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THE UNIMOLECULAR OZONE DECOMPOSITION REACTION.(U)
AUG 79 J M HEIMERL , T P COFFEE

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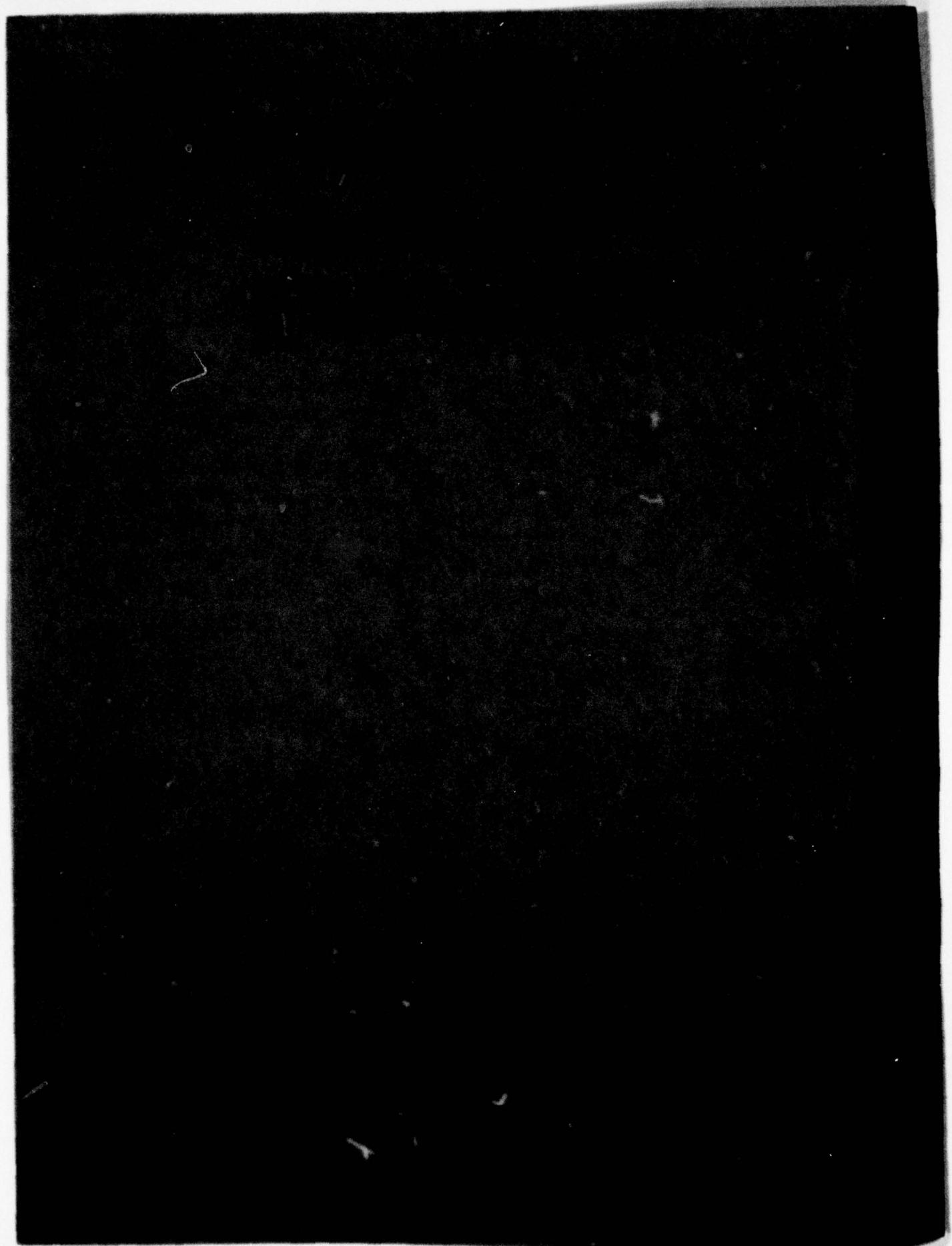
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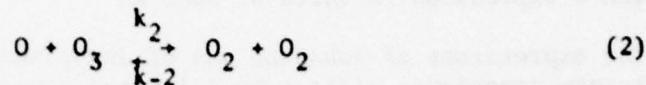
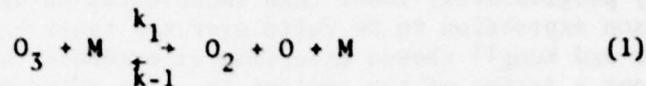
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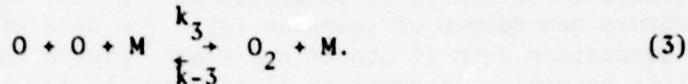
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I. INTRODUCTION

We have recently developed a one-dimensional, premixed, laminar flame code that considers detailed elementary reactions and detailed transport properties¹. As a test of this code we elected to examine the ozone flame, since its flame speed has been measured² over the range 17 to 100 mole % ozone. The reactions are



and



As expected, the most important reaction for our flame studies proved to be reaction (1). Since adiabatic flame temperatures range from 1027 K to 2677 K², we required a rate expression for reaction (1) valid over this temperature range.

In 1968 these reactions were reviewed in detail by Johnston³. He found that $k_1 (M = O_3) = 9.94 \times 10^{14} \exp(-22.72/RT) \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$ over the temperature range 200-1000 K. In 1976 the Leeds group⁴ recommended his value. (The value for R here is taken as 1.9872 kcal mole⁻¹ K⁻¹. To convert to SI units note that 4.184 joules = 1 calorie.)

The only data in the temperature range ~ 600-1000 K available to Johnston were those of Jones and Davidson⁵. All other direct measurements of reaction (1) used by Johnston lay in the range 303-559 K, with most of these taken at temperatures less than 400 K³.

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1. J. M. Heimerl and T. P. Coffee, to be published.
 2. A. G. Streng and A. V. Grosse, "The Ozone to Oxygen Flame," Sixth Symposium (International) on Combustion, Reinhold Publishing Co., 1957, pp 264-273.
 3. H. S. Johnston, "Gas Phase Reaction Kinetics of Neutral Oxygen Species", NSRDS-NBS20, September 1968.
 4. D. L. Baulch, D. D. Drysdale, J. Duxbury and S. J. Grant, "Evaluated Kinetic Data for High Temperature Reactions", Butterworths, Boston, 1976, Vol. 3.
 5. W. M. Jones and N. Davidson, J. Am. Chem. Soc. 84, 2868-2878, 1962.

Several investigators, all using shock tubes, found indications that the Arrhenius expression for reaction (1) given by Jones and Davidson⁵ might not be valid at higher temperatures. Over a combined temperature range of 1340-3300 K, Wray⁶ and Kiefer and Lutz^{7,8} found their experimental results were consistent with values of k_1/k_2 that were much lower than those predicted using the Jones and Davidson expression. Michael⁹ used Benson and Axworthy's¹⁰ value for k_2 and found that his values for k_1 lay progressively lower than those obtained by assuming the Jones and Davidson expression to be valid over the range ~ 1000 -1400 K. Finally Center and Kung¹¹ showed experimental evidence that this rate coefficient is about a factor of two smaller than the value obtained by assuming that Johnston's expression is valid at 3000 K.

The expressions of Johnston and of Jones and Davidson describe the temperature dependence of k_1 over a limited range. Sufficient information seemed to be available to arrive at a better description of the temperature dependence of reaction (1). The data of Michael⁹ and the high temperature data of Center and Kung¹² proved to be in a form that made this possible. A complete listing of the low temperature data compiled by Johnson³, essentially his Table XVIII, and that of Michael⁹ is listed in Appendix A. The data of Center and Kung¹² are listed in Appendix B.

II. ANALYSIS

A. General

We desired values for k_1 extending from 300-3000 K so that a valid fit (i.e. Arrhenius description) could be obtained. We should like to use as much of Michael's data and of Center and Kung's data as possible to extend the temperature range covered in Johnston's review. To this end we first examined the dependence of Michael's data for k_1 upon the

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6. K. L. Wray, *J. Chem. Phys.* 38, 1518-1524 (1963).
 7. J. H. Kiefer and R. W. Lutz, *J. Chem. Phys.* 42, 1709-1714 (1965).
 8. J. H. Kiefer and R. W. Lutz, "The Effect of Oxygen Atoms on the Vibrational Relaxation of Oxygen", *Proceedings of 11th Symposium (International) on Combustion*, August 1966, *Combustion Institute*, PA, 1967, pp 67-76.
 9. J. V. Michael, *J. Chem. Phys.* 54, 4455-4459 (1971).
 10. S. W. Benson and A. E. Axworthy, *J. Chem. Phys.* 42, 2614-2615 (1965).
 11. R. E. Center and R. T. V. Kung, *J. Chem. Phys.* 62, 801-807 (1975).
 12. R. T. V. Kung, private communication, 1978.

value of k_2 and then determined appropriate high temperature values for k_1 from the data of Center and Kung.

In evaluating both the data of Michael and of Center and Kung we have followed Johnston and have converted each of their measurements to equivalent ozone. To do so we have used $k_1(M=Ar)/k_1(M=Kr) = 1.25$ (ref. 9) and $k_1(M=O_3)/k_1(M=Ar) = 4.0$ (ref. 3) and have assumed that these ratios are independent of temperature. Should quantitative third body efficiencies as a function of temperature become available and be found to differ significantly from the values we have employed, the analysis presented below would have to be repeated using appropriately adjusted data.

B. Michael's Data

Michael⁹ operated his shock tube at low initial pressures ($\sim 0.04 - 0.2$ atmospheres) and large amounts ($\sim 95\%$) of krypton as a diluent and so the only reactions of importance are (1) and (2). This leads to the following rate equations:

$$d[O_3]/dt = - k_1 [O_3] [M] - k_2 [O_3] [O] \quad (4)$$

and

$$d[O]/dt = + k_1 [O_3] [M] - k_2 [O_3] [O]. \quad (5)$$

When the oxygen atom concentration reaches the steady state; i.e., $d[O]/dt = 0$, we can write

$$d[O_3]/dt = - 2 k_1 [O_3] [M]. \quad (6)$$

Reactions (1) and (2) were modeled by Michael and the logarithm of the calculated ozone concentration was plotted against time. He found no significant deviation from first order kinetics, and k_1 was described by equation (6). However, he had used Benson and Axworthy's value¹⁰ for $k_2 = 3.37 \times 10^{13} \exp(-5.70/RT) \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$. Later expressions of Johnston³, $k_2 = 1.20 \times 10^{13} \exp(-4.79/RT) \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$ (200-1000 K), and the Leeds group⁴, $k_2 = 5.2 \times 10^{12} \exp(-4.15/RT) \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$ (200-500 K) lead to smaller values for k_2 . This means that the time for the oxygen atom concentration to reach steady state will take longer than in Michael's calculations. The question is: how much longer?

