Supporting Information

Flowing atmospheric pressure afterglow for ambient ionization: Reaction pathways revealed by modeling

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a. Input parameters in the model

The geometrical and operating conditions which are used in the kinetic model and fluid dynamics model are presented in Table S1.

Table S1 Geometrical and operating conditions

Discharge	Calculation area (length x width)	50 mm x 12 mm
	Distance from cathode to anode	7.5 mm
	Anode orifice diameter	1.6 mm
	Gas Temperature	750 K
	Initial He flow rate	1.5 L/min
	DC power	11.25 W (450 V, 25 mA)
	Air impurity	N_2 = 7 ppm O_2 = 2 ppm H_2O = 1 ppm
Afterglow	Calculation area (length x width)	12 mm x 60 mm
	Distance from anode to sampler	12 mm
	Sampler orifice diameter	1 mm
	Gas Temperature	500 K
	Relative humidity	50%

b. Description of the 2D fluid dynamics model

We developed a simplified 2D fluid dynamics model by means of COMSOL CFD software to describe the gas flow dynamics. A schematic illustration of the FAPA source, considered in the 2D model, is presented in Figure 1 in the main paper. The gas

flow dynamics are calculated assuming laminar flow conditions, by solving conservation equations for mass and momentum (i.e., Navier-Stokes equation) for the gas flow for the given geometry, flux and boundary condition. Only the neutral background gas molecules, i.e, He in the discharge region and He and humid air for the afterglow region are considered, and the electric field in the plasma is assumed to have no influence on the flow field calculation. Note that we assume a laminar flow to simplify the solution process and to be able to apply the benefits of a quasi-1D kinetic model, i.e., reasonable calculation time. One can improve this model by considering turbulence in the flow, which would require a 2D kinetic model and therefore a much higher computational cost. FAPA source consists of a pin and a disk electrode placed 7.5 mm apart in a cylindrically symmetric discharge cell. There is a small (1.6 mm in diameter) orifice in the center of the disk electrode (anode), through which the helium gas can flow out from the discharge cell. The afterglow region has a length of 1.5 cm which ends by the interface to the mass spectrometer, so-called sampler. In this region the humid air mixes with the helium stream exiting from the discharge region. The sampler has an orifice of 1 mm in diameter.
The calculations are made for a two-dimensional axisymmetric geometry. For conservation of momentum, the Navier-Stokes equation has the following general form:

$$\rho\left(\frac{\partial v}{\partial t} + (\vec{v}.\nabla)\vec{v}\right) = -\nabla p + \nabla.\vec{\tau} + F \tag{1}$$

where ρ is the mass density (in $\mathrm{kg\,m^{-3}}$), v is the velocity (in $\mathrm{m\,s^{-1}}$), p is the pressure , $\vec{\tau}$ is the stress tensor and F is the body force (all in $\mathrm{N\,m^{-3}}$). The left hand side of the equation describes acceleration, and is composed of time dependent and convective effects. The right hand side of the equation denotes the divergence of stress (i.e., pressure and shear stress, first and second terms respectively) and the summation of body forces (third term). Here ∇p is called the pressure gradient and originates mainly from the difference between inlet and outlet pressures and partially from the electron distribution. $\nabla \cdot \overline{\tau}$ conventionally describes viscous forces and for incompressible flow, this is only a shear effect. As the FAPA source has only one inlet for the gas flow (in contrast for instance to ICP torches with three different inlets), and since for the 0D kinetic model, we could only use the velocity profile on the central axis, in one dimension, this term is not taken into account in this study. We also assumed that the electric field have no influence on the flow field calculation. Therefore, the term F which can be represented by the external electric force is also neglected.

The equation for conservation of mass (also called continuity equation for mass-flow) can be written as follows:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{v}) = S_{mass} \tag{2}$$

which reduces for steady flow conditions to:

$$\nabla \cdot (\rho \vec{v}) = S_{mass} \tag{3}$$

The source S_{mass} is the mass added to the continuous phase (gas) from a second dispersed phase (e.g., due to vaporization of liquid droplets). In the current study it is set to zero as the flow only has a continuous gas phase.

c. Description of the 0D plasma chemical kinetics model

The Zero-Dimensional Plasma Kinetics (ZDPlasKin) solver [1,2] is a model to describe the plasma chemistry by solving the conservation equations for all individual species. The number density (in $\mathrm{m^{-3}}$) of every species changes when different plasma reactions occur, leading to species production (formation term) and consumption (loss term). The evolution of the species densities over time is calculated by solving Equation (4) for every species, in which n_x is the density of species x (in $\mathrm{m^{-3}}$), j is the total number of reactions in which that particular species is produced or consumed, $a^L_{x,i}$ and $a^R_{x,i}$ are the stoichiometric coefficients at the left hand side and right hand side of a particular reaction equation, corresponding to formation and loss term, respectively. R_i is the rate of that reaction (in $\mathrm{m^{-3}s^{-1}}$) and is calculated from the reaction rate constant (k_i) multiplied with the densities of the reacting species j, using Equation (5).

$$\frac{\partial n_x}{\partial t} = \sum_{i=1}^{j}[(a^R_{x,i} - a^L_{x,i})R_i] \tag{4}$$

$$R_i = k_i \prod_s n_s^{a_{s,i}} \tag{5}$$

The reaction rate constant (k_i) in $cm^3\ s^{-1}$ or $cm^6\ s^{-1}$ for two-body or three-body reactions, respectively, is given in a different form depending on the type of reaction. For reactions between heavy particles (neutrals, ions, radicals), the rate constant is either a constant value or a function of the gas temperature, taken from literature[3-5] and references therein. The rate constants for electron impact reactions, on the other hand, depend on the electron temperature T_e (or the reduced electric field E/N, i.e., the electric field E divided by the number density of all neutral species N, usually expressed in $\mathrm{Td} = 10^{-21} \frac{\mathrm{V}}{\mathrm{m}^2}$), and they are calculated using the Boltzmann solver, BOLSIG+, built into ZDPlasKin.[2] This Boltzmann subroutine in the code calculates the Boltzmann equation for the electrons in a fixed reduced electric field and provides the rate coefficients of the electron impact reactions from the corresponding energy-dependent cross sections and the electron energy distribution function, using Equation (6).

$$k_i = \int_{\varepsilon_{th}}^{\infty} \sigma_i(\varepsilon) v(\varepsilon) f(\varepsilon) d\varepsilon \quad (6)$$

ε is the electron energy (e.g., in J), ε_{th} is the minimum threshold energy needed to induce the reaction, $v(\varepsilon)$ the velocity of the electrons (in $\mathrm{m\,s^{-1}}$), $\sigma_i(\varepsilon)$ is the collision cross section of collision i (in m^2), and $f(\varepsilon)$ is the electron energy distribution function. The collision cross sections were taken from an online database[6] and literature[3-5,7,8] and references therein. The electron velocity is calculated with Equation (7), in which m_e is the electron mass (9.10938×10^{-31} kg).

$$v(\varepsilon) = \sqrt{\frac{2\varepsilon}{m_e}} \quad (7)$$

The plasma power obtained from typical FAPA sources (corresponding to 450 V and 25 mA) is used as input for the 0D model to calculate the electric field (E) (in $\mathrm{V\,m^{-1}}$) with Equation (8):

$$E = \sqrt{\frac{P}{\sigma}} \quad (8)$$

P is the input power density (in $\mathrm{W\,m^{-3}}$) and σ is the plasma conductivity (in $\mathrm{A\,V^{-1}\,m^{-1}}$). The plasma conductivity is calculated using Equation (9), with e the elementary charge ($1.60217662 \times 10^{-19}\ C$), n_e the electron density (in $\mathrm{m^{-3}}$), and μ_e the electron mobility (in $\mathrm{m^2\,V^{-1}\,s^{-1}}$).

$$\sigma = e\, n_e\, \mu_e \quad (9)$$

d. Chemistry set used in the 0D kinetic model

Table S2 Plasma species included in the model

Neutral species	Ions/Electrons	Radicals	Excited species
	electrons		
He	He^+, He^+_2, HeH^+		He^*, He_2^*
N_2	N^+, N^+_2, N^+_3, N_4^+	N	$N_2(R)$, $N_2(V_{1-4})$, $N_2(A)^a$ $N_2(A')^a$, $N(^2P)$, $N(^2D)$
O_2, O_3	O^+, O^+_2, O^+_4, O^-, O^-_2, O^-_3	O	$O_2(^1D)$, $O_2(^1S)$, $O_2(R)$, $O_2(V_{1-5})$, $O(^1D)$, $O(^1S)$
N_2O, N_2O_3, N_2O_4, N_2O_5	NO^+, NO_2^+, NO_2^-, N_2O^- NO_3^-	NO, NO_2, NO_3	

H_2 , H_2O , H_2O_2	H^+ , H_2^+ , H_3^+ , OH^+, H_2O^+ , H_3O^+ , H^- , OH^- Heavy cluster ions: $O_2H_2O^-$, $O_2H_2O^+$ $(H_2O)_2^+$, $(H_2O)_2H^+$ $(H_2O)_3H^+$, $(H_2O)_4H^+$ $(H_2O)_5H^+$, $(H_2O)_6H^+$ $(H_2O)_7H^+$ $NO_3H_2O^-$, $NO_2H_2O^-$	H , HO_2 , OH	$H_2(V_1)$, $H_2(R_{02})$ $H_2(b)$, $H_2(c)$, $H_2(R_{13})$ $H(E_2)$, $H(E_3)$, OH(A)
HNO, HNO_2 , HNO_3 , HNO_4		NH	

Table S3 List of reactions included in the model

	Reaction	Reaction rate coefficient[a]	ref
	Electron impact reactions with He		
1	e + He → He^* + e	σ (ε)[b]	[6-8]
2	e + He → He^+ + e + e	σ (ε)	[6-8]
3	e + He^* → He^+ + e + e	σ (ε)	[6-8]
4	e + He^* → He + e	$7x10^{-10} (T_e/T_{gas})^{(0.5)}$	[4,5]
5	e + He_2^* → He + He + e	$4x10^{-9}$	[4]
6	e + He_2^* → He_2^+ + e + e	$9.75x10^{-10} (T_e/11600)^{(-0.71)}$ $\exp(-3.4*11600/T_e)$	[4,5]
7	e + He + O → He + O^-	10^{-31}	[4]
8	e + He + O_2 → He + O_2^-	$3.6x10^{-31} (T_{gas}/300)^{(-0.5)}$	[4]
9	e + He + O_3 → He + O_3^-	10^{-31}	[4]
	Electron-ion recombination with He		
10	e + He^+ → He^*	$6.76x10^{-13} (T_e/11600)^{(-0.5)}$	[4,5]
11	e + He^+ → He	$2x10^{-12}$	[4]
12	e + He_2^+ → He + He	10^{-8}	[4]
13	e + He_2^+ → He_2^*	$1.5x10^{-16}$	[4]
14	e + He_2^+ → He + He^*	$8.9x10^{-9} (T_e/T_{gas})^{(-1.5)}$	[4]
15	e + He + He^+ → He + He^*	10^{-27}	[4]
16	e + He + He_2^+ → He + He + He^*	$5x10^{-27} (T_e/T_{gas})^{(-1)}$	[4]
17	e + He + He_2^+ → He + He_2^*	$1.5x10^{-27}$	[4]
18	e + He + He_2^+ → He + He + He	$2x10^{-27} (T_e/T_{gas})^{(-2.5)}$	[4]
19	e + e + He^+ → He^* + e	$6x10^{-20} (T_e/T_{gas})^{(-4)}$	[4]
20	e + e + He^+ → He + e	$7x10^{-20} (T_e/T_{gas})^{(-4.5)}$	[4]
21	e + e + He_2^+ → He + He^* + e	$10^{-20} (T_e/T_{gas})^{(-4)}$	[4]
22	e + e + He_2^+ → He_2^* + e	$3x10^{-20} (T_e/T_{gas})^{(-4)}$	[4]
23	e + e + He_2^+ → He + He + e	$7x10^{-20} (T_e/T_{gas})^{(-4.5)}$	[4]
24	e + HeH^+ → H + He	$1.1x10^{-9} (T_e/11600)^{(0.6)}$	[5]
25	e + He + N^+ → He + N	$2x10^{-27} (T_e/T_{gas})^{(-2.5)}$	[4]
26	e + He + O^+ → He + O	$6x10^{-27} (T_e/T_{gas})^{(-2.5)}$	[4]
	Ion-ion recombination with He		
27	He^+ + H^- → He + H	$2.3x10^{-7} (T_{gas}/300)^{(-1)}$	[5]
28	He^+ + O^- → He + O	$2x10^{-7} (T_{gas}/300)^{(-1)}$	[4]
29	He^+ + O_2^- → He + O_2	$2x10^{-7} (T_{gas}/300)^{(-1)}$	[4]

30	$He^+ + O_3^- \rightarrow He + O_3$	$2x10^{-7} (T_{gas}/300)^{(-1)}$	[4]
31	$He_2^+ + H^- \rightarrow He + He + H$	10^{-7}	[5]
32	$He_2^+ + O^- \rightarrow He + He + O$	10^{-7}	[4,5]
33	$He_2^+ + O_2^- \rightarrow He + He + O_2$	10^{-7}	[4,5]
34	$He_2^+ + O_2^- \rightarrow He + He + O + O$	10^{-7}	[5]
35	$He_2^+ + O_3^- \rightarrow He + He + O_3$	10^{-7}	[4,5]
36	$He_2^+ + NO_2^- \rightarrow He + He + NO_2$	10^{-7}	[5][c]
37	$He_2^+ + NO_2^- \rightarrow He + He + NO + O$	10^{-7}	[5][c]
38	$He_2^+ + NO_3^- \rightarrow He + He + NO_3$	10^{-7}	[5][c]
39	$He_2^+ + NO_3^- \rightarrow He + He + NO_2 + O$	10^{-7}	[5][c]
40	$He_2^+ + OH^- \rightarrow He + He + OH$	10^{-7}	[4,5]
41	$He_2^+ + OH^- \rightarrow He + He + H + O$	10^{-7}	[4]
42	$HeH^+ + O^- \rightarrow OH + He$	10^{-7}	[5]
43	$HeH^+ + H^- \rightarrow H_2 + He$	10^{-7}	[5]
44	$HeH^+ + O_2^- \rightarrow HO_2 + He$	10^{-7}	[5]
45	$HeH^+ + OH^- \rightarrow H_2O + He$	10^{-7}	[5]
46	$He^+ + O^- + He \rightarrow He + He + O$	$2x10^{-25} (T_{gas}/300)^{(2.5)}$	[4]
47	$He^+ + O^- + O_2 \rightarrow He + O + O_2$	$2x10^{-25} (T_{gas}/300)^{(2.5)}$	[4]
48	$He^+ + O^- + N_2 \rightarrow He + O + N_2$	$2x10^{-25} (T_{gas}/300)^{(2.5)}$	[4]
49	$He^+ + O^- + M \rightarrow He + O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5]
50	$He^+ + O_2^- + M \rightarrow He + O_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5]
51	$He^+ + OH^- + M \rightarrow He + OH + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5]
52	$He^+ + NO_2^- + M \rightarrow He + NO_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5][c]
53	$He^+ + NO_3^- + M \rightarrow He + NO_3 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5][c]
54	$He_2^+ + O^- + M \rightarrow He + He + O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5]
55	$He_2^+ + OH^- + M \rightarrow He + He + OH + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[5]
56	$He_2^+ + O^- + He \rightarrow He + He + He + O$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
57	$He_2^+ + O^- + O_2 \rightarrow He + He + O + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
58	$He_2^+ + O_2^- + He \rightarrow He + He + He + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
59	$He_2^+ + O_2^- + O_2 \rightarrow He + He + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
60	$He_2^+ + O_3^- + He \rightarrow He + He + He + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
61	$He_2^+ + O_3^- + O_2 \rightarrow He + He + O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
62	$HeH^+ + O^- + M \rightarrow He + O + H + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4][d]
63	$HeH^+ + O_2^- + M \rightarrow He + O_2 + H + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4][d]
64	$HeH^+ + O_3^- + M \rightarrow He + O_3 + H + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4][d]
65	$O^+ + O^- + He \rightarrow He + O + O$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
66	$O^+ + O_2^- + He \rightarrow He + O + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
67	$O^+ + O_3^- + He \rightarrow He + O + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
68	$O_2^+ + O^- + He \rightarrow He + O + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
69	$O_2^+ + O_2^- + He \rightarrow He + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
70	$O_2^+ + O_3^- + He \rightarrow He + O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
71	$O_2^+ + O_2H_2O^- + He \rightarrow He + O_2 + O_2 + H_2O$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
72	$O_4^+ + O^- + He \rightarrow He + O + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
73	$O_4^+ + O_2^- + He \rightarrow He + O_2 + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
74	$O_4^+ + O_3^- + He \rightarrow He + O_2 + O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
75	$NO^+ + O_3^- + He \rightarrow He + O_3 + NO$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
	Negative ion-neutral reactions with He		
76	$He + O^- \rightarrow He + O + e$	$2.5x10^{-18} (T_{gas}/300)^{(0.6)}$	[4,5]
77	$He + O_2^- \rightarrow He + O_2 + e$	$3.9x10^{-10} exp(-7400/T_{gas})$	[4,5]
78	$He + O_3^- \rightarrow He + O_2 + O + e$	$3x10^{-10}$	[4]
79	$He + OH^- \rightarrow He + OH + e$	$2.0\text{-}9 exp(-24030/T_{gas})$	[5]
80	$He + NO^- \rightarrow He + NO + e$	$2.4x10^{-13}$	[5]
81	$He + H_2^+ \rightarrow He^+ + H_2$	$2.2x10^{-10}$	[4]
82	$He + NO_2H_2O^- \rightarrow He + H_2O + NO_2^-$	$5.6x10^{-16}$	[4]
83	$He + NO_3^- + H_2O \rightarrow He + NO_3H_2O^-$	$7.5x10^{-29} (T_{gas}/300)^{(-1)}$	[4]

84	$He + O^- + O_2 \rightarrow He + O_3^-$	$1.1x10^{-30} (T_{gas}/300)^{(-1)}$	[4]
85	$He + NO_2^- + H_2O \rightarrow He + NO_2H_2O^-$	$1.6x10^{-28}$	[4]
86	$He^* + O^- \rightarrow He + O + e$	$3x10^{-10}$	[4]
87	$He^* + O_2^- \rightarrow He + O_2 + e$	$3x10^{-10}$	[4]
88	$He^* + O_3^- \rightarrow He + O_3 + e$	$3x10^{-10}$	[4]
89	$He^* + O_2H_2O^- \rightarrow He + O_2 + H_2O + e$	$3x10^{-11}$	[4]
90	$He_2^* + O^- \rightarrow He + He + O + e$	$3x10^{-10}$	[4]
91	$He_2^* + O_2^- \rightarrow He + He + O_2 + e$	$3x10^{-10}$	[4]
92	$He_2^* + O_3^- \rightarrow He + He + O + O_2 + e$	$3x10^{-10}$	[4]
	Positive ion-neutral reactions with He		
93	$He^+ + He + He \rightarrow He + He_2^+$	$1.4x10^{-31} (T_{gas}/300)^{(-0.6)}$	[5]
94	$He^+ + O \rightarrow He + O^+$	$5x10^{-11} (T_{gas}/300)^{(0.5)}$	[4,5]
95	$He^+ + O(^1D) \rightarrow He + O^+$	$5x10^{-11} (T_{gas}/300)^{(0.5)}$	[4,5]
96	$He^+ + O(^1S) \rightarrow He + O^+$	$5x10^{-11} (T_{gas}/300)^{(0.5)}$	[4,5]
97	$He^+ + O_2 \rightarrow He + O^+ + O$	$1.07x10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
98	$He^+ + O_2 \rightarrow He + O_2^+$	$3.3x10^{-11} (T_{gas}/300)^{(0.5)}$	[4,5]
99	$He^+ + O_2(^1D) \rightarrow He + O^+ + O$	$1.07x10^{-9} (T_{gas}/300)^{(0.5)}$	[4]
100	$He^+ + O_2(^1D) \rightarrow He + O_2^+$	$3.3x10^{-11} (T_{gas}/300)^{(0.5)}$	[4]
101	$He^+ + O_3 \rightarrow He + O_2 + O^+$	$1.07x10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
102	$He^+ + NO \rightarrow He + O + N^+$	$1.25x10^{-9}$	[4]
103	$He^+ + NO \rightarrow He + NO^+$	$1.6x10^{-9}$	[4]
104	$He^+ + N_2 \rightarrow He + N + N^+$	$6x10^{-10}$	[4]
105	$He^+ + N_2 \rightarrow He + N_2^+$	$6x10^{-10}$	[4]
106	$He^+ + OH \rightarrow He + H + O^+$	$1.1x10^{-9}$	[4,5]
107	$He^+ + OH(A) \rightarrow He + H + O^+$	$1.1x10^{-9}$	[5]
108	$He^+ + H_2O \rightarrow He + H_2O^+$	$5.6x10^{-10}$	[4,5]
109	$He^+ + H \rightarrow He + H^+$	$1.9x10^{-15}$	[5]
110	$He^+ + H_2 \rightarrow He + H^+ + H$	$3.7x10^{-14} \exp(-35/T_{gas})$	[5]
111	$He^+ + H_2 \rightarrow He + H_2^+$	$7.2x10^{-15}$	[5]
112	$He^+ + H \rightarrow HeH^+$	$1.58x10^{-15} (T_{gas}/300)^{(-0.3)}$	[5]
113	$He^+ + H_2O \rightarrow HeH^+ + OH$	$3x10^{-10}$	[5]
114	$He_2^+ + He^* \rightarrow He + He + He^+$	10^{-10}	[4]
115	$He_2^+ + O \rightarrow He + He + O^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
116	$He_2^+ + O(^1D) \rightarrow He + He + O^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
117	$He_2^+ + O(^1S) \rightarrow He + He + O^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
118	$He_2^+ + O_2 \rightarrow He + He + O + O^+$	$1.05x10^{-9}$	[4]
119	$He_2^+ + O_2 \rightarrow He + He + O_2^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
120	$He_2^+ + O_2(^1D) \rightarrow He + He + O_2^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4]
121	$He_2^+ + O_2(^1S) \rightarrow He + He + O_2^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4]
122	$He_2^+ + O_3 \rightarrow He + He + O_2 + O^+$	$10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
123	$He_2^+ + O_3 \rightarrow He + He + O_2^+ + O$	$5x10^{-9}$	[4]
124	$He_2^+ + OH \rightarrow He + He + OH^+$	$1.2x10^{-9}$	[5]
125	$He_2^+ + OH(A) \rightarrow He + He + OH^+$	$1.2x10^{-9}$	[5]
126	$He_2^+ + NO \rightarrow He + He + NO^+$	$1.3x10^{-9}$	[4]
127	$He_2^+ + N_2 \rightarrow He + He + N_2^+$	$1.2x10^{-9}$	[4]
128	$He_2^+ + N_2 \rightarrow He_2^* + N_2^+$	$1.4x10^{-9}$	[4]
129	$He_2^+ + NO_2 \rightarrow He + He + NO_2^+$	$1.38x10^{-10}$	[4]
130	$He_2^+ + H \rightarrow He + He + H^+$	$3.5x10^{-10}$	[5]
131	$He_2^+ + H_2 \rightarrow He + He + H_2^+$	$3.5x10^{-10}$	[5]
132	$He_2^+ + H_2 \rightarrow HeH^+ + H + He$	$1.76x10^{-10}$	[5]
133	$He_2^+ + H_2O \rightarrow He + He + H_2O^+$	$1.6x10^{-9}$	[5]
134	$He_2^+ + H_2O \rightarrow HeH^+ + He + OH(A)$	$1.3x10^{-10}$	[5]
135	$He_2^+ + H_2O \rightarrow HeH^+ + He + OH$	$2.1x10^{-10}$	[5]
136	$HeH^+ + H \rightarrow H_2^+ + He$	$9.1x10^{-10}$	[5]
137	$HeH^+ + H_2 \rightarrow H_3^+ + He$	$1.5x10^{-9}$	[5]

138	$HeH^+ + H_2O \rightarrow H_3O^+ + He$	$4.3x10^{-10}$	[5]
139	$He + O_4^+ \rightarrow He + O_2 + O_2^+$	$3x10^{-17}$	[4]
140	$He + H^+ \rightarrow HeH^+$	$8.4x10^{-19} (T_{gas}/300)^{(-4.5)}$	[5]
141	$He + H_2^+ \rightarrow HeH^+ + H$	$1.3x10^{-10}$	[5]
142	$He + H_3^+ \rightarrow HeH^+ + H_2$	10^{-11}	[5]
143	$He + O^+ + O \rightarrow He + O_2^+$	$10^{-29} (T_{gas}/300)^{(0.5)}$	[4]
144	$He + O^+ + N_2 \rightarrow He + N + NO^+$	$6x10^{-29} (T_{gas}/300)^{(2)}$	[4]
145	$He + O_2^+ + O_2 \rightarrow He + O_4^+$	$3.9x10^{-30} (T_{gas}/300)^{(3.2)}$	[4]
146	$He + O_2^+ + H_2O \rightarrow He + H_2O_3^+$	$2.8x10^{-28} (T_{gas}/300)^{(2)}$	[4]
147	$He + N^+ + O \rightarrow He + NO^+$	10^{-29}	[4]
148	$He + N_2^+ + N_2 \rightarrow He + N_4^+$	$5x10^{-29} (T_{gas}/300)$	[4]
149	$He + H^+ + H_2 \rightarrow He + H_3^+$	$1.5x10^{-29}$	[5]
150	$He + H_3O^+ + H_2O \rightarrow He + (H_2O)_2H^+$	$6.65x10^{-28}$	[4]
151	$He^* + O_2^+ \rightarrow He + O + O^+$	10^{-20}	[4]
152	$He^* + O_4^+ \rightarrow He + O_2 + O_2^+$	10^{-10}	[4]
153	$He^* + NO^+ \rightarrow He + O + N^+$	$5x10^{-11}$	[4]
154	$He^* + NO^+ \rightarrow He + N + O^+$	$5x10^{-11}$	[4]
155	$He^* + N_2^+ \rightarrow He + N + N^+$	10^{-20}	[4]
156	$He^* + N_4^+ \rightarrow He + N_2 + N_2^+$	10^{-10}	[4]
157	$He^* + H_2O^+ \rightarrow He + H + O^+ + H$	10^{-20}	[4]
158	$He^* + H_3O^+ \rightarrow He + H + H_2O^+$	10^{-10}	[4]
159	$He^* + H_4O_2^+ \rightarrow He + OH + H_3O^+$	10^{-10}	[4]
160	$He^* + (H_2O)_2H^+ \rightarrow He + H_2O + H_3O^+$	10^{-10}	[4]
161	$He^* + H_2O_3^+ \rightarrow He + H_2O + O_2^+$	10^{-10}	[4]
162	$He_2^* + O_2^+ \rightarrow He + He + O + O^+$	10^{-10}	[4]
163	$He_2^* + O_4^+ \rightarrow He + He + O + O_2 + O^+$	10^{-10}	[4]
	Neutral/Excited species reactions with He		
164	$He^* + He + He \rightarrow He + He_2^*$	$1.5x10^{-34}$	[4,5]
165	$He^* + He^* \rightarrow He + He^+ + e$	$8.7x10^{-10} (T_{gas}/300)^{(0.5)}$	[4,5]
166	$He^* + He^* \rightarrow He_2^+ + e$	$2.03x10^{-9} (T_{gas}/300)^{(0.5)}$	[4,5]
167	$He^* + He_2^* \rightarrow He + He + He^+ + e$	$5x10^{-10}$	[4,5]
168	$He^* + He_2^* \rightarrow He + He_2^+ + e$	$2x10^{-9}$	[4,5]
169	$He_2^* + He_2^* \rightarrow He + He + He + He^+ + e$	$3x10^{-10}$	[4,5]
170	$He_2^* + He_2^* \rightarrow He + He + He_2^+ + e$	$1.2x10^{-9}$	[4,5]
171	$He_2^* + He \rightarrow He + He + He$	$4.9x10^{-16}$	[4]
172	$He + O(^1D) \rightarrow He + O$	10^{-13}	[4,5]
173	$He + O_2(^1D) \rightarrow He + O_2$	$8x10^{-21} (T_{gas}/300)^{(0.5)}$	[4]
174	$He + O_2(^1S) \rightarrow He + O_2(^1D)$	$10^{-17} (T_{gas}/300)^{(0.5)}$	[4]
175	$He + O_2(V_1) \rightarrow He + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
176	$He + O_2(V_2) \rightarrow He + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
177	$He + O_2(V_3) \rightarrow He + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
178	$He + O_2(V_4) \rightarrow He + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
179	$He + O_2(R) \rightarrow O_2 + He$	10^{-13}	[4]
180	$He + O_3 \rightarrow He + O + O_2$	$1.56x10^{-9} exp(-11400/T_{gas})$	[4]
181	$He + OH(A) \rightarrow He + OH$	$1.5x10^{-14}$	[5]
182	$He + N_2(R) \rightarrow N_2 + He$	10^{-13}	[4]
183	$He+N_2(V_1)\rightarrow N_2+He$	10^{-13}	[4]
184	$He+N_2(V_2)\rightarrow N_2+He$	10^{-13}	[4]
185	$He+N_2(V_3)\rightarrow N_2+He$	10^{-13}	[4]
186	$He+N_2(V_4)\rightarrow N_2+He$	10^{-13}	[4]
187	$He+H(E_2)\rightarrow H+He$	10^{-13}	[4][e]
188	$He+H(E_3)\rightarrow H+He$	10^{-13}	[4][e]
189	$He + H_2(V_1) \rightarrow H_2 + He$	10^{-13}	[4][e]
190	$He+H_2(R_{02})\rightarrow H_2+He$	10^{-13}	[4][e]
191	$He+H_2(R_{13})\rightarrow H_2+He$	10^{-13}	[4][e]

