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Reaction Rate and Photochemical Data for Atmospheric Chemistry - 1977

Reaction Rate and Photochemical Data for Atmospheric Chemistry - 1977 Special publication no. 513

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FOREWORD

The National Standard Reference Data System was established in 1963 for the purpose of promoting the critical evaluation and dissemination of numerical data of the physical sciences. The program is coordinated by the Office of Standard Reference Data of the National Bureau of Standards, but involves the efforts of many groups in universities, government laboratories, and private industry. The primary aim of the program is to provide compilations of critically evaluated numerical data. These tables are published in the Journal of Physical and Chemical Reference Data, The NSRDS-NBS Publication Series of the National Bureau of Standards, and through other appropriate channels.

The present report consists of tables of data assembled for use in modelling the chemistry of the stratosphere. It represents contributions from the Chemical Kinetics Information Center, other NSRDS data centers, and a number of individual experts. Support for the preparation of those tables has been provided by the Department of Transportation under the High Altitude Pollution Program, by the National Aeronautics and Space Administration under the Upper Atmosphere Research Program, and by the Office of Standard Reference Data, N.B.S. and the Office of Environmental Measurements, N.B.S.

David R. Lide, Jr.
Chief, Office of Standard
Reference Data

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Reaction Rate and Photochemical Data for Atmospheric Chemistry - 1977[*]

R. F. Hampson, D. Garvin, Editors

A table of data for gas phase chemical reactions
and photochemistry of neutral species is presented.
Specifically, it gives preferred values for
reaction rate constants, photoabsorption cross
sections, and quantum yields of primary photochemical
processes and also cites recent experimental work
(to December 1977). It is intended to provide the
basic physical chemical data needed as input data
for calculations modelling atmospheric chemistry.
An auxiliary table of thermochemical data for the
pertinent chemical species is given in the appendix.

Key words: Air pollution; atmospheric chemistry; chemical kinetics;
data evaluation; gas phase; photoabsorption cross section; photochemistry;
quantum yield; rate constant.

1.   Introduction

This technical note consists of a table of data on the kinetics
of chemical reactions and the photochemistry of neutral species. It
is designed for use in modelling the chemistry of the stratosphere
and, to a more limited extent, the polluted troposphere and also the
interpretation of laboratory experiments. The table of rate and
photochemical data is supplemented by a table of thermochemical
data for the species involved.

Earlier versions of this table have been issued as D. Garvin (editor) "Chemical Kinetics Data Survey IV" NBSIR 73-203 (1973); D. Garvin and R. F. Hampson (editors) "Chemical Kinetics Data Survey VII" NBSIR 74-430 (1974); and R. F. Hampson and D. Garvin (editors) "Chemical Kinetic and Photochemical Data for Modelling Atmospheric Chemistry" NBS Technical Note 866 (1975). The table appearing in NBS Technical Note 866 was also published in the U. S. Department of Transportation's Climatic Impact Assessment Program Monograph 1 "The Natural Stratosphere of 1974" E. Reiter, editor (1975). The present table supersedes all earlier versions.

Since the publication of NBS Technical Note 866 in 1975, a major effort in the evaluation of rate and photochemical data was undertaken for the NASA chlorofluoromethane assessment by its Laboratory Measurements Committee of which the present editors were members. The recommendations of this committee covering 104 chemical reactions and 48 photochemical processes are given in NASA Reference Publication 1010 "Chlorofluoromethanes and the Stratosphere" R. D. Hudson, editor, August 1977. These recommendations have been accepted by the editors of this table and are given here as preferred values. These recommendations are indicated either by the entry [†*NASA(1977)eval] or by the symbols [†*] immediately preceding the author's name in the reference column. The first notation is used to indicate that the committee has synthesized a preferred value from a consideration of all data sets. The latter designation is used when the committee has accepted the results of a particular study or of an existing evaluation.

Recommended values also are given for reactions not considered by the NASA Laboratory Measurements Committee. Some of these are drawn from other modern rate data evaluations, and the sources are indicated in the table. Other recommendations have been prepared for this work.

Rate data evaluation is a small but growing branch of physical chemistry. There are more recommended rate constants than contained in this table, but it does contain most of those which are applicable to atmospheric chemistry. Evaluations and compilations of rate data and on-going programs in these areas have been described in the recent review paper "Evaluation and Compilation of Reaction Rate Data" by R. F. Hampson and D. Garvin, Journal of Physical Chemistry 81, 2317-2319 (1977). A current extensive listing of sources of evaluated rate data, NBS List of Publications 73 "Chemical Kinetics Tables, Data Evaluations and Bibliographies. A Guide to the Literature" is available on request from the NBS Chemical Kinetics Information Center.

Three sets of detailed data sheets have been published by us in the course of preparing these tables. They are R. F. Hampson (editor) "Survey of Photochemical and Rate Data for Twenty-eight Reactions of Interest in Atmospheric Chemistry" J. Phys. Chem. Ref. Data 2, 267 (1973);

R. F. Hampson (editor) "Chemical Kinetics Data Survey VI, NBSIR 73-207 (1973); and D. Garvin (editor) "Chemical Kinetics Data Survey V" NBSIR 73-206 (1973), all recommendations contained in them (and still pertinent) are summarized in the present table.

We have also accepted many recommendations made by R. T. Watson in "Rate Constants for Reactions of $C\ell O_x$ of Atmospheric Interest" J. Phys. Chem. Ref. Data 6, 871 (1977) and by D. L. Baulch, et al "Evaluated Kinetic Data for High Temperature Reactions" Volume 1 (1972), Volume 2 (1973) and Volume 3 (1976), Butterworth and Co., London.

In addition to recommendations on rate and photochemical data the table includes listings of current research results. These data listings serve several purposes. Some simply record measurements, usually limited in number, on reactions for which it is not yet practical to give recommended values. Others show the data upon which a new recommendation is based. Still others show what has been done on a reaction since its rate constant was last evaluated. These new data may support the recommendation or suggest the need for modifications in the future.

2. Guide to the Table

2.1 General

This table provides current (December 1977) information on reaction rate constants, quantum yields and absorption cross sections. For many reactions, preferred values are given. The reactions included in the table are summarized in the index of reactions given in section 3.

Most of the important stratospheric reactions are in the tables. A number of the less important ones and some related systems are included, often simply for comparison.

The following remarks summarize the content of the table. It lists 416 reactions and gives a preferred value of the rate constant for 194 reactions; 136 based on recent reviews and 58 based on recent (1975-1977) experimental work. New data entries (1975-1977) are given for 252 reactions, showing substantial activity in the study of gas kinetics.

The following principles have been used in the selection and presentation of data:

a.   Where a preferred value is given for a rate constant or photochemical quantity, it is so indicated by an asterisk [*] placed ahead of the entry in the reference column.

b.   As indicated earlier an asterisk preceded by a dagger symbol [†*] is used to indicate those preferred values that have been recommended by the NASA Laboratory Measurements Committee and published in NASA Reference Publication 1010 "Chlorofluoro-methanes and the Stratosphere" R. D. Hudson, editor, August 1977.

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c.   Where there is a recent published evaluation of the data
     and there are no newer data, the evaluation is adopted
     and usually marked with an asterisk. The original data
     covered by the evaluation are not listed separately.
     However this latter rule has not been applied when the
     evaluation has appeared within the past year.

d.   Where there is an evaluation but there are new data, both
     are listed and a preferred value is indicated (marked by
     an asterisk).

e.   Where desirable, the available recent data sets are
     listed, and a selection is made or a preferred value is
     synthesized from them.

2.2   Uncertainty in Recommended Value of a Rate Constant

The uncertainty assigned here to the recommended value of
a rate constant is given in the column "Notes and reliability
of log k". This is an estimate by the evaluator of the absolute
accuracy of the preferred value. It is a subjective judgment
derived from intercomparison of data sets, consideration of related
reactions studied with the same technique, estimates of how well
the parameters could have been controlled, and comparison with
theory. It means that in the evaluators judgment, the true value
will lie within the indicated limits to a high level of confidence
(90 to 95 percent).

Usually the uncertainty is indicated by the term $\underline{D}$ in the
expression: $\log_{10} k = C \pm D$. This is equivalent to the statement
that k is uncertain to a factor of F where $D = \log_{10} F$. The
statement that k has the value k_o and is uncertain to a factor of
F means that $k_o/F < k < k_o \, F$.

Other forms used to indicate reliability are the following:

A < k < B   means k lies in the range between A and B
k < (>) B   means B is an upper (lower) limit
k ~ B   means B is only a rough guide to value of k
k = A ± B   alternative form for stating reliability limits

At times a rate constant expression is quoted from a paper with individual uncertainties for the rate parameters as k = (A ± a) exp(-B ± b/T). These measures are those provided by the author and often are indications of precision, not overall reliability.

Some notes are in order, regarding the statement of the uncertainty in the recommended value of the rate constant for those recommended values recommended by the NASA Laboratory Measurements Committee. Those recommendations were made for the limited temperature range 200-300 K. The uncertainty is indicated for T = 230 K, a typical midstratospheric temperature and in some cases allowance for extrapolation from higher temperatures was necessary. This is why occasionally the entry consists of the value of a rate constant measured at 298 K, the symbols [†*] immediately ahead of the entry in the reference column to show that this value has been adopted by the Committee for the temperature range 200-300 K, and a statement of the uncertainty in the preferred value at T = 230 K. This stated uncertainty will generally be larger than the uncertainty in the measured value (measured at 298 K) to allow for the additional uncertainty introduced by extrapolation to T = 230 K.

For the recommendations made by the NASA Laboratory Committee the indicated uncertainties in NASA Reference Publication 1010 have been doubled in the present table in order to make the reliability statement analogous to a "95 percent confidence level".

2.3 Conventions Concerning Rate Constants

a. <u>General Convention</u>. Almost all of the reactions in the table are elementary processes. For them the rate expression is derivable from a statement of the reaction, e.g.

$$A + 2B \rightarrow AB_2$$
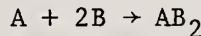
$$-d[A]/dt = -(1/2) \, d[B]/dt = d[AB_2]/dt = k[A][B]^2$$

Note that the stoichiometric coefficient for B, i.e. 2, appears in the denominator before B's rate of change (which is equal to $2k[A][B]^2$) and as a power on the right hand side.

Wherever there may be any doubt an explicit rate expression is given.

b.   Dissociation and Combination Reactions.   Some reactions
of these types are not of integral kinetic order over the
stratospheric pressure and temperature range.   That is, although
they require an energy transfer agent, "M," they are in the
"pressure fall-off region".   For some such reactions we tabulate
rate constants that include the effect of the energy transfer
agent and give rates for various altitudes.   The reactions are
written to demphasize "M," e.g.,

$$NO_2 + NO_3 \; (+M) \rightarrow N_2O_5 \; (+M)$$

$$HNO_3 \xrightarrow{M} HO + NO_2$$
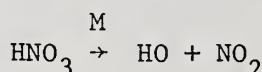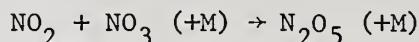
The rate expressions to be used do not have the concentration of M
in them, e.g., Rate = $k[NO_2] [NO_3]$ and $k[HNO_3]$ respectively.   The
units given for the k's, s^{-1} for first order, and cm^{+3} molecule$^{-1}s^{-1}$
for second order, are consistent with this convention.

The altitude, temperature and number density regime used in
these cases is

altitude/km	temp./K	log[M]/molecule cm^{-3}
15	217	18.60
20	217	18.27
25	222	17.93
30	227	17.58
35	237	17.26
40	251	16.92
45	265	16.60

This table follows the U. S. standard atmosphere, 1976.

c.   Forward and Reverse Reactions.   In some cases there are no
data on a reaction of interest but there are data on the "reverse"
reaction.   Occasionally, for

$$A \rightarrow B \; (f)$$
$$B \rightarrow A \; (r)$$
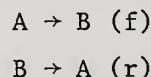
an evaluation will use the data on the "reverse" reaction together
with an equilibrium constant to obtain the other rate constant.
Obviously this is an approximation but it often is a useful method
of estimating non-measured physical properties.

The table contains notations to warn the reader when this procedure has been used, such as "based on reverse reaction," or when both reactions $\underline{f}$ and $\underline{r}$ are listed together "$k_f = k_r K_{eq}$" or $k_r = k_f/K_{eq}$. These expressions, which are those used in the analyses, are based on equating the two rates at equilibrium.

$$R_f = R_r$$

$$k_f[A] = k_r[B]$$

$$K_{eq} = [B]/[A] = k_f/k_r.$$

2.4 Convention Concerning Optical Absorption Coefficients

These are reported in the table as "absorption cross sections per molecule, base e". They are defined by the equations.

$$I/I_o = \exp(-\sigma[N]\ell)$$

$$\sigma = (1/([N]\ell))\ln(I_o/I)$$

where I_o and I are the intensities of incident and transmitted light, σ is the absorption cross section, $cm^2 molecule^{-1}$, $[N]$ is the concentration of absorbers, molecules cm^{-3}, and ℓ is the path length, cm. Other definitions and units are frequently used. The terms "absorption coefficient" and "extinction coefficient" are common. It is always necessary to know what concentration units, path length units and type of logarithm (base e or base 10) are used in the definition. To convert "cross-sections" to absorption coefficients in (atm at 273 K)$^{-1}$ cm^{-1}, base e, multiply by 2.69 x 10^{19}.

A table of conversion factors is given in the appendix.

3. Arrangement of the Table

Data on a reaction appear only once in the table. The normal location for a reaction is determined by its reactants. Each species has been assigned a sequence number (1 to 65) as shown in the index that follows. These sequence numbers are the same as those used in NBS Technical Note 866. New species have been inserted in appropriate positions and assigned sequence numbers such as 34a, 34b, etc. A reaction is filed under the lower numbered species. That is, the reaction of ozone (7) with an oxygen atom (1) is filed under reactions of oxygen atoms. The numbers for the reactants appear at the left margin of the table, preceding the statement of the reaction, e.g. $1,7 \quad O + O_3 \rightarrow O_2 + O_2$. These number pairs run in ascending order through the table.

If a reaction is not filed in the location described above, a cross reference is given there. The most common exception is the listing together of data on the forward and reverse reactions of a pair, i.e. $A \rightarrow B$, $B \rightarrow A$.

In the index that follows, bimolecular reactions are listed under both reactants. Frequently the listing of reaction partners for a particular species is divided into two parts by three dashes, separating species earlier in the list than the species indexed from those later in the list. Reactions of the particular species with those species listed before the three dashes should be sought under those reaction partners. There is no indexing of products of reactions. A few species are listed in the index for which there are no reactions in the table, in anticipation of expansion of the data set.

1. O   Rxn with: O, $O(^1S)$, O_2, O_3, N, NO, NO_2, NO_3, N_2, N_2O, N_2O_5, NH_2, NH_3, H, HO, HO_2, H_2, H_2O, H_2O_2, HNO_2, HNO_3, SO, SO_2, SO_3, HS, H_2S, CS, CS_2, OCS, ClO, BrO, OClO, HCl, HBr, NO_3Cl, Cl_2, Cl_2O, CO, CO_2, CN, CHO, CH_2O, CH_3, CH_3NO_2, CH_3ONO, CH_4, C_2H_4, C_2H_6, C_3H_6, alkane, C_6H_6, $C_6H_5CH_3$, CH_3Cl

2. $O(^1D)$ Rxn with: O_2, O_3, NO, NO_2, N_2, N_2O, NH_3, H_2, H_2O, H_2O_2, HCl, CO_2, CH_4, C_2H_6, CF_2Cl_2, $CFCl_3$

3. $O(^1S)$ Rxn with: O, O_2, O_3, NO, NO_2, N_2, N_2O, NH_3, H_2O, CO_2, CH_4

4. O_2 Rxn with: O, $O(^1D)$, $O(^1S)$ – – –
                            $h\nu$, N, NO, NO_2, NO_3, N_2, H, H_2, H_2O, H_2O_2, HNO, SO, HS, Cl, CN, CHO, CH_3, CH_3O

5. $O_2(^1\Delta)$ Rxn with: O_2, O_3, N, NO, N_2, H, SO, SO_2, H_2S, CO, CF_2Cl_2, CCl_4, CH_3Cl, CH_2Cl_2, $CHCl_3$

6. $O_2(^1\Sigma)$ Rxn with: O_2, N_2, H_2O

7. O_3 Rxn with: O, $O(^1D)$, $O(^1S)$, $O_2(^1\Delta)$ – – –
                            $h\nu$, M, N, NO, NO_2, H, HO, HO_2, SO, SO_2, H_2S, Cl, Br, ClO, BrO, CO, CH_2O, CH_3, CH_3O_2, CH_3ONO, CH_4, C_2H_4, C_3H_6, allene, butenes, butadiene, $C_2Cl_2H_2$

8. N   Rxn with: O, O_2, $O_2(^1\Delta)$, O_3 – – –

               N, NO, NO_2, HO, SO, SO_3, $OClO$

9. NO   Rxn with: O, $O(^1D)$, $O(^1S)$, O_2, $O_2(^1\Delta)$, O_3, N – – –

               $h\nu$, M, NO, $NO_2 + H_2O$, NO_3, NH, NH_2, H, HO,

               HO_2, H_2, H_2O, H_2O_2, Cl, ClO, BrO, $OClO$,

               CH_3, CH_3O, CH_3O_2

10. NO_2 Rxn with: O, $O(^1D)$, $O(^1S)$, O_2, O_3, N, $NO + H_2O$ – – –

               $h\nu$, M, NO_2, NO_3, NH_2, NH_3, H, HO, HO_2,

               SO_2, Cl, ClO, CH_3, CH_3O, CH_3O_2

11. NO_3 Rxn with: O, O_2, NO, NO_2 – – –

               $h\nu$, M, NO_3, H_2O, SO_2

12. N_2 Rxn with: O, $O(^1D)$, $O(^1S)$, O_2, $O_2(^1\Delta)$, $O_2(^1\Sigma)$ – – –

               M, HO

13. N_2O Rxn with: O, $O(^1D)$, $O(^1S)$ – – –

               $h\nu$, M, H, HO, ClO, CO

14. N_2O_5 Rxn with: O – – – $h\nu$, M, H_2O, SO_2

15. NH   Rxn with: NO – – –

16. NH_2 Rxn with: O, NO – – – H, HO, H_2, H_2O

17. NH_3 Rxn with: O, $O(^1D)$, $O(^1S)$, NO_2 – – –

               M, H, HO, ClO

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17a. N_2H_4 Rxn with: H

18.   H   Rxn with: O, O_2, $O_2(^1\Delta)$, O_3, NO, NO_2, N_2O, NH_2, NH_3,
                          N_2H_4 - - -
                          H, HO, HO_2, H_2O, H_2O_2, HNO, HNO_2, HNO_3,
                          SO_2, HS, H_2S, COS, $OClO$, HCl, $NOCl$, Cl_2, CO,
                          CO_2, CH_2O, CH_3OOH, CH_3ONO, CH_3Cl

19.   HO   Rxn with: O, O_3, N, NO, NO_2, N_2, N_2O, NH_2, NH_3, H - - -
                          M, HO, HO_2, H_2, D_2, H_2O, H_2O_2, HNO, HNO_2,
                          HNO_3, SO_2, H_2S, Cl, HCl, DCl, HBr, NO_3Cl,
                          CO, CH_2O, CH_3OH, CH_3NO_2, CH_3ONO, CH_4, C_2H_2,
                          C_2H_4, C_2H_6, C_3H_6, C_4H_{10}, alkane, C_6H_6,
                          $C_6H_5CH_3$, CF_2Cl_2, $CFCl_3$, CCl_4, CH_3Cl,
                          CH_2Cl_2, $CHCl_3$, $CH_iCl_jF_k$

20. HO_2 Rxn with: O, O_3, NO, NO_2, H, HO - - -
                          M, HO_2, H_2, H_2O, SO_2, Cl, Br, ClO, CO, CH_2O,
                          CH_3O_2, C_2H_4, C_2H_6, C_3H_8, C_4H_{10}

21. H_2 Rxn with: O, $O(^1D)$, O_2, NO, NH_2, HO, HO_2 - - -
                          M, Cl, ClO

22. H_2O Rxn with: O, $O(^1D)$, $O(^1S)$, O_2, $O_2(^1\Sigma)$, NO, NO_3, N_2O_5,
                          NH_2, H, HO, HO_2 - - - SO_3

23. H_2O_2 Rxn with: O, $O(^1D)$, O_2, NO, H, HO - - -
                          $h\nu$, M, Cl, Br

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24. HNO   Rxn with: O_2, H, HO – – – M, HNO

25. HNO_2 Rxn with: O, H, HO – – – hν

26. HNO_3 Rxn with: O, H, HO – – – hν, M, Cl

26a. S   Rxn with: CS_2, COS

27. SO   Rxn with: O, O_2, $O_2(^1\Delta)$, O_3, N – – – SO, SO_3

28. SO_2 Rxn with: O, $O_2(^1\Delta)$, O_3, NO_2, NO_3, N_2O_5, H, HO, HO_2 – – – CH_3

29. SO_3 Rxn with: O, N, H_2O, SO – – –

30. S_2O Rxn with:

31. HS   Rxn with: O, O_2, H – – – HS

32. H_2S Rxn with: O, $O_2(^1\Delta)$, O_3, H, HO – – –

33. HSO_3 Rxn with:

34. H_2SO_4 Rxn with:

34a. CS   Rxn with: O – – –

34b. CS_2 Rxn with: O, S – – –

34c. COS   Rxn with: O, H, S – – –

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35. Cl   Rxn with: O_2, O_3, NO, NO_2, HO, HO_2, H_2, H_2O_2,

                HNO_3 - - - Cl, OClO, ClOO, NOCl, NO_2Cl,

                NO_3Cl, Cl_2O, CH_4, C_2H_6

    Br   Rxn with: O_3, HO_2, H_2O_2 - - -

36. ClO   Rxn with: O, O_3, NO, NO_2, N_2O, NH_3, HO_2, H_2 - - -

                hν, ClO, BrO, CO, CH_4, C_2H_2, C_2H_4

    BrO   Rxn with: O, O_3, NO, ClO - - - BrO

37. ClOO   Rxn with: Cl - - - hν, M

    OClO   Rxn with: O, N, NO, H, Cl - - - hν

38. ClO_3 Rxn with:

39. HCl   Rxn with: O, $O(^1D)$, H, HO - - - hν

    HBr   Rxn with: O, HO - - -

40. HOCl   Rxn with: hν

41. HOClO   Rxn with:

42. NOCl   Rxn with: H, Cl - - - hν

43. NO_2Cl Rxn with: Cl - - - hν

43a. NO_3Cl Rxn with: O, HO, Cl - - - hν

44. Cl_2 Rxn with: O, H - - - hν

44a. Cl_2O Rxn with: O, Cl - - -

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45. CO   Rxn with: O, $O_2(^1\Delta)$, O_3, N_2O, H, HO, HO_2, ClO - - -
                                   CH_3O

46. CO_2 Rxn with: O, $O(^1D)$, $O(^1S)$, H - - -   M

46a. CN   Rxn with: O, O_2 - - -

47. CHO   Rxn with: O, O_2 - - -

48. CH_2O Rxn with: O, O_3, H, HO, HO_2 - - - $h\nu$

49. CH_3 Rxn with: O, O_2, O_3, NO, NO_2, SO_2 - - -

50. CH_3O Rxn with: O_2, NO, NO_2, CO

51. CH_3O_2 Rxn with: O_3, NO, NO_2, HO_2 - - - CH_3O_2

52. CH_3OH Rxn with: HO - - -

53. CH_3OOH Rxn with: H - - -

54. CH_3NO_2 Rxn with: O, HO - - -

      CH_3ONO Rxn with: O, O_3, H, HO - - - $h\nu$

55. CH_3NO_3 Rxn with:

56. CH_4 Rxn with: O, $O(^1D)$, $O(^1S)$, O_3, HO, Cl, ClO - - -

56a. C_2H_2 Rxn with: HO, ClO - - -

57. C_2H_4 Rxn with: O, O_3, HO, HO_2, ClO - - -

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58. C_2H_6 Rxn with: O, O(^{1}D), HO, HO$_2$, Cl - - -

*59. C_3H_6 Rxn with: O, O$_3$, HO - - -

†60. C_3H_8 Rxn with: O, HO, HO$_2$ - - -

∇60a. C_6H_6 Rxn with: O, HO - - -

61. CF_2Cl_2 Rxn with: O(^{1}D), O$_2$($^1\Delta$), HO - - -   hν

62. $CFCl_3$ Rxn with: O(^{1}D), HO - - -   hν

63. CCl_4 Rxn with: HO - - -   hν

64. CH_iCl_j Rxn with: O, O$_2$($^1\Delta$), O$_3$, H, HO - - - -

√65. $CH_iCl_jF_k$ Rxn with: HO - - -

*   and higher alkenes
†   and higher alkanes
∇   and other aromatics
√   and other halocarbons