We have numerically integrated equations (4) and (5) for Michael's conditions using the smallest value⁴ for k_2 and found that $d[O]/dt \approx 0$ is still valid in the time frame of Michael's experiment, typically 50 to 350 μ sec. (Rate coefficients derived using equation (6) will tend to be systematically low but the error is less than $\sim 10\%$). Note that we must assume that the expression for k_2 is valid up to ~ 1400 K. This approach appears to be reasonable since Michael's data are not very sensitive to the precise value of k_2 .

In summary we find that the later, lower values of k_2 do not significantly affect Michael's results.

C. Center and Kung's Data

Center and Kung¹¹ operated their shock tube at very low initial pressures ($\sim 7 \times 10^{-4}$ to 3×10^{-2} atmospheres) with a high (95-99%) argon diluent. The time scale of these measurements is tens of microseconds, much shorter than the time scale in Michael's experiment. A simple analytical unfolding of their ozone concentration relaxation time observations could be made provided that $[O] = 0$ or more precisely that $k_2 [O] \ll k_1 [M]$. Under these conditions

$$d[O_3]/dt = -k_1 [M] [O_3]. \quad (7)$$

Numerical integration of equations (4) and (5) for their experimental conditions shows that as one progresses from 2000 K to lower temperatures the more important the term involving atomic oxygen becomes (see Equation 4), and that for temperatures greater than 2000 K, the loss rate of ozone can be approximately described by equation (7). In this manner fourteen points of Center and Kung¹² were determined to be valid representations of k_1 and are listed in Table I. A complete listing of their data and a more detailed analysis of their data may be found in Appendix B.

The question remains: what is the sensitivity of these values of k_1 as listed in Table I to the value of k_2 ? It can be seen in equation (4) that the larger the value of k_2 the more important that term becomes. Here we have used Hampson's¹³ expression for $k_2 = 1.14 \times 10^{13} \exp(-4.57/RT) \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$ (200-1000 K). Again this expression for k_2 has been assumed to be valid at the higher temperatures. To test the sensitivity of the values of k_1 on the value of k_2 we have arbitrarily multiplied Hampson's expression for k_2 by two for the 2041 K case (see Table I). We have found that the computed ozone relaxation time (i.e., k_1) changes by about 10%. For the higher temperatures the change is less.

13. R. F. Hampson, ED., *J. Phys. and Chem. Ref. Data* 2, 267-308 (1973).

TABLE I. HIGH TEMPERATURE VALUES OF k_1 FROM CENTER AND KUNG

<u>T(K)</u>	<u>k_1 (M = Ar)</u>
2041	5.31(11)*
2128	9.48(11)
2273	1.54(12)
2353	1.76(12)
2439	1.18(12)
2500	9.98(11)
2564	1.08(12)
2564	1.30(12)
2632	1.37(12)
2667	1.62(12)
2703	1.84(12)
2778	2.25(12)
2857	2.24(12)
2941	1.90(12)

*Read as $5.31 \times 10^{11} \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$.

D. The Least Squares Fit

The data can be divided into four groups by temperature: the lower temperature values³ (303-359 K); the Jones and Davidson^{3,5} values, (769-910 K); Michael's⁹ values (971-1384 K); and Center and Kung's¹¹ values, (2041-2941 K). So that the preponderance of low temperature data points would not bias the fit, each group of data was weighted equally. For example, we used 14 values of k_1 from Center and Kung (see Table I) and in this group each value was weighted by 1/14. To avoid biasing the fit toward the higher absolute values of k_1 , errors between the least squares fit and the data points were all measured in a relative sense. This is accomplished by using a weight for each value of k_1 equal to the square of the reciprocal of that value. This weight is in addition to the weighting discussed above. The logarithmic method with proper transformation of the weights¹⁴ was used to fit the data points to the two parameter Arrhenius form: $A \exp(-E/RT)$, where $R=1.9872 \times 10^{-3}$ kcal mole⁻¹ K⁻¹ and T is the temperature. The value $k_1 (M=03) = 4.31 \times 10^{14} \exp(-22.2/RT)$ cm³ mole⁻¹ s⁻¹ was found. The number of digits carried is a measure of the precision of the fit and not of the accuracy of the experiments. A listing of the least squares fitting routine coded in FORTRAN for use on a CDC-7600 can be found in Appendix C.

Table II shows the average error for the points in each of the four data groups relative to our recommended fit. The average error for all the data points is also shown. The fact that the average relative error for each data group is comparable to the error in the overall fit is another indication that the fit is not dominated by any single data group. The size of the errors can be traced to the large amount of scatter in the data.

To check the consistency of these independent data and the robustness of the derived two parameter Arrhenius expression, fits were also made by deleting one group of data at a time. These results are given in Table III. The evaluation of these two parameters is seen to be independent of any single data group. Specifically, if the highest temperature data of Center and Kung are deleted, the subsequent expression for k_1 extrapolated to 2500 K yields values only 2% greater than all the data combined. Similarly if Michael's data are deleted the subsequent interpolated value of this expression for k_1 is 17% greater than all the data combined.

Separate fits were made to each of the four data groups. In some cases the parameters so obtained differed markedly from those obtained using all the data. This comes as no surprise since each of the four groups encompass a rather limited temperature range, while taken together they span a temperature range of about a factor of ten.

14. R. J. Cveticanovic and D. L. Singleton, *Internat. J. of Chem. Kin.* 9, 481-488, 1977. See also, R. J. Cveticanovic and D. L. Singleton, *Internat. J. of Chem. Kin.* 9, 1007-1009, 1977.

TABLE II. COMPARISON OF DATA FROM EACH GROUP
WITH OUR RECOMMENDED FIT

<u>Data Group</u>	<u>Average Relative Error</u>
Low Temp	25%
Jones & Davidson	43%
Michael	41%
Center & Kung	25%
All Data	33%

TABLE III. LEAST SQUARES FIT FOR ALL DATA
EXCLUDING DATA GROUPS ONE BY ONE

<u>All Data Except</u>	<u>Log A</u>	<u>E(kcal/mole)</u>
Low Temp	14.39	20.6
Jones & Davidson	14.60	22.2
Michael	14.70	22.3
Center & Kung	14.64	22.2
<hr/>		
All Data	14.63	22.2

A three parameter fit of the data was found to yield the expression $k_1 = 5.31 \times 10^{16} T^{-0.61} \exp(-23.1/RT) \text{ cm}^3 \text{ mole}^{-1} \text{ s}^{-1}$. The activation energy is about the same as the two parameter case and the average error for all the data in this case is 31%, slightly smaller than the two parameter case. The three parameter fit is sensitive to data deletion and thus we feel that the data are not sufficiently precise to support such a fit. The two parameter fit is essentially just as accurate.

Figure 1a, b, and c show a plot of all the data together with both the two parameter fit (solid line) and the three parameter fit (dashed line) to these data. Since the vertical scale spans about 15 powers of ten, the plot has been segmented into three sections.

For $T \sim 3000$ K the two parameter expression we have derived leads to values of k_1 that are about a factor of two lower than those obtained by assuming that the Johnston expression is valid. Because the Jones and Davidson data constituted the highest temperature available to him, Johnston necessarily weighted his fit heavily toward these data. However, as can be seen in the figure, our expression yields values for k_1 that lie below all the Jones and Davidson data. We do not know if the Jones and Davidson measurements are systematically too high¹⁵, or if there is actually some pre-exponential temperature dependence in the function representing k_1 that cannot yet be discerned because the data are not sufficiently accurate.

ACKNOWLEDGEMENT

We thank R. T. Kung for generously supplying his data. We also thank R. D. Anderson for his help with the figure.

