

# CHEMICAL KINETIC DATA FOR STRATOSPHERIC MODELING

The present compilation of kinetic data represents the 12th evaluation prepared by the NASA Panel for Data Evaluation. The Panel was established in 1977 by the NASA Upper Atmosphere Research Program Office for the purpose of providing a critical tabulation of the latest kinetic and photochemical data for use by modelers in computer simulations of stratospheric chemistry. The recommended rate data and cross sections are based on laboratory measurements. The major use of theoretical extrapolation of data is in connection with three-body reactions, in which the required pressure or temperature dependence is sometimes unavailable from laboratory measurements, and can be estimated by use of appropriate theoretical treatment. In the case of important rate constants for which no experimental data are available, the panel may provide estimates of rate constant parameters based on analogy to similar reactions for which data are available.

Rate constants are expressed in the form  $k(T) = A \exp(-E/RT)$ , where  $A$  is the pre-exponential factor,  $E$  the activation energy,  $R$  the gas constant, and  $T$  the absolute temperature. Uncertainties are expressed by the factor  $f$ , e.g., a value of  $4.2 \times 10^{-10}$  with  $f = 2$  indicates that the true value is believed to lie between  $2.1 \times 10^{-10}$  and  $8.4 \times 10^{-10}$ . The value of  $f$  at other temperatures may be calculated from  $f(298)$ , given in the last column, by:

$$f(T) = f(298) \exp[(\Delta E/R)(1/T - 1/298)],$$

where  $\Delta E/R$  is the uncertainty in  $E/R$ .

Table 1 covers rate constant data on second order reactions, grouped by class, while Table 2 covers association reactions. Relevant equilibrium constant data are given in Table 3. All concentrations are measured in molecules  $\text{cm}^{-3}$ . Notes on each reaction, as well as related photochemical data, may be found in the reference.

The assistance of Robert Hampson is gratefully acknowledged.

## Reference

DeMore, W. B., Sander, S. P., Golden, D. M., Hampson, R. F., Kurylo, M. J., Howard, C. J., Ravishankara, A. R., Kolb, C. E., and Molina, M. J., *Chemical Kinetics and Photochemical Data for Use in Atmospheric Modeling. Evaluation Number 12*, Jet Propulsion Laboratory Publication 97-4, Pasadena CA, 1997.

The report is also available at the World Wide Web site < <http://remus.jpl.nasa.gov/pub/jpl97>>.

TABLE 1. Rate Constants for Second Order Reactions

Reaction	A $\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$	E/R K	k (298 K) $\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$	f(298)
<i>O<sub>x</sub> Reactions</i>				
$\text{O} + \text{O}_3 \rightarrow \text{O}_2 + \text{O}_2$	$8.0 \times 10^{-12}$	2060±250	$8.0 \times 10^{-15}$	1.15
<i>O(<sup>1</sup>D) Reactions</i>				
$\text{O}(^1\text{D}) + \text{O}_2 \rightarrow \text{O} + \text{O}_2$	$3.2 \times 10^{-11}$	-(70±100)	$4.0 \times 10^{-11}$	1.2
$\text{O}(^1\text{D}) + \text{O}_3 \rightarrow \text{O}_2 + \text{O}_2$	$1.2 \times 10^{-10}$	0±100	$1.2 \times 10^{-10}$	1.3
$\rightarrow \text{O}_2 + \text{O} + \text{O}$	$1.2 \times 10^{-10}$	0±100	$1.2 \times 10^{-10}$	1.3
$\text{O}(^1\text{D}) + \text{H}_2 \rightarrow \text{OH} + \text{H}$	$1.1 \times 10^{-10}$	0±100	$1.1 \times 10^{-10}$	1.1
$\text{O}(^1\text{D}) + \text{H}_2\text{O} \rightarrow \text{OH} + \text{OH}$	$2.2 \times 10^{-10}$	0±100	$2.2 \times 10^{-10}$	1.2
$\text{O}(^1\text{D}) + \text{N}_2 \rightarrow \text{O} + \text{N}_2$	$1.8 \times 10^{-11}$	-(110±100)	$2.6 \times 10^{-11}$	1.2
$\text{O}(^1\text{D}) + \text{N}_2\text{O} \rightarrow \text{N}_2 + \text{O}_2$	$4.9 \times 10^{-11}$	0±100	$4.9 \times 10^{-11}$	1.3
$\rightarrow \text{NO} + \text{NO}$	$6.7 \times 10^{-11}$	0±100	$6.7 \times 10^{-11}$	1.3
$\text{O}(^1\text{D}) + \text{NH}_3 \rightarrow \text{OH} + \text{NH}_2$	$2.5 \times 10^{-10}$	0±100	$2.5 \times 10^{-10}$	1.3
$\text{O}(^1\text{D}) + \text{CO}_2 \rightarrow \text{O} + \text{CO}_2$	$7.4 \times 10^{-11}$	-(120±100)	$1.1 \times 10^{-10}$	1.2
$\text{O}(^1\text{D}) + \text{CH}_4 \rightarrow \text{products}$	$1.5 \times 10^{-10}$	0±100	$1.5 \times 10^{-10}$	1.2
$\text{O}(^1\text{D}) + \text{HCl} \rightarrow \text{products}$	$1.5 \times 10^{-10}$	0±100	$1.5 \times 10^{-10}$	1.2
$\text{O}(^1\text{D}) + \text{HF} \rightarrow \text{OH} + \text{F}$	$1.4 \times 10^{-10}$	0±100	$1.4 \times 10^{-10}$	2.0
$\text{O}(^1\text{D}) + \text{HBr} \rightarrow \text{products}$	$1.5 \times 10^{-10}$	0±100	$1.5 \times 10^{-10}$	2.0
$\text{O}(^1\text{D}) + \text{Cl}_2 \rightarrow \text{products}$	$2.8 \times 10^{-10}$	0±100	$2.8 \times 10^{-10}$	2.0
$\text{O}(^1\text{D}) + \text{CCl}_2\text{O} \rightarrow \text{products}$	$3.6 \times 10^{-10}$	0±100	$3.6 \times 10^{-10}$	2.0
$\text{O}(^1\text{D}) + \text{CClFO} \rightarrow \text{products}$	$1.9 \times 10^{-10}$	0±100	$1.9 \times 10^{-10}$	2.0
$\text{O}(^1\text{D}) + \text{CF}_2\text{O} \rightarrow \text{products}$	$7.4 \times 10^{-11}$	0±100	$7.4 \times 10^{-11}$	2.0
$\text{O}(^1\text{D}) + \text{CCl}_4 \rightarrow \text{products (CFC-10)}$	$3.3 \times 10^{-10}$	0±100	$3.3 \times 10^{-10}$	1.2
$\text{O}(^1\text{D}) + \text{CH}_3\text{Br} \rightarrow \text{products}$	$1.8 \times 10^{-10}$	0±100	$1.8 \times 10^{-10}$	1.3
$\text{O}(^1\text{D}) + \text{CH}_2\text{Br}_2 \rightarrow \text{products}$	$2.7 \times 10^{-10}$	0±100	$2.7 \times 10^{-10}$	1.3
$\text{O}(^1\text{D}) + \text{CHBr}_3 \rightarrow \text{products}$	$6.6 \times 10^{-10}$	0±100	$6.6 \times 10^{-10}$	1.5
$\text{O}(^1\text{D}) + \text{CH}_3\text{F} \rightarrow \text{products (HFC-41)}$	$1.5 \times 10^{-10}$	0±100	$1.5 \times 10^{-10}$	1.2
$\text{O}(^1\text{D}) + \text{CH}_2\text{F}_2 \rightarrow \text{products (HFC-32)}$	$5.1 \times 10^{-11}$	0±100	$5.1 \times 10^{-11}$	1.3
$\text{O}(^1\text{D}) + \text{CHF}_3 \rightarrow \text{products (HFC-23)}$	$9.1 \times 10^{-12}$	0±100	$9.1 \times 10^{-12}$	1.2
$\text{O}(^1\text{D}) + \text{CHCl}_2\text{F} \rightarrow \text{products (HCFC-21)}$	$1.9 \times 10^{-10}$	0±100	$1.9 \times 10^{-10}$	1.3

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
O( <sup>1</sup> D) + CHClF <sub>2</sub> → products (HCFC-22)	1.0×10 <sup>-10</sup>	0±100	1.0×10 <sup>-10</sup>	1.2
O( <sup>1</sup> D) + CCl <sub>3</sub> F → products (CFC-11)	2.3×10 <sup>-10</sup>	0±100	2.3×10 <sup>-10</sup>	1.2
O( <sup>1</sup> D) + CCl <sub>2</sub> F <sub>2</sub> → products (CFC-12)	1.4×10 <sup>-10</sup>	0±100	1.4×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CClF <sub>3</sub> → products (CFC-13)	8.7×10 <sup>-11</sup>	0±100	8.7×10 <sup>-11</sup>	1.3
O( <sup>1</sup> D) + CClBrF <sub>2</sub> → products (Halon-1211)	1.5×10 <sup>-10</sup>	0±100	1.5×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CBr <sub>2</sub> F <sub>2</sub> → products (Halon-1202)	2.2×10 <sup>-10</sup>	0±100	2.2×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CBrF <sub>3</sub> → products (Halon-1301)	1.0×10 <sup>-10</sup>	0±100	1.0×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CF <sub>4</sub> → CF <sub>4</sub> + O (CFC-14)	—	—	2.0×10 <sup>-14</sup>	1.5
O( <sup>1</sup> D) + CH <sub>3</sub> CH <sub>2</sub> F → products (HFC-161)	2.6×10 <sup>-10</sup>	0±100	2.6×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CH <sub>3</sub> CHF <sub>2</sub> → products (HFC-152a)	2.0×10 <sup>-10</sup>	0±100	2.0×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CH <sub>3</sub> CCl <sub>2</sub> F → products (HCFC-141b)	2.6×10 <sup>-10</sup>	0±100	2.6×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CH <sub>3</sub> CClF <sub>2</sub> → products (HCFC-142b)	2.2×10 <sup>-10</sup>	0±100	2.2×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CH <sub>3</sub> CF <sub>3</sub> → products (HFC-143a)	1.0×10 <sup>-10</sup>	0±100	1.0×10 <sup>-10</sup>	3.0
O( <sup>1</sup> D) + CH <sub>2</sub> ClCClF <sub>2</sub> → products (HCFC-132b)	1.6×10 <sup>-10</sup>	0±100	1.6×10 <sup>-10</sup>	2.0
O( <sup>1</sup> D) + CH <sub>2</sub> ClCF <sub>3</sub> → products (HCFC-133a)	1.2×10 <sup>-10</sup>	0±100	1.2×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CH <sub>2</sub> FCF <sub>3</sub> → products (HFC-134a)	4.9×10 <sup>-11</sup>	0±100	4.9×10 <sup>-11</sup>	1.3
O( <sup>1</sup> D) + CHCl <sub>2</sub> CF <sub>3</sub> → products (HCFC-123)	2.0×10 <sup>-10</sup>	0±100	2.0×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CHClFCF <sub>3</sub> → products (HCFC-124)	8.6×10 <sup>-11</sup>	0±100	8.6×10 <sup>-11</sup>	1.3
O( <sup>1</sup> D) + CHF <sub>2</sub> CF <sub>3</sub> → products (HFC-125)	1.2×10 <sup>-10</sup>	0±100	1.2×10 <sup>-10</sup>	2.0
O( <sup>1</sup> D) + CCl <sub>2</sub> CF <sub>3</sub> → products (CFC-113a)	2×10 <sup>-10</sup>	0±100	2×10 <sup>-10</sup>	2.0
O( <sup>1</sup> D) + CCl <sub>2</sub> FCClF <sub>2</sub> → products (CFC-113)	2×10 <sup>-10</sup>	0±100	2×10 <sup>-10</sup>	2.0
O( <sup>1</sup> D) + CCl <sub>2</sub> FCF <sub>3</sub> → products (CFC-114a)	1×10 <sup>-10</sup>	0±100	1×10 <sup>-10</sup>	2.0
O( <sup>1</sup> D) + CClF <sub>2</sub> CClF <sub>2</sub> → products (CFC-114)	1.3×10 <sup>-10</sup>	0±100	1.3×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CClF <sub>2</sub> CF <sub>3</sub> → products (CFC-115)	5×10 <sup>-11</sup>	0±100	5×10 <sup>-11</sup>	1.3
O( <sup>1</sup> D) + CBrF <sub>2</sub> CBrF <sub>2</sub> → products (Halon-2402)	1.6×10 <sup>-10</sup>	0±100	1.6×10 <sup>-10</sup>	1.3
O( <sup>1</sup> D) + CF <sub>3</sub> CF <sub>3</sub> → O + CF <sub>3</sub> CF <sub>3</sub> (CFC-116)	—	—	1.5×10 <sup>-13</sup>	1.5
O( <sup>1</sup> D) + CHF <sub>2</sub> CF <sub>2</sub> CF <sub>2</sub> CHF <sub>2</sub> → products (HFC-338pcc)	1.8×10 <sup>-11</sup>	0±100	1.8×10 <sup>-11</sup>	1.5
O( <sup>1</sup> D) + c-C <sub>4</sub> F <sub>8</sub> → products	—	—	8×10 <sup>-13</sup>	1.3
O( <sup>1</sup> D) + CF <sub>3</sub> CHFCF <sub>2</sub> CF <sub>3</sub> → products (HFC-43-10mee)	2.1×10 <sup>-10</sup>	0±100	2.1×10 <sup>-10</sup>	4
O( <sup>1</sup> D) + C <sub>5</sub> F <sub>12</sub> → products (CFC-41-12)	—	—	3.9×10 <sup>-13</sup>	2
O( <sup>1</sup> D) + C <sub>6</sub> F <sub>14</sub> → products (CFC-51-14)	—	—	1×10 <sup>-12</sup>	2
O( <sup>1</sup> D) + 1,2-(CF <sub>3</sub> ) <sub>2</sub> c-C <sub>4</sub> F <sub>6</sub> → products	—	—	2.8×10 <sup>-13</sup>	2
O( <sup>1</sup> D) + SF <sub>6</sub> → products	—	—	1.8×10 <sup>-14</sup>	1.5
<b>Singlet O<sub>2</sub> Reactions</b>				
O <sub>2</sub> ( <sup>1</sup> Δ) + O → products	—	—	<2×10 <sup>-16</sup>	—
O <sub>2</sub> ( <sup>1</sup> Δ) + O <sub>2</sub> → products	3.6×10 <sup>-18</sup>	220±100	1.7×10 <sup>-18</sup>	1.2
O <sub>2</sub> ( <sup>1</sup> Δ) + O <sub>3</sub> → O + 2O <sub>2</sub>	5.2×10 <sup>-11</sup>	2840±500	3.8×10 <sup>-15</sup>	1.2
O <sub>2</sub> ( <sup>1</sup> Δ) + H <sub>2</sub> O → products	—	—	4.8×10 <sup>-18</sup>	1.5
O <sub>2</sub> ( <sup>1</sup> Δ) + N → NO + O	—	—	<9×10 <sup>-17</sup>	—
O <sub>2</sub> ( <sup>1</sup> Δ) + N <sub>2</sub> → products	—	—	<10 <sup>-20</sup>	—
O <sub>2</sub> ( <sup>1</sup> Δ) + CO <sub>2</sub> → products	—	—	<2×10 <sup>-20</sup>	—
O <sub>2</sub> ( <sup>1</sup> Σ) + O → products	—	—	8×10 <sup>-14</sup>	5.0
O <sub>2</sub> ( <sup>1</sup> Σ) + O <sub>2</sub> → products	—	—	3.9×10 <sup>-17</sup>	1.5
O <sub>2</sub> ( <sup>1</sup> Σ) + O <sub>3</sub> → products	2.2×10 <sup>-11</sup>	0±200	2.2×10 <sup>-11</sup>	1.2
O <sub>2</sub> ( <sup>1</sup> Σ) + H <sub>2</sub> O → products	—	—	5.4×10 <sup>-12</sup>	1.3
O <sub>2</sub> ( <sup>1</sup> Σ) + N → products	—	—	<10 <sup>-13</sup>	—
O <sub>2</sub> ( <sup>1</sup> Σ) + N <sub>2</sub> → products	2.1×10 <sup>-15</sup>	0±200	2.1×10 <sup>-15</sup>	1.2
O <sub>2</sub> ( <sup>1</sup> Σ) + CO <sub>2</sub> → products	4.2×10 <sup>-13</sup>	0±200	4.2×10 <sup>-13</sup>	1.2
<b>HO<sub>x</sub> Reactions</b>				
O + OH → O <sub>2</sub> + H	2.2×10 <sup>-11</sup>	-(120±100)	3.3×10 <sup>-11</sup>	1.2
O + HO <sub>2</sub> → OH + O <sub>2</sub>	3.0×10 <sup>-11</sup>	-(200±100)	5.9×10 <sup>-11</sup>	1.2
O + H <sub>2</sub> O <sub>2</sub> → OH + HO <sub>2</sub>	1.4×10 <sup>-12</sup>	2000±1000	1.7×10 <sup>-15</sup>	2.0
H + O <sub>3</sub> → OH + O <sub>2</sub>	1.4×10 <sup>-10</sup>	470±200	2.9×10 <sup>-11</sup>	1.25
H + HO <sub>2</sub> → products	8.1×10 <sup>-11</sup>	0±100	8.1×10 <sup>-11</sup>	1.3
OH + O <sub>3</sub> → HO <sub>2</sub> + O <sub>2</sub>	1.6×10 <sup>-12</sup>	940±300	6.8×10 <sup>-14</sup>	1.3
OH + H <sub>2</sub> → H <sub>2</sub> O + H	5.5×10 <sup>-12</sup>	2000±100	6.7×10 <sup>-15</sup>	1.1
OH + HD → products	5.0×10 <sup>-12</sup>	2130±200	4.0×10 <sup>-15</sup>	1.2
OH + OH → H <sub>2</sub> O + O	4.2×10 <sup>-12</sup>	240±240	1.9×10 <sup>-12</sup>	1.4

