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Modelling the molecular composition and nuclear-spin chemistry of collapsing prestellar sources^{*}

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ABSTRACT

We study the gravitational collapse of prestellar sources and the associated evolution of their chemical composition. We use the *University of Grenoble Alpes Astrochemical Network (UGAN)*, which includes reactions involving the different nuclear-spin states of H_2 , H_3^+ , and of the hydrides of carbon, nitrogen, oxygen, and sulfur, for reactions involving up to seven protons. In addition, species-to-species rate coefficients are provided for the ortho/para interconversion of the $\text{H}_3^+ + \text{H}_2$ system and isotopic variants. The composition of the medium is followed from an initial steady state through the early phase of isothermal gravitational collapse. Both the freeze-out of the molecules on to grains and the coagulation of the grains were incorporated in the model. The predicted abundances and column densities of the spin isomers of ammonia and its deuterated forms are compared with those measured recently towards the prestellar cores H-MM1, L16293E, and Barnard B1. We find that gas-phase processes alone account satisfactorily for the observations, without recourse to grain-surface reactions. In particular, our model reproduces both the isotopologue abundance ratios and the ortho:para ratios of NH_2D and NHD_2 within observational uncertainties. More accurate observations are necessary to distinguish between full scrambling processes—as assumed in our gas-phase network—and direct nucleus- or atom-exchange reactions.

Key words:

Stars: formation—Molecular processes and data—Astrochemistry—ISM: abundances, molecules—ISM: individual objects H-MM1, L16293E, Barnard B1

1 INTRODUCTION

The gravitational collapse of gas and dust, which can lead ultimately to the formation of a star and planets, can be observed, in its early stages, through the molecular lines that are emitted by the contracting object. Many such observations have been performed in recent years, by means of ground-based and satellite observatories, and the ALMA array is now providing unprecedented angular resolution. Furthermore, there are converging lines of evidence that cometary ices carry signatures of prestellar core chemistry. Most recently, unexpectedly large abundances of O_2 and volatile S_2 in the coma of comet 67P/C-G were reported (Bieler et al. 2015; Calmonte et al. 2016), while observa-

tions with ground-based interferometers and with the sub-millimeter ESA/Herschel observatory indicate that more than about 80% of water from the prestellar core actually remains in solid form during the collapse of the protostellar envelope towards the protoplanetary disk (van Dishoeck et al. 2014).

As the object collapses, its density increases, and changes in the rates of physical and chemical processes cause the composition of the medium to evolve. These changes can be followed by means of models that incorporate both the dynamical processes associated with the collapse and the physical chemistry of the gas. Given that the timescale for gravitational collapse and those of many of the chemical processes are comparable, it is desirable that the numerical model should be able to solve simultaneously the dynamical and the chemical rate equations.

Our previous models of prestellar objects have either neglected the dynamics and assumed that the chemical com-

^{*} This paper is dedicated to the memory of Charles Malcolm Walmsley, outstanding astrophysicist and friend.

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position attains steady-state at a given density (Le Gal et al. 2014), or followed the contraction of the radius, R , of a core of mass M by means of the equation of gravitational free-fall,

$$\frac{1}{R} \frac{dR}{dt} \equiv \frac{1}{x} \frac{dx}{dt} = -\frac{\pi}{2\tau_{\text{ff}}x} \left(\frac{1}{x} - 1 \right)^{1/2} \quad (1)$$

(Flower et al. 2005), where t is the time and $x \equiv R/R_0 \leq 1$. The initial radius, R_0 , of the condensation is given by

$$R_0 = \left(\frac{3M}{4\pi\rho_0} \right)^{1/3} \quad (2)$$

with ρ_0 the initial mass density. The timescale, τ_{ff} , for free-fall collapse is

$$\tau_{\text{ff}} = \left(\frac{3\pi}{32G\rho_0} \right)^{1/2} \quad (3)$$

(Spitzer 1978). By integrating Equ. (1) in parallel with the chemical rate equations, the chemical composition of the medium may be derived, as a function of the (time-dependent) density of the cloud.

Seminal studies of the gravitational collapse of condensations of material in interstellar clouds (Larson 1969, 1972; Penston 1969) have shown that, in the initial isothermal phase, the collapsing core becomes surrounded by an envelope whose density varies as r^{-2} , where r is the radial distance to a point in the condensation. The central object subsequently acquires mass via an outwards-propagating expansion shock wave (Shu 1977). This model was adopted by Visser et al. (2009, 2011) in order to simulate the chemical evolution of a molecular medium that is undergoing gravitational collapse. Their (two-dimensional) simulation assumes the condensation to be rotating, and consequently some of the infalling material accumulates in a disk. More recently, Keto et al. (2015) have applied a one-dimensional (“Larson-Penston”) dynamical model in their study of the chemistry of collapsing prestellar cores.

In our approach, we distinguish between a central object (“core”), whose initial mass is equal to the Jeans mass and which is undergoing free-fall collapse, and the surrounding object (“envelope”), which forms through mass-loss from the core; the total mass of the core plus the envelope remains constant and equal to the Jeans mass. As the core evolves, its density increases but its mass decreases. The increasing density leads to an enhanced rate of adsorption of the molecular gas on to the grains, whilst an increasing fraction of the molecular column density is contributed by the surrounding envelope. We simulate the structure and chemical composition of the envelope by means of a time-dependent chemical model, assuming a r^{-2} density profile in the envelope and a constant temperature throughout. The column densities of atomic and molecular species are computed in the core and the envelope, and comparisons are made with the corresponding values observed in prestellar sources.

Our treatment of the chemistry of the medium distinguishes itself from other studies of protostellar collapse (Lesaffre et al. 2005; Visser et al. 2011; Aikawa et al. 2012; Keto et al. 2015) by including explicitly the various nuclear-spin states of the carbon, nitrogen, oxygen, and sulfur hydrides and their abundant deuterated forms. It has been known for over a decade that the (observed) deuterium enrichment of molecules such as ammonia is mediated by re-

actions with the deuterated forms of H_3^+ and is intimately linked to the evolution of ortho:para abundance ratios. Our model combines a chemistry of prestellar objects that incorporates isotopic and nuclear-spin modifications of the relevant species with a dynamical simulation of the initial phase of gravitational collapse that results in the formation of the prestellar object. The dynamical and chemical rate equations are solved numerically, in parallel, thereby allowing, in a self-consistent manner, for departures of the physical and chemical states of the medium from steady-state.

In Section 2, we summarize the characteristics of the model; Section 3 contains our results and comparisons with observations of prestellar objects, and Section 4 our concluding remarks.

2 THE MODEL

2.1 A new dynamical model

We consider a spherically-symmetric, isothermal, non-rotating medium, consisting of neutral, positively- and negatively-charged gas and dust. The mass contained in the collapsing sphere is

$$M_0 = \frac{4\pi}{3} R_0^3 \rho_0$$

where R_0 is the initial radius and ρ_0 is the initial, uniform, mass density. Both the Jeans mass, M_J , and the critical mass for stability of a Bonnor-Ebert sphere, M_{crit} , are of the same order, given by

$$M_J \approx M_{\text{crit}} \approx \left(\frac{\pi k_B T}{\mu G} \right)^{3/2} \left(\frac{1}{\rho_0} \right)^{1/2},$$

where $\mu = 2.33m_{\text{H}} = 3.9 \times 10^{-24}$ g is the mean molecular mass and $T = 10$ K is the kinetic temperature of the gas. Taking $\rho_0 \equiv n_0\mu = 1.4n_{\text{H}}m_{\text{H}}$, where $n_0 = 6.0 \times 10^3 \text{ cm}^{-3}$ is the initial number density of the gas (corresponding to molecular gas with $n_{\text{H}} = n(\text{H}) + 2n(\text{H}_2) = 10^4 \text{ cm}^{-3}$ and $n(\text{He})/n_{\text{H}} = 0.10$), yields $M_J \approx 7 M_{\odot}$; the corresponding free-fall time is $\tau_{\text{ff}} = 4.4 \times 10^5$ yr.

We compute the chemical evolution of a fluid particle that flows inwards, at speed, $v(R)$, where R is the radius of the free-falling core. Following the early study of Larson (1969), the free-falling core, of radius R , has a uniform density ρ and is progressively surrounded by an envelope whose density ρ_{env} evolves as

$$\rho_{\text{env}}(R_{\text{env}}) = \rho_0 \left(\frac{R_0}{R_{\text{env}}} \right)^2 = \rho \left(\frac{R}{R_{\text{env}}} \right)^2, \quad (4)$$

which implies that the mass of the core is

$$M(R) = M_0 \frac{R}{R_0}. \quad (5)$$

The equation of motion under conditions of free-fall gravitational collapse is

$$\frac{d^2R}{dt^2} = -\frac{GM(R)}{R^2} \quad (6)$$

where G is the gravitational constant. Using Equ. (5), Equ. (6) may be integrated, yielding

$$v(R) = \frac{dR}{dt} = - \left[\frac{2GM_0}{R_0} \ln \left(\frac{R_0}{R} \right) \right]^{1/2}. \quad (7)$$

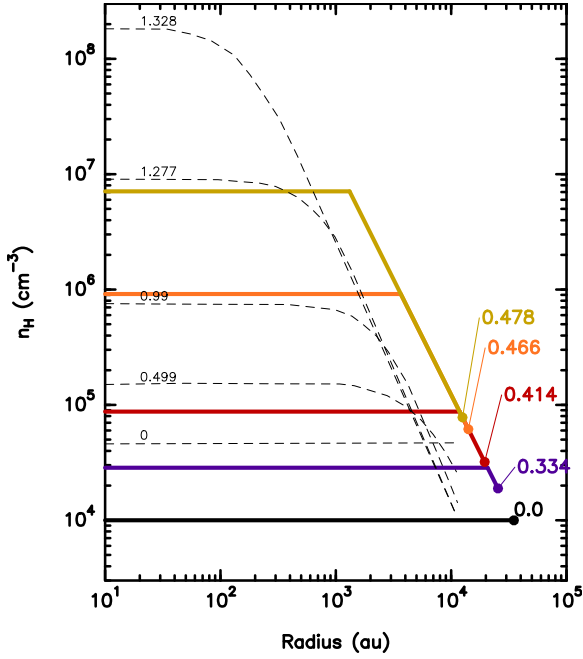


Figure 1. The evolution, in our “Larson-Penston” model, of the density profile of the gas (full curves), n_{H} , as a function of the radius for a mass $M_0 = 7M_{\odot}$ and an initial density of $n_{\text{H}} = 10^4 \text{ cm}^{-3}$. The time elapsed from the initial configuration (in Myr) is indicated for each curve. The filled circles indicate the location of the outer edge of the envelope, which varies with the core radius, in order that the total mass is conserved. The results of Larson (1969), for a $1M_{\odot}$ contracting cloud of initial density and radius $n_{\text{H}} = 4.7 \times 10^4 \text{ cm}^{-3}$ and $1.1 \times 10^4 \text{ au}$ respectively, are also shown for comparison (broken curves, labeled with the times in units of 10^{13} s).

with the initial condition that $v(R) = 0$ when $R = R_0$.

We note that Eqs. (4) and (5) have the form of the density and mass distributions of the “singular isothermal sphere” considered by Shu (1977) (his Equ. (2)). When transformed to his dimensionless variables, the infall velocity that we compute exhibits a profile that is similar to the isothermal collapse solutions plotted in his Fig. 3.

Our calculation traces the free-fall collapse of a particle at the edge of the core but is not truly Lagrangian. The flux of matter escaping outwards, across the boundary, R , of the collapsing condensation, is given by

$$4\pi R^2 \rho u = -\frac{dM}{dt} = -M_0 v(R)/R_0 \quad (8)$$

which can be written in the form

$$4\pi R_0^2 \rho_0 u = -\frac{dM}{dt} = -\frac{4\pi}{3} R_0^2 \rho_0 \frac{dR}{dt}. \quad (9)$$

It follows that the speed at which matter crosses the surface of the sphere is

$$u = -v(R)/3 \quad (10)$$

and hence the flow speed of this matter in an inertial frame is $2/3v(R)$. The outer radius R_{out} of the envelope contracts at this same speed (see Fig. 1), thereby ensuring conservation of the total mass of the core and the envelope.

In the following, comparisons to observations will be based on both abundances and column densities. To com-

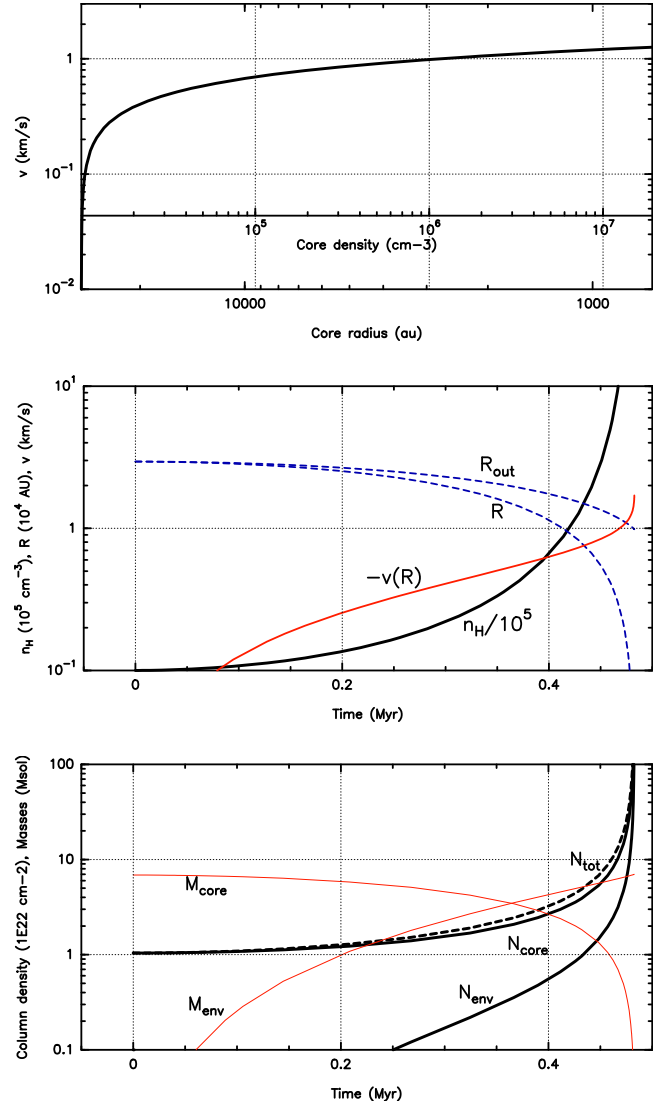


Figure 2. Our “Larson-Penston” model. *Top panel:* the velocity profile of the inner collapsing core as a function of its radius (in au) and its central density (in cm^{-3}). *Middle panel:* the temporal profiles of the total H nuclei density n_{H} (in units of 10^5 cm^{-3}), of the radii (in astronomical units) of the core (R) and the outer edge of the cloud (R_{out}), and of the infall velocity ($-v(R)$, Equ. 7). The parameters are those of Table 1. *Bottom panel:* contributions of the core and the envelope to the mass (in M_{\odot}), M_{core} and M_{env} , and to the total column density (in units of 10^{22} cm^{-2}), N_{core} and N_{env} . In all panels, the time is expressed in Myr.

pute the column densities, we note that during a time interval dt , the core contracts by a distance $-dR$ and the column density of any species in the envelope increases by

$$dN_{\text{env}} = -\frac{1}{3} n_{\text{H}}(R) X(R) dR, \quad (11)$$

where $n_{\text{H}}(R)$ and $X(R)$ represent the density and the abundance, with respect to total H nuclei, at radius R , respectively. Integration of that quantity thus gives the contribution of the envelope to the total column density. On the other hand, the column density of the uniform collapsing core is

Table 1. Initial parameters of the Flower et al. (2006b) (F06) and of the reference model used in our “Larson-Penston” collapse.

Parameter	Notation	Unit	Value	
			F06	Reference
Mass	M_0	M_\odot	–	7
Initial cloud radius	R_0	au [§]	–	3.5×10^4
Initial Density	n_H	cm^{-3}	10^4	10^4
Kinetic temperature	T	K	10	10
Cosmic ray ionization rate [†]	ζ	s^{-1}	1×10^{-17}	3×10^{-17}
Initial radius of the refractory grain core	a_g	μm	0.05	0.10
Initial free–fall time	τ_{ff}	Myr	0.43	0.43

§ The abbreviation “au” is used here for the astronomical unit of distance (1.5×10^{13} cm).

† ζ is the rate of cosmic-ray ionization of H_2 , namely the sum of the ionization and dissociative ionization of H_2 .

simply

$$N_{\text{core}}(R) = n_H(R)X(R)R. \quad (12)$$

Note that in our approach, the chemical composition of the envelope is not computed explicitly but is determined by that of the free–falling inner core (see Section 3.3.3). In the following, the contributions to the column densities from both the front and the rear of the cloud are included, assuming spherical symmetry. Although the mass of the envelope becomes greater than that of the contracting core early in the collapse process—when the density, n_H , of the core is about $2 \times 10^4 \text{ cm}^{-3}$ —the total column density remains dominated by the contracting core. As will be seen below, this is not necessarily the case for the chemical species, owing to freeze-out.

Our approach simulates well the density profile and, qualitatively, the velocity profile calculated by Larson (1969): the evolution of the density profile of the envelope and core is shown in Fig. 1. Initially, when $R = R_0$, the gas is at rest in an inertial frame. Subsequently, the infall velocity increases as R decreases, as may be seen from Equ. (7) and the results in Fig. 2, in which the contributions of the collapsing core and of the envelope to the total column density and mass are also shown. On the other hand, the infall velocity predicted by the “Larson-Penston” solution of Keto et al. (2015) increases with R . Furthermore, the gas is not initially at rest, which is inconsistent with one of the conditions specified by Larson (1969). Thus, whilst the profile of the density of the gas that we calculate is analogous to that of Keto et al., the velocity profile is qualitatively different.

The reason for the discrepancy in the velocity profiles is that the “Larson-Penston” profile of Keto et al. derives from the similarity solution considered in Appendix C of Larson (1969) and not from his numerical results. The similarity solution for the infall speed tends, at large radius, to a value of 3.28 times the isothermal sound speed; but Larson notes that the computed velocity profile approaches the similarity solution only slowly, and the collapse must be followed over at least 12 orders of magnitude in density to approach the limiting value. In practice, we are concerned with the early stage of the collapse process, during which the density increases by only a few orders of magnitude from its initial value and the gas at large radius remains approximately at rest.

In our model, the differential equations are solved where R is the only variable. The elapsed time is then computed as $t = \int_{R_0}^R dx/v(x)$. The equation of mass conservation applied to

each of the neutral, positively- and negatively-charged fluids in the free–falling core takes the generic form

$$\frac{1}{\rho} \frac{d\rho}{dR} = \frac{S}{\rho\dot{R}} - \frac{2}{R} \quad (13)$$

where $\rho(R)$ is the mass density, $S(R)$ is the rate of production of mass per unit volume, for the appropriate fluid, and $\dot{R} = v(R)$. In the case of a free–falling core with no envelope, such as in F06, the second term on the right hand side would be $3/R$. In our case, the core loses mass, hence building up the envelope (see Equ. 5), such that $dM/M = dR/R$ which yields $d\rho/\rho = -2dR/R$ instead of $-3dR/R$.

Chemical processes result in mass exchange amongst the three fluids (e.g. in the production of a neutral by recombination of a positive and a negative species), but overall mass conservation is maintained, i.e. $S_n + S_+ + S_- \equiv 0$. The three fluids are assumed to have a common flow speed, v , and kinetic temperature, T .

As the core contracts, from R_0 to R , its composition evolves. This chemical evolution is followed by means of

$$\frac{1}{n} \frac{dn}{dR} = \frac{N}{n\dot{R}} - \frac{2}{R} \quad (14)$$

where $n(R)$ is the number density of the species and $N(R)$ is its rate of (chemical) formation per unit volume. Over 200 species, comprising gas- and solid-phase atomic and molecular species and grains, participate in a set of over 3000 chemical reactions, which change the composition and degree of ionization of the medium, notably by the freeze-out of neutral species (including, where relevant, nuclear-spin variants and deuterated forms) on to the surfaces of grains.

The first–order differential equations representing the dynamical and physico-chemical processes were integrated by means of the DVODE algorithm for solving, in particular, “stiff” differential equations (Hindmarsh 1983). We allowed for the coagulation of grains during the collapse, following the description of this process by Flower et al. (2005) and using the measurements of Poppe & Blum (1997). Coagulation reduces the total surface area of the grains and hence the rate of adsorption of the neutral species on to the grains.

The physical parameters used for the two series of models—labeled “F06” and “reference”—of our study are summarized in Table 1. We adopted the initial distribution of the elements amongst the gas and solid phases summarized in Tables 2 and 3 (see also Flower 2005; the solid phase consists of grains with a refractory core and an ice mantle that increases in size during the collapse process, owing to freeze-out.

Table 2. Fractional elemental abundances, with respect to H nuclei, and their partitioning into volatiles (gas and grain mantles) and refractory (grain cores), and the corresponding levels of depletion (δ , in %) from the gas phase. Numbers in parentheses are powers of 10.

Element	Total	Volatile		Refractory	δ
		Gas	Mantles		
H	1.0	1.0			0
He	1.00(-1)	1.00(-1)			0
C	3.55(-4)	8.27(-5)	5.55(-5)	2.17(-4)	77
N	7.94(-5)	6.39(-5)	1.55(-5)		20
O	4.42(-4)	1.24(-4)	1.78(-4)	1.40(-4)	72
S	1.86(-5)	6.00(-7)	1.82(-5)		98
Mg	3.70(-5)			3.70(-5)	100
Si	3.37(-5)			3.37(-5)	100
Fe	3.23(-5)	1.50(-9)		3.23(-5)	100

Table 3. Initial fractional abundances in the grain mantles, expressed relative to the total H nuclei density $n_{\text{H}} = 10^4 \text{ cm}^{-3}$. Numbers in parentheses are powers of 10.

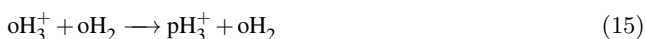
Species	Fractional abundance
H ₂ O	1.03(-4)
CO	8.27(-6)
CO ₂	1.34(-5)
CH ₄	1.55(-6)
CH ₃ OH	1.86(-5)
H ₂ CO	6.20(-6)
HCOOH	7.24(-6)
NH ₃	1.55(-5)
H ₂ S	1.80(-5)
OCS	2.07(-7)

2.2 A new chemical network

Since the Flower et al. (2006b) (hereafter F06) paper, there have been significant changes to the rate coefficients for chemical reactions, notably those determining ortho \leftrightarrow para inter-conversion, e.g. for H₃⁺ + H₂ and isotopic variants (see below). In addition, new THz facilities have provided the abundances of spin isomers of several hydride molecules, such as H₂D⁺, which motivated a complete revision of the spin-separated astrochemical network of F06. In the process, the rates of cosmic-ray-induced photo-reactions, which are significant in establishing the steady-state abundances, have also been revised. We provide here a summary of the most salient features of the new University of Grenoble Alpes Astrochemical Network (UGAN), while full details, and the entire network, can be found in the Appendices.

2.2.1 New conversion rates for H₃⁺ + H₂ and isotopic variants

An important addition to the reaction network is the exoergic proton-exchange reaction



which was excluded from the reaction set of F06 on the grounds that the change of proton spin orientation in the H₃⁺ ion must be accompanied by $\text{oH}_3^+ + \text{oH}_2 \longrightarrow \text{pH}_3^+ + \text{pH}_2$, yielding para-H₂. However, both forms of H₂ can be represented by the combinations of the “spin-up” (α) and “spin-

down” (β) single-particle nuclear spin functions, namely $2^{-\frac{1}{2}}(\alpha_1\beta_2 + \alpha_2\beta_1)$ and $2^{-\frac{1}{2}}(\alpha_1\beta_2 - \alpha_2\beta_1)$ for the ortho and para H₂ respectively, where the subscripts 1 and 2 label the protons. It follows that a quantum-statistical calculation, such as that undertaken by Hugo et al. (2009), can give rise to non-zero rate coefficients for processes that would be excluded in a more simplistic approach. In fact, Hugo et al. obtained a rate coefficient for reaction (15) that is 4 times larger than for the reaction leading to pH₂. As a consequence, the ortho:para-H₃⁺ ratio calculated using their data may be expected to be lower than when reaction (15) is neglected, as in F06. This expectation is confirmed by the results of the steady-state calculations, as may be seen in Table 5: even though the ortho:para-H₂ ratio is lower, the ortho:para-H₃⁺ ratio is also lower than was calculated by F06¹.

For the important ortho \leftrightarrow para inter-conversion reactions in the H₃⁺ + H₂ system and isotopic variants, we replaced the ground-state-to-species kinetic rates, published by Hugo et al. (2009) and used extensively in the astrophysical community, by *species-to-species* rates. To do so, the state-to-state rate coefficients computed by Hugo et al. (2009) were averaged, adopting LTE level populations for temperatures up to 50 K. For each reaction, the (logarithm of the) resulting temperature-dependent rates were fitted by a modified Arrhenius law. While the modifications are small for the lightest species—H₂, H₃⁺, and H₂D⁺—they become more important for the heavier, doubly- or triply-deuterated species. We note that our rates agree to within a factor of two with the species-to-species rates calculated by Sipilä et al. (2017) using a similar procedure. We also checked that our new rates correctly recover thermalized ortho-to-para ratios for H₃⁺ and its deuterated analogs, at temperatures larger than ≈ 16 K (Le Boulrot 1991; Flower et al. 2006a). These new rates are provided in Tables D7–D10.

2.2.2 State-of-the-art, fully separated hydride chemistry

Faure et al. (2013); Rist et al. (2013) and Le Gal et al. (2014) have revisited and revised the chemistry of nitrogen-bearing species, which now includes specifically the various nuclear-spin states of the carbon, nitrogen, oxygen, and sulfur hydrides and their abundant deuterated forms. The nuclear-spin state separation was performed using the permutation symmetry approach of Quack (1977). During this process, the rate coefficients of many bi-molecular reactions were updated, following a literature survey. Full details of the assumptions behind this new chemical network are provided in Appendices B and C. In Appendix D we specify the rate coefficients for these reactions that have been adopted in the present calculations, including the steady-state computations reported in columns 3 and 4 of Table 4.

2.2.3 Grain-surface processes

It should be noted that no explicit grain-surface reactions are included in the chemical network (except the formation of H₂ and isotopologues). The rates of adsorption of neutral

¹ Available at http://massey.dur.ac.uk/drf/protostellar/chemistry_species

Table 4. Steady–state abundances, expressed relative to $n_{\text{H}} = n(\text{H}) + 2n(\text{H}_2) = 10^4 \text{ cm}^{-3}$, as calculated using the chemical reaction set of Flower et al. (2006b) (F06) and our present, updated chemistry. Two values of the cosmic-ray ionization rate, ζ , and of the initial refractory grain core, a_g , have been used, which are indicated. Where the nuclear–spin state is not specified (e.g. NH_2D), the fractional abundance is the sum of the abundances of the individual nuclear–spin states. Numbers in parentheses are powers of 10.

Species	F06 [§]	Present	
	$\zeta = 1 \times 10^{-17} \text{ s}^{-1}$ $a_g = 0.05 \mu\text{m}$	1×10^{-17} 0.05	3×10^{-17} 0.10
H	2.2(-05)	2.3(-05)	6.9(-05)
pH ₂	5.0(-01)	5.0(-01)	5.0(-01)
oH ₂	1.4(-03)	4.1(-04)	5.4(-04)
N	1.2(-05)	5.3(-06)	8.4(-06)
pNH ₃	4.1(-08)	2.3(-09)	5.0(-09)
oNH ₃	1.4(-08)	1.2(-09)	2.7(-09)
NH ₂ D	4.6(-09)	2.6(-09)	4.7(-09)
NHD ₂	2.1(-11)	6.6(-11)	1.0(-10)
ND ₃	2.0(-14)	2.7(-13)	4.1(-13)
CN	9.2(-09)	2.0(-09)	7.4(-09)
HCN	1.1(-07)	1.6(-09)	2.8(-09)
HNC	1.4(-07)	1.4(-09)	2.9(-09)
N ₂	2.6(-05)	2.9(-05)	2.8(-05)
pH ₃ ⁺	7.4(-10)	1.5(-09)	4.1(-09)
oH ₃ ⁺	1.1(-09)	5.5(-10)	1.8(-09)
oH ₂ D ⁺	2.0(-11)	9.6(-11)	2.7(-10)
pH ₂ D ⁺	3.4(-12)	5.1(-11)	1.3(-10)
oHD ₂ ⁺	1.4(-12)	2.2(-11)	5.9(-11)
pHD ₂ ⁺	5.2(-13)	7.2(-12)	1.9(-11)
oD ₃ ⁺	3.0(-14)	8.8(-13)	2.2(-12)
mD ₃ ⁺	3.8(-14)	8.2(-13)	2.1(-12)
pD ₃ ⁺		4.3(-14)	1.1(-13)
N ₂ H ⁺	5.0(-10)	5.2(-10)	9.3(-10)
N ₂ D ⁺	2.5(-12)	1.8(-11)	3.1(-11)

[§]http://massey.dur.ac.uk/df/protostellar/chemistry_species

Table 5. *Top:* steady–state ortho:para (and also m:p in the cases of D₃⁺ and ND₃) abundance ratios for the species listed in Table 4. Also given are the corresponding thermalized ratios at 10 K and in the limit of high temperature. *Bottom:* abundances of the deuterated isotopologues of ammonia, relative to NH₃. The abundances are sums over the contributions of the individual nuclear–spin states. Numbers in parentheses are powers of 10.

Species	Present		F06 [§]	Thermalized	
	1×10^{-17}	3×10^{-17}	1×10^{-17}	10 K	∞
H ₂	7.4(-4)	1.1(-3)	2.8(-3)	3.5(-7)	3
H ₃ ⁺	3.6(-1)	4.3(-1)	1.4	7.5(-2)	1
H ₂ D ⁺	1.8	2.1	5.8	1.9(-3)	3
HD ₂ ⁺	3.0	3.1	2.7	9.8(1)	2
D ₃ ⁺ (o:p)	20.9	19.5		4.1(2)	16
D ₃ ⁺ (m:p)	19.2	19.3		1.8(3)	10
NH ₃	5.9(-1)	5.4(-1)	3.4(-1)	3.7	1
NH ₂ D	1.7	1.7		2.9	3
NHD ₂	2.1	2.1			2
ND ₃ (o:p)	16.6	16.5			16
ND ₃ (m:p)	10.8	10.7			10
NH ₃	1.0	1.0	1.0		
NH ₂ D	3.3(-1)	2.2(-1)	8.3(-2)		
NHD ₂	8.2(-3)	4.6(-3)	3.8(-4)		
ND ₃	4.3(-5)	1.9(-5)	3.6(-7)		

[§]http://massey.dur.ac.uk/df/protostellar/chemistry_species

species were computed with allowance for the contribution of the grain mantle to the grain cross section, as described in appendix B of Walmsley et al. (2004). Our treatment of the thermal desorption of molecules, following cosmic ray impact, follows Section 5 of Flower et al. (1995). Ortho- and para-H₂ are assumed to form on grains in the statistical 3:1 ratio of their corresponding nuclear spin states, $I = 1$ and $I = 0$. On the other hand, an ortho-to-para equal to unity is assumed for all other species upon desorption. The desorption of molecules by the cosmic ray–induced ultraviolet radiation field (see Appendix A) is also included.

2.2.4 H₂-driven non-LTE ortho:para ratios

The thermal equilibrium (LTE) ratio of the population densities of the lowest ortho and para states of H₃⁺ is

$$\frac{n(J_K = 1_0)}{n(J_K = 1_1)} = \frac{4}{2} \exp\left(-\frac{32.9}{T}\right)$$

where 4 and 2 are the statistical weights of the ortho and para states, respectively, and 32.9 K is the energy of the lowest ortho state above that of the lowest para state. At a kinetic temperature $T = 10$ K, the LTE ortho:para-H₃⁺ ratio is 0.075; Tables 4 and 5 show that their populations are indeed strongly inverted (i.e. the population ratio exceeds its value in LTE). This inversion is a consequence of the dominance of ortho-H₂ in establishing the relative populations of the ortho- and para-H₃⁺ states and the inversion of the populations of the $I = 1$ and $I = 0$ states of ortho- and para-H₂, respectively, through the grain–formation process. Similarly strong deviations from LTE (thermalized) ratios are found for most species (Faure et al. 2013).

3 RESULTS AND DISCUSSION

The initial distribution of the elements is specified in Tables 2 and 3.

3.1 Steady–state composition

It is instructive to compare the initial (steady–state) abundances of species incorporated in the model with the values obtained by F06 for a cloud having a uniform density ($n_{\text{H}} = 10^4 \text{ cm}^{-3}$) and kinetic temperature ($T = 10$ K). In these models, the cosmic-ray ionization rate of H₂ is $\zeta = 10^{-17} \text{ s}^{-1}$ and the initial radius of the refractory grain core is $a_g = 0.05 \mu\text{m}$ (see Table 1).

As may be seen from a comparison of columns 2 and 3 of Table 4, the recent revisions to the chemistry have repercussions on the composition of the gas. The corresponding ortho:para ratios are listed in the upper part of Table 5. Faure et al. (2013) calculated, in steady state at $T = 10$ K, an ortho:para-H₂ ratio of 9×10^{-4} , for a model that is similar to that considered in Tables 4 and 5; their ortho:para-NH₃ ratio was 0.7. As might be expected, these values are closer to the present results than those of F06. In the lower part of Table 5 are the degrees of deuteration of ammonia, which are seen to be greater in the present calculations than in those of F06. This deuteration process is mediated by the deuterated forms of H₃⁺, which are produced in reactions of H₃⁺ with HD; these reactions were also studied by Hugo

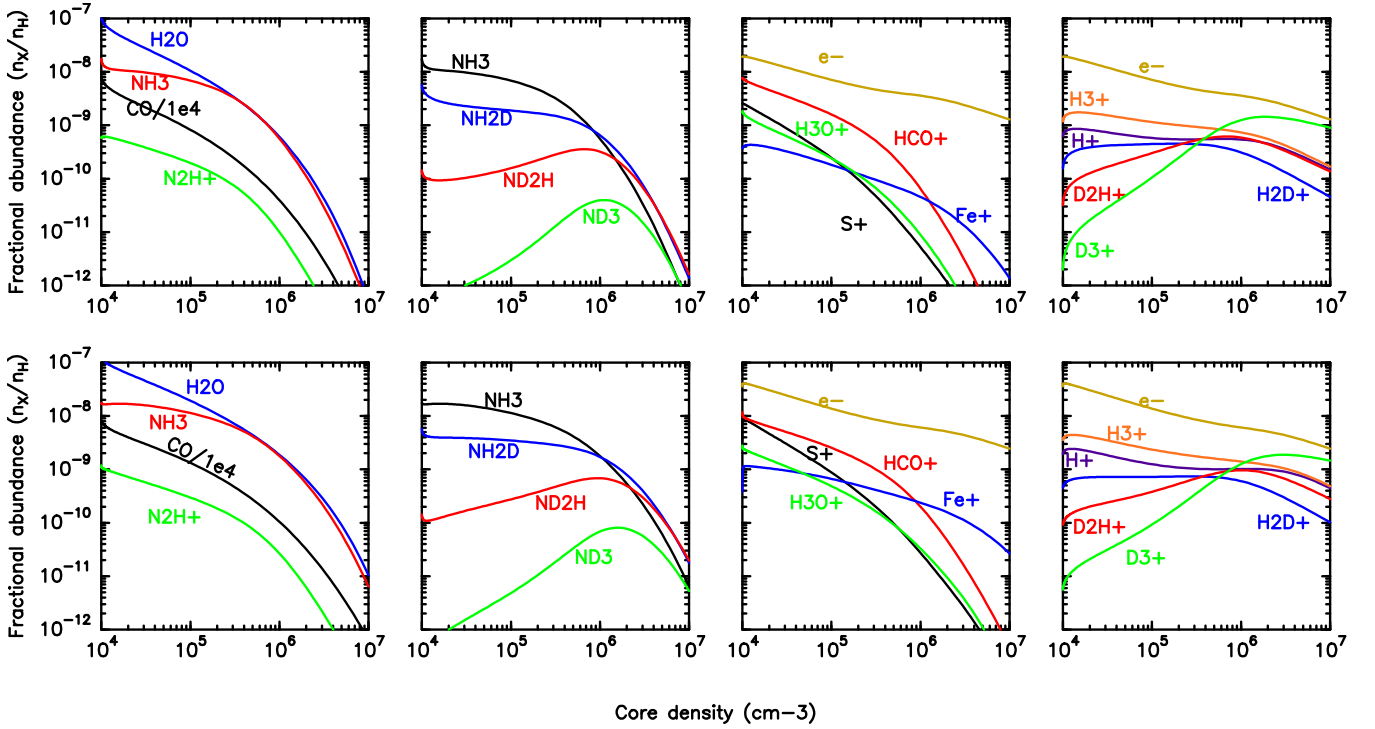


Figure 3. Evolution of the fractional abundances of selected chemical species—expressed relative to n_{H} —in a cloud that is undergoing contraction in a free-fall collapse (four upper panels), and from our “Larson-Penston” model (four lower panels). In each case, the two left (right) panels focus on neutral (charged) species. The chemical network is described in Section 3.1 and Appendix D. *Upper panels:* models with $\zeta = 1 \times 10^{-17} \text{ s}^{-1}$, and an initial radius of the refractory grain core $a_{\text{g}} = 0.05 \mu\text{m}$. *Lower panels:* initial parameters of the reference model of Table 1.

et al. (2009). It is the revisions to these rate coefficients that lead to higher abundances of the deuterated isotopologues of ammonia in the present study.

The significance of the steady-state fractional abundance of any given species depends on the associated equilibrium timescale, which can attain values in excess of 1 Myr under the conditions considered here. Although condensations may remain close to a quasi-static equilibrium for timescales as long as 500 kyr (Brünken et al. 2014), it is unlikely that the chemical composition of the cloud will evolve unperturbed over such long periods of time. Indeed, the timescale for free-fall collapse of the cloud is less than 1 Myr. It follows that the steady-state composition of the gas has limited relevance to observations of prestellar cores. Instead, the composition must be computed under conditions appropriate to collapse, as is described in the following Sections. Both our free-fall and Larson-Penston simulations assume an initial steady-state composition for the physical conditions of our reference model (see Table 1), except where otherwise specified.

3.2 Free-fall simulation

It is instructive to consider first the case of free-fall collapse, which provides a point of reference for subsequent models. In Fig. 3 are shown the variations with the collapsing cloud density, n_{H} , of the fractional abundances of selected species, notably some of those containing nitrogen.

The variations of the fractional abundances with the

density of the medium that are seen in Fig. 3 are qualitatively similar to the results of Flower et al. (2005), who also considered a free-fall model. For the purpose of this comparison, we adopt the same values of the cosmic-ray ionization rate ($\zeta = 1 \times 10^{-17} \text{ s}^{-1}$) and the initial radius of the refractory grain core ($a_{\text{g}} = 0.05 \mu\text{m}$) as Flower et al. (2005). On the other hand, there are quantitative differences, notably for H_3^+ and its isotopologues, which relate to the revisions of the chemistry, as discussed in Section 3.1.

3.3 Larson-Penston simulation

At the onset of gravitational collapse, an envelope begins to form around a core that is initially the principal contributor to the total column densities of the molecular species. As the collapse proceeds, the core contracts according to Equ. (6) and its density increases from its initial value; the density profile of the envelope follows from Equ. (4). The envelope becomes increasingly important and, as we shall see, its contribution ultimately dominates the total column densities—in part because the total mass of material advected into the envelope from the core during free-fall is greater than the residual mass of the core.

3.3.1 Fractional abundances

In Fig. 3 are shown the variations in the fractional abundances of selected neutral and charged species as functions of the current density, n_{H} , of the core (and hence at the

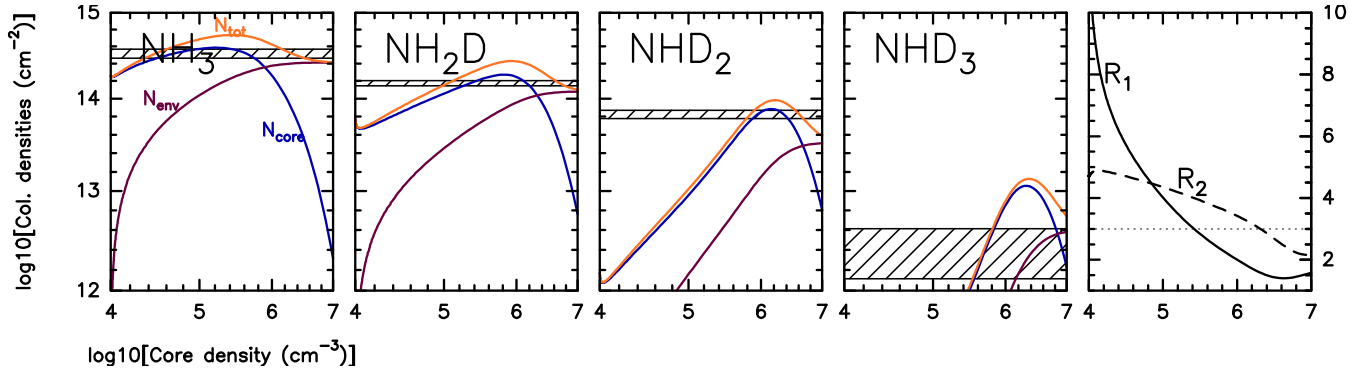


Figure 4. Contributions, in our reference “Larson-Penston” collapse model (Table 1), of the core, N_{core} , and the envelope, N_{env} , to the total column density $N_{\text{tot}} = N_{\text{core}} + N_{\text{env}}$ of the ammonia molecule and its deuterated forms, as functions of the density of the core. The column densities are evaluated as described in Section 2. The LTE column densities in the starless core Ophiuchus/H-MM1 (Harju et al. 2017) are shown for comparison (see also Table 6.) *Far right panel:* the column density double-ratios, R_1 and R_2 , defined in Eqs. (16) and (17).

current interface between the core and the envelope). As the density increases, atoms and molecules are adsorbed by the grains, whose radius (of the core and the ice mantle) increases from its initial value of $0.13 \mu\text{m}$ as more ice is deposited. In these calculations, we assumed the same value, $S = 1$, of the “sticking coefficient”² for all adsorbing species. As is evident from Fig. 3, the depletion timescale is slightly longer in the L-P than in free-fall model, as a consequence of the following factors: in the L-P model, the contraction timescale is $4.8 \times 10^5 \text{ yr}$, 10% longer than the free-fall time, and the value of ζ (and hence the cosmic-ray desorption rate) is three times larger; but, most significant, the initial radius of the grain core is smaller by a factor of 2 (and the total grain surface area correspondingly larger) in the free-fall than in the L-P model.

3.3.2 Total column densities

In order to illustrate the transition from the preponderance of the core to the preponderance of the envelope, we compare, in Fig. 4, the contributions of the core, N_{core} , and the envelope, N_{env} , to the column density of the ammonia molecule, NH_3 , and its deuterated forms, NH_2D , NHD_2 , ND_3 . Column densities in the core and in the envelope are evaluated as described in Section 2. The total column densities, $N_{\text{tot}} = N_{\text{core}} + N_{\text{env}}$, are also plotted, as are the column densities deduced by Harju et al. (2017) from their observations of the starless core Ophiuchus/H-MM1 by assuming a single excitation temperature and statistical ortho:para ratios (see Table 6).

It is clear from Fig. 4 that the total column density comes to be dominated by the contribution of the envelope, as the core contracts and its density increases but its mass decreases. The composition of the envelope is not uniform, as may be seen from Fig. 3: in the vicinity of the core, adsorption on to the grains depletes the neutral species, which has consequences for the degree of ionization of the gas. Agreement, to better than a factor of 2, with the observed column

densities of the ammonia molecule and all of its deuterated forms is found at a density, n_{H} , in the range $5 - 10 \times 10^5 \text{ cm}^{-3}$. Furthermore, since deriving mass, age, or size is not the chief objective of this work, no attempt was made to actually find the best fit to the data. This suggests that gas-phase processes can account for the deuteration of NH_3 , without the necessity of invoking additional grain-surface reactions, as concluded by Le Gal et al. (2014). In any case, our gas-grain chemistry is dominated by the adsorption of neutral species in the course of gravitational collapse; desorption processes occur too slowly to affect significantly the gas-phase molecular abundances. On the other hand, if molecules were returned to the gas phase by a mechanism that is intrinsically faster than the cosmic ray-induced desorption processes considered here, the molecular column densities might become dependent on chemical reactions on the surfaces of grains. Furthermore, surface processes, and especially those possibly involved in spin conversion, are still poorly constrained (Turgeon et al. 2017), and the impact of such processes on the observed gas-phase ortho:para ratios is difficult to anticipate. Finally, we note that the agreement with the observations is obtained at densities for which the main contribution to the column density of ammonia and deuterated analogs comes from the free-falling core, before freeze-out begins to be dominant.

3.3.3 Column densities of spin isomers

Column densities of specific isomers of ammonia and its deuterated forms have been measured towards starless and prestellar cores (Daniel et al. 2016; Harju et al. 2017). Figure 5 shows the comparison with the column densities predicted by our reference isothermal collapse model (see Table 1). We note first that agreement to better than a factor 3 is obtained for all sources and species. In the case of H-MM1, the agreement is obtained at core densities in the range $0.3 - 1 \times 10^6 \text{ cm}^{-3}$, as compared with the value of $1.2 \times 10^6 \text{ cm}^{-3}$ derived from the dust emission (Harju et al. 2017). Similarly, in the case of Barnard B1, our model suggests core densities above approximately 10^6 cm^{-3} , consistent with the value of $3 \times 10^6 \text{ cm}^{-3}$ determined by Daniel

² The sticking coefficient S is not to be confused with the mass production rate in Equ. (13).

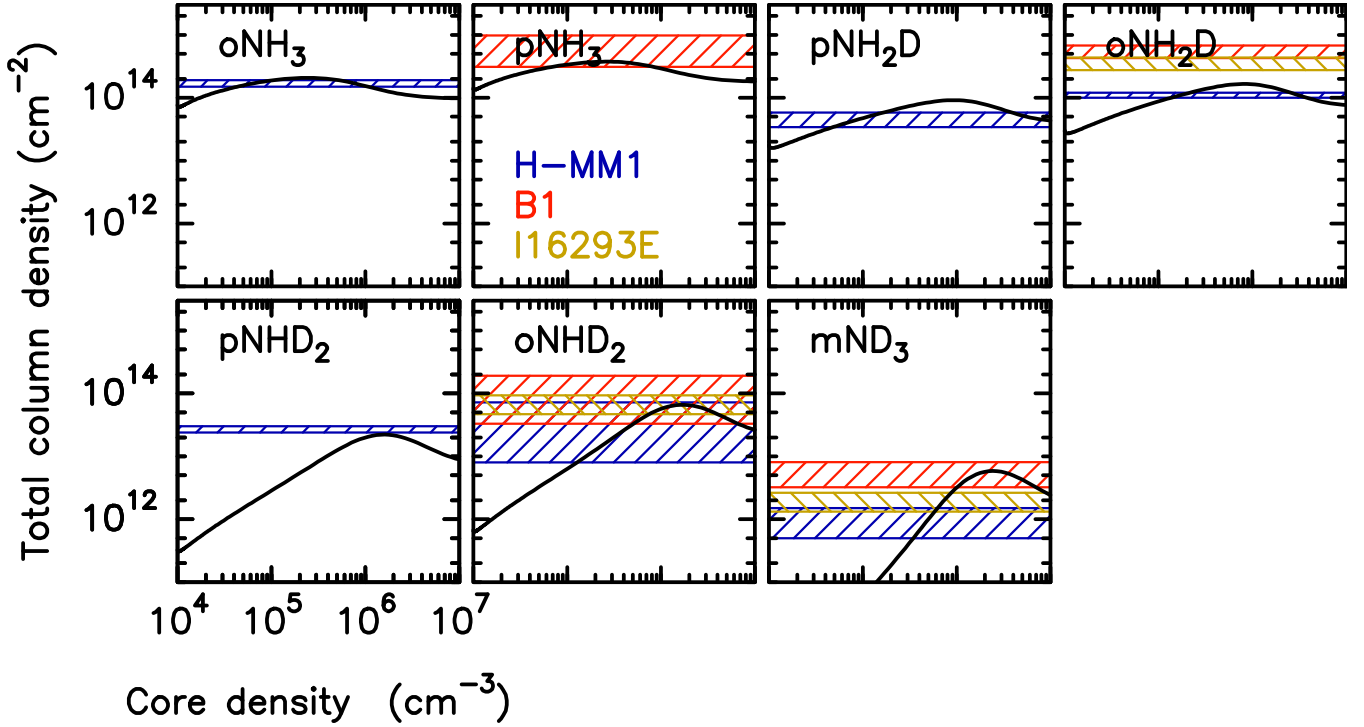


Figure 5. Column densities of ammonia and its deuterated forms, as predicted from our “Larson-Penston” collapse model (full lines) and from observations (hashed regions) of the I16293E, Barnard-B1, and H-MM1 prestellar cores (Daniel et al. 2016; Harju et al. 2017) (see Table 6). The initial parameters are those of Table 1.

et al. (2013). The observation that the core density is higher in B1 than in H-MM1 is correctly reproduced. However, Barnard B1 is likely to be at a more advanced stage of evolution than is described by our model (Gerin et al. 2015), and the agreement that we obtain suggests that ammonia is not tracing the innermost and densest regions. In addition, our calculations slightly under-produce p-NH₃ and o-NH₂D, which may indicate that gas-depletion through freeze-out is proceeding too rapidly in the model. Finally, in the case of the I16293E starless core, our model intercepts the observed ranges of column densities for o-NHD₂ and m-ND₃ at two densities, between approximately 10⁶ and 10⁷ cm⁻³. Although the latter density may seem too high for this type of object, we note that it is close to the value of 1.4 × 10⁷ cm⁻³ obtained from the dust-emission profiles (Bacmann et al. 2016). Overall, the level of agreement with the observations reported in Fig. 5 (and in Fig. 4) lends credence to the validity of the gas-phase chemical network.

Further support for our gas-phase network comes from the deuteration of ammonia, from NH₃ through to ND₃. In the far right panel of Fig. 4, we have plotted the ratios

$$R_1 = \frac{\text{NH}_2\text{D}/\text{NH}_3}{\text{NHD}_2/\text{NH}_2\text{D}} \quad (16)$$

and

$$R_2 = \frac{\text{NHD}_2/\text{NH}_2\text{D}}{\text{ND}_3/\text{NHD}_2} \quad (17)$$

Observationally, both ratios are close to 3, within their uncertainties (Daniel et al. 2016; Harju et al. 2017). If hydrogenation and deuteration were determined by statistics

only—as is presumably the case in ices—both these ratios would be exactly equal to 3. However, as Fig. 4 shows, ratios close to 3 can be produced by gas-phase chemistry at the core densities relevant to prestellar cores. It follows that ratios of 3 are not reliable indicators of deuteration taking place in ices, rather than in the gas-phase (Harju et al. 2017). We note also that these ratios evolve significantly from their steady-state values as the density increases.

Whilst our simulation of the Larson-Penston collapse enables us to include the contribution of the envelope to the column densities of the chemical species, the temporal evolution of the chemical composition of the envelope is not calculated explicitly; this approximation could lead to overestimating the contribution to the column densities of the outer regions of the envelope, owing to an underestimation of freeze-out. However, as freeze-out occurs least rapidly at the densities (lower than 10⁵ cm⁻³) prevailing in the outer envelope, and because the envelope contributes only marginally to the total column density until massive freeze-out in the core takes place, this approximation was verified to have negligible impact on our results.

3.3.4 Ortho-to-para ratios

In Fig. 6, we plot the spin-isomer abundance ratios of NH₃ and H₃⁺ and of their deuterated analogues. The calculated H₃⁺ ortho:para ratio tends to approximately 0.7 as the core density increases. In the case of NH₃, our assumption that the deuteration reactions proceed via long-lived intermediate complexes, in which complete scrambling of the nuclei occurs, leads to values of the ortho:para ratio of NH₂D and

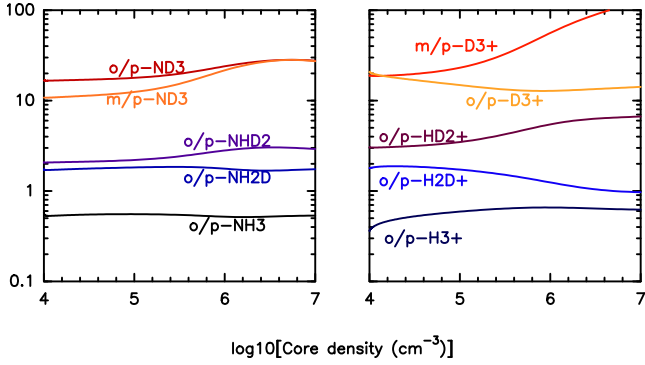


Figure 6. Variation with the core density of the ratios of the total column densities of the various nuclear spin states of NH_3 (left) and H_3^+ (right), and of their respective deuterated analogs. For reference, the corresponding thermalized ratios at 10 K are given in Table 5.

NHD_2 of approximately 1.8 and 2.0–2.8, respectively, over the density range 10^5 – 10^6 cm^{-3} . These values are consistent, within observational uncertainties, with the ratios measured in H-MM1 and listed in Table 6. The chemical model of Harju et al. (2017) predicts a similar ortho:para ratio for NH_2D , but a significantly larger one (in the range 3–5) for NHD_2 . On the other hand, the observed ratios are also consistent with the statistical values of 3 and 2, respectively. Ortho:para ratios close to their statistical values were observed by Daniel et al. (2016) in Barnard B1b also.

Statistical ratios could indicate that direct gas-phase proton/deuteron hops or hydrogen/deuterium abstraction—instead of full scrambling of nuclei in an intermediate reaction complex—plays an important role in the deuteration process (Harju et al. 2017). Deuteration was indeed found to inhibit the permutation of protons in the H_3^+ ion (Lin & McCoy 2015) thus preventing the full scrambling scheme adopted in the Harju et al. and our networks. To investigate the origin of the different predictions for NHD_2 from our model and from Harju et al. (2017), we have tested the influence of the reaction $\text{NH}_3 + \text{D}_3^+ \rightarrow \text{NH}_2\text{D}_2^+ + \text{HD}$ which eventually leads to NHD_2 upon dissociative recombination. This, and similar, reactions are not included in our network because we assume that single particle (H, H^+ , D or D^+) hop is the dominant outcome of the complex forming reaction. This particular reaction results in an increase of the ortho:para ratio of NHD_2 by less than 10%. Although other similar reactions have not been included in our network, it appears unlikely that the factor of 1.5–2 difference between our results and those of Harju et al. (2017) arises only from these reactions. We also checked that the difference is not due to the new species-to-species inter-conversion rates (see Section 2.2.1). Alternatively, it could be related to differences in the raw, unfractionated and unseparated, chemical networks. Furthermore, we emphasize that the details of the nuclear spin selection rules in deuteration reactions such as $\text{NH}_3 + \text{D}_3^+$ are currently not known, and the observational error bars are too large to allow a distinction to be made between complete scrambling and particle hop.

Table 6. Column densities (or their \log_{10}) of ammonia and its deuterated forms towards three prestellar cores.

Source	Species	N cm^{-2}	o/p
H-MM1 [†]	o NH_3	$1.7 \pm 0.2 \times 10^{14}$	2.4 ± 0.7
	o NH_2D	$1.1 \pm 0.1 \times 10^{14}$	
	p NH_2D	$4.6 \pm 1.2 \times 10^{13}$	
	o NHD_2	$4.0 \pm 3.2 \times 10^{13}$	
	p NHD_2	2.7×10^{13}	
B1 [§]	m ND_3	$1.0 \pm 0.5 \times 10^{12}$	~ 3
	p NH_3	14.74 ± 0.25	
	o NH_2D	14.73 ± 0.10	
	o NHD_2	13.90 ± 0.38	
I16293E [§]	m ND_3	12.71 ± 0.20	~ 3
	o NH_2D	14.54 ± 0.10	
	o NHD_2	13.82 ± 0.15	
	m ND_3	12.27 ± 0.15	

[†] LTE column densities from Harju et al. (2017).

[§] \log_{10} values from Daniel et al. (2016).

3.3.5 Depletion and collapse timescales

There remains an underlying issue with the dynamical model: the flow velocity, u (Equ. 10), increases too rapidly as a function of the density of the gas, attaining approximately 1 km s^{-1} when $n_{\text{H}} = 10^6 \text{ cm}^{-3}$; such velocities exceed the limiting values, of the order of 0.1 km s^{-1} , that are deduced from the observed line profiles (cf. bergin2007 and are predicted by hydrodynamical calculations (Foster & Chevalier 1993; Lesaffre et al. 2005; Keto et al. 2015). We remark that the singular isothermal–sphere model of Shu (1977) also produces excessive values of the collapse velocity over a significant fraction of the cloud. As pointed out by Keto et al. (2015), it is the velocity towards the outer edge of the cloud that is responsible for the differences in the shape of the emergent spectral lines. Although the velocity at large radii in our model is probably too high, radiative–transfer calculations are needed to confirm this conclusion.

A consequence of reducing the collapse velocity, and hence extending the duration of the collapse, is to deplete molecules on to grains more rapidly, as a function of n_{H} , resulting in molecular column densities that are lower than observed. This issue is unlikely to be resolved by slowing the freeze–out process, which would require improbably low sticking coefficients or high rates of grain coagulation. It seems more likely that molecules are returned to the gas phase at a rate which exceeds that of desorption by secondary photons (Appendix A) or as a consequence of heating by cosmic-ray impact (Leger et al. 1985), which are the only desorption processes presently incorporated in the model.

4 CONCLUDING REMARKS

We have studied the chemical composition of gas under the physical conditions that are believed to be appropriate to collapsing prestellar cores. A set of chemical reactions has been assembled that not only comprises the most recent determinations of the rates of gas–phase reactions but also discriminates between the various nuclear–spin states of H_2 , H_3^+ , and the abundant carbon, nitrogen, oxygen, and sulfur hydrides and their deuterated forms. The composition of the

medium has been investigated under both steady-state conditions and during the initial stage of gravitational collapse, which ultimately leads to the formation of a low-mass star. The freeze-out of the gas on to grains and the coagulation of the grains themselves are taken into account.

We compared the computed values of the column densities of key molecular species, notably of NH_3 and its deuterated forms, with the values observed in starless cores and found that the gas-phase chemistry alone yields satisfactory agreement between the model and the observations, without recourse to grain-surface reactions. Regarding the relative column densities of different nuclear-spin states of NH_3 and its deuterated forms, we find that our full scrambling assumption for proton and deuterium exchange yields good agreement with the observations, in contrast with the proposition of Harju et al. (2017) that direct nucleus- or atom-exchange reactions dominate the deuteration process. However, accurate observational measurements are needed to disentangle between the two processes.

The dynamical model that we used derives from the studies of gravitational collapse by Larson (1969, 1972) and Penston (1969). The gravitationally collapsing core loses mass to the surrounding envelope at a rate that ensures that the density profile in envelope $\rho_{\text{env}}(R_{\text{env}}) \propto R_{\text{env}}^{-2}$, where R_{env} is the radius; the total mass of the core and envelope is conserved. This simple model not only simulates the Larson–Penston density profile but also reproduces qualitatively their velocity profile. In order to test more quantitatively the kinematical aspects of the model, we are currently extending our study by computing the line profiles of key species such as CN and HCN and their isotopologues, including their hyperfine structure.

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APPENDIX A: COSMIC-RAY-INDUCED PHOTO-REACTIONS

As was discussed by Gredel et al. (1989), secondary electrons produced by cosmic-ray ionization of hydrogen can collisionally excite H_2 molecules in the gas, giving rise to ultraviolet photons in the subsequent radiative decay. Most of these photons are absorbed by dust, but some ionize atoms and dissociate or ionize molecules in the medium.

Equ. (5) of Gredel et al. (1989)—for the rate R_M per unit volume of ionization/dissociation of species M by the secondary photons—should read

$$R_M = \zeta n_{\text{H}_2} \frac{X(\text{M}) \int \sigma_{\text{M}}(\nu) P(\nu) d\nu}{(1 - \omega) X(\text{g}) \sigma_{\text{g}} + \sum_{\text{M}} X(\text{M}) \int \sigma_{\text{M}}(\nu) P(\nu) d\nu}$$

where ζn_{H_2} is the rate per unit volume of production of the secondary electrons, and the ratio is the relative probability that a photon is absorbed by an atomic or molecular species, M, rather than the grains, g; ω is the grain albedo, and n_{H} is the total number density of hydrogen nuclei. This equation may be rewritten

$$R_M = \zeta \frac{X(\text{H}_2) n(\text{M}) \int \sigma_{\text{M}}(\nu) P(\nu) d\nu}{(1 - \omega) X(\text{g}) \sigma_{\text{g}} + \sum_{\text{M}} X(\text{M}) \int \sigma_{\text{M}}(\nu) P(\nu) d\nu} \quad (\text{A1})$$

which becomes

$$R_M \approx \zeta X(\text{H}_2) n(\text{M}) \frac{p_M}{(1 - \omega)}$$

in the limit in which absorption of the secondary photons by the dust dominates; p_M is a photo-ionization or -dissociation probability. The factor $X(\text{H}_2)$ in this expression was omitted by Gredel et al. (1989), as was recognized by Woodall et al. (2007; section 3.6) and Flower et al. (2007; Appendix A); $X(\text{H}_2) = 0.5$ in mainly molecular gas. We have used Equ. A1, together with the more recent determinations of the photo-ionization/dissociation probabilities, p_M , of Heays et al. (2017) (Table 20), and adopted $\omega = 0.5$.

During the collapse, $X(\text{g}) \sigma_{\text{g}}$, where $\sigma_{\text{g}} = \pi a_{\text{g}}^2$ is the geometrical cross section of the grain, will tend to decrease, given that $X(\text{g}) \propto a_{\text{g}}^{-3}$ and that the grain radius, a_{g} , increases owing to coagulation. However, the fractional abundances $X(\text{M})$ also decrease, owing to freeze-out on to the grains.

The cosmic-ray-induced photons also desorb molecules M^* in the ice mantles, returning them to the gas phase. The rate of this process is given by

$$R_M^* \approx \zeta X(\text{H}_2) \frac{n(\text{M}^*)}{\sum_{\text{M}^*} n(\text{M}^*)} n_{\text{H}} \frac{\int Y(\nu) P(\nu) d\nu}{(1 - \omega)} \quad (\text{A2})$$

where $Y(\nu)$ is the desorption yield (probability of any molecule in the mantle being desorbed, per photon incident on the grain). Taking $\zeta = 1 \times 10^{-17} \text{ s}^{-1}$, $n_{\text{H}} = 10^4 \text{ cm}^{-3}$, $Y(\nu) = 10^{-3}$, independent of ν (Hollenbach et al. 2009), and estimating $\int P(\nu) d\nu \approx 0.4$ from fig. 1 of Gredel et al. (1989), yields a timescale (in yr) for this process

$$\frac{n(\text{M}^*)}{R_M^*} \approx 10^9$$

which is too long to be significant in the context of star formation. We note that Hollenbach et al. (2009) overestimate the rate of this process by about 2 orders of magnitude: they

calculate the flux of the far-ultraviolet secondary photons, F_{FUV} , to be of the order of $10^5 \text{ cm}^{-2} \text{ s}^{-1}$, whereas

$$F_{\text{FUV}} \approx \zeta \frac{\int P(\nu) d\nu}{\langle n_{\text{g}} \sigma_{\text{g}} \rangle / n_{\text{H}}}$$

and, taking $\zeta = 1 \times 10^{-17} \text{ s}^{-1}$ and $\langle n_{\text{g}} \sigma_{\text{g}} \rangle / n_{\text{H}} = 2 \times 10^{-21} \text{ cm}^2$ from Gredel et al. (1989), as did Hollenbach et al., we obtain $F_{\text{FUV}} \approx 2 \times 10^3 \text{ cm}^{-2} \text{ s}^{-1}$. We note that this value of F_{FUV} agrees with that derived from Fig. 4 of Shen et al. (2004; $E_0 = 400 \text{ MeV}$, corresponding to $\zeta = 3.1 \times 10^{-17} \text{ s}^{-1}$), when scaled to the same value of ζ . Hollenbach et al. (2009) appear to have been unaware of the work of Shen et al. (2004).

APPENDIX B: THE UGAN CHEMICAL NETWORK

The *University of Grenoble Alpes Astrochemical Network* (UGAN) is a significantly upgraded version of the gas-phase network of F06, which included reactions involving species containing H, D, He, C, N, O and S. F06 distinguished between the different nuclear-spin states of H_2 , H_2^+ , H_3^+ and their deuterated isotopologues, and between those of nitrogen hydrides. Nuclear-spin branching ratios were derived from simple statistical considerations (and conservation of the total nuclear spin) but without recourse to symmetry conservation. A first update of the F06 network consisted in a revision of nitrogen hydrides chemistry (excluding deuterated species) (Le Gal et al. 2014), with special attention to the most recent experimental results—in particular, for the conversion of N to N_2 through radical-radical reactions and for the dissociative recombination of the NH_n^+ ($n=2-4$) ions. The nuclear-spin selection rules were derived by the method of Oka (2004), as described in Rist et al. (2013) and Faure et al. (2013). These rules result from the conservation of the total nuclear-spin of identical nuclei and the conservation of their permutation symmetry (Quack 1977) or, alternatively, of their rotational symmetry (Oka 2004). Although conceptually different, the two methods are closely related and predict the same spin statistics when applied to multiple H nuclei (fermions). However, in the case of deuterium nuclei (bosons), the one-to-one correspondence between the nuclear-spin angular momentum and the permutation symmetry breaks down. A new method unifying the rotational and permutation symmetries was proposed recently (Schmiedt et al. 2016).

The present network extends the work of Le Gal et al. (2014) to the entire F06 chemical network in a systematic fashion for all hydrides containing C, N, O, and S atoms, and their deuterated forms. Nuclear-spin selection rules were derived from the permutation symmetry approach of Quack (1977), as explained below. Furthermore, many reaction rate coefficients were updated from a literature survey, including recommendations from the KIDA (KInetic Database for Astrochemistry³) data sheets.

After spin isomer separation on H and D, the complete new network contains 207 species—including grains (neutral and charged) and adsorbed species—and 3266 reactions (when including adsorption and desorption). The

³ <http://kida.obs.u-bordeaux1.fr/>

unseparated—or condensed—network contains 151 species and 1136 reactions. The list of chemical species and the corresponding chemistry files are provided in Appendix D.

B1 Nuclear-spin-state separation

In principle, all molecules with identical nuclei of non-zero spin in equivalent positions should be treated as distinct nuclear-spin isomers. However, distinguishing between nuclear-spin states leads to a large increase in the number of chemical reactions that have to be considered, especially when deuterated species are included. Therefore, we have restricted the spin-state separation to hydrides and their deuterated isotopologues, i.e. to molecules with a single heavy atom and two or more hydrogen or deuterium nuclei; this includes molecules like NH_2D_2^+ but excludes species like C_3H_2 .

B1.1 Exothermic reactions

For strongly exothermic reactions, we assume (i) conservation of the total nuclear spin and (ii) full scrambling of hydrogen and/or deuterium nuclei in the intermediate or activated complex. In such reactions, we assume that the intermediate complex is highly energetic and decays statistically to the many rotational states of the products. To obtain the nuclear-spin branching ratios, the probabilities of forming an intermediate complex in a given nuclear-spin state are multiplied by the probabilities for this complex to decay towards the nuclear-spin states of the products. In the process, the conservation of the total nuclear spin and of the permutation symmetry of identical nuclei is taken into account. The results of these calculations are then summed. This procedure also requires the nuclear-spin-symmetry statistical weights for reactions involving many (here up to seven) identical particles (see Appendix C and Sipila2015b). In practice, for a reaction involving identical hydrogen or deuterium nuclei,



where $n = i + j = k + l$ is the total number of identical particles, one needs to determine the possible permutation-symmetry species for the reactants ($\Gamma_i \otimes \Gamma_j$, where \otimes denotes a direct product), of the intermediate complex (Γ_n) and of the products ($\Gamma_k \otimes \Gamma_l$) in their respective permutation-symmetry groups ($S_i \otimes S_j, S_n$ and $S_k \otimes S_l$). One also needs the correlation tables between the symmetry group of the complex and the symmetry subgroups representing the reactants and the products. These tables, or matrices, are obtained using group theory and provide the required induction and subduction statistical weights $W_{(\Gamma_i \otimes \Gamma_j \uparrow \Gamma_n)}$. The statistical weights are the number of independent states of symmetry Γ_n induced from the Γ_i and Γ_j symmetries of the reactants. We note that the induction and subduction statistical weights are equal according to the Frobenius reciprocity theorem (Quack 1977). The correlation tables are given in Appendix C (see also Hugo2009, Sipila2015b). From these tables, simplified expressions for the nuclear-spin branching

ratios can be derived which involve matrix products only:

$$P_{(\Gamma_i \otimes \Gamma_j \rightarrow \Gamma_k \otimes \Gamma_l)} = \frac{\sum_{\Gamma_n} W_{(\Gamma_i \otimes \Gamma_j \uparrow \Gamma_n)} \times W_{(\Gamma_k \otimes \Gamma_l \uparrow \Gamma_n)}}{\left(\sum_{\Gamma_n'} W_{(\Gamma_i \otimes \Gamma_j \uparrow \Gamma_n')} \right) \times \left(\sum_{\Gamma_n''} W_{(\Gamma_k \otimes \Gamma_l \uparrow \Gamma_n'')} \right)}, \quad (\text{B2})$$

with $\sum_{\Gamma_k \Gamma_l} P_{(\Gamma_i \otimes \Gamma_j \rightarrow \Gamma_k \otimes \Gamma_l)} = 1^4$. Based on this formalism, we developed an automated FORTRAN routine, `spinstate.f90`, to calculate the branching ratios for reactions involving up to seven hydrogen (e.g. $\text{CH}_4 + \text{H}_3^+$) and six deuterium nuclei (e.g. $\text{D}_3^+ + \text{ND}_3$).

