

$$\frac{d[O(^1D)]}{dt} = \begin{array}{lll} -k_6^{bi}[O(^1D)][N_2] & -k_7^{bi}[O(^1D)][O_2] & -k_{32}^{bi}[H_2O][O(^1D)] \\ -k_{37}^{bi}[N_2O][O(^1D)] & -k_{39}^{bi}[H_2][O(^1D)] & -k_{40}^{bi}[CH_4][O(^1D)] \\ -k_{45}^{bi}[CH_4][O(^1D)] & -k_{61}^{bi}[N_2O][O(^1D)] & -k_{63}^{bi}[O(^1D)][CF_2Cl_2] \\ -k_{75}^{bi}[CH_4][O(^1D)] & -k_{76}^{bi}[O(^1D)][CH_3Br] & -k_{77}^{bi}[O(^1D)][O_3] \\ -k_{78}^{bi}[O(^1D)][O_3] & -k_{92}^{tri}[O(^1D)][N_2] & +j_{103}[BrO] \\ +j_{111}[CO_2] & +j_{119}[H_2O] & +j_{134}[N_2O] \\ +j_{138}[NO_2] & +j_{142}[O_2] & +j_{145}[O_3] \\ +j_{147}[OCIO] & & \end{array}$$

$$\frac{d[O(^3P)]}{dt} = \begin{array}{lll} -k_1^{bi}[O(^3P)][O_3] & +k_6^{bi}[O(^1D)][N_2] & +k_7^{bi}[O(^1D)][O_2] \\ +k_{16}^{bi}[N][O_2] & -k_{17}^{bi}[HCHO][O(^3P)] & -k_{21}^{bi}[ClO][O(^3P)] \\ -k_{27}^{bi}[O(^3P)][H_2O_2] & -k_{28}^{bi}[O(^3P)][ClONO_2] & -k_{34}^{bi}[OH][O(^3P)] \\ -k_{35}^{bi}[HO_2][O(^3P)] & -k_{36}^{bi}[NO_2][O(^3P)] & +k_{38}^{bi}[N][NO] \\ +k_{47}^{bi}[OH][OH] & +k_{58}^{bi}[H][HO_2] & +k_{64}^{bi}[N][NO_2] \\ -k_{74}^{bi}[BrO][O(^3P)] & +2k_{78}^{bi}[O(^1D)][O_3] & -k_{82}^{tri}[O(^3P)][O_2] \\ -k_{88}^{tri}[NO_2][O(^3P)] & -k_{91}^{tri}[NO][O(^3P)] & -2k_{93}^{tri}[O(^3P)][O(^3P)] \\ -k_{96}^{tri}[CO][O(^3P)] & +j_{102}[BrO] & +j_{110}[CO_2] \\ +j_{115}[ClO] & +j_{117}[ClOO] & +j_{118}[H_2O] \\ +j_{126}[HO_2] & +j_{133}[CH_3OOH] & +j_{135}[N_2O_5] \\ +j_{137}[NO] & +j_{139}[NO_2] & +j_{140}[NO_3] \\ +j_{142}[O_2] & +2j_{143}[O_2] & +j_{144}[O_3] \\ +j_{146}[OCIO] & & \end{array}$$

$$\frac{d[O_3]}{dt} = \begin{array}{lll} -k_1^{bi}[O(^3P)][O_3] & -k_2^{bi}[OH][O_3] & -k_3^{bi}[HO_2][O_3] \\ -k_8^{bi}[NO][O_3] & -k_9^{bi}[NO_2][O_3] & -k_{10}^{bi}[H][O_3] \\ -k_{20}^{bi}[Cl][O_3] & -k_{65}^{bi}[Br][O_3] & -k_{77}^{bi}[O(^1D)][O_3] \\ -k_{78}^{bi}[O(^1D)][O_3] & +k_{82}^{tri}[O(^3P)][O_2] & -j_{144}[O_3] \\ -j_{145}[O_3] & & \end{array}$$

$$\frac{d[N]}{dt} = \begin{array}{lll} -k_{16}^{bi}[N][O_2] & -k_{38}^{bi}[N][NO] & -k_{55}^{bi}[N][OH] \\ -k_{64}^{bi}[N][NO_2] & +j_{137}[NO] & \end{array}$$

$$\frac{d[NO]}{dt} = \begin{array}{lll} -k_8^{bi}[NO][O_3] & -k_{13}^{bi}[CH_3O_2][NO] & +k_{16}^{bi}[N][O_2] \\ -k_{24}^{bi}[ClO][NO] & -k_{31}^{bi}[NO][HO_2] & +k_{36}^{bi}[NO_2][O(^3P)] \\ +2k_{37}^{bi}[N_2O][O(^1D)] & -k_{38}^{bi}[N][NO] & -k_{53}^{bi}[BrO][NO] \\ +k_{55}^{bi}[N][OH] & -k_{60}^{bi}[NO][NO_3] & +k_{79}^{bi}[H][NO_2] \\ -k_{91}^{tri}[NO][O(^3P)] & +j_{135}[N_2O_5] & -j_{137}[NO] \\ +j_{138}[NO_2] & +j_{139}[NO_2] & +j_{141}[NO_3] \\ +k_{185}^{cr}[M] & & \end{array}$$

