Kinetic Scheme 1/12/2021

Category	Reaction Number	Collision	Rate Coefficient	Reference
e-He	1	$e + He^+ \Rightarrow He$	$2.7 \times 10^{-13}(T_e k_B/e)^{-3/4}$	[1]
	2	$2e + He^+ \Rightarrow He(2^1P) + e$	$1.1 \times 10^{-14}T_e^{-4.5}T_g^{2.3}$	[1]
	3	$2e + He^+ \Rightarrow He(2^3P) + e$	$1.1 \times 10^{-14}T_e^{-4.5}T_g^{2.3}$	[1]
	4	$2e + He^+ \Rightarrow He(2^1S) + e$	$1.1 \times 10^{-14}T_e^{-4.5}T_g^{2.3}$	[1]
	5	$2e + He^+ \Rightarrow He(2^3S) + e$	$1.1 \times 10^{-14}T_e^{-4.5}T_g^{2.3}$	[1]
	6	$e + He \Rightarrow He(2^3S) + e$	BOLSIG+	[2]
	7	$e + He \Rightarrow He(2^1S) + e$	BOLSIG+	[2]
	8	$e + He \Rightarrow He(2^3P) + e$	BOLSIG+	[2]
	9	$e + He \Rightarrow He(2^1P) + e$	BOLSIG+	[2]
	10	$e + He \Rightarrow He(3^3S) + e$	BOLSIG+	[2]
	11	$e + He \Rightarrow He(3^1S) + e$	BOLSIG+	[2]
	12	$e + He \Rightarrow He(3^3P) + e$	BOLSIG+	[2]
	13	$e + He \Rightarrow He(3^3D) + e$	BOLSIG+	[2]
	14	$e + He \Rightarrow He(3^1P) + e$	BOLSIG+	[2]
	15	$e + He \Rightarrow He(3^1D) + e$	BOLSIG+	[2]
	16	$e + He \Rightarrow He(4^3S) + e$	BOLSIG+	[2]
	17	$e + He \Rightarrow He(4^1S) + e$	BOLSIG+	[2]
	18	$e + He \Rightarrow He(4^3P) + e$	BOLSIG+	[2]
	19	$e + He \Rightarrow He(4^1D) + e$	BOLSIG+	[2]
	20	$e + He \Rightarrow He(4^3D) + e$	BOLSIG+	[2]
	21	$e + He \Rightarrow He(4^1F) + e$	BOLSIG+	[2]
	22	$e + He \Rightarrow He(4^3F) + e$	BOLSIG+	[2]
	23	$e + He \Rightarrow He(4^1P) + e$	BOLSIG+	[2]
	24	$e + He \Rightarrow He^+ + 2e$	BOLSIG+	[2]
	25	$e + He(2^1P) \Rightarrow He^+ + 2e$	$1.28 \times 10^{-7}(T_e k_B/e)^{0.6}\exp(-4.78/(T_e k_B/e))$	[1]
	26	$e + He(2^3P) \Rightarrow He^+ + 2e$	$1.28 \times 10^{-7}(T_e k_B/e)^{0.6}\exp(-4.78/(T_e k_B/e))$	[1]
	27	$e + He(2^1S) \Rightarrow He^+ + 2e$	$1.28 \times 10^{-7}(T_e k_B/e)^{0.6}\exp(-4.78/(T_e k_B/e))$	[1]
	28	$e + He(2^3S) \Rightarrow He^+ + 2e$	$1.28 \times 10^{-7}(T_e k_B/e)^{0.6}\exp(-4.78/(T_e k_B/e))$	[1]
	29	$e + He(2^1P) \Rightarrow He(2^3P) + e$	$1.8 \times 10^{-7}(1+0.47(T_e k_B/e))^{-1}$	[1]
	30	$e + He(2^1P) \Rightarrow He(2^1S) + e$	$3.7 \times 10^{-7}(1+0.37(T_e k_B/e))^{-1}$	[1]
	31	$e + He(2^1P) \Rightarrow He(2^3S) + e$	$3.1 \times 10^{-8}(1+0.13(T_e k_B/e)^2)^{-1}$	[1]
	32	$e + He(2^1P) \Rightarrow He + e$	5×10^{-10}	[1]
	33	$e + He(2^3P) \Rightarrow He(2^1S) + e$	$3.1 \times 10^{-8}(1+0.94(T_e k_B/e))^{-1}$	[1]
	34	$e + He(2^3P) \Rightarrow He(2^3S) + e$	$2.2 \times 10^{-7}(T_e k_B/e)^{1/3}$	[1]
	35	$e + He(2^3P) \Rightarrow He + e$	2.4×10^{-10}	[1]
	36	$e + He(2^1S) \Rightarrow He(2^3S) + e$	$3.8 \times 10^{-7}(1+T_e k_B/e)^{-1}$	[1]
	37	$e + He(2^1S) \Rightarrow He + e$	3×10^{-9}	[1]
	38	$e + He(2^3S) \Rightarrow He + e$	$4.1 \times 10^{-9}(1+T_e k_B/e)^{-1}$	[1]
	39	$e + He_2^+ \Rightarrow He(2^1P) + He$	$8.9 \times 10^{-9}(T_g/T_e)^{1.5}$	[1]
	40	$e + He_2^+ \Rightarrow He(2^3P) + He$	$8.9 \times 10^{-9}(T_g/T_e)^{1.5}$	[1]
	41	$e + He_2^+ \Rightarrow He(2^1S) + He$	$8.9 \times 10^{-9}(T_g/T_e)^{1.5}$	[1]
	42	$e + He_2^+ \Rightarrow He(2^3S) + He$	$8.9 \times 10^{-9}(T_g/T_e)^{1.5}$	[1]
	43	$e + He + He_2^+ \Rightarrow He(2^1P) + 2He$	$10^{-26}(T_g/T_e)^2$	[1]
	44	$e + He + He_2^+ \Rightarrow He(2^3P) + 2He$	$10^{-26}(T_g/T_e)^2$	[1]
	45	$e + He + He_2^+ \Rightarrow He(2^3S) + 2He$	$10^{-26}(T_g/T_e)^2$	[1]
e-H	46	$2e + H^+ \Rightarrow H + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
e-H$_2$	47	$e + H_2^+ \Rightarrow 2H$	$1.86 \times 10^{-7}/T_e^{0.43}$	[3]
	48	$2e + H_2^+ \Rightarrow H_2 + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	49	$e + H_2 \Rightarrow 2H + e$	$3.29 \times 10^{-9}(1.5T_e k_B/e)^{0.578}\exp(-7.56/(1.5T_e k_B/e))$	[3]

	50	$e + H_2 \Rightarrow H_2^+ + 2e$	$4 \times 10^{-11}(1.5T_ek_B/e)^{2.13}\exp(-14.9/(1.5T_ek_B/e))$	[3]
e-N	51	$e + N^+ + M \Rightarrow N + M$	$3.12 \times 10^{-23}/T_e^{1.5}$	[3]
	52	$2e + N^+ \Rightarrow N + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	53	$e + N \Rightarrow N^+ + 2e$	$1.45 \times 10^{-11} \times (1.5T_ek_B/e)^{2.58}\exp(-8.54/(1.5T_ek_B/e))$	[3]
e-N$_2$	54	$e + N_2^+ \Rightarrow 2N$	$2.8 \times 10^{-7}(300/T_e)^{0.5}$	[4]
	55	$e + N_2^+ \Rightarrow N_2^+(B^2\Sigma_u^+v0) + e$	$0.8765807 + 2.8182/(1 + (T_ek_B/e/5.78903)^{2.997126}) \times 100 \times (2T_ek_B/me)^{0.5}$	[5]*
	56	$e + N_2^+ + M \Rightarrow N_2 + M$	$3.12 \times 10^{-23}/T_e^{1.5}$	[3]
	57	$2e + N_2^+ \Rightarrow N_2 + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	58	$e + N_2 \Rightarrow N_2^+ + 2e$	BOLSIG+	[2]
	59	$e + N_2 \Rightarrow N_2(B^3\Pi_gv0) + e$	BOLSIG+	[2]
	60	$e + N_2 \Rightarrow N_2(B^3\Pi_gv1) + e$	BOLSIG+	[2]
	61	$e + N_2 \Rightarrow N_2(B^3\Pi_gv2) + e$	BOLSIG+	[2]
	62	$e + N_2 \Rightarrow N_2(B^3\Pi_gv3) + e$	BOLSIG+	[2]
	63	$e + N_2 \Rightarrow N_2(B^3\Pi_gv4) + e$	BOLSIG+	[2]
	64	$e + N_2 \Rightarrow N_2(C^3\Pi_uv0) + e$	BOLSIG+	[2]
	65	$e + N_2 \Rightarrow N_2(C^3\Pi_uv1) + e$	BOLSIG+	[2]
	66	$e + N_2 \Rightarrow N_2(C^3\Pi_uv2) + e$	BOLSIG+	[2]