It should be noted that because hydrogen and deuterium nuclei are distinguishable, reactions involving both multiple hydrogen and multiple deuterium nuclei were divided into two parts, each with separate branching ratios that were combined (multiplied) afterwards. In addition, for exothermic reactions involving a hydride and a non-hydride—but “separable”—species whose nuclear-spin isomers are ignored (e.g. C_3H_2), we adopted the above procedure to compute the branching ratios. Where the non-hydride species is a reactant, we assume equal abundances of the nuclear-spin isomers of the non-hydride species, while, if it is a product, the associated nuclear-spin branching ratios are summed. Finally, for charge-exchange reactions, we assumed that the nuclear spin of each reactant isomer is conserved.

B1.2 Inter-conversion reactions

For inter-conversion reactions involving H_2 or D_2 (e.g. $\text{H}^+ + \text{para-H}_2 \leftrightarrow \text{H}^+ + \text{ortho-H}_2$), rate coefficients were taken from either specific calculations or measurements in the literature, or estimated on a case-by-case basis. Indeed, for such “nearly thermo-neutral” reactions, the previous approach no longer applies because the full scrambling hypothesis is not guaranteed as the intermediate complex has small excess energy, and only a small amount of this energy is available for the products (Rist et al. 2013). In this case, a state-to-state (rotationally resolved) analysis is required to derive the nuclear-spin branching ratios. We have adopted a number of recent theoretical results from the literature for the inter-conversion of H_2 and D_2 . We note that inter-conversion processes were neglected in reactions involving highly-exothermic channels (e.g. $\text{NH}_3^+ + \text{H}_2$) because the reactive channels (in this example, leading to $\text{NH}_4^+ + \text{H}$) proceed much faster than the inter-conversion (see and references therein) Faure2013. Specifically, for the reactions between all isotopic variants of H_3^+ and H_2 , we have employed the state-to-state rate coefficients calculated by Hugo et al. (2009). These rate coefficients were used to derive *species-to-species* rate coefficients by assuming thermal population of the rotational levels within each nuclear-spin species; this supposes local thermal equilibrium (LTE), which should apply at densities above approximately 10^5 cm^{-3} . An alternative would be to use *ground-state-to-species* rate coefficients, assuming that all isotopologues are in their ground

⁴ We note that the two sums in the denominator of Eq. (B2) can be expressed from $\dim(\Gamma)$ and $f(\Gamma)$, the dimension and frequency of the Γ permutation symmetry representation, as $f(\Gamma_i \otimes \Gamma_j) \times \dim(\Gamma_i) \times \dim(\Gamma_j)$ and $f(\Gamma_k \otimes \Gamma_l) \times \dim(\Gamma_k) \times \dim(\Gamma_l)$, respectively.

rotational states. Intermediate situations are also possible, as discussed in the recent work of Sipilä et al. (2017). However, only the LTE situation allows us to track anomalies in nuclear–spin isomer ratios, i.e. departures from thermal equilibrium ratios.

For the inter-conversion reaction between H^+ and H_2 , we have employed state–to–state rate coefficients (Honvault et al. 2011, 2012), assuming that only the ground states of para- H_2 ($j=0$) and ortho- H_2 ($j=1$) are populated at low temperature. For the deuterated variant, $\text{D}^+ + \text{D}_2$, a statistical method was applied (Rist et al. 2013). This method—inspired by the work of Gerlich (1990)—was found to yield satisfactory agreement (typically better than a factor of 2) with time-independent quantum calculations (Honvault et al. 2011). The same statistical method was applied to the inter-conversion reactions between HCO^+ and H_2 and DCO^+ and D_2 .

B1.3 Endothermic reactions and exothermic reactions with an activation barrier

For endothermic reactions or exothermic reactions with an activation barrier, our strategy was to include only those reactions whose activation energy is less than 1000 K. The spin–state separation of the original network of F06 was restricted to reactions that are significant at low temperatures (in practice, below 50 K). These reactions are generally of secondary importance; but we note the exception of $\text{N}^+ + \text{H}_2$, which is at the root of the ammonia chemistry. For this reaction, we adopted the rate coefficients of Dislaire et al. (2012), as did Le Gal et al. (2014). For the deuterated variant $\text{N}^+ + \text{HD}$, we used the experimental rate coefficient of Marquette et al. (1988).

B2 Condensed network

An unseparated or “condensed” network, where the distinction between nuclear–spin states is removed, is also provided for applications where ortho:para ratios are not required. In doing so, some prescriptions are necessary for a number of reactions whose rate coefficients depend on the ortho:para ratio(s) of the reactant(s). A good example is $\text{N}^+ + \text{H}_2$ (?see]dislaire2012. In such case, the KIDA value—when validated by experts—is generally adopted by default. For the deuterated variants of $\text{H}_3^+ + \text{H}_2$, we adopt representative values of the rate coefficients at low temperature (~ 10 K), based on a close inspection of the individual nuclear-spin reactions.

APPENDIX C: NUCLEAR SPIN SYMMETRY INDUCTION AND SUBDUCTION MATRICES

We recall the pure nuclear spin symmetry induction (and subduction) statistical weights matrices for several hydrogen systems and for several deuterium systems used in the chemistry network. These matrices give the total number of nuclear spin states allowed from permutation symmetry conservation in reactions involving $n > 1$ identical nuclei. We denote the induction weight $W_{\Gamma_i \otimes \Gamma_j \uparrow \Gamma_{n=i+j}}$, the number of “complex” spin states in a symmetry species Γ_n formed from two reactants respectively in the symmetry species Γ_i

Table C1. Pure permutation symmetry induction/subduction statistical weights $W_{\Gamma_n \otimes \Gamma_1 \uparrow \Gamma_{n+1}} = W_{\Gamma_{n+1} \downarrow \Gamma_n \otimes \Gamma_1}$ for $\text{H}_n + \text{H} \rightarrow \text{H}_{n+1}$.

$\text{H} + \text{H} \rightarrow \text{H}_2$ (Hugo et al. 2009)						
		A	B	Total		
A	A	3	1	4		
Total		3	1	$4 = 2^2$		
$\text{H}_2 + \text{H} \rightarrow \text{H}_3$ (Hugo et al. 2009)						
		A_1	E	Total		
A	A	4	2	6		
B	A	0	2	2		
Total		4	4	$8 = 2^3$		
$\text{H}_3 + \text{H} \rightarrow \text{H}_4$ (Hugo et al. 2009)						
		A_1	E	F_1	Total	
A_1	A	5	0	3	8	
E	A	0	2	6	8	
Total		5	2	9	$16 = 2^4$	
$\text{H}_4 + \text{H} \rightarrow \text{H}_5$ (this work)						
		A_1	G_1	H_1	Total	
A_1	A	6	4	0	10	
E	A	0	0	4	4	
F_1	A	0	12	6	18	
Total		6	16	10	$32 = 2^5$	
$\text{H}_5 + \text{H} \rightarrow \text{H}_6$ (this work)						
		A_1	H_1	H_4	L_1	Total
A_1	A	7	5	0	0	12
G_1	A	0	20	0	12	32
H_1	A	0	0	5	15	20
Total		7	25	5	27	$64 = 2^6$
$\text{H}_6 + \text{H} \rightarrow \text{H}_7$ (this work)						
		A_1	I	X	Y	Total
A_1	A	8	6	0	0	14
H_1	A	0	30	0	20	50
H_4	A	0	0	10	0	10
L_1	A	0	0	18	36	54
Total		8	36	28	56	$128 = 2^7$

and Γ_j . The corresponding subduction weight $W_{\Gamma_{n=i+j} \downarrow \Gamma_i \otimes \Gamma_j}$ gives the number of allowed products spin states respectively in the symmetry species Γ_i and Γ_j from the decay of a complex in the symmetry species Γ_n . The reciprocity Froebenius theorem shows that $W_{\Gamma_{n=i+j} \downarrow \Gamma_i \otimes \Gamma_j} = W_{\Gamma_i \otimes \Gamma_j \uparrow \Gamma_{n=i+j}}$.

C1 Multi Hydrogen systems

See Tables C1 to C3.

C2 Multi Deuterium systems

See Tables C4 and C5.

Table C2. Pure permutation symmetry induction/subduction statistical weights $W_{\Gamma_n \otimes \Gamma_2 \uparrow \Gamma_{n+2}} = W_{\Gamma_{n+2} \downarrow \Gamma_n \otimes \Gamma_2}$ for $H_n + H_2 \rightarrow H_{n+2}$.

$H_2 + H_2 \rightarrow H_4$ (Hugo et al. 2009)					
		A ₁	E	F ₁	Total
A	A	5	1	3	9
A	B	0	0	3	3
B	A	0	0	3	3
B	B	0	1	0	1
Total		5	2	9	16 = 2 ⁴

$H_3 + H_2 \rightarrow H_5$ (Hugo et al. 2009)					
		A ₁	G ₁	H ₁	Total
A ₁	A	6	4	2	12
A ₁	B	0	4	0	4
E	A	0	8	4	12
E	B	0	0	4	4
Total		6	16	10	32 = 2 ⁵

$H_4 + H_2 \rightarrow H_6$ (Sipilä et al. 2015)						
		A ₁	H ₁	H ₄	L ₄	Total
A ₁	A	7	5	0	3	15
A ₁	B	0	5	0	0	5
E	A	0	0	0	6	6
E	B	0	0	2	0	2
F ₁	A	0	15	3	9	27
F ₁	B	0	0	0	9	9
Total		7	25	5	27	64 = 2 ⁴

$H_5 + H_2 \rightarrow H_7$ (this work)						
		A ₁	I	X	Y	Total
A ₁	A	8	6	0	4	18
A ₁	B	0	6	0	0	6
G ₁	A	0	24	8	16	48
G ₁	B	0	0	0	16	16
H ₁	A	0	0	10	20	30
H ₁	B	0	0	10	0	10
Total		8	36	28	56	128 = 2 ⁷

APPENDIX D: THE UGAN REACTION RATE COEFFICIENTS

In this section, we provide our separated *University of Grenoble Alpes Astrochemical Network (UGAN)*. Our convention for the names of the isotopologues follows Maue's rule (Maue 1937), namely that ortho species—noted with prefix o—have the largest statistical weight, and para species—with prefix p—have the smallest statistical weight. Species with intermediate degeneracy have prefix m, l, etc... in increasing order. Furthermore, for species that are separable with respect to both hydrogen and deuterium—such as NH_2D_2 —the isomers are indicated with one letter for each nucleus. In such instances, two letters are used with the previous convention applying equally to H and D, e.g. $ooNH_2D_2$.

In the following Tables, the rate coefficients are given in the traditional form of a modified Arrhenius law,

$$k(T) = \alpha(T/300)^\beta \exp(-\gamma/T) \quad \text{cm}^3 \text{s}^{-1}.$$

Note however that the reactions of formation of H_2 , HD,

Table C3. Pure permutation symmetry induction/subduction statistical weights $W_{\Gamma_n \otimes \Gamma_3 \uparrow \Gamma_{n+3}} = W_{\Gamma_{n+3} \downarrow \Gamma_n \otimes \Gamma_3}$ for $H_n + H_3 \rightarrow H_{n+3}$.

$H_3 + H_3 \rightarrow H_6$ (Sipilä et al. 2015)						
		A ₁	H ₁	H ₄	L ₁	Total
A ₁	A ₁	7	5	1	3	16
A ₁	E	0	10	0	6	16
E	A ₁	0	10	0	6	16
E	E	0	0	4	12	16
Total		7	25	5	27	64 = 2 ⁶

$H_4 + H_3 \rightarrow H_7$ (Sipilä et al. 2015)						
		A ₁	H ₁	H ₄	L ₁	Total
A ₁	A ₁	7	5	0	3	15
A ₁	E	0	5	0	0	5
E	A ₁	0	0	0	6	6
E	E	0	0	2	0	2
F ₁	A ₁	0	15	3	9	27
F ₁	E	0	0	0	9	9
Total		7	25	5	27	64 = 2 ⁶

Table C4. Pure permutation symmetry induction/subduction statistical weights $W_{\Gamma_n \otimes \Gamma_1 \uparrow \Gamma_{n+1}} = W_{\Gamma_{n+1} \downarrow \Gamma_n \otimes \Gamma_1}$ for $D_n + D \rightarrow D_{n+1}$.

$D + D \rightarrow D_2$ (Hugo et al. 2009)				Total
		A	B	
A	A	6	3	9
Total		6	3	9 = 3 ²

$D_2 + D \rightarrow D_3$ (Hugo et al. 2009)					Total
		A ₁	A ₂	E	
A	A	10	0	8	18
B	A	0	1	8	9
Total		4	4		27 = 3 ³

$D_3 + D \rightarrow D_4$ (Hugo et al. 2009)						Total
		A ₁	E	F ₁	F ₂	
A ₁	A	15	0	15	0	30
A ₂	A	0	0	0	3	3
E	A	0	12	30	6	48
Total		15	12	45	9	81 = 3 ⁴

$D_4 + D \rightarrow D_5$ (this work)						Total	
		A ₁	G ₁	H ₁	H ₂	I	
A ₁	A	21	24	0	0	0	45
E	A	0	0	30	6	0	36
F ₁	A	0	72	45	0	18	135
F ₂	A	0	0	0	9	18	27
Total		21	96	75	15	36	243 = 3 ⁵

and D_2 , which occur on dust surfaces, are computed as bi-molecular reactions using a rate coefficient which is not given by the modified Arrhenius law, but which is computed internally from the density and the grain parameters. In the following Tables, the species noted γ represents a photon (not to be confused with the exo/endothemicity), CRP are

Table C5. Pure permutation symmetry induction/subduction statistical weights $W_{\Gamma_n \otimes \Gamma_2 \uparrow \Gamma_{n+2}} = W_{\Gamma_{n+2} \downarrow \Gamma_n \otimes \Gamma_2}$ for $D_n + D_2 \longrightarrow D_{n+2}$ and $W_{\Gamma_n \otimes \Gamma_3 \uparrow \Gamma_{n+3}} = W_{\Gamma_{n+3} \downarrow \Gamma_n \otimes \Gamma_3}$ for $D_n + D_3 \longrightarrow D_{n+3}$.

$D_2 + D_2$		D_4 (Hugo et al. 2009)				
		A_1	E	F_1	F_2	Total
A	A	15	6	15	0	18
A	B	0	0	15	3	18
B	A	0	0	15	3	9
B	B	0	6	0	3	9
Total		15	12	45	9	$81 = 3^4$

$D_3 + D_2$		D_5 (Hugo et al. 2009)					
		A_1	G_1	H_1	H_2	I	Total
A_1	A	21	24	15	0	0	60
A_1	A	0	24	0	0	6	30
A_2	A	0	0	0	0	6	6
A_2	B	0	0	0	3	0	3
E	A	0	48	30	6	12	96
E	A	0	0	30	6	12	48
Total		21	96	75	15	36	$243 = 3^5$

$D_4 + D_2$		D_6 (Sipilä et al. 2015)							
		A_1	H_1	H_3	H_4	L_1	M_1	S	Total
A_1	A	28	35	0	0	27	0	0	90
A_1	A	0	35	0	0	0	10	0	45
E	A	0	0	2	0	54	0	16	72
E	A	0	0	0	20	0	0	16	36
F_1	A	0	105	0	30	81	30	24	270
F_1	B	0	0	0	0	81	30	24	135
F_2	A	0	0	0	0	0	30	24	54
F_2	B	0	0	3	0	0	0	24	27
Total		28	175	5	50	243	100	128	$729 = 3^6$

$D_3 + D_3$		D_6 (Sipilä et al. 2015)							
		A_1	H_1	H_3	H_4	L_1	M_1	S	Total
A_1	A_1	28	35	0	10	27	0	0	100
A_1	A_1	0	0	0	0	0	10	0	10
A_1	E	0	70	0	0	54	20	16	160
A_2	A_1	0	0	0	0	0	10	0	10
A_2	A_1	0	0	1	0	0	0	0	1
A_2	E	0	0	0	0	0	0	0	16
E	A_1	0	70	0	0	54	20	0	160
E	A_1	0	0	0	0	0	0	0	16
E	E	0	0	4	40	108	40	0	256
Total		28	175	5	50	243	100	128	$729 = 3^6$

primary cosmic-ray particles (essentially protons), and γ_2 are secondary photons.

Table D1. Species of our non-separated network (total: 151).

1	H	H ₂	D	HD	D ₂	He	O	OH
2	O ₂	OD	H ₂ O	HDO	D ₂ O	C	CH	CH ₂
3	CH ₃	CH ₄	C ₂	C ₂ H	C ₂ H ₂	C ₃	C ₃ H	C ₃ H ₂
4	N	N ₂	NH	NH ₂	NH ₃	ND	NHD	ND ₂
5	NH ₂ D	NHD ₂	ND ₃	S	SH	H ₂ S	CO	NO
6	CN	SO	CS	HNC	HCN	CO ₂	SO ₂	OCS
7	H ₂ CO	CH ₃ OH	HCO ₂ H	H ⁺	D ⁺	He ⁺	H ₂ ⁺	HD ⁺
8	D ₂ ⁺	H ₃ ⁺	H ₂ D ⁺	HD ₂ ⁺	D ₃ ⁺	O ⁺	OH ⁺	H ₂ O ⁺
9	OD ⁺	O ₂ ⁺	HDO ⁺	D ₂ O ⁺	H ₃ O ⁺	H ₂ DO ⁺	HD ₂ O ⁺	D ₃ O ⁺
10	C ⁺	CH ⁺	CH ₂ ⁺	CH ₃ ⁺	CH ₄ ⁺	CH ₅ ⁺	C ₂ ⁺	C ₂ H ⁺
11	C ₂ H ₂ ⁺	C ₂ H ₃ ⁺	C ₃ ⁺	C ₃ H ⁺	C ₃ H ₃ ⁺	C ₃ H ₂ ⁺	N ⁺	NH ⁺
12	ND ⁺	N ₂ ⁺	N ₂ H ⁺	NH ₂ ⁺	NH ₄ ⁺	N ₂ D ⁺	NH ₃ ⁺	NHD ⁺
13	ND ₂ ⁺	NH ₃ D ⁺	NH ₂ D ⁺	NHD ₂ ⁺	ND ₃ ⁺	NH ₂ D ₂ ⁺	NHD ₃ ⁺	ND ₄ ⁺
14	S ⁺	SH ⁺	SD ⁺	H ₂ S ⁺	H ₃ S ⁺	HCO ⁺	HCS ⁺	HCO ₂ ⁺
15	SO ⁺	CO ⁺	CS ⁺	DCO ⁺	NO ⁺	HCN ⁺	C ₂ N ⁺	HCNH ⁺
16	HNO ⁺	CN ⁺	HSO ⁺	HOCS ⁺	DCO ₂ ⁺	HSO ₂ ⁺	H ₂ NC ⁺	Fe
17	Fe ⁺	Gr	Gr ⁻	Gr ⁺	CH ₄ [*]	H ₂ O [*]	O ₂ [*]	CO [*]
18	CO ₂ [*]	N [*]	NH ₃ [*]	N ₂ [*]	H ₂ S [*]	OCS [*]	Fe [*]	HDO [*]
19	D ₂ O [*]	NH ₂ D [*]	NHD ₂ [*]	ND ₃ [*]	CH ₃ OH [*]	H ₂ CO [*]	HCO ₂ H [*]	

Notes:

Species labeled with '*' are species adsorbed in grain mantles.

Table D2. Separated species (total: 207).

1	H	oH ₂	pH ₂	D	HD	oD ₂	pD ₂	He
2	O	OH	O ₂	OD	oH ₂ O	pH ₂ O	HDO	oD ₂ O
3	pD ₂ O	C	CH	oCH ₂	pCH ₂	oCH ₃	pCH ₃	mCH ₄
4	pCH ₄	oCH ₄	C ₂	C ₂ H	C ₂ H ₂	C ₃	C ₃ H	C ₃ H ₂
5	N	N ₂	NH	oNH ₂	pNH ₂	oNH ₃	pNH ₃	ND
6	NHD	oND ₂	pND ₂	oNH ₂ D	pNH ₂ D	oNHD ₂	pNHD ₂	mND ₃
7	pND ₃	oND ₃	S	SH	oH ₂ S	pH ₂ S	CO	NO
8	SO	CN	CS	HNC	HCN	CO ₂	SO ₂	OCS
9	H ₂ CO	CH ₃ OH	HCO ₂ H	Fe	H ⁺	D ⁺	He ⁺	oH ₂ ⁺
10	pH ₂ ⁺	HD ⁺	oD ₂ ⁺	pD ₂ ⁺	oH ₂ D ⁺	pH ₂ D ⁺	oH ₃ ⁺	pH ₃ ⁺
11	oHD ₂ ⁺	pHD ₂ ⁺	mD ₃ ⁺	oD ₃ ⁺	pD ₃ ⁺	O ⁺	O ₂ ⁺	OH ⁺
12	oH ₂ O ⁺	pH ₂ O ⁺	OD ⁺	HDO ⁺	oD ₂ O ⁺	pD ₂ O ⁺	oH ₃ O ⁺	pH ₃ O ⁺
13	oH ₂ DO ⁺	pH ₂ DO ⁺	oHD ₂ O ⁺	pHD ₂ O ⁺	mD ₃ O ⁺	oD ₃ O ⁺	pD ₃ O ⁺	C ⁺
14	CH ⁺	oCH ₂ ⁺	pCH ₂ ⁺	C ₂ ⁺	C ₂ H ⁺	C ₂ H ₃ ⁺	C ₃ ⁺	C ₃ H ⁺
15	oCH ₃ ⁺	pCH ₃ ⁺	pCH ₅ ⁺	oCH ₅ ⁺	mCH ₅ ⁺	mCH ₄ ⁺	pCH ₄ ⁺	oCH ₄ ⁺
16	C ₂ H ₂ ⁺	C ₃ H ₃ ⁺	C ₃ H ₂ ⁺	N ⁺	N ₂ ⁺	ND ⁺	NH ⁺	N ₂ H ⁺
17	N ₂ D ⁺	oNH ₂ ⁺	pNH ₂ ⁺	mNH ₄ ⁺	oNH ₄ ⁺	pNH ₄ ⁺	oNH ₃ ⁺	pNH ₃ ⁺
18	NHD ⁺	oND ₂ ⁺	pND ₂ ⁺	oNH ₃ D ⁺	pNH ₃ D ⁺	oNH ₂ D ⁺	pNH ₂ D ⁺	oNHD ₂ ⁺
19	pNHD ₂ ⁺	mND ₃ ⁺	oND ₃ ⁺	pND ₃ ⁺	ooNH ₂ D ₂ ⁺	poNH ₂ D ₂ ⁺	opNH ₂ D ₂ ⁺	ppNH ₂ D ₂ ⁺
20	mNHD ₃ ⁺	oNHD ₃ ⁺	pNHD ₃ ⁺	IND ₄ ⁺	oND ₄ ⁺	pND ₄ ⁺	mND ₄ ⁺	S ⁺
21	SH ⁺	SD ⁺	oH ₂ S ⁺	pH ₂ S ⁺	oH ₃ S ⁺	pH ₃ S ⁺	HCO ⁺	HCO ₂ ⁺
22	SO ⁺	CO ⁺	CS ⁺	NO ⁺	CN ⁺	HCS ⁺	DCO ⁺	HCN ⁺
23	C ₂ N ⁺	HCNH ⁺	HNO ⁺	HSO ⁺	HOCS ⁺	DCO ₂ ⁺	HSO ₂ ⁺	H ₂ NC ⁺
24	Fe ⁺	Gr	Gr ⁻	Gr ⁺	CH ₄ [*]	H ₂ O [*]	O ₂ [*]	CO [*]
25	CO ₂ [*]	N [*]	NH ₃ [*]	N ₂ [*]	H ₂ S [*]	OCS [*]	Fe [*]	HDO [*]
26	D ₂ O [*]	NH ₂ D [*]	NHD ₂ [*]	ND ₃ [*]	CH ₃ OH [*]	H ₂ CO [*]	HCO ₂ H [*]	

Notes:

 o: ortho; m: meta; p: para; The statistical weights are such that $p < m < l < o$, i.e. IND_4^+ has a statistical weight larger than that of mND_4^+ and smaller than oND_4^+ ;

 poNH₂D₂: the first letter, p, refers to D nuclei symmetry, and the second, o, refers to symmetry of the H nuclei wavefunction.

Species labeled with '*' are species adsorbed in grain mantles.

Table D3. Sample of the “condensed” version of the UGAN chemical network (total: 1136 reactions).

#	Reactants		Products			α $\text{cm}^3 \text{s}^{-1}$	β	γ K
1	H	H	H ₂			1.0e+00		
2	H	D	HD			1.0e+00		
3	D	D	D ₂			9.9e-01		
4	H	CRP	H ⁺	e ⁻		4.6e-01	0.00	0.0
5	D	CRP	D ⁺	e ⁻		4.6e-01	0.00	0.0
6	He	CRP	He ⁺	e ⁻		5.0e-01	0.00	0.0
7	H ₂	CRP	H	H		1.0e-01	0.00	0.0
8	H ₂	CRP	H ⁺	H	e ⁻	2.3e-02	0.00	0.0
9	H ₂	CRP	H ₂ ⁺	e ⁻		9.8e-01	0.00	0.0
10	HD	CRP	H ⁺	D	e ⁻	2.0e-02	0.00	0.0
11	HD	CRP	D ⁺	H	e ⁻	2.0e-02	0.00	0.0
12	HD	CRP	H	D		1.5e+00	0.00	0.0
13	HD	CRP	HD ⁺	e ⁻		9.6e-01	0.00	0.0
14	D ₂	CRP	D ⁺	D	e ⁻	4.0e-02	0.00	0.0
15	D ₂	CRP	D	D		1.5e+00	0.00	0.0
16	D ₂	CRP	D ₂ ⁺	e ⁻		9.6e-01	0.00	0.0
17	H	H ₂ ⁺	H ₂	H ⁺		6.4e-10	0.00	0.0
18	H	H ₃ ⁺	H ₂ ⁺	H ₂		2.1e-09	0.00	20000.0
19	H	HD ⁺	H ⁺	HD		6.4e-10	0.00	0.0
20	H	HD ⁺	H ₂ ⁺	D		1.0e-09	0.00	154.0

Table D4. Sample of the “separated” version of the UGAN chemical network (total: 3266 reactions split into 43 tables).

#	Reactants		Products			α $\text{cm}^3 \text{s}^{-1}$	β	γ K
1	H	H	oH ₂			7.5e-01		
2	H	H	pH ₂			2.5e-01		
3	H	D	HD			1.0e+00		
4	D	D	oD ₂			6.6e-01		
5	D	D	pD ₂			3.3e-01	0.50	0.0
6	H	CRP	H ⁺	e ⁻		4.6e-01	0.00	0.0
7	D	CRP	D ⁺	e ⁻		4.6e-01	0.00	0.0
8	He	CRP	He ⁺	e ⁻		5.0e-01	0.00	0.0
9	oH ₂	CRP	H	H		1.0e-01	0.00	0.0
10	pH ₂	CRP	H	H		1.0e-01	0.00	0.0
11	oH ₂	CRP	H ⁺	H	e ⁻	2.3e-02	0.00	0.0
12	pH ₂	CRP	H ⁺	H	e ⁻	2.3e-02	0.00	0.0
13	oH ₂	CRP	oH ₂ ⁺	e ⁻		9.8e-01	0.00	0.0
14	pH ₂	CRP	pH ₂ ⁺	e ⁻		9.8e-01	0.00	0.0
15	HD	CRP	H ⁺	D	e ⁻	2.0e-02	0.00	0.0
16	HD	CRP	D ⁺	H	e ⁻	2.0e-02	0.00	0.0
17	HD	CRP	H	D		1.5e+00	0.00	0.0
18	HD	CRP	HD ⁺	e ⁻		9.6e-01	0.00	0.0
19	oD ₂	CRP	D ⁺	D	e ⁻	4.0e-02	0.00	0.0
20	pD ₂	CRP	D ⁺	D	e ⁻	4.0e-02	0.00	0.0

Table D5. The “condensed” version of the UGAN chemical network (total: 1136 reactions split into 15 Tables).

#	Reactants		Products			α	β	γ
1	H	H	H ₂			1.0e+00		
2	H	D	HD			1.0e+00		
3	D	D	D ₂			9.9e-01		
4	H	CRP	H ⁺	e ⁻		4.6e-01	0.00	0.0
5	D	CRP	D ⁺	e ⁻		4.6e-01	0.00	0.0
6	He	CRP	He ⁺	e ⁻		5.0e-01	0.00	0.0
7	H ₂	CRP	H	H		1.0e-01	0.00	0.0
8	H ₂	CRP	H ⁺	H	e ⁻	2.3e-02	0.00	0.0
9	H ₂	CRP	H ₂ ⁺	e ⁻		9.8e-01	0.00	0.0
10	HD	CRP	H ⁺	D	e ⁻	2.0e-02	0.00	0.0
11	HD	CRP	D ⁺	H	e ⁻	2.0e-02	0.00	0.0
12	HD	CRP	H	D		1.5e+00	0.00	0.0
13	HD	CRP	HD ⁺	e ⁻		9.6e-01	0.00	0.0
14	D ₂	CRP	D ⁺	D	e ⁻	4.0e-02	0.00	0.0
15	D ₂	CRP	D	D		1.5e+00	0.00	0.0
16	D ₂	CRP	D ₂ ⁺	e ⁻		9.6e-01	0.00	0.0
17	H	H ₂ ⁺	H ₂	H ⁺		6.4e-10	0.00	0.0
18	H	H ₃ ⁺	H ₂	H ₂		2.1e-09	0.00	20000.0
19	H	HD ⁺	H ⁺	HD		6.4e-10	0.00	0.0
20	H	HD ⁺	H ₂ ⁺	D		1.0e-09	0.00	154.0
21	H	HD ⁺	H ₂ D ⁺	γ		1.2e-17	1.80	-20.0
22	H	D ⁺	H ⁺	D		1.0e-09	0.00	0.0
23	H	D ⁺	HD ⁺	γ		3.9e-19	1.80	-20.0
24	H	H ₂ D ⁺	H ₃ ⁺	D		1.0e-09	0.00	597.8
25	H	HD ₂ ⁺	H ₂ D ⁺	D		1.0e-09	0.00	549.8
26	H	D ₂ ⁺	HD ⁺	D		1.0e-09	0.00	430.0
27	H	D ₂ ⁺	D ₂	H ⁺		6.4e-10	0.00	0.0
28	H	D ₃ ⁺	HD ₂ ⁺	D		1.0e-09	0.00	642.3
29	H ₂	He ⁺	H ⁺	H	He	3.3e-15	0.00	0.0
30	H ₂	He ⁺	H ₂ ⁺	He		9.6e-15	0.00	0.0
31	H ₂	H ⁺	H	H ₂ ⁺		6.4e-10	0.00	21300.0
32	H ₂	H ₂ ⁺	H ₃ ⁺	H		2.1e-09	0.00	0.0
33	H ₂	HD ⁺	H ₂ D ⁺	H		1.1e-09	0.00	0.0
34	H ₂	HD ⁺	H ₃ ⁺	D		1.1e-09	0.00	0.0
35	H ₂	D ⁺	H ⁺	HD		2.1e-09	0.00	0.0
36	H ₂	D ₂ ⁺	H ₂ D ⁺	D		1.1e-09	0.00	0.0
37	H ₂	D ₂ ⁺	HD ₂ ⁺	H		1.1e-09	0.00	0.0
38	HD	He ⁺	H ⁺	D	He	5.5e-14	-0.24	0.0
39	HD	He ⁺	D ⁺	H	He	5.5e-14	-0.24	0.0
40	HD	H ⁺	D ⁺	H ₂		1.0e-09	0.00	464.0
41	HD	H ₂ ⁺	H ₂ D ⁺	H		1.1e-09	0.00	0.0
42	HD	H ₂ ⁺	H ₃ ⁺	D		1.1e-09	0.00	0.0
43	HD	HD ⁺	H ₂ D ⁺	D		1.1e-09	0.00	0.0
44	HD	HD ⁺	HD ₂ ⁺	H		1.1e-09	0.00	0.0
45	HD	D ⁺	H ⁺	D ₂		1.0e-09	0.00	0.0
46	HD	D ₂ ⁺	HD ₂ ⁺	D		1.1e-09	0.00	0.0
47	HD	D ₂ ⁺	D ₃ ⁺	H		1.1e-09	0.00	0.0
48	D	H ⁺	D ⁺	H		1.0e-09	0.00	41.0
49	D	H ⁺	HD ⁺	γ		3.9e-19	1.80	-20.0
50	D	H ₂ ⁺	H ₂	D ⁺		6.4e-10	0.00	0.0
51	D	H ₂ ⁺	H ₂ D ⁺	γ		7.0e-18	1.80	-20.0
52	D	H ₂ ⁺	HD ⁺	H		1.0e-09	0.00	0.0
53	D	H ₃ ⁺	H ₂ D ⁺	H		1.0e-09	0.00	0.0
54	D	HD ⁺	D ₂ ⁺	H		1.0e-09	0.00	0.0
55	D	HD ⁺	D ⁺	HD		6.4e-10	0.00	0.0
56	D	H ₂ D ⁺	HD ₂ ⁺	H		1.0e-09	0.00	0.0
57	D	HD ₂ ⁺	D ₃ ⁺	H		1.0e-09	0.00	0.0
58	D	D ₂ ⁺	D ₂	D ⁺		6.4e-10	0.00	0.0
59	D ₂	He ⁺	D ⁺	D	He	1.1e-13	-0.24	0.0
60	D ₂	He ⁺	D ₂ ⁺	He		2.5e-14	0.00	0.0
61	D ₂	H ⁺	D ⁺	HD		2.1e-09	0.00	405.0
62	D ₂	H ₂ ⁺	H ₂ D ⁺	D		1.1e-09	0.00	0.0
63	D ₂	H ₂ ⁺	HD ₂ ⁺	H		1.1e-09	0.00	0.0
64	D ₂	HD ⁺	HD ₂ ⁺	D		1.1e-09	0.00	0.0
65	D ₂	HD ⁺	D ₃ ⁺	H		1.1e-09	0.00	0.0
66	D ₂	D ₂ ⁺	D ₃ ⁺	D		2.1e-09	0.00	0.0
67	Fe	H ⁺	Fe ⁺	H		7.4e-09	0.00	0.0
68	Fe	H ₃ ⁺	Fe ⁺	H ₂	H	4.9e-09	0.00	0.0
69	Fe	H ₂ D ⁺	Fe ⁺	H ₂	D	4.9e-09	0.00	0.0
70	Fe	HD ₂ ⁺	Fe ⁺	D ₂	H	1.6e-09	0.00	0.0
71	Fe	HD ₂ ⁺	Fe ⁺	HD	D	3.3e-09	0.00	0.0
72	Fe	D ₃ ⁺	Fe ⁺	D ₂	D	4.9e-09	0.00	0.0
73	H ⁺	e ⁻	H	γ		3.6e-12	-0.75	0.0
74	H ₂ ⁺	e ⁻	H	H		2.5e-07	-0.50	0.0

Table D5 – *continued* (part 2)

Reactants		Products			α	β	γ	
75	H ₂ ⁺	e ⁻	H ₂	γ		2.2e-07	-0.40	0.0
76	HD ⁺	e ⁻	H	D		9.0e-09	-0.50	0.0
77	D ⁺	e ⁻	D	γ		3.6e-12	-0.75	0.0
78	He ⁺	e ⁻	He	γ		4.5e-12	-0.67	0.0
79	H ₂ ⁺	γ	H ⁺	H		6.1e+02	0.00	0.0
80	H ⁺	Gr ⁻	Gr	H		1.6e-06	0.50	0.0
81	H ₃ ⁺	Gr ⁻	Gr	H ₂	H	4.6e-07	0.50	0.0
82	H ₃ ⁺	Gr ⁻	Gr	H	H	4.6e-07	0.50	0.0
83	He ⁺	Gr ⁻	Gr	He		8.0e-07	0.50	0.0
84	H ⁺	Gr	Gr ⁺	H		1.6e-06	0.50	0.0
85	H ₃ ⁺	Gr	Gr ⁺	H ₂	H	4.6e-07	0.50	0.0
86	H ₃ ⁺	Gr	Gr ⁺	H	H	4.6e-07	0.50	0.0
87	He ⁺	Gr	Gr ⁺	He		8.0e-07	0.50	0.0
88	D ⁺	Gr ⁻	Gr	D		1.1e-06	0.50	0.0
89	H ₂ D ⁺	Gr ⁻	Gr	H ₂	D	1.3e-07	0.50	0.0
90	H ₂ D ⁺	Gr ⁻	Gr	HD	H	2.7e-07	0.50	0.0
91	H ₂ D ⁺	Gr ⁻	Gr	D	H	4.0e-07	0.50	0.0
92	D ⁺	Gr	Gr ⁺	D		1.1e-06	0.50	0.0
93	H ₂ D ⁺	Gr	Gr ⁺	H ₂	D	1.3e-07	0.50	0.0
94	H ₂ D ⁺	Gr	Gr ⁺	HD	H	2.7e-07	0.50	0.0
95	H ₂ D ⁺	Gr	Gr ⁺	D	H	4.0e-07	0.50	0.0
96	HD ₂ ⁺	Gr ⁻	Gr	HD	D	2.4e-07	0.50	0.0
97	HD ₂ ⁺	Gr ⁻	Gr	D ₂	H	1.2e-07	0.50	0.0
98	HD ₂ ⁺	Gr ⁻	Gr	D	D	3.6e-07	0.50	0.0
99	HD ₂ ⁺	Gr	Gr ⁺	HD	D	2.4e-07	0.50	0.0
100	HD ₂ ⁺	Gr	Gr ⁺	D ₂	H	1.2e-07	0.50	0.0
101	HD ₂ ⁺	Gr	Gr ⁺	D	D	3.6e-07	0.50	0.0
102	D ₃ ⁺	Gr ⁻	Gr	D ₂	D	3.3e-07	0.50	0.0
103	D ₃ ⁺	Gr ⁻	Gr	D	D	3.3e-07	0.50	0.0
104	D ₃ ⁺	Gr	Gr ⁺	D ₂	D	3.3e-07	0.50	0.0
105	D ₃ ⁺	Gr	Gr ⁺	D	D	3.3e-07	0.50	0.0
106	O	CRP	O ⁺	e ⁻		2.8e+00	0.00	0.0
107	O	OH	O ₂	H		4.0e-11	0.00	0.0
108	O ⁺	H ₂	OH ⁺	H		1.2e-09	0.00	0.0
109	O ⁺	H	H ⁺	O		6.0e-10	0.00	0.0
110	O	H ⁺	O ⁺	H		6.0e-10	0.00	227.0
111	O	H ₂ ⁺	OH ⁺	H		1.5e-09	0.00	0.0
112	O	H ₃ ⁺	OH ⁺	H ₂		8.0e-10	-0.16	1.4
113	O	H ₃ ⁺	H ₂ O ⁺	H		3.4e-10	-0.16	1.4
114	O	H ₂ D ⁺	OH ⁺	HD		5.3e-10	0.00	0.0
115	O	H ₂ D ⁺	OD ⁺	H ₂		2.7e-10	0.00	0.0
116	O	HD ₂ ⁺	OH ⁺	D ₂		2.7e-10	0.00	0.0
117	O	HD ₂ ⁺	OD ⁺	HD		5.3e-10	0.00	0.0
118	O	D ₃ ⁺	OD ⁺	D ₂		8.0e-10	0.00	0.0
119	O ₂	He ⁺	O ⁺	O	He	1.0e-09	0.00	0.0
120	O ₂	H ⁺	O ₂ ⁺	H		1.2e-09	0.00	0.0
121	OH	He ⁺	OH ⁺	He		5.5e-10	0.00	0.0
122	OH	He ⁺	O ⁺	H	He	5.5e-10	0.00	0.0
123	OH	H ⁺	OH ⁺	H		2.1e-09	0.00	0.0
124	OH	H ₂ ⁺	H ₂	OH ⁺		7.6e-10	0.00	0.0
125	OH	H ₃ ⁺	H ₂ O ⁺	H ₂		1.3e-09	0.00	0.0
126	OH	H ₂ D ⁺	H ₂ O ⁺	HD		8.7e-10	0.00	0.0
127	OH	H ₂ D ⁺	HDO ⁺	H ₂		4.3e-10	0.00	0.0
128	OH	HD ₂ ⁺	H ₂ O ⁺	D ₂		4.3e-10	0.00	0.0
129	OH	HD ₂ ⁺	HDO ⁺	HD		8.7e-10	0.00	0.0
130	OH	D ₃ ⁺	HDO ⁺	D ₂		1.3e-09	0.00	0.0
131	OD	He ⁺	OD ⁺	He		5.5e-10	0.00	0.0
132	OD	He ⁺	O ⁺	D	He	5.5e-10	0.00	0.0
133	OD	H ⁺	OD ⁺	H		2.1e-09	0.00	0.0
134	OD	H ₃ ⁺	HDO ⁺	H ₂		1.3e-09	0.00	0.0
135	OD	H ₂ D ⁺	HDO ⁺	HD		8.7e-10	0.00	0.0
136	OD	H ₂ D ⁺	D ₂ O ⁺	H ₂		4.3e-10	0.00	0.0
137	OD	HD ₂ ⁺	HDO ⁺	D ₂		4.3e-10	0.00	0.0
138	OD	HD ₂ ⁺	D ₂ O ⁺	HD		8.7e-10	0.00	0.0
139	OD	D ₃ ⁺	D ₂ O ⁺	D ₂		1.3e-10	0.00	0.0
140	H ₂ O	He ⁺	OH ⁺	H	He	2.3e-10	-0.94	0.0
141	H ₂ O	He ⁺	H ₂ O ⁺	He		4.9e-11	-0.94	0.0
142	H ₂ O	He ⁺	H ⁺	OH	He	1.6e-10	-0.94	0.0
143	H ₂ O	H ⁺	H	H ₂ O ⁺		8.2e-09	0.00	0.0
144	H ₂ O	H ₂ ⁺	H ₂	H ₂ O ⁺		3.9e-09	0.00	0.0
145	H ₂ O	H ₂ ⁺	H ₃ O ⁺	H		3.4e-09	0.00	0.0
146	H ₂ O	H ₃ ⁺	H ₃ O ⁺	H ₂		4.3e-09	0.00	0.0
147	H ₂ O	H ₂ D ⁺	H ₃ O ⁺	HD		2.9e-09	0.00	0.0
148	H ₂ O	HD ₂ ⁺	H ₂ DO ⁺	HD		2.9e-09	0.00	0.0

Table D5 – continued (part 3)

Reactants	Products	α	β	γ
149	H ₂ O HD ₂ ⁺ H ₃ O ⁺ D ₂		1.4e-09	0.00 0.0
150	H ₂ O D ₃ ⁺ H ₂ DO ⁺ D ₂		4.3e-09	0.00 0.0
151	H ₂ O H ₂ D ⁺ H ₂ DO ⁺ H ₂		1.4e-09	0.00 0.0
152	HDO He ⁺ OD ⁺ H He		2.3e-10	-0.94 0.0
153	HDO He ⁺ HDO ⁺ He		4.9e-11	-0.94 0.0
154	HDO He ⁺ H ⁺ OD He		1.6e-10	-0.94 0.0
155	HDO H ⁺ HDO ⁺ H		8.2e-09	0.00 0.0
156	HDO H ₃ ⁺ H ₂ DO ⁺ H ₂		4.3e-09	0.00 0.0
157	HDO H ₂ D ⁺ H ₂ DO ⁺ HD		2.9e-09	0.00 0.0
158	HDO H ₂ D ⁺ HD ₂ O ⁺ H ₂		1.4e-09	0.00 0.0
159	HDO HD ₂ ⁺ HD ₂ O ⁺ HD		2.9e-09	0.00 0.0
160	HDO HD ₂ ⁺ H ₂ DO ⁺ D ₂		1.4e-09	0.00 0.0
161	HDO D ₃ ⁺ HD ₂ O ⁺ D ₂		4.3e-09	0.00 0.0
162	D ₂ O He ⁺ OD ⁺ D He		2.3e-10	-0.94 0.0
163	D ₂ O He ⁺ D ₂ O ⁺ He		4.9e-11	-0.94 0.0
164	D ₂ O He ⁺ D ⁺ OD He		1.6e-10	-0.94 0.0
165	D ₂ O H ⁺ D ₂ O ⁺ H		8.2e-09	0.00 0.0
166	D ₂ O H ₃ ⁺ HD ₂ O ⁺ H ₂		4.3e-09	0.00 0.0
167	D ₂ O H ₂ D ⁺ HD ₂ O ⁺ HD		2.9e-09	0.00 0.0
168	D ₂ O H ₂ D ⁺ D ₃ O ⁺ H ₂		1.4e-09	0.00 0.0
169	D ₂ O D ₃ ⁺ D ₃ O ⁺ D ₂		4.3e-09	0.00 0.0
170	D ₂ O HD ₂ ⁺ D ₃ O ⁺ HD		2.9e-09	0.00 0.0
171	D ₂ O HD ₂ ⁺ HD ₂ O ⁺ D ₂		1.4e-09	0.00 0.0
172	OH ⁺ H ₂ H ₂ O ⁺ H		1.0e-09	0.00 0.0
173	OH ⁺ HD HDO ⁺ H		5.1e-10	0.00 0.0
174	OH ⁺ HD H ₂ O ⁺ D		5.1e-10	0.00 0.0
175	OD ⁺ H ₂ HDO ⁺ H		1.0e-09	0.00 0.0
176	OD ⁺ HD D ₂ O ⁺ H		5.1e-10	0.00 0.0
177	OD ⁺ HD HDO ⁺ D		5.1e-10	0.00 0.0
178	OD ⁺ D ₂ D ₂ O ⁺ D		1.1e-09	0.00 0.0
179	H ₂ O ⁺ H ₂ H ₃ O ⁺ H		8.3e-10	0.00 0.0
180	H ₂ O ⁺ HD H ₂ DO ⁺ H		4.2e-10	0.00 0.0
181	H ₂ O ⁺ HD H ₃ O ⁺ D		4.2e-10	0.00 0.0
182	HDO ⁺ H ₂ H ₂ DO ⁺ H		8.3e-10	0.00 0.0
183	HDO ⁺ HD HD ₂ O ⁺ H		4.2e-10	0.00 0.0
184	HDO ⁺ HD H ₂ DO ⁺ D		4.2e-10	0.00 0.0
185	HDO ⁺ D ₂ HD ₂ O ⁺ D		8.3e-10	0.00 0.0
186	D ₂ O ⁺ D ₂ D ₃ O ⁺ D		8.3e-10	0.00 0.0
187	D ₂ O ⁺ H ₂ HD ₂ O ⁺ H		8.3e-10	0.00 0.0
188	D ₂ O ⁺ HD HD ₂ O ⁺ D		4.2e-10	0.00 0.0
189	D ₂ O ⁺ HD D ₃ O ⁺ H		4.2e-10	0.00 0.0
190	H ₃ O ⁺ Fe Fe ⁺ H ₂ O H		3.1e-09	0.00 0.0
191	O ₂ ⁺ Fe Fe ⁺ O ₂		1.1e-09	0.00 0.0
192	O ⁺ e ⁻ O γ		3.4e-12	-0.64 0.0
193	O ₂ ⁺ e ⁻ O O		2.0e-07	-0.70 0.0
194	OH ⁺ e ⁻ O H		3.7e-08	-0.50 0.0
195	H ₂ O ⁺ e ⁻ OH H		7.8e-08	-0.50 0.0
196	H ₂ O ⁺ e ⁻ O H ₂		3.4e-08	-0.50 0.0
197	H ₂ O ⁺ e ⁻ O H H		1.5e-07	-0.50 0.0
198	H ₃ O ⁺ e ⁻ OH H H		2.6e-07	-0.50 0.0
199	H ₃ O ⁺ e ⁻ H ₂ O H		1.1e-07	-0.50 0.0
200	H ₃ O ⁺ e ⁻ OH H ₂		6.0e-08	-0.50 0.0
201	H ₃ O ⁺ e ⁻ H ₂ H O		5.6e-09	-0.50 0.0
202	OD ⁺ e ⁻ O D		3.7e-08	-0.50 0.0
203	HDO ⁺ e ⁻ OD H		3.1e-08	-0.50 0.0
204	HDO ⁺ e ⁻ OH D		1.5e-08	-0.50 0.0
205	HDO ⁺ e ⁻ O HD		1.5e-08	-0.50 0.0
206	HDO ⁺ e ⁻ O H D		8.9e-08	-0.50 0.0
207	D ₂ O ⁺ e ⁻ OD D		7.8e-08	-0.50 0.0
208	D ₂ O ⁺ e ⁻ O D ₂		3.4e-08	-0.50 0.0
209	D ₂ O ⁺ e ⁻ O D D		1.5e-07	-0.50 0.0
210	H ₂ DO ⁺ e ⁻ OD H H		8.6e-08	-0.50 0.0
211	H ₂ DO ⁺ e ⁻ OH D H		1.7e-07	-0.50 0.0
212	H ₂ DO ⁺ e ⁻ H ₂ O D		3.6e-08	-0.50 0.0
213	H ₂ DO ⁺ e ⁻ HDO H		7.2e-08	-0.50 0.0
214	H ₂ DO ⁺ e ⁻ OD H ₂		2.0e-08	-0.50 0.0
215	H ₂ DO ⁺ e ⁻ OH HD		4.0e-08	-0.50 0.0
216	H ₂ DO ⁺ e ⁻ HD H O		3.7e-09	-0.50 0.0
217	H ₂ DO ⁺ e ⁻ H ₂ D O		1.9e-09	-0.50 0.0
218	HD ₂ O ⁺ e ⁻ OH D D		8.6e-08	-0.50 0.0
219	HD ₂ O ⁺ e ⁻ OD D H		1.7e-07	-0.50 0.0
220	HD ₂ O ⁺ e ⁻ D ₂ O H		3.6e-08	-0.50 0.0
221	HD ₂ O ⁺ e ⁻ HDO D		7.2e-08	-0.50 0.0
222	HD ₂ O ⁺ e ⁻ OH D ₂		2.0e-08	-0.50 0.0

Table D5 – continued (part 4)

Reactants		Products		α	β	γ		
223	HD ₂ O ⁺	e ⁻	OD	HD		4.0e-08	-0.50	0.0
224	HD ₂ O ⁺	e ⁻	HD	D	O	3.7e-09	-0.50	0.0
225	HD ₂ O ⁺	e ⁻	D ₂	H	O	1.9e-09	-0.50	0.0
226	D ₃ O ⁺	e ⁻	OD	D	D	2.6e-07	-0.50	0.0
227	D ₃ O ⁺	e ⁻	D ₂ O	D		1.1e-07	-0.50	0.0
228	D ₃ O ⁺	e ⁻	OD	D ₂		6.0e-08	-0.50	0.0
229	D ₃ O ⁺	e ⁻	D ₂	D	O	5.6e-09	-0.50	0.0
230	OH	γ	O	H		4.7e+02	0.00	0.0
231	OH ⁺	γ	O ⁺	H		8.6e+00	0.00	0.0
232	H ₂ O	γ	OH	H		1.0e+03	0.00	0.0
233	H ₂ O	γ	H ₂ O ⁺	e ⁻		2.3e+01	0.00	0.0
234	O ₂	γ	O	O		7.8e+02	0.00	0.0
235	O ₂	γ	O ₂ ⁺	e ⁻		2.8e+01	0.00	0.0
236	O ₂ ⁺	γ	O ⁺	O		7.0e+01	0.00	0.0
237	H ₃ O ⁺	Gr	Gr ⁺	H ₂ O	H	3.7e-07	0.50	0.0
238	H ₃ O ⁺	Gr ⁻	Gr	H ₂ O	H	3.7e-07	0.50	0.0
239	O	H ₂	OH	H		1.5e-13	2.80	2980.0
240	O ₂	H	OH	O		1.6e-09	-0.90	8750.0
241	OH	H	O	H ₂		7.0e-14	2.80	1950.0
242	OH	H ₂	H ₂ O	H		9.5e-13	2.00	1490.0
243	H ₂ O	H	OH	H ₂		5.2e-12	1.90	9265.0
244	H ₃ O ⁺	H	H ₂ O ⁺	H ₂		6.1e-10	0.00	20500.0
245	C ⁺	H	CH ⁺	γ		7.0e-17	0.00	0.0
246	C ⁺	H ₂	CH ₂ ⁺	γ		2.0e-16	-1.30	23.0
247	C ⁺	CH	C ₂ ⁺	H		3.8e-10	0.00	0.0
248	C ⁺	CH	CH ⁺	C		3.8e-10	0.00	0.0
249	C ⁺	CH ₂	CH ₂ ⁺	C		5.2e-10	0.00	0.0
250	C ⁺	CH ₂	C ₂ H ⁺	H		5.2e-10	0.00	0.0
251	C ⁺	CH ₄	C ₂ H ₂ ⁺	H ₂		3.3e-10	0.00	0.0
252	C ⁺	CH ₄	C ₂ H ₃ ⁺	H		9.8e-10	0.00	0.0
253	C ⁺	C ₂ H	C ₃ ⁺	H		1.0e-09	0.00	0.0
254	C ⁺	C ₂ H ₂	C ₃ H ⁺	H		2.2e-09	0.00	0.0
255	C ⁺	Fe	Fe ⁺	C		2.6e-09	0.00	0.0
256	CH ⁺	H	C ⁺	H ₂		1.5e-10	0.00	0.0
257	CH ⁺	H ₂	CH ₂ ⁺	H		1.2e-09	0.00	0.0
258	CH ₂ ⁺	H ₂	CH ₃ ⁺	H		7.0e-10	0.00	0.0
259	CH ₃ ⁺	H ₂	CH ₄ ⁺	γ		3.8e-16	-2.30	21.5
260	CH ₄ ⁺	H	CH ₃ ⁺	H ₂		2.0e-10	0.00	0.0
261	CH ₄ ⁺	H ₂	CH ₅ ⁺	H		4.0e-11	0.00	0.0
262	C ₂ ⁺	H ₂	C ₂ H ⁺	H		1.4e-09	0.00	0.0
263	C ₂ H ⁺	H ₂	C ₂ H ₂ ⁺	H		1.7e-09	0.00	0.0
264	C ₃ ⁺	H ₂	C ₃ H ⁺	H		3.0e-10	0.00	0.0
265	C ₃ H ⁺	H ₂	C ₃ H ₃ ⁺	γ		3.0e-13	-1.00	0.0
266	C	CRP	C ⁺	e ⁻		1.8e+00	0.00	0.0
267	C	H	CH	γ		1.0e-17	0.00	0.0
268	C	H ₂ ⁺	CH ⁺	H		2.4e-09	0.00	0.0
269	C	H ₃ ⁺	CH ⁺	H ₂		2.0e-09	0.00	0.0
270	CH	H	C	H ₂		1.2e-10	0.26	0.0
271	CH	He ⁺	C ⁺	H	He	1.1e-09	0.00	0.0
272	CH	H ⁺	H	CH ⁺		1.9e-09	0.00	0.0
273	CH	H ₂ ⁺	H ₂	CH ⁺		7.1e-10	0.00	0.0
274	CH	H ₃ ⁺	CH ₂ ⁺	H		7.1e-10	0.00	0.0
275	CH	H ₃ ⁺	CH ₃ ⁺	H ₂		1.2e-09	0.00	0.0
276	CH	H ₂ D ⁺	CH ₂ ⁺	HD		1.2e-09	0.00	0.0
277	CH	HD ₂ ⁺	CH ₂ ⁺	D ₂		1.2e-09	0.00	0.0
278	CH ₂	H	CH	H ₂		2.2e-10	0.00	0.0
279	CH ₂	He ⁺	C ⁺	H ₂	He	7.5e-10	0.00	0.0
280	CH ₂	He ⁺	CH ⁺	H	He	7.5e-10	0.00	0.0
281	CH ₂	H ⁺	CH ⁺	H ₂		1.4e-09	0.00	0.0
282	CH ₂	H ⁺	H	CH ₂ ⁺		1.4e-09	0.00	0.0
283	CH ₂	H ₂ ⁺	CH ₃ ⁺	H		1.0e-09	0.00	0.0
284	CH ₂	H ₂ ⁺	H ₂	CH ₂ ⁺		1.0e-09	0.00	0.0
285	CH ₂	H ₃ ⁺	CH ₃ ⁺	H ₂		1.7e-09	0.00	0.0
286	CH ₂	H ₂ D ⁺	CH ₃ ⁺	HD		1.7e-09	0.00	0.0
287	CH ₂	HD ₂ ⁺	CH ₃ ⁺	D ₂		1.7e-09	0.00	0.0
288	CH ₃	He ⁺	CH ⁺	H ₂	He	9.0e-10	0.00	0.0
289	CH ₃	He ⁺	CH ₂ ⁺	H	He	9.0e-10	0.00	0.0
290	CH ₃	H ⁺	H	CH ₃ ⁺		3.4e-09	0.00	0.0
291	CH ₃	H ₃ ⁺	CH ₄ ⁺	H ₂		2.1e-09	0.00	0.0
292	CH ₃	H ₂ D ⁺	CH ₄ ⁺	HD		2.1e-09	0.00	0.0
293	CH ₃	HD ₂ ⁺	CH ₄ ⁺	D ₂		2.1e-09	0.00	0.0
294	CH ₄	He ⁺	H ⁺	CH ₃	He	4.0e-10	0.00	0.0
295	CH ₄	He ⁺	CH ⁺	H ₂	H	2.6e-10	0.00	0.0
296	CH ₄	He ⁺	CH ₂ ⁺	H ₂	He	8.5e-10	0.00	0.0

Table D5 – continued (part 5)

Reactants		Products		α	β	γ		
297	CH ₄	He ⁺	CH ₃ ⁺	H	He	8.0e-11	0.00	0.0
298	CH ₄	He ⁺	CH ₄ ⁺	He		1.6e-11	0.00	0.0
299	CH ₄	H ⁺	CH ₃ ⁺	H ₂		2.3e-09	0.00	0.0
300	CH ₄	H ⁺	H	CH ₄ ⁺		1.5e-09	0.00	0.0
301	CH ₄	H ₃ ⁺	CH ₅ ⁺	H ₂		1.9e-09	0.00	0.0
302	CH ₄	H ₂ D ⁺	CH ₅ ⁺	HD		1.9e-09	0.00	0.0
303	CH ₄	HD ₂ ⁺	CH ₅ ⁺	D ₂		1.9e-09	0.00	0.0
304	C	H ₂ D ⁺	CH ⁺	HD		2.0e-09	0.00	0.0
305	C	HD ₂ ⁺	CH ⁺	D ₂		2.0e-09	0.00	0.0
306	C ₂	H ⁺	C ₂ ⁺	H		3.1e-09	0.00	0.0
307	C ₂ H	He ⁺	C ⁺	CH	He	5.1e-10	0.00	0.0
308	C ₂ H	He ⁺	CH ⁺	C	He	5.1e-10	0.00	0.0
309	C ₂ H	He ⁺	C ₂ ⁺	H	He	5.1e-10	0.00	0.0
310	C ₂ H	H ⁺	C ₂ ⁺	H ₂		1.5e-09	0.00	0.0
311	C ₂ H	H ⁺	C ₂ H ⁺	H		1.5e-09	0.00	0.0
312	C ₂ H	H ₃ ⁺	C ₂ H ₃ ⁺	H ₂		1.7e-09	0.00	0.0
313	C ₂ H	H ₂ D ⁺	C ₂ H ₂ ⁺	HD		1.7e-09	0.00	0.0
314	C ₂ H	HD ₂ ⁺	C ₂ H ₂ ⁺	D ₂		1.7e-09	0.00	0.0
315	C ₃ H	He ⁺	C ₃ ⁺	H	He	2.0e-09	0.00	0.0
316	C ₃ H	H ⁺	C ₃ ⁺	H ₂		2.0e-09	0.00	0.0
317	C ₃ H	H ⁺	C ₃ H ⁺	H		2.0e-09	0.00	0.0
318	C ₃ H	H ₃ ⁺	C ₃ H ₂ ⁺	H ₂		2.0e-09	0.00	0.0
319	C ₃ H	H ₂ D ⁺	C ₃ H ₂ ⁺	HD		2.0e-09	0.00	0.0
320	C ₃ H	HD ₂ ⁺	C ₃ H ₂ ⁺	D ₂		2.0e-09	0.00	0.0
321	C ₂ H ₂	He ⁺	CH ⁺	CH	He	7.7e-10	0.00	0.0
322	C ₂ H ₂	He ⁺	C ₂ ⁺	H ₂	He	1.6e-09	0.00	0.0
323	C ₂ H ₂	He ⁺	C ₂ H ⁺	H	He	8.7e-10	0.00	0.0
324	C ₂ H ₂	He ⁺	C ₂ H ₂ ⁺	He		2.4e-10	0.00	0.0
325	C ₂ H ₂	H ⁺	C ₂ H ⁺	H ₂		2.0e-09	0.00	0.0
326	C ₂ H ₂	H ⁺	C ₂ H ₂ ⁺	H		2.0e-09	0.00	0.0
327	C ₂ H ₂	H ₃ ⁺	C ₂ H ₃ ⁺	H ₂		2.9e-09	0.00	0.0
328	C ₂ H ₂	H ₂ D ⁺	C ₂ H ₃ ⁺	HD		2.9e-09	0.00	0.0
329	C ₂ H ₂	HD ₂ ⁺	C ₂ H ₃ ⁺	D ₂		2.9e-09	0.00	0.0
330	C ₃ H ₂	H ⁺	C ₃ H ⁺	H ₂		2.0e-09	0.00	0.0
331	C ₃ H ₂	H ⁺	C ₃ H ₂ ⁺	H		2.0e-09	0.00	0.0
332	C ₃ H ₂	He ⁺	C ₃ H ⁺	H	He	1.0e-09	0.00	0.0
333	C ₃ H ₂	He ⁺	C ₃ ⁺	H ₂	He	1.0e-09	0.00	0.0
334	C ₃ H ₂	H ₃ ⁺	C ₃ H ₃ ⁺	H ₂		2.0e-09	0.00	0.0
335	C ₃ H ₂	H ₂ D ⁺	C ₃ H ₃ ⁺	HD		2.0e-09	0.00	0.0
336	C ₃ H ₂	HD ₂ ⁺	C ₃ H ₃ ⁺	D ₂		2.0e-09	0.00	0.0
337	C ⁺	e ⁻	C	γ		4.4e-12	-0.61	0.0
338	CH ⁺	e ⁻	C	H		1.5e-07	-0.42	0.0
339	CH ₂ ⁺	e ⁻	C	H ₂		1.2e-07	-0.50	0.0
340	CH ₂ ⁺	e ⁻	CH	H		1.2e-07	-0.50	0.0
341	CH ₃ ⁺	e ⁻	C	H ₂	H	3.0e-07	-0.30	0.0
342	CH ₃ ⁺	e ⁻	CH	H	H	1.6e-07	-0.30	0.0
343	CH ₃ ⁺	e ⁻	CH	H ₂		1.4e-07	-0.30	0.0
344	CH ₃ ⁺	e ⁻	CH ₂	H		4.0e-07	-0.30	0.0
345	CH ₄ ⁺	e ⁻	CH ₃	H		3.0e-07	-0.50	0.0
346	CH ₄ ⁺	e ⁻	CH ₂	H	H	3.0e-07	-0.50	0.0
347	CH ₅ ⁺	e ⁻	CH	H ₂	H ₂	8.7e-08	-0.30	0.0
348	CH ₅ ⁺	e ⁻	CH ₂	H ₂	H	8.7e-08	-0.30	0.0
349	CH ₅ ⁺	e ⁻	CH ₃	H ₂		8.7e-08	-0.30	0.0
350	CH ₅ ⁺	e ⁻	CH ₄	H		8.7e-08	-0.30	0.0
351	C ₂ ⁺	e ⁻	C	C		3.0e-07	-0.50	0.0
352	C ₂ H ⁺	e ⁻	C ₂	H		1.4e-07	-0.50	0.0
353	C ₂ H ⁺	e ⁻	CH	C		1.4e-07	-0.50	0.0
354	C ₂ H ₂ ⁺	e ⁻	C ₂ H	H		1.5e-07	-0.50	0.0
355	C ₂ H ₂ ⁺	e ⁻	CH	CH		1.5e-07	-0.50	0.0
356	C ₂ H ₂ ⁺	e ⁻	C ₂ H	H ₂		1.4e-07	-0.50	0.0
357	C ₂ H ₃ ⁺	e ⁻	CH ₂	CH		1.4e-07	-0.50	0.0
358	C ₂ H ₃ ⁺	e ⁻	C ₂ H ₂	H		3.0e-08	-0.50	0.0
359	C ₃ ⁺	e ⁻	C ₂	C		3.0e-07	-0.50	0.0
360	C ₃ H ⁺	e ⁻	C ₂	CH		1.5e-07	-0.50	0.0
361	C ₃ H ⁺	e ⁻	C ₂ H	C		1.5e-07	-0.50	0.0
362	C ₃ H ₂ ⁺	e ⁻	C ₃ H	H		1.5e-07	-0.50	0.0
363	C ₃ H ₂ ⁺	e ⁻	C ₂ H	CH		1.5e-07	-0.50	0.0
364	C ₃ H ₃ ⁺	e ⁻	C ₃ H ₂	H		1.5e-07	-0.50	0.0
365	C ₃ H ₃ ⁺	e ⁻	C ₂ H ₂	CH		1.5e-07	-0.50	0.0
366	C	γ	C ⁺	e ⁻		2.6e+02	0.00	0.0
367	CH	γ	C	H		1.1e+03	0.00	0.0
368	CH	γ	CH ⁺	e ⁻		5.8e+02	0.00	0.0
369	CH ₂	γ	C	H ₂		2.9e+02	0.00	0.0
370	CH ₃	γ	CH	H ₂		2.8e+02	0.00	0.0

Table D5 – *continued* (part 6)

