

MEASUREMENT OF DIFFUSION COEFFICIENTS VIA DIFFUSION IN FLOWING GAS

II. RESULTS

C. J. ZWAKHALS and K. W. REUS

Fysisch Laboratorium, Rijksuniversiteit Utrecht, Princetonplein 5, 3508 TA Utrecht, The Netherlands

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We have applied the back-diffusion method, described in a previous publication (part I), to several noble-gas mixtures; the results are presented here (part II). In the measurements one of the two gases was present always in a relatively small concentration ($\lesssim 1\%$). The diffusion coefficients D determined at gas pressure p were converted to values D_s for 1 atm, and further to values $D_{s, 50}$ for an equimolar gas mixture (50%/50%). Tables and graphs of $D_s(T)$ and $D_{s, 50}(T)$ are given.

The text includes: the conversion $D_s \rightarrow D_{s, 50}$ (with the relevant parameter values), the results of a number of checks (such as variation of tube diameter, gas flow velocity, gas pressure), the results of the measurements for the ten combinations of the five noble gases and for a neon–neon isotope combination (each for the temperature range $T \approx 300\text{--}1300$ K), a simple fitting formula ($D_{s, 50} \approx cT^\gamma$ with $\gamma \approx 1.7$), and a comparison with the results of other methods.

1. Introduction; choice of gas mixtures

In part I of this paper [1] we described the “back-diffusion method” for the measurement of gas diffusion coefficients, together with the apparatus and procedure used. With this method one gas (“admixture gas”) diffuses against a constant flow of the other gas (“main gas”) in a tube in such a way that a stationary concentration profile builds up. The (exponential) upstream decrease of admixture gas is measured. This decrease, together with the mean flow velocity \bar{v} , yields the diffusion coefficient D via the relation:

$$n(x)/n(x') = \exp(-(x - x')\bar{v}/D). \quad (1)$$

Here $n(x)$ and $n(x')$ are admixture gas concentrations at two positions in the flow tube and $x - x'$ is the longitudinal distance between these positions. The experiment gives the values of $n(x)/n(x')$ (from mass spectrometric analysis of the sideways-extracted gas mixture) and \bar{v} (through measurement of the transport of main gas per second), whereas $x - x'$ is a precisely known apparatus constant. Formula (1) then gives the D value for the pressure p and temperature T chosen in the experiment. For more details see part I [1].

Because we wanted to measure diffusion coefficients ranging from room temperature to high temperatures, we used silica flow tubes in a thermostated furnace. Measurements have been done at temperatures up to about 1300 K. The reader is referred to part I for an explanation of our choice of magnitudes of the other variables, especially \bar{v} and p .

With this procedure and apparatus the diffusion coefficients for the 10 combinations of the 5 noble gases and for the combination $^{22}\text{Ne} + ^{20}\text{Ne}$ were measured in the temperature range $T \approx 300\text{--}1300$ K; see sect. 4. This choice of gases and temperature range makes it possible to compare the results with those obtained by other diffusion experiments, particularly with the cataphoresis method used by Freudenthal and Hogervorst; see sect. 5.

The diffusion coefficient D for a pair of gases, e.g. He + Xe, depends not only on the temperature and the (total) gas pressure but also slightly on the concentration ratio He/Xe, cf. sect. 2. In the back-diffusion measurements the concentration ratio alters along the flow tube and so D alters slightly too. However, formula 1 is valid for a constant D , that is for D independent of x . In order to get a constant D we chose the partial pressure of the admixture gas small

Table I

Gas combinations chosen, mean free paths of the atoms belonging to them, and parameter values for the conversion $D_s \rightarrow D_{s,50}$ (form. (4)).

Main gas	Admixture gas	Mean free path		Parameters for the conversion $D_s \rightarrow D_{s,50}$				
		λ_m	λ_a		T^*	$10^3 \times C^*$	ξ	a
He	Ne	155	74	15–65	946–948	1.64	0.098	0.45
Ar	He	55	117	7–30	940–948	1.67	0.18	1.17
Kr	He	43	102	7–30	940–948	1.65	0.23	1.56
Xe	He	31	83	6–26	938–948	1.78	0.29	2.08
Ar	Ne	55	87	5–20	932–947	1.2	0.059	0.57
Ne	Kr	108	40	4–20	924–947	1.01	0.12	0.87
Xe	Ne	31	69	3½–20	918–947	1.25	0.17	1.31
Ar	Kr	55	39	2–9	884–943	1.4	0.051	0.30
Ar	Xe	55	28	1½–7	863–940	1.8	0.086	0.57
Xe	Kr	31	40	1½–6	863–937	1.8	0.039	0.33
²⁰ Ne	²² Ne	108	108	7–30				

λ_m = mean free path of the main gas atoms in the diffusion medium, i.e. in the main gas at 1 Torr and 300 K.

λ_a = mean free path of the admixture gas atoms in the diffusion medium, i.e. in the main gas at 1 Torr and 300 K.

T^* and C^* values mentioned refer to the limits of the temperature trajet used: 300–1300 K.

($\leq 1\%$) relative to the main gas pressure; then everywhere in the measuring trajectory in the flow tube the D value for admixture gas percentage zero holds in very good approximation.

Further we had to decide which one of the two gases was to be the admixture gas. The mean free paths λ of the two gases in the mixture sometimes determined our choice. Because both these mean free paths must be between the same limits (viz. between the diameters of flow tube and extraction holes; see part I) it is essential that the mean free paths should not be too much different. For instance with He + Xe the λ values (for 300 K and 1 Torr) are respectively [2]: He in Xe-gas 0.083 mm and Xe in Xe-gas 0.031 mm, ratio 2.7, but on the other hand He in He-gas 0.154 mm and Xe in He-gas 0.014 mm, a ratio of 11. Therefore for this pair of gases it is desirable to choose xenon as the diffusion medium, so xenon will then be the main gas and helium will be the admixture gas. There are also gas pairs in which the difference in the mean free paths is not great; then the choice was determined by the gas supplies available. Table I shows the combinations used, together with the λ -values for main gas and admixture gas (in μm).

2. Conversion to equimolar mixtures

The diffusion coefficient D measured at pressure p and temperature T was always converted to the value D_s for 1 atm and temperature T .

For the sake of comparison with diffusion coefficients measured elsewhere D_s was converted to $D_{s,50}$ which is the value for an equimolar gas mixture (50%/50%) at 1 atm. This conversion was done in the following way:

The composition dependence of the diffusion coefficient is given in the second order approximation after Chapman and Enskog [3]. In the formulation after Mason and Marrero [4] this approximation runs:

$$D^{(2)} = D^{(1)} (1 + \delta) \quad (2)$$

in which $D^{(2)}$ and $D^{(1)}$ are 2nd and 1st order approximations and δ is a relatively small correction term. $D^{(1)}$ does not depend on the composition of the mixture, but δ does. The diffusion coefficient for a 50%/50% mixture is computed from that for a $u\%/(100-u)\%$ mixture according to:

$$D_{50}^{(2)} = D_u^{(2)} (1 + \delta_{50}) / (1 + \delta_u). \quad (3)$$

For δ_u we used the semi-empirical formula after Mason

and Marrero:

$$\delta_u = (6C^* - 5)^2 \zeta au / (100 + bu) \quad (4)$$

in which u is the heavy component percentage. The constants ζ , a and b depend on the gases used but not on the total gas pressure; ζ is independent of temperature and a and b are almost independent of temperature. Mason and Marrero determined the values for these constants from a great number of experimental results, using correlation techniques. C^* is a function of the reduced temperature $T^* \equiv kT/\epsilon$, in which ϵ is the depth of the minimum in a two-parameter potential model, e.g. the Lennard-Jones model. The function C^* we used is the one that has been tabulated for Lennard-Jones potentials by Hirschfelder, Curtis and Bird [5] and other authors.

