

**TABLE S1.** The reactions and corresponding rate coefficients in the plasma kinetics

	Reactions	Reaction coefficients	Reference
R1-8	$e+N_2 \rightarrow e+N_2(v_1-v_8)$	BOLSIG+	1
R9-16	$e+N_2(v_1-v_8) \rightarrow e+N_2$	BOLSIG+	1
R17-20	$e+O_2 \rightarrow e+O_2(v_1-v_4)$	BOLSIG+	1
R21-24	$e+O_2(v_1-v_4) \rightarrow e+O_2$	BOLSIG+	1
R25	$e+NO \rightarrow 2e+NO^+$	BOLSIG+	1
R26	$e+N_2O \rightarrow 2e+N_2O^+$	BOLSIG+	1
R27	$e+O_2 \rightarrow O^-+O$	BOLSIG+	1
R28	$e+O_3 \rightarrow O_2^-+O$	BOLSIG+	1
R29	$e+NO \rightarrow O^-+N$	BOLSIG+	1
R30	$e+O_3 \rightarrow O^-+O_2$	BOLSIG+	1
R31	$e+N_2O \rightarrow NO^-+N$	BOLSIG+	1
R32	$e+N_2 \rightarrow e+N_2(A3, v_0-v_4)$	BOLSIG+	1
R33	$e+N_2 \rightarrow e+N_2(A3, v_5-v_8)$	BOLSIG+	1
R34	$e+N_2 \rightarrow e+N_2(A3, v_{10})$	BOLSIG+	1
R35	$e+N_2 \rightarrow e+N_2(B3)$	BOLSIG+	1
R36	$e+N_2 \rightarrow e+N_2(W3)$	BOLSIG+	1
R37	$e+N_2 \rightarrow e+N_2(B'3)$	BOLSIG+	1
R38	$e+N_2 \rightarrow e+N_2(A'1)$	BOLSIG+	1
R39	$e+N_2 \rightarrow e+N_2(A1)$	BOLSIG+	1
R40	$e+N_2 \rightarrow e+N_2(W1)$	BOLSIG+	1
R41	$e+N_2 \rightarrow e+N_2(C3)$	BOLSIG+	1
R42	$e+N_2 \rightarrow e+N_2(e3)$	BOLSIG+	1
R43	$e+N_2 \rightarrow e+N_2(A''1)$	BOLSIG+	1
R44	$e+N_2 \rightarrow e+N+N(^2D)$	BOLSIG+	1
R45	$e+O_2 \rightarrow e+O_2(A1)$	BOLSIG+	1
R46	$e+O_2 \rightarrow e+O_2(B1)$	BOLSIG+	1
R47	$e+O_2 \rightarrow e+O_2(4.5eV)$	BOLSIG+	1
R48	$e+O_2 \rightarrow e+O(^3P)+O(^3P)$	BOLSIG+	1
R49	$e+O \rightarrow e+O(^1D)$	BOLSIG+	1

R50	$e+O \rightarrow e+O(^1S)$	BOLSIG+	1
R51	$e+N_2 \rightarrow 2e+N_2^+$	BOLSIG+	1
R52	$e+O_2 \rightarrow 2e+O_2^+$	BOLSIG+	1
R53	$e+N \rightarrow 2e+N^+$	BOLSIG+	1
R54	$e+O \rightarrow 2e+O^+$	BOLSIG+	1
R55	$e+N_2^+ \rightarrow N+N$	$0.90 \times 10^{-7} (300.0/T_e)^{0.39}$	1
R56	$e+N_2^+ \rightarrow N+N(^2D)$	$0.81 \times 10^{-7} (300.0/T_e)^{0.39}$	1
R57	$e+N_2^+ \rightarrow N+N(^2P)$	$0.90 \times 10^{-8} (300.0/T_e)^{0.39}$	1
R58	$e+O_2^+ \rightarrow O+O$	$1.49 \times 10^{-7} (300.0/T_e)^{0.7}$	1
R59	$e+O_2^+ \rightarrow O+O(^1D)$	$1.08 \times 10^{-7} (300.0/T_e)^{0.7}$	1
R60	$e+O_2^+ \rightarrow O+O(^1S)$	$1.40 \times 10^{-8} (300.0/T_e)^{0.7}$	1
R61	$e+N^++e \rightarrow N+e$	$7.00 \times 10^{-20} (300.0/T_e)^{4.5}$	1
R62	$e+O^++e \rightarrow O+e$	$7.00 \times 10^{-20} (300.0/T_e)^{4.5}$	1
R63	$e+N^++M \rightarrow N+M$	$6.00 \times 10^{-27} (300.0/T_e)^{1.5}$	1
R64	$e+O^++M \rightarrow O+M$	$6.00 \times 10^{-27} (300.0/T_e)^{1.5}$	1
R65	$N_2(A3) \rightarrow N_2$	$0.50 \times 10^0$	1
R66	$N_2(B3) \rightarrow N_2(A3)$	$1.34 \times 10^5$	1
R67	$N_2(A'1) \rightarrow N_2$	$1.00 \times 10^2$	1
R68	$N_2(C3) \rightarrow N_2(B3)$	$2.45 \times 10^7$	1
R69	$O_2(A1) \rightarrow O_2$	$2.60 \times 10^{-4}$	1
R70	$O_2(B1) \rightarrow O_2(A1)$	$1.50 \times 10^{-3}$	1
R71	$O_2(B1) \rightarrow O_2$	$8.50 \times 10^{-2}$	1
R72	$O_2(4.5eV) \rightarrow O_2$	$1.10 \times 10^1$	1
R73	$N^++O \rightarrow N+O^+$	$1.00 \times 10^{-12}$	1
R74	$N^++O_2 \rightarrow O_2^++N$	$2.80 \times 10^{-10}$	1
R75	$N^++O_2 \rightarrow NO^++O$	$2.50 \times 10^{-10}$	1
R76	$N^++O_2 \rightarrow O^++NO$	$2.80 \times 10^{-11}$	1
R77	$N_2(A3)+O \rightarrow NO+N(^2D)$	$7.00 \times 10^{-12}$	1
R78	$N_2(A3)+O \rightarrow N_2+O(^1S)$	$2.10 \times 10^{-11}$	1
R79	$N_2(A3)+N \rightarrow N_2+N$	$2.00 \times 10^{-12}$	1
R80	$N_2(A3)+N \rightarrow N_2+N(^2P)$	$4.00 \times 10^{-11} (300.0/T_g)^{0.67}$	1

R81	$N_2(A3)+O_2 \rightarrow N_2+O(^3P)+O(^1D)$	$2.10 \times 10^{-12}(T_g/300.0)^{0.55}$	1
R82	$N_2(A3)+O_2 \rightarrow N_2+O_2(A1)$	$2.00 \times 10^{-13}(T_g/300.0)^{0.55}$	1
R83	$N_2(A3)+O_2 \rightarrow N_2+O_2(B1)$	$2.00 \times 10^{-13}(T_g/300.0)^{0.55}$	1
R84	$N_2(A3)+N_2 \rightarrow N_2+N_2$	$3.0 \times 10^{-16}$	1
R85	$N_2(A3)+NO \rightarrow N_2+NO$	$6.90 \times 10^{-11}$	1
R86	$N_2(A3)+N_2(A3) \rightarrow N_2+N_2(B3)$	$3.00 \times 10^{-10}$	1
R87	$N_2(A3)+N_2(A3) \rightarrow N_2+N_2(C3)$	$1.50 \times 10^{-10}$	1
R88	$N_2(B3)+N_2 \rightarrow N_2(A3)+N_2$	$3.00 \times 10^{-11}$	1
R89	$N_2(B3)+N_2 \rightarrow N_2+N_2$	$2.00 \times 10^{-12}$	1
R90	$N_2(B3)+O_2 \rightarrow N_2+O(^3P)+O(^3P)$	$3.00 \times 10^{-10}$	1
R91	$N_2(B3)+NO \rightarrow N_2(A3)+NO$	$2.40 \times 10^{-10}$	1
R92	$N_2(C3)+N_2 \rightarrow N_2(A'1)+N_2$	$1.00 \times 10^{-11}$	1
R93	$N_2(C3)+O_2 \rightarrow N_2+O+O(^1S)$	$3.00 \times 10^{-10}$	1
R94	$N_2(A'1)+N_2 \rightarrow N_2(B3)+N_2$	$1.90 \times 10^{-13}$	1
R95	$N_2(A'1)+O_2 \rightarrow N_2+O(^3P)+O(^3P)$	$2.80 \times 10^{-11}$	1
R96	$N_2(A'1)+NO \rightarrow N_2+N+O$	$3.60 \times 10^{-10}$	1
R97	$N+N+N_2 \rightarrow N_2(A3)+N_2$	$1.70 \times 10^{-33}$	1
R98	$N+N+O_2 \rightarrow N_2(A3)+O_2$	$1.70 \times 10^{-33}$	1
R99	$N+N+NO \rightarrow N_2(A3)+NO$	$1.70 \times 10^{-33}$	1
R100	$N+N+N \rightarrow N_2(A3)+N$	$1.00 \times 10^{-32}$	1
R101	$N+N+O \rightarrow N_2(A3)+O$	$1.00 \times 10^{-32}$	1
R102	$N+N+N_2 \rightarrow N_2(B3)+N_2$	$2.40 \times 10^{-33}$	1
R103	$N+N+O_2 \rightarrow N_2(B3)+O_2$	$2.40 \times 10^{-33}$	1
R104	$N+N+NO \rightarrow N_2(B3)+NO$	$2.40 \times 10^{-33}$	1
R105	$N+N+N \rightarrow N_2(B3)+N$	$1.40 \times 10^{-32}$	1
R106	$N+N+O \rightarrow N_2(B3)+O$	$1.40 \times 10^{-32}$	1
R107	$N(^2D)+O \rightarrow N+O(^1D)$	$4.00 \times 10^{-13}$	1
R108	$N(^2D)+O_2 \rightarrow NO+O(^3P)$	$5.20 \times 10^{-12}$	1
R109	$N(^2D)+NO \rightarrow N_2+O$	$1.80 \times 10^{-10}$	1
R110	$N(^2D)+N_2 \rightarrow N+N_2$	$1.00 \times 10^{-13} \exp(-510.0/T_g)$	1
R111	$N(^2P)+N \rightarrow N+N$	$1.80 \times 10^{-12}$	1