$$\frac{d[NO_2]}{dt} = \begin{array}{lll} +k_8^{bi}[NO][O_3] & -k_9^{bi}[NO_2][O_3] & +k_{13}^{bi}[CH_3O_2][NO] \\ +k_{24}^{bi}[ClO][NO] & +k_{31}^{bi}[NO][HO_2] & -k_{36}^{bi}[NO_2][O(^3P)] \\ +k_{44}^{bi}[OH][HO_2NO_2] & +k_{53}^{bi}[BrO][NO] & +2k_{60}^{bi}[NO][NO_3] \\ -k_{64}^{bi}[N][NO_2] & -k_{79}^{bi}[H][NO_2] & -k_{85}^{tri}[OH][NO_2] \\ -k_{86}^{tri}[ClO][NO_2] & -k_{87}^{tri}[HO_2][NO_2] & -k_{88}^{tri}[NO_2][O(^3P)] \\ -k_{89}^{tri}[NO_2][NO_3] & +k_{91}^{tri}[NO][O(^3P)] & -k_{94}^{tri}[BrO][NO_2] \\ +k_{97}^{tri}[N_2O_5][M] & +k_{98}^{tri}[HO_2NO_2][M] & +j_{104}[BrONO] \\ +j_{105}[BrONO_2] & +j_{114}[ClNO_2] & +j_{127}[HO_2NO_2] \\ +j_{131}[HNO_3] & +j_{136}[N_2O_5] & -j_{138}[NO_2] \\ -j_{139}[NO_2] & +j_{140}[NO_3] & +k_{187}^{cr}[HNO_3] \end{array}$$

$$\frac{d[\text{NO}_3]}{dt} = \begin{array}{lll} +k_9^{\text{bi}}[\text{NO}_2][\text{O}_3] & +k_{11}^{\text{bi}}[\text{OH}][\text{ClONO}_2] & +k_{28}^{\text{bi}}[\text{O}(^3\text{P})][\text{ClONO}_2] \\ +k_{30}^{\text{bi}}[\text{HNO}_3][\text{OH}] & -k_{60}^{\text{bi}}[\text{NO}][\text{NO}_3] & +k_{88}^{\text{tri}}[\text{NO}_2][\text{O}(^3\text{P})] \\ -k_{89}^{\text{tri}}[\text{NO}_2][\text{NO}_3] & +k_{97}^{\text{tri}}[\text{N}_2\text{O}_5][\text{M}] & +j_{106}[\text{BrONO}_2] \\ +j_{116}[\text{ClONO}_2] & +j_{128}[\text{HO}_2\text{NO}_2] & +j_{135}[\text{N}_2\text{O}_5] \\ +j_{136}[\text{N}_2\text{O}_5] & -j_{140}[\text{NO}_3] & -j_{141}[\text{NO}_3] \end{array}$$

$$\frac{d[\text{N}_2\text{O}_5]}{dt} = \begin{array}{lll} -k_{62}^{\text{bi}}[\text{N}_2\text{O}_5][\text{H}_2\text{O}] & +k_{89}^{\text{tri}}[\text{NO}_2][\text{NO}_3] & -k_{97}^{\text{tri}}[\text{N}_2\text{O}_5][\text{M}] \\ -j_{135}[\text{N}_2\text{O}_5] & -j_{136}[\text{N}_2\text{O}_5] & -k_{154}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] \\ -k_{155}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] & -k_{156}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] & -k_{157}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] \\ -k_{158}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] & -k_{182}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] & -k_{183}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] \end{array}$$

$$\frac{d[\text{HNO}_3]}{dt} = \begin{array}{lll} -k_{30}^{\text{bi}}[\text{HNO}_3][\text{OH}] & +2k_{62}^{\text{bi}}[\text{N}_2\text{O}_5][\text{H}_2\text{O}] & +k_{85}^{\text{tri}}[\text{OH}][\text{NO}_2] \\ -j_{131}[\text{HNO}_3] & +k_{148}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & +k_{149}^{\text{h}}[\text{HCl}][\text{ClONO}_2] \\ +k_{150}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & +k_{151}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & +k_{152}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] \\ +k_{153}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & +2k_{154}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] & +2k_{155}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] \\ +2k_{156}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] & +k_{157}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] & +k_{158}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] \\ +k_{171}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & +k_{172}^{\text{h}}[\text{HBr}][\text{BrONO}_2] & +k_{173}^{\text{h}}[\text{HBr}][\text{BrONO}_2] \\ +k_{174}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & +k_{175}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & +k_{176}^{\text{h}}[\text{HCl}][\text{BrONO}_2] \\ +k_{177}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & +k_{178}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & +k_{179}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] \\ +k_{180}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & +k_{181}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & +k_{182}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] \\ +k_{183}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] & -k_{187}^{\text{h}}[\text{HNO}_3] & \end{array}$$

$$\frac{d[\text{HO}_2\text{NO}_2]}{dt} = \begin{array}{lll} -k_{44}^{\text{bi}}[\text{OH}][\text{HO}_2\text{NO}_2] & +k_{87}^{\text{tri}}[\text{HO}_2][\text{NO}_2] & -k_{98}^{\text{tri}}[\text{HO}_2\text{NO}_2][\text{M}] \\ -j_{127}[\text{HO}_2\text{NO}_2] & -j_{128}[\text{HO}_2\text{NO}_2] & \end{array}$$