In our case $u \approx 0$ or 100, depending on the choice of the admixture gas. The values used for ζ , a and b , together with some C^* -values are given in table I. The difference between $D_{50}^{(2)}$ and $D_u^{(2)}$ was at most 8%. So the difference between first and second order approximation in form. (2) is rather small. Therefore we did not consider a higher order approximation to be necessary; so we used form. (3) with $D_{50}^{(2)} = D_{s,50}$ and $D_u^{(2)} = D_s$. Fig. 1 shows an example of δ as a function of u . See also the difference of D_s and $D_{s,50}$ in tables II . . . XII.

3. Checks and check-results

Apart from the normal apparatus-checks such as a verification of the linearity of the detection system, we performed some special checks to verify the measuring method and its theory. These checks are reported in this section.

The calculation of the diffusion coefficient from the measured admixture gas concentrations through form. (1) is based on the assumption that the admixture gas concentration n is only a function of the longitudinal coordinate x and does not change across the flow tube. This approximation rests on the fact that the tube diameter $2R$ is much smaller than the tube length used and much smaller than the characteristic diffusion length D/\bar{v} (cf. form. (1)). Calculations showed the validity of this approximation: see part I. Checking measurements confirmed this. These included alternate use of the two flow tubes with different diameter $2R$ and use of different diffusion lengths by

varying the flow velocity \bar{v} and/or gas pressure p ($1/D$ is proportional to p). The quantities R , \bar{v} and p should have no influence (within the uncertainty limits) on the measured D_s values.

The influence of R . Measurements of the diffusion coefficient for ^{22}Ne in ^{20}Ne were performed with the wide flow tube (diameter about 5 mm) as well as with the narrow one (about 3 mm). The values found did not show significant differences.

The influence of \bar{v} . At a constant pressure (12.0 Torr) and temperature (972 K) the diffusion coefficient for 1% Ar in Ne was determined at different neon flow velocities. The results were:

\bar{v} (cm/s)	12.4	12.2	9.5	7.0
n_1/n_4	22.4	21.3	11.2	5.8
D_s (cm ² /s)	2.40	2.41	2.39	2.40

So in this case the diffusion coefficient was within the error limit (about 1%) independent of the flow velocity.

The influence of p . In the measurement of the diffusion coefficient for 1% Kr in Ne as a function of temperature the pressure was varied in an irregular way. The D_s values found did not show a significant relation with the pressure as can be seen from the $D_s/T^{1.7}$ values:

T (K)	640	688	735	779
p (Torr)	1.89	0.60	3.00	3.31
\bar{v} (cm/s)	7.33	9.21	12.00	6.88
D_s (cm ² /s)	0.95	1.07	1.19	1.33
$D_s/T^{1.7} = 10^{-5} \times$	1.61	1.60	1.59	1.61

The effect of interchanging of main and admixture gas. On the grounds of the measurements done it is possible to check the conversion from measured diffusion coefficients to diffusion coefficients for 50%/50% mixtures for one combination and one temperature. The diffusion coefficient for 1% Ne in Ar at 971.5 K, converted to a 50%/50% mixture, was found to be 2.41 cm²/s. The measurement for 1% Ar in Ne delivered a value of 2.43 cm²/s. These results agree within the uncertainty limit of about 0.03 cm²/s.

The exponential decrease of $n(x)$. According to theory (cf. part I) there should be a linear relationship between the logarithm of the admixture gas concentration n and the position x in the tube. We verified whether or not systematic deviations of this linear relationship were present. To this end the slope of the relevant graph was determined for two, three and four

extraction holes respectively. After the necessary corrections had been made the slopes turned out to be in good agreement with each other. This check was made for all measurements mentioned in sect. 4.

In the checks mentioned in section 3 we applied the corrections described in part I sect. 7, as far as was necessary.

4. Results concerning eleven noble-gas combinations

For ten binary noble-gas combinations and for ^{22}Ne in ^{20}Ne the diffusion coefficient was determined as a function of the temperature between about 300 K and 1300 K. Table I (sect. 1) shows for each pair which gas was present as admixture gas, i.e. in a small concentration, and which one was the main gas, i.e. the flowing medium. Tables II . . . XII show the (converted) results of the measurements. For the sake of brevity the values used for the gas pressure p and flow velocity \bar{v} (which varied with temperature, cf. part I sect. 4) are omitted here; they have been reported elsewhere [6] and for He + Kr they were reported in table I of part I [1]. Each D_s or $D_{s,50}$ value in the tables and figures represents the mean of at least three successive measurements at the same temperature.

The tables include the following columns:

- T = temperature of the gas mixture in which the diffusion took place;
 D_s = diffusion coefficient at 1 atm, calculated from the measurements at pressure p ;
 $D_{s,50}$ = idem, converted to mixture composition 50%/50%, cf. sect. 2;
 ΔD = % standard deviation in D_s (and $D_{s,50}$), obtained from the three successive measurements at constant T and p ;
 $D_{f,50}$ = approximation for $D_{s,50}$, computed with the cT^γ formula.

The standard deviation ΔD has been computed in the usual way (e.g. [7]). The differences between successive measurements as given under ΔD show the short-term fluctuations. The differences between $D_{s,50}$ and $D_{f,50}$ contain the long-term fluctuations because $D_{s,50}$ is affected by these and $D_{f,50}$ is hardly affected. The fact is that $D_{f,50}$ has been computed with c and γ values produced by a fitting procedure of cT^γ to $D_{s,50}$ over the whole temperature range; this implies an "averaging" over more than twenty measured values

and thus a much smaller influence of irregularities of the gas supply or detection sensitivity etc. The irregularities in the value of $D_{s,50} - D_{f,50}$ as a function of the temperature in each of the tables II . . . XII show that the long-term uncertainty in $D_{s,50}$ is generally a few per cent; these irregularities are different for different gas pairs and they will be caused chiefly by experimental errors. The values of $D_{s,50} - D_{f,50}$ for a gas pair are in general smaller than their variations, which means that $D_{f,50}$ does not differ significantly from $D_{s,50}$. The formula cT^γ with c and γ values found by a fitting procedure apparently gives an adequate approximation of the measured $D_{s,50}$ values in this temperature range. There is no need to add more parameters to the formula. This is also evident from graphs of $\ln D_{s,50}$ versus $\ln T$ (or $\ln \{D_{s,50}/T^{1.7}\}$ versus $\ln T$, for $\gamma \approx 1.7$); with each pair of gases the experimental points spread around a straight line, but there is no clear system in the deviations for the various gases and temperatures. Under each of the tables II . . . XII the corresponding c and γ values are given. The uncertainty in γ corresponding to the spread of the points in the experimental graphs of $\ln D_{s,50}$ versus $\ln T$ amounts to about 1%. If one chooses γ 1%

Table II
Neon in helium

T (K)	D_s (cm ² /s)	$D_{s,50}$ (cm ² /s)	ΔD (%)	$D_{f,50}$ (cm ² /s)
297.0 ^a	1.02	1.05	0.8	1.07
348.3	1.40	1.44	1.5	1.41
397.3	1.75	1.80	1.6	1.78
446.5	2.12	2.18	0.8	2.17
497.5	2.37	2.44	1.6	2.62
548.5	2.95	3.03	1.5	3.10
597.1	3.86	3.98	2.6	3.60
644.0	4.10	4.22	1.7	4.09
692.0	4.60	4.74	1.4	4.63
739.0	4.86	5.00	2.4	5.19
787.0	5.52	5.69	0.3	5.78
833.5	5.87	6.04	2.8	6.39
879.0	6.91	7.11	0.8	7.00
926.5	7.49	7.71	0.9	7.67
975.0	8.38	8.63	1.2	8.38
1070	9.73	10.0	2.0	9.84
1119	10.1	10.4	1.2	10.6
1167	11.1	11.4	0.3	11.4
1217	11.9	12.3	0.9	12.3
1268	12.7	13.0	0.0	13.1

$D_{f,50} \equiv cT^\gamma$ with $c = 5.70 \times 10^{-5}$ and $\gamma = 1.729$.

