

THERMAL CONDUCTIVITY OF ARGON-NEON MIXTURE

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1. INTRODUCTION

Gas analysis based on the thermal conductivity of gases was suggested by Daynes and Shakespear (1920), Daynes (1933) and suitable katharometers were constructed by them and by Ibbs and Hirst (1929), Trenner (1937), Archer (1938), Grew (1941) and others but the apparatus has so far been used more or less in an empirical way and calibration curves have been given in terms of galvanometer deflections against concentration. The disadvantages of this procedure are obvious. Ibbs and Hirst have tried to determine the conductivity of any gas or mixture of gases by reference to such an empirical curve and utilizing the experimentally determined values of thermal conductivity of any known gaseous mixture. The assumptions made by them that the apparatus will give the same reading for all gases or mixtures having the same thermal conductivity is not however sufficiently exact on account of the different accommodation coefficients and the unequal wall effects for different gases. As the katharometer is a very useful and inexpensive instrument for gas analysis, we attempt here to develop in the following pages a suitable design of the instrument from which accurate values of thermal conductivity can be readily obtained for any gas or mixture of gases.

A comprehensive account of the methods which have been employed in the past for the measurement of thermal conductivity of gases has been given by Gregory and Archer (1926), Trautz and Zundel (1931), and Bosworth (1952), and a short account of modern methods has been given by Keyes (1949). Nearly all precise thermal conductivity measurements on gases have been made with some form of the hot wire method. In this a metal wire which is heated by an electric current is mounted axially in a vertical glass or metal tube, immersed in a constant temperature bath. The wire remains at a uniform temperature along a central portion which will be relatively greater the longer the wire and the smaller its diameter. The lateral heat transfer through the gas is radial only for a limited central portion of the tube and the principal correction to be applied is for the heat conducted longitudinally by the wire. This difficulty has been met by applying three different types of procedure. In the first due to Schleiermacher, Weber (1917), Taylor and Johnston (1946) and others, a long thin wire is used and the resistance of the central portion of the wire which is at a uniform temperature is measured by attaching two very fine potential leads to the wire. In this potential lead method the end conduction is thus reduced to a very small correction of the order of 1%, but a very small and not accurately calculable lead wire correction is introduced. In the second method given by Goldschmidt, Gregory and Archer (1926), Dickins (1934) and others two tubes are employed, one long and the other short, usually called compensating cells. The differential measurements then refer to the central portion of the longer tube, where radial flow conditions hold. In this the end conduction cancels out but the difficulty of having exactly identical and inconveniently long columns is a great drawback. In the third type usually

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called the thick wire cell method developed by Kannuliuk and Martin (1933), Kannuliuk and Carman (1952), the end effect is very large but is corrected almost exactly by a rigorous application of the theory with the help of relatively simple boundary conditions.

In the present series of investigations we have adopted the third method with the modification that a much thinner wire is used so that the end conduction is minimized. The detailed theory as developed by Kannuliuk and Martin (1934) will still give the various corrections exactly and in particular the end correction and the correction for the curvature of lines of flow at the ends of the wire. Thus a simple apparatus has been developed to give relative conductivities of gases and gas mixtures readily, using an improved form of balance bridge method as adopted by Grew (1941).

2. METHOD AND THEORY

The general theory of the distribution of temperature along the axially mounted wire was given by Kannuliuk and Martin (1933, 1934) which as applied to our case may be briefly stated as follows:

Let us assume that the ends of the wire are held at the same steady temperature as the walls of the tube and this temperature is taken as an arbitrary zero. Neglecting convection and radiation for the present, the differential equation for the steady flow of heat is

$$\pi r_1^2 \lambda \frac{d^2 \theta}{dz^2} + 2\pi r_1 K_u \left(\frac{d\theta}{dr} \right)_{r=r_1} + \frac{I^2 \rho_0 (1 + \alpha \theta)}{J} = 0, \quad \dots \quad (1)$$

where λ and K_u are respectively the thermal conductivities of the wire and the gas in calories/cm. sec. deg., ρ_0 the resistance per unit length of the wire at 0°C., α the mean temperature coefficient of resistance of the wire between 0°C. and θ° and r_1 the radius of the wire. The radial flow of heat is

$$2\pi r_1 K_u \left(\frac{d\theta}{dr} \right)_{r=r_1} = - \frac{2\pi K_u \theta}{\log_e r_2/r_1} = -2\pi r_1 h \theta \text{ (say)}, \quad \dots \quad (2)$$

where r_2 is the internal radius of the tube. Equation (1) then becomes

$$\pi r_1^2 \lambda \frac{d^2 \theta}{dz^2} - 2\pi r_1 h \theta + I^2 \rho_0 (1 + \alpha \theta)/J = 0. \quad \dots \quad (3)$$