R112	$N(^2P)+O \rightarrow N+O$	$1.00 \times 10^{-12}$	1
R113	$N(^2P)+N \rightarrow N(^2D)+N$	$6.00 \times 10^{-13}$	1
R114	$N(^2P)+N_2 \rightarrow N+N_2$	$6.00 \times 10^{-14}$	1
R115	$N(^2P)+N(^2D) \rightarrow N_2^++e$	$1.00 \times 10^{-13}$	1
R116	$N(^2P)+O_2 \rightarrow NO+O$	$2.60 \times 10^{-12}$	1
R117	$N(^2P)+NO \rightarrow N_2(A3)+O$	$3.00 \times 10^{-11}$	1
R118	$O_2(A1)+O \rightarrow O_2+O$	$7.00 \times 10^{-16}$	1
R119	$O_2(A1)+N \rightarrow NO+O$	$2.00 \times 10^{-14} \exp(-600.0/T_g)$	1
R120	$O_2(A1)+O_2 \rightarrow O_2+O_2$	$3.80 \times 10^{-18} \exp(-205.0/T_g)$	1
R121	$O_2(A1)+N_2 \rightarrow O_2+N_2$	$3.00 \times 10^{-21}$	1
R122	$O_2(A1)+NO \rightarrow O_2+NO$	$2.50 \times 10^{-11}$	1
R123	$O_2(A1)+O_2(A1) \rightarrow O_2+O_2(B1)$	$7.00 \times 10^{-28} T_g^{3.8} \exp(700.0/T_g)$	1
R124	$O_2(B1)+O \rightarrow O_2(A1)+O$	$8.10 \times 10^{-14}$	1
R125	$O_2(B1)+O \rightarrow O_2+O(^1D)$	$3.40 \times 10^{-11} (300.0/T_g)^{0.1} \exp(-4200.0/T_g)$	1
R126	$O_2(B1)+O_2 \rightarrow O_2(A1)+O_2$	$4.30 \times 10^{-22} T_g^{2.4} \exp(-281.0/T_g)$	1
R127	$O_2(B1)+N_2 \rightarrow O_2(A1)+N_2$	$1.70 \times 10^{-15} (T_g/300.0)$	1
R128	$O_2(B1)+NO \rightarrow O_2(A1)+NO$	$6.00 \times 10^{-14}$	1
R129	$O_2(4.5eV)+O \rightarrow O_2+O(^1S)$	$9.00 \times 10^{-12}$	1
R130	$O_2(4.5eV)+O_2 \rightarrow O_2(B1)+O_2(B1)$	$3.00 \times 10^{-13}$	1
R131	$O_2(4.5eV)+N_2 \rightarrow O_2(B1)+N_2$	$9.00 \times 10^{-15}$	1
R132	$O(^1D)+O \rightarrow O+O$	$8.00 \times 10^{-12}$	1
R133	$O(^1D)+O_2 \rightarrow O+O_2$	$6.40 \times 10^{-12} \exp(67.0/T_g)$	1
R134	$O(^1D)+O_2 \rightarrow O+O_2(A1)$	$1.00 \times 10^{-12}$	1
R135	$O(^1D)+O_2 \rightarrow O+O_2(B1)$	$2.60 \times 10^{-11} \exp(67.0/T_g)$	1
R136	$O(^1D)+N_2 \rightarrow O(^3P)+N_2$	$2.30 \times 10^{-11}$	1
R137	$O(^1D)+NO \rightarrow O_2+N$	$1.70 \times 10^{-10}$	1
R138	$O(^1S)+O \rightarrow O(^1D)+O$	$5.00 \times 10^{-11} \exp(-300.0/T_g)$	1
R139	$O(^1S)+N \rightarrow O+N$	$1.00 \times 10^{-12}$	1
R140	$O(^1S)+O_2 \rightarrow O(^1D)+O_2$	$1.30 \times 10^{-12} \exp(-850.0/T_g)$	1
R141	$O(^1S)+O_2 \rightarrow O+O+O$	$3.00 \times 10^{-12} \exp(-850.0/T_g)$	1
R142	$O(^1S)+N_2 \rightarrow O+N_2$	$1.00 \times 10^{-17}$	1

R143	$O(^1S)+O_2(A1)\rightarrow O+O_2(4.5eV)$	$1.10\times 10^{-10}$	1
R144	$O(^1S)+O_2(A1)\rightarrow O(^1D)+O_2(B1)$	$2.90\times 10^{-11}$	1
R145	$O(^1S)+O_2(A1)\rightarrow O+O+O$	$3.20\times 10^{-11}$	1
R146	$O(^1S)+NO\rightarrow O+NO$	$2.90\times 10^{-10}$	1
R147	$O(^1S)+NO\rightarrow O(^1D)+NO$	$5.10\times 10^{-10}$	1
R148	$N+NO\rightarrow O+N_2$	$1.80\times 10^{-11}(T_g/300.0)^{0.5}$	1
R149	$N(^4S)+O_2\rightarrow O(^3P)+NO$	$3.20\times 10^{-12}(T_g/300.0)\exp(-3150.0/T_g)$	1
R150	$O+N_2\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-38370.0/T_g)$	1
R151	$O+NO\rightarrow N+O_2$	$7.50\times 10^{-12}(T_g/300.0)\exp(-19500.0/T_g)$	1
R152	$O(^3P)+NO\rightarrow NO_2$	$3.02\times 10^{-11}\exp(T_g/298)^{-0.75}$	1
R153	$N_2+O_2\rightarrow O+N_2O$	$2.50\times 10^{-10}\exp(-50390.0/T_g)$	1
R154	$NO+NO\rightarrow N+NO_2$	$3.30\times 10^{-16}(300.0/T_g)^{0.5}\exp(-39200.0/T_g)$	1
R155	$NO+NO\rightarrow O+N_2O$	$2.20\times 10^{-12}\exp(-32100.0/T_g)$	1
R156	$NO+NO\rightarrow N_2+O_2$	$5.10\times 10^{-13}\exp(-33660.0/T_g)$	1
R157	$NO+O_2\rightarrow O+NO_2$	$2.80\times 10^{-12}\exp(-23400.0/T_g)$	1
R158	$NO+N_2O\rightarrow N_2+NO_2$	$4.60\times 10^{-10}\exp(-25170.0/T_g)$	1
R159	$NO+NO_3\rightarrow NO_2+NO_2$	$1.70\times 10^{-11}$	1
R160	$O_2+O_2\rightarrow O+O_3$	$2.00\times 10^{-11}\exp(-49800.0/T_g)$	1
R161	$O_2+NO_2\rightarrow NO+O_3$	$2.80\times 10^{-12}\exp(-25400.0/T_g)$	1
R162	$NO_2+NO_2\rightarrow NO+NO+O_2$	$3.30\times 10^{-12}\exp(-13500.0/T_g)$	1
R163	$NO_2+NO_2\rightarrow NO+NO_3$	$4.50\times 10^{-10}\exp(-18500.0/T_g)$	1
R164	$NO_2+O_3\rightarrow O_2+NO_3$	$1.20\times 10^{-13}\exp(-2450.0/T_g)$	1
R165	$NO_2+NO_3\rightarrow NO+NO_2+O_2$	$2.30\times 10^{-13}\exp(-1600.0/T_g)$	1
R166	$NO_3+O_2\rightarrow NO_2+O_3$	$1.50\times 10^{-12}\exp(-15020.0/T_g)$	1
R167	$NO_3+NO_3\rightarrow O_2+NO_2+NO_2$	$4.30\times 10^{-12}\exp(-3850.0/T_g)$	1
R168	$N+NO_2\rightarrow O+O+N_2$	$9.10\times 10^{-13}$	1
R169	$N+NO_2\rightarrow O+N_2O$	$3.00\times 10^{-12}$	1
R170	$N+NO_2\rightarrow N_2+O_2$	$7.00\times 10^{-13}$	1
R171	$N+NO_2\rightarrow NO+NO$	$2.30\times 10^{-12}$	1
R172	$NO+O_3\rightarrow O_2+NO_2$	$2.50\times 10^{-13}\exp(-765.0/T_g)$	1
R173	$O+N_2O\rightarrow N_2+O_2$	$8.30\times 10^{-12}\exp(-14000.0/T_g)$	1