Table III
Helium in argon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
298.0	0.928	0.912	0.6	0.752
352.0	1.02	1.00	0.0	1.00
399.5	1.42	1.40	1.1	1.24
445.5	1.62	1.59	0.5	1.49
496.0	2.02	1.98	0.8	1.79
545.5	2.24	2.20	0.7	2.11
593.5	2.63	2.58	0.5	2.44
642.0	2.77	2.72	0.3	2.79
691.0	3.25	3.19	0.1	3.16
738.0	3.65	3.59	0.3	3.54
784.5	4.00	3.92	0.0	3.93
831.0	4.45	4.37	0.7	4.33
878.5	4.81	4.72	0.4	4.76
927.0	5.39	5.29	0.1	5.22
973.5	5.60	5.49	0.2	5.67
1021	6.30	6.18	0.7	6.16
1072	6.76	6.64	0.2	6.68
1122	7.36	7.22	0.6	7.23
1168	7.82	7.64	0.3	7.74
1217	8.46	8.31	0.7	8.31
1272	9.03	8.86	0.8	8.95

$$c = 4.49 \times 10^{-5}, \gamma = 1.707.$$

Table IV
Helium in krypton

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
307.0	0.716	0.680	0.8	0.70
351.5	0.928	0.881	1.2	0.88
398.5	1.15	1.09	0.1	1.09
448.0	1.39	1.33	0.4	1.32
496.0	1.63	1.56	1.2	1.56
547.5	1.93	1.85	0.6	1.85
595.0	2.24	2.14	0.5	2.12
645.0	2.54	2.43	0.9	2.43
692.0	2.84	2.73	0.0	2.73
738.5	3.21	3.09	0.2	3.04
785.5	3.49	3.36	0.4	3.37
836.0	3.79	3.66	0.5	3.74
879.5	4.22	4.07	0.3	4.07
927.5	4.67	4.51	0.7	4.46
974.0	4.97	4.80	0.4	4.83
1025	5.44	5.26	0.7	5.26
1072	5.85	5.66	0.3	5.67
1119	6.33	6.11	0.2	6.10
1170	6.73	6.50	0.5	6.57
1218	7.46	7.20	0.6	7.03
1274	7.98	7.71	0.4	7.57

$$c = 4.870 \times 10^{-5}, \gamma = 1.672.$$

Table V
Helium in xenon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
297.0	0.610	0.568	1.4	0.553
349.5	0.739	0.686	3.4	0.724
407.3	1.04	0.965	1.3	0.933
445.5	1.17	1.09	0.9	1.08
495.5	1.37	1.27	1.9	1.29
544.5	1.62	1.50	0.6	1.51
593.5	1.89	1.78	1.5	1.74
641.0	2.12	1.98	0.8	1.98
696.2	2.52	2.37	2.1	2.27
736.5	2.64	2.48	0.5	2.49
785.4	2.93	2.77	0.9	2.77
831.7	3.15	2.96	0.4	3.04
878.0	3.54	3.33	1.3	3.33
925.5	3.70	3.48	0.9	3.63
972.0	4.19	3.93	0.5	3.94
1022	4.31	4.12	0.7	4.28
1067	4.87	4.65	1.4	4.60
1118	5.06	4.85	0.4	4.97
1166	5.70	5.46	1.3	5.33
1221	5.93	5.69	0.3	5.75
1270	6.78	6.51	3.0	6.13

$$c = 4.42 \times 10^{-5}, \gamma = 1.657.$$

Table VI
Neon in argon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
297.0	0.303	0.301	0.8	0.319
349.5	0.416	0.413	1.0	0.423
397.0	0.566	0.562	2.4	0.526
448.2	0.666	0.661	1.1	0.648
550.0	0.811	0.805	1.5	0.782
548.0	0.961	0.954	0.9	0.915
646.0	1.24	1.23	2.3	1.21
691.5	1.31	1.30	4.8	1.36
738.5	1.52	1.51	0.6	1.53
787.0	1.76	1.74	0.3	1.71
831.5	1.91	1.89	0.4	1.87
880.0	2.11	2.10	1.2	2.07
927.5	2.23	2.21	0.2	2.26
975.0	2.40	2.38	0.9	2.46
1023	2.61	2.59	0.5	2.68
1070	2.74	2.72	0.6	2.89
1118	3.06	3.04	0.2	3.12
1169	3.36	3.34	0.7	3.36
1221	3.89	3.86	2.5	3.62
1274	4.16	4.12	1.4	3.90

$$c = 1.80 \times 10^{-5}, \gamma = 1.718.$$

Table VII
Krypton in neon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
269.0	0.253	0.252	5.8	0.247
402.0	0.414	0.412	2.3	0.421
443.0	0.485	0.485	1.2	0.498
492.7	0.594	0.595	2.0	0.599
544.9	0.712	0.714	0.9	0.714
593.0	0.791	0.794	1.5	0.827
640.0	0.953	0.956	0.6	0.945
688.1	1.07	1.07	1.3	1.07
735.2	1.19	1.20	0.4	1.20
779.0	1.33	1.33	1.0	1.33
830.2	1.53	1.54	0.3	1.49
877.0	1.65	1.66	0.5	1.63
923.0	1.74	1.75	1.2	1.79
971.0	1.95	1.96	1.3	1.95
1021	2.12	2.12	3.6	2.13
1071	2.28	2.28	2.0	2.31
1119	2.48	2.49	2.0	2.50
1169	2.65	2.66	1.0	2.69
1220	2.70	2.70	2.3	2.90
1271	2.96	2.97	1.2	3.11

$$c = 1.246 \times 10^{-5}, \gamma = 1.739.$$

Table VIII
Neon in xenon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
297.0	0.229	0.214	1.0	0.225
353.0	0.329	0.308	2.3	0.300
396.9	0.409	0.383	1.0	0.365
447.0	0.513	0.480	0.4	0.445
495.5	0.582	0.548	1.1	0.528
551.5	0.674	0.635	0.4	0.632
595.0	0.695	0.647	1.6	0.717
647.0	0.850	0.794	1.4	0.825
691.0	0.953	0.890	0.2	0.921
742.5	1.06	1.01	1.2	1.04
784.0	1.20	1.15	1.1	1.14
837.0	1.35	1.28	0.1	1.27
880.5	1.47	1.40	0.5	1.38
926.5	1.55	1.47	1.7	1.50
974.0	1.73	1.64	0.6	1.63
1024	1.82	1.72	2.1	1.78
1071	2.13	2.02	1.1	1.92
1119	2.18	2.09	1.6	2.06
1169	2.34	2.25	1.3	2.22
1218	2.54	2.44	1.4	2.37
1270	2.73	2.61	1.4	2.55