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
OH + HO <sub>2</sub> → H <sub>2</sub> O + O <sub>2</sub>	4.8×10 <sup>-11</sup>	-(250±200)	1.1×10 <sup>-10</sup>	1.3
OH + H <sub>2</sub> O <sub>2</sub> → H <sub>2</sub> O + HO <sub>2</sub>	2.9×10 <sup>-12</sup>	160±100	1.7×10 <sup>-12</sup>	1.2
HO <sub>2</sub> + O <sub>3</sub> → OH + 2O <sub>2</sub>	1.1×10 <sup>-14</sup>	500±	2.0×10 <sup>-15</sup>	1.3
HO <sub>2</sub> + HO <sub>2</sub> → H <sub>2</sub> O <sub>2</sub> + O <sub>2</sub>	2.3×10 <sup>-13</sup>	-(600±200)	1.7×10 <sup>-12</sup>	1.3
H <sub>2</sub> O <sub>2</sub> + O <sub>2</sub>	1.7×10 <sup>-33</sup> [M]	-(1000±400)	4.9×10 <sup>-32</sup> [M]	1.3
<b>NO<sub>x</sub> Reactions</b>				
O + NO <sub>2</sub> → NO + O <sub>2</sub>	6.5×10 <sup>-12</sup>	-(120±120)	9.7×10 <sup>-12</sup>	1.1
O + NO <sub>3</sub> → O <sub>2</sub> + NO <sub>2</sub>	1.0×10 <sup>-11</sup>	0±150	1.0×10 <sup>-11</sup>	1.5
O + N <sub>2</sub> O <sub>5</sub> → products			<3.0×10 <sup>-16</sup>	
O + HNO <sub>3</sub> → OH + NO <sub>3</sub>			<3.0×10 <sup>-17</sup>	
O + HO <sub>2</sub> NO <sub>2</sub> → products	7.8×10 <sup>-11</sup>	3400±750	8.6×10 <sup>-16</sup>	3.0
H + NO <sub>2</sub> → OH + NO	4.0×10 <sup>-10</sup>	340±300	1.3×10 <sup>-10</sup>	1.3
OH + NO <sub>3</sub> → products			2.2×10 <sup>-11</sup>	1.5
OH + HONO → H <sub>2</sub> O + NO <sub>2</sub>	1.8×10 <sup>-11</sup>	390±	4.5×10 <sup>-12</sup>	1.5
OH + HNO <sub>3</sub> → H <sub>2</sub> O + NO <sub>3</sub>	See reference	1.3		
OH + HO <sub>2</sub> NO <sub>2</sub> → products	1.3×10 <sup>-12</sup>	-(380±)	4.6×10 <sup>-12</sup>	1.5
OH + NH <sub>3</sub> → H <sub>2</sub> O + NH <sub>2</sub>	1.7×10 <sup>-12</sup>	710±200	1.6×10 <sup>-13</sup>	1.2
HO <sub>2</sub> + NO → NO <sub>2</sub> + OH	3.5×10 <sup>-12</sup>	-(250±50)	8.1×10 <sup>-12</sup>	1.15
HO <sub>2</sub> + NO <sub>2</sub> → HONO + O <sub>2</sub>	See reference			
HO <sub>2</sub> + NO <sub>3</sub> → products			3.5×10 <sup>-12</sup>	1.5
HO <sub>2</sub> + NH <sub>2</sub> → products			3.4×10 <sup>-11</sup>	2.0
N + O <sub>2</sub> → NO + O	1.5×10 <sup>-11</sup>	3600±400	8.5×10 <sup>-17</sup>	1.25
N + O <sub>3</sub> → NO + O <sub>2</sub>			<2.0×10 <sup>-16</sup>	
N + NO → N <sub>2</sub> + O	2.1×10 <sup>-11</sup>	-(100±100)	3.0×10 <sup>-11</sup>	1.3
N + NO <sub>2</sub> → N <sub>2</sub> O + O	5.8×10 <sup>-12</sup>	-(220±100)	1.2×10 <sup>-11</sup>	1.5
NO + O <sub>3</sub> → NO <sub>2</sub> + O <sub>2</sub>	2.0×10 <sup>-12</sup>	1400±200	1.8×10 <sup>-14</sup>	1.1
NO + NO <sub>3</sub> → 2NO <sub>2</sub>	1.5×10 <sup>-11</sup>	-(170±100)	2.6×10 <sup>-11</sup>	1.3
NO <sub>2</sub> + O <sub>3</sub> → NO <sub>3</sub> + O <sub>2</sub>	1.2×10 <sup>-13</sup>	2450±150	3.2×10 <sup>-17</sup>	1.15
NO <sub>2</sub> + NO <sub>3</sub> → NO + NO <sub>2</sub> + O <sub>2</sub>	See reference			
NO <sub>3</sub> + NO <sub>3</sub> → 2NO <sub>2</sub> + O <sub>2</sub>	8.5×10 <sup>-13</sup>	2450±500	2.3×10 <sup>-16</sup>	1.5
NH <sub>2</sub> + O <sub>2</sub> → products			<6.0×10 <sup>-21</sup>	
NH <sub>2</sub> + O <sub>3</sub> → products	4.3×10 <sup>-12</sup>	930±500	1.9×10 <sup>-13</sup>	3.0
NH <sub>2</sub> + NO → products	4.0×10 <sup>-12</sup>	-(450±150)	1.8×10 <sup>-11</sup>	1.3
NH <sub>2</sub> + NO <sub>2</sub> → products	2.1×10 <sup>-12</sup>	-(650±250)	1.9×10 <sup>-11</sup>	3.0
NH + NO → products	4.9×10 <sup>-11</sup>	0±300	4.9×10 <sup>-11</sup>	1.5
NH + NO <sub>2</sub> → products	3.5×10 <sup>-13</sup>	-(1140±500)	1.6×10 <sup>-11</sup>	2.0
O <sub>3</sub> + HNO <sub>2</sub> → O <sub>2</sub> + HNO <sub>3</sub>			<5.0×10 <sup>-19</sup>	
N <sub>2</sub> O <sub>5</sub> + H <sub>2</sub> O → 2HNO <sub>3</sub>			<2.0×10 <sup>-21</sup>	
N <sub>2</sub> (A,ν) + O <sub>2</sub> → products			2.5×10 <sup>-12</sup> , ν=0	1.5
N <sub>2</sub> (A,ν) + O <sub>3</sub> → products			4.1×10 <sup>-11</sup> , ν=0	2.0
<b>Reactions of Organic Compounds</b>				
O + CH <sub>3</sub> → products	1.1×10 <sup>-10</sup>	0±250	1.1×10 <sup>-10</sup>	1.3
O + HCN → products	1.0×10 <sup>-11</sup>	4000±1000	1.5×10 <sup>-17</sup>	10
O + C <sub>2</sub> H <sub>2</sub> → products	3.0×10 <sup>-11</sup>	1600±250	1.4×10 <sup>-13</sup>	1.3
O + H <sub>2</sub> CO → products	3.4×10 <sup>-11</sup>	1600±250	1.6×10 <sup>-13</sup>	1.25
O + CH <sub>3</sub> CHO → CH <sub>3</sub> CO + OH	1.8×10 <sup>-11</sup>	1100±200	4.5×10 <sup>-13</sup>	1.25
O <sub>3</sub> + C <sub>2</sub> H <sub>2</sub> → products	1.0×10 <sup>-14</sup>	4100±500	1.0×10 <sup>-20</sup>	3
O <sub>3</sub> + C <sub>2</sub> H <sub>4</sub> → products	1.2×10 <sup>-14</sup>	2630±100	1.7×10 <sup>-18</sup>	1.25
O <sub>3</sub> + C <sub>3</sub> H <sub>6</sub> → products	6.5×10 <sup>-15</sup>	1900±200	1.1×10 <sup>-17</sup>	1.2
OH + CO → products	1.5×10 <sup>-13</sup> x (1+0.6P <sub>atm</sub> )	0±300	1.5×10 <sup>-13</sup> x (1+0.6P <sub>atm</sub> )	1.3
OH + CH <sub>4</sub> → CH <sub>3</sub> + H <sub>2</sub> O	2.45×10 <sup>-12</sup>	1775±100	6.3×10 <sup>-15</sup>	1.1
OH + <sup>13</sup> CH <sub>4</sub> → <sup>13</sup> CH <sub>3</sub> + H <sub>2</sub> O	See reference			
OH + CH <sub>3</sub> D → products	3.5×10 <sup>-12</sup>	1950 ± 200	5.0×10 <sup>-15</sup>	1.15
OH + H <sub>2</sub> CO → H <sub>2</sub> O + HCO	1.0×10 <sup>-11</sup>	0±200	1.0×10 <sup>-11</sup>	1.25
OH + CH <sub>3</sub> OH → products	6.7×10 <sup>-12</sup>	600±300	8.9×10 <sup>-13</sup>	1.2
OH + CH <sub>3</sub> OOH → products	3.8×10 <sup>-12</sup>	-(200±200)	7.4×10 <sup>-12</sup>	1.5
OH + HC(O)OH → products	4.0×10 <sup>-13</sup>	0±200	4.0×10 <sup>-13</sup>	1.3