15. For a discussion of some data reduction problems, see H. B. Palmer, *Combustion and Flame* 11, 120-124, 1967.

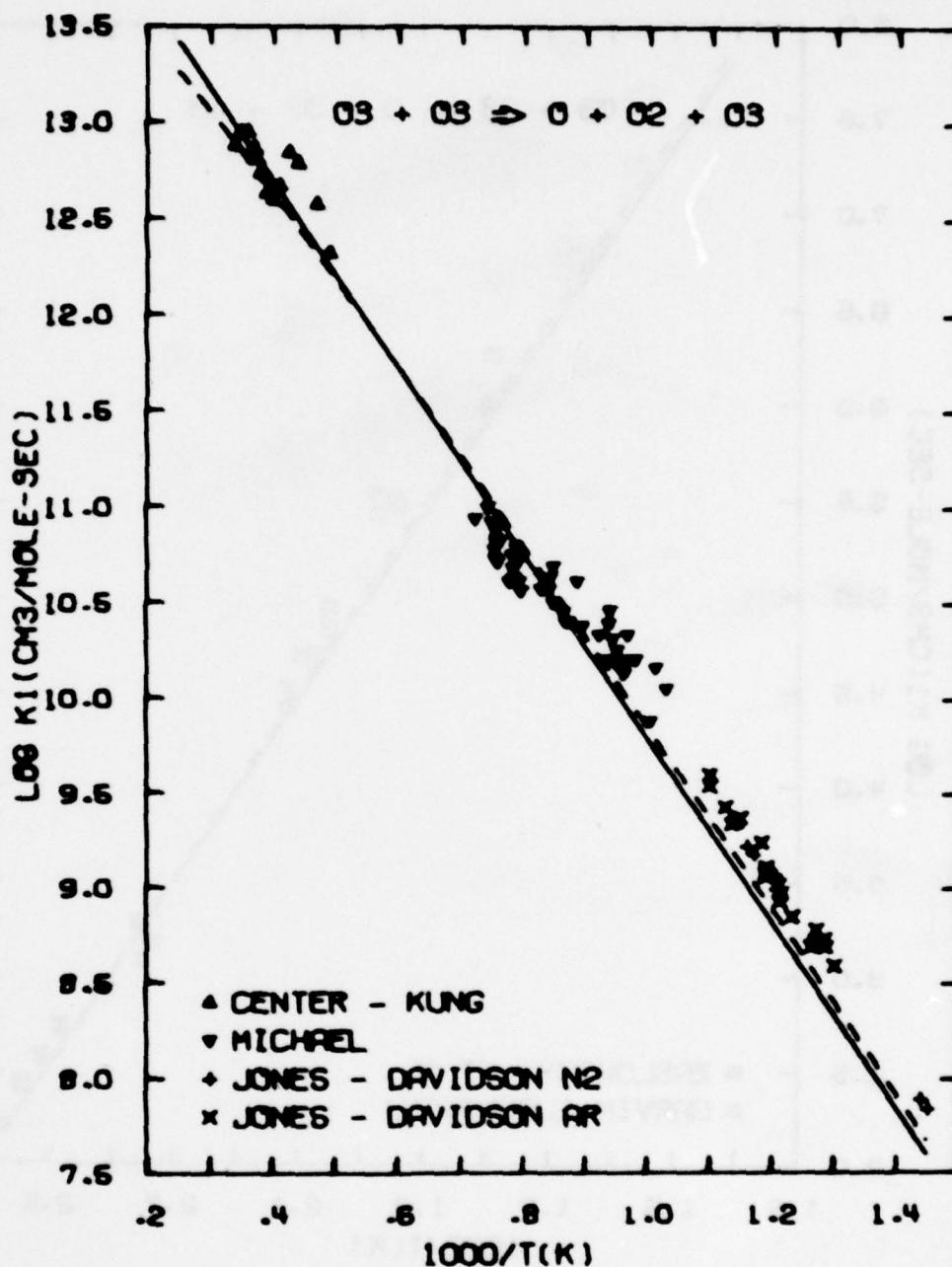


Figure 1a. High Temperature Data for the Unimolecular Ozone Decomposition Reaction. The data of Center and Kung are taken from Table I, the data of Michael from reference 9 of text and the data of Jones and Davidson from reference 3 of text. The data in the figure have been adjusted for $M = O_3$. The solid and dashed lines show respectively the best two and three parameter fits to all the data.

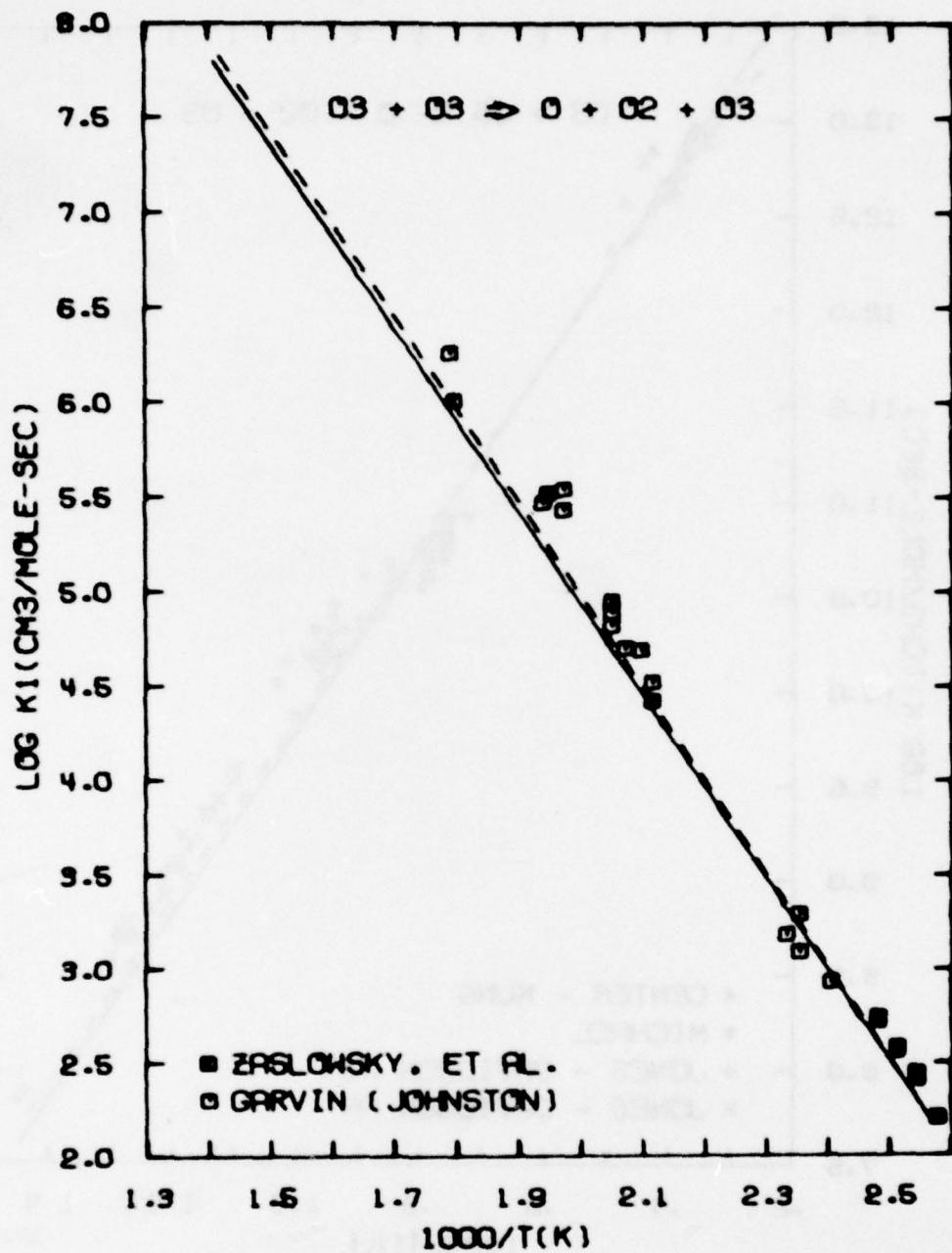


Figure 1b. Intermediate Temperature Range Data for the Unimolecular Ozone Decomposition Reaction. These data are taken from reference 3 of text, Table 18.

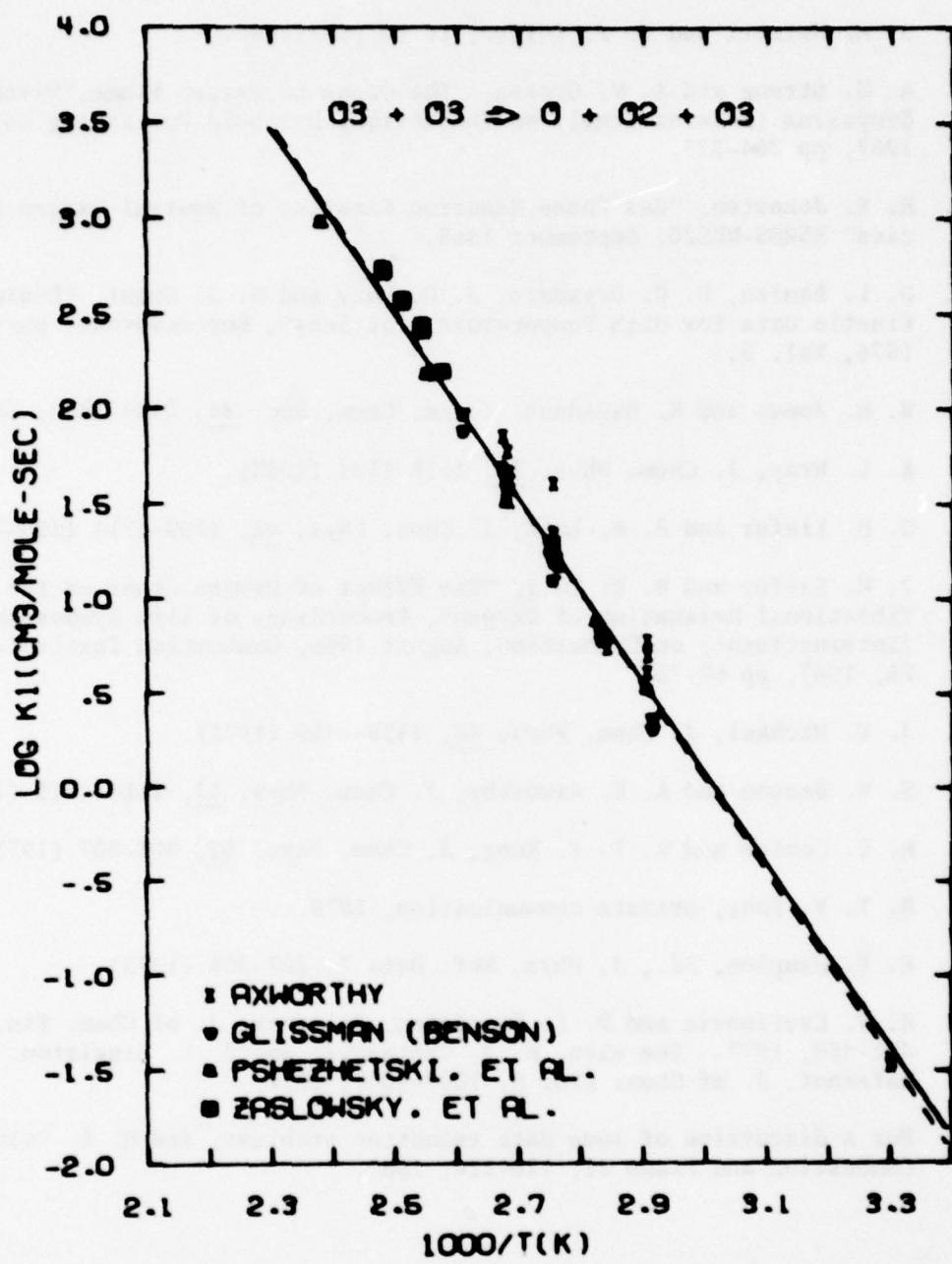


Figure 1c. Low Temperature Range Data for the Unimolecular Ozone Decomposition Reaction. These data are taken from reference 3 of text, Table 18.

