Tables S1-S4: Aqueous chemistry and gas-phase halogen chemistry

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The tables listed here give the reactions used to represent aqueous and halogen chemistry in the model described by *Sillman et al.* [2007] (Reactive mercury in the troposphere: Model formation and results for Florida, the northeastern U.S. and the Atlantic Ocean, *J. Geophys. Res.*, 10.1029/2006JD008227, 2007).

Reactions for atmospheric mercury are not included here. They are described separately (Tables S5-S8).

The mechanism for gas-phase photochemistry (other than mercury or halogens) is described in Appendix A of *Ito et al.* [2007].

The reactions and rates included here are taken from compilations by *Jacob et al.* [1986], *Pandis and Seinfeld* [1989], *Lelieveld et al.* [1990], *Liu et al.* [1997], *Sander and Crutzen* [1996] and *Sander et al.* [2003]. These studies are cited as references for the individual rates. Readers are referred there for the primary sources.

This file includes the following tables:

Table S1: Henry's law coefficients
Table S2: Aqueous equilibrium coefficients.
Table S3: Aqueous reactions.
Table S4: Gas-phase reactions involving halogens.

Table S1

Henry's Law coefficients

Values here represent the physical Henry constants (K_H) and do not take into account enhanced solubilities due to dissociation equilibria.

Abbreviations and units:

K_{H298}=Henry's law coefficient at 298 K, expresed in M atm^{-1}.

ΔH = enthalpy of solution, expressed as $\Delta H/R$ (where R represents the gas constant) in units °K.

The temperature dependence is represented by $K_H = K_{H298} \exp[-\Delta H/R(1/T - 1/298)]$ for temperature T in °K.

Species	**K_{H298}**	**$\Delta H/R$**	**Reference**
CO_2	3.4E-02	2420.	*Pandis*, 1989
H_2O_2	7.73E+04	-7310.	*JPL*, 2003
OH	2.5E+01	-5280.	*Jacob*, 1986
HO_2	2.0E+03	-6640.	*Jacob*, 1986
O_3	1.03E-02	-2830.	*JPL*, 2003
NO_2	1.0E-02	-2500.	*Pandis*, 1989
NO	1.9E-03	-1480.	*Pandis*, 1989
HNO_3	2.1E+05	0.	*Lelieveld*, 1991, *Sander*, 1996
HONO	5.1E-04	1260.	*Pandis*, 1989
NH_3	7.5E+01	-3400.	*Pandis*, 1989
PAN	2.9E+00	-5910.	*Pandis*, 1989
CH_3CO_3	1.0E+02	0.	*Pandis*, 1989
$CH_3C(O)OOH$	4.73E+02	-6170.	*Pandis*, 1989
CH_3O_2	6.0E+00	-5600.	*Pandis*, 1989
CH_3OOH (MP)	2.27E+02	-5610.	*Pandis*, 1989
HCHO	6.3E+03	-6460.	*Pandis*, 1989
CH_3CHO	1.14E+01	-6460.	*Hermann*, 2000

CH_3OH	2.2E+02	-4900.	*Pandis*, 1989
CH_3COOH (Acetic acid)	5.5E+03	-5740.	*Hermann*, 2000
H_2SO_4[1]	1.0E+08	0.	See note 1
HCl	1.1E+00	2023.	*Sander*, 1996
Cl_2	9.2E-02	0.	*Sander*, 1996
HOCl	4.8E+02	1633.	*Sander*, 1996
HBr	7.2E-01	6077.	*Sander*, 1996
HOBr	4.8E+01	0.	*Sander*, 1996

1. H_2SO_4 and other species that form soluble aerosols are represented by a gas-phase pseudo-species with a very high Henry constant, which insures rapid incorporation into the aqueous phase. This is used in model calculations that do not include explicit treatment of aerosols.

Table S2

Aqueous equilibrium coefficients

K_{aq} represents the equilibrium constant for reactions with the form C<=>A+B, with format Kaq = [A][B]/[C], in M.

Abbreviations and units:

K_{aq298}=equilibrium constant at 298 K, in M.

ΔH = reaction enthalpy, expressed as ΔH/R (where R represents the gas constant) in units °K.

The temperature dependence is represented by $K_{aq} = K_{aq298}\ \exp[-\Delta H/R(1/T - 1/298)]$ for temperature T in °K.