December 1977

No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$		Notes and Reliability of log k
1,1M	$O + O + M \rightarrow O_2 + M$				
	*Campbell, Gray (1973)	298	4.8×10^{-33}	$M = N_2$	±0.03
	*Johnston (1968) review	196	11.1×10^{-33}		±0.02
	Taylor (1975) review	1000-8000	$3.80 \times 10^{-30} \, T^{-1} exp(-170/T)$	$M = O_2$	±0.3
		2000-10000	$1.7 \times 10^{-32} \, T^{-1/2}$	$M = N_2$	
			$2.2 \times 10^{-28} \, T^{-3/2}$	$M = O_2$	
			$6.2 \times 10^{-28} \, T^{-3/2}$	$M = O$	
			$8.3 \times 10^{-33} \, T^{-1/2}$	$M = N, N4$	
1,3	$O + O(^1S) \rightarrow$				
	Baulch, et al (1976) review	190-4000	$5.2 \times 10^{-35} exp(900/T)$	$M = Ar$	±0.1 at 190K
1,4M	$O(^3P) + O_2 + M \rightarrow O_3 + M$ (f)		see $O(^1S) + O \rightarrow$		
7,M	$O_3 + M \rightarrow O + O_2 + M$ (r)				
	*This Survey	200-346	$k_f = 6.6 \times 10^{-35} exp(510/T)$	$M = Ar$	±.07
			Rel. M eff.: Ar(1.0), $N_2(1.5)$, $O_2(1.7)$, $H_2O(15)$		
	Baulch, et al (1976) review	300	$k_f = 5.5 \times 10^{-34}$	$M = N_2$	
		200-1000	$k_r = 4.1 \times 10^{-10} exp(-11430/T)$	$M = Ar$	
	Johnston (1968) eval.	200-1000	$k_f = 4.6 \times 10^{-35} exp(1050/T)$	$M = O_2$	±0.1
			$k_r = 1.65 \times 10^{-9} exp(-11400/T) cm^3 molecule^{-1}s^{-1}$		±0.1
			Rel. M eff.: $O_3(1.0)$, Ar(0.25), $O_2(0.44)$, $N_2(0.30)$		
	Huie, Herron, Davis (1972)	200-346	$k_f = 6.6 \times 10^{-35} exp(510/T)$	$M = Ar$	
			Rel. M efficiencies: Ar(1.0), He(0.9), $N_2(1.7)$		
	Mulcahy, Williams (1968)	213-386	$k_f = 4.7 \times 10^{-35} exp(840/T)$	$M = Ar$	
			Rel. M eff.: Ar(1.0), He(0.8), $CO_2(3.4)$, $O_2(1.1)$		
	Meaburn, et al (1968)	300	$k_f = 1.0 \times 10^{-33}$	$M = CO_2$	
			Rel. M eff.: $CO_2(1.0)$, CO(0.44), $N_2O(0.88)$		
	Stuhl, Niki (1971)	300	$k_f = 5.4 \times 10^{-34} \, cm^6 molecule^{-2}s^{-1}$	$M = N_2$	
			Rel. M efficiencies: $N_2(1.0)$ $O_2(1.18)$, CO(1.24)		
	Donovan, Husain, Kirsch (1970)	300	$k_f = 5.0 \times 10^{-34} \, cm^6 molecule^{-2}s^{-1}$	$M = Ar$	
			Rel. M efficiencies: Ar(1.0), Kr(0.98), He(0.92)		
	Hippler, Troe (1971)	300	$k_f = 8 \times 10^{-34}$	$M = N_2$	
	Slanger, Black (1970)	300	$k_f = 4.4 \times 10^{-34}$	$M = Ar$, Rel. eff. Ar(1.0), $N_2(1.6)$	
	Francis (1969)	300	$k_f = 1.24 \times 10^{-34}$	$M = O_2$	
	Sauer (1967)	300	$k_f = 2.28 \times 10^{-34}$	$M = Ar$	
	Ball and Larkin (1973)	295	$k_f = 5.4 \pm 1.2 \times 10^{-34}$	$M = N_2$	
			Rel. efficiencies: $N_2(1.0)$, $O_2(1.05)$, Ar(0.78)		
	Hippler, Schippert, Troe (1975)	300	$k_f \sim 8 \times 10^{-34} \, cm^6 molecule^{-2}s^{-1}$	$M = N_2$	(a)
			$k_{f(\infty)} \sim 2.8 \times 10^{-12} \, cm^3 molecule^{-1}s^{-1}$		(a,b)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
			$k/cm^3 molecule^{-1}s^{-1}$	
1,4M	$O + O_2 + M \rightarrow O_3^* + M$		(a) Reevaluation of work in Hippler, Troe (1971) (b) 2d order high pressure limit $M = O_2$	
	Hogan, Burch (1976)	300	6.3×10^{-34} $M = O_2$	
	Bevan, Johnson (1973)	300	$5.4 \times 10^{-34} cm^6 molecule^{-2}s^{-1}$ $M = O_2$ Rel. efficiencies: $O_2(1.0)$, $Ar(0.50)$, $N_2O(2.4)$, $CO_2(2.5)$, $SF_6(5.7)$	(a)
	von Rosenberg, Trainor (1974)	300	$3 \times 10^{-34} cm^6 molecule^{-2}s^{-1}$ (a) Vibrationally excited O_3 followed as fn. of time using absn. $250< \lambda <330$nm. (b) Vibrationally excited O_3 followed as fn. of time using i.r. emission at 9.6 and 14.3 μm Also see von Rosenberg, Trainor (1975)	(b)
1,7	$O(^3P) + O_3 \rightarrow O_2 + O_2$			
	*Hampson (1973) eval.	220-1000	$1.9 \times 10^{-11} \exp(-2300/T)$	±0.1
	Baulch, et al (1976) review	200-500	$8.6 \times 10^{-12} \exp(-2090/T)$	±0.2
	McCrumb, Kaufman (1972)	269-409	$1.1 \times 10^{-11} \exp(-2155/T)$	
	Lundell, Ketcheson, Schiff (1969)	300	1.5×10^{-14}	
	Husain, Kirsch, Donovan (1972)	300	1.3×10^{-14}	
	Davis, Wong, Lephardt (1973)	220-353	$2.0 \times 10^{-11} \exp(-2280/T)$	
1,8M	$O + N + M \rightarrow NO + M$			
	*Baulch, et al (1973) review	200-400	$1.8 \times 10^{-31}(T)^{-0.5} cm^6 molecule^{-2}s^{-1}$, $M = N_2$	±0.2
	Taylor (1975)	2000-10000	$2.8 \times 10^{-28}T^{-3/2}$ $M = N_2, O_2, N, O$ $5.5 \times 10^{-27}T^{-3/2}$ $M = NO$	
	Campbell, Gray (1973)	298 196	9.2×10^{-33} 12.1×10^{-33}	
1,9 4,8	$O + NO \rightarrow N + O_2$ (f) $O_2 + N \rightarrow NO + O$ (r)			
	*Baulch, et al (1973) review	1000-3000	$k_f = 2.5 \times 10^{-15}T \exp(-19500/T)$	±0.12 at 1000K (a)
	+*Becker, Groth, Kley (1969)	280-333	$k_r = 5.5 \times 10^{-12} \exp(-3200/T)$	±0.2 at 230K
	Baulch, et al (1973) review	300-3000	$k_f = 1.1 \times 10^{-14}T \exp(-3150/T)$ (a) $k_f = k_r Keq$. Error in log k increases to ±0.3 at 3000K	±0.12 at 300<T<1500K
1,9	$O + NO \rightarrow NO_2 + h\nu$			
	Taylor (1975)	2000-10000	$k_r = 2.2 \times 10^{-14}(T) \exp(-3560/T)$	
	Becker, et al (1973)	300	4.2×10^{-18}	
1,9M 10,M	$O + NO + M \rightarrow NO_2 + M$ (f) $NO_2 + M \rightarrow NO + O + M$ (r)			
	+*Whytock, Michael, Payne (1976)	220-500	$k_f = 1.55 \times 10^{-32}\exp(584/T)cm^6 molecule^{-2}s^{-1}$, $M = N_2$	±0.2
	Baulch, et al (1973) review	200-500	$k_f = 3.0 \times 10^{-33}\exp(940/T)cm^6 molecule^{-2}s^{-1}$, $M = O_2$ Rel. M efficiencies: $O_2(1.0)$, $N_2(1.4)$	±0.08 ±0.08
		1400-2400	$k_r = 1.8 \times 10^{-8} \exp(-33000/T)cm^3 molecule^{-1}s^{-1}$	±0.1

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
			M = Ar	
	Slanger, Wood, Black (1973)	296	$k_f = 6.0 \times 10^{-32}$ M = Ar	
		241	$k_f = 13.0 \times 10^{-32}$ M = Ar	
	Hippler, Schippert, Troe (1975)	300	$k_f = 7.4 \times 10^{-32}$ cm⁶molecule⁻²s⁻¹ M = N₂	(a)
			$k_f(\infty) = 3.0 \times 10^{-11}$ cm³molecule⁻¹s⁻¹	
			(a) 2d order high pressure limit	
	Atkinson, Pitts (1974)	300-392	$k_f = 2.6 \times 10^{-32}$ exp(450 ± 100/T) M = N₂O	
	Singleton, et al (1975)	298-473	$k_f = 1.7 \times 10^{-32}$ exp(620/T), M = N₂O	
	Campbell, Handy (1976)	285-425	$k_f = 5.0 \times 10^{-33}$ exp(900/T), M = N₂	
	Michael, Payne, Whytock (1976)	217-500	$k_f = 1.08 \times 10^{-32}$ exp(520/T), M = He	
			$k_f = 9.33 \times 10^{-33}$ exp(515/T), M = Ne	
			$k_f = 9.01 \times 10^{-33}$ exp(590/T), M = Ar	
			$k_f = 9.52 \times 10^{-33}$ exp(570/T), M = Kr	
1,9M	O + NO + M → NO₂ + M + hν			
	Becker, et al (1973)	300	7×10^{-32} cm⁶molecule⁻²s⁻¹	
1,10 4,9	O(³P) + NO₂ → NO + O₂ (f) O₂ + NO → NO₂ + O (r)			
	**Davis, Herron, Huie (1973)	230-339	$k_f = 9.1 \times 10^{-12}$	±0.06
	Baulch, et al (1973)	300-550	$k_f = 1.7 \times 10^{-11}$ exp(-300/T)	±0.1
			$k_r = k_f/K_{eq} = 2.8 \times 10^{-12}$ exp(-23400/T)	
	Clyne, Cruse (1971)	300	$k_f = 8.3 \times 10^{-12}$	
	Harker, Johnston (1973)	300	$k_f = 9.2 \times 10^{-12}$	(a)
	Clyne, Cruse (1972)	298	$k_f = 6.1 \times 10^{-12}$	
	Slanger, et al (1973)	300	$k_f = 9.3 \times 10^{-12}$	(b)
		240	$k_f = 10.5 \times 10^{-12}$	
	Hampson, et al (1973a) review	220-500	$k_f = 9.1 \times 10^{-12}$	±0.08
	Stuhl, Niki (1970)	300	$k_f = 4.4 \times 10^{-12}$	(b)
	Bemand, Clyne, Watson (1973)	230-1055	$k_f = 1.75 \times 10^{-10} \times (T)^{-0.52}$	(c)
		258	$k_f = 9.5 \pm 1.1 \times 10^{-12}$	

(a) k/k(O + NO + M) measured, where k(ref) = 6.9 x 10⁻³².
(b) Similar techniques were used by Slanger and by Stuhl and Niki: Flash photolysis - chemiluminescence.
(c) Based on this work (298 <T/K< 1055) and other recent work.

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability of log k
1,10M 11,M	O + NO₂ + M → NO₃ + M (f) NO₃ + M → NO₂ + O + M (r)			
	*Hampson, et al (1973a) review	298	$k_f = 1.0 \times 10^{-31}$ cm⁶ molecule⁻²s⁻¹ M = N₂	±0.2
	Baulch, et al (1973) review	295	$k_f = 6.3 \times 10^{-32}$ M = N₂	±0.4

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
	Hippler, Schippert, Troe (1975)	300	$k_r \sim 8 \times 10^{-42}$ cm³molecule⁻¹s⁻¹, M = N₂	(a)
			$k_f = 8.0 \times 10^{-32}$ cm⁶molecule⁻²s⁻¹ M = N₂	(b)
			$k_f(\infty) = 2.0 \times 10^{-11}$ cm³molecule⁻¹s⁻¹	
			(a) No reliable data. Value based on k_f	
			(b) 2d order high pressure limit	
1.11	O + NO₃ → O₂ + NO₂			
1.12	Graham, Johnston (1978)	300	$(1.0 \pm 0.4) \times 10^{-11}$	
1.12	O + N₂ → N + NO		see reverse reaction	
1.12M	O + N₂ + M → N₂O + M (f)			
13.M	N₂O + M → N₂ + O + M (r)			
	Baulch, et al (1973) review	1300-2500	$k_f = 3.9 \times 10^{-35}$ exp(-10400/T) cm⁶molecule⁻²s⁻¹ M = Ar	±0.2 (a)
			$k_r = 8.3 \times 10^{-10}$ exp(-29000/T) cm³molecule⁻¹s⁻¹ M = Ar	±0.2
		900-2100	$k_f = 5.5 \times 10^{-15}$ exp(-11300/T) cm³molecule⁻¹s⁻¹	±0.2 (a,b)
			$k_r = 1.3 \times 10^{+11}$ exp(-3000/T)s⁻¹	±0.2 (c)
			(a) $k_f = k_r K_{eq}$	
			(b) 2d order high pressure limit	
			(c) 1st order high pressure limit	
	Schofield (1973) review	300-568	$k_f \leq 5 \times 10^{-38}$ cm⁶molecule⁻²s⁻¹	upper limit only
		800-2100	$k_{r\infty} = 1.4 \times 10^{11}$ exp(-70,000/T)s⁻¹	1st order limit
1.13	O + N₂O → N₂ + O₂ (1)			
1.13	O + N₂O → NO + NO (2)			
9.9	NO + NO → N₂O + O (2r)			
	Baulch, et al (1973) review	1200-2000	$k_1 = 1.7 \times 10^{-10}$ exp(-14.1 × 10³/T)	±0.4 (a)
			$k_2 = 1.7 \times 10^{-10}$ exp(-14.1 × 10³/T)	±0.3
		1200-2000	$k_{2r} = 2.2 \times 10^{-12}$exp(-32100/T)	±0.3 (h)
			(a) Based on $k_1/k_2 = 1$	
			(b) d[NO]/dt = -2k₂ᵣ[NO]²	
	Taylor (1975) review	2000-10000	$k_{2r} = 0.4T^{-5/2}$exp(-43000/T)	
1.14	O + N₂O₅ → products			
	Graham, Johnston (1978)	300	< 2 × 10⁻¹⁴	
	Davis (1974)	300	< 2 × 10⁻¹³	preliminary
1.16	O + NH₂ → HNO + H (a)			
	→ HO + NH (b)			
	Gehring, et al (1973)	300	3.5×10^{-12} ($k_a + k_b$)	
1.17	O + NH₃ → HO + NH₂ (f)			
16.19	HO + NH₂ → O + NH₃ (r)			
	*Kurylo, et al (1969)	361-677	$k_f = 6.6 \times 10^{-12}$ exp(-3300/T)	±0.3
	Baulch, et al (1973) review	300-1000	$k_f = 2.5 \times 10^{-12}$ exp(-3020/T)	±0.2
		300-1000	$k_r = k_f/K_{eq} = 1 \times 10^{-13}$	±0.2 (a)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
	Albers, et al (1969)	300-1000	$k_f = 2 \times 10^{-12}\ \exp(-3000/T)$	
	Kondratiev (1970) review	350-1000	$k_f = 1.8 \times 10^{-12}\ \exp(-2500/T)$ Data of Albers, et al provide an upper limit when extrapolated to 220K	
			(a) $HO + NH_2 \rightarrow NH + H_2O$ may be preferred channel.	
1,18M	$O + H + M \rightarrow HO + M$ Schofield (1973) review Baulch, et al (1972) review	1000-3000	~2 $\times 10^{-32}$ cm⁶molecule⁻²s⁻¹ M = Ar No recommendation	±1 estimate
1,19 4,18	$O + HO \rightarrow H + O_2$ (f) $O_2 + H \rightarrow O + HO$ (r)			
	++Wilson (1972) review	300-2000	$k_f = 4.2 \pm 1.7 \times 10^{-11}$	±0.3
	*Baulch, et al (1972) review	700-2500	$k_r = 3.7 \times 10^{-10}\ \exp(-8450/T)$	±0.1
1,19M 20,M	$O + HO + M \rightarrow HO_2 + M$ (f) $HO_2 + M \rightarrow O + HO + M$ (r) Baulch, et al (1972) review	300	$k_f = 3.8 \pm 1.7 \times 10^{-11}$	±0.17
1,20	$O + HO_2 \rightarrow HO + O_2$ ++Burrows, Harris, Thrush (1977)	293	no recommendation for forward or reverse rxn 3.5 $\times 10^{-11}$ (a) Based on value for k(O + HO) and k(HO + H₂O₂)	±0.3 at 230K (a)
1,21 18,19	Lloyd (1974) review $O + H_2 \rightarrow HO + H$ (f) $H + HO \rightarrow O + H_2$ (r)	~300	8 $\times 10^{-11}\ \exp(-500/T)$	estimate
	Baulch, et al (1972) review	400-2000	$k_f = 3.0 \times 10^{-14}(T)\exp(-4480/T)$ $k_r = k_f/K_{eq} = 1.4 \times 10^{-14}(T)\exp(-3500/T)$	±0.1
	Dubinsky, McKenney (1975) Schott, et al (1974)	347-742 1400-1900	$k_f = 8.8 \times 10^{-12}\ \exp(-4200/T)$ $k_f/k_{ref} = 3.6 \pm 0.7$ Ref rxn is $O_2 + H \rightarrow O + HO$	±0.15
1,22 1,22	Campbell, Handy (1975) $O + H_2O \rightarrow HO + HO$ $O + H_2O \rightarrow H + HO_2$	363-490	$k_f = 5.1 \times 10^{-11}\ \exp(-4950/T)$ see reverse reaction	
1,23	Baulch, et al (1972) review $O(^3P) + H_2O_2 = HO_2 + OH$ (a) $= H_2O + O_2$ (b)		no recommendation	
	++Davis, Wong, Schiff (1974) Foner, Hudson (1962) Albers, et al (1971)	283-373 300 370-800	$k(a+b) = 2.75 \times 10^{-12}\ \exp(-2125/T)$ $< 4 \times 10^{-15}$ $k(a + b) = 4.6 \times 10^{-11}\ \exp(-3220/T)$ (a) Although there is no evidence, products are most likely $OH + HO_2$ as the channel to produce $H_2O + O_2$ requires a complex rearrangement.	±0.3 (a)
1,25	$O + HNO_2 \rightarrow HO + NO_2$ This survey		No data. Probably faster than $O + HNO_3$, since it is 94 kJ/mol more exothermic.	

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1,26	$O + HNO_3 \rightarrow HO + NO_3$			
	*Chapman, Wayne (1974)	300	$< 3 \times 10^{-17}$	
	Hampson, et al (1973) review	300	$< 1.5 \times 10^{-14}$	
	Morley, Smith (1972)	300	1.3×10^{-14}	
	Baulch, et al (1973) review	300	$<10^{-14}$	approximate upper limit
1,27	$O + SO \rightarrow SO_2 + h\nu$			
	Baulch et al (1976) review		no recommendation	
1,27M 28,M	$O + SO + M \rightarrow SO_2 + M$ (f) $SO_2 + M \rightarrow O + SO + M$ (r)			
	*Baulch, et al (1976) review	298	$k_f = 1.9 \times 10^{-31}$ cm⁶molecule⁻²s⁻¹ M = Ar k_r, no recommendation	±0.15
	Schofield (1973) review	300	$k_f = 8.8 \times 10^{-31}$, M = Ar $k_r = 4.2 \times 10^{-10}$ exp(-55000/T)	±0.3 ±0.3
1,28 4,27	$O + SO_2 \rightarrow O_2 + SO$ (f) $O_2 + SO \rightarrow O + SO_2$ (r)			
	*Baulch, et al (1976) review	440-2100	$k_f = 2.1 \times 10^{-10}T^{-0.5}$ exp(-9980/T)	±0.25 (a)
		440-2100	$k_r = 7.5 \times 10^{-13}$ exp(-3250/T)	±0.25
	Breckenridge, Miller (1972)	300	$k_r = < 8 \times 10^{-17}$	
	Schofield (1973) review	400-2500	$k_r = 3.0 \times 10^{-13}$ exp(-2800/T) (a) $k_f = k_r \times K_{eq}$	±0.3
1,28M	$O + SO_2 + M \rightarrow SO_3 + M$			
	*Davis (1976)	220-353	3.4×10^{-32} exp (-1130/T) cm⁶molecule⁻²s⁻¹ M = N₂ N₂(1.0), He(.45), Ar(.87), SO₂(56)	
	Schofield (1973) review	250-1000	1×10^{-33}exp(±500/T)cm⁶molecule⁻²s⁻¹ M = O₂, N₂, Ar, He	±0.3 at 300K ±0.6 at other temp.
	Atkinson, Pitts (1974)	299-392	9.2×10^{-32} exp(-1000/T), M = N₂O	
	Westenberg, deHaas(1975d)	248-415	1.07×10^{-31} exp(-1400/T), M = He Rel. eff: He(1.0), N₂(2.4), SO₂(9.5)	
1,29	$O + SO_3 \rightarrow$ products			
	Baulch, et al (1976) review		no recommendation	
	Westenberg, deHaas (1975c)	298-507	1.4×10^{-31} exp(785/T) cm⁶molecule⁻²s⁻¹ Rel. eff: He(1.0), N₂(1.4) (a) Reaction $O + SO_3 + M \rightarrow$ products found to be 3rd order up to P = 7 Torr; SO₄ not detected	(a)
	Schofield (1973) review	1480-1550	5×10^{-10} exp(-6000/T)	uncertain
	Jacob, Winkler (1972)	300-500	3×10^{-16} exp(-500/T)	
1,31	$O + HS \rightarrow H + SO$			
	Baulch, et al (1976) review		no recommendation	
	Cupitt, Glass (1975)	295	$1.6 \pm 0.5 \times 10^{-10}$	
1,32	$O + H_2S \rightarrow HO + HS$			
	*Whytock, et al (1976)	263-495	7.24×10^{-12} exp(-1660/T)	±0.1

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	Hollinden, Kurylo, Timmons (1970)	205-300	$2.9 \times 10^{-13} \exp(-750/T)$	(a)
	Baulch, et al (1976) review		no recommendation	
	Schofield (1973) review	200-350	$6.3 \times 10^{-13} \exp(-920/T)$	±0.3
			(a) Assumes stoichiometry of 3.5	
1,34a	O + CS → CO + S			
	*Baulch, et al (1976) review	300	2.2×10^{-11}	±0.2
	Bida, et al (1976)	300	2.24×10^{-11}	
	Slagle, et al (1975)	305	2.06×10^{-11}	
1,34b	O + CS₂ → CS + SO (a) → OCS + S (b)			
	*Baulch, et al (1976) review	200-1000	$k_a = 3.7 \times 10^{-11} \exp(-700/T)$	±0.15, T<360K
	Wei, Timmons (1975)	218-293	$k = 2.8 \times 10^{-11} \exp(-640/T)$	
	Slagle, et al (1974)	302	$k = 4.0 \times 10^{-12}$ $k_b/k = 0.093$	
	Graham, Gutman (1976)	249-500	k_b/k decreases from 0.098 at 249K to 0.081 at 500K	
1,34c	O + OCS → SO + CO			
	Manning, et al (1976)	296	$1.10 \pm 0.1 \times 10^{-14}$, P = 50 Torr $1.49 \pm 0.1 \times 10^{-14}$, P = 2 torr	
	Wei, Timmons (1975)	239-404	$2.0 \times 10^{-11} \exp(-2150/T)$	
	Klemm, Stief (1974)	263-502	$1.65 \times 10^{-11} \exp(-2165/T)$	
	Baulch, et al (1976) review	190-1200	$2.6 \times 10^{-11} \exp(-2250/T)$	
1,36	O + ClO → Cl + O₂			
	+NASA (1977) eval	200-300	$7.7 \times 10^{-11} \exp(-130/T)$	±0.12
	Clyne, Nip (1976)	220-425	$1.07 \times 10^{-10} \exp(-224/T)$	(a)
			(a) Selected by Watson (1977) review	
	Zahniser, Kaufman (1977)	218-295	$k/k_{ref} = (1.55 \pm 0.17)\exp(246 \pm 30/T)$	(b)
			(b) $k_{ref} = k(Cl + O_3)$	
1,36Br	O + BrO → Br + O₂			
	+NASA (1977) eval	200-300	3×10^{-11}	
1,37	O + OClO → ClO + O₂			
	+NASA (1977) eval	200-300	$2 \times 10^{-11} \exp(-1100/T)$	±0.6 at 230K (a)
	Bemand, et al (1973)	298	5×10^{-13}	±0.2
			(a) Based on room temp value of Bemand, et al	
1,39 19,35	O + HCl → HO + Cl (f) HO + Cl → O + HCl (r)			
	+Watson (1977) eval	200-300	$k_f = 1.14 \times 10^{-11} \exp(-3370/T)$	±0.3 at 230K
	+NASA (1977) eval	200-300	$k_r = k_f \times Keq = 1.0 \times 10^{-11} \exp(-2970/T)$	±0.3 at 230K
	Balakhnin, et al (1971)	295-371	$k_f = 1.74 \pm 0.6 \times 10^{-12} \exp(-2250/T)$	
	Brown, Smith (1974)	293-440	$k_f = 2.5 \times 10^{-12} \exp(-2970 \pm 150/T)$	
	Wong, Belles (1972)	356-628	$k_f = 1.9 \pm 0.3 \times 10^{-11} \exp(-3580/T)$	
1,39	O + HCl(v = 1) → HO + Cl (a) → O + HCl(v = 0) (b)			

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Arnoldi, Wolfrum (1974)	300	$3.6 \pm 1.2 \times 10^{-12}$	(a)
	Brown, Glass, Smith (1975)	196-400	$6.2 \times 10^{-12} \exp(-500/T)$	(a)
			(a) Total rate constant for sum of two reaction paths.	
1,39Br	O + HBr → HO + Br			
	†*NASA (1977) eval	200-300	$7.6 \times 10^{-12} \exp(-1570/T)$	±0.8 at 230K
	Brown, Smith (1975)	267-430	$4.0 \times 10^{-12} \exp(-1360 \pm 50/T)$	
	Takacs, Glass (1973)	298	$(4.4 \pm 1.0) \times 10^{-14}$	
1,43a	O + NO₃Cl → products			
	†*NASA (1977) eval	200-300	$3.0 \times 10^{-12} \exp(-808/T)$	±0.15 (a)
	Molina, et al (1977)	213-295	$3.4 \times 10^{-12} \exp(-840/T)$	
	Kurylo (1977)	225-273	$1.9 \times 10^{-12} \exp(-692/T)$	
	Ravishankara, et al (1977)	245	2×10^{-13}	
			(a) Recommended expression given by Kurylo (1977) based on his work and that of Molina, et al (1977)	
1,44	O + Cl₂ → ClO + Cl			
	*Clyne, et al (1976)	174-602	$4.2 \times 10^{-12} \exp(-1370/T)$	(a)
			(a) Recommendation based on this study (299-502K) and other recent work. Also recommended by Watson (1977) review.	
1,44a	O + Cl₂O → 2ClO			
	Watson (1977) review	300	1.4×10^{-11}	±0.1
1,45M 46M	O + CO + M → CO₂ + M (f) CO₂ + M → O + CO + M (r)			
	*Baulch, et al (1976) review	250-500	$k_f = 6.5 \times 10^{-33} \exp(-2180/)$ M = CO	±0.2 at 250K inc. to ±0.5 at 500K
		296	$k_f = 2.3 \times 10^{-36}$ M = N₂ no recommendation for k_r	
1,46 4,45	O + CO₂ → CO + O₂ (f) O₂ + CO → O + CO₂ (r)			
	*Baulch, et al (1976) review	1500-3000	$k_f = 2.8 \times 10^{-11} \exp(-26500/T)$	±0.3 (a)
		1500-3000	$k_r = 4.2 \times 10^{-12} \exp(-24000/T)$	±0.3
			(a) $k_f = k_r K_{eq}$	
1,46a	O + CN → CO + N			
	Schmatjko, Wolfrum (1976)	295	1.8×10^{-11}	
	Albers, et al (1975)	275-387	2.0×10^{-11}	
1,47	O + CHO → CO₂ + H (a) → CO + HO (b)			
	*Washida, et al (1974)	297	$2.1 \pm 0.4 \times 10^{-10}$ $(k_a + k_b)$	
1,48	O + CH₂O → CHO + OH			
	†*NASA (1977) eval	200-300	$2 \times 10^{-11} \exp(-1450/T)$	±0.4 at 230K (a)
	Herron, Hule (1973) review	300	1.5×10^{-13}	±0.15

