B^{1/3}\right)^2} \qquad (17)$$

with a constant B to be evaluated. Diffusion data from the literature (apparently over five hundred system points) were plotted on log-log coordinates as ordinates versus the right hand member of Equation (17) (without B of course) as abscissas. Also plotted for comparison was the Arnold-type Equation (12) having the added $\frac{T}{T+C}$ term.

It was found that the plot with Equation (17) gave the better correlation. The empirical constant B was determined to be 0.0043. Gilliland's equation is:

$$D = \frac{0.0043\, T^{3/2} \sqrt{\frac{1}{M_A} + \frac{1}{M_B}}}{\left(V_A^{1/3} + V_B^{1/3}\right)^2 P} \qquad (18)$$

3. Chen and Othmer (6). The work of Chen and Othmer followed the pattern of Hirschfelder, Bird, and Spots (9), which had itself been an investigation of Chapman and Cowling (4). The approach there differs somewhat from Arnold and Gilliland in the use of the collision integral Ω_D for the potential energy of attraction between gases. The collision integral was calculated by Hirschfelder, Bird and Spots as a function of kT/ε (k = Boltzmann's constant; T = °K; ε = Lennard-Jones force constant) and values were shown in a table. They also developed the relation between collision diameter σ and molal volume at the critical point V_c as

$$\sigma = 0.5894\, V_c^{0.4006} \qquad (19)$$

Also developed,

$$\varepsilon / k = 1.276\, T_c^{0.9061} \qquad (20)$$

The diffusion coefficient equation of Hirschfelder, Bird, and Spotz is as follows:

$$D_{12}P = \frac{0.001858\, T^{3/2} \left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{\frac{1}{2}}}{\sigma_{12}^{\,2}\ \Omega_D} \qquad (21)$$

Chen and Othmer's investigation was directed toward simplifying Equation (21) by eliminating the use of the collision integral table. Chen (5) reduced the table to an equation where

$$\Omega = \frac{1.075}{\left(\frac{kT}{\varepsilon}\right)_{12}^{0.1615}} + \frac{2}{\left(10\,\frac{kT}{\varepsilon}\right)_{12}^{0.74 \log \left(10\frac{kT}{\varepsilon}\right)_{12}}} \qquad (22)$$

Chen and Othmer further simplified Equation (22) by using Equation (20) to derive

$$\Omega = f\left[\frac{T}{\left(T_{c_1}\, T_{c_2}\right)^{0.453}}\right] \qquad (23)$$

and subsequent manipulations with Equation (21) led to

$$D_{12} = \frac{0.001858\, T^{3/2} \left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{\frac{1}{2}}}{P\ (0.2947)\left[\left(V_{c_1}^{\,0.4} + V_{c_2}^{\,0.4}\right)\right]^2 A \left[\frac{T}{\left(T_{c_1}\, T_{c_2}\right)^{0.453}}\right]^B} \qquad (24)$$

where A and B were to be determined.

Analysis of experimental data on log-log coordinates resulted in a final correlation as follows:

$$D_{12} = \frac{0.43\left(\frac{T}{100}\right)^{1.81}\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^{0.5}}{P\left(\frac{T_{c_1}\,T_{c_2}}{10,000}\right)^{0.1405}\left[\left(\frac{V_{c_1}}{100}\right)^{0.4}+\left(\frac{V_{c_2}}{100}\right)^{0.4}\right]^{2}} \qquad (25)$$

Using Equation (25), Chen and Othmer calculated $D_{12}P$ for 66 binary systems with an average absolute deviation (AAD) of 5.64%. By comparison, for the same 66 systems the AAD was 16.01% by the Arnold method, 16.80% by the Gilliland method, and 6.12% by the Hirschfelder, Bird, and Spots method using force constants from viscosity data.

4. Othmer and Chen (17). The Othmer and Chen correlation is based on the physical relationship of diffusion coefficients and viscosities of gases. This relationship and the use of the Othmer (16) reference substance plot was used to correlate diffusion coefficients in binary gas systems with viscosities, with air being the reference substance. This method has the desirable quality of using a parameter, the viscosity of air, which has been determined reliably over a wide temperature range, as one of the principle terms.

In addition to requiring the viscosity of air (μ, cp.)

at a given diffusing temperature, this correlation also requires data on the critical molal volumes (V_c, cc./g.-mole) and the molecular weights (M) of the two gases whose diffusion coefficient is to be calculated. The Othmer-Chen correlation follows:

$$D_{12}P = (2.52 \times 10^7)\mu^{2.74} \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{0.4} + V_{c_2}^{0.4}\right)^2} \right]^{1.23} \qquad (26)$$

where D_{12} = diffusion coefficient, component 1 through component 2, cm.^{2}/sec.

and P = pressure, atm.

As stated in the Introduction of this thesis, the object of this work was to develop a new correlation based on the fundamental structure, and corresponding derivation of the Othmer-Chen equation. For this reason, it is necessary to examine in detail the precise manner in which the subject equation was developed.

The initial relationship used showed that the logarithmic plot of $D_{12}P$ of any system versus the viscosity of a gas is linear, as follows:

$$\log D_{12}P = C_1 \log \mu + C_2 \text{ (C=const.)} \qquad (27)$$

The above statement was predicated on the ideal gas variation of the diffusion coefficient with temperature and pressure (6).

$$D_{12}P = aT^b \qquad (28)$$

and the variation of viscosity of gases with temperature (16),

$$\mu = cT^d \qquad (29)$$

Othmer and Chen plotted (logarithms) the diffusion coefficients of various systems versus a temperature scale derived from the viscosity of air and obtained a constant slope of 2.74 for Equation (27) such that

$$\log D_{12}P = 2.74 \log \mu + C \qquad (30)$$

To evaluate C in Equation (30) the Maxwell Equation (16) was rewritten as

$$D_{12}P = f\left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{d^2}\right] \qquad (31)$$

where d equals the distance between centers of unlike molecules on impact. Expressing the Lennard-Jones force constant as

$$\sigma = 0.5894\, V_c^{\,0.4} \qquad (32)$$

subsequently d is represented as

$$d = \sigma_{12} = \frac{\sigma_1 + \sigma_2}{2} = 0.2947\left(V_{c_1}^{\,0.4} + V_{c_2}^{\,0.4}\right) \qquad (33)$$

hence

$$D_{12}P = f\left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{\,0.4} + V_{c_2}^{\,0.4}\right)^2}\right] \qquad (34)$$

Equation (33) was plotted as $D_{12}P$ versus function M, V_c at constant temperature of 298°K. and for a linear representation the following equation was derived:

$$\log (D_{12}P)_{298^\circ K} = 1.23 \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}{}^{0.4} + V_{c_2}{}^{0.4}\right)^2} \right] + 2.64 \qquad (35)$$

A value of 0.0182 cp. was used for the viscosity of air in Equation (30) and the resulting equation was combined with Equation (35) to yield:

$$C = 1.23 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}{}^{0.4} + V_{c2}{}^{0.4}\right)^2} \right] + 7.4 \qquad (36)$$

Combining Equations (30) and (36) Othmer and Chen arrived at their final form of the correlation which was presented above as Equation (36). (They indicated that results from Equation (26) for helium systems should be multiplied by 1.39 to correct inherent deviations).

5. Fuller, Schettler, and Giddings (7). Fuller, Schettler, and Giddings (FSG) began their correlation development with the Stefan-Maxwell hard sphere model and the principle of additive atomic volumes first used by Arnold and Gilliland. Using the Chapman-Enskog (4) form

$$D_{AB} = \frac{3}{32n\,\sigma_{AB}{}^2} \left[\frac{8kT}{\pi} \left(1/M_A + 1/M_B\right) \right]^{\frac{1}{2}} \qquad (37)$$

D_{AB} = binary diffusion coefficient, cm.^{2}/sec.
n = total concentration of both species, molecules/cc.
T = temperature, $^\circ$K.
k = the Boltzmann constant, ergs/$^\circ$K.
M_A, M_B = molecular mass, grams
$\sigma_{AB} = 1/2\ (\sigma_A + \sigma_B)$, collision diameter, cm.

FSG claimed that the above Equation (37) was limited by (1) the 3/2 power temperature dependence since observed values are usually 1.6 to 1.8, and by (2) lack of available data on the values of σ. FSG commented on the use of the 0.4 power of the critical volume by Chen and Othmer saying it was also a limited approach in that experimental data were not widely available for critical volumes.

The following generalised function was fitted to the data by FSG:

$$D_{AB} = \frac{CT^{b}\ (1/M_A + 1/M_B)^{\frac{1}{2}}}{P\left[\left(\Sigma_A v_i\right)^{a_1} + \left(\Sigma_B v_i\right)^{a_2}\right]^{a_3}} \qquad (38)$$

C = an arbitrary constant
P = pressure, atm.
M_A, M_B = mol. wt., gram/mole

A least square analysis was used to optimise:

b = temperature power dependence
v = diffusion parameters to be summed over atoms, groups, and structural features of the diffusing species
a = arbitrary exponent

Analysis of 153 different binary systems (340 data points) resulted in the following equation

$$D_{AB} = \frac{1.00 \times 10^{-3} \; T^{1.75} \left(1/M_A + 1/M_B\right)^{\frac{1}{2}}}{P\left[\left(\Sigma_A v_i\right)^{1/3} + \left(\Sigma_B v_i\right)^{1/3}\right]^2} \qquad (39)$$

Values for the diffusion volumes were developed and are some 10 to 15% smaller than the LeBas volumes. A comparison was made of the above Equation (39) with results on the same 340 data points by other correlations. FSG reported an average per cent error of 4.3% and other calculated errors were 16.6% for Hirschfelder-Bird-Spotz; 10.7% for Othmer-Chen; 6.4% for Chen-Othmer; 6.8% for Gilliland; and 8.9% for Arnold. It was in the interest of establishing further reliability to the Othmer-Chen equation than the above 10.7% error indicates that this thesis investigation was undertaken.

III. INVESTIGATIONAL PROCEDURE

A. Selection of Experimental Diffusion Data

In order to analyze the Othmer-Chen correlation, it was necessary to first obtain a set of experimental data with which to compare the calculated results. A literature search revealed that Fuller, Schettler, and Giddings (FSG) (7) compiled quite an extensive and adequate listing of diffusion coefficients for 340 reference points. This compilation was selected as the one from which to choose sufficient points for study. It is particularly noteworthy that FSG calculated the percentage error resulting from the use of various equations, including Othmer-Chen, for the total data presented.

FSG developed their correlation from a nonlinear least squares analysis of 153 different binary systems comprising the 340 data points. However, their approach was with intent to directly include a temperature dependence term and, therefore, the chosen analysis used reference points over a temperature range from 90°K. to 1200°K. The work conducted herein was first directed toward a constant temperature relation, with later modification for temperature effects. For this reason, a total of 65 data points were selected from those presented by FSG, each representing a different binary system, at approximately 298°K. Actually the temperature range was from 288°K. to 311°K.

Additional data were required to fully investigate the relationship between diffusion coefficient and (1) temperature and (2) viscosity of air. These studies will be discussed in detail in a later section. In this case, data were needed on the same system over a range of temperatures. Of the systems considered, all but one were taken from the system groups available in FSC. The exception, which was found to be most reliable, was CO_2-N_2 data from Pakurar and Ferron (18).

B. Method of Calculation

All calculations were done by hand using five-place logarithms, with the assistance of a desk calculator.

Linear Least square analysis of the resulting expressions was accomplished by computer.

C. Determination of Temperature Dependence

1. Diffusion coefficients as a function of temperature.

Since the Othmer-Chen correlation takes as its principle relationship that there is a distinct connection between diffusion coefficient and viscosity, it was appropriate that initial investigation be on the mode of development of this relation. As discussed previously, Othmer and Chen used the reference substance technique to express the effect of temperature basis a corresponding viscosity of air at a given temperature.

Fuller, Schettler, and Giddings (7) derived a temperature power dependence of 1.75. In other words, a plot of diffusion coefficient (y) versus absolute temperature (x) on a logarithmic graph has a certain linear slope. Chen and Othmer (6) found this slope to be 1.81. The variation of diffusion coefficient with temperature was shown as Equation (28), repeated below:

$$D_{12}P = aT^b \qquad (28)$$

To check this power dependence, six different systems were chosen on the basis of sufficient available points to make a valid representation of the slope. These systems and the $D_{12}P$ (cm.^{2} atm./sec.) and T(°K.) data are presented in Table V of the Appendix, pages 54-63 . Least square analysis of all six systems (log DP vs. log T) indicated quite readily that too few data points were used in the analysis of all but two systems. Table V also presents results. Table V.A. , page 54, showing CO_2-N_2 was felt to be most representative of the DP-T effect. A slope of 1.79 was calculated and is plotted in Figure I , page 20 . Table I , page 21 , summarizes all results.

<u>2. Diffusion coefficients as correlated with the viscosity of air.</u> The next step was to observe these same data similarly in terms of the viscosity of air. Values for the viscosity of air were obtained from the International Critical Tables (10) for the range 273°K. - 773°K. Values

FIGURE I

DP vs. T FOR CO_2-N_2 SYSTEM

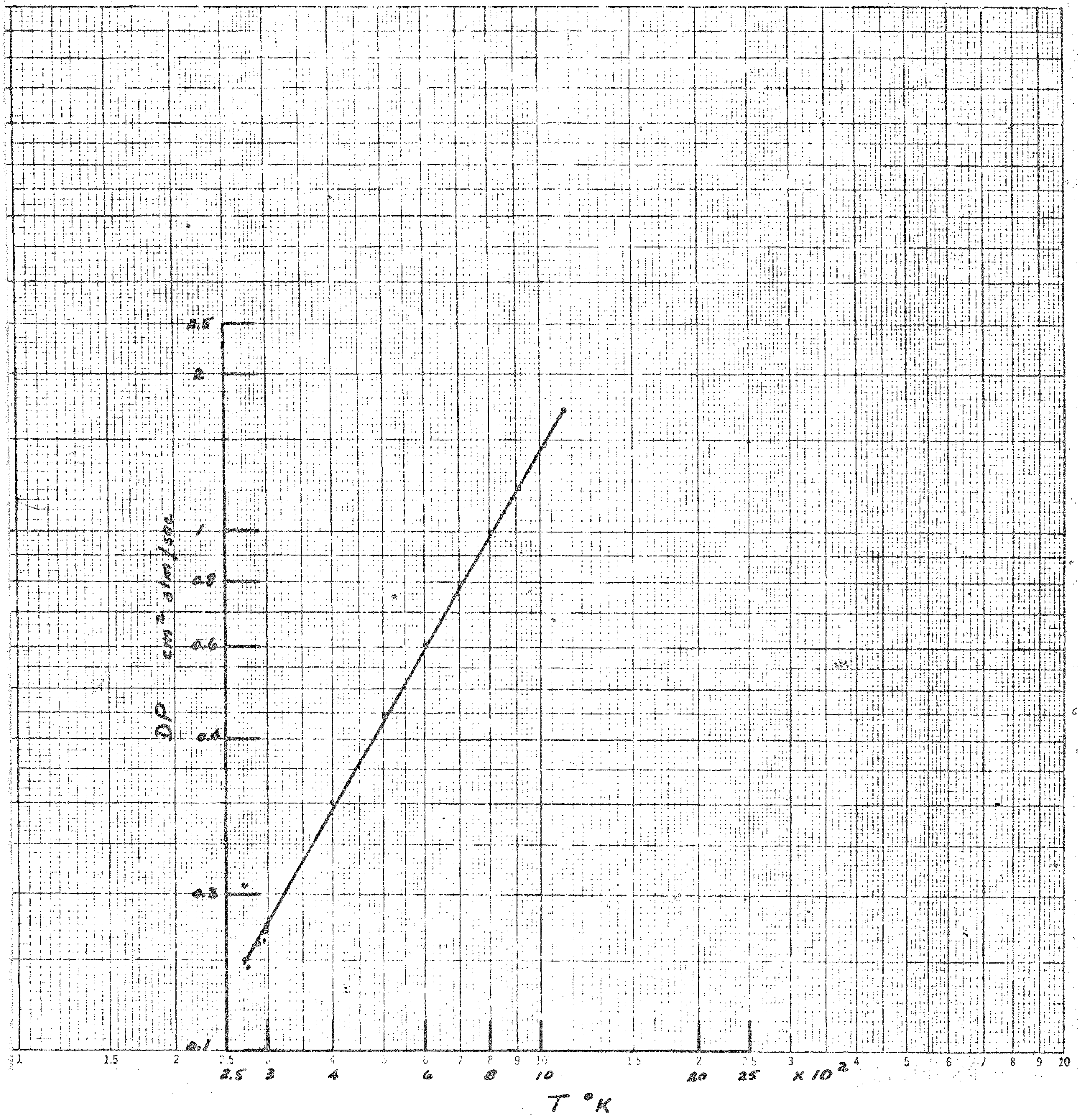


TABLE I

DIFFUSION COEFFICIENTS AS A FUNCTION OF TEMPERATURE

System	Data Points	Slope: log DP/log T
CO_2-N_2	14	1.79
He-Ar	15	1.78
H_2-N_2	12	1.65
He-CO_2	10	1.63
Ne-Ar	6	1.61
Ar-Kr	7	1.90

outside this range were calculated from Sutherland's formula

$$\frac{\mu}{\mu_0} = \frac{273 + C}{T + C} \left(\frac{T}{273}\right)^{1.5} \qquad (40)$$

as given in Perry (19), where

T = temperature, °K.
μ = viscosity of air at T, cp.
μ_0 = viscosity of air at 273°K. = .0171 cp.
C = constant = 114 for air

The six systems and the $D_{12}P$ and μ_{air} data are presented in Table VI of the Appendix, pages 64-73. As indicated previously when checking temperature dependence, not all systems gave satisfactory results due to limited data. However, the CO_2-N_2 system as expected indicated a smooth correlation for the DP-μ slope which was 2.60. Least square analysis results (log DP vs. log μ) are shown in Appendix, Table VI. Table II, page 23, summarises all results.

Figure II, page 24, is a log plot of the DP-μ data for the CO_2-N_2 system.