Reaction	**K_{aq298}**	**ΔH/R**	**Reference**
$CO_2 \leftrightarrow H^+ + HCO_3^-$	4.46E-07	1000.	*Pandis*, 1989
$HCO_3^- \leftrightarrow H^+ + CO_3^{-2}$	4.68E-11	1760.	*Pandis*, 1989
$SO_2 \leftrightarrow H^+ + HSO_3^-$	1.23E-02	1960.	*Pandis*, 1989
$HSO_3^- \leftrightarrow H^+ + SO_3^{-2}$	6.61E-08	-1500.	*Sander*, 1996
$H_2SO_4 \leftrightarrow H^+ + HSO_4^-$	1.0E+03		*Pandis*, 1989
$HSO_4^- \leftrightarrow H^+ + SO_4^{-2}$	1.02E-02	-2720.	*Pandis*, 1989
$H_2O_2 \leftrightarrow H^+ + HO_2^-$	2.2E-12	3730.	*Pandis*, 1989
$HO_2 \leftrightarrow H^+ + O_2^-$	1.6E-05	0.	*Sander*, 1996
$HNO_3 \leftrightarrow H^+ + NO_3^-$	1.54E+01	-8700.	*Pandis*, 1989
$HONO \leftrightarrow H^+ + NO_2^-$	5.1E-04	1260.	*Pandis*, 1989
$NH_3 \leftrightarrow OH^- + NH_4^+$	1.7E-05	-4325.	*Pandis*, 1989
$HCHO + H_2O \leftrightarrow H_2C(OH)_2$	1.82E+03[1]	-4020.	*Pandis*, 1989, *Sander*, 2004
$HCOOH \leftrightarrow H^+ + HCOO^-$	1.78E-04	20.	*Pandis*, 1989
$HOCH_2SO_3^-$ (HMS-) $\leftrightarrow$ $H^+ + OCH_2SO_3^{-2}$	2.0E-12		*Jacob et al*., 1986

$CH_3C(O)OOH \leftrightarrow H^+ + CH_3C(O)OO^-$	1.78E-04	0.	assumed equal to HCOOH
$CH_3COOH \leftrightarrow H^+ + CH_3COO^-$	1.75E-05	0.	*Hermann*, 2000
$HCl \leftrightarrow H^+ + Cl^-$	1.74E+06	-6900.	*Sander*, 1996
$Cl \leftrightarrow H^+ + ClOH^-$	6.19E-08	0.	*Pandis*, 1989, *Sander*, 1996. see note 1
$HOCl \leftrightarrow H^+ + OCl^-$	3.2E-08	0.	*Sander*, 1996
$HBr \leftrightarrow H^+ + Br^-$	1.0E+09	0.	*Sander*, 1996
$HOBr \leftrightarrow H^+ + OBr^-$	2.100E-09	0.	*Sander*, 1996
$Cl_2^- \leftrightarrow Cl + Cl^-$	5.26E-06		*Sander*, 1996
$Br_2^- \leftrightarrow Br + Br^-$	9.1E-06		*Sander*, 1996

Notes:

1. This equilibrium coefficient is derived from the rates reported by *Pandis and Seinfeld* [1989] and *Sander and Crutzen* [1996] for the reactions $Cl \rightarrow H^+ + ClOH^-$ and $H^+ + ClOH^- \rightarrow Cl$.

Table S3

Aqueous reactions

k_{298}: rate constant at 298 K, in M s^{-1} (for reactions involving two species) or s^{-1} for reactants involving a single species.

E_a: activation energy, expressed as E_a/R (where R represents the gas constant) in units °K.

The temperature dependence is represented by $k_T = k_{298} \exp[-E_a/R(1/T - 1/298)]$ for temperature T in °K.