$$c = 1.67 \times 10^{-5}, \gamma = 1.670.$$

Table IX
Krypton in argon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
300.0	0.144	0.137	2.5	0.149
345.0	0.201	0.191	2.9	0.189
349.5	0.197	0.187	3.3	0.193
447.0	0.301	0.289	2.1	0.294
497.8	0.381	0.366	1.7	0.353
546.3	0.441	0.424	0.6	0.413
595.0	0.498	0.486	2.0	0.478
639.0	0.555	0.542	1.3	0.540
642.8	0.555	0.541	0.1	0.545
691.0	0.630	0.618	1.1	0.617
738.5	0.689	0.677	0.8	0.690
788.0	0.768	0.755	0.1	0.771
832.0	0.871	0.856	0.0	0.846
879.0	0.945	0.930	0.2	0.929
926.5	1.03	1.02	0.7	1.02
975.0	1.13	1.11	1.1	1.11
1025	1.24	1.23	0.2	1.21
1073	1.32	1.30	0.4	1.30
1121	1.44	1.42	0.7	1.41
1170	1.56	1.52	0.8	1.51
1221	1.66	1.61	0.5	1.63
1274	1.76	1.71	1.4	1.75

$$c = 0.895 \times 10^{-5}, \gamma = 1.703.$$

Table X
Xenon in argon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
298.0	0.112	0.105	1.7	0.114
348.0	0.154	0.145	0.5	0.149
398.3	0.199	0.187	0.8	0.188
447.5	0.248	0.238	0.2	0.231
496.2	0.295	0.283	0.7	0.276
547.0	0.363	0.348	2.1	0.328
595.5	0.428	0.412	1.7	0.380
643.0	0.444	0.432	0.5	0.434
692.3	0.496	0.482	2.1	0.494
735.0	0.553	0.538	0.3	0.548
783.0	0.611	0.596	1.0	0.612
831.5	0.695	0.682	0.5	0.680
879.0	0.705	0.693	0.8	0.749
926.0	0.796	0.783	1.0	0.820
973.0	0.898	0.886	0.4	0.894
1023	0.992	0.980	0.0	0.975
1071	1.08	1.07	0.9	1.06
1119	1.17	1.16	1.2	1.14
1167	1.24	1.23	0.1	1.23
1219	1.36	1.35	0.2	1.32
1272	1.39	1.39	0.6	1.43

$$c = 0.552 \times 10^{-5}, \gamma = 1.743.$$

Table XI
Krypton in xenon

<i>T</i> (K)	<i>D_s</i> (cm ² /s)	<i>D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
297.7	0.077	0.072	3.4	0.078
348.7	0.086	0.081	3.8	0.104
395.9	0.140	0.132	1.5	0.131
446.8	0.174	0.164	1.6	0.162
495.1	0.208	0.191	2.2	0.195
546.4	0.254	0.234	0.3	0.232
593.7	0.275	0.262	3.9	0.270
641.1	0.338	0.323	3.1	0.309
690.1	0.374	0.357	2.9	0.353
735.8	0.407	0.386	1.0	0.396
784.3	0.476	0.454	0.4	0.444
831.9	0.518	0.498	2.7	0.493
877.5	0.561	0.539	0.6	0.543
927.5	0.624	0.600	4.0	0.599
973.8	0.684	0.654	1.1	0.654
1025	0.753	0.723	1.0	0.717
1073	0.801	0.769	2.6	0.778
1123	0.884	0.849	0.6	0.844
1172	0.939	0.899	3.7	0.910
1218	1.02	0.971	1.2	0.976
1223	1.02	0.983	0.5	0.983
1270	1.09	1.04	0.6	1.05

$$c = 0.292 \times 10^{-5}, \gamma = 1.790.$$

Table XII
Neon in neon

<i>T</i> (K)	<i>D_s = D_{s,50}</i> (cm ² /s)	ΔD (%)	<i>D_{f,50}</i> (cm ² /s)
295.6	0.494	0.8	0.507
349.9	0.689	1.2	0.675
400.4	0.897	0.6	0.847
447.4	1.05	0.9	1.02
500.4	1.20	0.6	1.24
547.0	1.38	0.7	1.44
596.2	1.60	0.8	1.66
645.4	1.97	1.2	1.90
692.5	2.10	3.5	2.14
738.1	2.40	0.7	2.39
784.4	2.67	1.4	2.64
839.5	2.93	0.7	2.97
877.9	3.21	0.2	3.20
930.3	3.50	0.4	3.53
973.6	3.83	0.2	3.81
1026	4.17	0.6	4.16
1071	4.52	0.2	4.48
1129	4.84	0.5	4.90
1170	5.26	0.4	5.20
1219	5.56	0.5	5.57

$$c = 3.34 \times 10^{-5}, \gamma = 1.692.$$

greater/smaller and keeps cT^γ at 800 K constant, then c has to be chosen circa 10% smaller/greater.

Moreover the experimental procedure and thus D_s , $D_{s,50}$, $D_{f,50}$, c and γ will also contain systematic errors. In consequence of a critical evaluation of the measuring method and apparatus used, we think the systematic errors in D should not be more than 1%.

Figs. 2 . . . 12 show $D_{s,50}$ values and also some results obtained by other authors, which have been converted to a 50%/50% mixture ratio as well.

5. Comparison with the results of other diffusion measurements

Figs. 2 . . . 12 contain not only the values obtained here but also the results obtained by Hogervorst [8] and averaged values of Mason and Marrero [4]. All values have been converted to equimolar mixtures.

Table XIII contains the mean deviations of other results in the temperature range between 300 and 800 K. In this range a lot of determinations had already been carried out; their results up to 1968 have been weighed and correlated by Mason and Marrero [4]. With the exception of the combinations Ne + Kr and Ar + Xe our results agree very well with the correlated results. The agreement with the data of Hogervorst [8], Weissman [9], Liner and Weissman [10], Kalinin and Suetin [11] and Nain and Saxena [12] is also good. The values published by Loiko, Ivakin and Suetin [13] are significantly higher.

Table XIII gives the corresponding deviations in the temperature range 800 to 1300 K. In this range only measurements by Hogervorst [8] and Weissman [9] are available. The comparison with Mason and Marrero [4] in table XIII is based mainly on their extrapolation above 800 K from correlated literature values for the temperature range below 800 K. As has been noted by Weissman [9] this extrapolation leads to diffusion coefficients which are too high (cf. [4] and [8]). Only for He + Ne and Ne + Xe the mean deviation is smaller than 2%.

A comparison of the results of Hogervorst's cataphoresis method with our results shows that his values are generally slightly lower. We have no reason to assume that systematic errors in the use of the back-diffusion method will become more important at higher temperatures. However, the same applies to the cataphoresis method. Dr. Hogervorst drew our atten-

Table XIII

The mean percentage by which the values found in literature deviate from our values of the (reduced) diffusion coefficients. (Column numbers relate to the references.)

	a. For temperatures $T < 800$ K							b. For $T > 800$ K			
	[4]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[4]	[8]	[9]
He + Ne	+0.7	+0.8			+0.8				-0.7	-3.9	
He + Ar	+0.5	-1.9		+1.9	-2.3			-4.1	+3.4	-4.5	
He + Kr	-0.5	-2.0					+3.3		+3.5	-2.3	
He + Xe	+0.6	-1.1					+4.0		+7.8	+3.8	
Ne + Ar	+0.2	-1.2	0.0		-0.4	+0.5			+2.2	-1.8	-1.3
Ne + Kr	+4.7	+3.1					+5.6		+5.1	0.0	
Ne + Xe	+0.1	-1.6				+0.4	+3.1		+0.9	-4.8	
Ar + Kr	+1.2	+0.2					+2.4		+2.1	-1.7	
Ar + Xe	+3.7	+3.3					+4.8		+6.8	+4.3	
Kr + Xe	-2.6						+3.5 ^x		-2.7		
Ne + Ne			+2.3								-3.1