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
1,49	Mack, Thrush (1973)	300	1.5×10^{-13} (a) "A factor" chosen; E_{act} calc to fit $k(300K)$	±0.05
	O + CH_3 → CH_2O + H (a) → CHO + HO (b)			
	Washida, Bayes (1976)	259-341	$k_a = 1.0 \pm 0.2 \times 10^{-10}$	
	Washida, et al (1973)	300	k_b negligible $k_b/k_a < 0.05$	
	Slagle, Pruss, Gutman (1974)	300	$k_a = 1.85 \pm 0.28 \times 10^{-10}$	
	Morris, Niki (1972)	300	k_a/k(O + tetramethylethylene) = 1.5	
	Peeters, Mahnen (1973)	1100-1900	$k_a = 2.2 \times 10^{-10} exp(-1000/T)$	
	Bowman (1975)	1875-2240	$k_a = 1.7 \times 10^{-10}$	
	Biordi, et al (1975)	1550-1725	$k_a = 1.7 \times 10^{-10}$	
1,54	O + CH_3NO_2 → products			
	Campbell, Goodman (1975a)	295	3.3×10^{-15}	
1,54	O + CH_3ONO → products			
1,56	O + CH_4 → products			
	Davidson, Thrush (1975)	300-410	$2.3 \times 10^{-11} exp(-2620/T)$	
1,57	*Herron, Huie (1973) review	350-1000	$3.5 \times 10^{-11} exp(-4550/T)$	±0.11
	O + C_2H_4 → CH_3 + HCO (a) → CH_2CO + H_2 (b)			
	*Herron, Huie (1973) evaluation	200-500	$5.5 \times 10^{-12} exp(-565/T)$ $(k_a + k_b)$	±0.08
	Pruss, Slagle, Gutman (1974)	300	$k_b = 3.81 \pm 0.95 \times 10^{-14}$ $k_b/(k_a + k_b) = 0.05$	(a)
	Atkinson, Pitts (1974)	300-392	$5.6 \times 10^{-12} exp(-640 \pm 100/T)$ $(k_a + k_b)$	
	Singleton, Cvetanovic (1976)	298-486	$1.16 \times 10^{-11} exp(-845/T)$ a) Calculated using above recommended value for $(k_a + k_b)$	
1,58	O + C_2H_6 → products			
	*Herron, Huie (1973) evaluation	300-650	$4.1 \times 10^{-11} exp(-3200/T)$	±0.11
1,59	O + C_3H_6 → products			
	*Herron, Huie (1973) evaluation	200-500	$4.1 \times 10^{-12} exp(-38/T)$	±0.08
	Atkinson, Pitts (1974)	300-392	$3.45 \times 10^{-12} exp(0 \pm 150/T)$	
	Singleton, Cvetanovic (1976)	298-483	$1.26 \times 10^{-11} exp(-363/T)$	
1,60	O + alkane → HO + alkyl radical			
	Herron, Huie (1969)	250-600	$k = [0.8 exp(-2900/T) N_p + 2.2 exp(-2250/T)$ $N_s + 2.6 exp(-1650/T)N_t] \times 10^{-11}$ Where N_p, N_s, and N_t are the number of primary, secondary, and tertiary hydrogen atoms, respectively. Do not use formula for CH_4.	
1,60a	O + C_6H_6 → products			
	Colussi, et al (1975)	298-462	$1.81 \times 10^{-11} exp(-2115/T)$	
	Atkinson, Pitts (1975a)	300-392	$1.84 \times 10^{-11} exp(-2000/T)$	

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	$O + C_6H_5CH_3 \rightarrow$ products			
	Colussi, et al (1975)	298-462	$3.82 \times 10^{-11} \exp(-1940/T)$	
	Atkinson, Pitts (1975a)	300-392	$1.36 \times 10^{-11} \exp(-2560/T)$	
1,64	$O + CH_3Cl \rightarrow HO + CH_2Cl$			
	Westenberg, deHaas (1975a)	500-1000	$5.8 \times 10^{-11}\exp(-4550/T)$	(a)
	Barassin, Combourieu (1974)	298-443	$2.2 \times 10^{-11}\exp(-3450/T)$	
			(a) Also measured $k(O + CH_3Br)/k(O + CH_3Cl)$ to be unity over same temp. range	
2,4	$O(^1D_2) + O_2 \rightarrow O_2(^1\Sigma_g^+) + O(^3P)$			
	+*Streit, et al (1976)	104-354	$2.9 \times 10^{-11} \exp(67/T)$	0.1
	+*Fletcher, Husain (1976b)	300	5.3×10^{-11}	
2,7	$O(^1D_2) + O_3 \rightarrow O_2 + O_2$ (a) $\rightarrow O_2 + 2O$ (b)			
	+*Streit, et al (1976)	103-393	2.4×10^{-10} ($k_a + k_b$)	±0.1
	Heidner, et al (1973)	300	2.7×10^{-10} ($k_a + k_b$)	
	+*Cvetanovic (1975) review	300	$k_a/k_b \sim 1$	
2,9	$O(^1D_2) + NO \rightarrow NO + O(^3P)$			
	This survey	300	3.5×10^{-11}	±0.3 (a)
	Heidner, Husain (1973)	300	8.5×10^{-11}	
			(a) 0.41 x k of Heidner and Husain; scaled to match other selected $O(^1D)$ rates	
2,10	$O(^1D_2) + NO_2 \rightarrow NO + O_2$			
	This survey	300	1.0×10^{-10}	±0.2 (a)
	Heidner, Husain (1973)	300	2.3×10^{-10}	
			(a) 0.41 x k of Heidner and Husain; scaled to match other selected $O(^1D)$ rates	
2,12	$O(^1D_2) + N_2 \rightarrow N_2 + O(^3P)$			
	+*Streit, et al (1976)	104-354	$2.0 \times 10^{-11} \exp(107/T)$	±0.1
	Heidner, et al (1973)	300	6.9×10^{-11}	
2,12M	$O(^1D_2) + N_2 + M \rightarrow N_2O + M$			
	+*NASA (1977) eval	300	3.5×10^{-37} $cm^6 molecule^{-2}s^{-1}$	(a)
			(a) Derived from data in Kajimoto and Cvetanovic (1976a) and value of $k(O(^1D) + N_2)$ this survey	
2,13	$O(^1D_2) + N_2O \rightarrow N_2 + O_2$ (a) $\rightarrow 2NO$ (b)			
	+*Davidson, et al (1977)	204-359	1.1×10^{-10} ($k_a + k_b$)	0.1
	Heidner, Husain (1973)	300	2.2×10^{-10} ($k_a + k_b$)	
	+*Cvetanovic (1975) review	300	$k_a/k_b \sim 1$	
2,17	$O(^1D_2) + NH_3 \rightarrow NH_2 + HO$			
	*Davidson, et al (1977)	204-354	2.5×10^{-10}	±0.1
	Fletcher, Husain (1976a)	300	6.3×10^{-10}	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
2,21	$O(^1D_2) + H_2 \rightarrow OH + H$			
	**Davidson, et al (1977)	204-352	9.9×10^{-11}	
	Heldner, Husain (1973)	300	2.7×10^{-10}	
2,22	$O(^1D_2) + H_2O \rightarrow 2OH$			
	**Streit, et al (1976)	253-353	2.3×10^{-10}	± 0.1
	Heldner, et al (1973)	300	3.0×10^{-10}	
2,23	$O(^1D_2) + H_2O_2 \rightarrow OH + HO_2$			
	Fletcher, Husain (1976a)	300	5.2×10^{-10}	
2,39	$O(^1D_2) + HCl \rightarrow$ products			
	**Davidson, et al (1977)	199-379	1.4×10^{-10}	± 0.1
2,45	$O(^1D_2) + CO \rightarrow CO + O(^3P)$			
	*This survey	300	3×10^{-11}	± 0.3 (a)
	Heldner, et al (1973)	300	7.3×10^{-11}	
	(a) 0.41 x k of Heldner, et al; scaled to match other selected $O(^1D)$ rates			
2,46	$O(^1D_2) + CO_2 \rightarrow CO_2 + O(^3P)$			
	*Streit, et al (1976)	139-200	1.2×10^{-10}	± 0.1
		200-354	$5.8 \times 10^{-11} \exp(117/T)$	± 0.1
	Fletcher, Husain (1976b)	300	1.7×10^{-10}	
2,55	$O(^1D_2) + CH_4 \rightarrow CH_3 + OH$ (a) $\rightarrow CH_2O + H_2$ (b)			
	**Davidson, et al (1977)	198-357	1.4×10^{-10} ($k_a + k_b$)	
	Heldner, Husain (1973)	300	3.1×10^{-10} ($k_a + k_b$)	
	**Cvetanovic (1975) review	300	$k_a/k_b = 10$	
2,58	$O(^1D_2) + C_2H_6 \rightarrow$ products			
	*This survey	300	3×10^{-10}	± 0.2 (a)
	Fletcher, Husain (1976a)	300	7.3×10^{-10}	
	(a) 0.41 x k of Fletcher and Husain; scaled to match other selected $O(^1D)$ rates			
2,61	$O(^1D_2) + CF_2Cl_2 \rightarrow$ products			
	**NASA (1977) eval	300	2×10^{-10}	± 0.2 (a)
	Fletcher, Husain (1976b)	300	4.8×10^{-10}	
	(a) 0.41 x k of Fletcher and Husain; scaled to match other selected $O(^1D)$ rates			
2,62	$O(^1D_2) + CFCl_3 \rightarrow$ products			
	**NASA (1977) eval	300	2.3×10^{-10}	± 0.2 (a)
	Fletcher, Husain (1976b)	300	5.5×10^{-10}	
	(a) 0.41 x k of Fletcher and Husain; scaled to match other selected $O(^1D)$ rates			
3,1	$O(^1S) + O(^3P) \rightarrow$?			
	Slanger, Black (1976a)	200-365	$5 \times 10^{-11} \exp(-305/T)$	± 0.15 a
3,4	$O(^1S) + O_2 \rightarrow$?	200-377	$4.3 \times 10^{-12} \exp(-850/T)$	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
3,7	$O(^1S) + O_3 \rightarrow$?	300	5.8×10^{-10}	±0.07 a
3,9	$O(^1S) + NO \rightarrow$?	200-291	$3.2 \times 10^{-11}(T)^{0.5}$	±0.05 a
3,10	$O(^1S) + NO_2 \rightarrow$?	300	5×10^{-10}	±0.2 a
3,12	$O(^1S) + N_2 \rightarrow$?	200-380	$< 5 \times 10^{-17}$	a
3,13	$O(^1S) + N_2O \rightarrow$?			
	Slanger, Black (1976b)			
3,17	$O(^1S) + NH_3 \rightarrow$?	200-368	$3.8 \times 10^{-11} \exp(-420/T)$	
3,22	$O(^1S) + H_2O \rightarrow$?	300	5×10^{-10}	±0.2 a
	Bingham, et al (1975)			
3,46	$O(^1S) + CO_2 \rightarrow$?	300	1.3×10^{-10}	±0.15 a
3,56	$O(^1S) + CH_4 \rightarrow$?	200-450	$3.1 \times 10^{-11}\exp(-1320/T)$	±0.4 a
		300	2×10^{-14}	
	a) Rate constants evaluated for this survey by T. G. Slanger and K. H. Welge (1973).			
4,hν	$O_2 + h\nu \rightarrow O(^3P) + O(^3P)$ Hampson, et al (1973a) review		$\emptyset = 1$ 175 < λ < 200 nm	
4,hν	$O_2 + h\nu \rightarrow O(^3P) + O(^1D)$ Hampson, et al (1973a) review		$\emptyset = 1$ 133 < λ <175 nm	
4,hν	$O_2 + h\nu \rightarrow$ 2 oxygen atoms Hampson, et al (1973a) review		$\emptyset = 1$ 106 < λ <200 nm	
4,hν	$O_2 + h\nu$ Hampson, et al (1973a) review		Recommended values of absorption cross section 135 < λ < 243 nm	
4,8	$O_2 + N \rightarrow NO + O$		see reverse reaction	
4,9,9	$O_2 + NO \rightarrow NO_2 + NO_2$ *Baulch, et al (1973) review Stedman, Niki (1973)	273-660 300	$-d[NO_2]/dt = d[NO_2]/dt = 2k_i[NO]^2[O_2]$ $3.3 \times 10^{-39} \exp(530/T)$ cm⁶molecule⁻²s⁻¹ 2.0×10^{-38} cm⁶molecule⁻²s⁻¹	±0.2 ±0.1
4,9,10	$O_2 + NO \rightarrow NO_2 + NO_3$		see reverse reaction	
4,9	$O_2 + NO \rightarrow NO_2 + O$		see reverse reaction	
4,9M	$O_2 + M \rightarrow NO_3 + M$ Baulch, et al (1973) review		No recommendation	
4,10	$O_2 + NO_2 \rightarrow NO + O_3$		see reverse reaction	
4,11	$O_2 + NO_3 \rightarrow NO_2 + O_3$		see reverse reaction	
4,12	$O_2 + N_2 \rightarrow N_2O + O$		see reverse reaction	
4,18	$O_2 + H \rightarrow HO + O$ *Baulch, et al (1973) review	1200-2000	$1.0 \times 10^{-10} \exp(-55.2 \times 10^3/T)$ (a) $k_f = k_r K_{eq}$	±0.4 (a)
4,18M	$O_2 + H + M \rightarrow HO_2 + M$ (f)		see reverse reaction	
20,M	$HO_2 + M \rightarrow O_2 + H + M$ (r) ++This Survey	203-404	$k_f = 6.7 \times 10^{-33} \exp(290/T)$ cm⁶molecule⁻²s⁻¹ M = Ar or He, k(300) = 1.8 × 10⁻³² Rel. M efficiencies: Ar(1.0), He(1.0), N₂(3.1), O₂(3.1), H₂O(25)	±.07 (a)

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			(a) This evaluation is based on the 300 K data reviewed by Baulch, et al (1972) and the recent studies by Hikida, et al (1971), Kurylo (1972) and Wong and Davis (1974).	
	Baulch, et al. (1972) eval.	300-2000	$k_f = 4.1 \times 10^{-33}$ exp(500/T) M = Ar Rel. M eff.: Ar(1.0), He(1.0), N_2(1.3), O_2(1.3), H_2O(21) $k_r = k_f/Keq = 3.5 \times 10^{-9}$ exp(-23000/T) M = Ar	±.2 ±0.2
	Bishop, Dorfman (1970)	300	$k_f = 2.35 \times 10^{-32}$ M = Ar	
	Hikida, Eyre, Dorfman (1971)	300	1.64×10^{-32} M = Ar	
	Ahumada, Michael, Osborne (1972)	300	0.75×10^{-32} M = He Rel. M efficiencies: He(1.0), Ar(0.8)	
	Allen, Moortgat (1973)	115-300	$1.4(\pm0.14) \times 10^{-33}$ exp(+700(±50)/T), M = Ar Rel. M eff.: at 297K: Ar(1.0), He(0.97), H_2(1.28).	
	Kurylo (1972)	203-404	6.7×10^{-33} exp(235/T) Rel. M eff.: Ar(1.0), He(1.0), N_2(3.4)	
	Wong, Davis (1974)	220-360	6.8×10^{-33} exp(340/T) Rel. M efficiencies: Ar(1.0), He(0.93) N_2(2.8), H_2(3.0), CH_4(21.5)	
	Westenberg, deHaas (1972a)	300	1.9×10^{-32} M = Ar or He	
	Slack (1977)	980-1176	$(9.1\pm1.6) \times 10^{-33}$ M = N_2	(a)
		964-1075	$(6.1\pm1.1) \times 10^{-33}$ M = Ar	(b)
		200-2000	$1.85 \times 10^{-28}T^{-1.42}$ M = N_2	
		200-2200	$5.8 \times 10^{-30}T^{-1}$ M = Ar	(b)
			(a) reanalysis of literature (b) recommendation based on this work and data from literature	
4,21	$O_2 + H_2 \rightarrow H + HO_2$		see reverse reaction	
4,21	$O_2 + H_2 \rightarrow HO + HO$			
	Baulch, et al (1972) review		no recommendation	
4,22	$O_2 + H_2O \rightarrow HO_2 + HO$			
	Baulch, et al (1972) review		no recommendation	
4,23	$O_2 + H_2O_2 \rightarrow HO_2 + HO_2$			
	Baulch, et al (1972) review		no recommendation	
4,24	$O_2 + HNO \rightarrow NO + HO_2$			
	Demerjian, et al (1974) review	300	$< 2.1 \times 10^{-20}$, E/R > 5000K	estimated
4,27	$O_2 + SO \rightarrow SO_2 + O$		see reverse reaction	
4,31	$O_2 + HS \rightarrow SO + HO$			
	Cupitt, Glass (1974)	295	$< 10^{-13}$	
4,35M	$O_2 + Cl + M \rightarrow ClOO + M$ (f)			
37,M	$ClOO + M \rightarrow Cl + O_2 + M$ (r)	200-300	$k_r = 5.8 \times 10^{-9}$ exp(-3580/T) $k_r = k_f/Keq$	(+2, -1) (a)
	†NASA (1977) eval		(a)	

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No.	Reaction/Reference ✦ = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
	†Nicholas, Norrish (1968)	293	$k_f = 1.7 \times 10^{-33}$ cm⁶molecule⁻²s⁻¹	
	Clyne and Coxon (1968)	300	$k_f = < 5.5 \times 10^{-33}$	
	Stedman (1968)	200-300	$k_f = 5.5 \times 10^{-34}$	(b)
			(b) As quoted by Clyne and Coxon (1968).	
4.46a	$O_2 + CN \rightarrow NCO + O$			
	Albers, et al (1975)	275-398	$5.3 \times 10^{-11} \exp(-500\pm170/T)$	
4.47	$O_2 + CHO \rightarrow CO + HO_2$			
	†*Washida, et al (1974)	297	$k/k(O + CHO) = 2.74 \pm0.21 \times 10^{-2}$ yielding k = $5.7 \pm1.2 \times 10^{-12}$	
4.49	$O_2 + CH_3 \rightarrow CH_2O + HO$			
	Demerjian, et al (1974) review	300	1.7×10^{-13}	estimated
	Peeters, Mahnen (1973)	1400-1800	5×10^{-11}	
	Washida, Bayes (1976)	259-341	$2.9 \times 10^{-13} \exp(-940/T)$	
	Basco, et al (1972)	295	3×10^{-16}	estimated (a)
			a. Based on negative result and sensitivity limit. Other measurements at higher T suggest an appreciable activation energy.	
4.49M	$O_2 + CH_3(+M) \rightarrow CH_3O_2(+M)$			
	Laufer, Bass (1975)	298	$\underline{10^{12} \times k} \quad \underline{P(N_2)/torr}$ 0.45 \quad 50 0.7 \quad 100 1.2 \quad 700 1.7	(a)
	Washida, Bayes (1976)	300	5.0×10^{-13}	(b)
			1.9×10^{-31}cm⁶molecule⁻²s⁻¹ \quad M = N_2	(b)
	Hochanadel, et al (1977)	295	2.2×10^{-12}	(c)
	Basco, et al (1972)	295	5.1×10^{-13}	(b)
			2.6×10^{-31} cm⁶molecule⁻²s⁻¹ \quad M = N_2	(c)
	van den Bergh, Callear (1971)	295	1.8×10^{-12} \quad preliminary	(b)
			6×10^{-31} cm⁶molecule⁻²s⁻¹ M = C_3H_8 preliminary	(c)
			(a) Values are based on k(CH₃ + CH₃) = 9.5×10^{-11}, given in Bass, Laufer (1973). (b) 2nd order high pressure limit. (c) 3rd order low pressure limit. see $CH_3O + O_2$	
4.50	$O_2 + CH_3O \rightarrow \cdots$			
5,M	$O_2(^1\Delta) + M \rightarrow O_2 + M$			
	*Hampson, et al (1973) review	285-322	$2.2 \times 10^{-18} (T/300)^{0.8}$ \quad M = O_2	±0.3
	Huestis, et al (1974)	77	1.1×10^{-18} \quad M = O_2	(a)
			(a) Liquid phase. When combined with gas phase data of Findlay and Snelling (1971a) (summarized in Hampson, et al (1973)) k = $2.2 \times 10^{-18} (T/300)^{0.5}$	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
	*Hampson, et al (1973) review	300	$<2 \times 10^{-20}$ M = N_2	
	Collins, et al (1973)	300	1.4×10^{-19}, M = N_2	±0.06
	*Penzhorn, et al (1974)	300	3.9×10^{-20} M = SO_2	
	Penzhorn, et al (1975)	300	2.1×10^{-19} M = H_2S	
			$\underline{k \times 10^{18}}$ $\underline{M}$	
			0.4 CF_2Cl_2	
			$\leq$0.08 CCl_4	
			1.01 CH_3Cl	
			0.87 CH_2Cl_2	
			0.92 $CHCl_3$	
	Breckenridge, Miller (1972)	300	$< 2 \times 10^{-15}$ M = SO_2	(a)
	Fisher, McCarty (1966)	300	$< 3 \times 10^{-16}$ M = CO	(a)
			(a) total rate, quenching and reaction	
5,7	$O_2(^1\Delta) + O_3 \to 2O_2 + O$	195-439	6.6×10^{-13} exp(-1560/T)	±0.24
	Clark, Jones, Wayne (1970)	283-321	4.5×10^{-11} exp(-2830/T)	±0.11
	Findlay, Snelling (1971)	296-360	6.0×10^{-11} exp(-2850/T)	±0.17
	Becker, et al (1972)	300	4.4×10^{-15}	±0.11
	Collins, et al (1973)	283-321	4.5×10^{-11} exp(-2830/T)	±0.11
	Schofield (1972) review			
5,8	$O_2(^1\Delta) + N \to NO + O$	300	$k < k(N + O_2 \to NO + O)$	probably
	Schmidt, Schiff (1973)	195-300	$k << k(N + O_2 \to NO + O)$	
	Westenberg, et al (1970)			
	Clark, Wayne (1970)	195-431	$k = 2 \times 10^{-14}$exp(-600/T)	(a)
			(a) probably refers to physical deactivation,	
			not chemical reaction; see above refs	
5,9	$O_2(^1\Delta) + NO \to O_2 + NO(v > 0)$	300	4.5×10^{-17}	±0.15
	Becker, et al (1971)	300	2.5×10^{-17}	±0.1
	Yaron, et al (1976)	293	$(4.5 \pm 1) \times 10^{-17}$	
	Glachardi, et al (1976)	300	NO(v = 4) observed	
	Ogryzlo, Thrush (1973)			
5,18	$O_2(^1\Delta) + H \to$ products	300	$(2.5 \pm 0.5) \times 10^{-14}$	(a)
	Schmidt, Schiff (1973)		(a) expt could not distinguish between	
			chemical rxn and physical quenching	
5,27	$O_2(^1\Delta) + SO \to O_2 + SO(^1\Delta)$	300	rxn to give HO + O as products not observed	
	Westenberg, et al (1970)			
6,M	$O_2(^1\Sigma) + M \to O_2 + M$	300	$3.5 \pm 0.36 \times 10^{-13}$	
	Breckenridge, Miller (1972)			
	*Hampson, et al (1973) review	300	1.5×10^{-16}, M = O_2	±0.12
			2.0×10^{-15}, M = N_2	±0.1
			4×10^{-12}, M = H_2O	±0.18

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
7,hν	$O_3 + h\nu \rightarrow O(^3P) + O_2(^3\Sigma_g^-)$ *Hampson, et al (1973) review		$\phi = 1$, 450< λ <750 nm - Chappuis bands $\phi = 0$, 250< λ <350 nm	
	Johnston (1973)		$k = 3.39 \times 10^{-4} s^{-1}$ (Daylight) (450< λ <750nm - Chappuis bands)	
7,hν	$O_3 + h\nu \rightarrow O(^3P) + O_2(^1\Delta \text{ or } ^1\Sigma)$ *This survey		$\phi = 0$, λ <303nm Total quantum yield $(O^3P + O^1D)$ equals unity for 307< λ <350nm	
7,hν	$O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta)$ †*Lin, DeMore (1973)			(a)

λ/nm	$\phi\,\sigma(^1D)$	λ/nm	$\phi\,\sigma(^1D)$
<303	1.00	310	0.25
304	0.99	311	0.15
305	0.95	312	0.10
306	0.90	313	0.07
307	0.80	314	0.04
308	0.55	315	0.02
309	0.35	≥316	0

(a) As tabulated in review by Molina (1977)
Relative values norm. to $\phi = 1$ for λ <300nm

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability of log k
7,hν	Hampson, et al (1973) review $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Sigma_g^+)$ *Hampson, et al (1973) review		See for discussion of earlier work $\phi = 0$, 250< λ <350 nm	
7,M 7,8	$O_3 + M \rightarrow O + O_2 + M$ $O_3 + N \rightarrow NO + O_2$		see reverse reaction	
	†*NASA (1977) eval	200-300	$2 \times 10^{-11} exp(-1070/T)$ (a) Accepts room temp. rec. of Baulch	±0.3 at 230K
	Baulch, et al (1973) review	300	5.7×10^{-13} "A factor" chosen; Eact derived	±0.2
7,9 4,10	$O_3 + NO \rightarrow NO_2 + O_2$ (f) $O_2 + NO_2 \rightarrow NO + O_3$ (r)			
	†*NASA (1977) eval	200-300	$k_f = 2.1 \times 10^{-12} exp(-1450/T)$ (a) based on results in Birks et al (1976). Lower "A factor" derived from reconsideration of primary data	±0.15 (a)
	Birks, et al (1976)	203-361	$k_f = 2.34\pm0.23 \times 10^{-12} exp(-1450\pm50/T)$	
	Hampson, et al (1973) review	198-330	$k_f = 9 \times 10^{-13} exp(-1200/T)$ $cm^3 molecule^{-1}s^{-1}$	±0.11
	Stedman, Niki (1973)	298	$k_f = 1.73 \pm0.1 \times 10^{-14}$	±0.2
	Baulch, et al (1973) review	200-350	$k_f = 1.5 \times 10^{-12} exp(-1330/T)$ $k_r = k_f/K_{eq} = 2.8 \times 10^{-12} exp(-25400/T)$	±0.2 ±0.2
	Ghormley, et al (1973)	298	$k_f = 1.41 \times 10^{-14}$	
	Bemand, et al (1974)	300	$k_f = 1.81 \pm0.13 \times 10^{-14}$	
	Becker, Schurath, Seitz (1974)	290	$k_f = 1.70 \times 10^{-14}$	
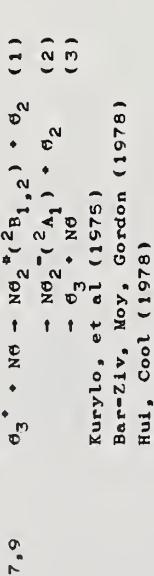
No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³ molecule⁻¹ s⁻¹	Notes and Reliability of log k
7,9	$O_3^* + NO \rightarrow NO_2^*(^2B_{1,2}) + O_2$ (1) $\rightarrow NO_2^*(^2A_1) + O_2$ (2) $\rightarrow O_3 + NO$ (3)			
	Kurylo, et al (1975)	153-373	see discussion	
	Bar-Ziv, Moy, Gordon (1978)	158-437	see discussion	
	Hui, Cool (1978)	138-410	$k_1 = 1.0 \times 10^{-12} \exp(-1450/T)$ $k_2 = 3.8 \times 10^{-13} \exp(-520/T)$ $k_3 = 1.1 \times 10^{-13}$ at 333 K and at 143 K with minimum value of 0.62×10^{-13} at approx. 230K	

Discussion

Measured quantity in all studies is ($k_1 + k_2 + k_3$). Values of this quantity measured by Kurylo et al and by Hui, Cool are in good agreement; values reported by Bar-Ziv, Moy and Gordon are systematically higher below 300K.