Reaction	**k_{298}**	**E_a/R**	**References**
$OH + HO_2 \rightarrow$	7.0E+09	1500.	*Pandis*, 1989
$OH + O_2^- \rightarrow OH^-$	1.0E+10	1500	*Pandis*, 1989
$OH + H_2O_2 \rightarrow HO_2$	2.7E+07	1700.	*Pandis*, 1989
$HO_2 + HO_2 \rightarrow H_2O_2$	8.6E+05	2365.	*Pandis*, 1989
$HO_2 + O_2^- \rightarrow H_2O_2 + OH^-$	1.0E+08	1500.	*Pandis*, 1989
$O_2^- + O_2^- \rightarrow H_2O_2 + 2OH^-$	3.0E-01	0.	*Pandis*, 1989
$HO_2 + H_2O_2 \rightarrow OH$	5.0E-01		*Pandis*, 1989
$O_2 + H_2O_2 \rightarrow OH$	1.3E-01		*Pandis*, 1989
$OH + O_3 \rightarrow HO_2$	2.0E+09		*Pandis*, 1989
$HO_2 + O_3 \rightarrow OH$	1.0E+04		*Pandis*, 1989
$O_2^- + O_3 \rightarrow OH + OH^-$	1.5E+09	1500.	*Pandis*, 1989
$OH^- + O_3 \rightarrow HO_2 + O_2^-$	7.0E+01		*Pandis*, 1989
$HO_2^- + O_3 \rightarrow OH + O_2^-$	2.8E+06	0.	*Pandis*, 1989
$HCO_3 + OH \rightarrow CO_3^-$	1.5E+07	1910.	*Pandis*, 1989
$HCO_3 + O_2^- \rightarrow CO_3^- + HO_2^-$	1.5E+06	0.	*Pandis*, 1989
$CO_3^- + O_2^- \rightarrow HCO_3 + OH^-$	4.0E+08	1500.	*Pandis*, 1989
$CO_3^- + H_2O_2 \rightarrow HCO_3 + HO_2$	8.0E+05	2820.	*Pandis*, 1989
$HCO_3 + OH \rightarrow CO_3^-$	1.4E-12	900	*Pandis*, 1989
$Cl^- + HOCl + H^+ \rightarrow Cl_2$	1.8E+04	6900.	*Sander*, 1996[1]

$Cl_2 \rightarrow Cl^- + HOCl$	1.1E+01	0.	*Sander*, 1996
$Cl_2^- + HO_2 \rightarrow 2Cl^- + H^+$	4.5E+09	0.	*Sander*, 1996
$Cl_2^- + O_2^- \rightarrow 2Cl^-$	1.0E+09	0.	*Sander*, 1996
$Cl_2^- + H_2O_2 \rightarrow 2Cl^- + HO_2 + H^+$	1.4E+05	3370.	*Pandis*, 1989
$Cl_2^- + OH^- \rightarrow 2Cl^- + OH$	7.3E+06	2160.	*Pandis*, 1989
$Cl + HO_2 \rightarrow Cl^- + H^+$	3.1E+09	1500.	*Pandis*, 1989
$Cl + H_2O_2 \rightarrow Cl^- + HO_2 + H^+$	4.5E+07	0.	*Pandis*, 1989
$Cl^- + OH \rightarrow ClOH^-$	4.3E+09	1500.	*Pandis*, 1989, *Sander*, 1996
$ClOH^- \rightarrow Cl^- + OH$	6.1E+09	0.	*Pandis*, 1989, *Sander*, 1996
$SO_4^- + Cl^- \rightarrow SO_4^{=} + Cl$	2.0E+08	1500.	*Pandis*, 1989
$NO_3 + Cl^- \rightarrow NO_3^- + Cl$	1.0E+8	1500.	*Pandis*, 1989
$Br_2^- + HO_2 \rightarrow 2Br^- + H^+$	4.4E+09	0.	*Sander*, 1996, 2004
$Br_2^- + O_2^- \rightarrow 2Br^-$	1.7E+08	0.	*Sander*, 1996
$Br_2^- + H_2O_2 \rightarrow 2Br^- + HO_2 + H^+$	1.0E+05	0.	*Sander*, 2004
$Br_2^- + OH^- \rightarrow 2Br^- + OH$	1.1E+10	0.	*Sander*, 2004
$HOBr + HO_2 \rightarrow Br^-$	1.0E+09	0.	*Sander*, 2004
$HOBr + O_2^- \rightarrow Br^-$	3.5E+09	0.	*Sander*, 2004
$SO_4 + Br^- \rightarrow SO_4^- + Br$	3.5E+09	0.	*Sander*, 1996
$NO_3 + Br^- \rightarrow NO_3^- + Br$	4.0E+09	1500.	*Sander*, 1996, 2004
$NO + NO_2 \rightarrow 2NO_2^- + H^+$	2.0E+8	1500.	*Pandis*, 1989
$NO_2 + NO_2 \rightarrow NO_2^- + NO_3^- + 2H^+$	1.0E+8	1500.	*Pandis*, 1989
$NO + OH \rightarrow NO_2^- + H^+$	2.0E+10	1500.	*Pandis*, 1989
$NO_2 + OH \rightarrow NO_3^- + H^+$	1.3E+09	1500.	*Pandis*, 1989
$HONO + OH \rightarrow NO_2$	1.0E+09	1500.	*Pandis*, 1989
$NO_2^- + OH \rightarrow NO_2 + OH^-$	1.0E+10	1500.	*Pandis*, 1989
$NO_2^- + O_3 \rightarrow NO_3^-$	5.0E+05	6950.	*Pandis*, 1989
$NO_2^- + NO_3 \rightarrow NO_2 + NO_3^-$	1.2E+09	1500.	*Pandis*, 1989