Reactants		Products		α	β	γ	
371	CH ₃	γ_2	CH ₃ ⁺	e ⁻	3.8e+02	0.00	0.0
372	CH ₄	γ_2	CH ₃ ⁺	H	1.5e+03	0.00	0.0
373	CH ₄	γ_2	CH ₄ ⁺	e ⁻	2.2e+01	0.00	0.0
374	CH ⁺	γ_2	C	H ⁺	2.2e+02	0.00	0.0
375	CH ₂ ⁺	γ_2	CH ⁺	H	8.9e+01	0.00	0.0
376	CH ₄ ⁺	γ_2	CH ₃ ⁺	H	2.7e+01	0.00	0.0
377	C ₂	γ_2	C	C	1.8e+02	0.00	0.0
378	C ₂	γ_2	C ₂ ⁺	e ⁻	2.5e+02	0.00	0.0
379	C ₂ H	γ_2	C ₂	H	1.1e+03	0.00	0.0
380	C ₂ H ₂	γ_2	C ₂ H	H	3.5e+03	0.00	0.0
381	C ₂ H ₂	γ_2	C ₂ H ₂ ⁺	e ⁻	3.8e+02	0.00	0.0
382	C ₃	γ_2	C ₂	C	6.9e+03	0.00	0.0
383	C ₃ H	γ_2	C ₃	H	3.0e+03	0.00	0.0
384	C ₃ H ₂	γ_2	C ₃ H	H	3.4e+03	0.00	0.0
385	C ⁺	Gr	Gr ⁺	C	4.6e-07	0.50	0.0
386	C ⁺	Gr ⁻	Gr	C	4.6e-07	0.50	0.0
387	C	H ₂	CH	H	1.2e-09	0.50	14100.0
388	CH	H ₂	CH ₂	H	2.4e-10	0.00	1760.0
389	CH ₂	H ₂	CH ₃	H	5.2e-11	0.17	6400.0
390	CH ₃	H ₂	CH ₄	H	3.0e-10	0.00	5460.0
391	C ₂	H ₂	C ₂ H	H	1.6e-10	0.00	1419.0
392	C ₂ H	H ₂	C ₂ H ₂	H	1.1e-11	0.00	950.0
393	CH ₃	H	CH ₂	H ₂	5.2e-11	0.17	5600.0
394	CH ₄	H	CH ₃	H ₂	3.0e-10	0.00	6560.0
395	C ⁺	H ₂	CH ⁺	H	1.5e-10	0.00	4640.0
396	CH ₂ ⁺	H	CH ⁺	H ₂	1.2e-09	0.00	2700.0
397	CH ₃ ⁺	H	CH ₂ ⁺	H ₂	7.0e-10	0.00	10560.0
398	CH ₃ ⁺	H ₂	CH ₄ ⁺	H	2.0e-10	0.00	32500.0
399	CH ₅ ⁺	H	CH ₄ ⁺	H ₂	4.0e-11	0.00	2200.0
400	C ₂ ⁺	H ₂	H ⁺	C ₂ H	1.5e-09	0.00	1260.0
401	C ₂ H ₂ ⁺	H ₂	C ₂ H ₃ ⁺	H	5.0e-10	0.00	800.0
402	C ₃ H ⁺	H ₂	C ₃ H ₂ ⁺	H	1.0e-09	0.00	500.0
403	C ₃ H ₂ ⁺	H ₂	C ₃ H ₃ ⁺	H	1.0e-10	0.00	2000.0
404	N	CRP	N ⁺	e ⁻	2.1e+00	0.00	0.0
405	N	NH	N ₂	H	5.0e-11	0.10	0.0
406	N	NH ₂	N ₂	H	1.2e-10	0.00	0.0
407	N ⁺	H ₂	NH ⁺	H	4.2e-10	0.00	41.9
408	N ⁺	HD	ND ⁺	H	4.2e-10	0.00	0.0
409	N ₂ ⁺	H ₂	N ₂ H ⁺	H	2.0e-09	0.24	0.0
410	NH ⁺	H ₂	NH ₂ ⁺	H	1.3e-09	0.00	0.0
411	NH ⁺	H ₂	H ₃ ⁺	N	2.2e-10	0.00	0.0
412	NH ⁺	H	N ⁺	H ₂	6.5e-10	0.00	0.0
413	N ₂ H ⁺	NH ₃	NH ₄ ⁺	N ₂	2.3e-09	0.00	0.0
414	N ₂ H ⁺	D	N ₂ D ⁺	H	1.0e-09	0.00	0.0
415	NH ₂ ⁺	H ₂	NH ₃ ⁺	H	2.7e-10	0.00	0.0
416	NH ₃ ⁺	H ₂	NH ₄ ⁺	H	2.4e-12	0.00	0.0
417	ND ⁺	H ₂	NHD ⁺	H	1.3e-09	0.00	0.0
418	ND ⁺	H ₂	H ₂ D ⁺	N	2.2e-10	0.00	0.0
419	ND ⁺	HD	NHD ⁺	D	6.3e-10	0.00	0.0
420	ND ⁺	HD	ND ₂ ⁺	H	6.3e-10	0.00	0.0
421	N ₂ D ⁺	H	N ₂ H ⁺	D	1.0e-09	0.00	170.0
422	N ₂ D ⁺	NH ₃	NH ₃ D ⁺	N ₂	2.3e-09	0.00	0.0
423	NHD ⁺	H ₂	NH ₂ D ⁺	H	2.7e-10	0.00	0.0
424	NHD ⁺	HD	NH ₂ D ⁺	D	1.3e-10	0.00	0.0
425	NHD ⁺	HD	NHD ₂ ⁺	H	1.3e-10	0.00	0.0
426	ND ₂ ⁺	H ₂	NHD ₂ ⁺	H	2.7e-10	0.00	0.0
427	ND ₂ ⁺	HD	NHD ₂ ⁺	D	1.3e-10	0.00	0.0
428	ND ₂ ⁺	HD	ND ₃ ⁺	H	1.3e-10	0.00	0.0
429	NH ₂ D ⁺	H ₂	NH ₃ D ⁺	H	2.4e-12	0.00	0.0
430	NH ₂ D ⁺	HD	NH ₃ D ⁺	D	1.2e-12	0.00	0.0
431	NH ₂ D ⁺	HD	NH ₂ D ₂ ⁺	H	1.2e-12	0.00	0.0
432	NHD ₂ ⁺	H ₂	NH ₂ D ₂ ⁺	H	2.4e-12	0.00	0.0
433	NHD ₂ ⁺	HD	NH ₂ D ₂ ⁺	D	1.2e-12	0.00	0.0
434	NHD ₂ ⁺	HD	NHD ₃ ⁺	H	1.2e-12	0.00	0.0
435	ND ₃ ⁺	H ₂	NHD ₃ ⁺	H	2.4e-12	0.00	0.0
436	ND ₃ ⁺	HD	NHD ₃ ⁺	D	1.2e-12	0.00	0.0
437	ND ₃ ⁺	HD	ND ₄ ⁺	H	1.2e-12	0.00	0.0
438	N	H ₃ ⁺	NH ₂ ⁺	H	0.0e+00	0.00	0.0
439	N ₂	H ₃ ⁺	N ₂ H ⁺	H ₂	1.3e-09	0.00	0.0
440	NH	He ⁺	N ⁺	H	1.1e-09	0.00	0.0
441	NH	H ⁺	NH ⁺	H	2.1e-09	0.00	0.0
442	NH	H ₃ ⁺	NH ₂ ⁺	H ₂	1.3e-09	0.00	0.0
443	NH ₂	He ⁺	NH ⁺	H	8.0e-10	0.00	0.0
444	NH ₂	He ⁺	N ⁺	H ₂	8.0e-10	0.00	0.0

Table D5 – continued (part 7)

Reactants		Products			α	β	γ	
445	NH ₂	H ⁺	H	NH ₂ ⁺		2.9e-09	0.00	0.0
446	NH ₂	H ₃ ⁺	NH ₃ ⁺	H ₂		1.8e-09	0.00	0.0
447	NH ₃	He ⁺	NH ₃ ⁺	He		2.6e-10	0.00	0.0
448	NH ₃	He ⁺	NH ₂ ⁺	H	He	1.8e-09	0.00	0.0
449	NH ₃	He ⁺	NH ⁺	H ₂	He	1.8e-10	0.00	0.0
450	NH ₃	H ⁺	H	NH ₃ ⁺		5.2e-09	0.00	0.0
451	NH ₃	H ₃ ⁺	NH ₄ ⁺	H ₂		9.1e-09	0.00	0.0
452	NH	H ₂ D ⁺	NH ₂ ⁺	HD		8.7e-10	0.00	0.0
453	NH	H ₂ D ⁺	NHD ⁺	H ₂		4.3e-10	0.00	0.0
454	NH	HD ₂ ⁺	NH ₂ ⁺	D ₂		4.3e-10	0.00	0.0
455	NH	HD ₂ ⁺	NHD ⁺	HD		8.7e-10	0.00	0.0
456	NH	D ₃ ⁺	NHD ⁺	D ₂		1.3e-09	0.00	0.0
457	NH ₂	H ₂ D ⁺	NH ₃ ⁺	HD		1.2e-09	0.00	0.0
458	NH ₂	H ₂ D ⁺	NH ₂ D ⁺	H ₂		6.0e-10	0.00	0.0
459	NH ₂	HD ₂ ⁺	NH ₃ ⁺	D ₂		6.0e-10	0.00	0.0
460	NH ₂	HD ₂ ⁺	NH ₂ D ⁺	HD		1.2e-09	0.00	0.0
461	NH ₂	D ₃ ⁺	NH ₂ D ⁺	D ₂		1.8e-09	0.00	0.0
462	NH ₃	H ₂ D ⁺	NH ₄ ⁺	HD		6.1e-09	0.00	0.0
463	NH ₃	H ₂ D ⁺	NH ₃ D ⁺	H ₂		3.0e-09	0.00	0.0
464	NH ₃	HD ₂ ⁺	NH ₄ ⁺	D ₂		3.0e-09	0.00	0.0
465	NH ₃	HD ₂ ⁺	NH ₃ D ⁺	HD		6.1e-09	0.00	0.0
466	NH ₃	D ₃ ⁺	NH ₃ D ⁺	D ₂		9.1e-09	0.00	0.0
467	ND	H ₃ ⁺	NHD ⁺	H ₂		1.3e-09	0.00	0.0
468	ND	H ₂ D ⁺	NHD ⁺	HD		8.7e-10	0.00	0.0
469	ND	H ₂ D ⁺	ND ₂ ⁺	H ₂		4.3e-10	0.00	0.0
470	ND	HD ₂ ⁺	NHD ⁺	D ₂		4.3e-10	0.00	0.0
471	ND	HD ₂ ⁺	ND ₂ ⁺	HD		8.7e-10	0.00	0.0
472	ND	D ₃ ⁺	ND ₂ ⁺	D ₂		1.3e-09	0.00	0.0
473	NHD	H ₃ ⁺	NH ₂ D ⁺	H ₂		1.8e-09	0.00	0.0
474	NHD	H ₂ D ⁺	NH ₂ D ⁺	HD		1.2e-09	0.00	0.0
475	NHD	H ₂ D ⁺	NHD ₂ ⁺	H ₂		6.0e-10	0.00	0.0
476	NHD	HD ₂ ⁺	NH ₂ D ⁺	D ₂		6.0e-10	0.00	0.0
477	NHD	HD ₂ ⁺	NHD ₂ ⁺	HD		1.2e-09	0.00	0.0
478	NHD	D ₃ ⁺	NHD ₂ ⁺	D ₂		1.8e-09	0.00	0.0
479	ND ₂	H ₃ ⁺	NHD ₂ ⁺	H ₂		1.8e-09	0.00	0.0
480	ND ₂	H ₂ D ⁺	NHD ₂ ⁺	HD		1.2e-09	0.00	0.0
481	ND ₂	H ₂ D ⁺	ND ₂ ⁺	H ₂		6.0e-10	0.00	0.0
482	ND ₂	HD ₂ ⁺	NHD ₂ ⁺	D ₂		6.0e-10	0.00	0.0
483	ND ₂	HD ₂ ⁺	ND ₂ ⁺	HD		1.2e-09	0.00	0.0
484	ND ₂	D ₃ ⁺	ND ₃ ⁺	D ₂		1.8e-09	0.00	0.0
485	NH ₂ D	H ⁺	NH ₂ D ⁺	H		5.2e-09	0.00	0.0
486	NH ₂ D	H ₃ ⁺	NH ₃ D ⁺	H ₂		9.1e-09	0.00	0.0
487	NH ₂ D	H ₂ D ⁺	NH ₃ D ⁺	HD		6.1e-09	0.00	0.0
488	NH ₂ D	H ₂ D ⁺	NH ₂ D ₂ ⁺	H ₂		3.0e-09	0.00	0.0
489	NH ₂ D	HD ₂ ⁺	NH ₃ D ⁺	D ₂		3.0e-09	0.00	0.0
490	NH ₂ D	HD ₂ ⁺	NH ₂ D ₂ ⁺	HD		6.1e-09	0.00	0.0
491	NH ₂ D	D ₃ ⁺	NH ₂ D ₂ ⁺	D ₂		9.1e-09	0.00	0.0
492	NHD ₂	H ⁺	NHD ₂ ⁺	H		5.2e-09	0.00	0.0
493	NHD ₂	H ₃ ⁺	NH ₂ D ₂ ⁺	H ₂		9.1e-09	0.00	0.0
494	NHD ₂	H ₂ D ⁺	NH ₂ D ₂ ⁺	HD		6.1e-09	0.00	0.0
495	NHD ₂	H ₂ D ⁺	NHD ₃ ⁺	H ₂		3.0e-09	0.00	0.0
496	NHD ₂	HD ₂ ⁺	NH ₂ D ₂ ⁺	D ₂		3.0e-09	0.00	0.0
497	NHD ₂	HD ₂ ⁺	NHD ₃ ⁺	HD		6.1e-09	0.00	0.0
498	NHD ₂	D ₃ ⁺	NHD ₃ ⁺	D ₂		9.1e-09	0.00	0.0
499	ND ₃	H ⁺	ND ₃ ⁺	H		5.2e-09	0.00	0.0
500	ND ₃	H ₃ ⁺	NHD ₃ ⁺	H ₂		9.1e-09	0.00	0.0
501	ND ₃	H ₂ D ⁺	NHD ₃ ⁺	HD		6.1e-09	0.00	0.0
502	ND ₃	H ₂ D ⁺	ND ₄ ⁺	H ₂		3.0e-09	0.00	0.0
503	ND ₃	HD ₂ ⁺	NHD ₃ ⁺	D ₂		3.0e-09	0.00	0.0
504	ND ₃	HD ₂ ⁺	ND ₄ ⁺	HD		6.1e-09	0.00	0.0
505	ND ₃	D ₃ ⁺	ND ₄ ⁺	D ₂		9.1e-09	0.00	0.0
506	N ₂	H ₂ D ⁺	N ₂ H ⁺	HD		8.7e-10	0.00	0.0
507	N ₂	H ₂ D ⁺	N ₂ D ⁺	H ₂		4.3e-10	0.00	0.0
508	N ₂	HD ₂ ⁺	N ₂ H ⁺	D ₂		4.3e-10	0.00	0.0
509	N ₂	HD ₂ ⁺	N ₂ D ⁺	HD		8.7e-10	0.00	0.0
510	N ₂	D ₃ ⁺	N ₂ D ⁺	D ₂		1.3e-09	0.00	0.0
511	N ⁺	e ⁻	N	γ		3.8e-12	-0.62	0.0
512	NH ⁺	e ⁻	N	H		2.0e-07	-0.50	0.0
513	NH ₂ ⁺	e ⁻	NH	H		1.2e-07	-0.50	0.0
514	NH ₂ ⁺	e ⁻	N	H ₂		1.2e-08	-0.50	0.0
515	NH ₂ ⁺	e ⁻	N	H	H	1.7e-07	-0.50	0.0
516	NH ₃ ⁺	e ⁻	NH ₂	H		1.5e-07	-0.50	0.0
517	NH ₃ ⁺	e ⁻	NH	H	H	1.5e-07	-0.50	0.0
518	NH ₄ ⁺	e ⁻	NH ₂	H ₂		1.9e-08	-0.60	0.0

Table D5 – *continued* (part 8)

	Reactants		Products			α	β	γ
519	NH ₄ ⁺	e ⁻	NH ₂	H	H	1.2e-07	-0.60	0.0
520	NH ₄ ⁺	e ⁻	NH ₃	H		8.0e-07	-0.60	0.0
521	N ₂ ⁺	e ⁻	N	N		3.6e-08	-0.42	0.0
522	N ₂ H ⁺	e ⁻	N ₂	H		2.8e-07	-0.74	0.0
523	N ₂ H ⁺	e ⁻	NH	N		2.1e-08	-0.74	0.0
524	ND ⁺	e ⁻	N	D		2.0e-07	-0.50	0.0
525	NHD ⁺	e ⁻	N	H	D	1.5e-07	-0.50	0.0
526	NHD ⁺	e ⁻	NH	D		7.5e-08	-0.50	0.0
527	NHD ⁺	e ⁻	ND	H		7.5e-08	-0.50	0.0
528	ND ₂ ⁺	e ⁻	ND	D		1.5e-07	-0.50	0.0
529	ND ₂ ⁺	e ⁻	N	D	D	1.5e-07	-0.50	0.0
530	NH ₂ D ⁺	e ⁻	NH ₂	D		1.0e-07	-0.50	0.0
531	NH ₂ D ⁺	e ⁻	NHD	H		2.0e-07	-0.50	0.0
532	NHD ₂ ⁺	e ⁻	ND ₂	H		1.0e-07	-0.50	0.0
533	NHD ₂ ⁺	e ⁻	NHD	D		2.0e-07	-0.50	0.0
534	ND ₃ ⁺	e ⁻	ND ₂	D		3.0e-07	-0.50	0.0
535	NH ₃ D ⁺	e ⁻	NH ₂	HD		2.5e-07	-0.50	0.0
536	NH ₃ D ⁺	e ⁻	NHD	H ₂		2.5e-07	-0.50	0.0
537	NH ₃ D ⁺	e ⁻	NH ₃	D		1.9e-07	-0.50	0.0
538	NH ₃ D ⁺	e ⁻	NH ₂ D	H		5.7e-07	-0.50	0.0
539	NH ₂ D ₂ ⁺	e ⁻	NH ₂	D ₂		8.5e-08	-0.50	0.0
540	NH ₂ D ₂ ⁺	e ⁻	NHD	HD		3.4e-07	-0.50	0.0
541	NH ₂ D ₂ ⁺	e ⁻	ND ₂	H ₂		8.5e-08	-0.50	0.0
542	NH ₂ D ₂ ⁺	e ⁻	NH ₂ D	D		3.8e-07	-0.50	0.0
543	NH ₂ D ₂ ⁺	e ⁻	NHD ₂	H		3.8e-07	-0.50	0.0
544	NHD ₃ ⁺	e ⁻	NHD	D ₂		2.5e-07	-0.50	0.0
545	NHD ₃ ⁺	e ⁻	ND ₂	HD		2.5e-07	-0.50	0.0
546	NHD ₃ ⁺	e ⁻	ND ₃	H		1.9e-07	-0.50	0.0
547	NHD ₃ ⁺	e ⁻	NHD ₂	D		5.7e-07	-0.50	0.0
548	ND ₄ ⁺	e ⁻	ND ₂	D ₂		5.1e-07	-0.50	0.0
549	ND ₄ ⁺	e ⁻	ND ₃	D		7.6e-07	-0.50	0.0
550	N ₂ D ⁺	e ⁻	N ₂	D		2.8e-07	-0.74	0.0
551	N ₂ D ⁺	e ⁻	ND	N		2.1e-08	-0.74	0.0
552	NH ⁺	γ_2	N ⁺	H		2.2e+01	0.00	0.0
553	N ₂	γ_2	N	N		3.9e+01	0.00	0.0
554	NH	γ_2	N	H		3.7e+02	0.00	0.0
555	NH	γ_2	NH ⁺	e ⁻		7.1e+00	0.00	0.0
556	NH ₂	γ_2	NH	H		7.2e+02	0.00	0.0
557	NH ₂	γ_2	NH ₂ ⁺	e ⁻		1.4e+02	0.00	0.0
558	NH ₃	γ_2	NH	H ₂		1.1e+03	0.00	0.0
559	NH ₃	γ_2	NH ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
560	ND	γ_2	N	D		3.7e+02	0.00	0.0
561	ND	γ_2	ND ⁺	e ⁻		7.1e+00	0.00	0.0
562	NHD	γ_2	NH	D		3.6e+02	0.00	0.0
563	NHD	γ_2	ND	H		3.6e+02	0.00	0.0
564	NHD	γ_2	NHD ⁺	e ⁻		1.4e+02	0.00	0.0
565	ND ₂	γ_2	ND	D		7.2e+02	0.00	0.0
566	ND ₂	γ_2	ND ₂ ⁺	e ⁻		1.4e+02	0.00	0.0
567	NH ₂ D	γ_2	NH	HD		4.5e+02	0.00	0.0
568	NH ₂ D	γ_2	ND	H ₂		2.2e+02	0.00	0.0
569	NH ₂ D	γ_2	NHD	H		2.9e+02	0.00	0.0
570	NH ₂ D	γ_2	NH ₂	D		1.4e+02	0.00	0.0
571	NH ₂ D	γ_2	NH ₂ D ⁺	e ⁻		2.2e+02	0.00	0.0
572	NHD ₂	γ_2	ND	HD		4.5e+02	0.00	0.0
573	NHD ₂	γ_2	NH	D ₂		2.2e+02	0.00	0.0
574	NHD ₂	γ_2	NHD	D		2.9e+02	0.00	0.0
575	NHD ₂	γ_2	ND ₂	H		1.4e+02	0.00	0.0
576	NHD ₂	γ_2	NHD ₂ ⁺	e ⁻		2.2e+02	0.00	0.0
577	ND ₃	γ_2	ND	D ₂		6.7e+02	0.00	0.0
578	ND ₃	γ_2	ND ₂	D		4.3e+02	0.00	0.0
579	ND ₃	γ_2	ND ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
580	NH ₄ ⁺	Gr	Gr ⁺	NH ₃	H	3.8e-07	0.50	0.0
581	NH ₄ ⁺	Gr ⁻	Gr	NH ₃	H	3.8e-07	0.50	0.0
582	N ₂ H ⁺	Gr	Gr ⁺	N ₂	H	1.0e-07	0.50	0.0
583	N ₂ H ⁺	Gr	Gr ⁺	NH	N	1.9e-07	0.50	0.0
584	N ₂ H ⁺	Gr ⁻	Gr	N ₂	H	1.0e-07	0.50	0.0
585	N ₂ H ⁺	Gr ⁻	Gr	NH	N	1.9e-07	0.50	0.0
586	N ₂ D ⁺	Gr	Gr ⁺	N ₂	D	3.0e-07	0.50	0.0
587	N ₂ D ⁺	Gr ⁻	Gr	N ₂	D	3.0e-07	0.50	0.0
588	N	H ₂	NH	H		8.7e-10	0.50	14600.0
589	NH	H ₂	NH ₂	H		5.2e-12	0.79	6700.0
590	NH	H	N	H ₂		8.7e-10	0.50	2400.0
591	NH ₂	H ₂	NH ₃	H		6.2e-11	0.50	6300.0
592	NH ₂	H	NH	H ₂		5.2e-12	0.79	2200.0

Table D5 – continued (part 9)

Reactants		Products			α	β	γ	
593	NH ₃	H	NH ₂	H ₂		6.2e-11	0.50	5700.0
594	NH ₂ ⁺	H	NH ⁺	H ₂		1.3e-09	0.00	24000.0
595	NH ₃ ⁺	H	NH ₂ ⁺	H ₂		2.2e-10	0.00	12800.0
596	NH ₄ ⁺	H	NH ₃ ⁺	H ₂		1.0e-09	0.00	11000.0
597	NH ₄ ⁺	N ₂	N ₂ H ⁺	NH ₃		2.3e-09	0.00	44000.0
598	N ₂ H ⁺	H	N ₂ ⁺	H ₂		2.1e-09	0.00	30300.0
599	N ₂ H ⁺	H ₂	H ₃ ⁺	N ₂		1.8e-09	0.00	8300.0
600	S	H ⁺	S ⁺	H		1.0e-15	0.00	0.0
601	S	H ₃ ⁺	SH ⁺	H ₂		2.6e-09	0.00	0.0
602	SH	H	S	H ₂		2.5e-11	0.00	0.0
603	SH	He ⁺	S ⁺	H	He	1.7e-09	0.00	0.0
604	SH	H ⁺	SH ⁺	H		1.6e-09	0.00	0.0
605	SH	H ⁺	S ⁺	H ₂		1.6e-09	0.00	0.0
606	SH	H ₃ ⁺	H ₃ S ⁺	H ₂		1.9e-09	0.00	0.0
607	H ₂ S	He ⁺	S ⁺	H ₂	He	3.6e-09	0.00	0.0
608	H ₂ S	He ⁺	SH ⁺	H	He	4.8e-10	0.00	0.0
609	H ₂ S	He ⁺	He	H ₂ S ⁺		3.1e-10	0.00	0.0
610	H ₂ S	H ⁺	H	H ₂ S ⁺		7.6e-09	0.00	0.0
611	H ₂ S	H ₃ ⁺	H ₃ S ⁺	H ₂		3.7e-09	0.00	0.0
612	S ⁺	Fe	Fe ⁺	S		1.8e-10	0.00	0.0
613	SH ⁺	H	S ⁺	H ₂		1.1e-10	0.00	0.0
614	SH ⁺	H ₂	H ₃ S ⁺	γ		1.0e-15	0.00	0.0
615	SH ⁺	S	S ⁺	SH		9.7e-10	0.00	0.0
616	SH ⁺	H ₂ S	H ₃ S ⁺	S		5.0e-10	0.00	0.0
617	SH ⁺	Fe	Fe ⁺	SH		1.6e-09	0.00	0.0
618	H ₂ S ⁺	H	SH ⁺	H ₂		2.0e-10	0.00	0.0
619	H ₂ S ⁺	S	H ₂ S	S ⁺		1.1e-09	0.00	0.0
620	H ₂ S ⁺	SH	H ₂ S	SH ⁺		5.0e-10	0.00	0.0
621	H ₂ S ⁺	Fe	H ₂ S	Fe ⁺		1.8e-09	0.00	0.0
622	H ₃ S ⁺	H	H ₂ S ⁺	H ₂		6.0e-11	0.00	0.0
623	S	H ₂ D ⁺	SH ⁺	HD		1.7e-09	0.00	0.0
624	S	H ₂ D ⁺	SD ⁺	H ₂		8.7e-10	0.00	0.0
625	S	HD ₂ ⁺	SH ⁺	D ₂		8.7e-10	0.00	0.0
626	S	HD ₂ ⁺	SD ⁺	HD		1.7e-09	0.00	0.0
627	S	D ₃ ⁺	SD ⁺	D ₂		2.6e-09	0.00	0.0
628	SH	H ₂ D ⁺	H ₂ S ⁺	HD		1.9e-09	0.00	0.0
629	SH	HD ₂ ⁺	H ₂ S ⁺	D ₂		1.9e-09	0.00	0.0
630	H ₂ S	H ₂ D ⁺	H ₃ S ⁺	HD		3.7e-09	0.00	0.0
631	H ₂ S	HD ₂ ⁺	H ₃ S ⁺	D ₂		3.7e-09	0.00	0.0
632	S ⁺	Gr	Gr ⁺	S		2.8e-07	0.50	0.0
633	S ⁺	Gr ⁻	Gr	S		2.8e-07	0.50	0.0
634	H ₃ S ⁺	Gr	Gr ⁺	H ₂ S	H	2.7e-07	0.50	0.0
635	H ₃ S ⁺	Gr ⁻	Gr	H ₂ S	H	2.7e-07	0.50	0.0
636	S ⁺	e ⁻	S	γ		3.9e-12	-0.63	0.0
637	SH ⁺	e ⁻	S	H		2.0e-07	-0.50	0.0
638	H ₂ S ⁺	e ⁻	SH	H		1.5e-07	-0.50	0.0
639	H ₂ S ⁺	e ⁻	S	H	H	1.5e-07	-0.50	0.0
640	H ₂ S ⁺	e ⁻	H ₂ S	γ		1.1e-10	-0.70	0.0
641	H ₃ S ⁺	e ⁻	H ₂ S	H		3.0e-07	-0.50	0.0
642	H ₃ S ⁺	e ⁻	SH	H ₂		1.0e-07	-0.50	0.0
643	SD ⁺	e ⁻	S	D		2.0e-07	-0.50	0.0
644	S	γ	S ⁺	e ⁻		8.0e+02	0.00	0.0
645	SH	γ	S	H		1.1e+03	0.00	0.0
646	SH	γ	SH ⁺	e ⁻		3.4e+01	0.00	0.0
647	H ₂ S	γ	SH	H		3.4e+03	0.00	0.0
648	H ₂ S	γ	H ₂ S ⁺	e ⁻		6.2e+02	0.00	0.0
649	SH ⁺	γ	S ⁺	H		4.6e+02	0.00	0.0
650	S	H ₂	SH	H		1.0e-10	0.13	9620.0
651	SH	H ₂	H ₂ S	H		6.4e-12	0.09	8050.0
652	H ₂ S	H	SH	H ₂		6.6e-11	0.00	1350.0
653	S ⁺	H ₂	SH ⁺	H		2.2e-10	0.00	9860.0
654	SH ⁺	H ₂	H ₂ S ⁺	H		1.9e-10	0.00	8500.0
655	SH ⁺	H ₂ S	H ₂ S ⁺	SH		5.0e-10	0.00	1000.0
656	H ₂ S ⁺	H ₂	H ₃ S ⁺	H		1.4e-11	0.00	2300.0
657	O	CH	HCO ⁺	e ⁻		2.4e-14	0.50	0.0
658	O	CH	CO	H		6.6e-11	0.00	0.0
659	O	CH ₂	CO	H	H	1.0e-10	0.00	0.0
660	O	CH ₂	CO	H ₂		4.0e-11	0.00	0.0
661	O	CH ₃	CO	H ₂	H	1.8e-10	0.50	0.0
662	O	C ₂	CO	C		2.0e-10	-0.12	0.0
663	O	C ₂ H	CO	CH		1.0e-10	0.00	250.0
664	O	C ₃	CO	C ₂		5.0e-11	0.50	0.0
665	O	C ₃ H	C ₂ H	CO		5.0e-11	0.50	0.0
666	O	C ₃ H ₂	C ₂ H ₂	CO		5.0e-11	0.50	0.0

Table D5 – *continued* (part 10)

Reactants		Products			α	β	γ
667	O	NH	NO	H	6.6e-11	0.00	0.0
668	O	NH ₂	NH	OH	7.0e-12	-0.10	0.0
669	O	CN	CO	N	5.0e-11	0.00	0.0
670	O	HNC	CO	NH	2.0e-10	0.50	200.0
671	O	SH	OH	S	1.7e-11	0.67	956.0
672	O	SH	SO	H	1.6e-10	0.00	0.0
673	O	CS	CO	S	2.6e-10	0.00	760.0
674	O	CH ₃ ⁺	HCO ⁺	H ₂	3.1e-10	0.00	0.0
675	O	CH ₃ ⁺	H ₃ ⁺	CO	1.3e-11	0.00	0.0
676	O	CH ₅ ⁺	H ₃ O ⁺	CH ₂	2.2e-10	0.00	0.0
677	O	HCO ₂ ⁺	HCO ⁺	O ₂	1.0e-09	0.00	0.0
678	O	SH ₂ ⁺	SO ⁺	H	2.9e-10	0.00	0.0
679	O	SH ⁺	S ⁺	OH	2.9e-10	0.00	0.0
680	O	H ₂ S ⁺	SH ⁺	OH	3.1e-10	0.00	0.0
681	O	H ₂ S ⁺	SO ⁺	H ₂	3.1e-10	0.00	0.0
682	O	HCS ⁺	HCO ⁺	S	1.0e-09	0.00	0.0
683	C	OH	CO	H	3.1e-11	-0.36	0.0
684	C	O ₂	CO	O	3.3e-11	0.50	0.0
685	C	NH	CN	H	1.2e-10	0.00	0.0
686	C	NH ₂	HCN	H	3.0e-11	-0.20	-6.0
687	C	NH ₂	HNC	H	3.0e-11	-0.20	-6.0
688	C	NO	CN	O	6.0e-11	-0.16	0.0
689	C	NO	CO	N	9.0e-11	-0.16	0.0
690	C	SH	CS	H	2.0e-11	0.00	0.0
691	C	SO	CO	S	7.2e-11	0.00	0.0
692	C	SO	CS	O	1.7e-10	0.00	0.0
693	C	H ₃ O ⁺	HCO ⁺	H ₂	1.0e-11	0.00	0.0
694	C	HCO ⁺	CH ⁺	CO	1.1e-09	0.00	0.0
695	C	O ₂ ⁺	CO ⁺	O	5.2e-11	0.00	0.0
696	C	O ₂ ⁺	C ⁺	O ₂	5.2e-11	0.00	0.0
697	C	SH ⁺	CS ⁺	H	9.9e-10	0.00	0.0
698	C	H ₂ S ⁺	HCS ⁺	H	1.0e-09	0.00	0.0
699	C	H ₂ DO ⁺	DCO ⁺	H ₂	1.0e-11	0.00	0.0
700	C	HD ₂ O ⁺	DCO ⁺	HD	1.0e-11	0.00	0.0
701	C	D ₃ O ⁺	DCO ⁺	D ₂	1.0e-11	0.00	0.0
702	N	CH	CN	H	1.4e-10	0.41	0.0
703	N	CN	N ₂	C	8.8e-11	0.42	0.0
704	N	NO	N ₂	O	7.3e-11	0.44	12.7
705	N	CH ₂	HCN	H	5.0e-11	0.17	0.0
706	N	CH ₂	HNC	H	3.0e-11	0.17	0.0
707	N	CH ₃	HCN	H ₂	1.3e-11	0.50	0.0
708	N	OH	NO	H	5.0e-11	0.00	6.0
709	N	O ₂ ⁺	NO ⁺	O	7.8e-11	0.00	0.0
710	N	CH ₂ ⁺	HCN ⁺	H	9.4e-10	0.00	0.0
711	N	C ₂ H ⁺	C ₂ N ⁺	H	8.3e-10	0.00	0.0
712	N	CH ₃ ⁺	HCN ⁺	H ₂	6.7e-11	0.00	0.0
713	N	CH ₃ ⁺	HCNH ⁺	H	6.7e-11	0.00	0.0
714	N	C ₂ H ₂ ⁺	CH ⁺	HCN	2.5e-11	0.00	0.0
715	N	SO	NO	S	1.7e-11	0.50	750.0
716	S	CH	CS	H	1.1e-12	0.00	0.0
717	S	OH	SO	H	1.0e-10	0.00	100.0
718	S	O ₂	SO	O	5.2e-12	0.00	265.0
719	S	CH ⁺	S ⁺	CH	4.7e-10	0.00	0.0
720	S	CH ⁺	SH ⁺	C	4.7e-10	0.00	0.0
721	S	CH ⁺	CS ⁺	H	4.7e-10	0.00	0.0
722	S	CH ₃ ⁺	HCS ⁺	H ₂	1.4e-09	0.00	0.0
723	S	CH ₅ ⁺	SH ⁺	CH ₄	1.3e-09	0.00	0.0
724	S	HCO ⁺	SH ⁺	CO	3.3e-10	0.00	0.0
725	S	O ₂ ⁺	SO ⁺	O	5.4e-10	0.00	0.0
726	S	O ₂ ⁺	S ⁺	O ₂	5.4e-10	0.00	0.0
727	S	HNO ⁺	SH ⁺	NO	1.1e-09	0.00	0.0
728	S	N ₂ H ⁺	SH ⁺	N ₂	1.1e-09	0.00	0.0
729	CO	He ⁺	C ⁺	O	1.5e-09	0.00	0.0
730	SO	He ⁺	O ⁺	S	8.3e-10	0.00	0.0
731	SO	He ⁺	S ⁺	O	8.3e-10	0.00	0.0
732	NO	He ⁺	N ⁺	O	1.4e-09	0.00	0.0
733	NO	He ⁺	O ⁺	N	2.2e-10	0.00	0.0
734	CN	He ⁺	C ⁺	N	8.8e-10	0.00	0.0
735	CN	He ⁺	N ⁺	C	8.8e-10	0.00	0.0
736	CS	He ⁺	C ⁺	S	1.3e-09	0.00	0.0
737	CS	He ⁺	S ⁺	C	1.3e-09	0.00	0.0
738	N ₂	He ⁺	N ⁺	N	7.9e-10	0.00	0.0
739	N ₂	He ⁺	N ₂ ⁺	He	4.1e-10	0.00	0.0
740	HCN	He ⁺	CN ⁺	H	1.5e-09	0.00	0.0

Table D5 – continued (part 11)

Reactants		Products			α	β	γ	
741	HCN	He ⁺	CH ⁺	N	He	6.2e-10	0.00	0.0
742	HCN	He ⁺	C ⁺	NH	He	7.8e-10	0.00	0.0
743	HCN	He ⁺	N ⁺	CH	He	2.5e-10	0.00	0.0
744	HNC	He ⁺	CN ⁺	H	He	1.6e-09	0.00	0.0
745	HNC	He ⁺	C ⁺	NH	He	1.6e-09	0.00	0.0
746	CO ₂	He ⁺	CO ⁺	O	He	7.7e-10	0.00	0.0
747	CO ₂	He ⁺	O ⁺	CO	He	1.8e-10	0.00	0.0
748	CO ₂	He ⁺	C ⁺	O ₂	He	4.0e-11	0.00	0.0
749	SO ₂	He ⁺	S ⁺	O ₂	He	8.6e-10	0.00	0.0
750	SO ₂	He ⁺	SO ⁺	O	He	3.4e-09	0.00	0.0
751	OCS	He ⁺	CS ⁺	O	He	7.6e-10	0.00	0.0
752	OCS	He ⁺	S ⁺	CO	He	7.6e-10	0.00	0.0
753	OCS	He ⁺	CO ⁺	S	He	7.6e-10	0.00	0.0
754	OCS	He ⁺	O ⁺	CS	He	7.6e-11	0.00	0.0
755	CH	SH ⁺	CH ₂ ⁺	S		5.8e-10	0.00	0.0
756	H ₂ O	CH ₅ ⁺	H ₃ O ⁺	CH ₄		3.7e-09	0.00	0.0
757	H ₂ O	C ₂ H ₄ ⁺	H ₃ O ⁺	C ₂ H		2.2e-10	0.00	0.0
758	H ₂ O	C ₂ H ₃ ⁺	H ₃ O ⁺	C ₂ H ₂		1.1e-09	0.00	0.0
759	H ₂ O	C ₃ H ⁺	HCO ⁺	C ₂ H ₂		2.5e-10	0.00	0.0
760	H ₂ O	C ₃ H ⁺	C ₂ H ₃ ⁺	CO		2.0e-10	0.00	0.0
761	H ₂ O	NH ₃ ⁺	NH ₄ ⁺	OH		2.5e-10	0.00	0.0
762	H ₂ O	N ₂ H ⁺	H ₃ O ⁺	N ₂		2.6e-09	0.00	0.0
763	H ₂ O	HNO ⁺	H ₃ O ⁺	NO		2.3e-09	0.00	0.0
764	H ₂ O	SH ⁺	H ₃ O ⁺	S		6.3e-10	0.00	0.0
765	H ₂ O	H ₂ S ⁺	H ₃ O ⁺	SH		8.1e-10	0.00	0.0
766	NH ₃	SH ⁺	SH	NH ₃ ⁺		5.3e-10	0.00	0.0
767	NH ₃	SH ⁺	NH ₄ ⁺	S		9.8e-10	0.00	0.0
768	NH ₃	H ₂ S ⁺	NH ₄ ⁺	SH		1.4e-09	0.00	0.0
769	NH ₃	H ₂ S ⁺	H ₂ S	NH ₃ ⁺		3.4e-10	0.00	0.0
770	NH ₃	H ₃ S ⁺	NH ₄ ⁺	H ₂ S		1.9e-09	0.00	0.0
771	NH ₃	SO ⁺	NH ₃ ⁺	SO		1.3e-09	0.00	0.0
772	NH ₃	O ₂ ⁺	NH ₃ ⁺	O ₂		2.0e-09	0.00	0.0
773	CO	OH	CO ₂	H		4.4e-13	-1.15	390.0
774	CO	H ₂ ⁺	HCO ⁺	H		2.2e-09	0.00	0.0
775	CO	H ₂ ⁺	CO ⁺	H ₂		6.4e-10	0.00	0.0
776	CO	H ₃ ⁺	HCO ⁺	H ₂		1.7e-09	0.00	0.0
777	CO	CH ₅ ⁺	HCO ⁺	CH ₄		9.9e-10	0.00	0.0
778	CO	H ₂ D ⁺	HCO ⁺	HD		1.1e-09	0.00	0.0
779	CO	H ₂ D ⁺	DCO ⁺	H ₂		5.7e-10	0.00	0.0
780	CO	HD ₂ ⁺	HCO ⁺	D ₂		5.7e-10	0.00	0.0
781	CO	HD ₂ ⁺	DCO ⁺	HD		1.1e-09	0.00	0.0
782	CO	D ₃ ⁺	DCO ⁺	D ₂		1.7e-09	0.00	0.0
783	SO	OH	SO ₂	H		2.0e-10	-0.17	0.0
784	SO	H ⁺	SO ⁺	H		3.2e-09	0.00	0.0
785	SO	H ₃ ⁺	HSO ⁺	H ₂		1.9e-09	0.00	0.0
786	SO	CH ⁺	OH ⁺	CS		1.0e-09	0.00	0.0
787	SO	CH ⁺	SH ⁺	CO		1.0e-09	0.00	0.0
788	SO	CH ₃ ⁺	HOCs ⁺	H ₂		9.5e-10	0.00	0.0
789	SO	HCO ⁺	HSO ⁺	CO		7.5e-10	0.00	0.0
790	NO	CH	HCN	O		1.2e-11	-0.13	0.0
791	NO	H ⁺	NO ⁺	H		1.9e-09	0.00	0.0
792	NO	H ₃ ⁺	HNO ⁺	H ₂		1.1e-09	0.00	0.0
793	NO	HCO ₂ ⁺	HNO ⁺	CO ₂		1.0e-10	0.00	0.0
794	NO	O ₂ ⁺	NO ⁺	O ₂		4.4e-10	0.00	0.0
795	NO	SH ⁺	NO ⁺	SH		3.3e-10	0.00	0.0
796	NO	H ₂ S ⁺	NO ⁺	H ₂ S		3.7e-10	0.00	0.0
797	NO	H ₂ D ⁺	HNO ⁺	HD		7.3e-10	0.00	0.0
798	NO	HD ₂ ⁺	HNO ⁺	D ₂		3.7e-10	0.00	0.0
799	CN	NH ₃	NH ₂	HCN		2.8e-11	-0.85	0.0
800	CN	H ₃ ⁺	HCN ⁺	H ₂		1.0e-09	0.00	0.0
801	CN	H ₃ ⁺	HCNH ⁺	H		1.0e-09	0.00	0.0
802	CN	H ₃ O ⁺	HCNH ⁺	OH		4.5e-09	0.00	0.0
803	CN	H ₂ D ⁺	HCNH ⁺	D		1.0e-09	0.00	0.0
804	CN	H ₂ D ⁺	HCN ⁺	HD		1.0e-09	0.00	0.0
805	CS	OH	OCS	H		1.7e-10	0.00	0.0
806	CS	OH	CO	SH		3.0e-11	0.00	0.0
807	CS	H ⁺	CS ⁺	H		4.9e-09	0.00	0.0
808	CS	H ₃ ⁺	HCS ⁺	H ₂		2.9e-09	0.00	0.0
809	CS	H ₂ D ⁺	HCS ⁺	HD		2.9e-09	0.00	0.0
810	CS	HD ₂ ⁺	HCS ⁺	D ₂		2.9e-09	0.00	0.0
811	SO	H ₂ D ⁺	HSO ⁺	HD		1.9e-09	0.00	0.0
812	SO	HD ₂ ⁺	HSO ⁺	D ₂		1.9e-09	0.00	0.0
813	HCN	H ⁺	HCN ⁺	H		1.1e-08	0.00	0.0
814	HCN	H ₃ ⁺	HCNH ⁺	H ₂		9.5e-09	0.00	0.0

Table D5 – *continued* (part 12)

Reactants		Products		α	β	γ	
815	HCN	H ₃ O ⁺	HCNH ⁺	H ₂ O	4.5e-09	0.00	0.0
816	HCN	H ₃ S ⁺	HCNH ⁺	H ₂ S	1.9e-09	0.00	0.0
817	HCN	HCO ⁺	HCNH ⁺	CO	3.7e-09	0.00	0.0
818	HCN	H ₂ D ⁺	HCNH ⁺	HD	9.5e-09	0.00	0.0
819	HNC	H	HCN	H	1.0e-15	0.00	0.0
820	HNC	H ⁺	H ⁺	HCN	1.0e-09	0.00	0.0
821	HNC	H ₃ ⁺	HCNH ⁺	H ₂	9.5e-09	0.00	0.0
822	HNC	H ₂ D ⁺	HCNH ⁺	HD	9.5e-09	0.00	0.0
823	HNC	H ₃ O ⁺	HCNH ⁺	H ₂ O	4.5e-09	0.00	0.0
824	HNC	HCO ⁺	HCNH ⁺	CO	3.7e-09	0.00	0.0
825	HNC	CH ₅ ⁺	C ₂ H ₃ ⁺	NH ₃	1.0e-09	0.00	0.0
826	CO ₂	H ⁺	HCO ⁺	O	4.2e-09	0.00	0.0
827	CO ₂	H ₃ ⁺	HCO ₂ ⁺	H ₂	2.0e-09	0.00	0.0
828	CO ₂	H ₂ D ⁺	HCO ₂ ⁺	HD	1.3e-09	0.00	0.0
829	CO ₂	H ₂ D ⁺	DCO ₂ ⁺	H ₂	6.7e-10	0.00	0.0
830	CO ₂	HD ₂ ⁺	HCO ₂ ⁺	D ₂	6.7e-10	0.00	0.0
831	CO ₂	HD ₂ ⁺	DCO ₂ ⁺	HD	1.3e-09	0.00	0.0
832	CO ₂	D ₃ ⁺	DCO ₂ ⁺	D ₂	2.0e-09	0.00	0.0
833	CO ₂	N ₂ D ⁺	DCO ₂ ⁺	N ₂	1.4e-09	0.00	0.0
834	SO ₂	H ₃ ⁺	HSO ₂ ⁺	H ₂	1.3e-09	0.00	0.0
835	SO ₂	H ₂ D ⁺	HSO ₂ ⁺	HD	1.3e-09	0.00	0.0
836	SO ₂	HD ₂ ⁺	HSO ₂ ⁺	D ₂	1.3e-09	0.00	0.0
837	OCS	H ⁺	SH ⁺	CO	5.9e-09	0.00	0.0
838	OCS	H ₃ ⁺	HOCS ⁺	H ₂	1.9e-09	0.00	0.0
839	OCS	HCO ⁺	HOCS ⁺	CO	1.1e-09	0.00	0.0
840	H ₂ S	H ₃ O ⁺	H ₃ S ⁺	H ₂ O	1.9e-09	0.00	0.0
841	SH	HCO ⁺	H ₂ S ⁺	CO	8.2e-10	0.00	0.0
842	CS	HCO ⁺	HCS ⁺	CO	1.2e-09	0.00	0.0
843	H ₂ S	HCO ⁺	H ₃ S ⁺	CO	1.6e-09	0.00	0.0
844	H ₂ S	O ₂ ⁺	H ₂ S ⁺	O ₂	1.4e-09	0.00	0.0
845	H ₂ S	NH ₃ ⁺	NH ₄ ⁺	SH	6.0e-10	0.00	0.0
846	OCS	H ₂ D ⁺	HOCS ⁺	HD	1.9e-09	0.00	0.0
847	OCS	HD ₂ ⁺	HOCS ⁺	D ₂	1.9e-09	0.00	0.0
848	S	N ₂ D ⁺	SD ⁺	N ₂	1.1e-09	0.00	0.0
849	H ₂ O	N ₂ D ⁺	H ₂ DO ⁺	N ₂	2.6e-09	0.00	0.0
850	CO	N ₂ D ⁺	DCO ⁺	N ₂	8.8e-10	0.00	0.0
851	C ⁺	S	S ⁺	C	5.5e-12	0.86	681.0
852	C ⁺	OH	CO ⁺	H	8.0e-10	0.00	0.0
853	C ⁺	OH	H ⁺	CO	8.0e-10	0.00	0.0
854	C ⁺	H ₂ O	HCO ⁺	H	2.4e-09	-0.63	0.0
855	C ⁺	O ₂	O ⁺	CO	5.1e-10	0.00	0.0
856	C ⁺	O ₂	CO ⁺	O	3.1e-10	0.00	0.0
857	C ⁺	CO ₂	CO ⁺	CO	1.1e-09	0.00	0.0
858	C ⁺	NH	CN ⁺	H	7.8e-10	0.00	0.0
859	C ⁺	NH ₂	HCN ⁺	H	1.1e-09	0.00	0.0
860	C ⁺	NH ₃	NH ₃ ⁺	C	5.3e-10	0.00	0.0
861	C ⁺	NH ₃	H ₂ NC ⁺	H	7.8e-10	0.00	0.0
862	C ⁺	NH ₃	HCNH ⁺	H	7.8e-10	0.00	0.0
863	C ⁺	NH ₃	HCN ⁺	H ₂	2.1e-10	0.00	0.0
864	C ⁺	HCN	C ₂ N ⁺	H	3.4e-09	0.00	0.0
865	C ⁺	HNC	C ₂ N ⁺	H	3.4e-09	0.00	0.0
866	C ⁺	NO	NO ⁺	C	3.4e-09	0.00	0.0
867	C ⁺	NO	N ⁺	CO	9.0e-10	0.00	0.0
868	C ⁺	SH	CS ⁺	H	1.1e-09	0.00	0.0
869	C ⁺	H ₂ S	HCS ⁺	H	1.3e-09	0.00	0.0
870	C ⁺	H ₂ S	H ₂ S ⁺	C	4.2e-10	0.00	0.0
871	C ⁺	SO	S ⁺	CO	2.6e-10	0.00	0.0
872	C ⁺	SO	CS ⁺	O	2.6e-10	0.00	0.0
873	C ⁺	SO	SO ⁺	C	2.6e-10	0.00	0.0
874	C ⁺	SO	CO ⁺	S	2.6e-10	0.00	0.0
875	C ⁺	SO ₂	SO ⁺	CO	2.3e-09	0.00	0.0
876	C ⁺	CS	CS ⁺	C	1.6e-09	0.00	700.0
877	C ⁺	OCS	CS ⁺	CO	1.6e-09	0.00	0.0
878	C ⁺	OD	CO ⁺	D	8.0e-10	0.00	0.0
879	C ⁺	OD	D ⁺	CO	8.0e-10	0.00	0.0
880	C ⁺	HDO	DCO ⁺	H	1.2e-09	-0.63	0.0
881	C ⁺	HDO	HCO ⁺	D	1.2e-09	-0.63	0.0
882	C ⁺	D ₂ O	DCO ⁺	D	2.4e-09	-0.63	0.0
883	N ⁺	O ₂	O ₂ ⁺	N	2.8e-10	0.00	0.0
884	N ⁺	O ₂	NO ⁺	O	2.4e-10	0.00	0.0
885	N ⁺	O ₂	O ⁺	NO	3.3e-11	0.00	0.0
886	N ⁺	CO	CO ⁺	N	8.3e-10	0.00	0.0
887	N ⁺	CO	NO ⁺	C	1.5e-10	0.00	0.0
888	N ⁺	NO	NO ⁺	N	4.5e-10	0.00	0.0

Table D5 – continued (part 13)

Reactants		Products		α	β	γ
889	N ⁺	NO	N ₂ ⁺	O	7.9e-11	0.00 0.0
890	S ⁺	CH	CS ⁺	H	6.2e-10	0.00 0.0
891	S ⁺	CH ₂	HCS ⁺	H	1.0e-11	0.00 0.0
892	S ⁺	OH	SO ⁺	H	6.1e-10	0.00 0.0
893	S ⁺	NO	NO ⁺	S	3.2e-10	0.00 0.0
894	S ⁺	NH ₃	NH ₃ ⁺	S	1.6e-09	0.00 0.0
895	S ⁺	O ₂	SO ⁺	O	2.3e-11	0.00 0.0
896	S ⁺	NH ₂ D	NH ₂ D ⁺	S	1.6e-09	0.00 0.0
897	S ⁺	NHD ₂	NHD ₂ ⁺	S	1.6e-09	0.00 0.0
898	S ⁺	ND ₃	ND ₃ ⁺	S	1.6e-09	0.00 0.0
899	CO ⁺	H ₂	HCO ⁺	H	1.3e-09	0.00 0.0
900	CO ⁺	H	H ⁺	CO	7.5e-10	0.00 0.0
901	HCO ⁺	CH	CH ₂ ⁺	CO	6.3e-10	0.00 0.0
902	HCO ⁺	CH ₂	CH ₃ ⁺	CO	8.6e-10	0.00 0.0
903	HCO ⁺	H ₂ O	H ₃ O ⁺	CO	2.5e-09	0.00 0.0
904	HCO ⁺	OH	HCO ₂ ⁺	H	1.0e-09	0.00 0.0
905	HCO ⁺	C ₂ H	C ₂ H ₂ ⁺	CO	7.8e-10	0.00 0.0
906	HCO ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	CO	1.4e-09	0.00 0.0
907	HCO ⁺	C ₃ H	C ₃ H ₂ ⁺	CO	1.4e-09	0.00 0.0
908	HCO ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	CO	1.4e-09	0.00 0.0
909	HCO ⁺	NH	NH ₂ ⁺	CO	6.4e-10	0.00 0.0
910	HCO ⁺	NH ₂	NH ₃ ⁺	CO	8.9e-10	0.00 0.0
911	HCO ⁺	NH ₃	NH ₄ ⁺	CO	1.9e-09	0.00 0.0
912	HCO ⁺	Fe	Fe ⁺	CO	1.9e-09	0.00 0.0
913	HCO ₂ ⁺	CO	HCO ⁺	CO ₂	1.0e-09	0.00 0.0
914	HCO ₂ ⁺	CH ₄	CH ₅ ⁺	CO ₂	7.8e-10	0.00 0.0
915	H ₃ O ⁺	CH	CH ₂ ⁺	H ₂ O	6.8e-10	0.00 0.0
916	H ₃ O ⁺	CH ₂	CH ₃ ⁺	H ₂ O	9.4e-10	0.00 0.0
917	H ₃ O ⁺	C ₃ H	C ₃ H ₂ ⁺	H ₂ O	2.0e-09	0.00 0.0
918	H ₃ O ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	H ₂ O	3.0e-09	0.00 0.0
919	H ₃ O ⁺	NH ₃	NH ₄ ⁺	H ₂ O	2.2e-09	0.00 0.0
920	CN ⁺	H ₂	HCN ⁺	H	1.0e-09	0.00 0.0
921	HCN ⁺	H ₂	HCNH ⁺	H	9.8e-10	0.00 0.0
922	HCNH ⁺	CH	CH ₂ ⁺	HCN	3.1e-10	0.00 0.0
923	HCNH ⁺	CH	CH ₂ ⁺	HNC	3.1e-10	0.00 0.0
924	HCNH ⁺	CH ₂	CH ₃ ⁺	HCN	4.3e-10	0.00 0.0
925	HCNH ⁺	CH ₂	CH ₃ ⁺	HNC	4.3e-10	0.00 0.0
926	HCNH ⁺	NH ₂	NH ₃ ⁺	HCN	4.5e-10	0.00 0.0
927	HCNH ⁺	NH ₂	NH ₃ ⁺	HNC	4.5e-10	0.00 0.0
928	HCNH ⁺	NH ₃	NH ₄ ⁺	HCN	1.1e-09	0.00 0.0
929	HCNH ⁺	NH ₃	NH ₄ ⁺	HNC	1.1e-09	0.00 0.0
930	HCNH ⁺	H ₂ S	H ₃ S ⁺	HCN	1.7e-10	0.00 0.0
931	HCNH ⁺	H ₂ S	H ₃ S ⁺	HNC	1.7e-10	0.00 0.0
932	N ₂ H ⁺	CO	HCO ⁺	N ₂	8.8e-10	0.00 0.0
933	N ₂ H ⁺	CO ₂	HCO ₂ ⁺	N ₂	1.4e-09	0.00 0.0
934	N ₂ H ⁺	NO	HNO ⁺	N ₂	3.4e-10	0.00 0.0
935	C ₂ N ⁺	NH ₃	N ₂ H ⁺	C ₂ H ₂	1.9e-09	0.00 0.0
936	NO ⁺	Fe	Fe ⁺	NO	1.0e-09	0.00 0.0
937	HNO ⁺	C	CH ⁺	NO	1.0e-09	0.00 0.0
938	HNO ⁺	CO	HCO ⁺	NO	1.0e-10	0.00 0.0
939	HNO ⁺	CO ₂	HCO ₂ ⁺	NO	1.0e-10	0.00 0.0
940	HNO ⁺	OH	H ₂ O ⁺	NO	6.2e-10	0.00 0.0
941	SO ⁺	Fe	Fe ⁺	SO	1.6e-09	0.00 0.0
942	CS ⁺	H ₂	HCS ⁺	H	4.8e-10	0.00 0.0
943	HCO ⁺	Gr	Gr ⁺	CO	3.0e-07	0.50 0.0
944	HCS ⁺	Gr	Gr ⁺	CS	2.4e-07	0.50 0.0
945	HCO ⁺	Gr ⁻	Gr	CO	3.0e-07	0.50 0.0
946	HCS ⁺	Gr ⁻	Gr	CS	2.4e-07	0.50 0.0
947	CO ⁺	e ⁻	C	O	1.0e-07	-0.46 0.0
948	HCO ⁺	e ⁻	CO	H	2.4e-07	-0.69 0.0
949	HCO ₂ ⁺	e ⁻	CO ₂	H	2.2e-07	-0.50 0.0
950	HCO ₂ ⁺	e ⁻	CO	OH	1.2e-07	-0.50 0.0
951	CN ⁺	e ⁻	C	N	1.8e-07	-0.50 0.0
952	C ₂ N ⁺	e ⁻	C ₂	N	1.0e-07	-0.50 0.0
953	C ₂ N ⁺	e ⁻	CN	C	2.0e-07	-0.50 0.0
954	HCN ⁺	e ⁻	CN	H	1.5e-07	-0.50 0.0
955	HCN ⁺	e ⁻	CH	N	1.5e-07	-0.50 0.0
956	HCNH ⁺	e ⁻	HCN	H	9.6e-08	-0.65 0.0
957	HCNH ⁺	e ⁻	HNC	H	9.6e-08	-0.65 0.0
958	HCNH ⁺	e ⁻	CN	H	9.1e-08	-0.65 0.0
959	H ₂ NC ⁺	e ⁻	HNC	H	1.8e-07	-0.50 0.0
960	H ₂ NC ⁺	e ⁻	CN	H	1.8e-08	-0.50 0.0
961	NO ⁺	e ⁻	N	O	4.3e-07	-0.37 0.0
962	HNO ⁺	e ⁻	NO	H	3.0e-07	-0.50 0.0

Table D5 – continued (part 14)

Reactants		Products			α	β	γ	
963	CS ⁺	e ⁻	C	S		2.0e-07	-0.50	0.0
964	HCS ⁺	e ⁻	CS	H		7.0e-07	-0.50	0.0
965	SO ⁺	e ⁻	S	O		2.0e-07	-0.50	0.0
966	HSO ⁺	e ⁻	SO	H		2.0e-07	-0.50	0.0
967	HSO ₂ ⁺	e ⁻	SO	H	O	1.0e-07	-0.50	0.0
968	HSO ₃ ⁺	e ⁻	SO	OH		1.0e-07	-0.50	0.0
969	HOCS ⁺	e ⁻	OH	CS		2.0e-07	-0.50	0.0
970	HOCS ⁺	e ⁻	OCS	H		2.0e-07	-0.50	0.0
971	Fe ⁺	e ⁻	Fe	γ		3.7e-12	-0.65	0.0
972	DCO ⁺	e ⁻	CO	D		2.4e-07	-0.69	0.0
973	DCO ₂ ⁺	e ⁻	CO ₂	D		2.2e-07	-0.50	0.0
974	DCO ₃ ⁺	e ⁻	CO	OD		1.2e-07	-0.50	0.0
975	CO ₂	η	CO	O		6.0e+02	0.00	0.0
976	CO	η	C	O		4.6e+01	0.00	0.0
977	CO	η	CO ⁺	e ⁻		1.4e+01	0.00	0.0
978	H ₂ CO	η	CO	H ₂		1.3e+03	0.00	0.0
979	CH ₃ OH	η	CH ₃	OH		1.6e+03	0.00	0.0
980	HCO ⁺	η	CO ⁺	H		3.3e+00	0.00	0.0
981	CO ⁺	η	C ⁺	O		7.7e+01	0.00	0.0
982	CN	η	C	N		4.5e+02	0.00	0.0
983	CN	η	CN ⁺	e ⁻		8.3e+00	0.00	0.0
984	HCN	η	CN	H		2.0e+03	0.00	0.0
985	HCN	η	HCN ⁺	e ⁻		1.4e+00	0.00	0.0
986	HNC	η	CN	H		2.0e+03	0.00	0.0
987	NO	η	N	O		3.0e+02	0.00	0.0
988	NO	η	NO ⁺	e ⁻		2.4e+02	0.00	0.0
989	SO	η	S	O		5.5e+03	0.00	0.0
990	SO	η	SO ⁺	e ⁻		4.5e+02	0.00	0.0
991	CS	η	S	C		1.9e+03	0.00	0.0
992	CS	η	CS ⁺	e ⁻		2.0e+01	0.00	0.0
993	OCS	η	CO	S		5.2e+03	0.00	0.0
994	SO ₂	η	SO	O		2.7e+03	0.00	0.0
995	O	NH ₃	NH ₂	OH		2.5e-12	0.00	3020.0
996	O	NO	O ₂	N		7.5e-13	1.00	16000.0
997	O	N ₂ H ⁺	OH ⁺	N ₂		1.4e-10	0.00	1400.0
998	O	H ₂ S	SH	OH		1.4e-11	0.00	1920.0
999	O	SO	S	O ₂		6.6e-13	0.00	2760.0
1000	O	SO ₂	SO	O ₂		9.3e-11	-0.46	9140.0
1001	O	OCS	SO	CO		2.6e-11	0.00	2250.0
1002	C	SH	CH	S		1.2e-11	0.58	5880.0
1003	N	O ₂	NO	O		3.3e-12	1.00	3150.0
1004	N	C ₂ H ₂ ⁺	CH ⁺	HNC		2.5e-11	0.00	2600.0
1005	S	CH	SH	C		1.7e-11	0.50	4000.0
1006	S	H ₃ O ⁺	SH ⁺	H ₂ O		3.2e-10	0.00	4930.0
1007	OH	NH ₃	NH ₂	H ₂ O		3.5e-12	0.00	925.0
1008	OH	NH ₄ ⁺	NH ₃ ⁺	H ₂ O		2.5e-10	0.00	3400.0
1009	OH	H ₂ S	SH	H ₂ O		6.1e-12	0.00	80.0
1010	OH	S ⁺	SH ⁺	O		2.9e-10	0.00	8820.0
1011	OH	SH ⁺	H ₂ S ⁺	O		3.1e-10	0.00	7500.0
1012	OH	SH ⁺	H ₂ O ⁺	S		4.3e-10	0.00	9200.0
1013	CO	H	OH	C		1.1e-10	0.50	77700.0
1014	CO	NH ₂ ⁺	HCO ⁺	NH		6.4e-10	0.00	6100.0
1015	CO	N ⁺	C ⁺	NO		9.0e-10	0.00	15400.0
1016	CO	SH	OCS	H		5.9e-14	1.12	8330.0
1017	CN	H ₂	HCN	H		5.7e-13	2.45	1130.0
1018	CN	H ⁺	CN ⁺	H		2.1e-09	0.00	6150.0
1019	HCN	CH ₅ ⁺	C ₂ H ₃ ⁺	NH ₃		1.0e-09	0.00	5120.0
1020	HCN	H ⁺	H ⁺	HNC		1.0e-09	0.00	7850.0
1021	HNC	O ₂	CO ₂	NH		2.0e-11	0.50	2000.0
1022	SO	H	OH	S		5.9e-10	-0.31	11100.0
1023	SO	O ₂	SO ₂	O		1.4e-12	0.00	2820.0
1024	SO ₂	H	SO	OH		9.3e-09	-0.74	14700.0
1025	OCS	H	SH	CO		1.7e-11	0.00	2000.0
1026	HCO ⁺	H	CO ⁺	H ₂		1.3e-09	0.00	24500.0
1027	HCO ⁺	CH ₃	CH ₄ ⁺	CO		1.4e-09	0.00	9060.0
1028	HCO ⁺	CH ₄	CH ₅ ⁺	CO		9.9e-10	0.00	4920.0
1029	HCO ⁺	O ₂	HCO ₂ ⁺	O		1.0e-09	0.00	1450.0
1030	HCO ⁺	CO ₂	HCO ₃ ⁺	CO		1.0e-09	0.00	5000.0
1031	HCO ⁺	N ₂	N ₂ H ⁺	CO		8.8e-10	0.00	11200.0
1032	HCO ₂ ⁺	H	HCO ⁺	OH		1.0e-09	0.00	7500.0
1033	HCO ₂ ⁺	N ₂	N ₂ H ⁺	CO ₂		1.4e-09	0.00	6400.0
1034	H ₃ O ⁺	C ₂ H	C ₂ H ₂ ⁺	H ₂ O		2.2e-10	0.00	4100.0
1035	H ₃ O ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	H ₂ O		1.0e-09	0.00	7330.0
1036	HCN ⁺	H	CN ⁺	H ₂		1.0e-09	0.00	15800.0

Table D5 – continued (part 15)

Reactants	Products	α	β	γ
1037	HCNH ⁺ H HCN ⁺ H ₂	9.8e-10	0.00	34400.0
1038	HCNH ⁺ H ₂ O H ₃ O ⁺ HCN	4.5e-09	0.00	2460.0
1039	HCNH ⁺ H ₂ O H ₃ O ⁺ HNC	4.5e-09	0.00	10300.0
1040	SO ⁺ H S ⁺ OH	6.1e-10	0.00	11380.0
1041	H ₃ ⁺ HD H ₂ D ⁺ H ₂	1.7e-09	0.00	0.0
1042	H ₃ ⁺ D ₂ HD ₂ ⁺ H ₂	8.0e-10	0.00	0.0
1043	H ₃ ⁺ D ₂ H ₂ D ⁺ HD	8.0e-10	0.00	0.0
1044	H ₂ D ⁺ H ₂ H ₃ ⁺ HD	9.4e-11	-0.79	154.6
1045	H ₂ D ⁺ HD HD ₂ ⁺ H ₂	1.3e-09	0.00	0.0
1046	H ₂ D ⁺ HD H ₃ ⁺ D ₂	1.1e-11	-0.49	106.9
1047	H ₂ D ⁺ D ₂ D ₃ ⁺ H ₂	3.0e-10	-0.00	0.0
1048	H ₂ D ⁺ D ₂ HD ₂ ⁺ HD	1.0e-09	0.00	-0.0
1049	HD ₂ ⁺ H ₂ H ₂ D ⁺ HD	3.3e-10	-0.55	144.3
1050	HD ₂ ⁺ H ₂ H ₃ ⁺ D ₂	3.5e-11	-0.82	249.9
1051	HD ₂ ⁺ HD H ₂ D ⁺ D ₂	6.8e-11	-0.27	113.0
1052	HD ₂ ⁺ HD D ₃ ⁺ H ₂	6.3e-10	0.00	0.0
1053	HD ₂ ⁺ D ₂ D ₃ ⁺ HD	1.0e-09	0.00	0.0
1054	D ₃ ⁺ H ₂ H ₂ D ⁺ D ₂	1.5e-10	-0.85	315.3
1055	D ₃ ⁺ H ₂ HD ₂ ⁺ HD	9.2e-10	-0.59	197.8
1056	D ₃ ⁺ HD HD ₂ ⁺ D ₂	4.2e-10	-0.85	259.0
1057	H ₃ ⁺ e ⁻ H ₂ H	2.3e-08	-0.52	0.0
1058	H ₃ ⁺ e ⁻ H H H	4.4e-08	-0.52	0.0
1059	H ₂ D ⁺ e ⁻ H H D	5.6e-07	0.44	-2.8
1060	H ₂ D ⁺ e ⁻ HD H H	1.3e-07	0.44	-2.8
1061	H ₂ D ⁺ e ⁻ H ₂ D D	5.2e-09	0.44	-2.8
1062	HD ₂ ⁺ e ⁻ D D H	9.4e-08	0.66	-12.5
1063	HD ₂ ⁺ e ⁻ HD D D	1.2e-08	0.66	-12.5
1064	HD ₂ ⁺ e ⁻ D ₂ H H	1.1e-08	0.66	-12.5
1065	D ₂ ⁺ e ⁻ D D D	2.3e-08	-0.69	0.0
1066	D ₃ ⁺ e ⁻ D D D	2.2e-08	-0.73	0.0
1067	D ₃ ⁺ e ⁻ D ₂ D D	1.3e-08	-0.73	0.0
1068	Gr Gr ⁺ e ⁻	6.3e+07	0.00	0.0
1069	Gr ⁻ Gr Gr e ⁻	4.2e+08	0.00	0.0
1070	Gr e ⁻ Gr ⁻ γ	6.9e-05	0.50	0.0
1071	Gr ⁺ e ⁻ Gr γ	6.9e-05	0.50	0.0
1072	Fe γ Fe ⁺ e ⁻	4.8e+02	0.00	0.0

Table D6. The separated version of the UGAN chemical network (total: 3266 reactions split into 43 Tables).