R174	$O+N_2O \rightarrow NO+NO$	$1.50 \times 10^{-10} \exp(-14090.0/T_g)$	1
R175	$O+NO_2 \rightarrow NO+O_2$	$9.10 \times 10^{-12} (T_g/300.0)^{0.18}$	1
R176	$O+NO_3 \rightarrow O_2+NO_2$	$1.00 \times 10^{-11}$	1
R177	$O_2(A1)+O_3 \rightarrow O_2+O_2+O(^1D)$	$5.20 \times 10^{-11} \exp(-2840.0/T_g)$	1
R178	$O+O_3 \rightarrow O_2+O_2(A1)$	$1.00 \times 10^{-11} \exp(-2300.0/T_g)$	1
R179	$O_2(B1)+O_3 \rightarrow O_2+O_2+O$	$2.20 \times 10^{-11}$	1
R180	$O(^1D)+O_3 \rightarrow O_2+O+O$	$1.20 \times 10^{-10}$	1
R181	$O(^1D)+O_3 \rightarrow O_2+O_2$	$1.20 \times 10^{-10}$	1
R182	$O(^1D)+N_2O \rightarrow NO+NO$	$7.20 \times 10^{-11}$	1
R183	$O(^1D)+N_2O \rightarrow O_2+N_2$	$4.40 \times 10^{-11}$	1
R184	$O(^1S)+O_3 \rightarrow O_2+O_2$	$2.90 \times 10^{-10}$	1
R185	$O(^1S)+O_3 \rightarrow O_2+O+O(^1D)$	$2.90 \times 10^{-10}$	1
R186	$O(^1S)+N_2O \rightarrow O+N_2O$	$6.30 \times 10^{-12}$	1
R187	$O(^1S)+N_2O \rightarrow O(^1D)+N_2O$	$3.10 \times 10^{-12}$	1
R188	$N_2(A3)+O_2 \rightarrow N_2O+O$	$2.00 \times 10^{-14} (T_g/300.0)^{0.55}$	1
R189	$N_2+N_2 \rightarrow N+N+N_2$	$5.40 \times 10^{-8} (1.0 - \exp(-3354.0/T_g)) \exp(-113200.0/T_g)$	1
R190	$N_2+O_2 \rightarrow N+N+O_2$	$5.40 \times 10^{-8} (1.0 - \exp(-3354.0/T_g)) \exp(-113200.0/T_g)$	1
R191	$N_2+NO \rightarrow N+N+NO$	$5.40 \times 10^{-8} (1.0 - \exp(-3354.0/T_g)) \exp(-113200.0/T_g)$	1
R192	$N_2+O \rightarrow N+N+O$	$3.56 \times 10^{-7} (1.0 - \exp(-3354.0/T_g)) \exp(-113200.0/T_g)$	1
R193	$N_2+N \rightarrow N+N+N$	$3.56 \times 10^{-7} (1.0 - \exp(-3354.0/T_g)) \exp(-113200.0/T_g)$	1
R194	$O_2+N_2 \rightarrow O+O+N_2$	$6.10 \times 10^{-9} (1.0 - \exp(-2240.0/T_g)) \exp(-59380.0/T_g)$	1
R195	$O_2+O_2 \rightarrow O+O+O_2$	$3.60 \times 10^{-8} (1.0 - \exp(-2240.0/T_g)) \exp(-59380.0/T_g)$	1
R196	$O_2+O \rightarrow O+O+O$	$6.10 \times 10^{-9} (1.0 - \exp(-2240.0/T_g)) \exp(-59380.0/T_g)$	1
R197	$O_2+N \rightarrow O+O+N$	$6.10 \times 10^{-9} (1.0 - \exp(-2240.0/T_g)) \exp(-59380.0/T_g)$	1
R198	$O_2+NO \rightarrow O+O+NO$	$6.10 \times 10^9 (1.0 - \exp(2240.0/T_g)) \exp(-59380.0/T_g)$	1
R199	$NO+N_2 \rightarrow N+O+N_2$	$8.70 \times 10^{-9} \exp(-75994.0/T_g)$	1
R200	$NO+O_2 \rightarrow N+O+O_2$	$8.70 \times 10^{-9} \exp(-75994.0/T_g)$	1
R201	$NO+O \rightarrow N+O+O$	$1.74 \times 10^{-7} \exp(-75994.0/T_g)$	1
R202	$NO+N \rightarrow N+O+N$	$1.74 \times 10^{-7} \exp(-75994.0/T_g)$	1
R203	$NO+NO \rightarrow N+O+NO$	$1.74 \times 10^{-7} \exp(-75994.0/T_g)$	1

R204	$O_3+N_2 \rightarrow O_2+O+N_2$	$6.60 \times 10^{-10} \exp(-11600.0/T_g)$	1
R205	$O_3+O_2 \rightarrow O_2+O+O_2$	$2.51 \times 10^{-10} \exp(-11600.0/T_g)$	1
R206	$O_3+N \rightarrow O_2+O+N$	$4.16 \times 10^{-9} \exp(-11600.0/T_g) \exp(170.0/T_g)$	1
R207	$O_3+O \rightarrow O_2+O+O$	$4.16 \times 10^{-9} \exp(-11600.0/T_g) \exp(170.0/T_g)$	1
R208	$N_2O+N_2 \rightarrow N_2+O+N_2$	$1.20 \times 10^{-8} (300.0/T_g) \exp(-29000.0/T_g)$	1
R209	$N_2O+O_2 \rightarrow N_2+O+O_2$	$1.20 \times 10^{-8} (300.0/T_g) \exp(-29000.0/T_g)$	1
R210	$N_2O+NO \rightarrow N_2+O+NO$	$2.40 \times 10^{-8} (300.0/T_g) \exp(-29000.0/T_g)$	1
R211	$N_2O+N_2O \rightarrow N_2+O+N_2O$	$4.8 \times 10^{-8} (300.0/T_g) \exp(-29000.0/T_g)$	1
R214	$NO_2+NO \rightarrow NO+O+NO$	$5.30 \times 10^{-5} (300.0/T_g)^2 \exp(-36180.0/T_g)$	1
R215	$NO_2+NO_2 \rightarrow NO+O+NO_2$	$4.01 \times 10^{-5} (300.0/T_g)^2 \exp(-36180.0/T_g)$	1
R216	$NO_3+N_2 \rightarrow NO_2+O+N_2$	$3.10 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R217	$NO_3+O_2 \rightarrow NO_2+O+O_2$	$3.10 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R218	$NO_3+NO \rightarrow NO_2+O+NO$	$3.10 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R219	$NO_3+N \rightarrow NO_2+O+N$	$3.10 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R220	$NO_3+O \rightarrow NO_2+O+O$	$3.10 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R221	$NO_3+N_2 \rightarrow NO+O_2+N_2$	$6.20 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R222	$NO_3+O_2 \rightarrow NO+O_2+O_2$	$6.20 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R223	$NO_3+NO \rightarrow NO+O_2+NO$	$6.20 \times 10^{-5} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R224	$NO_3+N \rightarrow NO+O_2+N$	$7.44 \times 10^{-4} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R225	$NO_3+O \rightarrow NO+O_2+O$	$7.44 \times 10^{-4} (300.0/T_g)^2 \exp(-25000.0/T_g)$	1
R226	$N_2O_5+M \rightarrow NO_2+NO_3+M$	$2.10 \times 10^{-11} (300.0/T_g)^{4.4} \exp(-11080.0/T_g)$	1
R227	$N+N+N_2 \rightarrow N_2+N_2$	$\max(8.30 \times 10^{-34} \exp(500.0/T_g), 1.91 \times 10^{-33})$	1
R228	$N+N+O_2 \rightarrow N_2+O_2$	$1.80 \times 10^{-33} \exp(435.0/T_g)$	1
R229	$N+N+NO \rightarrow N_2+NO$	$1.80 \times 10^{-33} \exp(435.0/T_g)$	1
R230	$N+N+N \rightarrow N_2+N$	$5.40 \times 10^{-33} \exp(435.0/T_g)$	1
R231	$N+N+O \rightarrow N_2+O$	$5.40 \times 10^{-33} \exp(435.0/T_g)$	1
R232	$O+O+N_2 \rightarrow O_2+N_2$	$\max(2.8 \times 10^{-34} \exp(720.0/T_g), 1.0 \times 10^{-33} (300.0/T_g)^{0.41})$	1
R233	$O+O+O_2 \rightarrow O_2+O_2$	$4.00 \times 10^{-33} (300.0/T_g)^{0.41}$	1
R234	$O+O+N \rightarrow O_2+N$	$3.20 \times 10^{-33} (300.0/T_g)^{0.41}$	1
R235	$O+O+O \rightarrow O_2+O$	$1.44 \times 10^{-32} (300.0/T_g)^{0.41}$	1
R236	$O+O+NO \rightarrow O_2+NO$	$0.68 \times 10^{-33} (300.0/T_g)^{0.41}$	1