192	$He+H_2(b) \rightarrow H_2+He$	10^{-13}	[4][e]
193	$He+H_2(c) \rightarrow H_2+He$	10^{-13}	[4][e]
194	$He^* + H \rightarrow He + H^+ + e$	$1.1x10^{-9}$	[5]
195	$He^* + H_2 \rightarrow He + H_2^+ + e$	$2.9x10^{-11}$	[5]
196	$He^* + H_2 \rightarrow He + H(E_2) + H$	$1.4x10^{-11}$	[4,5]
197	$He^* + O \rightarrow He + O^+ + e$	$3.96x10^{-10} (T_{gas}/300)^{(0.17)}$	[4,5]
198	$He^* + O(^1D) \rightarrow He + O^+ + e$	$3.96x10^{-10} (T_{gas}/300)^{(0.17)}$	[4,5]
199	$He^* + O(^1S) \rightarrow He + O^+ + e$	$3.96x10^{-10} (T_{gas}/300)^{(0.17)}$	[4,5]
200	$He^* + O_2 \rightarrow He + O_2^+ + e$	$2.54x10^{-10} (T_{gas}/300)^{(0.5)}$	[4,5]
201	$He^* + O_2(^1D) \rightarrow He + O_2^+ + e$	$2.54x10^{-10} (T_{gas}/300)^{(0.5)}$	[4]
202	$He^* + O_2(^1S) \rightarrow He + O_2^+ + e$	$2.54x10^{-10} (T_{gas}/300)^{(0.5)}$	[4]
203	$He^* + O_3 \rightarrow He + O_2^+ + O + e$	$2.54x10^{-10} (T_{gas}/300)^{(0.5)}$	[5]
204	$He^* + OH \rightarrow He + OH^+ + e$	$7.8x10^{-10}$	[5]
205	$He^* + OH(A) \rightarrow He + OH^+ + e$	$7.8x10^{-10}$	[4,5]
206	$He^* + N_2 \rightarrow He + N^+ + N + e$	$2.54x10^{-10} (T_{gas}/300)^{(0.5)}$	[4]
207	$He^* + N_2 \rightarrow He + N_2^+ + e$	10^{-10}	[4,5]
208	$He^* + H_2O \rightarrow He + H_2O^+ + e$	$6.6x10^{-10}$	[5]
209	$He^* + H_2 \rightarrow HeH^+ + H + e$	$3x10^{-12}$	[5]
210	$He^* + H_2O \rightarrow HeH^+ + OH + e$	$8.5x10^{-12}$	[5]
211	$He_2^* + H \rightarrow He + He + H^+ + e$	$2.2x10^{-10}$	[5]
212	$He_2^* + H_2 \rightarrow He + He + H_2^+ + e$	$2.2x10^{-10}$	[5]
213	$He_2^* + O \rightarrow He + He + O^+ + e$	10^{-10}	[5]
214	$He_2^* + O(^1D) \rightarrow He + He + O^+ + e$	10^{-10}	[5]
215	$He_2^* + O(^1S) \rightarrow He + He + O^+ + e$	10^{-10}	[5]
216	$He_2^* + O_2 \rightarrow He + He + O_2^+ + e$	10^{-10}	[5]
217	$He_2^* + O_3 \rightarrow He + He + O + O_2^+ + e$	10^{-10}	[5]
218	$He_2^* + N_2 \rightarrow He + He + N_2^+ + e$	$3x10^{-11}$	[4]
219	$He_2^* + O_2 \rightarrow He + He + O + O$	$4.6x10^{-11}$	[5]
220	$He_2^* + O_3 \rightarrow He + He + O_2 + O$	$2.1x10^{-10}$	[5]
221	$He_2^* + N_2 \rightarrow He + He + N_2(A)$	$1.2x10^{-11}$	[4]
222	$He_2^* + NO \rightarrow He + He + N + O$	$3.1x10^{-10}$	[4]
223	$He_2^* + NO_2 \rightarrow He + He + NO + O$	$8.44x10^{-10}$	[4]
224	$He_2^* + N_2O \rightarrow He + He + N_2 + O$	$5.5x10^{-10}$	[4]
225	$He_2^* + OH \rightarrow He + He + OH^+ + e$	$6x10^{-10}$	[5]
226	$He_2^* + OH(A) \rightarrow He + He + OH^+ + e$	$6x10^{-10}$	[5]
227	$He_2^* + H_2O \rightarrow He + He + H_2O^+ + e$	$6.6x10^{-10}$	[5]
228	$He_2^* + H_2O_2 \rightarrow He + He + OH^+ + OH + e$	$6.6x10^{-10}$	[5]
229	$He_2^* + H_2O \rightarrow He + He + OH + H$	10^{-10}	[5]
230	$He_2^* + M \rightarrow He + He + M$	$1.5x10^{-15}$	[5]
231	$He + H + O_2 \rightarrow HO_2 + He$	$6.09x10^{-32} (T_{gas}/300)^{(-0.8)}$	[5]
232	$He + H + H \rightarrow H_2 + He$	$2x10^{-32} (T_{gas}/300)^{(-1)}$	[5]
233	$He + OH + NO \rightarrow HNO_2 + He$	$7.4x10^{-31} (T_{gas}/300)^{(-2.4)}$	[4]
234	$He + OH + NO_2 \rightarrow HNO_3 + He$	$4.6x10^{-29} (T_{gas}/300)^{(-5.49)} exp(-1180/T_{gas})$	[4]
235	$He + OH + OH \rightarrow H_2O_2 + He$	$8x10^{-31} (T_{gas}/300)^{(-0.8)}$	[4]
236	$He + HO_2 + NO \rightarrow HNO_3 + He$	$5.6x10^{-33}$	[4]
237	$He + O + NO_2 \rightarrow NO_3 + He$	$9x10^{-32} (T_{gas}/300)^{(-2)}$	[4]
238	$He + NO_2 + NO_2 \rightarrow N_2O_4 + He$	$1.4x10^{-33} (T_{gas}/300)^{(-3.8)}$	[4]
239	$He + NO_2 + NO_3 \rightarrow N_2O_5 + He$	$2.8x10^{-30} (T_{gas}/300)^{(-3.5)}$	[4]
240	$He + H + N \rightarrow NH + He$	$5x10^{-32}$	[4]
241	$He + H + NO \rightarrow HNO + He$	$1.22x10^{-31} (T_{gas}/300)^{(-1.17)} exp(-212/T_{gas})$	[4]
242	$He + He^* + O \rightarrow He + He + O^+ + e$	$1.6x10^{-31}$	[4]
243	$He + He^* + O(^1D) \rightarrow He + He + O^+ + e$	$1.6x10^{-31}$	[4]
244	$He + He^* + O_2 \rightarrow He + He + O_2^+ + e$	$1.6x10^{-31}$	[4]
245	$He + He^* + O_2(^1D) \rightarrow He + He + O_2^+ + e$	$1.6x10^{-31}$	[4]

246	$He + He^* + O_2(^1S) \rightarrow He + He + O_2^+ + e$	$1.6x10^{-31}$	[4]
247	$He + He^* + O_3 \rightarrow He + He + O + O_2^+ + e$	$1.6x10^{-31}$	[4]
248	$He + O + O \rightarrow He + O_2$	10^{-33}	[4]
249	$He + O + O \rightarrow He + O_2(^1D)$	$9.88x10^{-35}$	[4]
250	$He + O + O_2 \rightarrow He + O_3$	$3.4x10^{-34} (T_{gas}/300)^{(1.2)}$	[4]
251	$He + O + O_2(^1D) \rightarrow He + O + O_2$	10^{-32}	[4]
252	$He + O + N \rightarrow He + NO$	$1.76x10^{-31} (T_{gas})^{(-0.5)}$	[4]
253	$He + O + NO \rightarrow He + NO_2$	10^{-31}	[4]
254	$He + O + H \rightarrow He + OH$	$3.2x10^{-33} (T_{gas}/300)$	[4]
255	$He + N + N \rightarrow He + N_2$	$7.6x10^{-34} exp(500/T_{gas})$	[4]
256	$He + H + OH \rightarrow He + H_2O$	$1.56x10^{-31} (T_{gas}/300)^{(2.6)}$	[4]
	Electron impact reactions		
257	$e + O(^1D) \rightarrow O + e$	σ (ε)	[2,3,6]
258	$e + O_2 \rightarrow O + O + e$	σ (ε)	[2,3,6]
259	$e + O_2 \rightarrow O + O^-$	σ (ε)	[2,3,6]
260	$e + O_2(^1D) \rightarrow O + O + e$	σ (ε)	[2,3,6]
261	$e + O_2(^1D) \rightarrow O + O^-$	σ (ε)	[2,3,6]
262	$e + O_2(^1D) \rightarrow O_2 + e$	σ (ε)	[2,3,6]
263	$e + O_2(^1S) \rightarrow O + O + e$	σ (ε)	[2,3,6]
264	$e + O_2(^1S) \rightarrow O + O^-$	σ (ε)	[2,3,6]
265	$e + O_2(^1S) \rightarrow O_2 + e$	σ (ε)	[2,3,6]
266	$e + O_3 \rightarrow O + O_2 + e$	10^{-8}	[3]
267	$e + O_3 \rightarrow O + O_2^-$	σ (ε)	[3,6]
268	$e + O_3 \rightarrow O_2 + O^-$	σ (ε)	[3,6]
269	$e + O^- \rightarrow O + e + e$	$5.47x10^{-8} (T_e/11600)^{(0.324)} exp(-2.98*11600/T_e)$	[3]
270	$e + NO \rightarrow O + N + e$	$7.4x10^{-9} exp(-6.5*11600/T_e)$	[4]
271	$e + NO_2 \rightarrow O + NO + e$	$5.6x10^{-9} exp(-3.11*11600/T_e)$	[4]
272	$e + NO_2 \rightarrow NO + O^-$	$3x10^{-11}$	[4]
273	$e + NO_2 \rightarrow NO_2^-$	$3x10^{-11}$	[4]
274	$e + N_2 \rightarrow N + N + e$	$10^{-8} (T_e/11600)^{(0.5)} exp(-16.0*11600/T_e)$	[4]
275	$e + N_2O \rightarrow O + N_2 + e$	$1.4x10^{-9} exp(-1.67*11600/T_e)$	[4]
276	$e + N_2O \rightarrow N + NO + e$	$10^{-10} exp(-4.93*11600/T_e)$	[4]
277	$e + OH \rightarrow O + H + e$	$2.08x10^{-7} (T_e/11600)^{(-0.76)} exp(-6.9*11600/T_e)$	[4]
278	$e + H_2O \rightarrow H + OH + e$	σ (ε)	[2,3,6]
279	$e + O_2 \rightarrow O_2(R) + e$	σ (ε)	[2,3,6]
280	$e + O_2 \rightarrow O_2(V_5) + e$	σ (ε)	[2,3,6]
281	$e + N_2 \rightarrow e + N_2(R)$	σ (ε)	[2,3,6]
282	$e + N_2 \rightarrow N_2(A) + e$	σ (ε)	[2,3,6]
283	$e + N_2 \rightarrow N_2(a') + e$	σ (ε)	[2,3,6]
284	$e + N_2(V_1) \rightarrow N_2(A) + e$	σ (ε)	[2,3,6]
285	$e + N_2(V_2) \rightarrow N_2(A) + e$	σ (ε)	[2,3,6]
286	$e + N_2(V_3) \rightarrow N_2(A) + e$	σ (ε)	[2,3,6]
287	$e + N_2(V_4) \rightarrow N_2(A) + e$	σ (ε)	[2,3,6]
288	$e + NO \rightarrow N + O^-$	σ (ε)	[2,3,6]
289	$e + H \rightarrow H(E_2) + e$	σ (ε)	[2,3,6]
290	$e + H \rightarrow H(E_3) + e$	σ (ε)	[2,3,6]
291	$e + H \rightarrow H^+ + e + e$	σ (ε)	[2,3,6]
292	$e + H(E_2) \rightarrow H^+ + e + e$	σ (ε)	[2,3,6]
293	$e + H(E_3) \rightarrow H^+ + e + e$	σ (ε)	[2,3,6]
294	$e + H^- \rightarrow H + e + e$	σ (ε)	[2,3,6]
295	$e + H_2 \rightarrow H_2(R_{02}) + e$	$1.84x10^{-16}$	[3]
296	$e + H_2 \rightarrow H_2(R_{13}) + e$	$1.07x10^{-16}$	[3]

297	$e + H_2 \rightarrow H_2(V_1) + e$	$0.5x10^{-16}$	[3]
298	$e + H_2 \rightarrow H_2(b) + e$	$0.28x10^{-16}$	[3]
299	$e + H_2 \rightarrow H_2(c) + e$	$0.56x10^{-16}$	[3]
300	$e + H_2 \rightarrow e + e + H_2^+$	$9.1x10^{-9} (T_e/11600)^{(0.5)} exp(-15.4*11600/T_e)$	[5]
301	$e + H_2 \rightarrow e + e + H^+ + H$	$1.8x10^{-9} (T_e/11600)^{(0.5)} exp(-18.1*11600/T_e)$	[5]
302	$e + H_2 \rightarrow e + H + H$	$8.73x10^{-8} (T_e/11600)^{(0.5)} exp(-11.7*11600/T_e)$	[5]
303	$e + H_2 \rightarrow e + H(E_2) + H$	$2.52x10^{-9} (T_e/11600)^{(0.36)} exp(-15.3*11600/T_e)$	[5]
304	$e + H_2 \rightarrow e + H(E_3) + H$	$2.059x10^{-11} (T_e/11600)^{(1.5)} exp(-17*11600/T_e)$	[5]
305	$e + H_2 \rightarrow H + H^-$	$5.69x10^{-13} (T_e/11600)^{(0.5)} exp(-5.5*11600/T_e)$	[5]
306	$e + H_2(b) \rightarrow e + e + H_2^+$	σ (ε)	[3,6]
307	$e + H_2(c) \rightarrow e + e + H_2^+$	σ (ε)	[3,6]
308	$e + OH \rightarrow e + OH(A)$	$1.52x10^{-6} (T_{gas}/300)^{(0.52)} exp(-3.85/T_{gas})$	[3,6]
309	$e + OH \rightarrow e + e + OH^+$	$1.16x10^{-17}*T_{gas}^{(1.78)} exp(-160267.1/T_{gas})$	[3]
310	$e + OH(A) \rightarrow e + e + OH^+$	$3.02x10^{-11} (T_{gas}/300)^{(2.61)} exp(-10.58/T_{gas})$	[3]
311	$e + OH(A) \rightarrow e + O + H$	$1.54x10^{-7} (T_{gas}/300)^{(-0.75)} exp(-3.9/T_{gas})$	[3]
312	$e + H_2O \rightarrow O^- + H_2$	σ (ε)	[3,6]
313	$e + H_2O \rightarrow H^- + OH$	σ (ε)	[3,6]
314	$e + H_2O_2 \rightarrow H_2O + O^-$	σ (ε)	[3,6]
315	$e + H_2O_2 \rightarrow OH + OH^-$	σ (ε)	[3,6]
316	$e + O + O_2 \rightarrow O + O_2^-$	10^{-31}	[4]
317	$e + O + O_2 \rightarrow O_2 + O^-$	10^{-31}	[4]
318	$e + O + N_2 \rightarrow N_2 + O^-$	10^{-31}	[4]
319	$e + O_2 + O_2 \rightarrow O_2 + O_2^-$	$3.6x10^{-31} (T_e/11600)^{(-0.5)}$	[4]
320	$e + O_2 + O_2(^1D) \rightarrow O_2 + O_2^-$	σ (ε)	[3,6]
321	$e + O_2 + O_2(V_1) \rightarrow O_2 + O_2^-$	σ (ε)	[3,6]
322	$e + O_2 + O_2(V_2) \rightarrow O_2 + O_2^-$	σ (ε)	[3,6]
323	$e + O_2 + O_2(V_3) \rightarrow O_2 + O_2^-$	σ (ε)	[3,6]
324	$e + O_2 + O_2(V_4) \rightarrow O_2 + O_2^-$	σ (ε)	[3,6]
325	$e + O_2 + O_3 \rightarrow O_2 + O_3^-$	10^{-31}	[4]
326	$e + O_2 + NO \rightarrow O_2 + NO^-$	10^{-30}	[4]
327	$e + O_2 + N_2 \rightarrow N_2 + O_2^-$	$1.24x10^{-31} (T_{gas}/300)^{(-0.5)}$	[4]
328	$e + O_2 + H_2O \rightarrow H_2O + O_2^-$	$1.4x10^{-29}$	[4]
329	$e + N_2 + NO \rightarrow N_2 + NO^-$	10^{-30}	[4]
330	$e + O \rightarrow O^+ + e + e$	σ (ε)	[2,3,6]
331	$e + O \rightarrow O(^1D) + e$	σ (ε)	[2,3,6]
332	$e + O \rightarrow O(^1S) + e$	σ (ε)	[2,3,6]
333	$e + O(^1D) \rightarrow O^+ + e + e$	σ (ε)	[2,3,6]
334	$e + O(^1S) \rightarrow O^+ + e + e$	σ (ε)	[2,3,6]
335	$e + O_2 \rightarrow O + O^+ + e + e$	$5.4x10^{-10} (T_e/11600)^{(0.5)} exp(-17.0*11600/T_e)$	[4]
336	$e + O_2 \rightarrow O^+ + O^- + e$	$7.1x10^{-11} (T_e/11600)^{(0.5)} exp(-17.0*11600/T_e)$	[4]
337	$e + O_2 \rightarrow O + O(^1D) + e$	$5x10^{-8} exp(-8.40*11600/T_e)$	[4]
338	$e + O_2 \rightarrow O + O(^1S) + e$	$5x10^{-8} exp(-8.40*11600/T_e)$	[4]
339	$e + O_2 \rightarrow O(^1D) + O(^1D) + e$	$1.95x10^{-10} (T_e/11600)^{(0.22)} exp(-12.62*11600/T_e)$	[4]

340	$e + O_2 \rightarrow O_2^+ + e + e$	σ (ε)	[2,3,6]
341	$e + O_2 \rightarrow O_2(^1D) + e$	σ (ε)	[2,3,6]
342	$e + O_2 \rightarrow O_2(^1S) + e$	σ (ε)	[2,3,6]
343	$e + O_2 \rightarrow O_2(V_1) + e$	σ (ε)	[2,3,6]
344	$e + O_2 \rightarrow O_2(V_2) + e$	σ (ε)	[2,3,6]
345	$e + O_2 \rightarrow O_2(V_3) + e$	σ (ε)	[2,3,6]
346	$e + O_2 \rightarrow O_2(V_4) + e$	σ (ε)	[2,3,6]
347	$e + O_2(^1D) \rightarrow O + O^+ + e + e$	σ (ε)	[2,3,6]
348	$e + O_2(^1D) \rightarrow O + O(^1D) + e$	σ (ε)	[2,3,6]
349	$e + O_2(^1D) \rightarrow O(^1D) + O^-$	$9.93x10^{-9} (T_e/11600)^{(-1.437)} exp(-7.44*11600/T_e)$	[4]
350	$e + O_2(^1D) \rightarrow O_2^+ + e + e$	σ (ε)	[2,3,6]
351	$e + O_2(^1D) \rightarrow O_2(^1S) + e$	$3.24x10^{-10} exp(-1.57*11600/T_e)$	[2,3,6]
352	$e + O_2(^1S) \rightarrow O + O^+ + e + e$	σ (ε)	[2,3,6]
353	$e + O_2(^1S) \rightarrow O + O(^1D) + e$	σ (ε)	[2,3,6]
354	$e + O_2(^1S) \rightarrow O_2^+ + e + e$	σ (ε)	[2,3,6]
355	$e + O_2(V_1) \rightarrow O_2 + e$	σ (ε)	[2,3,6]
356	$e + O_2(V_1) \rightarrow O_2(^1D) + e$	σ (ε)	[2,3,6]
357	$e + O_2(V_1) \rightarrow O_2(^1S) + e$	σ (ε)	[2,3,6]
358	$e + O_2(V_2) \rightarrow O_2 + e$	σ (ε)	[2,3,6]
359	$e + O_2(V_2) \rightarrow O_2(^1D) + e$	σ (ε)	[2,3,6]
360	$e + O_2(V_2) \rightarrow O_2(^1S) + e$	σ (ε)	[2,3,6]
361	$e + O_2(V_3) \rightarrow O_2 + e$	σ (ε)	[2,3,6]
362	$e + O_2(V_3) \rightarrow O_2(^1D) + e$	σ (ε)	[2,3,6]
363	$e + O_2(V_3) \rightarrow O_2(^1S) + e$	σ (ε)	[2,3,6]
364	$e + O_2(V_4) \rightarrow O_2 + e$	σ (ε)	[2,3,6]
365	$e + O_2(V_4) \rightarrow O_2(^1D) + e$	σ (ε)	[2,3,6]
366	$e + O_2(V_4) \rightarrow O_2(^1S) + e$	σ (ε)	[2,3,6]
367	$e + N \rightarrow N^+ + e + e$	σ (ε)	[2,3,6]
368	$e + N \rightarrow N(^2D) + e$	σ (ε)	[2,3,6]
369	$e + N \rightarrow N(^2P) + e$	σ (ε)	[2,3,6]
370	$e + N(^2D) \rightarrow N + e$	$10^{-8} (T_e/11600)^{(-0.36)} exp(-0.83*11600/T_e)$	[4]
371	$e + N(^2P) \rightarrow N + e$	$5.45x10^{-9} (T_e/11600)^{(-0.41)} exp(-1.05*11600/T_e)$	[4]
372	$e + N(^2P) \rightarrow N(^2D) + e$	$1.63x10^{-8} (T_e/11600)^{(-0.17)} exp(-2.69*11600/T_e)$	[4]
373	$e + N_2 \rightarrow N + N^+ + e + e$	σ (ε)	[2,3]
374	$e + N_2 \rightarrow N + N(^2D) + e$	$6.53x10^{-8} exp(-14.2*11600/T_e)$	[4]
375	$e + N_2 \rightarrow N + N(^2P) + e$	$6.53x10^{-8} exp(-14.2*11600/T_e)$	[4]
376	$e + N_2 \rightarrow N_2^+ + e + e$	σ (ε)	[2,3,6]
377	$e + N_2 \rightarrow N_2(V_1) + e$	σ (ε)	[2,3,6]
378	$e + N_2 \rightarrow N_2(V_2) + e$	σ (ε)	[2,3,6]
379	$e + N_2 \rightarrow N_2(V_3) + e$	σ (ε)	[2,3,6]
380	$e + N_2 \rightarrow N_2(V_4) + e$	σ (ε)	[2,3,6]
381	$e + N_2(V_1) \rightarrow N_2 + e$	σ (ε)	[2,3,6]
382	$e + N_2(V_1) \rightarrow N_2(V_2) + e$	(exp(-0.7*1.0)/(1+0.05*1.0)) σ (ε)	[4,6]
383	$e + N_2(V_2) \rightarrow N_2 + e$	σ (ε)	[2,3,6]
384	$e + N_2(V_2) \rightarrow N_2(V_1) + e$	(exp(-0.7*(-1.0))/(1+0.05*2.0))σ (ε)	[4,6]
385	$e + N_2(V_1) \rightarrow N_2(V_3) + e$	(exp(-0.7*2.0)/(1+0.05*1.0))σ (ε)	[4,6]

386	$e + N_2(V_3) \rightarrow N_2 + e$	σ (ε)	[2,3,6]
387	$e + N_2(V_3) \rightarrow N_2(V_1) + e$	(exp(-0.7*(-2.0))/(1+0.05*3.0)) σ (ε)	[4,6]
388	$e + N_2(V_1) \rightarrow N_2(V_4) + e$	(exp(-0.7*3.0)/(1+0.05*1.0)) σ (ε)	[4,6]
389	$e + N_2(V_4) \rightarrow N_2 + e$	σ (ε)	[2,3,6]
390	$e + N_2(V_4) \rightarrow N_2(V_1) + e$	(exp(-0.7*(-3.0))/(1+0.05*4.0) σ (ε)	[4,6]
391	$e + NO \rightarrow O + N^+ + e + e$	$2.4x10^{-9}$ $(T_e/11600)^{(0.5)}$ exp(-23.0*11600/T_e)	[4]
392	$e + NO \rightarrow N + O^+ + e + e$	$2.4x10^{-9}$ $(T_e/11600)^{(0.5)}$ exp(-23.0*11600/T_e)	[4]
393	$e + NO \rightarrow NO^+ + e + e$	$9x10^{-9}$ $(T_e/11600)^{(0.5)}$ exp(-12.1*11600/T_e)	[4]
394	$e + NO_2 \rightarrow O + NO^+ + e + e$	$8.1x10^{-9}$ $(T_e/11600)^{(0.5)}$ exp(-12.9*11600/T_e)	[4]
395	$e + N_2O \rightarrow O(^1D) + N_2 + e$	$1.2x10^{-9}$ exp(-3.46*11600/T_e)	[4]
	Electron-ion recomination		
396	$e + O^+ \rightarrow O(^1D)$	$5.3x10^{-13}$ $(T_e/11600)^{(-0.5)}$	[4]
397	$e + O_2^+ \rightarrow O(^1D) + O(^1D)$	$6.87x10^{-9}$ $(T_e/11600)^{(-0.7)}$	[4]
398	$e + OH^+ \rightarrow O + H$	$6.03x10^{-9}$ $(T_{gas}/300)^{(-0.5)}$	[3]
399	$e + H_2^+ \rightarrow e + H + H^+$	10^{-21}	[3]
400	$e + NO^+ \rightarrow O + N(^2D)$	$3x10^{-7}$ $(T_e/T_{gas})^{(-1)}$	[4]
401	$e + N_2^+ \rightarrow N + N(^2D)$	$2x10^{-7}$ $(T_e/T_{gas})^{(-0.5)}$	[4]
402	$e + e + O^+ \rightarrow O(^1D) + e$	$5.12x10^{-27}$ $(T_e/11600)^{(-4.5)}$	[4]
403	$e + NO_2^+ \rightarrow NO + O(^1D)$	$2x10^{-7}$ $(T_{gas}/300)^{(-0.5)}$	[3]
404	$e+ O^+ \rightarrow O$	$4x10^{-12}$	[4]
405	$e+ O_2^+ \rightarrow O + O$	$2.1x10^{-7}$ $(T_e/T_{gas})^{(-0.63)}$	[4]
406	$e+ O_2^+ \rightarrow O_2$	$4x10^{-12}$	[4]
407	$e+ O_4^+ \rightarrow O + O + O_2$	$2x10^{-6}$ $(T_e/T_{gas})^{(-1)}$	[4]
408	$e+ O_4^+ \rightarrow O_2 + O_2$	$2.25x10^{-7}$ $(T_e/11600)^{(-0.5)}$	[4]
409	$e+ N^+ \rightarrow N$	$3.5x10^{-12}$	[4]
410	$e+ NO^+ \rightarrow O + N$	$4x10^{-7}$ $(T_e/T_{gas})^{(-0.4)}$	[4]
411	$e+ NO^+ \rightarrow NO$	$4x10^{-12}$	[4]
412	$e+ NO_2^+ \rightarrow O + NO$	$2x10^{-7}$ $(0.026*11600/T_e)^{(0.5)}$	[4]
413	$e+ N_2^+ \rightarrow N + N$	$2.8x10^{-7}$ $(T_e/T_{gas})^{(-0.5)}$	[4]
414	$e+ N_2^+ \rightarrow N_2$	$4.8x10^{-7}$ $(T_e/T_{gas})^{(-0.5)}$	[4]
415	$e+ N_4^+ \rightarrow N + N + N_2$	$3.13x10^{-7}$ $(T_e/11600)^{(-0.41)}$	[4]
416	$e+ N_4^+ \rightarrow N_2 + N_2$	$2x10^{-6}$ $(T_e/T_{gas})^{(-0.5)}$	[4]
417	$e+ O^+ + e \rightarrow O + e$	$7x10^{-20}$ $(T_e/T_{gas})^{(-4.5)}$	[4]
418	$e+ O^+ + O_2 \rightarrow O + O_2$	$6x10^{-27}$ $(T_e/T_{gas})^{(-2.5)}$	[4]
419	$e+ O^+ + N_2 \rightarrow O + N_2$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]
420	$e+ O_2^+ + e \rightarrow O_2 + e$	$7x10^{-20}$ $(T_e/T_{gas})^{(-4.5)}$	[4]
421	$e+ O_2^+ + O_2 \rightarrow O_2 + O_2$	$2.49x10^{-29}$ $(T_e/11600)^{(-1.5)}$	[4]
422	$e+ O_2^+ + N_2 \rightarrow O_2 + N_2$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]
423	$e+ O_4^+ + e \rightarrow O_2 + O_2 + e$	$7x10^{-20}$ $(T_e/T_{gas})^{(-4.5)}$	[4]
424	$e+ N^+ + e \rightarrow N + e$	$7x10^{-20}$ $(T_e/T_{gas})^{(-4.5)}$	[4]
425	$e+ N^+ + O_2 \rightarrow O_2 + N$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]
426	$e+ N^+ + N_2 \rightarrow N + N_2$	$6x10^{-27}$ $(T_e/T_{gas})^{(-2.5)}$	[4]
427	$e+ NO^+ + e \rightarrow NO + e$	$7x10^{-20}$ $(T_e/T_{gas})^{(-4.5)}$	[4]
428	$e+ NO^+ + O_2 \rightarrow O_2 + NO$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]
429	$e+ NO^+ + N_2 \rightarrow N_2 + NO$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]
430	$e+ N_2^+ + e \rightarrow N_2 + e$	$7x10^{-20}$ $(T_e/T_{gas})^{(-4.5)}$	[4]
431	$e+ N_2^+ + O_2 \rightarrow O_2 + N_2$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]
432	$e+ N_2^+ + N_2 \rightarrow N_2 + N_2$	$6x10^{-27}$ $(T_e/T_{gas})^{(-1.5)}$	[4]

433	e+ N_4^+ + e → N_2 + N_2 + e	7x10^{-20} $(T_e/T_{gas})^{(-4.5)}$	[4]
	Electron-ion recombination (water clusters)		
434	e+ H_2O^+ → O + H_2	1.86x10^{-8} $(T_e/11600)^{(-0.5)}$	[3,5]
435	e+ H_2O^+ → O + H + H	2.32x10^{-8} $(T_e/11600)^{(-0.5)}$	[3,4,5]
436	e+ H_2O^+ → H + OH	5.1x10^{-8} $(T_e/11600)^{(-0.5)}$	[3,4,5]
437	e+ H_3O^+ → H + H + OH	1.05x10^{-7} $(T_e/11600)^{(-0.5)}$	[3,5]
438	e+ H_3O^+ → H + H_2O	5.63x10^{-8} $(T_e/11600)^{(-0.5)}$	[3,4,5]
439	e+ $H_2O_3^+$ → O_2 + H_2O	7.22x10^{-7} $(T_e/11600)^{(-0.2)}$	[4,5]
440	e+ $H_2O_3^+$ + e → O_2 + H_2O + e	5x10^{-27} $(T_e/11600)^{(-4.5)}$	[4,5]
441	e+ $H_4O_2^+$ → H + OH + H_2O	9.6x10^{-7} $(T_e/11600)^{(-0.2)}$	[3,4,5]
442	e+ $H_4O_2^+$ + e → H + OH + H_2O + e	5x10^{-27} $(T_e/11600)^{(-4.5)}$	[4,5]
443	e+ $(H_2O)_2H^+$ → H + H_2O + H_2O	1.62x10^{-6} $(T_e/11600)^{(-0.15)}$	[3,4,5]
444	e+ $(H_2O)_2H^+$ + e → H + H_2O + H_2O + e	5x10^{-27} $(T_e/11600)^{(-4.5)}$	[4,5]
445	e+ $(H_2O)_3H^+$ → H + H_2O + H_2O + H_2O	2.24x10^{-6} $(T_e/11600)^{(-0.08)}$	[5]
446	e+ $(H_2O)_4H^+$ → H + H_2O + H_2O + H_2O + H_2O	3.6x10^{-6}	[5]
447	e+ $(H_2O)_5H^+$ → H + H_2O + H_2O + H_2O + H_2O + H_2O	4x10^{-6}	[5]
448	e+ $(H_2O)_6H^+$ → H + H_2O + H_2O + H_2O + H_2O + H_2O + H_2O	4x10^{-6}	[5]
449	e+ $(H_2O)_7H^+$ → H + H_2O + H_2O + H_2O + H_2O + H_2O + H_2O + H_2O	4x10^{-6}	[5]
	Ion-ion reactions (two-body)		
450	O^+ + O^- → O + O	2.7x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
451	O^+ + O^- → O + O(^{1}D)	4.9x10^{-10} $(T_{gas}/300)^{(-0.5)}$	[4]
452	O^+ + O_2^- → O + O_2	2x10^{-7} $(T_{gas}/300)^{(-1)}$	[4]
453	O^+ + O_3^- → O + O_3	2x10^{-7} $(T_{gas}/300)^{(-1)}$	[4]
454	O^+ + NO^- → O + NO	2.7x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
455	O^+ + NO_2^- → O + NO_2	2.7x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
456	O^+ + NO_3^- → O + NO_3	2.7x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
457	O_2^+ + O^- → O + O + O	10^{-7}	[4]
458	O_2^+ + O^- → O + O_2	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
459	O_2^+ + O_2^- → O + O + O_2	10^{-7}	[4]
460	O_2^+ + O_2^- → O_2 + O_2	4.2x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
461	O_2^+ + O_3^- → O + O + O_3	10^{-7}	[4]
462	O_2^+ + O_3^- → O_2 + O_3	2x10^{-7} $(T_{gas}/300)^{(-1)}$	[4]
463	O_2^+ + NO^- → O + O + NO	10^{-7}	[4]
464	O_2^+ + NO^- → O_2 + NO	2.7x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
465	O_2^+ + NO_2^- → O + O + NO_2	10^{-7}	[4]
466	O_2^+ + NO_2^- → O_2 + NO_2	4.1x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
467	O_2^+ + NO_3^- → O + O + NO_3	10^{-7}	[4]
468	O_2^+ + NO_3^- → O_2 + NO_3	1.3x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
469	O_2^+ + $NO_3H_2O^-$ → O_2 + NO_3 + H_2O	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
470	O_4^+ + O^- → O + O_2 + O_2	10^{-7}	[4]
471	O_4^+ + O^- → O_2 + O_3	4x10^{-7}	[4]
472	O_4^+ + O_2^- → O + O + O_2 + O_2	2x10^{-6}	[4]
473	O_4^+ + O_2^- → O_2 + O_2 + O_2	10^{-7}	[4]
474	O_4^+ + O_3^- → O + O_2 + O_2 + O_2	10^{-7}	[4]
475	O_4^+ + O_3^- → O_2 + O_2 + O_3	10^{-7}	[4]
476	O_4^+ + NO^- → O_2 + O_2 + NO	10^{-7}	[4]
477	O_4^+ + NO_2^- → O_2 + O_2 + NO_2	10^{-7}	[4]
478	O_4^+ + NO_3^- → O_2 + O_2 + NO_3	10^{-7}	[4]
479	O_4^+ + $NO_3H_2O^-$ → O_2 + O_2 + NO_3 + H_2O	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
480	N^+ + O^- → O + N	2.6x10^{-7} $(T_{gas}/300)^{(-0.5)}$	[4]
481	N^+ + O_2^- → O_2 + N	4x10^{-7}	[4]