Recall that Othmer and Chen obtained a slope of 2.74 for the DP-μ data, as was shown in Equation (30). Basis the results discussed above it was decided to modify Equation (30) to reflect the new slope as follows:

$$\log D_{12}P = 2.6 \log \mu + C \qquad (41)$$

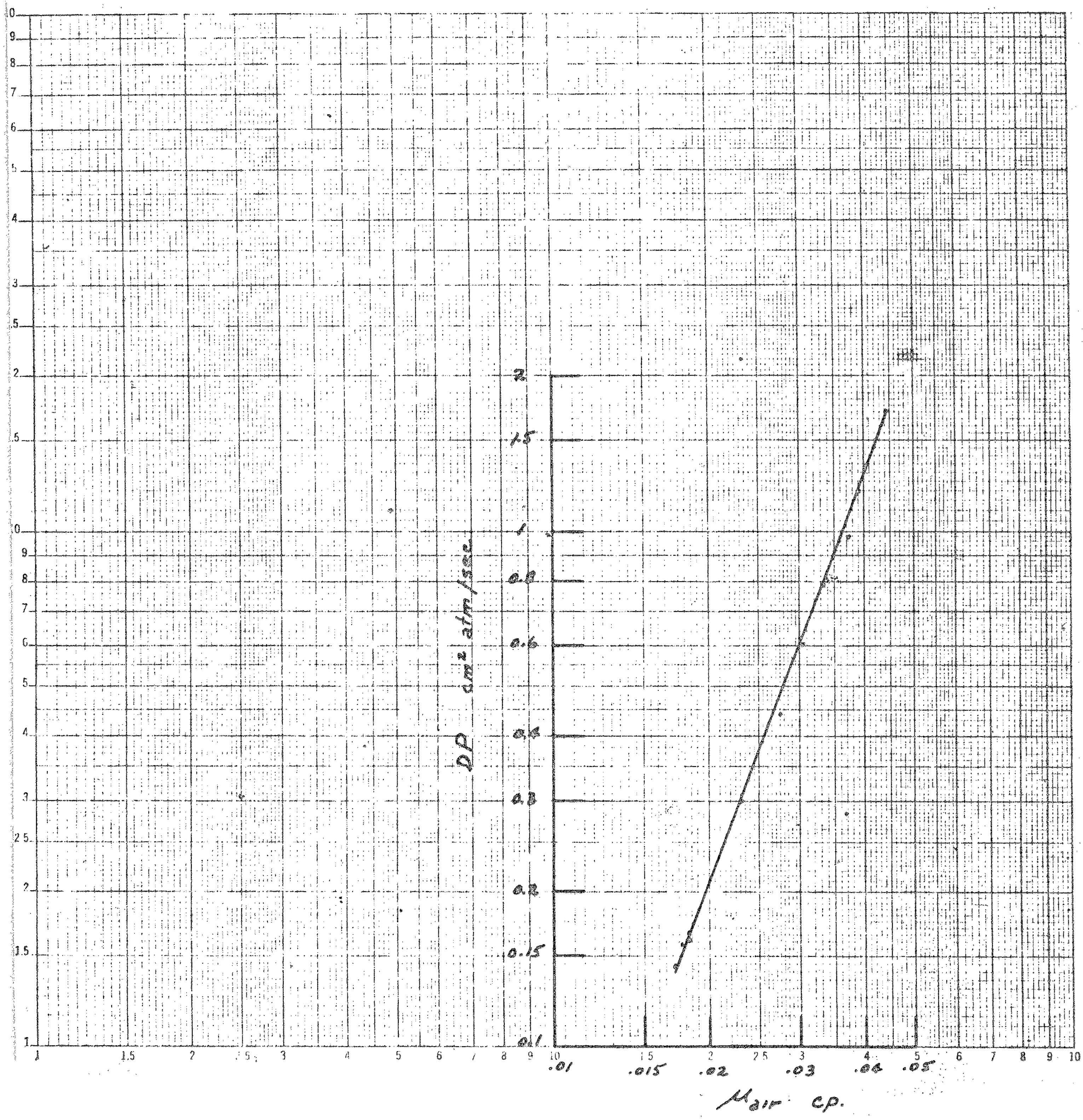
TABLE II

DIFFUSION COEFFICIENTS AS CORRELATED WITH THE VISCOSITY OF AIR

System	Data Points	Slope: log DP/log μ_{air}
CO_2-N_2	14	2.60
He-Ar	15	2.65
H_2-N_2	12	2.25
He-CO_2	10	2.27
Ne-Ar	6	2.38
Ar-Kr	7	2.55
He-N_2	11	2.60

FIGURE II

DP vs. μ_{AIR} FOR CO_2-N_2 SYSTEM



D. Analysis of Othmer and Chen Correlation

1. Varying exponent of inverse of molecular weight term. Recall from the Othmer-Chen correlation, Equation (26), that the term containing the molecular weights and critical volumes was written as follows:

$$D_{12}P = f\left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left({V_{c_1}}^{0.4} + {V_{c_2}}^{0.4}\right)^2}\right] \qquad (42)$$

It was decided that a check should be made on the reliability of using the 0.5 power as the exponent of the inverse molecular weight term. Sixty five data points from the list in the Fuller, Schettler, and Giddings paper were selected (as discussed in Section III.A.) for making the analysis. To evaluate the function in Equation (42), values for V_c were obtained from Bird, Stewart, and Lightfoot (2), page 744, and it was noted that these in turn had been obtained from Kobe and Lynn (13). These V_c values represent calculated numbers from ZRT_c/P_c. Table VII of the Appendix, page 74, presents the various logarithmic values of the function as calculated, along with the V_c values, versus the corresponding DP. The inverse molecular weight term was inserted with three different values for the power factor; 0.4, 0.5, and 0.6.

Least square analysis of Equation (42) indicated there was little difference in the adequacy of a curve fit using either 0.5 or 0.6 exponents, as shown in Table III, page 27. The percent error was 10.35 and 10.39, respectively, and absolute range of per cent error was a comparable 53.4 points versus 56.3. The 0.4 power was seen to be undesirable with a 12.60 per cent error. Basis the slight analysis edge favoring the 0.5 power and its reliability in earlier correlations it was believed appropriate that the 0.5 exponent be retained in this investigation. These results are tabulated in the Appendix, Table VIII, page 83.

2. Varying exponent of critical volume term. After establishing the 0.5 power as the exponent of the inverse molecular weight term, an analysis was made to fix the exponent of the critical volume term. The Othmer-Chen correlation used the presentation of $(V_{c1}^{0.4} + V_{c2}^{0.4})^2$. Recall from Equation (12) that Arnold used a $V_c^{1/3}$ as did Gilliland in Equation (17). On this basis the decision was made to compare $V_c^{0.4}$ with $V_c^{0.33}$ using Equation (42).

Once again the 65 data points from Fuller, Schettler, and Giddings were used for the analysis as previously used in examining the exponent of the molecular weight term in the preceding section. However, there was one difference in the evaluation of Equation (42) in this case compared to

TABLE III

OTHMER-CHEN CORRELATION

EFFECT OF VARIOUS EXPONENTS FOR MOLECULAR WEIGHT TERM

$$D_{12}P = f\left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{x}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4}\right)^{2}}\right]$$

Exponent, x	Average % Error	Maximum Range of Error	Percent of Calculated Values with Less than 10% Error
0.5	10.35	-22.1 to 31.3	61.5
0.6	10.39	-24.6 to 31.7	60.0
0.4	12.60	-29.4 to 35.9	44.6

that in Section III. D.1. The values for V_c used previously were all based on the ZRT_c/P_c calculation. This is satisfactory for most compounds, but there tends to be error introduced if this approach is used for the light elements H_2 and He and for the noble gases Ne, Ar, Kr, Xe. The more exact procedure for these elements is to use the collision diameter σ to calculate V_c by the following empirical relation from Bird, Stewart, and Lightfoot, page 22:

$$V_c = \left(\frac{\sigma}{.841}\right)^3 \qquad (43)$$

where σ is in Angstrom units for which values are given in Bird, Stewart, and Lightfoot on page 744. The Equation (43) as noted is primarily valid only for the elements mentioned above, but mistakenly the Equation (42) correlation was analyzed for all 65 points with the Equation (43) substitution for all V_c. Table IX of the Appendix, page 92, presents the data used.

Least square analysis revealed that the 0.4 exponent for V_c was the better choice basis an average per cent error of 11.7 as compared to 11.8% error for the 0.33 exponent. Granted this is a very minor difference in error and could rightfully be neglected and the two cases considered equivalent. However, the 0.4 exponent situation had 32.4% of all points with less than 5% error compared to 27.7% for the 0.33 exponent situation. It was decided that the 0.4

exponent would be retained for its slightly better reliability and on the strength of its demonstrated accuracy in the Othmer-Chen correlation. Table X of the Appendix, page 98 gives the error results for this analysis of critical volume exponent.

3. Final correlation selection. Basis the findings discussed in the above Sections III.D.1. and 2. the correlation function was established as originally presented in Equation (42), repeated below for convenience:

$$D_{12}P = f\left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left({V_{c_1}}^{0.4} + {V_{c_2}}^{0.4}\right)^2}\right] \tag{42}$$

It was mentioned in the explanation of the critical volume exponent selection that the empirical correlation of Equation (43) should be used for V_c for certain elements, in conjunction with the ZRT_c/P_c calculation of V_c for the remaining compounds. To ascertain the precision of Equation (42) in the proper manner, the appropriate V_c values were used to make a final check of the correlation. Table XI of the Appendix, page 105, presents the V_c values and the log value of the function in Equation (42), with the calculated DP and per cent error.

A slope of 1.096 was observed from the least square analysis, with an intercept of 2.274 such that the following expression could be written:

$$\log(DP)_{298^\circ K.} = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}{}^{0.4} + V_{c_2}{}^{0.4}\right)^2} \right] + 2.274 \qquad (44)$$

Recall the above equation is considered valid only around 298°K. since this was the temperature reference of the selected data (see Section III.A., page 17).

The least square analysis resulted in an 8.27% error for this final correlation on the total 65 points that have been examined throughout this work. Of the calculated values, 67.7% had less than 5% error. Thus the DP correlation was considered sufficiently firm to proceed to develop the complete equation for calculation of binary diffusion coefficients.

IV. DERIVATION OF FORMAL DIFFUSION COEFFICIENT EQUATION

A. Mathematical Derivation of Equation Based on Viscosity of Air

It was determined in Section III that Equation (44) was representative of the desired relationship at 298°F.:

$$\log (DP)_{298} = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2} \right)^{0.5}}{\left(V_{c_1}^{\ 0.4} + V_{c_2}^{\ 0.4} \right)^{2}} \right] + 2.274 \qquad (44)$$

The intent was then to expand Equation (44) to encompass all temperature situations. Equation (41) developed earlier, was next used in this regard:

$$\log DP = 2.6 \log \mu + C \qquad (41)$$

Using a value of 0.0182 cp. for the viscosity of air at 298°K., Equation (41) becomes:

$$\log (DP)_{298} = 2.6 \log (.0132) + C \qquad (45)$$

Substitution of Equation (44) into Equation (45) gives:

$$C = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2} \right)^{0.5}}{\left(V_{c_1}^{\ 0.4} + V_{c_2}^{\ 0.4} \right)^{2}} \right] + 2.274 - 2.6 \log(.0182) \qquad (46)$$

$$C = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2} \right)^{0.5}}{\left(V_{c_1}^{\ 0.4} + V_{c_2}^{\ 0.4} \right)^{2}} \right] + 6.794 \qquad (47)$$

Equation (41) and Equation (47) are then combined to yield:

$$\log DP = 2.6 \log \mu + 1.096 \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2} \right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4} \right)^2} \right] + 6.794 \qquad (48)$$

$$DP = (6.22 \times 10^6)\, \mu^{2.6} \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2} \right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4} \right)^2} \right]^{1.096} \qquad (49)$$

where μ is the viscosity of air in centipoises at the diffusing temperature. Equation (49) can be considered a final form if one wishes to work with μ_{air} values.

The above equation was used to calculate DP for 161 points representing the 65 separate binary systems that were used in the development. Table XII, Appendix, page 108 presents the values used to make these calculations and the resulting DP obtained, along with the per cent error. Error was 7.67%. In all, 72.0% of the points had less that 10% error.

B. Comparison of Derived Viscosity-Type Equation with Theoretical Development

The above derivation of Equation (49) was based on the reference substance plot, i.e. it was keyed to the DP-μ correlation from whence was developed the 2.6 exponent for the viscosity of air (Section III.C.2.).

However, there is a theoretical development that follows from Hirschfelder, Bird, and Spotz, Equation (21) in Section II.D.3. The collision integral Ω_D can be shown as a function of $kT/\mathcal{E}$. This function can be plotted and shown to exhibit a characteristic curve which contains two distinct regions marked by an obvious change in slope. (See Othmer and Chen for an illustration of this graph.) The correlation between Ω_D (which in turn can be shown as a function of DP) and $kT/\mathcal{E}$ is such that the following relationships can be shown to exist:

For $kT/\mathcal{E} < 2.5$ $\quad$ $\log DP = 2.0 \log \mu + C_1$ $\quad$ (50)

For $kT/\mathcal{E} > 2.5$ $\quad$ $\log DP = 2.5 \log \mu + C_2$ $\quad$ (51)

The development of the above can be followed in detail in Othmer and Chen.

The important point of interest here is that Equation (49) developed in this thesis differs from the above $kT/\mathcal{E}$ relationships in that only one exponent 2.6 suffices for all energy levels, a form of the type:

$$\log DP = 2.6 \log \mu + C \qquad (41)$$

It was thought that some refinement of Equation (49) could be attained if the exponents 2.0 or 2.5 were substituted for 2.6 for the appropriate conditions where the system of interest had a $kT/\mathcal{E}$ value below or above 2.5.

Recall Equation (44) could be used to calculate $\log (DP)_{298}$. Substitution of Equation (44) into Equation (50) gives:

$$C_1 = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4}\right)^2} \right] + 2.274 - 2.0 \log (.0182) \tag{52}$$

$$C_1 = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4}\right)^2} \right] + 5.754 \tag{53}$$

Equation (50) and Equation (53) combine as:

$$\log DP = 2.0 \log \mu + 1.096 \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4}\right)^2} \right] + 5.754 \tag{54}$$

$$DP = (5.68 \times 10^5)\, \mu^{2.0} \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4}\right)^2} \right]^{1.096} \tag{55}$$

when $kT/\varepsilon < 2.5$.

The above procedure was repeated for the relationship shown in Equation (51).

$$C_2 = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{\;0.4} + V_{c_2}^{\;0.4}\right)^2} \right] + 6.624 \tag{56}$$

Then from Equation (51):

$$DP = (4.20 \times 10^6)\ \mu^{2.5} \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}{}^{0.4} + V_{c_2}{}^{0.4}\right)^2} \right]^{1.096} \qquad (57)$$

when $kT/\varepsilon > 2.5$.

The above Equations (55) and (57) were used to calculate DP for the same 161 points used to check Equation (49). Table XIII, Appendix, page 116 presents the results. No improvement over Equation (49) could be shown. The error was 7.77% compared with 7.67% by Equation (49). As was expected there was little difference in the results from Equations (49) and (57) since the similar 2.6 and 2.5 exponents were involved. However, Equation (49) was better than Equation (55) with 59 points being applicable for $kT/\varepsilon < 2.5$. Equation (49) for those points had an error of 7.44% whereas the Equation (55) error was 7.75%. It was concluded that the derivations of the theoretical from the actual phenomena are accounted for by the larger exponent in the derived correlation.

C. Development of Reference Plot for Diffusion Coefficient-Temperature Relation

To simplify the obtaining of a diffusion coefficient at a given temperature when the coefficient is known at 298°K., a graphical presentation was developed. A total of

136 data points representing 33 different binary systems was selected from the Fuller, Schettler, and Giddings compilation. For each point T/T_{298} and DP/DP_{298} were calculated. These data are presented in Appendix, Table XIV, page 127. Then a least square analysis was made of log DP/DP_{298} versus log T/T_{298}. The resulting slope was 1.70. Figure III, page 37, provides a plot of this slope for ready reference in obtaining any DP from available DP_{298} and T/T_{298} values. Calculations are reported in the Appendix, page 134 on how the plot was drawn. The mathematical expression for this plot is shown below as Equation (58).

B. Derivation of Final Equation Based on Temperature Relation

Proceeding with the developed temperature relation, it can be written that:

$$\log \frac{DP}{DP_{298}} = 1.70 \log \frac{T}{298} - 0.0048 \qquad (58)$$

$$= 1.7 \log \frac{T}{298} + \log C \qquad (59)$$

where log C = -.0048
and C = 0.989

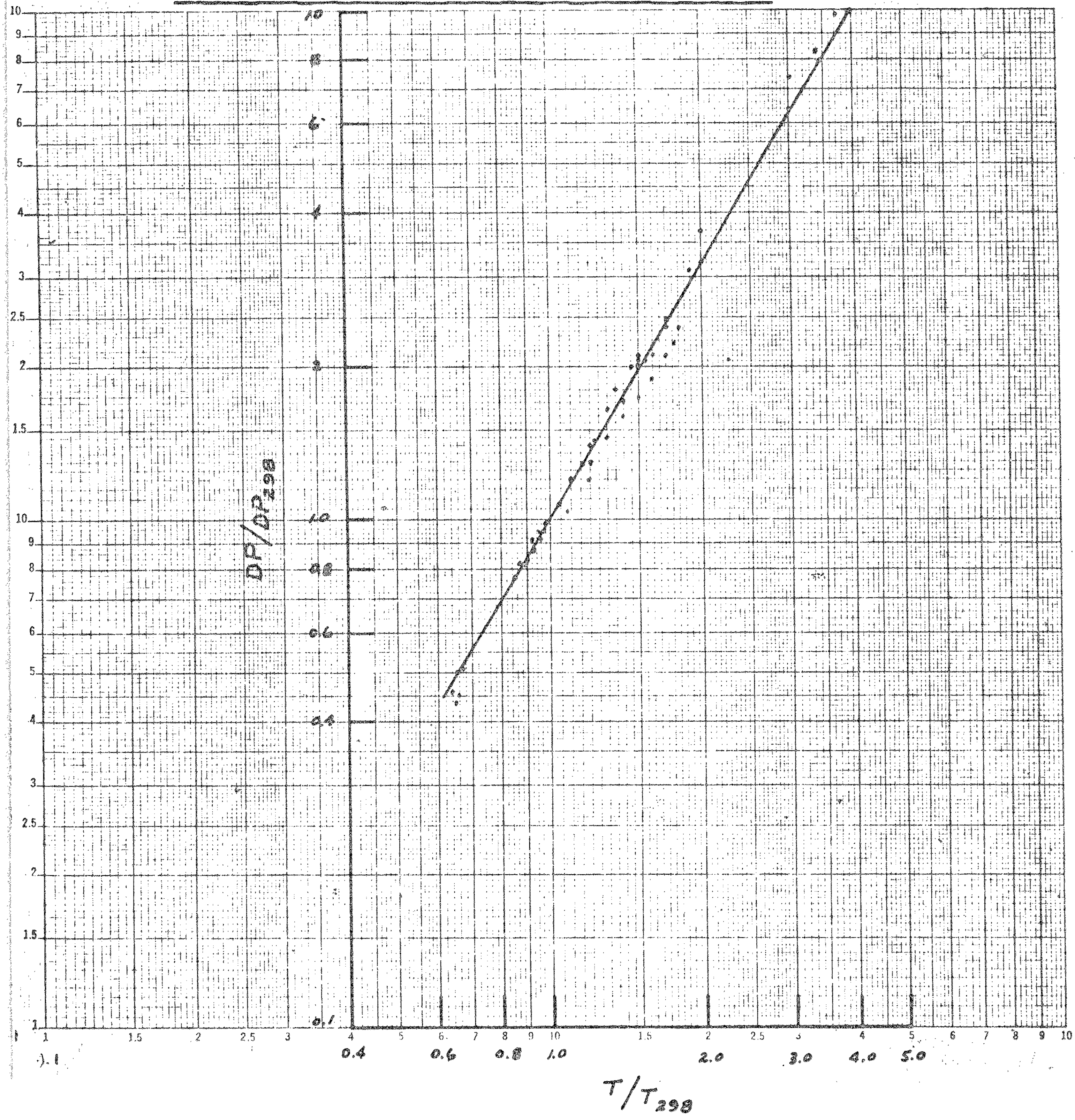
Thus:

$$DP = (DP)_{298} \left(\frac{T}{298}\right)^{1.7} (0.989) \qquad (60)$$

FIGURE III

DIFFUSION COEFFICIENT - TEMPERATURE RELATION

DP/DP_{298} vs. T/T_{298}



$$\log DP = \log (DP_{298}) + \log \left(\frac{T}{298}\right)^{1.7} + \log (.989) \qquad (61)$$

And recalling that:

$$\log DP_{298} = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left({V_{c_1}}^{0.4} + {V_{c_2}}^{0.4}\right)^2} \right] + 2.274 \qquad (44)$$

Equations (61) and (44) can be combined as:

$$\log DP = 1.096 \log \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left({V_{c_1}}^{0.4} + {V_{c_2}}^{0.4}\right)^2} \right] + 2.274 + \log \left(\frac{T}{298}\right)^{1.7} + \log (.989) \qquad (62)$$

$$DP = \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left({V_{c_1}}^{0.4} + {V_{c_2}}^{0.4}\right)^2} \right]^{1.096} (187.9) \left(\frac{T}{298}\right)^{1.7} (.989) \qquad (63)$$

Which finally yields the following equation as the formal expression for calculating any DP at any temperature:

$$DP = (186) \left(\frac{T}{298}\right)^{1.7} \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left({V_{c_1}}^{0.4} + {V_{c_2}}^{0.4}\right)^2} \right]^{1.096} \qquad (64)$$

Table XV, appendix, page 135 presents the values used in evaluating Equation (64), showing the calculated DP and the per cent error from the experimental data of 161 points. Error was 6.89% and 70.8% of the points had less than 10% error.