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
OH + HCN → products	1.2×10 <sup>-13</sup>	400±150	3.1×10 <sup>-14</sup>	3
OH + C <sub>2</sub> H <sub>6</sub> → H <sub>2</sub> O + C <sub>2</sub> H <sub>5</sub>	8.7×10 <sup>-12</sup>	1070±100	2.4×10 <sup>-13</sup>	1.1
OH + C <sub>3</sub> H <sub>8</sub> → H <sub>2</sub> O + C <sub>3</sub> H <sub>7</sub>	1.0×10 <sup>-11</sup>	660±100	1.1×10 <sup>-12</sup>	1.2
OH + CH <sub>3</sub> CHO → CH <sub>2</sub> CO + H <sub>2</sub> O	5.6×10 <sup>-12</sup>	-(270±200)	1.4×10 <sup>-11</sup>	1.2
OH + C <sub>2</sub> H <sub>5</sub> OH → products	7.0×10 <sup>-12</sup>	235±100	3.2×10 <sup>-12</sup>	1.3
OH + CH <sub>3</sub> C(O)OH → products	4.0×10 <sup>-13</sup>	-(200±400)	8.0×10 <sup>-13</sup>	1.3
OH + CH <sub>3</sub> C(O)CH <sub>3</sub> → CH <sub>3</sub> C(O)CH <sub>2</sub> + H <sub>2</sub> O	2.2×10 <sup>-12</sup>	685±100	2.2×10 <sup>-13</sup>	1.15
OH + CH <sub>3</sub> CN → products	7.8×10 <sup>-13</sup>	1050±200	2.3×10 <sup>-14</sup>	1.5
OH + CH <sub>3</sub> ONO <sub>2</sub> → products	5.0×10 <sup>-13</sup>	890±500	2.4×10 <sup>-14</sup>	3
OH + CH <sub>3</sub> C(O)O <sub>2</sub> NO <sub>2</sub> (PAN) → products			<4×10 <sup>-14</sup>	
OH + C <sub>2</sub> H <sub>5</sub> ONO <sub>2</sub> → products	8.2×10 <sup>-13</sup>	450±300	1.8×10 <sup>-13</sup>	3
HO <sub>2</sub> + CH <sub>2</sub> O → adduct	6.7×10 <sup>-15</sup>	-(600±600)	5.0×10 <sup>-14</sup>	5
HO <sub>2</sub> + CH <sub>3</sub> O <sub>2</sub> → CH <sub>3</sub> OOH + O <sub>2</sub>	3.8×10 <sup>-13</sup>	-(800±400)	5.6×10 <sup>-12</sup>	2
HO <sub>2</sub> + C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> → C <sub>2</sub> H <sub>5</sub> OOH + O <sub>2</sub>	7.5×10 <sup>-13</sup>	-(700±250)	8.0×10 <sup>-12</sup>	1.5
HO <sub>2</sub> + CH <sub>3</sub> C(O)O <sub>2</sub> → products	4.5×10 <sup>-13</sup>	-(1000±600)	1.3×10 <sup>-11</sup>	2
NO <sub>3</sub> + CO → products			<4.0×10 <sup>-19</sup>	
NO <sub>3</sub> + CH <sub>2</sub> O → products			5.8×10 <sup>-16</sup>	1.3
NO <sub>3</sub> + CH <sub>3</sub> CHO → products	1.4×10 <sup>-12</sup>	1900±300	2.4×10 <sup>-15</sup>	1.3
CH <sub>3</sub> + O <sub>2</sub> → products			<3.0×10 <sup>-16</sup>	
CH <sub>3</sub> + O <sub>3</sub> → products	5.4×10 <sup>-12</sup>	220±150	2.6×10 <sup>-12</sup>	2
HCO + O <sub>2</sub> → CO + HO <sub>2</sub>	3.5×10 <sup>-12</sup>	-(140±140)	5.5×10 <sup>-12</sup>	1.3
CH <sub>2</sub> OH + O <sub>2</sub> → CH <sub>2</sub> O + HO <sub>2</sub>	9.1×10 <sup>-12</sup>	0±200	9.1×10 <sup>-12</sup>	1.3
CH <sub>3</sub> O + O <sub>2</sub> → CH <sub>2</sub> O + HO <sub>2</sub>	3.9×10 <sup>-14</sup>	900±300	1.9×10 <sup>-15</sup>	1.5
CH <sub>3</sub> O + NO → CH <sub>2</sub> O + HNO	See reference			
CH <sub>3</sub> O + NO <sub>2</sub> → CH <sub>2</sub> O + HONO	1.1×10 <sup>-11</sup>	1200±600	2.0×10 <sup>-13</sup>	5
CH <sub>3</sub> O <sub>2</sub> + O <sub>3</sub> → products			<3.0×10 <sup>-17</sup>	
CH <sub>3</sub> O <sub>2</sub> + CH <sub>3</sub> O <sub>2</sub> → products	2.5×10 <sup>-13</sup>	-(190±190)	4.7×10 <sup>-13</sup>	1.5
CH <sub>3</sub> O <sub>2</sub> + NO → CH <sub>3</sub> O + NO <sub>2</sub>	3.0×10 <sup>-12</sup>	-(280±60)	7.7×10 <sup>-12</sup>	1.15
CH <sub>3</sub> O <sub>2</sub> + CH <sub>3</sub> C(O)O <sub>2</sub> → products	1.3×10 <sup>-12</sup>	-(640±200)	1.1×10 <sup>-11</sup>	1.5
C <sub>2</sub> H <sub>5</sub> + O <sub>2</sub> → C <sub>2</sub> H <sub>4</sub> + HO <sub>2</sub>			<2.0×10 <sup>-14</sup>	
C <sub>2</sub> H <sub>5</sub> O + O <sub>2</sub> → CH <sub>3</sub> CHO + HO <sub>2</sub>	6.3×10 <sup>-14</sup>	550±200	1.0×10 <sup>-14</sup>	1.5
C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> + C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> → products	6.8×10 <sup>-14</sup>	0±300	6.8×10 <sup>-14</sup>	2
C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> + NO → products	2.6×10 <sup>-12</sup>	-(365±150)	8.7×10 <sup>-12</sup>	1.2
CH <sub>3</sub> C(O)O <sub>2</sub> + CH <sub>3</sub> C(O)O <sub>2</sub> → products	2.9×10 <sup>-12</sup>	-(500±150)	1.5×10 <sup>-11</sup>	1.5
CH <sub>3</sub> C(O)O <sub>2</sub> + NO → products	5.3×10 <sup>-12</sup>	-(360±150)	1.8×10 <sup>-11</sup>	1.4
<b>FO<sub>x</sub> Reactions</b>				
O + FO → F + O <sub>2</sub>	2.7×10 <sup>-11</sup>	0±250	2.7×10 <sup>-11</sup>	3.0
O + FO <sub>2</sub> → FO + O <sub>2</sub>	5.0×10 <sup>-11</sup>	0±250	5.0×10 <sup>-11</sup>	5.0
OH + CH <sub>3</sub> F → CH <sub>2</sub> F + H <sub>2</sub> O (HFC-41)	3.0×10 <sup>-12</sup>	1500±300	2.0×10 <sup>-14</sup>	1.1
OH + CH <sub>2</sub> F <sub>2</sub> → CHF <sub>2</sub> + H <sub>2</sub> O (HFC-32)	1.9×10 <sup>-12</sup>	1550±200	1.0×10 <sup>-14</sup>	1.2
OH + CHF <sub>3</sub> → CF <sub>3</sub> + H <sub>2</sub> O (HFC-23)	1.0×10 <sup>-12</sup>	2440±200	2.8×10 <sup>-16</sup>	1.3
OH + CF <sub>3</sub> OH → CF <sub>3</sub> O + H <sub>2</sub> O			<2×10 <sup>-17</sup>	
OH + CH <sub>3</sub> CH <sub>2</sub> F → products (HFC-161)	7.0×10 <sup>-12</sup>	1100±300	1.7×10 <sup>-13</sup>	1.4
OH + CH <sub>3</sub> CHF <sub>2</sub> → products (HFC-152a)	2.4×10 <sup>-12</sup>	1260±200	3.5×10 <sup>-14</sup>	1.2
OH + CH <sub>2</sub> FCH <sub>2</sub> F → CHFCH <sub>2</sub> F (HFC-152) + H <sub>2</sub> O	1.7×10 <sup>-11</sup>	1500±500	1.1×10 <sup>-13</sup>	2.0
OH + CH <sub>3</sub> CF <sub>3</sub> → CH <sub>2</sub> CF <sub>3</sub> + H <sub>2</sub> O (HFC-143a)	1.8×10 <sup>-12</sup>	2170±150	1.2×10 <sup>-15</sup>	1.1
OH + CH <sub>2</sub> FCHF <sub>2</sub> → products (HFC-143)	4.0×10 <sup>-12</sup>	1650±300	1.6×10 <sup>-14</sup>	1.5
OH + CH <sub>2</sub> FCF <sub>3</sub> → CHFCF <sub>3</sub> + H <sub>2</sub> O (HFC-134a)	1.5×10 <sup>-12</sup>	1750±200	4.2×10 <sup>-15</sup>	1.1
OH + CHF <sub>2</sub> CHF <sub>2</sub> → CF <sub>2</sub> CHF <sub>2</sub> (HFC-134) + H <sub>2</sub> O	1.6×10 <sup>-12</sup>	1680±300	5.7×10 <sup>-15</sup>	2.0
OH + CHF <sub>2</sub> CF <sub>3</sub> → CF <sub>2</sub> CF <sub>3</sub> + H <sub>2</sub> O (HFC-125)	5.6×10 <sup>-13</sup>	1700±300	1.9×10 <sup>-15</sup>	1.3
OH + CH <sub>3</sub> OCHF <sub>2</sub> → products (HFOC-152a)	6.0×10 <sup>-12</sup>	1530±150	3.5×10 <sup>-14</sup>	1.2
OH + CF <sub>3</sub> OCH <sub>3</sub> → CF <sub>3</sub> OCH <sub>2</sub> + H <sub>2</sub> O (HFOC-143a)	1.5×10 <sup>-12</sup>	1450±150	1.2×10 <sup>-14</sup>	1.1
OH + CF <sub>2</sub> HOCHF <sub>2</sub> H → CF <sub>2</sub> OCF <sub>2</sub> H (HFOC-134) + H <sub>2</sub> O	1.9×10 <sup>-12</sup>	2000±150	2.3×10 <sup>-15</sup>	1.2
OH + CF <sub>3</sub> OCHF <sub>2</sub> → CF <sub>3</sub> OCF <sub>2</sub> + H <sub>2</sub> O (HFOC-125)	4.7×10 <sup>-13</sup>	2100±300	4.1×10 <sup>-16</sup>	1.2
OH + CF <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub> → products (HFC-263fb)	-	-	4.2×10 <sup>-14</sup>	1.5
OH + CH <sub>2</sub> FCF <sub>2</sub> CHF <sub>2</sub> → products (HFC-245ca)	2.4×10 <sup>-12</sup>	1660±150	9.1×10 <sup>-15</sup>	1.3
OH + CHF <sub>2</sub> CHFCHF <sub>2</sub> → products (HFC-245ea)	-	-	1.6×10 <sup>-14</sup>	2.0
OH + CF <sub>3</sub> CHFCH <sub>2</sub> F → products (HFC-245eb)	-	-	1.5×10 <sup>-14</sup>	2.0
OH + CHF <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub> → products (HFC-245fa)	6.1×10 <sup>-13</sup>	1330±150	7.0×10 <sup>-15</sup>	1.2