#	Reactants		Products		α	β	γ
1	H	H	oH ₂		7.5e-01		
2	H	H	pH ₂		2.5e-01		
3	H	D	HD		1.0e+00		
4	D	D	oD ₂		6.6e-01		
5	D	D	pD ₂		3.3e-01		
6	H	CRP	H ⁺	e ⁻	4.6e-01	0.00	0.0
7	D	CRP	D ⁺	e ⁻	4.6e-01	0.00	0.0
8	He	CRP	He ⁺	e ⁻	5.0e-01	0.00	0.0
9	oH ₂	CRP	H	H	1.0e-01	0.00	0.0
10	pH ₂	CRP	H	H	1.0e-01	0.00	0.0
11	oH ₂	CRP	H ⁺	H	e ⁻	2.3e-02	0.00
12	pH ₂	CRP	H ⁺	H	e ⁻	2.3e-02	0.00
13	oH ₂	CRP	oH ₂ ⁺	e ⁻	9.8e-01	0.00	0.0
14	pH ₂	CRP	pH ₂ ⁺	e ⁻	9.8e-01	0.00	0.0
15	HD	CRP	H ⁺	D	e ⁻	2.0e-02	0.00
16	HD	CRP	D ⁺	H	e ⁻	2.0e-02	0.00
17	HD	CRP	H	D		1.5e+00	0.00
18	HD	CRP	HD ⁺	e ⁻	9.6e-01	0.00	0.0
19	oD ₂	CRP	D ⁺	D	e ⁻	4.0e-02	0.00
20	pD ₂	CRP	D ⁺	D	e ⁻	4.0e-02	0.00
21	oD ₂	CRP	D	D		1.5e+00	0.00
22	pD ₂	CRP	D	D		1.5e+00	0.00
23	oD ₂	CRP	oD ₂ ⁺	e ⁻	9.6e-01	0.00	0.0
24	pD ₂	CRP	pD ₂ ⁺	e ⁻	9.6e-01	0.00	0.0
25	H	oH ₂ ⁺	oH ₂	H ⁺	6.4e-10	0.00	0.0
26	H	pH ₂ ⁺	pH ₂	H ⁺	6.4e-10	0.00	0.0
27	H	HD ⁺	H ⁺	HD	6.4e-10	0.00	0.0
28	H	HD ⁺	oH ₂ D ⁺	γ	9.0e-18	1.80	-20.0
29	H	HD ⁺	pH ₂ D ⁺	γ	3.0e-18	1.80	-20.0
30	H	D ⁺	H ⁺	D	1.0e-09	0.00	0.0
31	H	D ⁺	HD ⁺	γ	3.9e-19	1.80	-20.0
32	H	oD ₂ ⁺	HD ⁺	D	1.0e-09	0.00	430.0
33	H	pD ₂ ⁺	HD ⁺	D	1.0e-09	0.00	430.0
34	H	oD ₂ ⁺	oD ₂	H ⁺	6.4e-10	0.00	0.0
35	H	pD ₂ ⁺	pD ₂	H ⁺	6.4e-10	0.00	0.0
36	oH ₂	He ⁺	H ⁺	H	He	3.3e-15	0.00
37	pH ₂	He ⁺	H ⁺	H	He	3.3e-15	0.00
38	oH ₂	He ⁺	oH ₂ ⁺	He		9.6e-15	0.00
39	pH ₂	He ⁺	pH ₂ ⁺	He		9.6e-15	0.00
40	oH ₂	H ⁺	oH ₂ ⁺	H		6.4e-10	0.00
41	pH ₂	H ⁺	pH ₂ ⁺	H		6.4e-10	0.00
42	oH ₂	oH ₂ ⁺	oH ₃ ⁺	H		1.4e-09	0.00
43	oH ₂	oH ₂ ⁺	pH ₃ ⁺	H		7.0e-10	0.00
44	oH ₂	pH ₂ ⁺	oH ₃ ⁺	H		7.0e-10	0.00
45	oH ₂	pH ₂ ⁺	pH ₃ ⁺	H		1.4e-09	0.00
46	pH ₂	oH ₂ ⁺	oH ₃ ⁺	H		7.0e-10	0.00
47	pH ₂	oH ₂ ⁺	pH ₃ ⁺	H		1.4e-09	0.00
48	pH ₂	pH ₂ ⁺	pH ₃ ⁺	H		2.1e-09	0.00
49	oH ₂	HD ⁺	oH ₂ D ⁺	H		8.7e-10	0.00
50	oH ₂	HD ⁺	pH ₂ D ⁺	H		1.7e-10	0.00
51	pH ₂	HD ⁺	oH ₂ D ⁺	H		5.3e-10	0.00
52	pH ₂	HD ⁺	pH ₂ D ⁺	H		5.3e-10	0.00
53	oH ₂	HD ⁺	oH ₃ ⁺	D		7.0e-10	0.00
54	oH ₂	HD ⁺	pH ₃ ⁺	D		3.5e-10	0.00
55	pH ₂	HD ⁺	pH ₃ ⁺	D		1.1e-09	0.00
56	oH ₂	D ⁺	H ⁺	HD		2.1e-09	0.00
57	pH ₂	D ⁺	H ⁺	HD		2.1e-09	0.00
58	oH ₂	oD ₂ ⁺	oH ₂ D ⁺	D		1.1e-09	0.00
59	oH ₂	pD ₂ ⁺	oH ₂ D ⁺	D		1.1e-09	0.00
60	pH ₂	oD ₂ ⁺	pH ₂ D ⁺	D		1.1e-09	0.00
61	pH ₂	pD ₂ ⁺	pH ₂ D ⁺	D		1.1e-09	0.00
62	oH ₂	oD ₂ ⁺	oHD ₂ ⁺	H		1.1e-09	0.00
63	oH ₂	pD ₂ ⁺	pHD ₂ ⁺	H		1.1e-09	0.00
64	pH ₂	oD ₂ ⁺	oHD ₂ ⁺	H		1.1e-09	0.00
65	pH ₂	pD ₂ ⁺	pHD ₂ ⁺	H		1.1e-09	0.00
66	HD	He ⁺	H ⁺	D	He	5.5e-14	-0.24
67	HD	He ⁺	D ⁺	H	He	5.5e-14	-0.24
68	HD	oH ₂ ⁺	oH ₂ D ⁺	H		8.7e-10	0.00
69	HD	oH ₂ ⁺	pH ₂ D ⁺	H		1.7e-10	0.00
70	HD	pH ₂ ⁺	oH ₂ D ⁺	H		5.3e-10	0.00
71	HD	pH ₂ ⁺	pH ₂ D ⁺	H		5.3e-10	0.00
72	HD	oH ₂ ⁺	oH ₃ ⁺	D		7.0e-10	0.00
73	HD	oH ₂ ⁺	pH ₃ ⁺	D		3.5e-10	0.00
74	HD	pH ₂ ⁺	pH ₃ ⁺	D		1.1e-09	0.00

Table D6 – continued (part 2)

#	Reactants		Products		α	β	γ	
75	HD	HD ⁺	oH ₂ D ⁺	D	7.9e-10	0.00	0.0	
76	HD	HD ⁺	pH ₂ D ⁺	D	2.6e-10	0.00	0.0	
77	HD	HD ⁺	oHD ₂ ⁺	H	7.0e-10	0.00	0.0	
78	HD	HD ⁺	pHD ₂ ⁺	H	3.5e-10	0.00	0.0	
79	HD	D ⁺	oD ₂	H ⁺	6.7e-10	0.00	0.0	
80	HD	D ⁺	pD ₂	H ⁺	3.3e-10	0.00	0.0	
81	HD	oD ₂ ⁺	oHD ₂ ⁺	D	8.2e-10	0.00	0.0	
82	HD	oD ₂ ⁺	pHD ₂ ⁺	D	2.3e-10	0.00	0.0	
83	HD	pD ₂ ⁺	oHD ₂ ⁺	D	4.7e-10	0.00	0.0	
84	HD	pD ₂ ⁺	pHD ₂ ⁺	D	5.8e-10	0.00	0.0	
85	HD	oD ₂ ⁺	mD ₃ ⁺	H	5.8e-10	0.00	0.0	
86	HD	oD ₂ ⁺	oD ₃ ⁺	H	4.7e-10	0.00	0.0	
87	HD	pD ₂ ⁺	pD ₃ ⁺	H	1.2e-10	0.00	0.0	
88	HD	pD ₂ ⁺	oD ₃ ⁺	H	9.3e-10	0.00	0.0	
89	D	H ⁺	D ⁺	H	1.0e-09	0.00	41.0	
90	D	H ⁺	HD ⁺	γ	3.9e-19	1.80	-20.0	
91	D	oH ₂ ⁺	oH ₂	D ⁺	6.4e-10	0.00	0.0	
92	D	pH ₂ ⁺	pH ₂	D ⁺	6.4e-10	0.00	0.0	
93	D	oH ₂ ⁺	oH ₂ D ⁺	γ	7.0e-18	1.80	-20.0	
94	D	pH ₂ ⁺	pH ₂ D ⁺	γ	7.0e-18	1.80	-20.0	
95	D	oH ₂ ⁺	HD ⁺	H	1.0e-09	0.00	0.0	
96	D	pH ₂ ⁺	HD ⁺	H	1.0e-09	0.00	0.0	
97	D	oH ₂ ⁺	oH ₂ D ⁺	H	1.0e-09	0.00	0.0	
98	D	pH ₂ ⁺	oH ₂ D ⁺	H	5.0e-10	0.00	0.0	
99	D	pH ₂ ⁺	pH ₂ D ⁺	H	5.0e-10	0.00	0.0	
100	D	HD ⁺	oD ₂ ⁺	H	6.7e-10	0.00	0.0	
101	D	HD ⁺	pD ₂ ⁺	H	3.3e-10	0.00	0.0	
102	D	HD ⁺	D ⁺	HD	6.4e-10	0.00	0.0	
103	D	oH ₂ D ⁺	oHD ₂ ⁺	H	6.7e-10	0.00	0.0	
104	D	oH ₂ D ⁺	pHD ₂ ⁺	H	3.3e-10	0.00	0.0	
105	D	pH ₂ D ⁺	oHD ₂ ⁺	H	6.7e-10	0.00	0.0	
106	D	pH ₂ D ⁺	pHD ₂ ⁺	H	3.3e-10	0.00	0.0	
107	D	oHD ₂ ⁺	mD ₃ ⁺	H	5.6e-10	0.00	0.0	
108	D	oHD ₂ ⁺	oD ₃ ⁺	H	4.4e-10	0.00	0.0	
109	D	pHD ₂ ⁺	pD ₃ ⁺	H	1.1e-10	0.00	0.0	
110	D	pHD ₂ ⁺	oD ₃ ⁺	H	8.9e-10	0.00	0.0	
111	D	oD ₂ ⁺	oD ₂	D ⁺	6.4e-10	0.00	0.0	
112	D	pD ₂ ⁺	pD ₂	D ⁺	6.4e-10	0.00	0.0	
113	oD ₂	He ⁺	D ⁺	D	He	1.1e-13	-0.24	0.0
114	pD ₂	He ⁺	D ⁺	D	He	1.1e-13	-0.24	0.0
115	oD ₂	He ⁺	oD ₂ ⁺	He	2.5e-14	0.00	0.0	
116	pD ₂	He ⁺	pD ₂ ⁺	He	2.5e-14	0.00	0.0	
117	oD ₂	H ⁺	D ⁺	HD	2.1e-09	0.00	405.0	
118	pD ₂	H ⁺	D ⁺	HD	2.1e-09	0.00	405.0	
119	oD ₂	oH ₂ ⁺	oH ₂ D ⁺	D	1.1e-09	0.00	0.0	
120	pD ₂	oH ₂ ⁺	oH ₂ D ⁺	D	1.1e-09	0.00	0.0	
121	oD ₂	pH ₂ ⁺	pH ₂ D ⁺	D	1.1e-09	0.00	0.0	
122	pD ₂	pH ₂ ⁺	pH ₂ D ⁺	D	1.1e-09	0.00	0.0	
123	oD ₂	oH ₂ ⁺	oHD ₂ ⁺	H	1.1e-09	0.00	0.0	
124	pD ₂	oH ₂ ⁺	pHD ₂ ⁺	H	1.1e-09	0.00	0.0	
125	oD ₂	pH ₂ ⁺	oHD ₂ ⁺	H	1.1e-09	0.00	0.0	
126	pD ₂	pH ₂ ⁺	pHD ₂ ⁺	H	1.1e-09	0.00	0.0	
127	oD ₂	HD ⁺	oHD ₂ ⁺	D	8.2e-10	0.00	0.0	
128	oD ₂	HD ⁺	pHD ₂ ⁺	D	2.3e-10	0.00	0.0	
129	pD ₂	HD ⁺	oHD ₂ ⁺	D	4.7e-10	0.00	0.0	
130	pD ₂	HD ⁺	pHD ₂ ⁺	D	5.8e-10	0.00	0.0	
131	oD ₂	HD ⁺	mD ₃ ⁺	H	5.8e-10	0.00	0.0	
132	oD ₂	HD ⁺	oD ₃ ⁺	H	4.7e-10	0.00	0.0	
133	pD ₂	HD ⁺	pD ₃ ⁺	H	1.2e-10	0.00	0.0	
134	pD ₂	HD ⁺	oD ₃ ⁺	H	9.3e-10	0.00	0.0	
135	oD ₂	oD ₂ ⁺	mD ₃ ⁺	D	1.2e-09	0.00	0.0	
136	oD ₂	oD ₂ ⁺	oD ₃ ⁺	D	9.3e-10	0.00	0.0	
137	oD ₂	pD ₂ ⁺	mD ₃ ⁺	D	5.8e-10	0.00	0.0	
138	oD ₂	pD ₂ ⁺	pD ₃ ⁺	D	1.2e-10	0.00	0.0	
139	oD ₂	pD ₂ ⁺	oD ₃ ⁺	D	1.4e-09	0.00	0.0	
140	pD ₂	oD ₂ ⁺	mD ₃ ⁺	D	5.8e-10	0.00	0.0	
141	pD ₂	oD ₂ ⁺	pD ₃ ⁺	D	1.2e-10	0.00	0.0	
142	pD ₂	oD ₂ ⁺	oD ₃ ⁺	D	1.4e-09	0.00	0.0	
143	pD ₂	pD ₂ ⁺	pD ₃ ⁺	D	2.3e-10	0.00	0.0	
144	pD ₂	pD ₂ ⁺	oD ₃ ⁺	D	1.9e-09	0.00	0.0	
145	Fe	H ⁺	Fe ⁺	H	7.4e-09	0.00	0.0	
146	Fe	oH ₃ ⁺	oH ₂	H	Fe ⁺	4.9e-09	0.00	0.0
147	Fe	pH ₃ ⁺	oH ₂	H	Fe ⁺	2.5e-09	0.00	0.0
148	Fe	pH ₃ ⁺	pH ₂	H	Fe ⁺	2.5e-09	0.00	0.0

Table D6 – continued (part 3)

#	Reactants		Products			α	β	γ	
149	Fe	oH ₂ D ⁺	oH ₂	Fe ⁺	D	4.9e-09	0.00	0.0	
150	Fe	pH ₂ D ⁺	pH ₂	Fe ⁺	D	4.9e-09	0.00	0.0	
151	Fe	oHD ₂ ⁺	oD ₂	Fe ⁺	H	1.6e-09	0.00	0.0	
152	Fe	pHD ₂ ⁺	pD ₂	Fe ⁺	H	1.6e-09	0.00	0.0	
153	Fe	oHD ₂ ⁺	HD	D	Fe ⁺	3.3e-09	0.00	0.0	
154	Fe	pHD ₂ ⁺	HD	D	Fe ⁺	3.3e-09	0.00	0.0	
155	Fe	mD ₃ ⁺	oD ₂	D	Fe ⁺	4.9e-09	0.00	0.0	
156	Fe	pD ₃ ⁺	pD ₂	D	Fe ⁺	4.9e-09	0.00	0.0	
157	Fe	oD ₃ ⁺	oD ₂	D	Fe ⁺	2.5e-09	0.00	0.0	
158	Fe	oD ₃ ⁺	pD ₂	D	Fe ⁺	2.5e-09	0.00	0.0	
159	H ⁺	e ⁻	H	γ		3.6e-12	-0.75	0.0	
160	oH ₂ ⁺	e ⁻	H	H		2.5e-07	-0.50	0.0	
161	pH ₂ ⁺	e ⁻	H	H		2.5e-07	-0.50	0.0	
162	oH ₂ ⁺	e ⁻	oH ₂	γ		2.2e-07	-0.40	0.0	
163	pH ₂ ⁺	e ⁻	pH ₂	γ		2.2e-07	-0.40	0.0	
164	HD ⁺	e ⁻	H	D		9.0e-09	-0.50	0.0	
165	D ⁺	e ⁻	D	γ		3.6e-12	-0.75	0.0	
166	He ⁺	e ⁻	He	γ		4.5e-12	-0.67	0.0	
167	oH ₂ ⁺	γ	H ⁺	H		6.1e+02	0.00	0.0	
168	pH ₂ ⁺	γ	H ⁺	H		6.1e+02	0.00	0.0	
169	H ⁺	Gr ⁻	Gr	H		1.6e-06	0.50	0.0	
170	oH ₃ ⁺	Gr ⁻	oH ₂	H	Gr	4.6e-07	0.50	0.0	
171	pH ₃ ⁺	Gr ⁻	oH ₂	H	Gr	2.3e-07	0.50	0.0	
172	pH ₃ ⁺	Gr ⁻	pH ₂	H	Gr	2.3e-07	0.50	0.0	
173	oH ₃ ⁺	Gr ⁻	H	H	H	Gr	4.6e-07	0.50	0.0
174	pH ₃ ⁺	Gr ⁻	H	H	H	Gr	4.6e-07	0.50	0.0
175	He ⁺	Gr ⁻	Gr	He		8.0e-07	0.50	0.0	
176	H ⁺	Gr	Gr ⁺	H		1.6e-06	0.50	0.0	
177	oH ₃ ⁺	Gr	oH ₂	H	Gr ⁺	4.6e-07	0.50	0.0	
178	pH ₃ ⁺	Gr	oH ₂	H	Gr ⁺	2.3e-07	0.50	0.0	
179	pH ₃ ⁺	Gr	pH ₂	H	Gr ⁺	2.3e-07	0.50	0.0	
180	oH ₃ ⁺	Gr	H	H	H	Gr ⁺	4.6e-07	0.50	0.0
181	pH ₃ ⁺	Gr	H	H	H	Gr ⁺	4.6e-07	0.50	0.0
182	He ⁺	Gr	Gr ⁺	He		8.0e-07	0.50	0.0	
183	D ⁺	Gr ⁻	Gr	D		1.1e-06	0.50	0.0	
184	oH ₂ D ⁺	Gr ⁻	oH ₂	Gr	D	1.3e-07	0.50	0.0	
185	pH ₂ D ⁺	Gr ⁻	pH ₂	Gr	D	1.3e-07	0.50	0.0	
186	oH ₂ D ⁺	Gr ⁻	HD	H	Gr	2.7e-07	0.50	0.0	
187	pH ₂ D ⁺	Gr ⁻	HD	H	Gr	2.7e-07	0.50	0.0	
188	oH ₂ D ⁺	Gr ⁻	H	H	Gr	D	4.0e-07	0.50	0.0
189	pH ₂ D ⁺	Gr ⁻	H	H	Gr	D	4.0e-07	0.50	0.0
190	D ⁺	Gr	Gr ⁺	D		1.1e-06	0.50	0.0	
191	oH ₂ D ⁺	Gr	oH ₂	Gr ⁺	D	1.3e-07	0.50	0.0	
192	pH ₂ D ⁺	Gr	pH ₂	Gr ⁺	D	1.3e-07	0.50	0.0	
193	oH ₂ D ⁺	Gr	HD	H	Gr ⁺	2.7e-07	0.50	0.0	
194	pH ₂ D ⁺	Gr	HD	H	Gr ⁺	2.7e-07	0.50	0.0	
195	oH ₂ D ⁺	Gr	H	H	Gr ⁺	D	4.0e-07	0.50	0.0
196	pH ₂ D ⁺	Gr	H	H	Gr ⁺	D	4.0e-07	0.50	0.0
197	oHD ₂ ⁺	Gr ⁻	HD	D	Gr	2.4e-07	0.50	0.0	
198	pHD ₂ ⁺	Gr ⁻	HD	D	Gr	2.4e-07	0.50	0.0	
199	oHD ₂ ⁺	Gr ⁻	oD ₂	Gr	H	1.2e-07	0.50	0.0	
200	pHD ₂ ⁺	Gr ⁻	pD ₂	Gr	H	1.2e-07	0.50	0.0	
201	oHD ₂ ⁺	Gr ⁻	D	D	Gr	H	3.6e-07	0.50	0.0
202	pHD ₂ ⁺	Gr ⁻	D	D	Gr	H	3.6e-07	0.50	0.0
203	oHD ₂ ⁺	Gr	HD	D	Gr ⁺	2.4e-07	0.50	0.0	
204	pHD ₂ ⁺	Gr	HD	D	Gr ⁺	2.4e-07	0.50	0.0	
205	oHD ₂ ⁺	Gr	oD ₂	Gr ⁺	H	1.2e-07	0.50	0.0	
206	pHD ₂ ⁺	Gr	pD ₂	Gr ⁺	H	1.2e-07	0.50	0.0	
207	oHD ₂ ⁺	Gr	D	D	Gr ⁺	H	3.6e-07	0.50	0.0
208	pHD ₂ ⁺	Gr	D	D	Gr ⁺	H	3.6e-07	0.50	0.0
209	mD ₃ ⁺	Gr ⁻	oD ₂	D	Gr	3.3e-07	0.50	0.0	
210	pD ₃ ⁺	Gr ⁻	pD ₂	D	Gr	3.3e-07	0.50	0.0	
211	oD ₃ ⁺	Gr ⁻	oD ₂	D	Gr	1.6e-07	0.50	0.0	
212	oD ₃ ⁺	Gr ⁻	pD ₂	D	Gr	1.6e-07	0.50	0.0	
213	mD ₃ ⁺	Gr ⁻	D	D	D	Gr	3.3e-07	0.50	0.0
214	pD ₃ ⁺	Gr ⁻	D	D	D	Gr	3.3e-07	0.50	0.0
215	oD ₃ ⁺	Gr ⁻	D	D	D	Gr	3.3e-07	0.50	0.0
216	mD ₃ ⁺	Gr	oD ₂	D	Gr ⁺	3.3e-07	0.50	0.0	
217	pD ₃ ⁺	Gr	pD ₂	D	Gr ⁺	3.3e-07	0.50	0.0	
218	oD ₃ ⁺	Gr	oD ₂	D	Gr ⁺	1.6e-07	0.50	0.0	
219	oD ₃ ⁺	Gr	pD ₂	D	Gr ⁺	1.6e-07	0.50	0.0	
220	mD ₃ ⁺	Gr	D	D	D	Gr ⁺	3.3e-07	0.50	0.0
221	pD ₃ ⁺	Gr	D	D	D	Gr ⁺	3.3e-07	0.50	0.0
222	oD ₃ ⁺	Gr	D	D	D	Gr ⁺	3.3e-07	0.50	0.0

Table D6 – continued (part 4)

#	Reactants	Products	α	β	γ
223	O CRP	O ⁺ e ⁻	2.8e+00	0.00	0.0
224	O OH	O ₂ H	4.0e-11	0.00	0.0
225	O ⁺ oH ₂	OH ⁺ H	1.2e-09	0.00	0.0
226	O ⁺ pH ₂	OH ⁺ H	1.2e-09	0.00	0.0
227	O ⁺ H	H ⁺ O	6.0e-10	0.00	0.0
228	O H ⁺	O ⁺ H	6.0e-10	0.00	227.0
229	O oH ₂ ⁺	OH ⁺ H	1.5e-09	0.00	0.0
230	O pH ₂ ⁺	OH ⁺ H	1.5e-09	0.00	0.0
231	O oH ₃ ⁺	oH ₂ OH ⁺	8.0e-10	-0.16	1.4
232	O pH ₃ ⁺	oH ₂ OH ⁺	4.0e-10	-0.16	1.4
233	O pH ₃ ⁺	pH ₂ OH ⁺	4.0e-10	-0.16	1.4
234	O oH ₄ ⁺	oH ₂ O ⁺ H	3.4e-10	-0.16	1.4
235	O pH ₃ ⁺	oH ₂ O ⁺ H	1.7e-10	-0.16	1.4
236	O pH ₃ ⁺	pH ₂ O ⁺ H	1.7e-10	-0.16	1.4
237	O oH ₂ D ⁺	OH ⁺ HD	5.3e-10	0.00	0.0
238	O pH ₂ D ⁺	OH ⁺ HD	5.3e-10	0.00	0.0
239	O oH ₂ D ⁺	oH ₂ OD ⁺	2.7e-10	0.00	0.0
240	O pH ₂ D ⁺	pH ₂ OD ⁺	2.7e-10	0.00	0.0
241	O oHD ₂ ⁺	oD ₂ OH ⁺	2.7e-10	0.00	0.0
242	O pHD ₂ ⁺	pD ₂ OH ⁺	2.7e-10	0.00	0.0
243	O oHD ₂ ⁺	OD ⁺ HD	5.3e-10	0.00	0.0
244	O pHD ₂ ⁺	OD ⁺ HD	5.3e-10	0.00	0.0
245	O mD ₃ ⁺	oD ₂ OD ⁺	8.0e-10	0.00	0.0
246	O pD ₃ ⁺	pD ₂ OD ⁺	8.0e-10	0.00	0.0
247	O oD ₃ ⁺	oD ₂ OD ⁺	4.0e-10	0.00	0.0
248	O oD ₃ ⁺	pD ₂ OD ⁺	4.0e-10	0.00	0.0
249	O ₂ He ⁺	O ⁺ O	1.0e-09	0.00	0.0
250	O ₂ H ⁺	O ₂ ⁺ H	1.2e-09	0.00	0.0
251	OH He ⁺	OH ⁺ He	5.5e-10	0.00	0.0
252	OH He ⁺	O ⁺ H	5.5e-10	0.00	0.0
253	OH H ⁺	OH ⁺ H	2.1e-09	0.00	0.0
254	OH oH ₂ ⁺	oH ₂ OH ⁺	7.6e-10	0.00	0.0
255	OH pH ₂ ⁺	pH ₂ OH ⁺	7.6e-10	0.00	0.0
256	OH oH ₃ ⁺	oH ₂ O ⁺ oH ₂	9.8e-10	0.00	0.0
257	OH oH ₃ ⁺	oH ₂ O ⁺ pH ₂	1.6e-10	0.00	0.0
258	OH oH ₃ ⁺	pH ₂ O ⁺ oH ₂	1.6e-10	0.00	0.0
259	OH pH ₃ ⁺	oH ₂ O ⁺ oH ₂	4.9e-10	0.00	0.0
260	OH pH ₃ ⁺	oH ₂ O ⁺ pH ₂	3.3e-10	0.00	0.0
261	OH pH ₃ ⁺	pH ₂ O ⁺ oH ₂	3.3e-10	0.00	0.0
262	OH pH ₃ ⁺	pH ₂ O ⁺ pH ₂	1.6e-10	0.00	0.0
263	OH oH ₂ D ⁺	oH ₂ O ⁺ HD	7.2e-10	0.00	0.0
264	OH oH ₂ D ⁺	pH ₂ O ⁺ HD	1.4e-10	0.00	0.0
265	OH pH ₂ D ⁺	oH ₂ O ⁺ HD	4.3e-10	0.00	0.0
266	OH pH ₂ D ⁺	pH ₂ O ⁺ HD	4.3e-10	0.00	0.0
267	OH oH ₂ D ⁺	oH ₂ HDO ⁺	3.6e-10	0.00	0.0
268	OH oH ₂ D ⁺	pH ₂ HDO ⁺	7.2e-11	0.00	0.0
269	OH pH ₂ D ⁺	oH ₂ HDO ⁺	2.2e-10	0.00	0.0
270	OH pH ₂ D ⁺	pH ₂ HDO ⁺	2.2e-10	0.00	0.0
271	OH oHD ₂ ⁺	oD ₂ oH ₂ O ⁺	3.2e-10	0.00	0.0
272	OH pHD ₂ ⁺	pD ₂ oH ₂ O ⁺	3.2e-10	0.00	0.0
273	OH oHD ₂ ⁺	oD ₂ pH ₂ O ⁺	1.1e-10	0.00	0.0
274	OH pHD ₂ ⁺	pD ₂ pH ₂ O ⁺	1.1e-10	0.00	0.0
275	OH oHD ₂ ⁺	HDO ⁺ HD	8.7e-10	0.00	0.0
276	OH pHD ₂ ⁺	HDO ⁺ HD	8.7e-10	0.00	0.0
277	OH mD ₃ ⁺	oD ₂ HDO ⁺	1.3e-09	0.00	0.0
278	OH pD ₃ ⁺	pD ₂ HDO ⁺	1.3e-09	0.00	0.0
279	OH oD ₃ ⁺	oD ₂ HDO ⁺	6.5e-10	0.00	0.0
280	OH oD ₃ ⁺	pD ₂ HDO ⁺	6.5e-10	0.00	0.0
281	OD He ⁺	OD ⁺ He	5.5e-10	0.00	0.0
282	OD He ⁺	O ⁺ D	5.5e-10	0.00	0.0
283	OD H ⁺	OD ⁺ H	2.1e-09	0.00	0.0
284	OD oH ₃ ⁺	oH ₂ HDO ⁺	1.3e-09	0.00	0.0
285	OD pH ₃ ⁺	oH ₂ HDO ⁺	6.5e-10	0.00	0.0
286	OD pH ₃ ⁺	pH ₂ HDO ⁺	6.5e-10	0.00	0.0
287	OD oH ₂ D ⁺	HDO ⁺ HD	8.7e-10	0.00	0.0
288	OD pH ₂ D ⁺	HDO ⁺ HD	8.7e-10	0.00	0.0
289	OD oH ₂ D ⁺	oD ₂ O ⁺ oH ₂	2.9e-10	0.00	0.0
290	OD oH ₂ D ⁺	pD ₂ O ⁺ oH ₂	1.4e-10	0.00	0.0
291	OD pH ₂ D ⁺	oD ₂ O ⁺ pH ₂	2.9e-10	0.00	0.0
292	OD pH ₂ D ⁺	pD ₂ O ⁺ pH ₂	1.4e-10	0.00	0.0
293	OD oHD ₂ ⁺	oD ₂ HDO ⁺	3.4e-10	0.00	0.0
294	OD oHD ₂ ⁺	pD ₂ HDO ⁺	9.6e-11	0.00	0.0
295	OD pHD ₂ ⁺	oD ₂ HDO ⁺	1.9e-10	0.00	0.0
296	OD pHD ₂ ⁺	pD ₂ HDO ⁺	2.4e-10	0.00	0.0

Table D6 – continued (part 5)

#	Reactants		Products		α	β	γ
297	OD	oHD ₂ ⁺	oD ₂ O ⁺	HD	6.7e-10	0.00	0.0
298	OD	oHD ₂ ⁺	pD ₂ O ⁺	HD	1.9e-10	0.00	0.0
299	OD	pHD ₂ ⁺	oD ₂ O ⁺	HD	3.9e-10	0.00	0.0
300	OD	pHD ₂ ⁺	pD ₂ O ⁺	HD	4.8e-10	0.00	0.0
301	OD	mD ₃ ⁺	oD ₂ O ⁺	oD ₂	8.7e-11	0.00	0.0
302	OD	mD ₃ ⁺	oD ₂ O ⁺	pD ₂	2.2e-11	0.00	0.0
303	OD	mD ₃ ⁺	pD ₂ O ⁺	oD ₂	2.2e-11	0.00	0.0
304	OD	pD ₃ ⁺	oD ₂ O ⁺	pD ₂	4.3e-11	0.00	0.0
305	OD	pD ₃ ⁺	pD ₂ O ⁺	oD ₂	4.3e-11	0.00	0.0
306	OD	pD ₃ ⁺	pD ₂ O ⁺	pD ₂	4.3e-11	0.00	0.0
307	OD	oD ₃ ⁺	oD ₂ O ⁺	oD ₂	4.3e-11	0.00	0.0
308	OD	oD ₃ ⁺	oD ₂ O ⁺	pD ₂	3.2e-11	0.00	0.0
309	OD	oD ₃ ⁺	pD ₂ O ⁺	oD ₂	3.2e-11	0.00	0.0
310	OD	oD ₃ ⁺	pD ₂ O ⁺	pD ₂	2.2e-11	0.00	0.0
311	oH ₂ O	He ⁺	OH ⁺	H	2.3e-10	-0.94	0.0
312	pH ₂ O	He ⁺	OH ⁺	H	2.3e-10	-0.94	0.0
313	oH ₂ O	He ⁺	oH ₂ O ⁺	He	4.9e-11	-0.94	0.0
314	pH ₂ O	He ⁺	pH ₂ O ⁺	He	4.9e-11	-0.94	0.0
315	oH ₂ O	He ⁺	H ⁺	OH	1.6e-10	-0.94	0.0
316	pH ₂ O	He ⁺	H ⁺	OH	1.6e-10	-0.94	0.0
317	oH ₂ O	H ⁺	oH ₂ O ⁺	H	8.2e-09	0.00	0.0
318	pH ₂ O	H ⁺	pH ₂ O ⁺	H	8.2e-09	0.00	0.0
319	oH ₂ O	oH ₂ ⁺	oH ₂	oH ₂ O ⁺	3.9e-09	0.00	0.0
320	oH ₂ O	pH ₂ ⁺	oH ₂	pH ₂ O ⁺	3.9e-09	0.00	0.0
321	pH ₂ O	oH ₂ ⁺	pH ₂	oH ₂ O ⁺	3.9e-09	0.00	0.0
322	pH ₂ O	pH ₂ ⁺	pH ₂	pH ₂ O ⁺	3.9e-09	0.00	0.0
323	oH ₂ O	oH ₂ ⁺	oH ₃ O ⁺	H	2.3e-09	0.00	0.0
324	oH ₂ O	oH ₂ ⁺	pH ₃ O ⁺	H	1.1e-09	0.00	0.0
325	oH ₂ O	pH ₂ ⁺	oH ₃ O ⁺	H	1.1e-09	0.00	0.0
326	oH ₂ O	pH ₂ ⁺	pH ₃ O ⁺	H	2.3e-09	0.00	0.0
327	pH ₂ O	oH ₂ ⁺	oH ₃ O ⁺	H	1.1e-09	0.00	0.0
328	pH ₂ O	oH ₂ ⁺	pH ₃ O ⁺	H	2.3e-09	0.00	0.0
329	pH ₂ O	pH ₂ ⁺	pH ₃ O ⁺	H	3.4e-09	0.00	0.0
330	oH ₂ O	oH ₃ ⁺	oH ₃ O ⁺	oH ₂	2.7e-09	0.00	0.0
331	oH ₂ O	oH ₃ ⁺	oH ₃ O ⁺	pH ₂	3.6e-10	0.00	0.0
332	oH ₂ O	oH ₃ ⁺	pH ₃ O ⁺	oH ₂	1.0e-09	0.00	0.0
333	oH ₂ O	oH ₃ ⁺	pH ₃ O ⁺	pH ₂	2.9e-10	0.00	0.0
334	pH ₂ O	oH ₃ ⁺	oH ₃ O ⁺	oH ₂	1.1e-09	0.00	0.0
335	pH ₂ O	oH ₃ ⁺	oH ₃ O ⁺	pH ₂	1.1e-09	0.00	0.0
336	pH ₂ O	oH ₃ ⁺	pH ₃ O ⁺	oH ₂	2.1e-09	0.00	0.0
337	oH ₂ O	pH ₃ ⁺	oH ₃ O ⁺	oH ₂	1.0e-09	0.00	0.0
338	oH ₂ O	pH ₃ ⁺	oH ₃ O ⁺	pH ₂	7.2e-10	0.00	0.0
339	oH ₂ O	pH ₃ ⁺	pH ₃ O ⁺	oH ₂	2.0e-09	0.00	0.0
340	oH ₂ O	pH ₃ ⁺	pH ₃ O ⁺	pH ₂	5.7e-10	0.00	0.0
341	pH ₂ O	pH ₃ ⁺	oH ₃ O ⁺	oH ₂	8.6e-10	0.00	0.0
342	pH ₂ O	pH ₃ ⁺	pH ₃ O ⁺	oH ₂	1.7e-09	0.00	0.0
343	pH ₂ O	pH ₃ ⁺	pH ₃ O ⁺	pH ₂	1.7e-09	0.00	0.0
344	oH ₂ O	oH ₂ D ⁺	oH ₃ O ⁺	HD	1.9e-09	0.00	0.0
345	oH ₂ O	oH ₂ D ⁺	pH ₃ O ⁺	HD	9.6e-10	0.00	0.0
346	oH ₂ O	pH ₂ D ⁺	oH ₃ O ⁺	HD	9.6e-10	0.00	0.0
347	oH ₂ O	pH ₂ D ⁺	pH ₃ O ⁺	HD	1.9e-09	0.00	0.0
348	pH ₂ O	oH ₂ D ⁺	oH ₃ O ⁺	HD	9.6e-10	0.00	0.0
349	pH ₂ O	oH ₂ D ⁺	pH ₃ O ⁺	HD	1.9e-09	0.00	0.0
350	pH ₂ O	pH ₂ D ⁺	pH ₃ O ⁺	HD	2.9e-09	0.00	0.0
351	oH ₂ O	oHD ₂ ⁺	oH ₂ DO ⁺	HD	2.4e-09	0.00	0.0
352	oH ₂ O	pHD ₂ ⁺	oH ₂ DO ⁺	HD	2.4e-09	0.00	0.0
353	oH ₂ O	oHD ₂ ⁺	pH ₂ DO ⁺	HD	4.8e-10	0.00	0.0
354	oH ₂ O	pHD ₂ ⁺	pH ₂ DO ⁺	HD	4.8e-10	0.00	0.0
355	pH ₂ O	oHD ₂ ⁺	oH ₂ DO ⁺	HD	1.4e-09	0.00	0.0
356	pH ₂ O	pHD ₂ ⁺	oH ₂ DO ⁺	HD	1.4e-09	0.00	0.0
357	pH ₂ O	oHD ₂ ⁺	pH ₂ DO ⁺	HD	1.4e-09	0.00	0.0
358	pH ₂ O	pHD ₂ ⁺	pH ₂ DO ⁺	HD	1.4e-09	0.00	0.0
359	oH ₂ O	oHD ₂ ⁺	oD ₂	oH ₃ O ⁺	9.5e-10	0.00	0.0
360	oH ₂ O	pHD ₂ ⁺	pD ₂	oH ₃ O ⁺	9.5e-10	0.00	0.0
361	oH ₂ O	oHD ₂ ⁺	oD ₂	pH ₃ O ⁺	4.8e-10	0.00	0.0
362	oH ₂ O	pHD ₂ ⁺	pD ₂	pH ₃ O ⁺	4.8e-10	0.00	0.0
363	pH ₂ O	oHD ₂ ⁺	oD ₂	pH ₃ O ⁺	1.4e-09	0.00	0.0
364	pH ₂ O	pHD ₂ ⁺	pD ₂	pH ₃ O ⁺	1.4e-09	0.00	0.0
365	oH ₂ O	mD ₃ ⁺	oD ₂	oH ₂ DO ⁺	4.3e-09	0.00	0.0
366	oH ₂ O	pD ₃ ⁺	pD ₂	oH ₂ DO ⁺	4.3e-09	0.00	0.0
367	oH ₂ O	oD ₃ ⁺	oD ₂	oH ₂ DO ⁺	2.1e-09	0.00	0.0
368	oH ₂ O	oD ₃ ⁺	pD ₂	oH ₂ DO ⁺	2.1e-09	0.00	0.0
369	pH ₂ O	mD ₃ ⁺	oD ₂	pH ₂ DO ⁺	4.3e-09	0.00	0.0
370	pH ₂ O	pD ₃ ⁺	pD ₂	pH ₂ DO ⁺	4.3e-09	0.00	0.0

Table D6 – continued (part 6)

#	Reactants	Products	α	β	γ			
371	pH ₂ O	oD ₃ ⁺	oD ₂	pH ₂ DO ⁺	2.1e-09	0.00	0.0	
372	pH ₂ O	oD ₃ ⁺	pD ₂	pH ₂ DO ⁺	2.1e-09	0.00	0.0	
373	oH ₂ O	oH ₂ D ⁺	oH ₂ DO ⁺	oH ₂	1.0e-09	0.00	0.0	
374	oH ₂ O	oH ₂ D ⁺	oH ₂ DO ⁺	pH ₂	1.6e-10	0.00	0.0	
375	oH ₂ O	oH ₂ D ⁺	pH ₂ DO ⁺	oH ₂	1.6e-10	0.00	0.0	
376	oH ₂ O	oH ₂ D ⁺	pH ₂ DO ⁺	pH ₂	7.9e-11	0.00	0.0	
377	oH ₂ O	pH ₂ D ⁺	oH ₂ DO ⁺	oH ₂	4.8e-10	0.00	0.0	
378	oH ₂ O	pH ₂ D ⁺	oH ₂ DO ⁺	pH ₂	4.8e-10	0.00	0.0	
379	oH ₂ O	pH ₂ D ⁺	pH ₂ DO ⁺	oH ₂	4.8e-10	0.00	0.0	
380	pH ₂ O	oH ₂ D ⁺	oH ₂ DO ⁺	oH ₂	4.8e-10	0.00	0.0	
381	pH ₂ O	oH ₂ D ⁺	oH ₂ DO ⁺	pH ₂	4.8e-10	0.00	0.0	
382	pH ₂ O	oH ₂ D ⁺	pH ₂ DO ⁺	oH ₂	4.8e-10	0.00	0.0	
383	pH ₂ O	pH ₂ D ⁺	oH ₂ DO ⁺	oH ₂	7.2e-10	0.00	0.0	
384	pH ₂ O	pH ₂ D ⁺	pH ₂ DO ⁺	pH ₂	7.2e-10	0.00	0.0	
385	HDO	He ⁺	OD ⁺	H	He	2.3e-10	-0.94	0.0
386	HDO	He ⁺	HDO ⁺	He	He	4.9e-11	-0.94	0.0
387	HDO	He ⁺	H ⁺	OD	He	1.6e-10	-0.94	0.0
388	HDO	H ⁺	HDO ⁺	H	He	8.2e-09	0.00	0.0
389	HDO	oH ₃ ⁺	oH ₂ DO ⁺	oH ₂	He	3.2e-09	0.00	0.0
390	HDO	oH ₃ ⁺	oH ₂ DO ⁺	pH ₂	He	5.4e-10	0.00	0.0
391	HDO	oH ₃ ⁺	pH ₂ DO ⁺	oH ₂	He	5.4e-10	0.00	0.0
392	HDO	pH ₃ ⁺	oH ₂ DO ⁺	oH ₂	He	1.6e-09	0.00	0.0
393	HDO	pH ₃ ⁺	oH ₂ DO ⁺	pH ₂	He	1.1e-09	0.00	0.0
394	HDO	pH ₃ ⁺	pH ₂ DO ⁺	oH ₂	He	1.1e-09	0.00	0.0
395	HDO	pH ₃ ⁺	pH ₂ DO ⁺	pH ₂	He	5.4e-10	0.00	0.0
396	HDO	oH ₂ D ⁺	oH ₂ DO ⁺	HD	He	2.4e-09	0.00	0.0
397	HDO	oH ₂ D ⁺	pH ₂ DO ⁺	HD	He	4.8e-10	0.00	0.0
398	HDO	pH ₂ D ⁺	oH ₂ DO ⁺	HD	He	1.4e-09	0.00	0.0
399	HDO	pH ₂ D ⁺	pH ₂ DO ⁺	HD	He	1.4e-09	0.00	0.0
400	HDO	oH ₂ D ⁺	oHD ₂ O ⁺	oH ₂	He	7.9e-10	0.00	0.0
401	HDO	oH ₂ D ⁺	pHD ₂ O ⁺	oH ₂	He	4.0e-10	0.00	0.0
402	HDO	oH ₂ D ⁺	oHD ₂ O ⁺	pH ₂	He	1.6e-10	0.00	0.0
403	HDO	oH ₂ D ⁺	pHD ₂ O ⁺	pH ₂	He	7.9e-11	0.00	0.0
404	HDO	pH ₂ D ⁺	oHD ₂ O ⁺	oH ₂	He	4.8e-10	0.00	0.0
405	HDO	pH ₂ D ⁺	pHD ₂ O ⁺	oH ₂	He	2.4e-10	0.00	0.0
406	HDO	pH ₂ D ⁺	oHD ₂ O ⁺	pH ₂	He	4.8e-10	0.00	0.0
407	HDO	pH ₂ D ⁺	pHD ₂ O ⁺	pH ₂	He	2.4e-10	0.00	0.0
408	HDO	oHD ₂ ⁺	oHD ₂ O ⁺	HD	He	2.2e-09	0.00	0.0
409	HDO	oHD ₂ ⁺	pHD ₂ O ⁺	HD	He	6.4e-10	0.00	0.0
410	HDO	pHD ₂ ⁺	oHD ₂ O ⁺	HD	He	1.3e-09	0.00	0.0
411	HDO	pHD ₂ ⁺	pHD ₂ O ⁺	HD	He	1.6e-09	0.00	0.0
412	HDO	oHD ₂ ⁺	oD ₂	oH ₂ DO ⁺	He	8.3e-10	0.00	0.0
413	HDO	oHD ₂ ⁺	pD ₂	oH ₂ DO ⁺	He	2.4e-10	0.00	0.0
414	HDO	pHD ₂ ⁺	oD ₂	oH ₂ DO ⁺	He	4.8e-10	0.00	0.0
415	HDO	pHD ₂ ⁺	pD ₂	oH ₂ DO ⁺	He	6.0e-10	0.00	0.0
416	HDO	oHD ₂ ⁺	oD ₂	pH ₂ DO ⁺	He	2.8e-10	0.00	0.0
417	HDO	oHD ₂ ⁺	pD ₂	pH ₂ DO ⁺	He	7.9e-11	0.00	0.0
418	HDO	pHD ₂ ⁺	oD ₂	pH ₂ DO ⁺	He	1.6e-10	0.00	0.0
419	HDO	pHD ₂ ⁺	pD ₂	pH ₂ DO ⁺	He	2.0e-10	0.00	0.0
420	HDO	mD ₃ ⁺	oHD ₂ O ⁺	oD ₂	He	2.9e-09	0.00	0.0
421	HDO	mD ₃ ⁺	oHD ₂ O ⁺	pD ₂	He	7.2e-10	0.00	0.0
422	HDO	mD ₃ ⁺	pHD ₂ O ⁺	oD ₂	He	7.2e-10	0.00	0.0
423	HDO	pD ₃ ⁺	oHD ₂ O ⁺	pD ₂	He	1.4e-09	0.00	0.0
424	HDO	pD ₃ ⁺	pHD ₂ O ⁺	oD ₂	He	1.4e-09	0.00	0.0
425	HDO	pD ₃ ⁺	pHD ₂ O ⁺	pD ₂	He	1.4e-09	0.00	0.0
426	HDO	oD ₃ ⁺	oHD ₂ O ⁺	oD ₂	He	1.4e-09	0.00	0.0
427	HDO	oD ₃ ⁺	oHD ₂ O ⁺	pD ₂	He	1.1e-09	0.00	0.0
428	HDO	oD ₃ ⁺	pHD ₂ O ⁺	oD ₂	He	1.1e-09	0.00	0.0
429	HDO	oD ₃ ⁺	pHD ₂ O ⁺	pD ₂	He	7.2e-10	0.00	0.0
430	oD ₂ O	He ⁺	OD ⁺	D	He	2.3e-10	-0.94	0.0
431	pD ₂ O	He ⁺	OD ⁺	D	He	2.3e-10	-0.94	0.0
432	oD ₂ O	He ⁺	oD ₂ O ⁺	He	He	4.9e-11	-0.94	0.0
433	pD ₂ O	He ⁺	pD ₂ O ⁺	He	He	4.9e-11	-0.94	0.0
434	oD ₂ O	He ⁺	D ⁺	OD	He	1.6e-10	-0.94	0.0
435	pD ₂ O	He ⁺	D ⁺	OD	He	1.6e-10	-0.94	0.0
436	oD ₂ O	H ⁺	oD ₂ O ⁺	H	He	8.2e-09	0.00	0.0
437	pD ₂ O	H ⁺	pD ₂ O ⁺	H	He	8.2e-09	0.00	0.0
438	oD ₂ O	oH ₃ ⁺	oHD ₂ O ⁺	oH ₂	He	4.3e-09	0.00	0.0
439	pD ₂ O	oH ₃ ⁺	pHD ₂ O ⁺	oH ₂	He	4.3e-09	0.00	0.0
440	oD ₂ O	pH ₃ ⁺	oHD ₂ O ⁺	oH ₂	He	2.1e-09	0.00	0.0
441	pD ₂ O	pH ₃ ⁺	pHD ₂ O ⁺	oH ₂	He	2.1e-09	0.00	0.0
442	oD ₂ O	pH ₃ ⁺	oHD ₂ O ⁺	pH ₂	He	2.1e-09	0.00	0.0
443	pD ₂ O	pH ₃ ⁺	pHD ₂ O ⁺	pH ₂	He	2.1e-09	0.00	0.0
444	oD ₂ O	oH ₂ D ⁺	oHD ₂ O ⁺	HD	He	2.2e-09	0.00	0.0

Table D6 – continued (part 7)

#	Reactants		Products		α	β	γ
445	oD ₂ O	oH ₂ D ⁺	pHD ₂ O ⁺	HD	6.4e-10	0.00	0.0
446	pD ₂ O	oH ₂ D ⁺	oHD ₂ O ⁺	HD	1.3e-09	0.00	0.0
447	pD ₂ O	oH ₂ D ⁺	pHD ₂ O ⁺	HD	1.6e-09	0.00	0.0
448	oD ₂ O	pH ₂ D ⁺	oHD ₂ O ⁺	HD	2.2e-09	0.00	0.0
449	oD ₂ O	pH ₂ D ⁺	pHD ₂ O ⁺	HD	6.4e-10	0.00	0.0
450	pD ₂ O	pH ₂ D ⁺	oHD ₂ O ⁺	HD	1.3e-09	0.00	0.0
451	pD ₂ O	pH ₂ D ⁺	pHD ₂ O ⁺	HD	1.6e-09	0.00	0.0
452	oD ₂ O	oH ₂ D ⁺	mD ₃ O ⁺	oH ₂	7.9e-10	0.00	0.0
453	oD ₂ O	oH ₂ D ⁺	oD ₃ O ⁺	oH ₂	6.4e-10	0.00	0.0
454	pD ₂ O	oH ₂ D ⁺	pD ₃ O ⁺	oH ₂	1.6e-10	0.00	0.0
455	pD ₂ O	oH ₂ D ⁺	oD ₃ O ⁺	oH ₂	1.3e-09	0.00	0.0
456	oD ₂ O	pH ₂ D ⁺	mD ₃ O ⁺	pH ₂	7.9e-10	0.00	0.0
457	oD ₂ O	pH ₂ D ⁺	oD ₃ O ⁺	pH ₂	6.4e-10	0.00	0.0
458	pD ₂ O	pH ₂ D ⁺	pD ₃ O ⁺	pH ₂	1.6e-10	0.00	0.0
459	pD ₂ O	pH ₂ D ⁺	oD ₃ O ⁺	pH ₂	1.3e-09	0.00	0.0
460	oD ₂ O	mD ₃ ⁺	mD ₃ O ⁺	oD ₂	2.1e-09	0.00	0.0
461	oD ₂ O	mD ₃ ⁺	mD ₃ O ⁺	pD ₂	4.3e-10	0.00	0.0
462	oD ₂ O	mD ₃ ⁺	oD ₃ O ⁺	oD ₂	1.3e-09	0.00	0.0
463	oD ₂ O	mD ₃ ⁺	oD ₃ O ⁺	pD ₂	4.3e-10	0.00	0.0
464	pD ₂ O	mD ₃ ⁺	mD ₃ O ⁺	oD ₂	8.6e-10	0.00	0.0
465	pD ₂ O	mD ₃ ⁺	mD ₃ O ⁺	pD ₂	1.0e-09	0.00	0.0
466	pD ₂ O	mD ₃ ⁺	pD ₃ O ⁺	oD ₂	1.4e-10	0.00	0.0
467	pD ₂ O	mD ₃ ⁺	oD ₃ O ⁺	oD ₂	2.0e-09	0.00	0.0
468	pD ₂ O	mD ₃ ⁺	oD ₃ O ⁺	pD ₂	2.9e-10	0.00	0.0
469	oD ₂ O	pD ₃ ⁺	mD ₃ O ⁺	pD ₂	7.2e-10	0.00	0.0
470	oD ₂ O	pD ₃ ⁺	pD ₃ O ⁺	oD ₂	7.2e-10	0.00	0.0
471	oD ₂ O	pD ₃ ⁺	oD ₃ O ⁺	oD ₂	1.4e-09	0.00	0.0
472	oD ₂ O	pD ₃ ⁺	oD ₃ O ⁺	pD ₂	1.4e-09	0.00	0.0
473	pD ₂ O	pD ₃ ⁺	pD ₃ O ⁺	pD ₂	8.6e-10	0.00	0.0
474	pD ₂ O	pD ₃ ⁺	oD ₃ O ⁺	oD ₂	1.7e-09	0.00	0.0
475	pD ₂ O	pD ₃ ⁺	oD ₃ O ⁺	pD ₂	1.7e-09	0.00	0.0
476	oD ₂ O	oD ₃ ⁺	mD ₃ O ⁺	oD ₂	8.1e-10	0.00	0.0
477	oD ₂ O	oD ₃ ⁺	mD ₃ O ⁺	pD ₂	6.3e-10	0.00	0.0
478	oD ₂ O	oD ₃ ⁺	pD ₃ O ⁺	oD ₂	9.0e-11	0.00	0.0
479	oD ₂ O	oD ₃ ⁺	pD ₃ O ⁺	pD ₂	5.4e-11	0.00	0.0
480	oD ₂ O	oD ₃ ⁺	oD ₃ O ⁺	oD ₂	1.9e-09	0.00	0.0
481	oD ₂ O	oD ₃ ⁺	oD ₃ O ⁺	pD ₂	8.2e-10	0.00	0.0
482	pD ₂ O	oD ₃ ⁺	mD ₃ O ⁺	oD ₂	5.4e-10	0.00	0.0
483	pD ₂ O	oD ₃ ⁺	mD ₃ O ⁺	pD ₂	1.8e-10	0.00	0.0
484	pD ₂ O	oD ₃ ⁺	pD ₃ O ⁺	oD ₂	1.8e-10	0.00	0.0
485	pD ₂ O	oD ₃ ⁺	pD ₃ O ⁺	pD ₂	1.1e-10	0.00	0.0
486	pD ₂ O	oD ₃ ⁺	oD ₃ O ⁺	oD ₂	1.6e-09	0.00	0.0
487	pD ₂ O	oD ₃ ⁺	oD ₃ O ⁺	pD ₂	1.6e-09	0.00	0.0
488	oD ₂ O	oHD ₂ ⁺	mD ₃ O ⁺	HD	1.6e-09	0.00	0.0
489	oD ₂ O	oHD ₂ ⁺	oD ₃ O ⁺	HD	1.3e-09	0.00	0.0
490	oD ₂ O	pHD ₂ ⁺	mD ₃ O ⁺	HD	8.0e-10	0.00	0.0
491	oD ₂ O	pHD ₂ ⁺	pD ₃ O ⁺	HD	1.6e-10	0.00	0.0
492	oD ₂ O	pHD ₂ ⁺	oD ₃ O ⁺	HD	1.9e-09	0.00	0.0
493	pD ₂ O	oHD ₂ ⁺	mD ₃ O ⁺	HD	8.0e-10	0.00	0.0
494	pD ₂ O	oHD ₂ ⁺	pD ₃ O ⁺	HD	1.6e-10	0.00	0.0
495	pD ₂ O	oHD ₂ ⁺	oD ₃ O ⁺	HD	1.9e-09	0.00	0.0
496	pD ₂ O	pHD ₂ ⁺	pD ₃ O ⁺	HD	3.2e-10	0.00	0.0
497	pD ₂ O	pHD ₂ ⁺	oD ₃ O ⁺	HD	2.6e-09	0.00	0.0
498	oD ₂ O	oHD ₂ ⁺	oHD ₂ O ⁺	oD ₂	9.1e-10	0.00	0.0
499	oD ₂ O	oHD ₂ ⁺	oHD ₂ O ⁺	pD ₂	2.0e-10	0.00	0.0
500	oD ₂ O	oHD ₂ ⁺	pHD ₂ O ⁺	oD ₂	2.0e-10	0.00	0.0
501	oD ₂ O	oHD ₂ ⁺	pHD ₂ O ⁺	pD ₂	1.2e-10	0.00	0.0
502	oD ₂ O	pHD ₂ ⁺	oHD ₂ O ⁺	oD ₂	4.0e-10	0.00	0.0
503	oD ₂ O	pHD ₂ ⁺	oHD ₂ O ⁺	pD ₂	4.8e-10	0.00	0.0
504	oD ₂ O	pHD ₂ ⁺	pHD ₂ O ⁺	oD ₂	4.8e-10	0.00	0.0
505	oD ₂ O	pHD ₂ ⁺	pHD ₂ O ⁺	pD ₂	7.9e-11	0.00	0.0
506	pD ₂ O	oHD ₂ ⁺	oHD ₂ O ⁺	oD ₂	4.0e-10	0.00	0.0
507	pD ₂ O	oHD ₂ ⁺	oHD ₂ O ⁺	pD ₂	4.8e-10	0.00	0.0
508	pD ₂ O	oHD ₂ ⁺	pHD ₂ O ⁺	oD ₂	4.8e-10	0.00	0.0
509	pD ₂ O	oHD ₂ ⁺	pHD ₂ O ⁺	pD ₂	7.9e-11	0.00	0.0
510	pD ₂ O	pHD ₂ ⁺	oHD ₂ O ⁺	oD ₂	4.8e-10	0.00	0.0
511	pD ₂ O	pHD ₂ ⁺	oHD ₂ O ⁺	pD ₂	1.6e-10	0.00	0.0
512	pD ₂ O	pHD ₂ ⁺	pHD ₂ O ⁺	oD ₂	1.6e-10	0.00	0.0
513	pD ₂ O	pHD ₂ ⁺	pHD ₂ O ⁺	pD ₂	6.4e-10	0.00	0.0
514	OH ⁺	oH ₂	oH ₂ O ⁺	H	8.4e-10	0.00	0.0
515	OH ⁺	oH ₂	pH ₂ O ⁺	H	1.7e-10	0.00	0.0
516	OH ⁺	pH ₂	oH ₂ O ⁺	H	5.1e-10	0.00	0.0
517	OH ⁺	pH ₂	pH ₂ O ⁺	H	5.1e-10	0.00	0.0
518	OH ⁺	HD	HDO ⁺	H	5.1e-10	0.00	0.0

Table D6 – continued (part 8)

#	Reactants		Products		α	β	γ	
519	OH ⁺	HD	oH ₂ O ⁺	D	3.8e-10	0.00	0.0	
520	OH ⁺	HD	pH ₂ O ⁺	D	1.3e-10	0.00	0.0	
521	OD ⁺	oH ₂	HDO ⁺	H	1.0e-09	0.00	0.0	
522	OD ⁺	pH ₂	HDO ⁺	H	1.0e-09	0.00	0.0	
523	OD ⁺	HD	oD ₂ O ⁺	H	3.4e-10	0.00	0.0	
524	OD ⁺	HD	pD ₂ O ⁺	H	1.7e-10	0.00	0.0	
525	OD ⁺	HD	HDO ⁺	D	5.1e-10	0.00	0.0	
526	OD ⁺	oD ₂	oD ₂ O ⁺	D	8.6e-10	0.00	0.0	
527	OD ⁺	oD ₂	pD ₂ O ⁺	D	2.4e-10	0.00	0.0	
528	OD ⁺	pD ₂	oD ₂ O ⁺	D	4.9e-10	0.00	0.0	
529	OD ⁺	pD ₂	pD ₂ O ⁺	D	6.1e-10	0.00	0.0	
530	oH ₂ O ⁺	oH ₂	oH ₃ O ⁺	H	5.5e-10	0.00	0.0	
531	oH ₂ O ⁺	oH ₂	pH ₃ O ⁺	H	2.8e-10	0.00	0.0	
532	oH ₂ O ⁺	pH ₂	oH ₃ O ⁺	H	2.8e-10	0.00	0.0	
533	oH ₂ O ⁺	pH ₂	pH ₃ O ⁺	H	5.5e-10	0.00	0.0	
534	pH ₂ O ⁺	oH ₂	oH ₃ O ⁺	H	2.8e-10	0.00	0.0	
535	pH ₂ O ⁺	oH ₂	pH ₃ O ⁺	H	5.5e-10	0.00	0.0	
536	pH ₂ O ⁺	pH ₂	pH ₃ O ⁺	H	8.3e-10	0.00	0.0	
537	oH ₂ O ⁺	HD	oH ₂ DO ⁺	H	3.5e-10	0.00	0.0	
538	oH ₂ O ⁺	HD	pH ₂ DO ⁺	H	6.9e-11	0.00	0.0	
539	pH ₂ O ⁺	HD	oH ₂ DO ⁺	H	2.1e-10	0.00	0.0	
540	pH ₂ O ⁺	HD	pH ₂ DO ⁺	H	2.1e-10	0.00	0.0	
541	oH ₂ O ⁺	HD	oH ₃ O ⁺	D	2.8e-10	0.00	0.0	
542	oH ₂ O ⁺	HD	pH ₃ O ⁺	D	1.4e-10	0.00	0.0	
543	pH ₂ O ⁺	HD	pH ₃ O ⁺	D	4.2e-10	0.00	0.0	
544	HDO ⁺	oH ₂	oH ₂ DO ⁺	H	6.9e-10	0.00	0.0	
545	HDO ⁺	oH ₂	pH ₂ DO ⁺	H	1.4e-10	0.00	0.0	
546	HDO ⁺	pH ₂	oH ₂ DO ⁺	H	4.2e-10	0.00	0.0	
547	HDO ⁺	pH ₂	pH ₂ DO ⁺	H	4.2e-10	0.00	0.0	
548	HDO ⁺	HD	oHD ₂ O ⁺	H	2.8e-10	0.00	0.0	
549	HDO ⁺	HD	pHD ₂ O ⁺	H	1.4e-10	0.00	0.0	
550	HDO ⁺	HD	oH ₂ DO ⁺	D	3.1e-10	0.00	0.0	
551	HDO ⁺	HD	pH ₂ DO ⁺	D	1.0e-10	0.00	0.0	
552	HDO ⁺	oD ₂	oHD ₂ O ⁺	D	6.5e-10	0.00	0.0	
553	HDO ⁺	oD ₂	pHD ₂ O ⁺	D	1.8e-10	0.00	0.0	
554	HDO ⁺	pD ₂	oHD ₂ O ⁺	D	3.7e-10	0.00	0.0	
555	HDO ⁺	pD ₂	pHD ₂ O ⁺	D	4.6e-10	0.00	0.0	
556	oD ₂ O ⁺	oD ₂	mD ₃ O ⁺	D	4.6e-10	0.00	0.0	
557	oD ₂ O ⁺	oD ₂	oD ₃ O ⁺	D	3.7e-10	0.00	0.0	
558	oD ₂ O ⁺	pD ₂	mD ₃ O ⁺	D	2.3e-10	0.00	0.0	
559	oD ₂ O ⁺	pD ₂	pD ₃ O ⁺	D	4.6e-11	0.00	0.0	
560	oD ₂ O ⁺	pD ₂	oD ₃ O ⁺	D	5.5e-10	0.00	0.0	
561	pD ₂ O ⁺	oD ₂	mD ₃ O ⁺	D	2.3e-10	0.00	0.0	
562	pD ₂ O ⁺	oD ₂	pD ₃ O ⁺	D	4.6e-11	0.00	0.0	
563	pD ₂ O ⁺	oD ₂	oD ₃ O ⁺	D	5.5e-10	0.00	0.0	
564	pD ₂ O ⁺	pD ₂	pD ₃ O ⁺	D	9.2e-11	0.00	0.0	
565	pD ₂ O ⁺	pD ₂	oD ₃ O ⁺	D	7.4e-10	0.00	0.0	
566	oD ₂ O ⁺	oH ₂	oHD ₂ O ⁺	H	8.3e-10	0.00	0.0	
567	pD ₂ O ⁺	oH ₂	pHD ₂ O ⁺	H	8.3e-10	0.00	0.0	
568	oD ₂ O ⁺	pH ₂	oHD ₂ O ⁺	H	8.3e-10	0.00	0.0	
569	pD ₂ O ⁺	pH ₂	pHD ₂ O ⁺	H	8.3e-10	0.00	0.0	
570	oD ₂ O ⁺	HD	oHD ₂ O ⁺	D	3.2e-10	0.00	0.0	
571	oD ₂ O ⁺	HD	pHD ₂ O ⁺	D	9.2e-11	0.00	0.0	
572	pD ₂ O ⁺	HD	oHD ₂ O ⁺	D	1.8e-10	0.00	0.0	
573	pD ₂ O ⁺	HD	pHD ₂ O ⁺	D	2.3e-10	0.00	0.0	
574	oD ₂ O ⁺	HD	mD ₃ O ⁺	H	2.3e-10	0.00	0.0	
575	oD ₂ O ⁺	HD	oD ₃ O ⁺	H	1.8e-10	0.00	0.0	
576	pD ₂ O ⁺	HD	pD ₃ O ⁺	H	4.6e-11	0.00	0.0	
577	pD ₂ O ⁺	HD	oD ₃ O ⁺	H	3.7e-10	0.00	0.0	
578	oH ₃ O ⁺	Fe	oH ₂ O	H	Fe ⁺	3.1e-09	0.00	0.0
579	pH ₃ O ⁺	Fe	oH ₂ O	H	Fe ⁺	1.6e-09	0.00	0.0
580	pH ₃ O ⁺	Fe	pH ₂ O	H	Fe ⁺	1.6e-09	0.00	0.0
581	O ₂ ⁺	Fe	Fe ⁺	O ₂		1.1e-09	0.00	0.0
582	O ⁺	e ⁻	O	γ		3.4e-12	-0.64	0.0
583	O ₂ ⁺	e ⁻	O	O		2.0e-07	-0.70	0.0
584	OH ⁺	e ⁻	O	H		3.7e-08	-0.50	0.0
585	oH ₂ O ⁺	e ⁻	OH	H		7.8e-08	-0.50	0.0
586	pH ₂ O ⁺	e ⁻	OH	H		7.8e-08	-0.50	0.0
587	oH ₂ O ⁺	e ⁻	oH ₂	O		3.4e-08	-0.50	0.0
588	pH ₂ O ⁺	e ⁻	pH ₂	O		3.4e-08	-0.50	0.0
589	oH ₂ O ⁺	e ⁻	H	H	O	1.5e-07	-0.50	0.0
590	pH ₂ O ⁺	e ⁻	H	H	O	1.5e-07	-0.50	0.0
591	oH ₃ O ⁺	e ⁻	OH	H	H	2.6e-07	-0.50	0.0
592	pH ₃ O ⁺	e ⁻	OH	H	H	2.6e-07	-0.50	0.0

Table D6 – *continued* (part 9)

#	Reactants		Products			α	β	γ
593	oH ₃ O ⁺	e ⁻	oH ₂ O	H		1.1e-07	-0.50	0.0
594	pH ₃ O ⁺	e ⁻	oH ₂ O	H		5.4e-08	-0.50	0.0
595	pH ₃ O ⁺	e ⁻	pH ₂ O	H		5.4e-08	-0.50	0.0
596	oH ₃ O ⁺	e ⁻	oH ₂	OH		6.0e-08	-0.50	0.0
597	pH ₃ O ⁺	e ⁻	oH ₂	OH		3.0e-08	-0.50	0.0
598	pH ₃ O ⁺	e ⁻	pH ₂	OH		3.0e-08	-0.50	0.0
599	oH ₃ O ⁺	e ⁻	oH ₂	H	O	5.6e-09	-0.50	0.0
600	pH ₃ O ⁺	e ⁻	oH ₂	H	O	2.8e-09	-0.50	0.0
601	pH ₃ O ⁺	e ⁻	pH ₂	H	O	2.8e-09	-0.50	0.0
602	OD ⁺	e ⁻	O	D		3.7e-08	-0.50	0.0
603	HDO ⁺	e ⁻	OD	H		3.1e-08	-0.50	0.0
604	HDO ⁺	e ⁻	OH	D		1.5e-08	-0.50	0.0
605	HDO ⁺	e ⁻	O	HD		1.5e-08	-0.50	0.0
606	HDO ⁺	e ⁻	O	H	D	8.9e-08	-0.50	0.0
607	oD ₂ O ⁺	e ⁻	OD	D		7.8e-08	-0.50	0.0
608	pD ₂ O ⁺	e ⁻	OD	D		7.8e-08	-0.50	0.0
609	oD ₂ O ⁺	e ⁻	oD ₂	O		3.4e-08	-0.50	0.0
610	pD ₂ O ⁺	e ⁻	pD ₂	O		3.4e-08	-0.50	0.0
611	oD ₂ O ⁺	e ⁻	D	D	O	1.5e-07	-0.50	0.0
612	pD ₂ O ⁺	e ⁻	D	D	O	1.5e-07	-0.50	0.0
613	oH ₂ DO ⁺	e ⁻	H	H	OD	8.6e-08	-0.50	0.0
614	pH ₂ DO ⁺	e ⁻	H	H	OD	8.6e-08	-0.50	0.0
615	oH ₂ DO ⁺	e ⁻	OH	H	D	1.7e-07	-0.50	0.0
616	pH ₂ DO ⁺	e ⁻	OH	H	D	1.7e-07	-0.50	0.0
617	oH ₂ DO ⁺	e ⁻	oH ₂ O	D		3.6e-08	-0.50	0.0
618	pH ₂ DO ⁺	e ⁻	pH ₂ O	D		3.6e-08	-0.50	0.0
619	oH ₂ DO ⁺	e ⁻	HDO	H		7.2e-08	-0.50	0.0
620	pH ₂ DO ⁺	e ⁻	HDO	H		7.2e-08	-0.50	0.0
621	oH ₂ DO ⁺	e ⁻	oH ₂	OD		2.0e-08	-0.50	0.0
622	pH ₂ DO ⁺	e ⁻	pH ₂	OD		2.0e-08	-0.50	0.0
623	oH ₂ DO ⁺	e ⁻	OH	HD		4.0e-08	-0.50	0.0
624	pH ₂ DO ⁺	e ⁻	OH	HD		4.0e-08	-0.50	0.0
625	oH ₂ DO ⁺	e ⁻	HD	H	O	3.7e-09	-0.50	0.0
626	pH ₂ DO ⁺	e ⁻	HD	H	O	3.7e-09	-0.50	0.0
627	oH ₂ DO ⁺	e ⁻	oH ₂	D	O	1.9e-09	-0.50	0.0
628	pH ₂ DO ⁺	e ⁻	pH ₂	D	O	1.9e-09	-0.50	0.0
629	oHD ₂ O ⁺	e ⁻	D	D	OH	8.6e-08	-0.50	0.0
630	pHD ₂ O ⁺	e ⁻	D	D	OH	8.6e-08	-0.50	0.0
631	oHD ₂ O ⁺	e ⁻	OD	D	H	1.7e-07	-0.50	0.0
632	pHD ₂ O ⁺	e ⁻	OD	D	H	1.7e-07	-0.50	0.0
633	oHD ₂ O ⁺	e ⁻	oD ₂ O	H		3.6e-08	-0.50	0.0
634	pHD ₂ O ⁺	e ⁻	pD ₂ O	H		3.6e-08	-0.50	0.0
635	oHD ₂ O ⁺	e ⁻	HDO	D		7.2e-08	-0.50	0.0
636	pHD ₂ O ⁺	e ⁻	HDO	D		7.2e-08	-0.50	0.0
637	oHD ₂ O ⁺	e ⁻	oD ₂	OH		2.0e-08	-0.50	0.0
638	pHD ₂ O ⁺	e ⁻	pD ₂	OH		2.0e-08	-0.50	0.0
639	oHD ₂ O ⁺	e ⁻	OD	HD		4.0e-08	-0.50	0.0
640	pHD ₂ O ⁺	e ⁻	OD	HD		4.0e-08	-0.50	0.0
641	oHD ₂ O ⁺	e ⁻	HD	D	O	3.7e-09	-0.50	0.0
642	pHD ₂ O ⁺	e ⁻	HD	D	O	3.7e-09	-0.50	0.0
643	oHD ₂ O ⁺	e ⁻	oD ₂	H	O	1.9e-09	-0.50	0.0
644	pHD ₂ O ⁺	e ⁻	pD ₂	H	O	1.9e-09	-0.50	0.0
645	mD ₃ O ⁺	e ⁻	OD	D	D	2.6e-07	-0.50	0.0
646	pD ₃ O ⁺	e ⁻	OD	D	D	2.6e-07	-0.50	0.0
647	oD ₃ O ⁺	e ⁻	OD	D	D	2.6e-07	-0.50	0.0
648	mD ₃ O ⁺	e ⁻	oD ₂ O	D		1.1e-07	-0.50	0.0
649	pD ₃ O ⁺	e ⁻	pD ₂ O	D		1.1e-07	-0.50	0.0
650	oD ₃ O ⁺	e ⁻	oD ₂ O	D		5.4e-08	-0.50	0.0
651	oD ₃ O ⁺	e ⁻	pD ₂ O	D		5.4e-08	-0.50	0.0
652	mD ₃ O ⁺	e ⁻	oD ₂	OD		6.0e-08	-0.50	0.0
653	pD ₃ O ⁺	e ⁻	pD ₂	OD		6.0e-08	-0.50	0.0
654	oD ₃ O ⁺	e ⁻	oD ₂	OD		3.0e-08	-0.50	0.0
655	oD ₃ O ⁺	e ⁻	pD ₂	OD		3.0e-08	-0.50	0.0
656	mD ₃ O ⁺	e ⁻	oD ₂	D	O	5.6e-09	-0.50	0.0
657	pD ₃ O ⁺	e ⁻	pD ₂	D	O	5.6e-09	-0.50	0.0
658	oD ₃ O ⁺	e ⁻	oD ₂	D	O	2.8e-09	-0.50	0.0
659	oD ₃ O ⁺	e ⁻	pD ₂	D	O	2.8e-09	-0.50	0.0
660	OH	γ	O	H		4.7e+02	0.00	0.0
661	OH ⁺	γ	O ⁺	H		8.6e+00	0.00	0.0
662	oH ₂ O	γ	OH	H		1.0e+03	0.00	0.0
663	pH ₂ O	γ	OH	H		1.0e+03	0.00	0.0
664	oH ₂ O	γ	oH ₂ O ⁺	e ⁻		2.3e+01	0.00	0.0
665	pH ₂ O	γ	pH ₂ O ⁺	e ⁻		2.3e+01	0.00	0.0
666	O ₂	γ	O	O		7.8e+02	0.00	0.0