D. Multicomponent Relationship

An expression was developed to relate the diffusion coefficients of two systems at the same temperature. An expression was desired of the type

$$\frac{DP_{AB}}{DP_{AC}} = f\left(\frac{\alpha_{AB}^{1.096}}{\alpha_{AC}^{1.096}}\right) \qquad (65)$$

where

$$\alpha = \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{0.4} + V_{c_2}^{0.4}\right)^2}\right]$$

A total of 43 multicomponent combinations at 298°K. were chosen from the 65 systems used in the general development of the DP Equation (49). These 43 combinations are shown in Table XVI of the Appendix, page 143. Combinations of the type H_2-N_2 : H_2-Ar, and N_2-C_2H_4 : N_2-nC_4H_{10} were examined, that is AB : AC.

For each combination DP_{AB}/DP_{AC} and $\alpha_{AB}^{1.096} / \alpha_{AC}^{1.096}$ were calculated. Then a least square analysis was made of log DP_{AB}/DP_{AC} and log $\alpha_{AB}^{1.096} / \alpha_{AC}^{1.096}$. The slope found was 1.02. Figure IV, page 40, is a plot of this relationship. Calculations are reported in the Appendix, page 146 on the graph presentation. Then

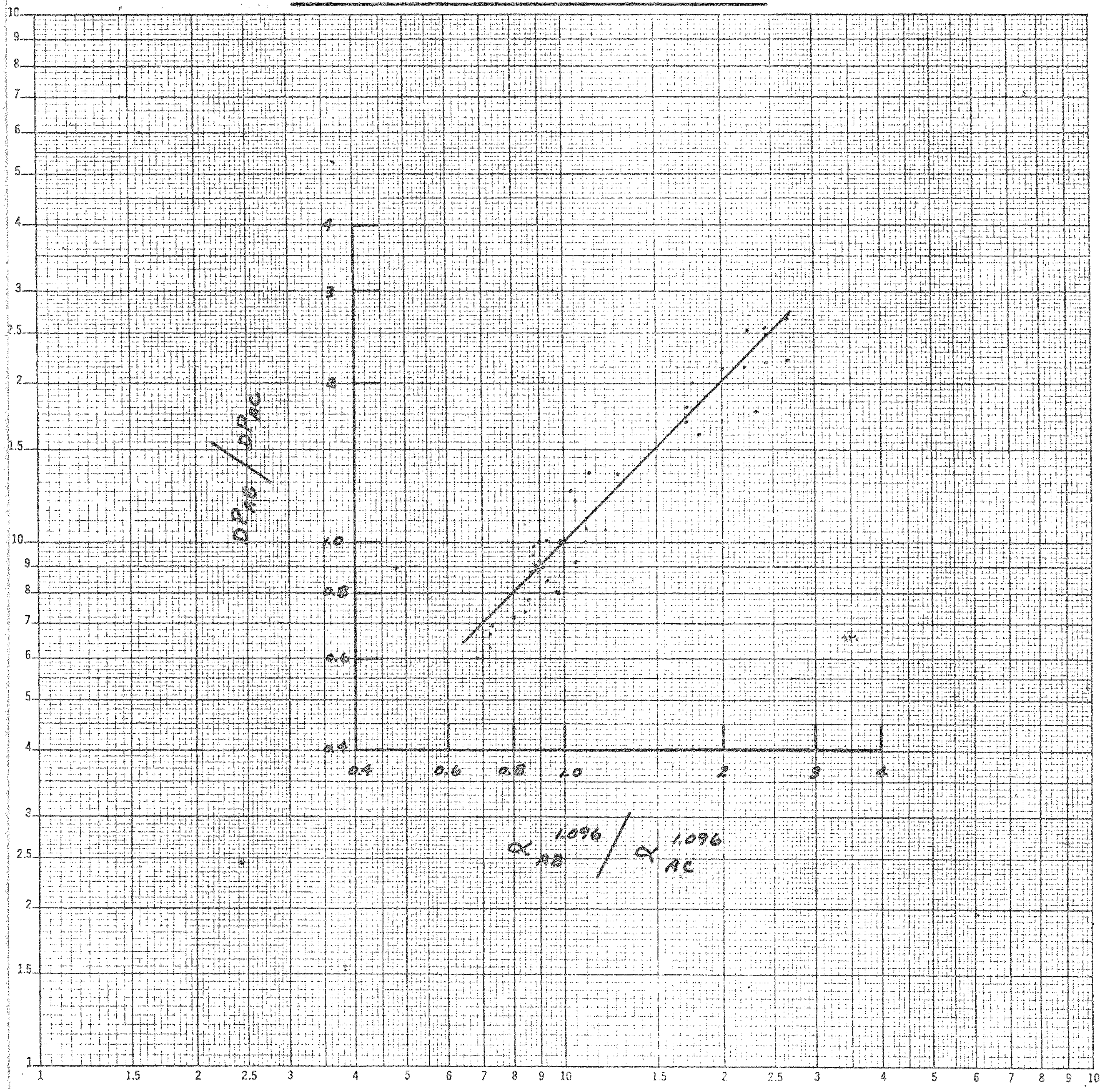
$$\log \frac{DP_{AB}}{DP_{AC}} = 1.02 \log\left(\frac{\alpha_{AB}^{1.096}}{\alpha_{AC}^{1.096}}\right) - .0045 \qquad (66)$$

FIGURE IV

MULTICOMPONENT RELATIONSHIP

DP_{AB}/DP_{AC} vs. $\alpha_{AB}^{1.096}/\alpha_{AC}^{1.096}$

(where α is MW, V_c function)



$$= 1.02 \log \left(\frac{\alpha_{AB}^{1.096}}{\alpha_{AC}^{1.096}} \right) + \log c \qquad (67)$$

where $\log c = -.0045$
and $c = 0.99$

Thus:

$$\frac{DP_{AB}}{DP_{AC}} = \left(\frac{\alpha_{AB}^{1.096}}{\alpha_{AC}^{1.096}} \right)^{1.02} (0.99) \qquad (68)$$

Overall per cent error for this relationship was 8.4%.

From Equation (68) one may calculate DP_{AB} if DP_{AC} is known at 298°K. Then if DP_{AB} is desired at some other temperature one can use Equation (60) where DP_{AB_T} is a function of $DP_{AB_{298}}$. Of course this procedure can be shortened to the use of Equation (64) where any DP_{AB} can be calculated directly.

V. RESULTS

In summary, the following significant results were obtained from the investigation reported herein:

(1) a correlation of diffusion coefficient with the
9 viscosity of air,

$$DP = \mu^{2.6}(6.22 \times 10^{6}) \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{e_1}^{\;0.4} + V_{e_2}^{\;0.4}\right)^{2}} \right]^{1.096} \qquad (49)$$

(2) a reference plot for diffusion coefficient versus temperature, plotted as

DP/DP_{298} vs. T/T_{298}

where $DP/DP_{298} = (.989)(T/T_{298})^{1.7}$ (60)

(3) a reference plot for multicomponent relationships at 298°K. where

$$DP_{AB}/DP_{AC} = \left(\frac{\alpha_{AB}^{\;1.096}}{\alpha_{AC}^{\;1.096}} \right)^{1.02} (0.99) \qquad (68)$$

and

(4) an equation for calculating diffusion coefficient basis a correlation with temperature,

$$DP = 186\left(\frac{T}{298}\right)^{1.7}\left[\frac{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}{}^{0.4}+V_{c_2}{}^{0.4}\right)^{2}}\right]^{1.096} \qquad (64)$$

A side by side comparison of the result of this work, Equation (64), and the FSG correlation was made on an arbitrarily chosen point, N_2-CO_2 at 300°K. Detailed calculations are shown in Appendix, page 155. For this example the following results were calculated:

$DP_{\text{this work}} = 0.164$

$DP_{FSG} = 0.169$

$DP_{obs} = 0.173$

It is apparent that the difference in the two methods is chiefly in the use of critical volume versus the diffusion parameters of Fuller, Schettler, and Giddings.

VI. COMPARISON OF RESULTING CORRELATION WITH EXPERIMENTAL DATA AND OTHER CORRELATIONS

The final equations developed are presented as Equation (64) and Equation (49). The value of DP was calculated for 161 points from the 65 systems used in the development and compared with experimental data. Results by the Othmer-Chen correlation, and by the FSG method were also compared with experimental data. In checking the precision of the Othmer-Chen and FSG methods, the per cent error for all the points of interest was taken directly from the FSG work, then summed and averaged to obtain the average per cent error. The following comparison was made:

Method	% Error
FSG	3.63
This work, Eq. (64)	6.89
This work, Eq. (49)	7.67
Othmer-Chen	9.34

It is noted that the FSG method is apparently the most accurate of the four (basis the data points analyzed here), whereas the equations developed in this thesis appear to be a slight improvement over the Othmer-Chen equation. A complete listing point by point showing per cent error for FSG, Equation (64), and Othmer-Chen is presented in the Appendix, Table XVII, page 147.

Table IV, page 46 presents a summary of the results by the above methods by comparing absolute average per cent errors for the particular systems examined.

TABLE IV

COMPARISON OF DIFFUSION COEFFICIENTS BY THIS WORK, FSG, AND OTHMER-CHEN

System Type	No. of Exptl. Pts.	Absolute Average % Error			
		This Work		FSG	Othmer-Chen
		Eq.(49)	Eq.(64)		
Air	16	6.78	6.36	4.60	4.94
H_2	37	9.23	5.56	4.10	19.91
He	48	6.35	6.86	3.69	6.77
N_2	48	6.31	6.95	3.47	9.07
O_2	5	6.63	6.78	2.35	3.48
CO_2	31	8.48	7.80	3.17	4.61
Hydrocarbon	53	6.79	6.72	4.15	10.72
All Points	161	7.67	6.89	3.63	9.34

VII. CONCLUSIONS

The correlation developed herein as a function of temperature is considered satisfactorily reliable for use in estimating diffusion coefficients within the accuracy of experimental data and with reasonable agreement with existing correlations. Overall this development is a slight improvement of the Othmer-Chen correlation, but not sufficiently so to disclaim the validity of that relationship.

When compared with the Othmer-Chen relation and the Fuller, Schettler, and Giddings relation, this work was found to have a 6.89% error for the 161 experimental points examined, where Othmer-Chen was 9.34% and FSG was 3.63%. In general this only indicates primarily the relative accuracy of the three methods as applied to the selected group of data. However, it is concluded that directionally the same relative accuracy would be exhibited within any given random selection of data involving more than several separate gas systems.

The FSG correlation would appear most accurate for all the separate systems studied. However, the correlation from this work compares favorably for systems where one component is air or hydrogen. This work has an improved precision over the Othmer-Chen method for hydrogen systems, hydrocarbon systems, and nitrogen systems.

Having concluded that this work is a reliable estimating procedure, it also has several favorable advantages over other methods. Namely the use of the temperature term rather than the viscosity of air greatly simplifies this correlation and eliminates the need for the additional viscosity data in order to apply this method.

VIII. RECOMMENDATIONS

It is recommended that the correlation developed herein, based on the absolute temperature, be utilized for the estimation of binary gas diffusion coefficients in the absence of experimental data. However, some caution should be exercised if this correlation is applied to systems not considered in the development as here reported, although it is believed the overall average error would be close to the 6.89% shown by this work.

Recommended further investigation might include the following items:

(1) development of a separate correlation for use with systems containing a hydrocarbon component, and

(2) additional refinement of this correlation by testing with different systems and a greater number of experimental diffusion coefficient values.

IX. APPENDIX

INDEX TO APPENDIX

Subject	Page
Calculation for DP/DP_{298} vs. T/T_{298} Plot	134
Calculation for DP_{AB}/DP_{AC} vs. $\alpha_{AB}^{1.096} / \alpha_{AC}^{1.096}$ Plot	146
Compare Calculations for DP of N_2-CO_2 at 300°K. Using this Work's Correlation Eq.(64) versus FSG Correlation	155

LIST OF TABLES

Page

V. Temperature Dependence Studies:
Temperature Function 54
- A. CO_2-N_2 54
- B. He-Ar 56
- C. H_2-N_2 58
- D. He-CO_2 60
- E. Ne-Ar 62
- F. Ar-Kr 63

VI. Temperature Dependence Studies:
Air Viscosity Function 64
- A. CO_2-N_2 64
- B. He-Ar 66
- C. H_2-N_2 68
- D. He-CO_2 70
- E. Ne-Ar 72
- F. Ar-Kr 73

VII. Data: Effect of Various Exponents for Molecular Weight Term 74

VIII. Results: Effect of Various Exponents for Molecular Weight Term 83

IX. Data: Effect of Various Exponents for Critical Volume Term 92

LIST OF TABLES (CONT'D)

X. Results: Effect of Various Exponents for Critical Volume Term 98

XI. Precision Check of the Final DP Function 105

XII. Evaluation of $DP = (6.22) \times 10^6 \mu^{2.6} \alpha^{1.096}$ 108

XIII. Equation of $DP = (4.20 \times 10^6) \mu^{2.5} \alpha^{1.096}$ and of $DP = (5.68 \times 10^6) \mu^{2.0} \alpha^{1.096}$ 116

XIV. Data: Reference Plot for Diffusion Coefficient Temperature Relation 127

XV. Evaluation of $DP = (186)(T/298)^{1.7} \alpha^{1.096}$ 135

XVI. Multicomponent Relationship $DP_{AB}/DP_{AC} = f \alpha_{AB}^{1.096} / \alpha_{AC}^{1.096}$ 143

XVII. Comparison of Diffusion Coefficients by Different Methods 147

TABLE V.A.

Temperature Dependence Studies

Temperature Function

CO_2-N_2

Data

T,°K.	log T	DP, cm.^{2}atm./sec.	log DP
273	2.4362	0.144	-0.8416
288	2.4594	0.158	-0.8013
293	2.4669	0.160	-0.7959
295	2.4698	0.159	-0.7986
298	2.4722	0.167	-0.7773
300	2.4771	0.17	-0.7696
400	2.6021	0.30	-0.5229
500	2.6990	0.44	-0.3566
600	2.7782	0.61	-0.2147
700	2.8451	0.79	-0.1024
800	2.9031	0.99	-0.0044
900	2.9542	1.21	0.0828
1000	3.0000	1.45	0.1614
1100	3.0414	1.70	0.2305

slope: log DP/log T = 1.79

TABLE V.A. (CONT'D)

Results

DP, calc.	% Error
0.144	0.0
0.159	0.6
0.164	2.5
0.166	4.4
0.167	0.0
0.171	0.6
0.286	4.7
0.426	3.2
0.591	3.1
0.779	1.4
0.999	0.9
1.22	0.8
1.48	2.1
1.75	2.9

avg. % error 1.9

TABLE V.B.

Temperature Dependence Studies

Temperature Function

He-Ar

Data

T	log T	DP	log DP
298	2.4722	0.754	-0.1226
317	2.5011	0.7968	-0.0986
323	2.5092	0.809	-0.0921
346	2.5391	0.9244	-0.0341
353	2.5478	0.978	-0.0097
354	2.5490	0.979	-0.0092
383	2.5832	1.122	0.0500
413	2.6160	1.237	0.0924
418	2.6212	1.398	0.1455
443	2.6464	1.401	0.1464
473	2.6749	1.612	0.2074
498	2.6972	1.728	0.2375
500	2.6990	1.860	0.2695
1000	3.0000	6.250	0.7959
1100	3.0414	7.380	0.8681

slope: log DP/log T = 1.78

TABLE V.B. (CONT'D)

Results

DP, calc.	% Error
0.726	3.7
0.800	0.4
0.827	2.2
0.935	1.2
0.969	0.9
0.974	0.5
1.121	0.1
1.283	3.7
1.310	6.3
1.453	3.7
1.633	1.3
1.790	3.6
1.803	3.1
6.205	0.7
7.354	0.4

avg. % error = 2.1

TABLE V. C.