482	$N^+ + O_3^- \rightarrow O_3 + N$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
483	$N^+ + NO^- \rightarrow N + NO$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
484	$N^+ + NO_2^- \rightarrow N + NO_2$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
485	$N^+ + NO_3^- \rightarrow N + NO_3$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
486	$NO^+ + O^- \rightarrow O + O + N$	10^{-7}	[4]
487	$NO^+ + O^- \rightarrow O + NO$	4.9x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
488	$NO^+ + O_2^- \rightarrow O + O_2 + N$	10^{-7}	[4]
489	$NO^+ + O_2^- \rightarrow O_2 + NO$	6x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
490	$NO^+ + O_3^- \rightarrow O + O_3 + N$	10^{-7}	[4]
491	$NO^+ + O_3^- \rightarrow O_3 + NO$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
492	$NO^+ + NO^- \rightarrow O + N + NO$	10^{-7}	[4]
493	$NO^+ + NO^- \rightarrow NO + NO$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
494	$NO^+ + NO_2^- \rightarrow O + N + NO_2$	10^{-7}	[4]
495	$NO^+ + NO_2^- \rightarrow NO + NO_2$	10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
496	$NO^+ + NO_3^- \rightarrow O + N + NO_3$	10^{-7}	[4]
497	$NO^+ + NO_3^- \rightarrow NO + NO_3$	9x10^{-8} (T_{gas}/300)$^{(-0.5)}$	[4]
498	$NO^+ + NO_3H_2O^- \rightarrow NO + NO_3 + H_2O$	10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
499	$N_2^+ + O^- \rightarrow O + N + N$	10^{-7}	[4]
500	$N_2^+ + O^- \rightarrow O + N_2$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
501	$N_2^+ + O_2^- \rightarrow O_2 + N + N$	10^{-7}	[4]
502	$N_2^+ + O_2^- \rightarrow O_2 + N_2$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
503	$N_2^+ + O_3^- \rightarrow O_3 + N + N$	10^{-7}	[4]
504	$N_2^+ + O_3^- \rightarrow O_3 + N_2$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
505	$N_2^+ + NO^- \rightarrow N + N + NO$	10^{-7}	[4]
506	$N_2^+ + NO^- \rightarrow N_2 + NO$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
507	$N_2^+ + NO_2^- \rightarrow N + N + NO_2$	10^{-7}	[4]
508	$N_2^+ + NO_2^- \rightarrow N_2 + NO_2$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
509	$N_2^+ + NO_3^- \rightarrow N + N + NO_3$	10^{-7}	[4]
510	$N_2^+ + NO_3^- \rightarrow N_2 + NO_3$	2.7x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[4]
511	$N_4^+ + O^- \rightarrow O + N_2 + N_2$	10^{-7}	[4]
512	$N_4^+ + O_2^- \rightarrow O_2 + N_2 + N_2$	10^{-7}	[4]
513	$N_4^+ + O_3^- \rightarrow O_3 + N_2 + N_2$	10^{-7}	[4]
514	$N_4^+ + NO^- \rightarrow N_2 + N_2 + NO$	10^{-7}	[4]
515	$N_4^+ + NO_2^- \rightarrow N_2 + N_2 + NO_2$	10^{-7}	[4]
516	$N_4^+ + NO_3^- \rightarrow N_2 + N_2 + NO_3$	10^{-7}	[4]
517	$H_2O^+ + O^- \rightarrow O + H_2O$	4x10^{-7}	[4]
518	$H_2O^+ + O_2^- \rightarrow O_2 + H_2O$	4x10^{-7}	[4]
519	$O_2^+ + O_3^- \rightarrow O_2 + O + O_2$	10^{-7}	[3]
520	$O_2^+ + O_3^- \rightarrow O_2 + O + O + O$	10^{-7}	[3]
521	$O_2^+ + NO_2^- \rightarrow NO + O + O_2$	10^{-7}	[3]
522	$O_2^+ + NO_2^- \rightarrow NO + O + O + O$	10^{-7}	[3]
523	$O_2^+ + NO_3^- \rightarrow NO_2 + O + O_2$	10^{-7}	[3]
524	$O_2^+ + NO_3^- \rightarrow NO_2 + O + O + O$	10^{-7}	[3]
525	$O_2^- + NO_2^+ \rightarrow O_2 + NO_2$	2x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[3]
526	$NO^+ + NO_3^- \rightarrow NO_2 + O + N + O$	10^{-7}	[3]
527	$H_2O^+ + O_3^- \rightarrow H_2O + O_3$	2x10^{-7} (T_{gas}/300)$^{(-0.5)}$	[3]
528	$H_3O^+ + O^- \rightarrow H_2O + H + O$	10^{-7}	[3]
529	$H_3O^+ + O_2^- \rightarrow H_2O + H + O_2$	10^{-7}	[3]
530	$H_3O^+ + O_2^- \rightarrow H_2O + H + O + O$	10^{-7}	[3]
	Ion-ion reactions (three-body)		
531	$O^+ + O^- + O_2 \rightarrow O + O + O_2$	2x10^{-25} (T_{gas}/300)$^{(-2.5)}$	[4]
532	$O^+ + O^- + O_2 \rightarrow O_2 + O_2$	2x10^{-25} (T_{gas}/300)$^{(-2.5)}$	[4]
533	$O^+ + O^- + N_2 \rightarrow O + O + N_2$	2x10^{-25} (T_{gas}/300)$^{(-2.5)}$	[4]
534	$O^+ + O^- + N_2 \rightarrow O_2 + N_2$	2x10^{-25} (T_{gas}/300)$^{(-2.5)}$	[4]
535	$O^+ + O_2^- + O_2 \rightarrow O + O_2 + O_2$	2x10^{-25} (T_{gas}/300)$^{(-2.5)}$	[4]

536	$O^+ + O_2^- + O_2 \rightarrow O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
537	$O^+ + O_2^- + N_2 \rightarrow O + O_2 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
538	$O^+ + O_2^- + N_2 \rightarrow O_3 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
539	$O^+ + O_3^- + O_2 \rightarrow O + O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
540	$O_2^+ + O^- + O_2 \rightarrow O + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
541	$O_2^+ + O^- + O_2 \rightarrow O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
542	$O_2^+ + O^- + N_2 \rightarrow O_2 + O + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
543	$O_2^+ + O^- + N_2 \rightarrow O_3 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
544	$O_2^+ + O_2^- + O_2 \rightarrow O_2 + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
545	$O_2^+ + O_2^- + N_2 \rightarrow O_2 + O_2 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
546	$O_2^+ + O_3^- + O_2 \rightarrow O_2 + O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
547	$O_2^+ + O_3^- + N_2 \rightarrow O + O_2 + O_2 + N_2$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
548	$O_2^+ + O_2H_2O^- + N_2 \rightarrow O_2 + O_2 + N_2 + H_2O$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
549	$O_4^+ + O^- + O_2 \rightarrow O + O_2 + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
550	$O_4^+ + O^- + N_2 \rightarrow O + O_2 + O_2 + N_2$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
551	$O_4^+ + O_2^- + O_2 \rightarrow O_2 + O_2 + O_2 + O_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
552	$O_4^+ + O_2^- + N_2 \rightarrow O_2 + O_2 + O_2 + N_2$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
553	$O_4^+ + O_3^- + O_2 \rightarrow O_2 + O_2 + O_2 + O_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
554	$O_4^+ + O_3^- + N_2 \rightarrow O_2 + O_2 + O_3 + N_2$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
555	$N^+ + O^- + O_2 \rightarrow O + O_2 + N$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
556	$N^+ + O^- + O_2 \rightarrow O_2 + NO$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
557	$N^+ + O^- + N_2 \rightarrow O + N_2 + N$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
558	$N^+ + O^- + N_2 \rightarrow N_2 + NO$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
559	$N^+ + O_2^- + O_2 \rightarrow O_2 + O_2 + N$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
560	$N^+ + O_2^- + O_2 \rightarrow O_2 + NO_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
561	$N^+ + O_2^- + N_2 \rightarrow O_2 + N_2 + N$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
562	$N^+ + O_2^- + N_2 \rightarrow N_2 + NO_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
563	$NO^+ + O^- + O_2 \rightarrow O + O_2 + NO$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
564	$NO^+ + O^- + O_2 \rightarrow O_2 + NO_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
565	$NO^+ + O^- + N_2 \rightarrow O + N_2 + NO$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
566	$NO^+ + O^- + N_2 \rightarrow N_2 + NO_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
567	$NO^+ + O_2^- + O_2 \rightarrow O_2 + O_2 + NO$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
568	$NO^+ + O_2^- + O_2 \rightarrow O_2 + NO_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
569	$NO^+ + O_2^- + N_2 \rightarrow O_2 + N_2 + NO$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
570	$NO^+ + O_2^- + N_2 \rightarrow N_2 + NO_3$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
571	$NO^+ + O_3^- + N_2 \rightarrow O + O_2 + N_2 + NO$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
572	$O_2H_2O^- + NO^+ + He \rightarrow He + O_2 + NO + H_2O$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
573	$NO^+ + O_2H_2O^- + N_2 \rightarrow O_2 + N_2 + NO + H_2O$	$10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
574	$N_2^+ + O^- + O_2 \rightarrow O + O_2 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
575	$N_2^+ + O^- + O_2 \rightarrow O_2 + N_2O$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
576	$N_2^+ + O^- + N_2 \rightarrow O + N_2 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
577	$N_2^+ + O^- + N_2 \rightarrow N_2 + N_2O$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
578	$N_2^+ + O_2^- + O_2 \rightarrow O_2 + O_2 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
579	$N_2^+ + O_2^- + N_2 \rightarrow O_2 + N_2 + N_2$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[4]
580	$O^+ + O^- + M \rightarrow O + O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
581	$O^+ + O_2^- + M \rightarrow O + O_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
582	$O^+ + O_2^- + M \rightarrow O_3 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
583	$O^+ + O_3^- + M \rightarrow O_3 + O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
584	$O^- + O_2^+ + M \rightarrow O + O_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
585	$O^- + O_4^+ + M \rightarrow O + O_2 + O_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
586	$O_2^+ + O_2^- + M \rightarrow O_2 + O_2 + M$	$10\text{-}24 (T_{gas}/300)^{(-2.5)}$	[3]
587	$O_2^+ + O_3^- + M \rightarrow O_3 + O_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
588	$O_2^- + O_4^+ + M \rightarrow O_2 + O_2 + O_2 + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
589	$O^+ + NO_2^- + M \rightarrow NO_2 + O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
590	$O^+ + NO_3^- + M \rightarrow NO_3 + O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
591	$O^- + N^+ + M \rightarrow NO + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]

592	$O^- + N^+ + M \rightarrow N + O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
593	$O^- + N_2^+ + M \rightarrow N_2 + O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
594	$O^- + N_2^+ + M \rightarrow N_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
595	$O^- + NO^+ + M \rightarrow O + NO + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
596	$O^- + NO^+ + M \rightarrow NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
597	$O^- + NO_2^+ + M \rightarrow O + NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
598	$O^- + NO_2^+ + M \rightarrow NO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
599	$O_2^+ + NO_2^- + M \rightarrow NO_2 + O_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
600	$O_2^+ + NO_3^- + M \rightarrow NO_3 + O_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
601	$O_2^- + N^+ + M \rightarrow O_2 + N + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
602	$O_2^- + N^+ + M \rightarrow NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
603	$O_2^- + NO^+ + M \rightarrow NO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
604	$O_2^- + NO^+ + M \rightarrow O_2 + NO + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
605	$O_2^- + NO_2^+ + M \rightarrow O_2 + NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
606	$O_3^- + N^+ + M \rightarrow O_3 + N + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
607	$O_3^- + N_2^+ + M \rightarrow O_3 + N_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
608	$O_3^- + NO^+ + M \rightarrow O_3 + NO + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
609	$O_3^- + NO_2^+ + M \rightarrow O_3 + NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
610	$O_4^+ + NO_2^- + M \rightarrow NO_2 + O_2 + O_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
611	$O_4^+ + NO_3^- + M \rightarrow NO_3 + O_2 + O_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
612	$N^+ + NO_2^- + M \rightarrow NO_2 + N + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
613	$N^+ + NO_3^- + M \rightarrow NO_3 + N + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
614	$N_2^+ + NO_2^- + M \rightarrow NO_2 + N_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
615	$N_2^+ + NO_3^- + M \rightarrow NO_3 + N_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
616	$NO^+ + NO_2^- + M \rightarrow NO + NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
617	$NO^+ + NO_3^- + M \rightarrow NO + NO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
618	$NO_2^+ + NO_2^- + M \rightarrow NO_2 + NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
619	$NO_2^+ + NO_3^- + M \rightarrow NO_2 + NO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
620	$H_2O^+ + O^- + M \rightarrow H_2O + O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
621	$H_2O^+ + O^- + M \rightarrow H_2O_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
622	$H_2O^+ + O_3^- + M \rightarrow H_2O + O_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
623	$H_2O^+ + NO_2^- + M \rightarrow H_2O + NO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
624	$H_2O^+ + NO_3^- + M \rightarrow H_2O + NO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
625	$H^- + O_2^+ + M \rightarrow HO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
626	$H^- + NO^+ + M \rightarrow HNO + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
627	$H^- + NO_2^+ + M \rightarrow HNO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
628	$H^+ + NO_3^- + M \rightarrow HNO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
629	$OH^+ + NO_3^- + M \rightarrow HNO_4 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
630	$OH^+ + OH^- + M \rightarrow H_2O_2 + M$	$1.6x10^{-9}$	[3]
631	$OH^- + O^+ + M \rightarrow HO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
632	$OH^- + O_2^+ + M \rightarrow OH + O_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
633	$OH^- + NO^+ + M \rightarrow HNO_2 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
634	$OH^- + NO_2^+ + M \rightarrow HNO_3 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
635	$OH^- + H_2O^+ + M \rightarrow OH + H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
636	$O_3^- + O_4^+ + M \rightarrow O_2 + O_2 + O_2 + O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
637	$NO_2^+ + NO_3^- + M \rightarrow N_2O_5 + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-0.5)}$	[3]
	Ion-ion reactions (water clusters)		
638	$H_2O_3^+ + O^- \rightarrow O_2 + O + H_2O$	10^{-7}	[3]
639	$H_2O_3^+ + O^- + M \rightarrow O_2 + O + H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3,4,5]
640	$H_2O_3^+ + O_2^- \rightarrow O_2 + O_2 + H_2O$	10^{-7}	[3]
641	$H_2O_3^+ + O_2^- \rightarrow O_2 + O + O + H_2O$	10^{-7}	[3]
642	$H_2O_3^+ + O_2^- + M \rightarrow O_2 + O_2 + H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3,4,5]
643	$H_2O_3^+ + O_3^- \rightarrow O_3 + O_2 + H_2O$	10^{-7}	[3]
644	$H_2O_3^+ + O_3^- \rightarrow O_2 + O_2 + O + H_2O$	10^{-7}	[3]
645	$H_2O_3^+ + O_3^- + M \rightarrow O_3 + O_2 + H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]

646	$H_2O_3^+ + NO_2^- \rightarrow NO_2 + O_2 + H_2O$	10^{-7}	[3]
647	$H_2O_3^+ + NO_2^- \rightarrow NO + O + O_2 + H_2O$	10^{-7}	[3]
648	$H_2O_3^+ + NO_2^- + M \rightarrow NO_2 + O_2 + H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
649	$H_2O_3^+ + NO_3^- \rightarrow NO_3 + O_2 + H_2O$	10^{-7}	[3]
650	$H_2O_3^+ + NO_3^- \rightarrow NO_2 + O + O_2 + H_2O$	10^{-7}	[3]
651	$H_2O_3^+ + NO_3^- + M \rightarrow NO_3 + O_2 + H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
652	$H_2O_3^+ + H^- \rightarrow O_2 + H + H_2O$	10^{-7}	[3]
653	$H_2O_3^+ + H^- + M \rightarrow O_2 + H + H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
654	$H_2O_3^+ + OH^- \rightarrow OH + O_2 + H_2O$	10^{-7}	[3]
655	$H_2O_3^+ + OH^- \rightarrow O_2 + O + H + H_2O$	10^{-7}	[3]
656	$H_2O_3^+ + OH^- + M \rightarrow OH + O_2 + H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
657	$H_2O_3^+ + O_2H_2O^- \rightarrow O_2 + O_2 + 2H_2O$	10^{-7}	[3]
658	$H_2O_3^+ + O_2H_2O^- + M \rightarrow O_2 + O_2 + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
659	$H_4O_2^+ + O^- \rightarrow O + 2H_2O$	10^{-7}	[3]
660	$H_4O_2^+ + O^- + M \rightarrow O + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
661	$H_4O_2^+ + O_2^- \rightarrow O_2 + 2H_2O$	10^{-7}	[3]
662	$H_4O_2^+ + O_2^- \rightarrow O + O + 2H_2O$	10^{-7}	[3]
663	$H_4O_2^+ + O_2^- + M \rightarrow O_2 + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
664	$H_4O_2^+ + O_3^- \rightarrow O_3 + 2H_2O$	10^{-7}	[3]
665	$H_4O_2^+ + O_3^- \rightarrow O_2 + O + 2H_2O$	10^{-7}	[3]
666	$H_4O_2^+ + O_3^- + M \rightarrow O_3 + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
667	$H_4O_2^+ + NO_2^- \rightarrow NO_2 + 2H_2O$	10^{-7}	[3]
668	$H_4O_2^+ + NO_2^- \rightarrow NO + O + 2H_2O$	10^{-7}	[3]
669	$H_4O_2^+ + NO_2^- + M \rightarrow NO_2 + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
670	$H_4O_2^+ + NO_3^- \rightarrow NO_3 + 2H_2O$	10^{-7}	[3]
671	$H_4O_2^+ + NO_3^- \rightarrow NO_2 + O + 2H_2O$	10^{-7}	[3]
672	$H_4O_2^+ + NO_3^- + M \rightarrow NO_3 + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
673	$H_4O_2^+ + H^- \rightarrow H + 2H_2O$	10^{-7}	[3]
674	$H_4O_2^+ + H^- + M \rightarrow H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
675	$H_4O_2^+ + OH^- \rightarrow OH + 2H_2O$	10^{-7}	[3]
676	$H_4O_2^+ + OH^- \rightarrow O + H + 2H_2O$	10^{-7}	[3]
677	$H_4O_2^+ + OH^- + M \rightarrow OH + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
678	$(H_2O)_2H^+ + O^- \rightarrow O + H + 2H_2O$	10^{-7}	[3]
679	$(H_2O)_2H^+ + O^- + M \rightarrow O + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
680	$(H_2O)_2H^+ + O_2^- \rightarrow O_2 + H + 2H_2O$	10^{-7}	[3]
681	$(H_2O)_2H^+ + O_2^- \rightarrow O + O + H + 2H_2O$	10^{-7}	[3]
682	$(H_2O)_2H^+ + O_2^- + M \rightarrow O_2 + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
683	$(H_2O)_2H^+ + O_3^- \rightarrow O_3 + H + 2H_2O$	10^{-7}	[3]
684	$(H_2O)_2H^+ + O_3^- \rightarrow O_2 + O + H + 2H_2O$	10^{-7}	[3]
685	$(H_2O)_2H^+ + O_3^- + M \rightarrow O_3 + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
686	$(H_2O)_2H^+ + NO_2^- \rightarrow NO_2 + H + 2H_2O$	10^{-7}	[3]
687	$(H_2O)_2H^+ + NO_2^- \rightarrow NO + O + H + 2H_2O$	10^{-7}	[3]
688	$(H_2O)_2H^+ + NO_2^- + M \rightarrow NO_2 + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
689	$(H_2O)_2H^+ + NO_3^- \rightarrow NO_3 + H + 2H_2O$	10^{-7}	[3]
690	$(H_2O)_2H^+ + NO_3^- \rightarrow NO_2 + O + H + 2H_2O$	10^{-7}	[3]
691	$(H_2O)_2H^+ + NO_3^- + M \rightarrow NO_3 + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
692	$(H_2O)_2H^+ + H^- \rightarrow H + H + 2H_2O$	10^{-7}	[3]
693	$(H_2O)_2H^+ + H^- + M \rightarrow H + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
694	$(H_2O)_2H^+ + OH^- \rightarrow OH + H + 2H_2O$	10^{-7}	[3]
695	$(H_2O)_2H^+ + OH^- \rightarrow O + H + H + 2H_2O$	10^{-7}	[3]
696	$(H_2O)_2H^+ + OH^- + M \rightarrow OH + H + 2H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
697	$(H_2O)_2H^+ + O_2H_2O^- \rightarrow O + OH + 3H_2O$	10^{-7}	[3]
698	$(H_2O)_2H^+ + O_2H_2O^- + M \rightarrow O + OH + 3H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
699	$(H_2O)_3H^+ + O^- \rightarrow O + H + 3H_2O$	10^{-7}	[3]
700	$(H_2O)_3H^+ + O^- + M \rightarrow O + H + 3H_2O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
701	$(H_2O)_3H^+ + O_2^- \rightarrow O_2 + H + 3H_2O$	10^{-7}	[3]

702	$(H_2O)_3H^+ + O_2^- \rightarrow O + O + H + 3H_2O$	10^{-7}	[3]
703	$(H_2O)_3H^+ + O_2^- + M \rightarrow O_2 + H + 3H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
704	$(H_2O)_3H^+ + O_3^- \rightarrow O_3 + H + 3H_2O$	10^{-7}	[3]
705	$(H_2O)_3H^+ + O_3^- \rightarrow O_2 + O + H + 3H_2O$	10^{-7}	[3]
706	$(H_2O)_3H^+ + O_3^- + M \rightarrow O_3 + H + 3H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
707	$(H_2O)_3H^+ + NO_2^- \rightarrow NO_2 + H + 3H_2O$	10^{-7}	[3]
708	$(H_2O)_3H^+ + NO_2^- \rightarrow NO + O + H + 3H_2O$	10^{-7}	[3]
709	$(H_2O)_3H^+ + NO_2^- + M \rightarrow NO_2 + H + 3H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
710	$(H_2O)_3H^+ + NO_3^- \rightarrow NO_3 + H + 3H_2O$	10^{-7}	[3]
711	$(H_2O)_3H^+ + NO_3^- \rightarrow NO_2 + O + H + 3H_2O$	10^{-7}	[3]
712	$(H_2O)_3H^+ + NO_3^- + M \rightarrow NO_3 + H + 3H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
713	$(H_2O)_3H^+ + H^- \rightarrow H + H + 3H_2O$	10^{-7}	[3]
714	$(H_2O)_3H^+ + H^- + M \rightarrow H + H + 3H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
715	$(H_2O)_3H^+ + OH^- \rightarrow OH + H + 3H_2O$	10^{-7}	[3]
716	$(H_2O)_3H^+ + OH^- \rightarrow O + H + H + 3H_2O$	10^{-7}	[3]
717	$(H_2O)_3H^+ + OH^- + M \rightarrow OH + H + 3H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
718	$(H_2O)_3H^+ + O_2H_2O^- \rightarrow O + OH + 4H_2O$	10^{-7}	[3]
719	$(H_2O)_3H^+ + O_2H_2O^- + M \rightarrow O + OH + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
720	$(H_2O)_4H^+ + O^- \rightarrow O + H + 4H_2O$	10^{-7}	[3]
721	$(H_2O)_4H^+ + O^- + M \rightarrow O + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
722	$(H_2O)_4H^+ + O_2^- \rightarrow O_2 + H + 4H_2O$	10^{-7}	[3]
723	$(H_2O)_4H^+ + O_2^- \rightarrow O + O + H + 4H_2O$	10^{-7}	[3]
724	$(H_2O)_4H^+ + O_2^- + M \rightarrow O_2 + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
725	$(H_2O)_4H^+ + O_3^- \rightarrow O_3 + H + 4H_2O$	10^{-7}	[3]
726	$(H_2O)_4H^+ + O_3^- \rightarrow O_2 + O + H + 4H_2O$	10^{-7}	[3]
727	$(H_2O)_4H^+ + O_3^- + M \rightarrow O_3 + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
728	$(H_2O)_4H^+ + NO_2^- \rightarrow NO_2 + H + 4H_2O$	10^{-7}	[3]
729	$(H_2O)_4H^+ + NO_2^- \rightarrow NO + O + H + 4H_2O$	10^{-7}	[3]
730	$(H_2O)_4H^+ + NO_2^- + M \rightarrow NO_2 + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
731	$(H_2O)_4H^+ + NO_3^- \rightarrow NO_3 + H + 4H_2O$	10^{-7}	[3]
732	$(H_2O)_4H^+ + NO_3^- \rightarrow NO_2 + O + H + 4H_2O$	10^{-7}	[3]
733	$(H_2O)_4H^+ + NO_3^- + M \rightarrow NO_3 + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
734	$(H_2O)_4H^+ + H^- \rightarrow H + H + 4H_2O$	10^{-7}	[3]
735	$(H_2O)_4H^+ + H^- + M \rightarrow H + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
736	$(H_2O)_4H^+ + OH^- \rightarrow OH + H + 4H_2O$	10^{-7}	[3]
737	$(H_2O)_4H^+ + OH^- \rightarrow O + H + H + 4H_2O$	10^{-7}	[3]
738	$(H_2O)_4H^+ + OH^- + M \rightarrow OH + H + 4H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
739	$(H_2O)_4H^+ + O_2H_2O^- \rightarrow O + OH + 5H_2O$	10^{-7}	[3]
740	$(H_2O)_4H^+ + O_2H_2O^- + M \rightarrow O + OH + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
741	$(H_2O)_5H^+ + O^- \rightarrow O + H + 5H_2O$	10^{-7}	[3]
742	$(H_2O)_5H^+ + O^- + M \rightarrow O + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
743	$(H_2O)_5H^+ + O_2^- \rightarrow O_2 + H + 5H_2O$	10^{-7}	[3]
744	$(H_2O)_5H^+ + O_2^- \rightarrow O + O + H + 5H_2O$	10^{-7}	[3]
745	$(H_2O)_5H^+ + O_2^- + M \rightarrow O_2 + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
746	$(H_2O)_5H^+ + O_3^- \rightarrow O_3 + H + 5H_2O$	10^{-7}	[3]
747	$(H_2O)_5H^+ + O_3^- \rightarrow O_2 + O + H + 5H_2O$	10^{-7}	[3]
748	$(H_2O)_5H^+ + O_3^- + M \rightarrow O_3 + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
749	$(H_2O)_5H^+ + NO_2^- \rightarrow NO_2 + H + 5H_2O$	10^{-7}	[3]
750	$(H_2O)_5H^+ + NO_2^- \rightarrow NO + O + H + 5H_2O$	10^{-7}	[3]
751	$(H_2O)_5H^+ + NO_2^- + M \rightarrow NO_2 + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
752	$(H_2O)_5H^+ + NO_3^- \rightarrow NO_3 + H + 5H_2O$	10^{-7}	[3]
753	$(H_2O)_5H^+ + NO_3^- \rightarrow NO_2 + O + H + 5H_2O$	10^{-7}	[3]
754	$(H_2O)_5H^+ + NO_3^- + M \rightarrow NO_3 + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
755	$(H_2O)_5H^+ + H^- \rightarrow H + H + 5H_2O$	10^{-7}	[3]
756	$(H_2O)_5H^+ + H^- + M \rightarrow H + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
757	$(H_2O)_5H^+ + OH^- \rightarrow OH + H + 5H_2O$	10^{-7}	[3]

758	$(H_2O)_5H^+ + OH^- \rightarrow O + H + H + 5H_2O$	10^{-7}	[3]
759	$(H_2O)_5H^+ + OH^- + M \rightarrow OH + H + 5H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
760	$(H_2O)_5H^+ + O_2H_2O^- \rightarrow O + OH + 6H_2O$	10^{-7}	[3]
761	$(H_2O)_5H^+ + O_2H_2O^- + M \rightarrow O + OH + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
762	$(H_2O)_6H^+ + O^- \rightarrow O + H + 6H_2O$	10^{-7}	[3]
763	$(H_2O)_6H^+ + O^- + M \rightarrow O + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
764	$(H_2O)_6H^+ + O_2^- \rightarrow O_2 + H + 6H_2O$	10^{-7}	[3]
765	$(H_2O)_6H^+ + O_2^- \rightarrow O + O + H + 6H_2O$	10^{-7}	[3]
766	$(H_2O)_6H^+ + O_2^- + M \rightarrow O_2 + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
767	$(H_2O)_6H^+ + O_3^- \rightarrow O_3 + H + 6H_2O$	10^{-7}	[3]
768	$(H_2O)_6H^+ + O_3^- \rightarrow O_2 + O + H + 6H_2O$	10^{-7}	[3]
769	$(H_2O)_6H^+ + O_3^- + M \rightarrow O_3 + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
770	$(H_2O)_6H^+ + NO_2^- \rightarrow NO_2 + H + 6H_2O$	10^{-7}	[3]
771	$(H_2O)_6H^+ + NO_2^- \rightarrow NO + O + H + 6H_2O$	10^{-7}	[3]
772	$(H_2O)_6H^+ + NO_2^- + M \rightarrow NO_2 + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
773	$(H_2O)_6H^+ + NO_3^- \rightarrow NO_3 + H + 6H_2O$	10^{-7}	[3]
774	$(H_2O)_6H^+ + NO_3^- \rightarrow NO_2 + O + H + 6H_2O$	10^{-7}	[3]
775	$(H_2O)_6H^+ + NO_3^- + M \rightarrow NO_3 + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
776	$(H_2O)_6H^+ + H^- \rightarrow H + H + 6H_2O$	10^{-7}	[3]
777	$(H_2O)_6H^+ + H^- + M \rightarrow H + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
778	$(H_2O)_6H^+ + OH^- \rightarrow OH + H + 6H_2O$	10^{-7}	[3]
779	$(H_2O)_6H^+ + OH^- \rightarrow O + H + H + 6H_2O$	10^{-7}	[3]
780	$(H_2O)_6H^+ + OH^- + M \rightarrow OH + H + 6H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
781	$(H_2O)_6H^+ + O_2H_2O^- \rightarrow O + OH + 7H_2O$	10^{-7}	[3]
782	$(H_2O)_6H^+ + O_2H_2O^- + M \rightarrow O + OH + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
783	$(H_2O)_7H^+ + O^- \rightarrow O + H + 7H_2O$	10^{-7}	[3]
784	$(H_2O)_7H^+ + O^- + M \rightarrow O + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
785	$(H_2O)_7H^+ + O_2^- \rightarrow O_2 + H + 7H_2O$	10^{-7}	[3]
786	$(H_2O)_7H^+ + O_2^- \rightarrow O + O + H + 7H_2O$	10^{-7}	[3]
787	$(H_2O)_7H^+ + O_2^- + M \rightarrow O_2 + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
788	$(H_2O)_7H^+ + O_3^- \rightarrow O_3 + H + 7H_2O$	10^{-7}	[3]
789	$(H_2O)_7H^+ + O_3^- \rightarrow O_2 + O + H + 7H_2O$	10^{-7}	[3]
790	$(H_2O)_7H^+ + O_3^- + M \rightarrow O_3 + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
791	$(H_2O)_7H^+ + NO_2^- \rightarrow NO_2 + H + 7H_2O$	10^{-7}	[3]
792	$(H_2O)_7H^+ + NO_2^- \rightarrow NO + O + H + 7H_2O$	10^{-7}	[3]
793	$(H_2O)_7H^+ + NO_2^- + M \rightarrow NO_2 + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
794	$(H_2O)_7H^+ + NO_3^- \rightarrow NO_3 + H + 7H_2O$	10^{-7}	[3]
795	$(H_2O)_7H^+ + NO_3^- \rightarrow NO_2 + O + H + 7H_2O$	10^{-7}	[3]
796	$(H_2O)_7H^+ + NO_3^- + M \rightarrow NO_3 + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
797	$(H_2O)_7H^+ + H^- \rightarrow H + H + 7H_2O$	10^{-7}	[3]
798	$(H_2O)_7H^+ + H^- + M \rightarrow H + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
799	$(H_2O)_7H^+ + OH^- \rightarrow OH + H + 7H_2O$	10^{-7}	[3]
800	$(H_2O)_7H^+ + OH^- \rightarrow O + H + H + 7H_2O$	10^{-7}	[3]
801	$(H_2O)_7H^+ + OH^- + M \rightarrow OH + H + 7H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
802	$(H_2O)_7H^+ + O_2H_2O^- \rightarrow O + OH + 8H_2O$	10^{-7}	[3]
803	$(H_2O)_7H^+ + O_2H_2O^- + M \rightarrow O + OH + 8H_2O + M$	$2x10^{-25}$ $(T_{gas}/300)^{(-2.5)}$	[3]
804	$H_2O_3^+ + NO_3H_2O^- \rightarrow O_2 + NO_3 + 2H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
805	$H_4O_2^+ + NO_3H_2O^- \rightarrow NO_3 + 3H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
806	$H_4O_2^+ + NO_3H_2O^- \rightarrow NO_3 + 2H_2O + OH + H$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
807	$(H_2O)_2H^+ + NO_3H_2O^- \rightarrow NO_3 + H + 3H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
808	$(H_2O)_3H^+ + NO_3H_2O^- \rightarrow NO_3 + H + 4H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
809	$(H_2O)_4H^+ + NO_3H_2O^- \rightarrow NO_3 + H + 5H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
810	$(H_2O)_5H^+ + NO_3H_2O^- \rightarrow NO_3 + H + 6H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
811	$(H_2O)_6H^+ + NO_3H_2O^- \rightarrow NO_3 + H + 7H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]
812	$(H_2O)_7H^+ + NO_3H_2O^- \rightarrow NO_3 + H + 8H_2O$	10^{-7} $(T_{gas}/300)^{(-0.5)}$	[3]