e-O	67	$e + O \Rightarrow O + e + h\nu(777.4nm)$	$10^7\exp(-75.42 - 1.44(T_ek_B/e)\ln(T_ek_B/e) + 9(T_ek_B/e)^{0.5}\ln(T_ek_B/e)) \times 100 \times (2T_ek_B/m_e)^{0.5}$	[6]
	68	$e + O^+ + M \Rightarrow O + M$	$3.12 \times 10^{-23}/T_e^{1.5}$	[3]
	69	$2e + O^+ \Rightarrow O + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	70	$e + O \Rightarrow O^+ + 2e$	$4.75 \times 10^{-9}(1.5T_ek_B/e)^{0.61}\exp(-22.1/(1.5T_ek_B/e))$	[3]
	71	$e + O + O_2 \Rightarrow O^- + O_2$	10^{-31}	[3]
	72	$e + O + O_2 \Rightarrow O + O_2^-$	10^{-31}	[3]
e-O$_2$	73	$e + O_2^+ \Rightarrow 2O$	$2 \times 10^{-7} \times (300/T_e)$	[4]
	74	$2e + O_2^+ \Rightarrow O_2 + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	75	$e + O_2^+ + M \Rightarrow O_2 + M$	$3.12 \times 10^{-23}/T_e^{1.5}$	[3]
	76	$e + O_2 \Rightarrow O^- + O$	BOLSIG+	[2]
	77	$e + O_2 \Rightarrow O_2^+ + 2e$	BOLSIG+	[2]
	78	$e + 2O_2 \Rightarrow O_2^- + O_2$	$1.4 \times 10^{-29}T_g/T_e\exp(-600/T_g)\exp(700(T_e-T_g)/(T_eT_g))$	[3]
	79	$e + O_2 + N_2 \Rightarrow O_2^- + N_2$	$1.4 \times 10^{-31}(T_g/T_e)^2\exp(-70/T_g)\exp(1500(T_e-T_g)/(T_eT_g))$	[3]
e-O$_3$	80	$e + O_3 \Rightarrow O_2^- + O$	10^{-9}	[4]
	81	$e + O_3 \Rightarrow O^- + O_2$	10^{-11}	[3]
	82	$e + O_3 \Rightarrow O + O_2 + e$	$1.78 \times 10^{-6}(1.5T_ek_B/e)^{-0.614}\exp(-11.5/(1.5T_ek_B/e))$	[3]
	83	$e + O_3 + M \Rightarrow O_3^- + M$	10^{-31}	[3]
e-H$_2$O	84	$e + H_2O^+ \Rightarrow O + 2H$	$1.37 \times 10^{-6}/T_e^{0.5}$	[3]
	85	$e + H_2O^+ \Rightarrow O + H_2$	$1.37 \times 10^{-6}/T_e^{0.5}$	[3]
	86	$e + H_2O^+ \Rightarrow OH + H$	$2.73 \times 10^{-6}/T_e^{0.5}$	[3]
	87	$2e + H_2O^+ \Rightarrow H_2O + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	88	$e + H_2O \Rightarrow H_2O^+ + 2e$	$9.65 \times 10^{-18}(1.5T_ek_B/e)^{2.53}\exp(-8.99/(1.5T_ek_B/e))$	[3]
	89	$e + H_2O \Rightarrow H_2 + O^-$	$2.97 \times 10^{-15}(1.5T_ek_B/e)^{-1.56}\exp(-13.67/(1.5T_ek_B/e))$	[3]
	90	$e + H_2O \Rightarrow OH + H^-$	$4.42 \times 10^{-14}(1.5T_ek_B/e)^{-2.0}\exp(-13.39/(1.5T_ek_B/e))$	[3]
	91	$e + H_2O \Rightarrow OH^+ + H + 2e$	$9.89 \times 10^{-6}(1.5T_ek_B/e)^{-1.64}\exp(-67.6/(1.5T_ek_B/e))$	[3]
	92	$e + H_2O \Rightarrow H^+ + OH + 2e$	$7.45 \times 10^{-9}(1.5T_ek_B/e)^{0.34}\exp(-54.2/(1.5T_ek_B/e))$	[3]
	93	$e + H_2O \Rightarrow O^+ + H_2 + 2e$	$7.4 \times 10^{-10}(1.5T_ek_B/e)^{0.45}\exp(-55.5/(1.5T_ek_B/e))$	[3]
	94	$e + H_2O \Rightarrow H_2^+ + O + 2e$	$8.49 \times 10^{-9}(1.5T_ek_B/e)^{-1.23}\exp(-74/(1.5T_ek_B/e))$	[3]
	95	$e + H_2O \Rightarrow OH + H + e$	$5.15 \times 10^{-9}(1.5T_ek_B/e)^{0.62}\exp(-10.9/(1.5T_ek_B/e))$	[3]
	96	$e + H_2O \Rightarrow OH^- + H$	$9.6 \times 10^{-10}(1.5T_ek_B/e)^{-1.7}\exp(-13.31/(1.5T_ek_B/e))$	[3]
e-OH	97	$e + OH \Rightarrow OH(A^2\Sigma^+v0) + e$	$1.17 \times 10^{-8}T_e^{0.52}\exp(-44642.8/T_e)$	[7]
	98	$2e + OH^+ \Rightarrow OH + e$	$10^{-19}(T_g/T_e)^{4.5}$	[3]

	99	e + NO$^+$ => N + O	$1.07 \times 10^{-5}/T_e^{0.85}$	[3]
e-NO	100	e + NO$^+$ + M => NO + M	$3.12 \times 10^{-23}/T_e^{1.5}$	[3]
	101	2e + NO$^+$ => NO + e	$10^{-19}(T_g/T_e)^{4.5}$	[3]
	102	e + NO + M => NO$^-$ + M	8×10^{-31}	[3]
e-NO$_2$	103	e + NO$_2^+$ => NO + O	$3.46 \times 10^{-6}/T_e^{0.5}$	[3]
	104	e + NO$_2$ + M => NO$_2^-$ + M	1.5×10^{-30}	[3]
	105	e + NO$_2$ => O$^-$ + NO	10^{-11}	[3]
e-N$_2$O	106	e + N$_2$O$^+$ => N$_2$ + O	$3.46 \times 10^{-6}/T_e^{0.5}$	[3]
	107	e + N$_2$O => O$^-$ + N$_2$	2×10^{-10}	[3]
e-HNO$_3$	108	e + HNO$_3$ => NO$_2^-$ + OH	5×10^{-8}	[3]
H$^+$	109	H$^+$ + H$^-$ => 2H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	110	H$^+$ + H$_2$ => H$^+$ + H$_2$	6.4×10^{-10}	[3]
	111	H$^+$ + O => O$^+$ + H	3.8×10^{-10}	[3]
	112	H$^+$ + O$^-$ => O + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	113	H$^+$ + OH$^-$ => OH + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	114	H$^+$ + H$_2$O => H$_2$O$^+$ + H	8.2×10^{-9}	[3]
	115	H$^+$ + NO => NO$^+$ + H	1.9×10^{-9}	[3]
	116	H$^+$ + NO$^-$ => NO + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	117	H$^+$ + O$_2$ => O$_2^+$ + H	1.17×10^{-9}	[3]
	118	H$^+$ + O$_2^-$ => O$_2$ + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	119	H$^+$ + N$_2$O$^-$ => N$_2$O + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	120	H$^+$ + NO$_2^-$ => NO$_2$ + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	121	H$^+$ + O$_3^-$ => O$_3$ + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	122	H$^+$ + NO$_3^-$ => NO$_3$ + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
H	123	H + H$^-$ => H$_2$ + e	1.8×10^{-9}	[3]
	124	H + O$^+$ => H$^+$ + O	6.8×10^{-10}	[3]
	125	H + O + M => OH + M	1.62×10^{-32}	[3]
	126	H + OH + M => H$_2$O + M	$6.1 \times 10^{-26}/T_g^2$	[3]
	127	H + OH$^-$ => H$_2$O + e	1.8×10^{-9}	[3]
	128	H + NO + M => HNO + M	$10^{-32}\exp(300/T_g)$	[3]
	129	H + O$_2$ + M => HO$_2$ + M	$5.4 \times 10^{-32}(T_g/300)^{-1.8}$	[3]
	130	H + O$_2^-$ => HO$_2$ + e	1.4×10^{-9}	[3]
	131	2H + M => H$_2$ + M	$1.8 \times 10^{-30}/T_g$	[3]