Temperature Dependence Studies

Temperature Function

H_2-N_2

Data

T	log T	DP	log DP
273	2.4362	0.708	-0.1500
288	2.4594	0.743	-0.1290
294	2.4684	0.763	-0.1175
297	2.4728	0.779	-0.1085
300	2.4771	0.800	-0.0969
304	2.4829	0.852	-0.0696
322	2.5079	0.903	-0.0443
398	2.5999	1.289	0.1103
400	2.6021	1.270	0.1038
450	2.6532	1.541	0.1878
506	2.7042	1.883	0.2749
573	2.7582	2.417	0.3833

slope: log DP/log T = 1.65

Results

DP, calc.	% Error
0.688	2.8
0.751	1.1

TABLE V.C. (CONT'D)

Results (cont'd)

DP, calc.	% Error
0.777	1.8
0.791	1.5
0.804	0.5
0.822	3.5
0.904	0.1
1.283	0.5
1.294	1.9
1.572	2.0
1.908	1.3
2.344	3.0

avg. % error = 1.7

TABLE V.D.

Temperature Dependence Studies

Temperature Function

He-CO_2

Data

T	log T	DP	log DP
298	2.4722	0.612	-0.2132
317	2.5011	0.6607	-0.1805
323	2.5092	0.678	-0.1688
346	2.5391	0.764	-0.1169
353	2.5478	0.800	-0.0969
383	2.5832	0.884	-0.0535
413	2.6160	1.040	0.0170
443	2.6464	1.133	0.0542
473	2.6749	1.279	0.1069
498	2.6972	1.414	0.1505

slope: log DP/log T = 1.63

Results

DP.calc.	% Error
0.597	2.5
0.665	0.6
0.686	1.2
0.768	0.5

TABLE V.D. (CONT'D)

Results (cont'd)

DP, calc.	% Error
0.793	0.9
0.906	2.5
1.025	1.4
1.149	1.4
1.280	0.1
1.392	1.6

avg. % error = 1.3

TABLE V.E.

Temperature Dependence Studies

Temperature Function

Ne-Ar

Data

T	log T	DP	log DP
273	2.4362	0.276	-0.5591
288	2.4594	0.300	-0.5229
303	2.4814	0.327	-0.4855
318	2.5024	0.357	-0.4473
353	2.5478	0.414	-0.3830
473	2.6749	0.671	-0.1733

slope: log DP/log T = 1.61

Results

DP, calc.	% Error
0.276	0.0
0.301	0.3
0.327	0.0
0.353	1.1
0.418	1.0
0.670	0.1

avg. % error = 0.4

TABLE V.F.

Temperature Dependence Studies

Temperature Function

Ar-Kr

Data

T	log T	DP	log DP
273	2.4362	0.119	-0.9245
288	2.4594	0.128	-0.8928
303	2.4814	0.140	-0.8539
318	2.5024	0.153	-0.8153
353	2.5478	0.197	-0.7055
373	2.5717	0.216	-0.6655
473	2.6749	0.327	-0.4855

slope: log DP/log T = 1.90

Results

DP. calc.	% Error
0.117	1.7
0.130	1.6
0.143	2.1
0.156	2.0
0.191	3.0
0.212	1.9
0.332	1.5

avg. % error = 2.0

TABLE VI.A.

Temperature Dependence Studies

Air Viscosity Function

CO_2-N_2

Data

T, °K.	μ air, cp.	log μ	log DP
273	.0171	-1.7670	-0.8416
288	.0176	-1.7545	-0.8013
293	.0181	-1.7423	-0.7959
295	.0182	-1.7399	-0.7986
298	.0183	-1.7375	-0.7773
300	.0184	-1.7352	-0.7696
400	.0229	-1.6402	-0.5229
500	.0268	-1.5719	-0.3566
600	.0304	-1.5171	-0.2147
700	.0328	-1.4841	-0.1024
800	.0367	-1.4353	-0.0044
900	.0392	-1.4067	0.0828
1000	.0418	-1.3788	0.1614
1100	.0440	-1.3565	0.2305

slope: log DP/log μ = 2.60

TABLE VI.A. (CONT'D)

Results

DP. calc.	% Error
0.140	2.8
0.151	4.4
0.163	1.9
0.165	3.8
0.167	0.0
0.170	0.0
0.30	0.0
0.451	2.5
0.627	2.8
0.765	3.2
1.03	4.0
1.22	0.8
1.44	0.7
1.64	3.5

avg. % error = 2.2

TABLE VI.B.

Temperature Dependence Studies

Air Viscosity Function

He-Ar

Data

T	μ	$\log \mu$	$\log DP$
298	0.0183	-1.7375	-0.1226
317	0.0193	-1.7144	-0.0986
323	0.0195	-1.7100	-0.0921
346	0.0205	-1.6882	-0.0341
353	0.0208	-1.6819	-0.0097
354	0.0208	-1.6819	-0.0092
383	0.0221	-1.6556	0.0500
413	0.0233	-1.6326	0.0924
418	0.0236	-1.6271	0.1455
443	0.0246	-1.6091	0.1464
473	0.0256	-1.5918	0.2074
498	0.0266	-1.5751	0.2375
500	0.0268	-1.5719	0.2695
1000	0.0418	-1.3788	0.7959
1100	0.0440	-1.3565	0.8681

slope: $\log DP/\log \mu = 2.65$

TABLE VI.B. (CONT'D)

Results

DP, calc.	% Error
0.686	9.0
0.790	0.9
0.811	0.2
0.926	0.2
0.963	1.5
0.963	1.6
1.131	0.8
1.301	5.2
1.345	3.8
1.502	7.2
1.669	3.5
1.848	6.9
1.884	1.3
6.122	2.1
7.015	5.0

avg. % error = 3.2

TABLE VI.C.

Temperature Dependence Studies

Air Viscosity Function

H_2-N_2

Data

T	μ	log μ	log DP
273	0.0171	-1.7670	-0.1500
288	0.0176	-1.7545	-0.1290
294	0.0182	-1.7399	-0.1175
297	0.0183	-1.7375	-0.1085
300	0.0184	-1.7352	-0.0969
304	0.0186	-1.7305	-0.0696
322	0.0195	-1.7100	-0.0443
398	0.0228	-1.6421	0.1103
400	0.0229	-1.6402	0.1038
450	0.0249	-1.6038	0.1878
506	0.0269	-1.5702	0.2749
573	0.0293	-1.5331	0.3833

slope: log DP/log μ = 2.25

TABLE VI.C. (CONT'D)

Results

DP. calc.	% Error
0.682	3.7
0.727	2.2
0.784	2.7
0.794	1.9
0.804	0.5
0.824	3.3
0.916	1.4
1.303	1.1
1.316	3.6
1.589	3.1
1.892	0.5
2.293	5.1

avg. % error = 2.4

TABLE VI.D.

Temperature Dependence Studies

Air Viscosity Function

$He-CO_2$

Data

T	μ	log μ	log DP
298	0.0183	-1.7375	-0.2132
317	0.0193	-1.7144	-0.1805
323	0.0195	-1.7100	-0.1688
346	0.0205	-1.6882	-0.1169
353	0.0208	-1.6819	-0.0969
383	0.0221	-1.6556	-0.0535
413	0.0233	-1.6326	0.0170
443	0.0246	-1.6091	0.0542
473	0.0256	-1.5918	0.1069
498	0.0266	-1.5751	0.1505

slope: log DP/log μ = 2.27

Results

DP, calc.	% Error
0.593	3.1
0.669	1.2
0.685	1.0
0.767	0.4
0.793	0.9

TABLE VI.D. (CONT'D)

Results (cont'd)

DP. calc.	% Error
0.910	2.9
1.026	1.3
1.160	1.2
1.270	0.7
1.386	2.0

avg. % error = 1.5

TABLE VI.E.

Temperature Dependence Studies

Air Viscosity Function

Ne-Ar

Data

T	μ	log μ	log DP
273	0.0171	-1.7670	-0.5591
288	0.0176	-1.7545	-0.5229
303	0.0186	-1.7305	-0.4855
318	0.0193	-1.7144	-0.4473
353	0.0208	-1.6819	-0.3830
473	0.0256	-1.5918	-0.1733

slope: log DP/log μ = 2.18

Results

DP. calc.	% Error
0.276	0.7
0.293	2.3
0.331	1.2
0.359	0.6
0.422	1.9
0.663	1.2

avg. % error = 1.3

TABLE VI.F.

Temperature Dependence Studies

Air Viscosity Function

Ar-Kr

Data

T	μ	log μ	log DP
273	0.0171	-1.7670	-0.9245
288	0.0176	-1.7545	-0.8928
303	0.0186	-1.7305	-0.8539
318	0.0193	-1.7144	-1.8153
353	0.0208	-1.6819	-0.7055
373	0.0217	-1.6635	-0.6655
473	0.0256	-1.5918	-0.4855

slope: log DP/log μ = 2.55

Results

DP, calc.	% Error
0.117	1.7
0.126	1.6
0.145	3.6
0.159	3.9
0.192	2.5
0.214	0.9
0.327	0.0

avg. % error = 2.0

TABLE VII

Data: Effect of Various Exponents for Molecular Weight Term

Note: log α term data show in order 0.4,0.5, 0.6 exponent use for x.

System	DP	log DP	V_{c_1}	V_{c_2}	$\log\left[\frac{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^x}{\left(V_{c_1}^{.4}+V_{c_2}^{.4}\right)^2}\right]$
H_2-N_2	0.7790	-0.10846	65.0	90.1	-2.22069
					-2.24812
					-2.27556
H_2-Ar	0.8280	-0.08197	65.0	75.2	-2.19134
					-2.21966
					-2.24798
H_2-CO_2	0.6460	-0.18977	65.0	94.0	-2.22286
					-2.25135
					-2.27987
H_2-NH_3	0.8560	-0.06753	65.0	72.4	-2.17682
					-2.20320
					-2.22957
He-N_2	0.7430	-0.12901	57.8	90.1	-2.30988
					-2.36431
					-2.41876
He-Ar	0.7540	-0.12263	57.8	75.2	-2.27290
					-2.32900
					-2.38510

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
He-CO_2	0.6120	-0.21325	57.8	94.0	-2.32603
					-2.38249
					-2.43895
He-NH_3	0.8420	-0.07469	57.8	72.4	-2.26157
					-2.31406
					-2.36655
Air-CO_2	0.1650	-0.78252	86.6	94.0	-2.66346
					-2.78772
					-2.91198
Air-NH_3	0.2470	-0.60730	86.6	72.4	-2.55326
					-2.66119
					-2.76913
N_2-CO_2	0.1650	-0.78252	90.1	94.0	-2.66667
					-2.79002
					-2.91339
He-Ar	0.3270	-0.48545	41.7	75.2	-2.45813
					-2.57092
					-2.68370
CO_2-C_3H_8	0.0863	-1.06399	94.0	200.	-2.83876
					-2.97306
					-3.10735
Air-CH_4	0.2240	-0.64975	86.6	99.3	-2.58183
					-2.68324
					-2.78465

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
N_2-C_2H_6	0.1480	-2.82974	90.1	148.	-2.72078
					-2.83689
					-2.95301
Air-C_6H_6	0.0962	-1.01682	86.6	260.	-2.89394
					-3.02645
					-3.15897
H_2-CH_4	0.7260	-0.13906	65.0	99.3	-2.23037
					-2.25568
					-2.28100
H_2-C_2H_6	0.5370	-0.27003	65.0	148.	-2.31754
					-2.34517
					-2.37280
H_2-nC_4H_{10}	0.3610	-0.44249	65.0	255.	-2.43778
					-2.43675
					-2.49573
H_2-nC_6H_{14}	0.2900	-0.53760	65.0	368.	-2.52389
					-2.55334
					-2.58279
H_2-cyclo-hexane	0.3190	-0.49621	65.0	308.	-2.48171
					-2.51113
					-2.54055
H_2-nC_7H_{16}	0.2830	-0.54821	65.0	426.	-2.55728
					-2.58686
					-2.61645

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
H_2-nC_8H_{18}	0.2770	-0.55752	65.0	485.	-2.58863
					-2.61832
					-2.64801
H_2-C_6H_6	0.4036	-0.39405	65.0	260.	-2.44356
					-2.47290
					-2.50225
H_2-2,4 DMP	0.2970	-0.52724	65.0	420.	-2.55394
					-2.58352
					-2.61310
He-CO	0.7020	-0.15366	57.8	93.1	-2.31612
					-2.37055
					-2.42499
He-nC_7H_{16}	0.2650	-0.57675	57.8	426.	-2.66024
					-2.71878
					-2.77732
He-nC_8H_{18}	0.2480	-0.60555	57.8	485.	-2.69243
					-2.75116
					-2.80990
He-2,4 DMP	0.2630	-0.58004	57.8	420.	-2.65682
					-2.71533
					-2.77385
He-C_6H_6	0.3840	-0.41567	57.8	260.	-2.54380
					-2.60187
					-2.65995

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
N_2-Ar	0.1940	-0.71220	90.1	75.2	-2.62172
					-2.74340
					-2.86509
N_2-CO	0.2120	-0.67366	90.1	93.1	-2.63006
					-2.74469
					-2.85932
N_2-NH_3	0.2480	-0.60555	90.1	72.4	-2.55790
					-2.66521
					-2.77252
N_2-C_2H_4	0.1630	-0.78781	90.1	124.	-2.68160
					-2.79623
					-2.91086
N_2-nC_4H_{10}	0.0960	-1.01773	90.1	255.	-2.87584
					-3.00349
					-3.13114
N_2-iC_4H_{10}	0.0905	-1.04335	90.1	263.	-2.88290
					-3.01055
					-3.13820
N_2-nC_6H_{14}	0.0757	-1.12090	90.1	368.	-2.97564
					-3.10815
					-3.24066
N_2-cyclohex	0.0760	-1.11919	90.1	307.	-2.93430
					-3.06653
					-3.19877

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
N_2-methyl-cyclopentane	0.0760	-1.11919	90.1	319.	-2.94190
					-3.07413
					-3.20637
N_2-nC_7H_{16}	0.0740	-1.13077	90.1	426.	-3.01297
					-3.14696
					-3.28099
N_2-2,4 DMP	0.0744	-1.12843	90.1	420.	-3.00943
					-3.14334
					-3.27726
N_2-nC_8H_{18}	0.0726	-1.13906	90.1	485.	-3.04724
					-3.18240
					-3.31756
N_2-C_6H_6	0.1022	-0.99055	90.1	260.	-2.89500
					-3.02643
					-3.15786
O_2-nC_6H_{14}	0.0753	-1.12321	74.4	368.	-2.96902
					-3.10577
					-3.24253
O_2-cyclohex	0.0744	-1.12843	74.4	308.	-2.92651
					-3.06296
					-3.19941
O_2-MCP	0.0742	-1.12960	74.4	319.	-2.93433
					-3.07076
					-3.20723

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
O_2-nC_8H_{18}	0.0705	-1.15181	74.4	485.	-3.04340
					-3.18309
					-3.32278
O_2-C_6H_6	0.1011	-0.99525	74.4	260.	-2.88582
					-3.02138
					-3.15694
Ar-Kr	0.1400	-0.85387	75.2	92.1	-2.71235
					-2.85564
					-2.99894
Ar-CO	0.1880	-0.72584	75.2	93.1	-2.62765
					-2.74932
					-2.87101
Ar-NH_3	0.2320	-0.63451	75.2	72.4	-2.54924
					-2.66243
					-2.77562
Ar-nC_6H_{14}	0.0663	-1.17849	75.2	260.	-2.99789
					-3.14154
					-3.28519
Ar-cyclohex	0.0719	-1.14327	75.2	308.	-2.95523
					-3.09852
					-3.24182
Ar-MCP	0.0731	-1.13698	75.2	319.	-2.96303
					-3.10632
					-3.24962

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
Ar-nC_7H_{16}	0.0658	-1.18177	75.2	426.	-3.03787
					-3.18346
					-3.32606
Ar-2,4 DMP	0.0655	-1.18376	75.2	420.	-3.03422
					-3.17958
					-3.32505
Ar-nC_8H_{18}	0.0587	-1.23136	75.2	485.	-3.07429
					-3.22140
					-3.36851
CO-CO_2	0.1520	-0.81816	93.1	94.0	-2.67234
					-2.79569
					-2.91905
CO-NH_3	0.2400	-0.61979	93.1	72.4	-2.56380
					-2.67129
					-2.77850
CO_2-H_2O	0.1170	-0.93181	94.0	96.3	-2.72194
					-2.85623
					-2.99052
H_2O-C_3H_8	0.0860	-1.06550	96.3	200.	-2.86234
					-2.99663
					-3.13092
Air-Cl_2	0.1240	-0.90658	86.6	124.	-2.74202
					-2.87336
					-3.00470

TABLE VII (CONT'D)

System	DP	log DP	V_{c_1}	V_{c_2}	log α
Air-Br_2	0.0910	-1.04096	86.6	144.	-2.78076
					-2.91969
					-3.05862
Air-chloro C_6H_6	0.0740	-1.13077	86.6	308.	-2.94516
					-3.08141
					-3.21767
Air-ethyl-acetate	0.0870	-1.06048	86.6	285.7	-2.91922
					-3.05303
					-3.18685

TABLE VIII

Results: Effect of Various Exponents for Molecular Weight Term

Note: Three consecutive results calculated for each system refer to use of 0.4,0.5,0.6 exponent (see Data, Table VII)

System	DP calculated	DP observed	% Error
H_2-N_2	.788	.779	1.15
	.802		2.96
	.808		3.72
H_2-Ar	.865	.828	4.47
	.868		4.84
	.865		4.47
H_2-CO_2	.782	.646	21.1
	.794		22.9
	.800		23.8
H_2-NH_3	.906	.856	5.84
	.909		6.19
	.906		5,84
He-N_2	.593	.743	20.2
	.580		21.9
	.568		23.6
He-Ar	.640	.754	11.5
	.667		15.1
	.617		18.2

TABLE VIII (CONT'D)

System	DP calculated	DP observed	% Error
$He-CO_2$	.563	.612	8.01
	.551		9.97
	.540		11.8
$He-NH_3$	.692	.842	17.8
	.667		20.8
	.646		23.2
$Air-CO_2$	.192	.165	16.4
	.178		7.88
	.168		1.82
$Air-NH_3$	.273	.247	10.5
	.253		2.43
	.239		3.24
N_2-CO_2	.190	.165	15.2
	.177		7.27
	.168		1.82
Ne-Ar	.370	.327	13.2
	.326		0.00
	.295		9.78
$CO_2-C_3H_8$	.110	.086	27.9
	.106		23.3
	.104		21.0

TABLE VIII (CONT'D)

System	DP calculated	DP observed	% Error
Air-CH_4	.249	.224	11.2
	.238		6.25
	.230		2.68
N_2-C_2H_6	.160	.148	12.3
	.155		4.73
	.174		2.70
Air-C_6H_6	.0921	.0962	4.26
	.0914		4.99
	.0914		4.99
H_2-CH_4	.764	.726	5.24
	.785		8.13
	.798		9.93
H_2-C_2H_6	.579	.537	7.83
	.611		13.8
	.636		18.4
H_2-nC_4H_{10}	.394	.361	9.15
	.474		31.3
	.470		30.2
H_2-nC_6H_{14}	.300	.290	3.45
	.342		17.9
	.379		30.7