	Negative ion-neutral reactions		
813	$O^- + O \rightarrow O_2 + e$	$2x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
814	$O^- + O(^1D) \rightarrow O + O + e$	10^{-10}	[4]
815	$O^- + O(^1S) \rightarrow O + O + e$	10^{-10}	[4]
816	$O^- + O_2 \rightarrow O + O_2^-$	$1.5x10^{-12}$	[4]
817	$O^- + O_2 \rightarrow O_3 + e$	$5x10^{-15}$ $(T_{gas}/300)^{(0.5)}$	[4]
818	$O^- + O_2(^1D) \rightarrow O + O_2^-$	$3x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
819	$O^- + O_2(^1D) \rightarrow O_3 + e$	$3x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
820	$O^- + O_2(^1S) \rightarrow O + O_2 + e$	$6.9x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
821	$O^- + O_3 \rightarrow O + O_3^-$	$1.99x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
822	$O^- + O_3 \rightarrow O_2 + O_2 + e$	$3.01x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
823	$O^- + N \rightarrow NO + e$	$2.6x10^{-10}$	[4]
824	$O^- + N(^2D) \rightarrow O + N + e$	10^{-10}	[4]
825	$O^- + N(^2P) \rightarrow O + N + e$	10^{-10}	[4]
826	$O^- + NO \rightarrow NO_2 + e$	$2.5x10^{-10}$ $(T_{gas}/300)^{(-0.8)}$	[4]
827	$O^- + NO_2 \rightarrow O + NO_2^-$	10^{-9}	[4]
828	$O^- + NO_3 \rightarrow O + NO_3^-$	$5x10^{-10}$	[4]
829	$O^- + N_2 \rightarrow N_2O + e$	10^{-14}	[4]
830	$O^- + N_2O \rightarrow NO + NO^-$	$2x10^{-10}$	[4]
831	$O^- + H \rightarrow OH + e$	$5x10^{-10}$	[4]
832	$O_2^- + O \rightarrow O_2 + O^-$	$1.5x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
833	$O_2^- + O \rightarrow O_3 + e$	$1.5x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
834	$O_2^- + O(^1D) \rightarrow O + O + O^-$	10^{-10}	[4]
835	$O_2^- + O(^1D) \rightarrow O + O_2 + e$	10^{-10}	[4]
836	$O_2^- + O(^1S) \rightarrow O + O + O^-$	10^{-10}	[4]
837	$O_2^- + O(^1S) \rightarrow O + O_2 + e$	10^{-10}	[4]
838	$O_2^- + O_2 \rightarrow O + O_3^-$	$3.5x10^{-15}$	[4]
839	$O_2^- + O_2 \rightarrow O_2 + O_2 + e$	$2.7x10^{-10}$ $(T_{gas}/300)^{(0.5)}$ exp(-5590/T_{gas})	[4]
840	$O_2^- + O_2(^1D) \rightarrow O_2 + O_2 + e$	$2x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
841	$O_2^- + O_2(^1S) \rightarrow O_2 + O_2 + e$	$3.6x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
842	$O_2^- + O_3 \rightarrow O_2 + O_3^-$	$6x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
843	$O_2^- + N \rightarrow NO + O^-$	10^{-10}	[4]
844	$O_2^- + N \rightarrow NO_2 + e$	$4x10^{-10}$	[4]
845	$O_2^- + N(^2D) \rightarrow O_2 + N + e$	10^{-10}	[4]
846	$O_2^- + N(^2P) \rightarrow O_2 + N + e$	10^{-10}	[4]
847	$O_2^- + NO_2 \rightarrow O_2 + NO_2^-$	$7x10^{-10}$	[4]
848	$O_2^- + NO_3 \rightarrow O_2 + NO_3^-$	$5x10^{-10}$	[4]
849	$O_2^- + N_2 \rightarrow O_2 + N_2 + e$	$1.9x10^{-12}$ $(T_{gas}/300)^{(1.5)}$ exp(-4990/T_{gas})	[4]
850	$O_2^- + N_2O \rightarrow NO + NO_2^-$	$2x10^{-14}$	[4]
851	$O_2^- + N_2O \rightarrow N_2 + O_3^-$	10^{-12}	[4]
852	$O_2^- + H_2O \rightarrow O_2 + H_2O + e$	$5x10^{-9}$ exp(-5000/T_{gas})	[4]
853	$O_3^- + O \rightarrow O_2 + O_2 + e$	$3x10^{-10}$	[4]
854	$O_3^- + O \rightarrow O_2 + O_2^-$	$2.5x10^{-10}$ $(T_{gas}/300)^{(0.5)}$	[4]
855	$O_3^- + O(^1D) \rightarrow O + O + O_2^-$	10^{-10}	[4]
856	$O_3^- + O(^1D) \rightarrow O + O_2 + O^-$	10^{-10}	[4]
857	$O_3^- + O(^1D) \rightarrow O + O_3 + e$	10^{-10}	[4]
858	$O_3^- + O(^1S) \rightarrow O + O + O_2^-$	10^{-10}	[4]
859	$O_3^- + O(^1S) \rightarrow O + O_2 + O^-$	10^{-10}	[4]
860	$O_3^- + O(^1S) \rightarrow O + O_3 + e$	10^{-10}	[4]
861	$O_3^- + O_2(^1D) \rightarrow O_2 + O_2 + O^-$	10^{-10}	[4]
862	$O_3^- + O_2(^1S) \rightarrow O_2 + O_2 + O^-$	10^{-10}	[4]
863	$O_3^- + O_3 \rightarrow O_2 + O_2 + O_2 + e$	10^{-10}	[4]
864	$O_3^- + N(^2D) \rightarrow O + N + O_2^-$	10^{-10}	[4]
865	$O_3^- + N(^2D) \rightarrow O_2 + N + O^-$	10^{-10}	[4]

866	$O_3^- + N(^2D) \rightarrow O_3 + N + e$	10^{-10}	[4]
867	$O_3^- + N(^2P) \rightarrow O + N + O_2^-$	10^{-10}	[4]
868	$O_3^- + N(^2P) \rightarrow O_2 + N + O^-$	10^{-10}	[4]
869	$O_3^- + N(^2P) \rightarrow O_3 + N + e$	10^{-10}	[4]
870	$O_3^- + NO \rightarrow O + NO_3^-$	10^{-11}	[4]
871	$O_3^- + NO \rightarrow O_2 + NO_2^-$	$2.6x10^{-11}$	[4]
872	$O_3^- + NO_2 \rightarrow O_2 + NO_3^-$	$2.8x10^{-10}$	[4]
873	$O_3^- + NO_2 \rightarrow O_3 + NO_2^-$	$2.8x10^{-10}$	[4]
874	$O_3^- + NO_3 \rightarrow O_3 + NO_3^-$	$5x10^{-10}$	[4]
875	$O_3^- + N_2O \rightarrow O_2 + O_2 + N_2 + e$	$2x10^{-14}$	[4]
876	$O_3^- + N_2O \rightarrow O_2 + N_2 + O_2^-$	$2x10^{-14}$	[4]
877	$O_3^- + N_2O \rightarrow NO + NO_3^-$	$2x10^{-14}$	[4]
878	$NO^- + O_2 \rightarrow NO + O_2^-$	$5x10^{-10}$	[4]
879	$NO^- + NO \rightarrow NO + NO + e$	$5x10^{-12}$	[4]
880	$NO^- + NO_2 \rightarrow NO + NO_2^-$	$7.4x10^{-10}$	[4]
881	$NO^- + N_2O \rightarrow NO + N_2O + e$	$5.1x10^{-12}$	[4]
882	$NO^- + N_2O \rightarrow N_2 + NO_2^-$	$2.8x10^{-14}$	[4]
883	$NO_2^- + O \rightarrow NO_3 + e$	10^{-12}	[4]
884	$NO_2^- + O_3 \rightarrow O_2 + NO_3^-$	$1.2x10^{-10}$	[4]
885	$NO_2^- + O_3 \rightarrow NO_2 + O_3^-$	$9x10^{-11}$	[4]
886	$NO_2^- + NO_2 \rightarrow NO + NO_3^-$	$2x10^{-13}$	[4]
887	$NO_2^- + NO_3 \rightarrow NO_2 + NO_3^-$	$5x10^{-10}$	[4]
888	$NO_2^- + N_2O \rightarrow N_2 + NO_3^-$	10^{-12}	[4]
889	$NO_3^- + O \rightarrow O_2 + NO_2 + e$	10^{-11}	[4]
890	$NO_3^- + O \rightarrow O_2 + NO_2^-$	10^{-11}	[4]
891	$NO_3^- + O \rightarrow NO + O_3^-$	10^{-11}	[4]
892	$NO_3^- + O \rightarrow NO_2 + O_2^-$	10^{-11}	[4]
893	$NO_3^- + O_3 \rightarrow O_2 + O_2 + NO_2^-$	10^{-13}	[4]
894	$NO_3^- + NO \rightarrow NO_2 + NO_2^-$	10^{-12}	[4]
895	$NO_3^- + NO_3 \rightarrow O_2 + NO + NO_3^-$	$5x10^{-10}$	[4]
896	$O_2H_2O^- + O(^1D) \rightarrow O + O_2 + H_2O + e$	10^{-10}	[4]
897	$O_2H_2O^- + O(^1D) \rightarrow O + H_2O + O_2^-$	10^{-10}	[4]
898	$O_2H_2O^- + O(^1S) \rightarrow O + O_2 + H_2O + e$	10^{-10}	[4]
899	$O_2H_2O^- + O(^1S) \rightarrow O + H_2O + O_2^-$	10^{-10}	[4]
900	$O_2H_2O^- + O_2(^1D) \rightarrow O_2 + O_2 + H_2O + e$	10^{-10}	[4]
901	$O_2H_2O^- + O_2(^1D) \rightarrow O_2 + H_2O + O_2^-$	10^{-10}	[4]
902	$O_2H_2O^- + O_2(^1S) \rightarrow O_2 + O_2 + H_2O + e$	10^{-10}	[4]
903	$O_2H_2O^- + O_2(^1S) \rightarrow O_2 + H_2O + O_2^-$	10^{-10}	[4]
904	$O_2H_2O^- + O_3 \rightarrow O_2 + H_2O + O_3^-$	$2.3x10^{-10}$	[4]
905	$O_2H_2O^- + N(^2D) \rightarrow O_2 + N + H_2O + e$	10^{-10}	[4]
906	$O_2H_2O^- + N(^2D) \rightarrow N + H_2O + O_2^-$	10^{-10}	[4]
907	$O_2H_2O^- + N(^2P) \rightarrow O_2 + N + H_2O + e$	10^{-10}	[4]
908	$O_2H_2O^- + N(^2P) \rightarrow N + H_2O + O_2^-$	10^{-10}	[4]
909	$O_2H_2O^- + NO \rightarrow H_2O + NO_3^-$	$3.1x10^{-10}$	[4]
910	$O_2H_2O^- + NO_2 \rightarrow O_2 + H_2O + NO_2^-$	$9x10^{-10}$	[4]
911	$NO_2H_2O^- + O_2 \rightarrow O_2 + H_2O + NO_2^-$	$5x10^{-15}$	[4]
912	$NO_2H_2O^- + O_3 \rightarrow O_2 + NO_3H_2O^-$	10^{-11}	[4]
913	$NO_3H_2O^- + O_2 \rightarrow O_2 + H_2O + NO_3^-$	$7.5x10^{-29} (T_{gas}/300)^{(-1)}$	[4]
914	$O^- + O_2 + O_2 \rightarrow O_2 + O_3^-$	$1.1x10^{-30} (T_{gas}/300)^{(-1)}$	[4]
915	$O^- + O_2 + NO \rightarrow O_2 + NO_2^-$	10^{-29}	[4]
916	$O^- + O_2 + N_2 \rightarrow N_2 + O_3^-$	$10^{-30} (T_{gas}/300)^{(-1)}$	[4]
917	$O^- + NO + N_2 \rightarrow N_2 + NO_2^-$	10^{-29}	[4]
918	$O_2^- + O_2 + H_2O \rightarrow O_2 + O_2H_2O^-$	$3x10^{-28} (T_{gas}/300)^{(-1)}$	[4]
919	$NO_2^- + O_2 + H_2O \rightarrow O_2 + NO_2H_2O^-$	$1.6x10^{-28}$	[4]
920	$NO_2^- + NO + H_2O \rightarrow NO + NO_2H_2O^-$	$1.3x10^{-28} (T_{gas}/300)^{(-1)}$	[4]
921	$NO_2^- + N_2 + H_2O \rightarrow N_2 + NO_2H_2O^-$	$1.6x10^{-28}$	[4]

922	$NO_3^- + O_2 + H_2O \rightarrow O_2 + NO_3H_2O^-$	$7.5x10^{-29} (T_{gas}/300)^{(-1)}$	[4]
923	$NO_3^- + N_2 + H_2O \rightarrow N_2 + NO_3H_2O^-$	$7.5x10^{-29} (T_{gas}/300)^{(-1)}$	[4]
924	$O_2^- + H \rightarrow HO_2 + e$	$7x10^{-10}$	[3]
925	$NO_2^- + H \rightarrow HNO_2 + e$	$3.7x10^{-10}$	[3]
926	$NO_3^- + H \rightarrow HNO_3 + e$	$1.66x10^{-11}$	[3]
927	$O^- + H_2 \rightarrow H_2O + e$	$6.72x10^{-10}$	[3]
928	$O^- + HNO_3 \rightarrow HNO_2 + O_2^-$	$1.5x10^{-9}$	[3]
929	$O_2^- + HNO_3 \rightarrow NO_3^- + HO_2$	$2.9x10^{-9}$	[3]
930	$NO_2^- + HNO_3 \rightarrow NO_3^- + HNO_2$	$1.6x10^{-9}$	[3]
931	$O^- + H_2O \rightarrow H_2O_2 + e$	$6x10^{-13}$	[3]
932	$NO_3^- + N \rightarrow NO_2^- + NO$	$5x10^{-12}$	[3]
933	$NO_3^- + H \rightarrow NO_2^- + OH$	$1.66x10^{-11}$	[3]
934	$O^- + N_2(A) \rightarrow N_2 + O + e$	$2.2x10^{-9}$	[3]
935	$O^- + HNO_3 \rightarrow HNO_4 + e$	$1.5x10^{-9}$	[3]
936	$H^- + O_2 \rightarrow HO_2 + e$	$1.2x10^{-9}$	[3]
937	$H^- + H_2O \rightarrow OH^- + H_2$	$3.8x10^{-9}$	[3]
938	$O_2^- + N_2(A) \rightarrow O_2 + N_2 + e$	$2.1x10^{-9}$	[3]
939	$NO_2^- + N_2O_5 \rightarrow NO_3^- + NO_3 + NO$	$7x10^{-10}$	[3]
940	$H + O_2^- \rightarrow H^- + O_2$	$7x10^{-10}$	[3]
941	$OH^- + H \rightarrow H_2O + e$	$1.8x10^{-9}$	[3]
942	$O_2^- + H_2 \rightarrow H^- + HO_2$	$5x10^{-13}$	[3]
943	$O_2^- + OH \rightarrow OH^- + O_2$	10^{-10}	[3]
944	$OH^- + O \rightarrow HO_2 + e$	$4x10^{-10} (T_{gas}/300)^{(0.5)}$	[3]
945	$OH^- + N \rightarrow HNO + e$	$10^{-11} (T_{gas}/300)^{(-0.5)}$	[3]
946	$OH^- + O_3 \rightarrow O_2^- + HO_2$	$1.08x10^{-11}$	[3]
947	$OH^- + NO_2 \rightarrow NO_2^- + OH$	$1.1x10^{-9} (T_{gas}/300)^{(-0.5)}$	[3]
948	$O_2^- + M \rightarrow O_2 + e + M$	$2.7x10^{-10} (T_{gas}/300)^{(-2.5)} exp(-5590/T_{gas})$	[3]
949	$O^- + NO + M \rightarrow NO_2^- + M$	$2x10^{-29} (T_{gas}/300)^{(-2.5)}$	[3]
950	$O^- + O_2 + M \rightarrow O_3^- + M$	$1.1x10^{-30} (T_{gas}/300)^{(-1)}$	[3]
951	$H^- + M \rightarrow H + e + M$	$2.7x10^{-10} (T_{gas}/300)^{(0.5)} exp(-5590/T_{gas})$	[3]
	Positive ion-neutral reactions		
952	$O^+ + O \rightarrow O + O^+$	$10^{-9} (T_{gas}/300)^{(-0.5)}$	[4]
953	$O^+ + O_2 \rightarrow O + O_2^+$	$2x10^{-11} (T_{gas}/300)^{(-0.4)}$	[4]
954	$O^+ + O_3 \rightarrow O_2 + O_2^+$	10^{-10}	[4]
955	$O^+ + N(^2D) \rightarrow O + N^+$	$1.3x10^{-10}$	[4]
956	$O^+ + NO \rightarrow O + NO^+$	$2.4x10^{-11}$	[4]
957	$O^+ + NO \rightarrow N + O_2^+$	$3x10^{-12}$	[4]
958	$O^+ + NO_2 \rightarrow O_2 + NO^+$	$5x10^{-10}$	[4]
959	$O^+ + N_2 \rightarrow O + N_2^+$	$4.9x10^{-9}$	[4]
960	$O^+ + N_2 \rightarrow N + NO^+$	$3x10^{-12} exp(-0.00311*T_{gas})$	[4]
961	$O^+ + N_2(V_1) \rightarrow N + NO^+$	$1.3x10^{-12}$	[4]
962	$O^+ + N_2(V_2) \rightarrow N + NO^+$	$1.3x10^{-12}$	[4]
963	$O^+ + N_2(V_3) \rightarrow N + NO^+$	$1.3x10^{-12}$	[4]
964	$O^+ + N_2(V_4) \rightarrow N + NO^+$	$1.3x10^{-12}$	[4]
965	$O^+ + N_2O \rightarrow NO + NO^+$	$2.3x10^{-10}$	[4]
966	$O^+ + N_2O \rightarrow N_2 + O_2^+$	$2x10^{-11}$	[4]
967	$O^+ + OH \rightarrow H + O_2^+$	$3.6x10^{-10}$	[4]
968	$O^+ + H_2O \rightarrow O + H_2O^+$	$2.3x10^{-9}$	[4]
969	$O_2^+ + O(^1D) \rightarrow O_2(^1D) + O^+$	$10^{-12} (T_{gas}/300)^{(-0.5)}$	[4]
970	$O_2^+ + O_2 \rightarrow O_2 + O_2^+$	$10^{-9} (T_{gas}/300)^{(-0.5)}$	[4]
971	$O_2^+ + N \rightarrow O + NO^+$	$1.2x10^{-10}$	[4]
972	$O_2^+ + NO \rightarrow O_2 + NO^+$	$4.4x10^{-10}$	[4]
973	$O_2^+ + NO_2 \rightarrow O_3 + NO^+$	10^{-11}	[4]
974	$O_2^+ + N_2 \rightarrow NO + NO^+$	10^{-17}	[4]

975	$O_4^+ + O \rightarrow O_3 + O_2^+$	$3x10^{-10}$	[4]
976	$O_4^+ + O(^1D) \rightarrow O + O_2 + O_2^+$	10^{-10}	[4]
977	$O_4^+ + O(^1D) \rightarrow O_3 + O_2^+$	$3x10^{-10}$	[4]
978	$O_4^+ + O(^1S) \rightarrow O + O_2 + O_2^+$	10^{-10}	[4]
979	$O_4^+ + O(^1S) \rightarrow O_3 + O_2^+$	$3x10^{-10}$	[4]
980	$O_4^+ + O_2 \rightarrow O_2 + O_2 + O_2^+$	$3.3x10^{-16}$ $(T_{gas}/300)^{(-4)}$ exp(-5030/T_{gas})	[4]
981	$O_4^+ + O_2(^1D) \rightarrow O_2 + O_2 + O_2^+$	10^{-10}	[4]
982	$O_4^+ + O_2(^1S) \rightarrow O_2 + O_2 + O_2^+$	10^{-10}	[4]
983	$O_4^+ + N(^2D) \rightarrow O_2 + N + O_2^+$	10^{-10}	[4]
984	$O_4^+ + N(^2P) \rightarrow O_2 + N + O_2^+$	10^{-10}	[4]
985	$O_4^+ + NO \rightarrow O_2 + O_2 + NO^+$	10^{-10}	[4]
986	$O_4^+ + N_2 \rightarrow O_2 + N_2 + O_2^+$	10^{-5} $(T_{gas}/300)^{(-4.2)}$ exp(-5400/T_{gas})	[4]
987	$N^+ + O \rightarrow N + O^+$	10^{-12}	[4]
988	$N^+ + O_2 \rightarrow O + NO^+$	$2.8x10^{-10}$	[4]
989	$N^+ + O_2 \rightarrow N + O_2^+$	$2.8x10^{-10}$	[4]
990	$N^+ + O_2 \rightarrow NO + O^+$	$2.8x10^{-11}$	[4]
991	$N^+ + O_3 \rightarrow O_2 + NO^+$	$5x10^{-10}$	[4]
992	$N^+ + NO \rightarrow O + N_2^+$	$3x10^{-12}$	[4]
993	$N^+ + NO \rightarrow N + NO^+$	$8x10^{-10}$	[4]
994	$N^+ + NO \rightarrow N_2 + O^+$	10^{-12}	[4]
995	$N^+ + NO_2 \rightarrow NO + NO^+$	$5x10^{-10}$	[4]
996	$N^+ + N_2O \rightarrow N_2 + NO^+$	$5.5x10^{-10}$	[4]
997	$N^+ + OH \rightarrow H + NO^+$	$3.4x10^{-10}$	[4]
998	$N^+ + H_2O \rightarrow N + H_2O^+$	$2.6x10^{-9}$	[4]
999	$N_2^+ + O \rightarrow N + NO^+$	$1.3x10^{-10}$ $(T_{gas}/300)^{(-0.46)}$	[4]
1000	$N_2^+ + O \rightarrow N_2 + O^+$	10^{-11} $(T_{gas}/300)^{(-0.2)}$	[4]
1001	$N_2^+ + O_2 \rightarrow NO + NO^+$	10^{-17}	[4]
1002	$N_2^+ + O_2 \rightarrow N_2 + O_2^+$	$5x10^{-11}$ $(T_{gas}/300)^{(-0.8)}$	[4]
1003	$N_2^+ + O_3 \rightarrow O + N_2 + O_2^+$	10^{-10}	[4]
1004	$N_2^+ + N \rightarrow N_2 + N^+$	$2.4x10^{-15}*T_{gas}$	[4]
1005	$N_2^+ + NO \rightarrow N_2 + NO^+$	$3.3x10^{-10}$	[4]
1006	$N_2^+ + N_2O \rightarrow N + N_2 + NO^+$	$4x10^{-10}$	[4]
1007	$N_2^+ + H_2O \rightarrow N_2 + H_2O^+$	$3x10^{-9}$	[4]
1008	$N_4^+ + O \rightarrow N_2 + N_2 + O^+$	$2.5x10^{-10}$	[4]
1009	$N_4^+ + O(^1S) \rightarrow O + N_2 + N_2^+$	10^{-10}	[4]
1010	$N_4^+ + O(^1D) \rightarrow O + N_2 + N_2^+$	10^{-10}	[4]
1011	$N_4^+ + O_2 \rightarrow O_2 + N_2 + N_2^+$	$2.5x10^{-10}$	[4]
1012	$N_4^+ + O_2 \rightarrow N_2 + N_2 + O_2^+$	$4x10^{-10}$	[4]
1013	$N_4^+ + O_2(^1D) \rightarrow O_2 + N_2 + N_2^+$	10^{-10}	[4]
1014	$N_4^+ + O_2(^1S) \rightarrow O_2 + N_2 + N_2^+$	10^{-10}	[4]
1015	$N_4^+ + N \rightarrow N_2 + N_2 + N^+$	10^{-11}	[4]
1016	$N_4^+ + N(^2D) \rightarrow N + N_2 + N_2^+$	10^{-10}	[4]
1017	$N_4^+ + N(^2P) \rightarrow N + N_2 + N_2^+$	10^{-10}	[4]
1018	$N_4^+ + NO \rightarrow N_2 + N_2 + NO^+$	$4x10^{-10}$	[4]
1019	$N_4^+ + H_2O \rightarrow N_2 + N_2 + H_2O^+$	$2.4x10^{-9}$	[4]
1020	$O^+ + O + O_2 \rightarrow O_2 + O_2^+$	10^{-29} $(T_{gas}/300)^{(0.5)}$	[4]
1021	$O^+ + O + N_2 \rightarrow N_2 + O_2^+$	10^{-29}	[4]
1022	$O^+ + O_2 + N \rightarrow O_2 + NO^+$	10^{-29}	[4]
1023	$O^+ + O_2 + N_2 \rightarrow O_2 + N + NO^+$	$6x10^{-29}$ $(T_{gas}/300)^{(-2)}$	[4]
1024	$O^+ + N + N_2 \rightarrow N_2 + NO^+$	10^{-29}	[4]
1025	$O^+ + N_2 + N_2 \rightarrow N + N_2 + NO^+$	$6x10^{-29}$ $(T_{gas}/300)^{(-2)}$	[4]
1026	$O_2^+ + O_2 + O_2 \rightarrow O_2 + O_4^+$	$3.9x10^{-30}$ $(T_{gas}/300)^{(-3.2)}$	[4]
1027	$O_2^+ + O_2 + H_2O \rightarrow O_2 + H_2O_3^+$	$2.9x10^{-28}$	[4]
1028	$O_2^+ + N_2 + H_2O \rightarrow N_2 + H_2O_3^+$	$2.8x10^{-28}$ $(T_{gas}/300)^{(-2)}$	[4]

1029	$O_4^+ + N_2 + H_2O \rightarrow O_2 + N_2 + H_2O_3^+$	$1.5x10^{-28} (T_{gas}/300)^{(-2)}$	[4]
1030	$N^+ + O + O_2 \rightarrow O_2 + NO^+$	10^{-29}	[4]
1031	$N^+ + O + N_2 \rightarrow N_2 + NO^+$	10^{-29}	[4]
1032	$N^+ + O + H_2O \rightarrow H_2O + NO^+$	10^{-29}	[4]
1033	$N^+ + O_2 + N \rightarrow O_2 + N_2^+$	10^{-29}	[4]
1034	$N^+ + N + N_2 \rightarrow N_2 + N_2^+$	10^{-29}	[4]
1035	$N_2^+ + N_2 + N_2 \rightarrow N_2 + N_4^+$	$5x10^{-29} (T_{gas}/300)^{(-1)}$	[4]
1036	$H_2 + NO_2^+ \rightarrow NO^+ + H_2O$	$1.5x10^{-10}$	[3]
1037	$H_2 + H_2O^+ \rightarrow H_3O^+ + H$	$1.4x10^{-9}$	[3]
1038	$H_2O^+ + N \rightarrow NO^+ + H_2$	$2.8x10^{-11}$	[3]
1039	$N^+ + N_2 \rightarrow N + N_2^+$	$4.45x10^{-10}$	[3]
1040	$NO_2^+ + O \rightarrow NO^+ + O_2$	$8x10^{-12}$	[3]
1041	$O^+ + NO_2 \rightarrow NO_2^+ + O$	$1.6x10^{-9}$	[3]
1042	$O_2^+ + NO_2 \rightarrow NO_2^+ + O_2$	$6.6x10^{-10}$	[3]
1043	$NO_2^+ + NO \rightarrow NO_2 + NO^+$	$2.9x10^{-10}$	[3]
1044	$NO_2^+ + H \rightarrow OH + NO^+$	$1.9x10^{-10}$	[3]
1045	$N^+ + H_2O \rightarrow NO^+ + H_2$	$4x10^{-10} (T_{gas}/300)^{(0.52)}$	[3]
1046	$H_2O^+ + NO_2 \rightarrow NO_2^+ + H_2O$	$1.2x10^{-9}$	[3]
1047	$H_2^+ + O_2 \rightarrow H_2 + O_2^+$	$8x10^{-10}$	[3]
1048	$H_3^+ + O \rightarrow H_2O^+ + H$	$3.6x10^{-10}$	[3]
1049	$H_3^+ + O \rightarrow OH^+ + H_2$	$8.4x10^{-10}$	[3]
1050	$H_3^+ + H_2O \rightarrow H_3O^+ + H_2$	$5.9x10^{-9}$	[3]
1051	$N_3^+ + O_2 \rightarrow NO_2^+ + N_2$	$1.5x10^{-11}$	[3]
1052	$O_2^+ + N_2O_5 \rightarrow NO_2^+ + NO_3 + O_2$	$8.8x10^{-10}$	[3]
1053	$NO^+ + N_2O_5 \rightarrow NO_2 + NO_2 + NO_2^+$	$5.9x10^{-10}$	[3]
1054	$O^+ + H \rightarrow H^+ + O$	$5.66x10^{-10} (T_{gas}/300)^{(0.36)} exp(8.6/T_{gas})$	[3]
1055	$N^+ + H \rightarrow N + H^+$	$2x10^{-9}$	[3]
1056	$H_2^+ + H \rightarrow H_2 + H^+$	$6.39x10^{-10}$	[3]
1057	$H^+ + O \rightarrow H + O^+$	$3.04x10^{-10} (T_{gas}/300)^{(0.47)} exp(11.5/T_{gas})$	[3]
1058	$H^+ + O_2 \rightarrow H + O_2^+$	$2x10^{-9}$	[3]
1059	$H^+ + OH \rightarrow H + OH^+$	$2.1x10^{-9}$	[3]
1060	$H^+ + H_2O \rightarrow H + H_2O^+$	$6.9x10^{-9}$	[3]
1061	$O^+ + H_2 \rightarrow OH^+ + H$	$1.62x10^{-9}$	[3]
1062	$H_3O^+ + H_2 \rightarrow H_2O + H_3^+$	$5x10^{-10}$	[3]
1063	$N_2^+ + OH \rightarrow OH^+ + N_2$	$6.3x10^{-10}$	[3]
1064	$OH^+ + O \rightarrow O_2^+ + H$	$7.1x10^{-10}$	[3]
1065	$OH^+ + O_2 \rightarrow OH + O_2^+$	$3.8x10^{-10}$	[3]
1066	$OH^+ + N \rightarrow NO^+ + H$	$8.9x10^{-10}$	[3]
1067	$OH^+ + H_2O \rightarrow H_2O^+ + OH$	$1.6x10^{-9}$	[3]
1068	$OH^+ + H_2O \rightarrow H_3O^+ + O$	$1.3x10^{-9}$	[3]
1069	$O_2^+ + NH \rightarrow NO_2^+ + H$	$3.2x10^{-10}$	[3]
1070	$N^+ + N + M \rightarrow N_2^+ + M$	10^{-29}	[3]
1071	$N^+ + O + M \rightarrow NO^+ + M$	10^{-29}	[3]
1072	$O^+ + N + M \rightarrow NO^+ + M$	10^{-29}	[3]
1073	$O^+ + N_2 + M \rightarrow NO^+ + N + M$	$6x10^{-29} (T_{gas}/300)^{(-2)}$	[3]
1074	$O_2^+ + O_2 + M \rightarrow O_4^+ + M$	$2.4x10^{-30} (T_{gas}/300)^{(-3.2)}$	[3]
1075	$O_4^+ + M \rightarrow O_2^+ + O_2 + M$	$3.3x10^{-6} (T_{gas}/300)^{(-2.5)} exp(-2650/T_{gas})$	[3]
1076	$N_2^+ + N + M \rightarrow N_3^+ + M$	$9x10^{-30} (T_{gas}/300) exp(400/T_{gas})$	[3]
1077	$N_2^+ + N_2 + M \rightarrow N_4^+ + M$	$6.8x10^{-29} (T_{gas}/300)^{(-1.64)}$	[3]
1078	$N_3^+ + M \rightarrow M + N + N_2^+$	$6.6x10^{-11}$	[3]
1079	$H_2O^+ + O_2 \rightarrow H_2O + O_2^+$	$2x10^{-10}$	[4]
1080	$H_2O^+ + NO \rightarrow H_2O + NO^+$	$5.9x10^{-10}$	[4]