	132	H + HNO => NO + H$_2$	$3 \times 10^{-11}\exp(-500/T_g)$	[3]
	133	H + HO$_2$ => H$_2$ + O$_2$	5.6×10^{-12}	[3]
	134	H + HO$_2$ => O + H$_2$O	2.4×10^{-12}	[3]
	135	H + HO$_2$ => 2OH	$4.2 \times 10^{-10}\exp(-950/T_g)$	[3]
	136	H + H$_2$O$_2$ => OH + H$_2$O	$1.69 \times 10^{-11}\exp(-1800/T_g)$	[3]
	137	H + H$_2$O$_2$ => HO$_2$ + H$_2$	$2.8 \times 10^{-12}\exp(-1900/T_g)$	[3]
	138	H + NO$_2$ => OH + NO	1.47×10^{-10}	[3]
	139	H + NO$_2^-$ => OH$^-$ + NO	4×10^{-10}	[3]
	140	H + HNO$_2$ => NO$_2$ + H$_2$	$2 \times 10^{-11}\exp(-3700/T_g)$	[3]
	141	H + O$_3$ => OH + O$_2$	$2.8 \times 10^{-11}(T_g/300)^{0.75}$	[3]
	142	H + O$_3^-$ => OH$^-$ + O$_2$	8.4×10^{-10}	[3]
	143	H + NO$_3$ => OH + NO$_2$	$5.8 \times 10^{-10}\exp(-750/T_g)$	[3]
	144	H + HNO$_3$ => NO$_2$ + H$_2$O	$1.39 \times 10^{-14}(T_g/298)^{3.29}\exp(-3160/T_g)$	[3]
H$^-$	145	H$^-$ + H$_2^+$ => H + H$_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	146	H$^-$ + H$_2^+$ => 3H	10^{-7}	[3]
	147	H$^-$ + N$^+$ => N + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	148	H$^-$ + O$^+$ => O + H	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]

	149	$H^- + OH^+ \Rightarrow H + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	150	$H^- + OH^+ \Rightarrow 2H + O$	10^{-7}	[3]
	151	$H^- + NO^+ \Rightarrow H + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	152	$H^- + NO^+ \Rightarrow H + N + O$	10^{-7}	[3]
	153	$H^- + H_2O \Rightarrow OH^- + H_2$	3.8×10^{-9}	[3]
	154	$H^- + H_2O^+ \Rightarrow H + H_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	155	$H^- + H_2O^+ \Rightarrow 2H + OH$	10^{-7}	[3]
	156	$H^- + N_2^+ \Rightarrow H + N_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	157	$H^- + N_2^+ \Rightarrow H + 2N$	10^{-7}	[3]
	158	$H^- + O_2^+ \Rightarrow H + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	159	$H^- + O_2^+ \Rightarrow H + 2O$	10^{-7}	[3]
	160	$H^- + N_2O^+ \Rightarrow H + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	161	$H^- + N_2O^+ \Rightarrow H + N_2 + O$	10^{-7}	[3]
	162	$H^- + N_2O \Rightarrow OH^- + N_2$	1.1×10^{-9}	[3]
	163	$H^- + NO_2^+ \Rightarrow H + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	164	$H^- + NO_2^+ \Rightarrow H + N + O_2$	10^{-7}	[3]
	165	$H^- + NO_2 \Rightarrow NO_2^- + H$	2.9×10^{-9}	[3]
H_2^+	166	$H_2^+ + O^- \Rightarrow O + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	167	$H_2^+ + O^- \Rightarrow O + 2H$	10^{-7}	[3]
	168	$H_2^+ + OH^- \Rightarrow OH + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	169	$H_2^+ + OH^- \Rightarrow OH + 2H$	10^{-7}	[3]
	170	$H_2^+ + H_2O \Rightarrow H_2O^+ + H_2$	3.86×10^{-9}	[3]
	171	$H_2^+ + NO^- \Rightarrow NO + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	172	$H_2^+ + NO^- \Rightarrow NO + 2H$	10^{-7}	[3]
	173	$H_2^+ + O_2 \Rightarrow O_2^+ + H_2$	7.83×10^{-10}	[3]
	174	$H_2^+ + O_2^- \Rightarrow O_2 + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	175	$H_2^+ + O_2^- \Rightarrow O_2 + 2H$	10^{-7}	[3]
	176	$H_2^+ + N_2O^- \Rightarrow N_2O + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	177	$H_2^+ + N_2O^- \Rightarrow N_2O + 2H$	10^{-7}	[3]
	178	$H_2^+ + NO_2^- \Rightarrow NO_2 + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	179	$H_2^+ + NO_2^- \Rightarrow NO_2 + 2H$	10^{-7}	[3]
	180	$H_2^+ + O_3^- \Rightarrow O_3 + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	181	$H_2^+ + O_3^- \Rightarrow O_3 + 2H$	10^{-7}	[3]
	182	$H_2^+ + NO_3^- \Rightarrow NO_3 + H_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	183	$H_2^+ + NO_3^- \Rightarrow NO_3 + 2H$	10^{-7}	[3]
H_2	184	$H_2 + O^+ \Rightarrow OH^+ + H$	1.7×10^{-9}	[3]
	185	$H_2 + O^- \Rightarrow OH^- + H$	3.3×10^{-11}	[3]
	186	$H_2 + O^- \Rightarrow H_2O + e$	7×10^{-10}	[3]
	187	$H_2 + OH^+ \Rightarrow H_2O^+ + H$	9.7×10^{-10}	[3]
	188	$H_2 + OH \Rightarrow H + H_2O$	$3.2 \times 10^{-11}\exp(-2600/T_g)$	[3]
He	189	$He + He(3^1S) \Rightarrow He_2^+ + e$	3.6×10^{-12}	[1]
	190	$He + He(3^1P) \Rightarrow He_2^+ + e$	1.11×10^{-10}	[1]
	191	$He + He(3^1D) \Rightarrow He_2^+ + e$	7.36×10^{-10}	[1]
	192	$He + He(3^3S) \Rightarrow He_2^+ + e$	3.625×10^{-13}	[1]
	193	$He + He(3^3P) \Rightarrow He_2^+ + e$	5.7263×10^{-11}	[1]
	194	$He + He(3^3D) \Rightarrow He_2^+ + e$	1.62×10^{-10}	[1]
	195	$He + He(4^3S) \Rightarrow He_2^+ + e$	7.6×10^{-10}	[1]
	196	$He + He(4^1S) \Rightarrow He_2^+ + e$	6.8×10^{-10}	[1]
	197	$He + He(4^3P) \Rightarrow He_2^+ + e$	8.7×10^{-10}	[1]
	198	$He + He(4^3D) \Rightarrow He_2^+ + e$	9.75×10^{-10}	[1]

199	He + He(4^1D) => He$_2^+$ + e	1.626 x 10^{-9}	[1]
200	He + He(4^3F) => He$_2^+$ + e	9.1973 x 10^{-10}	[1]
201	He + He(4^1F) => He$_2^+$ + e	9.26 x 10^{-10}	[1]
202	He + He(4^1P) => He$_2^+$ + e	4.7 x 10^{-10}	[1]
203	He + He(3^3D) => He(3^3P) + He	6.7 x 10^{-11}	[1]
204	He + He(3^1P) => He(3^1D) + He	5.8 x 10^{-10}	[1]
205	He + He(4^3P) => He(4^3S) + He	10^{-10}	[1]
206	He + He(4^3D) => He(4^3P) + He	9.3 x 10^{-11}	[1]