TABLE VIII (CONT'D)

System	DP		% Error
	calculated	observed	
H_2-cyclohex	.343	.319	7.53
	.385		20.7
	.420		31.7
H_2-nC_7H_{16}	.269	.283	4.95
	.312		10.0
	.349		23.3
H_2-nC_8H_{18}	.244	.277	11.9
	.285		2.89
	.322		16.2
H_2-C_6H_6	.387	.404	4.21
	.428		5.94
	.462		14.4
H_2-2,4 DMP	.272	.297	8.421
	.314		5.72
	.351		18.2
He-CO	.581	.702	17.2
	.570		18.8
	.559		20.4
He-nC_7H_{16}	.194	.265	26.8
	.216		18.5
	.234		11.7
He-nC_8H_{18}	.175	.248	29.4
	.197		20.6
	.216		12.9

TABLE VIII (CONT'D)

System	DP calculated	DP observed	% Error
He-2,4 DMP	.196	.263	25.5
	.218		17.1
	.236		10.3
He-C_6H_6	.281	.384	26.8
	.299		22.1
	.313		18.5
N_2-Ar	.219	.194	12.9
	.201		3.61
	.189		2.58
N_2-CO	.214	.212	0.94
	.201		5.19
	.191		9.91
N_2-NH_3	.269	.248	8.47
	.250		0.81
	.237		4.44
N_2-C_2H_4	.181	.163	11.0
	.174		6.75
	.169		3.68
N_2-nC_4H_{10}	.0976	.096	1.67
	.0975		1.56
	.0979		1.98
N_2-iC_4H_{10}	.0954	.0905	5.41
	.0956		5.64
	.0962		6.30

TABLE VIII (CONT'D)

System	DP		% Error
	calculated	observed	
N_2-nC_6H_{14}	.0710	.0757	6.21
	.0728		3.83
	.0747		1.32
N_2-cyclohex	.0810	.0760	6.58
	.0817		7.50
	.0828		8.95
N_2-MCP	.0790	.0760	3.95
	.0800		5.27
	.0813		6.97
N_2-nC_7H_{16}	.0630	.0740	14.9
	.0653		11.8
	.0676		8.65
N_2-2,4 DMP	.0637	.0744	14.4
	.0660		11.3
	.0682		8.34
N_2-nC_8H_{18}	.0565	.0726	22.2
	.0592		18.5
	.0618		14.9
N_2-C_6H_6	.0918	.1022	10.0
	.0914		10.4
	.0916		10.2
O_2-nC_6H_{14}	.0735	.0753	2.39
	.0733		2.66
	.0743		1.33

TABLE VIII (CONT'D)

System	DP		% Error
	calculated	observed	
O_2-cyclohex	.0830	.0744	11.6
	.0826		11.0
	.0827		11.2
O_2-MCP	.0810	.0742	9.16
	.0808		8.90
	.0811		9.30
O_2-nC_8H_{18}	.0572	.0705	18.9
	.0590		16.3
	.0610		13.5
O_2-C_6H_6	.0945	.1011	15.5
	.0927		8.22
	.0919		9.01
Ar-Kr	.164	.1400	17.1
	.147		5.00
	.136		2.86
Ar-CO	.215	.1880	14.4
	.198		5.32
	.186		1.06
Ar-NH_3	.276	.2320	19.0
	.252		8.62
	.235		1.29

TABLE VIII (CONT'D)

System	DP		% Error
	calculated	observed	
Ar-nC_6H_{14}	.0661	.0663	0.30
	.0663		0.0
	.0669		0.91
Ar-cyclohex	.0757	.0719	5.29
	.0748		4.04
	.0745		3.62
Ar-MCP	.0739	.0731	1.09
	.0731		0.0
	.0731		0.0
Ar-nC_7H_{16}	.0582	.0658	11.6
	.0590		10.3
	.0605		8.06
Ar-2,4 DMP	.0589	.0655	10.1
	.0596		9.01
	.0607		7.33
Ar-nC_8H_{18}	.0518	.0587	11.8
	.0531		9.55
	.0545		7.16
CO-CO_2	.187	.152	23.0
	.174		14.5
	.165		8.65
CO-NH_3	.264	.240	10.0
	.246		2.50
	.234		2.50

TABLE VIII (CONT'D)

System	DP		% Error
	calculated	observed	
CO_2-N_2O	.159	.1170	35.9
	.147		25.6
	.138		18.0
N_2O-C_3H_8	.0518	.086	18.6
	.0531		15.5
	.0545		13.8
Air-Cl_2	.149	.124	20.2
	.140		12.9
	.134		8.07
Air-Br_2	.132	.0910	45.1
	.123		3.52
	.117		28.6
Air-chloro C_6H_6	.0782	.0740	5.68
	.0784		5.95
	.0791		6.90
Air-ethylacetate	.0850	.0870	2.30
	.0849		2.42
	.0853		1.95

TABLE IX

Data: Effect of Various Exponents for Critical Volume Term

Note: log α term data show in order 0.4 and 0.33 exponent use for y.

System	log DP	V_{c_1}	V_{c_2}	$\log\left[\frac{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{y}+V_{c_2}^{y}\right)^{2}}\right]$
H_2-N_2	-0.10846	41.6	83.9	-2.16486
				-1.91420
N_2-Ar	-0.08197	41.6	67.1	-2.12590
				-1.88344
H_2-CO_2	-0.18977	41.6	107	-2.21930
				-1.95908
H_2-NH_3	-0.06753	41.6	89.5	-2.17244
				-1.91930
He-N_2	-0.12901	28.7	83.9	-2.24681
				-2.00381
He-Ar	-0.12263	28.7	67.1	-2.20891
				-1.97501
He-CO_2	-0.21325	28.7	107	-2.30899
				-2.05551
He-NH_3	-0.07469	28.7	89.5	-2.25073
				-2.00501
air-CO_2	-0.78252	79.6	107	-2.79694
				-2.52134

TABLE IX (CONT'D)

System	log DP	V_{e_1}	V_{e_2}	log α
air-NH_3	-0.60730	79.6	89.5	-2.68307
				-2.41331
N_2-CO_2	-0.78252	83.9	107	-2.80111
				-2.52411
Ne-Ar	-0.48545	36.5	67.1	-2.52800
				-2.28878
He-CO	-0.15366	28.7	77.8	-2.23101
				-1.99107
N_2-Ar	-0.71220	83.9	67.1	-2.71156
				-2.44876
N_2-CO	-0.67366	83.9	77.8	-2.70123
				-2.43413
N_2-NH_3	-0.60555	83.9	89.5	-2.68899
				-2.41771
Ar-Kr	-0.85387	67.1	71.9	-2.79204
				-2.53410
Ar-CO	-0.72584	67.1	77.8	-2.69794
				-2.43750
Ar-NH_3	-0.63451	67.1	89.5	-2.68093
				-2.41597
CO-CO_2	-0.81816	77.8	107	-2.78873
				-2.51371

TABLE IX (CONT'D)

System	log DP	V_{c_1}	V_{c_2}	log α
$CO-NH_3$	-0.61979	77.8	89.5	-2.67613
				-2.40697
CO_2-H_2O	-0.93181	107	98.17	-2.88209
				-2.60055
air-Cl_2	-0.90658	79.6	117	-2.84896
				-2.57026
air-Br_2	-1.04096	79.6	131	-2.90827
				-2.62563
$CO_2-C_3H_8$	-1.06399	107	218	-3.02937
				-2.72087
air-CH_4	-0.64975	79.6	93.9	-2.65909
				-2.38770
$N_2-C_2H_6$	-0.82974	83.9	145	-2.82191
				-2.53427
air-C_6H_6	-1.01682	79.6	246	-3.00327
				-2.69589
H_2-CH_4	-0.13906	41.6	93.9	-2.17686
				-1.92170
$H_2-C_2H_6$	-0.27005	41.6	145	-2.27927
				-2.00603
$H_2-nC_4H_{10}$	-0.44249	41.6	256	-2.41403
				-2.11435

TABLE IX (CONT'D)

System	log DP	V_{e_1}	V_{e_2}	log α
H_2-nC_6H_{14}	-0.53760	41.6	347	-2.48958
				-2.17402
H_2-cyclohexane	-0.49621	41.6	380	-2.51113
				-2.19139
H_2-nC_7H_{16}	-0.54821	41.6	489	-2.57486
				-2.24162
H_2-nC_8H_{18}	-0.55752	41.6	696	-2.66634
				-2.31352
H_2-C_6H_6	-0.39405	41.6	246	-2.40654
				-2.10890
H_2-2,4 DMP	-0.52724	41.6	420	-2.53664
				-2.21166
He-nC_7H_{16}	-0.57675	28.7	489	-2.68660
				-2.35510
He-nC_8H_{18}	-0.60555	28.7	696	-2.78174
				-2.42998
He-2,4 DMP	-0.58004	28.7	420	-2.64663
				-2.32399
He-C_6H_6	-0.41567	28.7	246	-2.50911
				-2.21603
N_2-C_2H_4	-0.78781	83.9	132	-2.79655
				-2.51227

TABLE IX (CONT'D)

System	log DP	V_{c_1}	V_{c_2}	log α
N_2-nC_4H_{10}	-1.01773	83.9	256	-2.99461
				-2.68453
N_2-iC_4H_{10}	-1.04335	83.9	256	-2.99461
				-2.68453
N_2-nC_6H_{14}	-1.12090	83.9	347	-3.08535
				-2.76139
N_2-cyclohexane	-1.11919	83.9	380	-3.10375
				-2.77615
N_2-MCP	-1.11919	83.9	206	-2.97229
				-2.67121
N_2-nC_7H_{16}	-1.13077	83.9	489	-3.17026
				-2.83066
N_2-2,4 DMP	-1.12843	83.9	420	-3.13474
				-2.80252
N_2-nC_8H_{18}	-1.13906	83.9	696	-3.25998
				-2.90270
N_2-C_6H_6	-0.99055	83.9	246	-3.00501
				-2.69669
O_2-nC_6H_{14}	-1.12321	68.0	347	-3.08087
				-2.75989
O_2-cyclohexane	-1.12843	68.0	380	-3.09974
				-2.77494

TABLE IX (CONT'D)

System	log DP	V_{c_1}	V_{e_2}	log α
O_2-MCP	-1.12960	68.0	206	-2.96410
				-2.66710
O_2-nC_8H_{18}	-1.15181	68.0	696	-3.26131
				-2.90575
O_2-C_6H_6	-0.99525	68.0	246	-2.99764
				-2.69302
Ar-nC_6H_{14}	-1.17840	67.1	347	-3.11376
				-2.79296
Ar-cyclohexane	-1.14327	67.1	380	-3.13238
				-2.80776
Ar-MCP	-1.13698	67.1	206	-2.99648
				-2.69972
Ar-nC_7H_{16}	-1.18177	67.1	489	-3.20324
				-2.86612
Ar-2,4 DMP	-1.18376	67.1	420	-3.16656
				-2.83710
Ar-nC_8H_{18}	-1.23136	67.1	696	-3.29712
				-2.94164
N_2O-C_3H_8	-1.06550	98.1	218	-3.01655
				-2.70995
air-chloro-benzene	-1.13077	79.6	206	-2.99485
				-2.69481
air-ethyl-acetate	-1.06048	79.6	201	-2.96697
				-2.66857

TABLE X

Results: Effect of Various Exponents for Critical Volume Term

Note: The two results calculated for each system refer to use of 0.4 and 0.33 exponent, respectively (See Data, Table IX)

System	DP calculated	DP observed	% Error
H_2-N_2	.795	.779	2.06
	.792		1.67
H_2-Ar	.944	.828	14.0
	.860		3.87
H_2-CO_2	.693	.646	7.28
	.701		8.51
H_2-NH_3	.780	.856	8.88
	.781		8.76
He-N_2	.647	.743	12.9
	.621		16.4
He-Ar	.712	.754	5.57
	.671		11.0
He-CO_2	.553	.612	9.64
	.540		11.8
He-NH_3	.641	.842	23.9
	.619		25.3
air-CO_2	.162	.165	1.82
	.153		7.27

TABLE X (CONT'D)

System	DP		% Error
	calculated	observed	
air-NH_3	.216	.247	12.6
	.205		17.0
N_2-CO_2	.161	.165	2.42
	.152		7.88
Ne-Ar	.319	.327	2.45
	.287		12.2
He-CO	.673	.702	4.13
	.643		8.41
N_2-Ar	.201	.194	3.61
	.186		4.12
N_2-CO	.206	.212	2.83
	.193		8.96
N_2-NH_3	.213	.248	14.1
	.202		18.5
Ar-Kr	.164	.140	17.1
	.148		5.71
Ar-CO	.208	.188	10.6
	.192		2.13
Ar-NH_3	.217	.232	6.46
	.203		12.5
CO-CO_2	.166	.152	9.21
	.156		2.63

TABLE X (CONT'D)

System	DP		% Error
	calculated	observed	
CO-NH_3	.220	.240	8.34
	.208		13.3
CO_2-N_2O	.131	.117	12.0
	.123		5.12
Air-Cl_2	.142	.124	14.5
	.134		8.06
Air-Br_2	.123	.091	35.2
	.115		26.4
CO_2-C_3H_8	.090	.086	4.65
	.089		3.49
Air-CH_4	.229	.224	2.23
	.219		2.23
N_2-C_2H_6	.152	.148	2.70
	.147		0.68
Air-C_6H_6	.097	.096	1.04
	.095		1.04
H_2-CH_4	.772	.726	6.33
	.775		6.75
H_2-C_2H_6	.596	.537	11.0
	.617		14.9
H_2-nC_4H_{10}	.425	.361	17.7
	.460		27.4

TABLE X (CONT'D)

System	DP calculated	DP observed	% Error
H_2-nC_6H_{14}	.351	.290	21.0
	.391		34.8
H_2-cyclohex	.333	.319	4.39
	.373		16.9
H_2-nC_7H_{16}	.284	.283	0.35
	.326		15.2
H_2-nC_8H_{18}	.225	.277	18.8
	.268		3.24
H_2-C_6H_6	.433	.404	7.18
	.467		15.6
H_2-2,4 DMP	.312	.297	5.15
	.353		18.9
He-nC_7H_{16}	.214	.265	19.3
	.240		5.67
He-nC_8H_{18}	.169	.248	31.8
	.196		21.0
He-2,4 DMP	.237	.263	9.89
	.261		0.76
He-C_6H_6	.335	.384	12.8
	.349		9.11
N_2-C_2H_4	.162	.163	0.61
	.157		3.68

TABLE X (CONT'D)

System	DP calculated	DP observed	% Error
N_2-nC_4H_{10}	.099	.096	3.12
	.098		2.08
N_2-iC_4H_{10}	.099	.091	8.79
	.098		7.70
N_2-nC_6H_{14}	.079	.076	3.95
	.080		5.27
N_2-cyclohex	.075	.076	1.32
	.077		1.32
N_2-MCP	.104	.076	36.9
	.102		34.2
N_2-nC_7H_{16}	.063	.074	14.9
	.066		16.2
N_2-2,4 DMP	.069	.074	6.76
	.071		9.46
N_2-nC_8H_{18}	.051	.073	30.2
	.054		26.0
N_2-C_6H_6	.096	.102	5.88
	.095		6.87
O_2-nC_6H_{14}	.079	.075	5.33
	.080		6.67
O_2-cyclohex	.076	.074	2.70
	.077		4.05

TABLE X (CONT'D)

System	DP		% Error
	calculated	observed	
O_2-MCP	.107	.074	44.6
	.103		39.2
O_2-nC_8H_{18}	.051	.071	28.2
	.052		26.8
O_2-C_6H_6	.098	.101	2.97
	.096		4.95
Ar-nC_6H_{14}	.073	.066	10.6
	.073		10.6
ar-cyclohex	.070	.072	2.78
	.070		2.78
ar-MCP	.098	.073	34.3
	.094		28.8
Ar-nC_7H_{16}	.058	.066	12.1
	.060		9.10
Ar-2,4 DMP	.064	.066	3.03
	.065		1.52
Ar-nC_8H_{18}	.046	.059	22.0
	.049		17.0
N_2O-C_3H_8	.093	.086	8.14
	.092		6.97
Air-Cl Bz	.099	.074	33.8
	.096		29.7

TABLE X (CONT'D)

System	DP		% Error
	calculated	observed	
Air-Et Acetate	.106	.087	21.8
	.102		17.2

average % error: $V_c^{.4}$ 11.7

$V_c^{.33}$ 11.8

TABLE XI

Precision Check of the Final DP Function

$$DP = f\left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{0.5}}{\left(V_{c_1}^{0.4} + V_{c_2}^{0.4}\right)^2}\right] = f\ \alpha$$

System	V_{c_1}	V_{c_2}	log α	DP calc	% Error
H_2-N_2	41.6	90.1	-2.17904	.767	1.54
H_2-Ar	41.6	67.1	-2.12590	.877	5.92
H_2-CO_2	41.6	94.0	-2.19290	.741	14.7
H_2-NH_3	41.6	72.4	-2.13076	.867	1.29
He-N_2	28.7	90.1	-2.26187	.622	16.3
He-Ar	28.7	67.1	-2.20891	.711	5.71
He-CO_2	28.7	94.0	-2.28101	.593	3.10
He-NH_3	28.7	72.4	-2.20639	.716	15.0
Air-CO_2	86.6	94.0	-2.78772	.165	0.0
Air-NH_3	86.6	72.4	-2.66119	.227	8.10
N_2-CO_2	90.1	94.0	-2.79002	.164	0.61
Ne-Ar	36.5	67.1	-2.52800	.318	2.75
He-CO	28.7	93.1	-2.26889	.611	13.0
N_2-Ar	90.1	67.1	-2.72456	.194	0.0
N_2-CO	90.1	93.1	-2.74469	.184	13.2
N_2-NH_3	90.1	72.4	-2.66521	.225	9.28
Ar-Kr	67.1	71.9	-2.79204	.163	16.4
Ar-CO	67.1	93.1	-2.73062	.191	1.60
Ar-NH_3	67.1	72.4	-2.64273	.238	2.58

TABLE XI (CONT'D)