Table D6 – continued (part 10)

#	Reactants	Products	α	β	γ
667	O ₂	γ	O ₂ ⁺	e ⁻	2.8e+01 0.00 0.0
668	O ₂ ⁺	γ	O ⁺	O	7.0e+01 0.00 0.0
669	oH ₃ O ⁺	Gr	oH ₂ O	H	Gr ⁺ 3.7e-07 0.50 0.0
670	pH ₃ O ⁺	Gr	oH ₂ O	H	Gr ⁺ 1.8e-07 0.50 0.0
671	pH ₃ O ⁺	Gr	pH ₂ O	H	Gr ⁺ 1.8e-07 0.50 0.0
672	oH ₃ O ⁺	Gr ⁻	oH ₂ O	H	Gr 3.7e-07 0.50 0.0
673	pH ₃ O ⁺	Gr ⁻	oH ₂ O	H	Gr 1.8e-07 0.50 0.0
674	pH ₃ O ⁺	Gr ⁻	pH ₂ O	H	Gr 1.8e-07 0.50 0.0
675	C ⁺	H	CH ⁺	γ	7.0e-17 0.00 0.0
676	C ⁺	oH ₂	oCH ₂ ⁺	γ	2.0e-16 -1.30 23.0
677	C ⁺	pH ₂	pCH ₂ ⁺	γ	2.0e-16 -1.30 23.0
678	C ⁺	CH	C ₂ ⁺	H	3.8e-10 0.00 0.0
679	C ⁺	CH	CH ⁺	C	3.8e-10 0.00 0.0
680	C ⁺	oCH ₂	oCH ₂ ⁺	C	5.2e-10 0.00 0.0
681	C ⁺	pCH ₂	pCH ₂ ⁺	C	5.2e-10 0.00 0.0
682	C ⁺	oCH ₂	C ₂ H ⁺	H	5.2e-10 0.00 0.0
683	C ⁺	pCH ₂	C ₂ H ⁺	H	5.2e-10 0.00 0.0
684	C ⁺	mCH ₄	C ₂ H ₃ ⁺	H	9.8e-10 0.00 0.0
685	C ⁺	pCH ₄	C ₂ H ₃ ⁺	H	9.8e-10 0.00 0.0
686	C ⁺	oCH ₄	C ₂ H ₃ ⁺	H	9.8e-10 0.00 0.0
687	C ⁺	C ₂ H	C ₃ ⁺	H	1.0e-09 0.00 0.0
688	C ⁺	C ₂ H ₂	C ₃ H ⁺	H	2.2e-09 0.00 0.0
689	C ⁺	Fe	Fe ⁺	C	2.6e-09 0.00 0.0
690	CH ⁺	H	oH ₂	C ⁺	1.1e-10 0.00 0.0
691	CH ⁺	H	pH ₂	C ⁺	3.7e-11 0.00 0.0
692	CH ⁺	oH ₂	oCH ₂ ⁺	H	1.0e-09 0.00 0.0
693	CH ⁺	oH ₂	pCH ₂ ⁺	H	2.0e-10 0.00 0.0
694	CH ⁺	pH ₂	oCH ₂ ⁺	H	6.0e-10 0.00 0.0
695	CH ⁺	pH ₂	pCH ₂ ⁺	H	6.0e-10 0.00 0.0
696	oCH ₂ ⁺	oH ₂	oCH ₃ ⁺	H	4.7e-10 0.00 0.0
697	oCH ₂ ⁺	oH ₂	pCH ₃ ⁺	H	2.3e-10 0.00 0.0
698	oCH ₂ ⁺	pH ₂	oCH ₃ ⁺	H	2.3e-10 0.00 0.0
699	oCH ₂ ⁺	pH ₂	pCH ₃ ⁺	H	4.7e-10 0.00 0.0
700	pCH ₂ ⁺	oH ₂	oCH ₃ ⁺	H	2.3e-10 0.00 0.0
701	pCH ₂ ⁺	oH ₂	pCH ₃ ⁺	H	4.7e-10 0.00 0.0
702	pCH ₂ ⁺	pH ₂	pCH ₃ ⁺	H	7.0e-10 0.00 0.0
703	oCH ₃ ⁺	oH ₂	pCH ₅ ⁺	γ	1.9e-16 -2.30 21.5
704	oCH ₃ ⁺	oH ₂	oCH ₅ ⁺	γ	1.3e-16 -2.30 21.5
705	oCH ₃ ⁺	oH ₂	mCH ₅ ⁺	γ	6.3e-17 -2.30 21.5
706	oCH ₃ ⁺	pH ₂	oCH ₅ ⁺	γ	3.8e-16 -2.30 21.5
707	pCH ₃ ⁺	oH ₂	oCH ₅ ⁺	γ	2.5e-16 -2.30 21.5
708	pCH ₃ ⁺	oH ₂	mCH ₅ ⁺	γ	1.3e-16 -2.30 21.5
709	pCH ₃ ⁺	pH ₂	mCH ₅ ⁺	γ	3.8e-16 -2.30 21.5
710	mCH ₄ ⁺	H	oCH ₃ ⁺	oH ₂	1.4e-10 0.00 0.0
711	mCH ₄ ⁺	H	oCH ₃ ⁺	pH ₂	2.0e-11 0.00 0.0
712	mCH ₄ ⁺	H	pCH ₃ ⁺	oH ₂	4.0e-11 0.00 0.0
713	pCH ₄ ⁺	H	oCH ₃ ⁺	oH ₂	4.0e-11 0.00 0.0
714	pCH ₄ ⁺	H	pCH ₃ ⁺	oH ₂	8.0e-11 0.00 0.0
715	pCH ₄ ⁺	H	pCH ₃ ⁺	pH ₂	8.0e-11 0.00 0.0
716	oCH ₄ ⁺	H	oCH ₃ ⁺	oH ₂	4.7e-11 0.00 0.0
717	oCH ₄ ⁺	H	oCH ₃ ⁺	pH ₂	3.3e-11 0.00 0.0
718	oCH ₄ ⁺	H	pCH ₃ ⁺	oH ₂	9.3e-11 0.00 0.0
719	oCH ₄ ⁺	H	pCH ₃ ⁺	pH ₂	2.7e-11 0.00 0.0
720	mCH ₄ ⁺	oH ₂	pCH ₅ ⁺	H	2.1e-11 0.00 0.0
721	mCH ₄ ⁺	oH ₂	oCH ₅ ⁺	H	1.4e-11 0.00 0.0
722	mCH ₄ ⁺	oH ₂	mCH ₅ ⁺	H	4.4e-12 0.00 0.0
723	mCH ₄ ⁺	pH ₂	pCH ₅ ⁺	H	8.0e-12 0.00 0.0
724	mCH ₄ ⁺	pH ₂	oCH ₅ ⁺	H	3.2e-11 0.00 0.0
725	pCH ₄ ⁺	oH ₂	oCH ₅ ⁺	H	1.8e-11 0.00 0.0
726	pCH ₄ ⁺	oH ₂	mCH ₅ ⁺	H	2.2e-11 0.00 0.0
727	pCH ₄ ⁺	pH ₂	mCH ₅ ⁺	H	4.0e-11 0.00 0.0
728	oCH ₄ ⁺	oH ₂	pCH ₅ ⁺	H	4.4e-12 0.00 0.0
729	oCH ₄ ⁺	oH ₂	oCH ₅ ⁺	H	2.4e-11 0.00 0.0
730	oCH ₄ ⁺	oH ₂	mCH ₅ ⁺	H	1.2e-11 0.00 0.0
731	oCH ₄ ⁺	pH ₂	oCH ₅ ⁺	H	1.8e-11 0.00 0.0
732	oCH ₄ ⁺	pH ₂	mCH ₅ ⁺	H	2.2e-11 0.00 0.0
733	C ₂ ⁺	oH ₂	C ₂ H ⁺	H	1.4e-09 0.00 0.0
734	C ₂ ⁺	pH ₂	C ₂ H ⁺	H	1.4e-09 0.00 0.0
735	C ₂ H ⁺	oH ₂	C ₂ H ₂ ⁺	H	1.7e-09 0.00 0.0
736	C ₂ H ⁺	pH ₂	C ₂ H ₂ ⁺	H	1.7e-09 0.00 0.0
737	C ₃ ⁺	oH ₂	C ₃ H ⁺	H	3.0e-10 0.00 0.0
738	C ₃ ⁺	pH ₂	C ₃ H ⁺	H	3.0e-10 0.00 0.0
739	C ₃ H ⁺	oH ₂	C ₃ H ₃ ⁺	γ	3.0e-13 -1.00 0.0
740	C ₃ H ⁺	pH ₂	C ₃ H ₃ ⁺	γ	3.0e-13 -1.00 0.0

Table D6 – *continued* (part 11)

#	Reactants		Products		α	β	γ
741	C	CRP	C ⁺	e ⁻	1.8e+00	0.00	0.0
742	C	H	CH	γ	1.0e-17	0.00	0.0
743	C	oH ₂ ⁺	CH ⁺	H	2.4e-09	0.00	0.0
744	C	pH ₂ ⁺	CH ⁺	H	2.4e-09	0.00	0.0
745	C	oH ₃ ⁺	oH ₂	CH ⁺	2.0e-09	0.00	0.0
746	C	pH ₃ ⁺	oH ₂	CH ⁺	1.0e-09	0.00	0.0
747	C	pH ₃ ⁺	pH ₂	CH ⁺	1.0e-09	0.00	0.0
748	CH	H	oH ₂	C	9.3e-11	0.26	0.0
749	CH	H	pH ₂	C	3.1e-11	0.26	0.0
750	CH	He ⁺	C ⁺	H	1.1e-09	0.00	0.0
751	CH	H ⁺	H	CH ⁺	1.9e-09	0.00	0.0
752	CH	oH ₂ ⁺	oH ₂	CH ⁺	7.1e-10	0.00	0.0
753	CH	pH ₂ ⁺	pH ₂	CH ⁺	7.1e-10	0.00	0.0
754	CH	oH ₂ ⁺	oCH ₂ ⁺	H	5.9e-10	0.00	0.0
755	CH	oH ₃ ⁺	pCH ₂ ⁺	H	1.2e-10	0.00	0.0
756	CH	pH ₂ ⁺	oCH ₂ ⁺	H	3.6e-10	0.00	0.0
757	CH	pH ₃ ⁺	pCH ₂ ⁺	H	3.6e-10	0.00	0.0
758	CH	oH ₃ ⁺	oCH ₂ ⁺	oH ₂	9.0e-10	0.00	0.0
759	CH	oH ₃ ⁺	oCH ₂ ⁺	pH ₂	1.5e-10	0.00	0.0
760	CH	oH ₃ ⁺	pCH ₂ ⁺	oH ₂	1.5e-10	0.00	0.0
761	CH	pH ₃ ⁺	oCH ₂ ⁺	oH ₂	4.5e-10	0.00	0.0
762	CH	pH ₃ ⁺	oCH ₂ ⁺	pH ₂	3.0e-10	0.00	0.0
763	CH	pH ₃ ⁺	pCH ₂ ⁺	oH ₂	3.0e-10	0.00	0.0
764	CH	pH ₃ ⁺	pCH ₂ ⁺	pH ₂	1.5e-10	0.00	0.0
765	CH	oH ₂ D ⁺	oCH ₂ ⁺	HD	1.0e-09	0.00	0.0
766	CH	oH ₂ D ⁺	pCH ₂ ⁺	HD	2.0e-10	0.00	0.0
767	CH	pH ₂ D ⁺	oCH ₂ ⁺	HD	6.0e-10	0.00	0.0
768	CH	pH ₂ D ⁺	pCH ₂ ⁺	HD	6.0e-10	0.00	0.0
769	CH	oHD ₂ ⁺	oD ₂	oCH ₂ ⁺	9.0e-10	0.00	0.0
770	CH	pHD ₂ ⁺	pD ₂	oCH ₂ ⁺	9.0e-10	0.00	0.0
771	CH	oHD ₂ ⁺	oD ₂	pCH ₂ ⁺	3.0e-10	0.00	0.0
772	CH	pHD ₂ ⁺	pD ₂	pCH ₂ ⁺	3.0e-10	0.00	0.0
773	oCH ₂	H	oH ₂	CH	1.8e-10	0.00	0.0
774	oCH ₂	H	pH ₂	CH	3.7e-11	0.00	0.0
775	pCH ₂	H	oH ₂	CH	1.1e-10	0.00	0.0
776	pCH ₂	H	pH ₂	CH	1.1e-10	0.00	0.0
777	oCH ₂	He ⁺	oH ₂	C ⁺	7.5e-10	0.00	0.0
778	pCH ₂	He ⁺	pH ₂	C ⁺	7.5e-10	0.00	0.0
779	oCH ₂	He ⁺	CH ⁺	H	7.5e-10	0.00	0.0
780	pCH ₂	He ⁺	CH ⁺	H	7.5e-10	0.00	0.0
781	oCH ₂	H ⁺	oH ₂	CH ⁺	1.2e-09	0.00	0.0
782	oCH ₂	H ⁺	pH ₂	CH ⁺	2.3e-10	0.00	0.0
783	pCH ₂	H ⁺	oH ₂	CH ⁺	7.0e-10	0.00	0.0
784	pCH ₂	H ⁺	pH ₂	CH ⁺	7.0e-10	0.00	0.0
785	oCH ₂	H ⁺	oCH ₂ ⁺	H	1.4e-09	0.00	0.0
786	pCH ₂	H ⁺	pCH ₂ ⁺	H	1.4e-09	0.00	0.0
787	oCH ₂	oH ₂ ⁺	oCH ₂ ⁺	H	6.7e-10	0.00	0.0
788	oCH ₂	oH ₃ ⁺	pCH ₂ ⁺	H	3.3e-10	0.00	0.0
789	oCH ₂	pH ₂ ⁺	oCH ₂ ⁺	H	3.3e-10	0.00	0.0
790	oCH ₂	pH ₃ ⁺	pCH ₂ ⁺	H	6.7e-10	0.00	0.0
791	pCH ₂	oH ₂ ⁺	oCH ₂ ⁺	H	3.3e-10	0.00	0.0
792	pCH ₂	oH ₃ ⁺	pCH ₂ ⁺	H	6.7e-10	0.00	0.0
793	pCH ₂	pH ₂ ⁺	pCH ₂ ⁺	H	1.0e-09	0.00	0.0
794	oCH ₂	oH ₂ ⁺	oH ₂	oCH ₂ ⁺	1.0e-09	0.00	0.0
795	oCH ₂	pH ₂ ⁺	oH ₂	pCH ₂ ⁺	1.0e-09	0.00	0.0
796	pCH ₂	oH ₂ ⁺	pH ₂	oCH ₂ ⁺	1.0e-09	0.00	0.0
797	pCH ₂	pH ₂ ⁺	pH ₂	pCH ₂ ⁺	1.0e-09	0.00	0.0
798	oCH ₂	oH ₃ ⁺	oCH ₂ ⁺	oH ₂	1.0e-09	0.00	0.0
799	oCH ₂	oH ₃ ⁺	oCH ₂ ⁺	pH ₂	1.4e-10	0.00	0.0
800	oCH ₂	oH ₃ ⁺	pCH ₂ ⁺	oH ₂	4.0e-10	0.00	0.0
801	oCH ₂	oH ₃ ⁺	pCH ₂ ⁺	pH ₂	1.1e-10	0.00	0.0
802	pCH ₂	oH ₃ ⁺	oCH ₂ ⁺	oH ₂	4.2e-10	0.00	0.0
803	pCH ₂	oH ₃ ⁺	oCH ₂ ⁺	pH ₂	4.2e-10	0.00	0.0
804	pCH ₂	oH ₃ ⁺	pCH ₂ ⁺	oH ₂	8.5e-10	0.00	0.0
805	oCH ₂	pH ₃ ⁺	oCH ₂ ⁺	oH ₂	4.0e-10	0.00	0.0
806	oCH ₂	pH ₃ ⁺	oCH ₂ ⁺	pH ₂	2.8e-10	0.00	0.0
807	oCH ₂	pH ₃ ⁺	pCH ₂ ⁺	oH ₂	7.9e-10	0.00	0.0
808	oCH ₂	pH ₃ ⁺	pCH ₂ ⁺	pH ₂	2.3e-10	0.00	0.0
809	pCH ₂	pH ₃ ⁺	oCH ₂ ⁺	oH ₂	3.4e-10	0.00	0.0
810	pCH ₂	pH ₃ ⁺	pCH ₂ ⁺	oH ₂	6.8e-10	0.00	0.0
811	pCH ₂	pH ₃ ⁺	pCH ₂ ⁺	pH ₂	6.8e-10	0.00	0.0
812	oCH ₂	oH ₂ D ⁺	oCH ₂ ⁺	HD	1.1e-09	0.00	0.0
813	oCH ₂	oH ₂ D ⁺	pCH ₂ ⁺	HD	5.7e-10	0.00	0.0
814	oCH ₂	pH ₂ D ⁺	oCH ₂ ⁺	HD	5.7e-10	0.00	0.0

Table D6 – continued (part 12)

#	Reactants	Products	α	β	γ			
815	oCH ₂	pH ₂ D ⁺	pCH ₃ ⁺	HD	1.1e-09	0.00	0.0	
816	pCH ₂	oH ₂ D ⁺	oCH ₃ ⁺	HD	5.7e-10	0.00	0.0	
817	pCH ₂	oH ₂ D ⁺	pCH ₃ ⁺	HD	1.1e-09	0.00	0.0	
818	pCH ₂	pH ₂ D ⁺	pCH ₃ ⁺	HD	1.7e-09	0.00	0.0	
819	oCH ₂	oHD ₂ ⁺	oD ₂	oCH ₃ ⁺	1.1e-09	0.00	0.0	
820	oCH ₂	pHD ₂ ⁺	pD ₂	oCH ₃ ⁺	1.1e-09	0.00	0.0	
821	oCH ₂	oHD ₂ ⁺	oD ₂	pCH ₃ ⁺	5.7e-10	0.00	0.0	
822	oCH ₂	pHD ₂ ⁺	pD ₂	pCH ₃ ⁺	5.7e-10	0.00	0.0	
823	pCH ₂	oHD ₂ ⁺	oD ₂	pCH ₃ ⁺	1.7e-09	0.00	0.0	
824	pCH ₂	pHD ₂ ⁺	pD ₂	pCH ₃ ⁺	1.7e-09	0.00	0.0	
825	oCH ₃	He ⁺	oH ₂	CH ⁺	He	9.0e-10	0.00	0.0
826	pCH ₃	He ⁺	oH ₂	CH ⁺	He	4.5e-10	0.00	0.0
827	pCH ₃	He ⁺	pH ₂	CH ⁺	He	4.5e-10	0.00	0.0
828	oCH ₃	He ⁺	oCH ₂ ⁺	H	He	9.0e-10	0.00	0.0
829	pCH ₃	He ⁺	oCH ₂ ⁺	H	He	4.5e-10	0.00	0.0
830	pCH ₃	He ⁺	pCH ₂ ⁺	H	He	4.5e-10	0.00	0.0
831	oCH ₃	H ⁺	oCH ₃ ⁺	H		3.4e-09	0.00	0.0
832	pCH ₃	H ⁺	pCH ₃ ⁺	H		3.4e-09	0.00	0.0
833	oCH ₃	oH ₃ ⁺	mCH ₄ ⁺	oH ₂		1.1e-09	0.00	0.0
834	oCH ₃	oH ₃ ⁺	mCH ₄ ⁺	pH ₂		1.3e-10	0.00	0.0
835	oCH ₃	oH ₃ ⁺	pCH ₄ ⁺	oH ₂		8.7e-11	0.00	0.0
836	oCH ₃	oH ₃ ⁺	pCH ₄ ⁺	pH ₂		5.2e-11	0.00	0.0
837	oCH ₃	oH ₃ ⁺	oCH ₄ ⁺	oH ₂		6.0e-10	0.00	0.0
838	oCH ₃	oH ₃ ⁺	oCH ₄ ⁺	pH ₂		1.3e-10	0.00	0.0
839	oCH ₃	pH ₃ ⁺	mCH ₄ ⁺	oH ₂		3.5e-10	0.00	0.0
840	oCH ₃	pH ₃ ⁺	mCH ₄ ⁺	pH ₂		2.6e-10	0.00	0.0
841	oCH ₃	pH ₃ ⁺	pCH ₄ ⁺	oH ₂		1.7e-10	0.00	0.0
842	oCH ₃	pH ₃ ⁺	oCH ₄ ⁺	oH ₂		1.1e-09	0.00	0.0
843	oCH ₃	pH ₃ ⁺	oCH ₄ ⁺	pH ₂		2.6e-10	0.00	0.0
844	pCH ₃	oH ₃ ⁺	mCH ₄ ⁺	oH ₂		3.5e-10	0.00	0.0
845	pCH ₃	oH ₃ ⁺	mCH ₄ ⁺	pH ₂		2.6e-10	0.00	0.0
846	pCH ₃	oH ₃ ⁺	pCH ₄ ⁺	oH ₂		1.7e-10	0.00	0.0
847	pCH ₃	oH ₃ ⁺	oCH ₄ ⁺	oH ₂		1.1e-09	0.00	0.0
848	pCH ₃	oH ₃ ⁺	oCH ₄ ⁺	pH ₂		2.6e-10	0.00	0.0
849	pCH ₃	pH ₃ ⁺	mCH ₄ ⁺	oH ₂		1.7e-10	0.00	0.0
850	pCH ₃	pH ₃ ⁺	pCH ₄ ⁺	oH ₂		3.5e-10	0.00	0.0
851	pCH ₃	pH ₃ ⁺	pCH ₄ ⁺	pH ₂		2.1e-10	0.00	0.0
852	pCH ₃	pH ₃ ⁺	oCH ₄ ⁺	oH ₂		8.4e-10	0.00	0.0
853	pCH ₃	pH ₃ ⁺	oCH ₄ ⁺	pH ₂		5.3e-10	0.00	0.0
854	oCH ₃	oH ₂ D ⁺	mCH ₄ ⁺	HD		1.2e-09	0.00	0.0
855	oCH ₃	oH ₂ D ⁺	pCH ₄ ⁺	HD		1.4e-10	0.00	0.0
856	oCH ₃	oH ₂ D ⁺	oCH ₄ ⁺	HD		7.4e-10	0.00	0.0
857	oCH ₃	pH ₂ D ⁺	mCH ₄ ⁺	HD		5.3e-10	0.00	0.0
858	oCH ₃	pH ₂ D ⁺	oCH ₄ ⁺	HD		1.6e-09	0.00	0.0
859	pCH ₃	oH ₂ D ⁺	mCH ₄ ⁺	HD		3.5e-10	0.00	0.0
860	pCH ₃	oH ₂ D ⁺	pCH ₄ ⁺	HD		2.8e-10	0.00	0.0
861	pCH ₃	oH ₂ D ⁺	oCH ₄ ⁺	HD		1.5e-09	0.00	0.0
862	pCH ₃	pH ₂ D ⁺	pCH ₄ ⁺	HD		8.4e-10	0.00	0.0
863	pCH ₃	pH ₂ D ⁺	oCH ₄ ⁺	HD		1.3e-09	0.00	0.0
864	oCH ₃	oHD ₂ ⁺	oD ₂	mCH ₄ ⁺		1.3e-09	0.00	0.0
865	oCH ₃	pHD ₂ ⁺	pD ₂	mCH ₄ ⁺		1.3e-09	0.00	0.0
866	oCH ₃	oHD ₂ ⁺	oD ₂	oCH ₄ ⁺		7.9e-10	0.00	0.0
867	oCH ₃	pHD ₂ ⁺	pD ₂	oCH ₄ ⁺		7.9e-10	0.00	0.0
868	pCH ₃	oHD ₂ ⁺	oD ₂	pCH ₄ ⁺		5.3e-10	0.00	0.0
869	pCH ₃	pHD ₂ ⁺	pD ₂	pCH ₄ ⁺		5.3e-10	0.00	0.0
870	pCH ₃	oHD ₂ ⁺	oD ₂	oCH ₄ ⁺		1.6e-09	0.00	0.0
871	pCH ₃	pHD ₂ ⁺	pD ₂	oCH ₄ ⁺		1.6e-09	0.00	0.0
872	mCH ₄	He ⁺	oCH ₃	H ⁺	He	4.0e-10	0.00	0.0
873	pCH ₄	He ⁺	pCH ₃	H ⁺	He	4.0e-10	0.00	0.0
874	oCH ₄	He ⁺	oCH ₃	H ⁺	He	1.3e-10	0.00	0.0
875	oCH ₄	He ⁺	pCH ₃	H ⁺	He	2.7e-10	0.00	0.0
876	mCH ₄	He ⁺	oCH ₂ ⁺	oH ₂	He	8.5e-10	0.00	0.0
877	pCH ₄	He ⁺	oCH ₂ ⁺	oH ₂	He	4.2e-10	0.00	0.0
878	pCH ₄	He ⁺	pCH ₂ ⁺	pH ₂	He	4.2e-10	0.00	0.0
879	oCH ₄	He ⁺	oCH ₂ ⁺	oH ₂	He	2.8e-10	0.00	0.0
880	oCH ₄	He ⁺	oCH ₂ ⁺	pH ₂	He	2.8e-10	0.00	0.0
881	oCH ₄	He ⁺	pCH ₂ ⁺	oH ₂	He	2.8e-10	0.00	0.0
882	mCH ₄	He ⁺	oCH ₃ ⁺	H	He	8.0e-11	0.00	0.0
883	pCH ₄	He ⁺	pCH ₃ ⁺	H	He	8.0e-11	0.00	0.0
884	oCH ₄	He ⁺	oCH ₃ ⁺	H	He	2.7e-11	0.00	0.0
885	oCH ₄	He ⁺	pCH ₃ ⁺	H	He	5.3e-11	0.00	0.0
886	mCH ₄	He ⁺	mCH ₄ ⁺	He		1.6e-11	0.00	0.0
887	pCH ₄	He ⁺	pCH ₄ ⁺	He		1.6e-11	0.00	0.0
888	oCH ₄	He ⁺	oCH ₄ ⁺	He		1.6e-11	0.00	0.0

Table D6 – *continued* (part 13)

#	Reactants		Products		α	β	γ	
889	mCH ₄	H ⁺	oCH ₃ ⁺	oH ₂	1.6e-09	0.00	0.0	
890	mCH ₄	H ⁺	oCH ₃ ⁺	pH ₂	2.3e-10	0.00	0.0	
891	mCH ₄	H ⁺	pCH ₃ ⁺	oH ₂	4.6e-10	0.00	0.0	
892	pCH ₄	H ⁺	oCH ₃ ⁺	oH ₂	4.6e-10	0.00	0.0	
893	pCH ₄	H ⁺	pCH ₃ ⁺	oH ₂	9.1e-10	0.00	0.0	
894	pCH ₄	H ⁺	pCH ₃ ⁺	pH ₂	9.1e-10	0.00	0.0	
895	oCH ₄	H ⁺	oCH ₃ ⁺	oH ₂	5.3e-10	0.00	0.0	
896	oCH ₄	H ⁺	oCH ₃ ⁺	pH ₂	3.8e-10	0.00	0.0	
897	oCH ₄	H ⁺	pCH ₃ ⁺	oH ₂	1.1e-09	0.00	0.0	
898	oCH ₄	H ⁺	pCH ₃ ⁺	pH ₂	3.0e-10	0.00	0.0	
899	mCH ₄	H ⁺	mCH ₄ ⁺	H	1.5e-09	0.00	0.0	
900	pCH ₄	H ⁺	pCH ₄ ⁺	H	1.5e-09	0.00	0.0	
901	oCH ₄	H ⁺	oCH ₄ ⁺	H	1.5e-09	0.00	0.0	
902	mCH ₄	oH ₃ ⁺	pCH ₅ ⁺	oH ₂	8.8e-10	0.00	0.0	
903	mCH ₄	oH ₃ ⁺	pCH ₅ ⁺	pH ₂	9.5e-11	0.00	0.0	
904	mCH ₄	oH ₃ ⁺	oCH ₅ ⁺	oH ₂	5.4e-10	0.00	0.0	
905	mCH ₄	oH ₃ ⁺	oCH ₅ ⁺	pH ₂	1.1e-10	0.00	0.0	
906	mCH ₄	oH ₃ ⁺	mCH ₅ ⁺	oH ₂	2.0e-10	0.00	0.0	
907	mCH ₄	oH ₃ ⁺	mCH ₅ ⁺	pH ₂	6.8e-11	0.00	0.0	
908	pCH ₄	oH ₃ ⁺	pCH ₅ ⁺	oH ₂	1.4e-10	0.00	0.0	
909	pCH ₄	oH ₃ ⁺	oCH ₅ ⁺	oH ₂	5.4e-10	0.00	0.0	
910	pCH ₄	oH ₃ ⁺	oCH ₅ ⁺	pH ₂	5.4e-10	0.00	0.0	
911	pCH ₄	oH ₃ ⁺	mCH ₅ ⁺	oH ₂	6.8e-10	0.00	0.0	
912	oCH ₄	oH ₃ ⁺	pCH ₅ ⁺	oH ₂	2.0e-10	0.00	0.0	
913	oCH ₄	oH ₃ ⁺	pCH ₅ ⁺	pH ₂	1.6e-10	0.00	0.0	
914	oCH ₄	oH ₃ ⁺	oCH ₅ ⁺	oH ₂	9.0e-10	0.00	0.0	
915	oCH ₄	oH ₃ ⁺	oCH ₅ ⁺	pH ₂	1.8e-10	0.00	0.0	
916	oCH ₄	oH ₃ ⁺	mCH ₅ ⁺	oH ₂	3.4e-10	0.00	0.0	
917	oCH ₄	oH ₃ ⁺	mCH ₅ ⁺	pH ₂	1.1e-10	0.00	0.0	
918	mCH ₄	pH ₃ ⁺	pCH ₅ ⁺	oH ₂	2.4e-10	0.00	0.0	
919	mCH ₄	pH ₃ ⁺	pCH ₅ ⁺	pH ₂	1.9e-10	0.00	0.0	
920	mCH ₄	pH ₃ ⁺	oCH ₅ ⁺	oH ₂	9.8e-10	0.00	0.0	
921	mCH ₄	pH ₃ ⁺	oCH ₅ ⁺	pH ₂	2.2e-10	0.00	0.0	
922	mCH ₄	pH ₃ ⁺	mCH ₅ ⁺	oH ₂	2.7e-10	0.00	0.0	
923	pCH ₄	pH ₃ ⁺	oCH ₅ ⁺	oH ₂	5.4e-10	0.00	0.0	
924	pCH ₄	pH ₃ ⁺	mCH ₅ ⁺	oH ₂	6.8e-10	0.00	0.0	
925	pCH ₄	pH ₃ ⁺	mCH ₅ ⁺	pH ₂	6.8e-10	0.00	0.0	
926	oCH ₄	pH ₃ ⁺	pCH ₅ ⁺	oH ₂	6.2e-11	0.00	0.0	
927	oCH ₄	pH ₃ ⁺	oCH ₅ ⁺	oH ₂	5.4e-10	0.00	0.0	
928	oCH ₄	pH ₃ ⁺	oCH ₅ ⁺	pH ₂	2.5e-10	0.00	0.0	
929	oCH ₄	pH ₃ ⁺	mCH ₅ ⁺	oH ₂	6.8e-10	0.00	0.0	
930	oCH ₄	pH ₃ ⁺	mCH ₅ ⁺	pH ₂	3.7e-10	0.00	0.0	
931	mCH ₄	oH ₂ D ⁺	pCH ₅ ⁺	HD	1.0e-09	0.00	0.0	
932	mCH ₄	oH ₂ D ⁺	oCH ₅ ⁺	HD	6.8e-10	0.00	0.0	
933	mCH ₄	oH ₂ D ⁺	mCH ₅ ⁺	HD	2.1e-10	0.00	0.0	
934	mCH ₄	pH ₂ D ⁺	pCH ₅ ⁺	HD	3.8e-10	0.00	0.0	
935	mCH ₄	pH ₂ D ⁺	oCH ₅ ⁺	HD	1.5e-09	0.00	0.0	
936	pCH ₄	oH ₂ D ⁺	oCH ₅ ⁺	HD	8.4e-10	0.00	0.0	
937	pCH ₄	oH ₂ D ⁺	mCH ₅ ⁺	HD	1.1e-09	0.00	0.0	
938	pCH ₄	pH ₂ D ⁺	mCH ₅ ⁺	HD	1.9e-09	0.00	0.0	
939	oCH ₄	oH ₂ D ⁺	pCH ₅ ⁺	HD	2.1e-10	0.00	0.0	
940	oCH ₄	oH ₂ D ⁺	oCH ₅ ⁺	HD	1.1e-09	0.00	0.0	
941	oCH ₄	oH ₂ D ⁺	mCH ₅ ⁺	HD	5.6e-10	0.00	0.0	
942	oCH ₄	pH ₂ D ⁺	oCH ₅ ⁺	HD	8.4e-10	0.00	0.0	
943	oCH ₄	pH ₂ D ⁺	mCH ₅ ⁺	HD	1.1e-09	0.00	0.0	
944	mCH ₄	oHD ₂ ⁺	oD ₂	pCH ₅ ⁺	1.1e-09	0.00	0.0	
945	mCH ₄	pHD ₂ ⁺	pD ₂	pCH ₅ ⁺	1.1e-09	0.00	0.0	
946	mCH ₄	oHD ₂ ⁺	oD ₂	oCH ₅ ⁺	7.6e-10	0.00	0.0	
947	mCH ₄	pHD ₂ ⁺	pD ₂	oCH ₅ ⁺	7.6e-10	0.00	0.0	
948	pCH ₄	oHD ₂ ⁺	oD ₂	mCH ₅ ⁺	1.9e-09	0.00	0.0	
949	pCH ₄	pHD ₂ ⁺	pD ₂	mCH ₅ ⁺	1.9e-09	0.00	0.0	
950	oCH ₄	oHD ₂ ⁺	oD ₂	oCH ₅ ⁺	1.3e-09	0.00	0.0	
951	oCH ₄	pHD ₂ ⁺	pD ₂	oCH ₅ ⁺	1.3e-09	0.00	0.0	
952	oCH ₄	oHD ₂ ⁺	oD ₂	mCH ₅ ⁺	6.3e-10	0.00	0.0	
953	oCH ₄	pHD ₂ ⁺	pD ₂	mCH ₅ ⁺	6.3e-10	0.00	0.0	
954	C	oH ₂ D ⁺	CH ⁺	HD	2.0e-09	0.00	0.0	
955	C	pH ₂ D ⁺	CH ⁺	HD	2.0e-09	0.00	0.0	
956	C	oHD ₂ ⁺	oD ₂	CH ⁺	2.0e-09	0.00	0.0	
957	C	pHD ₂ ⁺	pD ₂	CH ⁺	2.0e-09	0.00	0.0	
958	C ₂	H ⁺	C ₂ ⁺	H	3.1e-09	0.00	0.0	
959	C ₂ H	He ⁺	C ₂ ⁺	CH	He	5.1e-10	0.00	0.0
960	C ₂ H	He ⁺	CH ⁺	C	He	5.1e-10	0.00	0.0
961	C ₂ H	He ⁺	C ₂ ⁺	H	He	5.1e-10	0.00	0.0
962	C ₂ H	H ⁺	oH ₂	C ₂ ⁺	1.1e-09	0.00	0.0	

Table D6 – continued (part 14)

#	Reactants		Products		α	β	γ
963	C ₂ H	H ⁺	pH ₂	C ₂ ⁺	3.7e-10	0.00	0.0
964	C ₂ H	H ⁺	C ₂ H ⁺	H	1.5e-09	0.00	0.0
965	C ₂ H	oH ₂ D ⁺	C ₂ H ₂ ⁺	HD	1.7e-09	0.00	0.0
966	C ₂ H	pH ₂ D ⁺	C ₂ H ₂ ⁺	HD	1.7e-09	0.00	0.0
967	C ₂ H	oHD ₂ ⁺	oD ₂	C ₂ H ₂ ⁺	1.7e-09	0.00	0.0
968	C ₂ H	pHD ₂ ⁺	pD ₂	C ₂ H ₂ ⁺	1.7e-09	0.00	0.0
969	C ₃ H	He ⁺	C ₃ ⁺	H	2.0e-09	0.00	0.0
970	C ₃ H	H ⁺	oH ₂	C ₃ ⁺	1.5e-09	0.00	0.0
971	C ₃ H	H ⁺	pH ₂	C ₃ ⁺	5.0e-10	0.00	0.0
972	C ₃ H	H ⁺	C ₃ H ⁺	H	2.0e-09	0.00	0.0
973	C ₃ H	oH ₂ D ⁺	C ₃ H ₂ ⁺	HD	2.0e-09	0.00	0.0
974	C ₃ H	pH ₂ D ⁺	C ₃ H ₂ ⁺	HD	2.0e-09	0.00	0.0
975	C ₃ H	oHD ₂ ⁺	oD ₂	C ₃ H ₂ ⁺	2.0e-09	0.00	0.0
976	C ₃ H	pHD ₂ ⁺	pD ₂	C ₃ H ₂ ⁺	2.0e-09	0.00	0.0
977	C ₂ H ₂	He ⁺	CH ⁺	CH	7.7e-10	0.00	0.0
978	C ₂ H ₂	He ⁺	C ₂ H ⁺	H	8.7e-10	0.00	0.0
979	C ₂ H ₂	He ⁺	C ₂ H ₂ ⁺	He	2.4e-10	0.00	0.0
980	C ₂ H ₂	H ⁺	C ₂ H ₂ ⁺	H	2.0e-09	0.00	0.0
981	C ₃ H ₂	H ⁺	C ₃ H ₂ ⁺	H	2.0e-09	0.00	0.0
982	C ₃ H ₂	He ⁺	C ₃ H ⁺	H	1.0e-09	0.00	0.0
983	C ⁺	e ⁻	C	γ	4.4e-12	-0.61	0.0
984	CH ⁺	e ⁻	C	H	1.5e-07	-0.42	0.0
985	oCH ₂ ⁺	e ⁻	oH ₂	C	1.2e-07	-0.50	0.0
986	pCH ₂ ⁺	e ⁻	pH ₂	C	1.2e-07	-0.50	0.0
987	oCH ₂ ⁺	e ⁻	CH	H	1.2e-07	-0.50	0.0
988	pCH ₂ ⁺	e ⁻	CH	H	1.2e-07	-0.50	0.0
989	oCH ₃ ⁺	e ⁻	oH ₂	H	3.0e-07	-0.30	0.0
990	pCH ₃ ⁺	e ⁻	oH ₂	H	1.5e-07	-0.30	0.0
991	pCH ₃ ⁺	e ⁻	pH ₂	H	1.5e-07	-0.30	0.0
992	oCH ₃ ⁺	e ⁻	CH	H	1.6e-07	-0.30	0.0
993	pCH ₃ ⁺	e ⁻	CH	H	1.6e-07	-0.30	0.0
994	oCH ₃ ⁺	e ⁻	oH ₂	CH	1.4e-07	-0.30	0.0
995	pCH ₃ ⁺	e ⁻	oH ₂	CH	7.0e-08	-0.30	0.0
996	pCH ₃ ⁺	e ⁻	pH ₂	CH	7.0e-08	-0.30	0.0
997	oCH ₃ ⁺	e ⁻	oCH ₂	H	4.0e-07	-0.30	0.0
998	pCH ₃ ⁺	e ⁻	oCH ₂	H	2.0e-07	-0.30	0.0
999	pCH ₃ ⁺	e ⁻	pCH ₂	H	2.0e-07	-0.30	0.0
1000	mCH ₄ ⁺	e ⁻	oCH ₃	H	3.0e-07	-0.50	0.0
1001	pCH ₄ ⁺	e ⁻	pCH ₃	H	3.0e-07	-0.50	0.0
1002	oCH ₄ ⁺	e ⁻	oCH ₃	H	1.0e-07	-0.50	0.0
1003	oCH ₄ ⁺	e ⁻	pCH ₃	H	2.0e-07	-0.50	0.0
1004	pCH ₅ ⁺	e ⁻	oCH ₃	oH ₂	8.7e-08	-0.30	0.0
1005	oCH ₅ ⁺	e ⁻	oCH ₃	oH ₂	2.2e-08	-0.30	0.0
1006	oCH ₅ ⁺	e ⁻	oCH ₃	pH ₂	2.2e-08	-0.30	0.0
1007	oCH ₅ ⁺	e ⁻	pCH ₃	oH ₂	4.4e-08	-0.30	0.0
1008	mCH ₅ ⁺	e ⁻	oCH ₃	oH ₂	1.8e-08	-0.30	0.0
1009	mCH ₅ ⁺	e ⁻	pCH ₃	oH ₂	3.5e-08	-0.30	0.0
1010	mCH ₅ ⁺	e ⁻	pCH ₃	pH ₂	3.5e-08	-0.30	0.0
1011	pCH ₅ ⁺	e ⁻	mCH ₄	H	8.7e-08	-0.30	0.0
1012	oCH ₅ ⁺	e ⁻	mCH ₄	H	2.2e-08	-0.30	0.0
1013	oCH ₅ ⁺	e ⁻	oCH ₄	H	6.6e-08	-0.30	0.0
1014	mCH ₅ ⁺	e ⁻	pCH ₄	H	3.5e-08	-0.30	0.0
1015	mCH ₅ ⁺	e ⁻	oCH ₄	H	5.3e-08	-0.30	0.0
1016	C ₂ ⁺	e ⁻	C	C	3.0e-07	-0.50	0.0
1017	C ₂ H ⁺	e ⁻	C ₂	H	1.4e-07	-0.50	0.0
1018	C ₂ H ⁺	e ⁻	CH	C	1.4e-07	-0.50	0.0
1019	C ₂ H ₂ ⁺	e ⁻	C ₂ H	H	1.5e-07	-0.50	0.0
1020	C ₂ H ₂ ⁺	e ⁻	CH	CH	1.5e-07	-0.50	0.0
1021	C ₂ H ₃ ⁺	e ⁻	C ₂ H ₂	H	3.0e-08	-0.50	0.0
1022	C ₃ ⁺	e ⁻	C ₂	C	3.0e-07	-0.50	0.0
1023	C ₃ H ⁺	e ⁻	C ₂	CH	1.5e-07	-0.50	0.0
1024	C ₃ H ⁺	e ⁻	C ₂ H	C	1.5e-07	-0.50	0.0
1025	C ₃ H ₂ ⁺	e ⁻	C ₃ H	H	1.5e-07	-0.50	0.0
1026	C ₃ H ₂ ⁺	e ⁻	C ₂ H	CH	1.5e-07	-0.50	0.0
1027	C ₃ H ₃ ⁺	e ⁻	C ₃ H ₂	H	1.5e-07	-0.50	0.0
1028	C ₃ H ₃ ⁺	e ⁻	C ₂ H ₂	CH	1.5e-07	-0.50	0.0
1029	C	γ	C ⁺	e ⁻	2.6e+02	0.00	0.0
1030	CH	γ	C	H	1.1e+03	0.00	0.0
1031	CH	γ	CH ⁺	e ⁻	5.8e+02	0.00	0.0
1032	oCH ₂	γ	oH ₂	C	2.9e+02	0.00	0.0
1033	pCH ₂	γ	pH ₂	C	2.9e+02	0.00	0.0
1034	oCH ₃	γ	oH ₂	CH	2.8e+02	0.00	0.0
1035	pCH ₃	γ	oH ₂	CH	1.4e+02	0.00	0.0
1036	pCH ₃	γ	pH ₂	CH	1.4e+02	0.00	0.0

Table D6 – continued (part 15)

#	Reactants		Products		α	β	γ
1037	oCH ₃	γ_2	oCH ₃ ⁺	e ⁻	3.8e+02	0.00	0.0
1038	pCH ₃	γ_2	pCH ₃ ⁺	e ⁻	3.8e+02	0.00	0.0
1039	mCH ₄	γ_2	oCH ₃	H	1.5e+03	0.00	0.0
1040	pCH ₄	γ_2	pCH ₃	H	1.5e+03	0.00	0.0
1041	oCH ₄	γ_2	oCH ₃	H	5.0e+02	0.00	0.0
1042	oCH ₄	γ_2	pCH ₃	H	1.0e+03	0.00	0.0
1043	mCH ₄	γ_2	mCH ₄ ⁺	e ⁻	2.2e+01	0.00	0.0
1044	pCH ₄	γ_2	pCH ₄ ⁺	e ⁻	2.2e+01	0.00	0.0
1045	oCH ₄	γ_2	oCH ₄ ⁺	e ⁻	2.2e+01	0.00	0.0
1046	CH ⁺	γ_2	C	H ⁺	2.2e+02	0.00	0.0
1047	oCH ₂ ⁺	γ_2	CH ⁺	H	8.9e+01	0.00	0.0
1048	pCH ₂ ⁺	γ_2	CH ⁺	H	8.9e+01	0.00	0.0
1049	mCH ₄ ⁺	γ_2	oCH ₃ ⁺	H	2.7e+01	0.00	0.0
1050	pCH ₄ ⁺	γ_2	pCH ₃ ⁺	H	2.7e+01	0.00	0.0
1051	oCH ₄ ⁺	γ_2	oCH ₃ ⁺	H	9.0e+00	0.00	0.0
1052	oCH ₄ ⁺	γ_2	pCH ₃ ⁺	H	1.8e+01	0.00	0.0
1053	C ₂	γ_2	C	C	1.8e+02	0.00	0.0
1054	C ₂	γ_2	C ₂ ⁺	e ⁻	2.5e+02	0.00	0.0
1055	C ₂ H	γ_2	C ₂	H	1.1e+03	0.00	0.0
1056	C ₂ H ₂	γ_2	C ₂ H	H	3.5e+03	0.00	0.0
1057	C ₂ H ₂	γ_2	C ₂ H ₂ ⁺	e ⁻	3.8e+02	0.00	0.0
1058	C ₃	γ_2	C ₂	C	6.9e+03	0.00	0.0
1059	C ₃ H	γ_2	C ₃	H	3.0e+03	0.00	0.0
1060	C ₃ H ₂	γ_2	C ₃ H	H	3.4e+03	0.00	0.0
1061	C ⁺	Gr	Gr ⁺	C	4.6e-07	0.50	0.0
1062	C ⁺	Gr ⁻	Gr	C	4.6e-07	0.50	0.0
1063	C ⁺	mCH ₄	C ₂ H ₂ ⁺	oH ₂	3.3e-10	0.00	0.0
1064	C ⁺	pCH ₄	C ₂ H ₂ ⁺	oH ₂	1.6e-10	0.00	0.0
1065	C ⁺	pCH ₄	C ₂ H ₂ ⁺	pH ₂	1.6e-10	0.00	0.0
1066	C ⁺	oCH ₄	C ₂ H ₂ ⁺	oH ₂	2.2e-10	0.00	0.0
1067	C ⁺	oCH ₄	C ₂ H ₂ ⁺	pH ₂	1.1e-10	0.00	0.0
1068	C ₂ H	oH ₃ ⁺	C ₂ H ₂ ⁺	oH ₂	1.5e-09	0.00	0.0
1069	C ₂ H	oH ₃ ⁺	C ₂ H ₂ ⁺	pH ₂	2.1e-10	0.00	0.0
1070	C ₂ H	pH ₃ ⁺	C ₂ H ₂ ⁺	oH ₂	1.1e-09	0.00	0.0
1071	C ₂ H	pH ₃ ⁺	C ₂ H ₂ ⁺	pH ₂	6.4e-10	0.00	0.0
1072	C ₃ H	oH ₃ ⁺	C ₃ H ₂ ⁺	oH ₂	1.7e-09	0.00	0.0
1073	C ₃ H	oH ₃ ⁺	C ₃ H ₂ ⁺	pH ₂	2.5e-10	0.00	0.0
1074	C ₃ H	pH ₃ ⁺	C ₃ H ₂ ⁺	oH ₂	1.3e-09	0.00	0.0
1075	C ₃ H	pH ₃ ⁺	C ₃ H ₂ ⁺	pH ₂	7.5e-10	0.00	0.0
1076	C ₃ H ⁺	oH ₂	C ₃ H ₂ ⁺	H	1.0e-09	0.00	500.0
1077	C ₃ H ⁺	pH ₂	C ₃ H ₂ ⁺	H	1.0e-09	0.00	500.0
1078	N	CRP	N ⁺	e ⁻	2.1e+00	0.00	0.0
1079	N	NH	N ₂	H	5.0e-11	0.10	0.0
1080	N	oNH ₂	H	H	1.2e-10	0.00	0.0
1081	N	pNH ₂	H	H	1.2e-10	0.00	0.0
1082	N ⁺	HD	ND ⁺	H	4.2e-10	0.00	0.0
1083	N ₂ ⁺	oH ₂	N ₂ H ⁺	H	2.0e-09	0.24	0.0
1084	N ₂ ⁺	pH ₂	N ₂ H ⁺	H	2.0e-09	0.24	0.0
1085	NH ⁺	oH ₂	oNH ₂ ⁺	H	1.1e-09	0.00	0.0
1086	NH ⁺	oH ₂	pNH ₂ ⁺	H	2.1e-10	0.00	0.0
1087	NH ⁺	pH ₂	oNH ₂ ⁺	H	6.4e-10	0.00	0.0
1088	NH ⁺	pH ₂	pNH ₂ ⁺	H	6.4e-10	0.00	0.0
1089	NH ⁺	oH ₂	oH ₃ ⁺	N	1.5e-10	0.00	0.0
1090	NH ⁺	oH ₂	pH ₃ ⁺	N	7.5e-11	0.00	0.0
1091	NH ⁺	pH ₂	pH ₃ ⁺	N	2.2e-10	0.00	0.0
1092	NH ⁺	H	oH ₂	N ⁺	4.9e-10	0.00	0.0
1093	NH ⁺	H	pH ₂	N ⁺	1.6e-10	0.00	0.0
1094	N ₂ H ⁺	oNH ₃	mNH ₄ ⁺	N ₂	1.4e-09	0.00	0.0
1095	N ₂ H ⁺	oNH ₃	oNH ₄ ⁺	N ₂	8.6e-10	0.00	0.0
1096	N ₂ H ⁺	pNH ₃	pNH ₄ ⁺	N ₂	5.7e-10	0.00	0.0
1097	N ₂ H ⁺	pNH ₃	oNH ₄ ⁺	N ₂	1.7e-09	0.00	0.0
1098	N ₂ H ⁺	D	N ₂ D ⁺	H	1.0e-09	0.00	0.0
1099	oNH ₂ ⁺	oH ₂	oNH ₃ ⁺	H	1.8e-10	0.00	0.0
1100	oNH ₂ ⁺	oH ₂	pNH ₃ ⁺	H	9.0e-11	0.00	0.0
1101	oNH ₂ ⁺	pH ₂	oNH ₃ ⁺	H	9.0e-11	0.00	0.0
1102	oNH ₂ ⁺	pH ₂	pNH ₃ ⁺	H	1.8e-10	0.00	0.0
1103	pNH ₂ ⁺	oH ₂	oNH ₃ ⁺	H	9.0e-11	0.00	0.0
1104	pNH ₂ ⁺	oH ₂	pNH ₃ ⁺	H	1.8e-10	0.00	0.0
1105	pNH ₂ ⁺	pH ₂	pNH ₃ ⁺	H	2.7e-10	0.00	0.0
1106	oNH ₃ ⁺	oH ₂	mNH ₄ ⁺	H	1.4e-12	0.00	0.0
1107	oNH ₃ ⁺	oH ₂	pNH ₄ ⁺	H	1.6e-13	0.00	0.0
1108	oNH ₃ ⁺	oH ₂	oNH ₄ ⁺	H	8.4e-13	0.00	0.0
1109	oNH ₃ ⁺	pH ₂	mNH ₄ ⁺	H	6.0e-13	0.00	0.0
1110	oNH ₃ ⁺	pH ₂	oNH ₄ ⁺	H	1.8e-12	0.00	0.0

Table D6 – continued (part 16)

#	Reactants		Products		α	β	γ
1111	pNH ₄ ⁺	oH ₂	mNH ₄ ⁺	H	4.0e-13	0.00	0.0
1112	pNH ₄ ⁺	oH ₂	pNH ₄ ⁺	H	3.2e-13	0.00	0.0
1113	pNH ₃ ⁺	oH ₂	oNH ₄ ⁺	H	1.7e-12	0.00	0.0
1114	pNH ₃ ⁺	pH ₂	pNH ₄ ⁺	H	9.6e-13	0.00	0.0
1115	pNH ₃ ⁺	pH ₂	oNH ₄ ⁺	H	1.4e-12	0.00	0.0
1116	ND ⁺	oH ₂	NHD ⁺	H	1.3e-09	0.00	0.0
1117	ND ⁺	pH ₂	NHD ⁺	H	1.3e-09	0.00	0.0
1118	ND ⁺	oH ₂	oH ₂ D ⁺	N	2.2e-10	0.00	0.0
1119	ND ⁺	pH ₂	pH ₂ D ⁺	N	2.2e-10	0.00	0.0
1120	ND ⁺	HD	NHD ⁺	D	6.3e-10	0.00	0.0
1121	ND ⁺	HD	oND ₂ ⁺	H	4.2e-10	0.00	0.0
1122	ND ⁺	HD	pND ₂ ⁺	H	2.1e-10	0.00	0.0
1123	N ₂ D ⁺	H	N ₂ H ⁺	D	1.0e-09	0.00	170.0
1124	N ₂ D ⁺	oNH ₃	oNH ₃ D ⁺	N ₂	2.3e-09	0.00	0.0
1125	N ₂ D ⁺	pNH ₃	pNH ₃ D ⁺	N ₂	2.3e-09	0.00	0.0
1126	NHD ⁺	oH ₂	oNH ₂ D ⁺	H	2.2e-10	0.00	0.0
1127	NHD ⁺	oH ₂	pNH ₂ D ⁺	H	4.5e-11	0.00	0.0
1128	NHD ⁺	pH ₂	oNH ₂ D ⁺	H	1.3e-10	0.00	0.0
1129	NHD ⁺	pH ₂	pNH ₂ D ⁺	H	1.3e-10	0.00	0.0
1130	NHD ⁺	HD	oNH ₂ D ⁺	D	1.0e-10	0.00	0.0
1131	NHD ⁺	HD	pNH ₂ D ⁺	D	3.4e-11	0.00	0.0
1132	NHD ⁺	HD	oNHD ₂ ⁺	H	9.0e-11	0.00	0.0
1133	NHD ⁺	HD	pNHD ₂ ⁺	H	4.5e-11	0.00	0.0
1134	oND ₂ ⁺	oH ₂	oNHD ₂ ⁺	H	2.7e-10	0.00	0.0
1135	pND ₂ ⁺	oH ₂	pNHD ₂ ⁺	H	2.7e-10	0.00	0.0
1136	oND ₂ ⁺	pH ₂	oNHD ₂ ⁺	H	2.7e-10	0.00	0.0
1137	pND ₂ ⁺	pH ₂	pNHD ₂ ⁺	H	2.7e-10	0.00	0.0
1138	oND ₂ ⁺	HD	oNHD ₂ ⁺	D	1.0e-10	0.00	0.0
1139	oND ₂ ⁺	HD	pNHD ₂ ⁺	D	3.0e-11	0.00	0.0
1140	pND ₂ ⁺	HD	oNHD ₂ ⁺	D	6.0e-11	0.00	0.0
1141	pND ₂ ⁺	HD	pNHD ₂ ⁺	D	7.5e-11	0.00	0.0
1142	oND ₃ ⁺	HD	mND ₃ ⁺	H	7.5e-11	0.00	0.0
1143	oND ₃ ⁺	HD	oND ₃ ⁺	H	6.0e-11	0.00	0.0
1144	pND ₃ ⁺	HD	pND ₃ ⁺	H	1.5e-11	0.00	0.0
1145	pND ₂ ⁺	HD	oND ₃ ⁺	H	1.2e-10	0.00	0.0
1146	oNH ₂ D ⁺	oH ₂	oNH ₃ D ⁺	H	1.6e-12	0.00	0.0
1147	oNH ₂ D ⁺	oH ₂	pNH ₃ D ⁺	H	8.0e-13	0.00	0.0
1148	oNH ₂ D ⁺	pH ₂	oNH ₃ D ⁺	H	8.0e-13	0.00	0.0
1149	oNH ₂ D ⁺	pH ₂	pNH ₃ D ⁺	H	1.6e-12	0.00	0.0
1150	pNH ₂ D ⁺	oH ₂	oNH ₃ D ⁺	H	8.0e-13	0.00	0.0
1151	pNH ₂ D ⁺	oH ₂	pNH ₃ D ⁺	H	1.6e-12	0.00	0.0
1152	pNH ₂ D ⁺	pH ₂	pNH ₃ D ⁺	H	2.4e-12	0.00	0.0
1153	oNH ₂ D ⁺	HD	oNH ₃ D ⁺	D	8.0e-13	0.00	0.0
1154	oNH ₂ D ⁺	HD	pNH ₃ D ⁺	D	4.0e-13	0.00	0.0
1155	pNH ₂ D ⁺	HD	pNH ₃ D ⁺	D	1.2e-12	0.00	0.0
1156	oNH ₂ D ⁺	HD	ooNH ₂ D ₂ ⁺	H	6.7e-13	0.00	0.0
1157	oNH ₂ D ⁺	HD	poNH ₂ D ₂ ⁺	H	3.3e-13	0.00	0.0
1158	oNH ₂ D ⁺	HD	opNH ₂ D ₂ ⁺	H	1.3e-13	0.00	0.0
1159	oNH ₂ D ⁺	HD	ppNH ₂ D ₂ ⁺	H	6.7e-14	0.00	0.0
1160	pNH ₂ D ⁺	HD	ooNH ₂ D ₂ ⁺	H	4.0e-13	0.00	0.0
1161	pNH ₂ D ⁺	HD	poNH ₂ D ₂ ⁺	H	2.0e-13	0.00	0.0
1162	pNH ₂ D ⁺	HD	opNH ₂ D ₂ ⁺	H	4.0e-13	0.00	0.0
1163	pNH ₂ D ⁺	HD	ppNH ₂ D ₂ ⁺	H	2.0e-13	0.00	0.0
1164	oNHD ₂ ⁺	oH ₂	ooNH ₂ D ₂ ⁺	H	2.0e-12	0.00	0.0
1165	pNHD ₂ ⁺	oH ₂	poNH ₂ D ₂ ⁺	H	2.0e-12	0.00	0.0
1166	oNHD ₂ ⁺	oH ₂	opNH ₂ D ₂ ⁺	H	4.0e-13	0.00	0.0
1167	pNHD ₂ ⁺	oH ₂	ppNH ₂ D ₂ ⁺	H	4.0e-13	0.00	0.0
1168	oNHD ₂ ⁺	pH ₂	ooNH ₂ D ₂ ⁺	H	1.2e-12	0.00	0.0
1169	pNHD ₂ ⁺	pH ₂	poNH ₂ D ₂ ⁺	H	1.2e-12	0.00	0.0
1170	oNHD ₂ ⁺	pH ₂	opNH ₂ D ₂ ⁺	H	1.2e-12	0.00	0.0
1171	pNHD ₂ ⁺	pH ₂	ppNH ₂ D ₂ ⁺	H	1.2e-12	0.00	0.0
1172	oNHD ₂ ⁺	HD	ooNH ₂ D ₂ ⁺	D	7.0e-13	0.00	0.0
1173	oNHD ₂ ⁺	HD	poNH ₂ D ₂ ⁺	D	2.0e-13	0.00	0.0
1174	pNHD ₂ ⁺	HD	ooNH ₂ D ₂ ⁺	D	4.0e-13	0.00	0.0
1175	pNHD ₂ ⁺	HD	poNH ₂ D ₂ ⁺	D	5.0e-13	0.00	0.0
1176	oNHD ₂ ⁺	HD	opNH ₂ D ₂ ⁺	D	2.3e-13	0.00	0.0
1177	oNHD ₂ ⁺	HD	ppNH ₂ D ₂ ⁺	D	6.7e-14	0.00	0.0
1178	pNHD ₂ ⁺	HD	opNH ₂ D ₂ ⁺	D	1.3e-13	0.00	0.0
1179	pNHD ₂ ⁺	HD	ppNH ₂ D ₂ ⁺	D	1.7e-13	0.00	0.0
1180	oNHD ₃ ⁺	HD	mNHD ₃ ⁺	H	6.7e-13	0.00	0.0
1181	oNHD ₃ ⁺	HD	oNHD ₃ ⁺	H	5.3e-13	0.00	0.0
1182	pNHD ₃ ⁺	HD	pNHD ₃ ⁺	H	1.3e-13	0.00	0.0
1183	pNHD ₂ ⁺	HD	oNHD ₃ ⁺	H	1.1e-12	0.00	0.0
1184	mND ₃ ⁺	oH ₂	mNHD ₃ ⁺	H	2.4e-12	0.00	0.0

Table D6 – *continued* (part 17)

#	Reactants		Products		α	β	γ
1185	pND ₂ ⁺	oH ₂	pNHD ₃ ⁺	H	2.4e-12	0.00	0.0
1186	oND ₃ ⁺	oH ₂	oNHD ₃ ⁺	H	2.4e-12	0.00	0.0
1187	mND ₃ ⁺	pH ₂	mNHD ₃ ⁺	H	2.4e-12	0.00	0.0
1188	pND ₃ ⁺	pH ₂	pNHD ₃ ⁺	H	2.4e-12	0.00	0.0
1189	oND ₃ ⁺	pH ₂	oNHD ₃ ⁺	H	2.4e-12	0.00	0.0
1190	mND ₃ ⁺	HD	mNHD ₃ ⁺	D	8.0e-13	0.00	0.0
1191	mND ₃ ⁺	HD	oNHD ₃ ⁺	D	4.0e-13	0.00	0.0
1192	pND ₃ ⁺	HD	pNHD ₃ ⁺	D	4.0e-13	0.00	0.0
1193	pND ₃ ⁺	HD	oNHD ₃ ⁺	D	8.0e-13	0.00	0.0
1194	oND ₃ ⁺	HD	mNHD ₃ ⁺	D	2.5e-13	0.00	0.0
1195	oND ₃ ⁺	HD	pNHD ₃ ⁺	D	5.0e-14	0.00	0.0
1196	oND ₃ ⁺	HD	oNHD ₃ ⁺	D	9.0e-13	0.00	0.0
1197	mND ₃ ⁺	HD	IND ₄ ⁺	H	6.0e-13	0.00	0.0
1198	mND ₃ ⁺	HD	oND ₄ ⁺	H	6.0e-13	0.00	0.0
1199	pND ₃ ⁺	HD	pND ₄ ⁺	H	1.2e-12	0.00	0.0
1200	oND ₃ ⁺	HD	mND ₄ ⁺	H	3.0e-13	0.00	0.0
1201	oND ₃ ⁺	HD	oND ₄ ⁺	H	7.5e-13	0.00	0.0
1202	oND ₃ ⁺	HD	pND ₄ ⁺	H	1.5e-13	0.00	0.0
1203	N	oH ₃ ⁺	oNH ₂ ⁺	H	0.0e+00	0.00	0.0
1204	N	pH ₃ ⁺	oNH ₂ ⁺	H	0.0e+00	0.00	0.0
1205	N	pH ₃ ⁺	pNH ₂ ⁺	H	0.0e+00	0.00	0.0
1206	N ₂	oH ₃ ⁺	oH ₂	N ₂ H ⁺	1.3e-09	0.00	0.0
1207	N ₂	pH ₃ ⁺	oH ₂	N ₂ H ⁺	6.5e-10	0.00	0.0
1208	N ₂	pH ₃ ⁺	pH ₂	N ₂ H ⁺	6.5e-10	0.00	0.0
1209	NH	He ⁺	N ⁺	H	1.1e-09	0.00	0.0
1210	NH	H ⁺	NH ⁺	H	2.1e-09	0.00	0.0
1211	NH	oH ₃ ⁺	oNH ₂ ⁺	oH ₂	9.8e-10	0.00	0.0
1212	NH	oH ₃ ⁺	oNH ₂ ⁺	pH ₂	1.6e-10	0.00	0.0
1213	NH	oH ₃ ⁺	pNH ₂ ⁺	oH ₂	1.6e-10	0.00	0.0
1214	NH	pH ₃ ⁺	oNH ₂ ⁺	oH ₂	4.9e-10	0.00	0.0
1215	NH	pH ₃ ⁺	oNH ₂ ⁺	pH ₂	3.3e-10	0.00	0.0
1216	NH	pH ₃ ⁺	pNH ₂ ⁺	oH ₂	3.3e-10	0.00	0.0
1217	NH	pH ₃ ⁺	pNH ₂ ⁺	pH ₂	1.6e-10	0.00	0.0
1218	oNH ₂	He ⁺	NH ⁺	H	8.0e-10	0.00	0.0
1219	pNH ₂	He ⁺	NH ⁺	H	8.0e-10	0.00	0.0
1220	oNH ₂	He ⁺	oH ₂	N ⁺	8.0e-10	0.00	0.0
1221	pNH ₂	He ⁺	pH ₂	N ⁺	8.0e-10	0.00	0.0
1222	oNH ₂	H ⁺	oNH ₂ ⁺	H	2.9e-09	0.00	0.0
1223	pNH ₂	H ⁺	pNH ₂ ⁺	H	2.9e-09	0.00	0.0
1224	oNH ₂	oH ₃ ⁺	oNH ₃ ⁺	oH ₂	1.1e-09	0.00	0.0
1225	oNH ₂	oH ₃ ⁺	oNH ₃ ⁺	pH ₂	1.5e-10	0.00	0.0
1226	oNH ₂	oH ₃ ⁺	pNH ₃ ⁺	oH ₂	4.2e-10	0.00	0.0
1227	oNH ₂	oH ₃ ⁺	pNH ₃ ⁺	pH ₂	1.2e-10	0.00	0.0
1228	pNH ₂	oH ₃ ⁺	oNH ₃ ⁺	oH ₂	4.5e-10	0.00	0.0
1229	pNH ₂	oH ₃ ⁺	oNH ₃ ⁺	pH ₂	4.5e-10	0.00	0.0
1230	pNH ₂	oH ₃ ⁺	pNH ₃ ⁺	oH ₂	9.0e-10	0.00	0.0
1231	oNH ₂	pH ₃ ⁺	oNH ₃ ⁺	oH ₂	4.2e-10	0.00	0.0
1232	oNH ₂	pH ₃ ⁺	oNH ₃ ⁺	pH ₂	3.0e-10	0.00	0.0
1233	oNH ₂	pH ₃ ⁺	pNH ₃ ⁺	oH ₂	8.4e-10	0.00	0.0
1234	oNH ₂	pH ₃ ⁺	pNH ₃ ⁺	pH ₂	2.4e-10	0.00	0.0
1235	pNH ₂	pH ₃ ⁺	oNH ₃ ⁺	oH ₂	3.6e-10	0.00	0.0
1236	pNH ₂	pH ₃ ⁺	pNH ₃ ⁺	oH ₂	7.2e-10	0.00	0.0
1237	pNH ₂	pH ₃ ⁺	pNH ₃ ⁺	pH ₂	7.2e-10	0.00	0.0
1238	oNH ₃	He ⁺	oNH ₃ ⁺	He	2.6e-10	0.00	0.0
1239	pNH ₃	He ⁺	pNH ₃ ⁺	He	2.6e-10	0.00	0.0
1240	oNH ₃	He ⁺	oNH ₂ ⁺	H	1.8e-09	0.00	0.0
1241	pNH ₃	He ⁺	oNH ₂ ⁺	H	8.8e-10	0.00	0.0
1242	pNH ₃	He ⁺	pNH ₂ ⁺	H	8.8e-10	0.00	0.0
1243	oNH ₃	He ⁺	oH ₂	NH ⁺	1.8e-10	0.00	0.0
1244	pNH ₃	He ⁺	oH ₂	NH ⁺	8.8e-11	0.00	0.0
1245	pNH ₃	He ⁺	pH ₂	NH ⁺	8.8e-11	0.00	0.0
1246	oNH ₃	H ⁺	oNH ₃ ⁺	H	5.2e-09	0.00	0.0
1247	pNH ₃	H ⁺	pNH ₃ ⁺	H	5.2e-09	0.00	0.0
1248	oNH ₃	oH ₃ ⁺	mNH ₄ ⁺	oH ₂	4.7e-09	0.00	0.0
1249	oNH ₃	oH ₃ ⁺	mNH ₄ ⁺	pH ₂	5.7e-10	0.00	0.0
1250	oNH ₃	oH ₃ ⁺	pNH ₄ ⁺	oH ₂	3.8e-10	0.00	0.0
1251	oNH ₃	oH ₃ ⁺	pNH ₄ ⁺	pH ₂	2.3e-10	0.00	0.0
1252	oNH ₃	oH ₃ ⁺	oNH ₄ ⁺	oH ₂	2.6e-09	0.00	0.0
1253	oNH ₃	oH ₃ ⁺	oNH ₄ ⁺	pH ₂	5.7e-10	0.00	0.0
1254	oNH ₃	pH ₃ ⁺	mNH ₄ ⁺	oH ₂	1.5e-09	0.00	0.0
1255	oNH ₃	pH ₃ ⁺	mNH ₄ ⁺	pH ₂	1.1e-09	0.00	0.0
1256	oNH ₃	pH ₃ ⁺	pNH ₄ ⁺	oH ₂	7.6e-10	0.00	0.0
1257	oNH ₃	pH ₃ ⁺	oNH ₄ ⁺	oH ₂	4.6e-09	0.00	0.0
1258	oNH ₃	pH ₃ ⁺	oNH ₄ ⁺	pH ₂	1.1e-09	0.00	0.0