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
OH + CF <sub>3</sub> CF <sub>2</sub> CH <sub>2</sub> F → CF <sub>3</sub> CF <sub>2</sub> CHF (HFC-236cb) + H <sub>2</sub> O	1.5×10 <sup>-12</sup>	1750±500	4.2×10 <sup>-15</sup>	2.0
OH + CF <sub>3</sub> CHFCHF <sub>2</sub> → products (HFC-236ea)	1.1×10 <sup>-12</sup>	1590±150	5.3×10 <sup>-15</sup>	1.1
OH + CF <sub>3</sub> CH <sub>2</sub> CF <sub>3</sub> → CF <sub>3</sub> CHCF <sub>3</sub> (HFC-236fa) + H <sub>2</sub> O	1.3×10 <sup>-12</sup>	2480±150	3.2×10 <sup>-16</sup>	1.1
OH + CF <sub>3</sub> CHFCF <sub>3</sub> → CF <sub>3</sub> CFCF <sub>3</sub> + H <sub>2</sub> O (HFC-227ea)	5.0×10 <sup>-13</sup>	1700±300	1.7×10 <sup>-15</sup>	1.1
OH + CHF <sub>2</sub> OCH <sub>2</sub> CF <sub>3</sub> → products (HFOC-245fa)	2.6×10 <sup>-12</sup>	1610±150	1.2×10 <sup>-14</sup>	2.0
OH + CF <sub>3</sub> CH <sub>2</sub> CF <sub>2</sub> CH <sub>3</sub> → products (HFC-365mfc)	2.0×10 <sup>-12</sup>	1750±200	5.7×10 <sup>-15</sup>	1.3
OH + CF <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub> → products (HFC-356mff)	3.0×10 <sup>-12</sup>	1800±300	7.1×10 <sup>-15</sup>	1.3
OH + CF <sub>3</sub> CF <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> F → products (HFC-356mcf)	1.7×10 <sup>-12</sup>	1110±200	4.2×10 <sup>-14</sup>	2.0
OH + CHF <sub>2</sub> CF <sub>2</sub> CF <sub>2</sub> CF <sub>2</sub> H → products (HFC-338pcc)	7.8×10 <sup>-13</sup>	1530±200	4.6×10 <sup>-15</sup>	1.5
OH + CF <sub>3</sub> CH <sub>2</sub> CF <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub> → products (HFC-458mfcf)	1.2×10 <sup>-12</sup>	1830±200	2.6×10 <sup>-15</sup>	2.0
OH + CF <sub>3</sub> CHFCHF <sub>2</sub> CF <sub>3</sub> → products (HFC-43-10mee)	5.2×10 <sup>-13</sup>	1500±300	3.4×10 <sup>-15</sup>	1.3
OH + CF <sub>3</sub> CF <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CF <sub>2</sub> CF <sub>3</sub> → (HFC-55-10-mcff) products	–	–	8.3×10 <sup>-15</sup>	1.5
F + O <sub>3</sub> → FO + O <sub>2</sub>	2.2×10 <sup>-11</sup>	230±200	1.0×10 <sup>-11</sup>	1.5
F + H <sub>2</sub> → HF + H	1.4×10 <sup>-10</sup>	500±200	2.6×10 <sup>-11</sup>	1.2
F + H <sub>2</sub> O → HF + OH	1.4×10 <sup>-11</sup>	0±200	1.4×10 <sup>-11</sup>	1.3
F + HNO <sub>3</sub> → HF + NO <sub>3</sub>	6.0×10 <sup>-12</sup>	–(400±200)	2.3×10 <sup>-11</sup>	1.3
F + CH <sub>4</sub> → HF + CH <sub>3</sub>	1.6×10 <sup>-10</sup>	260±200	6.7×10 <sup>-11</sup>	1.4
FO + O <sub>3</sub> → products			<1×10 <sup>-14</sup>	
FO + NO → NO <sub>2</sub> + F	8.2×10 <sup>-12</sup>	–(300±200)	2.2×10 <sup>-11</sup>	1.5
FO + FO → 2 F + O <sub>2</sub>	1.0×10 <sup>-11</sup>	0±250	1.0×10 <sup>-11</sup>	1.5
FO <sub>2</sub> + O <sub>3</sub> → products			<3.4×10 <sup>-16</sup>	
FO <sub>2</sub> + NO → FNO + O <sub>2</sub>	7.5×10 <sup>-12</sup>	690±400	7.5×10 <sup>-13</sup>	2.0
FO <sub>2</sub> + NO <sub>2</sub> → products	3.8×10 <sup>-11</sup>	2040±500	4.0×10 <sup>-14</sup>	2.0
FO <sub>2</sub> + CO → products			<5.1×10 <sup>-16</sup>	
FO <sub>2</sub> + CH <sub>4</sub> → products			<2×10 <sup>-16</sup>	
CF <sub>3</sub> O + O <sub>2</sub> → FO <sub>2</sub> + CF <sub>2</sub> O	<3×10 <sup>-11</sup>	5000	<1.5×10 <sup>-18</sup>	
CF <sub>3</sub> O + O <sub>3</sub> → CF <sub>3</sub> O <sub>2</sub> + O <sub>2</sub>	2×10 <sup>-12</sup>	1400±600	1.8×10 <sup>-14</sup>	1.3
CF <sub>3</sub> O + H <sub>2</sub> O → OH + CF <sub>3</sub> OH	3×10 <sup>-12</sup>	>3600	<2×10 <sup>-17</sup>	
CF <sub>3</sub> O + NO → CF <sub>2</sub> O + FNO	3.7×10 <sup>-11</sup>	–(110±70)	5.4×10 <sup>-11</sup>	1.2
CF <sub>3</sub> O + NO <sub>2</sub> → products	See reference			
CF <sub>3</sub> O + CO → products			<2×10 <sup>-15</sup>	
CF <sub>3</sub> O + CH <sub>4</sub> → CH <sub>3</sub> + CF <sub>3</sub> OH	2.6×10 <sup>-12</sup>	1420±200	2.2×10 <sup>-14</sup>	1.1
CF <sub>3</sub> O + C <sub>2</sub> H <sub>6</sub> → C <sub>2</sub> H <sub>5</sub> + CF <sub>3</sub> OH	4.9×10 <sup>-12</sup>	400±100	1.3×10 <sup>-12</sup>	1.2
CF <sub>3</sub> O <sub>2</sub> + O <sub>3</sub> → CF <sub>3</sub> O + 2O <sub>2</sub>			<3×10 <sup>-15</sup>	
CF <sub>3</sub> O <sub>2</sub> + CO → CF <sub>3</sub> O + CO <sub>2</sub>			<5×10 <sup>-16</sup>	
CF <sub>3</sub> O <sub>2</sub> + NO → CF <sub>3</sub> O + NO <sub>2</sub>	5.4×10 <sup>-12</sup>	–(320±150)	1.6×10 <sup>-11</sup>	1.1
<b>ClO<sub>x</sub> Reactions</b>				
O + ClO → Cl + O <sub>2</sub>	3.0×10 <sup>-11</sup>	–(70±70)	3.8×10 <sup>-11</sup>	1.2
O + OClO → ClO + O <sub>2</sub>	2.4×10 <sup>-12</sup>	960±300	1.0×10 <sup>-13</sup>	2.0
O + Cl <sub>2</sub> O → ClO + ClO	2.7×10 <sup>-11</sup>	530±150	4.5×10 <sup>-12</sup>	1.3
O + HCl → OH + Cl	1.0×10 <sup>-11</sup>	3300±350	1.5×10 <sup>-16</sup>	2.0
O + HOCl → OH + ClO	1.7×10 <sup>-13</sup>	0±300	1.7×10 <sup>-13</sup>	3.0
O + ClONO <sub>2</sub> → products	2.9×10 <sup>-12</sup>	800±200	2.0×10 <sup>-13</sup>	1.5
O <sub>3</sub> + OClO → products	2.1×10 <sup>-12</sup>	4700±1000	3.0×10 <sup>-19</sup>	2.5
O <sub>3</sub> + Cl <sub>2</sub> O <sub>2</sub> → products	–	–	<1.0×10 <sup>-19</sup>	–
OH + Cl <sub>2</sub> → HOCl + Cl	1.4×10 <sup>-12</sup>	900±400	6.7×10 <sup>-14</sup>	1.2
OH + ClO → products	1.1×10 <sup>-11</sup>	–(120±150)	1.7×10 <sup>-11</sup>	1.5
OH + OClO → HOCl + O <sub>2</sub>	4.5×10 <sup>-13</sup>	–(800±200)	6.8×10 <sup>-12</sup>	2.0
OH + HCl → H <sub>2</sub> O + Cl	2.6×10 <sup>-12</sup>	350±100	8.0×10 <sup>-13</sup>	1.2
OH + HOCl → H <sub>2</sub> O + ClO	3.0×10 <sup>-12</sup>	500±500	5.0×10 <sup>-13</sup>	3.0
OH + ClNO <sub>2</sub> → HOCl + NO <sub>2</sub>	2.4×10 <sup>-12</sup>	1250±300	3.6×10 <sup>-14</sup>	2.0
OH + ClONO <sub>2</sub> → products	1.2×10 <sup>-12</sup>	330±200	3.9×10 <sup>-13</sup>	1.5
OH + CH <sub>3</sub> Cl → CH <sub>2</sub> Cl + H <sub>2</sub> O	4.0×10 <sup>-12</sup>	1400±250	3.6×10 <sup>-14</sup>	1.2
OH + CH <sub>2</sub> Cl <sub>2</sub> → CHCl <sub>2</sub> + H <sub>2</sub> O	3.8×10 <sup>-12</sup>	1050±150	1.1×10 <sup>-13</sup>	1.4
OH + CHCl <sub>3</sub> → CCl <sub>3</sub> + H <sub>2</sub> O	2.0×10 <sup>-12</sup>	900±150	1.0×10 <sup>-13</sup>	1.2
OH + CCl <sub>4</sub> → products	~1.0×10 <sup>-12</sup>	>2300	<5.0×10 <sup>-16</sup>	–
OH + CFCl <sub>3</sub> → products (CFC-11)	~1.0×10 <sup>-12</sup>	>3700	<5.0×10 <sup>-18</sup>	–
OH + CF <sub>2</sub> Cl <sub>2</sub> → products (CFC-12)	~1.0×10 <sup>-12</sup>	>3600	<6.0×10 <sup>-18</sup>	–
OH + CH <sub>2</sub> ClF → CHClF + H <sub>2</sub> O (HCFC-31)	2.8×10 <sup>-12</sup>	1270±200	3.9×10 <sup>-14</sup>	1.2