R237	$N+O+N_2 \rightarrow NO+N_2$	$1.00 \times 10^{-32} (300.0/T_g)^{0.5}$	1
R238	$N+O+O_2 \rightarrow NO+O_2$	$1.00 \times 10^{-32} (300.0/T_g)^{0.5}$	1
R239	$N+O+N \rightarrow NO+N$	$1.80 \times 10^{-31} (300.0/T_g)$	1
R240	$N+O+O \rightarrow NO+O$	$1.80 \times 10^{-31} (300.0/T_g)$	1
R241	$N+O+NO \rightarrow NO+NO$	$1.80 \times 10^{-31} (300.0/T_g)$	1
R242	$O+O_2+N_2 \rightarrow O_3+N_2$	$\max(5.00 \times 10^{-34} (300.0/T_g)^{2.8}, 5.4 \times 10^{-34} (300.0/T_g)^{1.9})$	1
R243	$O+O_2+O_2 \rightarrow O_3+O_2$	$7.6 \times 10^{-34} (300.0/T_g)^{1.9}$	1
R244	$O+O_2+NO \rightarrow O_3+NO$	$7.6 \times 10^{-34} (300.0/T_g)^{1.9}$	1
R245	$O+O_2+N \rightarrow O_3+N$	$\min(3.90 \times 10^{-33} (300.0/T_g)^{1.9}, 1.10 \times 10^{-34} \exp(1060.0/T_g))$	1
R246	$O+O_2+O \rightarrow O_3+O$	$\min(3.90 \times 10^{-33} (300.0/T_g)^{1.9}, 1.10 \times 10^{-34} \exp(1060.0/T_g))$	1
R247	$O+N_2+M \rightarrow N_2O+M$	$3.90 \times 10^{-35} \exp(-10400.0/T_g)$	1
R248	$O+NO+N_2 \rightarrow NO_2+N_2$	$1.20 \times 10^{-31} (300.0/T_g)^{1.8}$	1
R249	$O+NO+O_2 \rightarrow NO_2+O_2$	$0.64 \times 10^{-31} (300.0/T_g)^{1.8}$	1
R250	$O+NO+NO \rightarrow NO_2+NO$	$0.64 \times 10^{-31} (300.0/T_g)^{1.8}$	1
R251	$O+NO_2+N_2 \rightarrow NO_3+N_2$	$8.90 \times 10^{-32} (300.0/T_g)^2$	1
R252	$O+NO_2+O_2 \rightarrow NO_3+O_2$	$8.90 \times 10^{-32} (300.0/T_g)^2$	1
R253	$O+NO_2+N \rightarrow NO_3+N$	$1.15 \times 10^{-30} (300.0/T_g)^2$	1
R254	$O+NO_2+O \rightarrow NO_3+O$	$1.15 \times 10^{-30} (300.0/T_g)^2$	1
R255	$O+NO_2+NO \rightarrow NO_3+NO$	$2.14 \times 10^{-31} (300.0/T_g)^2$	1
R256	$NO_2+NO_3+M \rightarrow N_2O_5+M$	$3.70 \times 10^{-30} (300.0/T_g)^{4.1}$	1
R257	$e+NO^+ \rightarrow O+N$	$0.84 \times 10^{-7} (300.0/T_e)^{0.85}$	1
R258	$e+NO^+ \rightarrow O+N(^2D)$	$3.36 \times 10^{-7} (300.0/T_e)^{0.85}$	1
R259	$e+N_2O^+ \rightarrow N_2+O$	$2.00 \times 10^{-7} (300.0/T_e)^{0.5}$	1
R260	$e+NO_2 \rightarrow O+NO$	$1.00 \times 10^{-11}$	1
R261	$O^++O \rightarrow O_2+e$	$1.40 \times 10^{-10}$	1
R262	$O^++N \rightarrow NO+e$	$2.60 \times 10^{-10}$	1
R263	$O^++NO \rightarrow NO_2+e$	$2.60 \times 10^{-10}$	1
R264	$O^++N_2 \rightarrow N_2O+e$	$5.00 \times 10^{-13}$	1
R265	$O^++O_2 \rightarrow O_3+e$	$5.00 \times 10^{-15}$	1
R266	$O^++O_2(A1) \rightarrow O_3+e$	$3.00 \times 10^{-10}$	1
R267	$O^++O_2(B1) \rightarrow O+O_2+e$	$6.90 \times 10^{-10}$	1



R268	$O^- + N_2(A3) \rightarrow O + N_2 + e$	$2.20 \times 10^{-9}$	1
R269	$O^- + N_2(B3) \rightarrow O + N_2 + e$	$1.90 \times 10^{-9}$	1
R270	$O^- + O_3 \rightarrow O_2 + O_2 + e$	$3.00 \times 10^{-10}$	1
R271	$O_2^- + N \rightarrow NO_2 + e$	$5.00 \times 10^{-10}$	1
R272	$O_2^- + O_2 \rightarrow O_2 + O_2 + e$	$2.70 \times 10^{-10} (T_{eFFN2}/300.0)^{0.5} \exp(-5590.0/T_{eFFN2})$	1
R273	$O_2^- + O_2(A1) \rightarrow O_2 + O_2 + e$	$2.00 \times 10^{-10}$	1
R274	$O_2^- + O_2(B1) \rightarrow O_2 + O_2 + e$	$3.60 \times 10^{-10}$	1
R275	$O_2^- + N_2 \rightarrow O_2 + N_2 + e$	$1.90 \times 10^{-12} (T_{eFFN2}/300.0)^{0.5} \exp(-4990.0/T_{eFFN2})$	1
R276	$O_2^- + N_2(A3) \rightarrow O_2 + N_2 + e$	$2.10 \times 10^{-9}$	1
R277	$O_2^- + N_2(B3) \rightarrow O_2 + N_2 + e$	$2.50 \times 10^{-9}$	1
R278	$N^+ + O_3 \rightarrow NO^+ + O_2$	$5.00 \times 10^{-10}$	1
R279	$N^+ + NO \rightarrow NO^+ + N$	$8.00 \times 10^{-10}$	1
R280	$N^+ + NO \rightarrow N_2^+ + O$	$3.00 \times 10^{-12}$	1
R281	$N^+ + NO \rightarrow O^+ + N_2$	$1.00 \times 10^{-12}$	1
R282	$N^+ + N_2O \rightarrow NO^+ + N_2$	$5.50 \times 10^{-10}$	1
R283	$O^+ + O_3 \rightarrow O_2^+ + O_2$	$1.00 \times 10^{-10}$	1
R284	$O^+ + NO \rightarrow NO^+ + O$	$2.40 \times 10^{-11}$	1
R285	$O^+ + NO \rightarrow O_2^+ + N$	$3.00 \times 10^{-12}$	1
R286	$O^+ + N(^2D) \rightarrow N^+ + O$	$1.30 \times 10^{-10}$	1
R287	$O^+ + N_2O \rightarrow NO^+ + NO$	$2.30 \times 10^{-10}$	1
R288	$O^+ + N_2O \rightarrow N_2O^+ + O$	$2.20 \times 10^{-10}$	1
R289	$O^+ + N_2O \rightarrow O_2^+ + N_2$	$2.00 \times 10^{-11}$	1
R290	$O^+ + NO_2 \rightarrow NO_2^+ + O$	$1.60 \times 10^{-9}$	1
R291	$N_2^+ + O_3 \rightarrow O_2^+ + O + N_2$	$1.00 \times 10^{-10}$	1
R292	$N_2^+ + NO \rightarrow NO^+ + N_2$	$3.30 \times 10^{-10}$	1
R293	$N_2^+ + N_2O \rightarrow N_2O^+ + N_2$	$5.00 \times 10^{-10}$	1
R294	$N_2^+ + N_2O \rightarrow NO^+ + N + N_2$	$4.00 \times 10^{-10}$	1
R295	$O_2^+ + NO \rightarrow NO^+ + O_2$	$6.30 \times 10^{-10}$	1
R296	$O_2^+ + NO_2 \rightarrow NO^+ + O_3$	$1.00 \times 10^{-11}$	1
R297	$O_2^+ + NO_2 \rightarrow NO_2^+ + O_2$	$6.60 \times 10^{-10}$	1
R298	$NO_2^+ + NO \rightarrow NO^+ + NO_2$	$2.90 \times 10^{-10}$	1

R299	$N_2O^+ + NO \rightarrow NO^+ + N_2O$	$2.90 \times 10^{-10}$	1
R300	$N + N \rightarrow N_2^+ + e$	$2.70 \times 10^{-11} \exp(-6.74 \times 10^4 / T_g)$	1
R301	$N + O \rightarrow NO^+ + e$	$1.60 \times 10^{-12} (T_g / 300.0)^{0.5} (0.19 + 8.6 T_g) \exp(-32000.0 / T_g)$	1
R302	$N_2^+ + N + N_2 \rightarrow N_3^+ + N_2$	$9.00 \times 10^{-30} \exp(400.0 / T_{eFFN2})$	1
R303	$N^+ + N_2 + N_2 \rightarrow N_3^+ + N_2$	$1.70 \times 10^{-29} (300.0 / T_{eFFN2})^{2.1}$	1
R304	$e + N_3^+ \rightarrow N_2 + N$	$2.00 \times 10^{-7} (300.0 / T_e)^{0.5}$	1
R305	$N_3^+ + O_2 \rightarrow O_2^+ + N + N_2$	$2.30 \times 10^{-11}$	1
R306	$N_3^+ + O_2 \rightarrow NO_2^+ + N_2$	$4.40 \times 10^{-11}$	1
R307	$N_3^+ + N \rightarrow N_2^+ + N_2$	$6.60 \times 10^{-11}$	1
R308	$N_3^+ + NO \rightarrow NO^+ + N + N_2$	$7.00 \times 10^{-11}$	1
R309	$N_3^+ + NO \rightarrow N_2O^+ + N_2$	$7.00 \times 10^{-11}$	1
R310	$N_2^+ + N_2 + N_2 \rightarrow N_4^+ + N_2$	$5.20 \times 10^{-29} (300.0 / T_{eFFN2})^{2.2}$	1
R311	$e + N_4^+ \rightarrow N_2 + N_2$	$2.30 \times 10^{-6} (300.0 / T_e)^{0.53}$	1
R312	$N_4^+ + N_2 \rightarrow N_2^+ + N_2 + N_2$	$\min(2.10 \times 10^{-16} \exp(T_{eFFN4} / 121.0), 1.00 \times 10^{-10})$	1
R313	$N_4^+ + O_2 \rightarrow O_2^+ + N_2 + N_2$	$2.50 \times 10^{-10}$	1
R314	$N_4^+ + O \rightarrow O^+ + N_2 + N_2$	$2.50 \times 10^{-10}$	1
R315	$N_4^+ + N \rightarrow N^+ + N_2 + N_2$	$1.00 \times 10^{-11}$	1
R316	$N_4^+ + NO \rightarrow NO^+ + N_2 + N_2$	$4.00 \times 10^{-10}$	1
R317	$e + O_4^+ \rightarrow O_2 + O_2$	$1.40 \times 10^{-6} (300.0 / T_e)^{0.5}$	1
R318	$O_2^+ + O_2 + O_2 \rightarrow O_4^+ + O_2$	$2.40 \times 10^{-30} (300.0 / T_{eFFN2})^{3.2}$	1
R319	$O_4^+ + O \rightarrow O_2^+ + O_3$	$3.00 \times 10^{-10}$	1
R320	$e + O_2^+ N_2 \rightarrow O_2 + N_2$	$1.30 \times 10^{-6} (300.0 / T_e)^{0.5}$	1
R321	$O_2^+ + N_2 + N_2 \rightarrow O_2^+ N_2 + N_2$	$9.00 \times 10^{-31} (300.0 / T_{eFFN2})^2$	1
R322	$O_2^+ N_2 + N_2 \rightarrow O_2^+ + N_2 + N_2$	$1.10 \times 10^{-6} (300.0 / T_{eFFN4})^{5.3} \exp(-2360.0 / T_{eFFN4})$	1
R323	$O_2^+ N_2 + O_2 \rightarrow O_4^+ + N_2$	$1.00 \times 10^{-9}$	1
R324	$O^- + NO_2 \rightarrow NO_2^- + O$	$1.20 \times 10^{-9}$	1
R325	$O^- + N_2O \rightarrow NO^- + NO$	$2.00 \times 10^{-10}$	1
R326	$O_2^- + NO_2 \rightarrow NO_2^- + O_2$	$7.00 \times 10^{-10}$	1
R327	$O_2^- + NO_3 \rightarrow NO_3^- + O_2$	$5.00 \times 10^{-10}$	1
R328	$O^- + N_2O \rightarrow N_2O^- + O$	$2.00 \times 10^{-12}$	1
R329	$NO^- + NO_2 \rightarrow NO_2^- + NO$	$7.40 \times 10^{-10}$	1