1081	$H_2O^+ + H_2O \rightarrow OH + H_3O^+$	$1.8x10^{-9}$	[4]
1082	$H_3O^+ + NO \rightarrow H + H_2O + NO^+$	$1.5x10^{-12}$	[4]
1083	$H_2O_3^+ + O(^1D) \rightarrow O + H_2O + O_2^+$	10^{-10}	[4]
1084	$H_2O_3^+ + O(^1S) \rightarrow O + H_2O + O_2^+$	10^{-10}	[4]
1085	$H_2O_3^+ + O_2 \rightarrow H_2O + O_4^+$	$2x10^{-10}$ exp(-2300/T_{gas})	[4]
1086	$H_2O_3^+ + O_2(^1D) \rightarrow O_2 + H_2O + O_2^+$	10^{-10}	[4]
1087	$H_2O_3^+ + O_2(^1S) \rightarrow O_2 + H_2O + O_2^+$	10^{-10}	[4]
1088	$H_2O_3^+ + N(^2D) \rightarrow N + H_2O + O_2^+$	10^{-10}	[4]
1089	$H_2O_3^+ + N(^2P) \rightarrow N + H_2O + O_2^+$	10^{-10}	[4]
1090	$H_4O_2^+ + O(^1D) \rightarrow O + OH + H_3O^+$	10^{-10}	[4]
1091	$H_4O_2^+ + O(^1S) \rightarrow O + OH + H_3O^+$	10^{-10}	[4]
1092	$H_4O_2^+ + O_2(^1D) \rightarrow O_2 + OH + H_3O^+$	10^{-10}	[4]
1093	$H_4O_2^+ + O_2(^1S) \rightarrow O_2 + OH + H_3O^+$	10^{-10}	[4]
1094	$H_4O_2^+ + N(^2D) \rightarrow N + OH + H_3O^+$	10^{-10}	[4]
1095	$H_4O_2^+ + N(^2P) \rightarrow N + OH + H_3O^+$	10^{-10}	[4]
1096	$(H_2O)_2H^+ + O(^1D) \rightarrow O + H_2O + H_3O^+$	10^{-10}	[4]
1097	$(H_2O)_2H^+ + O(^1S) \rightarrow O + H_2O + H_3O^+$	10^{-10}	[4]
1098	$(H_2O)_2H^+ + O_2(^1S) \rightarrow O_2 + H_2O + H_3O^+$	10^{-10}	[4]
1099	$(H_2O)_2H^+ + N(^2D) \rightarrow N + H_2O + H_3O^+$	10^{-10}	[4]
1100	$(H_2O)_2H^+ + N(^2P) \rightarrow N + H_2O + H_3O^+$	10^{-10}	[4]
1101	$(H_2O)_2H^+ + N_2 \rightarrow N_2 + H_2O + H_3O^+$	7x10-26	[4]
1102	$H_3O^+ + O_2 + H_2O \rightarrow O_2 + (H_2O)_2H^+$	$3.7x10^{-27}$	[4]
1103	$H_3O^+ + N_2 + H_2O \rightarrow N_2 + (H_2O)_2H^+$	$3.4x10^{-27}$ $(T_{gas}/300)^{(-4)}$	[4]
1104	$H_3O^+ + H_2O + H_2O \rightarrow H_2O + (H_2O)_2H^+$	$7x10^{-28}$	[4]
1105	$O_2^+ + H_2O + M \rightarrow H_2O_3^+ + M$	$2.6x10^{-28}$ $(T_{gas}/300)^{(-4)}$	[5]
1106	$O_4^+ + H_2O \rightarrow H_2O_3^+ + O_2$	$1.7x10^{-9}$	[3]
1107	$H_2O_3^+ + M \rightarrow O_2^+ + H_2O + M$	$9.72x10^4$ $(T_{gas})^{(-4)}$ exp(-7610/T_{gas})	[5]
1108	$H_2O_3^+ + H_2O \rightarrow H_3O^+ + OH + O_2$	$3x10^{-10}$	[3]
1109	$H_2O_3^+ + H_2O \rightarrow O_2 + H_4O_2^+$	10^{-9}	[3]
1110	$H_2O_3^+ + NO \rightarrow O_2 + H_2O + NO^+$	$5.3x10^{-10}$	[3]
1111	$H_4O_2^+ + H_2O \rightarrow OH + (H_2O)_2H^+$	$1.4x10^{-9}$	[3]
1112	$H_3O^+ + H_2O + M \rightarrow (H_2O)_2H^+ + M$	$3.2x10^{-27}$ $(T_{gas}/300)^{(-4)}$	[5]
1113	$(H_2O)_2H^+ + M \rightarrow H_3O^+ + H_2O + M$	$1.05x10^8$ $(T_{gas})^{(-4)}$ exp(-16430/T_{gas})	[5]
1114	$(H_2O)_2H^+ + H_2O + M \rightarrow (H_2O)_3H^+ + M$	$7.4x10^{-27}$ $(T_{gas}/300)^{(-7.5)}$	[5]
1115	$(H_2O)_3H^+ + M \rightarrow (H_2O)_2H^+ + H_2O + M$	$8x10^{16}$ $(T_{gas})^{(-7.5)}$ exp(-10030/T_{gas})	[5]
1116	$(H_2O)_3H^+ + H_2O + M \rightarrow (H_2O)_4H^+ + M$	$2.5x10^{-27}$ $(T_{gas}/300)^{(-8.1)}$	[5]
1117	$(H_2O)_4H^+ + M \rightarrow (H_2O)_3H^+ + H_2O + M$	$2x10^{18}$ $(T_{gas})^{(-8.1)}$ exp(-8360/T_{gas})	[5]
1118	$(H_2O)_4H^+ + H_2O + M \rightarrow (H_2O)_5H^+ + M$	$3.3x10^{-28}$ $(T_{gas}/300)^{(-14)}$	[5]
1119	$(H_2O)_5H^+ + M \rightarrow (H_2O)_4H^+ + H_2O + M$	6.3x1030 $(T_{gas})^{(-14)}$ exp(-5750/T_{gas})	[5]
1120	$(H_2O)_5H^+ + H_2O + M \rightarrow (H_2O)_6H^+ + M$	$4x10^{-29}$ $(T_{gas}/300)^{(-15.3)}$	[5]
1121	$(H_2O)_6H^+ + M \rightarrow (H_2O)_5H^+ + H_2O + M$	$2.62x10^{33}$ $(T_{gas})^{(-15.3)}$ exp(-5000/T_{gas})	[5]
1122	$(H_2O)_6H^+ + H_2O + M \rightarrow (H_2O)_7H^+ + M$	$4.5x10^{-30}$ $(T_{gas}/300)^{(-16)}$	[5]
1123	$(H_2O)_7H^+ + M \rightarrow (H_2O)_6H^+ + H_2O + M$	$2x10^{35}$ $(T_{gas})^{(-16)}$ exp(-5000/T_{gas})	[5]
	Neutral-neutral reactions		
1124	$O + O \rightarrow O_2$	$9.26x10^{-34}$ $(T_{gas}/300)^{(-1)}$	[4]
1125	$O + O(^1D) \rightarrow O + O$	$8x10^{-12}$	[4]
1126	$O + O(^1S) \rightarrow O + O$	$3.33x10^{-11}$ exp(-300/T_{gas})	[4]
1127	$O + O(^1S) \rightarrow O + O(^1D)$	$1.67x10^{-11}$ exp(-300/T_{gas})	[4]
1128	$O + O_2(^1D) \rightarrow O + O_2$	$2x10^{-16}$	[4]

1129	$O + O_2(^1S) \rightarrow O + O_2$	$8x10^{-15}$ $(T_{gas}/300)^{(0.5)}$	[4]
1130	$O + O_2(^1S) \rightarrow O + O_2(^1D)$	$7.2x10^{-14}$ $(T_{gas}/300)^{(0.5)}$	[4]
1131	$O + O_2(^1S) \rightarrow O(^1D) + O_2$	$5.97x10^{-14}$	[4]
1132	$O + O_2(V_1) \rightarrow O + O_2$	10^{-14} $(T_{gas}/300)^{(0.5)}$	[4]
1133	$O + O_2(V_2) \rightarrow O + O_2$	10^{-14} $(T_{gas}/300)^{(0.5)}$	[4]
1134	$O + O_2(V_3) \rightarrow O + O_2$	10^{-14} $(T_{gas}/300)^{(0.5)}$	[4]
1135	$O + O_2(V_4) \rightarrow O + O_2$	10^{-14} $(T_{gas}/300)^{(0.5)}$	[4]
1136	$O + O_3 \rightarrow O + O + O_2$	$9.4x10^{-11}$ exp(-11400/T_{gas})	[4]
1137	$O + O_3 \rightarrow O_2 + O_2$	$8x10^{-12}$ exp(-2060/T_{gas})	[4]
1138	$O + N(^2D) \rightarrow O(^1D) + N$	$4x10^{-13}$	[4]
1139	$O + N(^2D) \rightarrow NO^+ + e$	10^{-12}	[4]
1140	$O + N(^2P) \rightarrow NO^+ + e$	10^{-12}	[4]
1141	$O + NO \rightarrow O_2 + N$	$8.93x10^{-13}$ $(T_{gas}/300)$ exp(-19494.5/T_{gas})	[4]
1142	$O + NO_2 \rightarrow O_2 + NO$	$6.5x10^{-12}$ exp(120/T_{gas})	[4]
1143	$O + NO_3 \rightarrow O + O + NO_2$	$3.1x10^{-4}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1144	$O + NO_3 \rightarrow O + O_2 + NO$	$7.44x10^{-4}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1145	$O + NO_3 \rightarrow O_2 + NO_2$	10^{-11}	[4]
1146	$O + N_2 \rightarrow N + NO$	$1.06x10^{-6}$*$T_{gas}^{(-1)}$ exp(-38400/T_{gas})	[4]
1147	$O + H \rightarrow OH$	$4.36x10^{-32}$ $(T_{gas}/300)^{(-1)}$	[4]
1148	$O + OH \rightarrow O_2 + H$	$2.2x10^{-11}$ exp(120/T_{gas})	[4]
1149	$O + H_2O \rightarrow OH + OH$	$2.5x10^{-14}$*$T_{gas}^{(1.14)}$ exp(-8624.0/T_{gas})	[4]
1150	$O(^1D) + O_2 \rightarrow O + O_2$	$4.8x10^{-12}$ exp(-67.0/T_{gas})	[4]
1151	$O(^1D) + O_2 \rightarrow O + O_2(^1D)$	$2.6x10^{-11}$ exp(-67.0/T_{gas})	[4]
1152	$O(^1D) + O_2 \rightarrow O + O_2(^1S)$	$2.56x10^{-11}$ exp(-67.0/T_{gas})	[4]
1153	$O(^1D) + O_3 \rightarrow O + O + O_2$	$1.2x10^{-10}$	[4]
1154	$O(^1D) + O_3 \rightarrow O + O_3$	$2.41x10^{-10}$	[4]
1155	$O(^1D) + O_3 \rightarrow O_2 + O_2$	$1.2x10^{-10}$	[4]
1156	$O(^1D) + NO \rightarrow O + NO$	$1.5x10^{-10}$	[4]
1157	$O(^1D) + NO \rightarrow O_2 + N$	$1.7x10^{-10}$	[4]
1158	$O(^1D) + NO_2 \rightarrow O_2 + NO$	$3x10^{-10}$	[4]
1159	$O(^1D) + N_2 \rightarrow O + N_2$	$1.8x10^{-11}$ exp(107.0/T_{gas})	[4]
1160	$O(^1D) + N_2O \rightarrow O + O + N_2$	$7x10^{-11}$	[4]
1161	$O(^1D) + N_2O \rightarrow O + N_2O$	10^{-12}	[4]
1162	$O(^1D) + N_2O \rightarrow O_2 + N_2$	$4.4x10^{-11}$	[4]
1163	$O(^1D) + N_2O \rightarrow NO + NO$	$7x10^{-11}$	[4]
1164	$O(^1D) + H \rightarrow OH$	$4.36x10^{-32}$ $(T_{gas}/300)^{(-1)}$	[4]
1165	$O(^1D) + OH \rightarrow O_2 + H$	$6x10^{-11}$ $(T_{gas}/300)^{(-0.186)}$ exp(-154.0/T_{gas})	[4]
1166	$O(^1D) + H_2O \rightarrow O + H_2O$	$1.2x10^{-11}$	[4]
1167	$O(^1D) + H_2O \rightarrow OH + OH$	$1.62x10^{-10}$ exp(-64.95/T_{gas})	[4]
1168	$O(^1S) + O_2 \rightarrow O + O_2$	$1.6x10^{-12}$ exp(-850/T_{gas})	[4]
1169	$O(^1S) + O_2 \rightarrow O(^1D) + O_2$	$3.2x10^{-12}$ exp(-850/T_{gas})	[4]
1170	$O(^1S) + O_2(^1D) \rightarrow O + O + O$	$3.2x10^{-11}$	[4]
1171	$O(^1S) + O_2(^1D) \rightarrow O + O_2$	$1.1x10^{-10}$	[4]
1172	$O(^1S) + O_2(^1D) \rightarrow O + O_2(^1S)$	$1.3x10^{-10}$	[4]
1173	$O(^1S) + O_2(^1D) \rightarrow O(^1D) + O_2$	$3.6x10^{-11}$	[4]
1174	$O(^1S) + O_2(^1D) \rightarrow O(^1D) + O_2(^1S)$	$2.9x10^{-11}$	[4]
1175	$O(^1S) + O_3 \rightarrow O + O + O_2$	10^{-10}	[4]
1176	$O(^1S) + O_3 \rightarrow O + O(^1D) + O_2$	$2.9x10^{-10}$	[4]
1177	$O(^1S) + O_3 \rightarrow O_2 + O_2$	$5.8x10^{-10}$	[4]
1178	$O(^1S) + NO \rightarrow O + NO$	$2.9x10^{-10}$	[4]

1179	$O(^1S) + NO \rightarrow O(^1D) + NO$	$5x10^{-10}$	[4]
1180	$O(^1S) + NO_2 \rightarrow O + O + NO$	10^{-10}	[4]
1181	$O(^1S) + N_2 \rightarrow O + N_2$	$5x10^{-17}$	[4]
1182	$O(^1S) + N_2O \rightarrow O + O + N_2$	10^{-10}	[4]
1183	$O(^1S) + N_2O \rightarrow O + N_2O$	$9.3x10^{-12}$	[4]
1184	$O(^1S) + N_2O \rightarrow O(^1D) + N_2O$	$3.1x10^{-12}$	[4]
1185	$O(^1S) + H \rightarrow OH$	$4.36x10^{-32} (T_{gas}/300)^{(-1)}$	[4]
1186	$O(^1S) + OH \rightarrow O_2 + H$	$6x10^{-11} (T_{gas}/300)^{(-0.186)} exp(-154.0/T_{gas})$	[4]
1187	$O(^1S) + H_2O \rightarrow O + H_2O$	$3x10^{-10}$	[4]
1188	$O(^1S) + H_2O \rightarrow O(^1D) + H_2O$	$1.5x10^{-10}$	[4]
1189	$O(^1S) + H_2O \rightarrow OH + OH$	$5x10^{-10}$	[4]
1190	$O_2 + O_2 \rightarrow O + O + O_2$	$6.6x10^{-9} (T_{gas}/300)^{(-1.5)} exp(-59000/T_{gas})$	[4]
1191	$O_2 + O_2(^1D) \rightarrow O + O_3$	$2.94x10^{-21} (T_{gas}/300)^{(0.5)}$	[4]
1192	$O_2 + O_2(^1D) \rightarrow O_2 + O_2$	$3x10^{-18} exp(-200/T_{gas})$	[4]
1193	$O_2 + O_2(^1S) \rightarrow O_2 + O_2$	$4x10^{-18} (T_{gas}/300)^{(0.5)}$	[4]
1194	$O_2 + O_2(^1S) \rightarrow O_2 + O_2(^1D)$	$3.6x10^{-17} (T_{gas}/300)^{(0.5)}$	[4]
1195	$O_2 + O_2(V_1) \rightarrow O + O + O_2$	$6.6x10^{-9} (T_{gas}/300)^{(-1.5)} exp(-56760/T_{gas})$	[4]
1196	$O_2 + O_2(V_2) \rightarrow O + O + O_2$	$6.6x10^{-9} (T_{gas}/300)^{(-1.5)} exp(-54520/T_{gas})$	[4]
1197	$O_2 + O_2(V_3) \rightarrow O + O + O_2$	$6.6x10^{-9} (T_{gas}/300)^{(-1.5)} exp(-52281.0/T_{gas})$	[4]
1198	$O_2 + O_2(V_4) \rightarrow O + O + O_2$	$6.6x10^{-9} (T_{gas}/300)^{(-1.5)} exp(-50041.0/T_{gas})$	[4]
1199	$O_2 + O_2(V_1) \rightarrow O_2 + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
1200	$O_2 + O_2(V_2) \rightarrow O_2 + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
1201	$O_2 + O_2(V_3) \rightarrow O_2 + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
1202	$O_2 + O_2(V_4) \rightarrow O_2 + O_2$	$10^{-14} (T_{gas}/300)^{(0.5)}$	[4]
1203	$O_2 + O_3 \rightarrow O + O_2 + O_2$	$1.6x10^{-9} exp(-11400/T_{gas})$	[4]
1204	$O_2 + N(^2D) \rightarrow O + NO$	$1.5x10^{-12} (T_{gas}/300)^{(0.5)}$	[4]
1205	$O_2 + N(^2D) \rightarrow O(^1D) + NO$	$6x10^{-12} (T_{gas}/300)^{(0.5)}$	[4]
1206	$O_2 + N(^2P) \rightarrow O + NO$	$2.6x10^{-12}$	[4]
1207	$O_2 + N(^2P) \rightarrow O(^1D) + NO$	$2x10^{-12}$	[4]
1208	$O_2 + N(^2P) \rightarrow O(^1S) + NO$	$2x10^{-12}$	[4]
1209	$O_2 + NO_2 \rightarrow O + O_2 + NO$	$5.3x10^{-6} (T_{gas}/300)^{(-2)} exp(-36180/T_{gas})$	[4]
1210	$O_2 + NO_3 \rightarrow O + O_2 + NO_2$	$3.1x10^{-5} (T_{gas}/300)^{(-2)} exp(-25000/T_{gas})$	[4]
1211	$O_2 + NO_3 \rightarrow O_2 + O_2 + NO$	$6.2x10^{-5} (T_{gas}/300)^{(-2)} exp(-25000/T_{gas})$	[4]
1212	$O_2 + H \rightarrow O + OH$	$3.7x10^{-10} exp(-8455.0/T_{gas})$	[4]
1213	$O_2(^1D) + O_2(^1D) \rightarrow O_2 + O_2$	$9x10^{-17} exp(-560/T_{gas})$	[4]
1214	$O_2(^1D) + O_2(^1D) \rightarrow O_2 + O_2(^1S)$	$9x10^{-17} exp(-560/T_{gas})$	[4]
1215	$O_2(^1D) + O_3 \rightarrow O + O_2 + O_2$	$5.2x10^{-11} exp(-2840/T_{gas})$	[4]
1216	$O_2(^1D) + N \rightarrow O + NO$	$2x10^{-14} exp(-600/T_{gas})$	[4]
1217	$O_2(^1D) + NO \rightarrow O + NO_2$	$4.88x10^{-18}$	[4]
1218	$O_2(^1D) + N_2 \rightarrow O_2 + N_2$	$3x10^{-21}$	[4]
1219	$O_2(^1D) + H \rightarrow O + OH$	$1.83x10^{-13} exp(-1550/T_{gas})$	[4]
1220	$O_2(^1D) + H_2O \rightarrow O_2 + H_2O$	$1.5x10^{-17}$	[4]
1221	$O_2(^1S) + O_2(^1S) \rightarrow O_2 + O_2(^1D)$	$3.6x10^{-17} (T_{gas}/300)^{(0.5)}$	[4]
1222	$O_2(^1S) + O_3 \rightarrow O + O_2 + O_2$	$7.33x10^{-12} (T_{gas}/300)^{(0.5)}$	[4]
1223	$O_2(^1S) + O_3 \rightarrow O + O_2(^1D) + O_2(^1D)$	$1.8x10^{-11}$	[4]
1224	$O_2(^1S) + O_3 \rightarrow O_2 + O_3$	$7.33x10^{-12} (T_{gas}/300)^{(0.5)}$	[4]
1225	$O_2(^1S) + O_3 \rightarrow O_2(^1D) + O_3$	$7.33x10^{-12} (T_{gas}/300)^{(0.5)}$	[4]

1226	$O_2(^1S) + NO \rightarrow O_2(^1D) + NO$	$4x10^{-14}$	[4]
1227	$O_2(^1S) + N_2 \rightarrow O_2 + N_2$	$2x10^{-15}$	[4]
1228	$O_2(^1S) + N_2 \rightarrow O_2(^1D) + N_2$	$2.1x10^{-15}$	[4]
1229	$O_2(^1S) + H_2O \rightarrow O_2 + H_2O$	$4x10^{-12}$	[4]
1230	$O_2(^1S) + H_2O \rightarrow O_2(^1D) + H_2O$	$2.3x10^{-12}$	[4]
1231	$O_3 + O_3 \rightarrow O + O_2 + O_3$	$1.6x10^{-9}$ exp(-11400/T_{gas})	[4]
1232	$O_3 + N(^2D) \rightarrow O + O_2 + N$	10^{-10}	[4]
1233	$O_3 + N(^2D) \rightarrow O_2 + NO$	10^{-10}	[4]
1234	$O_3 + N(^2P) \rightarrow O + O_2 + N$	10^{-10}	[4]
1235	$O_3 + NO \rightarrow O_2 + NO_2$	$2x10^{-12}$ exp(-1400/T_{gas})	[4]
1236	$O_3 + NO_2 \rightarrow O_2 + NO_3$	$1.2x10^{-13}$ exp(-2450/T_{gas})	[4]
1237	$O_3 + N_2 \rightarrow O + O_2 + N_2$	$1.6x10^{-9}$ exp(-11400/T_{gas})	[4]
1238	$O_3 + H \rightarrow O_2 + OH$	$2.71x10^{-11}$ $(T_{gas}/300)^{(0.75)}$	[4]
1239	$O_3 + H_2O \rightarrow O + O_2 + H_2O$	$1.6x10^{-9}$ exp(-11400/T_{gas})	[4]
1240	$N + O_2 \rightarrow O + NO$	$1.5x10^{-11}$ exp(-3600/T_{gas})	[4]
1241	$N + O_3 \rightarrow O_2 + NO$	$2x10^{-16}$	[4]
1242	$N + N(^2P) \rightarrow N + N(^2D)$	$1.8x10^{-12}$	[4]
1243	$N + NO \rightarrow O + N_2$	$8.2x10^{-11}$ exp(-410/T_{gas})	[4]
1244	$N + NO_2 \rightarrow O + O + N_2$	$9.1x10^{-13}$	[4]
1245	$N + NO_2 \rightarrow O + N_2O$	$1.66x10^{-12}$ exp(220/T_{gas})	[4]
1246	$N + NO_2 \rightarrow O_2 + N_2$	$7x10^{-13}$	[4]
1247	$N + NO_2 \rightarrow NO + NO$	$1.33x10^{-12}$ exp(220/T_{gas})	[4]
1248	$N + NO_3 \rightarrow O + N + NO_2$	$3.1x10^{-4}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1249	$N + NO_3 \rightarrow O_2 + N + NO$	$7.44x10^{-4}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1250	$N + NO_3 \rightarrow NO + NO_2$	$3x10^{-12}$	[4]
1251	$N + OH \rightarrow NO + H$	$4.7x10^{-11}$	[4]
1252	$N(^2D) + N(^2P) \rightarrow N_2^+ + e$	10^{-12}	[4]
1253	$N(^2D) + NO \rightarrow O + N_2$	$1.8x10^{-10}$	[4]
1254	$N(^2D) + NO \rightarrow O(^1D) + N_2$	$4.5x10^{-11}$	[4]
1255	$N(^2D) + NO \rightarrow O(^1S) + N_2$	$4.5x10^{-11}$	[4]
1256	$N(^2D) + NO \rightarrow N_2O$	$6x10^{-11}$	[4]
1257	$N(^2D) + N_2 \rightarrow N + N_2$	$6x10^{-15}$	[4]
1258	$N(^2D) + N_2O \rightarrow O + N + N_2$	10^{-10}	[4]
1259	$N(^2D) + N_2O \rightarrow N_2 + NO$	$3x10^{-12}$	[4]
1260	$N(^2P) + NO \rightarrow O + N_2$	$3x10^{-11}$	[4]
1261	$N(^2P) + NO_2 \rightarrow O + N + NO$	10^{-10}	[4]
1262	$N(^2P) + N_2 \rightarrow N + N_2$	$2x10^{-18}$	[4]
1263	$N(^2P) + N_2 \rightarrow N(^2D) + N_2$	$2x10^{-18}$	[4]
1264	$N(^2P) + N_2O \rightarrow O + N + N_2$	10^{-10}	[4]
1265	$NO + NO_2 \rightarrow O + NO + NO$	$5.3x10^{-5}$ $(T_{gas}/300)^{(-2)}$ exp(-36180/T_{gas})	[4]
1266	$NO + NO_3 \rightarrow O + NO + NO_2$	$3.1x10^{-5}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1267	$NO + NO_3 \rightarrow O_2 + NO + NO$	$6.2x10^{-5}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1268	$NO + NO_3 \rightarrow NO_2 + NO_2$	$1.8x10^{-11}$ exp(110/T_{gas})	[4]
1269	$NO_2 + NO_2 \rightarrow O + NO + NO_2$	$4x10^{-5}$ $(T_{gas}/300)^{(-2)}$ exp(-36180/T_{gas})	[4]
1270	$NO_2 + NO_3 \rightarrow O_2 + NO + NO_2$	$2x10^{-13}$ exp(-1600/T_{gas})	[4]
1271	$NO_2 + H \rightarrow NO + OH$	$4x10^{-10}$ exp(-340/T_{gas})	[4]
1272	$NO_3 + NO_3 \rightarrow O_2 + NO_2 + NO_2$	$8.5x10^{-13}$ exp(-2450/T_{gas})	[4]
1273	$NO_3 + H \rightarrow NO_2 + OH$	$5.8x10^{-10}$ exp(-750/T_{gas})	[4]
1274	$N_2 + N_2 \rightarrow N + N + N_2$	$3.5x10^{-9}$ $(T_{gas}/300)^{(-1.6)}$ exp(-113000/T_{gas})	[4]

1275	$N_2 + N_2(V_1) \rightarrow N + N + N_2$	$3.5x10^{-9}$ $(T_{gas}/300)^{(-1.6)}$ exp(-109648.0/T_{gas})	[4]
1276	$N_2 + N_2(V_2) \rightarrow N + N + N_2$	$3.5x10^{-9}$ $(T_{gas}/300)^{(-1.6)}$ exp(-106297.0/T_{gas})	[4]
1277	$N_2 + N_2(V_3) \rightarrow N + N + N_2$	$3.5x10^{-9}$ $(T_{gas}/300)^{(-1.6)}$ exp(-102946.0/T_{gas})	[4]
1278	$N_2 + N_2(V_4) \rightarrow N + N + N_2$	$3.5x10^{-9}$ $(T_{gas}/300)^{(-1.6)}$ exp(-99595.0/T_{gas})	[4]
1279	$N_2 + N_2(V_1) \rightarrow N_2 + N_2$	$3.5x10^{-21}$	[4]
1280	$N_2 + N_2(V_2) \rightarrow N_2 + N_2(V_1)$	$1.5x10^{-20}$	[4]
1281	$N_2 + N_2(V_3) \rightarrow N_2 + N_2(V_2)$	$1.5x10^{-20}$	[4]
1282	$N_2 + N_2(V_4) \rightarrow N_2 + N_2(V_3)$	$2.5x10^{-20}$	[4]
1283	$N_2(V_1) + N_2(V_1) \rightarrow N_2 + N_2(V_2)$	$3x10^{-14}$	[4]
1284	$N_2(V_1) + N_2(V_2) \rightarrow N_2 + N_2(V_3)$	$4x10^{-14}$	[4]
1285	$N_2(V_1) + N_2(V_3) \rightarrow N_2 + N_2(V_4)$	$5x10^{-14}$	[4]
1286	$N_2 + NO_2 \rightarrow O + N_2 + NO$	$6.8x10^{-6}$ $(T_{gas}/300)^{(-2)}$ exp(-36180/T_{gas})	[4]
1287	$N_2 + NO_3 \rightarrow O + N_2 + NO_2$	$3.1x10^{-5}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1288	$N_2 + NO_3 \rightarrow O_2 + N_2 + NO$	$6.2x10^{-5}$ $(T_{gas}/300)^{(-2)}$ exp(-25000/T_{gas})	[4]
1289	$H + OH \rightarrow H_2O$	$6.87x10^{-31}$ $(T_{gas}/300)^{(-2)}$	[4]
1290	$OH + OH \rightarrow O + H_2O$	$4.2x10^{-12}$ exp(-240/T_{gas})	[4]
1291	$O + O + O \rightarrow O + O_2$	$9.21x10^{-34}$ $(T_{gas}/300)^{(-0.63)}$	[4]
1292	$O + O + O \rightarrow O + O_2(^1D)$	$6.93x10^{-35}$ $(T_{gas}/300)^{(-0.63)}$	[4]
1293	$O + O + O_2 \rightarrow O + O_3$	$3.4x10^{-34}$ $(T_{gas}/300)^{(-1.2)}$	[4]
1294	$O + O + O_2 \rightarrow O_2 + O_2$	$2.56x10^{-34}$ $(T_{gas}/300)^{(-0.63)}$	[4]
1295	$O + O + O_2 \rightarrow O_2 + O_2(^1D)$	$1.93x10^{-35}$ $(T_{gas}/300)^{(-0.63)}$	[4]
1296	$O + O + O_2(^1D) \rightarrow O_2 + O_2(^1D)$	$7.4x10^{-33}$	[4]
1297	$O + O + N \rightarrow O_2 + N$	$3.2x10^{-33}$ $(T_{gas}/300)^{(-0.41)}$	[4]
1298	$O + O + N_2 \rightarrow O_2 + N_2$	$6.49x10^{-35}$ exp(1039.0/T_{gas})	[4]
1299	$O + O + H_2O \rightarrow O_2 + H_2O$	$1.7x10^{-32}$ $(T_{gas}/300)^{(-1)}$	[4]
1300	$O + O_2 + O_2 \rightarrow O_2 + O_3$	$6x10^{-34}$ $(T_{gas}/300)^{(-2.8)}$	[4]
1301	$O + O_2 + O_2(^1D) \rightarrow O + O_2 + O_2$	10^{-32}	[4]
1302	$O + O_2 + O_3 \rightarrow O_3 + O_3$	$2.3x10^{-35}$ exp(-1057.0/T_{gas})	[4]
1303	$O + O_2 + N \rightarrow O_2 + NO$	$1.76x10^{-31}$ $(T_{gas})^{(-0.5)}$	[4]
1304	$O + O_2 + NO \rightarrow O_2 + NO_2$	$6.34x10^{-32}$ $(T_{gas}/300)^{(-1.8)}$	[4]
1305	$O + O_2 + NO_2 \rightarrow O_2 + NO_3$	$8.08x10^{-33}$ $(1000/T_{gas})^{(2.0)}$	[4]
1306	$O + O_2 + N_2 \rightarrow O_3 + N_2$	$6.4x10^{-35}$ exp(-663/T_{gas})	[4]
1307	$O + N + N_2 \rightarrow N_2 + NO$	$1.76x10^{-31}$ $(T_{gas})^{(-0.5)}$	[4]
1308	$O + N + H_2O \rightarrow NO + H_2O$	$1.76x10^{-31}$ $(T_{gas})^{(-0.5)}$	[4]
1309	$O + NO + NO \rightarrow NO + NO_2$	$6.34x10^{-32}$ $(T_{gas}/300)^{(-1.8)}$	[4]
1310	$O + NO + NO_2 \rightarrow NO_2 + NO_2$	$6.34x10^{-32}$ $(T_{gas}/300)^{(-1.8)}$	[4]
1311	$O + NO + N_2O \rightarrow NO_2 + N_2O$	$6.34x10^{-32}$ $(T_{gas}/300)^{(-1.8)}$	[4]
1312	$O + N_2 + NO \rightarrow N_2 + NO_2$	$9x10^{-32}$ $(T_{gas}/300)^{(-1.5)}$	[4]
1313	$O + N_2 + NO_2 \rightarrow N_2 + NO_3$	$9x10^{-32}$ $(T_{gas}/300)^{(-2)}$	[4]
1314	$O + H + H_2O \rightarrow OH + H_2O$	$2.76x10^{-32}$ $(T_{gas}/300)^{(-1)}$	[4]
1315	$O(^1D) + N_2 + N_2 \rightarrow N_2 + N_2O$	$9x10^{-37}$	[4]
1316	$O_2 + O_2(^1D) + O_2(^1D) \rightarrow O_3 + O_3$	10^{-31}	[4]
1317	$O_2 + N + N \rightarrow O_2 + N_2$	$3.9x10^{-33}$	[4]
1318	$O_2 + NO + NO \rightarrow NO_2 + NO_2$	$3.3x10^{-39}$ exp(530/T_{gas})	[4]
1319	$O_2 + H + OH \rightarrow O_2 + H_2O$	$6.88x10^{-31}$ $(T_{gas}/300)^{(-2)}$	[4]
1320	$N + N + N \rightarrow N + N_2$	$3.31x10^{-27}$ $(T_{gas}/300)^{(-1.5)}$	[4]
1321	$N + N + N_2 \rightarrow N_2 + N_2$	$7.6x10^{-34}$ exp(500/T_{gas})	[4]
1322	$N + N + H_2O \rightarrow N_2 + H_2O$	$3.9x10^{-33}$	[4]
1323	$N_2 + H + OH \rightarrow N_2 + H_2O$	$6.88x10^{-31}$ $(T_{gas}/300)^{(-2)}$	[4]