Table D6 – continued (part 18)

#	Reactants	Products	α	β	γ
1259	pNH ₃ oH ₃ ⁺	mNH ₄ ⁺ oH ₂	1.5e-09	0.00	0.0
1260	pNH ₃ oH ₃ ⁺	mNH ₄ ⁺ pH ₂	1.1e-09	0.00	0.0
1261	pNH ₃ oH ₃ ⁺	pNH ₄ ⁺ oH ₂	7.6e-10	0.00	0.0
1262	pNH ₃ oH ₃ ⁺	oNH ₄ ⁺ oH ₂	4.6e-09	0.00	0.0
1263	pNH ₃ oH ₃ ⁺	oNH ₄ ⁺ pH ₂	1.1e-09	0.00	0.0
1264	pNH ₃ pH ₃ ⁺	mNH ₄ ⁺ oH ₂	7.6e-10	0.00	0.0
1265	pNH ₃ pH ₃ ⁺	pNH ₄ ⁺ oH ₂	1.5e-09	0.00	0.0
1266	pNH ₃ pH ₃ ⁺	pNH ₄ ⁺ pH ₂	9.1e-10	0.00	0.0
1267	pNH ₃ pH ₃ ⁺	oNH ₄ ⁺ oH ₂	3.6e-09	0.00	0.0
1268	pNH ₃ pH ₃ ⁺	oNH ₄ ⁺ pH ₂	2.3e-09	0.00	0.0
1269	NH oH ₂ D ⁺	oNH ₂ ⁺ HD	7.2e-10	0.00	0.0
1270	NH oH ₂ D ⁺	pNH ₂ ⁺ HD	1.4e-10	0.00	0.0
1271	NH pH ₂ D ⁺	oNH ₂ ⁺ HD	4.3e-10	0.00	0.0
1272	NH pH ₂ D ⁺	pNH ₂ ⁺ HD	4.3e-10	0.00	0.0
1273	NH oH ₂ D ⁺	oH ₂ NHD ⁺	3.6e-10	0.00	0.0
1274	NH oH ₂ D ⁺	pH ₂ NHD ⁺	7.2e-11	0.00	0.0
1275	NH pH ₂ D ⁺	oH ₂ NHD ⁺	2.2e-10	0.00	0.0
1276	NH pH ₂ D ⁺	pH ₂ NHD ⁺	2.2e-10	0.00	0.0
1277	NH oHD ₂ ⁺	oD ₂ oNH ₂ ⁺	3.2e-10	0.00	0.0
1278	NH pHD ₂ ⁺	pD ₂ oNH ₂ ⁺	3.2e-10	0.00	0.0
1279	NH oHD ₂ ⁺	oD ₂ pNH ₂ ⁺	1.1e-10	0.00	0.0
1280	NH pHD ₂ ⁺	pD ₂ pNH ₂ ⁺	1.1e-10	0.00	0.0
1281	NH oHD ₂ ⁺	NHD ⁺ HD	8.7e-10	0.00	0.0
1282	NH pHD ₂ ⁺	NHD ⁺ HD	8.7e-10	0.00	0.0
1283	NH mD ₃ ⁺	oD ₂ NHD ⁺	1.3e-09	0.00	0.0
1284	NH pD ₃ ⁺	pD ₂ NHD ⁺	1.3e-09	0.00	0.0
1285	NH oD ₃ ⁺	oD ₂ NHD ⁺	6.5e-10	0.00	0.0
1286	NH oD ₃ ⁺	pD ₂ NHD ⁺	6.5e-10	0.00	0.0
1287	oNH ₂ oH ₂ D ⁺	oNH ₃ ⁺ HD	8.0e-10	0.00	0.0
1288	oNH ₂ oH ₂ D ⁺	pNH ₃ ⁺ HD	4.0e-10	0.00	0.0
1289	oNH ₂ pH ₂ D ⁺	oNH ₃ ⁺ HD	4.0e-10	0.00	0.0
1290	oNH ₂ pH ₂ D ⁺	pNH ₃ ⁺ HD	8.0e-10	0.00	0.0
1291	pNH ₂ oH ₂ D ⁺	oNH ₃ ⁺ HD	4.0e-10	0.00	0.0
1292	pNH ₂ oH ₂ D ⁺	pNH ₃ ⁺ HD	8.0e-10	0.00	0.0
1293	pNH ₂ pH ₂ D ⁺	pNH ₃ ⁺ HD	1.2e-09	0.00	0.0
1294	oNH ₂ oH ₂ D ⁺	oNH ₂ D ⁺ oH ₂	4.3e-10	0.00	0.0
1295	oNH ₂ oH ₂ D ⁺	oNH ₂ D ⁺ pH ₂	6.7e-11	0.00	0.0
1296	oNH ₂ oH ₂ D ⁺	pNH ₂ D ⁺ oH ₂	6.7e-11	0.00	0.0
1297	oNH ₂ oH ₂ D ⁺	pNH ₂ D ⁺ pH ₂	3.3e-11	0.00	0.0
1298	oNH ₂ pH ₂ D ⁺	oNH ₂ D ⁺ oH ₂	2.0e-10	0.00	0.0
1299	oNH ₂ pH ₂ D ⁺	oNH ₂ D ⁺ pH ₂	2.0e-10	0.00	0.0
1300	oNH ₂ pH ₂ D ⁺	pNH ₂ D ⁺ oH ₂	2.0e-10	0.00	0.0
1301	pNH ₂ oH ₂ D ⁺	oNH ₂ D ⁺ oH ₂	2.0e-10	0.00	0.0
1302	pNH ₂ oH ₂ D ⁺	oNH ₂ D ⁺ pH ₂	2.0e-10	0.00	0.0
1303	pNH ₂ oH ₂ D ⁺	pNH ₂ D ⁺ oH ₂	2.0e-10	0.00	0.0
1304	pNH ₂ pH ₂ D ⁺	oNH ₂ D ⁺ oH ₂	3.0e-10	0.00	0.0
1305	pNH ₂ pH ₂ D ⁺	pNH ₂ D ⁺ pH ₂	3.0e-10	0.00	0.0
1306	oNH ₂ oHD ₂ ⁺	oD ₂ oNH ₃ ⁺	4.0e-10	0.00	0.0
1307	oNH ₂ pHD ₂ ⁺	pD ₂ oNH ₃ ⁺	4.0e-10	0.00	0.0
1308	oNH ₂ oHD ₂ ⁺	oD ₂ pNH ₃ ⁺	2.0e-10	0.00	0.0
1309	oNH ₂ pHD ₂ ⁺	pD ₂ pNH ₃ ⁺	2.0e-10	0.00	0.0
1310	pNH ₂ oHD ₂ ⁺	oD ₂ pNH ₃ ⁺	6.0e-10	0.00	0.0
1311	pNH ₂ pHD ₂ ⁺	pD ₂ pNH ₃ ⁺	6.0e-10	0.00	0.0
1312	oNH ₂ oHD ₂ ⁺	oNH ₂ D ⁺ HD	1.0e-09	0.00	0.0
1313	oNH ₂ pHD ₂ ⁺	oNH ₂ D ⁺ HD	1.0e-09	0.00	0.0
1314	oNH ₂ oHD ₂ ⁺	pNH ₂ D ⁺ HD	2.0e-10	0.00	0.0
1315	oNH ₂ pHD ₂ ⁺	pNH ₂ D ⁺ HD	2.0e-10	0.00	0.0
1316	pNH ₂ oHD ₂ ⁺	oNH ₂ D ⁺ HD	6.0e-10	0.00	0.0
1317	pNH ₂ pHD ₂ ⁺	oNH ₂ D ⁺ HD	6.0e-10	0.00	0.0
1318	pNH ₂ oHD ₂ ⁺	pNH ₂ D ⁺ HD	6.0e-10	0.00	0.0
1319	pNH ₂ pHD ₂ ⁺	pNH ₂ D ⁺ HD	6.0e-10	0.00	0.0
1320	oNH ₂ mD ₃ ⁺	oD ₂ oNH ₂ D ⁺	1.8e-09	0.00	0.0
1321	oNH ₂ pD ₃ ⁺	pD ₂ oNH ₂ D ⁺	1.8e-09	0.00	0.0
1322	oNH ₂ oD ₃ ⁺	oD ₂ oNH ₂ D ⁺	9.0e-10	0.00	0.0
1323	oNH ₂ oD ₃ ⁺	pD ₂ oNH ₂ D ⁺	9.0e-10	0.00	0.0
1324	pNH ₂ mD ₃ ⁺	oD ₂ pNH ₂ D ⁺	1.8e-09	0.00	0.0
1325	pNH ₂ pD ₃ ⁺	pD ₂ pNH ₂ D ⁺	1.8e-09	0.00	0.0
1326	pNH ₂ oD ₃ ⁺	oD ₂ pNH ₂ D ⁺	9.0e-10	0.00	0.0
1327	pNH ₂ oD ₃ ⁺	pD ₂ pNH ₂ D ⁺	9.0e-10	0.00	0.0
1328	oNH ₃ oH ₂ D ⁺	mNH ₄ ⁺ HD	3.5e-09	0.00	0.0
1329	oNH ₃ oH ₂ D ⁺	pNH ₄ ⁺ HD	4.0e-10	0.00	0.0
1330	oNH ₃ oH ₂ D ⁺	oNH ₄ ⁺ HD	2.1e-09	0.00	0.0
1331	oNH ₃ pH ₂ D ⁺	mNH ₄ ⁺ HD	1.5e-09	0.00	0.0
1332	oNH ₃ pH ₂ D ⁺	oNH ₄ ⁺ HD	4.5e-09	0.00	0.0

Table D6 – continued (part 19)

#	Reactants	Products	α	β	γ
1333	pNH ₃ oH ₂ D ⁺	mNH ₄ ⁺ HD	1.0e-09	0.00	0.0
1334	pNH ₃ oH ₂ D ⁺	pNH ₄ ⁺ HD	8.1e-10	0.00	0.0
1335	pNH ₃ oH ₂ D ⁺	oNH ₄ ⁺ HD	4.2e-09	0.00	0.0
1336	pNH ₃ pH ₂ D ⁺	pNH ₄ ⁺ HD	2.4e-09	0.00	0.0
1337	pNH ₃ pH ₂ D ⁺	oNH ₄ ⁺ HD	3.6e-09	0.00	0.0
1338	oNH ₃ oH ₂ D ⁺	oNH ₃ D ⁺ oH ₂	1.9e-09	0.00	0.0
1339	oNH ₃ oH ₂ D ⁺	oNH ₃ D ⁺ pH ₂	2.5e-10	0.00	0.0
1340	oNH ₃ oH ₂ D ⁺	pNH ₃ D ⁺ oH ₂	7.1e-10	0.00	0.0
1341	oNH ₃ oH ₂ D ⁺	pNH ₃ D ⁺ pH ₂	2.0e-10	0.00	0.0
1342	oNH ₃ pH ₂ D ⁺	oNH ₃ D ⁺ oH ₂	7.6e-10	0.00	0.0
1343	oNH ₃ pH ₂ D ⁺	oNH ₃ D ⁺ pH ₂	7.6e-10	0.00	0.0
1344	oNH ₃ pH ₂ D ⁺	pNH ₃ D ⁺ oH ₂	1.5e-09	0.00	0.0
1345	pNH ₃ oH ₂ D ⁺	oNH ₃ D ⁺ oH ₂	7.1e-10	0.00	0.0
1346	pNH ₃ oH ₂ D ⁺	oNH ₃ D ⁺ pH ₂	5.1e-10	0.00	0.0
1347	pNH ₃ oH ₂ D ⁺	pNH ₃ D ⁺ oH ₂	1.4e-09	0.00	0.0
1348	pNH ₃ oH ₂ D ⁺	pNH ₃ D ⁺ pH ₂	4.0e-10	0.00	0.0
1349	pNH ₃ pH ₂ D ⁺	oNH ₃ D ⁺ oH ₂	6.1e-10	0.00	0.0
1350	pNH ₃ pH ₂ D ⁺	pNH ₃ D ⁺ oH ₂	1.2e-09	0.00	0.0
1351	pNH ₃ pH ₂ D ⁺	pNH ₃ D ⁺ pH ₂	1.2e-09	0.00	0.0
1352	oNH ₃ oHD ₂ ⁺	oD ₂ mNH ₄ ⁺	1.9e-09	0.00	0.0
1353	oNH ₃ pHD ₂ ⁺	pD ₂ mNH ₄ ⁺	1.9e-09	0.00	0.0
1354	oNH ₃ oHD ₂ ⁺	oD ₂ oNH ₄ ⁺	1.1e-09	0.00	0.0
1355	oNH ₃ pHD ₂ ⁺	pD ₂ oNH ₄ ⁺	1.1e-09	0.00	0.0
1356	pNH ₃ oHD ₂ ⁺	oD ₂ pNH ₄ ⁺	7.6e-10	0.00	0.0
1357	pNH ₃ pHD ₂ ⁺	pD ₂ pNH ₄ ⁺	7.6e-10	0.00	0.0
1358	pNH ₃ oHD ₂ ⁺	oD ₂ oNH ₄ ⁺	2.3e-09	0.00	0.0
1359	pNH ₃ pHD ₂ ⁺	pD ₂ oNH ₄ ⁺	2.3e-09	0.00	0.0
1360	oNH ₃ oHD ₂ ⁺	oNH ₃ D ⁺ HD	4.5e-09	0.00	0.0
1361	oNH ₃ pHD ₂ ⁺	oNH ₃ D ⁺ HD	4.5e-09	0.00	0.0
1362	oNH ₃ oHD ₂ ⁺	pNH ₃ D ⁺ HD	1.5e-09	0.00	0.0
1363	oNH ₃ pHD ₂ ⁺	pNH ₃ D ⁺ HD	1.5e-09	0.00	0.0
1364	pNH ₃ oHD ₂ ⁺	oNH ₃ D ⁺ HD	1.5e-09	0.00	0.0
1365	pNH ₃ pHD ₂ ⁺	oNH ₃ D ⁺ HD	1.5e-09	0.00	0.0
1366	pNH ₃ oHD ₂ ⁺	pNH ₃ D ⁺ HD	4.5e-09	0.00	0.0
1367	pNH ₃ pHD ₂ ⁺	pNH ₃ D ⁺ HD	4.5e-09	0.00	0.0
1368	oNH ₃ mD ₃ ⁺	oD ₂ oNH ₃ D ⁺	9.1e-09	0.00	0.0
1369	oNH ₃ pD ₃ ⁺	pD ₂ oNH ₃ D ⁺	9.1e-09	0.00	0.0
1370	oNH ₃ oD ₃ ⁺	oD ₂ oNH ₃ D ⁺	4.6e-09	0.00	0.0
1371	oNH ₃ oD ₃ ⁺	pD ₂ oNH ₃ D ⁺	4.6e-09	0.00	0.0
1372	pNH ₃ mD ₃ ⁺	oD ₂ pNH ₃ D ⁺	9.1e-09	0.00	0.0
1373	pNH ₃ pD ₃ ⁺	pD ₂ pNH ₃ D ⁺	9.1e-09	0.00	0.0
1374	pNH ₃ oD ₃ ⁺	oD ₂ pNH ₃ D ⁺	4.6e-09	0.00	0.0
1375	pNH ₃ oD ₃ ⁺	pD ₂ pNH ₃ D ⁺	4.6e-09	0.00	0.0
1376	ND oH ₃ ⁺	oH ₂ NHD ⁺	1.3e-09	0.00	0.0
1377	ND pH ₃ ⁺	oH ₂ NHD ⁺	6.5e-10	0.00	0.0
1378	ND pH ₃ ⁺	pH ₂ NHD ⁺	6.5e-10	0.00	0.0
1379	ND oH ₂ D ⁺	NHD ⁺ HD	8.7e-10	0.00	0.0
1380	ND pH ₂ D ⁺	NHD ⁺ HD	8.7e-10	0.00	0.0
1381	ND oH ₂ D ⁺	oND ₂ ⁺ oH ₂	2.9e-10	0.00	0.0
1382	ND oH ₂ D ⁺	pND ₂ ⁺ oH ₂	1.4e-10	0.00	0.0
1383	ND pH ₂ D ⁺	oND ₂ ⁺ pH ₂	2.9e-10	0.00	0.0
1384	ND pH ₂ D ⁺	pND ₂ ⁺ pH ₂	1.4e-10	0.00	0.0
1385	ND oHD ₂ ⁺	oD ₂ NHD ⁺	3.4e-10	0.00	0.0
1386	ND oHD ₂ ⁺	pD ₂ NHD ⁺	9.6e-11	0.00	0.0
1387	ND pHD ₂ ⁺	oD ₂ NHD ⁺	1.9e-10	0.00	0.0
1388	ND pHD ₂ ⁺	pD ₂ NHD ⁺	2.4e-10	0.00	0.0
1389	ND oHD ₂ ⁺	oND ₂ ⁺ HD	6.7e-10	0.00	0.0
1390	ND oHD ₂ ⁺	pND ₂ ⁺ HD	1.9e-10	0.00	0.0
1391	ND pHD ₂ ⁺	oND ₂ ⁺ HD	3.9e-10	0.00	0.0
1392	ND pHD ₂ ⁺	pND ₂ ⁺ HD	4.8e-10	0.00	0.0
1393	ND mD ₃ ⁺	oND ₂ ⁺ oD ₂	8.7e-10	0.00	0.0
1394	ND mD ₃ ⁺	oND ₂ ⁺ pD ₂	2.2e-10	0.00	0.0
1395	ND mD ₃ ⁺	pND ₂ ⁺ oD ₂	2.2e-10	0.00	0.0
1396	ND pD ₃ ⁺	oND ₂ ⁺ pD ₂	4.3e-10	0.00	0.0
1397	ND pD ₃ ⁺	pND ₂ ⁺ oD ₂	4.3e-10	0.00	0.0
1398	ND pD ₃ ⁺	pND ₂ ⁺ pD ₂	4.3e-10	0.00	0.0
1399	ND oD ₃ ⁺	oND ₂ ⁺ oD ₂	4.3e-10	0.00	0.0
1400	ND oD ₃ ⁺	oND ₂ ⁺ pD ₂	3.3e-10	0.00	0.0
1401	ND oD ₃ ⁺	pND ₂ ⁺ oD ₂	3.3e-10	0.00	0.0
1402	ND oD ₃ ⁺	pND ₂ ⁺ pD ₂	2.2e-10	0.00	0.0
1403	NHD oH ₃ ⁺	oNH ₂ D ⁺ oH ₂	1.4e-09	0.00	0.0
1404	NHD oH ₃ ⁺	oNH ₂ D ⁺ pH ₂	2.2e-10	0.00	0.0
1405	NHD oH ₃ ⁺	pNH ₂ D ⁺ oH ₂	2.2e-10	0.00	0.0
1406	NHD pH ₃ ⁺	oNH ₂ D ⁺ oH ₂	6.8e-10	0.00	0.0

Table D6 – continued (part 20)

#	Reactants	Products	α	β	γ		
1407	NHD	pH_3^+	oNH_2D^+	pH_2	4.5e-10	0.00	0.0
1408	NHD	pH_3^+	pNH_2D^+	oH_2	4.5e-10	0.00	0.0
1409	NHD	pH_3^+	pNH_2D^+	pH_2	2.2e-10	0.00	0.0
1410	NHD	oH_2D^+	oNH_2D^+	HD	1.0e-09	0.00	0.0
1411	NHD	oH_2D^+	pNH_2D^+	HD	2.0e-10	0.00	0.0
1412	NHD	pH_2D^+	oNH_2D^+	HD	6.0e-10	0.00	0.0
1413	NHD	pH_2D^+	pNH_2D^+	HD	6.0e-10	0.00	0.0
1414	NHD	oH_2D^+	oNHD_2^+	oH_2	3.3e-10	0.00	0.0
1415	NHD	oH_2D^+	pNHD_2^+	oH_2	1.7e-10	0.00	0.0
1416	NHD	oH_2D^+	oNHD_2^+	pH_2	6.7e-11	0.00	0.0
1417	NHD	oH_2D^+	pNHD_2^+	pH_2	3.3e-11	0.00	0.0
1418	NHD	pH_2D^+	oNHD_2^+	oH_2	2.0e-10	0.00	0.0
1419	NHD	pH_2D^+	pNHD_2^+	oH_2	1.0e-10	0.00	0.0
1420	NHD	pH_2D^+	oNHD_2^+	pH_2	2.0e-10	0.00	0.0
1421	NHD	pH_2D^+	pNHD_2^+	pH_2	1.0e-10	0.00	0.0
1422	NHD	oHD_2^+	oD_2	oNH_2D^+	3.5e-10	0.00	0.0
1423	NHD	oHD_2^+	pD_2	oNH_2D^+	1.0e-10	0.00	0.0
1424	NHD	pHD_2^+	oD_2	oNH_2D^+	2.0e-10	0.00	0.0
1425	NHD	pHD_2^+	pD_2	oNH_2D^+	2.5e-10	0.00	0.0
1426	NHD	oHD_2^+	oD_2	pNH_2D^+	1.2e-10	0.00	0.0
1427	NHD	oHD_2^+	pD_2	pNH_2D^+	3.3e-11	0.00	0.0
1428	NHD	pHD_2^+	oD_2	pNH_2D^+	6.7e-11	0.00	0.0
1429	NHD	pHD_2^+	pD_2	pNH_2D^+	8.3e-11	0.00	0.0
1430	NHD	oHD_2^+	oNHD_2^+	HD	9.3e-10	0.00	0.0
1431	NHD	oHD_2^+	pNHD_2^+	HD	2.7e-10	0.00	0.0
1432	NHD	pHD_2^+	oNHD_2^+	HD	5.3e-10	0.00	0.0
1433	NHD	pHD_2^+	pNHD_2^+	HD	6.7e-10	0.00	0.0
1434	NHD	mD_3^+	oNHD_2^+	oD_2	1.2e-09	0.00	0.0
1435	NHD	mD_3^+	oNHD_2^+	pD_2	3.0e-10	0.00	0.0
1436	NHD	mD_3^+	pNHD_2^+	oD_2	3.0e-10	0.00	0.0
1437	NHD	pD_3^+	oNHD_2^+	pD_2	6.0e-10	0.00	0.0
1438	NHD	pD_3^+	pNHD_2^+	oD_2	6.0e-10	0.00	0.0
1439	NHD	pD_3^+	pNHD_2^+	pD_2	6.0e-10	0.00	0.0
1440	NHD	oD_3^+	oNHD_2^+	oD_2	6.0e-10	0.00	0.0
1441	NHD	oD_3^+	oNHD_2^+	pD_2	4.5e-10	0.00	0.0
1442	NHD	oD_3^+	pNHD_2^+	oD_2	4.5e-10	0.00	0.0
1443	NHD	oD_3^+	pNHD_2^+	pD_2	3.0e-10	0.00	0.0
1444	oND_2	oH_3^+	oNHD_2^+	oH_2	1.8e-09	0.00	0.0
1445	pND_2	oH_3^+	pNHD_2^+	oH_2	1.8e-09	0.00	0.0
1446	oND_2	pH_3^+	oNHD_2^+	oH_2	9.0e-10	0.00	0.0
1447	pND_2	pH_3^+	pNHD_2^+	oH_2	9.0e-10	0.00	0.0
1448	oND_2	pH_3^+	oNHD_2^+	pH_2	9.0e-10	0.00	0.0
1449	pND_2	pH_3^+	pNHD_2^+	pH_2	9.0e-10	0.00	0.0
1450	oND_2	oH_2D^+	oNHD_2^+	HD	9.3e-10	0.00	0.0
1451	oND_2	oH_2D^+	pNHD_2^+	HD	2.7e-10	0.00	0.0
1452	pND_2	oH_2D^+	oNHD_2^+	HD	5.3e-10	0.00	0.0
1453	pND_2	oH_2D^+	pNHD_2^+	HD	6.7e-10	0.00	0.0
1454	oND_2	pH_2D^+	oNHD_2^+	HD	9.3e-10	0.00	0.0
1455	oND_2	pH_2D^+	pNHD_2^+	HD	2.7e-10	0.00	0.0
1456	pND_2	pH_2D^+	oNHD_2^+	HD	5.3e-10	0.00	0.0
1457	pND_2	pH_2D^+	pNHD_2^+	HD	6.7e-10	0.00	0.0
1458	oND_2	oH_2D^+	mND_3^+	oH_2	3.3e-10	0.00	0.0
1459	oND_2	oH_2D^+	oND_3^+	oH_2	2.7e-10	0.00	0.0
1460	pND_2	oH_2D^+	pND_3^+	oH_2	6.7e-11	0.00	0.0
1461	pND_2	oH_2D^+	oND_3^+	oH_2	5.3e-10	0.00	0.0
1462	oND_2	pH_2D^+	mND_3^+	pH_2	3.3e-10	0.00	0.0
1463	oND_2	pH_2D^+	oND_3^+	pH_2	2.7e-10	0.00	0.0
1464	pND_2	pH_2D^+	pND_3^+	pH_2	6.7e-11	0.00	0.0
1465	pND_2	pH_2D^+	oND_3^+	pH_2	5.3e-10	0.00	0.0
1466	oND_2	oHD_2^+	oNHD_2^+	oD_2	3.8e-10	0.00	0.0
1467	oND_2	oHD_2^+	oNHD_2^+	pD_2	8.3e-11	0.00	0.0
1468	oND_2	oHD_2^+	pNHD_2^+	oD_2	8.3e-11	0.00	0.0
1469	oND_2	oHD_2^+	pNHD_2^+	pD_2	5.0e-11	0.00	0.0
1470	oND_2	pHD_2^+	oNHD_2^+	oD_2	1.7e-10	0.00	0.0
1471	oND_2	pHD_2^+	oNHD_2^+	pD_2	2.0e-10	0.00	0.0
1472	oND_2	pHD_2^+	pNHD_2^+	oD_2	2.0e-10	0.00	0.0
1473	oND_2	pHD_2^+	pNHD_2^+	pD_2	3.3e-11	0.00	0.0
1474	pND_2	oHD_2^+	oNHD_2^+	oD_2	1.7e-10	0.00	0.0
1475	pND_2	oHD_2^+	oNHD_2^+	pD_2	2.0e-10	0.00	0.0
1476	pND_2	oHD_2^+	pNHD_2^+	oD_2	2.0e-10	0.00	0.0
1477	pND_2	oHD_2^+	pNHD_2^+	pD_2	3.3e-11	0.00	0.0
1478	pND_2	pHD_2^+	oNHD_2^+	oD_2	2.0e-10	0.00	0.0
1479	pND_2	pHD_2^+	oNHD_2^+	pD_2	6.7e-11	0.00	0.0
1480	pND_2	pHD_2^+	pNHD_2^+	oD_2	6.7e-11	0.00	0.0

Table D6 – *continued* (part 21)

#	Reactants	Products	α	β	γ		
1481	pND ₂	pHD ₂ ⁺	pNHD ₂ ⁺	pD ₂	2.7e-10	0.00	0.0
1482	oND ₂	oHD ₂ ⁺	mND ₃ ⁺	HD	6.7e-10	0.00	0.0
1483	oND ₂	oHD ₂ ⁺	oND ₃ ⁺	HD	5.3e-10	0.00	0.0
1484	oND ₂	pHD ₂ ⁺	mND ₃ ⁺	HD	3.3e-10	0.00	0.0
1485	oND ₂	pHD ₂ ⁺	pND ₃ ⁺	HD	6.7e-11	0.00	0.0
1486	oND ₂	pHD ₂ ⁺	oND ₃ ⁺	HD	8.0e-10	0.00	0.0
1487	pND ₂	oHD ₂ ⁺	mND ₃ ⁺	HD	3.3e-10	0.00	0.0
1488	pND ₂	oHD ₂ ⁺	pND ₃ ⁺	HD	6.7e-11	0.00	0.0
1489	pND ₂	oHD ₂ ⁺	oND ₃ ⁺	HD	8.0e-10	0.00	0.0
1490	pND ₂	pHD ₂ ⁺	pND ₃ ⁺	HD	1.3e-10	0.00	0.0
1491	pND ₂	pHD ₂ ⁺	oND ₃ ⁺	HD	1.1e-09	0.00	0.0
1492	oND ₂	mD ₃ ⁺	mND ₃ ⁺	oD ₂	9.0e-10	0.00	0.0
1493	oND ₂	mD ₃ ⁺	mND ₃ ⁺	pD ₂	1.8e-10	0.00	0.0
1494	oND ₂	mD ₃ ⁺	oND ₃ ⁺	oD ₂	5.4e-10	0.00	0.0
1495	oND ₂	mD ₃ ⁺	oND ₃ ⁺	pD ₂	1.8e-10	0.00	0.0
1496	pND ₂	mD ₃ ⁺	mND ₃ ⁺	oD ₂	3.6e-10	0.00	0.0
1497	pND ₂	mD ₃ ⁺	mND ₃ ⁺	pD ₂	4.2e-10	0.00	0.0
1498	pND ₂	mD ₃ ⁺	pND ₃ ⁺	oD ₂	6.0e-11	0.00	0.0
1499	pND ₂	mD ₃ ⁺	oND ₃ ⁺	oD ₂	8.4e-10	0.00	0.0
1500	pND ₂	mD ₃ ⁺	oND ₃ ⁺	pD ₂	1.2e-10	0.00	0.0
1501	oND ₂	pD ₃ ⁺	mND ₃ ⁺	pD ₂	3.0e-10	0.00	0.0
1502	oND ₂	pD ₃ ⁺	pND ₃ ⁺	oD ₂	3.0e-10	0.00	0.0
1503	oND ₂	pD ₃ ⁺	oND ₃ ⁺	oD ₂	6.0e-10	0.00	0.0
1504	oND ₂	pD ₃ ⁺	oND ₃ ⁺	pD ₂	6.0e-10	0.00	0.0
1505	pND ₂	pD ₃ ⁺	pND ₃ ⁺	pD ₂	3.6e-10	0.00	0.0
1506	pND ₂	pD ₃ ⁺	oND ₃ ⁺	oD ₂	7.2e-10	0.00	0.0
1507	pND ₂	pD ₃ ⁺	oND ₃ ⁺	pD ₂	7.2e-10	0.00	0.0
1508	oND ₂	oD ₃ ⁺	mND ₃ ⁺	oD ₂	3.4e-10	0.00	0.0
1509	oND ₂	oD ₃ ⁺	mND ₃ ⁺	pD ₂	2.6e-10	0.00	0.0
1510	oND ₂	oD ₃ ⁺	pND ₃ ⁺	oD ₂	3.7e-11	0.00	0.0
1511	oND ₂	oD ₃ ⁺	pND ₃ ⁺	pD ₂	2.2e-11	0.00	0.0
1512	oND ₂	oD ₃ ⁺	oND ₃ ⁺	oD ₂	8.0e-10	0.00	0.0
1513	oND ₂	oD ₃ ⁺	oND ₃ ⁺	pD ₂	3.4e-10	0.00	0.0
1514	pND ₂	oD ₃ ⁺	mND ₃ ⁺	oD ₂	2.2e-10	0.00	0.0
1515	pND ₂	oD ₃ ⁺	mND ₃ ⁺	pD ₂	7.5e-11	0.00	0.0
1516	pND ₂	oD ₃ ⁺	pND ₃ ⁺	oD ₂	7.5e-11	0.00	0.0
1517	pND ₂	oD ₃ ⁺	pND ₃ ⁺	pD ₂	4.5e-11	0.00	0.0
1518	pND ₂	oD ₃ ⁺	oND ₃ ⁺	oD ₂	6.9e-10	0.00	0.0
1519	pND ₂	oD ₃ ⁺	oND ₃ ⁺	pD ₂	6.9e-10	0.00	0.0
1520	oNH ₂ D	H ⁺	oNH ₂ D ⁺	H	5.2e-09	0.00	0.0
1521	pNH ₂ D	H ⁺	pNH ₂ D ⁺	H	5.2e-09	0.00	0.0
1522	oNH ₂ D	oH ₃ ⁺	oNH ₃ D ⁺	oH ₂	5.6e-09	0.00	0.0
1523	oNH ₂ D	oH ₃ ⁺	oNH ₃ D ⁺	pH ₂	7.6e-10	0.00	0.0
1524	oNH ₂ D	oH ₃ ⁺	pNH ₃ D ⁺	oH ₂	2.1e-09	0.00	0.0
1525	oNH ₂ D	oH ₃ ⁺	pNH ₃ D ⁺	pH ₂	6.1e-10	0.00	0.0
1526	pNH ₂ D	oH ₃ ⁺	oNH ₃ D ⁺	oH ₂	2.3e-09	0.00	0.0
1527	pNH ₂ D	oH ₃ ⁺	oNH ₃ D ⁺	pH ₂	2.3e-09	0.00	0.0
1528	pNH ₂ D	oH ₃ ⁺	pNH ₃ D ⁺	oH ₂	4.6e-09	0.00	0.0
1529	oNH ₂ D	pH ₃ ⁺	oNH ₃ D ⁺	oH ₂	2.1e-09	0.00	0.0
1530	oNH ₂ D	pH ₃ ⁺	oNH ₃ D ⁺	pH ₂	1.5e-09	0.00	0.0
1531	oNH ₂ D	pH ₃ ⁺	pNH ₃ D ⁺	oH ₂	4.2e-09	0.00	0.0
1532	oNH ₂ D	pH ₃ ⁺	pNH ₃ D ⁺	pH ₂	1.2e-09	0.00	0.0
1533	pNH ₂ D	pH ₃ ⁺	oNH ₃ D ⁺	oH ₂	1.8e-09	0.00	0.0
1534	pNH ₂ D	pH ₃ ⁺	pNH ₃ D ⁺	oH ₂	3.6e-09	0.00	0.0
1535	pNH ₂ D	pH ₃ ⁺	pNH ₃ D ⁺	pH ₂	3.6e-09	0.00	0.0
1536	oNH ₂ D	oH ₂ D ⁺	oNH ₃ D ⁺	HD	4.0e-09	0.00	0.0
1537	oNH ₂ D	oH ₂ D ⁺	pNH ₃ D ⁺	HD	2.0e-09	0.00	0.0
1538	oNH ₂ D	pH ₂ D ⁺	oNH ₃ D ⁺	HD	2.0e-09	0.00	0.0
1539	oNH ₂ D	pH ₂ D ⁺	pNH ₃ D ⁺	HD	4.0e-09	0.00	0.0
1540	pNH ₂ D	oH ₂ D ⁺	oNH ₃ D ⁺	HD	2.0e-09	0.00	0.0
1541	pNH ₂ D	oH ₂ D ⁺	pNH ₃ D ⁺	HD	4.0e-09	0.00	0.0
1542	pNH ₂ D	pH ₂ D ⁺	pNH ₃ D ⁺	HD	6.1e-09	0.00	0.0
1543	oNH ₂ D	oH ₂ D ⁺	ooNH ₂ D ₂ ⁺	oH ₂	1.5e-09	0.00	0.0
1544	oNH ₂ D	oH ₂ D ⁺	poNH ₂ D ₂ ⁺	oH ₂	7.3e-10	0.00	0.0
1545	oNH ₂ D	oH ₂ D ⁺	ooNH ₂ D ₂ ⁺	pH ₂	2.2e-10	0.00	0.0
1546	oNH ₂ D	oH ₂ D ⁺	poNH ₂ D ₂ ⁺	pH ₂	1.1e-10	0.00	0.0
1547	oNH ₂ D	oH ₂ D ⁺	opNH ₂ D ₂ ⁺	oH ₂	2.2e-10	0.00	0.0
1548	oNH ₂ D	oH ₂ D ⁺	ppNH ₂ D ₂ ⁺	oH ₂	1.1e-10	0.00	0.0
1549	oNH ₂ D	oH ₂ D ⁺	opNH ₂ D ₂ ⁺	pH ₂	1.1e-10	0.00	0.0
1550	oNH ₂ D	oH ₂ D ⁺	ppNH ₂ D ₂ ⁺	pH ₂	5.6e-11	0.00	0.0
1551	oNH ₂ D	pH ₂ D ⁺	ooNH ₂ D ₂ ⁺	oH ₂	6.7e-10	0.00	0.0
1552	oNH ₂ D	pH ₂ D ⁺	poNH ₂ D ₂ ⁺	oH ₂	3.4e-10	0.00	0.0
1553	oNH ₂ D	pH ₂ D ⁺	ooNH ₂ D ₂ ⁺	pH ₂	6.7e-10	0.00	0.0
1554	oNH ₂ D	pH ₂ D ⁺	poNH ₂ D ₂ ⁺	pH ₂	3.4e-10	0.00	0.0

Table D6 – continued (part 22)

#	Reactants	Products	α	β	γ		
1555	oNH ₂ D	pH ₂ D ⁺	opNH ₂ D ₂ ⁺	oH ₂	6.7e-10	0.00	0.0
1556	oNH ₂ D	pH ₂ D ⁺	ppNH ₂ D ₂ ⁺	oH ₂	3.4e-10	0.00	0.0
1557	pNH ₂ D	oH ₂ D ⁺	ooNH ₂ D ₂ ⁺	oH ₂	6.7e-10	0.00	0.0
1558	pNH ₂ D	oH ₂ D ⁺	poNH ₂ D ₂ ⁺	oH ₂	3.4e-10	0.00	0.0
1559	pNH ₂ D	oH ₂ D ⁺	ooNH ₂ D ₂ ⁺	pH ₂	6.7e-10	0.00	0.0
1560	pNH ₂ D	oH ₂ D ⁺	poNH ₂ D ₂ ⁺	pH ₂	3.4e-10	0.00	0.0
1561	pNH ₂ D	oH ₂ D ⁺	opNH ₂ D ₂ ⁺	oH ₂	6.7e-10	0.00	0.0
1562	pNH ₂ D	oH ₂ D ⁺	ppNH ₂ D ₂ ⁺	oH ₂	3.4e-10	0.00	0.0
1563	pNH ₂ D	pH ₂ D ⁺	ooNH ₂ D ₂ ⁺	oH ₂	1.0e-09	0.00	0.0
1564	pNH ₂ D	pH ₂ D ⁺	poNH ₂ D ₂ ⁺	oH ₂	5.1e-10	0.00	0.0
1565	pNH ₂ D	pH ₂ D ⁺	opNH ₂ D ₂ ⁺	pH ₂	1.0e-09	0.00	0.0
1566	pNH ₂ D	pH ₂ D ⁺	ppNH ₂ D ₂ ⁺	pH ₂	5.1e-10	0.00	0.0
1567	oNH ₂ D	oHD ₂ ⁺	oD ₂	oNH ₃ D ⁺	1.6e-09	0.00	0.0
1568	oNH ₂ D	oHD ₂ ⁺	pD ₂	oNH ₃ D ⁺	4.5e-10	0.00	0.0
1569	oNH ₂ D	pHD ₂ ⁺	oD ₂	oNH ₃ D ⁺	9.0e-10	0.00	0.0
1570	oNH ₂ D	pHD ₂ ⁺	pD ₂	oNH ₃ D ⁺	1.1e-09	0.00	0.0
1571	oNH ₂ D	oHD ₂ ⁺	oD ₂	pNH ₃ D ⁺	7.9e-10	0.00	0.0
1572	oNH ₂ D	oHD ₂ ⁺	pD ₂	pNH ₃ D ⁺	2.2e-10	0.00	0.0
1573	oNH ₂ D	pHD ₂ ⁺	oD ₂	pNH ₃ D ⁺	4.5e-10	0.00	0.0
1574	oNH ₂ D	pHD ₂ ⁺	pD ₂	pNH ₃ D ⁺	5.6e-10	0.00	0.0
1575	pNH ₂ D	oHD ₂ ⁺	oD ₂	pNH ₃ D ⁺	2.4e-09	0.00	0.0
1576	pNH ₂ D	oHD ₂ ⁺	pD ₂	pNH ₃ D ⁺	6.7e-10	0.00	0.0
1577	pNH ₂ D	pHD ₂ ⁺	oD ₂	pNH ₃ D ⁺	1.3e-09	0.00	0.0
1578	pNH ₂ D	pHD ₂ ⁺	pD ₂	pNH ₃ D ⁺	1.7e-09	0.00	0.0
1579	oNH ₂ D	oHD ₂ ⁺	ooNH ₂ D ₂ ⁺	HD	3.9e-09	0.00	0.0
1580	oNH ₂ D	oHD ₂ ⁺	poNH ₂ D ₂ ⁺	HD	1.1e-09	0.00	0.0
1581	oNH ₂ D	pHD ₂ ⁺	ooNH ₂ D ₂ ⁺	HD	2.2e-09	0.00	0.0
1582	oNH ₂ D	pHD ₂ ⁺	poNH ₂ D ₂ ⁺	HD	2.8e-09	0.00	0.0
1583	oNH ₂ D	oHD ₂ ⁺	opNH ₂ D ₂ ⁺	HD	7.9e-10	0.00	0.0
1584	oNH ₂ D	oHD ₂ ⁺	ppNH ₂ D ₂ ⁺	HD	2.2e-10	0.00	0.0
1585	oNH ₂ D	pHD ₂ ⁺	opNH ₂ D ₂ ⁺	HD	4.5e-10	0.00	0.0
1586	oNH ₂ D	pHD ₂ ⁺	ppNH ₂ D ₂ ⁺	HD	5.6e-10	0.00	0.0
1587	pNH ₂ D	oHD ₂ ⁺	ooNH ₂ D ₂ ⁺	HD	2.4e-09	0.00	0.0
1588	pNH ₂ D	oHD ₂ ⁺	poNH ₂ D ₂ ⁺	HD	6.7e-10	0.00	0.0
1589	pNH ₂ D	pHD ₂ ⁺	ooNH ₂ D ₂ ⁺	HD	1.3e-09	0.00	0.0
1590	pNH ₂ D	pHD ₂ ⁺	poNH ₂ D ₂ ⁺	HD	1.7e-09	0.00	0.0
1591	pNH ₂ D	oHD ₂ ⁺	opNH ₂ D ₂ ⁺	HD	2.4e-09	0.00	0.0
1592	pNH ₂ D	oHD ₂ ⁺	ppNH ₂ D ₂ ⁺	HD	6.7e-10	0.00	0.0
1593	pNH ₂ D	pHD ₂ ⁺	opNH ₂ D ₂ ⁺	HD	1.3e-09	0.00	0.0
1594	pNH ₂ D	pHD ₂ ⁺	ppNH ₂ D ₂ ⁺	HD	1.7e-09	0.00	0.0
1595	oNH ₂ D	mD ₃ ⁺	ooNH ₂ D ₂ ⁺	oD ₂	6.1e-09	0.00	0.0
1596	oNH ₂ D	mD ₃ ⁺	poNH ₂ D ₂ ⁺	pD ₂	1.5e-09	0.00	0.0
1597	oNH ₂ D	mD ₃ ⁺	ooNH ₂ D ₂ ⁺	oD ₂	1.5e-09	0.00	0.0
1598	oNH ₂ D	pD ₃ ⁺	ooNH ₂ D ₂ ⁺	pD ₂	3.0e-09	0.00	0.0
1599	oNH ₂ D	pD ₃ ⁺	poNH ₂ D ₂ ⁺	oD ₂	3.0e-09	0.00	0.0
1600	oNH ₂ D	pD ₃ ⁺	poNH ₂ D ₂ ⁺	pD ₂	3.0e-09	0.00	0.0
1601	oNH ₂ D	oD ₃ ⁺	ooNH ₂ D ₂ ⁺	oD ₂	3.0e-09	0.00	0.0
1602	oNH ₂ D	oD ₃ ⁺	ooNH ₂ D ₂ ⁺	pD ₂	2.3e-09	0.00	0.0
1603	oNH ₂ D	oD ₃ ⁺	poNH ₂ D ₂ ⁺	oD ₂	2.3e-09	0.00	0.0
1604	oNH ₂ D	oD ₃ ⁺	poNH ₂ D ₂ ⁺	pD ₂	1.5e-09	0.00	0.0
1605	pNH ₂ D	mD ₃ ⁺	opNH ₂ D ₂ ⁺	oD ₂	6.1e-09	0.00	0.0
1606	pNH ₂ D	mD ₃ ⁺	opNH ₂ D ₂ ⁺	pD ₂	1.5e-09	0.00	0.0
1607	pNH ₂ D	mD ₃ ⁺	ppNH ₂ D ₂ ⁺	oD ₂	1.5e-09	0.00	0.0
1608	pNH ₂ D	pD ₃ ⁺	opNH ₂ D ₂ ⁺	pD ₂	3.0e-09	0.00	0.0
1609	pNH ₂ D	pD ₃ ⁺	ppNH ₂ D ₂ ⁺	oD ₂	3.0e-09	0.00	0.0
1610	pNH ₂ D	pD ₃ ⁺	ppNH ₂ D ₂ ⁺	pD ₂	3.0e-09	0.00	0.0
1611	pNH ₂ D	oD ₃ ⁺	opNH ₂ D ₂ ⁺	oD ₂	3.0e-09	0.00	0.0
1612	pNH ₂ D	oD ₃ ⁺	opNH ₂ D ₂ ⁺	pD ₂	2.3e-09	0.00	0.0
1613	pNH ₂ D	oD ₃ ⁺	ppNH ₂ D ₂ ⁺	oD ₂	2.3e-09	0.00	0.0
1614	pNH ₂ D	oD ₃ ⁺	ppNH ₂ D ₂ ⁺	pD ₂	1.5e-09	0.00	0.0
1615	oNHD ₂	H ⁺	oNHD ₂ ⁺	H	5.2e-09	0.00	0.0
1616	pNHD ₂	H ⁺	pNHD ₂ ⁺	H	5.2e-09	0.00	0.0
1617	oNHD ₂	oH ₃ ⁺	ooNH ₂ D ₂ ⁺	oH ₂	6.8e-09	0.00	0.0
1618	pNHD ₂	oH ₃ ⁺	poNH ₂ D ₂ ⁺	oH ₂	6.8e-09	0.00	0.0
1619	oNHD ₂	oH ₃ ⁺	ooNH ₂ D ₂ ⁺	pH ₂	1.1e-09	0.00	0.0
1620	pNHD ₂	oH ₃ ⁺	poNH ₂ D ₂ ⁺	pH ₂	1.1e-09	0.00	0.0
1621	oNHD ₂	oH ₃ ⁺	opNH ₂ D ₂ ⁺	oH ₂	1.1e-09	0.00	0.0
1622	pNHD ₂	oH ₃ ⁺	ppNH ₂ D ₂ ⁺	oH ₂	1.1e-09	0.00	0.0
1623	oNHD ₂	pH ₃ ⁺	ooNH ₂ D ₂ ⁺	oH ₂	3.4e-09	0.00	0.0
1624	pNHD ₂	pH ₃ ⁺	poNH ₂ D ₂ ⁺	oH ₂	3.4e-09	0.00	0.0
1625	oNHD ₂	pH ₃ ⁺	ooNH ₂ D ₂ ⁺	pH ₂	2.3e-09	0.00	0.0
1626	pNHD ₂	pH ₃ ⁺	poNH ₂ D ₂ ⁺	pH ₂	2.3e-09	0.00	0.0
1627	oNHD ₂	pH ₃ ⁺	opNH ₂ D ₂ ⁺	oH ₂	2.3e-09	0.00	0.0
1628	pNHD ₂	pH ₃ ⁺	ppNH ₂ D ₂ ⁺	oH ₂	2.3e-09	0.00	0.0

Table D6 – continued (part 23)

#	Reactants	Products	α	β	γ
1629	oNHD ₂ pH ₃ ⁺	opNH ₂ D ₂ ⁺ pH ₂	1.1e-09	0.00	0.0
1630	pNHD ₂ pH ₃ ⁺	ppNH ₂ D ₂ ⁺ pH ₂	1.1e-09	0.00	0.0
1631	oNHD ₂ oH ₂ D ⁺	ooNH ₂ D ₂ ⁺ HD	3.9e-09	0.00	0.0
1632	oNHD ₂ oH ₂ D ⁺	poNH ₂ D ₂ ⁺ HD	1.1e-09	0.00	0.0
1633	pNHD ₂ oH ₂ D ⁺	ooNH ₂ D ₂ ⁺ HD	2.2e-09	0.00	0.0
1634	pNHD ₂ oH ₂ D ⁺	poNH ₂ D ₂ ⁺ HD	2.8e-09	0.00	0.0
1635	oNHD ₂ oH ₂ D ⁺	opNH ₂ D ₂ ⁺ HD	7.9e-10	0.00	0.0
1636	oNHD ₂ oH ₂ D ⁺	ppNH ₂ D ₂ ⁺ HD	2.2e-10	0.00	0.0
1637	pNHD ₂ oH ₂ D ⁺	opNH ₂ D ₂ ⁺ HD	4.5e-10	0.00	0.0
1638	pNHD ₂ oH ₂ D ⁺	ppNH ₂ D ₂ ⁺ HD	5.6e-10	0.00	0.0
1639	oNHD ₂ pH ₂ D ⁺	ooNH ₂ D ₂ ⁺ HD	2.4e-09	0.00	0.0
1640	oNHD ₂ pH ₂ D ⁺	poNH ₂ D ₂ ⁺ HD	6.7e-10	0.00	0.0
1641	pNHD ₂ pH ₂ D ⁺	ooNH ₂ D ₂ ⁺ HD	1.3e-09	0.00	0.0
1642	pNHD ₂ pH ₂ D ⁺	poNH ₂ D ₂ ⁺ HD	1.7e-09	0.00	0.0
1643	oNHD ₂ pH ₂ D ⁺	opNH ₂ D ₂ ⁺ HD	2.4e-09	0.00	0.0
1644	oNHD ₂ pH ₂ D ⁺	ppNH ₂ D ₂ ⁺ HD	6.7e-10	0.00	0.0
1645	pNHD ₂ pH ₂ D ⁺	opNH ₂ D ₂ ⁺ HD	1.3e-09	0.00	0.0
1646	pNHD ₂ pH ₂ D ⁺	ppNH ₂ D ₂ ⁺ HD	1.7e-09	0.00	0.0
1647	oNHD ₂ oH ₂ D ⁺	mNHD ₃ oH ₂	1.4e-09	0.00	0.0
1648	oNHD ₂ oH ₂ D ⁺	oNHD ₃ ⁺ oH ₂	1.1e-09	0.00	0.0
1649	pNHD ₂ oH ₂ D ⁺	pNHD ₃ ⁺ oH ₂	2.8e-10	0.00	0.0
1650	pNHD ₂ oH ₂ D ⁺	oNHD ₃ ⁺ oH ₂	2.2e-09	0.00	0.0
1651	oNHD ₂ oH ₂ D ⁺	mNHD ₃ ⁺ pH ₂	2.8e-10	0.00	0.0
1652	oNHD ₂ oH ₂ D ⁺	oNHD ₃ ⁺ pH ₂	2.2e-10	0.00	0.0
1653	pNHD ₂ oH ₂ D ⁺	pNHD ₃ ⁺ pH ₂	5.6e-11	0.00	0.0
1654	pNHD ₂ oH ₂ D ⁺	oNHD ₃ ⁺ pH ₂	4.5e-10	0.00	0.0
1655	oNHD ₂ pH ₂ D ⁺	mNHD ₃ ⁺ oH ₂	8.4e-10	0.00	0.0
1656	oNHD ₂ pH ₂ D ⁺	oNHD ₃ ⁺ oH ₂	6.7e-10	0.00	0.0
1657	pNHD ₂ pH ₂ D ⁺	pNHD ₃ ⁺ oH ₂	1.7e-10	0.00	0.0
1658	pNHD ₂ pH ₂ D ⁺	oNHD ₃ ⁺ oH ₂	1.3e-09	0.00	0.0
1659	oNHD ₂ pH ₂ D ⁺	mNHD ₃ ⁺ pH ₂	8.4e-10	0.00	0.0
1660	oNHD ₂ pH ₂ D ⁺	oNHD ₃ ⁺ pH ₂	6.7e-10	0.00	0.0
1661	pNHD ₂ pH ₂ D ⁺	pNHD ₃ ⁺ pH ₂	1.7e-10	0.00	0.0
1662	pNHD ₂ pH ₂ D ⁺	oNHD ₃ ⁺ pH ₂	1.3e-09	0.00	0.0
1663	oNHD ₂ oHD ₂ ⁺	ooNH ₂ D ₂ ⁺ oD ₂	1.5e-09	0.00	0.0
1664	oNHD ₂ oHD ₂ ⁺	ooNH ₂ D ₂ ⁺ pD ₂	3.2e-10	0.00	0.0
1665	oNHD ₂ oHD ₂ ⁺	poNH ₂ D ₂ ⁺ oD ₂	3.2e-10	0.00	0.0
1666	oNHD ₂ oHD ₂ ⁺	poNH ₂ D ₂ ⁺ pD ₂	1.9e-10	0.00	0.0
1667	oNHD ₂ pHD ₂ ⁺	ooNH ₂ D ₂ ⁺ oD ₂	6.3e-10	0.00	0.0
1668	oNHD ₂ pHD ₂ ⁺	ooNH ₂ D ₂ ⁺ pD ₂	7.6e-10	0.00	0.0
1669	oNHD ₂ pHD ₂ ⁺	poNH ₂ D ₂ ⁺ oD ₂	7.6e-10	0.00	0.0
1670	oNHD ₂ pHD ₂ ⁺	poNH ₂ D ₂ ⁺ pD ₂	1.3e-10	0.00	0.0
1671	pNHD ₂ oHD ₂ ⁺	ooNH ₂ D ₂ ⁺ oD ₂	6.3e-10	0.00	0.0
1672	pNHD ₂ oHD ₂ ⁺	ooNH ₂ D ₂ ⁺ pD ₂	7.6e-10	0.00	0.0
1673	pNHD ₂ oHD ₂ ⁺	poNH ₂ D ₂ ⁺ oD ₂	7.6e-10	0.00	0.0
1674	pNHD ₂ oHD ₂ ⁺	poNH ₂ D ₂ ⁺ pD ₂	1.3e-10	0.00	0.0
1675	pNHD ₂ pHD ₂ ⁺	ooNH ₂ D ₂ ⁺ oD ₂	7.6e-10	0.00	0.0
1676	pNHD ₂ pHD ₂ ⁺	ooNH ₂ D ₂ ⁺ pD ₂	2.5e-10	0.00	0.0
1677	pNHD ₂ pHD ₂ ⁺	poNH ₂ D ₂ ⁺ oD ₂	2.5e-10	0.00	0.0
1678	pNHD ₂ pHD ₂ ⁺	poNH ₂ D ₂ ⁺ pD ₂	1.0e-09	0.00	0.0
1679	oNHD ₂ oHD ₂ ⁺	opNH ₂ D ₂ ⁺ oD ₂	4.8e-10	0.00	0.0
1680	oNHD ₂ oHD ₂ ⁺	opNH ₂ D ₂ ⁺ pD ₂	1.1e-10	0.00	0.0
1681	oNHD ₂ oHD ₂ ⁺	ppNH ₂ D ₂ ⁺ oD ₂	1.1e-10	0.00	0.0
1682	oNHD ₂ oHD ₂ ⁺	ppNH ₂ D ₂ ⁺ pD ₂	6.3e-11	0.00	0.0
1683	oNHD ₂ pHD ₂ ⁺	opNH ₂ D ₂ ⁺ oD ₂	2.1e-10	0.00	0.0
1684	oNHD ₂ pHD ₂ ⁺	opNH ₂ D ₂ ⁺ pD ₂	2.5e-10	0.00	0.0
1685	oNHD ₂ pHD ₂ ⁺	ppNH ₂ D ₂ ⁺ oD ₂	2.5e-10	0.00	0.0
1686	oNHD ₂ pHD ₂ ⁺	ppNH ₂ D ₂ ⁺ pD ₂	4.2e-11	0.00	0.0
1687	pNHD ₂ oHD ₂ ⁺	opNH ₂ D ₂ ⁺ oD ₂	2.1e-10	0.00	0.0
1688	pNHD ₂ oHD ₂ ⁺	opNH ₂ D ₂ ⁺ pD ₂	2.5e-10	0.00	0.0
1689	pNHD ₂ oHD ₂ ⁺	ppNH ₂ D ₂ ⁺ oD ₂	2.5e-10	0.00	0.0
1690	pNHD ₂ oHD ₂ ⁺	ppNH ₂ D ₂ ⁺ pD ₂	4.2e-11	0.00	0.0
1691	pNHD ₂ pHD ₂ ⁺	opNH ₂ D ₂ ⁺ oD ₂	2.5e-10	0.00	0.0
1692	pNHD ₂ pHD ₂ ⁺	opNH ₂ D ₂ ⁺ pD ₂	8.4e-11	0.00	0.0
1693	pNHD ₂ pHD ₂ ⁺	ppNH ₂ D ₂ ⁺ oD ₂	8.4e-11	0.00	0.0
1694	pNHD ₂ pHD ₂ ⁺	ppNH ₂ D ₂ ⁺ pD ₂	3.4e-10	0.00	0.0
1695	oNHD ₂ oHD ₂ ⁺	mNHD ₃ HD	3.4e-09	0.00	0.0
1696	oNHD ₂ oHD ₂ ⁺	oNHD ₃ HD	2.7e-09	0.00	0.0
1697	oNHD ₂ pHD ₂ ⁺	mNHD ₃ HD	1.7e-09	0.00	0.0
1698	oNHD ₂ pHD ₂ ⁺	pNHD ₃ HD	3.4e-10	0.00	0.0
1699	oNHD ₂ pHD ₂ ⁺	oNHD ₃ HD	4.0e-09	0.00	0.0
1700	pNHD ₂ oHD ₂ ⁺	mNHD ₃ HD	1.7e-09	0.00	0.0
1701	pNHD ₂ oHD ₂ ⁺	pNHD ₃ HD	3.4e-10	0.00	0.0
1702	pNHD ₂ oHD ₂ ⁺	oNHD ₃ HD	4.0e-09	0.00	0.0

Table D6 – continued (part 24)

#	Reactants	Products	α	β	γ		
1703	pNHD ₂	pHD ₂ ⁺	pNHD ₃ ⁺	HD	6.7e-10	0.00	0.0
1704	pNHD ₂	pHD ₂ ⁺	oNHD ₃ ⁺	HD	5.4e-09	0.00	0.0
1705	oNHD ₂	mD ₃ ⁺	mNHD ₃ ⁺	oD ₂	4.6e-09	0.00	0.0
1706	oNHD ₂	mD ₃ ⁺	mNHD ₃ ⁺	pD ₂	9.1e-10	0.00	0.0
1707	oNHD ₂	mD ₃ ⁺	oNHD ₃ ⁺	oD ₂	2.7e-09	0.00	0.0
1708	oNHD ₂	mD ₃ ⁺	oNHD ₃ ⁺	pD ₂	9.1e-10	0.00	0.0
1709	pNHD ₂	mD ₃ ⁺	mNHD ₃ ⁺	oD ₂	1.8e-09	0.00	0.0
1710	pNHD ₂	mD ₃ ⁺	mNHD ₃ ⁺	pD ₂	2.1e-09	0.00	0.0
1711	pNHD ₂	mD ₃ ⁺	pNHD ₃ ⁺	oD ₂	3.0e-10	0.00	0.0
1712	pNHD ₂	mD ₃ ⁺	oNHD ₃ ⁺	oD ₂	4.2e-09	0.00	0.0
1713	pNHD ₂	mD ₃ ⁺	oNHD ₃ ⁺	pD ₂	6.1e-10	0.00	0.0
1714	oNHD ₂	pD ₃ ⁺	mNHD ₃ ⁺	pD ₂	1.5e-09	0.00	0.0
1715	oNHD ₂	pD ₃ ⁺	pNHD ₃ ⁺	oD ₂	1.5e-09	0.00	0.0
1716	oNHD ₂	pD ₃ ⁺	oNHD ₃ ⁺	oD ₂	3.0e-09	0.00	0.0
1717	oNHD ₂	pD ₃ ⁺	oNHD ₃ ⁺	pD ₂	3.0e-09	0.00	0.0
1718	pNHD ₂	pD ₃ ⁺	pNHD ₃ ⁺	pD ₂	1.8e-09	0.00	0.0
1719	pNHD ₂	pD ₃ ⁺	oNHD ₃ ⁺	oD ₂	3.6e-09	0.00	0.0
1720	pNHD ₂	pD ₃ ⁺	oNHD ₃ ⁺	pD ₂	3.6e-09	0.00	0.0
1721	oNHD ₂	oD ₃ ⁺	mNHD ₃ ⁺	oD ₂	1.7e-09	0.00	0.0
1722	oNHD ₂	oD ₃ ⁺	mNHD ₃ ⁺	pD ₂	1.3e-09	0.00	0.0
1723	oNHD ₂	oD ₃ ⁺	pNHD ₃ ⁺	oD ₂	1.9e-10	0.00	0.0
1724	oNHD ₂	oD ₃ ⁺	pNHD ₃ ⁺	pD ₂	1.1e-10	0.00	0.0
1725	oNHD ₂	oD ₃ ⁺	oNHD ₃ ⁺	oD ₂	4.0e-09	0.00	0.0
1726	oNHD ₂	oD ₃ ⁺	oNHD ₃ ⁺	pD ₂	1.7e-09	0.00	0.0
1727	pNHD ₂	oD ₃ ⁺	mNHD ₃ ⁺	oD ₂	1.1e-09	0.00	0.0
1728	pNHD ₂	oD ₃ ⁺	mNHD ₃ ⁺	pD ₂	3.8e-10	0.00	0.0
1729	pNHD ₂	oD ₃ ⁺	pNHD ₃ ⁺	oD ₂	3.8e-10	0.00	0.0
1730	pNHD ₂	oD ₃ ⁺	pNHD ₃ ⁺	pD ₂	2.3e-10	0.00	0.0
1731	pNHD ₂	oD ₃ ⁺	oNHD ₃ ⁺	oD ₂	3.5e-09	0.00	0.0
1732	pNHD ₂	oD ₃ ⁺	oNHD ₃ ⁺	pD ₂	3.5e-09	0.00	0.0
1733	mND ₃	H ⁺	mND ₃ ⁺	H	5.2e-09	0.00	0.0
1734	pND ₃	H ⁺	pND ₃ ⁺	H	5.2e-09	0.00	0.0
1735	oND ₃	H ⁺	oND ₃ ⁺	H	5.2e-09	0.00	0.0
1736	mND ₃	oH ₃ ⁺	mNHD ₃ ⁺	oH ₂	9.1e-09	0.00	0.0
1737	pND ₃	oH ₃ ⁺	pNHD ₃ ⁺	oH ₂	9.1e-09	0.00	0.0
1738	oND ₃	oH ₃ ⁺	oNHD ₃ ⁺	oH ₂	9.1e-09	0.00	0.0
1739	mND ₃	pH ₃ ⁺	mNHD ₃ ⁺	oH ₂	4.6e-09	0.00	0.0
1740	pND ₃	pH ₃ ⁺	pNHD ₃ ⁺	oH ₂	4.6e-09	0.00	0.0
1741	oND ₃	pH ₃ ⁺	oNHD ₃ ⁺	oH ₂	4.6e-09	0.00	0.0
1742	mND ₃	pH ₃ ⁺	mNHD ₃ ⁺	pH ₂	4.6e-09	0.00	0.0
1743	pND ₃	pH ₃ ⁺	pNHD ₃ ⁺	pH ₂	4.6e-09	0.00	0.0
1744	oND ₃	pH ₃ ⁺	oNHD ₃ ⁺	pH ₂	4.6e-09	0.00	0.0
1745	mND ₃	oH ₂ D ⁺	mNHD ₃ ⁺	HD	4.0e-09	0.00	0.0
1746	mND ₃	oH ₂ D ⁺	oNHD ₃ ⁺	HD	2.0e-09	0.00	0.0
1747	pND ₃	oH ₂ D ⁺	pNHD ₃ ⁺	HD	2.0e-09	0.00	0.0
1748	pND ₃	oH ₂ D ⁺	oNHD ₃ ⁺	HD	4.0e-09	0.00	0.0
1749	oND ₃	oH ₂ D ⁺	mNHD ₃ ⁺	HD	1.3e-09	0.00	0.0
1750	oND ₃	oH ₂ D ⁺	pNHD ₃ ⁺	HD	2.5e-10	0.00	0.0
1751	oND ₃	oH ₂ D ⁺	oNHD ₃ ⁺	HD	4.5e-09	0.00	0.0
1752	mND ₃	pH ₂ D ⁺	mNHD ₃ ⁺	HD	4.0e-09	0.00	0.0
1753	mND ₃	pH ₂ D ⁺	oNHD ₃ ⁺	HD	2.0e-09	0.00	0.0
1754	pND ₃	pH ₂ D ⁺	pNHD ₃ ⁺	HD	2.0e-09	0.00	0.0
1755	pND ₃	pH ₂ D ⁺	oNHD ₃ ⁺	HD	4.0e-09	0.00	0.0
1756	oND ₃	pH ₂ D ⁺	mNHD ₃ ⁺	HD	1.3e-09	0.00	0.0
1757	oND ₃	pH ₂ D ⁺	pNHD ₃ ⁺	HD	2.5e-10	0.00	0.0
1758	oND ₃	pH ₂ D ⁺	oNHD ₃ ⁺	HD	4.5e-09	0.00	0.0
1759	mND ₃	oH ₂ D ⁺	IND ₄ ⁺	oH ₂	1.5e-09	0.00	0.0
1760	mND ₃	oH ₂ D ⁺	oND ₄ ⁺	oH ₂	1.5e-09	0.00	0.0
1761	pND ₃	oH ₂ D ⁺	pND ₄ ⁺	oH ₂	3.0e-09	0.00	0.0
1762	oND ₃	oH ₂ D ⁺	mND ₄ ⁺	oH ₂	7.6e-10	0.00	0.0
1763	oND ₃	oH ₂ D ⁺	oND ₄ ⁺	oH ₂	1.9e-09	0.00	0.0
1764	oND ₃	oH ₂ D ⁺	pND ₄ ⁺	oH ₂	3.8e-10	0.00	0.0
1765	mND ₃	pH ₂ D ⁺	IND ₄ ⁺	pH ₂	1.5e-09	0.00	0.0
1766	mND ₃	pH ₂ D ⁺	oND ₄ ⁺	pH ₂	1.5e-09	0.00	0.0
1767	pND ₃	pH ₂ D ⁺	pND ₄ ⁺	pH ₂	3.0e-09	0.00	0.0
1768	oND ₃	pH ₂ D ⁺	mND ₄ ⁺	pH ₂	7.6e-10	0.00	0.0
1769	oND ₃	pH ₂ D ⁺	oND ₄ ⁺	pH ₂	1.9e-09	0.00	0.0
1770	oND ₃	pH ₂ D ⁺	pND ₄ ⁺	pH ₂	3.8e-10	0.00	0.0
1771	mND ₃	oHD ₂ ⁺	mNHD ₃ ⁺	oD ₂	1.5e-09	0.00	0.0
1772	mND ₃	oHD ₂ ⁺	mNHD ₃ ⁺	pD ₂	3.0e-10	0.00	0.0
1773	mND ₃	oHD ₂ ⁺	oNHD ₃ ⁺	oD ₂	9.1e-10	0.00	0.0
1774	mND ₃	oHD ₂ ⁺	oNHD ₃ ⁺	pD ₂	3.0e-10	0.00	0.0
1775	mND ₃	pHD ₂ ⁺	mNHD ₃ ⁺	oD ₂	6.1e-10	0.00	0.0
1776	mND ₃	pHD ₂ ⁺	mNHD ₃ ⁺	pD ₂	7.1e-10	0.00	0.0