Hui and Cool derived values as a function of temperature for k_1, k_2, and k_3 given above from an analysis of the temperature dependent data for ($k_1 + k_2 + k_3$) reported by the three groups, the temperature dependence of the enhancement factor for rxn channel (1) reported by Moy, Bar-Ziv and Gordon (1977), their own temperature dependent data for the ratio of the enhancement factors for rxn channels (1) and (2) and the rate constant for channels (1) and (2) for thermal ozone reported by Clough and Thrush (1967)

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability of log k
7,10 4,11	$O_3 + NO_2 \rightarrow NO_3 + O_2$ (f) $O_2 + NO_3 \rightarrow O_3 + NO_2$ (r)			
	+*NASA (1977) eval	220-340	$k_f = 1.2 \times 10^{-13} \exp(-2450/T)$	±0.1 (a)
	Davis, Prusazcyk, Dwyer, Kim (1974)	260-343	$k_f = 9.76 ± 0.54 \times 10^{-14} \exp(-2427 ± 140/T)$	
	Graham, Johnston (1974)	231-298	$k_f = 1.34 ± 0.11 \times 10^{-13} \exp(-2466 ± 30/T)$	
	Hui, Herron (1974a)	259-362	$k_f = 1.57 ± 0.41 \times 10^{-13} \exp(-2509 ± 76/T)$	
	Baulch, et al (1973) review	286-302	$k_f = 9.8 \times 10^{-12} \exp(-3500/T)$	±0.7 (b)
		300	$k_r = 7 \times 10^{-34}$ based on k_f	±0.3
	Wu, Morris, Niki (1973)	299	$k_f = 4.4 \times 10^{-17}$	±0.06 (c)
	Ghormley, et al (1973)	298	$k_f = 3.2 \times 10^{-17}$	±0.07
	Stedman, Niki (1973)	298	$k_f = 6.5 ±0.8 \times 10^{-17}$	
	Becker, Schurath, Seitz (1974)	289	$k_f = 3.24 \times 10^{-17}$	

(a) Derived by combining results from the three 1974 temperature dependent studies

(b) Based on Johnston, Yost (1949)

(c) Revision, based on later experiments, of value reported by Stedman and Niki (1973)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm^3 molecule^{-1} s^{-1}	Notes and Reliability of log k
7,18	$O_3 + H \rightarrow HO + O_2$			
	*Clyne, Monkhouse (1977)	298-638	$1.0 \pm 0.2 \times 10^{-10} \exp(-516 \pm 50/T)$	± 0.2 (a)
			(a) NASA (1977) evaluation selected preliminary value reported by these authors, $k = 1.2 \times 10^{-10} \exp(-560/T)$ with $\Delta \log k$ increased to ± 0.3 at 230K.	
	Lee, et al (1978)	219-360	$1.3 \pm 0.3 \times 10^{-10} \exp(-449 \pm 58/T)$	
	Phillips, Schiff (1962)	300	$2.6 \pm 0.5 \times 10^{-11}$	(b)
			(b) Quoted by Hampson, et al (1973) review and Baulch, et al (1976) review	
7,19	$O_3 + HO \rightarrow HO_2 + O_2$			
	+*NASA (1977) eval	200-300	$1.5 \times 10^{-12} \exp(-1000/T)$	± 0.3 (a)
			(a) Adjusted from recommendation in Hampson et al (1973) review because of error in derivation of O_3 conc. from absorption meas.	
	Hampson, et al (1973) review	220-450	$1.6 \times 10^{-12} \exp(-1000/T)$	± 0.3
	Anderson, Kaufman (1973)	220-450	$1.3 \times 10^{-12} \exp(-956/T)$	± 0.7
	Baulch, et al (1976) review	300	6.5×10^{-14}	
	DeMore (1973)	300	8×10^{-14}	
	DeMore (1975)	271-333	$k/k(OH + CO) = 16.8 \exp(-1230/T)$ at 700 torr CO_2	
	Davis (1976)	300	$7.5 \pm 0.3 \times 10^{-14}$	
	Kurylo (1973)	298	6.5×10^{-14}	± 0.06
7,19	$O_3 + HO(v_1 > 0) \rightarrow$ products			
	Coltharp, Worley, Potter (1971)	300		
	Streit, Johnston (1976)			

$v_1(HO)$	$10^{12} \times k(300\ K)$ CWP	SJ
2	1.9 ± 1.1	
3	2.4 ± 0.9	
4	2.8 ± 0.8	3.7 ± 0.1
5	3.4 ± 0.7	4.5 ± 0.1
6	5.3 ± 0.6	7.1 ± 0.2
7	6.5 ± 0.5	8.5 ± 0.2
8	6.7 ± 0.5	8.9 ± 0.2
9	7.7 ± 0.3	11 ± 0.4

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability
7,20	$O_3 + HO_2 \rightarrow HO + 2O_2$			
	+*NASA (1977) eval.	200-300	$7.3 \times 10^{-14} \exp(1275/T)$	± 0.7
	Simonaitis, Heicklen (1973b)	225-298	$k/(k_{ref})^{0.5} = 1.9 \times 10^{-8} \exp(-1000/T)$	(a)
	DeMore, Tschuikow-Roux (1974)	273-332	$k/(k_{ref})^{0.5} = 1.1 \times 10^{-7} \exp(-1550 \pm 250/T)$	(a)
	Lloyd (1974) review	200-500	$1.7 \times 10^{-13} \exp(-1400/T)$	$> \pm 0.3$
	Baulch, et al (1976) review	300	1.5×10^{-15}	± 0.2
			(a) $k_{ref} = k(HO_2 + HO_2 \rightarrow H_2O_2 + O_2)$ Preferred value averages temp. dependence of these studies and is based on k_{ref} value given in this table.	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
7.27	$O_3 + SO \rightarrow O_2 + SO_2$			
	Schofield (1973) review	223-303	$2.5 \times 10^{-12} \exp(-1050/T)$	±0.5
	Baulch et al (1976) review		no recommendation	
7.28	$O_3 + SO_2 \rightarrow SO_3 + O_2$			
	Daubendiek, Calvert (1974)	300	$k < 8 \times 10^{-24}$	
	Davis, Prusazcyk, Dwyer, Kim (1974)	300	$k < 2 \times 10^{-22}$	
7.32	$O_3 + H_2S \rightarrow$ products			
7.35	$O_3 + Cl \rightarrow ClO + O_2$			
	Glavas, Toby (1975)	298-343	$7 \times 10^{-14} \exp(-3400/T)$	±0.4
	Becker, Inocencio, Schurath (1975)	300	$< 2 \times 10^{-20}$	
	+*Watson (1977) review	205-298	$2.7 \times 10^{-11} \exp(-257/T)$	±0.12 at 230K
	Clyne, Nip (1976)	221-629	$5.18 \times 10^{-11} \exp(-418/T)$	
	Kurylo, Braun (1976)	213-298	$2.72 \times 10^{-11} \exp(-298/T)$	
	Watson, et al (1976)	220-350	$3.08 \times 10^{-11} \exp(-290/T)$	
	Zahniser, et al (1976)	210-360	$2.17 \times 10^{-11} \exp(-171/T)$	
7.35Br	$O_3 + Br \rightarrow BrO + O_2$			
7.36	+*Leu, DeMore (1977)	224-422	$3.34 \times 10^{-11} \exp(-978/T)$	±0.2 at 230K
	$O_3 + ClO \rightarrow OClO + O_2$ (a) $\rightarrow ClOO + O_2$ (b)	200-300	$k_a = 1 \times 10^{-12} \exp(-4000/T)$ $k_b = 1 \times 10^{-12} \exp(-4000/T)$	+0.6, -2.0 at 230K (a)
	+NASA (1977) eval			
	Watson (1977) review	300	$< 5 \times 10^{-15}$	
			(a) Based on unpublishd 300K results of Lin and DeMore. Branching ratio unknown - assumed equal to unity.	
7.36Br	$O_3 + BrO \rightarrow$ products			
7.45	+*Clyne, Cruse (1970)	293	$k < 1 \times 10^{-14}$	upper limit only
	$O_3 + CO \rightarrow CO_2 + O_2$			
7.48	Arin, Warneck (1972)	296	$< 4 \times 10^{-25}$	
	$O_3 + CH_2O \rightarrow$ products			
7.49	Braslavsky, Heicklen (1976)	300	$\leq 2 \times 10^{-24}$	±0.3 upper limit
	$O_3 + CH_3 \rightarrow CH_3O + O_2$ (a) $\rightarrow CH_2O + HO_2$ (b)			
7.51	Simonaitis, Heicklen (1975)	221-298	$(k_a + k_b)/k_{ref} = 12 \exp(-525/T)$ k_{ref} is 2nd order high pressure limit for $CH_3 + O_2(+ M) \rightarrow CH_3O_2(+ M)$	(a)
	$O_3 + CH_3O_2 \rightarrow$ products			
7.54	Simonaitis, Heicklen (1975)	300	$< 2.4 \times 10^{-17}$	
	$O_3 + CH_3CN \rightarrow$			
7.56	Hastie, et al (1976)	298-325	$6.8 \times 10^{-13} \exp(-5315/T)$	
	$O_3 + CH_4 \rightarrow$ products			
	Dillemuth, et al (1960)	310-340	$2.7 \times 10^{-13} \exp(-7700/T)$	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
7,57	$O_3 + C_2H_4 \rightarrow$ products			
	*Herron, Huie (1974)	235-362	$9.0 \times 10^{-15} \exp(-2560/T)$	±0.1
	Demerjian, et al (1974) review	300	2.7×10^{-18}	
	DeMore (1969)	178-233	$3.2 \times 10^{-15} \exp(-2400/T)$	
	Stedman, et al (1973)	300	$1.55 \pm 0.15 \times 10^{-18}$	
	Davis (1974)	300	$1.6 \pm 0.2 \times 10^{-18}$	
	Becker, Schurath, Seitz (1974)	280-360	$1.2 \times 10^{-14} \exp(-2490 \pm 100/T)$	
	Japar, Wu, Niki (1974)	298	$1.9 \pm 0.1 \times 10^{-18}$	
	Toby, et al (1976)	303	$1.7 \pm 0.1 \times 10^{-18}$	
7,59	$O_3 + C_3H_6 \rightarrow$ products			
	*Herron, Huie (1974)	235-362	$6.1 \times 10^{-15} \exp(-1900/T)$	±0.1
	Demerjian et al (1974) review	300	1.0×10^{-17}	
	DeMore (1969)	183, 193, 300	$1.6 \times 10^{-15} \exp(-1600/T)$	(a)
	Stedman, et al (1973)	300	$1.25 \pm 0.1 \times 10^{-17}$	
	Becker, Schurath, Seitz (1974)	280-360	$1.1 \times 10^{-14} \exp(-1970 \pm 100/T)$	
	Japar, Wu, Niki (1974)	298	1.30×10^{-17}	

(a) Includes 300 K point of Hanst et al (1958).

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability
7,59	$O_3 + allene \rightarrow$ products			
	Toby, Toby (1975)	273-343	$1.6 \times 10^{-15} \exp(-2750/T)$	±0.7 (a)

(a) Mechanism reconsidered. Data in Toby and Toby (1974a)

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability
7,59	$O_3 + 1\text{-}butene \rightarrow$ products			
	Huie, Herron (1975)	225-363	$2.9 \pm 0.2 \times 10^{-15} \exp(-1686 \pm 20/T)$	
	Japar, Wu, Niki (1974)	298	1.23×10^{-17}	
7,59	$O_3 + cis\text{-}2\text{-}butene \rightarrow$ products			
	Huie, Herron (1975)	225-363	$3.1 \pm 0.7 \times 10^{-15} \exp(-956 \pm 54/T)$	
	Japar, Wu, Niki (1974)	298	1.61×10^{-16}	
7,59	$O_3 + trans\text{-}2\text{-}butene \rightarrow$ products			
	Huie, Herron (1975)	225-363	$6.0 \pm 1.0 \times 10^{-15} \exp(-1051 \pm 43/T)$	
	Japar, Wu, Niki (1974)	298	2.60×10^{-16}	
7,59	$O_3 + 1,3\text{-}butadiene \rightarrow$ products			
	Toby, Toby (1975)	273-343	$1 \times 10^{-13} \exp(-2900/T)$	±0.5
	Becker, Schurath, Seitz (1974)	280-360	$5.4 \times 10^{-14} \exp(-2680/T)$	
7,64	$O_3 + cis\text{-}C_2Cl_2H_2 \rightarrow$ products			
	Blume et al (1976)	296	3.7×10^{-20}	
7,64	$O_3 + trans\text{-}C_2Cl_2H_2 \rightarrow$ products			
	Blume et al (1976)	296	2.5×10^{-19}	
8,8M	$N + N + M \rightarrow N_2 + M$			
	*Baulch, et al (1973) review	100-600	$8.3 \times 10^{-34}\exp(+500/T)cm^6 molecule^{-2}s^{-1}$ $M = N_2$	±0.2(200-600K) <0.2 (T<200K)
			where $-d[N]/dt = 2k[N]^2[M]$ $\quad M = N_2$	
	Taylor (1975) review	2000-10000	$7.6 \times 10^{-32} T^{-1/2}$ $\quad M = N_2$	

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
8,9 1,12	N + NO → N₂ + O (f) O + N₂ → N + NO (r)		$3.0 \times 10^{-32}\ T^{-1/2}$ M = O_2, O, NO $6.5 \times 10^{-27}\ T^{-3/2}$ M = N	
	†*Clyne, McDermid (1975) Baulch, et al (1973) review	298-670 300-5000 2000-5000	$k_f = 8.2 \times 10^{-11} \exp(-410/T)$ $k_f = 2.7 \times 10^{-11}$ $k_r = 1.3 \times 10^{-10}\ \exp(-38000/T)$ (a) Uncertainty increases to ±0.3 for T> 2000. k_f based on 300 K data and k_r(T> 7000).	±0.2 at 230K ±0.1 (a) ±0.7
	Taylor (1975) review N + NO₂ → N₂O + O	2000-10000	$k_f = 2.7 \times 10^{-11}$	
8,10	†*NASA (1977) eval. Clyne, McDermid (1975)	200-300 298	$2 \times 10^{-11} \exp(-800/T)$ 1.4×10^{-12} (a) Accepts room temp. result of Clyne + McDermid "A factor" chosen; E_{act} derived (b) Believed to be sole reaction channel	±0.3 at 230K (a,b)
8,19	N + HO → NO + H *Baulch, et al (1973) review	300	5.3×10^{-11} (a) Based on k/k(O + HO → O₂ + H) = 1.4	±0.3 (a)
8,27	N + SO → products Baulch, et al (1976) review		no recommendation	
8,29	N + SO₃ → products Baulch, et al (1976) review		no recommendation	
8,37	N + OClO → NO + ClO Watson (1977) review	298	$k < 6 \times 10^{-13}$	preliminary value
9,hν	NO + hν Hampson, et al (1973a) review		Recommended values of oscillator strengths from which absorption cross sections can be derived are given for β, γ, and ε bands. Recommended values of absorption cross section 106 < λ < 135 nm. No recommended quantum yield values. Oscillator strength for 6 bands, confirmed by Mandelman and Carrington (1974)	
	*Bethke (1959)		Insufficient data for a reliable recommendation. Use, with caution:	
9,M	NO + M → N + O + M Baulch, et al (1973) review	4200-6700	$6.6 \times 10^{-4}\ T^{-1.5}\ \exp(-75.5 \times 10^3/T)$ cm³ molecule⁻¹s⁻¹ (M = Ar, O_2, N_2) k(M = NO, N, O)/k(Ar) ~ ±8	
9,9	NO + NO → N + NO₂ Baulch, et al (1973) review		Endothermic. Unimportant compared to NO + NO → N₂O + O	
9,9	NO + NO → N₂O + O		see reverse reaction	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
9.9,4	$NO + NO + O_2 \rightarrow NO_2 + NO_2$		see $O_2 + N_4 + NO \rightarrow NO_2 + NO_2$	
9.10,22	$NO + NO_2 + H_2O \rightarrow 2HNO_2$ (f) $2HNO_2 \rightarrow NO + NO_2 + H_2O$ (r)			
	*Chan, et al (1976)	296	$k_f = 6.0 \times 10^{-38}$ cm⁶molecule⁻²s⁻¹ $k_r = 9.5 \times 10^{-19}$ cm³molecule⁻¹s⁻¹	
9.11	$NO + NO_3 \rightarrow 2NO_2$			
	Hampson, et al (1973) review	300	Reviewed earlier work, probably heterogeneous	
	Graham, Johnston (1978)	300	$(1.9 \pm 0.4) \times 10^{-11}$	
	Baulch, et al (1973) review	300	$\sim 2 \times 10^{-11}$	±0.7 estimated
	Johnston (1966) review	300	8.3×10^{-12}	
			Temperature effect is probably zero or very small.	
9.15	$NO + NH \rightarrow$ products			
	Hansen, et al (1976)	300	4.7×10^{-11}	±0.1
	Gordon, et al (1971)	300	3.8×10^{-11}	
	Mulvihill, Phillips (1975)	1500	$N_2 + O + H$ identified as products of major rxn channel	
9.16	$NO + NH_2 \rightarrow N_2 + H_2O$*			
	*Hancock, et al (1975)	298	2.1×10^{-11}	
	Lesclaux, et al (1975)	300	1.8×10^{-11}	(e)
			(a) $T^{-1.25}$ dependence observed 300-500K	
	Gehring, et al (1973)	300	8×10^{-12}	±0.1
	Gordon, et al (1971)	300	2.7×10^{-11}	
9.18M	$NO + H + M \rightarrow HNO + M$			
	*This survey	220-400	2.1×10^{-32} exp(300/T)	±0.2
	Baulch, et al (1973) review	230-700	1.5×10^{-32} exp(300/T) cm⁶molecule⁻²s⁻¹ M = H_2	±0.2
	Atkinson, Cvetanovic (1973)	286-390	2.5×10^{-32} exp(270/T) M = H_2	
	Allen, Moortgat (1973)	180-300	$5.6(\pm0.6) \times 10^{-33}$ exp(+375(±65)/T), M = Ar	
	Thrush (1973) review	230-700	2×10^{-32} exp(+300/T), M = H_2	
9.19	$NO + HO \rightarrow NO_2 + H$			
	Baulch, et al (1973) review	298-633	5.2×10^{-12} exp(-15.1 x 10³/T) based on k = 5.8×10^{-10} exp(-740/T) for reverse reaction (a) corrected expression	±0.2 (298K) (a) increasing to ±0.3(633K)
9.19M	$NO + HO(+M) \rightarrow HNO_2(+M)$			
	Hampson, et al (1973a) review			

Elevation/km	Temp.	k(T,M)	
15	217	2.4×10^{-12}	Abs. value of log k ± 0.5
20	217	1.5×10^{-12}	Relative value of k
25	222	8.9×10^{-13}	at different altitudes
30	227	4.8×10^{-13}	reliable to ± 30%
35	237	2.6×10^{-13}	M = N_2
40	251	1.1×10^{-13}	
45	265	5.9×10^{-14}	

Baulch, et al (1973) review	273-395	2.2×10^{-32} exp(+1110/T) cm⁶molecule⁻²s⁻¹ M=He (3rd order low pressure limit)	±0.2 at 300K inc. to ±0.3 at 395K

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm^{3}molecule^{-1}s^{-1}	Notes and Reliability of log k
	Anderson, et al (1974)	300	2×10^{-12} cm^{3}molecule^{-1}s^{-1} (2d order high pressure limit)	±0.?
		295,439	$5.8 \pm 1.2 \times 10^{-31} \times (295/T)^{+2.4}$ cm^{6}molecule^{-2}s^{-1} M = N$_2$ (3rd order low pressure limit) Relative efficiencies: N$_2$(1.0), Ar(0.58), He(0.57)	
	Howard, Evenson (1974)	296	$7.8 \pm 1.2 \times 10^{-31}$ cm^{6}molecule^{-2}s^{-1} M = N$_2$ (3rd order low pressure limit) Relative efficiencies: N$_2$(1.0), Ar(0.55), He(0.51)	
	Cox (1974a)	294	$k/k(HO + CO) = 40 \pm 7$ $k = 1.2 \times 10^{-11}$ cm^{3}molecule^{-1}s^{-1} (a) 2nd order rate constant, [M] = 1 atm N$_2$ + O$_2$; $k_{ref} = 3 \times 10^{-13}$, this survey	(a)
	Harris, Wayne (1975)	300	$7 \pm 2 \times 10^{-31}$ cm^{6}molecule^{-2}s^{-1}, M = Ar $15 \pm 5 \times 10^{-31}$, M = N$_2$ (3rd order low pressure limits)	
	Gordon, Mulac (1975)	435	$7.5 \pm 0.3 \times 10^{-12}$ cm^{3}molecule^{-1}s^{-1} (2nd order rate constant at 1 atm. H$_2$O vapor)	
	Atkinson, Hansen, Pitts (1975a)	298	$4.94 \pm 0.5 \times 10^{-13}$ M = 25 Torr N$_2$ (b) also data for M = Ar at 25-655 torr	(b)
	Cox, Derwent, Holt (1976)	298	1.17×10^{-11} M = 1 atm N$_2$ + O$_2$ (c) relative to k(HO + H$_2$) = 7×10^{-15}	(c)
	Øverend, et al (1976)	295	$0.956 \pm 0.05 \times 10^{-12}$ M = 25 torr N$_2$	
	Sie, et al (1976b)	298	$6.89 \pm 0.68 \times 10^{-12}$ M = 770 torr N$_2$ $k/k_{ref} = 16.1$ at 95 torr and = 22 at 408 and 768 torr total pressure, mostly H$_2$ where ref rxn is HO + CO → CO$_2$ + H	
9.20	NO + HO$_2$ → NO$_2$ + HO			
	**Howard, Evenson (1977)	296	$(8.1 \pm 1.5) \times 10^{-12}$	±0.4 at 230K
	Hack, et al (1975)	298-670	2.0×10^{-11} exp(-1200/T)	
	Simonaitis, Heicklen (1978)	245-328	$k/(k_{ref})^{0.5} = 6.4 \times 10^{-6}$ exp(-700/T) (a) ref rxn: 2HO$_2$ → H$_2$O$_2$ + O$_2$	(a)
	Cox, Derwent (1975)	296	1.2×10^{-12}	
	Payne, Stief, Davis (1973)	300	3×10^{-13}	±0.5
	Glanzer, Troe (1975)	1350-1700	7.5×10^{-12}	±0.5
9.20M	NO + HO$_2$(+M) → HNO$_3$(+M)			
	Cox, Derwent (1975)	296	1.4×10^{-13} at 1 atm N$_2$ + O$_2$	
	Simonaitis, Heicklen (1976a)	296	$< 2 \times 10^{-15}$	
9.21	NO + H$_2$ → HNO + H			
	Baulch, et al (1973) review	2000	5.3×10^{-18} cm^{3}molecule^{-1}s^{-1} (a) No data. Value based on reverse rate	±0.? (a)

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
9.22	$NO + H_2O \rightarrow HNO + HO$ Baulch, et al (1973) review	2000	4×10^{-18} (a) No data. Value based on reverse rate. (corrected)	
9.23	$NO + H_2O_2 \rightarrow HO + HNO_2$ *Hampson, et al (1973) review Gray, et al (1972)	300 500 300	$< 5 \times 10^{-20}$ $\sim 2 \times 10^{-20}$ $< 5 \times 10^{-20}$	± 0.2 (a)
9.35M	$NO + Cl + M \rightarrow ClNO + M$ †*NASA (1977) eval	200-300	$1.7 \times 10^{-32} exp(+530/T)$ $M = N_2$ (a) see Watson (1977) review	± 0.6 at 230K (a)
9.36	$NO + ClO \rightarrow NO_2 + Cl$ †*NASA (1977) eval Watson (1977) review Zahniser, Kaufman (1977)	200-300 220-298 230-298	$1.0 \times 10^{-11} exp(200 \pm 100/T)$ $8 \times 10^{-12} exp(250/T)$ $k/k_{ref} = (0.52 \pm 0.05) exp(373 \pm 23/T)$ (a) $k_{ref} = k(Cl + O_3)$	± 0.3 at 230K ± 0.1 (a)
9.36Br	$NO + BrO \rightarrow NO_2 + Br$ †*NASA (1977) eval Clyne, Watson (1975)	200-300 298	2.1×10^{-11} 2.2×10^{-11}	± 0.4 at 230K ± 0.1
9.37	$NO + OClO \rightarrow NO_2 + ClO$ †*NASA (1977) eval Bemand, Clyne, Watson (1973)	200-300 300	$2.5 \times 10^{-12} exp(-600/T)$ 3.4×10^{-13} (a) Based on room temp. value of Bemand, Clyne, Watson; temp dependence estimated	± 0.6 at 230K (a)
9.49M	$NO + CH_3 (+M) \rightarrow CH_3NO (+M)$ Laufer, Bass (1975) Basco, et al (1970) van den Bergh, Callear (1971)	298 258 295	$10^{11} \underline{\times k}$ $\underline{P(N_2)/torr}$ .3 50 .45 100 1.1 700 4×10^{-12} 1.7×10^{-11} (a) Values are based on $k(CH_3 + CH_3) =$ 9.5×10^{-11} given in Bass, Laufer (1973). (b) 2nd order high pressure limit.	(a) (b) (b)
9.50	$NO + CH_3O \rightarrow \ldots$ see $CH_3O + NO \rightarrow \ldots$			
9.51	$NO + CH_3O_2 \rightarrow CH_3O_2NO$ (a) $\rightarrow CH_2O + HONO$ (b) $\rightarrow CH_3O + NO_2$ (c) †Demerjian, et al (1974) review Cox, et al (1976) Pate, Finlayson, Pitts (1974) Simonaitis, Heicklen (1974)	 300 298 296 298	$k_c = 3.3 \times 10^{-12} exp(-500/T)$ $k_c \geq 1.2 \times 10^{-12}$ (a) based on value of $k(CH_3O_2 + CH_3O_2)$ Reaction proceeds exclusively through channel (c) $k_c/k = 0.80 \pm 0.15$ $(k = k_a + k_b + k_c)$	estimate lower limit (a)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
10,hν	$NO_2 + h\nu \rightarrow NO + O$ *Bayes (1974)			

λ/nm	$\phi(O(^3P))$	
295-398	$1.0 - 0.0008(\lambda - 275)$	(a)
398	0.90 ± 0.05	
400	0.76 ± 0.04	
405	0.37 ± 0.02	
410	0.14 ± 0.01	

(a) Based on analysis of data in Jones and Bayes (1973)

*Bass, Ledford, Laufer (1976)   235-298   Extinction coefficient values tabulated for $\lambda = 185$-410nm at 0.125nm intervals. Also gives values for N_2O_4 see reverse reaction
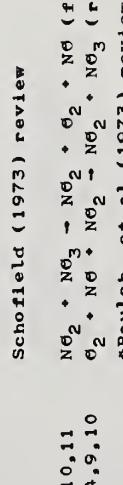
No recommendation
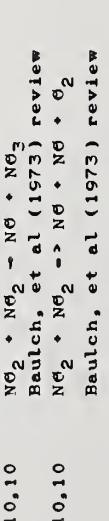
No.	Reaction	Temp. Range/K	Rate Constant	Notes
10,M	$NO_2 + M \rightarrow NO + O + M$			
10,10	$NO_2 + NO_2 \rightarrow NO + NO_3$ Baulch, et al (1973) review			
10,10	$NO_2 + NO_2 \rightarrow NO + NO + O_2$ Baulch, et al (1973) review	600-2000	$3.3 \times 10^{-12} \exp(-13540/T)$ $k_1[NO_2]^2 = -(1/2)d[NO_2]/dt$	±0.15 (600-1000K) increasing to 0.3 at 2000K
10,10M	$NO_2 + NO_2 + M \rightarrow N_2O_4 + M$ (f) $N_2O_4 + M \rightarrow NO_2 + NO_2 + M$ (r) Baulch, et al (1973) review	250-350	$k_f = 3.0 \times 10^{-35}\exp(1040/T)cm^6molecule^{-2}s^{-1}$ (a) corrected expression; $k_f = k_r k_{eq}$	$M = N_2 \pm0.15$(a)
	Baulch, et al (1973) review	250-350	$k_r = 4.2 \times 10^{-7} \exp(-5550/T)$	$M = N_2 \pm0.15$
	Schofield (1973) review	250-350	$k_r = 3.3 \times 10^{-7} \exp(-5540/T)$	$M = N_2 \pm0.15$
10,11 4,9,10	$NO_2 + NO_3 \rightarrow NO_2 + O_2 + NO$ (f) $O_2 + NO + NO_2 \rightarrow NO_2 + NO_3$ (r) *Baulch, et al (1973) review	300-850 300-500	$k_f = 2.3 \times 10^{-13} \exp(-1000/T)$ $k_r = k_f/K_{eq} = 8 \times 10^{-41}\exp(400/T)cm^6molecule^{-2}s^{-1}$	±0.4 (a) ±0.4
	Graham, Johnston (1978)	338-396	$k_f = 2.5 \times 10^{-14}\exp(1230/T)$ (a) Based on $N_2O_5 + M \rightarrow NO_2 + NO_3 + M$ and $2NO_2 \rightarrow 2NO + O_2$	
10,11M	$NO_2 + NO_3 (+M) \rightarrow N_2O_5 (+M)$ This survey			