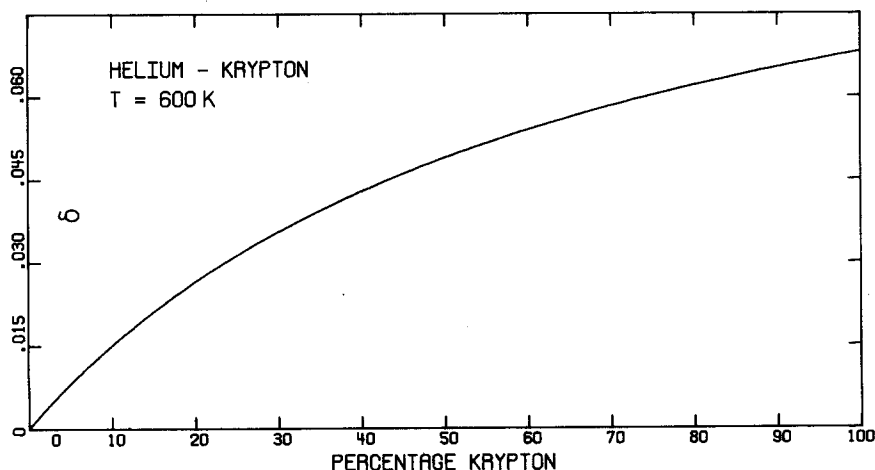


Fig. 1. The relative increase δ (cf. form. 2) of the diffusion coefficient of krypton in helium at 600 K as a function of the percentage krypton.

tion to the fact that with some gas pairs his main/admixture gas choice was the reverse of ours. This means that a possible incorrectness in the formula for the conversion to equimolar mixtures (cf. sect. 2) also contributes to the differences between his results and ours.

In summary, it can be concluded that the back-diffusion method gives good results for temperatures up to 800 K; and above 800 K the measurements probably do not contain considerable systematic errors. Furthermore the back-diffusion method is expected to be very useful for measurements of non-noble gases.

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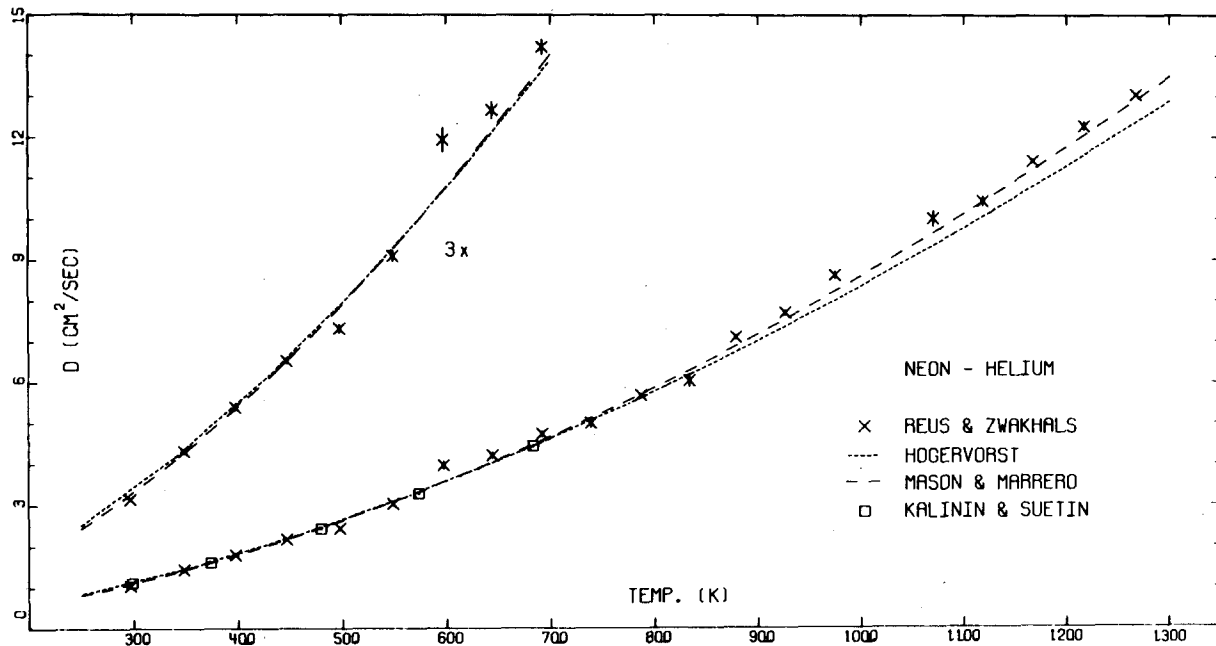


Fig. 2.

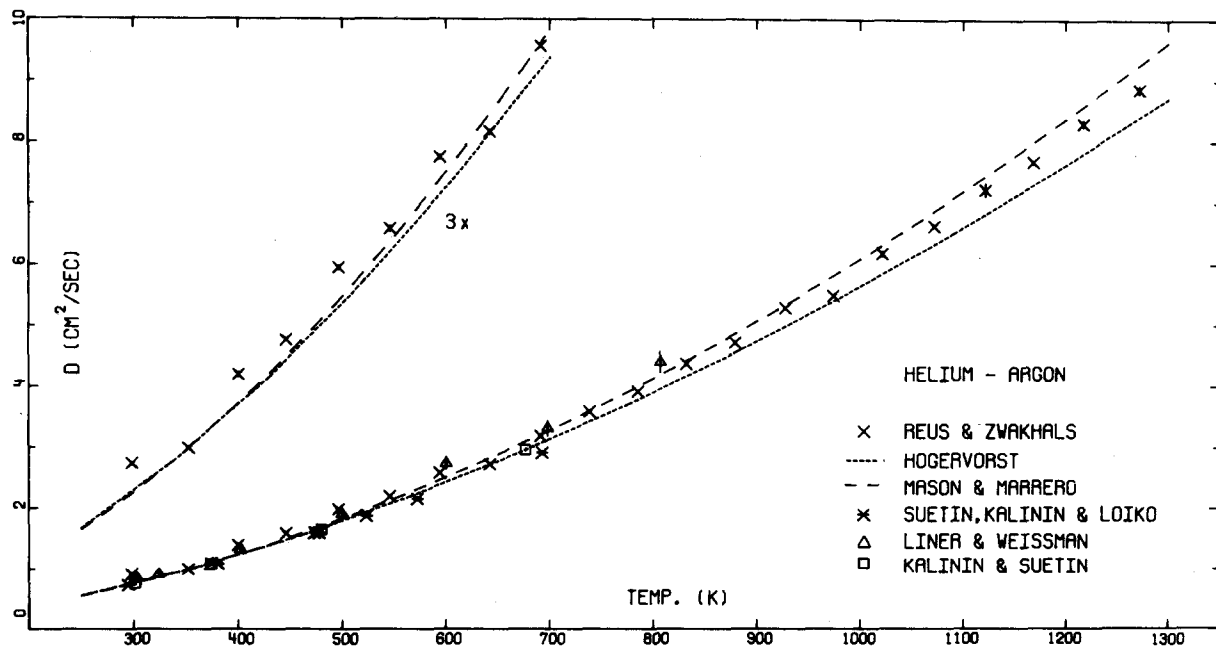


Fig. 3.