$$\frac{d[\text{Cl}]}{dt} = \begin{array}{lll} -k_5^{\text{bi}}[\text{Cl}][\text{H}_2\text{O}_2] & -k_{19}^{\text{bi}}[\text{Cl}][\text{H}_2] & -k_{20}^{\text{bi}}[\text{Cl}][\text{O}_3] \\ +k_{21}^{\text{bi}}[\text{ClO}][\text{O}(^3\text{P})] & -k_{22}^{\text{bi}}[\text{Cl}][\text{CH}_4] & +k_{23}^{\text{bi}}[\text{HCl}][\text{OH}] \\ +k_{24}^{\text{bi}}[\text{ClO}][\text{NO}] & -k_{43}^{\text{bi}}[\text{Cl}][\text{HO}_2] & +k_{48}^{\text{bi}}[\text{ClO}][\text{OH}] \\ -k_{51}^{\text{bi}}[\text{Cl}][\text{HCHO}] & -k_{54}^{\text{bi}}[\text{Cl}][\text{HO}_2] & +k_{63}^{\text{bi}}[\text{O}(^1\text{D})][\text{CF}_2\text{Cl}_2] \\ +k_{81}^{\text{bi}}[\text{ClO}][\text{CH}_3\text{O}_2] & +j_{101}[\text{BrCl}] & +2j_{107}[\text{CF}_2\text{Cl}_2] \\ +2j_{112}[\text{Cl}_2] & +j_{113}[\text{Cl}_2\text{O}_2] & +j_{114}[\text{ClONO}_2] \\ +j_{115}[\text{ClO}] & +j_{116}[\text{ClONO}_2] & +j_{125}[\text{HCl}] \\ +j_{130}[\text{HOCl}] & +k_{186}^{\text{cr}}[\text{HCl}] & \end{array}$$

$$\frac{d[\text{Cl}_2]}{dt} = \begin{array}{lll} -j_{112}[\text{Cl}_2] & +k_{148}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & +k_{149}^{\text{h}}[\text{HCl}][\text{ClONO}_2] \\ +k_{150}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & +k_{159}^{\text{h}}[\text{HCl}][\text{HOCl}] & +k_{160}^{\text{h}}[\text{HCl}][\text{HOCl}] \\ +k_{161}^{\text{h}}[\text{HCl}][\text{HOCl}] & & \end{array}$$

$$\frac{d[\text{ClO}]}{dt} = \begin{array}{lll} -k_4^{\text{bi}}[\text{ClO}][\text{HO}_2] & +k_{20}^{\text{bi}}[\text{Cl}][\text{O}_3] & -k_{21}^{\text{bi}}[\text{ClO}][\text{O}(^3\text{P})] \\ -k_{24}^{\text{bi}}[\text{ClO}][\text{NO}] & +k_{28}^{\text{bi}}[\text{O}(^3\text{P})][\text{ClONO}_2] & -k_{48}^{\text{bi}}[\text{ClO}][\text{OH}] \\ -k_{49}^{\text{bi}}[\text{ClO}][\text{OH}] & +k_{50}^{\text{bi}}[\text{HOCl}][\text{OH}] & +k_{54}^{\text{bi}}[\text{Cl}][\text{HO}_2] \\ +k_{63}^{\text{bi}}[\text{O}(^1\text{D})][\text{CF}_2\text{Cl}_2] & -k_{70}^{\text{bi}}[\text{BrO}][\text{ClO}] & -k_{71}^{\text{bi}}[\text{BrO}][\text{ClO}] \\ -k_{72}^{\text{bi}}[\text{BrO}][\text{ClO}] & -k_{81}^{\text{bi}}[\text{ClO}][\text{CH}_3\text{O}_2] & -k_{86}^{\text{tri}}[\text{ClO}][\text{NO}_2] \\ -2k_{95}^{\text{tri}}[\text{ClO}][\text{ClO}] & +k_{99}^{\text{tri}}[\text{Cl}_2\text{O}_2][\text{M}] & -j_{115}[\text{ClO}] \\ +j_{117}[\text{ClOO}] & +j_{146}[\text{OCIO}] & +j_{147}[\text{OCIO}] \end{array}$$

$$\frac{d[\text{ClOO}]}{dt} = +k_{71}^{\text{bi}}[\text{BrO}][\text{ClO}] + j_{113}[\text{Cl}_2\text{O}_2] - j_{117}[\text{ClOO}]$$

$$\frac{d[\text{OCIO}]}{dt} = +k_{70}^{\text{bi}}[\text{BrO}][\text{ClO}] - j_{146}[\text{OCIO}] - j_{147}[\text{OCIO}]$$

$$\frac{d[\text{Cl}_2\text{O}_2]}{dt} = +k_{95}^{\text{tri}}[\text{ClO}][\text{ClO}] - k_{99}^{\text{tri}}[\text{Cl}_2\text{O}_2][\text{M}] - j_{113}[\text{Cl}_2\text{O}_2]$$

$$\frac{d[\text{ClONO}_2]}{dt} = -j_{114}[\text{ClONO}_2] + k_{157}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] + k_{158}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5]$$

$$\frac{d[\text{ClONO}_2]}{dt} = \begin{array}{lll} -k_{111}^{\text{bi}}[\text{OH}][\text{ClONO}_2] & -k_{28}^{\text{bi}}[\text{O}(^3\text{P})][\text{ClONO}_2] & +k_{86}^{\text{tri}}[\text{ClO}][\text{NO}_2] \\ -j_{116}[\text{ClONO}_2] & -k_{148}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & -k_{149}^{\text{h}}[\text{HCl}][\text{ClONO}_2] \\ -k_{150}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & -k_{151}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & -k_{152}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] \\ -k_{153}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & -k_{171}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & -k_{177}^{\text{h}}[\text{HBr}][\text{ClONO}_2] \\ -k_{178}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & & \end{array}$$