R330	$\text{NO}^- + \text{N}_2\text{O} \rightarrow \text{NO}_2^- + \text{N}_2$	$2.80 \times 10^{-14}$	1
R331	$\text{NO}_2^- + \text{O}_3 \rightarrow \text{NO}_3^- + \text{O}_2$	$1.80 \times 10^{-11}$	1
R332	$\text{NO}_2^- + \text{NO}_2 \rightarrow \text{NO}_3^- + \text{NO}$	$4.00 \times 10^{-12}$	1
R333	$\text{NO}_2^- + \text{NO}_3 \rightarrow \text{NO}_3^- + \text{NO}_2$	$5.00 \times 10^{-10}$	1
R334	$\text{NO}_2^- + \text{N}_2\text{O}_5 \rightarrow \text{NO}_3^- + \text{NO}_2 + \text{NO}_2$	$7.00 \times 10^{-10}$	1
R335	$\text{NO}_3^- + \text{NO} \rightarrow \text{NO}_2^- + \text{NO}_2$	$3.00 \times 10^{-15}$	1
R336	$\text{N}_2(\text{A}3) + \text{N}_2\text{O} \rightarrow \text{N}_2 + \text{N} + \text{NO}$	$1.00 \times 10^{-11}$	1
R337	$\text{N}_2(\text{A}3) + \text{NO}_2 \rightarrow \text{N}_2 + \text{O} + \text{NO}$	$1.00 \times 10^{-12}$	1
R338	$\text{N}_2(\text{A}^1) + \text{N}_2(\text{A}3) \rightarrow \text{N}_4^+ + \text{e}$	$4.00 \times 10^{-12}$	1
R339	$\text{N}_2(\text{A}^1) + \text{N}_2(\text{A}^1) \rightarrow \text{N}_4^+ + \text{e}$	$1.00 \times 10^{-11}$	1
R340	$\text{N}(^2\text{D}) + \text{N}_2\text{O} \rightarrow \text{NO} + \text{N}_2$	$3.50 \times 10^{-12}$	1
R341	$\text{O}^- + \text{N}^+ \rightarrow \text{O} + \text{N}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R342	$\text{O}^- + \text{N}_2^+ \rightarrow \text{O} + \text{N}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R343	$\text{O}^- + \text{O}^+ \rightarrow \text{O} + \text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R344	$\text{O}^- + \text{O}_2^+ \rightarrow \text{O} + \text{O}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R345	$\text{O}^- + \text{NO}^+ \rightarrow \text{O} + \text{NO}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R346	$\text{O}^- + \text{N}_2\text{O}^+ \rightarrow \text{O} + \text{N}_2\text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R347	$\text{O}^- + \text{NO}_2^+ \rightarrow \text{O} + \text{NO}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R348	$\text{O}_2^- + \text{N}^+ \rightarrow \text{O}_2 + \text{N}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R349	$\text{O}_2^- + \text{N}_2^+ \rightarrow \text{O}_2 + \text{N}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R350	$\text{O}_2^- + \text{O}^+ \rightarrow \text{O}_2 + \text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R351	$\text{O}_2^- + \text{O}_2^+ \rightarrow \text{O}_2 + \text{O}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R352	$\text{O}_2^- + \text{NO}^+ \rightarrow \text{O}_2 + \text{NO}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R353	$\text{O}_2^- + \text{N}_2\text{O}^+ \rightarrow \text{O}_2 + \text{N}_2\text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R354	$\text{O}_2^- + \text{NO}_2^+ \rightarrow \text{O}_2 + \text{NO}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R355	$\text{NO}^- + \text{N}^+ \rightarrow \text{NO} + \text{N}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R356	$\text{NO}^- + \text{N}_2^+ \rightarrow \text{NO} + \text{N}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R357	$\text{NO}^- + \text{O}^+ \rightarrow \text{NO} + \text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R358	$\text{NO}^- + \text{O}_2^+ \rightarrow \text{NO} + \text{O}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R359	$\text{NO}^- + \text{NO}^+ \rightarrow \text{NO} + \text{NO}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R360	$\text{NO}^- + \text{N}_2\text{O}^+ \rightarrow \text{NO} + \text{N}_2\text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1

R361	$\text{NO}^- + \text{NO}_2^+ \rightarrow \text{NO} + \text{NO}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R362	$\text{N}_2\text{O}^- + \text{N}^+ \rightarrow \text{N}_2\text{O} + \text{N}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R363	$\text{N}_2\text{O}^- + \text{N}_2^+ \rightarrow \text{N}_2\text{O} + \text{N}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R364	$\text{N}_2\text{O}^- + \text{O}^+ \rightarrow \text{N}_2\text{O} + \text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R365	$\text{N}_2\text{O}^- + \text{O}_2^+ \rightarrow \text{N}_2\text{O} + \text{O}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R366	$\text{N}_2\text{O}^- + \text{NO}^+ \rightarrow \text{N}_2\text{O} + \text{NO}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R367	$\text{N}_2\text{O}^- + \text{N}_2\text{O}^+ \rightarrow \text{N}_2\text{O} + \text{N}_2\text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R368	$\text{N}_2\text{O}^- + \text{NO}_2^+ \rightarrow \text{N}_2\text{O} + \text{NO}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R369	$\text{NO}_2^- + \text{N}^+ \rightarrow \text{NO}_2 + \text{N}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R370	$\text{NO}_2^- + \text{N}_2^+ \rightarrow \text{NO}_2 + \text{N}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R371	$\text{NO}_2^- + \text{O}^+ \rightarrow \text{NO}_2 + \text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R372	$\text{NO}_2^- + \text{O}_2^+ \rightarrow \text{NO}_2 + \text{O}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R373	$\text{NO}_2^- + \text{NO}^+ \rightarrow \text{NO}_2 + \text{NO}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R374	$\text{NO}_2^- + \text{N}_2\text{O}^+ \rightarrow \text{NO}_2 + \text{N}_2\text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R375	$\text{NO}_2^- + \text{NO}_2^+ \rightarrow \text{NO}_2 + \text{NO}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R376	$\text{NO}_3^- + \text{N}^+ \rightarrow \text{NO}_3 + \text{N}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R377	$\text{NO}_3^- + \text{N}_2^+ \rightarrow \text{NO}_3 + \text{N}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R378	$\text{NO}_3^- + \text{O}^+ \rightarrow \text{NO}_3 + \text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R379	$\text{NO}_3^- + \text{O}_2^+ \rightarrow \text{NO}_3 + \text{O}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R380	$\text{NO}_3^- + \text{NO}^+ \rightarrow \text{NO}_3 + \text{NO}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R381	$\text{NO}_3^- + \text{N}_2\text{O}^+ \rightarrow \text{NO}_3 + \text{N}_2\text{O}$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R382	$\text{NO}_3^- + \text{NO}_2^+ \rightarrow \text{NO}_3 + \text{NO}_2$	$2.00 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R383	$\text{O}^- + \text{N}_2^+ \rightarrow \text{O} + \text{N} + \text{N}$	$1.00 \times 10^{-7}$	1
R384	$\text{O}^- + \text{N}_3^+ \rightarrow \text{O} + \text{N} + \text{N}_2$	$1.00 \times 10^{-7}$	1
R385	$\text{O}^- + \text{N}_4^+ \rightarrow \text{O} + \text{N}_2 + \text{N}_2$	$1.00 \times 10^{-7}$	1
R386	$\text{O}^- + \text{O}_2^+ \rightarrow \text{O} + \text{O} + \text{O}$	$1.00 \times 10^{-7}$	1
R387	$\text{O}^- + \text{O}_4^+ \rightarrow \text{O} + \text{O}_2 + \text{O}_2$	$1.00 \times 10^{-7}$	1
R388	$\text{O}^- + \text{NO}^+ \rightarrow \text{O} + \text{N} + \text{O}$	$1.00 \times 10^{-7}$	1
R389	$\text{O}^- + \text{N}_2\text{O}^+ \rightarrow \text{O} + \text{N}_2 + \text{O}$	$1.00 \times 10^{-7}$	1
R390	$\text{O}^- + \text{NO}_2^+ \rightarrow \text{O} + \text{N} + \text{O}_2$	$1.00 \times 10^{-7}$	1
R391	$\text{O}^- + \text{O}_2^+ \text{N}_2 \rightarrow \text{O} + \text{O}_2 + \text{N}_2$	$1.00 \times 10^{-7}$	1