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
OH + CHFCl <sub>2</sub> → CFCl <sub>2</sub> + H <sub>2</sub> O (HCFC-21)	1.7×10 <sup>-12</sup>	1250±150	2.6×10 <sup>-14</sup>	1.2
OH + CHF <sub>2</sub> Cl → CF <sub>2</sub> Cl + H <sub>2</sub> O (HCFC-22)	1.0×10 <sup>-12</sup>	1600±150	4.7×10 <sup>-15</sup>	1.1
OH + CH <sub>3</sub> OCl → products	2.4×10 <sup>-12</sup>	360±200	7.2×10 <sup>-13</sup>	3.0
OH + CH <sub>3</sub> CCl <sub>3</sub> → CH <sub>2</sub> CCl <sub>3</sub> + H <sub>2</sub> O (HCC-140)	1.8×10 <sup>-12</sup>	1550±150	1.0×10 <sup>-14</sup>	1.1
OH + C <sub>2</sub> HCl <sub>3</sub> → products	4.9×10 <sup>-13</sup>	-(450±200)	2.2×10 <sup>-12</sup>	1.25
OH + C <sub>2</sub> Cl <sub>4</sub> → products	9.4×10 <sup>-12</sup>	1200±200	1.7×10 <sup>-13</sup>	1.25
OH + CCl <sub>3</sub> CHO → H <sub>2</sub> O + CCl <sub>3</sub> CO	8.2×10 <sup>-12</sup>	600±300	1.1×10 <sup>-12</sup>	1.5
OH + CH <sub>3</sub> CFCl <sub>2</sub> → CH <sub>2</sub> CFCl <sub>2</sub> + H <sub>2</sub> O (HCFC-141b)	1.7×10 <sup>-12</sup>	1700±150	5.7×10 <sup>-15</sup>	1.2
OH + CH <sub>3</sub> CF <sub>2</sub> Cl → CH <sub>2</sub> CF <sub>2</sub> Cl + H <sub>2</sub> O (HCFC-142b)	1.3×10 <sup>-12</sup>	1800±150	3.1×10 <sup>-15</sup>	1.2
OH + CH <sub>2</sub> ClCF <sub>2</sub> Cl → CHClCF <sub>2</sub> Cl (HCFC-132b) + H <sub>2</sub> O	3.6×10 <sup>-12</sup>	1600±400	1.7×10 <sup>-14</sup>	2.0
OH + CHCl <sub>2</sub> CF <sub>2</sub> Cl → CCl <sub>2</sub> CF <sub>2</sub> Cl (HCFC-122) + H <sub>2</sub> O	1.0×10 <sup>-12</sup>	900±150	4.9×10 <sup>-14</sup>	1.2
OH + CHFClCFCl <sub>2</sub> → CFClCFCl <sub>2</sub> (HCFC-122a) + H <sub>2</sub> O	1.0×10 <sup>-12</sup>	1250±150	1.5×10 <sup>-14</sup>	1.1
OH + CH <sub>2</sub> ClCF <sub>3</sub> → CHClCF <sub>3</sub> + H <sub>2</sub> O (HCFC-133a)	5.2×10 <sup>-13</sup>	1100±300	1.3×10 <sup>-14</sup>	1.3
OH + CHCl <sub>2</sub> CF <sub>3</sub> → CCl <sub>2</sub> CF <sub>3</sub> + H <sub>2</sub> O (HCFC-123)	7.0×10 <sup>-13</sup>	900±150	3.4×10 <sup>-14</sup>	1.2
OH + CHFClCF <sub>2</sub> Cl → CFClCF <sub>2</sub> Cl (HCFC-123a) + H <sub>2</sub> O	9.2×10 <sup>-13</sup>	1280±150	1.3×10 <sup>-14</sup>	1.2
OH + CHFClCF <sub>3</sub> → CFClCF <sub>3</sub> + H <sub>2</sub> O (HCFC-124)	8.0×10 <sup>-13</sup>	1350±150	8.6×10 <sup>-15</sup>	1.2
OH + CH <sub>3</sub> CF <sub>2</sub> CFCl <sub>2</sub> → products (HCFC-243cc)	7.7×10 <sup>-13</sup>	1700±300	2.6×10 <sup>-15</sup>	2.0
OH + CF <sub>3</sub> CF <sub>2</sub> CHCl <sub>2</sub> → products (HCFC-225ca)	1.0×10 <sup>-12</sup>	1100±200	2.5×10 <sup>-14</sup>	1.3
OH + CF <sub>2</sub> ClCF <sub>2</sub> CHFCl → products (HCFC-225cb)	5.5×10 <sup>-13</sup>	1250±200	8.3×10 <sup>-15</sup>	1.3
HO <sub>2</sub> + Cl → HCl + O <sub>2</sub>	1.8×10 <sup>-11</sup>	-(170±200)	3.2×10 <sup>-11</sup>	1.5
→ OH + ClO	4.1×10 <sup>-11</sup>	450±200	9.1×10 <sup>-12</sup>	2.0
HO <sub>2</sub> + ClO → HOCl + O <sub>2</sub>	4.8×10 <sup>-13</sup>	-(700±)	5.0×10 <sup>-12</sup>	1.4
H <sub>2</sub> O + ClONO <sub>2</sub> → products	-	-	<2.0×10 <sup>-21</sup>	-
NO + OClO → NO <sub>2</sub> + ClO	2.5×10 <sup>-12</sup>	600±300	3.4×10 <sup>-13</sup>	2.0
NO + Cl <sub>2</sub> O <sub>2</sub> → products	-	-	<2.0×10 <sup>-14</sup>	-
NO <sub>3</sub> + HCl → HNO <sub>3</sub> + Cl	-	-	<5.0×10 <sup>-17</sup>	-
HO <sub>3</sub> NO <sub>2</sub> + HCl → products	-	-	<1.0×10 <sup>-21</sup>	-
Cl + O <sub>3</sub> → ClO + O <sub>2</sub>	2.9×10 <sup>-11</sup>	260±100	1.2×10 <sup>-11</sup>	1.15
Cl + H <sub>2</sub> → HCl + H	3.7×10 <sup>-11</sup>	2300±200	1.6×10 <sup>-14</sup>	1.25
Cl + H <sub>2</sub> O <sub>2</sub> → HCl + HO <sub>2</sub>	1.1×10 <sup>-11</sup>	980±500	4.1×10 <sup>-13</sup>	1.5
Cl + NO <sub>3</sub> → ClO + NO <sub>2</sub>	2.4×10 <sup>-11</sup>	0±400	2.4×10 <sup>-11</sup>	1.5
Cl + N <sub>2</sub> O → ClO + N <sub>2</sub>	See reference	-	-	-
Cl + HNO <sub>3</sub> → products	-	-	<2.0×10 <sup>-16</sup>	-
Cl + CH <sub>4</sub> → HCl + CH <sub>3</sub>	1.1×10 <sup>-11</sup>	1400±150	1.0×10 <sup>-13</sup>	1.1
Cl + CH <sub>3</sub> D → products	-	-	7.4×10 <sup>-14</sup>	2.0
Cl + H <sub>2</sub> CO → HCl + HCO	8.1×10 <sup>-11</sup>	30±100	7.3×10 <sup>-11</sup>	1.15
Cl + CH <sub>3</sub> O <sub>2</sub> → products	-	-	1.6×10 <sup>-10</sup>	1.5
Cl + CH <sub>3</sub> OH → CH <sub>2</sub> OH + HCl	5.4×10 <sup>-11</sup>	0±250	5.4×10 <sup>-11</sup>	1.5
Cl + C <sub>2</sub> H <sub>6</sub> → HCl + C <sub>2</sub> H <sub>5</sub>	7.7×10 <sup>-11</sup>	90±90	5.7×10 <sup>-11</sup>	1.1
Cl + C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> → ClO + C <sub>2</sub> H <sub>5</sub> O	-	-	7.4×10 <sup>-11</sup>	2.0
→ HCl + C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>	-	-	7.7×10 <sup>-11</sup>	2.0
Cl + CH <sub>3</sub> CN → products	1.6×10 <sup>-11</sup>	2140±300	1.2×10 <sup>-14</sup>	2.0
Cl + CH <sub>3</sub> CO <sub>3</sub> NO <sub>2</sub> → products	-	-	<1×10 <sup>-14</sup>	-
Cl + C <sub>3</sub> H <sub>8</sub> → HCl + C <sub>3</sub> H <sub>7</sub>	1.2×10 <sup>-10</sup>	-(40±250)	1.4×10 <sup>-10</sup>	1.3
Cl + OClO → ClO + ClO	3.4×10 <sup>-11</sup>	-(160±200)	5.8×10 <sup>-11</sup>	1.25
Cl + ClOO → Cl <sub>2</sub> + O <sub>2</sub>	2.3×10 <sup>-10</sup>	0±250	2.3×10 <sup>-10</sup>	3.0
→ ClO + ClO	1.2×10 <sup>-11</sup>	0±250	1.2×10 <sup>-11</sup>	3.0
Cl + Cl <sub>2</sub> O → Cl <sub>2</sub> + ClO	6.2×10 <sup>-11</sup>	-(130±130)	9.6×10 <sup>-11</sup>	1.2
Cl + Cl <sub>2</sub> O <sub>2</sub> → products	-	-	1.0×10 <sup>-10</sup>	2.0
Cl + HOCl → products	2.5×10 <sup>-12</sup>	130±250	1.6×10 <sup>-12</sup>	1.5
Cl + ClNO → NO + Cl <sub>2</sub>	5.8×10 <sup>-11</sup>	-(100±200)	8.1×10 <sup>-11</sup>	1.5
Cl + ClONO <sub>2</sub> → products	6.5×10 <sup>-12</sup>	-(135±50)	1.0×10 <sup>-11</sup>	1.2
Cl + CH <sub>3</sub> Cl → CH <sub>2</sub> Cl + HCl	3.2×10 <sup>-11</sup>	1250±200	4.8×10 <sup>-13</sup>	1.2
Cl + CH <sub>2</sub> Cl <sub>2</sub> → HCl + CHCl <sub>2</sub>	3.1×10 <sup>-11</sup>	1350±500	3.3×10 <sup>-13</sup>	1.5
Cl + CHCl <sub>3</sub> → HCl + CCl <sub>3</sub>	8.2×10 <sup>-12</sup>	1325±300	9.6×10 <sup>-14</sup>	1.3
Cl + CH <sub>3</sub> F → HCl + CH <sub>2</sub> F (HFC-41)	2.0×10 <sup>-11</sup>	1200±500	3.5×10 <sup>-13</sup>	1.3
Cl + CH <sub>2</sub> F <sub>2</sub> → HCl + CHF <sub>2</sub> (HFC-32)	1.2×10 <sup>-11</sup>	1630±500	5.0×10 <sup>-14</sup>	1.5
Cl + CF <sub>3</sub> H → HCl + CF <sub>3</sub> (HFC-23)	-	-	3.0×10 <sup>-18</sup>	5.0
Cl + CH <sub>2</sub> FCl → HCl + CHFCl (HCFC-31)	1.2×10 <sup>-11</sup>	1390±500	1.1×10 <sup>-13</sup>	2.0
Cl + CHFCl <sub>2</sub> → HCl + CFCl <sub>2</sub> (HCFC-21)	5.5×10 <sup>-12</sup>	1675±200	2.0×10 <sup>-14</sup>	1.3

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
Cl + CHF <sub>2</sub> Cl → HCl + CF <sub>2</sub> Cl (HCFC-22)	5.9×10 <sup>-12</sup>	2430±200	1.7×10 <sup>-15</sup>	1.3
Cl + CH <sub>3</sub> CCl <sub>3</sub> → CH <sub>2</sub> CCl <sub>3</sub> + HCl	2.8×10 <sup>-12</sup>	1790±400	7.0×10 <sup>-15</sup>	2.0
Cl + CH <sub>3</sub> CH <sub>2</sub> F → HCl + CH <sub>3</sub> CHF (HFC-161)	1.8×10 <sup>-11</sup>	290±500	6.8×10 <sup>-12</sup>	3.0
→ HCl + CH <sub>2</sub> CH <sub>2</sub> F	1.4×10 <sup>-11</sup>	880±500	7.3×10 <sup>-13</sup>	3.0
Cl + CH <sub>3</sub> CHF <sub>2</sub> → HCl + CH <sub>3</sub> CF <sub>2</sub> (HFC-152a)	6.4×10 <sup>-12</sup>	950±500	2.6×10 <sup>-13</sup>	1.3
→ HCl + CH <sub>2</sub> CHF <sub>2</sub>	7.2×10 <sup>-12</sup>	2390±500	2.4×10 <sup>-15</sup>	3.0
Cl + CH <sub>2</sub> FCH <sub>2</sub> F → HCl + CHFCH <sub>2</sub> F (HFC-152)	2.6×10 <sup>-11</sup>	1060±500	7.5×10 <sup>-13</sup>	3.0
Cl + CH <sub>3</sub> CFCl <sub>2</sub> → HCl + CH <sub>2</sub> CFCl <sub>2</sub> (HCFC-141b)	1.8×10 <sup>-12</sup>	2000±300	2.2×10 <sup>-15</sup>	1.2
Cl + CH <sub>3</sub> CF <sub>2</sub> Cl → HCl + CH <sub>2</sub> CF <sub>2</sub> Cl (HCFC-142b)	1.4×10 <sup>-12</sup>	2420±500	4.2×10 <sup>-16</sup>	1.2
Cl + CH <sub>3</sub> CF <sub>3</sub> → HCl + CH <sub>2</sub> CF <sub>3</sub> (HFC-143a)	1.2×10 <sup>-11</sup>	3880±500	2.6×10 <sup>-17</sup>	5.0
Cl + CH <sub>2</sub> FCHF <sub>2</sub> → HCl + CH <sub>2</sub> FCF <sub>2</sub> (HFC-143)	5.5×10 <sup>-12</sup>	1610±500	2.5×10 <sup>-14</sup>	3.0
→ HCl + CHFCHF <sub>2</sub>	7.7×10 <sup>-12</sup>	1720±500	2.4×10 <sup>-14</sup>	3.0
Cl + CH <sub>2</sub> ClCF <sub>3</sub> → HCl + CHClCF <sub>3</sub> (HCFC-133a)	1.8×10 <sup>-12</sup>	1710±500	5.9×10 <sup>-15</sup>	3.0
Cl + CH <sub>2</sub> FCF <sub>3</sub> → HCl + CHF <sub>2</sub> CF <sub>3</sub> (HFC-134a)	–	–	1.5×10 <sup>-15</sup>	1.2
Cl + CHF <sub>2</sub> CHF <sub>2</sub> → HCl + CF <sub>2</sub> CHF <sub>2</sub> (HFC-134)	7.5×10 <sup>-12</sup>	2430±500	2.2×10 <sup>-15</sup>	1.5
Cl + CHCl <sub>2</sub> CF <sub>3</sub> → HCl + CCl <sub>2</sub> CF <sub>3</sub> (HCFC-123)	4.4×10 <sup>-12</sup>	1750±500	1.2×10 <sup>-14</sup>	1.3
Cl + CHFClCF <sub>3</sub> → HCl + CFCICF <sub>3</sub> (HCFC-124)	1.1×10 <sup>-12</sup>	1800±500	2.7×10 <sup>-15</sup>	1.3
Cl + CHF <sub>2</sub> CF <sub>3</sub> → HCl + CF <sub>2</sub> CF <sub>3</sub> (HFC-125)	–	–	2.4×10 <sup>-16</sup>	1.3
ClO + O <sub>3</sub> → ClOO + O <sub>2</sub>	–	–	<1.4×10 <sup>-17</sup>	–
→ OClO + O <sub>2</sub>	1.0×10 <sup>-12</sup>	>4000	<1.0×10 <sup>-18</sup>	–
ClO + H <sub>2</sub> → products	~1.0×10 <sup>-12</sup>	>4800	<1.0×10 <sup>-19</sup>	–
ClO + NO → NO <sub>2</sub> + Cl	6.4×10 <sup>-12</sup>	–(290±100)	1.7×10 <sup>-11</sup>	1.15
ClO + NO <sub>3</sub> → ClOO + NO <sub>2</sub>	4.7×10 <sup>-13</sup>	0±400	4.7×10 <sup>-13</sup>	1.5
ClO + N <sub>2</sub> O → products	~1.0×10 <sup>-12</sup>	>4300	<6.0×10 <sup>-19</sup>	–
ClO + CO → products	~1.0×10 <sup>-12</sup>	>3700	<4.0×10 <sup>-18</sup>	–
ClO + CH <sub>4</sub> → products	~1.0×10 <sup>-12</sup>	>3700	<4.0×10 <sup>-18</sup>	–
ClO + H <sub>2</sub> CO → products	~1.0×10 <sup>-12</sup>	>2100	<1.0×10 <sup>-15</sup>	–
ClO + CH <sub>3</sub> O <sub>2</sub> → products	3.3×10 <sup>-12</sup>	115±115	2.2×10 <sup>-12</sup>	1.5
ClO + ClO → Cl <sub>2</sub> + O <sub>2</sub>	1.0×10 <sup>-12</sup>	1590±300	4.8×10 <sup>-15</sup>	1.5
→ ClOO + Cl	3.0×10 <sup>-11</sup>	2450±500	8.0×10 <sup>-15</sup>	1.5
→ OClO + Cl	3.5×10 <sup>-13</sup>	1370±300	3.5×10 <sup>-15</sup>	1.5
HCl + ClONO <sub>2</sub> → products	–	–	<1.0×10 <sup>-20</sup>	–
CH <sub>2</sub> ClO + O <sub>2</sub> → CHClO + HO <sub>2</sub>	–	–	6×10 <sup>-14</sup>	5
CH <sub>2</sub> ClO <sub>2</sub> + HO <sub>2</sub> → CH <sub>2</sub> ClO <sub>2</sub> H + O <sub>2</sub>	3.3×10 <sup>-13</sup>	–(820±200)	5.2×10 <sup>-12</sup>	1.5
CH <sub>2</sub> ClO <sub>2</sub> + NO → CH <sub>2</sub> ClO + NO <sub>2</sub>	7×10 <sup>-12</sup>	–(300±200)	1.9×10 <sup>-11</sup>	1.5
CCl <sub>3</sub> O <sub>2</sub> + NO → CCl <sub>2</sub> O + NO <sub>2</sub> + Cl	7.3×10 <sup>-12</sup>	–(270±200)	1.8×10 <sup>-11</sup>	1.3
CCl <sub>2</sub> FO <sub>2</sub> + NO → CClFO + NO <sub>2</sub> + Cl	4.5×10 <sup>-12</sup>	–(350±200)	1.5×10 <sup>-11</sup>	1.3
CClF <sub>2</sub> O <sub>2</sub> + NO → CF <sub>2</sub> O + NO <sub>2</sub> + Cl	3.8×10 <sup>-12</sup>	–(400±200)	1.5×10 <sup>-11</sup>	1.2
<b>BrO<sub>x</sub> Reactions</b>				
O + BrO → Br + O <sub>2</sub>	1.9×10 <sup>-11</sup>	–(230±150)	4.1×10 <sup>-11</sup>	1.5
O + HBr → OH + Br	5.8×10 <sup>-12</sup>	1500±200	3.8×10 <sup>-14</sup>	1.3
O + HOBr → OH + BrO	1.2×10 <sup>-10</sup>	430±300	2.8×10 <sup>-11</sup>	3.0
OH + Br <sub>2</sub> → HOBr + Br	4.2×10 <sup>-11</sup>	0±600	4.2×10 <sup>-11</sup>	1.3
OH + BrO → products	–	–	7.5×10 <sup>-11</sup>	3.0
OH + HBr → H <sub>2</sub> O + Br	1.1×10 <sup>-11</sup>	0±250	1.1×10 <sup>-11</sup>	1.2
OH + CH <sub>3</sub> Br → CH <sub>2</sub> Br + H <sub>2</sub> O	4.0×10 <sup>-12</sup>	1470±150	2.9×10 <sup>-14</sup>	1.1
OH + CH <sub>2</sub> Br <sub>2</sub> → CHBr <sub>2</sub> + H <sub>2</sub> O	2.4×10 <sup>-12</sup>	900±300	1.2×10 <sup>-13</sup>	1.1
OH + CHBr <sub>3</sub> → CBr <sub>3</sub> + H <sub>2</sub> O	1.6×10 <sup>-12</sup>	710±200	1.5×10 <sup>-13</sup>	2.0
OH + CHF <sub>2</sub> Br → CF <sub>2</sub> Br + H <sub>2</sub> O	1.1×10 <sup>-12</sup>	1400±200	1.0×10 <sup>-14</sup>	1.1
OH + CH <sub>2</sub> ClBr → CHClBr + H <sub>2</sub> O	2.3×10 <sup>-12</sup>	930±150	1.0×10 <sup>-13</sup>	1.2
OH + CF <sub>2</sub> ClBr → products	–	–	<1.5×10 <sup>-16</sup>	–
OH + CF <sub>2</sub> Br <sub>2</sub> → products	–	–	<5.0×10 <sup>-16</sup>	–
OH + CF <sub>3</sub> Br → products	–	–	<1.2×10 <sup>-16</sup>	–
OH + CH <sub>2</sub> BrCF <sub>3</sub> → CHBrCF <sub>3</sub> + H <sub>2</sub> O	1.4×10 <sup>-12</sup>	1340±200	1.6×10 <sup>-14</sup>	1.3
OH + CHFBrCF <sub>3</sub> → CFBrCF <sub>3</sub>	7.2×10 <sup>-13</sup>	1110±150	1.8×10 <sup>-14</sup>	1.5
OH + CHClBrCF <sub>3</sub> → CClBrCF <sub>3</sub> + H <sub>2</sub> O	1.3×10 <sup>-12</sup>	995±150	4.5×10 <sup>-14</sup>	1.5
OH + CF <sub>2</sub> BrCHFCl → CF <sub>2</sub> BrCFCl + H <sub>2</sub> O	9.3×10 <sup>-13</sup>	1250±150	1.4×10 <sup>-14</sup>	1.5
OH + CF <sub>2</sub> BrCF <sub>2</sub> Br → products	–	–	<1.5×10 <sup>-16</sup>	–
HO <sub>2</sub> + Br → HBr + O <sub>2</sub>	1.5×10 <sup>-11</sup>	600±600	2.0×10 <sup>-12</sup>	2.0