$$\frac{d[\text{HCl}]}{dt} = \begin{array}{lll} +k_5^{\text{bi}}[\text{Cl}][\text{H}_2\text{O}_2] & +k_{19}^{\text{bi}}[\text{Cl}][\text{H}_2] & +k_{22}^{\text{bi}}[\text{Cl}][\text{CH}_4] \\ -k_{23}^{\text{bi}}[\text{HCl}][\text{OH}] & +k_{43}^{\text{bi}}[\text{Cl}][\text{HO}_2] & +k_{49}^{\text{bi}}[\text{ClO}][\text{OH}] \\ +k_{51}^{\text{bi}}[\text{Cl}][\text{HCHO}] & -j_{125}[\text{HCl}] & -k_{148}^{\text{h}}[\text{HCl}][\text{ClONO}_2] \\ -k_{149}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & -k_{150}^{\text{h}}[\text{HCl}][\text{ClONO}_2] & -k_{157}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] \\ -k_{158}^{\text{h}}[\text{HCl}][\text{N}_2\text{O}_5] & -k_{159}^{\text{h}}[\text{HCl}][\text{HOCl}] & -k_{160}^{\text{h}}[\text{HCl}][\text{HOCl}] \\ -k_{161}^{\text{h}}[\text{HCl}][\text{HOCl}] & -k_{165}^{\text{h}}[\text{HCl}][\text{HOBr}] & -k_{166}^{\text{h}}[\text{HCl}][\text{HOBr}] \\ -k_{167}^{\text{h}}[\text{HCl}][\text{HOBr}] & -k_{174}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & -k_{175}^{\text{h}}[\text{HCl}][\text{BrONO}_2] \\ -k_{176}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & -k_{186}^{\text{c}}[\text{HCl}] & \end{array}$$

$$\frac{d[\text{HOCl}]}{dt} = \begin{array}{lll} +k_4^{\text{bi}}[\text{ClO}][\text{HO}_2] & +k_{11}^{\text{bi}}[\text{OH}][\text{ClONO}_2] & -k_{50}^{\text{bi}}[\text{HOCl}][\text{OH}] \\ -j_{130}[\text{HOCl}] & +k_{151}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & +k_{152}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] \\ +k_{153}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & -k_{159}^{\text{h}}[\text{HCl}][\text{HOCl}] & -k_{160}^{\text{h}}[\text{HCl}][\text{HOCl}] \\ -k_{161}^{\text{h}}[\text{HCl}][\text{HOCl}] & -k_{168}^{\text{h}}[\text{HBr}][\text{HOCl}] & -k_{169}^{\text{h}}[\text{HBr}][\text{HOCl}] \\ -k_{170}^{\text{h}}[\text{HBr}][\text{HOCl}] & & \end{array}$$

$$\frac{d[\text{Br}]}{dt} = \begin{array}{lll} +k_{53}^{\text{bi}}[\text{BrO}][\text{NO}] & -k_{56}^{\text{bi}}[\text{Br}][\text{HCHO}] & -k_{65}^{\text{bi}}[\text{Br}][\text{O}_3] \\ -k_{66}^{\text{bi}}[\text{Br}][\text{HO}_2] & +2k_{67}^{\text{bi}}[\text{BrO}][\text{BrO}] & +k_{68}^{\text{bi}}[\text{OH}][\text{HBr}] \\ +k_{69}^{\text{bi}}[\text{CH}_3\text{Br}][\text{OH}] & +k_{70}^{\text{bi}}[\text{BrO}][\text{ClO}] & +k_{71}^{\text{bi}}[\text{BrO}][\text{ClO}] \\ +k_{74}^{\text{bi}}[\text{BrO}][\text{O}(^3\text{P})] & +k_{76}^{\text{bi}}[\text{O}(^1\text{D})][\text{CH}_3\text{Br}] & +k_{80}^{\text{bi}}[\text{BrO}][\text{CH}_3\text{O}_2] \\ +2j_{100}[\text{Br}_2] & +j_{101}[\text{BrCl}] & +j_{102}[\text{BrO}] \\ +j_{103}[\text{BrO}] & +j_{104}[\text{BrONO}] & +j_{106}[\text{BrONO}_2] \\ +j_{108}[\text{CH}_3\text{Br}] & +j_{129}[\text{HOBr}] & \end{array}$$

$$\frac{d[\text{Br}_2]}{dt} = \begin{array}{lll} -j_{100}[\text{Br}_2] & +k_{162}^{\text{h}}[\text{HBr}][\text{HOBr}] & +k_{163}^{\text{h}}[\text{HBr}][\text{HOBr}] \\ +k_{164}^{\text{h}}[\text{HBr}][\text{HOBr}] & +k_{172}^{\text{h}}[\text{HBr}][\text{BrONO}_2] & +k_{173}^{\text{h}}[\text{HBr}][\text{BrONO}_2] \end{array}$$

$$\frac{d[\text{BrO}]}{dt} = \begin{array}{lll} -k_{53}^{\text{bi}}[\text{BrO}][\text{NO}] & +k_{65}^{\text{bi}}[\text{Br}][\text{O}_3] & -2k_{67}^{\text{bi}}[\text{BrO}][\text{BrO}] \\ -k_{70}^{\text{bi}}[\text{BrO}][\text{ClO}] & -k_{71}^{\text{bi}}[\text{BrO}][\text{ClO}] & -k_{72}^{\text{bi}}[\text{BrO}][\text{ClO}] \\ -k_{73}^{\text{bi}}[\text{BrO}][\text{HO}_2] & -k_{74}^{\text{bi}}[\text{BrO}][\text{O}(^3\text{P})] & -k_{80}^{\text{bi}}[\text{BrO}][\text{CH}_3\text{O}_2] \\ -k_{94}^{\text{tri}}[\text{BrO}][\text{NO}_2] & -j_{102}[\text{BrO}] & -j_{103}[\text{BrO}] \\ +j_{105}[\text{BrONO}_2] & & \end{array}$$