For the case when the cell is highly evacuated the second term in eq. (3) is to represent the loss by radiation from the wire, h denoting the loss of heat per unit area per unit difference of temperature.

Writing eq. (3) in the form

$$d^2 \theta / dz^2 = P^2 \theta - Q,$$

where

$$P^2 = 2h/r_1 \lambda - I^2 \rho_0 \alpha / \pi r_1^2 \lambda J, \quad \left. \begin{array}{l} \\ \end{array} \right\} \quad \dots \quad (4)$$

and

$$Q = I^2 \rho_0 / \pi r_1^2 \lambda J,$$

assuming P to be positive, we get as solution

$$\theta = Q/P^2 + A \sinh z + B \cosh z. \quad \dots \quad (5)$$

The constants A and B are determined from the boundary conditions $\theta = 0$ at $x = \pm l$, $2l$ being the length of the wire. Eq. (5) then yields

$$\theta = \frac{Q}{P^2} \left[1 - \frac{\cosh Pz}{\cosh Pl} \right]. \quad \dots \quad (6)$$

The resistance R of the wire under present conditions of heating is given by

$$R = \int_{-l}^{+l} (1 + \alpha\theta) dz. \quad \dots \quad (7)$$

Substituting the value of θ from (6) and integrating for z from $-l$ to $+l$ we obtain

$$\frac{R - R_0}{R_0} = \frac{Q\alpha}{P} \left[1 - \frac{\tanh Pl}{Pl} \right], \quad \dots \quad (8)$$

where

$$R_0 = 2\rho_0 l.$$

This equation can be written in the form

$$\left(\frac{1}{Pl} \right)^2 \left(1 - \frac{\tanh Pl}{Pl} \right) = \frac{2\pi r_1^2 \lambda J (R - R_0)}{R_0^2 I^2 \alpha l}. \quad \dots \quad (9)$$

Substituting the experimentally determined values of R , R_0 , α and λ , the value of the L.H. side of eq. (9) is known and hence the conductivity K_u of the gas found from eqs. (4) and (2).

To determine λ the experiment is performed in perfect vacuum. The solution is again given by (9). Calculation shows that for the small current and thin wire used in the experiments P^2 is positive and therefore eq. (9) cannot be further simplified as done by Kannuliuk. Hence eq. (9) was used to determine λ .

Eq. (9) has been obtained above on the assumption that the flow of heat through the gas is strictly radial. Actually, however, the lines of heat flow show some curvature at the ends of the tube. Under these conditions the exact solution of eq. (1) has been given by Kannuliuk and Martin (1934), who show that the error due to this correction is less than 1%. Convection is eliminated by working at sufficiently low pressures when the observed conductivity becomes independent of the pressure.

3. DESCRIPTION OF THE APPARATUS

The apparatus consists of (i) the conductivity cell, (ii) the electrical bridge, (iii) the thermostatic bath, (iv) the gas mixing apparatus and (v) the pressure regulation unit.

The conductivity cell forms part of the thermal conductivity analyser, originally intended for measurements of gaseous separation in the thermal diffusion experiments and is based on an analyser described by Grew (1941), and depicted in Fig. 1. A very thin metallic wire was welded to short platinum wires which were then sealed in a uniform capillary tubing. A 4-mm. side tube led to the bulb L of about 14 c.c. capacity and the mercury reservoir R , the pressure being measured by the mercury manometer M . The assembly was suitably mounted on a wooden stand and immersed in thermostat containing paraffin oil and fitted with a glass side to enable readings to be taken from outside. Efficient stirring and mercury toluene regulator enable the bath temperature to be kept constant, which was recorded on a Hartmann-Braun NiCr-Ni thermocouple.