207	He + He(4^3D) => He(4^3S) + He	5.8 x 10^{-11}	[1]
208	He + He(4^1D) => He(4^1S) + He	2.2 x 10^{-10}	[1]
209	He + He(4^3F) => He(4^3D) + He	1.8 x 10^{-10}	[1]
210	He + He(4^3F) => He(4^3P) + He	6.6 x 10^{-11}	[1]
211	He + He(4^3F) => He(4^3S) + He	4.1 x 10^{-11}	[1]
212	He + He(4^1F) => He(4^1D) + He	5.9 x 10^{-10}	[1]
213	He + He(4^1F) => He(4^1S) + He	1.6 x 10^{-10}	[1]
214	He + He(4^1P) => He(4^1F) + He	7.6 x 10^{-10}	[1]
215	He + He(4^1P) => He(4^1D) + He	7.4 x 10^{-10}	[1]
216	He + He(4^1P) => He(4^1S) + He	3.6 x 10^{-10}	[1]
217	He + He(3^3P) => He(3^3D) + He	8.1 x 10^{-11}	[1]
218	He + He(3^1D) => He(3^1P) + He	3.3 x 10^{-10}	[1]
219	He + He(4^3S) => He(4^3P) + He	1.7 x 10^{-10}	[1]
220	He + He(4^3P) => He(4^3D) + He	1.4 x 10^{-10}	[1]
221	He + He(4^3S) => He(4^3D) + He	1.5 x 10^{-10}	[1]
222	He + He(4^1S) => He(4^1D) + He	8.2 x 10^{-10}	[1]
223	He + He(4^3D) => He(4^3F) + He	2.5 x 10^{-10}	[1]
224	He + He(4^3P) => He(4^3F) + He	1.3 x 10^{-10}	[1]
225	He + He(4^3S) => He(4^3F) + He	1.5 x 10^{-10}	[1]
226	He + He(4^1D) => He(4^1F) + He	8.3 x 10^{-10}	[1]
227	He + He(4^1S) => He(4^1F) + He	8.3 x 10^{-11}	[1]
228	He + He(4^1F) => He(4^1P) + He	3.2 x 10^{-10}	[1]
229	He + He(4^1D) => He(4^1P) + He	4.3 x 10^{-10}	[1]
230	He + He(4^1S) => He(4^1P) + He	7.8 x 10^{-10}	[1]
231	2He + He(2^1P) => 3He	1.8 x 10^{-31}	[1]
232	2He + He(2^1S) => 3He	1.3 x 10^{-33}	[1]
233	2He + He$^+$ => He$_2^+$ + He	1.4 x $10^{-31}(T_g/300)^{-0.6}$	[1]
234	He + He$_2^+$ => 2He + He$^+$	1.4 x $10^{-6}T_g^{-0.67}\exp(-28100/T_g)$	[1]
235	He(2^3P) => He(2^3S) + hv(1083nm)	1.022 x 10^7	[1]
236	He(2^1P) => He(2^1S) + hv(2058.7nm)	1.976 x 10^6	[1]
237	He(2^1P) => He + hv(58.43nm)	1.799 x 10^9	[1]
238	He(3^1S) => He(2^1P) + hv(728.14nm)	1.81 x 10^7	[1]
239	He(3^1P) => He(2^1S) + hv(501.57nm)	1.338 x 10^7	[1]
240	He(3^1P) => He + hv(53.7nm)	5.66 x 10^8	[1]
241	He(3^1D) => He(2^1P) + hv(667.82nm)	6.38 x 10^7	[1]
242	He(3^3S) => He(2^3P) + hv(706.52nm)	1.54 x 10^7	[1]
243	He(3^3P) => He(2^3S) + hv(388.86nm)	9.478 x 10^6	[1]
244	He(3^3D) => He(2^3P) + hv(587.56nm)	7.06 x 10^7	[1]
245	He(4^1S) => He(2^1P) + hv(504.77nm)	6.55 x 10^6	[1]
246	He(4^1S) => He(3^1P) + hv(211.37nm)	4.59 x 10^6	[1]
247	He(4^1P) => He(2^1S) + hv(396.47nm)	7.17 x 10^6	[1]

	248	He(4^{1}P) => He + hv(52.22nm)	2.46 x 10^8	[1]
	249	He(4^{1}D) => He(2^{1}P) + hv(492.19nm)	2.02 x 10^7	[1]
	250	He(4^{1}D) => He(3^{1}P) + hv(190.89nm)	7.11 x 10^6	[1]
	251	He(4^{1}F) => He(3^{1}D) + hv(186.97nm)	1.38 x 10^7	[1]
	252	He(4^{3}S) => He(2^{3}P) + hv(471.32nm)	5.89 x 10^6	[1]
	253	He(4^{3}S) => He(3^{3}P) + hv(211.25nm)	3.62 x 10^6	[1]
	254	He(4^{3}P) => He(2^{3}S) + hv(318.77nm)	5.05 x 10^6	[1]
	255	He(4^{3}D) => He(2^{3}P) + hv(447.15nm)	2.51 x 10^7	[1]
	256	He(4^{3}D) => He(3^{3}P) + hv(170.02nm)	6.68 x 10^6	[1]
	257	He(4^{3}F) => He(3^{3}D) + hv(186.85nm)	1.55 x 10^6	[1]
N$^+$	258	N$^+$ + O => O$^+$ + N	10^{-12}	[3]
	259	N$^+$ + O + M => NO$^+$ + M	10^{-29}	[3]
	260	N$^+$ + O$^-$ => O + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
	261	N$^+$ + OH => OH$^+$ + N	3.4 x 10^{-10}	[3]
	262	N$^+$ + OH => NO$^+$ + H	3.4 x 10^{-10}	[3]
	263	N$^+$ + N + M => N$_2^+$ + M	10^{-29}	[3]
	264	N$^+$ + H$_2$O => H$_2$O$^+$ + N	1.19 x 10^{-9}	[3]
	265	N$^+$ + H$_2$O => NO$^+$ + H$_2$	2.1 x 10^{-10}	[3]
	266	N$^+$ + NO => NO$^+$ + N	4.72 x 10^{-10}	[3]
	267	N$^+$ + NO => N$_2^+$ + O	8.33 x 10^{-11}	[3]
	268	N$^+$ + NO => O$^+$ + N$_2$	10^{-12}	[3]
	269	N$^+$ + NO$^-$ => NO + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
	270	N$^+$ + O$_2$ => NO$^+$ + O	2.7 x 10^{-10}	[3]
	271	N$^+$ + O$_2$ => O$^+$ + NO	2.8 x 10^{-11}	[3]
	272	N$^+$ + O$_2$ => O$_2^+$ + N	3 x 10^{-10}	[3]
	273	N$^+$ + O$_2^-$ => O$_2$ + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
	274	N$^+$ + O$_3^-$ => O$_3$ + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
	275	N$^+$ + N$_2$O => NO$^+$ + N$_2$	5.5 x 10^{-10}	[3]
	276	N$^+$ + N$_2$O$^-$ => N$_2$O + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
	277	N$^+$ + NO$_2$ => NO$_2^+$ + N	3 x 10^{-10}	[3]
	278	N$^+$ + NO$_2$ => NO$^+$ + NO	5 x 10^{-10}	[3]
	279	N$^+$ + NO$_2^-$ => NO$_2$ + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
	280	N$^+$ + O$_3$ => NO$^+$ + O$_2$	5 x 10^{-10}	[3]
	281	N$^+$ + NO$_3^-$ => NO$_3$ + N	2 x 10^{-7}(300/T$_g$)$^{0.5}$	[3]
N	282	N + O$^+$ + M => NO$^+$ + M	10^{-29}	[3]
	283	N + O + M => NO + M	6.3 x 10^{-33}exp(140/T$_g$)	[3]
	284	N + O$^-$ => NO + e	2.6 x 10^{-10}	[4]
	285	N + OH => H + NO	7.5 x 10^{-11}	[3]
	286	N + H$_2$O$^+$ => NO$^+$ + H$_2$	1.9 x 10^{-10}	[3]
	287	2N + M => N$_2$ + M	8.3 x 10^{-34}exp(500/T$_g$)	[3]
	288	N + N$_2^+$ => N$^+$ + N$_2$	10^{-12}	[3]
	289	N + NO$^+$ + M => N$_2$O$^+$ + M	10^{-29}(300/T$_g$)	[3]
	290	N + NO => N$_2$ + O	2.1 x 10^{-11}exp(100/T$_g$)	[3]
	291	N + O$_2^+$ => NO$^+$ + O	1.5 x 10^{-10}	[3]
	292	N + O$_2$ => NO + O	1.5 x 10^{-11}exp(-3600/T$_g$)	[3]
	293	N + O$_2^-$ => NO$_2$ + e	5 x 10^{-10}	[4]