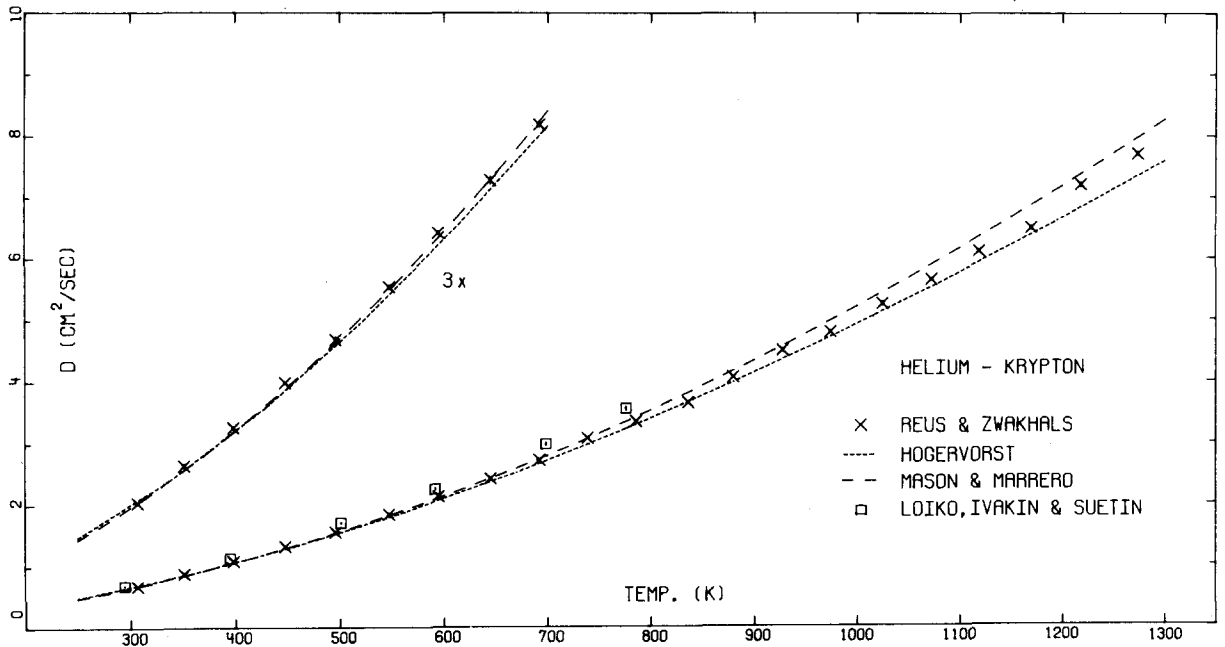


Fig. 4.

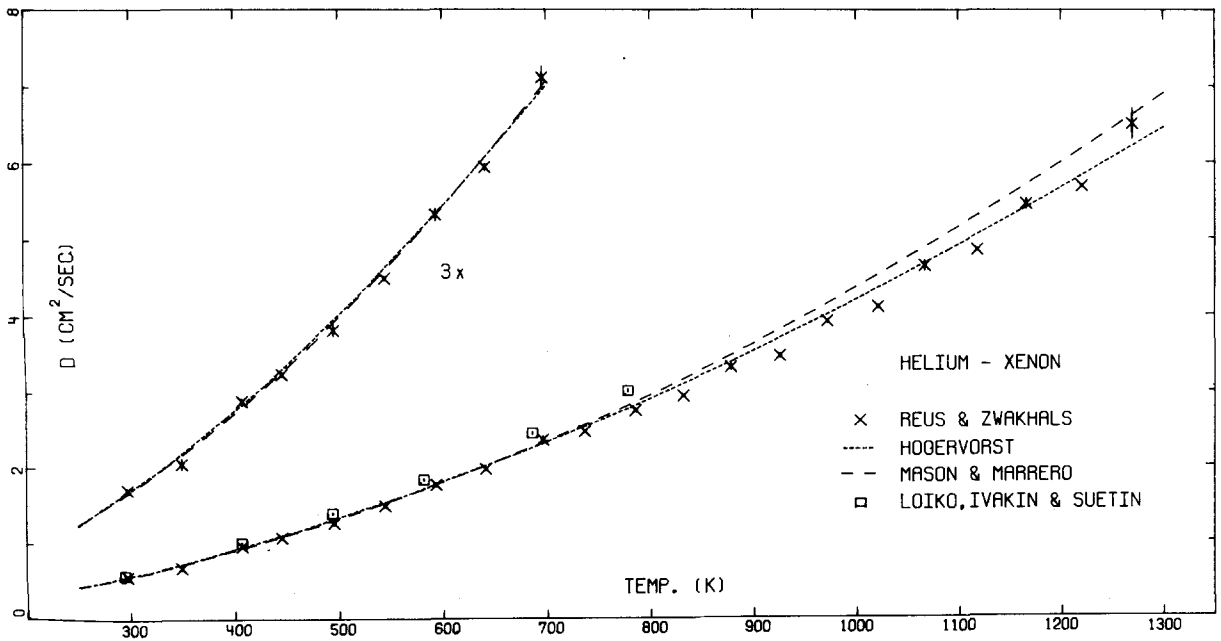


Fig. 5.

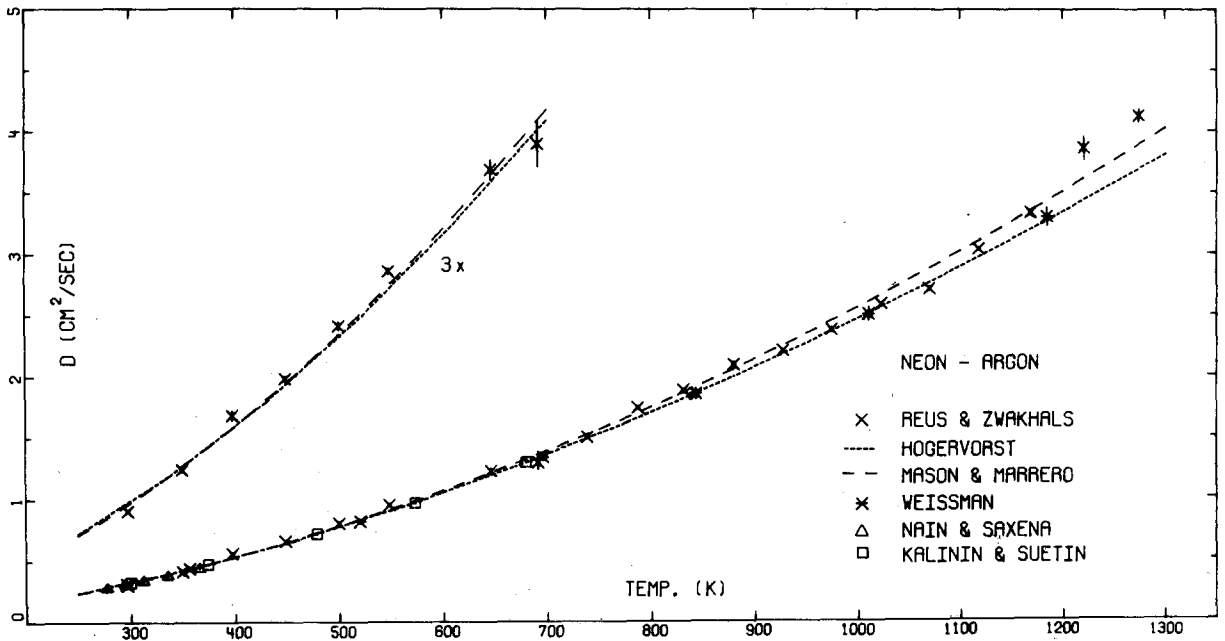


Fig. 6.