REFERENCES

1. J. M. Heimerl and T. P. Coffee, to be published.
2. A. G. Streng and A. V. Grosse, "The Ozone to Oxygen Flame," Sixth Symposium (International) on Combustion, Reinhold Publishing Co., 1957, pp 264-273.
3. H. S. Johnston, "Gas Phase Reaction Kinetics of Neutral Oxygen Species" NSRDS-NBS20, September 1968.
4. D. L. Baulch, D. D. Drysdale, J. Duxbury and S. J. Grant, "Evaluated Kinetic Data for High Temperature Reactions", Butterworths, Boston, 1976, Vol. 3.
5. W. M. Jones and N. Davidson, J. Am. Chem. Soc. 84, 2868-2878, 1962.
6. K. L. Wray, J. Chem. Phys. 38, 1518-1524 (1963).
7. J. H. Kiefer and R. W. Lutz, J. Chem. Phys. 42, 1709-1714 (1965).
8. J. H. Kiefer and R. W. Lutz, "The Effect of Oxygen Atoms on the Vibrational Relaxation of Oxygen", Proceedings of 11th Symposium (International) on Combustion, August 1966, Combustion Institute, PA, 1967, pp 67-76.
9. J. V. Michael, J. Chem. Phys. 54, 4455-4459 (1971).
10. S. W. Benson and A. E. Axworthy, J. Chem. Phys. 42, 2614-2615 (1965).
11. R. E. Center and R. T. V. Kung, J. Chem. Phys. 62, 801-807 (1975).
12. R. T. V. Kung, private communication, 1978.
13. R. F. Hampson, Ed., J. Phys. Ref. Data 2, 267-308 (1973).
14. R. J. Cvitanovic and D. L. Singleton, Internat. J. of Chem. Kin. 9, 481-488, 1977. See also, R. J. Cvitanovic and D. L. Singleton, Internat. J. of Chem. Kin. 9, 1007-1009, 1977.
15. For a discussion of some data reduction problems, see H. B. Palmer, Combustion and Flame 11, 120-124, 1967.

APPENDIX A. DATA EXCLUSIVE OF CENTER & KUNG

The purpose for this appendix is to list all the data used for this evaluation of k_1 so that, together with Table I, it would be available in one location for future use.

The bulk of Table I-A that comprises this appendix is taken directly from Johnston (reference 3 of text). The only change from his Table 18 is the deletion of the six data points for which Axworthy added H_2O_2 or H_2O to the gaseous mixture. The references for this table are to be found in reference 3 (of text). Following Johnston, these data are listed for equivalent ozone (i.e., $M = O_3$), and we have converted these to cm^3/moles using the conversion 6.023×10^{23} particles/mole.

Michael's data are taken from reference 9 (in text) where equivalent ozone has been found using

$$k_1 (M = Ar)/k_1 (M = Kr) = 1.25$$

and

$$k_1 (M = O_3)/k_1 (M = Ar) = 4.0.$$

Table I-A is comprised of three columns. The first lists degrees Kelvin, the second column lists the reciprocal of the first multiplied by 1000. The third column lists the logarithm to the base ten of the rate coefficient for reaction (1) in units of $cm^3/\text{mole-sec}$. All these values are given for ozone as the third body. To convert to other third bodies see references 3 and 9 (of text).

TABLE I-A. DATA EXCLUSIVE OF
CENTER AND KUNG

JONES AND DAVIDSON DATA (MEAN).

T	1000/T	LOG(1)
769.	1.300	8.59
776.	1.284	8.60
779.	1.286	8.73
787.	1.271	8.78
792.	1.263	8.68
812.	1.237	8.65
826.	1.214	8.67
825.	1.212	8.69
827.	1.209	8.68
828.	1.208	8.67
840.	1.190	9.66
840.	1.190	9.11
861.	1.189	9.66
866.	1.182	9.72
871.	1.168	9.37
876.	1.142	9.35
881.	1.135	9.36
890.	1.124	9.63
910.	1.084	9.43
910.	1.099	9.66

JONES AND DAVIDSON DATA (MEAN).

T	1000/T	LOG(1)
689.	1.651	7.86
696.	1.641	7.86
788.	1.269	8.76
831.	1.203	9.62
837.	1.195	9.66
855.	1.170	9.16
863.	1.159	9.72

PSETHETSKY ET AL. DATA.

T	1000/T	LOG(1)
366.	2.497	.52
356.	2.825	.66
373.	2.641	1.51
392.	2.551	2.16
426.	2.381	2.08

ZASLOWSKY ET AL. DATA.

T	1000/T	LOG(1)
384.	2.577	2.29
388.	2.577	2.29
403.	2.545	2.42
403.	2.545	2.41
393.	2.605	2.64
393.	2.645	2.41
393.	2.645	2.46
393.	2.645	2.42
393.	2.645	2.43
393.	2.645	2.44

TABLE I-A. DATA EXCLUSIVE OF
CENTER AND ENDG. (Cont'd.)

	640V DATA	1000V	1000V
363.	2.565	2.9	2.9
364.	2.513	2.56	2.56
365.	2.513	2.56	2.56
366.	2.481	2.71	2.71
367.	2.481	2.71	2.71
368.	2.481	2.71	2.71
369.	2.481	2.71	2.71

	640V DATA	1000V	1000V
370.	2.046	2.9	2.9
371.	2.353	3.06	3.06
372.	2.353	3.06	3.06
373.	2.331	3.16	3.16
374.	2.116	4.52	4.52
375.	2.116	4.52	4.52
376.	2.046	4.52	4.52
377.	2.046	4.52	4.52
378.	2.070	4.52	4.52
379.	2.070	4.52	4.52
380.	2.046	4.52	4.52
381.	2.046	4.52	4.52
382.	2.046	4.52	4.52
383.	2.046	4.52	4.52
384.	2.046	4.52	4.52
385.	2.046	4.52	4.52
386.	2.046	4.52	4.52
387.	1.972	4.52	4.52
388.	1.972	4.52	4.52
389.	1.946	5.02	5.02
390.	1.946	5.02	5.02
391.	1.938	5.02	5.02
392.	1.765	6.61	6.61
393.	1.765	6.61	6.61
394.	1.765	6.61	6.61

	640V DATA	1000V	1000V
395.	2.915	1.31	1.31
396.	2.915	1.31	1.31
397.	2.835	1.32	1.32
398.	2.835	1.32	1.32
399.	2.835	1.32	1.32
400.	2.745	1.10	1.10
401.	2.745	1.10	1.10
402.	2.745	1.20	1.20
403.	2.745	1.20	1.20
404.	2.745	1.20	1.20
405.	2.745	1.20	1.20
406.	2.745	1.20	1.20
407.	2.745	1.20	1.20
408.	2.745	1.20	1.20
409.	2.745	1.20	1.20
410.	2.745	1.20	1.20
411.	2.745	1.20	1.20
412.	2.745	1.20	1.20
413.	2.745	1.20	1.20
414.	2.745	1.20	1.20

TABLE I-A. DATA EXCLUSIVE OF CENTER AND KUNG. (Cont'd.)

ANALYTIC DATA.

	10000/T	LOG ₁₀ E
303.	3.300	-1.66
346.	2.907	-0.76
346.	2.907	-0.76
346.	2.907	-0.76
346.	2.907	-0.76
352.	2.841	-0.74
362.	2.762	-1.21
362.	2.762	-1.16
363.	2.755	-1.10
363.	2.755	-1.26
363.	2.755	-1.23
363.	2.755	-1.23
363.	2.745	-1.27
363.	2.745	-1.27
363.	2.745	-1.27
363.	2.745	-1.27
364.	2.747	-1.27
364.	2.747	-1.27
364.	2.747	-1.29
373.	2.661	-1.78
373.	2.661	-1.66
374.	2.674	-1.66
374.	2.674	-1.66

TABLE I-A DATA EXCLUSIVE OF
CENTER AND KING (Cont'd)

MICHAEL DATA.		Loss
1	1060/7	10.57
1207.	.629	10.57
1227.	.783	10.75
1255.	.767	10.46
1305.	.763	11.00
1273.	.786	10.63
1285.	.778	10.61
1310.	.754	10.71
1276.	.784	10.68
1386.	.723	10.66
1329.	.754	10.73
1266.	.790	10.70
1326.	.754	10.74
1265.	.791	10.71
1861.	.643	10.31
1146.	.673	10.46
1322.	.756	10.66
1179.	.668	10.59
1119.	.664	10.26
1861.	.661	10.13
1065.	.977	10.33
1336.	.750	10.62
1152.	.668	10.46
1196.	.876	10.61
1323.	.756	10.63
1869.	.935	10.20
1820.	.846	10.70
996.	1.004	9.88
1311.	.743	10.62
1852.	.651	10.14
1266.	.794	10.61
1179.	.687	10.61
1179.	.688	10.66
1033.	.664	10.20
1165.	.866	10.63
1188.	.842	10.57
1150.	.864	10.65
1121.	.892	10.36
1034.	.667	10.33
971.	1.030	10.05
1061.	.937	10.39
1052.	.861	10.75
988.	1.012	10.14
1065.	.938	10.46

APPENDIX B. DATA OF CENTER AND KUNG

The purpose of this appendix is two fold. First and foremost to serve as a repository* for the actual tabular data upon which Center and Kung have published their paper (see Figure 4 of reference 11 in text). The second purpose lies in providing more detail to the analysis given this data.

Center and Kung's data (reference 12) are given in Table B-I. The terms employed are defined in the Glossary for this appendix. In analyzing this data set, the main problem lies in finding a value for k_1 given the measured relaxation time, τ_p .

Provided $k_2[0] \ll k_1[M]$ in equation 4 (in text) we can write $d[O_3]/dt = -k_1[M][O_3]$. Since their measurements are made after the shock we have

$$[M] = \rho_2 [Y_{Ar}/W_{Ar} + 4Y_{O_3}/W_{O_3}], \quad (B-1)$$

where following Johnston (reference 3) we have taken $k_1 (M = O_3) = 4k_1 (M = Ar)$. Since 95% or more of the gas is argon it is a good approximation to take $[M] = \text{constant}$. Then equation 7 (in text) can be readily integrated, to wit

$$[O_3] = [O_3]_0 \exp (-k_1[M]t). \quad (B-2)$$

The experiment consists of optically monitoring the ozone concentration and noting the time, τ_p , that the post shock intensity equals the pre-shock intensity. This corresponds to a change in the O_3 concentration equal to ρ_2/ρ_1 . Then

$$\ln(\rho_1/\rho_2) = -k_1[M] \tau_p. \quad (B-3)$$

We want an expression for k_1 in terms of experimentally measurable parameters. Using equation (B-1), equation (B-3) can be rewritten as

*Dr. Kung has graciously consented that this be done since these data do not appear anywhere else.

$$k_1 = \frac{\ln(\rho_2/\rho_1)}{(\rho_2/\rho_1) (p_1 \tau_p) (Y_{Ar}/W_{Ar} + 4Y_{O_3}/W_{O_3})} \quad (B-4)$$

An expression for ρ_1/ρ_1 can be found from the ideal gas law:

$$\rho_1/p_1 = [RT_1 (Y_{Ar}/W_{Ar} + Y_{O_3}/W_{O_3})]^{-1} \quad (B-5)$$

and measuring τ_p in μsec we find

$$k_1 (\text{M} = \text{Ar}) = \frac{10^6 \ln(\rho_2/\rho_1) RT_1 (Y_{Ar}/W_{Ar} + Y_{O_3}/W_{O_3})}{(\rho_2/\rho_1) (p_1 \tau_p) (Y_{Ar}/W_{Ar} + 4Y_{O_3}/W_{O_3})} \text{ cm}^3 \text{ mole}^{-1} \text{s}^{-1}. \quad (B-6)$$

Before accepting any value of k_1 derived from equation B-6, we must verify the basic assumption that $k_2 [O] \ll k_1 [M]$. To do this, equations (4) and (5) (in text) are integrated numerically. Because of the uncertainty in using expressions for the value of k_2 at the higher temperatures, a value twice as large as the largest recommended value (reference 13 of text) has been used in the numerical integration. Those integrations that gave relaxation times within 10% of the measured relaxation times were accepted as meeting the criterion $k_1 [M] \ll k_2 [O]$.