Elevation/km	Temp./K	$k(T,M)$ $cm^3molecule^{-1}s^{-1}$	Log (M)
15	217	1.9×10^{-12}	18.60
20	217	1.1×10^{-12}	18.27
25	222	5.6×10^{-13}	17.93
30	237	4.5×10^{-13}	17.58
35	251	2.7×10^{-13}	17.26
40	251	1.5×10^{-13}	16.92
45	265	7.1×10^{-14}	16.60

10,11M	$NO_2 + NO_3 + M \rightarrow N_2O_5 + M$ (f)
14,M	$N_2O_5 + M \rightarrow NO_2 + NO_3 + M$ (r)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
		300	$k_f = 3.8 \times 10^{-12}$ cm³molecule⁻¹s⁻¹ (2d order high pressure limit)	±0.4 (a)
		300-340	$k_r = 2.2 \times 10^{-5}$ exp(-9700/T) cm³molecule⁻¹s⁻¹	±0.3 (a)
		273-300	$k_r = 5.7 \times 10^{14}$ exp(-10600/T) s⁻¹ (limiting first order expression)	±0.4 (a)
	Graham, Johnston (1978)	298-329	$K_{eq} = 1.2 \times 10^{-27}$ exp(+11180/T)cm³molecule⁻¹	
		273-300	$k_f(M) = 1.48 \times 10^{-13}$ exp(+861/T)cm³molecule⁻¹s⁻¹	(b)
			$k_r(M) = 1.24 \times 10^{14}$ exp(-10317/T)s⁻¹	(c)
			(a) $k_f = K_{eq} k_r$. M = N_2^{65} + N0	
			(b) 2d order rate const at 1 atm	
			(c) 1st order rate const at 1 atm	
10,16	$NO_2 + NH_2 \rightarrow$ products Jayanty, et al (1975d)			
10,17	$NO_2 + NH_3 \rightarrow NH_2 + HNO_2$ Bedford, Thomas (1972)	300	$k > k(NO + NH_2)$	
10,18	$NO_2 + H \rightarrow HO + NO$	615-660	6.7×10^{-12} exp(-13900/T)	
	Wagner, et al (1976a)	243-461	7.1×10^{-10} exp(-505 ± 84/T)	±0.1
	Clyne, Monkhouse (1977)	298-653	4.80×10^{-10} exp(-400 ± 70/T)	±0.1
	Bemend, Clyne (1977)	298	$1.13 \pm 0.22 \times 10^{-10}$	
10,19M 26,M	$NO_2 + HO + M \rightarrow HNO_3 + M$ (f) $HNO_3 + M \rightarrow HO + NO_2 + M$ (r) +*NASA (1977) eval	200-350	$\log_{10}(k_f) = -AT/(B + T) - 0.5 \log_{10}(T/280)$	
			$A = A_1 + A_2Z + A_3Z^2 + A_4Z^3$	
			$B = B_1 + B_2Z + B_3Z^2$	
			$A_1 = 31.62273$ $B_1 = -327.372$	
			$A_2 = -0.258304$ $B_2 = 44.5586$	
			$A_3 = -0.0889287$ $B_3 = -1.38092$	
			$A_4 = -2.520173 \times 10^{-3}$	
			where $Z = \log_{10}[N_2]$ and is applicable only for the ranges $200 < T/K < 350$ and $16.3 < \log_{10}([N_2]/\text{molecule}.cm^{-3}) < 19.5$, with an estimated reliability in log k of ±0.10 (reliability analogous to 1σ). Air is approximately 6 percent less efficient than nitrogen as a third body; i.e., k for (M = Air) - 0.94 k for M = N_2 For normal tropospheric conditions of 1 atm air and T = 300K, above expression yields value of $k_f = 1.1 \times 10^{-11}$	
	Anastasi, Smith (1976)	296	$k_f = 2.6 \times 10^{-30}$ M = N_2 Rel. Efficiencies: $N_2(1.0)$, He(0.34), Ar(0.42), $O_2(0.68)$, $SF_6(2.5)$	
		220-550	$n = -2.5$ for temp dependence of form T^n, M = N_2 values given for bimolecular rate constant over	

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No.	Reaction/Reference * Preferred Value † NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Baulch, et al (1973) review	273-400	ranges T = 220-550K and $[N_2]$ = 3 x 10^{17} to 1.6 x 10^{19} molecule cm^{-3} k_f = 3.6 x 10^{-32} exp(+1100/T)$cm^6 molecule^{-2}s^{-1}$ M = He	±0.2
		800-1200	k_r = 2.7 x 10^{-9} exp(-15400/T)$cm^3 molecule^{-1}s^{-1}$ M = Ar	±0.4
		300	k_f = 8 x 10^{-12} $cm^3 molecule^{-1}s^{-1}$ (2d order high pressure limit)	±0.4
	Anderson, et al. (1974)	295-450	k_f = 2.3 ± 0.5 x 10^{-30} x $(295/T)^{+2.5}$ $cm^6 molecule^{-2}s^{-1}$ M = N_2 Relative efficiencies: N_2(1.0), Ar(0.43), He(0.43)	
	Howard, Evenson (1974)	296	k_f = 2.9 ± 0.4 x 10^{-30} M = N_2	
	Gordon, Mulac (1975)	435	k_f = 5.3 x 10^{-12} $cm^3 molecule^{-1}s^{-1}$ (2nd order rate constant at 1 atm. H_2O vapor)	
	Harris, Wayne (1975)	300	15 ± 5 x 10^{-31} $cm^6 molecule^{-2}s^{-1}$, M = Ar 26 ± 10 x 10^{-31} M = N_2	
	Atkinson, Perry, Pitts (1976)	298	k_f = (1.0 ± 0.1) x 10^{-30} M = Ar values given for bimolecular rate constant over pressure range 25-646 torr Ar	
10,20M	NO_2 + HO_2 + M → HO_2NO_2 + M †*NASA (1977) eval	200-300	tentatively, use expression given for rxn 10,36M NO_2 + ClO → NO_2ClO + M with twice the assigned uncertainty	
	Simonaitis, Heicklen (1978)	245	$k[M]/k(HO_2 + NO)$ = 0.61	(a)
		295	$k[M]/k(HO_2 + NO)$ = 0.036	(a)
			(a) M = 700 torr H_2. Rxn to give HONO + O_2 is negligible	
	Howard (1977)	300	(2.09 ± 0.52) x 10^{-31} M = N_2 Rel. eff: N_2(1.0), He(0.48); O_2(0.72); NO_2(3.2)	
	Cox, Derwent (1975)	298	$k(HO_2 + NO_2 → HONO + O_2)$ < 3 x 10^{-15} $k[M]$ = 1.2 x 10^{-13} for [M] = 1 atm product probably HO_2NO_2 not HONO + O_2 as assumed by authors	
10,28	NO_2 + SO_2 → SO_3 + NO Davis (1974)	300	k < 2 x 10^{-24}	
10,35M	NO_2 + Cl + M → NO_2Cl + M †*Clyne, White (1974)	298	7.2 x $10^{-31} cm^6 molecule^{-2}s^{-1}$	±0.6 at 230K
10,36M	NO_2 + ClO + M → ClONO_2 + M †*NASA (1977) eval	200-300	$\dfrac{3.3 \times 10^{-23} T^{-3.34}}{1 + 8.7 \times 10^{-9} T^{-0.5}[M]^{0.5}}$ M = N_2 (a) Expression developed by Zahniser, Chang, Kaufman (1977)	+0.3, -0.1 at 230K (a)
	Birks, et al (1977)	250-356	(4.40 ± 0.66) x 10^{-33}exp(1087/T) M = N_2	

No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Leu, Lin, DeMore (1977)	297	$9.57 \pm 0.28 \times 10^{-32}$ M = He	
		258-417	$(3.69 \pm 0.24) \times 10^{-33} exp(1150/T)$ M = N_2	
	Zahniser, Chang, Kaufman (1977)	248-417	$(2.66 \pm 0.35) \times 10^{-33} exp(1140/T)$ M = He	
		251-365	$(3.54 \pm 0.06) \times 10^{-33} exp(950/T)$ M = He	(a)
		251-365	$5.53 \times 10^{-24} T^{-3.15}$ M = He	
		297	1.52×10^{-31} M = N_2	
			(a) Two forms of temp dependence are given: $exp(B/T)$ and T^{-n}	
10,49	$NO_2 + CH_3 \rightarrow CH_3O + NO$ Glanzer, Troe (1973) review	300-1400	3.3×10^{-11}	± 0.25 (a)
			(a) Based on $k/k(CH_3 + NO) = 3.3$ at room temperature and on shock wave pyrolysis of CH_3NO_2	
10,49M	$NO_2 + CH_3 (+M) \rightarrow CH_3NO_2 (+M)$ Glanzer, Troe (1973) review	295	2.8×10^{-11} $cm^3molecule^{-1}s^{-1}$	± 0.1 (a)
			(a) Based on high pressure limit rate ratio $k/k(CH_3 + NO) = 1.7$	
10,49M	$NO_2 + CH_3 + M \rightarrow CH_3NO_2 + M$ Glanzer, Troe (1973) review	900-1400	6.9×10^{-31} $cm^6molecule^{-2}s^{-1}$, M = Ar	(a)
			(a) $k_f = k_r K_{eq}$	
10,50 10,51	$NO_2 + CH_3O \rightarrow \ldots$ $NO_2 + CH_3O_2 \rightarrow CH_3O_2NO_2$ (a) $\rightarrow CH_2O + HONO_2$ (b) $\rightarrow CH_3O + NO_3$ (c) *Heicklen (1973) review	298	see $CH_3O + NO_2 \rightarrow \ldots$ $k_a/k = 0.75 \pm 0.05$ $k_b/k = 0.25 \pm 0.1$ $k_c/k < 0.1$	
11,hν	$NO_3 + hν \rightarrow NO_2 + O$ (1) $\rightarrow NO + O_2$ (2) Graham, Johnston (1978)	300	table of absorption cross sections for wavelength region 400-700nm $J_1 = 0.009 s^{-1}$ $J_2 = 0.04 s^{-1}$ (a) This table also given in Molina's review (1977). Values supersede results in Johnston, Graham (1974) (b) Specific photodissociation rates for troposphere with overhead sun. see reverse reaction	(a) (b) (b)
11,M 11,11	$NO_3 + M \rightarrow NO_2 + O + M$ $NO_3 + NO_3 \rightarrow 2NO_2 + O_2$ Graham, Johnston (1978) Baulch, et al (1973) review	298-329 293-309	$8.5 \times 10^{-13} exp(-2450/T)$ $5 \times 10^{-12} exp(-3000/T)$ (a) $-d[NO_3]/dt = 2k[NO_3]^2$. Based on rate of O_3 decomp. in presence of N_2O_5	± 0.5 (a)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
11,22	$NO_3 + H_2O \rightarrow HNO_3 + HO$ Baulch, et al (1973) review	300	2.3×10^{-26} (a) $k_f = k_r K_{eq}$	±0.3 (a)
11,28	$NO_3 + SO_2 \rightarrow NO_2 + SO_3$ Daubendiek, Calvert (1975) Davis (1976)	300 300	$k < 7 \times 10^{-21}$ $k < 1 \times 10^{-21}$	preliminary
12,M	$N_2 + M \rightarrow N + N + M$ *Baulch, et al (1973) review	6000-15000	$6.1 \times 10^{-3}T^{-1.6}\exp(-113,200/T)cm^3 molecule^{-1}s^{-1}$ $M = N_2$	±0.5
12,19	$N_2 + HO \rightarrow N_2O + H$ *Baulch, et al (1973) review	700-2500	$5.4 \times 10^{-12}\exp(-40.4 \times 10^3/T)$ (a) $k_f = k_r K_{eq}$ (corrected expression)	±0.2 (a)
13,hν	$N_2O + h\nu \rightarrow$ products Johnston, Selwyn (1975)	294	figures of absorption cross section vs λ for $\lambda = 210-728nm$. Negligible absorption for $\lambda>260nm$	
	Selwyn, et al (1977)	194-302	Absorption cross section values tabulated for $\lambda = 173-240nm$ at 1 nm intervals for T = 194, 225, 243, 265 and 302K see reverse reaction	
13,M 13,18	$N_2O + M \rightarrow N_2 + O + M$ $N_2O + H \rightarrow N_2 + HO$ Albers, et al (1975) Baulch, et al (1973) review Baldwin, et al (1973)	718-1111 700-2500 773	$(3.6 \pm 1.2) \times 10^{-10}\exp(-8710 \pm 350/T)$ $1.26 \times 10^{-10}\exp(-7600/T)$ 4.3×10^{-15}	±0.2 ±0.15
13,19	$N_2O + HO \rightarrow$ products Chang, Kaufman (1977) Biermann, et al (1976) Atkinson, Perry, Pitts (1976)	480 298 298 443 440	$< 4 \times 10^{-16}$ $3.8 \pm 1.2 \times 10^{-17}$ $< 2 \times 10^{-16}$ $< 2 \times 10^{-16}$ $< 2 \times 10^{-14}$	upper limit only
13,36	$N_2O + ClO \rightarrow$ products **NASA (1977) eval	200-300	$k < 1 \times 10^{-12}\exp(-4260/T)$ (a) "A factor" chosen. Eact fitted to upper limit at T = 587K reported in Watson's review (1977)	±2 at 230K (a)
13,45	$N_2O + CO \rightarrow$ products Milks, Matula (1973)	1169-1655	$3.5 \times 10^{-13}\exp(-8650/T)$	
14,hν	$N_2O_5 + h\nu \rightarrow \dots$ Molina (1977) review		table of absorption cross sections for wavelength range 206-380nm (a) Gives values for $\lambda = 205-310nm$ from Graham, Johnston (1977) which supersede results in Johnston, Graham (1974). Also gives values for $\lambda = 320-380nm$ from Jones, Wulf (1937)	(a)

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Murphy (1969)		$0.5 \times \emptyset(-N_2\emptyset_5) = \emptyset(\emptyset) = 0.31$ $\lambda = 280$ nm Meas. by Holmes, Daniels (1934) are consistent	
	Hampson, et al (1973a) review Daubendiek, Calvert (1974)		Survey of photochemistry Figure giving molar extinction coefficient vs λ. $250 < \lambda/nm < 350$	
14,M	$N_2\emptyset_5 (+M) \rightarrow N\emptyset_2 + N\emptyset_3 (+M)$		Elevation/km k/s^{-1}	
	*This survey	217	15 5.0×10^{-7}	±0.5
		217	20 1.8×10^{-7}	
		222	25 3.0×10^{-7}	
		227	30 5.5×10^{-7}	
		237	35 1.9×10^{-6}	
		251	40 1.6×10^{-5}	
		265	45 4.4×10^{-5}	
			Extrapolated from data taken between 273 and 353 F.	
14,M	$N_2\emptyset_5 + M \rightarrow N\emptyset_2 + N\emptyset_3 + M$		see reverse reaction	
14,22	$N_2\emptyset_5 + H_2\emptyset \rightarrow 2HN\emptyset_3$			
	Hampson, et al (1973) review	300	$k < 1 \times 10^{-20}$	
	Morris, Niki (1973)	298	$< 1.3 \times 10^{-20}$	
14,28	$N_2\emptyset_5 + S\emptyset_2 \rightarrow$ products			
	Daubendiek, Calvert (1974)	300	$k < 4 \times 10^{-23}$	
	Davis (1974)	300	$k < 8 \times 10^{-24}$	
16,18M	$NH_2 + H + M \rightarrow NH_3 + M$			
	Baulch, et al (1973) review	2000-3000	$1.2 \times 10^{-33} \exp(11200/T)$ cm^6 $molecule^{-2}s^{-1}$, $M \rightarrow Ar$ ±0.3 (a) (a) $k_f \rightarrow K_{eq} k_r$	
16,19	$NH_2 + H\emptyset \rightarrow NH_3 + \emptyset$		see reverse reaction	
16,21	$NH_2 + H_2 \rightarrow NH_3 + H$			
	Baulch, et al (1973) review	800	$< 10^{-16}$ $k_f = K_{eq} k_r$	approximate
16,22	$NH_2 + H_2\emptyset \rightarrow NH_3 + H\emptyset$		no data, no recommendation	
	Baulch, et al (1973) review			
17,M	$NH_3 + M \rightarrow NH_2 + H + M$			
	Baulch, et al (1973) review	2000-3000	$k = 1.5 \times 10^{-8} \exp(-42400/T)$ (M = Ar) (a) To be used when P(M) < 4 atm.	±0.3 (a)
17,18	$NH_3 + H \rightarrow NH_2 + H_2$			
	Baulch, et al (1973) review	800	$< 10^{-16}$	approximate
17,19	$NH_3 + H\emptyset \rightarrow NH_2 + H_2\emptyset$			
	*Smith, Zellner (1975)	228-472	$2.3 \times 10^{-12} \exp(-800/T)$	±0.1
	Perry, Atkinson, Pitts (1976a)	298-427	$2.93 \times 10^{-12} \exp(-850 \pm 150/T)$	
	Davis (1977)	300	$(1.4 \pm 0.1) \times 10^{-13}$	preliminary
	Cox, Derwent, Holt (1975)	300	$(1.2 \pm 0.4) \times 10^{-13}$	
	Hack, et al (1974)	298-669	$5.3 \pm 0.8 \times 10^{-12} \exp(-920/T)$	
	Stuhl (1973a)	298	1.5×10^{-13}	±0.1
	Kurylo (1973)	298	4.1×10^{-14}	±0.1
	Gordon, Mulac (1975)	418	$4.5 \pm 0.5 \times 10^{-13}$	±0.06

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
17,36	$NH_3 + C\ell \rightarrow$ products Walker (1972)	670	$k < 5 \times 10^{-16}$ (a) As quoted by Watson (1977) review.	(a)
17a,18	$N_2H_4 + H \rightarrow H_2 + N_2H_3$ Stief, Payne (1976)	228-400	$(9.87 \pm 1.17) \times 10^{-12} exp(-1200 \pm 50/T)$	
18,18M 21,M	$H + H + M \rightarrow H_2 + M$ (f) $H_2 + M \rightarrow H + H + M$ (r) Baulch, et al (1972) review	300 1700-5000 2500-5000	$k_f = 8.3 \times 10^{-33}$ $cm^6 molecule^{-2}s^{-1}$ $M = H_2$ $= 1.8 \times 10^{-30}$ T^{-1} $M = Ar$ Rel. efficiencies: $H_2(1.0)$, $Ar(0.25)$ $-d[H]/dt = 2k[H]^2[M]$ $k_r = 3.7 \times 10^{-10} exp(-4300/T) cm^3 molecule^{-1}s^{-1}$, $M = Ar$ see reverse reaction	± 0.2 ± 0.3 ± 0.3
18,19 18,19M 22,M	$H + HO \rightarrow H_2 + O$ (f) $H + HO + M \rightarrow H_2O + M$ (r) $H_2O + M \rightarrow H + HO + M$ (r) *Baulch, et al (1972) review	1000-3000 2000-6000	$k_f = 6.1 \times 10^{-26} T^{-2}$ $cm^6 molecule^{-2}s^{-1}$, $M = N_2$ $k_r = 5.8 \times 10^{-9} exp(-52900/T)$ $cm^3 molecule^{-1}s^{-1}$ $M = N_2$	± 0.3 ± 0.2
	Zellner, Erler, Field (1977)	230-300	$k_f = 4.3 \times 10^{-25} T^{-2.6}$ $M = He$ Rel eff: $He(1.0)$, $Ar(1.5)$, $N_2(3.2)$	
18,20 19,19 18,20 18,20	$H + HO_2 \rightarrow HO + HO$ (1f) $HO + HO \rightarrow H + HO_2$ (1r) $H + HO_2 \rightarrow H_2 + O_2$ (2) $H + HO_2 \rightarrow H_2O + O$ (3) Baulch, et al (1972) review	290-800 290-800	$k_{1f} = 4.2 \times 10^{-10} exp(-950/T)$ $k_{1r} = k_{1f}/K_{eq} = 2.0 \times 10^{-11}$ $exp(-20200/T)$ $k_2 = 4.2 \times 10^{-11} exp(-350/T)$ $k_{2r} = k_{2f}/K_{eq} = 9.1 \times 10^{-11}$ $exp(-29100/T)$ $k_3 =$ no recommendation	± 0.3 (a) ± 0.3 ± 0.4 ± 0.4
	Lloyd (1974) review	300-1000	k_{1f} and k_2 - same as Baulch, et al $k_3 = 8.3 \times 10^{-11} exp(-500/T)$	$> \pm 0.7$ (a) $> \pm 0.5$ (b)
	Moortgat, Allen (1973)	297	$k_{1f} = 8.3 \times 10^{-12}$ $k_2 = 1 \times 10^{-11}$ $k_3 = 6.7 \times 10^{-12}$	? (c) ? (c) ? (c)

(a) Reaction 1 and rate ratios control values for reactions 2 and 3.
(b) Temperature coefficient estimated.
(c) Secondary reaction in $H + O_2 + M$ systems, fit of concentration vs. time plots.

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
18,22	$H + H_2O \rightarrow H_2 + HO$ Baulch, et al (1972) review	300-2500	1.5×10^{-10} exp($-10250/T$)	±0.06 at 300K increasing to ±0.2 at high temp.
18,23	$H + H_2O_2 \rightarrow H_2 + HO_2$ (a) $\rightarrow HO + H_2O$ (b) *Klemm, Payne, Stief (1975) Gorse, Volman (1974) Hampson, et al (1973)	283-353 300 300-800	$k_a + k_b = 5.2 \pm 2.0 \times 10^{-12}$ exp($-1400 \pm 140/T$) $k_a = 3.1 \pm 0.8 \times 10^{-15}$ $k_b = 5.7 \pm 1.4 \times 10^{-15}$ $k_a = 2.8 \times 10^{-12}$ exp($-1900/T$) k_b no recommendation (a) Accepts recommendations of Baulch, et al (1972).	(a) (a)
18,24	$H + HNO \rightarrow H_2 + NO$ Meagher, Heicklen (1975) Hampson, et al (1973) review Baulch, et al (1973) review	298 211-703 2000 300 2000	$k_b/k_a = 1.3$ $> 5 \times 10^{-14}$ 7×10^{-12} $10^{-13} < k < 10^{-12}$ 8×10^{-12}	±0.7 ±0.3 ±0.2
18,25	$H + HNO_2 \rightarrow$ products Hampson, et al (1973) review Baulch, et al (1973) review		No data No recommendation	
18,26	$H + HNO_3 \rightarrow$ products Hampson, et al (1973) review Chapman, Wayne (1974) Baulch, et al (1973) review	300 300 300	$< 1 \times 10^{-13}$ $< 2 \times 10^{-15}$ $< 10^{-13}$	
18,28M	$H + SO_2 + M \rightarrow HSO_2 + M$ Baulch, et al (1976) review	1660-2120	1.4×10^{-32}	approximate upper limit
18,31 21,26a	$H + HS \rightarrow H_2 + S$ (f) $H_2 + S \rightarrow H + HS$ (r) Baulch, et al (1976) review	298	$k_f = 2.5 \times 10^{-11}$ $k_r = 2.2 \times 10^{-25}$ (a) $k_r = k_f/Keq$ $k_f = 2.5 \pm 0.8 \times 10^{-11}$	±0.2 ±0.? (a)
18,32	$H + H_2S \rightarrow H_2 + HS$ Cupitt, Glass (1974) Kurylo, Peterson, Braun (1971)	295 190-464	1.29×10^{-11}exp($860/T$) (a) Selected by Baulch, et al (1976) review	(a)
18,34c	$H + COS \rightarrow CO + HS$ Baulch, et al (1976) review	300	2.2×10^{-14}	±0.2
18,37	$H + OClO \rightarrow HO + ClO$ *Watson (1977) review	298	$5.7 \pm 1.2 \times 10^{-11}$	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
18,39	H + HCl → H₂ + Cl	298-521	7.8 x 10⁻¹²exp(-1600±84/T)	
	Ambidge, et al (1976a)	295	4.3 x 10⁻¹⁴	
	Spencer, Glass (1975)			
18,42	H + NOCl → HCl + NO	255-461	7.6 x 10⁻¹¹exp(-457 ± 72/T)	
	Wagner, et al (1976a)			
18,44	H + Cl₂ → HCl + Cl	250-700	1.46 x 10⁻¹⁰exp(-593/T)	
	*This survey		(a) Based on data in Bemand, Clyne and Wagner, et al	±0.1 (a)
	Bemand, Clyne (1977)	300-730	(1.41 ± 0.24) x 10⁻¹⁰exp(-575 ± 65/T)	
	Wagner, et al (1976)	252-458	(1.44 ± 0.28) x 10⁻¹⁰exp(-600 ± 70/T)	
	Ambidge, et al (1976)	292-434	(7.6 ± 2.2) x 10⁻¹¹exp(-714 ± 100/T)	
18,45M	H + CO + M → HCO + M	298-773	2.0 x 10⁻³³exp(-850/T), M = H₂	±0.12
	Baulch, et al (1976) review			
18,46	H + CO₂ → HO + CO		see reverse reaction	
18,48	H + CH₂O → H₂ + CHO	297	5.4 x 10⁻¹⁴	±0.04
	Ridley, et al (1972)	297-652	2.2 x 10⁻¹¹ exp(-1890/T)	
	Westenberg, deHaas (1972b)			
18,53	H + CH₃OOH → CH₃O + H₂O (a) → CH₃O₂ + H₂ (b) → CH₂OOH + H₂ (c)	250-358	k = (2.8 ± 0.9) x 10⁻¹³exp(-930 ± 95/T) overall rate const kₐ/k = 0.43 ± 0.07 k_b/k = 0.52 ± 0.07 k_c/k = 0.05	
	Slemr, Warneck (1977)			
18,54	H + CH₃ONO → CH₃OH + NO (a) → CH₂ONO + H₂ (b) → CH₃O + HNO (c)	223-398	k = (4.3 ± 0.9) x 10⁻¹³exp(-950 ± 55/T) overall rate const kₐ/k = 0.47 ± 0.05 (k_b + k_c)/k = 0.53 ± 0.05	
	Moortgat, et al (1977)			
18,64	H + CH₃Cl → HCl + CH₃	500-800	6.2 x 10⁻¹¹exp(-4650/T)	
	Westenberg, deHaas (1975a)			
19,M	HO + M → H + O + M		no recommendation (E/R > 50000 K)	
	Baulch, et al (1972) review		see reverse reaction	
19,19	HO + HO → H + HO₂		no recommendation	
19,19	HO + HO → H₂ + O₂			
	Baulch, et al (1972) review			
19,19	HO + HO → H₂O + O (f)	300-2000	k_f = 1.0 x 10⁻¹¹ exp(-550/T)	±0.2
1,22	O + H₂O → HO + HO (r)	300-2000	k_r = 1.1 x 10⁻¹⁰ exp(-9240/T)	±0.2
	*Baulch, et al (1972) review			
	Rawlins, Gardiner (1974)	1500-2000	k_f = 5.1 x 10⁻¹¹ exp(-3500/T)	
	Westenberg, deHaas (1973a)	300	k₂ = 2.3 x 10⁻¹²	±0.06