The cell wire forms one arm of a Wheatstone bridge and a thicker wire (compensating resistance) made of the same material forms the second arm, the remaining two arms consisted of two equal eureka resistances, all being immersed in the bath. The temperature and therefore resistance of the cell wire depends on the conductivity of the gas surrounding it and on the current flowing through it. Its resistance was measured at the bath temperature and the compensating resistance so adjusted that when the bridge is balanced, the cell wire is about 20°C. above the bath

temperature. As the compensating resistance was made of the same material as the cell wire, but relatively many times thicker so that its resistance may be practically independent of the bridge current, the fluctuations in the temperature of the bath do not affect the bridge balance. To ensure this the compensating coil was mounted as near the conductivity cell as possible.

In operation the conductivity apparatus is completely evacuated by an oil diffusion pump and a small amount of the desired gas or gas mixture of known composition prepared with the aid of a gas mixing system, is introduced by turning slowly the stopcock *S* (Fig. 1). The gas so introduced into the system is then com-

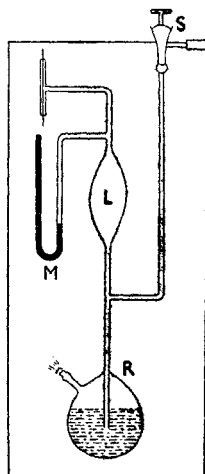


Fig. 1

pressed to the desired pressure below 20 cm. with the help of a pressure regulation unit attached to the reservoir *R*, which consisted of a manometer, an air-chamber and a mechanical pump capable of creating a rough vacuum. The current is then adjusted approximately to balance the bridge and sufficient time allowed for the temperature of the cell wire and surrounding bath liquid to attain steady state. The current is then exactly adjusted for the balance and is measured across a standard 1 ohm.

4. EXPERIMENTAL PROCEDURE AND CORRECTIONS

The geometrical constants of the apparatus, namely the length and the diameter of the wire and the internal and external radii of the tube, were first accurately determined. Then the tube was highly evacuated and different currents passed through it and *R* measured for each current by the potentiometer method, and extrapolated to zero current.

The temperature coefficient of resistance was determined by placing the cell in a constant temperature bath, filling it with hydrogen at low pressures and sending a very small heating current through the wire and then measuring the resistance by the potentiometer method. This resistance was measured for various very small heating currents and graphically extrapolated for zero current. In this way *R* is determined at different temperatures giving α . This value of α was substituted in (9) and the observations already obtained for the evacuated cell giving *R* for different *I*'s, were utilized to determine λ . *h* was calculated by assuming 0.032 as

the emissivity of aged tungsten at the experimental temperature. By substituting the value of h in (4) and utilizing (9), six values of λ were calculated for the different currents and the mean taken.

Next the experimental gas, single or mixed in known proportions was introduced into the cell, and confined at a suitable pressure below 20 cm. of mercury and the bridge balanced by sending the proper current. For this balance the resistance of the cell will be equal to the resistance of the compensating coil at the temperature of the bath, which is known from the previous calibration. This value of R , along with the value of R_0 , α and λ is substituted in eq. (9) to give P from which h and K_u are calculated with the help of eq. (4). This value of K_u has to be corrected for radiation. For a single heating current observations are taken at various gas pressures.

This value of K_u requires to be further corrected for the temperature gradient across the wall, for the accommodation coefficient (or the temperature jump effect) at the surfaces of the wire and the tube, and for the curvature of the lines of heat flow near the ends.

The wall effect is corrected for by treating the present case as a conduction through composite cylinders of gas and glass. We have for the heat transmission

$$\frac{2\pi K_u'(\theta_1 - \theta_w)}{\log_e r_2/r_1} = \frac{2\pi K_g \theta_w}{\log_e r_3/r_2}, \quad \dots \quad (10)$$

where θ_1 is the excess temperature of the wire over that of the bath, θ_w the difference in temperature between inner and outer walls of the tube, r_3 is the external radius of the tube and K_g the conductivity of the glass tube.