For example at $T_1 = 2041 \text{ K}$, the measured relaxation time is $13.4 \mu\text{sec}$. If Hampson's value (reference 13 of text) for k_2 is used, we calculated a $12.7 \mu\text{sec}$ relaxation time. If twice Hampson's value is used, the relaxation time is found to be $12.2 \mu\text{sec}$. Since the term $k_2 [O]$ in equation 4 (of text) becomes the more important the lower the temperature, the datum at $T_1 = 2041 \text{ K}$ is the lowest temperature we have accepted.

TABLE B-1. THE DATA COLLECTED BY CENTER AND KUNG

Run	$x_{0_3 I}$	u_s (mm/ μ s)	p_1 (torr)	p_2/p_1	$\tau_p p_1$ (atmos- μ sec)	$\tau_J p_1$ (atmos- μ sec)	$1000/T$ (K $^{-1}$)
686	6	1.27	0.74	3.645	4.5 (-2)*	3.1 (-2)	0.63
687	6	1.53	0.738	3.86	7.7 (-2)	5.6 (-3)	0.47
688	5	1.45	0.725	3.8	1.2 (-3)**	9.0 (-3)	0.515
690	5	1.315	0.70	3.69	3.85(-2)	2.3 (-2)	0.60
691	5	1.30	0.682	3.67	3.9 (-2)	2.5 (-2)	0.61
692	5	1.28	0.675	3.65	4.2 (-2)	2.8 (-2)	0.62
694	5	1.27	0.655	3.645	4.8 (-2)	3.05(-2)	0.63
695	5	1.725	0.650	3.97	4.6 (-3)	1.9 (-3)	0.375
698	5	1.42	0.620	3.77	2.0 (-2)	1.10(-2)	0.53
699	5	1.21	0.610	3.58	0.70	5.3 (-2)	0.67
700	5	1.12	0.603	3.47	0.145	0.135	0.74
701	5	1.06	1.68	3.38	0.255	0.205	0.78
702	5	1.04	2.05	3.35	0.27	0.25	0.80
703	5	1.095	2.41	3.43	0.247	0.145	0.75
710	2	1.59	0.773	3.75	8.2 (-3)	3.5 (-3)	0.40
715	2	0.96	2.72	3.15	0.91	0.74	0.92
716	2	1.01	2.57	3.21	0.61	0.42	0.86
744	5	1.37	0.767	3.73	2.25(-2)	1.52(-2)	0.565
745	5	1.65	0.755	3.93	6.3 (-3)	2.85(-3)	0.41
746	5	1.69	0.425	3.95	6.9 (-3)	2.3 (-3)	0.39
747	5	1.27	0.435	3.65	4.3 (-2)	3.2 (-2)	0.63
748	2	1.42	0.88	3.65	1.55(-2)	1.0 (-2)	0.49
750	2	1.615	0.86	3.77	6.3 (-3)	3.1 (-3)	0.39
751	2	1.14	1.68	3.39	0.14	0.11	0.72
752	2	1.175	1.65	3.43	9.6 (-2)	7.2 (-2)	0.70
753	2	1.27	1.60	3.53	5.1 (-2)	3.1 (-2)	0.60
754	1.3	1.255	3.05	3.4	5.5 (-2)	3.5 (-2)	0.61
757	1.3	0.995	2.82	3.1	0.62	0.57	0.88
758	1.2	0.955	2.75	3.1	0.65	0.57	0.88
759	1.2	1.205	1.38	3.35	7.7 (-2)	5.5 (-2)	0.655
760	1.2	1.235	2.62	3.39	4.2 (-2)	4.2 (-2)	0.625
762	1.2	1.03	2.51	3.15	0.67	0.40	0.835
763	1.2	1.12	2.48	3.25	0.246	0.138	0.755
766	1.0	1.3	2.42	3.44	3.2 (-2)	2.4 (-2)	0.575
767	4.5	1.815	0.4	4.01	3.95(-3)	1.42(-3)	0.34
768	4.5	1.615	0.382	3.91	4.3 (-3)	3.4 (-3)	0.425
769	4.5	1.60	0.378	3.90	4.9 (-3)	3.0 (-3)	0.44
771	4.5	1.715	0.380	3.97	5.5 (-3)	2.12(-3)	0.38
774	4.5	1.77	0.35	3.99	3.35(-3)	1.7 (-3)	0.36
775	4.5	1.743	0.337	3.98	4.1 (-3)	1.87(-3)	0.37
776	4.5	1.79	0.34	4.00	3.35(-3)	1.56(-3)	0.35
782	5	1.41	0.63	3.78	1.6 (-2)	1.2 (-2)	0.54
783	5	1.425	0.613	3.78	1.19(-2)	1.1 (-2)	0.525
784	3/4	0.99	3.02	3.09	0.75	.66	0.89
785	3/4	1.0	2.96	3.1	0.73	.57	0.88
786	3/4	1.0	2.84	3.1	0.69	.57	0.88
787	3/4	1.06	2.75	3.18	0.355	.275	0.80
789	3/4	1.05	2.60	3.17	0.43	.31	0.81
790	3/4	0.97	2.55	3.06	0.97	.85	0.91
791	3/4	1.035	2.47	3.15	0.43	.37	0.83
788	3/4	1.03	2.68	3.15	0.46	.4	0.835

* Read 4.5(-2) as 4.5×10^{-2}

**Apparent misprint, we take this value to be 1.2(-2)

GLOSSARY FOR APPENDIX B

x_{O_3I} Initial mole fraction of O_3 .

u_s Shock speed ($\text{mm } \mu\text{sec}^{-1}$).

p_1 Initial pressure (torr).

ρ_1 Initial density (gm/cm^3).

ρ_2 Post-shock density (gm/cm^3).

t_p Relaxation time measured by Center and Kung (μsec). This is the time in which the O_3 concentration changes by a factor of ρ_2/ρ_1 .

τ_J Relaxation time predicted by Johnston recommended rates (μsec).

$\tau_p p_1$ Relaxation time multiplied by initial pressure ($\mu\text{sec} - \text{atm}$).

T_1 Initial temperature (K).

Y_{Ar} Mass fraction of argon.

Y_{O_3} Mass fraction of ozone.

W_{Ar} Molecular weight of argon (40 gm/mole).

W_{O_3} Molecular weight of ozone (48 gm/mole).

R Gas constant ($82.05 \text{ cm}^3 - \text{atm/mole-deg}$).

[M] Concentration of "third" body, (moles/cm^3).

APPENDIX C. LEAST SQUARES FITTING PROGRAM

Below is a listing of the subroutine used to compute a least square fit to k_1 using the data listed in Appendix A and Table I. The program can be easily modified to produce three parameter fits of the form $aT^b \exp(C/T)$.

PROGRAM RTE1 76/76 OPTICAL BUMPER-9
 DATA 4.6-052
 PAGE 2
 11/30/76 13:30:29

```

    * 363. *363. *363. *363. *363. /
    * 363. *373. *373. *373. *373. /
    * 353. *363. *363. *363. *353. *353. /
    DATA (L61111).L666 .119) / .161. *363. /
    * 223.61 *222.98 *222.98 *222.98 *222.98 *222.98 *
    * 222.57 *222.55 *222.55 *222.55 *222.55 *222.55 *
    * 222.56 *222.54 *222.52 *222.52 *222.52 *222.52 *
    * 222.52 *222.51 *222.49 *222.49 *222.49 *222.49 *
    * 222.47 *222.19 *222.19 *222.19 *222.19 *222.19 *
    * 222.10 *221.89 *221.89 *221.89 *221.89 *221.89 *
    * 222.96 *222.94 *222.94 *222.94 *222.94 *222.94 *
    * 222.52 *222.19 *222.18 *222.18 *222.18 *222.18 *
    * 222.96 *222.57 *222.55 *222.55 *222.55 *222.55 *
    * 222.96 *222.55 *222.55 *222.55 *222.55 *222.55 *
    C ABSORBER DATA M=03 21 POINTS
    DATA (T (1).L6120.140) / .162. /
    * 363. *363. *363. *363. *363. *363. /
    * 362. *363. *363. *363. *363. *363. /
    * 363. *363. *363. *363. *363. *363. /
    DATA (L61111).L6720.140) / .163. /
    * 223.60 *223.58 *223.58 *223.58 *223.58 *223.58 *
    * 222.60 *222.60 *222.60 *222.60 *222.60 *222.60 *
    * 222.51 *222.51 *222.49 *222.49 *222.49 *222.49 *
    C MICHAEL DATA M=BEVTON 43 POINTS
    C R(MICHAELITERE-7/MOLE-5) * R-JOE-144N (M=03) (CM003/PARTICLE-S)
    DATA (T (1).L61161.143) / .164. /
    * 1267. *1277. *1285. *1285. *1273. *1285. *
    * 1325. *1266. *1266. *1266. *1265. *1266. *
    * 1119. *1061. *1065. *1065. *1136. *1136. *
    * 1323. *1660. *1620. *1620. *1605. *1605. *
    * 1128. *1179. *1093. *1107. *1107. *1107. *
    * 1036. *971. *1087. *1052. *988. *1065. /
    DATA (L61111).L6161.143) / .165. /
    * 1321. *13.03 *13.22 *12.78 *13.15 *13.17 *
    * 13.05 *12.69 *12.69 *12.69 *13.07 *13.07 *
    * 13.26. *13.60 *13.60 *13.60 *13.67 *13.67 *
    * 12.95 *13.60 *13.65 *13.65 *12.86 *12.86 *
    * 12.95 *13.58 *13.58 *13.58 *12.96 *12.96 *
    * 13.17 *13.09 *13.58 *13.58 *13.21 *13.21 *
    * 13.65 *13.23 *13.39 *13.53 *13.62 *13.62 /
    C CENTER AND RADIUS FROM TABLE
    C USING FORMULA 1 DERIVED
    C THIS DATA IS IN UNITS CM=3/MOLE-SECOND. MEANING
    DATA (T (1).L61161.197) / .166. /
    * 2041. *2126. *2273. *2351. *2439. *2500. *2564. /
    * 2564. *2632. *2667. *2703. *2778. *2837. *2901. /
    DATA (R9111).L6161.197) / .167. /
    * 5.31611.9.4ME11.1.1.56E12.0.1.1ME12.9.9ME11.0.1.06E12.0
    * 1.36F12.1.37E12.1.62E12.1.84E12.7.25E12.7.25E12.1.9E12.0
    DO 10 K=1,143
    L61161=L61161
    BR1161=L61161
    C CONVERT TO CM003/MOLE-SECUND.
    BR1161=M01161
    10 CONTINUE
    C CONVERT CENTER AND RADIUS DATA TO M = 03
    NO 15 ME161.J07
    15 BR1161=M01161
  