$NO_3 + HO_2 \rightarrow NO_3^- + H^+$	1.2E+09	1500.	*Jacob,* 1986
$NO_3 + O_2^- \rightarrow NO_3^-$	1.0E+09	1500.	*Jacob,* 1986
$NO_3 + H_2O_2 \rightarrow NO_3^- + HO_2 + H^+$	1.0E+06	2800.	*Pandis*, 1989
$NO_2^- + CO_3^- \rightarrow NO_2 + CO_3^{-2}$	4.0E+05	0.	*Pandis*, 1989
$NO_2^- + Cl_2^- \rightarrow NO_2 + 2Cl^-$	2.5E+08	1500.	*Pandis*, 1989
$NO_2^- + Br_2^- \rightarrow NO_2 + 2Br^-$	1.7E+07	0.	*Sander*, 2004
$H_2C(OH)_2 + OH \rightarrow HCOOH + HO_2$	2.0E+09	1500.	*Pandis*, 1989
$HCOOH + OH \rightarrow CO_2 + HO_2$	1.6E+08	1500.	*Pandis*, 1989
$HCOO^- + OH \rightarrow CO_2 + HO_2 + OH^-$	2.5E+09	1500.	*Pandis*, 1989
$HCOOH + NO_3 \rightarrow NO_3^- + CO_2 + HO_2 + H^+$	2.1E+05	3200.	*Pandis*, 1989
$HCOO^- + NO_3 \rightarrow NO_3^- + CO_2 + HO_2$	6.0E+07	1500.	*Jacob,* 1986
$HCOOH + O_3 \rightarrow CO_2 + HO_2 + OH$	5.0E+00	0.	*Pandis*, 1989
$HCOO^- + O_3 \rightarrow CO_2 + O_2^- + OH$	1.0E+02	0.	*Pandis*, 1989
$HCOO^- + CO_3^- \rightarrow HCO_3^- + CO_2 + HO_2 + OH^-$	1.1E+05	3400.	*Pandis*, 1989
$HCOOH + Cl_2^- \rightarrow CO_2 + HO_2 + 2Cl^- + H^+$	6.7E+03	4300.	*Pandis*, 1989
$HCOO^- + Cl_2^- \rightarrow CO_2 + HO_2 + 2Cl^-$	1.9E+6	2600.	*Pandis*, 1989
$CH_3O_2 + HO_2 \rightarrow CH_3OOH$	4.3E+05	3000.	*Jacob,* 1986
$CH_3O_2 + O_2^- \rightarrow CH_3OOH + OH^-$	5.0E+07	1600.	*Jacob,* 1986
$CH_3OOH + OH \rightarrow CH_3O_2$	2.7E+07	1700.	*Jacob,* 1986
$CH_3OOH + OH \rightarrow HCHO + OH$	1.9E+07	1800.	*Jacob,* 1986
$CH_3OH + OH \rightarrow HCHO + HO_2$	4.5E+06	1500.	*Pandis*, 1989
$CH_3OH + CO_3^- \rightarrow HCHO + HO_2 + HCO_3^-$	2.6E+03	4500.	*Pandis*, 1989
$CH_3OH + Cl_2^- \rightarrow HCHO + HO_2 + 2Cl^- + H^+$	3.5E+03	4400.	*Pandis*, 1989
$CH_3OH + NO_3 \rightarrow HCHO + HO_2 + NO_3^- + H^+$	1.0E+06	2800	*Pandis*, 1989