$$\frac{d[\text{BrONO}_2]}{dt} = \begin{array}{lll} +k_{94}^{\text{tri}}[\text{BrO}][\text{NO}_2] & -j_{105}[\text{BrONO}_2] & -j_{106}[\text{BrONO}_2] \\ -k_{172}^{\text{h}}[\text{HBr}][\text{BrONO}_2] & -k_{173}^{\text{h}}[\text{HBr}][\text{BrONO}_2] & -k_{174}^{\text{h}}[\text{HCl}][\text{BrONO}_2] \\ -k_{175}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & -k_{176}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & -k_{179}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] \\ -k_{180}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & -k_{181}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & \end{array}$$

$$\frac{d[\text{BrONO}]}{dt} = -j_{104}[\text{BrONO}] + k_{182}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] + k_{183}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5]$$

$$\frac{d[\text{HBr}]}{dt} = \begin{array}{lll} +k_{56}^{\text{bi}}[\text{Br}][\text{HCHO}] & +k_{66}^{\text{bi}}[\text{Br}][\text{HO}_2] & -k_{68}^{\text{bi}}[\text{OH}][\text{HBr}] \\ -k_{162}^{\text{h}}[\text{HBr}][\text{HOBr}] & -k_{163}^{\text{h}}[\text{HBr}][\text{HOBr}] & -k_{164}^{\text{h}}[\text{HBr}][\text{HOBr}] \\ -k_{168}^{\text{h}}[\text{HBr}][\text{HOCl}] & -k_{169}^{\text{h}}[\text{HBr}][\text{HOCl}] & -k_{170}^{\text{h}}[\text{HBr}][\text{HOCl}] \\ -k_{171}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & -k_{172}^{\text{h}}[\text{HBr}][\text{BrONO}_2] & -k_{173}^{\text{h}}[\text{HBr}][\text{BrONO}_2] \\ -k_{177}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & -k_{178}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & -k_{182}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] \\ -k_{183}^{\text{h}}[\text{HBr}][\text{N}_2\text{O}_5] & & \end{array}$$

$$\frac{d[\text{HOBr}]}{dt} = \begin{array}{lll} +k_{73}^{\text{bi}}[\text{BrO}][\text{HO}_2] & -j_{129}[\text{HOBr}] & -k_{162}^{\text{h}}[\text{HBr}][\text{HOBr}] \\ -k_{163}^{\text{h}}[\text{HBr}][\text{HOBr}] & -k_{164}^{\text{h}}[\text{HBr}][\text{HOBr}] & -k_{165}^{\text{h}}[\text{HCl}][\text{HOBr}] \\ -k_{166}^{\text{h}}[\text{HCl}][\text{HOBr}] & -k_{167}^{\text{h}}[\text{HCl}][\text{HOBr}] & +k_{179}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] \\ +k_{180}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & +k_{181}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & \end{array}$$

$$\frac{d[\text{BrCl}]}{dt} = \begin{array}{lll} +k_{72}^{\text{bi}}[\text{BrO}][\text{ClO}] & -j_{101}[\text{BrCl}] & +k_{165}^{\text{h}}[\text{HCl}][\text{HOBr}] \\ +k_{166}^{\text{h}}[\text{HCl}][\text{HOBr}] & +k_{167}^{\text{h}}[\text{HCl}][\text{HOBr}] & +k_{168}^{\text{h}}[\text{HBr}][\text{HOCl}] \\ +k_{169}^{\text{h}}[\text{HBr}][\text{HOCl}] & +k_{170}^{\text{h}}[\text{HBr}][\text{HOCl}] & +k_{171}^{\text{h}}[\text{HBr}][\text{ClONO}_2] \\ +k_{174}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & +k_{175}^{\text{h}}[\text{HCl}][\text{BrONO}_2] & +k_{176}^{\text{h}}[\text{HCl}][\text{BrONO}_2] \\ +k_{177}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & +k_{178}^{\text{h}}[\text{HBr}][\text{ClONO}_2] & \end{array}$$

$$\frac{d[\text{H}_2]}{dt} = \begin{array}{lll} -k_{19}^{\text{bi}}[\text{Cl}][\text{H}_2] & -k_{26}^{\text{bi}}[\text{H}_2][\text{OH}] & -k_{39}^{\text{bi}}[\text{H}_2][\text{O}(^1\text{D})] \\ +k_{45}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] & +k_{57}^{\text{bi}}[\text{H}][\text{HO}_2] & +j_{119}[\text{H}_2\text{O}] \\ +j_{122}[\text{HCHO}] & & \end{array}$$

$$\frac{d[\text{H}]}{dt} = \begin{array}{lll} -k_{10}^{\text{bi}}[\text{H}][\text{O}_3] & +k_{19}^{\text{bi}}[\text{Cl}][\text{H}_2] & +k_{26}^{\text{bi}}[\text{H}_2][\text{OH}] \\ +k_{29}^{\text{bi}}[\text{CO}][\text{OH}] & +k_{34}^{\text{bi}}[\text{OH}][\text{O}(^3\text{P})] & +k_{39}^{\text{bi}}[\text{H}_2][\text{O}(^1\text{D})] \\ +k_{55}^{\text{bi}}[\text{N}][\text{OH}] & -k_{57}^{\text{bi}}[\text{H}][\text{HO}_2] & -k_{58}^{\text{bi}}[\text{H}][\text{HO}_2] \\ -k_{59}^{\text{bi}}[\text{H}][\text{HO}_2] & +k_{75}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] & -k_{79}^{\text{bi}}[\text{H}][\text{NO}_2] \\ -k_{83}^{\text{tri}}[\text{H}][\text{O}_2] & +j_{109}[\text{CH}_4] & +2j_{118}[\text{H}_2\text{O}] \\ +j_{120}[\text{H}_2\text{O}] & +j_{123}[\text{HCHO}] & +2j_{124}[\text{HCHO}] \\ +j_{125}[\text{HCl}] & +j_{133}[\text{CH}_3\text{OOH}] & +k_{184}^{\text{cr}}[\text{M}] \\ +k_{186}^{\text{cr}}[\text{HCl}] & & \end{array}$$