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	McKenzie, et al (1973)	298	$k_f = 2.1 \pm 0.5 \times 10^{-12}$	
	Clyne, Down (1974)	300	$k_f = 1.4 \pm 0.2 \times 10^{-12}$	
		300	$k_f = 1.7 \pm 0.6 \times 10^{-12}$	(a)
	Trainor, von Rosenberg (1974)	300	$k_f = 2.1 \pm 0.2 \times 10^{-12}$	
	Wilson (1972) review	300	$k_f = 2.57 \times 10^{-12}$	+0.1, -0.5
			(a) Evaluation based on authors' work and other recent data $-d[OH]/dt = 2k[OH]^2[M]$	
19,19M 23,M	$OH + OH + N \rightarrow H_2O_2 + M$ (f) $H_2O_2 + M \rightarrow OH + OH + M$ (r)			
	++NASA (1977) eval	200-300	$k_f = 1.25 \times 10^{-32}exp(900/T)$	(a)
			(a) Accepts room temp value of Trainor, von Rosenberg. E/R value chosen same as for comb. of OH with NO	
	Trainor, von Rosenberg (1974)	300	$k_f = 2.5 \pm 0.3 \times 10^{-31}$ M = N_2	±0.1
	Baulch, et al (1972) review	700-1500	$k_f = 2.5 \times 10^{-33} exp(+2550/T)cm^6molecule^{-2}s^{-1}$ M = N_2	700<T<950K
			$k_r = 2.0 \times 10^{-7} exp(-22900/T)cm^3molecule^{-1}s^{-1}$,	±0.3 at 1500K
			M = N_2; $k_f = k_r K_{eq}$	
19,20	$OH + HO_2 \rightarrow H_2O + O_2$			
	++NASA (1977) eval	200-300	3×10^{-11}	0.5 at 230K
	Burrows, Harris, Thrush (1977)	293	5.1×10^{-11}	(a)
			(a) Based on k(OH + H_2O_2) = 7.9 × 10^{-13}	
	Lloyd (1974) review	300-1000	$8.3 \times 10^{-11} exp(-500/T)$	±0.3
	Hochanadel, et al (1972)	300	2×10^{-10}	
	DeMore, Tschulkow-Roux (1974)	300	1.1×10^{-10}	±0.5 (a)
			(a) Adjusted value - based on reported ratio and values of k(O_3 + HO) and k(HO_2 + HO₂) in this survey.	
19,21	$OH + H_2 \rightarrow H_2O + H$			
	*Baulch, et al (1972) review	300-2500	$3.6 \times 10^{-11} exp(-2590/T)$ cm^{3}molecule^{-1}s^{-1}	±0.08 at 300K, ±0.2 at high temp.
	Wilson (1972) review	300-2000	$3.8 \times 10^{-11} exp(-2600/T)$	±0.3
	Stuhl, Niki (1972)	298	7.1×10^{-15}	±0.06
	Westenberg (1973a)	298	7.6×10^{-15}	±0.04
		352	1.8×10^{-14}	
		403	3.2×10^{-14}	
		518	1.4×10^{-13}	
		628	3.6×10^{-13}	
		745	6.6×10^{-13}	
	Smith, Zellner (1974a)	210-460	$1.8 \times 10^{-11} exp(-2330/T)$	
	Gardiner, et al (1974)	1350-1600	$8.7 \times 10^{-11} exp(-3250/T)$	
	Greiner (1969)	300-500	$6.8 \times 10^{-12} exp(-2020/T)$	
	Atkinson, Hansen, Pitts (1975)	297-434	$5.9 \times 10^{-12} exp(-2008 \pm 150/T)$	±0.15

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
	Overend, et al (1975)	295	$(5.80 \pm 0.26) \times 10^{-15}$	
	Trainor, von Rosenberg (1975)	300	5.3×10^{-15}	
	Vandooren, et al (1975)	600-1300	$1.2 \times 10^{-11}\exp(-2200/T)$	
19,21	OH + D₂ → HDO + D			
	Smith, Zellner (1974a)	210-460	$1.25 \times 10^{-11} \exp(-2590/T)$	
19,22	OH + H₂O → H₂O₂ + H			
	Baulch, et al (1972) review		no recommendation	
19,23	OH + H₂O₂ → H₂O + HO₂			
	+*NASA (1977) eval	200-300	$1 \times 10^{-11}\exp(-750/T)$	±0.3 at 230K (a)
	Hack, et al (1975)	298-670	$8.0 \times 10^{-12}\exp(-670/T)$	
	Greiner (1968)	300-458	$4.1 \times 10^{-13}T^{1/2}\exp(-600/T)$	
	Hampson (1973) quoting	300-800	$1.7 \times 10^{-11} \exp(-910/T)$	±0.?
	Baulch, et al (1972) review			
	Gorse, Volman (1972)	300	k/k(OH + CO) = 8.13	
	Meagher, Heicklen (1974)	298	k/k(OH + CO) = 4.1 ± 0.6	
	(a) Based on results of Hack, et al (1975) and Greiner (1968)			
19,24	OH + HNO → H₂O + NO			
	Hampson, et al (1973) review	1600-2100	7×10^{-11}	±0.7
	Baulch, et al (1973) review	2000	6×10^{-11}	±0.2
19,25	OH + HNO₂ → H₂O + NO₂			
	Cox, Derwent, Holt (1976)	296	$(6.6 \pm 0.3) \times 10^{-12}$ ref. rxn is OH + H₂ → H₂O + H with $k_{ref} = 7 \times 10^{-15}$	
	Cox (1974a)	294	k/k(OH + CO) = 15 ± 1 at 1 atm air	
19,26	OH + HNO₃ → H₂O + NO₃			
	+*Smith, Zellner (1975)	240-406	$8 \pm 2 \times 10^{-14}$	±0.1 at 230K (a)
	Margitan, et al (1975)	270-470	$8.9 \pm 1.3 \times 10^{-14}$	
	Hampson, et al (1973) review	300-650	$6 \times 10^{-13} \exp(-400/T)$	±0.5
	Johnston (1974) review	300-700	$(1.5 \text{ to } 2.0) \times 10^{-13}$	±0.2
	Baulch, et al (1973) review	300	1.3×10^{-13}	±0.3
	(a) Value recommended by authors for T ≤ 298K.			
19,28M	OH + SO₂ + M → HSO₃ + M			
	Davis (1976)	300		(a)

$10^{13} \times k$	P(He)/torr
0.87 ± 0.06	50
1.6 ± 0.1	150
2.7 ± 0.2	500

$10^{13} \times k$	P(Ar)/torr
1.37 ± 0.06	50
2.50 ± 0.3	150
3.71 ± 0.3	500

$10^{13} \times k$	P(N₂)/torr
0.08 ± 0.08	5
1.43 ± 0.14	10

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	Harris, Wayne (1975)	300	2.44 ± 0.3 20 ~9 760 (b) Extrapolated value.	
	Cox (1974a)	294	4.5 ± 1.5 x 10⁻³¹ cm⁶molecule⁻²s⁻¹, M = Ar 7.2 ± 2.6 x 10⁻³¹, M = N₂ (c) k/k(HO + CO) = 4 ± 0.5 (c)	
	Gordon, Mulac (1975)	435	(c) 2nd order rate constant, [M] = 1 atm. N₂ + O₂ (c) see entry for k(HO + CO) 1.8 x 10⁻¹² cm³molecule⁻¹s⁻¹	
	Castleman, Tang (1977)	297	(2d order rate constant at 1 atm. H₂O vapor) 1.6 x 10⁻³¹cm⁶molecule⁻²s⁻¹, M = N₂ (d) k/k(HO + CO) = 4.3 (d) Measured ratio of 2d order rate constants at 1 atm N₂.	
	Atkinson, Perry, Pitts (1976)	298	Values for k given in paper assumed k_{ref} = 1.5 x 10⁻¹³ over entire pressure range. See entry for k(HO + CO) (e) 10¹³ x k P(Ar)/torr 1.35 25 2.16 50 3.10 100 4.38 202 5.87 402 6.55 648 (e) Effective 2nd order rate constant in cm³molecule⁻¹s⁻¹	
19,32	HO + H₂S → H₂O + HS			
	Baulch, et al (1976) review	300-500	1.05 x 10⁻¹¹ exp(-200/T)	±0.15
	Perry, Atkinson, Pitts (1976a)	297-427	(5.2 ± 0.5) x 10⁻¹²	
	Stuhl (1974)	298	3.1 ± 0.5 x 10⁻¹²	
19,35	HO + Cl → O + HCl		see reverse reaction	
19,39	HO + HCl → H₂O + Cl			
	†*Watson (1977) review	220-300	3.0 x 10⁻¹²exp(-425/T)	±0.1 at 230K
	Smith, Zellner (1974a)	210-460	4.1 x 10⁻¹² exp(-530/T)	
	Zahniser, et al (1974)	224-460	2.0 ± 0.1 x 10⁻¹² exp(-312 ± 10/T)	
	Takacs, Glass (1973)	295	6.4 ±1.5 x 10⁻¹³	
	Davis (1974)	300	6.5 ± 0.4 x 10⁻¹³	±0.1
19,39	HO + DCl → HDO + Cl			
	Smith, Zellner (1974a)	210-460	4.7 x 10⁻¹² exp(-780/T)	
19,39Br	HO + HBr → H₂O + Br			
	†*Takacs, Glass (1973)	300	5.1 x 10⁻¹²	±0.36 at 230K
19,43a	HO + NO₃Cl → products			
	†*Zahniser, et al (1977)	246-387	(1.19 ± 0.10) x 10⁻¹²exp(-333 ± 22/T)	±0.36 at 230K
	Ravishankara, et al (1977)	245	3.7 x 10⁻¹³	
19,45	HO + CO → CO₂ + H (f)			
18,46	H + CO₂ → HO + CO (r)			
	†NASA (1977) eval	200-400	k_f = 1.4 x 10⁻¹³ low pressure value	±0.1

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
	*Baulch, et al (1976) review	250-2500	$\log k_f = -12.95 + 3.94 \times 10^{-4} \times T$ same as given in Baulch, Drysdale (1974) recommendation based on low pressure studies $k_r = k_f/K_{eq} = 2.5 \times 10^{-10}$ exp(-13300/T)	±0.1
	*This survey	1000-3000		±0.1
		300	$k_f = 3.0 \times 10^{-13}$ 1 atmosphere air (a) Tentative rec. Recent experiments at room temperature have shown an apparent increase in k in the presence of SF_6, H_2, N_2/O_2, but not He or Ar. Biermann, et al (1978) have identified a combined effect of inert gas and O_2. Trace impurities of O_2 have a significant effect and 1 torr is sufficient to produce the limiting rate constant in the presence of 1 atm of N_2.	±0.1 (a)

Experiments bearing on the "pressure effect"

	Butler, et al (1977)	298	Mole fractions	

k_f/k_{ref}	P/torr	$N_2/O_2/CO$
0.094	100	0.49/0.33/0.15
0.10	200	0.50/0.34/0.15
0.17	300	0.73/0.17/0.08
0.15	400	0.50/0.34/0.15
0.16	500	0.73/0.17/0.07
0.18	600	0.74/0.17/0.08

Ref. rxn is $HO + $ isobutane $\rightarrow$ products, with 6-28%
correction for side rxn. Ratios calculated from reported
data using authors' value for $k_{ref} = 1.59 \times 10^{-12}$ which was
determined in the 100 torr expt. relative to
$k(HO + CO) = 1.5 \times 10^{-13}$

| | Chan, et al (1977) | 298 | | |

k_f/k_{ref}	P/torr	
0.059	100	in "synthetic air"
0.127	700	

Ref. rxn is $HO + $ isobutane $\rightarrow$ products

| | Sie, Simonaitis, Heicklen (1976a) | 217-298 | | |
| | | 298 | | |

k_f/k_{ref}	P/torr	
$0.2\exp(1700/T)$	high pressure limit in H_2	
14	20	(H_2)
21	83	(H_2)
42	296	(H_2)
49	702	(H_2)
17	605	$(He) + 2O$ (H_2)
33	550	$(SF_6) + 2O$ (H_2)
49	605	$(SF_6) + 2O$ (H_2)

Ref. rxn is $HO + H_2 \rightarrow H_2O + H$

| | Cox, Derwent, Holt (1976) | 296 | | |

k_f/k_{ref}	P/torr	
38.6	700	$N_2/O_2 = 2$

Ref. rxn. is $HO + H_2 \rightarrow H_2O + H$

| | Atkinson, Perry, Pitts (1976) | 299 | $(1.54 \pm 0.16) \times 10^{-13}$ P = 25-654 torr Ar | |

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No.	Reaction/Reference *= Preferred Value += NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1} s^{-1}$		Notes and Reliability of log k
			$10^{13} \times k$	$P(SF_6)/torr$	
	Perry, Atkinson, Pitts (1977a)	299	1.53	25	
			1.93	76	
			2.40	208	
			3.09	403	
			3.43	603	
	Overend, Paraskevopoulos (1977)	296	$(2.03 \pm 0.08) \times 10^{-13}$ at 50 torr He		
			$(3.24 \pm 0.20) \times 10^{-13}$ at 200, 350 torr SF_6		
	Gordon, Mulac (1975)	298	1.50×10^{-13} at 710 torr Ar, 10 torr H_2O		
			Experiments either at low pressure or for which pressure effects were not studied.		
	Trainor, von Rosenberg (1975)	300	1.25×10^{-13}		
	Vandooren, et al (1975)	400-800	1.33×10^{-13}		
		1000-1800	$3.85 \times 10^{-12} \exp(-2850/T)$		
	Biordi, et al (1975)	1350-1750	7.8×10^{-13}		
	Steinert, Zellner (1975)	300-900	$\log k = -12.93 + 4.0 \times 10^{-4} \times T$		
	Wilson (1972) review	300-2000	$5.1 \times 10^{-13} \exp(-300/T)$		± 0.3
	Stuhl, Niki (1972)	300	1.35×10^{-13}		± 0.06
	Westenberg, deHaas (1973a)	298	1.33×10^{-13}		± 0.04
		396	1.38×10^{-13}		
		523	1.44×10^{-13}		
		707	1.69×10^{-13}		
		915	2.17×10^{-13}		
	Davis, Fischer, Schiff (1974)	220-373	$2.15 \pm 0.15 \times 10^{-13} \exp(-80 \pm 40/T)$		± 0.04
	Greiner (1969)	300-500	$2.1 \times 10^{-13} \exp(-115/T)$		± 0.1
	Smith, Zellner (1973)	300	1.45×10^{-13}		(h)
			(b) Data reported 210 <T< 460 K. Slight positive temperature dependence, possibly curved.		
19,48	$HO + CH_2O \rightarrow H_2O + CHO$				
	+*NASA (1977) eval	200-300	$3 \times 10^{-11} \exp(-250/T)$		± 0.4 at 230K (a)
	*Morris, Niki (1971)	300	1.4×10^{-11}		± 0.1
	Wilson (1972) review	300-1600	8×10^{-11}		± 1
	Peeters, Mahnen (1973)	1400-1800	3.8×10^{-11}		
			(a) "A factor" chosen; E_{act} fitted to room temp value of Morris, Niki		
19,52	$HO + CH_3OH \rightarrow products$				
	Campbell, et al (1976)	292	9.5×10^{-13}		
19,54	$HO + CH_3NO_2 \rightarrow products$				
	Campbell, Goodman (1975b)	292	9.2×10^{-13}		
19,54	$HO + CH_3ONO \rightarrow products$				
	Campbell, Goodman (1975b)	292	1.3×10^{-12}		

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
19.56	$HO + CH_4 \rightarrow CH_3 + H_2O$			
	+*Davis, Fischer, Schiff (1974)	240-373	$2.36 \pm 0.21 \times 10^{-12} \exp(-1710 \pm 88/T)$	±0.04
	Margitan, et al (1974)	290-440	$3.83 \times 10^{-12} \exp(-1840 \pm 20/T)$	±0.06
	Wilson (1972) review	300-2000	$4.7 \times 10^{-11} \exp(-2500/T)$	±0.7
	Overend, et al (1975)	300	$6.51 \pm 0.26 \times 10^{-15}$	
	Peeters, Mahnen (1973)	1100-1900	$5 \times 10^{-11} \exp(-3000/T)$	
	Greiner (1970)	300-500	$5.5 \times 10^{-12} \exp(-1900/T)$	±0.1
	Gordon, Mulac (1975)	381	2.6×10^{-14} (1 atm H_2O vapor)	
		416	5.5×10^{-14} (1 atm H_2O vapor)	
	Zellner, Steinert (1976)	300-900	$5.76 \times 10^{-21}T^{3.08}\exp(-1010/T)$	
	Howard, Evenson (1976)	296	$(9.5 \pm 1.4) \times 10^{-15}$	
	Cox, Derwent, Holt (1976)	296	$(7.3 \pm 0.9) \times 10^{-15}$	
			ref rxn is $HO + H_2 \rightarrow H_2O + H$ with $k_{ref} = 7 \times 10^{-15}$	
19.56a	$HO + C_2H_2 \rightarrow products$			
	Smith, Zellner (1973)	210-460	$2.0 \times 10^{-12} \exp(-250/T)$	
	Pastrana, Carr (1974)	300	$2.0 \pm 0.6 \times 10^{-13}$	
	Davis, et al (1975)	300	$1.65 \pm 0.15 \times 10^{-13}$	
19.57	$HO + C_2H_4 \rightarrow products$			
	Atkinson, Perry, Pitts (1977)	299-425	$2.2 \times 10^{-12}\exp(385 \pm 150/T)$	(a)
			(a) High pressure values (225-660 torr Ar) Values also given for 25 and 75 torr pressure dependent values given over range 1 to 7 torr He	
	Howard (1976)	296	$1.0 \pm 0.2 \times 10^{-11}$	(b)
	Overend, Paraskevopoulos (1977)	296	(b) Authors' suggested limiting high pressure value based on expts at 400 torr SF_6 and CF_4 and analysis of dependence of k on [H_2O] at low values of [H_2O]	
	Stuhl (1973c)	298	3×10^{-12}	
	Smith, Zellner (1973)	210-460	$7.5 \times 10^{-12} \exp(-110/T)$	±0.12
	Davis, et al (1975)	300		

10^{12} x k | P(He)/torr
10^{12} x k	P(He)/torr
2.24	3
2.78	5
3.63	10
4.06	20
4.72	100
5.33	300

		300	3.64×10^{-12} at 3 torr N_2	
	Morris, et al (1971)	300	1.8×10^{-12}	
	Bradley, et al (1973)	300	$1.7 \pm 0.5 \times 10^{-12}$	
	Greiner (1970a)	300-500	$1.25 \times 10^{-12} \exp(454/T)$ at 100 torr He	
	Gordon, Mulac (1975)	381	6.2×10^{-12} (1 atm H_2O vapor)	
		416	7.3×10^{-12} (1 atm H_2O vapor)	

No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
19,58	$H\theta + C_2H_6 \rightarrow$ products			
	Overend, et al (1975)	300	$2.64 \pm 0.17 \times 10^{-13}$	
	Greiner (1970)	300-500	$1.86 \times 10^{-11} \exp(-1230/T)$	
	Howard, Evenson (1976)	296	$(2.9 \pm 0.6) \times 10^{-13}$	
19,59	$H\theta + C_3H_6 \rightarrow$ products			
	Atkinson, Pitts (1975b)	297-425	$4.1 \times 10^{-12} \exp(540 \pm 150/T)$	± 0.05
	Stuhl (1973c)	298	1.45×10^{-11}	
	Morris, et al (1971)	300	1.7×10^{-11}	
	Bradley, et al (1973)	300	$5.0 \pm 1.7 \times 10^{-12}$	
	Gorse, Volman (1974)	300	$k/k(C\theta + H\theta) = 89.3$ (low pressure)	
			$k = 1.2 \times 10^{-11}$	(a)
			(a) $k(C\theta + H\theta) = 1.4 \times 10^{-13}$, this survey	
	Davis (1976)	300	$1.53 \pm 0.06 \times 10^{-11}$	
	Gordon, Mulac (1975)	381	1.4×10^{-11} (1 atm $H_2\theta$ vapor)	
		416	2.0×10^{-11} (1 atm $H_2\theta$ vapor)	
19,60	$H\theta + n-C_4H_{10} \rightarrow$ products			
	Stuhl (1973b)	300	2.35×10^{-12}	± 0.06
	Perry, Atkinson, Pitts (1976b)	297-420	$1.76 \times 10^{-11} \exp(-560/T)$	
	Greiner (1970)	300-500	$1.41 \times 10^{-11} \exp(-524/T)$	
	Gorse, Volman (1974)	300	$k/k(C\theta + H\theta) = 19.4$ (low pressure)	
			$k = 2.7 \times 10^{-12}$	(a)
			(a) $k(C\theta + H\theta) = 1.4 \times 10^{-13}$, this survey	
19,60	$H\theta + isobutane \rightarrow$ products			
	Greiner (1970)	300-500	$8.7 \times 10^{-12} \exp(-387/T)$	
	Gorse, Volman (1974)	300	$k/k(H\theta + C\theta) = 23.5$ (low pressure)	
			$k = 3.3 \times 10^{-12}$	(a)
	Butler, et al (1977)	300	(a) $k(C\theta + \theta H) = 1.4 \times 10^{-13}$, this survey	
			1.6×10^{-12}	(b)
			(b) Determined in expt. at 100 torr relative to	
			$k(H\theta + C\theta) = 1.5 \times 10^{-13}$	
19,60	$H\theta + alkane \rightarrow H_2\theta + alkyl \; radical$			
	Greiner (1970)	300-500	$k = [1.0 \exp(-820/T) N_p + 2.3 \exp(-430/T)$	total rxn; P = 100 torr Ar
			$N_s + 2.1 \exp(+95/T) N_t] \times 10^{-12}$	
			Where N_p, N_s, and N_t are the number of primary	
			secondary, and tertiary hydrogen atoms respectively.	
			Do not use formula for CH_4 and C_2H_6.	
19,60a	$H\theta + C_6H_6 \rightarrow$ products			
	Perry, Atkinson, Pitts (1977)	298	$(1.20 \pm 0.15) \times 10^{-12}$	
		380-470	$k_1 = 4 \times 10^{-11} \exp(-2000/T)$	(a)
		298	$k_1/k = 0.05$	(b)
			(a) k_1 refers to abstraction rxn	
			(b) Fraction of rxn proceeding by abstraction;	
			expression for k_1 extrapolated to 298K	
	Hansen, Atkinson, Pitts (1975)	298	$(1.24 \pm 0.12) \times 10^{-12}$	total rxn; P = 50-600 torr Ar

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Davis, Bollinger, Fischer (1975)	298	0.85×10^{-12} P = 3 torr He	total rxn
			1.36×10^{-12} P = 20 torr He	total rxn
			1.59×10^{-12} P = 100 torr He	total rxn
19,60a	$H\emptyset + C_6H_5CH_3 \rightarrow$ products			
	Perry, Atkinson, Pitts (1977)	298	$(6.40 \pm 0.64) \times 10^{-12}$ total rxn; P = 200 torr Ar	
		380-470	$k_1 = 5 \times 10^{-12}exp(-450/T)$	(a)
		298	$k_1/k = 0.16$	(b)
			(a) k_1 refers to H atom abstraction	
			(b) Fraction of rxn proceeding by abstraction; expression for k_1 extrapolated to 298K	
	Hansen, Atkinson, Pitts (1975)	298	$(5.78 \pm 0.58) \times 10^{-12}$ total rxn; P = 100-600 torr Ar	
	Davis, Bollinger, Fischer (1975)	298	3.60×10^{-12} P = 3 torr He	total rxn
			5.00×10^{-12} P = 20 torr He	total rxn
			6.11×10^{-12} P = 100 torr He	total rxn
19,61	$H\emptyset + CF_2Cl_2 \rightarrow$ products			
	†*NASA (1977) eval	200-300	$k < 1 \times 10^{-12}exp(-3560/T)$	(a,b)
	Atkinson, Hansen, Pitts (1975)	297-424	$k < 1 \times 10^{-15}$	(a)
	Howard, Evenson (1976a)	296	$k < 4 \times 10^{-16}$	(a)
	Chang, Kaufman (1977)	480	$k < 6 \times 10^{-16}$	(a)
			(a) upper limit only	
			(b) Expression based on upper limit at 480K reported by Chang and Kaufman. "A factor" chosen; E/R value derived	
19,62	$H\emptyset + CFCl_3 \rightarrow$ products			
	†*NASA (1977) eval	200-300	$k < 1 \times 10^{-12}exp(-3650/T)$	(a,b)
	Atkinson, Hansen, Pitts (1975)	297-424	$k < 1 \times 10^{-15}$	(a)
	Howard, Evenson (1976a)	296	$k < 5 \times 10^{-16}$	(a)
	Chang, Kaufman (1977)	480	$k < 5 \times 10^{-16}$	(a)
			(a) upper limit only	
			(b) Expression based on upper limit at 480K reported by Chang and Kaufman. "A factor" chosen; E/R value derived	
19,63	$H\emptyset + CCl_4 \rightarrow$ products			
	Howard, Evenson (1976a)	296	$k < 4 \times 10^{-15}$	upper limit only
19,64	$H\emptyset + CH_3Cl \rightarrow H_2\emptyset + CH_2Cl$			
	†*NASA (1977) eval	200-300	$2.2 \times 10^{-12}exp(-1142/T)$	
	Davis, et al (1976)	250-350	$(1.84 \pm 0.18) \times 10^{-12}exp(-1098 \pm 35/T)$	
	Perry, Atkinson, Pitts (1976)	298-423	$4.1 \times 10^{-12}exp(-1359 \pm 150/T)$	
	Howard, Evenson (1976a)	296	$(3.6 \pm 0.8) \times 10^{-14}$	±0.2 at 230K
19,64	$H\emptyset + CH_2Cl_2 \rightarrow H_2\emptyset + CHCl_2$			
	†*NASA (1977) eval	200-300	$5.2 \times 10^{-12}exp(-1094/T)$	
	Davis, et al (1976)	245-375	$(4.27 \pm 0.63) \times 10^{-12}exp(-1094 \pm 81/T)$	±0.2 at 230K
	Perry, Atkinson, Pitts (1976)	298	$(1.45 \pm 0.20) \times 10^{-13}$	
	Howard, Evenson (1976)	296	$(1.55 \pm 0.14) \times 10^{-13}$	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
19,64	HO + CHCl₃ → H₂O + CCl₃			
	++Davis, et al (1976)	245-375	$(4.69 \pm 0.71) \times 10^{-12}\exp(-1134 \pm 108/T)$	±0.2 at ?30K
	Howard, Evenson (1976a)	296	$1.01 \pm 0.15 \times 10^{-13}$	
19,65	HO + CHFCl₂ → H₂O + CFCl₂			
	++NASA (1977) eval	200-300	$1.3 \times 10^{-12}\exp(-1127/T)$	±0.2 at 230K
	Perry, Atkinson, Pitts (1976)	298-422	$1.75 \times 10^{-12}\exp(-1253 \pm 150/T)$	
	Chang, Kaufman (1977)	241-396	$(1.16 \pm 0.17) \times 10^{-12}\exp(-1073 \pm 40/T)$	
	Watson, et al (1977)	245-375	$(1.87 \pm 0.2) \times 10^{-12}\exp(-1245 \pm 26/T)$	
	Howard, Evenson (1976a)	296	2.6×10^{-14}	
19,65	HO + CHF₂Cl → H₂O + CF₂Cl			
	++NASA (1977) eval	200-300	$1.2 \times 10^{-12}\exp(-1660/T)$	±0.08 at 230K
	Atkinson, Hansen, Pitts (1975)	297-434	$1.21 \times 10^{-12}\exp(-1636 \pm 150/T)$	
	Chang, Kaufman (1977)	253-427	$(1.20 \pm 0.16) \times 10^{-12}\exp(-1657 \pm 39/T)$	
	Watson, et al (1977)	250-350	$(9.25 \pm 1.0) \times 10^{-13}\exp(-1575 \pm 71/T)$	
	Howard, Evenson (1976a)	296	3.4×10^{-15}	
19,65	HO + CH₂FCl → H₂O + CHFCl			
	++Watson, et al (1977)	245-375	$(2.84 \pm 0.3) \times 10^{-12}\exp(-1259 \pm 50/T)$	±0.?
	Howard, Evenson (1976a)	296	$3.7 \pm 0.6 \times 10^{-14}$	
19,65	HO + CH₃F → products			
	Howard, Evenson (1976a)	296	$16 \pm 2 \times 10^{-15}$	
19,65	HO + CH₂F₂ → products			
	Howard, Evenson (1976a)	296	$7.8 \pm 1.2 \times 10^{-15}$	
19,65	HO + CHF₃ → products			
	Howard, Evenson (1976a)	296	2×10^{-16}	
19,65	HO + CF₄ → products			
	Howard, Evenson (1976a)	296	$k < 4 \times 10^{-16}$	upper limit only
19,65	HO + CF₃Cl → products			
	Howard, Evenson (1976a)	296	$k < 7 \times 10^{-16}$	upper limit only
19,65	HO + CH₃Br → H₂O + CH₂Br			
	++Davis, et al (1976)	245-350	$(7.93 \pm 0.79) \times 10^{-13}\exp(-889 \pm 98/T)$	±0.2 at 230K
	Howard, Evenson (1976a)	296	$35 \pm 8 \times 10^{-13}$	
19,65	HO + CH₃CCl₃ → products			
	++NASA (1977) eval	200-300	$3.5 \times 10^{-12}\exp(-1562/T)$	±0.36 at 230K
	Watson, et al (1977)	260-375	$(3.72 \pm 0.4) \times 10^{-12}\exp(-1627 \pm 50/T)$	
	Chang, Kaufman (1977)	275-405	$(1.95 \pm 0.24) \times 10^{-12}\exp(-1333 \pm 37/T)$	
	Howard, Evenson (1976b)	296	$15 \pm 3 \times 10^{-15}$	
19,65	HO + C₂HCl₃ → products			
	++NASA (1977) eval	200-300	2.3×10^{-12}	±0.36
	Chang, Kaufman (1977)	234-420	$(5.32 \pm 0.71) \times 10^{-13}\exp(+445 \pm 41/T)$	
	Davis (1977)	300	$2.35 \pm 0.25 \times 10^{-12}$	
	Howard (1976)	296	$2.0 \pm 0.4 \times 10^{-12}$	preliminary