$CH_3CO_3+O_2^-\rightarrow CH_3C(O)OO^-$	1.0E+09	0.	
$CH_3C(O)OOH+CH_3CHO\rightarrow 2CH_3COOH-+2H^+$	1.5E-02	0.	
$SO_2+O_3\rightarrow H_2SO_4$	2.4E+04	0.	*Pandis*, 1989
$HSO_3^-+O_3\rightarrow HSO_4^-$	3.7E+05	5530.	*Pandis*, 1989
$SO_3^{-2}+O_3\rightarrow SO_4^{-2}$	1.5E+09	5280.	*Pandis*, 1989
$SO_2+H_2O_2\rightarrow H_2SO_4$	1.3E+06	4430.	*Pandis*, 1989
$HSO_3^-+H_2O_2\rightarrow HSO_4^-$	5.2E+06	3650.	*Sander*, 2004
$HSO_3^-+OH\rightarrow SO_5^-$	4.2E+09	1500.	*Pandis*, 1989
$SO_3^{-2}+OH\rightarrow SO_5^-+OH^-$	4.6E+09	1500.	*Pandis*, 1989
$SO_5^-+HSO_3^-\rightarrow SO_5^-+HSO_5^-$	3.0E+05	3100.	*Pandis*, 1989
$SO_5^-+SO_3^{-2}\rightarrow SO_4^{-2}+SO_4^-$	1.3E+07	2000.	*Jacob,* 1986 (1.0E07)
$SO_5^-+O_2^-\rightarrow HSO_5^-+OH^-$	1.0E+08	1500.	*Jacob,* 1986
$SO_5^-+HCOOH\rightarrow HSO_5^-+CO_2+HO_2$	2.0E+02	5300.	*Jacob,* 1986
$SO_5^-+HCOO^-\rightarrow HSO_5^-+CO_2+O_2^-$	1.4E+04	4000.	*Jacob,* 1986
$SO_5^-+SO_5^-\rightarrow 2SO_4^-$	2.0E+08	1500.	*Jacob,* 1986
$HSO_5^-+OH\rightarrow SO_5^-$	1.7E+07	1900.	*Jacob,* 1986
$HSO_5^-+SO_4^-\rightarrow SO_5^-+SO_4^{-2}+H^+$	1.0E+05	0.	*Jacob,* 1986
$HSO_5^-+NO_2^-\rightarrow HSO_4^-+NO_3^-$	3.1E-01	6650.	*Jacob,* 1986
$SO_4^-+HSO_3^-\rightarrow SO_5^-+SO_4^{-2}+H^+$	1.3E+09	1500.	*Jacob,* 1986
$SO_4^-+SO_3^{-2}\rightarrow SO_5^-+SO_4^{-2}$	5.3E+08	1500.	*Jacob,* 1986
$SO_4^-+HO_2\rightarrow SO_4^{-2}+H^+$	5.0E+09	1500.	*Jacob,* 1986
$SO_4^-+O_2^-\rightarrow SO_4^{-2}$	5.0E+09	1500.	*Jacob,* 1986
$SO_4^-+OH^-\rightarrow SO_4^{-2}+OH$	8.0E+07	1500.	*Jacob,* 1986
$SO_4^-+H_2O_2^-\rightarrow SO_4^{-2-}+HO_2+H^+$	1.2E+07	2000.	*Pandis*, 1989
$SO_4^-+NO_2^-\rightarrow SO_4^{-2-}+NO_2$	8.8E+08	1500.	*Jacob,* 1986
$SO_4^-+HCO_3^-\rightarrow SO_4^{-2-}+CO_3^-+H^+$	9.1E+06	2100.	*Pandis*, 1989

$SO_4^-+HCOO^-\rightarrow SO_4^{-2-}+CO_2+HO_2$	1.7E+08	1500.	*Jacob,* 1986
$SO_4^-+HCOOH\rightarrow SO_4^{-2-}+CO_2+HO_2+H^+$	1.4E+06	2700.	*Jacob,* 1986
$SO_2+HO_2\rightarrow H_2SO_4+OH$	1.0E+06	0.	*Pandis*, 1989
$SO_4^-+CH_3OH\rightarrow SO_4^{-2}+HCHO+HO_2+H^+$	2.5E+07	1800.	*Pandis*, 1989
$SO_4^-+Cl_2^-\rightarrow SO_4^{-2}+2Cl^-+H^+$	3.4E+08	1500.	*Pandis*, 1989
$SO_3^-+Cl_2^-\rightarrow SO_5^-+2Cl^-$	1.6E+08	1500.	*Pandis*, 1989
H_2O_2(aq)+ hν→ 2 OH(aq)	same as gas-phase $H_2O_2+h\nu\rightarrow 2OH$		*Sander*, 1996
O_3(aq) + hν→ H_2O_2(aq)	same as gas-phase $O_3+ h\nu\rightarrow O(^1D)$		*Pandis*, 1989, *Sander*, 1996
HONO(aq) + hν→ NO+OH	same as gas-phase HONO+hν→ NO+OH		*Pandis*, 1989
HNO_2^- + hν→ NO+OH	same as gas-phase HONO+hν→ NO+OH		*Pandis*, 1989
NO_3^- + hν→ NO_2+OH+OH^-	same as gas-phase HNO_3 + hν		*Pandis*, 1989
NO_3 + hν→ NO	same as gas-phase NO_3 + hν→ NO		*Pandis*, 1989