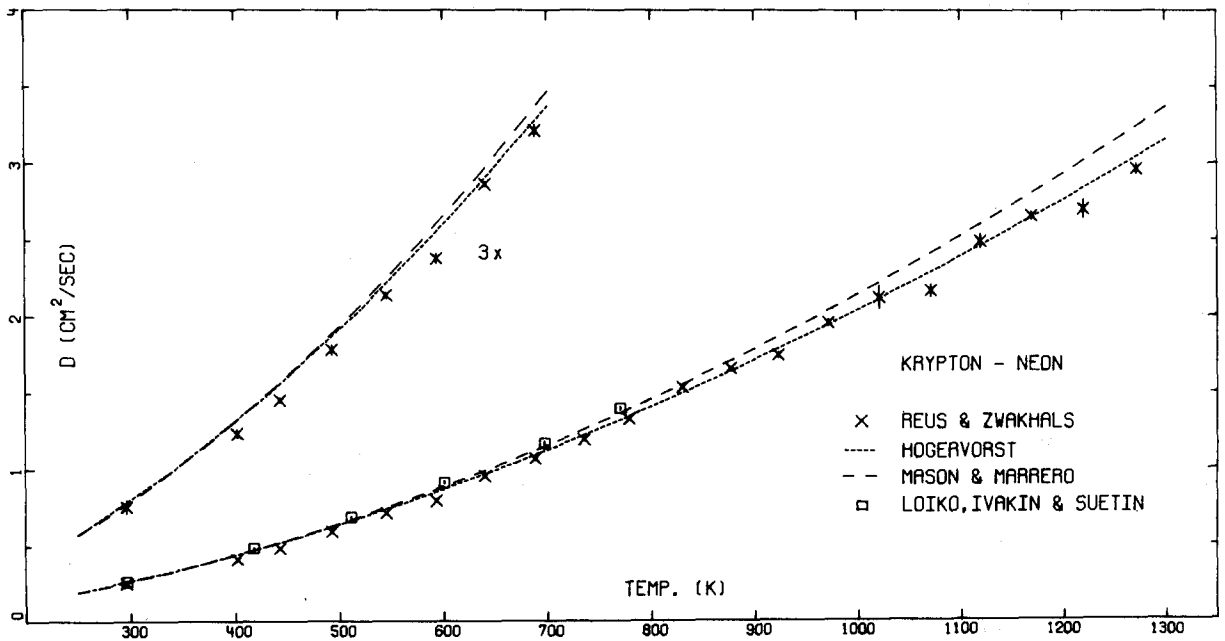


Fig. 7.

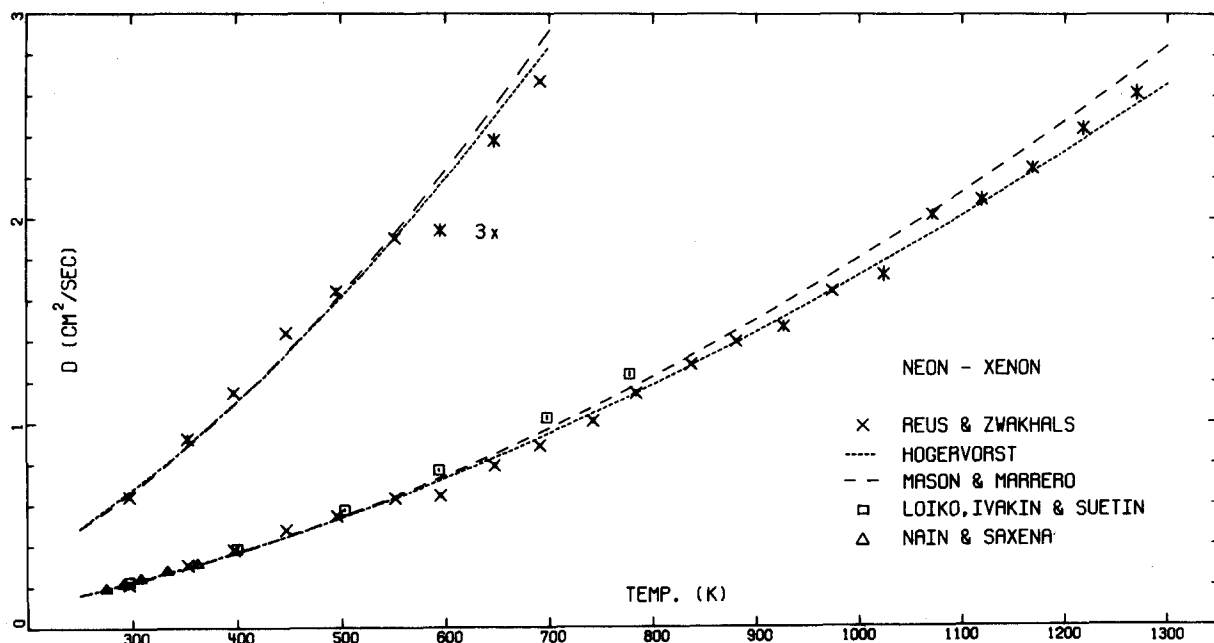


Fig. 8.

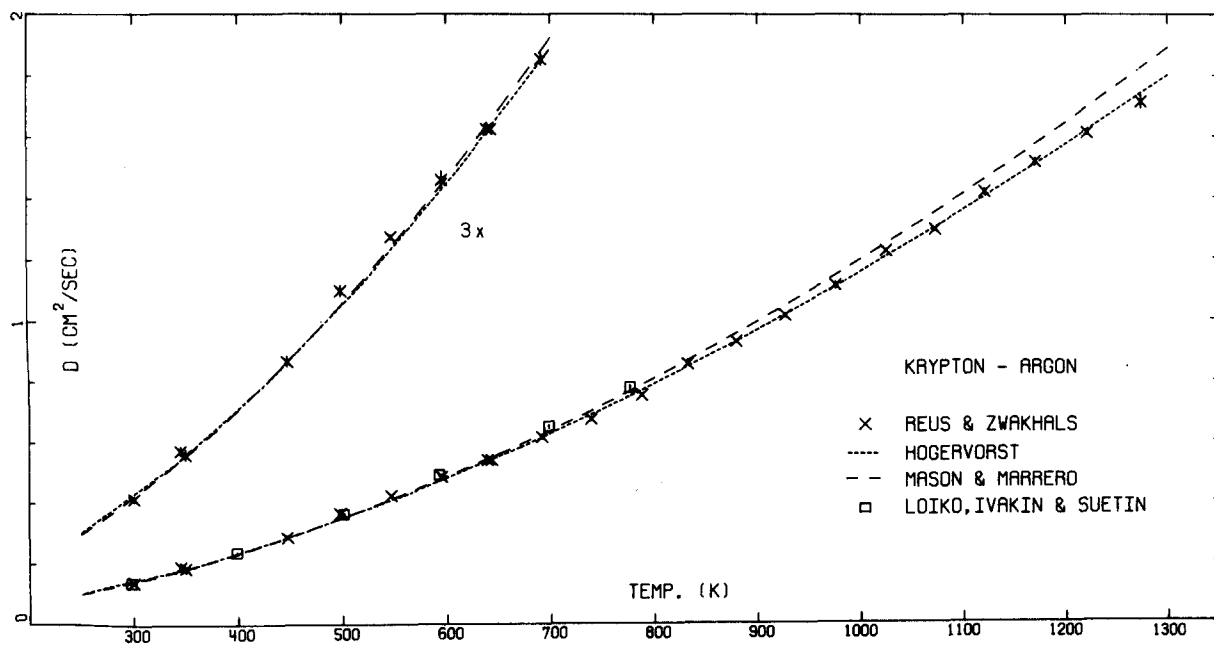


Fig. 9.