Table D6 – *continued* (part 25)

#	Reactants	Products	α	β	γ
1777	mND ₃ pHD ₂ ⁺	pNHD ₃ ⁺ oD ₂	1.0e-10	0.00	0.0
1778	mND ₃ pHD ₂ ⁺	oNHD ₃ ⁺ oD ₂	1.4e-09	0.00	0.0
1779	mND ₃ pHD ₂ ⁺	oNHD ₃ ⁺ pD ₂	2.0e-10	0.00	0.0
1780	pND ₃ oHD ₂ ⁺	mNHD ₃ ⁺ pD ₂	5.1e-10	0.00	0.0
1781	pND ₃ oHD ₂ ⁺	pNHD ₃ ⁺ oD ₂	5.1e-10	0.00	0.0
1782	pND ₃ oHD ₂ ⁺	oNHD ₃ ⁺ oD ₂	1.0e-09	0.00	0.0
1783	pND ₃ oHD ₂ ⁺	oNHD ₃ ⁺ pD ₂	1.0e-09	0.00	0.0
1784	pND ₃ pHD ₂ ⁺	pNHD ₃ ⁺ pD ₂	6.1e-10	0.00	0.0
1785	pND ₃ pHD ₂ ⁺	oNHD ₃ ⁺ oD ₂	1.2e-09	0.00	0.0
1786	pND ₃ pHD ₂ ⁺	oNHD ₃ ⁺ pD ₂	1.2e-09	0.00	0.0
1787	oND ₃ oHD ₂ ⁺	mNHD ₃ ⁺ oD ₂	5.7e-10	0.00	0.0
1788	oND ₃ oHD ₂ ⁺	mNHD ₃ ⁺ pD ₂	4.4e-10	0.00	0.0
1789	oND ₃ oHD ₂ ⁺	pNHD ₃ ⁺ oD ₂	6.3e-11	0.00	0.0
1790	oND ₃ oHD ₂ ⁺	pNHD ₃ ⁺ pD ₂	3.8e-11	0.00	0.0
1791	oND ₃ oHD ₂ ⁺	oNHD ₃ ⁺ oD ₂	1.3e-09	0.00	0.0
1792	oND ₃ oHD ₂ ⁺	oNHD ₃ ⁺ pD ₂	5.8e-10	0.00	0.0
1793	oND ₃ pHD ₂ ⁺	mNHD ₃ ⁺ oD ₂	3.8e-10	0.00	0.0
1794	oND ₃ pHD ₂ ⁺	mNHD ₃ ⁺ pD ₂	1.3e-10	0.00	0.0
1795	oND ₃ pHD ₂ ⁺	pNHD ₃ ⁺ oD ₂	1.3e-10	0.00	0.0
1796	oND ₃ pHD ₂ ⁺	pNHD ₃ ⁺ pD ₂	7.6e-11	0.00	0.0
1797	oND ₃ pHD ₂ ⁺	oNHD ₃ ⁺ oD ₂	1.2e-09	0.00	0.0
1798	oND ₃ pHD ₂ ⁺	oNHD ₃ ⁺ pD ₂	1.2e-09	0.00	0.0
1799	mND ₃ oHD ₂ ⁺	IND ₄ ⁺ HD	2.7e-09	0.00	0.0
1800	mND ₃ oHD ₂ ⁺	mND ₄ ⁺ HD	6.1e-10	0.00	0.0
1801	mND ₃ oHD ₂ ⁺	oND ₄ ⁺ HD	2.7e-09	0.00	0.0
1802	mND ₃ pHD ₂ ⁺	IND ₄ ⁺ HD	1.2e-09	0.00	0.0
1803	mND ₃ pHD ₂ ⁺	oND ₄ ⁺ HD	4.2e-09	0.00	0.0
1804	mND ₃ pHD ₂ ⁺	pND ₄ ⁺ HD	6.1e-10	0.00	0.0
1805	pND ₃ oHD ₂ ⁺	oND ₄ ⁺ HD	3.0e-09	0.00	0.0
1806	pND ₃ oHD ₂ ⁺	pND ₄ ⁺ HD	3.0e-09	0.00	0.0
1807	pND ₃ pHD ₂ ⁺	mND ₄ ⁺ HD	2.4e-09	0.00	0.0
1808	pND ₃ pHD ₂ ⁺	pND ₄ ⁺ HD	3.6e-09	0.00	0.0
1809	oND ₃ oHD ₂ ⁺	IND ₄ ⁺ HD	7.6e-10	0.00	0.0
1810	oND ₃ oHD ₂ ⁺	mND ₄ ⁺ HD	9.1e-10	0.00	0.0
1811	oND ₃ oHD ₂ ⁺	oND ₄ ⁺ HD	3.8e-09	0.00	0.0
1812	oND ₃ oHD ₂ ⁺	pND ₄ ⁺ HD	6.1e-10	0.00	0.0
1813	oND ₃ pHD ₂ ⁺	mND ₄ ⁺ HD	1.8e-09	0.00	0.0
1814	oND ₃ pHD ₂ ⁺	oND ₄ ⁺ HD	3.0e-09	0.00	0.0
1815	oND ₃ pHD ₂ ⁺	pND ₄ ⁺ HD	1.2e-09	0.00	0.0
1816	mND ₃ mD ₃ ⁺	IND ₄ ⁺ oD ₂	3.5e-09	0.00	0.0
1817	mND ₃ mD ₃ ⁺	IND ₄ ⁺ pD ₂	6.4e-10	0.00	0.0
1818	mND ₃ mD ₃ ⁺	mND ₄ ⁺ oD ₂	5.5e-10	0.00	0.0
1819	mND ₃ mD ₃ ⁺	mND ₄ ⁺ pD ₂	3.6e-10	0.00	0.0
1820	mND ₃ mD ₃ ⁺	oND ₄ ⁺ oD ₂	3.3e-09	0.00	0.0
1821	mND ₃ mD ₃ ⁺	oND ₄ ⁺ pD ₂	8.2e-10	0.00	0.0
1822	mND ₃ pD ₃ ⁺	IND ₄ ⁺ pD ₂	9.1e-10	0.00	0.0
1823	mND ₃ pD ₃ ⁺	oND ₄ ⁺ oD ₂	2.7e-09	0.00	0.0
1824	mND ₃ pD ₃ ⁺	oND ₄ ⁺ pD ₂	2.7e-09	0.00	0.0
1825	mND ₃ pD ₃ ⁺	pND ₄ ⁺ oD ₂	2.7e-09	0.00	0.0
1826	mND ₃ oD ₃ ⁺	IND ₄ ⁺ oD ₂	1.1e-09	0.00	0.0
1827	mND ₃ oD ₃ ⁺	IND ₄ ⁺ pD ₂	9.1e-10	0.00	0.0
1828	mND ₃ oD ₃ ⁺	mND ₄ ⁺ oD ₂	8.0e-10	0.00	0.0
1829	mND ₃ oD ₃ ⁺	mND ₄ ⁺ pD ₂	1.1e-10	0.00	0.0
1830	mND ₃ oD ₃ ⁺	oND ₄ ⁺ oD ₂	3.9e-09	0.00	0.0
1831	mND ₃ oD ₃ ⁺	oND ₄ ⁺ pD ₂	1.5e-09	0.00	0.0
1832	mND ₃ oD ₃ ⁺	pND ₄ ⁺ oD ₂	5.1e-10	0.00	0.0
1833	mND ₃ oD ₃ ⁺	pND ₄ ⁺ pD ₂	1.7e-10	0.00	0.0
1834	pND ₃ mD ₃ ⁺	IND ₄ ⁺ pD ₂	9.1e-10	0.00	0.0
1835	pND ₃ mD ₃ ⁺	oND ₄ ⁺ oD ₂	2.7e-09	0.00	0.0
1836	pND ₃ mD ₃ ⁺	oND ₄ ⁺ pD ₂	2.7e-09	0.00	0.0
1837	pND ₃ mD ₃ ⁺	pND ₄ ⁺ oD ₂	2.7e-09	0.00	0.0
1838	pND ₃ pD ₃ ⁺	mND ₄ ⁺ oD ₂	3.6e-09	0.00	0.0
1839	pND ₃ pD ₃ ⁺	pND ₄ ⁺ pD ₂	5.5e-09	0.00	0.0
1840	pND ₃ oD ₃ ⁺	mND ₄ ⁺ oD ₂	1.1e-09	0.00	0.0
1841	pND ₃ oD ₃ ⁺	mND ₄ ⁺ pD ₂	1.1e-09	0.00	0.0
1842	pND ₃ oD ₃ ⁺	oND ₄ ⁺ oD ₂	1.7e-09	0.00	0.0
1843	pND ₃ oD ₃ ⁺	oND ₄ ⁺ pD ₂	1.7e-09	0.00	0.0
1844	pND ₃ oD ₃ ⁺	pND ₄ ⁺ oD ₂	1.7e-09	0.00	0.0
1845	pND ₃ oD ₃ ⁺	pND ₄ ⁺ pD ₂	1.7e-09	0.00	0.0
1846	oND ₃ mD ₃ ⁺	IND ₄ ⁺ oD ₂	1.1e-09	0.00	0.0
1847	oND ₃ mD ₃ ⁺	IND ₄ ⁺ pD ₂	9.1e-10	0.00	0.0
1848	oND ₃ mD ₃ ⁺	mND ₄ ⁺ oD ₂	8.0e-10	0.00	0.0
1849	oND ₃ mD ₃ ⁺	mND ₄ ⁺ pD ₂	1.1e-10	0.00	0.0
1850	oND ₃ mD ₃ ⁺	oND ₄ ⁺ oD ₂	3.9e-09	0.00	0.0

Table D6 – continued (part 26)

#	Reactants	Products	α	β	γ			
1851	oND ₃	mD ₃ ⁺	oND ₄ ⁺	pD ₂	1.5e-09	0.00	0.0	
1852	oND ₃	mD ₃ ⁺	pND ₄ ⁺	oD ₂	5.1e-10	0.00	0.0	
1853	oND ₃	mD ₃ ⁺	pND ₄ ⁺	pD ₂	1.7e-10	0.00	0.0	
1854	oND ₃	pD ₃ ⁺	mND ₄ ⁺	oD ₂	1.1e-09	0.00	0.0	
1855	oND ₃	pD ₃ ⁺	mND ₄ ⁺	pD ₂	1.1e-09	0.00	0.0	
1856	oND ₃	pD ₃ ⁺	oND ₄ ⁺	oD ₂	1.7e-09	0.00	0.0	
1857	oND ₃	pD ₃ ⁺	oND ₄ ⁺	pD ₂	1.7e-09	0.00	0.0	
1858	oND ₃	pD ₃ ⁺	pND ₄ ⁺	oD ₂	1.7e-09	0.00	0.0	
1859	oND ₃	pD ₃ ⁺	pND ₄ ⁺	pD ₂	1.7e-09	0.00	0.0	
1860	oND ₃	oD ₃ ⁺	IND ₄ ⁺	oD ₂	4.3e-10	0.00	0.0	
1861	oND ₃	oD ₃ ⁺	IND ₄ ⁺	pD ₂	1.4e-10	0.00	0.0	
1862	oND ₃	oD ₃ ⁺	mND ₄ ⁺	oD ₂	1.2e-09	0.00	0.0	
1863	oND ₃	oD ₃ ⁺	mND ₄ ⁺	pD ₂	8.5e-10	0.00	0.0	
1864	oND ₃	oD ₃ ⁺	oND ₄ ⁺	oD ₂	3.0e-09	0.00	0.0	
1865	oND ₃	oD ₃ ⁺	oND ₄ ⁺	pD ₂	2.1e-09	0.00	0.0	
1866	oND ₃	oD ₃ ⁺	pND ₄ ⁺	oD ₂	8.5e-10	0.00	0.0	
1867	oND ₃	oD ₃ ⁺	pND ₄ ⁺	pD ₂	5.1e-10	0.00	0.0	
1868	N ₂	oH ₂ D ⁺	N ₂ H ⁺	HD	8.7e-10	0.00	0.0	
1869	N ₂	pH ₂ D ⁺	N ₂ H ⁺	HD	8.7e-10	0.00	0.0	
1870	N ₂	oH ₂ D ⁺	oH ₂	N ₂ D ⁺	4.3e-10	0.00	0.0	
1871	N ₂	pH ₂ D ⁺	pH ₂	N ₂ D ⁺	4.3e-10	0.00	0.0	
1872	N ₂	oHD ₂ ⁺	oD ₂	N ₂ H ⁺	4.3e-10	0.00	0.0	
1873	N ₂	pHD ₂ ⁺	pD ₂	N ₂ H ⁺	4.3e-10	0.00	0.0	
1874	N ₂	oHD ₂ ⁺	N ₂ D ⁺	HD	8.7e-10	0.00	0.0	
1875	N ₂	pHD ₂ ⁺	N ₂ D ⁺	HD	8.7e-10	0.00	0.0	
1876	N ₂	mD ₃ ⁺	oD ₂	N ₂ D ⁺	1.3e-09	0.00	0.0	
1877	N ₂	pD ₃ ⁺	pD ₂	N ₂ D ⁺	1.3e-09	0.00	0.0	
1878	N ₂	oD ₃ ⁺	oD ₂	N ₂ D ⁺	6.5e-10	0.00	0.0	
1879	N ₂	oD ₃ ⁺	pD ₂	N ₂ D ⁺	6.5e-10	0.00	0.0	
1880	N ⁺	e ⁻	N	γ	3.8e-12	-0.62	0.0	
1881	NH ⁺	e ⁻	N	H	2.0e-07	-0.50	0.0	
1882	oNH ₂ ⁺	e ⁻	NH	H	1.2e-07	-0.50	0.0	
1883	pNH ₂ ⁺	e ⁻	NH	H	1.2e-07	-0.50	0.0	
1884	oNH ₂ ⁺	e ⁻	oH ₂	N	1.2e-08	-0.50	0.0	
1885	pNH ₂ ⁺	e ⁻	pH ₂	N	1.2e-08	-0.50	0.0	
1886	oNH ₂ ⁺	e ⁻	H	H	N	1.7e-07	-0.50	0.0
1887	pNH ₂ ⁺	e ⁻	H	H	N	1.7e-07	-0.50	0.0
1888	oNH ₃ ⁺	e ⁻	oNH ₂	H	1.5e-07	-0.50	0.0	
1889	pNH ₃ ⁺	e ⁻	oNH ₂	H	7.7e-08	-0.50	0.0	
1890	pNH ₃ ⁺	e ⁻	pNH ₂	H	7.7e-08	-0.50	0.0	
1891	oNH ₃ ⁺	e ⁻	NH	H	H	1.5e-07	-0.50	0.0
1892	pNH ₃ ⁺	e ⁻	NH	H	H	1.5e-07	-0.50	0.0
1893	mNH ₄ ⁺	e ⁻	oNH ₂	oH ₂	1.9e-08	-0.60	0.0	
1894	pNH ₄ ⁺	e ⁻	oNH ₂	oH ₂	9.4e-09	-0.60	0.0	
1895	pNH ₄ ⁺	e ⁻	pNH ₂	pH ₂	9.4e-09	-0.60	0.0	
1896	oNH ₄ ⁺	e ⁻	oNH ₂	oH ₂	6.3e-09	-0.60	0.0	
1897	oNH ₄ ⁺	e ⁻	oNH ₂	pH ₂	6.3e-09	-0.60	0.0	
1898	oNH ₄ ⁺	e ⁻	pNH ₂	oH ₂	6.3e-09	-0.60	0.0	
1899	mNH ₄ ⁺	e ⁻	oNH ₃	H	8.0e-07	-0.60	0.0	
1900	pNH ₄ ⁺	e ⁻	pNH ₃	H	8.0e-07	-0.60	0.0	
1901	oNH ₄ ⁺	e ⁻	oNH ₃	H	2.7e-07	-0.60	0.0	
1902	oNH ₄ ⁺	e ⁻	pNH ₃	H	5.3e-07	-0.60	0.0	
1903	N ₂ ⁺	e ⁻	N	N	3.6e-08	-0.42	0.0	
1904	N ₂ H ⁺	e ⁻	N ₂	H	2.8e-07	-0.74	0.0	
1905	N ₂ H ⁺	e ⁻	NH	N	2.1e-08	-0.74	0.0	
1906	ND ⁺	e ⁻	N	D	2.0e-07	-0.50	0.0	
1907	NHD ⁺	e ⁻	N	H	D	1.5e-07	-0.50	0.0
1908	NHD ⁺	e ⁻	NH	D	7.5e-08	-0.50	0.0	
1909	NHD ⁺	e ⁻	ND	H	7.5e-08	-0.50	0.0	
1910	oND ₂ ⁺	e ⁻	ND	D	1.5e-07	-0.50	0.0	
1911	pND ₂ ⁺	e ⁻	ND	D	1.5e-07	-0.50	0.0	
1912	oND ₂ ⁺	e ⁻	D	D	N	1.5e-07	-0.50	0.0
1913	pND ₂ ⁺	e ⁻	D	D	N	1.5e-07	-0.50	0.0
1914	oNH ₂ D ⁺	e ⁻	oNH ₂	D	1.0e-07	-0.50	0.0	
1915	pNH ₂ D ⁺	e ⁻	pNH ₂	D	1.0e-07	-0.50	0.0	
1916	oNH ₂ D ⁺	e ⁻	NHD	H	2.0e-07	-0.50	0.0	
1917	pNH ₂ D ⁺	e ⁻	NHD	H	2.0e-07	-0.50	0.0	
1918	oNHD ₂ ⁺	e ⁻	oND ₂	H	1.0e-07	-0.50	0.0	
1919	pNHD ₂ ⁺	e ⁻	pND ₂	H	1.0e-07	-0.50	0.0	
1920	oNHD ₂ ⁺	e ⁻	NHD	D	2.0e-07	-0.50	0.0	
1921	pNHD ₂ ⁺	e ⁻	NHD	D	2.0e-07	-0.50	0.0	
1922	mND ₃ ⁺	e ⁻	oND ₂	D	3.0e-07	-0.50	0.0	
1923	pND ₃ ⁺	e ⁻	pND ₂	D	3.0e-07	-0.50	0.0	
1924	oND ₃ ⁺	e ⁻	oND ₂	D	1.5e-07	-0.50	0.0	

Table D6 – *continued* (part 27)

#	Reactants		Products		α	β	γ
1925	oND_3^+	e^-	pND ₂ D		1.5e-07	-0.50	0.0
1926	oNH_3D^+	e^-	oNH ₂ HD		2.5e-07	-0.50	0.0
1927	pNH_3D^+	e^-	oNH ₂ HD		1.3e-07	-0.50	0.0
1928	pNH_3D^+	e^-	pNH ₂ HD		1.3e-07	-0.50	0.0
1929	oNH_3D^+	e^-	oH ₂ NHD		2.5e-07	-0.50	0.0
1930	pNH_3D^+	e^-	oH ₂ NHD		1.3e-07	-0.50	0.0
1931	pNH_3D^+	e^-	pH ₂ NHD		1.3e-07	-0.50	0.0
1932	oNH_3D^+	e^-	oNH ₃ D		1.9e-07	-0.50	0.0
1933	pNH_3D^+	e^-	pNH ₃ D		1.9e-07	-0.50	0.0
1934	oNH_3D^+	e^-	oNH ₂ D H		5.7e-07	-0.50	0.0
1935	pNH_3D^+	e^-	oNH ₂ D H		2.9e-07	-0.50	0.0
1936	pNH_3D^+	e^-	pNH ₂ D H		2.9e-07	-0.50	0.0
1937	$\text{ooNH}_2\text{D}_2^+$	e^-	oD ₂ oNH ₂		8.5e-08	-0.50	0.0
1938	$\text{poNH}_2\text{D}_2^+$	e^-	pD ₂ oNH ₂		8.5e-08	-0.50	0.0
1939	$\text{opNH}_2\text{D}_2^+$	e^-	oD ₂ pNH ₂		8.5e-08	-0.50	0.0
1940	$\text{ppNH}_2\text{D}_2^+$	e^-	pD ₂ pNH ₂		8.5e-08	-0.50	0.0
1941	$\text{ooNH}_2\text{D}_2^+$	e^-	NHD HD		3.4e-07	-0.50	0.0
1942	$\text{poNH}_2\text{D}_2^+$	e^-	NHD HD		3.4e-07	-0.50	0.0
1943	$\text{opNH}_2\text{D}_2^+$	e^-	NHD HD		3.4e-07	-0.50	0.0
1944	$\text{ppNH}_2\text{D}_2^+$	e^-	NHD HD		3.4e-07	-0.50	0.0
1945	$\text{ooNH}_2\text{D}_2^+$	e^-	oND ₂ oH ₂		8.5e-08	-0.50	0.0
1946	$\text{poNH}_2\text{D}_2^+$	e^-	pND ₂ oH ₂		8.5e-08	-0.50	0.0
1947	$\text{opNH}_2\text{D}_2^+$	e^-	oND ₂ pH ₂		8.5e-08	-0.50	0.0
1948	$\text{ppNH}_2\text{D}_2^+$	e^-	pND ₂ pH ₂		8.5e-08	-0.50	0.0
1949	$\text{ooNH}_2\text{D}_2^+$	e^-	oNH ₂ D D		3.8e-07	-0.50	0.0
1950	$\text{poNH}_2\text{D}_2^+$	e^-	oNH ₂ D D		3.8e-07	-0.50	0.0
1951	$\text{opNH}_2\text{D}_2^+$	e^-	pNH ₂ D D		3.8e-07	-0.50	0.0
1952	$\text{ppNH}_2\text{D}_2^+$	e^-	pNH ₂ D D		3.8e-07	-0.50	0.0
1953	$\text{ooNH}_2\text{D}_2^+$	e^-	oNHD ₂ H		3.8e-07	-0.50	0.0
1954	$\text{poNH}_2\text{D}_2^+$	e^-	pNHD ₂ H		3.8e-07	-0.50	0.0
1955	$\text{opNH}_2\text{D}_2^+$	e^-	oNHD ₂ H		3.8e-07	-0.50	0.0
1956	$\text{ppNH}_2\text{D}_2^+$	e^-	pNHD ₂ H		3.8e-07	-0.50	0.0
1957	mNHD_3^+	e^-	oD ₂ NHD		2.5e-07	-0.50	0.0
1958	pNHD_3^+	e^-	pD ₂ NHD		2.5e-07	-0.50	0.0
1959	oNHD_3^+	e^-	oD ₂ NHD		1.3e-07	-0.50	0.0
1960	oNHD_3^+	e^-	pD ₂ NHD		1.3e-07	-0.50	0.0
1961	mNHD_3^+	e^-	oND ₂ HD		2.5e-07	-0.50	0.0
1962	pNHD_3^+	e^-	pND ₂ HD		2.5e-07	-0.50	0.0
1963	oNHD_3^+	e^-	oND ₂ HD		1.3e-07	-0.50	0.0
1964	oNHD_3^+	e^-	pND ₂ HD		1.3e-07	-0.50	0.0
1965	mNHD_3^+	e^-	mND ₃ H		1.9e-07	-0.50	0.0
1966	pNHD_3^+	e^-	pND ₃ H		1.9e-07	-0.50	0.0
1967	oNHD_3^+	e^-	oND ₃ H		1.9e-07	-0.50	0.0
1968	mNHD_3^+	e^-	oNHD ₂ D		5.7e-07	-0.50	0.0
1969	pNHD_3^+	e^-	pNHD ₂ D		5.7e-07	-0.50	0.0
1970	oNHD_3^+	e^-	oNHD ₂ D		2.9e-07	-0.50	0.0
1971	oNHD_3^+	e^-	pNHD ₂ D		2.9e-07	-0.50	0.0
1972	IND_4^+	e^-	oND ₂ oD ₂		5.1e-07	-0.50	0.0
1973	mND_4^+	e^-	oND ₂ oD ₂		2.5e-07	-0.50	0.0
1974	mND_4^+	e^-	pND ₂ pD ₂		2.5e-07	-0.50	0.0
1975	oND_4^+	e^-	oND ₂ oD ₂		1.7e-07	-0.50	0.0
1976	oND_4^+	e^-	oND ₂ pD ₂		1.7e-07	-0.50	0.0
1977	oND_4^+	e^-	pND ₂ oD ₂		1.7e-07	-0.50	0.0
1978	pND_4^+	e^-	oND ₂ pD ₂		1.7e-07	-0.50	0.0
1979	pND_4^+	e^-	pND ₂ oD ₂		1.7e-07	-0.50	0.0
1980	pND_4^+	e^-	pND ₂ pD ₂		1.7e-07	-0.50	0.0
1981	IND_4^+	e^-	mND ₃ D		7.6e-07	-0.50	0.0
1982	mND_4^+	e^-	oND ₃ D		7.6e-07	-0.50	0.0
1983	oND_4^+	e^-	mND ₃ D		2.5e-07	-0.50	0.0
1984	oND_4^+	e^-	oND ₃ D		5.1e-07	-0.50	0.0
1985	pND_4^+	e^-	pND ₃ D		2.5e-07	-0.50	0.0
1986	pND_4^+	e^-	oND ₃ D		5.1e-07	-0.50	0.0
1987	N_2D^+	e^-	N ₂ D		2.8e-07	-0.74	0.0
1988	N_2D^+	e^-	ND N		2.1e-08	-0.74	0.0
1989	NH ⁺	γ	N ⁺ H		2.2e+01	0.00	0.0
1990	N ₂	γ	N N		3.9e+01	0.00	0.0
1991	NH	γ	N H		3.7e+02	0.00	0.0
1992	NH	γ	NH ⁺ e ⁻		7.1e+00	0.00	0.0
1993	oNH ₂	γ	NH H		7.2e+02	0.00	0.0
1994	pNH ₂	γ	NH H		7.2e+02	0.00	0.0
1995	oNH ₂	γ	oNH ₂ ⁺ e ⁻		1.4e+02	0.00	0.0
1996	pNH ₂	γ	pNH ₂ ⁺ e ⁻		1.4e+02	0.00	0.0
1997	oNH ₃	γ	oH ₂ NH		1.1e+03	0.00	0.0
1998	pNH ₃	γ	oH ₂ NH		5.5e+02	0.00	0.0

Table D6 – continued (part 28)

#	Reactants		Products			α	β	γ
1999	pNH ₃	γ	pH ₂	NH		5.5e+02	0.00	0.0
2000	oNH ₃	γ	oNH ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
2001	pNH ₃	γ	pNH ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
2002	ND	γ	N	D		3.7e+02	0.00	0.0
2003	ND	γ	ND ⁺	e ⁻		7.1e+00	0.00	0.0
2004	NHD	γ	NH	D		3.6e+02	0.00	0.0
2005	NHD	γ	ND	H		3.6e+02	0.00	0.0
2006	NHD	γ	NHD ⁺	e ⁻		1.4e+02	0.00	0.0
2007	oND ₂	γ	ND	D		7.2e+02	0.00	0.0
2008	pND ₂	γ	ND	D		7.2e+02	0.00	0.0
2009	oND ₂	γ	oND ₂ ⁺	e ⁻		1.4e+02	0.00	0.0
2010	pND ₂	γ	pND ₂ ⁺	e ⁻		1.4e+02	0.00	0.0
2011	oNH ₂ D	γ	NH	HD		4.5e+02	0.00	0.0
2012	pNH ₂ D	γ	NH	HD		4.5e+02	0.00	0.0
2013	oNH ₂ D	γ	oH ₂	ND		2.2e+02	0.00	0.0
2014	pNH ₂ D	γ	pH ₂	ND		2.2e+02	0.00	0.0
2015	oNH ₂ D	γ	NHD	H		2.9e+02	0.00	0.0
2016	pNH ₂ D	γ	NHD	H		2.9e+02	0.00	0.0
2017	oNH ₂ D	γ	oNH ₂	D		1.4e+02	0.00	0.0
2018	pNH ₂ D	γ	pNH ₂	D		1.4e+02	0.00	0.0
2019	oNH ₂ D	γ	oNH ₂ D ⁺	e ⁻		2.2e+02	0.00	0.0
2020	pNH ₂ D	γ	pNH ₂ D ⁺	e ⁻		2.2e+02	0.00	0.0
2021	oNHD ₂	γ	ND	HD		4.5e+02	0.00	0.0
2022	pNHD ₂	γ	ND	HD		4.5e+02	0.00	0.0
2023	oNHD ₂	γ	oD ₂	NH		2.2e+02	0.00	0.0
2024	pNHD ₂	γ	pD ₂	NH		2.2e+02	0.00	0.0
2025	oNHD ₂	γ	NHD	D		2.9e+02	0.00	0.0
2026	pNHD ₂	γ	NHD	D		2.9e+02	0.00	0.0
2027	oNHD ₂	γ	oND ₂	H		1.4e+02	0.00	0.0
2028	pNHD ₂	γ	pND ₂	H		1.4e+02	0.00	0.0
2029	oNHD ₂	γ	oNHD ₂ ⁺	e ⁻		2.2e+02	0.00	0.0
2030	pNHD ₂	γ	pNHD ₂ ⁺	e ⁻		2.2e+02	0.00	0.0
2031	mND ₃	γ	oD ₂	ND		6.7e+02	0.00	0.0
2032	pND ₃	γ	pD ₂	ND		6.7e+02	0.00	0.0
2033	oND ₃	γ	oD ₂	ND		3.4e+02	0.00	0.0
2034	oND ₃	γ	pD ₂	ND		3.4e+02	0.00	0.0
2035	mND ₃	γ	oND ₂	D		4.3e+02	0.00	0.0
2036	pND ₃	γ	pND ₂	D		4.3e+02	0.00	0.0
2037	oND ₃	γ	oND ₂	D		2.1e+02	0.00	0.0
2038	oND ₃	γ	pND ₂	D		2.1e+02	0.00	0.0
2039	mND ₃	γ	mND ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
2040	pND ₃	γ	pND ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
2041	oND ₃	γ	oND ₃ ⁺	e ⁻		2.2e+02	0.00	0.0
2042	mNH ₄ ⁺	Gr	oNH ₃	H	Gr ⁺	3.8e-07	0.50	0.0
2043	pNH ₄ ⁺	Gr	pNH ₃	H	Gr ⁺	3.8e-07	0.50	0.0
2044	oNH ₄ ⁺	Gr	oNH ₃	H	Gr ⁺	1.3e-07	0.50	0.0
2045	oNH ₄ ⁺	Gr	pNH ₃	H	Gr ⁺	2.5e-07	0.50	0.0
2046	mNH ₄ ⁺	Gr ⁻	oNH ₃	H	Gr	3.8e-07	0.50	0.0
2047	pNH ₄ ⁺	Gr ⁻	pNH ₃	H	Gr	3.8e-07	0.50	0.0
2048	oNH ₄ ⁺	Gr ⁻	oNH ₃	H	Gr	1.3e-07	0.50	0.0
2049	oNH ₄ ⁺	Gr ⁻	pNH ₃	H	Gr	2.5e-07	0.50	0.0
2050	N ₂ H ⁺	Gr	Gr ⁺	N ₂	H	1.0e-07	0.50	0.0
2051	N ₂ H ⁺	Gr	Gr ⁺	NH	N	1.9e-07	0.50	0.0
2052	N ₂ H ⁺	Gr ⁻	Gr	N ₂	H	1.0e-07	0.50	0.0
2053	N ₂ H ⁺	Gr ⁻	Gr	NH	N	1.9e-07	0.50	0.0
2054	N ₂ D ⁺	Gr	Gr ⁺	N ₂	D	3.0e-07	0.50	0.0
2055	N ₂ D ⁺	Gr ⁻	Gr	N ₂	D	3.0e-07	0.50	0.0
2056	S	H ⁺	S ⁺	H		1.0e-15	0.00	0.0
2057	S	oH ₃ ⁺	oH ₂	SH ⁺		2.6e-09	0.00	0.0
2058	S	pH ₃ ⁺	oH ₂	SH ⁺		1.3e-09	0.00	0.0
2059	S	pH ₃ ⁺	pH ₂	SH ⁺		1.3e-09	0.00	0.0
2060	SH	H	oH ₂	S		1.9e-11	0.00	0.0
2061	SH	H	pH ₂	S		6.3e-12	0.00	0.0
2062	SH	He ⁺	S ⁺	H	He	1.7e-09	0.00	0.0
2063	SH	H ⁺	SH ⁺	H		1.6e-09	0.00	0.0
2064	SH	H ⁺	oH ₂	S ⁺		1.2e-09	0.00	0.0
2065	SH	H ⁺	pH ₂	S ⁺		4.0e-10	0.00	0.0
2066	SH	oH ₃ ⁺	oH ₂ S ⁺	oH ₂		1.4e-09	0.00	0.0
2067	SH	oH ₃ ⁺	oH ₂ S ⁺	pH ₂		2.4e-10	0.00	0.0
2068	SH	oH ₃ ⁺	pH ₂ S ⁺	oH ₂		2.4e-10	0.00	0.0
2069	SH	pH ₃ ⁺	oH ₂ S ⁺	oH ₂		7.1e-10	0.00	0.0
2070	SH	pH ₃ ⁺	oH ₂ S ⁺	pH ₂		4.8e-10	0.00	0.0
2071	SH	pH ₃ ⁺	pH ₂ S ⁺	oH ₂		4.8e-10	0.00	0.0
2072	SH	pH ₃ ⁺	pH ₂ S ⁺	pH ₂		2.4e-10	0.00	0.0

Table D6 – continued (part 29)

#	Reactants		Products			α	β	γ
2073	oH ₂ S	He ⁺	oH ₂	S ⁺	He	3.6e-09	0.00	0.0
2074	pH ₂ S	He ⁺	pH ₂	S ⁺	He	3.6e-09	0.00	0.0
2075	oH ₂ S	He ⁺	SH ⁺	H	He	4.8e-10	0.00	0.0
2076	pH ₂ S	He ⁺	SH ⁺	H	He	4.8e-10	0.00	0.0
2077	oH ₂ S	He ⁺	oH ₂ S ⁺	He		3.1e-10	0.00	0.0
2078	pH ₂ S	He ⁺	pH ₂ S ⁺	He		3.1e-10	0.00	0.0
2079	oH ₂ S	H ⁺	oH ₂ S ⁺	H		7.6e-09	0.00	0.0
2080	pH ₂ S	H ⁺	pH ₂ S ⁺	H		7.6e-09	0.00	0.0
2081	oH ₂ S	oH ₃ ⁺	oH ₃ S ⁺	oH ₂		2.3e-09	0.00	0.0
2082	oH ₂ S	oH ₃ ⁺	oH ₃ S ⁺	pH ₂		3.1e-10	0.00	0.0
2083	oH ₂ S	oH ₃ ⁺	pH ₃ S ⁺	oH ₂		8.6e-10	0.00	0.0
2084	oH ₂ S	oH ₃ ⁺	pH ₃ S ⁺	pH ₂		2.5e-10	0.00	0.0
2085	pH ₂ S	oH ₃ ⁺	oH ₃ S ⁺	oH ₂		9.3e-10	0.00	0.0
2086	pH ₂ S	oH ₃ ⁺	oH ₃ S ⁺	pH ₂		9.3e-10	0.00	0.0
2087	pH ₂ S	oH ₃ ⁺	pH ₃ S ⁺	oH ₂		1.9e-09	0.00	0.0
2088	oH ₂ S	pH ₃ ⁺	oH ₃ S ⁺	oH ₂		8.6e-10	0.00	0.0
2089	oH ₂ S	pH ₃ ⁺	oH ₃ S ⁺	pH ₂		6.2e-10	0.00	0.0
2090	oH ₂ S	pH ₃ ⁺	pH ₃ S ⁺	oH ₂		1.7e-09	0.00	0.0
2091	oH ₂ S	pH ₃ ⁺	pH ₃ S ⁺	pH ₂		4.9e-10	0.00	0.0
2092	pH ₂ S	pH ₃ ⁺	oH ₃ S ⁺	oH ₂		7.4e-10	0.00	0.0
2093	pH ₂ S	pH ₃ ⁺	pH ₃ S ⁺	oH ₂		1.5e-09	0.00	0.0
2094	pH ₂ S	pH ₃ ⁺	pH ₃ S ⁺	pH ₂		1.5e-09	0.00	0.0
2095	S ⁺	Fe	Fe ⁺	S		1.8e-10	0.00	0.0
2096	SH ⁺	H	oH ₂	S ⁺		8.2e-11	0.00	0.0
2097	SH ⁺	H	pH ₂	S ⁺		2.7e-11	0.00	0.0
2098	SH ⁺	oH ₂	oH ₃ S ⁺	γ		6.7e-16	0.00	0.0
2099	SH ⁺	oH ₂	pH ₃ S ⁺	γ		3.3e-16	0.00	0.0
2100	SH ⁺	pH ₂	pH ₃ S ⁺	γ		1.0e-15	0.00	0.0
2101	SH ⁺	S	S ⁺	SH		9.7e-10	0.00	0.0
2102	SH ⁺	oH ₂ S	oH ₃ S ⁺	S		3.3e-10	0.00	0.0
2103	SH ⁺	oH ₂ S	pH ₃ S ⁺	S		1.7e-10	0.00	0.0
2104	SH ⁺	pH ₂ S	pH ₃ S ⁺	S		5.0e-10	0.00	0.0
2105	SH ⁺	Fe	Fe ⁺	SH		1.6e-09	0.00	0.0
2106	oH ₂ S ⁺	H	oH ₂	SH ⁺		1.7e-10	0.00	0.0
2107	oH ₂ S ⁺	H	pH ₂	SH ⁺		3.3e-11	0.00	0.0
2108	pH ₂ S ⁺	H	oH ₂	SH ⁺		1.0e-10	0.00	0.0
2109	pH ₂ S ⁺	H	pH ₂	SH ⁺		1.0e-10	0.00	0.0
2110	oH ₂ S ⁺	S	oH ₂ S	S ⁺		1.1e-09	0.00	0.0
2111	pH ₂ S ⁺	S	pH ₂ S	S ⁺		1.1e-09	0.00	0.0
2112	oH ₂ S ⁺	SH	oH ₂ S	SH ⁺		5.0e-10	0.00	0.0
2113	pH ₂ S ⁺	SH	pH ₂ S	SH ⁺		5.0e-10	0.00	0.0
2114	oH ₂ S ⁺	Fe	oH ₂ S	Fe ⁺		1.8e-09	0.00	0.0
2115	pH ₂ S ⁺	Fe	pH ₂ S	Fe ⁺		1.8e-09	0.00	0.0
2116	oH ₃ S ⁺	H	oH ₂ S ⁺	oH ₂		4.5e-11	0.00	0.0
2117	oH ₃ S ⁺	H	oH ₂ S ⁺	pH ₂		7.5e-12	0.00	0.0
2118	oH ₃ S ⁺	H	pH ₂ S ⁺	oH ₂		7.5e-12	0.00	0.0
2119	pH ₃ S ⁺	H	oH ₂ S ⁺	oH ₂		2.2e-11	0.00	0.0
2120	pH ₃ S ⁺	H	oH ₂ S ⁺	pH ₂		1.5e-11	0.00	0.0
2121	pH ₃ S ⁺	H	pH ₂ S ⁺	oH ₂		1.5e-11	0.00	0.0
2122	pH ₃ S ⁺	H	pH ₂ S ⁺	pH ₂		7.5e-12	0.00	0.0
2123	S	oH ₂ D ⁺	SH ⁺	HD		1.7e-09	0.00	0.0
2124	S	pH ₂ D ⁺	SH ⁺	HD		1.7e-09	0.00	0.0
2125	S	oH ₂ D ⁺	oH ₂	SD ⁺		8.7e-10	0.00	0.0
2126	S	pH ₂ D ⁺	pH ₂	SD ⁺		8.7e-10	0.00	0.0
2127	S	oHD ₂ ⁺	oD ₂	SH ⁺		8.7e-10	0.00	0.0
2128	S	pHD ₂ ⁺	pD ₂	SH ⁺		8.7e-10	0.00	0.0
2129	S	oHD ₂ ⁺	SD ⁺	HD		1.7e-09	0.00	0.0
2130	S	pHD ₂ ⁺	SD ⁺	HD		1.7e-09	0.00	0.0
2131	S	mD ₃ ⁺	oD ₂	SD ⁺		2.6e-09	0.00	0.0
2132	S	pD ₃ ⁺	pD ₂	SD ⁺		2.6e-09	0.00	0.0
2133	S	oD ₃ ⁺	oD ₂	SD ⁺		1.3e-09	0.00	0.0
2134	S	oD ₃ ⁺	pD ₂	SD ⁺		1.3e-09	0.00	0.0
2135	SH	oH ₂ D ⁺	oH ₂ S ⁺	HD		1.6e-09	0.00	0.0
2136	SH	oH ₂ D ⁺	pH ₂ S ⁺	HD		3.2e-10	0.00	0.0
2137	SH	pH ₂ D ⁺	oH ₂ S ⁺	HD		9.5e-10	0.00	0.0
2138	SH	pH ₂ D ⁺	pH ₂ S ⁺	HD		9.5e-10	0.00	0.0
2139	SH	oHD ₂ ⁺	oD ₂	oH ₂ S ⁺		1.4e-09	0.00	0.0
2140	SH	pHD ₂ ⁺	pD ₂	oH ₂ S ⁺		1.4e-09	0.00	0.0
2141	SH	oHD ₂ ⁺	oD ₂	pH ₂ S ⁺		4.8e-10	0.00	0.0
2142	SH	pHD ₂ ⁺	pD ₂	pH ₂ S ⁺		4.8e-10	0.00	0.0
2143	oH ₂ S	oH ₂ D ⁺	oH ₃ S ⁺	HD		2.5e-09	0.00	0.0
2144	oH ₂ S	oH ₂ D ⁺	pH ₃ S ⁺	HD		1.2e-09	0.00	0.0
2145	oH ₂ S	pH ₂ D ⁺	oH ₃ S ⁺	HD		1.2e-09	0.00	0.0
2146	oH ₂ S	pH ₂ D ⁺	pH ₃ S ⁺	HD		2.5e-09	0.00	0.0

Table D6 – continued (part 30)

#	Reactants		Products		α	β	γ	
2147	pH ₂ S	oH ₂ D ⁺	oH ₃ S ⁺	HD	1.2e-09	0.00	0.0	
2148	pH ₂ S	oH ₂ D ⁺	pH ₃ S ⁺	HD	2.5e-09	0.00	0.0	
2149	pH ₂ S	pH ₂ D ⁺	pH ₃ S ⁺	HD	3.7e-09	0.00	0.0	
2150	oH ₂ S	oHD ₂ ⁺	oD ₂	oH ₃ S ⁺	2.5e-09	0.00	0.0	
2151	oH ₂ S	pHD ₂ ⁺	pD ₂	oH ₃ S ⁺	2.5e-09	0.00	0.0	
2152	oH ₂ S	oHD ₂ ⁺	oD ₂	pH ₃ S ⁺	1.2e-09	0.00	0.0	
2153	oH ₂ S	pHD ₂ ⁺	pD ₂	pH ₃ S ⁺	1.2e-09	0.00	0.0	
2154	pH ₂ S	oHD ₂ ⁺	oD ₂	pH ₃ S ⁺	3.7e-09	0.00	0.0	
2155	pH ₂ S	pHD ₂ ⁺	pD ₂	pH ₃ S ⁺	3.7e-09	0.00	0.0	
2156	S ⁺	Gr	Gr ⁺	S	2.8e-07	0.50	0.0	
2157	S ⁺	Gr ⁻	Gr	S	2.8e-07	0.50	0.0	
2158	oH ₃ S ⁺	Gr	oH ₂ S	H	Gr ⁺	2.7e-07	0.50	0.0
2159	pH ₃ S ⁺	Gr	oH ₂ S	H	Gr ⁺	1.4e-07	0.50	0.0
2160	pH ₃ S ⁺	Gr	pH ₂ S	H	Gr ⁺	1.4e-07	0.50	0.0
2161	oH ₃ S ⁺	Gr ⁻	oH ₂ S	H	Gr	2.7e-07	0.50	0.0
2162	pH ₃ S ⁺	Gr ⁻	oH ₂ S	H	Gr	1.4e-07	0.50	0.0
2163	pH ₃ S ⁺	Gr ⁻	pH ₂ S	H	Gr	1.4e-07	0.50	0.0
2164	S ⁺	e ⁻	S	γ	3.9e-12	-0.63	0.0	
2165	SH ⁺	e ⁻	S	H	2.0e-07	-0.50	0.0	
2166	oH ₂ S ⁺	e ⁻	SH	H	1.5e-07	-0.50	0.0	
2167	pH ₂ S ⁺	e ⁻	SH	H	1.5e-07	-0.50	0.0	
2168	oH ₂ S ⁺	e ⁻	H	H	S	1.5e-07	-0.50	0.0
2169	pH ₂ S ⁺	e ⁻	H	H	S	1.5e-07	-0.50	0.0
2170	oH ₂ S ⁺	e ⁻	oH ₂ S	γ	1.1e-10	-0.70	0.0	
2171	pH ₂ S ⁺	e ⁻	pH ₂ S	γ	1.1e-10	-0.70	0.0	
2172	oH ₃ S ⁺	e ⁻	oH ₂ S	H	3.0e-07	-0.50	0.0	
2173	pH ₃ S ⁺	e ⁻	oH ₂ S	H	1.5e-07	-0.50	0.0	
2174	pH ₃ S ⁺	e ⁻	pH ₂ S	H	1.5e-07	-0.50	0.0	
2175	oH ₃ S ⁺	e ⁻	oH ₂	SH	1.0e-07	-0.50	0.0	
2176	pH ₃ S ⁺	e ⁻	oH ₂	SH	5.0e-08	-0.50	0.0	
2177	pH ₃ S ⁺	e ⁻	pH ₂	SH	5.0e-08	-0.50	0.0	
2178	SD ⁺	e ⁻	S	D	2.0e-07	-0.50	0.0	
2179	S	γ_2	S ⁺	e ⁻	8.0e+02	0.00	0.0	
2180	SH	γ_2	S	H	1.1e+03	0.00	0.0	
2181	SH	γ_2	SH ⁺	e ⁻	3.4e+01	0.00	0.0	
2182	oH ₂ S	γ_2	SH	H	3.4e+03	0.00	0.0	
2183	pH ₂ S	γ_2	SH	H	3.4e+03	0.00	0.0	
2184	oH ₂ S	γ_2	oH ₂ S ⁺	e ⁻	6.2e+02	0.00	0.0	
2185	pH ₂ S	γ_2	pH ₂ S ⁺	e ⁻	6.2e+02	0.00	0.0	
2186	SH ⁺	γ_2	S ⁺	H	4.6e+02	0.00	0.0	
2187	O	CH	HCO ⁺	e ⁻	2.4e-14	0.50	0.0	
2188	O	CH	CO	H	6.6e-11	0.00	0.0	
2189	O	oCH ₂	H	H	CO	1.0e-10	0.00	0.0
2190	O	pCH ₂	H	H	CO	1.0e-10	0.00	0.0
2191	O	oCH ₂	oH ₂	CO	4.0e-11	0.00	0.0	
2192	O	pCH ₂	pH ₂	CO	4.0e-11	0.00	0.0	
2193	O	oCH ₃	oH ₂	H	CO	1.8e-10	0.50	0.0
2194	O	pCH ₃	oH ₂	H	CO	9.0e-11	0.50	0.0
2195	O	pCH ₃	pH ₂	H	CO	9.0e-11	0.50	0.0
2196	O	C ₂	CO	C	2.0e-10	-0.12	0.0	
2197	O	C ₂ H	CO	CH	1.0e-10	0.00	250.0	
2198	O	C ₃	CO	C ₂	5.0e-11	0.50	0.0	
2199	O	C ₃ H	C ₂ H	CO	5.0e-11	0.50	0.0	
2200	O	C ₃ H ₂	C ₂ H ₂	CO	5.0e-11	0.50	0.0	
2201	O	NH	NO	H	6.6e-11	0.00	0.0	
2202	O	oNH ₂	NH	OH	7.0e-12	-0.10	0.0	
2203	O	pNH ₂	NH	OH	7.0e-12	-0.10	0.0	
2204	O	CN	CO	N	5.0e-11	0.00	0.0	
2205	O	HNC	CO	NH	2.0e-10	0.50	200.0	
2206	O	SH	OH	S	1.7e-11	0.67	956.0	
2207	O	SH	SO	H	1.6e-10	0.00	0.0	
2208	O	CS	CO	S	2.6e-10	0.00	760.0	
2209	O	oCH ₃ ⁺	oH ₂	HCO ⁺	3.1e-10	0.00	0.0	
2210	O	pCH ₃ ⁺	oH ₂	HCO ⁺	1.6e-10	0.00	0.0	
2211	O	pCH ₃ ⁺	pH ₂	HCO ⁺	1.6e-10	0.00	0.0	
2212	O	oCH ₃ ⁺	oH ₃ ⁺	CO	1.3e-11	0.00	0.0	
2213	O	pCH ₃ ⁺	pH ₃ ⁺	CO	1.3e-11	0.00	0.0	
2214	O	pCH ₃ ⁺	oH ₃ O ⁺	oCH ₂	2.2e-10	0.00	0.0	
2215	O	oCH ₃ ⁺	oH ₃ O ⁺	oCH ₂	5.4e-11	0.00	0.0	
2216	O	oCH ₃ ⁺	oH ₃ O ⁺	pCH ₂	5.4e-11	0.00	0.0	
2217	O	oCH ₃ ⁺	pH ₃ O ⁺	oCH ₂	1.1e-10	0.00	0.0	
2218	O	mCH ₅ ⁺	oH ₃ O ⁺	oCH ₂	4.3e-11	0.00	0.0	
2219	O	mCH ₅ ⁺	pH ₃ O ⁺	oCH ₂	8.6e-11	0.00	0.0	
2220	O	mCH ₅ ⁺	pH ₃ O ⁺	pCH ₂	8.6e-11	0.00	0.0	

Table D6 – continued (part 31)

#	Reactants	Products	α	β	γ
2221	O HCO ₂ ⁺	HCO ⁺ O ₂	1.0e-09	0.00	0.0
2222	O SH ⁺	SO ⁺ H	2.9e-10	0.00	0.0
2223	O SH ⁺	S ⁺ OH	2.9e-10	0.00	0.0
2224	O oH ₂ S ⁺	SH ⁺ OH	3.1e-10	0.00	0.0
2225	O pH ₂ S ⁺	SH ⁺ OH	3.1e-10	0.00	0.0
2226	O oH ₂ S ⁺	oH ₂ SO ⁺	3.1e-10	0.00	0.0
2227	O pH ₂ S ⁺	pH ₂ SO ⁺	3.1e-10	0.00	0.0
2228	O HCS ⁺	HCO ⁺ S	1.0e-09	0.00	0.0
2229	C OH	CO H	3.1e-11	-0.36	0.0
2230	C O ₂	CO O	3.3e-11	0.50	0.0
2231	C NH	CN H	1.2e-10	0.00	0.0
2232	C oNH ₂	HCN H	3.0e-11	-0.20	-6.0
2233	C pNH ₂	HCN H	3.0e-11	-0.20	-6.0
2234	C oNH ₂	HNC H	3.0e-11	-0.20	-6.0
2235	C pNH ₂	HNC H	3.0e-11	-0.20	-6.0
2236	C NO	CN O	6.0e-11	-0.16	0.0
2237	C NO	CO N	9.0e-11	-0.16	0.0
2238	C SH	CS H	2.0e-11	0.00	0.0
2239	C SO	CO S	7.2e-11	0.00	0.0
2240	C SO	CS O	1.7e-10	0.00	0.0
2241	C oH ₃ O ⁺	oH ₂ HCO ⁺	1.0e-11	0.00	0.0
2242	C pH ₃ O ⁺	oH ₂ HCO ⁺	5.0e-12	0.00	0.0
2243	C pH ₃ O ⁺	pH ₂ HCO ⁺	5.0e-12	0.00	0.0
2244	C HCO ⁺	CH ⁺ CO	1.1e-09	0.00	0.0
2245	C O ₂ ⁺	CO ⁺ O	5.2e-11	0.00	0.0
2246	C O ₂ ⁺	C ⁺ O ₂	5.2e-11	0.00	0.0
2247	C SH ⁺	CS ⁺ H	9.9e-10	0.00	0.0
2248	C oH ₂ S ⁺	HCS ⁺ H	1.0e-09	0.00	0.0
2249	C pH ₂ S ⁺	HCS ⁺ H	1.0e-09	0.00	0.0
2250	C oH ₂ DO ⁺	oH ₂ DCO ⁺	1.0e-11	0.00	0.0
2251	C pH ₂ DO ⁺	pH ₂ DCO ⁺	1.0e-11	0.00	0.0
2252	C oHD ₂ O ⁺	DCO ⁺ HD	1.0e-11	0.00	0.0
2253	C pHD ₂ O ⁺	DCO ⁺ HD	1.0e-11	0.00	0.0
2254	C mD ₃ O ⁺	oD ₂ DCO ⁺	1.0e-11	0.00	0.0
2255	C pD ₃ O ⁺	pD ₂ DCO ⁺	1.0e-11	0.00	0.0
2256	C oD ₃ O ⁺	oD ₂ DCO ⁺	5.0e-12	0.00	0.0
2257	C oD ₃ O ⁺	pD ₂ DCO ⁺	5.0e-12	0.00	0.0
2258	N CH	CN H	1.4e-10	0.41	0.0
2259	N CN	N ₂ C	8.8e-11	0.42	0.0
2260	N NO	N ₂ O	7.3e-11	0.44	12.7
2261	N oCH ₂	HCN H	5.0e-11	0.17	0.0
2262	N pCH ₂	HCN H	5.0e-11	0.17	0.0
2263	N oCH ₂	HNC H	3.0e-11	0.17	0.0
2264	N pCH ₂	HNC H	3.0e-11	0.17	0.0
2265	N oCH ₃	oH ₂ HCN	1.3e-11	0.50	0.0
2266	N pCH ₃	oH ₂ HCN	6.5e-12	0.50	0.0
2267	N pCH ₃	pH ₂ HCN	6.5e-12	0.50	0.0
2268	N OH	NO H	5.0e-11	0.00	6.0
2269	N O ₂ ⁺	NO ⁺ O	7.8e-11	0.00	0.0
2270	N oCH ₂ ⁺	HCN ⁺ H	9.4e-10	0.00	0.0
2271	N pCH ₂ ⁺	HCN ⁺ H	9.4e-10	0.00	0.0
2272	N C ₂ H ⁺	C ₂ N ⁺ H	8.3e-10	0.00	0.0
2273	N oCH ₃ ⁺	oH ₂ HCN ⁺	6.7e-11	0.00	0.0
2274	N pCH ₃ ⁺	oH ₂ HCN ⁺	3.4e-11	0.00	0.0
2275	N pCH ₃ ⁺	pH ₂ HCN ⁺	3.4e-11	0.00	0.0
2276	N oCH ₃ ⁺	HCNH ⁺ H	6.7e-11	0.00	0.0
2277	N pCH ₃ ⁺	HCNH ⁺ H	6.7e-11	0.00	0.0
2278	N C ₂ H ₂ ⁺	CH ⁺ HCN	2.5e-11	0.00	0.0
2279	N SO	NO S	1.7e-11	0.50	750.0
2280	S CH	CS H	1.1e-12	0.00	0.0
2281	S OH	SO H	1.0e-10	0.00	100.0
2282	S O ₂	SO O	5.2e-12	0.00	265.0
2283	S CH ⁺	S ⁺ CH	4.7e-10	0.00	0.0
2284	S CH ⁺	SH ⁺ C	4.7e-10	0.00	0.0
2285	S CH ⁺	CS ⁺ H	4.7e-10	0.00	0.0
2286	S oCH ₃ ⁺	oH ₂ HCS ⁺	1.4e-09	0.00	0.0
2287	S pCH ₃ ⁺	oH ₂ HCS ⁺	7.0e-10	0.00	0.0
2288	S pCH ₃ ⁺	pH ₂ HCS ⁺	7.0e-10	0.00	0.0
2289	S pCH ₅ ⁺	mCH ₄ SH ⁺	1.3e-09	0.00	0.0
2290	S oCH ₅ ⁺	mCH ₄ SH ⁺	3.3e-10	0.00	0.0
2291	S oCH ₅ ⁺	oCH ₄ SH ⁺	9.8e-10	0.00	0.0
2292	S mCH ₅ ⁺	pCH ₄ SH ⁺	5.2e-10	0.00	0.0
2293	S mCH ₅ ⁺	oCH ₄ SH ⁺	7.8e-10	0.00	0.0
2294	S HCO ⁺	SH ⁺ CO	3.3e-10	0.00	0.0

Table D6 – continued (part 32)

#	Reactants		Products			α	β	γ
2295	S	O ₂ ⁺	SO ⁺	O		5.4e-10	0.00	0.0
2296	S	O ₂ ⁺	S ⁺	O ₂		5.4e-10	0.00	0.0
2297	S	HNO ⁺	SH ⁺	NO		1.1e-09	0.00	0.0
2298	S	N ₂ H ⁺	SH ⁺	N ₂		1.1e-09	0.00	0.0
2299	CO	He ⁺	C ⁺	O	He	1.5e-09	0.00	0.0
2300	SO	He ⁺	O ⁺	S	He	8.3e-10	0.00	0.0
2301	SO	He ⁺	S ⁺	O	He	8.3e-10	0.00	0.0
2302	NO	He ⁺	N ⁺	O	He	1.4e-09	0.00	0.0
2303	NO	He ⁺	O ⁺	N	He	2.2e-10	0.00	0.0
2304	CN	He ⁺	C ⁺	N	He	8.8e-10	0.00	0.0
2305	CN	He ⁺	N ⁺	C	He	8.8e-10	0.00	0.0
2306	CS	He ⁺	C ⁺	S	He	1.3e-09	0.00	0.0
2307	CS	He ⁺	S ⁺	C	He	1.3e-09	0.00	0.0
2308	N ₂	He ⁺	N ⁺	N	He	7.9e-10	0.00	0.0
2309	N ₂	He ⁺	N ₂ ⁺	He		4.1e-10	0.00	0.0
2310	HCN	He ⁺	CN ⁺	H	He	1.5e-09	0.00	0.0
2311	HCN	He ⁺	CH ⁺	N	He	6.2e-10	0.00	0.0
2312	HCN	He ⁺	C ⁺	NH	He	7.8e-10	0.00	0.0
2313	HCN	He ⁺	N ⁺	CH	He	2.5e-10	0.00	0.0
2314	HNC	He ⁺	CN ⁺	H	He	1.6e-09	0.00	0.0
2315	HNC	He ⁺	C ⁺	NH	He	1.6e-09	0.00	0.0
2316	CO ₂	He ⁺	CO ⁺	O	He	7.7e-10	0.00	0.0
2317	CO ₂	He ⁺	O ⁺	CO	He	1.8e-10	0.00	0.0
2318	CO ₂	He ⁺	C ⁺	O ₂	He	4.0e-11	0.00	0.0
2319	SO ₂	He ⁺	S ⁺	O ₂	He	8.6e-10	0.00	0.0
2320	SO ₂	He ⁺	SO ⁺	O	He	3.4e-09	0.00	0.0
2321	OCS	He ⁺	CS ⁺	O	He	7.6e-10	0.00	0.0
2322	OCS	He ⁺	S ⁺	CO	He	7.6e-10	0.00	0.0
2323	OCS	He ⁺	CO ⁺	S	He	7.6e-10	0.00	0.0
2324	OCS	He ⁺	O ⁺	CS	He	7.6e-11	0.00	0.0
2325	CH	SH ⁺	oCH ₂ ⁺	S		4.3e-10	0.00	0.0
2326	CH	SH ⁺	pCH ₂ ⁺	S		1.4e-10	0.00	0.0
2327	oH ₂ O	pCH ₅ ⁺	mCH ₄	oH ₃ O ⁺		1.9e-09	0.00	0.0
2328	oH ₂ O	pCH ₅ ⁺	pCH ₄	oH ₃ O ⁺		1.6e-10	0.00	0.0
2329	oH ₂ O	pCH ₅ ⁺	oCH ₄	oH ₃ O ⁺		8.5e-10	0.00	0.0
2330	oH ₂ O	pCH ₅ ⁺	mCH ₄	pH ₃ O ⁺		5.7e-10	0.00	0.0
2331	oH ₂ O	pCH ₅ ⁺	oCH ₄	pH ₃ O ⁺		2.0e-10	0.00	0.0
2332	pH ₂ O	pCH ₅ ⁺	mCH ₄	oH ₃ O ⁺		6.2e-10	0.00	0.0
2333	pH ₂ O	pCH ₅ ⁺	oCH ₄	oH ₃ O ⁺		1.9e-09	0.00	0.0
2334	pH ₂ O	pCH ₅ ⁺	mCH ₄	pH ₃ O ⁺		1.2e-09	0.00	0.0
2335	oH ₂ O	oCH ₅ ⁺	mCH ₄	oH ₃ O ⁺		4.7e-10	0.00	0.0
2336	oH ₂ O	oCH ₅ ⁺	pCH ₄	oH ₃ O ⁺		2.3e-10	0.00	0.0
2337	oH ₂ O	oCH ₅ ⁺	oCH ₄	oH ₃ O ⁺		1.4e-09	0.00	0.0
2338	oH ₂ O	oCH ₅ ⁺	mCH ₄	pH ₃ O ⁺		8.5e-10	0.00	0.0
2339	oH ₂ O	oCH ₅ ⁺	pCH ₄	pH ₃ O ⁺		1.8e-10	0.00	0.0
2340	oH ₂ O	oCH ₅ ⁺	oCH ₄	pH ₃ O ⁺		5.6e-10	0.00	0.0
2341	pH ₂ O	oCH ₅ ⁺	mCH ₄	oH ₃ O ⁺		3.5e-10	0.00	0.0
2342	pH ₂ O	oCH ₅ ⁺	pCH ₄	oH ₃ O ⁺		7.0e-10	0.00	0.0
2343	pH ₂ O	oCH ₅ ⁺	oCH ₄	oH ₃ O ⁺		1.1e-09	0.00	0.0
2344	pH ₂ O	oCH ₅ ⁺	mCH ₄	pH ₃ O ⁺		7.0e-10	0.00	0.0
2345	pH ₂ O	oCH ₅ ⁺	oCH ₄	pH ₃ O ⁺		8.8e-10	0.00	0.0
2346	oH ₂ O	mCH ₅ ⁺	mCH ₄	oH ₃ O ⁺		3.2e-10	0.00	0.0
2347	oH ₂ O	mCH ₅ ⁺	pCH ₄	oH ₃ O ⁺		4.7e-10	0.00	0.0
2348	oH ₂ O	mCH ₅ ⁺	oCH ₄	oH ₃ O ⁺		9.7e-10	0.00	0.0
2349	oH ₂ O	mCH ₅ ⁺	mCH ₄	pH ₃ O ⁺		4.7e-10	0.00	0.0
2350	oH ₂ O	mCH ₅ ⁺	pCH ₄	pH ₃ O ⁺		3.5e-10	0.00	0.0
2351	oH ₂ O	mCH ₅ ⁺	oCH ₄	pH ₃ O ⁺		1.1e-09	0.00	0.0
2352	pH ₂ O	mCH ₅ ⁺	mCH ₄	oH ₃ O ⁺		2.6e-10	0.00	0.0
2353	pH ₂ O	mCH ₅ ⁺	oCH ₄	oH ₃ O ⁺		7.9e-10	0.00	0.0
2354	pH ₂ O	mCH ₅ ⁺	pCH ₄	pH ₃ O ⁺		1.1e-09	0.00	0.0
2355	pH ₂ O	mCH ₅ ⁺	oCH ₄	pH ₃ O ⁺		1.6e-09	0.00	0.0
2356	oH ₂ O	C ₃ H ⁺	C ₂ H ₂	HCO ⁺		2.5e-10	0.00	0.0
2357	pH ₂ O	C ₃ H ⁺	C ₂ H ₂	HCO ⁺		2.5e-10	0.00	0.0
2358	oH ₂ O	C ₃ H ⁺	C ₂ H ₃ ⁺	CO		2.0e-10	0.00	0.0
2359	pH ₂ O	C ₃ H ⁺	C ₂ H ₃ ⁺	CO		2.0e-10	0.00	0.0
2360	oH ₂ O	oNH ₃ ⁺	mNH ₄ ⁺	OH		1.5e-10	0.00	0.0
2361	oH ₂ O	oNH ₃ ⁺	pNH ₄ ⁺	OH		1.7e-11	0.00	0.0
2362	oH ₂ O	oNH ₃ ⁺	oNH ₄ ⁺	OH		8.7e-11	0.00	0.0
2363	pH ₂ O	oNH ₃ ⁺	mNH ₄ ⁺	OH		6.3e-11	0.00	0.0
2364	pH ₂ O	oNH ₃ ⁺	oNH ₄ ⁺	OH		1.9e-10	0.00	0.0
2365	oH ₂ O	pNH ₃ ⁺	mNH ₄ ⁺	OH		4.2e-11	0.00	0.0
2366	oH ₂ O	pNH ₃ ⁺	pNH ₄ ⁺	OH		3.3e-11	0.00	0.0
2367	oH ₂ O	pNH ₃ ⁺	oNH ₄ ⁺	OH		1.7e-10	0.00	0.0
2368	pH ₂ O	pNH ₃ ⁺	pNH ₄ ⁺	OH		1.0e-10	0.00	0.0

Table D6 – continued (part 33)