No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm^3molecule^{-1}s^{-1}	Notes and Reliability of log k
19,65	HΘ + C_2Cl_4 → products			
	+*Chang, Kaufman (1977)	297-420	$(9.44 \pm 1.34) \times 10^{-12}exp(-1199 \pm 55/T)$	±0.36 at 230K
	Davis (1977)	260-375	$(1.06 \pm 0.5) \times 10^{-11}exp(-1300 \pm 150/T)$	preliminary
	Howard (1976)	296	$1.70 \times 0.34 \times 10^{-13}$	
19,65	HΘ + CH_3CF_2Cl → products			
	Watson, et al (1977)	273-375	$(1.15 \pm 0.15) \times 10^{-12}exp(-1748 \pm 30/T)$	
	Howard, Evenson (1976b)	296	$2.8 \pm 0.4 \times 10^{-15}$	
19,65	HΘ + $CF_2ClCFCl_2$ → products			
	Watson, et al (1977)	298	$k < 3 \times 10^{-16}$	upper limit only
20,M	$HΘ_2$ + M → H + $Θ_2$ + M		see reverse reaction	
20,M	$HΘ_2$ + M → HΘ + Θ + M		see reverse reaction	
20,20	$HΘ_2$ + $HΘ_2$ → $H_2Θ_2$ + $Θ_2$		$-d[HΘ_2]/dt = 2k[HΘ_2]^2$	
	+*Hamilton, Lii (1977)	258	2.5×10^{-12}	±0.3 (a)
			(a) Supersedes result reported in Hamilton (1975)	
	Baulch, et al (1972) review	300	3.3×10^{-12}	
	Lloyd (1974) review	300-1000	1.7×10^{-11} exp(-500/T) Temperature coefficient	larger at higher T
20,21	$HΘ_2$ + H_2 → $H_2Θ_2$ + H			
	Baulch, et al (1972) review	300-800	1.2×10^{-12} exp(-9400/T)	±0.3
	Lloyd (1974) review	300-1000	same recommendation. $k_f = k_r K_{eq}$	
20,22	$HΘ_2$ + $H_2Θ$ → $H_2Θ_2$ + HΘ			
	Baulch, et al (1972) review	300-800	4.7×10^{-11} exp(-16,500/T)	±0.2
	Lloyd (1974) review	300-1000	same recommendation $k_f = k_r K_{eq}$	
20,28	$HΘ_2$ + $SΘ_2$ → $SΘ_3$ + HΘ			
	*Payne, Stief, Davis (1973)	300	9×10^{-16} cm^{3}molecule^{-1}s^{-1}	±0.3 (a)
			(a) Relative rate measurement. Value based on k($HΘ_2$ + $HΘ_2$) this survey.	
20,35	$HΘ_2$ + Cl → HCl + $Θ_2$			
	+*Leu, DeMore (1976)			
20,35Br	$HΘ_2$ + Br → HBr + $Θ_2$		3×10^{-11}	±0.6 at 230K
	+*NASA (1977) eval	200-300	5×10^{-12} (a) estimate - no data	±1.5 at 230K (a)
20,36	$HΘ_2$ + ClΘ → HΘCl + $Θ_2$			
	+*NASA (1977) eval	200-300	2×10^{-13}	±1 at 230K (a)
			(a) No data; value assumed to be intermediate between k($HΘ_2$ + $HΘ_2$) and k(ClΘ + ClΘ)	
20,45	$HΘ_2$ + CΘ → $CΘ_2$ + HΘ			
	*This survey	300	$<10^{-19}$	
	Baulch, et al (1976) review	700-1000	$2.5 \times 10^{-10}exp(-11900/T)$	±0.5 [a]

No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Lloyd (1974) eval.	300-1000	1.7×10^{-13} exp(-5000/T)	b
	Westenberg, deHaas (1972a)	300	~1 x 10^{-12}	c,d
	Davis, Payne, Stief (1973)	300	<10^{-20}	e
	Wyrsch, et al (1974)	300	<3 x 10^{-18}	e
	Simonaitis, Heicklen (1973a)	373-473	<5 x 10^{-18}	e
	Volman, Gorse (1972)	330	<10^{-15}	f
	Baldwin, Walker, Webster (1970)	713-773	1 x 10^{-10} exp(-11500/T)	e
	Vardanyan, Dangyan, Sachyan (1972)	878-952	2.2×10^{-10} exp(-11500/T)	

NOTE:

a. The low value of k selected in this evaluation is based on the evaluation by Lloyd and the measurements by Davis, Payne, Stief and Simonaitis, Heicklen.

b. Based on Davis, Payne and Stief (1972) and high T results. Temperature coef. probably maximum value.

c. Indirect measurement using a low-pressure discharge flow system.

d. Relative rate measurement - reference reaction:
$H + HO_2 \rightarrow HO + HO$

e. Relative rate measurement - reference reaction:
$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$

f. Relative rate measurement - reference reaction:
$HO_2 + CO \rightarrow CO_2 + H$

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability
20,48	$HO_2 + CH_2O \rightarrow H_2O_2 + CHO$ *Lloyd (1974) review	300-800	1.7×10^{-12} exp(-4000/T)	>±1 at 300K, ±0.2 at 800K (a)
	Baldwin, et al (1972)	773	1.6 x 10^{-15}	(a)

(a) Derived by computer fit to data. Based on
$k(HO_2 + HO_2 \rightarrow H_2O_2 + O_2) = 3.0 \times 10^{-12} cm^3 molecule^{-1}s^{-1}$

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes
20,51	$HO_2 + CH_3O_2 \rightarrow CH_3O_2H + O_2$ Demerjian et al (1972) review	300	6.7 x 10^{-14}	estimate
20,57	$HO_2 + C_2H_4 \rightarrow C_2H_4O + HO$? Walker (1973)	773	2.5 x 10^{-17}	(a)

(a) Relative to k ($HO_2 + HCHO$) = 1.6 x 10^{-15}

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes
20,57	$HO_2 + C_2H_4 \rightarrow$ addition products Lloyd (1974) review	300	~1.7 x 10^{-17}	> ±1 (a)

(a) Suggestion. Data are irreconcilable.

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes
20,58	$HO_2 + C_2H_6 \rightarrow H_2O_2 + C_2H_5$ Lloyd (1974) review	300-1000	~1.7 x 10^{-12} exp(-7000/T)	±1 (a)

(a) Relative rate data versus $2HO_2 \rightarrow H_2O_2 + O_2$
and $HO_2 + CO \rightarrow HO + CO_2$. Temp. coef. estimated.

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes
20,60	$HO_2 + C_3H_8 \rightarrow H_2O_2 + 1-C_3H_7$ Lloyd (1974) review	300-1000	<3.3 x 10^{-13} exp(-5300/T)	±1 (a)

No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k
20,60	$HO_2 + n\text{-}C_4H_{10} \rightarrow H_2O_2 + s\text{-}C_4H_9$ (primarily) Lloyd (1974) review	300-1000	$8.3 \times 10^{-13} \exp(-5300/T)$	±1 (a)
20,60	$HO_2 + i\text{-}C_4H_{10} \rightarrow H_2O_2 + t\text{-}C_4H_9$ Lloyd (1974) review	300-1000	$1.7 \times 10^{-13} \exp(-3500/T)$	±1 (a)
20,60	$HO_2 + $ alkane $\rightarrow H_2O_2 + $ alkyl radical Walker (1977)	300-800	$k = 8 \times 10^{-14}[N_p\exp(-7520/T) + N_s\exp(-6330/T) + N_t\exp(-4990/T)]$	
21,M 21,35	$H_2 + M \rightarrow H + H + M$ $H_2 + Cl \rightarrow HCl + H$ **Watson (1977) eval Watson, et al (1977) Lee, et al (1977)	200-300 213-350 200-500	$3.5 \times 10^{-11}\exp(-2290/T)$ $(5.5 \pm 0.5) \times 10^{-11}\exp(-2375 \pm 100/T)$ $(2.66 \pm 0.42) \times 10^{-11}\exp(-2230 \pm 60/T)$	±0.12 at 230K
21,36	$H_2 + ClO \rightarrow$ products **NASA (1977) eval	200-300	$k \leq 1 \times 10^{-12}\exp(-4800/T)$	±2 at 230K (a)
22,29	$H_2O + SO_3 \rightarrow$ products Castleman, et al (1975)	298	$9.1 \pm 2.9 \times 10^{-13}$	
23,hv	$H_2O_2 + h\nu \rightarrow HO + HO$ DeMore (1977)			

Notes:

(a) Based on upper limit meas. Temp. coef. estimated.

(a) Based on upper limit meas. Temp. coef. estimated.

(a) Based on upper limit meas. Temp. coef. estimated.

where N_p, N_s, and N_t are the number of primary, secondary, and tertiary hydrogen atoms respectively
see reverse reaction

(a) "A factor" chosen. Fact fitted to upper limit at T = 670K reported in Watson's review (1977)

λ/nm	10²⁰ x σ		λ/nm	10²⁰ x σ	(a)
200	48.3		280	2.1	
210	36.3		290	1.14	
220	26.4		300	0.66	
230	18.7		310	0.38	
240	12.9		320	0.21	
250	8.9		330	0.13	
260	5.5		340	0.08	
270	3.4		350	0.04	

(a) σ is the absorption cross section in units of cm²molecule⁻¹(base e). These values by DeMore (private communication) are in good agreement (within 10%) with unpublished results by Molina, et el and with results of Holt, et al (1948) over common ranges of measurements

Quantum yields (primary)
$\emptyset(-H_2O_2) = 1.0 \quad \lambda > 200nm$
Hampson (1973) review

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No.	Reaction/Reference * = Preferred Value † = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3 molecule^{-1}s^{-1}$	Notes and Reliability of log k
23,M 23,35	$H_2O_2 + M \rightarrow HO + HO + M$ $H_2O_2 + Cl \rightarrow HCl + HO_2$		see reverse equation	
23,35Br	$H_2O_2 + Br \rightarrow HBr + HO_2$ †Watson (1977) review	265-400	$1.7 \times 10^{-12} exp(-384/T)$	±0.35 at 230K
24,M	$HO + M \rightarrow H + NO + M$ †NASA (1977) eval	200-300	$5 \times 10^{-12} exp(-1570/T)$	±0.6 at 230K
	*Baulch, et al (1973) review	230-700	$5 \times 10^{-8} exp(-24,500/T)$ M = H_2 (a) No data. Value based on reverse rate	±0.2 (a)
24,24	$HO + HNO \rightarrow H_2O + N_2O$ *Baulch, et al (1973) review	300	4×10^{-15}	±0.3
25,hν	$HNO_2 + h\nu \rightarrow NO$ (a) $\rightarrow H + NO_2$ (b) Molina (1977) review	300	table of absorption cross sections for wavelength range 200-400nm. (a) Gives corrected values which supersede results in Johnston, Graham (1974). Also gives results of Cox and Derwent (1976)	(a)
	Cox, Derwent (1976)	300	table of absorption cross sections for λ = 200-400nm Φa ≥ 0.97	(a)
	Cox (1974b)		(a) Photolysis 330 < λ/nm < 380	(a)

Elevation/km   k(noon)/s⁻¹   k(24 hr. av.)/s⁻¹

Elevation/km	k(noon)/s⁻¹	k(24 hr. av.)/s⁻¹
15	5.1×10^{-7}	1.5×10^{-7}
20	7.7×10^{-7}	2.3×10^{-7}
25	2.8×10^{-6}	6.8×10^{-7}
30	1.4×10^{-5}	3.5×10^{-6}
35	4.1×10^{-5}	1.2×10^{-5}
40	7.6×10^{-5}	2.7×10^{-5}
45	1.1×10^{-4}	4.2×10^{-5}

±0.15 Rates are for 45° latitude solar equinox standard ozone background

No.	Reaction/Reference	Temp. Range/K	Reaction Rate Constant	Notes and Reliability
26,hν	$HNO_3 + h\nu \rightarrow HO + NO_2$ *Johnston (1974) review	217 217 222 227 237 251 265	Table of absorption coefficients for λ = 190-325nm	
	Johnston, et al (1974)		Φ = 1 200 < λ < 315nm (a) Products probably those shown above.	(a)
	Biaume (1973)		Absorption cross section data for 185 < λ < 325 nm in good agreement with that of Johnston and Graham (1973).	
	Beddard, et al (1974)		figure showing extinction coefficient vs λ for λ = 120-170nm see reverse reaction	
26,M 26,35	$HNO_3 + M \rightarrow HO + NO_2 + M$ $HNO_3 + Cl \rightarrow HCl + NO_3$ †NASA (1977) eval	200-300	$1.0 \times 10^{-11} exp(-2170/T)$	±0.6 at 230K (a)
	Leu, DeMore (1976)	295	$(6.8 \pm 3.4) \times 10^{-15}$ (a) "A factor" chosen. Eact derived to fit room temp. result of Leu, DeMore.	

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3\,molecule^{-1}s^{-1}$	Notes and Reliability of log k
26,34b	S + CS$_2$ → S$_2$ + CS			
	Baulch, et al (1976) review			
26,34c	S + COS → CO + S$_2$	298	6.5×10^{-13}	±0.2
	Baulch, et al (1976) review			
27,27	SO + SO → SO$_2$ + S or (SO)$_2$	230–2600	$2.8 \times 10^{-12}\exp(-2050/T)$	±0.5
	Schofield (1973) review	300	$< 3 \times 10^{-15}$	
		1000	$< 2 \times 10^{-13}$	
27,29	SO + SO$_3$ → 2SO$_2$	300	$8.3 \pm 6.7 \times 10^{-16}$	±0.1
	Chung, Calvert, Bottenheim (1975)			
28,49M	SO$_2$ + CH$_3$ (+M) → CH$_3$SO$_2$ (+M)	300	$2 \pm 1.2 \times 10^{-15}$	±0.2
	Chung, Calvert, Bottenheim (1975)			
31,31	HS + HS → H$_2$S + S	300	3×10^{-13} cm^3 molecule^{-1} s^{-1}	
	James, et al (1973)			
35,35M	Cl + Cl + M → Cl$_2$ + M	295	1.2×10^{-11}	
	Baulch, et al (1976) review			
35,37	Cl + OClO → 2ClO	200–500	$6 \times 10^{-34}\exp(900 \pm 250/T)$ cm^6 molecule^{-2} s^{-1}	M = Ar
	*Watson (1977) review			
35,37	Cl + ClOO → Cl$_2$ + O$_2$ (a) → 2ClO (b)	300–588	$(5.9 \pm 0.9) \times 10^{-11}\exp(0 \pm 120/T)$	±0.1
	++Watson (1977) review			
	++NASA (1977) eval		$k_a = 1.6 \times 10^{-10}$	
			$k_b = 1.1 \times 10^{-11}$	
	Johnston, et al (1969)	298	$k_a/k_b = 108$	
	Nicholas, Norrish (1968)		$k_a = 1.56 \times 10^{-10}$	
			$k_a/k_b = 15$	
35,44a	Cl + Cl$_2$O → Cl$_2$ + ClO	298	6.8×10^{-13}	
	*Watson (1977) review			
35,42	Cl + NOCl → NO + Cl$_2$	300	$3 \pm 0.5 \times 10^{-11}$	
	++Watson (1977) review			
35,43	Cl + NO$_2$Cl → NO$_2$ + Cl$_2$	298	$k >> 3 \times 10^{-14}$	
	Watson (1977) review			
35,43a	Cl + NO$_3$Cl → products	224–273	$1.68 \times 10^{-12}\exp(-607/T)$	±0.3
	++Kurylo, Manning (1977)			
35,56	Cl + CH$_4$ → HCl + CH$_3$	200–300	$7.3 \times 10^{-12}\exp(-1269/T)$	
	++Watson (1977) review	218–322	$(7.93 \pm 1.53) \times 10^{-12}\exp(-1273 \pm 51/T)$	
	Manning, Kurylo (1977)	218–401	$(7.94 \pm 0.7) \times 10^{-12}\exp(-1260 \pm 35/T)$	
	Watson, et al (1976)	200–500	$5.44 \times 10^{-19}\,T^{2.50}\exp(-608/T)$	(a)
	Whytock, et al (1977)	200–299	$(6.51 \pm 0.79) \times 10^{-12}\exp(-1229 \pm 27/T)$	
	Zahniser, et al (1978)	200–500	$8.6 \times 10^{-18}\,T^{2.11}\exp(-795/T)$	(b)
		200–300	$(8.2 \pm 0.6) \times 10^{-12}\exp(-1320 \pm 20/T)$	
	Davis, et al (1970)	300	$1.5 \pm 0.1 \times 10^{-13}$	

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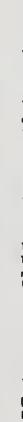| No.	Reaction/Reference * = Prefered Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3\,molecule^{-1}s^{-1}$	Notes and Reliability of log k
	Fettis, Knox (1964) Clyne, Walker (1973)	300-686	$4 \times 10^{-11} \exp(-1930/T)$ $5.1 \times 10^{-11} \exp(-1790/T)$ (a) Based on four direct 1976, 1977 studies listed immediately below. Uncertainty in log k(230K) is +0.12 and -0.36 (b) Value changed subsequent to publication to allow for effect of small C_2H_6 impurity see Watson's review (1977)	
35,58	$Cl + C_2H_6 \rightarrow HCl + C_2H_5$			
36,hv	Manning, Kurylo (1977) $ClO + hv \rightarrow Cl + O$ *Watson (1977) review	22-322	$(7.29 \pm 1.23) \times 10^{-11} \exp(+50 \pm 44/T)$ absorption cross section data $225 < \lambda < 300$ nm	
36,36	$ClO + ClO \rightarrow ClOO$ (a) $\rightarrow Cl_2 + O_2$ (b) $\rightarrow OClO + Cl$ (c) +*NASA (1977) eval	200-300	$k_a = 1 \times 10^{-12} \exp(-1238/T)$ $k_b = 5 \times 10^{-13} \exp(-1238/T)$ $k_c = 2 \times 10^{-12} \exp(-2200/T)$ (a) $-d[ClO]/dt = k[ClO]^2$. Low pressure. See Watson's review (1977) for high pressure rec.	±0.2 at 230K (a) ±0.2 at 230K ±1 at 230K
36,36Br	$ClO + BrO \rightarrow Br + OClO$ (a) $\rightarrow Br + ClOO$ (b) +*Watson (1977) review		$k_a = (6.7 \pm 1.0) \times 10^{-12}$ $k_b = (6.7 \pm 1.0) \times 10^{-12}$	±0.36 at 230K ±0.36 at 230K
36,45	$ClO + CO \rightarrow CO_2 + Cl$ +*NASA (1977) eval	200-300	$k \leq 1 \times 10^{-12} \exp(-3700/T)$ (a) "A factor" chosen. E_{act} fitted to upper limit at T = 587K reported in Watson's review (1977)	±2 at 230K (a)
36,56	$ClO + CH_4 \rightarrow$ products +*NASA (1977) eval	200-300	$k \leq 1 \times 10^{-12} \exp(-3700/T)$ (a) "A factor" chosen. E_{act} fitted to upper limit at T = 670K reported in Watson's review (1977)	±2 at 230K (a)
36,57	$ClO + C_2H_4 \rightarrow$ products Walker (1972)	670	$k < 5 \times 10^{-16}$ (a) As quoted by Watson (1977) review.	(a)
36,59	$ClO + C_2H_2 \rightarrow$ products Walker (1972)	670	$k < 5 \times 10^{-16}$ (a) As quoted by Watson (1977) review.	(a)
36Br,36Br	$BrO + BrO \rightarrow 2Br + O_2$ +*NASA (1977) eval Clyne, Watson (1975) Clyne, Cruse (1970)	200-300 298 293	$2.9 \times 10^{-11} \exp(-450/T)$ 6.4×10^{-12} $5.3 \times 10^{-12} \exp(-450/T)$	±0.36 at 230K

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k

37,M — ClOO + M → Cl + O₂ + M / Watson (1977) review
Table of values of rate constant as a function of altitude.

37,hv — ClOO + hv → ClO + O / Watson (1977) review
absorption cross section data $225 < \lambda < 280$ nm

37,hv — OClO + hv → ClO + O / Watson (1977) review
Abs. cross section data $150 < \lambda < 480$nm

39,hv — HCl + hv → H + Cl / Watson (1977) review
absorption cross section data $140 < \lambda < 220$ nm

40,hv — HOCl + hv → products / Watson (1977) review

42,hv — NOCl + hv / Watson (1977) review
Abs. cross section data $290 < \lambda < 450$nm
Table of absorption cross section values for $\lambda = 190\text{-}400$nm

43,hv — ClNO₂ + hv / Molina (1977) review
Absorption cross section data for $\lambda = 190\text{-}400$nm

43,hv — ClONO + hv / Molina (1977)
Absorption cross section data for $\lambda = 235\text{-}400$nm
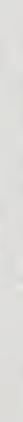
43a,hv — NO₃Cl + hv / Rowland, Spencer, Molina (1976)
Table of absorption cross section values for $\lambda = 186\text{-}460$nm. Also table of solar photodissociation coefficients Data also tabulated in reviews by Watson (1977) and by Molina (1977). Molina's review also discusses quantum yield data

44,hv — Cl₂ + hv → 2Cl / Watson (1977) review
absorption cross section data $240 < \lambda < 450$ nm

45,50 — CO + CH₃ → · · · ·
see CH₃O + CO

48,hv — CH₂O + hv → CH₂O* → H + HCO (1) → H₂ + CO (2) / This survey (1978)

λ/nm	ϕ_1	$\phi_1 + \phi_2$
285	0.61	0.90
290	0.74	1
295	0.74	1
300	0.74	1
305	0.74	1
310	0.74	1
315	0.74	1
320	0.60	1
325	0.45	1
330	0.31	1

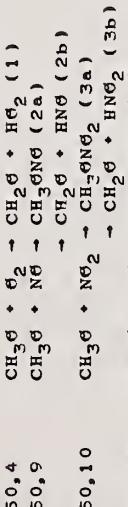| No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant k/cm³molecule⁻¹s⁻¹	Notes and Reliability of log k

$$
\begin{array}{lll}
& 335 & 0.17 & 1 \\
& 340 & 0.02 & 0.64
\end{array}
$$

Tentative recommendation based principally on results reported by Horowitz and Calvert (1978a) and by Moortgat, et al (1978). Also considers results reported in Clark, Moore and Nogar (1977), Horowitz and Calvert (1978b), Houston and Moore (1976), Lewis and Lee (1977), Lewis, Tang and Lee (1976) and Marling (1977).

Apparent quantum yield values are slightly higher in presence of O_2. Effect is assumed here to be due to secondary reactions.

Calvert, et al (1972)

λ/nm	$10^{20} \times \sigma$	λ/nm	$10^{20} \times \sigma$	(a)
290	3.18	330	2.36	
300	3.25	340	1.97	
310	3.14	350	0.84	
320	2.34	360	0.18	

(a) σ is the value of the absorption cross section averaged for 10nm bands. See McQuigg, Calvert (1969) for figure of of absn. coeff. vs wave length. Also see Miller and Lee (1977) for higher resolution spectra from which absorption cross section values can be derived.

50,4	$CH_3O + O_2 \rightarrow CH_2O + HO_2$ (1)			
50,9	$CH_3O + NO \rightarrow CH_3ONO$ (2a)			
	$\rightarrow CH_2O + HNO$ (2b)			
50,10	$CH_3O + NO_2 \rightarrow CH_3ONO_2$ (3a)			
	$\rightarrow CH_2O + HNO_2$ (3b)			
50,45	$CH_3O + CO \rightarrow products$ (4)			

*Heicklen (1973)

298    $k_1 \sim 3 \times 10^{-18}$

     $\sim 1.6 \times 10^{-13} \exp(-3300/T)$

     $k_2 \sim 8 \times 10^{-14}$

298    $k_1/k_2 = 4.7 \times 10^{-5}$ ±20%   ratio probably is smaller at 220K

     $k_{2b}/k_2 = 0.145$ ±0.015

298    $k_2/k_3 = 1.2$ ±0.1

363    $k_{2a}/k_{3a} = 1.1$

403          $= 1.8$

           $= 2.7$

298    $k_{3a}/k_3 = 0.9$ ±0.1 k_{3a}/k_{3b}

258    $k_{3b}/k_3 = 0.1$ ±0.01   probably constant 300-400K

298-423 $k_4/k_2 = 5 \times 10^{-4}$

Demerjian, et al (1974) review

300-400 $k_1 = 1.6 \times 10^{-17}$

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No.	Reaction/Reference * = Preferred Value + = NASA (1977) eval	Temp. Range/K	Reaction Rate Constant $k/cm^3\,molecule^{-1}s^{-1}$	Notes and Reliability of log k
			$\sim 4.2 \times 10^{-13}\ exp(-3000/T)$ adjusted to fit C_4H_{10}/NO_x simulation studies	
	Batt, McCulloch, Milne (1975)	393-473	$k_{2a} = 1.7 \times 10^{-13}$ $k_{2b}/k_{2a} = 0.17$ $k_{3a} = 3.3 \times 10^{-13}$ $k_{3b}/k_{3a} = 0.1$	±0.4
51,51	Barker, et al (1977) $2CH_3O_2 \rightarrow 2CH_3O + O_2$ (a) $\rightarrow CH_3OH + CH_2O + O_2$ (b) $\rightarrow CH_3O_2CH_3 + O_2$ (c)	396-442	$k_{2a} \sim 3 \times 10^{-11}$ $k_{2b} \sim 7 \times 10^{-12}$ $k_1 = 5 \times 10^{-13}exp(-2000/T)$	±0.5
	Weaver, et al (1975)	300	$k_a/k = 0.43$ $k_b/k = 0.50$ $k_c/k = 0.07$	
	Parkes (1977)	300	$k_a = 1.6 \pm 0.4 \times 10^{-13}$ $k_b + k_c = 3.0 \pm 0.8 \times 10^{-13}$	
54,hν	$CH_3ONO + h\nu \rightarrow CH_3O^* + NO$ (a) $\rightarrow$ isomer (b) $\rightarrow CH_2O + HNO$ (c) $\rightarrow CH_2O + H + NO$ (d) *Heicklen (1973) review	298 298 298	$k_a/k = 0.76 \pm 0.02, \lambda = 366nm$ $k_b/k = 0.24 \pm 0.04, \lambda = 366nm$ $(k_c + k_d)/k < 0.02, \lambda = 366nm$ $k = k_a + k_b + k_c + k_d$	
61,hν	$CF_2Cl_2 + h\nu$ Watson (1977) review		Absorption cross section data for $174 < \lambda/nm < 220$ Low temperature absorption cross section data	
62,hν	$CFCl_3 + h\nu$ Watson (1977) review		Tabulated values of absorption cross sections for $174 < \lambda/nm < 230$. Low temperature abs. cross section data	
63,hν	$CCl_4 + h\nu$ Watson (1977) review		Absorption cross section data for $174 < \lambda/nm < 238$. see Watson's review (1977)	

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APPENDIX 1.