System	V_{c_1}	V_{c_2}	log α	DP calc	% Error
$CO-CO_2$	93.1	94.0	-2.79569	.162	6.58
$CO-NH_3$	93.1	72.4	-2.67119	.221	7.92
CO_2-N_2O	94.0	96.3	-2.85623	.139	18.8
$Air-Cl_2$	86.6	124.	-2.87336	.133	7.26
$Air-Br_2$	86.6	114.	-2.91969	.118	29.7
$CO_2-C_3H_8$	94.0	200.	-2.97306	.103	19.8
$Air-CH_4$	86.6	99.3	-2.68324	.215	4.02
$N_2-C_2H_6$	90.1	148.	-2.83689	.146	1.35
$Air-C_6H_6$	86.6	260.	-3.02645	.090	6.25
H_2-CH_4	41.6	99.3	-2.18816	.750	3.31
$H_2-C_2H_6$	41.6	148.	-2.26367	.590	9.87
$H_2-nC_4H_{10}$	41.6	255.	-2.41309	.426	18.0
$H_2-nC_6H_{14}$	41.6	368.	-2.50480	.337	16.2
H_2-cyclohex	41.6	308.	-2.46009	.377	18.2
$H_2-nC_7H_{16}$	41.6	426.	-2.54016	.308	8.84
$H_2-nC_8H_{18}$	41.6	485.	-2.57328	.284	4.70
$H_2-C_6H_6$	41.6	260.	-2.41952	.418	3.46
H_2-2,4 DMP	41.6	420.	-2.53664	.311	4.72
$He-nC_7H_{16}$	28.7	426.	-2.65036	.233	12.1
$He-nC_8H_{18}$	28.7	485.	-2.68526	.214	13.7
He-2,4 DMP	28.7	420.	-2.64663	.236	10.3
$He-C_6H_6$	28.7	260.	-2.52337	.322	16.2
$H_2-C_2H_4$	90.1	124.	-2.79623	.162	0.61

TABLE XI (CONT'D)

System	V_{c_1}	V_{c_2}	log α	DP calc	% Error
N_2-nC_4H_{10}	90.1	255.	-3.00349	.096	0.0
N_2-iC_4H_{10}	90.1	263.	-3.01055	.094	3.30
N_2-nC_6H_{14}	90.1	368.	-3.10815	.074	2.63
N_2-cyclohex	90.1	308.	-3.06653	.082	7.90
N_2-MCP	90.1	319.	-3.07413	.080	5.27
N_2-nC_7H_{16}	90.1	426.	-3.14698	.067	9.45
N_2-2,4 DMP	90.1	420.	-3.14334	.067	9.45
N_2-nC_8H_{18}	90.1	485.	-3.18240	.061	16.5
N_2-C_6H_6	90.1	260.	-3.02643	.090	11.8
O_2-nC_6H_{14}	74.4	368.	-3.10577	.074	1.33
O_2-cyclohex	74.4	308.	-3.06296	.082	10.8
O_2-MCP	74.4	319.	-3.07078	.081	9.47
O_2-nC_8H_{18}	74.4	485.	-3.18309	.061	14.1
O_2-C_6H_6	74.4	260.	-3.02138	.092	8.91
Ar-nC_6H_{14}	67.1	368.	-3.12806	.070	6.06
Ar-cyclohex	67.1	308.	-3.08438	.078	8.34
Ar-MCP	67.1	319.	-3.09230	.077	5.48
Ar-nC_7H_{16}	67.1	426.	-3.17046	.063	4.55
Ar-2,4 DMP	67.1	420.	-3.16656	.063	4.55
Ar-nC_8H_{18}	67.1	485.	-3.20888	.057	3.39
N_2O-C_3H_8	96.3	200.	-2.99663	.097	12.8
Air- Cl Bz	86.6	308.	-3.08141	.079	6.76
Air-ethylacet.	86.6	286.	-3.05303	.085	2.30

TABLE XII

Evaluation of $DP = (6.22 \times 10^{6})\ \mu^{2.6}\ \alpha^{1.096}$

System	T	$\mu^{2.6} \times 10^{5}$	DP calculated	DP observed	% Error
H_2-N_2	193	1.20	.305	.368	17.12
	200	1.29	.315	.401	21.45
	253	2.09	.511	.600	14.83
	273	2.51	.613	.708	13.42
	288	2.82	.689	.743	7.27
	294	3.02	.738	.763	3.28
	297	3.02	.738	.779	5.26
	300	3.02	.738	.800	7.75
	304	3.16	.772	.852	9.39
	322	3.55	.868	.903	3.88
	398	5.49	1.342	1.289	4.11
	400	5.49	1.342	1.270	5.67
	450	6.92	1.691	1.541	9.73
	506	8.32	2.033	1.883	7.97
	573	10.5	2.566	2.417	6.16
H_2-Ar	288	2.82	.821	.828	0.85
	354	4.26	1.240	1.111	11.61
	418	5.88	1.712	1.714	0.12
H_2-CO_2	289	2.82	.693	.619	11.95
	298	3.02	.742	.646	14.86

TABLE XII (CONT'D)

System	T	$\mu^{2.6} \times 10^5$	DP		% Error
			calculated	observed	
H_2-NH_3	273	2.51	.721	.745	3.22
	293	2.95	.848	.834	1.68
	297	3.02	.868	.856	1.40
	333	3.80	1.092	1.021	6.95
	413	5.75	1.652	1.435	15.12
	533	8.71	2.503	2.149	16.47
He-N_2	300	3.02	.624	.743	16.02
	323	3.55	.733	.766	4.31
	353	4.26	.880	.893	1.46
	383	4.78	.987	1.077	8.36
	413	5.75	1.187	1.200	1.08
	443	6.61	1.365	1.289	5.90
	473	7.24	1.495	1.569	4.72
	498	8.13	1.679	1.650	1.76
	600	11.2	2.313	2.400	3.63
	900	21.4	4.419	4.760	7.16
	1200	34.7	7.166	7.740	7.42
He-Ar	276	2.63	.620	.646	4.02
	288	2.82	.665	.697	4.59
	298	3.02	.712	.754	5.57
	317	3.39	.799	.797	0.25
	323	3.55	.837	.809	3.46

TABLE XII (CONT'D)

System	T	$\mu^{2.6} \times 10^5$	DP		% Error
			calculated	observed	
	346	4.07	.959	.924	3.79
	353	4.26	1.004	.978	2.66
	383	4.78	1.127	1.122	0.45
	413	5.75	1.356	1.237	9.62
	418	5.88	1.386	1.398	0.86
	443	6.61	1.558	1.401	11.21
	473	7.24	1.707	1.612	5.89
	498	8.13	1.917	1.728	10.94
	500	8.32	1.961	1.860	5.43
	1000	26.3	6.200	6.250	0.80
	1100	28.8	6.789	7.380	8.01
$He-CO_2$	276	2.63	.517	.531	2.57
	298	3.02	.594	.612	2.94
	317	3.39	.666	.661	0.76
	323	3.55	.698	.678	2.95
	346	4.07	.800	.764	4.71
	353	4.26	.837	.800	4.63
	383	4.78	.940	.884	6.33
	413	5.75	1.130	1.040	8.65
	443	6.61	1.299	1.133	14.65
	473	7.24	1.423	1.279	11.26
	498	8.13	1.598	1.414	13.01

TABLE XII (CONT'D)

System	T	$\mu^{2.6} \times 10^5$	DP		% Error
			calculated	observed	
Air-CO_2	276	2.63	.144	.142	1.41
	293	2.95	.161	.165	2.42
	317	3.39	.186	.177	5.08
Air-NH_3	295	3.02	.227	.247	8.10
N_2-CO_2	289	2.82	.153	.158	3.16
	293	2.95	.161	.163	1.23
	298	3.02	.164	.165	0.61
	300	3.02	.164	.173	5.20
	600	11.2	.610	.605	0.83
	900	21.4	1.165	1.217	4.27
	1200	34.7	1.889	1.976	4.40
Ne-Ar	195	1.20	.127	.153	16.99
	273	2.51	.265	.271	2.21
	288	2.82	.298	.300	0.67
	303	3.16	.334	.327	2.14
	318	3.39	.358	.357	0.28
	353	4.26	.450	.414	8.70
	473	7.24	.766	.671	14.16
He-CO	296	3.02	.612	.702	12.82
N_2-CO	290	2.82	.172	.211	18.48
	296	3.02	.184	.212	13.21

TABLE XII (CONT'D)

System	T	$\mu^{2.6} x 10^5$	DP calculated	DP observed	% Error
N_2-NH_3	295	3.02	.225	.248	9.27
Ar-Kr	200	1.29	.070	.072	2.78
	273	2.51	.136	.126	7.94
	288	2.82	.153	.128	19.53
	303	3.16	.171	.140	22.14
	318	3.39	.184	.153	20.26
	353	4.26	.231	.197	17.26
	373	4.79	.260	.216	20.37
	473	7.24	.392	.327	19.88
Ar-CO	296	3.02	.192	.188	2.13
Ar-NH_3	295	3.02	.239	.232	3.02
CO-CO_2	296	3.02	.162	.152	6.58
CO-NH_3	295	3.02	.222	.240	7.50
CO_2-N_2O	195	1.20	.055	.053	3.77
	273	2.51	.116	.099	17.17
	287	2.82	.130	.107	21.50
	298	3.02	.139	.117	18.80
	313	3.39	.156	.128	21.88
	363	4.57	.211	.168	25.60
Air-Cl_2	293	2.95	.130	.124	4.84
Air-Br_2	293	2.95	.116	.091	27.47
CO_2-C_3H_8	298	3.02	.103	.086	19.77

TABLE XII (CONT'D)

System	T	$\mu^{2.6} \times 10^5$	DP calculated	DP observed	% Error
Air-CH_4	289	2.82	.202	.219	7.76
	295	3.02	.216	.224	3.57
N_2-C_2H_6	298	3.02	.146	.148	1.35
Air-C_6H_6	298	3.02	.091	.096	5.21
	308	3.09	.093	.102	8.82
H_2-CH_4	298	3.02	.751	.726	3.44
H_2-C_2H_6	298	3.02	.590	.537	9.87
H_2-nC_4H_{10}	288	2.82	.398	.361	10.25
	354	4.26	.601	.507	18.54
	430	6.16	.870	.763	14.02
H_2-nC_6H_{14}	289	2.82	.316	.290	8.97
H_2-cyclohex	289	2.82	.353	.319	10.66
H_2-nC_7H_{16}	303	3.16	.322	.283	13.78
H_2-nC_8H_{18}	303	3.16	.297	.277	7.22
H_2-C_6H_6	311	3.31	.459	.404	13.37
H_2-2,4 DMP	303	3.16	.326	.297	9.76
He-nC_7H_{16}	3-3	3.16	.246	.265	7.17
He-nC_8H_{18}	303	3.16	.224	.248	9.68
He-2,4 DMP	303	3.16	.248	.263	5.70
He-C_6H_6	298	3.02	.323	.384	15.89
	423	6.17	.660	.610	8.20

TABLE XII (CONT'D)

System	T	$\mu^{2.6} \times 10^5$	DP calculated	DP observed	% Error
	463	6.92	.740	.715	3.50
	503	8.32	.890	.815	9.20
	523	8.71	.932	.861	8.25
N_2-C_2H_4	298	3.02	.162	.163	0.61
N_2-nC_4H_{10}	298	3.02	.096	.096	0
N_2-iC_4H_{10}	298	3.02	.094	.091	3.30
N_2-nC_6H_{14}	289	2.82	.069	.076	9.21
N_2-cyclohex	289	2.82	.076	.076	0
N_2-MCP	289	2.82	.075	.076	1.32
N_2-nC_7H_{16}	303	3.16	.070	.074	5.41
N_2-2,4 DMP	303	3.16	.071	.074	4.06
N_2-nC_8H_{18}	303	3.16	.064	.073	12.33
N_2-C_6H_6	311	3.31	.099	.102	2.94
O_2-nC_6H_{14}	289	2.82	.069	.075	8.00
O_2-cyclohex	289	2.82	.077	.074	4.06
O_2-MCP	287	2.82	.076	.074	1.35
O_2-nC_8H_{18}	303	3.16	.064	.071	9.86
O_2-C_6H_6	311	3.31	.100	.101	9.90
Ar-nC_6H_{14}	289	2.82	.065	.066	1.52
Ar-cyclohex	289	2.82	.073	.072	1.39
Ar-MCP	287	2.82	.072	.073	1.37
Ar-nC_7H_{16}	303	3.16	.066	.066	0

TABLE XII (CONT'D)

System	T	$\mu^{2.6} \times 10^5$	DP calculated	DP observed	% Error
Ar-2,4 DMP	303	3.16	.066	.066	0
Ar-nC_8H_{18}	303	3.16	.060	.059	1.70
$N_2O-C_3H_8$	298	3.02	.098	.086	13.95
Air-Chl Bz	299	3.02	.079	.074	6.76
	313	3.39	.089	.079	12.67
	333	3.80	.099	.090	10.00
Air-ethyl-acetate	299	3.02	.085	.087	2.30
	313	3.39	.095	.094	1.06
	333	3.80	.107	.106	0.94

TABLE XIII

Evaluation of $DP = (4.20 \times 10^6)\mu^{2.5}\alpha^{1.096}$
and $DP = (5.68 \times 10^6)\mu^{2.0}\alpha^{1.096}$

System	T	kT/ε = 1.30 Tr	$\mu^{2.5} \times 10^5$	DP calc	% Error
H_2-N_2	193	> 2.5	1.86	.320	13.04
T_c=64.8	200		1.99	.342	14.70
	253		3.16	.543	9.50
	273		3.71	.638	9.88
	288		4.26	.733	1.35
	294		4.47	.770	0.92
	297		4.47	.770	1.15
	300		4.47	.770	3.75
	304		4.68	.805	5.51
	322		5.37	.923	2.22
	398		7.94	1.364	5.81
	400		7.94	1.364	7.40
	450		9.88	1.700	10.32
	506		12.0	2.065	9.67
	573		15.1	2.595	7.39
H_2-Ar	288	> 2.5	4.26	.838	1.21
T_c=70.9	354		6.31	1.240	11.61
	418		8.51	1.675	2.28
H_2CO_2	289	> 2.5	4.26	.707	14.22
T_c= 101	298		4.47	.741	14.70

TABLE XIII (CONT'D)

System	T	$kT/\varepsilon = 1.30\ T_r$	$\mu^{2.5} \times 10^5$	DP calc	% Error
H_2-NH_3	273	> 2.5	3.71	.719	3.49
T_c=116	293		4.46	.863	3.48
	297		4.47	.865	1.05
	333		5.62	1.088	6.56
	413		8.41	1.630	13.60
	533		13.2	2.555	18.90
He-N_2	300	> 2.5	4.47	.623	16.15
T_c=25.7	323		5.37	.750	2.14
	353		6.31	.880	1.46
	383		7.08	.985	9.33
	413		8.51	1.187	1.08
	443		9.44	1.315	2.02
	473		10.7	1.490	4.79
	498		11.5	1.604	2.78
	600		15.8	2.205	8.85
	900		30.6	4.270	10.30
	1200		46.5	6.490	16.18
He-Ar	276	> 2.5	3.98	.634	1.86
T_c=28.2	288		4.26	.678	2.72
	298		4.47	.711	5.70
	317		5.01	.797	0.00
	323		5.37	.855	5.70

TABLE XIII (CONT'D)

System	T	kT/ε = 1.30 T_r	$\mu^{2.5}$x 10^5	DP calc	% Error
	346		5.88	.936	1.30
	353		6.31	1.050	7.37
	383		7.08	1.128	0.54
	413		8.51	1.354	9.47
	418		8.51	1.354	3.14
	443		9.44	1.501	7.14
	473		10.7	1.703	5.64
	498		11.5	1.831	5.96
	500		11.7	1.862	0.01
	1000		35.5	5.650	10.62
	1100		39.8	6.340	16.40
He-CO_2	276	> 2.5	3.98	.528	0.55
T_c = 40.0	298		4.47	.594	2.94
	317		5.01	.665	0.61
	323		5.37	.714	5.31
	346		5.88	.780	2.10
	353		6.31	.837	4.63
	383		7.08	.940	6.33
	413		8.51	1.130	8.65
	443		9.44	1.253	10.59
	473		10.7	1.420	11.03
	498		11.5	1.527	7.98

TABLE XIII (CONT'D)

System	T	kT/ε = 1.30 T_r	$\mu^{2.5} \times 10^5$	DP calc	% Error
He-NH_3	297	> 2.5	4.47	.718	14.72
$T_c = 46.2$					
			$\mu^{2.0} \times 10^5$		
Air-CO_2	276	< 2.5	3.02	.151	6.34
$T_c = 201$	293		3.31	.165	0.00
	317		3.63	.181	2.25
Air-NH_3	295	< 2.5	3.31	.228	7.69
$T_c = 232$					
N_2-CO_2	289	< 2.5	3.16	.157	0.63
T_c=196	293		3.31	.165	1.23
	298		3.31	.165	0.00
	300		3.47	.173	0.00
		> 2.5	$\mu^{2.5} \times 10^5$		
	600		1.58	.580	4.13
	900		3.02	1.110	8.80
	1200		4.78	1.758	10.93
Ne-Ar	195	> 2.5	1.86	.133	13.07
$T_c = 82.0$	273		3.71	.265	2.21
	288		4.26	.304	1.33
	303		4.68	.335	2.44
	318		5.01	.358	0.28
	353		6.31	.451	8.92
	473		10.7	.765	14.01

TABLE XIII (CONT'D)

System	T	$kT/\varepsilon = 1.30\ T_r$	$\mu^{2.5} \times 10^5$	DP calc	% Error
He-CO	296	> 2.5	4.47	.612	12.82
$T_c = 26.4$					
N_2-Ar	293	> 2.5	4.46	.193	0.52
$T_c = 138$					
N_2-CO	290	> 2.5	4.26	.175	17.02
$T_c = 129$	296		4.47	.184	13.21
			$\mu^{2.0} \times 10^5$		
N_2-NH_3	295	< 2.5	3.31	.226	8.88
$T_c = 171$					
Ar-Kr	200	< 2.5	1.74	.086	19.50
$T_c = 178$	273		2.88	.142	12.70
	288		3.16	.156	17.95
	303		3.46	.171	22.14
	318		3.63	.179	17.00
			$\mu^{2.5} \times 10^5$		
	353	> 2.5	6.31	.231	17.26
	373		7.08	.259	19.90
	473		10.7	.391	19.58
Ar-CO	296	> 2.5	4.47	.192	2.13
$T_c = 142$					

TABLE XIII (CONT'D)

System	T	$kT/\varepsilon = 1.30\ T_r$	$\mu^{2.0} \times 10^5$	DP calc	% Error
Ar-NH_3	295	< 2.5	3.31	.238	2.58
T_c = 248					
CO-CO_2	296	< 2.5	3.31	.162	6.58
T_c = 201					
CO-NH_3	295	< 2.5	3.31	.222	7.50
T_c = 232					
CO_2-N_2O	195	< 2.5	1.66	.070	32.10
T_c = 307	273		2.88	.121	22.21
	287		3.16	.133	19.55
	298		3.31	.139	18.80
	313		3.63	.152	18.78
	363		4.57	.192	14.29
Air-Cl_2	293	< 2.5	3.31	.133	7.26
T_c = 235					
Air-Br_2	293	< 2.5	3.31	.118	29.70
T_c = 279					
CO_2-C_3H_8	298	< 2.5	3.31	.103	19.77
T_c = 335					