$$\therefore \theta_w = (K_u'/K_g) [(\log_e r_3/r_2)/(\log_e r_2/r_1)] (\theta_1 - \theta_w) \quad \dots \quad (11)$$

and in place of the second term in eq. (1), we have

$$\frac{2\pi K_u'}{\log_e(r_2/r_1)} (\theta - \theta_w) = \frac{2\pi K_u'}{\log_e r_2/r_1} \theta \left(1 - \frac{K_u'}{K_g} \frac{\log_e r_3/r_2}{\log_e r_2/r_1} \right), \quad \dots \quad (12)$$

and hence on taking the wall correction, h in eq. (3) must be replaced by h' where

$$h' = \frac{K_u'}{r_1 \log_e r_2/r_1} \left(1 - \frac{K_u'}{K_g} \frac{\log_e r_3/r_2}{\log_e r_2/r_1} \right). \quad \dots \quad (13)$$

Thus knowing K_g , K_u' (corrected for wall effect) can be determined.

The correction for the temperature jump at the wire and the tube surfaces has been fully discussed by Gregory and Archer (#926) and Taylor and Johnston (1946). It has been shown by them that

$$\frac{1}{K_a} = \frac{1}{K} + \frac{1}{p \log_e r_2/r_1} \left[\frac{g_1}{K_1 r_1} + \frac{g_2}{K_2 r_2} \right]. \quad \dots \quad (14)$$

where K_a is the apparent conductivity, K the conductivity corrected for temperature jump effect, K_1 , K_2 the gas conductivities at the temperatures of the wire and the tube surface; and g_1 , g_2 depend upon the accommodation coefficient at the surface of the wire and of the tube. Thus by plotting $1/K_a$ against $1/p$, the true conductivity can be determined from the intercept.

Kannuliuk and Martin (1934) have discussed the effect of slight displacement δ of the wire from the axis of the tube and have shown that

$$K = K_u \left[1 - \frac{\delta^2/(r_2^2 - r_1^2)}{\log_e r_2/r_1} \right] = K_u(1 - C), \quad \dots \quad (15)$$

where K_u is the uncorrected conductivity, and C is independent of the gas. By working with a gas whose conductivity is known, the constant C for the cell is determined once for all and the apparatus can then be used for finding the conductivity of any gas or gaseous mixture.

5. EXPERIMENTAL RESULTS

The experimental procedure has already been explained in detail in §4. The constants of the cell are given in Table I.

TABLE I

Constants of the Cell

Length of the cell wire	= 8.343 cm.
Radius of the cell wire	= 0.001867 cm.
External radius of the tube	= 0.313 cm.
Internal radius of the tube	= 0.088 cm.
Mean	$\alpha = 20.92 \times 10^{-4}$
Resistance of the wire at the temperature of the bath (35°C.)	$\lambda = 0.094$ cal./cm. sec. deg.
		= 7.510 ohms.

The resistance of the compensating arm and the combined resistance of the equal arms, when measured at the temperature of the bath, were found to be 7.788 ohm and 21.32 ohm. From the value of α and the resistance of the compensating arm, it was calculated that the bridge would be balanced at a temperature difference of 17.7°C., half of which when added to the bath temperature may be taken as the temperature to which conductivity measurements refer, i.e. 43.8°C.

The argon and neon gases used for the conductivity measurements were supplied by the British Oxygen Co. both being spectroscopically pure. The thermal conductivity calculated with the help of eqs. (4) and (9), together with the values after applying various corrections, are given in Tables II and III.

TABLE II

Pressure cm.	Current through wire (amps.)	Uncorrected $K_u \times 10^5$ (cal./cm. sec. deg.)	Pressure cm.	Current through wire (amps.)	Uncorrected $K_u \times 10^5$ (cal./cm. sec. deg.)
% A = 0			% A = 24.06		
13.4	0.1349	13.88	8.5	0.12133	11.19
12.1	0.1351	13.92	10.2	0.12145	11.20
12.3	0.1352	13.93	13.2	0.12168	11.25
			12.8	0.12140	11.19
% A = 57.4			% A = 79		
6.8	0.10205	7.893	10.4	0.09143	6.325
7.3	0.10210	7.902	13.1	0.09137	6.323
12.8	0.10220	7.918	8.0	0.09131	6.301
8.5	0.10215	7.905			
% A = 100					
7.5	0.08588	5.568			
11.2	0.08606	5.588			
12.3	0.08600	5.576			

Experiments were performed in the pressure range from 2 cm. to 14 cm. and calculation showed that the temperature jump effect vanishes at the higher pressures and convection losses were negligible. Hence only readings at higher pressures are recorded in Table II. The values of the conductivities were reduced to 0°C. by applying the temperature coefficient of conductivity whose value as given by Kannuliuk and Martin (1934) for inert gases is 0.003, and are recorded in Table III.