```

PRINTED DATE: 76/76 DATA POINTS WOULD--*/
RTN 4.6654
11/30/76 13.38.29 PAGE 3

115 25 WRITE (4,25) *
*FORMAT/READ/WRITE OF DATA POINTS •••••)
CALL SOLSTICE,LINE1
STOP
END
120

PAGE

11/30/78 13:38:29

STN 0.60052

SUMMARY FILE SOURCE TA/TB INPUT MESSAGES

1 SUMMARIZING SOL STATION
DISTRIBUTION (21) (21) (21) (21) (21)

* ALGORITHM (21) (21) (21) (21)
DISTRIBUTION (21) (21) (21)

CORPORATION/TA/BU (21)

C REFERENCES.

C M. J. Cvetkovic AND D. L. SINGHUTA,

C INTERNAL J. OF CHEM. PHYS. 9,

pp. 1007-1009, 1977.

C *****

C ERRORS ARE MEASURED IN A RELATIVE SENSE,

DO IN REL.

IS UNKNOWNS/TRANSFORMED

C EACH GROUP OF DATA IS WEIGHTED EQUALLY.

DO 16 READ(27)

16 READ(27)

DO 17 READ(16)

17 READ(16)

DO 18 READ(16)

18 READ(16)

DO 19 READ(16)

19 READ(16)

LEAST SQUARES FIT BY A FUNCTION OF THE FORM

C Y = A + Bx + Cx^2

C *****

C FIT BY A FUNCTION OF THE FORM

C Y = A + Bx + Cx^2

C CAN BE MADE BY CHANGING THE LADS WITH PAD AT THE END.

C EXPRESSIONS MUST BE REPLACED BY ALGOL(X) EXPRESSIONS.

C *****

END.0

C IF FILE ACTUALLY USED WITH A SET OF TWO FORMS

C LN Y = LN A + C/X

C THE WEIGHTS MUST BE TRANSFORMED.

C THIS IS A FIRST APPROXIMATION TO THE DIRECT TRANSFORMED WEIGHTS.

DO 20 READ

READ(27)

20 READ(27)

C IT IS WISE TO FIND THE CORRECT TRANSFORMED WEIGHTS.

DO 500 READ(10)

DO 30 I=1:2

READ(10)

DO 30 J=1:2

READ(10)

DO 40 K=1:2

READ(10)

DO 10 L=1:2

READ(10)

DO 10 M=1:2

READ(10)

DO 10 N=1:2

READ(10)

DO 10 O=1:2

READ(10)

DO 10 P=1:2

READ(10)

C SOLVE FOR A AND C BY SOLVING THE APPROPRIATE SET OF TWO

C EQUATIONS IN TWO UNKNOWNs.

END

THIS PAGE IS BEST QUALITY PRATICABLE
FROM COPY PUBLISHED IN DDC

```

      SUBROUTINE DECOMP  PIVTHN  OPTAL WORKD=0.0
      FTN 6.60042  11/30/76  13.36.29  PAGE

      SUBROUTINE DECOMP (A)
      DIMENSION SCALES(2)
      COMMON/CS/SCALES(2)
      C THIS IS A STANDARD ALGORITHM FOR SOLVING A SET OF LINEAR
      C ALGEBRAIC EQUATIONS. IT USES AN LU DECOMPOSITION AND
      C BACK SUBSTITUTION.
      C DIFFERENCE.
      C FORESTHE AND MOLER. COMPUTE SOLUTION OF LINEAR ALGEBRAIC SYSTEMS.

      DO 5 I=1,N
      IF(PIVTHN)10,11,12
      10 IF(PIVTHN)13,14,15
      11 CONTINUE
      12 IF(PIVTHN)16,17,18
      13 PIVTHN=.15
      14 PIVTHN=.15
      15 PIVTHN=.15
      16 PIVTHN=.15
      17 CONTINUE
      18 IF(PIVTHN)19,20,21
      19 PIVTHN=.15
      20 CALL SING(1)
      21 IF(PIVTHN)22,23,24
      22 IF(PIVTHN)25,26,27
      23 CONTINUE
      24 IF(PIVTHN)28,29,30
      25 IF(PIVTHN)31,32,33
      26 CONTINUE
      27 IF(PIVTHN)34,35,36
      28 IF(PIVTHN)37,38,39
      29 CONTINUE
      30 IF(PIVTHN)40,41,42
      31 IF(PIVTHN)43,44,45
      32 CONTINUE
      33 IF(PIVTHN)46,47,48
      34 IF(PIVTHN)49,50,51
      35 CONTINUE
      36 IF(PIVTHN)52,53,54
      37 IF(PIVTHN)55,56,57
      38 CONTINUE
      39 IF(PIVTHN)58,59,60
      40 IF(PIVTHN)61,62,63
      41 CONTINUE
      42 IF(PIVTHN)64,65,66
      43 IF(PIVTHN)67,68,69
      44 CONTINUE
      45 IF(PIVTHN)70,71,72
      46 IF(PIVTHN)73,74,75
      47 CONTINUE
      48 IF(PIVTHN)76,77,78
      49 IF(PIVTHN)79,80,81
      50 CONTINUE
      51 IF(PIVTHN)82,83,84
      52 IF(PIVTHN)85,86,87
      53 CONTINUE
      54 IF(PIVTHN)88,89,90
      55 IF(PIVTHN)91,92,93
      56 CONTINUE
      57 IF(PIVTHN)94,95,96
      58 IF(PIVTHN)97,98,99
      59 CONTINUE
      60 IF(PIVTHN)100,101,102
      61 IF(PIVTHN)103,104,105
      62 CONTINUE
      63 IF(PIVTHN)106,107,108
      64 IF(PIVTHN)109,110,111
      65 CONTINUE
      66 IF(PIVTHN)112,113,114
      67 IF(PIVTHN)115,116,117
      68 CONTINUE
      69 IF(PIVTHN)118,119,120
      70 IF(PIVTHN)121,122,123
      71 CONTINUE
      72 IF(PIVTHN)124,125,126
      73 IF(PIVTHN)127,128,129
      74 CONTINUE
      75 IF(PIVTHN)130,131,132
      76 IF(PIVTHN)133,134,135
      77 CONTINUE
      78 IF(PIVTHN)136,137,138
      79 IF(PIVTHN)139,140,141
      80 CONTINUE
      81 IF(PIVTHN)142,143,144
      82 IF(PIVTHN)145,146,147
      83 CONTINUE
      84 IF(PIVTHN)148,149,150
      85 IF(PIVTHN)151,152,153
      86 CONTINUE
      87 IF(PIVTHN)154,155,156
      88 IF(PIVTHN)157,158,159
      89 CONTINUE
      90 IF(PIVTHN)160,161,162
      91 IF(PIVTHN)163,164,165
      92 CONTINUE
      93 IF(PIVTHN)166,167,168
      94 IF(PIVTHN)169,170,171
      95 CONTINUE
      96 IF(PIVTHN)172,173,174
      97 IF(PIVTHN)175,176,177
      98 CONTINUE
      99 IF(PIVTHN)178,179,180
      100 IF(PIVTHN)181,182,183
      101 CONTINUE
      102 IF(PIVTHN)184,185,186
      103 IF(PIVTHN)187,188,189
      104 CONTINUE
      105 IF(PIVTHN)190,191,192
      106 IF(PIVTHN)193,194,195
      107 CONTINUE
      108 IF(PIVTHN)196,197,198
      109 IF(PIVTHN)199,200,201
      110 CONTINUE
      111 IF(PIVTHN)202,203,204
      112 IF(PIVTHN)205,206,207
      113 CONTINUE
      114 IF(PIVTHN)208,209,210
      115 IF(PIVTHN)211,212,213
      116 CONTINUE
      117 IF(PIVTHN)214,215,216
      118 IF(PIVTHN)217,218,219
      119 CONTINUE
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SUMMARY SHEET

76/76

OPTICAL GROUND

FTN 4.00002

11/20/76 13:38:29

PAGE 7

1 SUMMERTIME SOLAR (NN.4•4)
 DIMENTION M(2)•A(2)
 COMBINE/DS/IPS(12)
 COMBINE/TAH/DS/L(2•2)
 NAME
 N/A
 N/A
 TYPE[DS(1)]
 ATTACH[IP]
 DO 2 IMP•N
 IP[IPS(1)]
 TWI=1
 SUM=0.0
 DO 1 JDL,IML
 SUM=SUM(IP,JDL,IML)
 X(1111(IP))=SUM
 IP[IPS(1)]
 X(N1111(IP))=SUM(IP,N)
 DO 1 IHACKZ•N
 IHP=IHACKZ
 IP[IPS(1)]
 IPL=1
 SUM=0.0
 DO 3 JATPL,N
 SUM=SUM(IP,JATPL,N)
 X(IATPL(IP))=SUM(IP,N)
 RETURN
 END

THIS PAGE IS OF POOR QUALITY FROM THE
FROM ONLY TRANSLATED TO DOO

ROUTINE SING PA/TB OPTAL GROUNDZERO
#7N 4.60052 11/30/76 13.38.29 PAGE 8

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1      SUBROUTINE SING(LBRY)
      NOUT=6
      IF(LBRY.EQ.1) WRITE(NOUT,11)
      IF(LBRY.EQ.2) WRITE(NOUT,12)
      11  FORMAT(1H0,1HFORMAT(SIMILAR WITH ZERO ROW IN DECOMPOSE,
      12  FORMAT(1H0,1HFORMAT(SIMILAR MATRIX IN DECOMPOSE. ZERO DIVIDE IN SOLVE. )
      RETURN
      END
```