	294	N + HO$_2$ => NO + OH	1.7 x 10^{-11}exp(-1000/T$_g$)	[3]
	295	N + NO$_2$ => N$_2$O + O	5.8 x 10^{-12}exp(220/T$_g$)	[3]
	296	N + NO$_2$ => N$_2$ + 2O	9.1 x 10^{-13}	[3]
	297	N + NO$_2$ => 2NO	6 x 10^{-13}	[3]

	298	$N + NO_2 \Rightarrow N_2 + O_2$	7×10^{-13}	[3]
	299	$N + NO_2^- \Rightarrow N_2 + O_2 + e$	10^{-12}	[3]
	300	$N + O_3 \Rightarrow NO + O_2$	5×10^{-16}	[3]
	301	$N + NO_3^- \Rightarrow N_2 + O_3 + e$	10^{-12}	[3]
O^+	302	$O^+ + O + M \Rightarrow O_2^+ + M$	10^{-29}	[3]
	303	$O^+ + O^- \Rightarrow 2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[4]
	304	$O^+ + OH \Rightarrow O_2^+ + H$	3.6×10^{-10}	[3]
	305	$O^+ + OH \Rightarrow OH^+ + O$	3.3×10^{-10}	[3]
	306	$O^+ + OH^- \Rightarrow O + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	307	$O^+ + NO \Rightarrow NO^+ + O$	10^{-12}	[3]
	308	$O^+ + NO \Rightarrow O_2^+ + N$	3×10^{-12}	[3]
	309	$O^+ + H_2O \Rightarrow H_2O^+ + O$	3.2×10^{-9}	[3]
	310	$O^+ + N_2 + M \Rightarrow NO^+ + N + M$	$6 \times 10^{-29}(300/T_g)^2$	[3]
	311	$O^+ + NO^- \Rightarrow NO + O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	312	$O^+ + O_2 \Rightarrow O_2^+ + O$	$2.1 \times 10^{-11}(300/T_g)^{0.5}$	[3]
	313	$O^+ + O_2^- \Rightarrow O_2 + O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	314	$O^+ + N_2O \Rightarrow N_2O^+ + O$	6.3×10^{-10}	[3]
	315	$O^+ + N_2O \Rightarrow NO^+ + NO$	2.3×10^{-10}	[3]
	316	$O^+ + N_2O \Rightarrow O_2^+ + N_2$	2×10^{-11}	[3]
	317	$O^+ + N_2O^- \Rightarrow N_2O + O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	318	$O^+ + NO_2 \Rightarrow NO^+ + O_2$	5×10^{-10}	[3]
	319	$O^+ + NO_2 \Rightarrow NO_2^+ + O$	1.6×10^{-9}	[3]
	320	$O^+ + NO_2^- \Rightarrow NO_2 + O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	321	$O^+ + O_3 \Rightarrow O_2^+ + O_2$	10^{-10}	[3]
	322	$O^+ + O_3^- \Rightarrow O_3 + O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	323	$O^+ + NO_3^- \Rightarrow NO_3 + O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
O	324	$O + O^- \Rightarrow O_2 + e$	1.4×10^{-10}	[3]
	325	$O + OH \Rightarrow H + O_2$	$2.2 \times 10^{-11}\exp(-350/T_g)$	[3]
	326	$O + OH^- \Rightarrow HO_2 + e$	2×10^{-10}	[3]
	327	$O + H_2O^+ \Rightarrow O_2^+ + H_2$	5.5×10^{-11}	[3]
	328	$O + N_2^+ \Rightarrow O^+ + N_2$	$1 \times 10^{-11}(300/T_g)^{0.5}$	[3]
	329	$O + N_2^+ \Rightarrow NO^+ + N$	1.4×10^{-10}	[3]
	330	$O + NO + M \Rightarrow NO_2 + M$	$10^{-31}(300/T_g)^{1.6}$	[3]
	331	$O + NO^- \Rightarrow O^- + NO$	3×10^{-10}	[3]
	332	$O + HNO \Rightarrow OH + NO$	5.99×10^{-11}	[3]
	333	$O + O_2 + M \Rightarrow O_3 + M$	$3.4 \times 10^{-34}(T_g/300)^{-1.2}$	[8]
	334	$O + O_2^- \Rightarrow O^- + O_2$	3.3×10^{-10}	[3]
	335	$O + O_2^- \Rightarrow O_3 + e$	1.5×10^{-10}	[3]
	336	$2O + M \Rightarrow O_2 + M$	$3.2 \times 10^{-35}\exp(900/T_g)$	[3]
	337	$O + HO_2 \Rightarrow OH + O_2$	$8.3 \times 10^{-11}\exp(-500/T_g)$	[3]
	338	$O + H_2O_2 \Rightarrow OH + HO_2$	$3.3 \times 10^{-11}\exp(-2950/T_g)$	[3]
	339	$O + NO_2 \Rightarrow NO + O_2$	$6.5 \times 10^{-12}\exp(120/T_g)$	[3]
	340	$O + NO_2 + M \Rightarrow NO_3 + M$	$9 \times 10^{-32}(300/T_g)^2$	[3]
	341	$O + NO_2^- \Rightarrow NO_3 + e$	10^{-12}	[3]
	342	$O + HNO_2 \Rightarrow NO_2 + OH$	$2 \times 10^{-11}\exp(-3000/T_g)$	[3]
	343	$O + O_3 \Rightarrow 2O_2$	$8 \times 10^{-12}\exp(-2060/T_g)$	[3]
	344	$O + O_3^- \Rightarrow 2O_2 + e$	3×10^{-10}	[3]
	345	$O + O_3^- \Rightarrow O_2^- + O_2$	10^{-11}	[3]
	346	$O + NO_3 \Rightarrow O_2 + NO_2$	1.7×10^{-11}	[3]
	347	$O + NO_3^- \Rightarrow NO_2 + O_2 + e$	10^{-12}	[3]

	348	$O^- + OH^+ => 2O + H$	10^{-7}	[3]
	349	$O^- + OH^+ => O + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	350	$O^- + N_2 => N_2O + e$	10^{-12}	[3]
	351	$O^- + NO => NO_2 + e$	2.6×10^{-10}	[3]
	352	$O^- + NO + M => NO_2^- + M$	10^{-29}	[3]
	353	$O^- + N_2^+ => O + N_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	354	$O^- + N_2^+ => O + 2N$	10^{-7}	[3]
	355	$O^- + NO^+ => 2O + N$	10^{-7}	[3]
	356	$O^- + NO^+ => O + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	357	$O^- + O_2^+ => 3O$	10^{-7}	[3]
	358	$O^- + O_2^+ => O + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	359	$O^- + O_2 => O_3 + e$	10^{-12}	[3]
O^-	360	$O^- + O_2 + M => O_3^- + M$	$1.1 \times 10^{-30}(300/T_g)$	[3]
	361	$O^- + H_2O^+ => O + OH + H$	10^{-7}	[3]
	362	$O^- + H_2O^+ => O + H_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	363	$O^- + H_2O => OH^- + OH$	1.4×10^{-9}	[3]
	364	$O^- + N_2^+ => O + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	365	$O^- + N_2O^+ => 2O + N_2$	10^{-7}	[3]
	366	$O^- + N_2O => NO^- + NO$	2×10^{-10}	[3]
	367	$O^- + N_2O => N_2O^- + O$	2×10^{-12}	[3]
	368	$O^- + NO_2^+ => O + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	369	$O^- + NO_2^+ => O + N + O_2$	10^{-7}	[3]
	370	$O^- + NO_2 => NO_2^- + O$	1.2×10^{-9}	[3]
	371	$O^- + O_3 => O_3^- + O$	8×10^{-10}	[3]
	372	$O^- + O_3 => 2O_2 + e$	3×10^{-10}	[3]