$CH_3OOH + h\nu \rightarrow$ $HCHO+OH+HO_2$	$5.0E\text{-}04 * j_{NO2}$		*Pandis*, 1989

1. *Sander and Crutzen* [1996] give this reaction as a $H^+ + Cl^- + HOCL$. We have converted this into an equivalent reaction for HCl+HOCl, with a rate equal to $k_s * K_e$, where k_s is the rate from *Sander and Crutzen* [1996] and Ke is the equilibrium constant for $HCl \leftrightarrow H^+ + Cl^-$.

Table S4

Gas-phase reactions: Halogens

k_0=rate constant at 0 K, in molec. cm^{-3} s^{-1} (for reactions involving two species) or s^{-1} (for reactants involving a single species).

E_a = activation energy, expressed as $-E_a/R$ (where R represents the gas constant) in units °K.

The temperature dependence is represented by $k_T = k_0 \exp[-E_a/R(1/T)]$ for temperature T in °K.

Reaction	**k_0**	**E_a/R**	**References**
Cl_2+ OH→ HOCl	1.4E-12	900.	*JPL*, 2003
HCl+ OH→ Cl	2.6E-12	350.	*JPL*, 2003
HOCl+ OH→ ClO	3.0E-12	500.	*JPL*, 2003
Cl+ HO_2→ HCl	1.8E-11	-170.	*JPL*, 2003
Cl+ HO_2→ OH+ClO	4.1E–11	450.	*JPL*, 2003
ClO+ HO_2→ HOCl	2.7E-12	-220.	*JPL*, 2003
ClO+ NO→ Cl+NO_2	6.4E-12	-290.	*JPL*, 2003
ClO+ OH→ Cl+HO_2	7.4E-12	-270.	*JPL*, 2003
ClO+ OH→ HCl	6.0E-13	-230.	*JPL*, 2003
Cl+ H_2O_2→ HCl+HO_2	1.1E-11	980.	*JPL*, 2003
Cl+ NO_3→ ClO+NO_2	2.4E-11	0.	*JPL*, 2003
Cl+ H_2→ HCl+HO_2	3.7E-11	2300.	*JPL*, 2003
Cl+ CH_4→ HCl+CH_3O_2	9.6E-12	1360.	*JPL*, 2003
Cl+ O_3→ ClO	2.3E-11	200.	*JPL*, 2003
Br_2+ OH→ HOBr+Br	4.2E-11		*JPL*, 2003.
HBr + OH→ Br	1.1E-11	0.	*JPL*, 2003
HOBr + OH→ BrO	3.0E-12	500.	assumed equal to HOCl+OH→ ClO

$Br + HO_2 \rightarrow HBr$	1.5E-11	600.	*JPL*, 2003
$BrO + HO_2 \rightarrow HOBr$	3.4E-12	-540.	rate from *JPL*, 2003, products from *Sander*, 1996
$BrO + NO \rightarrow Br + NO_2$	8.8E-12	-260.	*JPL*, 2003
$Br + NO_3 \rightarrow Br_2 + NO_2$	1.6E-11	0.	*JPL*, 2003
$Br + HCHO \rightarrow HBr + HO_2 + CO$	1.7E-11	800.	*JPL*, 2003
$Br + O_3 \rightarrow BrO$	1.7E-11	800.	*JPL*, 2003
$Br + HO_2 \rightarrow HBr$	1.5E-11	600.	*JPL*, 2003
$Cl_2 + h\nu \rightarrow 2\ Cl$	$0.267 * j_{NO2}$		*Sander*, 1996
$Br_2 + h\nu \rightarrow 2\ Br$	$4.444 * j_{NO2}$		*Sander*, 1996

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