1324	$H + OH + H_2O \rightarrow H_2O + H_2O$	$2.46x10^{-30} (T_{gas}/300)^{(-2)}$	[4]
1325	$H + O_2 + N_2 \rightarrow HO_2 + N_2$	$6.09x10^{-32} (T_{gas}/300)^{(-0.8)}$	[3]
1326	$H + O_2 + O_2 \rightarrow HO_2 + O_2$	$6.09x10^{-32} (T_{gas}/300)^{(-0.8)}$	[3]
1327	$H + HO_2 \rightarrow H_2 + O_2$	$2.06x10^{-11} (T_{gas}/300)^{(0.84)} exp(-277/T_{gas})$	[3]
1328	$H + HO_2 \rightarrow OH + OH$	$1.66x10^{-10} exp(-413/T_{gas})$	[3]
1329	$H + HO_2 \rightarrow H_2O + O$	$5x10^{-11} exp(-866/T_{gas})$	[3]
1330	$H + HO_2 \rightarrow H_2O + O(^1D)$	$2.32x10^{-12} (T_{gas}/300)^{(1.55)} exp(80.85/T_{gas})$	[3]
1331	$H + H_2O_2 \rightarrow HO_2 + H_2$	$8x10^{-11} exp(-4000/T_{gas})$	[3]
1332	$H + H_2O_2 \rightarrow H_2O + OH$	$4x10^{-11} exp(-2000/T_{gas})$	[3]
1333	$H + HNO_2 \rightarrow H_2 + NO_2$	$2x10^{-11} exp(-3700/T_{gas})$	[3]
1334	$H + HNO_3 \rightarrow HNO_2 + OH$	$3.16x10^{-13} (T_{gas}/300)^{(2.3)} exp(-3512.8/T_{gas})$	[3]
1335	$H_2 + O \rightarrow OH + H$	$1.6x10^{-11} exp(-4570/T_{gas})$	[3]
1336	$H_2 + OH \rightarrow H_2O + H$ S1(a)	$9.54x10^{-13} (T_{gas}/300)^{(2)} exp(-1490/T_{gas})$	[3]
1337	$OH + O_3 \rightarrow HO_2 + O_2$	$1.69x10^{-12} exp(-941/T_{gas})$	[3]
1338	$OH + N_2O \rightarrow HO_2 + N_2$	$3.69x10^{-13} exp(-2740/T_{gas})$	[3]
1339	$OH + NO_3 \rightarrow HO_2 + NO_2$	$2x10^{-11}$	[3]
1340	$OH + HO_2 \rightarrow H_2O + O_2$	$4.8x10^{-11} exp(250/T_{gas})$	[3]
1341	$OH + H_2O_2 \rightarrow H_2O + HO_2$	$4.53x10^{-12} exp(-288.9/T_{gas})$	[3]
1342	$OH + HNO_2 \rightarrow H_2O + NO_2$	$2.7x10^{-12} exp(260/T_{gas})$	[3]
1343	$OH + HNO_3 \rightarrow H_2O + NO_3$	$1.5x10^{-13}$	[3]
1344	$HO_2 + O \rightarrow OH + O_2$	$2.71x10^{-11} exp(224/T_{gas})$	[3]
1345	$HO_2 + O_2(^1D) \rightarrow OH + O_2 + O$	$1.66x10^{-11}$	[3]
1346	$HO_2 + O_3 \rightarrow OH + O_2 + O_2$	$1.4x10^{-14} exp(-600/T_{gas})$	[3]
1347	$HO_2 + N \rightarrow OH + NO$	$2.2x10^{-11}$	[3]
1348	$OH + NO + N_2 \rightarrow HNO_2 + N_2$	$7.4x10^{-31} (T_{gas}/300)^{(-2.4)}$	[3]
1349	$OH + NO + O_2 \rightarrow HNO_2 + O_2$	$7.4x10^{-31} (T_{gas}/300)^{(-2.4)}$	[3]
1350	$OH + NO_2 + O_2 \rightarrow HNO_3 + O_2$	$4.6x10^{-29} (T_{gas}/300)^{(-5.49)} exp(-1180/T_{gas})$	[3]
1351	$OH + NO_2 + N_2 \rightarrow HNO_3 + N_2$	$4.6x10^{-29} (T_{gas}/300)^{(-5.49)} exp(-1180/T_{gas})$	[3]
1352	$OH + OH + N_2 \rightarrow H_2O_2 + N_2$	$8x10^{-31} (T_{gas}/300)^{(-0.9)}$	[3]
1353	$OH + OH + O_2 \rightarrow H_2O_2 + O_2$	$8x10^{-31} (T_{gas}/300)^{(-0.9)}$	[3]
1354	$HO_2 + NO + N_2 \rightarrow HNO_3 + N_2$	$5.6x10^{-33}$	[3]
1355	$HO_2 + NO_2 + N_2 \rightarrow HNO_2 + O_2 + N_2$	$1.8x10^{-31} (T_{gas}/300)^{(-3.2)}$	[3]
1356	$HO_2 + NO_2 + O_2 \rightarrow HNO_2 + O_2 + O_2$	$1.8x10^{-31} (T_{gas}/300)^{(-3.2)}$	[3]
1357	$H_2O + O(^1D) \rightarrow H_2 + O_2$	$2.2x10^{-12}$	[3]
1358	$H_2O_2 + O \rightarrow HO_2 + OH$	$1.79x10^{-13} (T_{gas}/300)^{(2.92)} exp(-1394/T_{gas})$	[3]
1359	$H_2O_2 + O \rightarrow H_2O + O_2$	$1.45x10^{-15}$	[3]
1360	$H_2O_2 + NO_3 \rightarrow HO_2 + HNO_3$	$4.1x10^{-16}$	[3]
1361	$HNO_2 + O \rightarrow OH + NO_2$	$2x10^{-11} exp(-3000/T_{gas})$	[3]
1362	$HNO_2 + NO_3 \rightarrow NO_2 + HNO_3$	$2x10^{-15}$	[3]
1363	$HNO_3 + O \rightarrow OH + NO_3$	$3x10^{-17}$	[3]
1364	$O_2 + NO_3 \rightarrow NO_2 + O_3$	10^{-17}	[3]
1365	$O_3 + NO_2 \rightarrow NO + O_2 + O_2$	10^{-18}	[3]
1366	$N_2 + O_2(V_1) \rightarrow O_2 + N_2$	10^{-13}	[3]
1367	$N_2 + O_2(V_2) \rightarrow O_2 + N_2$	10^{-13}	[3]
1368	$N_2 + O_2(V_3) \rightarrow O_2 + N_2$	10^{-13}	[3]
1369	$N_2 + O_2(V_4) \rightarrow O_2 + N_2$	10^{-13}	[3]
1370	$N_2 + O_2(V_5) \rightarrow O_2 + N_2$	10^{-13}	[3]
1371	$N_2 + O_2(R) \rightarrow O_2 + N_2$	10^{-13}	[3]
1372	$N_2 + N_2(V_2) \rightarrow N_2 + N_2$	10^{-13}	[3]

1373	$N_2 + N_2(V_3) \rightarrow N_2 + N_2$	10^{-13}	[3]
1374	$N_2 + N_2(V_4) \rightarrow N_2 + N_2$	10^{-13}	[3]
1375	$N_2(A) + N_2(a') \rightarrow N_4^+ + e$	$9x10^{-12}$	[3]
1376	$N_2(A) + O \rightarrow N_2 + O$	$2.7x10^{-11}$	[3]
1377	$N_2(A) + H_2O \rightarrow N_2 + H_2O$	$2.1x10^{-10}$	[3]
1378	$N_2(a') + H_2O \rightarrow N_2 + H_2O$	$2.1x10^{-10}$	[3]
1379	$O + N_2(A) \rightarrow NO + N$	$7x10^{-12}$	[3]
1380	$O + N_2(A) \rightarrow NO + N(^2D)$	10^{-12}	[3]
1381	$O + N_2(a') \rightarrow NO + N(^2D)$	10^{-12}	[3]
1382	$O_2 + N_2(A) \rightarrow N_2 + O + O$	$2.54x10^{-12}$	[3]
1383	$O_2 + N_2(A) \rightarrow N_2 + O_2(^1D)$	$1.29x10^{-12}$	[3]
1384	$O_2 + N_2(A) \rightarrow N_2 + O_2(^1S)$	$1.29x10^{-12}$	[3]
1385	$O_2 + N_2(A) \rightarrow N_2O + O$	$7.8x10^{-14}$	[3]
1386	$O_2 + N_2(A) \rightarrow N_2O + O(^1D)$	$3x10^{-14}$	[3]
1387	$O_2(^1D) + N_2(A) \rightarrow N_2 + O + O$	$2x10^{-11}$	[3]
1388	$O_2(^1S) + N_2(A) \rightarrow N_2 + O + O$	$2x10^{-11}$	[3]
1389	$O_3 + N_2(A) \rightarrow N_2 + O_2 + O$	$3.36x10^{-11}$	[3]
1390	$N_2(A) + NO_2 \rightarrow N_2 + NO + O$	$1.3x10^{-11}$	[3]
1391	$N_2(a') + NO \rightarrow N_2 + N + O$	$3.6x10^{-10}$	[3]
1392	$NO + NO_2 \rightarrow N_2O_3$	$7.9x10^{-12} (T_{gas}/300)^{(1.4)}$	[3]
1393	$NO_2 + NO_2 + N_2 \rightarrow N_2O_4 + N_2$	$1.4x10^{-33} (T_{gas}/300)^{(-3.8)}$	[3]
1394	$NO_2 + NO_3 + N_2 \rightarrow N_2O_5 + N_2$	$2.8x10^{-30} (T_{gas}/300)^{(-3.5)}$	[3]
1395	$H + NO + N_2 \rightarrow HNO + N_2$	$1.22x10^{-31} (T_{gas}/300)^{(-1.17)} exp(-212/T_{gas})$	[3]
1396	$H + NH \rightarrow H_2 + N$	$1.7x10^{-11}$	[3]
1397	$H + HNO \rightarrow H_2 + NO$	$3x10^{-11} exp(-500/T_{gas})$	[3]
1398	$H + HNO_4 \rightarrow HO_2 + HNO_2$	$2.46x10^{-14}$	[3]
1399	$N_2 + H(E_2) \rightarrow H + N_2$	10^{-13}	[3]
1400	$N_2 + H(E_3) \rightarrow H + N_2$	10^{-13}	[3]
1401	$H_2(V_1) + N_2 \rightarrow H_2 + N_2$	10^{-13}	[3]
1402	$N_2 + H_2(R_{02}) \rightarrow H_2 + N_2$	10^{-13}	[3]
1403	$N_2 + H_2(R_{13}) \rightarrow H_2 + N_2$	10^{-13}	[3]
1404	$N_2 + H_2(b) \rightarrow H_2 + N_2$	10^{-13}	[3]
1405	$N_2 + H_2(C) \rightarrow H_2 + N_2$	10^{-13}	[3]
1406	$OH + N_2(A) \rightarrow OH(A) + N_2$	10^{-10}	[3]
1407	$OH + N_2(a') \rightarrow OH(A) + N_2$	10^{-10}	[3]
1408	$OH + N_2O \rightarrow HNO + NO$	$3.8x10^{-17}$	[3]
1409	$OH + NH \rightarrow H_2 + NO$	$4x10^{-11}$	[3]
1410	$OH + NH \rightarrow HNO + H$	$4x10^{-11}$	[3]
1411	$OH + HNO \rightarrow H_2O + NO$	$8x10^{-11} exp(-500/T_{gas})$	[3]
1412	$OH + HNO_4 \rightarrow H_2O_2 + NO_3$	$1.9x10^{-13} exp(270/T_{gas})$	[3]
1413	$OH + HNO_4 \rightarrow H_2O + NO_2 + O_2$	$1.71x10^{-12} exp(270/T_{gas})$	[3]
1414	$OH(A) + H_2O \rightarrow OH + H_2O$	$7.61x10^{-10} (T_{gas}/300)^{(-0.5)}$	[3]
1415	$HO_2 + N \rightarrow NH + O_2$	$1.7x10^{-13}$	[3]
1416	$HO_2 + NO \rightarrow HNO + O_2$	$9.1x10^{-19} exp(2819/T_{gas})$	[3]
1417	$H_2O + N(^2D) \rightarrow OH + NH$	$2.5x10^{-10}$	[3]
1418	$H_2O + N_2O_3 \rightarrow HNO_2 + HNO_2$	$6.29x10^{-11} exp(-4471/T_{gas})$	[3]
1419	$NH + O \rightarrow H + NO$	$1.16x10^{-10}$	[3]
1420	$NH + O \rightarrow OH + N$	$1.16x10^{-10}$	[3]
1421	$NH + O_2 \rightarrow HNO + O$	$2.3x10^{-13}$	[3]
1422	$H_2O_2 + N_2(a') \rightarrow OH + OH + N_2$	$3x10^{-10}$	[3]
1423	$NH + N \rightarrow H + N_2$	$2.5x10^{-11}$	[3]
1424	$HNO + O \rightarrow OH + NO$	$6x10^{-11}$	[3]
1425	$HNO + O \rightarrow O_2 + NH$	$2.94x10^{-12} (T_{gas}/300)^{(0.5)} exp(-3500/T_{gas})$	[3]
1426	$HNO + O_2 \rightarrow HO_2 + NO$	$5.25x10^{-12} exp(-1510/T_{gas})$	[3]

1427	$OH(A) \rightarrow OH$	1.25x10+6	[3]
1428	$O + O + M \rightarrow O_2(^1D) + M$	$6.93x10^{-35} (T_{gas}/300)^{(-0.63)}$	[3]
1429	$O + O + M \rightarrow O_2(^1S) + M$	$6.93x10^{-35} (T_{gas}/300)^{(-0.63)}$	[3]
1430	$O + O(^1D) + M \rightarrow O_2 + M$	$9.9x10^{-33}$	[3]
1431	$O + O^+ + M \rightarrow O_2^+ + M$	10^{-29}	[3]
1432	$O(^1D) + M \rightarrow O + M$	$2x10^{-25} (T_{gas}/300)^{(-2.5)}$	[3]
1433	$N(^2D) + M \rightarrow N + M$	$2.4x10^{-14}$	[3]
1434	$N_2O_3 + M \rightarrow NO + NO_2 + M$	$1.91x10^{-7} (T_{gas}/300)^{(-8.7)} exp(-4882/T_{gas})$	[3]
1435	$N_2O_4 + M \rightarrow NO_2 + NO_2 + M$	$1.3x10^{-5} (T_{gas}/300)^{(-3.5)} exp(-6403/T_{gas})$	[3]
1436	$N_2O_5 + M \rightarrow NO_2 + NO_3 + M$	$1.33x10^{-3} (T_{gas}/300)^{(-3.5)} exp(-11000/T_{gas})$	[3]
1437	$HNO_4 + M \rightarrow HO_2 + NO_2 + M$	$5x10^{-6} exp(-10000/T_{gas})$	[3]

[a] Reaction rate coefficients have units of cm^3s^{-1} for two-body reactions and cm^6s^{-1} for three-body reactions.T_e is in eV and T_{gas} in K.

[b] When the reaction rate coefficients are calculated by the Boltzmann solver with cross sectional data, this is indicated by σ (ε), where ε is the mean electron energy.

[c] Estimated to be the same as O_2^-

[d] Estimated to be the same as He_2^+

[e] Estimated to be the same as N_2

e. Results

Species densities

In Figure S1 the density profiles of various species in both discharge and afterglow region are compared. For the sake of clarity, the neutral species (M^0) are illustrated in two panels (Figure S1(a) and S1(b)), and the most important positive ions (M^+) and negative ions (M^-) are plotted in Figure S1(c) and S1(d), respectively. The densities of electronically and vibrationally excited species are not shown, to avoid too many data in this figure. The corresponding time scale is also shown on the top axis.

As is clear from Figure S1, most of the species are created as soon as the discharge is turned on, with a rapid increase in density during the first 30 μs (~10 μm from the cathode), but some species (being the result of secondary reactions) show up only in the afterglow region, such as N_2O_4 and N_2O_5 (Figure S1(b)), heavy water clusters (Figure S1(c)), and $NO_3H_2O^-$ and $NO_2H_2O^-$ (Figure S1(d)). In the afterglow region, some species continue to increase, sometimes even by a few orders of magnitude, while others stay almost constant or decrease, depending on their formation and loss reactions (see section (c) in the main paper).

The N, O and H atoms are the dominant species (higher densities compared to the ions as well) in the discharge region, and they reach their highest density at the end of the discharge, followed by a drop in the afterglow, where power density and gas temperature also drop rapidly. More specifically, the N atoms are consumed to form NO, the O atoms associate with O_2 to form O_3, and the H atoms contribute to form HO_2 and OH, which are indeed the dominant neutrals in the afterglow (cf. Table 1 in the main paper), and their rising density is shown in Figure S1(a) and S1(b). More details about the reaction pathways are given in section (c) in the main paper.

Note that we introduced impurities in the discharge region, to produce species that are also reported in experimental studies. Andrade et al.[9] presented an emission spectrum from a He APGD in a sealed discharge chamber. In addition to the expected emission lines from He, they also observed atomic emission from oxygen and nitrogen, as well as emission bands of various diatomic species (NO, OH, N_2, and N_2^+). Likewise, for a DC He APGD similar to that employed in the FAPA, Gielniak et al.[10] also discovered the presence of NH. In both cases, the presence of these species was attributed to impurities in the gas supply or transfer lines.

When we compare the N_2^+ and N^+ densities with the N_2 density, as well as the O_2^+ and O^+ densities with the O_2 density (see Table 1 in the main paper), we can conclude that the ionization degree of N_2 and O_2 in the discharge is significantly higher than the He ionization degree, i.e., in the order of 0.01 % and 2%, respectively (vs 10^{-6} % for He). Hence, in spite of the much lower N_2 and O_2 density in the discharge (i.e., present as impurity of 7 and 2 ppm, respectively), their corresponding ions are more important than the He^+ ions, and comparable to the He_2^+ ions. Indeed, the N_2 and O_2 gas molecules are more efficiently ionized, by Penning ionization due to He^* and He_2^* as well as charge transfer with He_2^+ ions. This finding is important for analytical applications, because it suggests that the FAPA in He can also in general efficiently ionize gaseous analytes or aerosols for detection with mass spectrometry, which was also demonstrated in previous studies.[8-11-14]

Finally, while the electron density is fairly constant in the discharge region, it drops over several orders of magnitude in the first few millimeters of the afterglow, due to the absence of an electric field, and therefore, the electrons are only subject to loss reactions (electron-ion recombination, or electron attachment) and not to formation reactions (electron-impact ionization).

Moreover, the rapid air diffusion into the He stream, and thus the rising density of air components in the afterglow, results in efficient electron attachment to various oxygen, water and NO*x* species, creating various negative ions (see Figure S1(d)). This also explains the significant drop in electron density (as indicated in “red” in Table 1 in the main paper). The main production and loss processes of the electrons are discussed in the next section.

Although here and in the main paper, we dicuss the density pattern and reaction pathway of the most important species, the information given in Figure S1, Table S3, S4 and Table 1 (in the main paper) allows to obtain a general overview on the journey of the other species from the cathode to the MS interface.

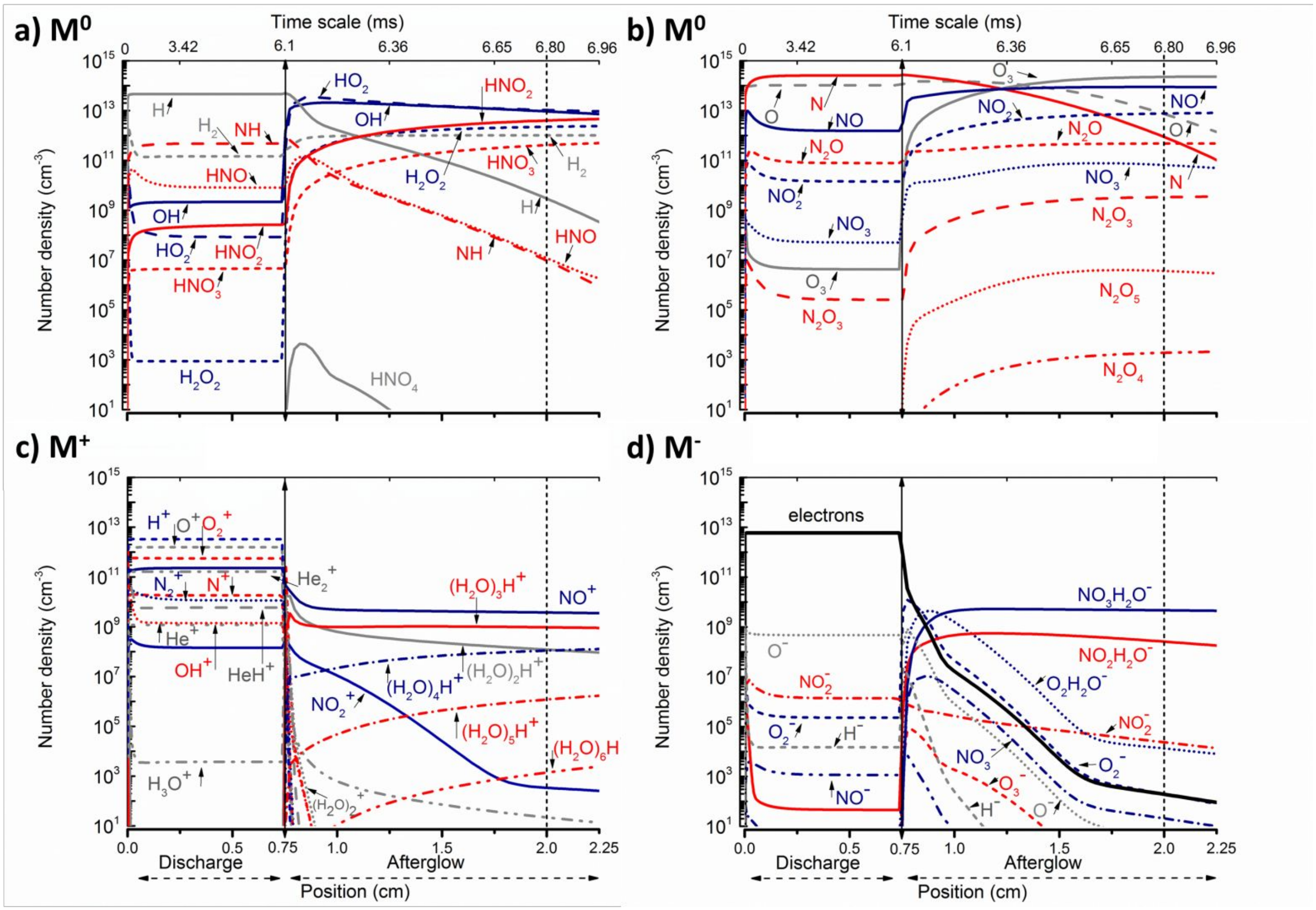

Figure S1 Number densities along the symmetry axis of the FAPA source of the most important species: (a) H, H-O, H-N neutrals, (b) N-O neutrals, (c) positive ions, and (d) negative ions and electrons. The time scale (upper x-axes) and position (lower x-axes) are correlated with the calculated gas velocity profile. The color and type of the lines are just to distinguish the different species. The vertical lines indicate the positions at which the number densities are listed in Table 1. The He atoms are not indicated, for the sake of clarity, but for comparison: they have a density of 2.5x10^{19} cm^{-3} in the discharge region, and 2.1x10^{19} cm^{-3} in the afterglow.

Table S4: List of excited species number densities

Number density of excited species (cm^{-3})			
Discharge		**Afterglow**	
$N(^2P)$	$2.9x10^{13}$	$O_2(^1D)$	$3.9x10^{12}$
$N_2(A)$	$2.5x10^{13}$	$O_2(^1S)$	$2.8x10^5$
$N(^2D)$	$9.4x10^{12}$	$N_2(R)$	$1.1x10^5$
$O_2(V_5)$	$5.9x10^{12}$	$O_2(R)$	$1.1x10^4$
$O(^1S)$	$5.8x10^{12}$	$O(^1D)$	$1.5x10^3$
He_2^*	$1.7x10^{12}$	$OH(A)$	$1.2x10^2$
He^*	$1.6x10^{12}$	$O_2(V_1)$	$5.1x10^1$
$O(^1D)$	$3.9x10^{11}$	$N_2(V_1)$	$6.2x10^{-1}$
$N_2(R)$	$2.3x10^{11}$	$N(^2D)$	$1.2x10^{-2}$
$N_2(A')$	$7.5x10^{10}$	$N_2(V_3)$	$2.8x10^8$
$OH(A)$	$1.5x10^{10}$	$N_2(V_4)$	$1.8x10^8$
$O_2(^1D)$	$1.1x10^{10}$	$O_2(V_2)$	$1.4x10^8$
$O_2(^1S)$	$5.7x10^9$	$O_2(V_3)$	$5.8x10^7$
$H(E_2)$	$2.2x10^9$	$O_2(V_4)$	$3.1x10^7$
$O_2(R)$	$1.5x10^9$	$H_2(R_{02})$	6.3x10
$N_2(V_1)$	$5.0x10^9$	$H_2(R_{13})$	3.6x10
$N_2(V_2)$	$3.1x10^8$	$H_2(C)$	1.9x10
$O_2(V_1)$	$1.2x10^8$	$H_2(V_1)$	1.7x10
$H(E_3)$	$1.2x10^8$	$H_2(B)$	9.56

Role of electrons

The behaviour of the various species is strongly correlated with the electron density profile and vice versa. In the discharge region, the electrons are mainly created by electron impact ionization of He^* (reaction 3 in Table S3, contribution of 19%) and Penning ionization of H and O atoms, mainly by He^* and to some extent by He_2^* (reactions 194, 195, 213, and 214; with contributions of 28%, 28% , 6%, and 6%, respectively). Ionization upon collision of two He^* atoms to produce either He^+ or He_2^+ , or upon collision of He^* with He_2^* to produce He_2^+ , also contribute for 6% to electron formation (reactions 165, 166, and 168). Finally, electron impact ionization of He_2^* and ionization upon collision of two He_2^* excimer species also contribute for 1.3% each (reaction 6 and 170, respectively). Note that in total, there are 140 reactions in our chemistry set contributing to electron formation, but we only mention here the dominant ones.

The dominant electron consumption in the discharge region is dissociative attachment (with total contribution of 85%), mainly to NO^+ (forming O and N (44.7%) or $N(^2D)$ (4%)) and to O_2^+ (forming 2 O (25.3%) or 2 O (^1D) (4.4%)). Dissociative attachment happens also at lower rates to He_2^+ (forming 2 He (3.3%) or He and He^* (1.2%)) and to N_2^+ (forming 2 N (2%)). Finally, 12.4% of the electrons are consumed by electron-ion recombination with He_2^+ into He_2^* (reaction 17 in Table S3). In the afterglow, however, these reactions are not important anymore, because of the low electron density. In fact, immediately after the discharge region (at 0.75 cm), the power density goes to zero, and as a result Te quickly drops to room temperature as well. Consequently, there are few electrons left with enough energy for dissociative attachment. In the afterglow region, the dominant electron consumption is electron attachment to O_2, forming O_2^-, by three-body collisions (reactions 8 and 319, with contributions of 88% and 1.5%). This explains the O_2^- peak in the beginning of the afterglow. 7% of the electrons are also consumed upon collision with H_2O_2, forming H_2O and O^-. Finally, there are 93 other reactions which in total contribute for 3.3% of the electron consumption in the afterglow.

Reaction rates

The reaction rates for the reactions numbered in Table S3 are presented in Table S5 at two positions along the central axis, i.e., near the end of the discharge (0.73 cm) and near the end of the afterglow (at 2 cm, i.e., 0.25 cm upstream the MS sampler). Note that the reaction rates are not constant values, but they are a function of time and position. Note that in Table S5, we only present the values at the end of both regions, which are different from the values at the beginning of each region. Several reactions that are important in the discharge are negligible in the end of the afterglow, reflected by very low reaction rates. Reaction rates below 1 are written as zero.

Table S5 Reaction rates at the end of discharge and afterglow (in cm^{-3} s^{-1}).

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
1	4.3x10^{17}	0.0	**51**	0.0	0.0	**101**	8.5x10^{6}	0.0	**151**	8.8x10^{3}	0.0
2	7.7x10^{12}	0.0	**52**	8.2x10^{8}	0.0	**102**	2.3x10^{12}	0.0	**152**	2.7x10^{4}	0.0
3	5.4x10^{16}	0.0	**53**	2.1x10^{3}	0.0	**103**	2.9x10^{12}	0.0	**153**	1.8x10^{13}	0.0
4	3.8x10^{16}	0.0	**54**	3.9x10^{13}	0.0	**104**	8.3x10^{11}	0.0	**154**	1.8x10^{13}	0.0
5	4.1x10^{16}	0.0	**55**	0.0	0.0	**105**	8.3x10^{11}	0.0	**155**	1.8x10^{2}	0.0
6	3.7x10^{15}	0.0	**56**	3.9x10^{13}	0.0	**106**	2.8x10^{9}	0.0	**156**	3.0x10^{9}	0.0
7	1.5x10^{15}	2.6x10^{3}	**57**	6.4x10^{4}	0.0	**107**	1.9x10^{10}	0.0	**157**	0.0	0.0
8	1.4x10^{12}	8.4x10^{8}	**58**	1.9x10^{10}	0.0	**108**	7.7x10^{7}	0.0	**158**	5.9x10^{5}	0.0
9	6.2x10^{7}	8.8x10^{4}	**59**	3.1x10	0.0	**109**	1.0x10^{8}	0.0	**159**	0.0	0.0
10	3.1x10^{9}	0.0	**60**	5.4x10^{3}	0.0	**110**	6.1x10^{6}	0.0	**160**	0.0	0.0
11	1.4x10^{10}	0.0	**61**	0.0	0.0	**111**	1.2x10^{6}	0.0	**161**	1.5x10^{6}	0.0
12	9.6x10^{15}	0.0	**62**	1.4x10^{12}	0.0	**112**	6.5x10^{7}	0.0	**162**	9.7x10^{13}	0.0
13	1.4x10^{8}	0.0	**63**	6.7x10^{8}	0.0	**113**	4.1x10^{7}	0.0	**163**	3.0x10^{4}	0.0
14	4.3x10^{13}	0.0	**64**	1.9x10^{2}	0.0	**114**	2.6x10^{13}	0.0	**164**	1.5x10^{17}	0.0
15	1.7x10^{14}	0.0	**65**	3.7x10^{14}	0.0	**115**	2.7x10^{16}	0.0	**165**	3.5x10^{15}	0.0
16	3.5x10^{15}	0.0	**66**	1.8x10^{11}	0.0	**116**	1.0x10^{14}	0.0	**166**	8.2x10^{15}	0.0
17	3.6x10^{16}	0.0	**67**	5.1x10^{4}	0.0	**117**	1.5x10^{15}	0.0	**167**	1.4x10^{15}	0.0
18	7.1x10^{12}	0.0	**68**	1.3x10^{14}	0.0	**118**	7.1x10^{12}	0.0	**168**	5.6x10^{15}	0.0
19	1.8x10^{9}	0.0	**69**	6.3x10^{10}	0.0	**119**	1.1x10^{13}	0.0	**169**	9.2x10^{14}	0.0
20	3.6x10^{8}	0.0	**70**	1.8x10^{4}	0.0	**120**	2.8x10^{12}	0.0	**170**	3.7x10^{15}	0.0
21	4.2x10^{10}	0.0	**71**	0.0	0.0	**121**	1.5x10^{12}	0.0	**171**	2.2x10^{16}	0.0
22	1.3x10^{11}	0.0	**72**	4.0x10^{4}	0.0	**122**	1.1x10^{9}	0.0	**172**	9.8x10^{17}	3.1x10^{9}
23	5.0x10^{10}	0.0	**73**	1.9x10	0.0	**123**	3.5x10^{9}	0.0	**173**	3.4x10^{9}	6.4x10^{11}
24	6.1x10^{13}	0.0	**74**	0.0	0.0	**124**	4.2x10^{11}	0.0	**174**	2.3x10^{12}	7.8x10^{7}
25	7.9x10^{11}	0.0	**75**	3.7x10^{3}	4.2x10^{2}	**125**	2.9x10^{12}	0.0	**175**	1.2x10^{14}	1.4x10^{7}
26	2.0x10^{14}	0.0	**76**	5.1x10^{10}	2.0x10^{2}	**126**	3.3x10^{14}	0.0	**176**	5.5x10^{13}	2.4x10^{3}
27	1.6x10^{6}	0.0	**77**	1.1x10^{11}	5.7x10^{5}	**127**	2.3x10^{14}	0.0	**177**	2.3x10^{13}	2.3x10
28	4.4x10^{10}	0.0	**78**	4.9x10^{8}	1.2x10^{9}	**128**	2.7x10^{14}	0.0	**178**	1.2x10^{13}	1.8
29	2.1x10^{7}	0.0	**79**	3.4x10^{5}	1.8x10^{5}	**129**	3.2x10^{11}	0.0	**179**	3.7x10^{15}	2.4x10^{10}
30	6.1	0.0	**80**	6.8x10^{9}	7.7x10^{2}	**130**	2.6x10^{15}	0.0	**180**	4.1x10^{10}	9.4x10^{14}
31	2.4x10^{8}	0.0	**81**	2.1x10^{14}	0.0	**131**	8.4x10^{12}	0.0	**181**	5.5x10^{15}	3.8x10^{7}
32	7.7x10^{12}	0.0	**82**	6.4x10^{5}	3.0x10^{12}	**132**	4.2x10^{12}	0.0	**182**	5.9x10^{17}	2.4x10^{11}
33	3.7x10^{9}	0.0	**83**	0.0	8.3x10^{8}	**133**	3.1x10^{10}	0.0	**183**	2.6x10^{15}	1.3x10^{6}
34	3.7x10^{9}	0.0	**84**	2.1x10^{8}	2.9x10^{7}	**134**	2.5x10^{9}	0.0	**184**	1.2x10^{15}	0.0
35	1.1x10^{3}	0.0	**85**	6.4x10^{5}	3.4x10^{12}	**135**	4.0x10^{9}	0.0	**185**	7.1x10^{14}	0.0
36	2.2x10^{10}	0.0	**86**	2.2x10^{11}	0.0	**136**	2.5x10^{14}	0.0	**186**	4.5x10^{14}	0.0
37	2.2x10^{10}	0.0	**87**	1.1x10^{8}	0.0	**137**	1.3x10^{12}	0.0	**187**	5.6x10^{15}	0.0
38	5.7x10^{4}	0.0	**88**	3.1x10	0.0	**138**	2.9x10^{8}	4.8x10^{3}	**188**	7.1x10^{14}	0.0
39	5.7x10^{4}	0.0	**89**	0.0	0.0	**139**	1.3x10^{5}	0.0	**189**	4.3x10^{7}	0.0
40	0.0	0.0	**90**	2.5x10^{11}	0.0	**140**	1.1x10^{12}	0.0	**190**	1.6x10^{8}	0.0
41	0.0	0.0	**91**	1.2x10^{8}	0.0	**141**	1.2x10^{14}	0.0	**191**	9.2x10^{7}	0.0
42	2.8x10^{11}	0.0	**92**	3.4x10	0.0	**142**	1.8x10^{14}	4.8x10^{3}	**192**	2.4x10^{7}	0.0
43	8.7x10^{6}	0.0	**93**	6.0x10^{16}	0.0	**143**	6.4x10^{16}	0.0	**193**	4.8x10^{7}	0.0
44	1.3x10^{8}	0.0	**94**	9.6x10^{12}	0.0	**144**	1.7x10^{16}	0.0	**194**	8.1x10^{16}	0.0
45	0.0	0.0	**95**	3.7x10^{10}	0.0	**145**	4.1x10^{13}	0.0	**195**	6.8x10^{12}	0.0
46	2.7x10^{13}	0.0	**96**	5.4x10^{11}	0.0	**146**	2.8x10^{12}	0.0	**196**	3.3x10^{12}	0.0
47	4.5x10^{4}	0.0	**97**	8.2x10^{10}	0.0	**147**	4.7x10^{14}	0.0	**197**	7.6x10^{16}	0.0
48	1.3x10^{6}	0.0	**98**	2.5x10^{9}	0.0	**148**	4.2x10^{13}	0.0	**198**	2.9x10^{14}	0.0
49	2.8x10^{11}	0.0	**99**	2.2x10^{10}	0.0	**149**	1.8x10^{14}	0.0	**199**	4.3x10^{15}	0.0
50	1.4x10^{8}	0.0	**100**	6.7x10^{8}	0.0	**150**	7.2x10^{3}	1.3x10^{10}	**200**	2.6x10^{13}	0.0