TABLE III
Mean Values

% A	Mean $K_u \times 10^5$	Corrected for wall effect $K_u' \times 10^5$	$K_0 \times 10^5$
0.0	13.910	14.300	12.630
24.06	11.210	11.470	10.130
57.40	7.904	8.026	7.089
79.00	6.316	6.395	5.648
100.00	5.577	5.637	4.979

As already emphasized, the aim of our experiments has been to devise a quick method of obtaining relative values of conductivity of mixtures of different concentrations and not their absolute values. Eq. (15) shows that the absolute value may be less than the observed value on account of the asymmetries in the cell. For this reason the absolute value of neon as determined by Weber was used to determine C and thereby calibrate the cell.

Weber's value was chosen because it agrees well with the theoretically calculated value of conductivity from the 12 : 6 model using the force constants from thermal diffusion and viscosity, as shown in the next section. This value of C was used to correct the observed values at various concentrations and the corrected values are given in Table V. The theoretically calculated values for the conductivity of argon does not agree so well with Weber's value and so argon was not used for calibrating the cell.

6. COMPARISON OF THEORY WITH EXPERIMENT

For the case of a monatomic gas the first approximation to the coefficient of conductivity can be written for the case of inverse power model in the form (Chapman and Cowling, 1939)

$$[K_1]_1 = \frac{5}{2} [\mu]_1 C_v, \quad \dots \dots \dots (16)$$

where $[\mu]_1$ is the first approximation to the coefficient of viscosity and C_v is the specific heat of the gas at constant volume.

For the case of Lennard-Jones 12 : 6 model, eq. (16) takes the form (Hirschfelder *et al.*, 1954)

$$[K]_1 \times 10^7 = 1989 \cdot 1 \frac{(T/M)^{\frac{1}{2}}}{r_0^2 W_2^{(2)}}, \quad \dots \dots \dots (17)$$

where K is the thermal conductivity in cal./cm. sec. deg., T the temperature in °K, M the molecular weight, r_0 the collision diameter in Å and $W_2^{(2)}$ the collision integral depending on kT/ϵ .

For the case of binary mixture of two monatomic gases the coefficient of conductivity can be written in the form (Chapman and Cowling, 1939)

$$[K_{\text{mix}}]_1 = \frac{R_1[K_1]_1(x_1/x_2) + R_2[K_2]_1(x_2/x_1) + R'_{12}}{R_1(x_1/x_2) + R_2(x_2/x_1) + R_{12}}, \quad \dots \quad (18)$$

where

$$R_{12} = 3 \left(\frac{M_1 - M_2}{M_1 + M_2} \right)^2 (5 - 4B) + \frac{4M_1M_2}{(M_1 + M_2)^2} A(11 - 4B) + \frac{2F^2}{[K_1]_1[K_2]_1}$$

$$R'_{12} = 2F \{ F/[K_1]_1 + F/[K_2]_1 + (11 - 4B - 8A)M_1M_2/(M_1 + M_2)^2 \}$$

$$R_1 = F [6 \{ M_2/(M_1 + M_2) \}^2 + \{ M_1/(M_1 + M_2) \}^2 (5 - 4B) + 8M_1M_2A/(M_1 + M_2)^2] / [K_1]_1$$

and a similar expression for R_2 .

F is connected with the coefficient of diffusion by the relation

$$F = \frac{5}{2} p [D_{12}]_1 / T. \quad \dots \quad (19)$$

The constants A and B depend upon the law of molecular interaction and have been tabulated by Hirschfelder *et al.* (1948) for the 12 : 6 model. For the purpose of calculation eq. (18) has been written in a more convenient form by Hirschfelder *et al.* (1954).