Chemical Thermodynamic Properties of Selected Molecular Species

E. S. Domalski, D. Garvin, and D. D. Wagman

Two tables are provided showing chemical thermodynamic properties of selected molecular species of interest in stratospheric chemistry. In these tables there are sufficient data for the usual calculations of heats of reaction and equilibria.

The first table lists enthalpy and Gibbs energy of formation, entropy and heat capacity data. The information was extracted from "Selected Values of Chemical Thermodynamic Properties" (D. D. Wagman, et al, NBS Technical Note 270-3, January 1968) except as indicated in the Notes. The thermodynamic properties tabluated are:

1. enthalpy of formation at OK and 298.15K,

2. Gibbs energy of formation at 298.15K,

3. enthalpy increment between OK and 298.15K,

4. entropy at 298.15K,

5. heat capacity at constant pressure at 298.15K.

The values given for the heats of formation are based on experimental thermodynamic and spectroscopic measurements except where otherwise indicated; the values of $S°$, $C_p°$ and $H_{298}° - H_0°$ for gaseous species were calculated by standard statistical-mechanical equations, using corrections for vibrational anharmonicities, rotational stretching, and rotation-vibration interactions where these data were available.

The second table presents bond dissociation energies or bond strengths. These usually are the enthalpies of simple bond scission reactions. However, there are some cases in which there is a substantial contribution from rearrangement of electronic structure in the products (reducing the bond energy).

The values given here for some molecules may differ slightly from values adopted by the CODATA Task Group on Key Values for Thermodynamics (see CODATA Bulletin 17, published by the International Council of Scientific Unions Committee on Data for Science and Technology, January 1976). These differences will have no significant effect on the enthalpies or free energies of reaction calculated from the tables.

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity *

Substance Formula and Description	State	Formula Weight	ΔHf_0° 0°K	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°	
					298.15°K (25°C)				
				kcal/mol			cal/deg mol		
O oxygen, atomic	g	15.9994	58.983	59.553	55.389	1.607	38.467	5.237	(1)
O(^{1}D)	g	15.9994	104.34·	104.78		1.481			(1)
O(^{1}S)	g	15.9994	155.60	156.04		1.481			(2)
O$_2$ oxygen, molecular, ($^3\Sigma_g^-$)	g	31.9988	0	0	0	2.0746	49.003	7.016	(1)
O$_2$($^1\Delta$)	g	31.9988	22.54	22.54		1.481			(1)
O$_2$($^1\Sigma$)	g	31.9988	37.51	37.51		1.481			
O$_3$ ozone	g	47.9982	34.74	34.1	39.0	2.4736	57.08	9.37	(30)
H hydrogen, atomic	g	1.0080	51.633	52.103	48.588	1.481	27.391	4.9679	
H$_2$ hydrogen, molecular	g	2.0159	0	0	0	2.0238	31.208	6.889	
OH hydroxyl	g	17.0074	9.25	9.31	8.18	2.1070	43.890	7.143	
HO$_2$ hydroperoxyl	g	33.0068	1.2±2	0.5±2	3.4	2.39	54.73	8.34	(34)
H$_2$O water	g	18.0153	-57.102	-57.796	-54.634	2.3667	45.104	8.025	
H$_2$O$_2$ hydrogen peroxide	g	34.0147	-31.08	-32.58	-25.24	2.594	55.6	10.3	
N nitrogen, atomic	g	14.0067	112.534	112.979	108.883	1.481	36.622	4.968	
N$_2$ nitrogen, molecular	g	28.0134	0	0	0	2.072	45.77	6.961	
NO nitric oxide	g	30.0061	21.45	21.57	20.69	2.197	50.347	7.133	
NO$_2$ nitrogen dioxide	g	46.0055	8.60	7.93	12.26	2.438	57.35	8.89	
NO$_3$ nitrogen trioxide	g	62.008	18.5	17.0	27.7	2.62	60.4	11.2	
N$_2$O nitrous oxide	g	44.0128	20.435	19.61	24.90	2.284	52.52	9.19	(3)
N$_2$O$_4$ dinitrogen tetroxide	g	92.0110	4.49	2.19	23.38	3.918	72.70	18.47	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

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Substance — Formula and Description	State	Formula Weight	$\Delta Hf°$ 0°K	$\Delta Hf°$	$\Delta Gf°$	$H°_{298} - H°_0$	$S°$	$C°_p$	
				298.15°K (25°C)					
				kcal/mol			cal/deg mol		
N₂O₅ dinitrogen pentoxide	g	108.0104	5.7	2.7	27.5	4.237	85.0	20.2	
NH imino (imidogen)	g	15.0147	82.	82.	80.6	2.060	43.29	6.97	(29)
NH₂ amino	g	16.0226	46.2	45.5	47.8	2.37	46.51	8.02	(4)
NH₃ ammonia	g	17.0306	-9.31	-10.98	-3.93	2.40	46.05	8.38	(30)
HNO nitroxyl hydride	g	31.0142	24.5	23.8	26.859	2.387	52.729	8.279	(3)
HNO₂ cis, nitrous acid	g	47.0135	-17.12	-18.64	-10.27	2.608	59.43	10.70	
trans, nitrous acid	g	47.0135	-17.68	-19.15	-10.82	2.652	59.54	11.01	
cis-trans mixture, equil.	g	47.0135		-19.0	-11.0		60.7	10.9	
HNO₃ nitric acid	g	63.0129	-29.94	-32.28	-17.87	2.815	63.64	12.75	
S sulfur, rhombic	c	32.064	0	0	0	1.054	7.60	5.41	
S sulfur, rhombic	g	32.064	65.7	66.20	56.52	1.591	40.085	5.658	(30)
SO monosulfur monoxide	g	48.0634	1.2	1.2	-5.0	2.087	53.02	7.21	(32)
SO₂ sulfur dioxide	g	64.0628	-70.33	-70.94	-71.74	2.521	59.30	9.53	(30)
SO₃ sulfur trioxide	c	80.0622		-108.63	-88.19		12.5		
	liq	80.0622		-105.41	-88.04		22.85		
	g	80.0622	-93.21	-94.58	-88.69	2.796	61.34	12.11	
H₂SO₄ sulfuric acid	c	98.0775							
	liq	98.0775	-194.069	-194.548	-164.938	6.748	37.501	33.20	(3)
S₂O disulfur monoxide	g	80.1274		33.3	26.3	2.66	63.8	10.5	(3)
HS sulfur monohydride	g	33.0720	33.1	33.3	26.3	2.22	46.73	7.76	(5)

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Substance	State	Formula Weight	ΔHf°0	ΔHf°	ΔGf°	H°298 − H°0	S°	C°p	Ref
Formula and Description			0°K	kcal/mol	298.15°K (25°C)			cal/deg mol	
H_2S hydrogen sulfide	g	34.0799	-4.232	-4.93	-8.02	2.379	49.16	8.18	
C graphite, Acheson spectroscopic	c	12.0112	0	0	0	0.251	1.372	2.038	
CO carbon monoxide	g	28.0106	-27.199	-26.416	-32.780	2.0716	47.219	6.959	
CO_2 carbon dioxide	g	44.0100	-93.963	-94.051	-94.254	2.2378	51.06	8.87	
CH_3 methyl	g	15.0351	35.6	34.8	35.3	2.49	46.38	9.25	(3)
CH_4 methane	g	16.0430	-15.970	-17.88	-12.13	2.388	44.492	8.439	(8)
HCO formyl	g	29.0185	8.9	9.0	5.36	2.386	53.68	8.26	(6)
HCHO formaldehyde	g	30.0265	-25.03	-25.95	-24.51	2.394	52.26	8.46	(7) (24)
CH_3O methoxy	g	31.0345	5.8	3.9	6.4	2.41	64.2	8.9	(8)
CH_3O_2 methylperoxyl	g	47.0339		6.7					(9)
CH_3OOH methyl hydroperoxide	g	48.0347		-30.8	-17.4		67.9	15.	
CH_3NO_2 nitromethane	g	61.0406	-14.546	-17.86	-1.65	3.083	65.69	13.70	(10)(24)
CH_3ONO methyl nitrite	g	61.0406	-13.5	-16.5	-1.5	3.36	69.7	16.5	(11, 12)(24)
CH_3NO_3 methyl nitrate	g	77.0400	-25.9	-29.8	-9.4	3.55	76.1	16.1	(13)
$COCl_2$ phosgene	g	98.9166	-52.195	-52.61	-49.20	3.067	67.74	13.78	

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES

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Table _____

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Formula and Description	State	Formula Weight	ΔHf_0° 0°K	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°	
				kcal/mol	298.15°K (25°C)		cal/deg mol		
C_2H_2 acetylene	g	26.0382	54.324	54.19	50.00	2.392	48.00	10.50	
C_2H_4 ethylene	g	28.0542	14.515	12.49	16.28	2.525	52.45	10.41	
C_2H_5 ethyl radical	g	29.0627		25.7	32.0		59.6	10.9	(14)
C_2H_6 ethane	g	30.0701	-16.323	-20.04	-7.66	2.856	54.85	12.58	(15,16)
C_3H_6 propylene	g	42.0816	8.467	4.88	15.00	3.237	63.80	15.27	(15)
C_3H_8 propane	g	44.0976	-19.684	-25.02	-5.81	3.512	64.51	17.57	(15,16)
C_4H_{10} n-butane	g	58.1248	-23.552	-30.03	-3.97	4.645	74.12	23.29	(15,16)
C_4H_{10} isobutane	g	58.1248	-25.223	-32.07	-4.91	4.276	70.42	23.14	(15,16)
CH_2CO ketene	g	42.0376	-10.66	-11.4	-11.6	2.819	59.16	12.37	(17)
CH_3CO acetyl radical	g	43.0456		-5.8	-3.0		64.5	12.7	(19)
CH_3CHO acetaldehyde	g	44.0536	-37.14	-39.72	-30.31	3.01	59.8	13.7	(18)
CH_3COCl acetyl chloride	g	78.4986	-57.93	-60.07	-51.08	3.529	70.56	16.25	(18)
Cl chlorine, atomic	g	35.453	28.59	28.992	25.173	1.499	39.457	5.220	(30)
ClO chlorine monoxide	g	51.4524	24.33	24.47	23.68	2.278	53.78	8.23	(20)
ClO_2 chlorine dioxide (sym.)	g	67.4518	25.09	24.5	28.8	2.580	61.36	10.03	

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

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Table

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Substance — Formula and Description	State	Formula Weight	ΔHf°_0 (0°K)	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
				kcal/mol	298.15°K (25°C)		cal/deg mol	
ClO_2 chlorine dioxide (unsym.)	g	67.4518	21.7	21.3	25.1	2.78	63.0	11.0 (21)
ClO_3 chlorine trioxide	g	83.4512		37				
HCl hydrogen chloride	g	36.4610	-22.020	-22.062	-22.777	2.066	44.646	6.96 (31)
$HOCl$ hypochlorous acid	g	52.4604	-18.0	-18.7	-15.7	2.440	56.54	8.88
$NOCl$ nitrosyl chloride	g	65.4591	12.81	12.36	15.77	2.716	62.52	10.68
NO_2Cl nitryl chloride	g	81.4585	4.29	3.0	13.0	2.915	65.02	12.71
NO_3Cl chlorine nitrate	g	97.458		6.28				(33)
Cl_2 chlorine, molecular	g	70.906	0	0	0	2.193	53.288	8.104
Cl_2O dichlorine monoxide	g	86.9054	19.62	19.20	23.3	2.806	64.07	11.48 (22)
Cl_2O_4 chlorine perchlorate	g	134.9036				4.16	78.21	20.56 (23)
CF_4 carbon tetrafluoride	g	88.0048	-221.61	-223.04	-212.37	3.043	62.45	14.59 (3)
$CClF_3$ chlorotrifluoromethane	g	104.4594	-168.0	-169.2	-159.5	3.294	68.17	15.99 (3)
CF_2Cl_2 dichlorodifluoromethane	g	120.9140	-116.5	-117.5	-108.2	3.553	71.91	17.31 (3)
CCl_3F trichlorofluoromethane	g	137.3686	-68.24	-69.0	-59.6	3.838	74.00	18.65 (3)
CCl_4 carbon tetrachloride	g	153.8232	-22.42	-22.94	-12.83	4.120	74.02	19.93 (3, 25, 26)

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SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES · SERIES I

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Table

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°	
Formula and Description			0°K		298.15°K (25°C)			cal/deg mol	
				kcal/mol					
CH_3Cl methyl chloride	g	50.4881	-17.69	-19.59	-13.98	2.489	55.99	9.73	(3, 27)
CH_2Cl_2 methylene dichloride	g	84.9331	-21.19	-22.83	-16.49	2.830	64.57	12.16	(3, 25)
$CHCl_3$ chloroform	g	119.3781	-23.49	-24.66	-16.83	3.383	70.63	15.63	(3, 25)
CF_3 trifluoromethyl radical	g	69.0064	-111.7	-112.4	-109.21	2.754	63.33	11.90	(3)
CCl_3 trichloromethyl radical	g	118.3702	19.15	19.	22.09	3.392	70.92	15.21	(3)
C_2Cl_4 tetrachloroethylene	g	165.8343	-2.83	-2.97	5.15	4.759	82.05	22.84	(3)
C_2HCl_3 trichloroethylene	g	131.3893	-1.032	-1.86	4.31	3.975	77.6	19.18	(3)
CH_3CCl_3	g	133.4052	-34.65	-34.01	-18.21	4.30	76.49	22.07	(28)
1,1,1-trichloroethane									
(methyl chloroform)									

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7.   Data obtained from Benson and O'Neal ("Kinetic Data on Gas
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8.   Heat formation value from S. W. Benson "Thermochemical
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9.   Values for $\Delta Hf°$, $S°$, and $Cp°$ at 298.15 K were calculated using
the group additivity method described by Benson and O'Neal
("Kinetic Data on Gas Phase Unimolecular Reactions", NSRDS-NBS-
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10.   The value for ΔHf° [$CH_3ONO(g)$] = -16.5 kcal mol^{-1} was derived
      from the combustion data of Geiseler and Thierfelder (Z. physik.
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      Leermakers and Ramsperger (J. Am. Chem. Soc. 54, 1837-1845
      (1932)) for: $CH_3OH(g) + NOC\ell(g) = CH_3ONO(g) + HC\ell(g)$.

11.   The value for ΔHf° ($CH_3ONO_2(g)$) = -29.8 kcal mol^{-1} was derived
      from the work of Ray and Ogg (J. Phys. Chem. 63, 1522-1523
      (1959)) on the enthalpy of reaction of N_2O_5 with CH_3ONO.

12.   We have chosen S° [$CH_3ONO_2(g)$] = 76.1 cal mol^{-1}K^{-1} based upon
      low temperature thermal data of Gray and Smith (J. Chem. Soc.
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Bond Dissociation Energies, D_o^o at 0 K

Calculated from heats of formation in the accompanying table

Reaction	kJ/mol	kcal/mol	Note
$O_2 \rightarrow 2O$	493.59±0.4	117.97±0.1	
$O_3 \rightarrow O_2 + O$	101.4±2.1	24.24±0.5	
$H_2 \rightarrow 2H$	432.00±0.04	103.25±0.01	
$HO \rightarrow H + O$	423.8±2.1	101.3±0.5	
$HO_2 \rightarrow HO + O$	280±8	67±2	
$\rightarrow H + O_2$	210±8	50±2	
$H_2O \rightarrow HO + H$	493.7±0.8	118.0±0.2	
$H_2O_2 \rightarrow 2HO$	207.1±2.1	49.5±0.5	
$H_2O_2 \rightarrow H + HO_2$	350±8	84±2	
$N_2 \rightarrow N + N$	941.69±0.04	225.07±0.01	
$NO \rightarrow N + O$	627.9	150.1	
$NO_2 \rightarrow NO + O$	300.5	71.83	
$NO_3 \rightarrow NO_2 + O$	205±21	49±5	
$N_2O \rightarrow N + NO$	474.9±4	113.5±1	
$\rightarrow N_2 + O$	161.3	38.58	
$N_2O_3 \rightarrow NO + NO_2$	35.1±0.8	8.4±0.2	
$N_2O_4 \rightarrow NO_2 + NO_2$	53.2	12.7	
$N_2O_5 \rightarrow NO_2 + NO_3$	89.5	21.4	
$HNO \rightarrow H + NO$	203	48.6	
$\rightarrow NH + O$	487	116.5	
$trans\text{-}HNO_2 \rightarrow HO + NO$	202	48.4	
$HNO_3 \rightarrow HO + NO_2$	200	47.8	
$NH \rightarrow H + N$	343	82	

Bond Dissociation Energies, D_o^o at 0 K

Calculated from heats of formation in the accompanying table

Reaction	kJ/mol	kcal/mol	Note
$NH_2 \rightarrow H + HN$	366	87.4	
$NH_3 \rightarrow NH_2 + H$	448	107	
$CO \rightarrow C + O$	1071.94±0.4	256.2±0.1	
$CO_2 \rightarrow CO + O$	525.9±0.4	125.7±0.1	
$CHO \rightarrow CO + H$	70	16.7	(1)
$CH_2O \rightarrow CHO + H$	364	87	(1)
$CH_3O \rightarrow CH_3 + O$	378	90.4	(1)
$\rightarrow H + H_2CO$	93	22	(1)
$CH_3O_2 \rightarrow CH_3O + O$	237	56.8	(1)
$\rightarrow CH_3 + O_2$	118	28.1	(1)
$CH_4 \rightarrow CH_3 + H$	432	103.2	
$CH_3OOH \rightarrow CH_3O + HO$	184.	44.0	(1)
$\rightarrow CH_3 + HO_2$	276±8	66±2	(1)
$CH_3ONO \rightarrow CH_3 + NO_2$	248	59.2	(1)
$CH_3NO_2 \rightarrow CH_3 + NO_2$	254	60.6	(1)
$CH_3ONO_2 \rightarrow CH_3O + NO_2$	174	41.6	(1)
$\rightarrow CH_3 + NO_3$	341	81.6	(1)
$SO \rightarrow S + O$	515.4±8	123.2±2	
$SO_2 \rightarrow SO + O$	547.3±8	130.8±2.0	
$SO_3 \rightarrow SO_2 + O$	342.7±4	81.9±1	

Note 1. Calculated for T = 298K

APPENDIX 2. CONVERSION TABLES

EQUIVALENT SECOND ORDER RATE CONSTANTS

A \ B	$cm^3 mol^{-1} s^{-1}$	$dm^3 mol^{-1} s^{-1}$	$m^3 mol^{-1} s^{-1}$	$cm^3 molecule^{-1} s^{-1}$	$(mm\ Hg)^{-1} s^{-1}$	$atm^{-1} s^{-1}$	$ppm^{-1} min^{-1}$	$m^2 kN^{-1} s^{-1}$
$1\ cm^3 mol^{-1} s^{-1} =$	1	10^{-3}	10^{-6}	1.66×10^{-24}	$1.604 \times 10^{-5} T$	$1.219 \times 10^{-2} T$	2.453×10^{-9}	$1.203 \times 10^{-4} T$
$1\ dm^3 mol^{-1} s^{-1} =$	10^3	1	10^{-3}	1.66×10^{-21}	$1.604 \times 10^{-2} T$	$12.19\ T$	2.453×10^{-6}	$1.203 \times 10^{-1} T$
$1\ m^3 mol^{-1} s^{-1} =$	10^6	10^3	1	1.66×10^{-18}	$16.04\ T$	$1.219 \times 10^4 T$	2.453×10^{-3}	$120.3\ T$
$1\ cm^3 molecule^{-1} s^{-1} =$	6.023×10^{23}	6.023×10^{20}	6.023×10^{17}	1	$9.658 \times 10^{18} T$	$7.34 \times 10^{21} T$	1.478×10^{15}	$7.244 \times 10^{19} T$
$1\ (mm\ Hg)^{-1} s^{-1} =$	$6.236 \times 10^4 T$	$62.36\ T$	$6.236 \times 10^{-2} T$	$1.035 \times 10^{-19} T$	1	760	4.56×10^{-2}	7.500
$1\ atm^{-1} s^{-1} =$	$82.06\ T$	$8.206 \times 10^{-2} T$	$8.206 \times 10^{-5} T$	$1.362 \times 10^{-22} T$	1.316×10^{-3}	1	6×10^{-5}	9.869×10^{-3}
$1\ ppm^{-1} min^{-1} =$ at 298K, 1 atm. total pressure	4.077×10^8	4.077×10^5	407.7	6.76×10^{-16}	21.93	1.667×10^4	1	164.5
$1\ m^2 kN^{-1} s^{-1} =$	$8314\ T$	$8.314\ T$	$8.314 \times 10^{-3} T$	$1.38 \times 10^{-20} T$	0.1333	101.325	6.079×10^{-3}	1

To convert a rate constant from one set of units $\underline{A}$ to a new set $\underline{B}$ find the conversion factor for the row $\underline{A}$ under Column $\underline{B}$ and multiply the old value by it, e.g. to convert $cm^3 molecule^{-1} s^{-1}$ to $m^3 mol^{-1} s^{-1}$ multiply by 6.023×10^{17}.

EQUIVALENT THIRD ORDER RATE CONSTANTS

A \ B	$cm^6 mol^{-2} s^{-1}$	$dm^6 mol^{-2} s^{-1}$	$m^6 mol^{-2} s^{-1}$	$cm^6 molecule^{-2} s^{-1}$	$(mm\ Hg)^{-2} s^{-1}$	$atm^{-2} s^{-1}$	$ppm^{-2} min^{-1}$	$m^4 kN^{-2} s^{-1}$
1 $cm^6 mol^{-2} s^{-1}$ =	1	10^{-6}	10^{-12}	2.76×10^{-48}	$2.57 \times 10^{-10} T^{-2}$	$1.48 \times 10^{-4} T^{-2}$	1.003×10^{-19}	$1.447 \times 10^{-8} T^{-2}$
1 $dm^6 mol^{-2} s^{-1}$ =	10^6	1	10^{-6}	2.76×10^{-42}	$2.57 \times 10^{-4} T^{-2}$	$148\ T^{-2}$	1.003×10^{-13}	$1.447 \times 10^{-2} T^{-2}$
1 $m^6 mol^{-2} s^{-1}$ =	10^{12}	10^6	1	2.76×10^{-36}	$257\ T^{-2}$	$1.48 \times 10^8 T^{-2}$	1.003×10^{-7}	$1.447 \times 10^4 T^{-2}$
1 $cm^6 molecule^{-2} s^{-1}$ =	3.628×10^{47}	3.628×10^{41}	3.628×10^{35}	1	$9.328 \times 10^{37} T^{-2}$	$5.388 \times 10^{43} T^{-2}$	3.64×10^{28}	$5.248 \times 10^{39} T^{-2}$
1 $(mm\ Hg)^{-2} s^{-1}$ =	$3.89 \times 10^9 T^2$	$3.89 \times 10^3 T^2$	$3.89 \times 10^{-3} T^2$	$1.07 \times 10^{-38} T^2$	1	5.776×10^5	3.46×10^{-5}	56.25
1 $atm^{-2} s^{-1}$ =	$6.733 \times 10^3 T^2$	$6.733 \times 10^{-3} T^2$	$6.733 \times 10^{-9} T^2$	$1.86 \times 10^{-44} T^2$	1.73×10^{-6}	1	6×10^{-11}	9.74×10^{-5}
1 $ppm^{-2} min^{-1}$ = at 298K, 1 atm. total pressure	9.97×10^{18}	9.97×10^{12}	9.97×10^6	2.75×10^{-29}	2.89×10^4	1.667×10^{10}	1	1.623×10^6
1 $m^4 kN^{-2} s^{-1}$ =	$6.91 \times 10^7 T^2$	$69.1\ T^2$	$6.91 \times 10^{-5} T^2$	$1.904 \times 10^{-40} T^2$	0.0178	1.027×10^4	6.16×10^{-7}	1

See note to Table for Second Order Rate Constants

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CONVERSION FACTORS FOR UNITS OF OPTICAL ABSORPTION COEFFICIENTS

A \ B	(cross section σ) cm^2 molecule^{-1} base e	(atm at 273)$^{-1}$ cm^{-1} base e	dm^3 mol^{-1} cm^{-1} base 10	cm^2 mol^{-1} base 10
1 (atm at 298)$^{-1}$cm^{-1} base e =	4.06×10^{-20}	1.09	10.6	1.06×10^4
1 (atm at 298)$^{-1}$cm^{-1} base 10 =	9.35×10^{-20}	2.51	24.4	2.44×10^4
1 (mm Hg at 298)$^{-1}$cm^{-1} base 10 =	7.11×10^{-17}	1.91×10^3	1.86×10^4	1.86×10^7
1 (atm at 273)$^{-1}$cm^{-1} base e =	3.72×10^{-20}	1	9.73	9.73×10^3
1 (atm at 273)$^{-1}$cm^{-1} base 10 =	8.57×10^{-20}	2.303	22.4	2.24×10^4
1 dm^3 mol^{-1}cm^{-1} base 10 =	3.82×10^{-21}	0.103	1	10^3
1 cm^2 mol^{-1} base 10 =	3.82×10^{-24}	1.03×10^{-4}	10^{-3}	1
1 cm^2 molecule^{-1} base e =	1	2.69×10^{19}	2.62×10^{-20}	2.62×10^{23}

To convert an absorption coefficient from one set of units A to a new set B, multiply by the value tabulated for row A under column B, e.g. to convert the value of the absorption coefficient expressed in dm^3 mol^{-1}cm^{-1} base 10 to (atm at 273)$^{-1}$cm^{-1} base e, multiply by 0.103.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A table of data for gas phase chemical reactions and photochemistry of neutral species is presented. Specifically, it gives preferred values for reaction rate constants, photoabsorption cross sections, and quantum yields of primary photochemical processes and also cites recent experimental work (to December 1977). It is intended to provide the basic physical chemical data needed as input data for calculations modelling atmospheric chemistry. An auxiliary table of thermochemical data for the pertinent chemical species is given in the appendix.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant

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Note: The Journal was formerly published in two sections: Section A "Physics and Chemistry" and Section B "Mathematical Sciences."

DIMENSIONS/NBS

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

Annual subscription: Domestic, $12.50; Foreign $15.65.

NONPERIODICALS

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Special Publications—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Applied Mathematics Series—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a world-wide program coordinated by NBS. Program under authority of National Standard Data Act (Public Law 90-396).

NOTE: At present the principal publication outlet for these data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St. N.W., Wash., D.C. 20056.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

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