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
HO <sub>2</sub> + BrO → products	3.4×10 <sup>-12</sup>	-(540±200)	2.1×10 <sup>-11</sup>	1.5
NO <sub>3</sub> + HBr → HNO <sub>3</sub> + Br	—	—	<1.0×10 <sup>-16</sup>	—
Cl + CH <sub>2</sub> ClBr → HCl + CHClBr	4.3×10 <sup>-11</sup>	1370±500	4.3×10 <sup>-13</sup>	3.0
Cl + CH <sub>3</sub> Br → HCl + CH <sub>2</sub> Br	1.5×10 <sup>-11</sup>	1060±100	4.3×10 <sup>-13</sup>	1.2
Cl + CH <sub>2</sub> Br <sub>2</sub> → HCl + CHBr <sub>2</sub>	6.4×10 <sup>-12</sup>	810±100	4.2×10 <sup>-13</sup>	1.2
Br + O <sub>3</sub> → BrO + O <sub>2</sub>	1.7×10 <sup>-11</sup>	800±200	1.2×10 <sup>-12</sup>	1.2
Br + H <sub>2</sub> O <sub>2</sub> → HBr + HO <sub>2</sub>	1.0×10 <sup>-11</sup>	>3000	<5.0×10 <sup>-16</sup>	—
Br + NO <sub>3</sub> → BrO + NO <sub>2</sub>	—	—	1.6×10 <sup>-11</sup>	2.0
Br + H <sub>2</sub> CO → HBr + HCO	1.7×10 <sup>-11</sup>	800±200	1.1×10 <sup>-12</sup>	1.3
Br + OCIO → BrO + ClO	2.6×10 <sup>-11</sup>	1300±300	3.4×10 <sup>-13</sup>	2.0
Br + Cl <sub>2</sub> O → BrCl + ClO	2.1×10 <sup>-11</sup>	470±150	4.3×10 <sup>-12</sup>	1.3
Br + Cl <sub>2</sub> O <sub>2</sub> → products	—	—	3.0×10 <sup>-12</sup>	2.0
BrO + O <sub>3</sub> → products	~1.0×10 <sup>-12</sup>	>3200	<2.0×10 <sup>-17</sup>	—
BrO + NO → NO <sub>2</sub> + Br	8.8×10 <sup>-12</sup>	-(260±130)	2.1×10 <sup>-11</sup>	1.15
BrO + NO <sub>3</sub> → products	—	—	1.0×10 <sup>-12</sup>	3.0
BrO + ClO → Br + OClO	1.6×10 <sup>-12</sup>	-(430±200)	6.8×10 <sup>-12</sup>	1.25
→ Br + ClOO	2.9×10 <sup>-12</sup>	-(220±200)	6.1×10 <sup>-12</sup>	1.25
→ BrCl + O <sub>2</sub>	5.8×10 <sup>-13</sup>	-(170±200)	1.0×10 <sup>-12</sup>	1.25
BrO + BrO → products	1.5×10 <sup>-12</sup>	-(230±150)	3.2×10 <sup>-12</sup>	1.15
CH <sub>2</sub> BrO <sub>2</sub> + NO → CH <sub>2</sub> O + NO <sub>2</sub> + Br	4×10 <sup>-12</sup>	-(300±200)	1.1×10 <sup>-11</sup>	1.5
<i>IO<sub>x</sub> Reactions</i>				
O + I <sub>2</sub> → IO + I	1.4×10 <sup>-10</sup>	0±250	1.4×10 <sup>-10</sup>	1.4
O + IO → O <sub>2</sub> + I	—	—	1.2×10 <sup>-10</sup>	2.0
OH + I <sub>2</sub> → HOI + I	—	—	1.8×10 <sup>-10</sup>	2.0
OH + HI → H <sub>2</sub> O + I	—	—	3.0×10 <sup>-11</sup>	2.0
OH + CH <sub>3</sub> I → H <sub>2</sub> O + CH <sub>2</sub> I	3.1×10 <sup>-12</sup>	1120±500	7.2×10 <sup>-14</sup>	3.0
OH + CF <sub>3</sub> I → HOI + CF <sub>3</sub>	—	—	3.1×10 <sup>-14</sup>	5.0
HO <sub>2</sub> + I → HI + O <sub>2</sub>	1.5×10 <sup>-11</sup>	1090±500	3.8×10 <sup>-13</sup>	2.0
HO <sub>2</sub> + IO → HOI + O <sub>2</sub>	—	—	8.4×10 <sup>-11</sup>	1.5
NO <sub>3</sub> + HI → HNO <sub>3</sub> + I	See reference	—	—	—
I + O <sub>3</sub> → IO + O <sub>2</sub>	2.3×10 <sup>-11</sup>	870±200	1.2×10 <sup>-12</sup>	1.2
I + BrO → IO + Br	—	—	1.2×10 <sup>-11</sup>	2.0
IO + NO → I + NO <sub>2</sub>	9.1×10 <sup>-12</sup>	-(240±150)	2.0×10 <sup>-11</sup>	1.2
IO + ClO → products	5.1×10 <sup>-12</sup>	-(280±200)	1.3×10 <sup>-11</sup>	2.0
IO + BrO → products	—	—	6.9×10 <sup>-11</sup>	1.5
IO + IO → products	1.5×10 <sup>-11</sup>	-(500±500)	8.0×10 <sup>-11</sup>	1.5
INO + INO → I <sub>2</sub> + 2NO	8.4×10 <sup>-11</sup>	2620±600	1.3×10 <sup>-14</sup>	2.5
INO <sub>2</sub> + INO <sub>2</sub> → I <sub>2</sub> + 2NO <sub>2</sub>	2.9×10 <sup>-11</sup>	2600±1000	4.7×10 <sup>-15</sup>	3.0
<i>SO<sub>x</sub> Reactions</i>				
O + SH → SO + H	—	—	1.6×10 <sup>-10</sup>	5.0
O + CS → CO + S	2.7×10 <sup>-10</sup>	760±250	2.1×10 <sup>-11</sup>	1.1
O + H <sub>2</sub> S → OH + SH	9.2×10 <sup>-12</sup>	1800±550	2.2×10 <sup>-14</sup>	1.7
O + OCS → CO + SO	2.1×10 <sup>-11</sup>	2200±150	1.3×10 <sup>-14</sup>	1.2
O + CS <sub>2</sub> → CS + SO	3.2×10 <sup>-11</sup>	650±150	3.6×10 <sup>-12</sup>	1.2
O + CH <sub>3</sub> SCH <sub>3</sub> → CH <sub>3</sub> SO + CH <sub>3</sub>	1.3×10 <sup>-11</sup>	-(410±100)	5.0×10 <sup>-11</sup>	1.1
O + CH <sub>3</sub> SSCH <sub>3</sub> → CH <sub>3</sub> SO + CH <sub>3</sub> S	5.5×10 <sup>-11</sup>	-(250±100)	1.3×10 <sup>-10</sup>	1.3
O <sub>3</sub> + H <sub>2</sub> S → products	—	—	<2.0×10 <sup>-20</sup>	—
O <sub>3</sub> + CH <sub>3</sub> SCH <sub>3</sub> → products	—	—	<1.0×10 <sup>-18</sup>	—
O <sub>3</sub> + SO <sub>2</sub> → SO <sub>3</sub> + O <sub>2</sub>	3.0×10 <sup>-12</sup>	>7000	<2.0×10 <sup>-22</sup>	—
OH + H <sub>2</sub> S → SH + H <sub>2</sub> O	6.0×10 <sup>-12</sup>	75±75	4.7×10 <sup>-12</sup>	1.2
OH + OCS → products	1.1×10 <sup>-13</sup>	1200±500	1.9×10 <sup>-15</sup>	2.0
OH + CS <sub>2</sub> → products	See reference	—	—	—
OH + CH <sub>3</sub> SH → CH <sub>3</sub> S + H <sub>2</sub> O	9.9×10 <sup>-12</sup>	-(360±100)	3.3×10 <sup>-11</sup>	1.2
OH + CH <sub>3</sub> SCH <sub>3</sub> → H <sub>2</sub> O + CH <sub>2</sub> SCH <sub>3</sub>	1.2×10 <sup>-11</sup>	260±100	5.0×10 <sup>-12</sup>	1.15
OH + CH <sub>3</sub> SSCH <sub>3</sub> → products	6.0×10 <sup>-11</sup>	-(400±200)	2.3×10 <sup>-10</sup>	1.2
OH + S → H + SO	—	—	6.6×10 <sup>-11</sup>	3.0
OH + SO → H + SO <sub>2</sub>	—	—	8.6×10 <sup>-11</sup>	2.0
HO <sub>2</sub> + H <sub>2</sub> S → products	—	—	<3.0×10 <sup>-15</sup>	—