SCORER 2 LOAD MAP
PROGRAM WILL BE ENTERED AT HTBL

L0404 VER510 1.0 11/30/76 13:38:44. PAST 1
SCM LENGTH 11476 LCM LENGTH 0

BLOCK	ADDRESS	LENGTH	FILE
/TABLES/ HTBL	110	3	L60
/TABLES/ SQLST	113	226	L60
SQLST	2313	4	L60
SQLST	2317	304	L60
/MSV	5367	7	L60
DECODF	5361	164	L60
SOLVE	5545	127	L60
SING	5674	44	L60
/SIP-END/	5740	1	SL-FNL18
/FCL,C/	5741	23	SL-FNL18
/QR,10./	5766	136	SL-FNL18
QMPRYS	6122	1	SL-FNL18
COM10s	6123	44	SL-FNL18
PCMSK	6167	41	SL-FNL18
FLOUTS	6230	115	SL-FNL18
FATAP	6545	373	SL-FNL18
FORSYS	7140	513	SL-FNL18
FORUTL	7673	44	SL-FNL18
GETITL	7737	63	SL-FNL18
KOOPA	10002	467	SL-FNL18
OUTC	10471	171	SL-FNL18
OUTC	10662	204	SL-FNL18
ALG	11046	77	SL-FNL18
FAP	11165	160	SL-FNL18
ITMS	11265	10	SL-FNL18
QCAT	11275	46	SL-FNL18
SYSA1s	11343	1	SL-FNL18
SYSE1T	11344	62	SL-FNL18

NO. OF DATA POINTS = 197

A = 5.049E-16	C = -1.1195E+04
WEIGHTED ERING = 5.7454E-02	
A = 4.2740E+14	C = -1.1156E+04
WEIGHTED ERING = 6.0494E-02	
A = 4.3174E+14	C = -1.1161E+04
WEIGHTED ERING = 6.0494E-02	
A = 4.3131E+14	C = -1.1161E+04
WEIGHTED ERING = 6.0494E-02	
A = 4.3137E+14	C = -1.1161E+04
WEIGHTED ERING = 6.0494E-02	
A = 4.3136E+14	C = -1.1161E+04
WEIGHTED ERING = 6.0494E-02	
A = 4.3136E+14	C = -1.1161E+04
WEIGHTED ERING = 6.0494E-02	
8.6900E+02	3.0484E+08
7.7400E+02	4.0457E+08
7.7900E+02	4.3640E+08
7.8700E+02	6.0230E+08
7.9200E+02	6.8957E+08
8.1200E+02	7.0748E+08
8.2400E+02	9.3248E+08
8.2500E+02	9.5074E+08
8.2700E+02	1.0467E+09
8.2900E+02	1.0467E+09
8.4000E+02	1.1477E+09

6.4000E+02	1.24877E+09	7.3204E+008	6.5154E+008	6.3151E+01
6.4100E+02	1.25177E+09	7.4379E+008	6.5803E+008	5.6115E+01
6.4200E+02	1.25371E+09	8.0637E+008	9.3226E+008	5.3693E+01
6.4300E+02	1.25561E+09	8.7687E+008	1.1688E+009	4.9876E+01
6.4400E+02	1.25746E+09	1.2638E+009	9.7396E+008	4.3524E+01
6.4500E+02	1.25928E+09	1.2585E+009	8.2828E+008	3.7872E+01
6.4600E+02	1.26108E+09	1.2532E+009	8.1462E+008	3.2402E+01
6.4700E+02	1.26282E+09	1.2482E+009	8.0342E+008	2.7402E+01
6.4800E+02	1.26454E+09	1.2432E+009	7.9342E+008	2.2402E+01
6.4900E+02	1.26624E+09	1.2382E+009	7.8342E+008	1.7402E+01
6.5000E+02	1.26791E+09	1.2332E+009	7.7342E+008	1.2402E+01
6.5100E+02	1.26957E+09	1.2282E+009	7.6342E+008	6.402E+00
6.5200E+02	1.27121E+09	1.2232E+009	7.5342E+008	1.402E+00
6.5300E+02	1.27284E+09	1.2182E+009	7.4342E+008	5.402E+00
6.5400E+02	1.27446E+09	1.2132E+009	7.3342E+008	4.402E+00
6.5500E+02	1.27607E+09	1.2082E+009	7.2342E+008	3.402E+00
6.5600E+02	1.27767E+09	1.2032E+009	7.1342E+008	2.402E+00
6.5700E+02	1.27924E+09	1.1982E+009	7.0342E+008	1.402E+00
6.5800E+02	1.28078E+09	1.1932E+009	6.9342E+008	6.402E+00
6.5900E+02	1.28231E+09	1.1882E+009	6.8342E+008	1.402E+00
6.6000E+02	1.28384E+09	1.1832E+009	6.7342E+008	5.402E+00
6.6100E+02	1.28535E+09	1.1782E+009	6.6342E+008	4.402E+00
6.6200E+02	1.28687E+09	1.1732E+009	6.5342E+008	3.402E+00
6.6300E+02	1.28838E+09	1.1682E+009	6.4342E+008	2.402E+00
6.6400E+02	1.28989E+09	1.1632E+009	6.3342E+008	1.402E+00
6.6500E+02	1.29139E+09	1.1582E+009	6.2342E+008	6.402E+00
6.6600E+02	1.29289E+09	1.1532E+009	6.1342E+008	5.402E+00
6.6700E+02	1.29439E+09	1.1482E+009	6.0342E+008	4.402E+00
6.6800E+02	1.29588E+09	1.1432E+009	5.9342E+008	3.402E+00
6.6900E+02	1.29737E+09	1.1382E+009	5.8342E+008	2.402E+00
6.7000E+02	1.29886E+09	1.1332E+009	5.7342E+008	1.402E+00
6.7100E+02	1.30035E+09	1.1282E+009	5.6342E+008	6.402E+00
6.7200E+02	1.30184E+09	1.1232E+009	5.5342E+008	5.402E+00
6.7300E+02	1.30332E+09	1.1182E+009	5.4342E+008	4.402E+00
6.7400E+02	1.30481E+09	1.1132E+009	5.3342E+008	3.402E+00
6.7500E+02	1.30629E+09	1.1082E+009	5.2342E+008	2.402E+00
6.7600E+02	1.30778E+09	1.1032E+009	5.1342E+008	1.402E+00
6.7700E+02	1.30927E+09	1.0982E+009	5.0342E+008	6.402E+00
6.7800E+02	1.31075E+09	1.0932E+009	4.9342E+008	5.402E+00
6.7900E+02	1.31224E+09	1.0882E+009	4.8342E+008	4.402E+00
6.8000E+02	1.31372E+09	1.0832E+009	4.7342E+008	3.402E+00
6.8100E+02	1.31521E+09	1.0782E+009	4.6342E+008	2.402E+00
6.8200E+02	1.31669E+09	1.0732E+009	4.5342E+008	1.402E+00
6.8300E+02	1.31817E+09	1.0682E+009	4.4342E+008	6.402E+00
6.8400E+02	1.31965E+09	1.0632E+009	4.3342E+008	5.402E+00
6.8500E+02	1.32113E+09	1.0582E+009	4.2342E+008	4.402E+00
6.8600E+02	1.32261E+09	1.0532E+009	4.1342E+008	3.402E+00
6.8700E+02	1.32409E+09	1.0482E+009	4.0342E+008	2.402E+00
6.8800E+02	1.32557E+09	1.0432E+009	3.9342E+008	1.402E+00
6.8900E+02	1.32705E+09	1.0382E+009	3.8342E+008	6.402E+00
6.9000E+02	1.32853E+09	1.0332E+009	3.7342E+008	5.402E+00
6.9100E+02	1.32999E+09	1.0282E+009	3.6342E+008	4.402E+00
6.9200E+02	1.33147E+09	1.0232E+009	3.5342E+008	3.402E+00
6.9300E+02	1.33295E+09	1.0182E+009	3.4342E+008	2.402E+00
6.9400E+02	1.33443E+09	1.0132E+009	3.3342E+008	1.402E+00
6.9500E+02	1.33591E+09	1.0082E+009	3.2342E+008	6.402E+00
6.9600E+02	1.33739E+09	1.0032E+009	3.1342E+008	5.402E+00
6.9700E+02	1.33887E+09	1.0082E+009	3.0342E+008	4.402E+00
6.9800E+02	1.34035E+09	1.0032E+009	2.9342E+008	3.402E+00
6.9900E+02	1.34183E+09	1.0082E+009	2.8342E+008	2.402E+00
7.0000E+02	1.34331E+09	1.0032E+009	2.7342E+008	1.402E+00
7.0100E+02	1.34479E+09	1.0082E+009	2.6342E+008	6.402E+00
7.0200E+02	1.34627E+09	1.0032E+009	2.5342E+008	5.402E+00
7.0300E+02	1.34775E+09	1.0082E+009	2.4342E+008	4.402E+00
7.0400E+02	1.34923E+09	1.0032E+009	2.3342E+008	3.402E+00
7.0500E+02	1.35071E+09	1.0082E+009	2.2342E+008	2.402E+00
7.0600E+02	1.35219E+09	1.0032E+009	2.1342E+008	1.402E+00
7.0700E+02	1.35367E+09	1.0082E+009	2.0342E+008	6.402E+00
7.0800E+02	1.35515E+09	1.0032E+009	1.9342E+008	5.402E+00
7.0900E+02	1.35663E+09	1.0082E+009	1.8342E+008	4.402E+00
7.1000E+02	1.35811E+09	1.0032E+009	1.7342E+008	3.402E+00
7.1100E+02	1.35959E+09	1.0082E+009	1.6342E+008	2.402E+00
7.1200E+02	1.36107E+09	1.0032E+009	1.5342E+008	1.402E+00
7.1300E+02	1.36255E+09	1.0082E+009	1.4342E+008	6.402E+00
7.1400E+02	1.36403E+09	1.0032E+009	1.3342E+008	5.402E+00
7.1500E+02	1.36551E+09	1.0082E+009	1.2342E+008	4.402E+00
7.1600E+02	1.36699E+09	1.0032E+009	1.1342E+008	3.402E+00
7.1700E+02	1.36847E+09	1.0082E+009	1.0342E+008	2.402E+00
7.1800E+02	1.36995E+09	1.0032E+009	9.342E+007	1.402E+00
7.1900E+02	1.37143E+09	1.0082E+009	8.342E+007	6.402E+00
7.2000E+02	1.37291E+09	1.0032E+009	7.342E+007	5.402E+00
7.2100E+02	1.37439E+09	1.0082E+009	6.342E+007	4.402E+00
7.2200E+02	1.37587E+09	1.0032E+009	5.342E+007	3.402E+00
7.2300E+02	1.37735E+09	1.0082E+009	4.342E+007	2.402E+00
7.2400E+02	1.37883E+09	1.0032E+009	3.342E+007	1.402E+00
7.2500E+02	1.38031E+09	1.0082E+009	2.342E+007	6.402E+00
7.2600E+02	1.38179E+09	1.0032E+009	1.342E+007	5.402E+00
7.2700E+02	1.38327E+09	1.0082E+009	2.342E+007	4.402E+00
7.2800E+02	1.38475E+09	1.0032E+009	1.342E+007	3.402E+00
7.2900E+02	1.38623E+09	1.0082E+009	2.342E+007	2.402E+00
7.3000E+02	1.38771E+09	1.0032E+009	1.342E+007	1.402E+00
7.3100E+02	1.38919E+09	1.0082E+009	2.342E+007	6.402E+00
7.3200E+02	1.39067E+09	1.0032E+009	1.342E+007	5.402E+00
7.3300E+02	1.39215E+09	1.0082E+009	2.342E+007	4.402E+00
7.3400E+02	1.39363E+09	1.0032E+009	1.342E+007	3.402E+00
7.3500E+02	1.39511E+09	1.0082E+009	2.342E+007	2.402E+00
7.3600E+02	1.39659E+09	1.0032E+009	1.342E+007	1.402E+00
7.3700E+02	1.39807E+09	1.0082E+009	2.342E+007	6.402E+00
7.3800E+02	1.39955E+09	1.0032E+009	1.342E+007	5.402E+00
7.3900E+02	1.40103E+09	1.0082E+009	2.342E+007	4.402E+00
7.4000E+02	1.40251E+09	1.0032E+009	1.342E+007	3.402E+00
7.4100E+02	1.40399E+09	1.0082E+009	2.342E+007	2.402E+00
7.4200E+02	1.40547E+09	1.0032E+009	1.342E+007	1.402E+00
7.4300E+02	1.40695E+09	1.0082E+009	2.342E+007	6.402E+00
7.4400E+02	1.40843E+09	1.0032E+009	1.342E+007	5.402E+00
7.4500E+02	1.40991E+09	1.0082E+009	2.342E+007	4.402E+00
7.4600E+02	1.41139E+09	1.0032E+009	1.342E+007	3.402E+00
7.4700E+02	1.41287E+09	1.0082E+009	2.342E+007	2.402E+00
7.4800E+02	1.41435E+09	1.0032E+009	1.342E+007	1.402E+00
7.4900E+02	1.41583E+09	1.0082E+009	2.342E+007	6.402E+00
7.5000E+02	1.41731E+09	1.0032E+009	1.342E+007	5.402E+00
7.5100E+02	1.41879E+09	1.0082E+009	2.342E+007	4.402E+00
7.5200E+02	1.42027E+09	1.0032E+009	1.342E+007	3.402E+00
7.5300E+02	1.42175E+09	1.0082E+009	2.342E+007	2.402E+00
7.5400E+02	1.42323E+09	1.0032E+009	1.342E+007	1.402E+00
7.5500E+02	1.42471E+09	1.0082E+009	2.342E+007	6.402E+00
7.5600E+02	1.42619E+09	1.0032E+009	1.342E+007	5.402E+00
7.5700E+02	1.42767E+09	1.0082E+009	2.342E+007	4.402E+00
7.5800E+02	1.42915E+09	1.0032E+009	1.342E+007	3.402E+00
7.5900E+02	1.43063E+09	1.0082E+009	2.342E+007	2.402E+00
7.6000E+02	1.43211E+09	1.0032E+009	1.342E+007	1.402E+00
7.6100E+02	1.43359E+09	1.0082E+009	2.342E+007	6.402E+00
7.6200E+02	1.43507E+09	1.0032E+009	1.342E+007	5.402E+00
7.6300E+02	1.43655E+09	1.0082E+009	2.342E+007	4.402E+00
7.6400E+02	1.43803E+09	1.0032E+009	1.342E+007	3.402E+00
7.6500E+02	1.43951E+09	1.0082E+009	2.342E+007	2.402E+00
7.6600E+02	1.44099E+09	1.0032E+009	1.342E+007	1.402E+00
7.6700E+02	1.44247E+09	1.0082E+009	2.342E+007	6.402E+00
7.6800E+02	1.44395E+09	1.0032E+009	1.342E+007	5.402E+00
7.6900E+02	1.44543E+09	1.0082E+009	2.342E+007	4.402E+00
7.7000E+02	1.44691E+09	1.0032E+009	1.342E+007	3.402E+00
7.7100E+02	1.44839E+09	1.0082E+009	2.342E+007	2.402E+00
7.7200E+02	1.44987E+09	1.0032E+009	1.342E+007	1.402E+00
7.7300E+02	1.45135E+09	1.0082E+009	2.342E+007	6.402E+00
7.7400E+02	1.45283E+09	1.0032E+009	1.342E+007	5.402E+00
7.7500E+02	1.45431E+09	1.0082E+009	2.342E+007	4.402E+00
7.7600E+02	1.45579E+09	1.0032E+009	1.342E+007	3.402E+00
7.7700E+02	1.45727E+09	1.0082E+009</		