TABLE XIII (CONT'D)

System	T	$kT/\varepsilon = 1.30\ T_r$	$\mu^{2.0} \times 10^5$	DP calc	% Error
Air-cyclohex	289	< 2.5	3.16	.206	5.93
$T_c = 259$	295		3.31	.216	3.57
N_2-C_2H_6	298	< 2.5	3.31	.146	1.35
$T_c = 296$					
Air-C_6H_6	298	< 2.5	3.31	.091	5.21
$T_c = 296$	308		3.46	.095	6.86
			$\mu^{2.5} \times 10^5$		
H_2-CH_4	298	> 2.5	4.47	.753	3.72
$T_c = 79.8$					
H_2-C_2H_6	298	> 2.5	4.47	.590	9.87
$T_c = 102$					
H_2-nC_4H_{10}	288	> 2.5	4.26	.406	12.45
$T_c = 119$	354		6.31	.602	18.73
	430		8.91	.850	11.89
H_2-nC_6H_{14}	289	> 2.5	4.26	.322	11.02
$T_c = 130$					
H_2-cyclohex	289	> 2.5	4.26	.370	16.00
$T_c = 136$					
$H_2nC_7H_{16}$	303	> 2.5	4.68	.322	13.78
$T_c = 134$					

TABLE XIII (CONT'D)

System	T	$kT/\varepsilon = 1.30\ T_r$	$\mu^{2.5} \times 10^5$	DP calc	% Error
H_2-nC_8H_{18}	303	> 2.5	4.68	.296	6.86
$T_c = 138$					
H_2-C_6H_6	311	> 2.5	5.01	.469	16.10
$T_c = 137$					
H_2-2,4 DMP	303	> 2.5	4.68	.327	10.01
$T_c = 132$					
He-nC_7H_{16}	303	> 2.5	4.68	.246	7.17
$T_c = 53.3$					
He-nC_8H_{18}	303	> 2.5	4.68	.224	9.68
$T_c = 54.7$					
He-2,4 DMP	303	> 2.5	4.68	.248	5.70
$T_c = 52.3$					
He-C_6H_6	298	> 2.5	4.47	.323	15.89
$T_c = 54.4$	423		8.91	.644	5.57
	463		10.0	.722	0.98
	503		12.0	.866	5.89
	523		12.6	.910	5.38
			$\mu^{2.0} \times 10^5$		
H_2-C_2H_4	298	< 2.5	3.31	.162	0.61
$T_c = 189$					

TABLE XIII (CONT'D)

System	T	kT/ε = 1.30 Tr	$\mu^{2.0} \times 10^5$	DP calc	% Error
N_2-nC_4H_{10} T_c = 231	298	< 2.5	3.31	.096	0.00
N_2-iC_4H_{10} T_c = 227	298	< 2.5	3.31	.094	3.30
N_2-nC_6H_{14} T_c = 253	289	< 2.5	3.16	.070	8.57
N_2-cyclohex T_c = 264	289	< 2.5	3.16	.078	2.56
N_2-MCP T_c = 259	289	< 2.5	3.16	.077	1.32
N_2-nC_7H_{16} T_c = 261	303	< 2.5	3.46	.070	5.41
N_2-2,4 DMP T_c = 256	303	< 2.5	3.46	.071	4.06
N_2-nC_8H_{18} T_c = 268	303	< 2.5	3.46	.064	12.33
N_2-C_6H_6 T_c = 266	311	< 2.5	3.63	.099	2.94

TABLE XIII (CONT'D)

System	T	kT/ε = 1.30 T_r	$\mu^{2.0} \times 10^5$	DP calc	% Error
O_2-nC_6H_{14} T_c = 280	289	< 2.5	3.16	.071	5.33
O_2-cyclohex T_c = 292	289	< 2.5	3.16	.079	6.76
O_2-MCP T_c = 287	287	< 2.5	3.16	.077	4.06
O_2-nC_8H_{18} T_c = 296	303	< 2.5	3.46	.064	9.86
O_2-C_6H_6 T_c = 294	311	< 2.5	3.63	.101	0.00
Ar-nC_6H_{14} T_c = 277	289	< 2.5	3.16	.067	1.52
Ar-cyclohex T_c = 289	289	< 2.5	3.16	.075	4.00
Ar-MCP T_c = 284	287	< 2.5	3.16	.073	0.00
Ar-nC_7H_{16} T_c = 283	303	< 2.5	3.46	.066	0.00

TABLE XIII (CONT'D)

System	T	kT/ε = 1.30 Tr	$\mu^{2.0} x 10^5$	DP calc	% Error
Ar-2,4 DMP	303	< 2.5	3.46	.066	0.00
T_c = 280					
Ar-nC_8H_{18}	303	< 2.5	3.46	.060	1.70
T_c = 293					
N_2O-C_3H_8	298	< 2.5	3.31	.098	13.95
T_c = 338					
Air-Chl Bz	299	< 2.5	3.31	.079	6.76
T_c = 290	313		3.63	.087	10.12
	333		3.98	.095	5.56
Air-ethyl-acetate	299	< 2.5	3.31	.085	2.30
T_c = 264	313		3.63	.093	1.06
	333		3.98	1.02	3.77

TABLE XIV

Data: Reference Plot for Diffusion Coefficient - Temperature Relation

System,	(T_{298})	(DP_{298})	T/T_{298}	DP/DP_{298}
H_2-D_2	(295)	(1.250)	0.976	0.993
H_2-N_2	(297)	(0.779)	0.650	0.473
			0.674	0.515
			0.852	0.770
			0.920	0.908
			0.968	0.954
			0.991	0.980
			1.01	1.03
			1.02	1.09
			1.08	1.16
			1.34	1.65
			1.35	1.63
			1.52	1.98
			1.70	2.42
			1.93	3.10
H_2-Ar	(288)	(0.828)	1.23	1.34
			1.45	2.07
H_2-CO_2	(298)	(0.646)	0.970	0.958

TABLE XIV (CONT'D)

System,	(T_{298})	(DP_{298})	T/T_{298}	DP/DP_{298}
H_2-H_2O	(307)	(1.020)	1.07	1.10
			1.15	1.18
H_2-NH_3	(297)	(0.856)	0.918	0.870
			0.987	0.975
			1.12	1.19
			1.39	1.68
			1.79	2.51
H_2-SF_6	(307)	(0.458)	0.932	0.865
			1.21	1.41
			1.36	1.83
H_2-nC_4	(288)	(0.361)	1.23	1.40
			1.49	2.11
He-N_2	(300)	(0.743)	1.08	1.03
			1.18	1.20
			1.28	1.45
			1.38	1.62
			1.48	1.74
			1.58	2.11
			1.66	2.22
			2.00	3.23
			3.00	6.41
			4.00	10.4

TABLE XIV (CONT'D)

System,	(T_{298})	(DP_{298})	T/T_{298}	DP/DP_{298}
$He-O_2$	(323)	(0.809)	1.09	1.22
			1.19	1.39
			1.28	1.54
			1.37	1.76
			1.46	1.97
			1.54	2.08
He-Ar	(298)	(0.754)	0.926	0.856
			0.966	0.924
			1.06	1.06
			1.08	1.07
			1.16	1.22
			1.19	1.30
			1.19	1.30
			1.29	1.49
			1.39	1.64
			1.40	1.85
			1.49	1.86
			1.59	2.14
			1.67	2.29
			1.68	2.47
			3.36	8.29
			3.69	9.79

TABLE XIV (CONT'D)

System,	(T_{298})	(DP_{298})	T/T_{298}	DP/DP_{298}
He-Air	(317)	(0.765)	0.871	0.816
			1.09	1.18
He-CO_2	(298)	(0.612)	0.926	0.869
			1.06	1.08
			1.08	1.11
			1.16	1.25
			1.18	1.31
			1.29	1.44
			1.39	1.70
			1.49	1.85
			1.59	2.09
			1.67	2.31
He-H_2O	(298)	(0.908)	1.03	0.993
			1.10	1.11
			1.18	1.23
He-C_6H_6	(298)	(0.384)	1.42	1.59
			1.55	1.86
			1.69	2.12
			1.76	2.24

TABLE XIV (CONT'D)

System,	(T_{298})	(DP_{298})	T/T_{298}	DP/DP_{298}
He-ethamol	(298)	(0.494)	1.42	1.66
			1.55	1.87
			1.69	2.12
			1.76	2.37
H_2-CO_2	(298)	(0.165)	0.970	0.957
			0.984	0.988
			1.01	1.05
			2.01	3.67
			3.02	7.37
			4.03	12.0
N_2-H_2O	(308)	(0.256)	1.07	1.18
			1.15	1.40
O_2-H_2O	(308)	(0.282)	1.07	1.13
			1.14	1.25
He-Ar	(303)	(0.327)	0.644	0.468
			0.901	0.829
			0.950	0.917
			1.05	1.09
			1.17	1.27
			1.56	2.05

TABLE XIV (CONT'D)

System,	(T_{298}) (DP_{298})	T/T_{298}	DP/DP_{298}
Ne-Kr	(303) (0.266)	0.901	0.838
		0.950	0.902
		1.05	1.07
Ar-Kr	(303) (0.140)	0.659	0.514
		0.901	9.901
		0.950	0.914
		1.05	1.09
		1.17	1.41
		1.23	1.54
		1.56	2.34
CO_2-H_2O	(298) (0.117)	0.655	0.453
		0.916	0.845
		0.963	0.915
		1.05	1.09
		1.22	1.43
CH_4-H_2O	(308) (0.292)	1.07	1.13
		1.14	1.22
C_2H_4-H_2O	(308) (0.204)	1.07	1.14
		1.14	1.21

TABLE XIV (CONT'D)

System,	(T_{298})	(DP_{298})	T/T_{298}	DP/DP_{298}
Air-CO_2	(293)	(0.165)	0.943	0.860
			1.08	1.07
Air-toluene	(299)	(0.086)	1.04	1.07
			1.11	1.22
Air-Chl Bz	(299)	(0.074)	1.04	1.07
			1.11	1.22
Air-aniline	(299)	(0.074)	1.04	1.07
			1.11	1.22
Air-2 propanol	(299)	(0.099)	1.04	1.08
			1.11	1.22
Air-butanol	(299)	(0.087)	1.04	1.06
			1.11	1.20
Air-2 pentanol	(299)	(0.071)	1.04	1.07
			1.11	1.21
Air-ethylacetate	(299)	(0.087)	1.04	1.08
			1.11	1.22

Calculation for DP/DP_{298} vs. T/T_{298} Plot

$\log y = 1.70 \log x - .0048$

at $y = 1$

$0 = 1.70 \log x - .0048$

$\log x = .00282$

$x = 1.007$

at $y = 3$

$\log 3 = 1.70 \log x - .0048$

$\log x = .4819/1.70 = .284$

$x = 1.923$

Plot $y = 1 ; x = 1$

$y = 3 ; x = 1.92$

TABLE XV

Evaluation of $DP = (186)(T/298)^{1.7}\,\alpha^{1.096}$

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP calc	DP obs.	% Error
H_2-N_2	.478	.00409	.364	.368	1.09
	.507		.386	.401	3.74
	.757		.576	.600	4.00
	.837		.637	.708	10.03
	.945		.719	.743	3.23
	.978		.744	.763	2.49
	.995		.757	.779	2.82
	1.009		.768	.800	4.00
	1.034		.787	.852	4.11
	1.14		.868	.903	3.88
	1.63		1.240	1.289	3.80
	1.65		1.256	1.270	1.10
	2.01		1.530	1.541	0.71
	2.47		1.880	1.883	0.16
	3.03		2.306	2.417	4.59
H_2-Ar	.945	.00468	.822	.828	0.72
	1.34		1.166	1.111	4.95
	1.775		1.544	1.714	9.92
H_2-CO_2	.950	.00395	.698	.619	12.76
	1.0		.735	.646	13.78

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
H_2-NH_3	.862	.00462	.740	.745	0.67
	.973		.836	.834	0.24
	.995		.855	.856	0.12
	1.209		1.039	1.021	1.76
	1.74		1.495	1.435	4.18
	2.69		2.311	2.149	2.89
He-N_2	1.009	.00332	.624	.743	16.02
	1.145		.708	.766	7.57
	1.332		.823	.892	7.84
	1.532		.947	1.077	12.07
	1.74		1.075	1.200	10.42
	1.96		1.211	1.289	6.05
	2.20		1.360	1.569	13.32
	2.39		1.477	1.650	10.48
	3.28		2.027	2.400	15.54
	6.54		4.042	4.760	15.08
	10.3		6.365	7.740	17.89
He-Ar	.877	.00379	.618	.646	4.33
	.945		.666	.697	4.45
	1.0		.705	.754	6.50
	1.109		.782	.797	1.88
	1.145		.807	.809	0.25
	1.289		.908	.924	1.73

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
	1.332		.939	.978	3.99
	1.532		1.080	1.122	3.74
	1.74		1.227	1.237	0.81
	1.775		1.251	1.398	10.52
	1.96		1.382	1.401	1.36
	2.20		1.551	1.612	3.78
	2.39		1.685	1.728	2.49
	2.43		1.713	1.860	7.90
	7.83		5.520	6.250	11.68
	9.20		6.486	7.380	12.11
He-CO_2	.858	.00316	.505	.531	4.90
	1.0		.588	.612	3.92
	1.109		.652	.661	1.36
	1.145		.673	.678	0.74
	1.287		.757	.764	0.92
	1.332		.783	.800	2.13
	1.532		.901	.884	1.92
	1.74		1.023	1.040	1.63
	1.96		1.152	1.133	1.68
	2.20		1.294	1.279	1.17
	2.39		1.405	1.414	0.64
He-NH_3	.995	.00382	.707	.842	16.03

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
Air-CO_2	.877		.144	.142	1.41
	.973		.160	.165	3.03
	1.109		.182	.177	2.82
Air-NH_3	.983	.00121	.221	.247	10.53
N_2-CO_2	.950	.000875	.155	.158	1.90
	.973		.159	.163	2.45
	1.0		.163	.165	1.21
	1.009		.164	.173	5.20
	3.28		.535	.605	11.57
	6.54		1.066	1.217	12.41
	10.3		1.679	1.976	15.03
Ne-Ar	.486	.00170	.154	.153	0.65
	.837		.264	.271	2.58
	.945		.299	.300	0.33
	1.031		.326	.327	0.31
	1.1118		.353	.357	1.12
	1.332		.421	.414	1.69
	2.20		.695	.671	2.09
He-CO	.990	.00326	.600	.702	14.53
N_2-Ar	.973	.00103	.187	.194	3.61
N_2-CO	.956	.000981	.174	.211	12.54
	.990		.180	.212	15.09

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
N_2-NH_3	.983	.00120	.219	.248	11.69
Ar-Kr	.507	.00871	.082	.072	13.89
	.837		.136	.126	7.94
	.945		.153	.128	19.53
	1.031		.167	.140	19.29
	1.118		.181	.153	18.30
	1.332		.216	.197	9.64
	1.464		.237	.216	9.72
	2.20		.356	.327	8.87
Ar-CO	.990	.00102	.188	.188	0
Ar-NH_3	.983	.00127	.232	.232	0
CO-CO_2	.990	.000863	.159	.152	4.61
CO-NH_3	.983	.00118	.215	.240	10.42
CO_2-N_2O	.486	.000741	.067	.053	26.42
	.837		.116	.099	17.17
	.940		.130	.107	21.50
	1.0		.138	.117	17.95
	1.087		.150	.128	17.19
	1.398		.193	.168	14.88
Air-Cl_2	.973	.000709	.128	.124	3.23
Air-Br_2	.973	.000631	.114	.091	25.27
CO_2-C_3H_8	1.0	.000551	.102	.086	18.60

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
Air-CH_4	.950	.00115	.203	.219	7.31
	.983		.210	.224	6.25
N_2-C_2H_6	1.0	.000778	.145	.148	2.03
Air-C_6H_6	1.0	.000482	.090	.096	6.25
	1.057		.095	.102	6.86
H_2-CH_4	1.0	.00400	.744	.726	2.48
H_2-C_2H_6	1.0	.00314	.584	.537	8.75
H_2-nC_4H_{10}	.945	.00227	.399	.361	10.52
	1.34		.565	.507	11.44
	1.863		.786	.763	3.02
H_2-nC_6H_{14}	.950	.00180	.318	.290	9.66
H_2-cyclohex	.950	.00201	.355	.319	11.28
H_2-nC_7H_{16}	1.031	.00164	.314	.283	24.38
H_2-nC_8H_{18}	1.031	.00151	.290	.277	4.69
H_2-C_6H_6	1.074	.00223	.446	.404	10.38
H_2-2,4 DMP	1.031	.00166	.319	.297	7.41
He-nC_7H_{16}	1.031	.00125	.239	.265	9.81
He-nC_8H_{18}	1.031	.00114	.219	.248	11.68
He-2,4 DMP	1.031	.00126	.241	.263	8.37
He-C_6H_6	1.0	.00172	.320	.384	16.68
	1.42		.581	.610	4.76
	1.554		.677	.715	5.32
	1.688		.778	.815	4.54
	1.755		.803	.861	6.74

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
N_2-C_2H_4	1.0	.000862	.160	.163	1.84
N_2-nC_4H_{10}	1.0	.000511	.095	.096	1.04
N_2-iC_4H_{10}	1.0	.000502	.093	.091	2.20
N_2-nC_6H_{14}	.950	.000392	.069	.076	9.22
N_2-cyclohex	.950	.000436	.077	.076	1.32
N_2-MCP	.950	.000427	.075	.076	1.32
N_2-nC_7H_{16}	1.031	.000356	.068	.074	8.11
N_2-2,4 DMP	1.031	.000359	.069	.074	6.76
N_2-nC_8H_{18}	1.031	.000325	.062	.073	15.08
N_2-C_6H_6	1.074	.000482	.097	.102	4.90
O_2-nC_6H_{14}	.950	.000395	.069	.075	12.50
O_2-cyclohex	.950	.000439	.073	.074	5.41
O_2-MCP	.940	.000431	.075	.074	1.35
O_2-nC_8H_{18}	1.031	.000325	.062	.071	12.68
O_2-C_6H_6	1.074	.000488	.098	.101	2.97
Ar-nC_6H_{14}	.950	.000373	.066	.066	0
Ar-cyclohex	.950	.000416	.073	.072	1.39
Ar-MCP	.940	.000408	.071	.073	2.74
Ar-nC_7H_{16}	1.031	.000335	.064	.066	3.03
Ar-2,4 DMP	1.031	.000338	.065	.066	1.52
Ar-nC_8H_{18}	1.031	.000304	.059	.059	0
N_2O-C_3H_8	1.0	.000520	.097	.086	12.79