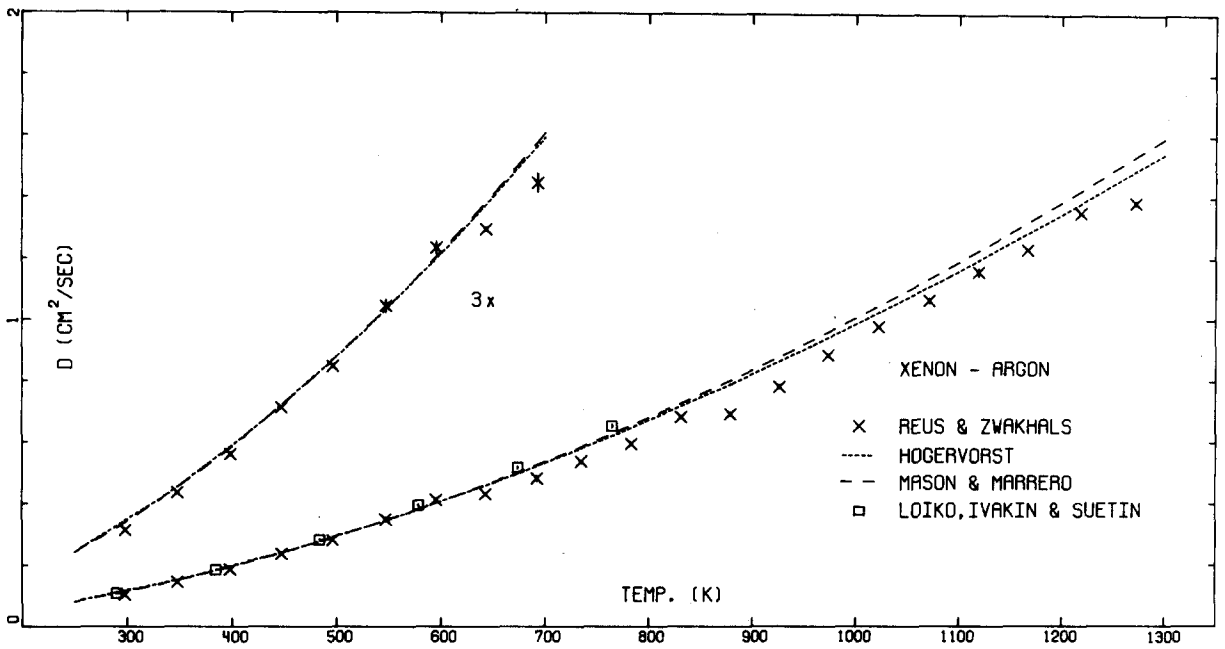


Fig. 10.

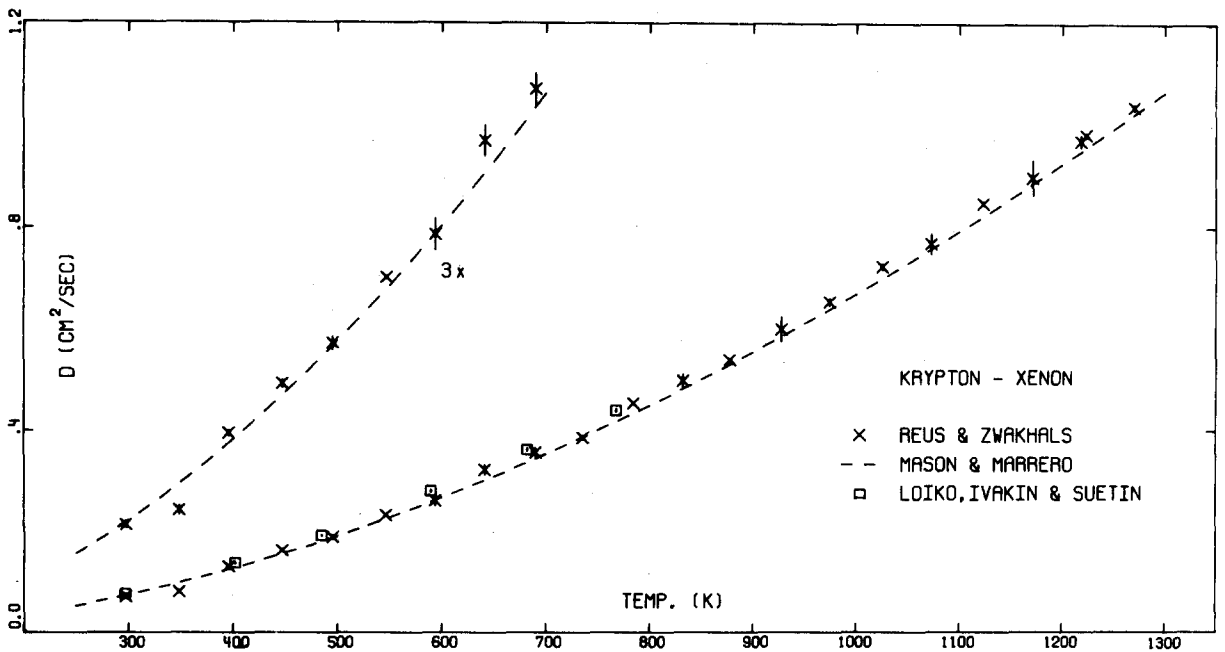


Fig. 11.

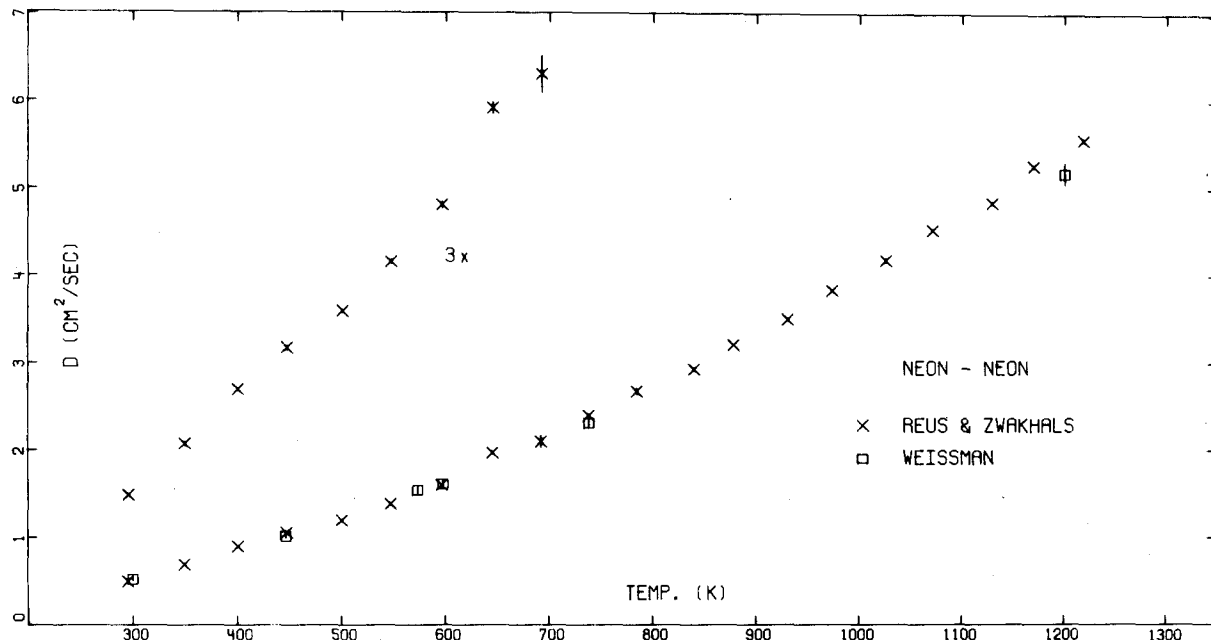


Fig. 12.

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