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
201	$7.0x10^{12}$	0.0	**251**	$2.8x10^{11}$	$4.1x10^{12}$	**301**	$6.1x10^{11}$	0.0	**351**	$1.0x10^{13}$	0.0
202	$3.7x10^{12}$	0.0	**252**	$4.2x10^{15}$	$8.5x10^{11}$	**302**	$5.4x10^{14}$	0.0	**352**	$5.4x10^{6}$	0.0
203	$2.7x10^{9}$	0.0	**253**	$3.9x10^{14}$	$1.2x10^{15}$	**303**	$2.7x10^{12}$	0.0	**353**	$3.4x10^{13}$	0.0
204	$2.7x10^{12}$	0.0	**254**	$9.4x10^{14}$	$1.9x10^{9}$	**304**	$2.5x10^{10}$	0.0	**354**	$3.0x10^{11}$	0.0
205	$1.8x10^{13}$	0.0	**255**	$2.4x10^{15}$	$2.6x10^{10}$	**305**	$5.9x10^{10}$	0.0	**355**	$1.0x10^{12}$	0.0
206	$7.5x10^{14}$	0.0	**256**	$4.2x10^{12}$	$3.0x10^{11}$	**306**	$8.9x10^{3}$	0.0	**356**	$9.4x10^{11}$	0.0
207	$1.9x10^{14}$	0.0	**257**	$8.7x10^{15}$	0.0	**307**	$7.5x10^{4}$	0.0	**357**	$2.2x10^{11}$	0.0
208	$1.2x10^{11}$	0.0	**258**	$2.1x10^{13}$	0.0	**308**	$3.1x10^{16}$	$3.3x10^{9}$	**358**	$2.3x10^{11}$	0.0
209	$7.0x10^{11}$	0.0	**259**	$5.2x10^{12}$	0.0	**309**	3.0x10-83	0.0	**359**	$4.4x10^{11}$	0.0
210	$1.6x10^{9}$	0.0	**260**	$9.2x10^{12}$	0.0	**310**	$2.8x10^{13}$	0.0	**360**	$1.0x10^{11}$	0.0
211	$1.8x10^{16}$	0.0	**261**	$1.4x10^{12}$	0.0	**311**	$6.6x10^{15}$	0.0	**361**	$4.7x10^{10}$	0.0
212	$5.6x10^{13}$	0.0	**262**	$5.0x10^{13}$	$2.0x10^{3}$	**312**	$2.7x10^{9}$	0.0	**362**	$1.9x10^{11}$	0.0
213	$1.8x10^{16}$	0.0	**263**	$6.7x10^{12}$	0.0	**313**	$3.9x10^{10}$	0.0	**363**	$4.6x10^{10}$	0.0
214	$6.9x10^{13}$	0.0	**264**	$7.2x10^{11}$	0.0	**314**	$2.2x10^{9}$	$7.1x10^{7}$	**364**	$1.5x10^{10}$	0.0
215	$1.0x10^{15}$	0.0	**265**	$8.1x10^{12}$	0.0	**315**	$6.7x10^{5}$	$1.3x10^{4}$	**365**	$1.1x10^{11}$	0.0
216	$7.2x10^{12}$	0.0	**266**	$2.5x10^{11}$	$4.1x10^{8}$	**316**	$2.5x10^{6}$	9.3x10	**366**	$2.5x10^{10}$	0.0
217	$7.4x10^{8}$	0.0	**267**	$4.3x10^{9}$	$1.5x10^{5}$	**317**	$2.5x10^{6}$	9.3x10	**367**	$1.1x10^{15}$	0.0
218	$6.2x10^{13}$	0.0	**268**	$1.0x10^{10}$	$8.3x10^{5}$	**318**	$7.0x10^{7}$	$3.5x10^{2}$	**368**	$5.2x10^{18}$	0.0
219	$3.3x10^{12}$	0.0	**269**	$5.0x10^{13}$	0.0	**319**	$2.4x10^{3}$	$2.0x10^{8}$	**369**	$1.1x10^{18}$	0.0
220	$1.6x10^{9}$	0.0	**270**	$3.5x10^{15}$	0.0	**320**	$4.7x10^{3}$	$3.4x10^{3}$	**370**	$2.9x10^{17}$	0.0
221	$2.5x10^{13}$	0.0	**271**	$1.1x10^{14}$	0.0	**321**	$1.3x10^{2}$	0.0	**371**	$4.1x10^{17}$	0.0
222	$8.4x10^{14}$	0.0	**272**	$2.5x10^{12}$	$4.2x10^{4}$	**322**	6.0x10	0.0	**372**	$7.1x10^{17}$	0.0
223	$2.1x10^{13}$	0.0	**273**	$2.5x10^{12}$	$4.2x10^{4}$	**323**	2.5x10	0.0	**373**	0.0	0.0
224	$7.6x10^{13}$	0.0	**274**	$7.0x10^{13}$	0.0	**324**	1.3x10	0.0	**374**	$7.0x10^{14}$	0.0
225	$2.3x10^{12}$	0.0	**275**	$3.0x10^{14}$	0.0	**325**	0.0	$3.2x10^{3}$	**375**	$7.0x10^{14}$	0.0
226	$1.5x10^{13}$	0.0	**276**	$4.9x10^{12}$	0.0	**326**	$3.7x10^{5}$	$1.2x10^{4}$	**376**	$2.7x10^{12}$	0.0
227	$1.3x10^{11}$	0.0	**277**	$6.2x10^{13}$	0.0	**327**	$2.2x10^{4}$	$3.9x10^{7}$	**377**	$4.3x10^{16}$	$1.3x10^{6}$
228	$1.0x10^{6}$	0.0	**278**	$2.9x10^{11}$	0.0	**328**	$3.9x10^{2}$	$8.7x10^{7}$	**378**	$2.4x10^{16}$	0.0
229	$2.0x10^{10}$	0.0	**279**	$3.7x10^{15}$	$2.7x10^{10}$	**329**	$1.1x10^{7}$	$4.6x10^{4}$	**379**	$1.6x10^{16}$	0.0
230	$6.6x10^{16}$	0.0	**280**	$1.2x10^{14}$	0.0	**330**	$1.6x10^{15}$	0.0	**380**	$1.1x10^{16}$	0.0
231	$1.4x10^{12}$	$1.7x10^{15}$	**281**	$5.9x10^{17}$	$2.4x10^{11}$	**331**	$9.5x10^{17}$	0.0	**381**	$4.1x10^{13}$	0.0
232	$4.2x10^{14}$	$1.7x10^{6}$	**282**	$3.9x10^{13}$	0.0	**332**	$3.4x10^{16}$	0.0	**382**	$1.8x10^{13}$	0.0
233	$6.8x10^{9}$	$3.7x10^{15}$	**283**	$6.7x10^{13}$	0.0	**333**	$2.3x10^{13}$	0.0	**383**	$1.2x10^{13}$	0.0
234	$4.8x10^{7}$	$3.9x10^{14}$	**284**	$4.0x10^{16}$	0.0	**334**	$1.4x10^{15}$	0.0	**384**	$3.6x10^{13}$	0.0
235	$4.4x10^{7}$	$9.4x10^{14}$	**285**	$2.3x10^{16}$	0.0	**335**	$8.4x10^{10}$	0.0	**385**	$8.7x10^{12}$	0.0
236	$1.8x10^{7}$	$1.1x10^{14}$	**286**	$1.5x10^{16}$	0.0	**336**	$1.1x10^{10}$	0.0	**386**	$5.0x10^{12}$	0.0
237	$5.3x10^{11}$	$3.5x10^{13}$	**287**	$1.1x10^{16}$	0.0	**337**	$2.6x10^{14}$	0.0	**387**	$4.0x10^{13}$	0.0
238	$2.2x10^{5}$	$2.5x10^{11}$	**288**	$8.0x10^{13}$	$1.8x10^{3}$	**338**	$2.6x10^{14}$	0.0	**388**	$4.3x10^{12}$	0.0
239	$2.1x10^{6}$	$4.9x10^{12}$	**289**	$5.6x10^{15}$	0.0	**339**	$1.8x10^{11}$	0.0	**389**	$2.3x10^{12}$	0.0
240	$1.5x10^{16}$	$2.1x10^{9}$	**290**	$7.2x10^{14}$	0.0	**340**	$7.5x10^{11}$	0.0	**390**	$4.9x10^{13}$	0.0
241	$5.6x10^{13}$	$2.1x10^{11}$	**291**	$1.0x10^{15}$	0.0	**341**	$1.2x10^{14}$	0.0	**391**	$9.2x10^{11}$	0.0
242	$6.6x10^{14}$	0.0	**292**	$1.5x10^{13}$	0.0	**342**	$2.8x10^{13}$	0.0	**392**	$9.2x10^{11}$	0.0
243	$2.5x10^{12}$	0.0	**293**	$3.5x10^{12}$	0.0	**343**	$1.3x10^{14}$	$2.9x10^{7}$	**393**	$4.9x10^{14}$	0.0
244	$2.6x10^{11}$	0.0	**294**	$8.0x10^{9}$	0.0	**344**	$5.6x10^{13}$	$4.8x10^{3}$	**394**	$2.9x10^{12}$	0.0
245	$6.9x10^{10}$	0.0	**295**	$1.6x10^{8}$	0.0	**345**	$2.3x10^{13}$	4.8x10	**395**	$1.1x10^{14}$	0.0
246	$3.6x10^{10}$	0.0	**296**	$9.2x10^{7}$	0.0	**346**	$1.2x10^{13}$	3.7	**396**	$3.3x10^{12}$	0.0
247	$2.7x10^{7}$	0.0	**297**	$4.3x10^{7}$	0.0	**347**	$7.5x10^{5}$	0.0	**397**	$1.3x10^{16}$	0.0
248	$2.6x10^{14}$	$9.3x10^{11}$	**298**	$2.4x10^{7}$	0.0	**348**	$4.5x10^{13}$	0.0	**398**	$3.1x10^{13}$	0.0
249	$2.6x10^{13}$	$9.2x10^{10}$	**299**	$4.8x10^{7}$	0.0	**349**	$6.9x10^{12}$	0.0	**399**	0.0	0.0
250	$1.1x10^{11}$	$6.8x10^{16}$	**300**	$1.0x10^{13}$	0.0	**350**	$3.8x10^{11}$	0.0	**400**	$1.2x10^{16}$	$2.3x10^{5}$

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
401	2.3×10^{15}	0.0	**451**	2.3×10^{11}	0.0	**501**	2.6×10^{8}	0.0	**551**	0.0	0.0
402	7.9×10^{9}	0.0	**452**	2.8×10^{10}	0.0	**502**	4.4×10^{8}	0.0	**552**	0.0	0.0
403	1.1×10^{14}	0.0	**453**	8.1×10^{3}	0.0	**503**	7.4×10	0.0	**553**	0.0	0.0
404	3.7×10^{13}	0.0	**454**	3.0×10^{8}	0.0	**504**	1.3×10^{2}	0.0	**554**	0.0	0.0
405	7.4×10^{16}	0.0	**455**	3.6×10^{11}	0.0	**505**	1.3×10^{6}	0.0	**555**	7.1×10^{3}	0.0
406	1.3×10^{13}	0.0	**456**	9.3×10^{5}	0.0	**506**	2.2×10^{6}	0.0	**556**	7.1×10^{3}	0.0
407	5.8×10^{7}	0.0	**457**	2.6×10^{13}	0.0	**507**	1.6×10^{9}	0.0	**557**	2.0×10^{5}	0.0
408	1.5×10^{8}	0.0	**458**	1.6×10^{13}	0.0	**508**	2.7×10^{9}	0.0	**558**	2.0×10^{5}	0.0
409	3.7×10^{11}	0.0	**459**	1.2×10^{10}	0.0	**509**	4.0×10^{3}	0.0	**559**	3.4	0.0
410	1.3×10^{17}	2.9×10^{5}	**460**	3.3×10^{10}	0.0	**510**	6.8×10^{3}	0.0	**560**	3.4	0.0
411	5.3×10^{12}	2.7	**461**	3.6×10^{3}	0.0	**511**	8.9×10^{8}	0.0	**561**	9.8×10	0.0
412	1.8×10^{13}	0.0	**462**	2.9×10^{3}	0.0	**512**	4.3×10^{5}	0.0	**562**	9.8×10	0.0
413	3.2×10^{15}	0.0	**463**	6.3×10^{7}	0.0	**513**	0.0	0.0	**563**	8.9×10^{4}	4.3×10^{2}
414	5.5×10^{15}	0.0	**464**	1.1×10^{8}	0.0	**514**	2.2×10^{3}	0.0	**564**	8.9×10^{4}	4.3×10^{2}
415	2.5×10^{13}	0.0	**465**	7.5×10^{10}	0.0	**515**	2.6×10^{6}	0.0	**565**	2.5×10^{6}	1.6×10^{3}
416	3.8×10^{13}	0.0	**466**	2.0×10^{11}	0.0	**516**	6.6	0.0	**566**	2.5×10^{6}	1.6×10^{3}
417	4.8×10^{11}	0.0	**467**	1.9×10^{5}	0.0	**517**	1.7×10^{9}	0.0	**567**	4.3×10	2.9×10^{4}
418	3.3×10^{5}	0.0	**468**	1.6×10^{5}	0.0	**518**	8.2×10^{5}	0.0	**568**	4.3×10	2.9×10^{4}
419	3.3×10^{8}	0.0	**469**	0.0	0.0	**519**	3.6×10^{3}	0.0	**569**	1.2×10^{3}	1.1×10^{5}
420	1.7×10^{11}	0.0	**470**	8.0×10^{3}	0.0	**520**	3.6×10^{3}	0.0	**570**	1.2×10^{3}	1.1×10^{5}
421	1.0×10^{6}	0.0	**471**	3.2×10^{4}	0.0	**521**	7.5×10^{10}	0.0	**571**	0.0	5.7×10
422	1.1×10^{8}	0.0	**472**	7.7×10	0.0	**522**	7.5×10^{10}	0.0	**572**	0.0	2.8×10^{7}
423	5.2×10	0.0	**473**	3.8	0.0	**523**	1.9×10^{5}	0.0	**573**	0.0	3.8×10^{6}
424	5.6×10^{9}	0.0	**474**	0.0	0.0	**524**	1.9×10^{5}	0.0	**574**	4.5×10^{3}	0.0
425	1.3×10^{5}	0.0	**475**	0.0	0.0	**525**	4.1×10^{6}	0.0	**575**	4.5×10^{3}	0.0
426	1.1×10^{5}	0.0	**476**	0.0	0.0	**526**	7.9×10^{4}	7.3×10^{3}	**576**	1.3×10^{5}	0.0
427	7.0×10^{10}	0.0	**477**	2.3×10	0.0	**527**	0.0	0.0	**577**	1.3×10^{5}	0.0
428	1.7×10^{6}	3.9×10^{3}	**478**	0.0	0.0	**528**	1.7×10^{5}	0.0	**578**	2.1	0.0
429	4.7×10^{7}	1.4×10^{4}	**479**	0.0	0.0	**529**	8.4×10	0.0	**579**	6.1×10	0.0
430	3.5×10^{9}	0.0	**480**	1.4×10^{12}	0.0	**530**	8.4×10	0.0	**580**	3.7×10^{14}	0.0
431	8.3×10^{4}	0.0	**481**	1.6×10^{9}	0.0	**531**	6.1×10^{5}	0.0	**581**	1.8×10^{11}	0.0
432	2.4×10^{6}	0.0	**482**	2.0×10^{2}	0.0	**532**	6.1×10^{5}	0.0	**582**	1.8×10^{11}	0.0
433	5.8×10^{6}	0.0	**483**	3.5×10^{6}	0.0	**533**	1.7×10^{7}	0.0	**583**	5.1×10^{4}	0.0
434	6.6×10^{11}	0.0	**484**	4.2×10^{9}	0.0	**534**	1.7×10^{7}	0.0	**584**	1.3×10^{14}	0.0
435	8.3×10^{11}	0.0	**485**	1.1×10^{4}	0.0	**535**	2.9×10^{2}	0.0	**585**	4.0×10^{4}	0.0
436	1.8×10^{12}	0.0	**486**	1.1×10^{13}	1.0×10^{3}	**536**	2.9×10^{2}	0.0	**586**	3.2×10^{11}	0.0
437	1.5×10^{9}	0.0	**487**	3.3×10^{13}	3.8×10^{3}	**537**	8.4×10^{3}	0.0	**587**	1.8×10^{4}	0.0
438	8.2×10^{8}	0.0	**488**	5.1×10^{9}	6.8×10^{4}	**538**	8.4×10^{3}	0.0	**588**	1.9×10	0.0
439	3.3×10^{10}	0.0	**489**	2.0×10^{10}	3.2×10^{5}	**539**	0.0	0.0	**589**	1.1×10^{12}	0.0
440	4.6×10	0.0	**490**	1.5×10^{3}	7.1×10	**540**	2.1×10^{5}	0.0	**590**	2.8×10^{6}	0.0
441	1.1×10^{3}	0.0	**491**	2.5×10^{3}	1.5×10^{2}	**541**	2.1×10^{5}	0.0	**591**	4.3×10^{12}	0.0
442	0.0	0.0	**492**	2.6×10^{7}	0.0	**542**	6.2×10^{6}	0.0	**592**	4.3×10^{12}	0.0
443	6.2×10^{3}	5.7×10^{4}	**493**	4.4×10^{7}	0.0	**543**	6.2×10^{6}	0.0	**593**	2.7×10^{12}	0.0
444	0.0	0.0	**494**	3.1×10^{10}	8.4×10^{6}	**544**	1.0×10^{2}	0.0	**594**	2.7×10^{12}	0.0
445	0.0	5.0×10^{5}	**495**	2.0×10^{10}	6.5×10^{6}	**545**	3.0×10^{3}	0.0	**595**	5.4×10^{13}	1.4×10^{4}
446	0.0	7.3×10^{4}	**496**	7.9×10^{4}	7.3×10^{3}	**546**	0.0	0.0	**596**	5.4×10^{13}	1.4×10^{4}
447	0.0	8.9×10^{2}	**497**	4.5×10^{4}	5.1×10^{3}	**547**	0.0	0.0	**597**	3.4×10^{10}	0.0
448	0.0	1.0	**498**	0.0	1.3×10^{12}	**548**	0.0	0.0	**598**	3.4×10^{10}	0.0
449	0.0	0.0	**499**	5.4×10^{11}	0.0	**549**	0.0	0.0	**599**	3.8×10^{11}	0.0
450	1.3×10^{14}	0.0	**500**	9.2×10^{11}	0.0	**550**	0.0	0.0	**600**	9.8×10^{5}	0.0

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
601	2.1x10^{9}	0.0	651	0.0	0.0	701	0.0	1.7x10^{4}	751	0.0	3.8x10^{4}
602	2.1x10^{9}	0.0	652	1.4x10	0.0	702	0.0	1.7x10^{4}	752	0.0	2.4
603	2.6x10^{10}	9.5x10^{5}	653	6.9x10	0.0	703	0.0	2.4x10^{5}	753	0.0	2.4
604	2.6x10^{10}	9.5x10^{5}	654	0.0	0.0	704	0.0	1.8x10	754	0.0	3.3x10
605	1.6x10^{7}	0.0	655	0.0	0.0	705	0.0	1.8x10	755	0.0	0.0
606	6.0x10^{2}	0.0	656	0.0	0.0	706	0.0	2.5x10^{2}	756	0.0	0.0
607	3.8x10^{2}	0.0	657	0.0	0.0	707	0.0	2.1x10^{6}	757	0.0	0.0
608	7.5x10^{3}	9.9x10^{2}	658	0.0	0.0	708	0.0	2.1x10^{6}	758	0.0	0.0
609	4.7	0.0	659	0.0	0.0	709	0.0	3.0x10^{7}	759	0.0	0.0
610	1.2x10^{2}	0.0	660	0.0	0.0	710	0.0	1.9x10^{3}	760	0.0	1.6x10^{3}
611	0.0	0.0	661	0.0	0.0	711	0.0	1.9x10^{3}	761	0.0	2.2x10^{4}
612	1.3x10^{10}	0.0	662	0.0	0.0	712	0.0	2.6x10^{4}	762	0.0	0.0
613	3.2x10^{4}	0.0	663	0.0	0.0	713	0.0	0.0	763	0.0	0.0
614	7.9x10^{9}	0.0	664	0.0	0.0	714	0.0	0.0	764	0.0	0.0
615	2.0x10^{4}	0.0	665	0.0	0.0	715	0.0	0.0	765	0.0	0.0
616	1.6x10^{11}	1.2x10^{8}	666	0.0	0.0	716	0.0	0.0	766	0.0	0.0
617	4.0x10^{5}	1.0x10^{5}	667	0.0	0.0	717	0.0	0.0	767	0.0	0.0
618	9.9x10^{7}	1.0x10	668	0.0	0.0	718	0.0	1.2x10^{6}	768	0.0	0.0
619	2.5x10^{2}	0.0	669	0.0	0.0	719	0.0	1.7x10^{7}	769	0.0	0.0
620	2.2x10^{9}	0.0	670	0.0	0.0	720	0.0	3.0x10	770	0.0	3.2
621	2.2x10^{9}	0.0	671	0.0	0.0	721	0.0	4.2x10^{2}	771	0.0	3.2
622	0.0	0.0	672	0.0	0.0	722	0.0	2.0x10^{3}	772	0.0	4.5x10
623	6.3x10^{6}	0.0	673	0.0	0.0	723	0.0	2.0x10^{3}	773	0.0	0.0
624	1.6x10	0.0	674	0.0	0.0	724	0.0	2.8x10^{4}	774	0.0	0.0
625	4.1x10^{9}	0.0	675	0.0	0.0	725	0.0	2.1	775	0.0	0.0
626	1.7x10^{9}	0.0	676	0.0	0.0	726	0.0	2.1	776	0.0	0.0
627	1.1x10^{6}	0.0	677	0.0	0.0	727	0.0	3.0x10	777	0.0	0.0
628	5.8x10^{6}	0.0	678	0.0	3.2x10	728	0.0	2.5x10^{5}	778	0.0	0.0
629	2.5x10^{3}	0.0	679	0.0	4.5x10^{2}	729	0.0	2.5x10^{5}	779	0.0	0.0
630	3.8x10^{5}	0.0	680	0.0	2.2x10^{3}	730	0.0	3.5x10^{6}	780	0.0	0.0
631	0.0	0.0	681	0.0	2.2x10^{3}	731	0.0	2.2x10^{2}	781	0.0	1.8
632	0.0	0.0	682	0.0	3.0x10^{4}	732	0.0	2.2x10^{2}	782	0.0	2.6x10
633	0.0	0.0	683	0.0	2.3	733	0.0	3.0x10^{3}	783	0.0	0.0
634	0.0	0.0	684	0.0	2.3	734	0.0	0.0	784	0.0	0.0
635	0.0	0.0	685	0.0	3.2x10	735	0.0	0.0	785	0.0	0.0
636	0.0	0.0	686	0.0	2.7x10^{5}	736	0.0	0.0	786	0.0	0.0
637	1.6x10^{3}	0.0	687	0.0	2.7x10^{5}	737	0.0	0.0	787	0.0	0.0
638	4.3x10^{5}	0.0	688	0.0	3.7x10^{6}	738	0.0	0.0	788	0.0	0.0
639	2.2x10^{6}	0.0	689	0.0	2.3x10^{2}	739	0.0	1.4x10^{5}	789	0.0	0.0
640	2.1x10^{2}	0.0	690	0.0	2.3x10^{2}	740	0.0	2.0x10^{6}	790	0.0	0.0
641	2.1x10^{2}	0.0	691	0.0	3.3x10^{3}	741	0.0	0.0	791	0.0	0.0
642	1.1x10^{3}	0.0	692	0.0	0.0	742	0.0	4.6	792	0.0	0.0
643	0.0	0.0	693	0.0	0.0	743	0.0	2.2x10	793	0.0	0.0
644	0.0	0.0	694	0.0	0.0	744	0.0	2.2x10	794	0.0	0.0
645	0.0	0.0	695	0.0	0.0	745	0.0	3.1x10^{2}	795	0.0	0.0
646	1.3x10^{3}	0.0	696	0.0	0.0	746	0.0	0.0	796	0.0	0.0
647	1.3x10^{3}	0.0	697	0.0	1.5x10^{5}	747	0.0	0.0	797	0.0	0.0
648	6.4x10^{3}	0.0	698	0.0	2.1x10^{6}	748	0.0	0.0	798	0.0	0.0
649	0.0	0.0	699	0.0	2.6x10^{2}	749	0.0	2.7x10^{3}	799	0.0	0.0
650	0.0	0.0	700	0.0	3.6x10^{3}	750	0.0	2.7x10^{3}	800	0.0	0.0
											0.0

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
801	0.0	0.0	**851**	1.8x10^{4}	8.7x10	**901**	0.0	3.7x10^{6}	**951**	9.1x10^{10}	0.0
802	0.0	0.0	**852**	1.7x10^{2}	1.8x10^{6}	**902**	0.0	0.0	**952**	1.0x10^{17}	0.0
803	0.0	0.0	**853**	2.0x10^{3}	3.8x10^{2}	**903**	0.0	0.0	**953**	8.9x10^{11}	0.0
804	0.0	0.0	**854**	2.6x10^{3}	4.1x10^{2}	**904**	0.0	6.6x10^{8}	**954**	6.6x10^{8}	0.0
805	0.0	0.0	**855**	2.5	0.0	**905**	0.0	0.0	**955**	1.9x10^{15}	0.0
806	0.0	0.0	**856**	2.5	0.0	**906**	0.0	0.0	**956**	5.8x10^{13}	0.0
807	0.0	4.3x10^{10}	**857**	2.5	0.0	**907**	0.0	0.0	**957**	7.2x10^{12}	0.0
808	0.0	3.4x10^{11}	**858**	3.7x10	0.0	**908**	0.0	0.0	**958**	1.1x10^{13}	0.0
809	0.0	4.0x10^{10}	**859**	3.7x10	0.0	**909**	0.0	3.5x10^{8}	**959**	9.0x10^{15}	0.0
810	0.0	4.4x10^{8}	**860**	3.7x10	0.0	**910**	0.0	8.8x10^{7}	**960**	5.3x10^{11}	0.0
811	0.0	5.2x10^{5}	**861**	0.0	5.5x10	**911**	0.0	9.7x10^{11}	**961**	2.1x10^{9}	0.0
812	0.0	4.9x10	**862**	0.0	0.0	**912**	0.0	5.7x10^{11}	**962**	1.0x10^{9}	0.0
813	1.5x10^{13}	4.6x10^{3}	**863**	0.0	4.3x10^{3}	**913**	0.0	0.0	**963**	5.8x10^{8}	0.0
814	1.8x10^{10}	0.0	**864**	6.1x10	0.0	**914**	0.0	1.1x10^{6}	**964**	3.7x10^{8}	0.0
815	2.7x10^{11}	0.0	**865**	6.1x10	0.0	**915**	3.0x10^{2}	1.8x10^{3}	**965**	2.8x10^{13}	0.0
816	2.9x10^{7}	3.1x10^{6}	**866**	6.1x10	0.0	**916**	9.0	3.6x10^{6}	**966**	2.5x10^{12}	0.0
817	1.5x10^{5}	1.3x10^{4}	**867**	1.9x10^{2}	0.0	**917**	8.5x10^{3}	6.9x10^{3}	**967**	1.2x10^{12}	0.0
818	2.4x10^{9}	3.0x10^{3}	**868**	1.9x10^{2}	0.0	**918**	0.0	1.1x10^{9}	**968**	4.2x10^{11}	0.0
819	2.4x10^{9}	3.0x10^{3}	**869**	1.9x10^{2}	0.0	**919**	0.0	1.2x10^{11}	**969**	1.4x10^{11}	0.0
820	2.9x10^{9}	0.0	**870**	1.0	1.7x10^{2}	**920**	0.0	6.9x10^{6}	**970**	1.4x10^{13}	0.0
821	6.3x10^{5}	1.6x10^{5}	**871**	2.6	4.4x10^{2}	**921**	0.0	4.6x10^{11}	**971**	1.7x10^{16}	0.0
822	9.5x10^{5}	2.4x10^{5}	**872**	0.0	4.1x10^{2}	**922**	0.0	3.0x10^{7}	**972**	3.7x10^{14}	0.0
823	3.1x10^{13}	5.4x10^{2}	**873**	0.0	4.1x10^{2}	**923**	0.0	1.1x10^{8}	**973**	7.9x10^{10}	0.0
824	4.4x10^{11}	0.0	**874**	0.0	6.1	**924**	7.3x10^{9}	3.3x10^{2}	**974**	6.5x10^{6}	0.0
825	1.4x10^{12}	0.0	**875**	0.0	0.0	**925**	2.3x10^{10}	2.2x10^{4}	**975**	5.2x10^{6}	0.0
826	8.7x10^{10}	4.0x10^{4}	**876**	0.0	0.0	**926**	2.7x10^{3}	0.0	**976**	6.6x10^{3}	0.0
827	6.7x10^{9}	2.1x10^{4}	**877**	0.0	0.0	**927**	4.6x10^{10}	1.8x10^{3}	**977**	2.0x10^{4}	0.0
828	1.2x10^{7}	8.7x10	**878**	2.3x10^{4}	5.8x10^{4}	**928**	3.2x10^{6}	1.7x10^{3}	**978**	9.8x10^{4}	0.0
829	5.5x10^{6}	7.8x10^{4}	**879**	8.7x10^{3}	0.0	**929**	3.0x10^{3}	2.2x10^{5}	**979**	3.0x10^{5}	0.0
830	7.4x10^{9}	2.6x10^{2}	**880**	1.2x10^{4}	0.0	**930**	9.9x10^{3}	1.5x10^{7}	**980**	0.0	0.0
831	1.1x10^{13}	3.5	**881**	4.5x10^{2}	0.0	**931**	3.3x10^{4}	7.2x10^{4}	**981**	1.8x10^{2}	0.0
832	5.5x10^{9}	2.3x10^{5}	**882**	2.5	0.0	**932**	4.5x10^{3}	7.5x10	**982**	9.7x10	0.0
833	5.5x10^{9}	2.3x10^{5}	**883**	1.4x10^{8}	1.5x10^{5}	**933**	2.7x10^{3}	0.0	**983**	1.6x10^{5}	0.0
834	8.8x10^{6}	0.0	**884**	6.9x10^{2}	6.1x10^{8}	**934**	2.6x10^{13}	0.0	**984**	4.9x10^{5}	0.0
835	8.8x10^{6}	0.0	**885**	5.2x10^{2}	4.6x10^{8}	**935**	3.2x10^{6}	1.7x10^{3}	**985**	2.6x10^{4}	0.0
836	1.3x10^{8}	0.0	**886**	3.9x10^{3}	3.5x10^{4}	**936**	7.2x10^{5}	3.6x10^{2}	**986**	3.2x10^{4}	0.0
837	1.3x10^{8}	0.0	**887**	3.5x10^{4}	7.3x10^{5}	**937**	6.5x10^{3}	6.6x10	**987**	1.9x10^{12}	0.0
838	3.2x10	4.9x10^{5}	**888**	1.1x10^{5}	1.1x10^{4}	**938**	1.2x10^{10}	0.0	**988**	2.1x10^{11}	0.0
839	2.3x10^{3}	6.9x10^{5}	**889**	3.6x10^{3}	1.3x10^{3}	**939**	0.0	5.7x10	**989**	2.1x10^{11}	0.0
840	7.8x10^{5}	1.4x10^{5}	**890**	3.6x10^{3}	1.3x10^{3}	**940**	7.3x10^{9}	3.3x10^{2}	**990**	2.1x10^{10}	0.0
841	7.3x10^{5}	0.0	**891**	3.6x10^{3}	1.3x10^{3}	**941**	0.0	0.0	**991**	3.9x10^{7}	0.0
842	9.1x10^{2}	3.2x10^{7}	**892**	3.6x10^{3}	1.3x10^{3}	**942**	1.7x10^{4}	9.3x10	**992**	8.4x10^{10}	0.0
843	5.8x10^{9}	1.4x10^{4}	**893**	0.0	4.4x10^{2}	**943**	4.8x10^{4}	1.7x10^{5}	**993**	2.2x10^{13}	0.0
844	2.3x10^{10}	5.6x10^{4}	**894**	5.4	1.7x10^{3}	**944**	0.0	0.0	**994**	2.8x10^{10}	0.0
845	2.1x10^{8}	0.0	**895**	0.0	6.3x10^{2}	**945**	0.0	0.0	**995**	1.3x10^{11}	0.0
846	6.5x10^{8}	0.0	**896**	0.0	0.0	**946**	0.0	0.0	**996**	7.9x10^{11}	0.0
847	2.3x10^{6}	9.8x10^{5}	**897**	0.0	0.0	**947**	0.0	0.0	**997**	1.3x10^{10}	0.0
848	5.7x10^{3}	5.9x10^{3}	**898**	0.0	0.0	**948**	8.9x10^{10}	4.8x10^{6}	**998**	5.5x10^{9}	0.0
849	2.6x10^{3}	1.0x10^{5}	**899**	0.0	0.0	**949**	3.7x10^{10}	3.3x10^{4}	**999**	1.0x10^{14}	0.0
850	3.5x10^{2}	1.7	**900**	0.0	3.7x10^{6}	**950**	2.1x10^{8}	3.5x10^{7}	**1000**	9.8x10^{12}	0.0