R392	$O_2^- + N_2^+ \rightarrow O_2 + N + N$	$1.00 \times 10^{-7}$	1
R393	$O_2^- + N_3^+ \rightarrow O_2 + N + N_2$	$1.00 \times 10^{-7}$	1
R394	$O_2^- + N_4^+ \rightarrow O_2 + N_2 + N_2$	$1.00 \times 10^{-7}$	1
R395	$O_2^- + O_2^+ \rightarrow O_2 + O + O$	$1.00 \times 10^{-7}$	1
R396	$O_2^- + O_4^+ \rightarrow O_2 + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R397	$O_2^- + NO^+ \rightarrow O_2 + N + O$	$1.00 \times 10^{-7}$	1
R398	$O_2^- + N_2O^+ \rightarrow O_2 + N_2 + O$	$1.00 \times 10^{-7}$	1
R399	$O_2^- + NO_2^+ \rightarrow O_2 + N + O_2$	$1.00 \times 10^{-7}$	1
R400	$O_2^- + O_2^+ N_2 \rightarrow O_2 + O_2 + N_2$	$1.0 \times 10^{-7}$	1
R401	$NO^- + N_2^+ \rightarrow NO + N + N$	$1.00 \times 10^{-7}$	1
R402	$NO^- + N_3^+ \rightarrow NO + N + N_2$	$1.00 \times 10^{-7}$	1
R403	$NO^- + N_4^+ \rightarrow NO + N_2 + N_2$	$1.00 \times 10^{-7}$	1
R404	$NO^- + O_2^+ \rightarrow NO + O + O$	$1.00 \times 10^{-7}$	1
R405	$NO^- + O_4^+ \rightarrow NO + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R406	$NO^- + NO^+ \rightarrow NO + N + O$	$1.00 \times 10^{-7}$	1
R407	$NO^- + N_2O^+ \rightarrow NO + N_2 + O$	$1.00 \times 10^{-7}$	1
R408	$NO^- + NO_2^+ \rightarrow NO + N + O_2$	$1.00 \times 10^{-7}$	1
R409	$NO^- + O_2^+ N_2 \rightarrow NO + O_2 + N_2$	$1.00 \times 10^{-7}$	1
R410	$N_2O^- + N_2^+ \rightarrow N_2O + N + N$	$1.00 \times 10^{-7}$	1
R411	$N_2O^- + N_3^+ \rightarrow N_2O + N + N_2$	$1.00 \times 10^{-7}$	1
R412	$N_2O^- + N_4^+ \rightarrow N_2O + N_2 + N_2$	$1.00 \times 10^{-7}$	1
R413	$N_2O^- + O_2^+ \rightarrow N_2O + O + O$	$1.00 \times 10^{-7}$	1
R414	$N_2O^- + O_4^+ \rightarrow N_2O + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R415	$N_2O^- + NO^+ \rightarrow N_2O + N + O$	$1.00 \times 10^{-7}$	1
R416	$N_2O^- + N_2O^+ \rightarrow N_2O + N_2 + O$	$1.00 \times 10^{-7}$	1
R417	$N_2O^- + NO_2^+ \rightarrow N_2O + N + O_2$	$1.00 \times 10^{-7}$	1
R418	$N_2O^- + O_2^+ N_2 \rightarrow N_2O + O_2 + N_2$	$1.00 \times 10^{-7}$	1
R419	$NO_2^- + N_2^+ \rightarrow NO_2 + N + N$	$1.00 \times 10^{-7}$	1
R420	$NO_2^- + N_3^+ \rightarrow NO_2 + N + N_2$	$1.00 \times 10^{-7}$	1
R421	$NO_2^- + N_4^+ \rightarrow NO_2 + N_2 + N_2$	$1.00 \times 10^{-7}$	1
R422	$NO_2^- + O_2^+ \rightarrow NO_2 + O + O$	$1.00 \times 10^{-7}$	1

R423	$O_2^- + O_4^+ \rightarrow NO_2 + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R424	$NO_2^- + NO^+ \rightarrow NO_2 + N + O$	$1.00 \times 10^{-7}$	1
R425	$NO_2^- + N_2O^+ \rightarrow NO_2 + N_2 + O$	$1.00 \times 10^{-7}$	1
R426	$NO_2^- + NO_2^+ \rightarrow NO_2 + N + O_2$	$1.00 \times 10^{-7}$	1
R427	$NO_2^- + O_2^+ N_2 \rightarrow NO_2 + O_2 + N_2$	$1.00 \times 10^{-7}$	1
R428	$NO_3^- + N_2^+ \rightarrow NO_3 + N + N$	$1.00 \times 10^{-7}$	1
R429	$NO_3^- + N_3^+ \rightarrow NO_3 + N + N_2$	$1.00 \times 10^{-7}$	1
R430	$NO_3^- + N_4^+ \rightarrow NO_3 + N_2 + N_2$	$1.00 \times 10^{-7}$	1
R431	$NO_3^- + O_2^+ \rightarrow NO_3 + O + O$	$1.00 \times 10^{-7}$	1
R432	$NO_3^- + O_4^+ \rightarrow NO_3 + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R433	$NO_3^- + NO^+ \rightarrow NO_3 + N + O$	$1.00 \times 10^{-7}$	1
R434	$NO_3^- + N_2O^+ \rightarrow NO_3 + N_2 + O$	$1.00 \times 10^{-7}$	1
R435	$NO_3^- + NO_2^+ \rightarrow NO_3 + N + O_2$	$1.00 \times 10^{-7}$	1
R436	$NO_3^- + O_2^+ N_2 \rightarrow NO_3 + O_2 + N_2$	$1.00 \times 10^{-7}$	1
R437	$O^- + N^+ + M \rightarrow O + N + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R438	$O^- + N_2^+ + M \rightarrow O + N_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R439	$O^- + O^+ + M \rightarrow O + O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R440	$O^- + O_2^+ + M \rightarrow O + O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R441	$O^- + NO^+ + M \rightarrow O + NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R442	$O_2^- + N^+ + M \rightarrow O_2 + N + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R443	$O_2^- + N_2^+ + M \rightarrow O_2 + N_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R444	$O_2^- + O^+ + M \rightarrow O_2 + O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R445	$O_2^- + O_2^+ + M \rightarrow O_2 + O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R446	$O_2^- + NO^+ + M \rightarrow O_2 + NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R447	$O^- + N^+ + M \rightarrow NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R448	$O^- + N_2^+ + M \rightarrow N_2O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R449	$O^- + O^+ + M \rightarrow O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R450	$O^- + O_2^+ + M \rightarrow O_3 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R451	$O^- + NO^+ + M \rightarrow NO_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R452	$O_2^- + N^+ + M \rightarrow NO_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R453	$O_2^- + O^+ + M \rightarrow O_3 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1

R454	$O_2^- + NO^+ + M \rightarrow NO_3 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R455	$NO^- + N^+ + M \rightarrow NO + N + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R456	$NO^- + N_2^+ + M \rightarrow NO + N_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R457	$NO^- + O^+ + M \rightarrow NO + O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R458	$NO^- + O_2^+ + M \rightarrow NO + O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R459	$NO^- + NO^+ + M \rightarrow NO + NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R460	$NO^- + N_2O^+ + M \rightarrow NO + N_2O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R461	$NO^- + NO_2^+ + M \rightarrow NO + NO_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R462	$N_2O^- + N^+ + M \rightarrow N_2O + N + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R463	$N_2O^- + N_2^+ + M \rightarrow N_2O + N_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R464	$N_2O^- + O^+ + M \rightarrow N_2O + O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R465	$N_2O^- + O_2^+ + M \rightarrow N_2O + O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R466	$N_2O^- + NO^+ + M \rightarrow N_2O + NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R467	$N_2O^- + N_2O^+ + M \rightarrow N_2O + N_2O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R468	$N_2O^- + NO_2^+ + M \rightarrow N_2O + NO_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R469	$NO_2^- + N^+ + M \rightarrow NO_2 + N + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R470	$NO_2^- + N_2^+ + M \rightarrow NO_2 + N_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R471	$NO_2^- + O^+ + M \rightarrow NO_2 + O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R472	$NO_2^- + O_2^+ + M \rightarrow NO_2 + O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R473	$NO_2^- + NO^+ + M \rightarrow NO_2 + NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R474	$NO_2^- + N_2O^+ + M \rightarrow NO_2 + N_2O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R475	$NO_2^- + NO_2^+ + M \rightarrow NO_2 + NO_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R476	$NO_3^- + N^+ + M \rightarrow NO_3 + N + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R477	$NO_3^- + N_2^+ + M \rightarrow NO_3 + N_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R478	$NO_3^- + O^+ + M \rightarrow NO_3 + O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R479	$NO_3^- + O_2^+ + M \rightarrow NO_3 + O_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R480	$NO_3^- + NO^+ + M \rightarrow NO_3 + NO + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R481	$NO_3^- + N_2O^+ + M \rightarrow NO_3 + N_2O + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R482	$NO_3^- + NO_2^+ + M \rightarrow NO_3 + NO_2 + M$	$2.00 \times 10^{-25} (300.0/T_{IONN})^{2.5}$	1
R483	$O_2^- + O \rightarrow O_3 + e$	$1.50 \times 10^{-10}$	1
R484	$e + N_2O + M \rightarrow N_2O^- + M$	$6.00 \times 10^{-33}$	1