	373	$O^- + NO_3 => NO_3^- + O$	3×10^{-10}	[3]
	374	$OH^+ + OH => H_2O^+ + O$	7×10^{-10}	[3]
	375	$OH^+ + OH^- => 2OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	376	$OH^+ + OH^- => OH + O + H$	10^{-7}	[3]
	377	$OH^+ + H_2O => H_2O^+ + OH$	1.59×10^{-9}	[3]
	378	$OH^+ + NO => NO^+ + OH$	5.2×10^{-10}	[3]
	379	$OH^+ + NO^- => NO + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	380	$OH^+ + NO^- => NO + O + H$	10^{-7}	[3]
	381	$OH^+ + O_2 => O_2^+ + OH$	5.9×10^{-10}	[3]
	382	$OH^+ + O_2^- => O_2 + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
OH^+	383	$OH^+ + O_2^- => O_2 + O + H$	10^{-7}	[3]
	384	$OH^+ + N_2O => N_2O^+ + OH$	2.13×10^{-10}	[3]
	385	$OH^+ + N_2O^- => N_2O + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	386	$OH^+ + N_2O^- => N_2O + O + H$	10^{-7}	[3]
	387	$OH^+ + NO_2 => NO^+ + HO_2$	1.3×10^{-9}	[3]
	388	$OH^+ + NO_2^- => NO_2 + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	389	$OH^+ + NO_2^- => NO_2 + O + H$	10^{-7}	[3]
	390	$OH^+ + O_3^- => O_3 + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	391	$OH^+ + O_3^- => O_3 + O + H$	10^{-7}	[3]
	392	$OH^+ + NO_3^- => NO_3 + OH$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	393	$OH^+ + NO_3^- => NO_3 + O + H$	10^{-7}	[3]
	394	$OH(A^2\Sigma^+v0) => OH + hv(308.9nm)$	3.48×10^4	[9]
OH	395	$2OH => O + H_2O$	$8.8 \times 10^{-12}\exp(-503/T_g)$	[3]
	396	$2OH + M => H_2O_2 + M$	$6.9 \times 10^{-31}(T_g/300)^{-0.8}$	[3]
	397	$OH + NO + M => HNO_2 + M$	$7.4 \times 10^{-31}(300/T_g)^{2.4}$	[3]

	398	OH + HNO => NO + H$_2$O	8×10^{-11}exp(-500/T$_g$)	[3]
	399	OH + HO$_2$ => O$_2$ + H$_2$O	4.8×10^{-11}exp(250/T$_g$)	[3]
	400	OH + H$_2$O$_2$ => HO$_2$ + H$_2$O	2.9×10^{-12}exp(-160/T$_g$)	[3]
	401	OH + NO$_2$ + M => HNO3 + M	2.2×10^{-30}(300/T$_g$)$^{2.9}$	[3]
	402	OH + HNO$_2$ => NO$_2$ + H$_2$O	1.8×10^{-11}exp(-390/T$_g$)	[3]
	403	OH + O$_3$ => HO$_2$ + O$_2$	1.6×10^{-12}exp(-1000/T$_g$)	[3]
	404	OH + NO$_3$ => HO$_2$ + NO$_2$	2×10^{-11}	[3]
	405	OH + HNO$_3$ => NO$_3$ + H$_2$O	1.5×10^{-14}exp(650/T$_g$)	[3]
OH$^-$	406	OH$^-$ + N$^+$ => N + OH	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	407	OH$^-$ + H$_2$O$^+$ => OH + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	408	OH$^-$ + H$_2$O$^+$ => 2OH + H	10^{-7}	[3]
	409	OH$^-$ + N$_2^+$ => OH + N$_2$	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	410	OH$^-$ + N$_2^+$ => OH + 2N	10^{-7}	[3]
	411	OH$^-$ + NO$^+$ => OH + NO	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	412	OH$^-$ + NO$^+$ => OH + N + O	10^{-7}	[3]
	413	OH$^-$ + O$_2^+$ => OH + O$_2$	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	414	OH$^-$ + O$_2^+$ => OH + 2O	10^{-7}	[3]
	415	OH$^-$ + N$_2$O$^+$ => OH + N$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	416	OH$^-$ + N$_2$O$^+$ => OH + N$_2$ + O	10^{-7}	[3]
	417	OH$^-$ + NO$_2^+$ => OH + NO$_2$	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	418	OH$^-$ + NO$_2^+$ => OH + N + O$_2$	10^{-7}	[3]
	419	OH$^-$ + NO$_2$ => NO$_2^-$ + OH	1.9×10^{-9}	[3]
	420	OH$^-$ + O$_3$ => O$_3^-$ + OH	9×10^{-10}	[3]
H$_2$O$^+$	421	H$_2$O$^+$ + O$_2$ => O$_2^+$ + H$_2$O	4.3×10^{-10}	[3]
	422	H$_2$O$^+$ + O$_2^-$ => O$_2$ + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	423	H$_2$O$^+$ + O$_2^-$ => O$_2$ + OH + H	10^{-7}	[3]
	424	H$_2$O$^+$ + NO => NO$^+$ + H$_2$O	4.6×10^{-10}	[3]
	425	H$_2$O$^+$ + NO$^-$ => NO + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	426	H$_2$O$^+$ + NO$^-$ => NO + OH + H	10^{-7}	[3]
	427	H$_2$O$^+$ + N$_2$O$^-$ => N$_2$O + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	428	H$_2$O$^+$ + N$_2$O$^-$ => N$_2$O + OH + H	10^{-7}	[3]
	429	H$_2$O$^+$ + NO$_2$ => NO$_2^+$ + H$_2$O	1.2×10^{-9}	[3]
	430	H$_2$O$^+$ + NO$_2^-$ => NO$_2$ + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	431	H$_2$O$^+$ + NO$_2^-$ => NO$_2$ + OH + H	10^{-7}	[3]
	432	H$_2$O$^+$ + O$_3^-$ => O$_3$ + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	433	H$_2$O$^+$ + O$_3^-$ => O$_3$ + OH + H	10^{-7}	[3]
	434	H$_2$O$^+$ + NO$_3^-$ => NO$_3$ + H$_2$O	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	435	H$_2$O$^+$ + NO$_3^-$ => NO$_3$ + OH + H	10^{-7}	[3]
H$_2$O	436	H$_2$O + N$_2^+$ => H$_2$O$^+$ + N$_2$	2.3×10^{-9}	[3]
N$_2^+$	437	N$_2^+$ + NO => NO$^+$ + N$_2$	3.9×10^{-10}	[3]
	438	N$_2^+$ + NO$^-$ => NO + N$_2$	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	439	N$_2^+$ + NO$^-$ => NO + 2N	10^{-7}	[3]
	440	N$_2^+$ + O$_2$ => O$_2^+$ + N$_2$	5×10^{-11}	[3]
	441	N$_2^+$ + O$_2^-$ => O$_2$ + N$_2$	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	442	N$_2^+$ + O$_2^-$ => O$_2$ + 2N	10^{-7}	[3]
	443	N$_2^+$ + N$_2$O => N$_2$O$^+$ + N$_2$	6×10^{-10}	[3]
	444	N$_2^+$ + N$_2$O => NO$^+$ + N + N$_2$	4×10^{-10}	[3]
	445	N$_2^+$ + N$_2$O$^-$ => N$_2$O + N$_2$	2×10^{-7}(300/T$_g$)$^{0.5}$	[3]
	446	N$_2^+$ + N$_2$O$^-$ => N$_2$O + 2N	10^{-7}	[3]
	447	N$_2^+$ + NO$_2$ => NO$^+$ + N$_2$O	5×10^{-11}	[3]