It is convenient to define a quantity by the relation

$$[K_{12}]_1 \times 10^7 = 1989 \cdot 1 \frac{[T(M_1 + M_2)/2M_1M_2]^{\ddagger}}{r_{12}^2(\text{\AA})^2 W^{(2)}(2; kT/\epsilon_{12})}; \quad \dots \quad (20)$$

then in terms of this quantity and the thermal conductivities of the pure components, the thermal conductivity of a mixture of monatomic gases may be written as

$$\frac{1}{[K_{\text{mix}}]_1} = \frac{X_\lambda + Y_\lambda}{1 + Z_\lambda}, \quad \dots \quad (21)$$

where

$$X_\lambda = x_1^2/[K_1]_1 + 2x_1x_2/[K_{12}]_1 + x_2^2/[K_2]_2$$

$$Y_\lambda = x_1^2U^{(1)}/[K_1]_1 + 2x_1x_2U^{(Y)}/[K_{12}]_1 + x_2^2U^{(2)}/[K_2]_1$$

$$Z_\lambda = x_1^2U^{(1)} + 2x_1x_2U^{(Z)} + x_2^2U^{(2)}$$

$$U^{(1)} = \frac{4}{15} A_{12}^* - \frac{1}{12} \left(\frac{12}{5} B_{12}^* + 1 \right) \frac{M_1}{M_2} + \frac{1}{2} \frac{(M_1 - M_2)^2}{M_1M_2}$$

$$U^{(2)} = \frac{4}{15} A_{12}^* - \frac{1}{12} \left(\frac{12}{5} B_{12}^* + 1 \right) \frac{M_2}{M_1} + \frac{1}{2} \frac{(M_2 - M_1)^2}{M_1M_2}$$

$$U^{(Y)} = \frac{4}{15} A_{12}^* \left[\frac{(M_1 + M_2)^2}{4M_1M_2} \right] \frac{[K_{12}]_1^2}{[K_1]_1 [K_2]_1} - \frac{1}{12} \left(\frac{12}{5} B_{12}^* + 1 \right) - \frac{5}{32A_{12}^*} \left(\frac{12}{5} B_{12}^* - 5 \right) \frac{(M_1 - M_2)^2}{M_1M_2}$$

$$U^{(Z)} = \frac{4}{15} A_{12}^* \left[\frac{(M_1 + M_2)^2}{4M_1M_2} \right] \left(\frac{[K_{12}]_1}{[K_1]_1} + \frac{[K_{12}]_1}{[K_2]_1} - 1 \right) - \frac{1}{12} \left(\frac{12}{5} B_{12}^* + 1 \right)$$

and M_1 , M_2 are the molecular weights of species 1 and 2, x_1 , x_2 the mole fractions of species 1 and 2 and $A^* = A/0.4$ and $B^* = B/0.6$, the constants A and B being the same as those in eq. (18).

Using eqs. (17), (18) and (21) we have calculated the values of the coefficient of conductivity of neon-argon mixture at various concentrations. These are given in Table V. The force constants ϵ_{12} , r_{12} , ϵ_{ii} , r_{ii} used in these calculations were those already determined by us at 0°C. from the thermal diffusion data (Srivastava and Madan, 1953 *a* and *b*) of argon and neon-argon mixture. The force constants ϵ and r for pure neon were obtained in a similar way by using the experimental data of Stier (1942). These force constants are listed in Table IV, while the values of the conductivities are given in Table V.

TABLE IV

Argon	Neon	Ne-A.
$\epsilon_1/k = 139^\circ\text{K}$ $r_1 = 3.358\text{\AA}$	$\epsilon_2/k = 44.79^\circ\text{K}$ $r_2 = 2.733\text{\AA}$	$\epsilon_{12}/k = 56.92^\circ\text{K}$ $r_{12} = 3.17\text{\AA}$

TABLE V

K_0 (Weber: listed by Chapman and Cowling, 1939) = 1087×10^{-7} cal./cm. sec. deg.