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
HO <sub>2</sub> + CH <sub>3</sub> SH → products	–	–	<4.0×10 <sup>-15</sup>	–
HO <sub>2</sub> + CH <sub>3</sub> SCH <sub>3</sub> → products	–	–	<5.0×10 <sup>-15</sup>	–
HO <sub>2</sub> + SO <sub>2</sub> → products	–	–	<1.0×10 <sup>-18</sup>	–
NO <sub>2</sub> + SO <sub>2</sub> → products	–	–	<2.0×10 <sup>-26</sup>	–
NO <sub>3</sub> + H <sub>2</sub> S → products	–	–	<8.0×10 <sup>-16</sup>	–
NO <sub>3</sub> + OCS → products	–	–	<1.0×10 <sup>-16</sup>	–
NO <sub>3</sub> + CS <sub>2</sub> → products	–	–	<4.0×10 <sup>-16</sup>	–
NO <sub>3</sub> + CH <sub>3</sub> SH → products	4.4×10 <sup>-13</sup>	–(210±210)	8.9×10 <sup>-13</sup>	1.25
NO <sub>3</sub> + CH <sub>3</sub> SCH <sub>3</sub> → CH <sub>3</sub> SCH <sub>2</sub> + HNO <sub>3</sub>	1.9×10 <sup>-13</sup>	–(500±200)	1.0×10 <sup>-12</sup>	1.2
NO <sub>3</sub> + CH <sub>3</sub> SSCH <sub>3</sub> → products	1.3×10 <sup>-12</sup>	270±270	5.3×10 <sup>-13</sup>	1.4
NO <sub>3</sub> + SO <sub>2</sub> → products	–	–	<7.0×10 <sup>-21</sup>	–
N <sub>2</sub> O <sub>5</sub> + CH <sub>3</sub> SCH <sub>3</sub> → products	–	–	<1.0×10 <sup>-17</sup>	–
CH <sub>3</sub> O <sub>2</sub> + SO <sub>2</sub> → products	–	–	<5.0×10 <sup>-17</sup>	–
F + CH <sub>3</sub> SCH <sub>3</sub> → products	–	–	2.4×10 <sup>-10</sup>	2.0
Cl + H <sub>2</sub> S → HCl + SH	3.7×10 <sup>-11</sup>	–(210±100)	7.4×10 <sup>-11</sup>	1.25
Cl + OCS → products	–	–	<1.0×10 <sup>-16</sup>	–
Cl + CS <sub>2</sub> → products	–	–	<4.0×10 <sup>-15</sup>	–
Cl + CH <sub>3</sub> SH → CH <sub>3</sub> S + HCl	1.2×10 <sup>-10</sup>	–(150±50)	2.0×10 <sup>-10</sup>	1.25
Cl + CH <sub>3</sub> SCH <sub>3</sub> → products	See reference	–	–	–
ClO + OCS → products	–	–	<2.0×10 <sup>-16</sup>	–
ClO + CH <sub>3</sub> SCH <sub>3</sub> → products	–	–	9.5×10 <sup>-15</sup>	2.0
ClO + SO → Cl + SO <sub>2</sub>	2.8×10 <sup>-11</sup>	0±50	2.8×10 <sup>-11</sup>	1.3
ClO + SO <sub>2</sub> → Cl + SO <sub>3</sub>	–	–	<4.0×10 <sup>-18</sup>	–
Br + H <sub>2</sub> S → HBr + SH	1.4×10 <sup>-11</sup>	2750±300	1.4×10 <sup>-15</sup>	2.0
Br + CH <sub>3</sub> SH → CH <sub>3</sub> S + HBr	9.2×10 <sup>-12</sup>	390±100	2.5×10 <sup>-12</sup>	2.0
Br + CH <sub>3</sub> SCH <sub>3</sub> → products	See reference	–	–	–
BrO + CH <sub>3</sub> SCH <sub>3</sub> → products	1.5×10 <sup>-14</sup>	–(850±200)	2.6×10 <sup>-13</sup>	1.3
BrO + SO → Br + SO <sub>2</sub>	–	–	5.7×10 <sup>-11</sup>	1.4
IO + CH <sub>3</sub> SH → products	–	–	6.6×10 <sup>-16</sup>	2.0
IO + CH <sub>3</sub> SCH <sub>3</sub> → products	–	–	1.2×10 <sup>-14</sup>	1.5
S + O <sub>2</sub> → SO + O	2.3×10 <sup>-12</sup>	0±200	2.3×10 <sup>-12</sup>	1.2
S + O <sub>3</sub> → SO + O <sub>2</sub>	–	–	1.2×10 <sup>-11</sup>	2.0
SO + O <sub>2</sub> → SO <sub>2</sub> + O	2.6×10 <sup>-13</sup>	2400±500	8.4×10 <sup>-17</sup>	2.0
SO + O <sub>3</sub> → SO <sub>2</sub> + O <sub>2</sub>	3.6×10 <sup>-12</sup>	1100±200	9.0×10 <sup>-14</sup>	1.2
SO + NO <sub>2</sub> → SO <sub>2</sub> + NO	1.4×10 <sup>-11</sup>	0±50	1.4×10 <sup>-11</sup>	1.2
SO + OClO → SO <sub>2</sub> + ClO	–	–	1.9×10 <sup>-12</sup>	3.0
SO <sub>3</sub> + H <sub>2</sub> O → products	See reference	–	–	–
SO <sub>3</sub> + NO <sub>2</sub> → products	–	–	1.0×10 <sup>-19</sup>	10.0
SH + O <sub>2</sub> → OH + SO	–	–	<4.0×10 <sup>-19</sup>	–
SH + O <sub>3</sub> → HSO + O <sub>2</sub>	9.0×10 <sup>-12</sup>	280±200	3.5×10 <sup>-12</sup>	1.3
SH + H <sub>2</sub> O <sub>2</sub> → products	–	–	<5.0×10 <sup>-15</sup>	–
SH + NO <sub>2</sub> → HSO + NO	2.9×10 <sup>-11</sup>	–(240±50)	6.5×10 <sup>-11</sup>	1.2
SH + Cl <sub>2</sub> → ClSH + Cl	1.7×10 <sup>-11</sup>	690±200	1.7×10 <sup>-12</sup>	2.0
SH + BrCl → products	2.3×10 <sup>-11</sup>	–(350±200)	7.4×10 <sup>-11</sup>	2.0
SH + Br <sub>2</sub> → BrSH + Br	6.0×10 <sup>-11</sup>	–(160±160)	1.0×10 <sup>-10</sup>	2.0
SH + F <sub>2</sub> → FSH + F	4.3×10 <sup>-11</sup>	1390±200	4.0×10 <sup>-13</sup>	2.0
HSO + O <sub>2</sub> → products	–	–	<2.0×10 <sup>-17</sup>	–
HSO + O <sub>3</sub> → products	–	–	1.0×10 <sup>-13</sup>	1.3
HSO + NO → products	–	–	<1.0×10 <sup>-15</sup>	–
HSO + NO <sub>2</sub> → HSO <sub>2</sub> + NO	–	–	9.6×10 <sup>-12</sup>	2.0
HSO <sub>2</sub> + O <sub>2</sub> → HO <sub>2</sub> + SO <sub>2</sub>	–	–	3.0×10 <sup>-13</sup>	3.0
HOSO <sub>2</sub> + O <sub>2</sub> → HO <sub>2</sub> + SO <sub>3</sub>	1.3×10 <sup>-12</sup>	330±200	4.4×10 <sup>-13</sup>	1.2
CS + O <sub>2</sub> → OCS + O	–	–	2.9×10 <sup>-19</sup>	2.0
CS + O <sub>3</sub> → OCS + O <sub>2</sub>	–	–	3.0×10 <sup>-16</sup>	3.0
CS + NO <sub>2</sub> → OCS + NO	–	–	7.6×10 <sup>-17</sup>	3.0
CH <sub>3</sub> S + O <sub>2</sub> → products	–	–	<3.0×10 <sup>-18</sup>	–
CH <sub>3</sub> S + O <sub>3</sub> → products	2.0×10 <sup>-12</sup>	–(290±100)	5.3×10 <sup>-12</sup>	1.15
CH <sub>3</sub> S + NO → products	–	–	<1.0×10 <sup>-13</sup>	–
CH <sub>3</sub> S + NO <sub>2</sub> → CH <sub>3</sub> SO + NO	2.1×10 <sup>-11</sup>	–(320±100)	6.1×10 <sup>-11</sup>	1.15
CH <sub>2</sub> SH + O <sub>2</sub> → products	–	–	6.5×10 <sup>-12</sup>	2.0

Reaction	A cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	E/R K	k (298 K) cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	f(298)
CH <sub>2</sub> SH + O <sub>3</sub> → products			3.5×10 <sup>-11</sup>	2.0
CH <sub>2</sub> SH + NO → products			1.9×10 <sup>-11</sup>	2.0
CH <sub>2</sub> SH + NO <sub>2</sub> → products			5.2×10 <sup>-11</sup>	2.0
CH <sub>3</sub> SO + O <sub>3</sub> → products			6.0×10 <sup>-13</sup>	1.5
CH <sub>3</sub> SO + NO <sub>2</sub> → CH <sub>3</sub> SO <sub>2</sub> + NO			1.2×10 <sup>-11</sup>	1.4
CH <sub>3</sub> SOO + O <sub>3</sub> → products			<8.0×10 <sup>-13</sup>	—
CH <sub>3</sub> SOO + NO → products	1.1×10 <sup>-11</sup>	0±100	1.1×10 <sup>-11</sup>	2.0
CH <sub>3</sub> SO <sub>2</sub> + NO <sub>2</sub> → products	2.2×10 <sup>-11</sup>	0±100	2.2×10 <sup>-11</sup>	2.0
CH <sub>3</sub> SCH <sub>2</sub> + NO <sub>3</sub> → products			3.0×10 <sup>-10</sup>	2.0
CH <sub>3</sub> SCH <sub>2</sub> O <sub>2</sub> + NO → CH <sub>3</sub> SCH <sub>2</sub> O + NO <sub>2</sub>			1.9×10 <sup>-11</sup>	2.0
CH <sub>3</sub> SS + O <sub>3</sub> → products			4.6×10 <sup>-13</sup>	2.0
CH <sub>3</sub> SS + NO <sub>2</sub> → products			1.8×10 <sup>-11</sup>	2.0
CH <sub>3</sub> SSO + NO <sub>2</sub> → products			4.5×10 <sup>-12</sup>	2.0
<i>Metal Reactions</i>				
Na + O <sub>3</sub> → NaO + O <sub>2</sub>	1.0×10 <sup>-9</sup>	95±50	7.3×10 <sup>-10</sup>	1.2
→ NaO <sub>2</sub> + O	—	—	<4.0×10 <sup>-11</sup>	—
Na + N <sub>2</sub> O → NaO + N <sub>2</sub>	2.8×10 <sup>-10</sup>	1600±400	1.3×10 <sup>-12</sup>	1.2
Na + Cl <sub>2</sub> → NaCl + Cl	7.3×10 <sup>-10</sup>	0±200	7.3×10 <sup>-10</sup>	1.3
NaO + O → Na + O <sub>2</sub>	3.7×10 <sup>-10</sup>	0±400	3.7×10 <sup>-10</sup>	3.0
NaO + O <sub>3</sub> → NaO <sub>2</sub> + O <sub>2</sub>	1.1×10 <sup>-9</sup>	570±300	1.6×10 <sup>-10</sup>	1.5
→ Na + 2O <sub>2</sub>	6.0×10 <sup>-11</sup>	0±800	6.0×10 <sup>-11</sup>	3.0
NaO + H <sub>2</sub> → NaOH + H	2.6×10 <sup>-11</sup>	0±600	2.6×10 <sup>-11</sup>	2.0
NaO + H <sub>2</sub> O → NaOH + OH	2.2×10 <sup>-10</sup>	0±400	2.2×10 <sup>-10</sup>	2.0
NaO + NO → Na + NO <sub>2</sub>	1.5×10 <sup>-10</sup>	0±400	1.5×10 <sup>-10</sup>	4.0
NaO + HCl → products	2.8×10 <sup>-10</sup>	0±400	2.8×10 <sup>-10</sup>	3.0
NaO <sub>2</sub> + O → NaO + O <sub>2</sub>	2.2×10 <sup>-11</sup>	0±600	2.2×10 <sup>-11</sup>	5.0
NaO <sub>2</sub> + NO → NaO + NO <sub>2</sub>	—	—	<10 <sup>-14</sup>	—
NaO <sub>2</sub> + HCl → products	2.3×10 <sup>-10</sup>	0±400	2.3×10 <sup>-10</sup>	3.0
NaOH + HCl → NaCl + H <sub>2</sub> O	2.8×10 <sup>-10</sup>	0±400	2.8×10 <sup>-10</sup>	3.0

TABLE 2. Rate Constants for Association Reactions

The values quoted are suitable for air as the third body, M. The integer in parentheses is the power of ten.

Reaction	Low pressure limit		High pressure limit	
	$k_0(T) = k_0(300) (T/300)^{-n}$ cm <sup>6</sup> molecule <sup>-2</sup> s <sup>-1</sup>	$n$	$k_\infty(T) = k_\infty(300) (T/300)^{-m}$ cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup>	$m$
<i>O<sub>x</sub> Reactions</i>				
O + O <sub>2</sub> → O <sub>3</sub>	(6.0±0.5) (-34)	2.3±0.5	—	—
<i>O(<sup>1</sup>D) Reactions</i>				
O( <sup>1</sup> D) + N <sub>2</sub> → N <sub>2</sub> O	(3.5±3.0) (-37)	0.6	—	—
<i>HO<sub>x</sub> Reactions</i>				
H + O <sub>2</sub> → HO <sub>2</sub>	(5.7±0.5) (-32)	1.6±0.5	(7.5±4.0) (-11)	0±1.0
OH + OH → H <sub>2</sub> O <sub>2</sub>	(6.2±1.2) (-31)	1.0	(2.6±1.0) (-11)	0±0.5
<i>NO<sub>x</sub> Reactions</i>				
O + NO → NO <sub>2</sub>	(9.0±2.0) (-32)	1.5±0.3	(3.0±1.0) (-11)	0±1.0
O + NO <sub>2</sub> → NO <sub>3</sub>	(9.0±1.0) (-32)	2.0±1.0	(2.2±0.3) (-11)	0±1.0
OH + NO → HONO	(7.0±1.0) (-31)	2.6±0.3	(3.6±1.0) (-11)	0.1±0.5
OH + NO <sub>2</sub> → HNO <sub>3</sub>	(2.5±0.1) (-30)	4.4±0.3	(1.6±0.2) (-11)	1.7±0.2
HO <sub>2</sub> + NO <sub>2</sub> → HO <sub>2</sub> NO <sub>2</sub>	(1.8±0.3) (-31)	3.2±0.4	(4.7±1.0) (-12)	1.4±1.4
NO <sub>2</sub> + NO <sub>3</sub> → N <sub>2</sub> O <sub>5</sub>	(2.2±0.5) (-30)	3.9±1.0	(1.5±0.8) (-12)	0.7±0.4
NO <sub>3</sub> → NO + O <sub>2</sub>	See reference			
<i>Hydrocarbon Reactions</i>				
CH <sub>3</sub> + O <sub>2</sub> → CH <sub>3</sub> O <sub>2</sub>	(4.5±1.5) (-31)	3.0±1.0	(1.8±0.2) (-12)	1.7±1.7
C <sub>2</sub> H <sub>5</sub> + O <sub>2</sub> → C <sub>2</sub> H <sub>5</sub> O <sub>2</sub>	(1.5±1.0) (-28)	3.0±1.0	(8.0±1.0) (-12)	0±1.0