	448	$N_2^+ + NO_2 \Rightarrow NO_2^+ + N_2$	3×10^{-10}	[3]
	449	$N_2^+ + NO_2^- \Rightarrow NO_2 + N_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	450	$N_2^+ + NO_2^- \Rightarrow NO_2 + 2N$	10^{-7}	[3]
	451	$N_2^+ + O_3^- \Rightarrow O_3 + N_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	452	$N_2^+ + O_3^- \Rightarrow O_3 + 2N$	10^{-7}	[3]
	453	$N_2^+ + O_3 \Rightarrow O_2^+ + O + N_2$	10^{-10}	[3]
	454	$N_2^+ + NO_3^- \Rightarrow NO_3 + N_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	455	$N_2^+ + NO_3^- \Rightarrow NO_3 + 2N$	10^{-7}	[3]
N_2	456	$N_2^+(B^2\Sigma_u^+v0) \Rightarrow N_2^+ + h\nu(391.44nm)$	6.53×10^8	[11]
	457	$N_2^+(B^2\Sigma_u^+v0) \Rightarrow N_2^+(X^2\Sigma_g^+v1) + h\nu(427.81nm)$	6.34×10^8	[11]
	458	$N_2 + O_2^+ \Rightarrow NO^+ + NO$	10^{-17}	[3]
	459	$N_2 + O_2^- \Rightarrow N_2 + O_2 + e$	$1.9 \times 10^{-12}(T_g/300)^{0.5}exp(-4990/T_g)$	[3]
	460	$N_2^+(B^2\Sigma_u^+v0) + N_2 \Rightarrow N_2^+ + N_2$	4.2×10^{-9}	[12]
	461	$N_2(C^3\Pi_uv0) \Rightarrow N_2(B^3\Pi_gv0) + h\nu(337.13nm)$	12.1×10^6	[13]
	462	$N_2(C^3\Pi_uv0) \Rightarrow N_2(B^3\Pi_gv1) + h\nu(357.69nm)$	8.6×10^6	[13]
	463	$N_2(C^3\Pi_uv0) \Rightarrow N_2(B^3\Pi_gv2) + h\nu(380.49nm)$	3×10^6	[13]
	464	$N_2(C^3\Pi_uv0) \Rightarrow N_2(B^3\Pi_gv3) + h\nu(405.94nm)$	10^6	[13]
	465	$N_2(C^3\Pi_uv1) \Rightarrow N_2(B^3\Pi_gv0) + h\nu(315.93nm)$	11×10^6	[13]
	466	$N_2(C^3\Pi_uv1) \Rightarrow N_2(B^3\Pi_gv2) + h\nu(353.67nm)$	5.2×10^6	[13]
	467	$N_2(C^3\Pi_uv1) \Rightarrow N_2(B^3\Pi_gv3) + h\nu(375.54nm)$	4.6×10^6	[13]
	468	$N_2(C^3\Pi_uv1) \Rightarrow N_2(B^3\Pi_gv4) + h\nu(399.85nm)$	2.4×10^6	[13]
	469	$N_2(C^3\Pi_uv2) \Rightarrow N_2(B^3\Pi_gv4) + h\nu(371.05nm)$	3.12×10^6	[13]
NO^+	470	$NO^+ + NO^- \Rightarrow 2NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	471	$NO^+ + NO^- \Rightarrow NO + N + O$	10^{-7}	[3]
	472	$NO^+ + O_2^- \Rightarrow O_2 + N + O$	10^{-7}	[3]
	473	$NO^+ + O_2^- \Rightarrow O_2 + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	474	$NO^+ + N_2O^- \Rightarrow N_2O + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	475	$NO^+ + N_2O^- \Rightarrow N_2O + N + O$	10^{-7}	[3]
	476	$NO^+ + NO_2^- \Rightarrow NO_2 + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	477	$NO^+ + NO_2^- \Rightarrow NO_2 + N + O$	10^{-7}	[3]
	478	$NO^+ + O_3 \Rightarrow NO_2^+ + O_2$	10^{-15}	[3]
	479	$NO^+ + O_3^- \Rightarrow O_3 + N + O$	10^{-7}	[3]
	480	$NO^+ + O_3^- \Rightarrow O_3 + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	481	$NO^+ + NO_3^- \Rightarrow NO_3 + NO$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	482	$NO^+ + NO_3^- \Rightarrow NO_3 + N + O$	10^{-7}	[3]
	483	$NO^+ + N_2O_5 \Rightarrow NO_2^+ + 2NO_2$	5.9×10^{-10}	[3]
NO	484	$NO + NO^- \Rightarrow 2NO + e$	5×10^{-12}	[3]
	485	$NO + O_2^+ \Rightarrow NO^+ + O_2$	4.6×10^{-10}	[3]
	486	$NO + HO_2 \Rightarrow OH + NO_2$	$3.4 \times 10^{-12}exp(270/T_g)$	[3]
	487	$NO + HO_2 \Rightarrow O_2 + HNO$	$3.3 \times 10^{-13}exp(-1000/T_g)$	[3]
	488	$NO + N_2O^+ \Rightarrow NO^+ + N_2O$	2.3×10^{-10}	[3]
	489	$NO + NO_2^+ \Rightarrow NO^+ + NO_2$	2.75×10^{-10}	[3]
	490	$NO + NO_2^- \Rightarrow NO^- + NO_2$	2.75×10^{-10}	[3]
	491	$NO + O_3 \Rightarrow NO_2 + O_2$	$1.8 \times 10^{-12}exp(-1370/T_g)$	[3]
	492	$NO + O_3 \Rightarrow NO_2^- + O_2$	10^{-11}	[3]
	493	$NO + O_3^- \Rightarrow NO_3^- + O$	10^{-11}	[3]
	494	$NO + NO_3 \Rightarrow 2NO_2$	$1.8 \times 10^{-11}exp(110/T_g)$	[3]
	495	$NO + NO_3^- \Rightarrow NO_2^- + NO_2$	3×10^{-15}	[3]
NO^-	496	$NO^- + H_2 \Rightarrow NO + H_2 + e$	2.3×10^{-13}	[3]

	497	$NO^- + M \Rightarrow NO + M + e$	2.4×10^{-13}	[3]
	498	$NO^- + O_2^+ \Rightarrow NO + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	499	$NO^- + O_2^+ \Rightarrow NO + 2O$	10^{-7}	[3]
	500	$NO^- + O_2 \Rightarrow O_2^- + NO$	5×10^{-10}	[3]
	501	$NO^- + NO_2^+ \Rightarrow NO + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	502	$NO^- + NO_2^+ \Rightarrow NO + N + O_2$	10^{-7}	[3]
	503	$NO^- + O_3 \Rightarrow O_3^- + NO$	3×10^{-10}	[3]
	504	$NO^- + N_2O^+ \Rightarrow NO + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	505	$NO^- + N_2O^+ \Rightarrow NO + N_2 + O$	10^{-7}	[3]
	506	$NO^- + N_2O \Rightarrow NO + N_2O + e$	5.1×10^{-12}	[3]
	507	$NO^- + N_2O \Rightarrow NO_2^- + N_2$	2.8×10^{-14}	[3]
	508	$NO^- + NO_2 \Rightarrow NO_2^- + NO$	3×10^{-10}	[3]
	509	$NO^- + NO_3 \Rightarrow NO_3^- + NO$	3×10^{-10}	[3]
O_2^+	510	$O_2^+ + O_2^- \Rightarrow 2O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[4]
	511	$O_2^+ + O_2^- \Rightarrow O_2 + 2O$	10^{-7}	[3]
	512	$O_2^+ + N_2O^- \Rightarrow N_2O + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	513	$O_2^+ + N_2O^- \Rightarrow N_2O + 2O$	10^{-7}	[3]
	514	$O_2^+ + NO_2 \Rightarrow NO_2^+ + O_2$	6.6×10^{-10}	[3]
	515	$O_2^+ + NO_2 \Rightarrow NO^+ + O_3$	10^{-11}	[3]
	516	$O_2^+ + NO_2^- \Rightarrow NO_2 + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	517	$O_2^+ + NO_2^- \Rightarrow NO_2 + 2O$	10^{-7}	[3]