% A	$K_0 \times 10^7$ in cal. cm. ⁻¹ sec. ⁻¹ deg. ⁻¹			K_0/K_0 (exp.)		
	Present exp.	12 : 6 model	Inverse power model	Present exp.	12 : 6 model	Inverse power model
0.0	1087	1092	1087	1	1.005	1
24.06	871.6	881	780.2	0.8017	0.8106	0.7194
57.4	610.3	640.4	502	0.5614	0.5892	0.4618
79.0	486.3	507.5	432	0.4473	0.4669	0.3975
100	428.7	389.8	392.2	0.3944	0.3587	0.3608

The values of the coefficient of conductivity for the inverse power model are given in column 4 of Table V. They were calculated by using eq. (18). The value of r_{12} , the force index for unlike molecules was taken from thermal diffusion data (Chapman and Cowling, 1939) as 7.9 for neon-argon mixture. As experimental measurements on inter-diffusion are not available, the value of the factor F was determined by using the calculated value of D_{12} for this mixture as 0.265 at 0°C. (Madan, 1953).

As already explained, the neon values of Weber were taken to be correct and ratios to this were found for the conductivity of other mixtures calculated theoretically or obtained experimentally. The ratios thus obtained are also given in Table V and plotted in figure 2. It is seen from the figure that the agreement is very good indeed, the deviation being less than 3% for the different concentration ratios. The experimental errors in these ratios due mainly to error in the determination of α and in measuring the change in resistances will be about $\pm 2\%$. The experimentally determined ratio for pure argon differs by about 10% and is probably due to some experimental error, which however could not be checked due to some accident to the apparatus.

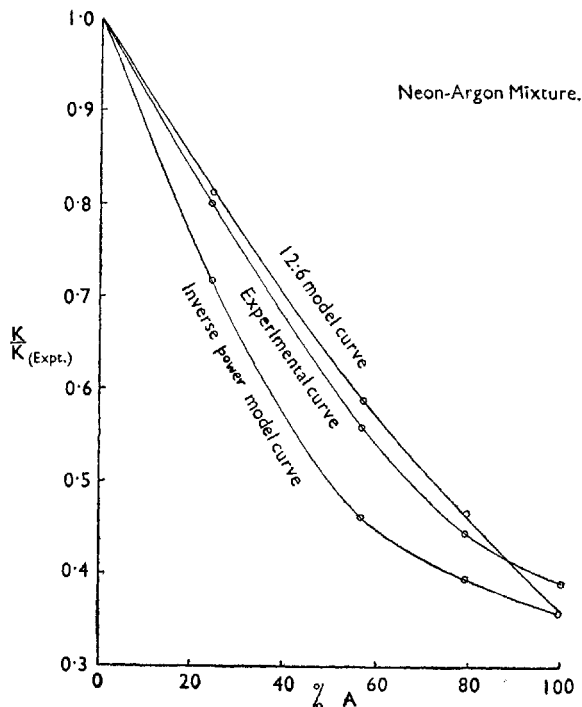


FIG. 2

Table V and figure 2, show that the 12 : 6 model is more in accord with the experimental values than the inverse power model. This has also been shown by Hirschfelder for He-A mixture. Improvements in the design of the cell are being undertaken after which a whole programme of determining conductivity of different mixtures will be taken up.

We are indebted to Prof. J. O. Hirschfelder for his kindness in communicating to us certain portions of his book 'Molecular Theory of Gases and Liquids' in advance of publication. We express our gratitude to Prof. M. R. Nayar of the Chemistry Department for many helpful suggestions and to Prof. P. N. Sharma for affording the laboratory facilities. Thanks are also due to Mr. F. Kiss, Chief Glass Technologist, National Physical Laboratory of India, for the construction of the glass apparatus used in these investigations. We also record our thanks to the Government of Uttar Pradesh for the award of a research grant.

SUMMARY

A gas analysis apparatus based on the thermal conductivity of gas mixtures has been constructed using a hot-wire cell. A rigorous mathematical theory has been applied to calculate the various corrections and yield the value of the thermal conductivity in terms of the conveniently observed quantities. The measurements have been made for argon-neon mixtures of various concentrations and the experimentally determined thermal conductivities for each concentration tabulated. The results are compared with the theory of the thermal conductivity of binary mixtures using the Lennard-Jones 12 : 6 model and the inverse power model, utilizing the known force constants. The results show a satisfactory agreement with the 12 : 6 model but not with the inverse power model.

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