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
1001	4.7x10^{3}	0.0	**1051**	1.0x10^{6}	0.0	**1101**	0.0	2.4x10	**1151**	3.8x10^{11}	2.6x10^{10}
1002	1.1x10^{10}	0.0	**1052**	1.7	0.0	**1102**	0.0	2.7x10^{9}	**1152**	3.8x10^{11}	2.5x10^{10}
1003	4.9x10^{6}	0.0	**1053**	0.0	7.9x10^{6}	**1103**	0.0	1.2x10^{9}	**1153**	2.0x10^{8}	3.9x10^{7}
1004	5.3x10^{12}	0.0	**1054**	5.7x10^{16}	0.0	**1104**	0.0	2.9x10^{7}	**1154**	4.0x10^{8}	7.9x10^{7}
1005	5.8x10^{12}	0.0	**1055**	1.7x10^{15}	0.0	**1105**	1.1x10^{10}	0.0	**1155**	2.0x10^{8}	3.9x10^{7}
1006	3.6x10^{11}	0.0	**1056**	1.1x10^{9}	0.0	**1106**	3.4x10	0.0	**1156**	9.0x10^{13}	1.9x10^{7}
1007	4.0x10^{9}	0.0	**1057**	1.6x10^{17}	0.0	**1107**	2.8x10^{12}	0.0	**1157**	1.0x10^{14}	2.2x10^{7}
1008	4.9x10^{11}	0.0	**1058**	2.7x10^{14}	0.0	**1108**	3.2x10^{2}	0.0	**1158**	1.7x10^{12}	3.4x10^{6}
1009	1.1x10^{10}	0.0	**1059**	1.5x10^{13}	0.0	**1109**	1.1x10^{3}	0.0	**1159**	9.5x10^{12}	9.4x10^{10}
1010	7.4x10^{8}	0.0	**1060**	2.6x10^{12}	0.0	**1110**	7.5x10^{6}	0.0	**1160**	2.1x10^{12}	4.9x10^{4}
1011	1.9x10^{8}	0.0	**1061**	3.7x10^{14}	0.0	**1111**	0.0	0.0	**1161**	3.1x10^{10}	6.9x10^{2}
1012	3.1x10^{8}	0.0	**1062**	2.7x10^{5}	1.1x10^{4}	**1112**	8.8x10^{2}	9.7x10^{9}	**1162**	1.4x10^{12}	3.1x10^{4}
1013	2.1x10^{7}	0.0	**1063**	1.5x10^{10}	0.0	**1113**	1.9x10^{3}	2.7x10^{10}	**1163**	2.1x10^{12}	4.9x10^{4}
1014	1.1x10^{7}	0.0	**1064**	1.0x10^{14}	0.0	**1114**	0.0	2.1x10^{16}	**1164**	0.0	0.0
1015	4.9x10^{10}	0.0	**1065**	2.2x10^{10}	0.0	**1115**	0.0	2.1x10^{16}	**1165**	3.5x10^{10}	5.3x10^{5}
1016	1.8x10^{10}	0.0	**1066**	3.2x10^{14}	0.0	**1116**	0.0	4.2x10^{16}	**1166**	5.5x10^{8}	7.8x10^{8}
1017	5.5x10^{10}	0.0	**1067**	2.6x10^{8}	0.0	**1117**	0.0	4.2x10^{16}	**1167**	6.8x10^{9}	9.2x10^{9}
1018	1.2x10^{10}	0.0	**1068**	2.1x10^{8}	0.0	**1118**	0.0	3.2x10^{13}	**1168**	1.2x10^{11}	0.0
1019	5.3x10^{6}	0.0	**1069**	8.4x10^{13}	0.0	**1119**	0.0	3.2x10^{13}	**1169**	2.4x10^{11}	0.0
1020	1.0x10^{8}	0.0	**1070**	1.2x10^{15}	0.0	**1120**	0.0	2.2x10^{10}	**1170**	2.0x10^{12}	0.0
1021	1.9x10^{9}	0.0	**1071**	4.7x10^{14}	0.0	**1121**	0.0	2.2x10^{10}	**1171**	6.9x10^{12}	0.0
1022	1.6x10^{8}	0.0	**1072**	1.0x10^{17}	0.0	**1122**	0.0	2.0x10^{6}	**1172**	8.2x10^{12}	0.0
1023	7.2x10^{5}	0.0	**1073**	4.4x10^{14}	0.0	**1123**	0.0	2.0x10^{6}	**1173**	2.3x10^{12}	0.0
1024	4.7x10^{9}	0.0	**1074**	7.2x10^{10}	0.0	**1124**	0.0	20.0	**1174**	1.8x10^{12}	0.0
1025	2.1x10^{7}	0.0	**1075**	4.2x10^{13}	0.0	**1125**	3.2x10^{14}	7.7x10^{4}	**1175**	2.5x10^{9}	0.0
1026	1.9x10^{2}	0.0	**1076**	2.8x10^{15}	0.0	**1126**	1.3x10^{16}	0.0	**1176**	7.1x10^{9}	0.0
1027	7.6x10^{2}	0.0	**1077**	5.1x10^{12}	0.0	**1127**	6.6x10^{15}	0.0	**1177**	1.4x10^{10}	0.0
1028	3.4x10^{3}	0.0	**1078**	2.8x10^{15}	0.0	**1128**	2.2x10^{8}	3.8x10^{9}	**1178**	2.6x10^{15}	0.0
1029	0.0	0.0	**1079**	7.4x10^{7}	0.0	**1129**	7.4x10^{9}	1.9x10^{4}	**1179**	4.4x10^{15}	0.0
1030	7.6x10^{5}	0.0	**1080**	8.2x10^{9}	0.0	**1130**	6.7x10^{10}	1.7x10^{5}	**1180**	8.3x10^{12}	0.0
1031	2.2x10^{7}	0.0	**1081**	1.9x10^{6}	0.0	**1131**	3.5x10^{10}	1.1x10^{5}	**1181**	3.4x10^{8}	0.0
1032	2.2x10^{3}	0.0	**1082**	8.6x10^{3}	2.8x10^{3}	**1132**	5.0x10^{8}	4.4	**1182**	4.5x10^{13}	0.0
1033	1.9x10^{6}	0.0	**1083**	3.6x10^{5}	0.0	**1133**	2.2x10^{8}	0.0	**1183**	4.2x10^{12}	0.0
1034	5.5x10^{7}	0.0	**1084**	5.4x10^{6}	0.0	**1134**	9.4x10^{7}	0.0	**1184**	1.4x10^{12}	0.0
1035	3.1x10^{5}	0.0	**1085**	3.5x10^{3}	0.0	**1135**	5.0x10^{7}	0.0	**1185**	0.0	0.0
1036	3.1x10^{9}	5.0x10^{4}	**1086**	1.0x10^{4}	0.0	**1136**	1.0x10^{4}	1.8x10^{7}	**1186**	5.1x10^{11}	0.0
1037	1.9x10^{9}	0.0	**1087**	5.3x10^{3}	0.0	**1137**	2.2x10^{8}	1.9x10^{14}	**1187**	2.0x10^{11}	1.5x10
1038	6.5x10^{10}	0.0	**1088**	8.7x10^{6}	0.0	**1138**	3.9x10^{14}	0.0	**1188**	1.0x10^{11}	7.5
1039	9.5x10^{12}	0.0	**1089**	2.7x10^{7}	0.0	**1139**	9.7x10^{14}	0.0	**1189**	3.4x10^{11}	2.5x10
1040	1.2x10^{11}	1.7x10^{4}	**1090**	0.0	0.0	**1140**	3.0x10^{15}	0.0	**1190**	0.0	0.0
1041	3.6x10^{13}	0.0	**1091**	0.0	0.0	**1141**	1.8x10^{3}	0.0	**1191**	2.1	8.4x10^{9}
1042	5.2x10^{12}	0.0	**1092**	0.0	0.0	**1142**	1.1x10^{13}	4.2x10^{14}	**1192**	1.0x10^{3}	4.5x10^{12}
1043	6.4x10^{10}	8.5x10^{6}	**1093**	0.0	0.0	**1143**	8.6x10^{2}	0.0	**1193**	1.5x10^{3}	1.1x10^{6}
1044	1.2x10^{12}	1.6x10^{2}	**1094**	0.0	0.0	**1144**	2.1x10^{3}	0.0	**1194**	1.3x10^{4}	1.0x10^{7}
1045	1.4x10^{9}	0.0	**1095**	0.0	0.0	**1145**	5.2x10^{10}	4.2x10^{12}	**1195**	0.0	0.0
1046	1.6x10^{8}	0.0	**1096**	0.0	1.7x10	**1146**	0.0	0.0	**1196**	0.0	8.9x10-41
1047	1.2x10^{6}	0.0	**1097**	0.0	0.0	**1147**	0.0	0.0	**1197**	0.0	7.7x10-41
1048	2.7x10^{10}	0.0	**1098**	0.0	3.4x10^{3}	**1148**	5.7x10^{12}	1.7x10^{15}	**1198**	0.0	0.0
1049	6.3x10^{10}	0.0	**1099**	0.0	0.0	**1149**	5.7x10^{6}	2.8x10^{11}	**1199**	2.0x10^{5}	5.1x10^{5}
1050	5.0x10^{5}	5.8x10^{3}	**1100**	2.1	0.0	**1150**	7.0x10^{10}	4.7x10^{9}	**1200**	9.0x10^{4}	8.5x10

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
1201	3.8x10^{4}	0.0	**1251**	2.6x10^{13}	3.3x10^{14}	**1301**	4.6x10^{2}	1.5x10^{11}	**1351**	2.2	5.3x10^{13}
1202	2.0x10^{4}	0.0	**1252**	2.7x10^{14}	0.0	**1302**	0.0	3.2x10^{9}	**1352**	1.9	1.2x10^{14}
1203	7.0x10	3.5x10^{13}	**1253**	2.6x10^{15}	1.9x10^{2}	**1303**	6.9x10^{6}	3.1x10^{10}	**1353**	0.0	3.2x10^{13}
1204	9.2x10^{11}	1.8x10^{4}	**1254**	6.5x10^{14}	4.8x10	**1304**	7.9x10^{4}	1.1x10^{13}	**1354**	0.0	1.5x10^{13}
1205	3.7x10^{12}	7.3x10^{4}	**1255**	6.5x10^{14}	4.8x10	**1305**	8.6x10^{2}	1.3x10^{12}	**1355**	0.0	8.0x10^{12}
1206	3.1x10^{12}	0.0	**1256**	8.7x10^{14}	6.5x10	**1306**	1.3x10^{2}	2.5x10^{14}	**1356**	0.0	2.2x10^{12}
1207	2.4x10^{12}	0.0	**1257**	6.6x10^{10}	2.1x10^{2}	**1307**	2.0x10^{8}	1.1x10^{11}	**1357**	1.0x10^{8}	1.4x10^{8}
1208	2.4x10^{12}	0.0	**1258**	7.4x10^{13}	0.0	**1308**	2.0x10^{4}	1.8x10^{9}	**1358**	3.6x10^{4}	7.3x10^{11}
1209	0.0	0.0	**1259**	2.2x10^{12}	0.0	**1309**	3.0x10^{6}	1.3x10^{9}	**1359**	1.3x10^{2}	2.1x10^{10}
1210	0.0	1.1x10^{2}	**1260**	1.3x10^{15}	0.0	**1310**	2.7x10^{4}	1.1x10^{8}	**1360**	0.0	5.9x10^{7}
1211	0.0	2.1x10^{2}	**1261**	4.1x10^{13}	0.0	**1311**	1.5x10^{5}	7.0x10^{6}	**1361**	9.8x10^{9}	1.3x10^{12}
1212	8.9x10^{9}	3.3x10^{10}	**1262**	6.8x10^{7}	0.0	**1312**	4.2x10^{6}	7.0x10^{13}	**1362**	2.7x10	5.2x10^{8}
1213	5.0x10^{3}	2.4x10^{8}	**1263**	6.8x10^{7}	0.0	**1313**	2.5x10^{4}	4.7x10^{12}	**1363**	1.4x10^{4}	8.2x10^{7}
1214	5.0x10^{3}	2.4x10^{8}	**1264**	2.3x10^{14}	0.0	**1314**	6.0x10^{3}	1.3x10^{7}	**1364**	2.1x10	5.0x10^{11}
1215	5.4x10^{4}	1.2x10^{14}	**1265**	0.0	0.0	**1315**	0.0	1.1x10^{4}	**1365**	0.0	1.7x10^{9}
1216	2.5x10^{10}	1.3x10^{10}	**1266**	1.3	0.0	**1316**	0.0	6.4x10^{11}	**1366**	3.6x10^{7}	1.5x10^{7}
1217	8.1x10^{4}	1.2x10^{9}	**1267**	2.6	0.0	**1317**	1.1x10^{7}	1.8x10^{9}	**1367**	1.6x10^{7}	2.5x10^{3}
1218	3.8x10	2.5x10^{10}	**1268**	1.6x10^{9}	1.3x10^{14}	**1318**	0.0	5.7x10^{7}	**1368**	6.8x10^{6}	2.4x10
1219	1.2x10^{10}	6.2x10^{7}	**1269**	0.0	0.0	**1319**	4.5x10^{2}	4.5x10^{9}	**1369**	3.6x10^{6}	1.9
1220	1.9x10	1.9x10^{12}	**1270**	1.7x10^{4}	4.0x10^{9}	**1320**	1.4x10^{16}	7.0x10^{8}	**1370**	6.9x10^{11}	0.0
1221	1.9x10^{3}	0.0	**1271**	1.7x10^{14}	4.0x10^{12}	**1321**	1.1x10^{8}	3.5x10^{9}	**1371**	1.7x10^{8}	3.2x10^{9}
1222	2.8x10^{5}	6.1x10^{8}	**1272**	8.3x10	2.6x10^{7}	**1322**	3.0x10^{4}	1.0x10^{8}	**1372**	5.8x10^{7}	0.0
1223	4.4x10^{5}	1.2x10^{9}	**1273**	5.0x10^{11}	2.2x10^{10}	**1323**	1.3x10^{4}	1.7x10^{10}	**1373**	3.3x10^{7}	0.0
1224	2.8x10^{5}	6.1x10^{8}	**1274**	0.0	9.0x10-71	**1324**	4.5	9.3x10^{8}	**1374**	2.1x10^{7}	0.0
1225	2.8x10^{5}	6.1x10^{8}	**1275**	0.0	0.0	**1325**	6.5x10^{4}	2.3x10^{14}	**1375**	1.7x10^{13}	0.0
1226	3.5x10^{8}	1.0x10^{6}	**1276**	0.0	0.0	**1326**	2.3x10^{3}	6.2x10^{13}	**1376**	6.9x10^{16}	0.0
1227	1.3x10^{7}	1.6x10^{9}	**1277**	0.0	0.0	**1327**	1.2x10^{11}	4.9x10^{11}	**1377**	6.1x10^{11}	0.0
1228	1.4x10^{7}	1.7x10^{9}	**1278**	0.0	0.0	**1328**	3.7x10^{11}	2.0x10^{12}	**1378**	1.8x10^{9}	0.0
1229	2.7x10^{6}	5.0x10^{10}	**1279**	4.2	0.0	**1329**	6.1x10^{10}	2.4x10^{11}	**1379**	1.8x10^{16}	0.0
1230	1.5x10^{6}	2.9x10^{10}	**1280**	8.8	0.0	**1330**	4.2x10^{10}	1.6x10^{11}	**1380**	2.6x10^{15}	0.0
1231	0.0	1.0x10^{10}	**1281**	5.0	0.0	**1331**	1.5x10^{4}	1.6x10^{8}	**1381**	7.7x10^{12}	0.0
1232	4.0x10^{9}	2.7x10^{2}	**1282**	5.3	0.0	**1332**	1.1x10^{5}	4.3x10^{9}	**1382**	2.6x10^{12}	0.0
1233	4.0x10^{9}	2.7x10^{2}	**1283**	3.1x10^{4}	0.0	**1333**	1.7x10^{9}	1.3x10^{8}	**1383**	1.3x10^{12}	0.0
1234	1.2x10^{10}	0.0	**1284**	2.0x10^{4}	0.0	**1334**	5.0x10^{6}	9.8x10^{5}	**1384**	1.3x10^{12}	0.0
1235	2.0x10^{6}	2.4x10^{15}	**1285**	1.5x10^{4}	0.0	**1335**	5.4x10^{11}	1.1x10^{10}	**1385**	8.0x10^{10}	0.0
1236	2.8x10^{2}	1.5x10^{12}	**1286**	0.0	0.0	**1336**	2.6x10^{8}	1.2x10^{12}	**1386**	3.1x10^{10}	0.0
1237	2.0x10^{3}	1.3x10^{14}	**1287**	0.0	4.0x10^{2}	**1337**	4.4x10^{3}	5.3x10^{14}	**1387**	5.4x10^{12}	0.0
1238	1.1x10^{10}	2.3x10^{13}	**1288**	2.0	8.0x10^{2}	**1338**	1.6x10^{6}	6.7x10^{9}	**1388**	2.8x10^{12}	0.0
1239	0.0	2.0x10^{12}	**1289**	0.0	0.0	**1339**	2.2x10^{6}	1.2x10^{13}	**1389**	3.6x10^{9}	0.0
1240	1.3x10^{12}	6.6x10^{15}	**1290**	1.4x10^{7}	2.2x10^{14}	**1340**	1.2x10^{7}	7.5x10^{15}	**1390**	4.6x10^{12}	0.0
1241	2.2x10^{5}	3.5x10^{10}	**1291**	5.6x10^{8}	1.9x10^{5}	**1341**	5.8	5.2x10^{13}	**1391**	4.2x10^{13}	0.0
1242	1.3x10^{16}	0.0	**1292**	4.2x10^{7}	1.4x10^{4}	**1342**	2.2x10^{6}	1.7x10^{14}	**1392**	6.3x10^{11}	1.1x10^{16}
1243	1.9x10^{16}	2.4x10^{15}	**1293**	4.9x10^{4}	6.2x10^{9}	**1343**	1.5x10^{3}	5.7x10^{11}	**1393**	0.0	3.4x10^{10}
1244	3.3x10^{12}	5.3x10^{12}	**1294**	6.2x10^{4}	6.2x10^{9}	**1344**	3.2x10^{11}	2.9x10^{15}	**1394**	0.0	6.6x10^{11}
1245	8.2x10^{12}	1.5x10^{13}	**1295**	4.7x10^{3}	4.7x10^{8}	**1345**	1.5x10^{7}	5.0x10^{14}	**1395**	2.6x10^{6}	2.9x10^{10}
1246	2.6x10^{12}	4.1x10^{12}	**1296**	8.4x10^{5}	9.3x10^{5}	**1346**	2.3	9.9x10^{12}	**1396**	3.7x10^{14}	3.6x10^{5}
1247	6.6x10^{12}	1.2x10^{13}	**1297**	5.9x10^{9}	8.7x10^{4}	**1347**	4.8x10^{11}	1.8x10^{14}	**1397**	5.8x10^{12}	3.0x10^{5}
1248	2.2x10^{3}	0.0	**1298**	3.2x10^{6}	6.5x10^{10}	**1348**	3.2x10^{2}	5.0x10^{14}	**1398**	0.0	0.0
1249	5.2x10^{3}	0.0	**1299**	8.3x10^{3}	2.0x10^{10}	**1349**	1.1x10	1.3x10^{14}	**1399**	2.6x10^{8}	0.0
1250	3.9x10^{10}	1.5x10^{11}	**1300**	7.9	5.6x10^{14}	**1350**	0.0	1.4x10^{13}	**1400**	3.3x10^{7}	0.0

no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow	no	Discharge	Afterglow
1401	2.0	0.0	**1411**	$7.2x10^{8}$	$2.8x10^{9}$	**1421**	$4.5x10^{9}$	$1.5x10^{12}$	**1431**	$4.0x10^{16}$	0.0
1402	7.4	0.0	**1412**	0.0	0.0	**1422**	$2.0x10^{4}$	0.0	**1432**	$2.0x10^{5}$	0.0
1403	4.3	0.0	**1413**	0.0	0.0	**1423**	$3.0x10^{15}$	$1.6x10^{8}$	**1433**	$5.7x10^{18}$	$7.3x10^{3}$
1404	1.1	0.0	**1414**	$8.2x10^{8}$	$3.1x10^{9}$	**1424**	$5.0x10^{13}$	$4.2x10^{9}$	**1434**	$6.3x10^{11}$	$1.1x10^{16}$
1405	2.2	0.0	**1415**	$3.7x10^{9}$	$1.4x10^{12}$	**1425**	$3.6x10^{10}$	$2.4x10^{5}$	**1435**	$2.2x10^{5}$	$2.9x10^{11}$
1406	$5.4x10^{12}$	0.0	**1416**	$5.1x10^{3}$	$2.3x10^{11}$	**1426**	$2.3x10^{8}$	$2.1x10^{12}$	**1436**	$2.1x10^{6}$	$5.6x10^{12}$
1407	$1.6x10^{10}$	0.0	**1417**	$2.7x10^{11}$	$1.4x10^{5}$	**1427**	$1.8x10^{16}$	$1.5x10^{8}$	**1437**	$3.2x10^{6}$	$1.7x10^{3}$
1408	$6.4x10^{3}$	$1.6x10^{8}$	**1418**	4.8	$1.2x10^{12}$	**1428**	$1.0x10^{13}$	$5.5x10^{10}$			
1409	$4.1x10^{10}$	$3.0x10^{9}$	**1419**	$5.6x10^{15}$	$6.3x10^{9}$	**1429**	$1.0x10^{13}$	$5.5x10^{10}$			
1410	$4.1x10^{10}$	$3.0x10^{9}$	**1420**	$5.6x10^{15}$	$6.3x10^{9}$	**1430**	$9.9x10^{12}$	$2.4x10^{3}$			

Absence of He_2^+ in the chemistry set

In this section, we present the results of a case study without He_2^+ in the chemistry set. For the following reactions, which are responsible for the formation of He_2^+, we set the rate coefficient to zero.

	He_2^+ production reactions
6	$e + He_2^* \rightarrow He_2^+ + e + e$
93	$He^+ + 2He \rightarrow He + He_2^+$
166	$He^* + He^* \rightarrow He_2^+ + e$
168	$He^* + He_2^* \rightarrow He + He_2^+ + e$
170	$He_2^* + He_2^* \rightarrow He + He + He_2^+ + e$

The reason behind this case study is that we could not find a direct experimental proof for the presence of He_2^+ ions in He plasma discharges, although it is commonly agreed in literature that for pressures above 5 Torr, He_2^+ is formed[15,16] and other simulation papers also included He_2^+ in their chemistry set.[4,5,8] Thus, we also included it in our model, but we performed a simulation without this species, as an extreme case, to evaluate the effect of it on the calculation results.

Species densities

Figure S2 shows the species densities along the symmetry axis of the FAPA source for the case study without He_2^+. Except for He^+, for all other species, the number density stays very close to the values in Figure S1. In fact, as we do not include the formation of He_2^+, He^+ is not converted into He_2^+ and its density increases drastically.

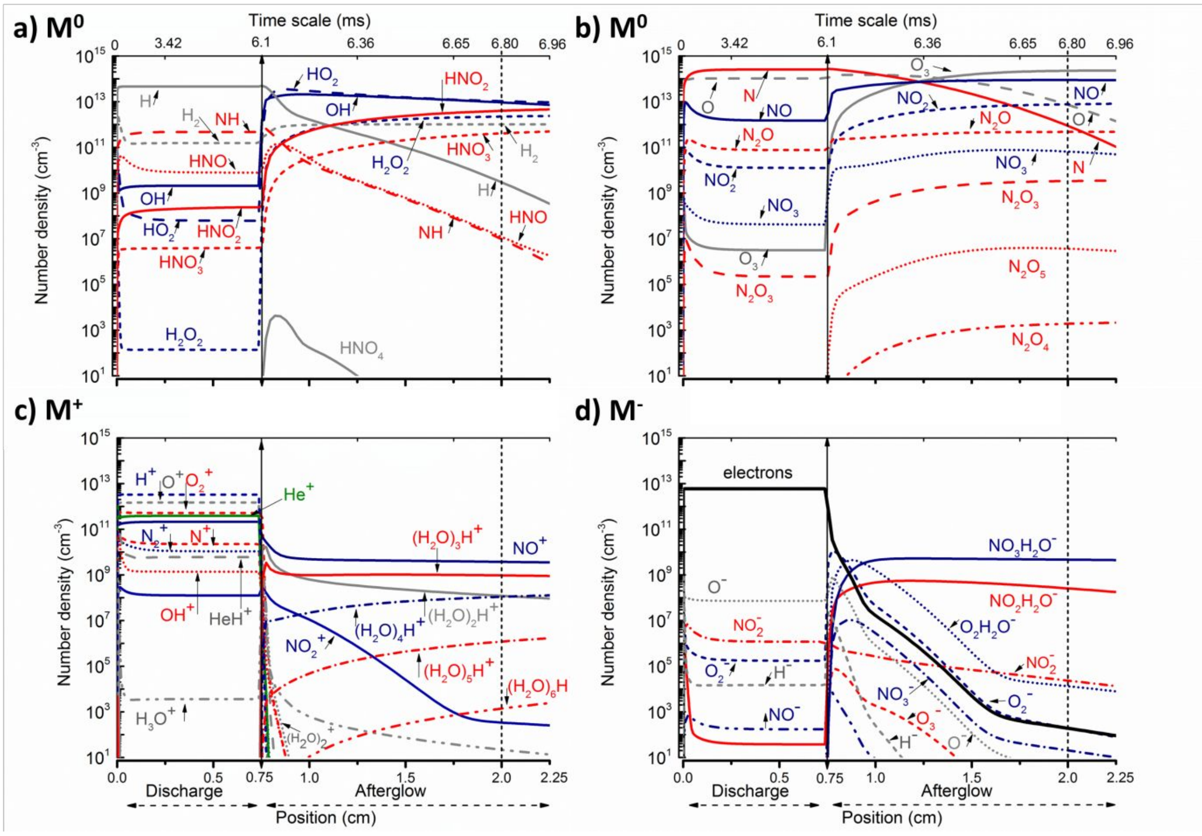

Figure S2 Number densities along the symmetry axis of the FAPA source of the most important species: (a) H, H-O, H-N neutrals, (b) N-O neutrals, (c) positive ions, and (d) negative ions and electrons, when neglecting He_2^+ in the model.

Reaction pathways

Figure S3 shows the number density profiles of the He species in the absence of He_2^+, and their reaction pathways in producing reagent ions inside the discharge region.

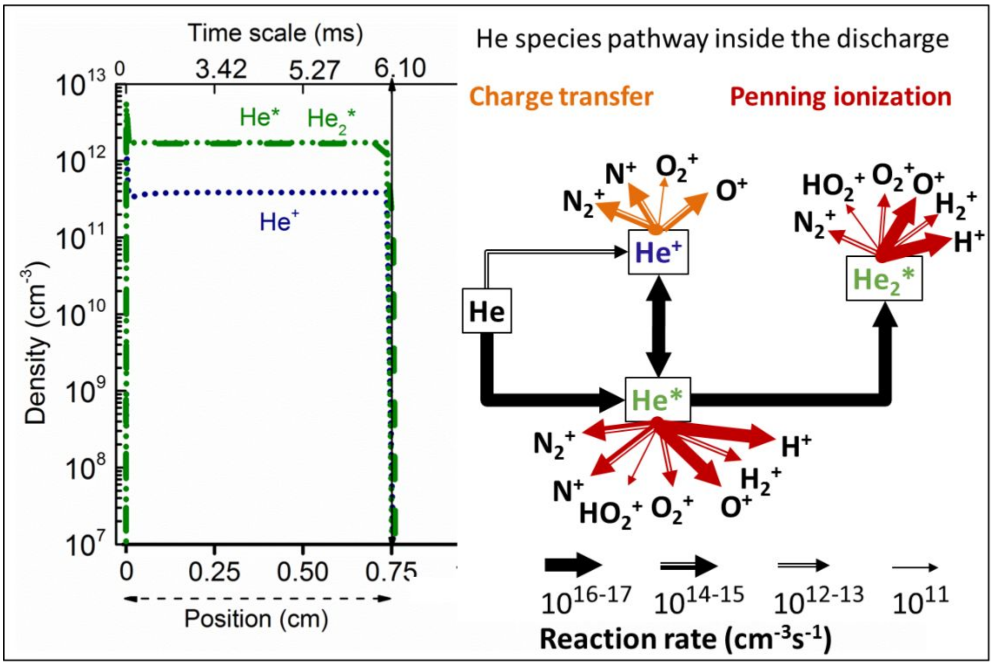

Figure S3 Number density profiles of the He species, when assuming no He_2^+ is formed (left), and their reaction pathways in producing reagent ions (right), inside the discharge region. The thickness of the arrow lines indicates the magnitude of the corresponding reaction rate.

Figure S3 should be compared with Figure 3 in the main manuscript. Note that without He_2^+, the main charge transfer ionization happens by He^+ instead of He_2^+ for O^+, O_2^+, N^+, and N_2^+. In addition, the formation of H^+ and H_2^+ now occurs upon Penning ionization by He*. Note that the changes give rise to the same range of reaction rates, and therefore the thickness of the arrows for He* stays the same as in Figure 3.

The reaction pathways for the discharge and afterglow region stay the same as presented in Figure 4 and Figure 5 in the main manuscript. Note that in Figure 4, where He_2^+ is written on an arrow, it should be replaced by He^+ in case He_2^+ would be neglected. In Figure 4, we can see that among the He species, the main reagent species are He* and He_2* and therefore, removing He_2^+ from the chemistry set does not change these reaction pathways.

Conclusion

It is commonly accepted in literature that He_2^+ is formed in helium plasmas for pressures higher than 5 torr.[15,16] Therefore, this species is included in numerical studies for He plasmas.[4,5,8] However, we did not find a direct measurement of He_2^+ in literature, and therefore, we also performed calculations without He_2^+. Our results show that the number density of species, as well as the main formation pathways, stay the same. Only the pathway of ionization from He_2^+ is now replaced by ionization from either He^+ or He*. This means that the assumption of the formation of He_2^+ in He discharges would require some further experimental proof.

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