$$\frac{d[\text{OH}]}{dt} = \begin{array}{lll} -k_2^{\text{bi}}[\text{OH}][\text{O}_3] & +k_3^{\text{bi}}[\text{HO}_2][\text{O}_3] & +k_{10}^{\text{bi}}[\text{H}][\text{O}_3] \\ -k_{11}^{\text{bi}}[\text{OH}][\text{ClONO}_2] & -k_{12}^{\text{bi}}[\text{CH}_4][\text{OH}] & +k_{17}^{\text{bi}}[\text{HCHO}][\text{O}(^3\text{P})] \\ -k_{23}^{\text{bi}}[\text{HCl}][\text{OH}] & -k_{25}^{\text{bi}}[\text{OH}][\text{H}_2\text{O}_2] & -k_{26}^{\text{bi}}[\text{H}_2][\text{OH}] \\ +k_{27}^{\text{bi}}[\text{O}(^3\text{P})][\text{H}_2\text{O}_2] & -k_{29}^{\text{bi}}[\text{CO}][\text{OH}] & -k_{30}^{\text{bi}}[\text{HNO}_3][\text{OH}] \\ +k_{31}^{\text{bi}}[\text{NO}][\text{HO}_2] & +2k_{32}^{\text{bi}}[\text{H}_2\text{O}][\text{O}(^1\text{D})] & -k_{33}^{\text{bi}}[\text{OH}][\text{HO}_2] \\ -k_{34}^{\text{bi}}[\text{OH}][\text{O}(^3\text{P})] & +k_{35}^{\text{bi}}[\text{HO}_2][\text{O}(^3\text{P})] & +k_{39}^{\text{bi}}[\text{H}_2][\text{O}(^1\text{D})] \\ +k_{40}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] & -k_{41}^{\text{bi}}[\text{HCHO}][\text{OH}] & -k_{44}^{\text{bi}}[\text{OH}][\text{HO}_2\text{NO}_2] \\ -k_{46}^{\text{bi}}[\text{OH}][\text{CH}_3\text{OOH}] & -2k_{47}^{\text{bi}}[\text{OH}][\text{OH}] & -k_{48}^{\text{bi}}[\text{ClO}][\text{OH}] \\ -k_{49}^{\text{bi}}[\text{ClO}][\text{OH}] & -k_{50}^{\text{bi}}[\text{HOCl}][\text{OH}] & +k_{54}^{\text{bi}}[\text{Cl}][\text{HO}_2] \\ -k_{55}^{\text{bi}}[\text{N}][\text{OH}] & +2k_{59}^{\text{bi}}[\text{H}][\text{HO}_2] & -k_{68}^{\text{bi}}[\text{OH}][\text{HBr}] \\ -k_{69}^{\text{bi}}[\text{CH}_3\text{Br}][\text{OH}] & +k_{79}^{\text{bi}}[\text{H}][\text{NO}_2] & -2k_{84}^{\text{tri}}[\text{OH}][\text{OH}] \\ -k_{85}^{\text{tri}}[\text{OH}][\text{NO}_2] & +j_{120}[\text{H}_2\text{O}] & +2j_{121}[\text{H}_2\text{O}_2] \\ +j_{126}[\text{HO}_2] & +j_{128}[\text{HO}_2\text{NO}_2] & +j_{129}[\text{HOBr}] \\ +j_{130}[\text{HOCl}] & +j_{131}[\text{HNO}_3] & +j_{132}[\text{CH}_3\text{OOH}] \\ +k_{184}^{\text{cr}}[\text{M}] & +k_{187}^{\text{cr}}[\text{HNO}_3] & \end{array}$$

$$\frac{d[\text{HO}_2]}{dt} = \begin{array}{lll} +k_2^{\text{bi}}[\text{OH}][\text{O}_3] & -k_3^{\text{bi}}[\text{HO}_2][\text{O}_3] & -k_4^{\text{bi}}[\text{ClO}][\text{HO}_2] \\ +k_5^{\text{bi}}[\text{Cl}][\text{H}_2\text{O}_2] & +k_{14}^{\text{bi}}[\text{CH}_3\text{O}][\text{O}_2] & -2k_{15}^{\text{bi}}[\text{HO}_2][\text{HO}_2] \\ -k_{18}^{\text{bi}}[\text{CH}_3\text{O}_2][\text{HO}_2] & +k_{25}^{\text{bi}}[\text{OH}][\text{H}_2\text{O}_2] & +k_{27}^{\text{bi}}[\text{O}(^3\text{P})][\text{H}_2\text{O}_2] \\ -k_{31}^{\text{bi}}[\text{NO}][\text{HO}_2] & -k_{33}^{\text{bi}}[\text{OH}][\text{HO}_2] & -k_{35}^{\text{bi}}[\text{HO}_2][\text{O}(^3\text{P})] \\ +k_{42}^{\text{bi}}[\text{HCO}][\text{O}_2] & -k_{43}^{\text{bi}}[\text{Cl}][\text{HO}_2] & +k_{48}^{\text{bi}}[\text{ClO}][\text{OH}] \\ -2k_{52}^{\text{bi}}[\text{HO}_2][\text{HO}_2] & -k_{54}^{\text{bi}}[\text{Cl}][\text{HO}_2] & -k_{57}^{\text{bi}}[\text{H}][\text{HO}_2] \\ -k_{58}^{\text{bi}}[\text{H}][\text{HO}_2] & -k_{59}^{\text{bi}}[\text{H}][\text{HO}_2] & -k_{66}^{\text{bi}}[\text{Br}][\text{HO}_2] \\ -k_{73}^{\text{bi}}[\text{BrO}][\text{HO}_2] & +k_{83}^{\text{tri}}[\text{H}][\text{O}_2] & -k_{87}^{\text{tri}}[\text{HO}_2][\text{NO}_2] \\ +k_{98}^{\text{tri}}[\text{HO}_2\text{NO}_2][\text{M}] & -j_{126}[\text{HO}_2] & +j_{127}[\text{HO}_2\text{NO}_2] \end{array}$$