S-1501E-02	0.1633E+01	0.3656E+01	-0.3346E+04
S-1600E-02	0.9457E+01	0.7292E+01	1.6848E+01
S-1700E-02	7.2012E+01	0.7292E+01	2.5120E+01
S-1700E-03	3.7138E+01	0.1456E+01	0.0585E+01
S-1700E-04	5.6293E+10	0.9053E+10	2.2463E+10
S-1750E-05	0.3629E+10	0.5266E+10	0.34262E+01
S-1840E-03	0.9457E+10	1.0742E+11	-7.4620E+04
S-17310E-03	0.2640E+10	0.7182E+10	-2.4543E+10
S-1730E-04	0.2020E+10	0.7291E+10	-3.2196E+10
S-1730E-05	0.1268E+10	0.1210E+10	-3.9468E+10
S-17190E-03	0.1268E+10	0.1210E+10	-2.0739E+10
S-17260E-03	0.7462E+10	0.3529E+10	-5.3436E+01
S-17640E-03	0.7462E+10	1.3522E+11	0.6585E+10
S-17230E-03	0.5364E+10	0.4773E+10	-6.1054E+04
S-17230E-04	0.1623E+10	0.0039E+10	-7.3703E+09
S-17260E-03	0.1268E+10	0.5379E+10	-5.1474E+10
S-17260E-04	0.1268E+10	0.3529E+10	-5.3436E+01
S-17410E-03	2.0009E+10	1.1653E+10	0.7555E+09
S-17410E-04	2.1600E+10	2.5420E+10	-1.7406E+04
S-17320E-03	2.1600E+10	9.3579E+10	-1.7406E+04
S-17320E-04	3.1600E+10	3.3395E+10	-1.7658E+04
S-17190E-03	3.1600E+10	2.3978E+10	-3.4754E+04
S-17190E-04	1.1600E+10	9.4211E+09	-3.9628E+04
S-17050E-03	0.6495E+10	2.1370E+10	1.4766E+10
S-17050E-04	0.3360E+03	2.1520E+10	2.6795E+10
S-17050E-05	0.1520E+03	1.0000E+10	-1.4621E+09
S-17060E-03	0.1660E+10	3.8720E+10	2.5157E+09
S-17060E-04	0.8300E+03	6.7519E+10	9.3748E+10
S-17320E+03	0.1520E+03	1.5662E+10	1.2608E+10
S-17320E+04	0.6990E+03	1.5662E+10	3.2462E+09
S-17050E+03	0.6990E+03	1.5662E+10	7.6351E+09
S-17050E+04	0.3360E+02	7.5925E+09	5.8657E+09
S-17110E+03	0.6990E+03	1.5662E+10	1.7032E+10
S-17110E+04	0.3360E+03	1.5129E+10	0.0651E+10
S-17200E+03	0.1268E+10	0.0720E+10	6.1372E+10
S-17200E+04	0.6220E+10	0.0720E+10	2.1767E+10
S-17190E+03	0.4957E+10	2.1209E+10	3.3395E+10
S-17190E+04	0.13110E+03	1.5642E+10	0.4562E+10
S-17310E+03	0.13110E+03	1.5642E+10	1.7448E+09
S-17310E+04	0.6462E+10	0.6622E+10	3.11262E+10
S-1730E+03	0.14650E+03	1.1600E+10	3.5476E+10
S-1730E+04	0.7200E+10	0.17757E+10	1.2597E+09
S-17190E+03	0.15800E+03	2.8172E+10	2.8127E+10
S-17190E+04	0.12100E+03	2.2469E+10	2.0466E+10
S-17260E+03	0.12100E+03	2.1370E+10	0.4545E+09
S-17260E+04	0.71000E+02	1.5642E+10	0.3656E+09
S-17260E+05	0.3656E+02	4.2640E+10	3.5035E+10
S-17260E+06	0.14650E+03	3.7138E+10	3.5476E+10
S-17260E+07	0.11600E+03	2.8172E+10	2.8127E+10
S-17260E+08	0.15800E+03	2.2469E+10	2.0466E+10
S-17260E+09	0.12100E+03	2.1370E+10	0.4545E+09
S-17260E+10	0.71000E+02	1.5642E+10	0.3656E+09
S-17260E+11	0.3656E+02	4.2640E+10	3.5035E+10
S-17260E+12	0.14650E+03	3.7138E+10	3.5476E+10
S-17260E+13	0.11600E+03	2.8172E+10	2.8127E+10
S-17260E+14	0.15800E+03	2.2469E+10	2.0466E+10
S-17260E+15	0.12100E+03	2.1370E+10	0.4545E+09
S-17260E+16	0.71000E+02	1.5642E+10	0.3656E+09
S-17260E+17	0.3656E+02	4.2640E+10	3.5035E+10
S-17260E+18	0.14650E+03	3.7138E+10	3.5476E+10
S-17260E+19	0.11600E+03	2.8172E+10	2.8127E+10
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