	518	$O_2^+ + O_3^- \Rightarrow O_3 + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	519	$O_2^+ + O_3^- \Rightarrow O_3 + 2O$	10^{-7}	[3]
	520	$O_2^+ + NO_3^- \Rightarrow NO_3 + O_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	521	$O_2^+ + NO_3^- \Rightarrow NO_3 + 2O$	10^{-7}	[3]
	522	$O_2^+ + N_2O_5 \Rightarrow NO_2^+ + NO_3 + O_2$	8.8×10^{-10}	[3]
O_2	523	$O_2 + O_2^- \Rightarrow 2O_2 + e$	$2.7 \times 10^{-10}(T_g/300)^{0.5}exp(-5590/T_g)$	[3]
	524	$O_2 + N_2O^+ \Rightarrow NO^+ + NO_2$	4.59×10^{-11}	[3]
	525	$O_2 + N_2O^+ \Rightarrow O_2^+ + N_2O$	2.24×10^{-10}	[3]
	526	$O_2 + HNO \Rightarrow NO + HO_2$	$5.25 \times 10^{-12}exp(-1510/T_g)$	[3]
	527	$O_2 + HNO \Rightarrow NO_2 + OH$	1.66×10^{-15}	[3]
	528	$O_2 + O_3^- \Rightarrow O_3 + O_2 + e$	2.3×10^{-11}	[3]
HNO	529	$2HNO \Rightarrow N_2O + H_2O$	$1.4 \times 10^{-15}exp(-1600/T_g)$	[3]
O_2^-	530	$O_2^- + O_3 \Rightarrow O_3 + O_2 + e$	6×10^{-10}	[3]
	531	$O_2^- + O_3 \Rightarrow O_3^- + O_2$	3.5×10^{-10}	[3]
	532	$O_2^- + N_2O^+ \Rightarrow O_2 + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	533	$O_2^- + N_2O^+ \Rightarrow O_2 + N_2 + O$	10^{-7}	[3]
	534	$O_2^- + N_2O \Rightarrow O_3^- + N_2$	10^{-11}	[3]
	535	$O_2^- + NO_2^+ \Rightarrow O_2 + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	536	$O_2^- + NO_2^+ \Rightarrow O_2 + N + O_2$	10^{-7}	[3]
	537	$O_2^- + NO_2 \Rightarrow NO_2^- + O_2$	7×10^{-10}	[3]
	538	$O_2^- + NO_3 \Rightarrow NO_3^- + O_2$	5×10^{-10}	[3]
	539	$O_2^- + HNO_3 \Rightarrow NO_3^- + HO_2$	2.8×10^{-10}	[3]
M	540	$M + O_3 \Rightarrow O + O_2 + M$	$3.92 \times 10^{-10}exp(-11400/T_g)$	[3]
HO_2	541	$2HO_2 \Rightarrow H_2O_2 + O_2$	$2.2 \times 10^{-13}exp(600/T_g)$	[3]
	542	$HO_2 + O_3 \Rightarrow OH + 2O_2$	$1.4 \times 10^{-14}exp(-600/T_g)$	[3]
	543	$HO_2 + NO_3 \Rightarrow NO_2 + OH + O_2$	4.8×10^{-12}	[3]
	544	$HO_2 + NO_3 \Rightarrow HNO_3 + O_2$	9.2×10^{-13}	[3]
N_2O^+	545	$N_2O^+ + N_2O \Rightarrow NO^+ + NO + N_2$	1.2×10^{-11}	[3]
	546	$N_2O^+ + N_2O^- \Rightarrow 2N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]

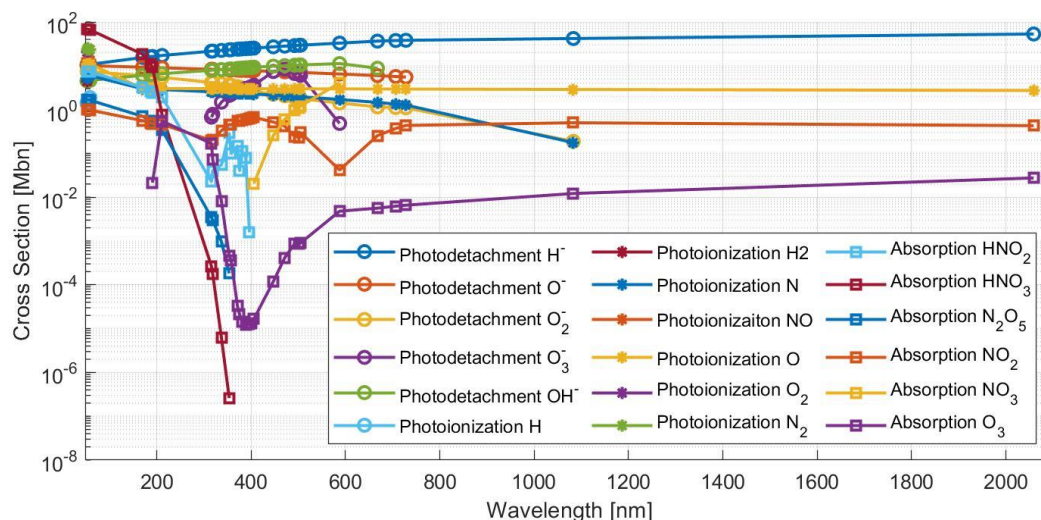|	547	$N_2O^+ + N_2O^- \Rightarrow N_2O + N_2 + O$	10^{-7}	[3]
	548	$N_2O^+ + NO_2 \Rightarrow NO^+ + N_2 + O_2$	4.29×10^{-10}	[3]
	549	$N_2O^+ + NO_2 \Rightarrow NO_2^+ + N_2O$	2.21×10^{-10}	[3]
	550	$N_2O^+ + NO_2^- \Rightarrow NO_2 + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	551	$N_2O^+ + NO_2^- \Rightarrow NO_2 + N_2 + O$	10^{-7}	[3]
	552	$N_2O^+ + O_3^- \Rightarrow O_3 + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	553	$N_2O^+ + O_3^- \Rightarrow O_3 + N_2 + O$	10^{-7}	[3]
	554	$N_2O^+ + NO_3^- \Rightarrow NO_3 + N_2O$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	555	$N_2O^+ + NO_3^- \Rightarrow NO_3 + N_2 + O$	10^{-7}	[3]
N_2O	556	$N_2O + NO_2^- \Rightarrow NO_3^- + N_2$	5×10^{-13}	[3]
N_2O^-	557	$N_2O^- + NO_2^+ \Rightarrow N_2O + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	558	$N_2O^- + NO_2^+ \Rightarrow N_2O + N + O_2$	10^{-7}	[3]
NO_2^+	559	$NO_2^+ + NO_2^- \Rightarrow 2NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	560	$NO_2^+ + NO_2^- \Rightarrow NO_2 + N + O_2$	10^{-7}	[3]
	561	$NO_2^+ + O_3^- \Rightarrow O_3 + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	562	$NO_2^+ + O_3^- \Rightarrow O_3 + N + O_2$	10^{-7}	[3]
	563	$NO_2^+ + NO_3^- \Rightarrow NO_3 + NO_2$	$2 \times 10^{-7}(300/T_g)^{0.5}$	[3]
	564	$NO_2^+ + NO_3^- \Rightarrow NO_3 + N + O_2$	10^{-7}	[3]
NO_2	565	$NO_2 + NO_2 \Rightarrow NO_3 + NO$	4×10^{-12}	[3]
	566	$NO_2 + O_3 \Rightarrow NO_3 + O_2$	$1.4 \times 10^{-13}\exp(-2470/T_g)$	[3]
	567	$NO_2 + O_3^- \Rightarrow NO_2^- + O_3$	7×10^{-11}	[3]
	568	$NO_2 + O_3^- \Rightarrow NO_3^- + O_2$	2×10^{-11}	[3]
	569	$NO_2 + NO_3 \Rightarrow NO_2 + NO + O_2$	$2.3 \times 10^{-13}\exp(-1600/T_g)$	[3]
NO_2^-	570	$NO_2^- + O_3 \Rightarrow NO_3^- + O_2$	1.8×10^{-11}	[3]
	571	$NO_2^- + NO_3 \Rightarrow NO_3^- + NO_2$	5×10^{-10}	[3]
	572	$NO_2^- + HNO_3 \Rightarrow NO_3^- + HNO_2$	1.6×10^{-9}	[3]
	573	$NO_2^- + N_2O_5 \Rightarrow NO_3^- + NO_3 + NO$	7×10^{-10}	[3]
O_3	574	$O_3 + O_3^- \Rightarrow 3O_2 + e$	3×10^{-10}	[3]
O_3^-	575	$O_3^- + NO_3 \Rightarrow NO_3^- + O_3$	5×10^{-10}	[3]
HNO_2	576	$2HNO_2 \Rightarrow NO + NO_2 + H_2O$	10^{-20}	[3]
	577	$HNO_2 + HNO_3 \Rightarrow 2NO_2 + H_2O$	1.6×10^{-17}	[3]
NO_3	578	$2NO_3 \Rightarrow 2NO_2 + O_2$	$5 \times 10^{-12}\exp(-3000/T_g)$	[3]
Expansion	579-905	RONS Absorptions of Photons List	See Figure	See Figure

T_g and T_e are both in [K].
The rate coefficients of photon emissions are in [s^{-1}].
The rate coefficients of two-body collisions are in [cm^3/s], and the ones of three-body collisions are in [cm^6/s].
The species M represents He, N_2, and O_2 which plays the major part of the mixture.
* For $T_e < 3.3$ eV, the value is 0.

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