$$\frac{d[\text{H}_2\text{O}_2]}{dt} = \begin{array}{lll} -k_5^{\text{bi}}[\text{Cl}][\text{H}_2\text{O}_2] & +k_{15}^{\text{bi}}[\text{HO}_2][\text{HO}_2] & -k_{25}^{\text{bi}}[\text{OH}][\text{H}_2\text{O}_2] \\ -k_{27}^{\text{bi}}[\text{O}(^3\text{P})][\text{H}_2\text{O}_2] & +k_{52}^{\text{bi}}[\text{HO}_2][\text{HO}_2] & +k_{84}^{\text{tri}}[\text{OH}][\text{OH}] \\ -j_{121}[\text{H}_2\text{O}_2] & & \end{array}$$

$$\frac{d[\text{CH}_3]}{dt} = \begin{array}{lll} +k_{12}^{\text{bi}}[\text{CH}_4][\text{OH}] & +k_{22}^{\text{bi}}[\text{Cl}][\text{CH}_4] & +k_{40}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] \\ -k_{90}^{\text{tri}}[\text{CH}_3][\text{O}_2] & +j_{108}[\text{CH}_3\text{Br}] & +j_{109}[\text{CH}_4] \end{array}$$

$$\frac{d[\text{CH}_3\text{O}]}{dt} = \begin{array}{lll} +k_{13}^{\text{bi}}[\text{CH}_3\text{O}_2][\text{NO}] & -k_{14}^{\text{bi}}[\text{CH}_3\text{O}][\text{O}_2] & +k_{75}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] \\ +k_{76}^{\text{bi}}[\text{O}(^1\text{D})][\text{CH}_3\text{Br}] & +k_{80}^{\text{bi}}[\text{BrO}][\text{CH}_3\text{O}_2] & +k_{81}^{\text{bi}}[\text{ClO}][\text{CH}_3\text{O}_2] \\ +j_{132}[\text{CH}_3\text{OOH}] & +j_{133}[\text{CH}_3\text{OOH}] & \end{array}$$

$$\frac{d[\text{CH}_3\text{O}_2]}{dt} = \begin{array}{lll} -k_{13}^{\text{bi}}[\text{CH}_3\text{O}_2][\text{NO}] & -k_{18}^{\text{bi}}[\text{CH}_3\text{O}_2][\text{HO}_2] & +k_{46}^{\text{bi}}[\text{OH}][\text{CH}_3\text{OOH}] \\ -k_{80}^{\text{bi}}[\text{BrO}][\text{CH}_3\text{O}_2] & -k_{81}^{\text{bi}}[\text{ClO}][\text{CH}_3\text{O}_2] & +k_{90}^{\text{tri}}[\text{CH}_3][\text{O}_2] \end{array}$$

$$\frac{d[\text{CH}_3\text{OOH}]}{dt} = \begin{array}{lll} +k_{18}^{\text{bi}}[\text{CH}_3\text{O}_2][\text{HO}_2] & -k_{46}^{\text{bi}}[\text{OH}][\text{CH}_3\text{OOH}] & -j_{132}[\text{CH}_3\text{OOH}] \\ -j_{133}[\text{CH}_3\text{OOH}] & & \end{array}$$

$$\frac{d[\text{HCO}]}{dt} = \begin{array}{lll} +k_{17}^{\text{bi}}[\text{HCHO}][\text{O}(^3\text{P})] & +k_{41}^{\text{bi}}[\text{HCHO}][\text{OH}] & -k_{42}^{\text{bi}}[\text{HCO}][\text{O}_2] \\ +k_{51}^{\text{bi}}[\text{Cl}][\text{HCHO}] & +k_{56}^{\text{bi}}[\text{Br}][\text{HCHO}] & +j_{123}[\text{HCHO}] \end{array}$$

$$\frac{d[\text{HCHO}]}{dt} = \begin{array}{lll} +k_{14}^{\text{bi}}[\text{CH}_3\text{O}][\text{O}_2] & -k_{17}^{\text{bi}}[\text{HCHO}][\text{O}(^3\text{P})] & -k_{41}^{\text{bi}}[\text{HCHO}][\text{OH}] \\ +k_{45}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] & -k_{51}^{\text{bi}}[\text{Cl}][\text{HCHO}] & -k_{56}^{\text{bi}}[\text{Br}][\text{HCHO}] \\ -j_{122}[\text{HCHO}] & -j_{123}[\text{HCHO}] & -j_{124}[\text{HCHO}] \end{array}$$