R485	$e+\text{NO}+\text{M}\rightarrow\text{NO}^{-}+\text{M}$	$8.00\times 10^{-31}$	1
R486	$\text{NO}^{-}+\text{N}\rightarrow\text{N}_2\text{O}+\text{e}$	$5.0\times 10^{-10}$	1
R487	$\text{NO}^{-}+\text{O}\rightarrow\text{NO}_2+\text{e}$	$1.50\times 10^{-10}$	1
R488	$\text{N}^{+}+\text{O}+\text{M}\rightarrow\text{NO}^{+}+\text{M}$	$1.00\times 10^{-29}$	1
R489	$\text{N}^{+}+\text{N}+\text{M}\rightarrow\text{N}_2^{+}+\text{M}$	$1.00\times 10^{-29}$	1
R490	$\text{O}^{+}+\text{N}_2+\text{M}\rightarrow\text{NO}^{+}+\text{N}+\text{M}$	$6.00\times 10^{-29}(300.0/T_{\text{eFFN}})^2$	1
R491	$\text{O}^{+}+\text{O}+\text{M}\rightarrow\text{O}_2^{+}+\text{M}$	$1.00\times 10^{-29}$	1
R492	$\text{O}^{+}+\text{N}+\text{M}\rightarrow\text{NO}^{+}+\text{M}$	$1.00\times 10^{-29}$	1
R493	$\text{O}^{-}+\text{O}_3\rightarrow\text{O}_3^{-}+\text{O}$	$8.00\times 10^{-10}$	1
R494	$\text{O}_2^{-}+\text{O}_3\rightarrow\text{O}_3^{-}+\text{O}_2$	$3.50\times 10^{-10}$	1
R495	$e+\text{O}_3+\text{M}\rightarrow\text{O}_3^{-}+\text{M}$	$5.00\times 10^{-31}T_{\text{e}}^{(-0.5)}$	1
R496	$\text{O}_3^{-}+\text{O}\rightarrow\text{O}_2+\text{O}_2^{-}$	$2.50\times 10^{-10}$	1
R497	$\text{O}_3^{-}+\text{O}\rightarrow\text{O}_3+\text{O}^{-}$	$1.00\times 10^{-13}$	1
R498	$\text{O}_3^{-}+\text{O}\rightarrow\text{O}_2+\text{O}_2+\text{e}$	$1.00\times 10^{-13}$	1
R499	$\text{O}_3^{-}+\text{O}_2\rightarrow\text{O}_2+\text{O}_3+\text{e}$	$2.30\times 10^{-11}$	1
R500	$\text{O}_3^{-}+\text{O}_3\rightarrow\text{O}_2+\text{O}_2+\text{O}_2+\text{e}$	$3.00\times 10^{-10}$	1
R501	$\text{O}_3^{-}+\text{N}\rightarrow\text{NO}+\text{O}_2+\text{e}$	$5.00\times 10^{-10}$	1
R502	$\text{N}_2\text{O}^{-}+\text{N}\rightarrow\text{NO}+\text{N}_2+\text{e}$	$5.00\times 10^{-10}$	1
R503	$\text{NO}_2^{-}+\text{N}\rightarrow\text{NO}+\text{NO}+\text{e}$	$5.00\times 10^{-10}$	1
R504	$\text{NO}_3^{-}+\text{N}\rightarrow\text{NO}+\text{NO}_2+\text{e}$	$5.00\times 10^{-10}$	1
R505	$\text{N}_2\text{O}^{-}+\text{O}\rightarrow\text{NO}+\text{NO}+\text{e}$	$1.50\times 10^{-10}$	1
R506	$\text{NO}_2^{-}+\text{O}\rightarrow\text{NO}+\text{O}_2+\text{e}$	$1.50\times 10^{-10}$	1
R507	$\text{NO}_3^{-}+\text{O}\rightarrow\text{NO}+\text{O}_3+\text{e}$	$1.50\times 10^{-10}$	1
R508	$\text{O}_3^{-}+\text{N}_2(\text{A3})\rightarrow\text{O}_3+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R509	$\text{NO}^{-}+\text{N}_2(\text{A3})\rightarrow\text{NO}+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R510	$\text{N}_2\text{O}^{-}+\text{N}_2(\text{A3})\rightarrow\text{N}_2\text{O}+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R511	$\text{NO}_2^{-}+\text{N}_2(\text{A3})\rightarrow\text{NO}_2+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R512	$\text{NO}_3^{-}+\text{N}_2(\text{A3})\rightarrow\text{NO}_3+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R513	$\text{O}_3^{-}+\text{N}_2(\text{B3})\rightarrow\text{O}_3+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R514	$\text{NO}^{-}+\text{N}_2(\text{B3})\rightarrow\text{NO}+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1
R515	$\text{N}_2\text{O}^{-}+\text{N}_2(\text{B3})\rightarrow\text{N}_2\text{O}+\text{N}_2+\text{e}$	$2.10\times 10^{-9}$	1



R516	$\text{NO}_2^- + \text{N}_2(\text{B3}) \rightarrow \text{NO}_2 + \text{N}_2 + \text{e}$	$2.10 \times 10^{-9}$	1
R517	$\text{NO}_3^- + \text{N}_2(\text{B3}) \rightarrow \text{NO}_3 + \text{N}_2 + \text{e}$	$2.10 \times 10^{-9}$	1
R518	$\text{O}_3^- + \text{N}^+ + \text{M} \rightarrow \text{O}_3 + \text{N} + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R519	$\text{O}_3^- + \text{N}_2^+ + \text{M} \rightarrow \text{O}_3 + \text{N}_2 + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R520	$\text{O}_3^- + \text{O}^+ + \text{M} \rightarrow \text{O}_3 + \text{O} + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R521	$\text{O}_3^- + \text{O}_2^+ + \text{M} \rightarrow \text{O}_3 + \text{O}_2 + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R522	$\text{O}_3^- + \text{NO}^+ + \text{M} \rightarrow \text{O}_3 + \text{NO} + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R523	$\text{O}_3^- + \text{N}_2\text{O}^+ + \text{M} \rightarrow \text{O}_3 + \text{N}_2\text{O} + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R524	$\text{O}_3^- + \text{NO}_2^+ + \text{M} \rightarrow \text{O}_3 + \text{NO}_2 + \text{M}$	$2.00 \times 10^{-25} (300.0/T_{\text{IONN}})^{2.5}$	1
R525	$\text{O}_3^- + \text{N}_2^+ \rightarrow \text{O}_3 + \text{N} + \text{N}$	$1.00 \times 10^{-7}$	1
R526	$\text{O}_3^- + \text{N}_3^+ \rightarrow \text{O}_3 + \text{N} + \text{N}_2$	$1.00 \times 10^{-7}$	1
R527	$\text{O}_3^- + \text{N}_4^+ \rightarrow \text{O}_3 + \text{N}_2 + \text{N}_2$	$1.00 \times 10^{-7}$	1
R528	$\text{O}_3^- + \text{O}_2^+ \rightarrow \text{O}_3 + \text{O} + \text{O}$	$1.00 \times 10^{-7}$	1
R529	$\text{O}_3^- + \text{O}_4^+ \rightarrow \text{O}_3 + \text{O}_2 + \text{O}_2$	$1.00 \times 10^{-7}$	1
R530	$\text{O}_3^- + \text{NO}^+ \rightarrow \text{O}_3 + \text{N} + \text{O}$	$1.00 \times 10^{-7}$	1
R531	$\text{O}_3^- + \text{N}_2\text{O}^+ \rightarrow \text{O}_3 + \text{N}_2 + \text{O}$	$1.00 \times 10^{-7}$	1
R532	$\text{O}_3^- + \text{NO}_2^+ \rightarrow \text{O}_3 + \text{N} + \text{O}_2$	$1.00 \times 10^{-7}$	1
R533	$\text{O}_3^- + \text{O}_2^+ \text{N}_2 \rightarrow \text{O}_3 + \text{O}_2 + \text{N}_2$	$1.00 \times 10^{-7}$	1
R534	$\text{O}_3^- + \text{N}^+ \rightarrow \text{O}_3 + \text{N}$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R535	$\text{O}_3^- + \text{N}_2^+ \rightarrow \text{O}_3 + \text{N}_2$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R536	$\text{O}_3^- + \text{O}^+ \rightarrow \text{O}_3 + \text{O}$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R537	$\text{O}_3^- + \text{O}_2^+ \rightarrow \text{O}_3 + \text{O}_2$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R538	$\text{O}_3^- + \text{NO}^+ \rightarrow \text{O}_3 + \text{NO}$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R539	$\text{O}_3^- + \text{N}_2\text{O}^+ \rightarrow \text{O}_3 + \text{N}_2\text{O}$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R540	$\text{O}_3^- + \text{NO}_2^+ \rightarrow \text{O}_3 + \text{NO}_2$	$2.0 \times 10^{-7} (300.0/T_{\text{IONN}})^{0.5}$	1
R541	$\text{O}_3^- + \text{NO} \rightarrow \text{NO}_3^- + \text{O}$	$1.00 \times 10^{-11}$	1
R542	$\text{O}_3^- + \text{NO} \rightarrow \text{NO}_2^- + \text{O}_2$	$2.60 \times 10^{-12}$	1
R543	$\text{O}_3^- + \text{NO}_2 \rightarrow \text{NO}_2^- + \text{O}_3$	$7.00 \times 10^{-11}$	1
R544	$\text{O}_3^- + \text{NO}_2 \rightarrow \text{NO}_3^- + \text{O}_2$	$2.00 \times 10^{-11}$	1
R545	$\text{O}_3^- + \text{NO}_3 \rightarrow \text{NO}_3^- + \text{O}_3$	$5.00 \times 10^{-10}$	1
R546	$\text{O}_2^- + \text{O}_2 + \text{M} \rightarrow \text{O}_4^- + \text{M}$	$3.50 \times 10^{-31} (300.0/T_{\text{eFFN2}})$	1