TABLE XV (CONT'D)

System	$(T/298)^{1.7}$	$\alpha^{1.096}$	DP		% Error
			calc.	obs.	
Air-ChBz	1.005	.000420	.078	.074	5.41
	1.087		.085	.079	7.59
	1.208		.094	.090	4.44
Air-ethylacetate	1.005	.000451	.084	.087	3.45
	1.087		.091	.094	3.19
	1.208		.101	.106	4.72

TABLE XVI

Multicomponent Relationship

$$DP_{AB}/DP_{AC} = f\,\alpha_{AB}^{1.096}/\alpha_{AC}^{1.096}$$

No.	System	Combination	DP_{AB}/DP_{AC} obs.	DP_{AB}/DP_{AC} calc.	% Error
1	H_2-N_2				
2	H_2-Ar	1/2	.941	.863	8.3
3	H_2-CO_2	1/3	1.26	1.02	19.0
4	H_2-NH_3	1/4	.910	.873	4.1
5	He-N_2				
6	He-Ar	5/6	.984	.863	12.3
7	He-CO_2	5/7	1.21	1.04	14.0
8	He-NH_3	5/8	.883	.858	2.8
9	Air-CO_2				
10	Air-NH_3	9/10	.668	.714	6.9
11	N_2-Ar				
12	N_2-CO	11/12	.916	1.04	13.1
13	N_2-NH_3	11/13	.782	.847	8.3
14	Ar-Kr				
15	Ar-CO	14/15	.745	.842	13.0
16	Ar-NH_3	14/16	.604	.672	11.3
17	CO-CO_2				
18	CO-NH_3	17/18	.633	.717	13.3
19	Air-Cl_2				
20	Air-Br_2	19/20	1.36	1.11	18.4
21	N_2-CH_4				

TABLE XVI (CONT'D)

No.	System	Combination	DP_{AB}/DP_{AC}		% Error
			obs.	calc.	
22	H_2-C_2H_6	21/22	1.35	1.26	6.7
23	H_2-nC_4H_{10}	21/23	2.01	1.77	11.9
24	H_2-nC_6H_{14}	21/24	2.50	2.24	10.4
25	H_2-cyclohex	21/25	2.28	2.00	12.3
26	H_2-nC_7H_{16}	21/26	2.56	2.45	4.3
27	H_2-nC_8H_{18}	21/27	2.62	2.69	2.7
28	H_2-C_6H_6	21/28	1.80	1.80	0
29	H_2-2,4 DMP	21/29	2.45	2.44	0.4
30	He-nC_7H_{16}				
31	He-nC_8H_{18}	30/31	1.07	1.09	1.9
32	He-2,4 DMP	30/32	1.01	.983	3.0
33	He-C_6H_6	30/32	.690	.715	3.6
34	N_2-C_2H_4				
35	N_2-nC_4H_{10}	34/35	1.70	1.70	0
36	N_2-iC_4H_{10}	34/36	1.79	1.73	3.4
37	N_2-nC_6H_{14}	34/37	2.14	2.22	3.7
38	N_2-cyclohex	34/38	2.14	1.98	7.5
39	N_2-MCP	34/39	2.14	2.03	5.1
40	N_2-nC_7H_{16}	34/40	2.20	2.45	11.4
41	N_2-2,4 DMP	34/41	2.20	2.43	10.5
42	N_2-nC_8H_{18}	34/42	2.23	2.69	20.6
43	N_2-C_6H_6	34/43	1.60	1.80	12.5
44	O_2-nC_6H_{14}				

TABLE XVI (CONT'D)

No.	System	Combination	DP_{AB}/DP_{AC} obs.	DP_{AB}/DP_{AC} calc.	% Error
45	O_2-cyclohex	44/45	1.01	.888	11.9
46	O_2-MCP	44/46	1.01	.905	9.9
47	O_2-nC_8H_{18}	44/41	1.05	1220	14.3
48	O_2-C_6H_6	44/48	.742	.798	7.6
49	Ar-nC_6H_{14}				
50	Ar-cyclohex	49/50	.918	.885	3.6
51	Ar-MCP	49/51	.904	.902	0.2
52	Ar-nC_7H_{16}	49/52	1.0	1.10	10.0
53	Ar-2,4 DMP	49/53	1.0	1.09	9.0
54	Ar-nC_8H_{18}	49/54	1.12	1.22	8.9
55	Air-Cl Bz				
56	Air-ethylacetate	55/56	.850	.919	8.1

Overall % Error 8.4

Calculation for DP_{AB}/DP_{AC} vs. $\alpha_{AB}^{1.096}/\alpha_{AC}^{1.096}$ Plot

$\log y = 1.02 \log x - .0045$

at $y = 1$

$0 = 1.02 \log x - .0045$

$\log x = .00441$

$x = 1.010$

at $y = 2$

$\log 3 = 1.02 \log x - .0045$

$\log x = .4816/1.02 = .472$

$x = 2.965$

Plot $y = 1$; $x = 1.01$

$y = 3$; $x = 2.97$

TABLE XVII

Comparison of Diffusion Coefficients by Different Methods

System	T.°K	% Error		
		This Work, Eq. (64)	FSG	Othmer-Chen
H_2-N_2	193	1.09	3.72	19.05
	200	3.74	5.96	16.49
	253	4.00	5.16	18.12
	273	10.03	8.19	14.30
	288	3.23	4.22	19.13
	294	2.49	3.01	20.57
	297	2.82	3.18	20.31
	300	4.00	4.16	19.06
	304	4.11	8.17	14.05
	322	3.88	3.90	19.08
	398	3.80	2.46	19.38
	400	1.10	0.12	22.18
	450	0.71	1.15	22.53
	506	0.16	1.64	21.69
	573	4.59	1.56	16.19
H_2-Ar	288	0.72	11.19	4.71
	354	4.95	4.87	12.00
	418	9.92	17.61	3.63
H_2-CO_2	289	12.76	2.34	25.99
	298	13.78	1.38	27.37

TABLE XVII (CONT'D)

System	T,°K	% Error		
		Eq.(64)	FSG	Othmer-Chen
H_2-NH_3	273	0.67	4.50	1.00
	293	0.24	3.37	0.90
	297	0.12	3.74	0.63
	333	1.76	1.29	4.13
	413	4.18	2.37	9.00
	533	2.89	6.82	13.65
He-N_2	300	16.02	4.65	6.24
	323	7.57	5.36	3.38
	353	7.84	5.57	3.17
	383	12.07	0.95	1.79
	413	10.42	3.38	0.04
	443	6.05	8.80	4.70
	473	13.32	0.24	4.10
	498	10.48	4.31	0.70
	600	15.54	0.71	7.42
	900	15.08	1.78	10.43
	1200	17.89	3.55	13.27
He-Ar	276	4.33	2.56	9.75
	288	4.45	2.89	9.97
	298	6.50	4.65	11.55
	317	1.88	0.65	6.59
	323	0.25	2.44	4.93
	346	1.73	1.11	6.22

TABLE XVII (CONT'D)

System	T, °K	% Error Eq. (64)	 FSG	 Othmer-Chen
	353	3.99	1.03	8.23
	383	3.74	0.50	7.93
	413	0.81	2.98	5.00
	418	10.52	7.02	14.27
	443	1.36	2.79	5.51
	473	3.78	0.18	8.27
	498	2.49	2.27	6.70
	500	7.90	4.39	12.80
	1000	11.68	4.29	19.53
	1100	12.11	4.24	20.69
He-CO_2	276	4.90	5.82	2.53
	298	3.92	6.53	2.87
	317	1.36	3.53	0.47
	323	0.74	2.86	1.23
	346	0.92	2.85	1.38
	353	2.13	3.84	0.37
	383	1.92	0.37	4.78
	413	1.63	2.66	1.52
	443	1.68	1.01	5.16
	473	1.17	0.35	4.22
	498	0.64	0.67	2.91
He-NH_3	297	16.03	7.00	24.05

TABLE XVII (CONT'D)

System	T, °K	% Error		
		Eq. (64)	FSG	Othmer-Chen
Air-CO_2	276	1.41	3.48	0.88
	293	3.03	7.89	3.06
	317	2.82	1.45	4.56
Air-NH_3	295	10.53	3.18	16.79
N_2-CO_2	289	1.90	1.50	2.38
	293	2.45	2.31	3.04
	298	1.21	0.59	1.15
	300	5.20	4.07	4.54
	600	11.57	7.74	5.91
	900	12.41	6.75	7.31
	1200	15.03	4.98	8.51
Ne-Ar	195	0.65	2.20	8.20
	273	2.58	0.06	4.55
	288	0.33	0.87	5.25
	303	0.31	0.60	4.99
	318	1.12	0.92	5.33
	353	1.69	2.57	2.22
	473	2.09	5.61	0.91
He-CO	296	14.53	3.95	1.29
N_2-Ar	293	3.61	0.27	6.76
N_2-CO	290	17.54	7.69	4.76
	296	15.09	4.60	1.49

TABLE XVII (CONT'D)

System	T,°K	% Error		
		Eq. (64)	FSG	Othmer-Chen
N_2-NH_3	295	11.69	1.01	18.53
Ar-Kr	200	13.89	1.59	19.97
	273	7.94	2.64	16.14
	298	19.538	5.24	8.68
	303	19.29	5.16	8.16
	318	18.30	4.72	8.04
	353	9.64	2.37	13.38
	373	9.72	1.94	12.62
	473	8.87	1.84	11.53
Ar-CO	296	0	2.66	0.42
Ar-NH_3	295	0	5.43	22.16
CO-CO_2	296	4.61	4.91	7.90
CO-NH_3	295	10.42	2.44	14.31
CO_2-N_2O	195	26.42	2.89	7.55
	273	17.17	0.15	1.54
	287	21.50	0.79	0.53
	298	17.95	1.74	1.22
	313	17.19	2.23	0.73
	263	14.88	3.61	0.53
Air-Cl_2	293	3.23	0.08	1.04
Air-Br_2	293	25.27	0.03	9.84
CO_2-C_3H_8	298	18.60	6.96	0.62

TABLE XVII (CONT'D)

System	T,°K	% Error		
		Eq. (64)	FSG	Othmer-Chen
Air-CH_4	289	7.31	8.86	0.32
	295	6.25	7.85	1.61
H_2-C_2H_6	298	2.03	0.37	1.36
Air-C_6H_6	298	6.25	6.96	6.59
	308	6.86	7.23	6.32
H_2-CH_4	298	2.48	5.33	27.25
H_2-C_2H_6	298	8.75	3.33	29.24
H_2-nC_4H_{10}	288	10.52	0.34	31.04
	354	11.44	1.99	35.20
	430	3.02	4.85	26.14
H_2-nC_6H_{14}	289	9.66	3.08	34.72
H_2-cyclohex	289	11.28	4.94	30.60
H_2-nC_7H_{16}	303	24.38	6.85	39.91
H_2-nC_8H_{18}	303	4.69	2.27	33.85
H_2-C_6H_6	311	10.38	0.82	29.21
H_2-2,4 DMP	303	7.41	1.87	34.41
He-nC_7H_{16}	303	9.81	5.68	6.38
He-nC_8H_{18}	303	11.68	6.12	6.30
He-2,4 DMP	303	8.37	4.96	8.02
He-C_6H_6	298	16.68	18.39	10.43
	423	4.76	5.20	5.97
	463	5.32	5.27	5.96
	503	4.54	3.93	7.38
	523	6.74	2.65	8.73

TABLE XVII (CONT'D)

System	T, °K	% Error		
		Eq. (64)	FSG	Othmer-Chen
N_2-C_2H_4	298	1.84	4.68	0.30
N_2-nC_4H_{10}	298	1.04	3.72	2.02
N_2-iC_4H_{10}	298	2.20	10.03	9.15
N_2-nC_6H_{14}	289	9.22	0.50	4.34
N_2-cyclohex	289	1.32	0.79	0.93
N_2-MCP	289	1.32	0.79	0.48
N_2-nC_7H_{16}	303	8.11	2.06	1.48
N_2-2,4 DMP	303	6.76	1.46	1.04
N_2-nC_8H_{18}	303	15.08	3.25	6.95
N_2-C_6H_6	311	4.90	1.62	5.42
O_2-nC_6H_{14}	289	12.50	3.15	3.48
O_2-cyclohex	289	5.41	0.27	3.56
O_2-MCP	287	1.35	0.91	-2.34
O_2-nC_8H_{18}	303	12.68	3.96	4.26
O_2-C_6H_6	311	2.97	3.46	3.74
Ar-nC_6H_{14}	289	0	2.40	9.28
Ar-cyclohex	289	1.39	3.82	11.39
Ar-MCP	287	2.74	6.31	14.11
Ar-nC_7H_{16}	303	3.03	2.84	8.36
Ar-2,4 DMP	303	1.52	3.32	6.88
Ar-nC_8H_{18}	303	0	6.75	5.25
N_2O-C_3H_8	298	12.79	1.35	5.06

TABLE XVII (CONT'D)

System	T, °k	% Error		
		Eq. (64)	FSG	Othmer-Chen
Air-Chl Bz	299	5.41	8.13	6.74
	313	7.59	9.42	8.94
	333	4.44	7.39	8.15
Air-ethylacetate	299	3.45	0.85	1.95
	313	3.19	0.84	1.20
	333	4.72	0.01	1.02

Compare Calculations for DP of N_2-CO_2 at 300 °K Using This Work's Correlation Eq. (64) versus FSG Correlation

$$DP_{TW} = \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{\frac{1}{2}}}{\left(V_{c_1}^{.4} + V_{c_2}^{.4}\right)^2}\right]^{1.096} (T/298)^{1.7} \quad (186)$$

versus

$$DP_{FSG} = \left[\frac{\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^{\frac{1}{2}}}{\left(v_1^{.33} + v_2^{.33}\right)^2}\right] T^{1.75} \quad (10^{-3})$$

$$(T/298)^{1.7} (186) = (300/298)^{1.7} (186) = 187.7$$

$$T^{1.75} (10^{-3}) = (300)^{1.75} (10^{-3}) = 21.6$$

$V_{c_1} = 90.1$

$V_{c_2} = 94.0 \quad (V_{c_1}^{.4} + V_{c_2}^{.4})^2 = (12.21)^2 = 149.08$

$v_1 = 17.9$

$v_2 = 26.9 \quad (v_1^{.33} + v_2^{.33})^2 = (5.55)^2 = 30.8$

$$\left[\frac{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^{\frac{1}{2}}}{\left(V_{c_1}{}^{.4}+V_{c_2}{}^{.4}\right)^2}\right]_{TW} = .00162 \quad (.00162)^{1.096} = .00875$$

$$\left[\frac{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^{\frac{1}{2}}}{\left(v_1{}^{.33}+v_2{}^{.33}\right)^2}\right]_{FSG} = .00784$$

$DP_{TW} = (8.75 \times 10^{-4})\ (1.877 \times 10^2) = 0.164$

$DP_{FSG} = (78.4 \times 10^{-4})\ (0.216 \times 10^2) = 0.169$

$DP_{obs} =$ 0.173

X. REFERENCES

(1) Arnold, J.H.
Ind. Eng. Chem. 22, 1091-95 (1930).

(2) Bird, R.B., Stewart, W.E., Lightfoot, E.N.
"Transport Phenomena"
John Wiley & Sons, New York, 1960.

(3) Chapman, S.
Trans. Roy. Soc. (London) 211, 433 (1912).

(4) Chapman, S., Cowling, T.G.
"The Mathematical Theory of Non-Uniform Gases"
Cambridge Univ. Press, New York, 1939.

(5) Chen, N.H.
Ind. Eng. Chem. 51, 1494 (1959).

(6) Chen, N.H., Othmer, D.F.
J. Chem. Eng. Data, 7, 37-41 (1962).

(7) Fuller, E.N., Schettler, P.D., Giddings, J.C.
Ind. Eng. Chem. 58, 19-27 (1966).

(8) Gilliland, E.R.
Ind. Eng. Chem. 26, 681-85 (1934).

(9) Hirschfelder, J.O., Bird, R.B., Spotz, E.L.
Trans. ASME 72, 921-37 (1949).

Chem. Revs. 44, 205-31 (1949).
J. Chem. Phys. 16, 968-81 (1948).

(10) National Research Council
International Critical Tables
Vol. I, p. 102, Vol V, p.2.
McGraw-Hill, New York, 1926.

(11) Jeans, J.H.
"Dynamical Theory of Gases"
Third edition, Cambridge Univ. Press, New York, 1921.

(12) Kirk, R.E., Othmer, D.F.
"Encyclopedia of Chemical Technology"
Vol. V, p. 88, Interscience, New York, 1949.

(13) Kobe, K.A., Lynn, Jr., R.E.
Chem. Rev. 52, 117-236 (1952).

(14) LeBas, G.
"The Molecular Volumes of Liquid Chemical Compounds"
Longman, London, 1915.

(15) Maxwell, J.C.
Phil. Mag. 35, 185 (1868).

(16) Othmer, D.F.
Ind. Eng. Chem. 32, 841 (1940).

(17) Othmer, D.F., Chen, H.T.

Ind. Eng. Chem., Proc. Design & Develop. 1, 249 (1962).

(18) Pakurar, T.A., Ferron, J.R.

Ind. Eng. Chem, Fundamentals 5, 553-557 (1966).

(19) Perry, J.H., Editor

"Chemical Engineers' Handbook"

Third edition, McGraw-Hill, New York, 1950.

(20) Reid, R.C., Sherwood, T.K.

"The Properties of Gases and Liquids"

McGraw-Hill, New York, 1956.

(21) Smith, J.M., Van Ness, H.C.

"Introduction to Chemical Engineering Thermodynamics"

Second Edition, McGraw-Hill, New York, 1959.

(22) Stefan, J.

Sitzber. Akad. Wiss. Wien. 63, 63 (1871).

(23) Sutherland, W.

Phil. Mag. 36, 507 (1893).

XI. VITA

Raymond G. Bailey

Born: April 2, 1941, Houston, Texas

Present Address: 3 Van Dolft Dr., Apt. 3
South Amboy, New Jersey 08879

Education:

Aldine High School, Houston, Texas, 1959

University of Houston, Houston, Texas B.S.Ch.E., 1963

Professional Activity:

American Institute of Chemical Engineers

National Society of Professional Engineers

Registered P.E. in Texas, No. 28771

Employment:

Texaco Inc., Petrochemical Dept., New York, New York
(with Texaco since June, 1963)