$$\frac{d[\text{CH}_4]}{dt} = \begin{array}{lll} -k_{12}^{\text{bi}}[\text{CH}_4][\text{OH}] & -k_{22}^{\text{bi}}[\text{Cl}][\text{CH}_4] & -k_{40}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] \\ -k_{45}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] & -k_{75}^{\text{bi}}[\text{CH}_4][\text{O}(^1\text{D})] & -j_{109}[\text{CH}_4] \end{array}$$

$$\frac{d[\text{CH}_3\text{Br}]}{dt} = \begin{array}{lll} -k_{69}^{\text{bi}}[\text{CH}_3\text{Br}][\text{OH}] & -k_{76}^{\text{bi}}[\text{O}(^1\text{D})][\text{CH}_3\text{Br}] & -j_{108}[\text{CH}_3\text{Br}] \end{array}$$

$$\frac{d[\text{CF}_2\text{Cl}_2]}{dt} = \begin{array}{lll} -k_{63}^{\text{bi}}[\text{O}(^1\text{D})][\text{CF}_2\text{Cl}_2] & -j_{107}[\text{CF}_2\text{Cl}_2] & \end{array}$$

$$\frac{d[\text{CO}]}{dt} = \begin{array}{lll} -k_{29}^{\text{bi}}[\text{CO}][\text{OH}] & +k_{42}^{\text{bi}}[\text{HCO}][\text{O}_2] & -k_{96}^{\text{tri}}[\text{CO}][\text{O}(^3\text{P})] \\ +j_{110}[\text{CO}_2] & +j_{111}[\text{CO}_2] & +j_{122}[\text{HCHO}] \\ +j_{124}[\text{HCHO}] & & \end{array}$$

$$\frac{d[\text{N}_2\text{O}]}{dt} = \begin{array}{l} -k_{37}^{\text{bi}}[\text{N}_2\text{O}][\text{O}(^1\text{D})] - k_{61}^{\text{bi}}[\text{N}_2\text{O}][\text{O}(^1\text{D})] + k_{64}^{\text{bi}}[\text{N}][\text{NO}_2] \\ + k_{92}^{\text{tri}}[\text{O}(^1\text{D})][\text{N}_2] - j_{134}[\text{N}_2\text{O}] \end{array}$$

$$\frac{d[\text{CO}_2]}{dt} = \begin{array}{l} +k_{29}^{\text{bi}}[\text{CO}][\text{OH}] + k_{96}^{\text{tri}}[\text{CO}][\text{O}(^3\text{P})] - j_{110}[\text{CO}_2] \\ -j_{111}[\text{CO}_2] \end{array}$$

$$\frac{d[\text{H}_2\text{O}]}{dt} = \begin{array}{lll} +k_{12}^{\text{bi}}[\text{CH}_4][\text{OH}] & +k_{23}^{\text{bi}}[\text{HCl}][\text{OH}] & +k_{25}^{\text{bi}}[\text{OH}][\text{H}_2\text{O}_2] \\ +k_{26}^{\text{bi}}[\text{H}_2][\text{OH}] & +k_{30}^{\text{bi}}[\text{HNO}_3][\text{OH}] & -k_{32}^{\text{bi}}[\text{H}_2\text{O}][\text{O}(^1\text{D})] \\ +k_{33}^{\text{bi}}[\text{OH}][\text{HO}_2] & +k_{41}^{\text{bi}}[\text{HCHO}][\text{OH}] & +k_{44}^{\text{bi}}[\text{OH}][\text{HO}_2\text{NO}_2] \\ +k_{46}^{\text{bi}}[\text{OH}][\text{CH}_3\text{OOH}] & +k_{47}^{\text{bi}}[\text{OH}][\text{OH}] & +k_{50}^{\text{bi}}[\text{HOCl}][\text{OH}] \\ +k_{58}^{\text{bi}}[\text{H}][\text{HO}_2] & -k_{62}^{\text{bi}}[\text{N}_2\text{O}_5][\text{H}_2\text{O}] & +k_{68}^{\text{bi}}[\text{OH}][\text{HBr}] \\ -j_{118}[\text{H}_2\text{O}] & -j_{119}[\text{H}_2\text{O}] & -j_{120}[\text{H}_2\text{O}] \\ -k_{151}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & -k_{152}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] & -k_{153}^{\text{h}}[\text{H}_2\text{O}][\text{ClONO}_2] \\ -k_{154}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] & -k_{155}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] & -k_{156}^{\text{h}}[\text{H}_2\text{O}][\text{N}_2\text{O}_5] \\ +k_{159}^{\text{h}}[\text{HCl}][\text{HOCl}] & +k_{160}^{\text{h}}[\text{HCl}][\text{HOCl}] & +k_{161}^{\text{h}}[\text{HCl}][\text{HOCl}] \\ +k_{162}^{\text{h}}[\text{HBr}][\text{HOBr}] & +k_{163}^{\text{h}}[\text{HBr}][\text{HOBr}] & +k_{164}^{\text{h}}[\text{HBr}][\text{HOBr}] \\ +k_{165}^{\text{h}}[\text{HCl}][\text{HOBr}] & +k_{166}^{\text{h}}[\text{HCl}][\text{HOBr}] & +k_{167}^{\text{h}}[\text{HCl}][\text{HOBr}] \\ +k_{168}^{\text{h}}[\text{HBr}][\text{HOCl}] & +k_{169}^{\text{h}}[\text{HBr}][\text{HOCl}] & +k_{170}^{\text{h}}[\text{HBr}][\text{HOCl}] \\ -k_{179}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & -k_{180}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] & -k_{181}^{\text{h}}[\text{H}_2\text{O}][\text{BrONO}_2] \end{array}$$