Reaction	Low pressure limit		High pressure limit	
	$k_0(T) = k_0(300) (T/300)^{-n} \text{ cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$	$n$	$k_\infty(T) = k_\infty(300) (T/300)^{-m} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$	$m$
OH + C <sub>2</sub> H <sub>2</sub> → HOCHCH	(5.5±2.0) (-30)	0.0±0.2	(8.3±1.0) (-13)	-2
OH + C <sub>2</sub> H <sub>4</sub> → HOCH <sub>2</sub> CH <sub>2</sub>	(1.0±0.6) (-28)	0.8±2.0	(8.8±0.9) (-12)	0
CH <sub>3</sub> O + NO → CH <sub>3</sub> ONO	(1.4±0.5) (-29)	3.8±1.0	(3.6±1.6) (-11)	0.6±1.0
CH <sub>3</sub> O + NO <sub>2</sub> → CH <sub>3</sub> ONO <sub>2</sub>	(1.1±0.4) (-28)	4.0±2.0	(1.6±0.5) (-11)	1.0±1.0
C <sub>2</sub> H <sub>5</sub> O + NO → C <sub>2</sub> H <sub>5</sub> ONO	(2.8±1.0) (-27)	4.0±2.0	(5.0±1.0) (-11)	1.0±1.0
C <sub>2</sub> H <sub>5</sub> O + NO <sub>2</sub> → C <sub>2</sub> H <sub>5</sub> ONO <sub>2</sub>	(2.0±1.0) (-27)	4.0±2.0	(2.8±0.4) (-11)	1.0±1.0
CH <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> → CH <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>	(1.5±0.8) (-30)	4.0±2.0	(6.5±3.2) (-12)	2.0±2.0
CH <sub>3</sub> C(O)O <sub>2</sub> + NO <sub>2</sub> → CH <sub>3</sub> C(O)O <sub>2</sub> NO <sub>2</sub>	(9.7±3.8) (-29)	5.6±2.8	(9.3±0.4) (-12)	1.5±0.3
<i>FO<sub>x</sub> Reactions</i>				
F + O <sub>2</sub> → FO <sub>2</sub>	(4.4±0.4) (-33)	1.2±0.5	-	-
F + NO → FNO	(1.8±0.3) (-31)	1.0±10	(2.8±1.4) (-10)	0.0±1.0
F + NO <sub>2</sub> → FNO <sub>2</sub>	(6.3±3.0) (-32)	2.0±2.0	(2.6±1.3) (-10)	0.0±1.0
FO + NO <sub>2</sub> → FONO <sub>2</sub>	(2.6±2.0) (-31)	1.3±1.3	(2.0±1.0) (-11)	1.5±1.5
CF <sub>3</sub> + O <sub>2</sub> → CF <sub>3</sub> O <sub>2</sub>	(3.0±0.3) (-29)	4.0±2.0	(4.0±1.0) (-12)	1.0±1.0
CF <sub>3</sub> O + NO <sub>2</sub> → CF <sub>3</sub> ONO <sub>2</sub>	See reference			
CF <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> → CF <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>	(2.2±0.5) (-29)	5.0±1.0	(6.0±1.0) (-12)	2.5±1.0
CF <sub>3</sub> O + CO → CF <sub>3</sub> OCO	(2.5±0.2) (-31)	-	(6.8±0.4) (-14)	-1.2
CF <sub>3</sub> O → CF <sub>2</sub> O + F	See reference			
<i>ClO<sub>x</sub> Reactions</i>				
Cl + O <sub>2</sub> → ClOO	(2.7±1.0) (-33)	1.5±0.5	-	-
Cl + NO → ClNO	(9.0±2.0) (-32)	1.6±0.5	-	-
Cl + NO <sub>2</sub> → ClONO	(1.3±0.2) (-30)	2.0±1.0	(1.0±0.5) (-10)	1.0±1.0
Cl + NO <sub>2</sub> → ClONO <sub>2</sub>	(1.8±0.3) (-31)	2.0±1.0	(1.0±0.5) (-10)	1.0±1.0
Cl + CO → ClCO	(1.3±0.5) (-33)	3.8±0.5	-	-
Cl + C <sub>2</sub> H <sub>2</sub> → ClC <sub>2</sub> H <sub>2</sub>	((5.9±1.0) (-30)	2.1±1.0	(2.1±0.4) (-10)	1.0±0.5
Cl + C <sub>2</sub> H <sub>4</sub> → ClC <sub>2</sub> H <sub>4</sub>	(1.6±1) (-29)	3.3±1.0	(3.1±2) (-10)	1.0±0.5
Cl + C <sub>2</sub> Cl <sub>4</sub> → C <sub>2</sub> Cl <sub>5</sub>	(1.4±0.6) (-28)	8.5±1.0	(4.0±1.0) (-11)	1.2±0.5
ClO + NO <sub>2</sub> → ClONO <sub>2</sub>	(1.8±0.3) (-31)	3.4±1.0	(1.5±0.7) (-11)	1.9±1.9
OCIO + NO <sub>3</sub> → O <sub>2</sub> ClONO <sub>2</sub>	See reference			
ClO + ClO → Cl <sub>2</sub> O <sub>2</sub>	(2.2±0.4) (-32)	3.1±0.5	(3.5±2) (-12)	1.0±1.0
ClO + OCIO → Cl <sub>2</sub> O <sub>3</sub>	(6.2±1.0) (-32)	4.7±0.6	(2.4±1.2) (-11)	0±1.0
OCIO + O → ClO <sub>3</sub>	(1.9±0.5) (-31)	1.1±1.0	(3.1±0.8) (-11)	0±1.0
CH <sub>2</sub> Cl + O <sub>2</sub> → CH <sub>2</sub> ClO <sub>2</sub>	(1.9±0.1) (-30)	3.2±0.2	(2.9±0.2) (-12)	1.2±0.6
CHCl <sub>2</sub> + O <sub>2</sub> → CHCl <sub>2</sub> O <sub>2</sub>	(1.3±0.1) (-30)	4.0±0.2	(2.8±0.2) (-12)	1.4±0.6
CCl <sub>3</sub> + O <sub>2</sub> → CCl <sub>3</sub> O <sub>2</sub>	(6.9±0.2) (-31)	6.4±0.3	(2.4±0.2) (-12)	2.1±0.6
CFCl <sub>2</sub> + O <sub>2</sub> → CFCl <sub>2</sub> O <sub>2</sub>	(5.0±0.8) (-30)	4.0±2.0	(6.0±1.0) (-12)	1.0±1.0
CF <sub>2</sub> Cl + O <sub>2</sub> → CF <sub>2</sub> ClO <sub>2</sub>	(3.0±1.5) (-30)	4.0±2.0	(3±2) (-12)	1.0±1.0
CCl <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> → CCl <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>	(5.0±1.0) (-29)	5.0±1.0	(6.0±1.0) (-12)	2.5±1.0
CFCl <sub>2</sub> O <sub>2</sub> + NO <sub>2</sub> → CFCl <sub>2</sub> O <sub>2</sub> NO <sub>2</sub>	(3.5±0.5) (-29)	5.0±1.0	(6.0±1.0) (-12)	2.5±1.0
CF <sub>2</sub> ClO <sub>2</sub> + NO <sub>2</sub> → CF <sub>2</sub> ClO <sub>2</sub> NO <sub>2</sub>	(3.3±0.7) (-29)	6.7±1.3	(4.1±1.9) (-12)	2.8±0.7
<i>BrO<sub>x</sub> Reactions</i>				
Br + NO <sub>2</sub> → BrNO <sub>2</sub>	(4.2±0.8) (-31)	2.4±0.5	(2.7±0.5) (-11)	0±1.0
BrO + NO <sub>2</sub> → BrONO <sub>2</sub>	(5.2±0.6) (-31)	3.2±0.8	(6.9±1.0) (-12)	2.9±1.0
<i>IO<sub>x</sub> Reactions</i>				
I + NO → INO	(1.8±0.5) (-32)	1.0±0.5	(1.7±1.0) (-11)	0±1.0
I + NO <sub>2</sub> → INO <sub>2</sub>	(3.0±1.5) (-31)	1.0±1.0	(6.6±5.0) (-11)	0±1.0
IO + NO <sub>2</sub> → IONO <sub>2</sub>	(5.9±2.0) (-31)	3.5±1.0	(9.0±1.0) (-12)	1.5±1.0
<i>SO<sub>x</sub> Reactions</i>				
HS + NO → HSNO	(2.4±0.4) (-31)	3.0±1.0	(2.7±0.5) (-11)	0
CH <sub>3</sub> S + NO → CH <sub>3</sub> SNO	(3.2±0.4) (-29)	4.0±1.0	(3.9±0.6) (-11)	2.7±1.0
O + SO <sub>2</sub> → SO <sub>3</sub>	(1.3±)(-33)	-3.6±0.7		
OH + SO <sub>2</sub> → HOSO <sub>2</sub>	(3.0±1.0) (-31)	3.3±1.5	(1.5±0.5) (-12)	0
CH <sub>3</sub> SCH <sub>2</sub> + O <sub>2</sub> → CH <sub>3</sub> SCH <sub>2</sub> O <sub>2</sub>	See reference			
SO <sub>3</sub> + NH <sub>3</sub> → H <sub>3</sub> NSO <sub>3</sub>	(3.9±0.8) (-30)	3.0±3.0	(4.7±1.3) (-11)	0±1.0

Reaction	Low pressure limit		High pressure limit	
	$k_0(T) = k_0(300) (T/300)^{-n} \text{ cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$	$n$	$k_\infty(T) = k_\infty(300) (T/300)^{-m} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$	$m$
<i>Metal Reactions</i>				
$\text{Na} + \text{O}_2 \rightarrow \text{NaO}_2$	(3.2±0.3) (-30)	1.4±0.3	(6.0±2.0) (-10)	0±1.0
$\text{NaO} + \text{O}_2 \rightarrow \text{NaO}_3$	(3.5±0.7) (-30)	2.0±2.0	(5.7±3.0) (-10)	0±1.0
$\text{NaO} + \text{CO}_2 \rightarrow \text{NaCO}_3$	(8.7±2.6) (-28)	2.0±2.0	(6.5±3.0) (-10)	0±1.0
$\text{NaOH} + \text{CO}_2 \rightarrow \text{NaHCO}_3$	(1.3±0.3) (-28)	2.0±2.0	(6.8±4.0) (-10)	0±1.0

TABLE 3. Equilibrium Constants

 $K(T)/\text{cm}^3 \text{ molecule}^{-1} = A \exp(B/T) \quad [200 < T/K < 300]$ 

Reaction	$A/\text{cm}^3 \text{ molecule}^{-1}$	$B/K$	$K(298 \text{ K})$	$f(298 \text{ K})$
$\text{HO}_2 + \text{NO}_2 \rightarrow \text{HO}_2\text{NO}_2$	$2.1 \times 10^{-27}$	10900±1000	$1.6 \times 10^{-11}$	5
$\text{NO} + \text{NO}_2 \rightarrow \text{N}_2\text{O}_3$	$3.3 \times 10^{-27}$	4667±100	$2.1 \times 10^{-20}$	2
$\text{NO}_2 + \text{NO}_2 \rightarrow \text{N}_2\text{O}_4$	$5.2 \times 10^{-29}$	6643±250	$2.5 \times 10^{-19}$	2
$\text{NO}_2 + \text{NO}_3 \rightarrow \text{N}_2\text{O}_5$	$2.7 \times 10^{-27}$	11000±500	$2.9 \times 10^{-11}$	1.3
$\text{CH}_3\text{O}_2 + \text{NO}_2 \rightarrow \text{CH}_3\text{O}_2\text{NO}_2$	$1.3 \times 10^{-28}$	11200±1000	$2.7 \times 10^{-12}$	2
$\text{CH}_3\text{C(O)O}_2 + \text{NO}_2 \rightarrow \text{CH}_3\text{C(O)O}_2\text{NO}_2$	$9.0 \times 10^{-29}$	14000±200	$2.3 \times 10^{-8}$	2
$\text{F} + \text{O}_2 \rightarrow \text{FOO}$	$3.2 \times 10^{-25}$	6100±1200	$2.5 \times 10^{-16}$	1.0
$\text{Cl} + \text{O}_2 \rightarrow \text{ClOO}$	$5.7 \times 10^{-25}$	2500±750	$2.5 \times 10^{-21}$	2
$\text{Cl} + \text{CO} \rightarrow \text{ClCO}$	$1.6 \times 10^{-25}$	4000±500	$1.1 \times 10^{-19}$	5
$\text{ClO} + \text{O}_2 \rightarrow \text{ClOO}_2$	$2.9 \times 10^{-26}$	<3700	$<7.2 \times 10^{-21}$	–
$\text{ClO} + \text{ClO} \rightarrow \text{Cl}_2\text{O}_2$	$1.3 \times 10^{-27}$	8744±850	$7.2 \times 10^{-15}$	1.5
$\text{ClO} + \text{OCIO} \rightarrow \text{Cl}_2\text{O}_3$	$1.1 \times 10^{-24}$	5455±300	$9.8 \times 10^{-17}$	3
$\text{OCIO} + \text{NO}_3 \rightarrow \text{O}_2\text{ClONO}_2$	$1 \times 10^{-28}$	9300±1000	$3.6 \times 10^{-15}$	5
$\text{OH} + \text{CS}_2 \rightarrow \text{CS}_2\text{OH}$	$4.5 \times 10^{-25}$	5140±500	$1.4 \times 10^{-17}$	1.4
$\text{CH}_3\text{S} + \text{O}_2 \rightarrow \text{CH}_3\text{SO}_2$	$1.8 \times 10^{-27}$	5545±300	$2.2 \times 10^{-19}$	1.4