R547	$O_4^- + N_2 \rightarrow O_2^- + O_2 + N_2$	$1.00 \times 10^{-10} \exp(-1044.0/T_{eFFN4})$	1
R548	$O_4^- + O_2 \rightarrow O_2^- + O_2 + O_2$	$1.00 \times 10^{-10} \exp(-1044.0/T_{eFFN4})$	1
R549	$O_4^- + O \rightarrow O_3^- + O_2$	$4.00 \times 10^{-10}$	1
R550	$O_4^- + O \rightarrow O^- + O_2 + O_2$	$3.00 \times 10^{-10}$	1
R551	$O_4^- + O_2(A1) \rightarrow O_2^- + O_2 + O_2$	$1.00 \times 10^{-10}$	1
R552	$O_4^- + O_2(B1) \rightarrow O_2^- + O_2 + O_2$	$1.00 \times 10^{-10}$	1
R553	$O_4^- + NO \rightarrow NO_3^- + O_2$	$2.50 \times 10^{-10}$	1
R554	$O_4^- + N^+ \rightarrow O_2 + O_2 + N$	$1.00 \times 10^{-7}$	1
R555	$O_4^- + N_2^+ \rightarrow O_2 + O_2 + N_2$	$1.00 \times 10^{-7}$	1
R556	$O_4^- + O^+ \rightarrow O_2 + O_2 + O$	$1.00 \times 10^{-7}$	1
R557	$O_4^- + O_2^+ \rightarrow O_2 + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R558	$O_4^- + NO^+ \rightarrow O_2 + O_2 + NO$	$1.00 \times 10^{-7}$	1
R559	$O_4^- + N_2O^+ \rightarrow O_2 + O_2 + N_2O$	$1.00 \times 10^{-7}$	1
R560	$O_4^- + NO_2^+ \rightarrow O_2 + O_2 + NO_2$	$1.00 \times 10^{-7}$	1
R561	$O_4^- + N_3^+ \rightarrow O_2 + O_2 + N_2 + N$	$1.00 \times 10^{-7}$	1
R562	$O_4^- + N_4^+ \rightarrow O_2 + O_2 + N_2 + N_2$	$1.00 \times 10^{-7}$	1
R563	$O_4^- + O_4^+ \rightarrow O_2 + O_2 + O_2 + O_2$	$1.00 \times 10^{-7}$	1
R564	$O_4^- + O_2^+ N_2 \rightarrow O_2 + O_2 + O_2 + N_2$	$1.00 \times 10^{-7}$	1
R565	$NO^- + O_2 \rightarrow O_2^- + NO$	$5.00 \times 10^{-10}$	1
R566	$O^- + O_2(A1) \rightarrow O_2^- + O$	$1.00 \times 10^{-10}$	1
R567	$O_2^- + O \rightarrow O^- + O_2$	$3.30 \times 10^{-10}$	1
R568	$O^+ + N_2 \rightarrow NO^+ + N$	$(1.5-2.0 \times 10^{-3} T_{eFFN} + 9.6 \times 10^{-7} T_{eFFN}^2) \times 10^{-12}$	1
R569	$O^+ + O_2 \rightarrow O_2^+ + O$	$2.00 \times 10^{-11} (300.0/T_{eFFN})^{0.5}$	1
R570	$N_2^+ + O \rightarrow NO^+ + N$	$1.30 \times 10^{-10} (300.0/T_{eFFN2})^{0.5}$	1
R571	$O_2^+ + N_2 \rightarrow NO^+ + NO$	$1.00 \times 10^{-17}$	1
R572	$O_2^+ + N \rightarrow NO^+ + O$	$1.20 \times 10^{-10}$	1
R573	$N_2^+ + N \rightarrow N^+ + N_2$	$7.20 \times 10^{-13} (T_{eFFN2}/300.0)$	1
R574	$N_2^+ + O_2 \rightarrow O_2^+ + N_2$	$6.00 \times 10^{-11} (300.0/T_{eFFN2})^{0.5}$	1
R575	$O_4^{++} + N_2 \rightarrow O_2^+ N_2 + O_2$	$4.60 \times 10^{-12} (T_{eFFN4}/300.0)^{2.5} \exp(-2650.0/T_{eFFN4})$	1
R576	$O_4^{++} + O_2 \rightarrow O_2^+ + O_2 + O_2$	$3.30 \times 10^{-6} (300.0/T_{eFFN4})^4 \exp(-5030.0/T_{eFFN4})$	1
R577	$O_4^{++} + O_2(A1) \rightarrow O_2^+ + O_2 + O_2$	$1.00 \times 10^{-10}$	1

R578	$O_4^++O_2(B1)\rightarrow O_2^++O_2+O_2$	$1.00\times 10^{-10}$	1
R579	$O_4^++NO\rightarrow NO^++O_2+O_2$	$1.00\times 10^{-10}$	1
R580	$N+O_2(v_1)\rightarrow O+NO$	$3.20\times 10^{-12}(T_g/300.0)\exp(-(3150.0-2205.14)/T_g)$	2
R581	$N+O_2(v_2)\rightarrow O+NO$	$3.20\times 10^{-12}(T_g/300.0)\exp(-(3150.0-4410.28)/T_g)$	2
R582	$N+O_2(v_3)\rightarrow O+NO$	$3.20\times 10^{-12}(T_g/300.0)\exp(-(3150.0-6615.42)/T_g)$	2
R583	$N+O_2(v_4)\rightarrow O+NO$	$3.20\times 10^{-12}(T_g/300.0)\exp(-(3150.0-8704.5)/T_g)$	2
R584	$O+N_2(v_1)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-3380)/T_g)$	2
R585	$O+N_2(v_2)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-6850)/T_g)$	2
R586	$O+N_2(v_3)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-10200)/T_g)$	2
R587	$O+N_2(v_4)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-13600)/T_g)$	2
R588	$O+N_2(v_5)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-17100)/T_g)$	2
R589	$O+N_2(v_6)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-20400)/T_g)$	2
R590	$O+N_2(v_7)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-23908)/T_g)$	2
R591	$O+N_2(v_8)\rightarrow N+NO$	$3.00\times 10^{-10}\exp(-(38370.0-27274)/T_g)$	2
R592	$N_2(v_1)+N_2\rightarrow N_2+N_2(v_1)$	$1.09\times 10^{-13}(T_g/300.0)^{1.5}$	3
R593	$O_2(v_1)+O_2\rightarrow O_2+O_2(v_1)$	$2.00\times 10^{-14}(T_g/300.0)^{1.04}$	3
R594	$O_2(v_1)+N_2\rightarrow O_2+N_2(v_1)$	$3.69\times 10^{-12}(T_g/300.0)\exp(-104/T_g^{(1.0/3.0)})$	3
R595	$N_2(v_1)+N_2\rightarrow N_2+N_2$	$7.80\times 10^{-12}T_g\exp(-218.0/T_g^{(1.0/3.0)}+690.0/T_g)/(1.0-\exp(-3365.7/T_g))$	3
R596	$N_2+N_2\rightarrow N_2(v_1)+N_2$	$7.80\times 10^{-12}T_g\exp(-218.0/T_g^{(1.0/3.0)}+690.0/T_g)/(1.0-\exp(-3365.7/T_g))\exp(-3365/T_g)$	3
R597	$N_2(v_1)+N\rightarrow N_2+N$	$4.00\times 10^{-16}(T_g/300.0)^{0.5}$	3
R598	$N_2+N\rightarrow N_2(v_1)+N$	$4.00\times 10^{-16}(T_g/300.0)^{0.5}\exp(-3365/T_g)$	3
R599	$N_2(v_1)+O\rightarrow N_2+O$	$1.20\times 10^{-13}\exp(-27.6/T_g^{(1.0/3.0)})$	3
R600	$N_2+O\rightarrow N_2(v_1)+O$	$1.20\times 10^{-13}\exp(-27.6/T_g^{(1.0/3.0)})\exp(-3365/T_g)$	3
R601	$O_2(v_1)+O_2\rightarrow O_2+O_2$	$1.35\times 10^{-12}T_g\exp(-137.9/T_g^{(1.0/3.0)})/(1.0-\exp(-2205.1/T_g))$	3
R602	$O_2+O_2\rightarrow O_2(v_1)+O_2$	$1.35\times 10^{-12}T_g\exp(-137.9/T_g^{(1.0/3.0)})\exp(-2205/T_g)/(1.0-\exp(2205.1/T_g))$	3
R603	$O_2(v_1)+O\rightarrow O_2+O$	$4.50\times 10^{-15}T_g$	3
R604	$O_2+O\rightarrow O_2(v_1)+O$	$4.50\times 10^{-15}T_g\exp(-2205/T_g)$	3

$dT_{ION}=6.0\times 1.3807\times 10^{-16}\times 1.6605\times 10^{-24}(1.0\times 10^{-17}EN)^2$ , EN is reduced electric field

$$T_{\text{IONN}}=T_{\text{g}}+(dT_{\text{ION}}\times 14.0\times 8.0\times 10^{19})^2$$

$$T_{\text{IONN2}}=T_{\text{g}}+(dT_{\text{ION}}\times 28.0\times 4.1\times 10^{19})^2$$

$$T_{\text{IONN3}}=T_{\text{g}}+(dT_{\text{ION}}\times 42.0\times 6.1\times 10^{19})^2$$

$$T_{\text{IONN4}}=T_{\text{g}}+(dT_{\text{ION}}\times 56.0\times 7.0\times 10^{19})^2$$

$$T_{\text{eFFN}}=(T_{\text{IONN}}+0.5T_{\text{g}})/1.5$$

$$T_{\text{eFFN2}}=(T_{\text{IONN2}}+1.0T_{\text{g}})/2.0$$

$$T_{\text{eFFN3}}=(T_{\text{IONN3}}+1.5T_{\text{g}})/2.5$$

$$T_{\text{eFFN4}}=(T_{\text{IONN4}}+2.0T_{\text{g}})/3.0$$

1.S. Pancheshnyi, B. Eismann, G. Hagelaar, L. C. Pitchford, *Computer code ZDPlasKin*, [www.zdplaskin.laplace.univ-tlse.fr](http://www.zdplaskin.laplace.univ-tlse.fr), 2020.

2.A. Fridman, *Plasma Chemistry*, Cambridge University Press, Cambridge, 2008.

3.M. Capitelli, C. M. Ferreira and B. F. Gordiets, *Plasma kinetics in atmospheric gases*, Springer Series on Atomic, Optical, and Plasma Physics, 2000.