#	Reactants		Products		α	β	γ
2369	pH ₂ O	pNH ₃ ⁺	oNH ₄ ⁺	OH	1.5e-10	0.00	0.0
2370	oH ₂ O	N ₂ H ⁺	oH ₃ O ⁺	N ₂	1.7e-09	0.00	0.0
2371	oH ₂ O	N ₂ H ⁺	pH ₃ O ⁺	N ₂	8.7e-10	0.00	0.0
2372	pH ₂ O	N ₂ H ⁺	pH ₃ O ⁺	N ₂	2.6e-09	0.00	0.0
2373	oH ₂ O	HNO ⁺	oH ₃ O ⁺	NO	1.5e-09	0.00	0.0
2374	oH ₂ O	HNO ⁺	pH ₃ O ⁺	NO	7.7e-10	0.00	0.0
2375	pH ₂ O	HNO ⁺	pH ₃ O ⁺	NO	2.3e-09	0.00	0.0
2376	oH ₂ O	SH ⁺	oH ₃ O ⁺	S	4.2e-10	0.00	0.0
2377	oH ₂ O	SH ⁺	pH ₃ O ⁺	S	2.1e-10	0.00	0.0
2378	pH ₂ O	SH ⁺	pH ₃ O ⁺	S	6.3e-10	0.00	0.0
2379	oH ₂ O	oH ₂ S ⁺	oH ₃ O ⁺	SH	5.4e-10	0.00	0.0
2380	oH ₂ O	oH ₂ S ⁺	pH ₃ O ⁺	SH	2.7e-10	0.00	0.0
2381	oH ₂ O	pH ₂ S ⁺	oH ₃ O ⁺	SH	2.7e-10	0.00	0.0
2382	oH ₂ O	pH ₂ S ⁺	pH ₃ O ⁺	SH	5.4e-10	0.00	0.0
2383	pH ₂ O	oH ₂ S ⁺	oH ₃ O ⁺	SH	2.7e-10	0.00	0.0
2384	pH ₂ O	oH ₂ S ⁺	pH ₃ O ⁺	SH	5.4e-10	0.00	0.0
2385	pH ₂ O	pH ₂ S ⁺	pH ₃ O ⁺	SH	8.1e-10	0.00	0.0
2386	oNH ₃	SH ⁺	oNH ₃ ⁺	SH	5.3e-10	0.00	0.0
2387	pNH ₃	SH ⁺	pNH ₃ ⁺	SH	5.3e-10	0.00	0.0
2388	oNH ₃	SH ⁺	mNH ₄ ⁺	S	6.1e-10	0.00	0.0
2389	oNH ₃	SH ⁺	oNH ₄ ⁺	S	3.7e-10	0.00	0.0
2390	pNH ₃	SH ⁺	pNH ₄ ⁺	S	2.4e-10	0.00	0.0
2391	pNH ₃	SH ⁺	oNH ₄ ⁺	S	7.3e-10	0.00	0.0
2392	oNH ₃	oH ₂ S ⁺	mNH ₄ ⁺	SH	7.9e-10	0.00	0.0
2393	oNH ₃	oH ₂ S ⁺	pNH ₄ ⁺	SH	9.1e-11	0.00	0.0
2394	oNH ₃	oH ₂ S ⁺	oNH ₄ ⁺	SH	4.8e-10	0.00	0.0
2395	oNH ₃	pH ₂ S ⁺	mNH ₄ ⁺	SH	3.4e-10	0.00	0.0
2396	oNH ₃	pH ₂ S ⁺	oNH ₄ ⁺	SH	1.0e-09	0.00	0.0
2397	pNH ₃	oH ₂ S ⁺	mNH ₄ ⁺	SH	2.3e-10	0.00	0.0
2398	pNH ₃	oH ₂ S ⁺	pNH ₄ ⁺	SH	1.8e-10	0.00	0.0
2399	pNH ₃	oH ₂ S ⁺	oNH ₄ ⁺	SH	9.5e-10	0.00	0.0
2400	pNH ₃	pH ₂ S ⁺	pNH ₄ ⁺	SH	5.4e-10	0.00	0.0
2401	pNH ₃	pH ₂ S ⁺	oNH ₄ ⁺	SH	8.2e-10	0.00	0.0
2402	oNH ₃	oH ₂ S ⁺	oNH ₃ ⁺	oH ₂ S	3.4e-10	0.00	0.0
2403	oNH ₃	pH ₂ S ⁺	oNH ₃ ⁺	pH ₂ S	3.4e-10	0.00	0.0
2404	pNH ₃	oH ₂ S ⁺	pNH ₃ ⁺	oH ₂ S	3.4e-10	0.00	0.0
2405	pNH ₃	pH ₂ S ⁺	pNH ₃ ⁺	pH ₂ S	3.4e-10	0.00	0.0
2406	oNH ₃	oH ₃ S ⁺	mNH ₄ ⁺	oH ₂ S	9.9e-10	0.00	0.0
2407	oNH ₃	oH ₃ S ⁺	mNH ₄ ⁺	pH ₂ S	1.2e-10	0.00	0.0
2408	oNH ₃	oH ₃ S ⁺	pNH ₄ ⁺	oH ₂ S	7.9e-11	0.00	0.0
2409	oNH ₃	oH ₃ S ⁺	pNH ₄ ⁺	pH ₂ S	4.7e-11	0.00	0.0
2410	oNH ₃	oH ₃ S ⁺	oNH ₄ ⁺	oH ₂ S	5.5e-10	0.00	0.0
2411	oNH ₃	oH ₃ S ⁺	oNH ₄ ⁺	pH ₂ S	1.2e-10	0.00	0.0
2412	oNH ₃	pH ₃ S ⁺	mNH ₄ ⁺	oH ₂ S	3.2e-10	0.00	0.0
2413	oNH ₃	pH ₃ S ⁺	mNH ₄ ⁺	pH ₂ S	2.4e-10	0.00	0.0
2414	oNH ₃	pH ₃ S ⁺	pNH ₄ ⁺	oH ₂ S	1.6e-10	0.00	0.0
2415	oNH ₃	pH ₃ S ⁺	oNH ₄ ⁺	oH ₂ S	9.5e-10	0.00	0.0
2416	oNH ₃	pH ₃ S ⁺	oNH ₄ ⁺	pH ₂ S	2.4e-10	0.00	0.0
2417	pNH ₃	oH ₃ S ⁺	mNH ₄ ⁺	oH ₂ S	3.2e-10	0.00	0.0
2418	pNH ₃	oH ₃ S ⁺	mNH ₄ ⁺	pH ₂ S	2.4e-10	0.00	0.0
2419	pNH ₃	oH ₃ S ⁺	pNH ₄ ⁺	oH ₂ S	1.6e-10	0.00	0.0
2420	pNH ₃	oH ₃ S ⁺	oNH ₄ ⁺	oH ₂ S	9.5e-10	0.00	0.0
2421	pNH ₃	oH ₃ S ⁺	oNH ₄ ⁺	pH ₂ S	2.4e-10	0.00	0.0
2422	pNH ₃	pH ₃ S ⁺	mNH ₄ ⁺	oH ₂ S	1.6e-10	0.00	0.0
2423	pNH ₃	pH ₃ S ⁺	pNH ₄ ⁺	oH ₂ S	3.2e-10	0.00	0.0
2424	pNH ₃	pH ₃ S ⁺	pNH ₄ ⁺	pH ₂ S	1.9e-10	0.00	0.0
2425	pNH ₃	pH ₃ S ⁺	oNH ₄ ⁺	oH ₂ S	7.6e-10	0.00	0.0
2426	pNH ₃	pH ₃ S ⁺	oNH ₄ ⁺	pH ₂ S	4.8e-10	0.00	0.0
2427	oNH ₃	SO ⁺	oNH ₃ ⁺	SO	1.3e-09	0.00	0.0
2428	pNH ₃	SO ⁺	pNH ₃ ⁺	SO	1.3e-09	0.00	0.0
2429	oNH ₃	O ₂ ⁺	oNH ₃ ⁺	O ₂	2.0e-09	0.00	0.0
2430	pNH ₃	O ₂ ⁺	pNH ₃ ⁺	O ₂	2.0e-09	0.00	0.0
2431	CO	OH	CO ₂	H	4.4e-13	-1.15	390.0
2432	CO	oH ₂ ⁺	HCO ⁺	H	2.2e-09	0.00	0.0
2433	CO	pH ₂ ⁺	HCO ⁺	H	2.2e-09	0.00	0.0
2434	CO	oH ₂ ⁺	oH ₂	CO ⁺	6.4e-10	0.00	0.0
2435	CO	pH ₂ ⁺	pH ₂	CO ⁺	6.4e-10	0.00	0.0
2436	CO	oH ₃ ⁺	oH ₂	HCO ⁺	1.7e-09	0.00	0.0
2437	CO	pH ₃ ⁺	oH ₂	HCO ⁺	8.5e-10	0.00	0.0
2438	CO	pH ₃ ⁺	pH ₂	HCO ⁺	8.5e-10	0.00	0.0
2439	CO	pCH ₅ ⁺	mCH ₄	HCO ⁺	9.9e-10	0.00	0.0
2440	CO	oCH ₅ ⁺	mCH ₄	HCO ⁺	2.5e-10	0.00	0.0
2441	CO	oCH ₅ ⁺	oCH ₄	HCO ⁺	7.4e-10	0.00	0.0
2442	CO	mCH ₅ ⁺	pCH ₄	HCO ⁺	4.0e-10	0.00	0.0

Table D6 – continued (part 34)

#	Reactants	Products	α	β	γ		
2443	CO	mCH ₅ ⁺	oCH ₄	HCO ⁺	5.9e-10	0.00	0.0
2444	CO	oH ₂ D ⁺	HCO ⁺	HD	1.1e-09	0.00	0.0
2445	CO	pH ₂ D ⁺	HCO ⁺	HD	1.1e-09	0.00	0.0
2446	CO	oH ₂ D ⁺	oH ₂	DCO ⁺	5.7e-10	0.00	0.0
2447	CO	pH ₂ D ⁺	pH ₂	DCO ⁺	5.7e-10	0.00	0.0
2448	CO	oHD ₂ ⁺	oD ₂	HCO ⁺	5.7e-10	0.00	0.0
2449	CO	pHD ₂ ⁺	pD ₂	HCO ⁺	5.7e-10	0.00	0.0
2450	CO	oHD ₂ ⁺	DCO ⁺	HD	1.1e-09	0.00	0.0
2451	CO	pHD ₂ ⁺	DCO ⁺	HD	1.1e-09	0.00	0.0
2452	CO	mD ₃ ⁺	oD ₂	DCO ⁺	1.7e-09	0.00	0.0
2453	CO	pD ₃ ⁺	pD ₂	DCO ⁺	1.7e-09	0.00	0.0
2454	CO	oD ₃ ⁺	oD ₂	DCO ⁺	8.5e-10	0.00	0.0
2455	CO	oD ₃ ⁺	pD ₂	DCO ⁺	8.5e-10	0.00	0.0
2456	SO	OH	SO ₂	H	2.0e-10	-0.17	0.0
2457	SO	H ⁺	SO ⁺	H	3.2e-09	0.00	0.0
2458	SO	oH ₃ ⁺	oH ₂	HSO ⁺	1.9e-09	0.00	0.0
2459	SO	pH ₃ ⁺	oH ₂	HSO ⁺	9.5e-10	0.00	0.0
2460	SO	pH ₃ ⁺	pH ₂	HSO ⁺	9.5e-10	0.00	0.0
2461	SO	CH ⁺	OH ⁺	CS	1.0e-09	0.00	0.0
2462	SO	CH ⁺	SH ⁺	CO	1.0e-09	0.00	0.0
2463	SO	oCH ₃ ⁺	oH ₂	HOCS ⁺	9.5e-10	0.00	0.0
2464	SO	pCH ₃ ⁺	oH ₂	HOCS ⁺	4.8e-10	0.00	0.0
2465	SO	pCH ₃ ⁺	pH ₂	HOCS ⁺	4.8e-10	0.00	0.0
2466	SO	HCO ⁺	HSO ⁺	CO	7.5e-10	0.00	0.0
2467	NO	CH	HCN	O	1.2e-11	-0.13	0.0
2468	NO	H ⁺	NO ⁺	H	1.9e-09	0.00	0.0
2469	NO	oH ₃ ⁺	oH ₂	HNO ⁺	1.1e-09	0.00	0.0
2470	NO	pH ₃ ⁺	oH ₂	HNO ⁺	5.5e-10	0.00	0.0
2471	NO	pH ₃ ⁺	pH ₂	HNO ⁺	5.5e-10	0.00	0.0
2472	NO	HCO ₂ ⁺	HNO ⁺	CO ₂	1.0e-10	0.00	0.0
2473	NO	O ₂ ⁺	NO ⁺	O ₂	4.4e-10	0.00	0.0
2474	NO	SH ⁺	NO ⁺	SH	3.3e-10	0.00	0.0
2475	NO	oH ₂ S ⁺	oH ₂ S	NO ⁺	3.7e-10	0.00	0.0
2476	NO	pH ₂ S ⁺	pH ₂ S	NO ⁺	3.7e-10	0.00	0.0
2477	NO	oH ₂ D ⁺	HNO ⁺	HD	7.3e-10	0.00	0.0
2478	NO	pH ₂ D ⁺	HNO ⁺	HD	7.3e-10	0.00	0.0
2479	NO	oHD ₂ ⁺	oD ₂	HNO ⁺	3.7e-10	0.00	0.0
2480	NO	pHD ₂ ⁺	pD ₂	HNO ⁺	3.7e-10	0.00	0.0
2481	CN	oNH ₃	oNH ₂	HCN	2.8e-11	-0.85	0.0
2482	CN	pNH ₃	oNH ₂	HCN	1.4e-11	-0.85	0.0
2483	CN	pNH ₃	pNH ₂	HCN	1.4e-11	-0.85	0.0
2484	CN	oH ₃ ⁺	oH ₂	HCN ⁺	1.0e-09	0.00	0.0
2485	CN	pH ₃ ⁺	oH ₂	HCN ⁺	5.0e-10	0.00	0.0
2486	CN	pH ₃ ⁺	pH ₂	HCN ⁺	5.0e-10	0.00	0.0
2487	CN	oH ₃ ⁺	HCNH ⁺	H	1.0e-09	0.00	0.0
2488	CN	pH ₃ ⁺	HCNH ⁺	H	1.0e-09	0.00	0.0
2489	CN	oH ₃ O ⁺	HCNH ⁺	OH	4.5e-09	0.00	0.0
2490	CN	pH ₃ O ⁺	HCNH ⁺	OH	4.5e-09	0.00	0.0
2491	CN	oH ₂ D ⁺	HCNH ⁺	D	1.0e-09	0.00	0.0
2492	CN	pH ₂ D ⁺	HCNH ⁺	D	1.0e-09	0.00	0.0
2493	CN	oH ₂ D ⁺	HCN ⁺	HD	1.0e-09	0.00	0.0
2494	CN	pH ₂ D ⁺	HCN ⁺	HD	1.0e-09	0.00	0.0
2495	CS	OH	OCS	H	1.7e-10	0.00	0.0
2496	CS	OH	CO	SH	3.0e-11	0.00	0.0
2497	CS	H ⁺	CS ⁺	H	4.9e-09	0.00	0.0
2498	CS	oH ₃ ⁺	oH ₂	HCS ⁺	2.9e-09	0.00	0.0
2499	CS	pH ₃ ⁺	oH ₂	HCS ⁺	1.4e-09	0.00	0.0
2500	CS	pH ₃ ⁺	pH ₂	HCS ⁺	1.4e-09	0.00	0.0
2501	CS	oH ₂ D ⁺	HCS ⁺	HD	2.9e-09	0.00	0.0
2502	CS	pH ₂ D ⁺	HCS ⁺	HD	2.9e-09	0.00	0.0
2503	CS	oHD ₂ ⁺	oD ₂	HCS ⁺	2.9e-09	0.00	0.0
2504	CS	pHD ₂ ⁺	pD ₂	HCS ⁺	2.9e-09	0.00	0.0
2505	SO	oH ₂ D ⁺	HSO ⁺	HD	1.9e-09	0.00	0.0
2506	SO	pH ₂ D ⁺	HSO ⁺	HD	1.9e-09	0.00	0.0
2507	SO	oHD ₂ ⁺	oD ₂	HSO ⁺	1.9e-09	0.00	0.0
2508	SO	pHD ₂ ⁺	pD ₂	HSO ⁺	1.9e-09	0.00	0.0
2509	HCN	H ⁺	HCN ⁺	H	1.1e-08	0.00	0.0
2510	HCN	oH ₃ ⁺	oH ₂	HCNH ⁺	9.5e-09	0.00	0.0
2511	HCN	pH ₃ ⁺	oH ₂	HCNH ⁺	4.8e-09	0.00	0.0
2512	HCN	pH ₃ ⁺	pH ₂	HCNH ⁺	4.8e-09	0.00	0.0
2513	HCN	oH ₃ O ⁺	oH ₂ O	HCNH ⁺	4.5e-09	0.00	0.0
2514	HCN	pH ₃ O ⁺	oH ₂ O	HCNH ⁺	2.2e-09	0.00	0.0
2515	HCN	pH ₃ O ⁺	pH ₂ O	HCNH ⁺	2.2e-09	0.00	0.0
2516	HCN	oH ₃ S ⁺	oH ₂ S	HCNH ⁺	1.9e-09	0.00	0.0

Table D6 – continued (part 35)

#	Reactants	Products	α	β	γ
2517	HCN pH ₃ S ⁺	oH ₂ S HCNH ⁺	9.5e-10	0.00	0.0
2518	HCN pH ₃ S ⁺	pH ₂ S HCNH ⁺	9.5e-10	0.00	0.0
2519	HCN HCO ⁺	HCNH ⁺ CO	3.7e-09	0.00	0.0
2520	HCN oH ₂ D ⁺	HCNH ⁺ HD	9.5e-09	0.00	0.0
2521	HCN pH ₂ D ⁺	HCNH ⁺ HD	9.5e-09	0.00	0.0
2522	HNC H	HCN H	1.0e-15	0.00	0.0
2523	HNC H ⁺	H ⁺ HCN	1.0e-09	0.00	0.0
2524	HNC oH ₃ ⁺	oH ₂ HCNH ⁺	9.5e-09	0.00	0.0
2525	HNC pH ₃ ⁺	oH ₂ HCNH ⁺	4.8e-09	0.00	0.0
2526	HNC pH ₃ ⁺	pH ₂ HCNH ⁺	4.8e-09	0.00	0.0
2527	HNC oH ₂ D ⁺	HCNH ⁺ HD	9.5e-09	0.00	0.0
2528	HNC pH ₂ D ⁺	HCNH ⁺ HD	9.5e-09	0.00	0.0
2529	HNC oH ₃ O ⁺	oH ₂ O HCNH ⁺	4.5e-09	0.00	0.0
2530	HNC pH ₃ O ⁺	oH ₂ O HCNH ⁺	2.2e-09	0.00	0.0
2531	HNC pH ₃ O ⁺	pH ₂ O HCNH ⁺	2.2e-09	0.00	0.0
2532	HNC HCO ⁺	HCNH ⁺ CO	3.7e-09	0.00	0.0
2533	CO ₂ H ⁺	HCO ⁺ O	4.2e-09	0.00	0.0
2534	CO ₂ oH ₃ ⁺	oH ₂ HCO ₂ ⁺	2.0e-09	0.00	0.0
2535	CO ₂ pH ₃ ⁺	oH ₂ HCO ₂ ⁺	1.0e-09	0.00	0.0
2536	CO ₂ pH ₃ ⁺	pH ₂ HCO ₂ ⁺	1.0e-09	0.00	0.0
2537	CO ₂ oH ₂ D ⁺	HCO ₂ ⁺ HD	1.3e-09	0.00	0.0
2538	CO ₂ pH ₂ D ⁺	HCO ₂ ⁺ HD	1.3e-09	0.00	0.0
2539	CO ₂ oH ₂ D ⁺	oH ₂ DCO ₂ ⁺	6.7e-10	0.00	0.0
2540	CO ₂ pH ₂ D ⁺	pH ₂ DCO ₂ ⁺	6.7e-10	0.00	0.0
2541	CO ₂ oHD ₂ ⁺	oD ₂ HCO ₂ ⁺	6.7e-10	0.00	0.0
2542	CO ₂ pHD ₂ ⁺	pD ₂ HCO ₂ ⁺	6.7e-10	0.00	0.0
2543	CO ₂ oHD ₂ ⁺	DCO ₂ ⁺ HD	1.3e-09	0.00	0.0
2544	CO ₂ pHD ₂ ⁺	DCO ₂ ⁺ HD	1.3e-09	0.00	0.0
2545	CO ₂ mD ₃ ⁺	oD ₂ DCO ₂ ⁺	2.0e-09	0.00	0.0
2546	CO ₂ pD ₃ ⁺	pD ₂ DCO ₂ ⁺	2.0e-09	0.00	0.0
2547	CO ₂ oD ₃ ⁺	oD ₂ DCO ₂ ⁺	1.0e-09	0.00	0.0
2548	CO ₂ oD ₃ ⁺	pD ₂ DCO ₂ ⁺	1.0e-09	0.00	0.0
2549	CO ₂ N ₂ D ⁺	DCO ₂ ⁺ N ₂	1.4e-09	0.00	0.0
2550	SO ₂ oH ₃ ⁺	oH ₂ HSO ₂ ⁺	1.3e-09	0.00	0.0
2551	SO ₂ pH ₃ ⁺	oH ₂ HSO ₂ ⁺	6.5e-10	0.00	0.0
2552	SO ₂ pH ₃ ⁺	pH ₂ HSO ₂ ⁺	6.5e-10	0.00	0.0
2553	SO ₂ oH ₂ D ⁺	HSO ₂ ⁺ HD	1.3e-09	0.00	0.0
2554	SO ₂ pH ₂ D ⁺	HSO ₂ ⁺ HD	1.3e-09	0.00	0.0
2555	SO ₂ oHD ₂ ⁺	oD ₂ HSO ₂ ⁺	1.3e-09	0.00	0.0
2556	SO ₂ pHD ₂ ⁺	pD ₂ HSO ₂ ⁺	1.3e-09	0.00	0.0
2557	OCS H ⁺	SH ⁺ CO	5.9e-09	0.00	0.0
2558	OCS oH ₃ ⁺	oH ₂ HOCS ⁺	1.9e-09	0.00	0.0
2559	OCS pH ₃ ⁺	oH ₂ HOCS ⁺	9.5e-10	0.00	0.0
2560	OCS pH ₃ ⁺	pH ₂ HOCS ⁺	9.5e-10	0.00	0.0
2561	OCS HCO ⁺	HOCS ⁺ CO	1.1e-09	0.00	0.0
2562	oH ₂ S oH ₃ O ⁺	oH ₃ S ⁺ oH ₂ O	1.2e-09	0.00	0.0
2563	oH ₂ S oH ₃ O ⁺	oH ₃ S ⁺ pH ₂ O	1.6e-10	0.00	0.0
2564	oH ₂ S oH ₃ O ⁺	pH ₃ S ⁺ oH ₂ O	4.4e-10	0.00	0.0
2565	oH ₂ S oH ₃ O ⁺	pH ₃ S ⁺ pH ₂ O	1.3e-10	0.00	0.0
2566	pH ₂ S oH ₃ O ⁺	oH ₃ S ⁺ oH ₂ O	4.8e-10	0.00	0.0
2567	pH ₂ S oH ₃ O ⁺	oH ₃ S ⁺ pH ₂ O	4.8e-10	0.00	0.0
2568	pH ₂ S oH ₃ O ⁺	pH ₃ S ⁺ oH ₂ O	9.5e-10	0.00	0.0
2569	oH ₂ S pH ₃ O ⁺	oH ₃ S ⁺ oH ₂ O	4.4e-10	0.00	0.0
2570	oH ₂ S pH ₃ O ⁺	oH ₃ S ⁺ pH ₂ O	3.2e-10	0.00	0.0
2571	oH ₂ S pH ₃ O ⁺	pH ₃ S ⁺ oH ₂ O	8.9e-10	0.00	0.0
2572	oH ₂ S pH ₃ O ⁺	pH ₃ S ⁺ pH ₂ O	2.5e-10	0.00	0.0
2573	pH ₂ S pH ₃ O ⁺	oH ₃ S ⁺ oH ₂ O	3.8e-10	0.00	0.0
2574	pH ₂ S pH ₃ O ⁺	pH ₃ S ⁺ oH ₂ O	7.6e-10	0.00	0.0
2575	pH ₂ S pH ₃ O ⁺	pH ₃ S ⁺ pH ₂ O	7.6e-10	0.00	0.0
2576	SH HCO ⁺	oH ₂ S ⁺ CO	6.2e-10	0.00	0.0
2577	SH HCO ⁺	pH ₂ S ⁺ CO	2.0e-10	0.00	0.0
2578	CS HCO ⁺	HCS ⁺ CO	1.2e-09	0.00	0.0
2579	oH ₂ S HCO ⁺	oH ₃ S ⁺ CO	1.1e-09	0.00	0.0
2580	oH ₂ S HCO ⁺	pH ₃ S ⁺ CO	5.3e-10	0.00	0.0
2581	pH ₂ S HCO ⁺	pH ₃ S ⁺ CO	1.6e-09	0.00	0.0
2582	oH ₂ S O ₂ ⁺	oH ₂ S ⁺ O ₂	1.4e-09	0.00	0.0
2583	pH ₂ S O ₂ ⁺	pH ₂ S ⁺ O ₂	1.4e-09	0.00	0.0
2584	oH ₂ S oNH ₃ ⁺	mNH ₄ ⁺ SH	3.5e-10	0.00	0.0
2585	oH ₂ S oNH ₃ ⁺	pNH ₄ ⁺ SH	4.0e-11	0.00	0.0
2586	oH ₂ S oNH ₃ ⁺	oNH ₄ ⁺ SH	2.1e-10	0.00	0.0
2587	pH ₂ S oNH ₃ ⁺	mNH ₄ ⁺ SH	1.5e-10	0.00	0.0
2588	pH ₂ S oNH ₃ ⁺	oNH ₄ ⁺ SH	4.5e-10	0.00	0.0
2589	oH ₂ S pNH ₃ ⁺	mNH ₄ ⁺ SH	1.0e-10	0.00	0.0
2590	oH ₂ S pNH ₃ ⁺	pNH ₄ ⁺ SH	8.0e-11	0.00	0.0

Table D6 – continued (part 36)

#	Reactants	Products	α	β	γ		
2591	oH_2S	pNH_3^+	oNH_4^+	SH	4.2e-10	0.00	0.0
2592	pH_2S	pNH_3^+	pNH_4^+	SH	2.4e-10	0.00	0.0
2593	pH_2S	pNH_3^+	oNH_4^+	SH	3.6e-10	0.00	0.0
2594	OCS	oH_2D^+	HOCS ⁺	HD	1.9e-09	0.00	0.0
2595	OCS	pH_2D^+	HOCS ⁺	HD	1.9e-09	0.00	0.0
2596	OCS	oHD_2^+	oD_2	HOCS ⁺	1.9e-09	0.00	0.0
2597	OCS	pHD_2^+	pD_2	HOCS ⁺	1.9e-09	0.00	0.0
2598	S	N_2D^+	SD^+	N_2	1.1e-09	0.00	0.0
2599	oH_2O	N_2D^+	oH_2DO^+	N_2	2.6e-09	0.00	0.0
2600	pH_2O	N_2D^+	pH_2DO^+	N_2	2.6e-09	0.00	0.0
2601	CO	N_2D^+	DCO ⁺	N_2	8.8e-10	0.00	0.0
2602	C ⁺	S	S ⁺	C	5.5e-12	0.86	681.0
2603	C ⁺	OH	CO ⁺	H	8.0e-10	0.00	0.0
2604	C ⁺	OH	H ⁺	CO	8.0e-10	0.00	0.0
2605	C ⁺	oH_2O	HCO ⁺	H	2.4e-09	-0.63	0.0
2606	C ⁺	pH_2O	HCO ⁺	H	2.4e-09	-0.63	0.0
2607	C ⁺	O ₂	O ⁺	CO	5.1e-10	0.00	0.0
2608	C ⁺	O ₂	CO ⁺	O	3.1e-10	0.00	0.0
2609	C ⁺	CO ₂	CO ⁺	CO	1.1e-09	0.00	0.0
2610	C ⁺	NH	CN ⁺	H	7.8e-10	0.00	0.0
2611	C ⁺	oNH_2	HCN ⁺	H	1.1e-09	0.00	0.0
2612	C ⁺	pNH_2	HCN ⁺	H	1.1e-09	0.00	0.0
2613	C ⁺	oNH_3	oNH_3^+	C	5.3e-10	0.00	0.0
2614	C ⁺	pNH_3	pNH_3^+	C	5.3e-10	0.00	0.0
2615	C ⁺	oNH_3	H_2NC^+	H	7.8e-10	0.00	0.0
2616	C ⁺	pNH_3	H_2NC^+	H	7.8e-10	0.00	0.0
2617	C ⁺	oNH_3	HCNH ⁺	H	7.8e-10	0.00	0.0
2618	C ⁺	pNH_3	HCNH ⁺	H	7.8e-10	0.00	0.0
2619	C ⁺	oNH_3	oH_2	HCN ⁺	2.1e-10	0.00	0.0
2620	C ⁺	pNH_3	oH_2	HCN ⁺	1.0e-10	0.00	0.0
2621	C ⁺	pNH_3	pH_2	HCN ⁺	1.0e-10	0.00	0.0
2622	C ⁺	HCN	C_2N^+	H	3.4e-09	0.00	0.0
2623	C ⁺	HNC	C_2N^+	H	3.4e-09	0.00	0.0
2624	C ⁺	NO	NO ⁺	C	3.4e-09	0.00	0.0
2625	C ⁺	NO	N ⁺	CO	9.0e-10	0.00	0.0
2626	C ⁺	SH	CS ⁺	H	1.1e-09	0.00	0.0
2627	C ⁺	oH_2S	HCS ⁺	H	1.3e-09	0.00	0.0
2628	C ⁺	pH_2S	HCS ⁺	H	1.3e-09	0.00	0.0
2629	C ⁺	oH_2S	oH_2S^+	C	4.2e-10	0.00	0.0
2630	C ⁺	pH_2S	pH_2S^+	C	4.2e-10	0.00	0.0
2631	C ⁺	SO	S ⁺	CO	2.6e-10	0.00	0.0
2632	C ⁺	SO	CS ⁺	O	2.6e-10	0.00	0.0
2633	C ⁺	SO	SO ⁺	C	2.6e-10	0.00	0.0
2634	C ⁺	SO	CO ⁺	S	2.6e-10	0.00	0.0
2635	C ⁺	SO ₂	SO ⁺	CO	2.3e-09	0.00	0.0
2636	C ⁺	CS	CS ⁺	C	1.6e-09	0.00	700.0
2637	C ⁺	OCS	CS ⁺	CO	1.6e-09	0.00	0.0
2638	C ⁺	OD	CO ⁺	D	8.0e-10	0.00	0.0
2639	C ⁺	OD	D ⁺	CO	8.0e-10	0.00	0.0
2640	C ⁺	HDO	DCO ⁺	H	1.2e-09	-0.63	0.0
2641	C ⁺	HDO	HCO ⁺	D	1.2e-09	-0.63	0.0
2642	C ⁺	oD_2O	DCO ⁺	D	2.4e-09	-0.63	0.0
2643	C ⁺	pD_2O	DCO ⁺	D	2.4e-09	-0.63	0.0
2644	N ⁺	O ₂	O_2^+	N	2.8e-10	0.00	0.0
2645	N ⁺	O ₂	NO ⁺	O	2.4e-10	0.00	0.0
2646	N ⁺	O ₂	O ⁺	NO	3.3e-11	0.00	0.0
2647	N ⁺	CO	CO ⁺	N	8.3e-10	0.00	0.0
2648	N ⁺	CO	NO ⁺	C	1.5e-10	0.00	0.0
2649	N ⁺	NO	NO ⁺	N	4.5e-10	0.00	0.0
2650	N ⁺	NO	N_2^+	O	7.9e-11	0.00	0.0
2651	S ⁺	CH	CS ⁺	H	6.2e-10	0.00	0.0
2652	S ⁺	oCH_2	HCS ⁺	H	1.0e-11	0.00	0.0
2653	S ⁺	pCH_2	HCS ⁺	H	1.0e-11	0.00	0.0
2654	S ⁺	OH	SO ⁺	H	6.1e-10	0.00	0.0
2655	S ⁺	NO	NO ⁺	S	3.2e-10	0.00	0.0
2656	S ⁺	oNH_3	oNH_3^+	S	1.6e-09	0.00	0.0
2657	S ⁺	pNH_3	pNH_3^+	S	1.6e-09	0.00	0.0
2658	S ⁺	O ₂	SO ⁺	O	2.3e-11	0.00	0.0
2659	S ⁺	oNH_2D	oNH_2D^+	S	1.6e-09	0.00	0.0
2660	S ⁺	pNH_2D	pNH_2D^+	S	1.6e-09	0.00	0.0
2661	S ⁺	oNHD_2	oNHD_2^+	S	1.6e-09	0.00	0.0
2662	S ⁺	pNHD_2	pNHD_2^+	S	1.6e-09	0.00	0.0
2663	S ⁺	mND_3	mND_3^+	S	1.6e-09	0.00	0.0
2664	S ⁺	pND_3	pND_3^+	S	1.6e-09	0.00	0.0

Table D6 – continued (part 37)

#	Reactants		Products		α	β	γ
2665	S ⁺	oND ₃	oND ₃ ⁺	S	1.6e-09	0.00	0.0
2666	CO ⁺	oH ₂	HCO ⁺	H	1.3e-09	0.00	0.0
2667	CO ⁺	pH ₂	HCO ⁺	H	1.3e-09	0.00	0.0
2668	CO ⁺	H	H ⁺	CO	7.5e-10	0.00	0.0
2669	HCO ⁺	CH	oCH ₂ ⁺	CO	4.7e-10	0.00	0.0
2670	HCO ⁺	CH	pCH ₂ ⁺	CO	1.6e-10	0.00	0.0
2671	HCO ⁺	oCH ₂	oCH ₃ ⁺	CO	5.7e-10	0.00	0.0
2672	HCO ⁺	oCH ₂	pCH ₃ ⁺	CO	2.9e-10	0.00	0.0
2673	HCO ⁺	pCH ₂	pCH ₃ ⁺	CO	8.6e-10	0.00	0.0
2674	HCO ⁺	oH ₂ O	oH ₃ O ⁺	CO	1.7e-09	0.00	0.0
2675	HCO ⁺	oH ₂ O	pH ₃ O ⁺	CO	8.3e-10	0.00	0.0
2676	HCO ⁺	pH ₂ O	pH ₃ O ⁺	CO	2.5e-09	0.00	0.0
2677	HCO ⁺	OH	HCO ₂ ⁺	H	1.0e-09	0.00	0.0
2678	HCO ⁺	C ₂ H	C ₂ H ₂ ⁺	CO	7.8e-10	0.00	0.0
2679	HCO ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	CO	1.4e-09	0.00	0.0
2680	HCO ⁺	C ₃ H	C ₃ H ₂ ⁺	CO	1.4e-09	0.00	0.0
2681	HCO ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	CO	1.4e-09	0.00	0.0
2682	HCO ⁺	NH	oNH ₂ ⁺	CO	4.8e-10	0.00	0.0
2683	HCO ⁺	NH	pNH ₂ ⁺	CO	1.6e-10	0.00	0.0
2684	HCO ⁺	oNH ₂	oNH ₃ ⁺	CO	5.9e-10	0.00	0.0
2685	HCO ⁺	oNH ₂	pNH ₃ ⁺	CO	3.0e-10	0.00	0.0
2686	HCO ⁺	pNH ₂	pNH ₃ ⁺	CO	8.9e-10	0.00	0.0
2687	HCO ⁺	oNH ₃	mNH ₄ ⁺	CO	1.2e-09	0.00	0.0
2688	HCO ⁺	oNH ₃	oNH ₄ ⁺	CO	7.1e-10	0.00	0.0
2689	HCO ⁺	pNH ₃	pNH ₄ ⁺	CO	4.8e-10	0.00	0.0
2690	HCO ⁺	pNH ₃	oNH ₄ ⁺	CO	1.4e-09	0.00	0.0
2691	HCO ⁺	Fe	Fe ⁺	CO	1.9e-09	0.00	0.0
2692	HCO ₂ ⁺	CO	HCO ₂ ⁺	CO ₂	1.0e-09	0.00	0.0
2693	HCO ₂ ⁺	mCH ₄	pCH ₅ ⁺	CO ₂	4.7e-10	0.00	0.0
2694	HCO ₂ ⁺	mCH ₄	oCH ₅ ⁺	CO ₂	3.1e-10	0.00	0.0
2695	HCO ₂ ⁺	pCH ₄	mCH ₅ ⁺	CO ₂	7.8e-10	0.00	0.0
2696	HCO ₂ ⁺	oCH ₄	oCH ₅ ⁺	CO ₂	5.2e-10	0.00	0.0
2697	HCO ₂ ⁺	oCH ₄	mCH ₅ ⁺	CO ₂	2.6e-10	0.00	0.0
2698	oH ₃ O ⁺	CH	oCH ₂ ⁺	oH ₂ O	5.1e-10	0.00	0.0
2699	oH ₃ O ⁺	CH	oCH ₂ ⁺	pH ₂ O	8.5e-11	0.00	0.0
2700	oH ₃ O ⁺	CH	pCH ₂ ⁺	oH ₂ O	8.5e-11	0.00	0.0
2701	pH ₃ O ⁺	CH	oCH ₂ ⁺	oH ₂ O	2.5e-10	0.00	0.0
2702	pH ₃ O ⁺	CH	oCH ₂ ⁺	pH ₂ O	1.7e-10	0.00	0.0
2703	pH ₃ O ⁺	CH	pCH ₂ ⁺	oH ₂ O	1.7e-10	0.00	0.0
2704	pH ₃ O ⁺	CH	pCH ₂ ⁺	pH ₂ O	8.5e-11	0.00	0.0
2705	oH ₃ O ⁺	oCH ₂	oCH ₃ ⁺	oH ₂ O	5.8e-10	0.00	0.0
2706	oH ₃ O ⁺	oCH ₂	oCH ₃ ⁺	pH ₂ O	7.8e-11	0.00	0.0
2707	oH ₃ O ⁺	oCH ₂	pCH ₃ ⁺	oH ₂ O	2.2e-10	0.00	0.0
2708	oH ₃ O ⁺	oCH ₂	pCH ₃ ⁺	pH ₂ O	6.3e-11	0.00	0.0
2709	oH ₃ O ⁺	pCH ₂	oCH ₃ ⁺	oH ₂ O	2.4e-10	0.00	0.0
2710	oH ₃ O ⁺	pCH ₂	oCH ₃ ⁺	pH ₂ O	2.4e-10	0.00	0.0
2711	oH ₃ O ⁺	pCH ₂	pCH ₃ ⁺	oH ₂ O	4.7e-10	0.00	0.0
2712	pH ₃ O ⁺	oCH ₂	oCH ₃ ⁺	oH ₂ O	2.2e-10	0.00	0.0
2713	pH ₃ O ⁺	oCH ₂	oCH ₃ ⁺	pH ₂ O	1.6e-10	0.00	0.0
2714	pH ₃ O ⁺	oCH ₂	pCH ₃ ⁺	oH ₂ O	4.4e-10	0.00	0.0
2715	pH ₃ O ⁺	oCH ₂	pCH ₃ ⁺	pH ₂ O	1.3e-10	0.00	0.0
2716	pH ₃ O ⁺	pCH ₂	oCH ₃ ⁺	oH ₂ O	1.9e-10	0.00	0.0
2717	pH ₃ O ⁺	pCH ₂	pCH ₃ ⁺	oH ₂ O	3.8e-10	0.00	0.0
2718	pH ₃ O ⁺	pCH ₂	pCH ₃ ⁺	pH ₂ O	3.8e-10	0.00	0.0
2719	oH ₃ O ⁺	oNH ₃	mNH ₄ ⁺	oH ₂ O	1.1e-09	0.00	0.0
2720	oH ₃ O ⁺	oNH ₃	mNH ₄ ⁺	pH ₂ O	1.4e-10	0.00	0.0
2721	oH ₃ O ⁺	oNH ₃	pNH ₄ ⁺	oH ₂ O	9.2e-11	0.00	0.0
2722	oH ₃ O ⁺	oNH ₃	pNH ₄ ⁺	pH ₂ O	5.5e-11	0.00	0.0
2723	oH ₃ O ⁺	oNH ₃	oNH ₄ ⁺	oH ₂ O	6.3e-10	0.00	0.0
2724	oH ₃ O ⁺	oNH ₃	oNH ₄ ⁺	pH ₂ O	1.4e-10	0.00	0.0
2725	oH ₃ O ⁺	pNH ₃	mNH ₄ ⁺	oH ₂ O	3.7e-10	0.00	0.0
2726	oH ₃ O ⁺	pNH ₃	mNH ₄ ⁺	pH ₂ O	2.7e-10	0.00	0.0
2727	oH ₃ O ⁺	pNH ₃	pNH ₄ ⁺	oH ₂ O	1.8e-10	0.00	0.0
2728	oH ₃ O ⁺	pNH ₃	oNH ₄ ⁺	oH ₂ O	1.1e-09	0.00	0.0
2729	oH ₃ O ⁺	pNH ₃	oNH ₄ ⁺	pH ₂ O	2.7e-10	0.00	0.0
2730	pH ₃ O ⁺	oNH ₃	mNH ₄ ⁺	oH ₂ O	3.7e-10	0.00	0.0
2731	pH ₃ O ⁺	oNH ₃	mNH ₄ ⁺	pH ₂ O	2.7e-10	0.00	0.0
2732	pH ₃ O ⁺	oNH ₃	pNH ₄ ⁺	oH ₂ O	1.8e-10	0.00	0.0
2733	pH ₃ O ⁺	oNH ₃	oNH ₄ ⁺	oH ₂ O	1.1e-09	0.00	0.0
2734	pH ₃ O ⁺	oNH ₃	oNH ₄ ⁺	pH ₂ O	2.7e-10	0.00	0.0
2735	pH ₃ O ⁺	pNH ₃	mNH ₄ ⁺	oH ₂ O	1.8e-10	0.00	0.0
2736	pH ₃ O ⁺	pNH ₃	pNH ₄ ⁺	oH ₂ O	3.7e-10	0.00	0.0
2737	pH ₃ O ⁺	pNH ₃	pNH ₄ ⁺	pH ₂ O	2.2e-10	0.00	0.0
2738	pH ₃ O ⁺	pNH ₃	oNH ₄ ⁺	oH ₂ O	8.8e-10	0.00	0.0

Table D6 – continued (part 38)

#	Reactants		Products			α	β	γ
2739	pH ₃ O ⁺	pNH ₃	oNH ₄ ⁺	pH ₂ O		5.5e-10	0.00	0.0
2740	CN ⁺	oH ₂	HCN ⁺	H		1.0e-09	0.00	0.0
2741	CN ⁺	pH ₂	HCN ⁺	H		1.0e-09	0.00	0.0
2742	HCN ⁺	oH ₂	HCNH ⁺	H		9.8e-10	0.00	0.0
2743	HCN ⁺	pH ₂	HCNH ⁺	H		9.8e-10	0.00	0.0
2744	HCNH ⁺	CH	oCH ₂ ⁺	HCN		2.4e-10	0.00	0.0
2745	HCNH ⁺	CH	pCH ₂ ⁺	HCN		7.9e-11	0.00	0.0
2746	HCNH ⁺	CH	oCH ₂ ⁺	HNC		2.4e-10	0.00	0.0
2747	HCNH ⁺	CH	pCH ₂ ⁺	HNC		7.9e-11	0.00	0.0
2748	HCNH ⁺	oCH ₂	oCH ₃ ⁺	HCN		2.9e-10	0.00	0.0
2749	HCNH ⁺	oCH ₂	pCH ₃ ⁺	HCN		1.4e-10	0.00	0.0
2750	HCNH ⁺	pCH ₂	pCH ₃ ⁺	HCN		4.3e-10	0.00	0.0
2751	HCNH ⁺	oCH ₂	oCH ₃ ⁺	HNC		2.9e-10	0.00	0.0
2752	HCNH ⁺	oCH ₂	pCH ₃ ⁺	HNC		1.4e-10	0.00	0.0
2753	HCNH ⁺	pCH ₂	pCH ₃ ⁺	HNC		4.3e-10	0.00	0.0
2754	HCNH ⁺	oNH ₂	oNH ₃ ⁺	HCN		3.0e-10	0.00	0.0
2755	HCNH ⁺	oNH ₂	pNH ₃ ⁺	HCN		1.5e-10	0.00	0.0
2756	HCNH ⁺	pNH ₂	pNH ₃ ⁺	HCN		4.5e-10	0.00	0.0
2757	HCNH ⁺	oNH ₂	oNH ₃ ⁺	HNC		3.0e-10	0.00	0.0
2758	HCNH ⁺	oNH ₂	pNH ₃ ⁺	HNC		1.5e-10	0.00	0.0
2759	HCNH ⁺	pNH ₂	pNH ₃ ⁺	HNC		4.5e-10	0.00	0.0
2760	HCNH ⁺	oNH ₃	mNH ₄ ⁺	HCN		6.9e-10	0.00	0.0
2761	HCNH ⁺	oNH ₃	oNH ₄ ⁺	HCN		4.1e-10	0.00	0.0
2762	HCNH ⁺	pNH ₃	pNH ₄ ⁺	HCN		2.7e-10	0.00	0.0
2763	HCNH ⁺	pNH ₃	oNH ₄ ⁺	HCN		8.3e-10	0.00	0.0
2764	HCNH ⁺	oNH ₃	mNH ₄ ⁺	HNC		6.9e-10	0.00	0.0
2765	HCNH ⁺	oNH ₃	oNH ₄ ⁺	HNC		4.1e-10	0.00	0.0
2766	HCNH ⁺	pNH ₃	pNH ₄ ⁺	HNC		2.7e-10	0.00	0.0
2767	HCNH ⁺	pNH ₃	oNH ₄ ⁺	HNC		8.3e-10	0.00	0.0
2768	HCNH ⁺	oH ₂ S	oH ₃ S ⁺	HCN		1.1e-10	0.00	0.0
2769	HCNH ⁺	oH ₂ S	pH ₃ S ⁺	HCN		5.7e-11	0.00	0.0
2770	HCNH ⁺	pH ₂ S	pH ₃ S ⁺	HCN		1.7e-10	0.00	0.0
2771	HCNH ⁺	oH ₂ S	oH ₃ S ⁺	HNC		1.1e-10	0.00	0.0
2772	HCNH ⁺	oH ₂ S	pH ₃ S ⁺	HNC		5.7e-11	0.00	0.0
2773	HCNH ⁺	pH ₂ S	pH ₃ S ⁺	HNC		1.7e-10	0.00	0.0
2774	N ₂ H ⁺	CO	HCO ⁺	N ₂		8.8e-10	0.00	0.0
2775	N ₂ H ⁺	CO ₂	HCO ₂ ⁺	N ₂		1.4e-09	0.00	0.0
2776	N ₂ H ⁺	NO	HNO ⁺	N ₂		3.4e-10	0.00	0.0
2777	C ₂ N ⁺	oNH ₃	C ₂ H ₂	N ₂ H ⁺		1.9e-09	0.00	0.0
2778	C ₂ N ⁺	pNH ₃	C ₂ H ₂	N ₂ H ⁺		1.9e-09	0.00	0.0
2779	NO ⁺	Fe	Fe ⁺	NO		1.0e-09	0.00	0.0
2780	HNO ⁺	C	CH ⁺	NO		1.0e-09	0.00	0.0
2781	HNO ⁺	CO	HCO ⁺	NO		1.0e-10	0.00	0.0
2782	HNO ⁺	CO ₂	HCO ₂ ⁺	NO		1.0e-10	0.00	0.0
2783	HNO ⁺	OH	oH ₂ O ⁺	NO		4.6e-10	0.00	0.0
2784	HNO ⁺	OH	pH ₂ O ⁺	NO		1.6e-10	0.00	0.0
2785	SO ⁺	Fe	Fe ⁺	SO		1.6e-09	0.00	0.0
2786	CS ⁺	oH ₂	HCS ⁺	H		4.8e-10	0.00	0.0
2787	CS ⁺	pH ₂	HCS ⁺	H		4.8e-10	0.00	0.0
2788	HCO ⁺	Gr	Gr ⁺	CO	H	3.0e-07	0.50	0.0
2789	HCS ⁺	Gr	Gr ⁺	CS	H	2.4e-07	0.50	0.0
2790	HCO ⁺	Gr ⁻	Gr	CO	H	3.0e-07	0.50	0.0
2791	HCS ⁺	Gr ⁻	Gr	CS	H	2.4e-07	0.50	0.0
2792	CO ⁺	e ⁻	C	O		1.0e-07	-0.46	0.0
2793	HCO ⁺	e ⁻	CO	H		2.4e-07	-0.69	0.0
2794	HCO ₂ ⁺	e ⁻	CO ₂	H		2.2e-07	-0.50	0.0
2795	HCO ₂ ⁺	e ⁻	CO	OH		1.2e-07	-0.50	0.0
2796	CN ⁺	e ⁻	C	N		1.8e-07	-0.50	0.0
2797	C ₂ N ⁺	e ⁻	C ₂	N		1.0e-07	-0.50	0.0
2798	C ₂ N ⁺	e ⁻	CN	C		2.0e-07	-0.50	0.0
2799	HCN ⁺	e ⁻	CN	H		1.5e-07	-0.50	0.0
2800	HCN ⁺	e ⁻	CH	N		1.5e-07	-0.50	0.0
2801	HCNH ⁺	e ⁻	HCN	H		9.6e-08	-0.65	0.0
2802	HCNH ⁺	e ⁻	HNC	H		9.6e-08	-0.65	0.0
2803	HCNH ⁺	e ⁻	CN	H	H	9.1e-08	-0.65	0.0
2804	H ₂ NC ⁺	e ⁻	HNC	H		1.8e-07	-0.50	0.0
2805	H ₂ NC ⁺	e ⁻	CN	H	H	1.8e-08	-0.50	0.0
2806	NO ⁺	e ⁻	N	O		4.3e-07	-0.37	0.0
2807	HNO ⁺	e ⁻	NO	H		3.0e-07	-0.50	0.0
2808	CS ⁺	e ⁻	C	S		2.0e-07	-0.50	0.0
2809	HCS ⁺	e ⁻	CS	H		7.0e-07	-0.50	0.0
2810	SO ⁺	e ⁻	S	O		2.0e-07	-0.50	0.0
2811	HSO ⁺	e ⁻	SO	H		2.0e-07	-0.50	0.0
2812	HSO ₂ ⁺	e ⁻	SO	H	O	1.0e-07	-0.50	0.0

Table D6 – continued (part 39)

#	Reactants		Products		α	β	γ
2813	HSO ₂ ⁺	e ⁻	SO	OH	1.0e-07	-0.50	0.0
2814	HOCS ⁺	e ⁻	OH	CS	2.0e-07	-0.50	0.0
2815	HOCS ⁺	e ⁻	OCS	H	2.0e-07	-0.50	0.0
2816	Fe ⁺	e ⁻	Fe	γ	3.7e-12	-0.65	0.0
2817	DCO ⁺	e ⁻	CO	D	2.4e-07	-0.69	0.0
2818	DCO ₂ ⁺	e ⁻	CO ₂	D	2.2e-07	-0.50	0.0
2819	DCO ₂ ⁺	e ⁻	CO	OD	1.2e-07	-0.50	0.0
2820	CO ₂	η	CO	O	6.0e+02	0.00	0.0
2821	CO	η	C	O	4.6e+01	0.00	0.0
2822	CO	η	CO ⁺	e ⁻	1.4e+01	0.00	0.0
2823	HCO ⁺	η	CO ⁺	H	3.3e+00	0.00	0.0
2824	CO ⁺	η	C ⁺	O	7.7e+01	0.00	0.0
2825	CN	η	C	N	4.5e+02	0.00	0.0
2826	CN	η	CN ⁺	e ⁻	8.3e+00	0.00	0.0
2827	HCN	η	CN	H	2.0e+03	0.00	0.0
2828	HCN	η	HCN ⁺	e ⁻	1.4e+00	0.00	0.0
2829	HNC	η	CN	H	2.0e+03	0.00	0.0
2830	NO	η	N	O	3.0e+02	0.00	0.0
2831	NO	η	NO ⁺	e ⁻	2.4e+02	0.00	0.0
2832	SO	η	S	O	5.5e+03	0.00	0.0
2833	SO	η	SO ⁺	e ⁻	4.5e+02	0.00	0.0
2834	CS	η	S	C	1.9e+03	0.00	0.0
2835	CS	η	CS ⁺	e ⁻	2.0e+01	0.00	0.0
2836	OCS	η	CO	S	5.2e+03	0.00	0.0
2837	SO ₂	η	SO	O	2.7e+03	0.00	0.0
2838	N	C ₂ H ₂ ⁺	CH ⁺	HNC	2.5e-11	0.00	2600.0
2839	HNC	pCH ₅ ⁺	C ₂ H ₃ ⁺	oNH ₃	8.3e-10	0.00	0.0
2840	HNC	pCH ₅ ⁺	C ₂ H ₃ ⁺	pNH ₃	1.7e-10	0.00	0.0
2841	HNC	oCH ₅ ⁺	C ₂ H ₃ ⁺	oNH ₃	5.0e-10	0.00	0.0
2842	HNC	oCH ₅ ⁺	C ₂ H ₃ ⁺	pNH ₃	5.0e-10	0.00	0.0
2843	HNC	mCH ₅ ⁺	C ₂ H ₃ ⁺	oNH ₃	3.0e-10	0.00	0.0
2844	HNC	mCH ₅ ⁺	C ₂ H ₃ ⁺	pNH ₃	7.0e-10	0.00	0.0
2845	oH ₃ O ⁺	C ₃ H	C ₃ H ₂ ⁺	oH ₂ O	1.7e-09	0.00	0.0
2846	oH ₃ O ⁺	C ₃ H	C ₃ H ₂ ⁺	pH ₂ O	2.5e-10	0.00	0.0
2847	pH ₃ O ⁺	C ₃ H	C ₃ H ₂ ⁺	oH ₂ O	1.3e-09	0.00	0.0
2848	pH ₃ O ⁺	C ₃ H	C ₃ H ₂ ⁺	pH ₂ O	7.5e-10	0.00	0.0
2849	C ₂ H ₃ ⁺	e ⁻	oH ₂	C ₂ H	1.0e-07	-0.50	0.0
2850	C ₂ H ₃ ⁺	e ⁻	oCH ₂	CH	1.0e-07	-0.50	0.0
2851	C ₂ H ₃ ⁺	e ⁻	pCH ₂	CH	6.8e-08	-0.50	0.0
2852	C ₂ H ₂	H ⁺	oH ₂	C ₂ H ⁺	1.3e-09	0.00	0.0
2853	C ₂ H ₂	H ⁺	pH ₂	C ₂ H ⁺	6.7e-10	0.00	0.0
2854	C ₃ H ₂	H ⁺	oH ₂	C ₃ H ⁺	1.3e-09	0.00	0.0
2855	C ₃ H ₂	H ⁺	pH ₂	C ₃ H ⁺	6.7e-10	0.00	0.0
2856	C ₂ H ₂	He ⁺	pH ₂	C ₂ ⁺	1.6e-09	0.00	0.0
2857	C ₃ H ₂	He ⁺	pH ₂	C ₃ ⁺	1.0e-09	0.00	0.0
2858	oH ₃ ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	oH ₂	2.3e-09	0.00	0.0
2859	oH ₃ ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	pH ₂	5.1e-10	0.00	0.0
2860	pH ₃ ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	oH ₂	1.9e-09	0.00	0.0
2861	pH ₃ ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	pH ₂	1.0e-09	0.00	0.0
2862	oH ₃ ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	oH ₂	1.6e-09	0.00	0.0
2863	oH ₃ ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	pH ₂	4.0e-10	0.00	0.0
2864	pH ₃ ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	oH ₂	1.3e-09	0.00	0.0
2865	pH ₃ ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	pH ₂	7.0e-10	0.00	0.0
2866	oH ₂ D ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	HD	2.9e-09	0.00	0.0
2867	pH ₂ D ⁺	C ₂ H ₂	C ₂ H ₃ ⁺	HD	2.9e-09	0.00	0.0
2868	oH ₂ D ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	HD	2.0e-09	0.00	0.0
2869	pH ₂ D ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	HD	2.0e-09	0.00	0.0
2870	C ₂ H ₂	pHD ₂ ⁺	C ₂ H ₃ ⁺	pD ₂	2.9e-09	0.00	0.0
2871	C ₃ H ₂	pHD ₂ ⁺	C ₃ H ₃ ⁺	pD ₂	2.0e-09	0.00	0.0
2872	C ₂ H ₂ ⁺	oH ₂ O	oH ₃ O ⁺	C ₂ H	1.1e-10	0.00	0.0
2873	C ₂ H ₂ ⁺	oH ₂ O	pH ₃ O ⁺	C ₂ H	1.1e-10	0.00	0.0
2874	C ₂ H ₂ ⁺	pH ₂ O	oH ₃ O ⁺	C ₂ H	7.3e-11	0.00	0.0
2875	C ₂ H ₂ ⁺	pH ₂ O	pH ₃ O ⁺	C ₂ H	1.8e-10	0.00	0.0
2876	C ₂ H ₂ ⁺	N	oH ₂	C ₂ N ⁺	2.2e-10	0.00	0.0
2877	C ₂ H ₂ ⁺	N	pH ₂	C ₂ N ⁺	2.2e-10	0.00	0.0
2878	H ₂ CO	η	oH ₂	CO	1.1e+04	0.00	0.0
2879	H ₂ CO	η	pH ₂	CO	1.1e+04	0.00	0.0
2880	oH ₃ O ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	oH ₂ O	2.4e-09	0.00	0.0
2881	oH ₃ O ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	pH ₂ O	6.0e-10	0.00	0.0
2882	pH ₃ O ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	oH ₂ O	2.0e-09	0.00	0.0
2883	pH ₃ O ⁺	C ₃ H ₂	C ₃ H ₃ ⁺	pH ₂ O	1.1e-09	0.00	0.0
2884	C ₂ H ₃ ⁺	oH ₂ O	oH ₃ O ⁺	C ₂ H ₂	6.1e-10	0.00	0.0
2885	C ₂ H ₃ ⁺	oH ₂ O	pH ₃ O ⁺	C ₂ H ₂	5.0e-10	0.00	0.0
2886	C ₂ H ₃ ⁺	pH ₂ O	oH ₃ O ⁺	C ₂ H ₂	3.9e-10	0.00	0.0

Table D6 – continued (part 40)

#	Reactants	Products	α	β	γ
2887	$C_2H_3^+$	pH_2O	pH_3O^+	C_2H_2	7.2e-10 0.00 0.0
2888	oH_3^+	HD	pH_3^+	HD	7.7e-11 0.44 -4.8
2889	oH_3^+	HD	pH_2D^+	oH_2	1.6e-10 -0.02 -0.4
2890	oH_3^+	HD	oH_2D^+	pH_2	1.5e-10 -0.16 1.1
2891	oH_3^+	HD	oH_2D^+	oH_2	1.1e-09 0.01 0.3
2892	pH_3^+	HD	oH_3^+	HD	1.2e-10 0.33 29.2
2893	pH_3^+	HD	pH_2D^+	pH_2	1.1e-10 -0.41 2.9
2894	pH_3^+	HD	pH_2D^+	oH_2	2.5e-10 -0.27 3.3
2895	pH_3^+	HD	oH_2D^+	pH_2	2.8e-10 -0.32 1.9
2896	pH_3^+	HD	oH_2D^+	oH_2	1.2e-09 0.30 22.8
2897	oH_3^+	oH_2	pH_3^+	pH_2	1.3e-10 0.08 -0.7
2898	oH_3^+	oH_2	oH_3^+	pH_2	9.7e-11 0.00 -0.2
2899	oH_3^+	pH_2	pH_3^+	oH_2	3.5e-10 -0.90 154.2
2900	oH_3^+	pH_2	oH_3^+	oH_2	5.0e-10 -0.42 180.4
2901	oH_3^+	oH_2	pH_3^+	oH_2	4.1e-10 0.02 -0.5
2902	pH_3^+	oH_2	pH_3^+	pH_2	1.9e-10 -0.18 1.1
2903	pH_3^+	oH_2	oH_3^+	pH_2	1.7e-10 -0.28 1.7
2904	pH_3^+	oH_2	oH_3^+	oH_2	6.7e-10 -0.07 33.3
2905	pH_3^+	pH_2	pH_3^+	oH_2	1.0e-09 -0.57 180.4
2906	pH_3^+	pH_2	oH_3^+	oH_2	9.2e-10 -0.54 216.9
2907	oH_3^+	oD_2	oH_2D^+	HD	1.2e-09 0.34 -0.8
2908	oH_3^+	oD_2	oHD_2^+	oH_2	6.2e-10 -0.22 1.2
2909	oH_3^+	pD_2	oH_2D^+	HD	9.1e-10 0.05 -0.4
2910	oH_3^+	pD_2	pHD_2^+	oH_2	6.5e-10 -0.06 0.5
2911	pH_3^+	oD_2	pH_2D^+	HD	5.3e-10 0.24 -1.6
2912	pH_3^+	oD_2	oH_2D^+	HD	5.8e-10 0.38 -3.7
2913	pH_3^+	oD_2	oHD_2^+	pH_2	2.6e-10 -0.27 2.2
2914	pH_3^+	oD_2	oHD_2^+	oH_2	4.0e-10 -0.13 1.3
2915	pH_3^+	pD_2	pH_2D^+	HD	4.0e-10 0.06 -1.1
2916	pH_3^+	pD_2	oH_2D^+	HD	4.7e-10 -0.03 0.2
2917	pH_3^+	pD_2	pHD_2^+	pH_2	2.6e-10 -0.06 0.5
2918	pH_3^+	pD_2	pHD_2^+	oH_2	4.1e-10 0.00 0.6
2919	oH_2D^+	oH_2	pH_3^+	HD	7.9e-11 0.27 -4.0
2920	oH_2D^+	oH_2	oH_3^+	HD	1.3e-10 -0.12 7.4
2921	oH_2D^+	oH_2	pH_2D^+	pH_2	7.6e-11 -0.00 -1.3
2922	oH_2D^+	oH_2	pH_2D^+	oH_2	1.5e-10 -0.04 -0.7
2923	oH_2D^+	oH_2	oH_2D^+	pH_2	1.4e-10 -0.16 0.6
2924	oH_2D^+	pH_2	pH_3^+	HD	9.4e-11 -0.79 154.6
2925	oH_2D^+	pH_2	oH_3^+	HD	1.1e-10 -0.52 184.4
2926	oH_2D^+	pH_2	pH_2D^+	oH_2	8.2e-10 -0.04 82.2
2927	oH_2D^+	pH_2	oH_2D^+	oH_2	9.3e-10 -0.41 177.1
2928	pH_2D^+	oH_2	pH_3^+	HD	9.0e-11 -0.69 68.2
2929	pH_2D^+	oH_2	oH_3^+	HD	8.7e-11 -0.58 99.6
2930	pH_2D^+	oH_2	oH_2D^+	pH_2	4.9e-10 -0.40 3.8
2931	pH_2D^+	oH_2	oH_2D^+	oH_2	7.5e-10 -0.43 91.3
2932	pH_2D^+	pH_2	pH_3^+	HD	2.7e-10 -1.08 245.4
2933	pH_2D^+	pH_2	oH_2D^+	oH_2	3.1e-09 -0.55 267.1
2934	oH_2D^+	HD	pH_3^+	pD_2	4.8e-12 -0.61 155.0
2935	oH_2D^+	HD	pH_3^+	oD_2	4.7e-12 -0.10 65.3
2936	oH_2D^+	HD	oH_3^+	pD_2	1.5e-11 -0.61 188.4
2937	oH_2D^+	HD	oH_3^+	oD_2	1.1e-11 -0.49 106.9
2938	oH_2D^+	HD	pH_2D^+	HD	1.7e-10 0.31 -3.5
2939	oH_2D^+	HD	pHD_2^+	pH_2	3.2e-11 -0.30 3.2
2940	oH_2D^+	HD	pHD_2^+	oH_2	2.0e-10 -0.16 0.8
2941	oH_2D^+	HD	oHD_2^+	pH_2	6.0e-11 -0.39 3.7
2942	oH_2D^+	HD	oHD_2^+	oH_2	4.7e-10 -0.04 -0.3
2943	pH_2D^+	HD	pH_3^+	pD_2	2.5e-11 -0.49 218.2
2944	pH_2D^+	HD	pH_3^+	oD_2	2.2e-11 -0.40 140.6
2945	pH_2D^+	HD	oH_2D^+	HD	8.4e-10 -0.11 88.8
2946	pH_2D^+	HD	pHD_2^+	pH_2	8.6e-11 -0.65 5.4
2947	pH_2D^+	HD	pHD_2^+	oH_2	1.0e-10 -0.76 53.4
2948	pH_2D^+	HD	oHD_2^+	pH_2	2.3e-10 -0.48 4.9
2949	pH_2D^+	HD	oHD_2^+	oH_2	4.7e-10 0.35 -3.5
2950	oH_2D^+	oD_2	oH_2D^+	pD_2	1.1e-10 0.27 83.4
2951	oH_2D^+	oD_2	pHD_2^+	HD	2.7e-10 -0.02 -0.1
2952	oH_2D^+	oD_2	oHD_2^+	HD	9.3e-10 0.02 0.3
2953	oH_2D^+	oD_2	oD_3^+	oH_2	6.0e-11 -0.10 -0.2
2954	oH_2D^+	oD_2	mD_3^+	oH_2	7.2e-11 -0.32 1.2
2955	oH_2D^+	pD_2	oH_2D^+	oD_2	8.1e-11 0.30 -2.5
2956	oH_2D^+	pD_2	pHD_2^+	HD	5.8e-10 -0.05 0.7
2957	oH_2D^+	pD_2	oHD_2^+	HD	5.1e-10 -0.01 -0.4
2958	oH_2D^+	pD_2	pD_3^+	oH_2	1.4e-11 -0.03 -0.2
2959	oH_2D^+	pD_2	oD_3^+	oH_2	1.1e-10 -0.10 1.4
2960	pH_2D^+	oD_2	pH_2D^+	pD_2	8.5e-11 0.28 73.5

Table D6 – *continued* (part 41)

#	Reactants	Products	α	β	γ
2961	pH ₂ D ⁺	oD ₂ pH ₂ D ⁺	2.7e-10	0.02	-0.8
2962	pH ₂ D ⁺	oD ₂ oHD ₂ ⁺	1.2e-09	0.21	-1.2
2963	pH ₂ D ⁺	oD ₂ oD ₃ ⁺	4.6e-11	-0.52	5.0
2964	pH ₂ D ⁺	oD ₂ mD ₃ ⁺	3.8e-11	-0.74	5.8
2965	pH ₂ D ⁺	pD ₂ pH ₂ D ⁺	3.5e-11	-0.11	-0.4
2966	pH ₂ D ⁺	pD ₂ pH ₂ D ⁺	6.9e-10	0.01	-0.2
2967	pH ₂ D ⁺	pD ₂ oHD ₂ ⁺	5.6e-10	0.01	0.7
2968	pH ₂ D ⁺	pD ₂ pD ₃ ⁺	5.6e-12	-0.45	3.4
2969	pH ₂ D ⁺	pD ₂ oD ₃ ⁺	5.7e-11	-0.37	2.2
2970	oHD ₂ ⁺	oH ₂ pH ₃ ⁺	7.1e-12	-1.09	182.4
2971	oHD ₂ ⁺	oH ₂ oH ₃ ⁺	1.9e-11	-1.24	215.7
2972	oHD ₂ ⁺	oH ₂ pH ₂ D ⁺	2.6e-10	0.44	12.3
2973	oHD ₂ ⁺	oH ₂ oH ₂ D ⁺	1.2e-09	-0.42	109.4
2974	oHD ₂ ⁺	oH ₂ oHD ₂ ⁺	1.4e-10	-0.47	4.2
2975	oHD ₂ ⁺	pH ₂ pH ₃ ⁺	4.0e-11	-1.29	357.6
2976	oHD ₂ ⁺	pH ₂ pH ₂ D ⁺	8.1e-10	-0.64	196.4
2977	oHD ₂ ⁺	pH ₂ oH ₂ D ⁺	1.2e-09	-0.92	288.2
2978	oHD ₂ ⁺	pH ₂ oHD ₂ ⁺	9.2e-10	-0.68	178.8
2979	pHD ₂ ⁺	oH ₂ pH ₃ ⁺	9.8e-12	-0.87	220.4
2980	pHD ₂ ⁺	oH ₂ oH ₃ ⁺	3.5e-11	-0.82	249.9
2981	pHD ₂ ⁺	oH ₂ pH ₂ D ⁺	1.9e-10	0.37	-1.4
2982	pHD ₂ ⁺	oH ₂ oH ₂ D ⁺	8.1e-10	-0.06	53.5
2983	pHD ₂ ⁺	oH ₂ pH ₂ D ⁺	1.3e-10	-0.31	2.1
2984	pHD ₂ ⁺	pH ₂ pH ₃ ⁺	9.3e-11	-0.68	388.7
2985	pHD ₂ ⁺	pH ₂ pH ₂ D ⁺	3.3e-10	-0.55	144.3
2986	pHD ₂ ⁺	pH ₂ oH ₂ D ⁺	7.0e-10	-0.59	236.4
2987	pHD ₂ ⁺	pH ₂ pH ₂ D ⁺	6.5e-10	-0.73	182.4
2988	oHD ₂ ⁺	HD pH ₂ D ⁺	4.3e-11	-0.49	200.3
2989	oHD ₂ ⁺	HD pH ₂ D ⁺	6.8e-11	-0.27	113.0
2990	oHD ₂ ⁺	HD oH ₂ D ⁺	2.2e-10	-0.85	290.0
2991	oHD ₂ ⁺	HD oH ₂ D ⁺	2.7e-10	-0.82	205.4
2992	oHD ₂ ⁺	HD pH ₂ D ⁺	6.7e-10	0.03	53.0
2993	oHD ₂ ⁺	HD oD ₃ ⁺	1.3e-11	-0.93	8.6
2994	oHD ₂ ⁺	HD oD ₃ ⁺	4.7e-11	-0.77	7.0
2995	oHD ₂ ⁺	HD mD ₃ ⁺	2.0e-11	-0.84	8.1
2996	oHD ₂ ⁺	HD mD ₃ ⁺	5.9e-11	-0.52	4.7
2997	pHD ₂ ⁺	HD pH ₂ D ⁺	7.3e-11	-0.11	143.7
2998	pHD ₂ ⁺	HD pH ₂ D ⁺	2.5e-11	0.05	56.0
2999	pHD ₂ ⁺	HD oH ₂ D ⁺	2.9e-10	-0.64	238.6
3000	pHD ₂ ⁺	HD oH ₂ D ⁺	1.0e-10	-0.49	149.5
3001	pHD ₂ ⁺	HD oHD ₂ ⁺	9.0e-10	0.40	-1.7
3002	pHD ₂ ⁺	HD pD ₃ ⁺	3.6e-12	-0.58	4.6
3003	pHD ₂ ⁺	HD pD ₃ ⁺	1.2e-11	-0.49	3.6
3004	pHD ₂ ⁺	HD oD ₃ ⁺	3.2e-11	-0.51	3.9
3005	pHD ₂ ⁺	HD oD ₃ ⁺	1.2e-10	-0.48	5.1
3006	oHD ₂ ⁺	oD ₂ pH ₂ D ⁺	1.8e-10	-0.36	143.7
3007	oHD ₂ ⁺	oD ₂ pH ₂ D ⁺	1.6e-10	-0.05	55.6
3008	oHD ₂ ⁺	oD ₂ oHD ₂ ⁺	2.5e-10	0.17	83.8
3009	oHD ₂ ⁺	oD ₂ oD ₃ ⁺	3.3e-10	-0.24	2.7
3010	oHD ₂ ⁺	oD ₂ mD ₃ ⁺	4.7e-10	-0.09	0.9
3011	oHD ₂ ⁺	pD ₂ pH ₂ D ⁺	1.0e-10	0.07	54.2
3012	oHD ₂ ⁺	pD ₂ pH ₂ D ⁺	1.3e-10	-0.14	0.5
3013	oHD ₂ ⁺	pD ₂ oHD ₂ ⁺	1.8e-10	0.22	-2.6
3014	oHD ₂ ⁺	pD ₂ pD ₃ ⁺	2.3e-11	-0.45	3.2
3015	oHD ₂ ⁺	pD ₂ oD ₃ ⁺	4.9e-10	-0.13	2.3
3016	oHD ₂ ⁺	pD ₂ mD ₃ ⁺	1.9e-10	-0.15	0.6
3017	pHD ₂ ⁺	oD ₂ pH ₂ D ⁺	7.8e-11	-0.01	86.3
3018	pHD ₂ ⁺	oD ₂ oHD ₂ ⁺	2.6e-10	0.20	31.9
3019	pHD ₂ ⁺	oD ₂ oHD ₂ ⁺	2.1e-10	0.32	0.8
3020	pHD ₂ ⁺	oD ₂ pD ₃ ⁺	4.1e-11	-0.26	2.7
3021	pHD ₂ ⁺	oD ₂ oD ₃ ⁺	5.0e-10	-0.16	0.8
3022	pHD ₂ ⁺	oD ₂ mD ₃ ⁺	2.2e-10	-0.12	1.4
3023	pHD ₂ ⁺	pD ₂ pH ₂ D ⁺	5.7e-11	0.04	-0.3
3024	pHD ₂ ⁺	pD ₂ oHD ₂ ⁺	1.4e-10	0.44	-0.7
3025	pHD ₂ ⁺	pD ₂ oHD ₂ ⁺	2.1e-10	0.17	-0.4
3026	pHD ₂ ⁺	pD ₂ pD ₃ ⁺	7.0e-11	-0.08	-0.5
3027	pHD ₂ ⁺	pD ₂ oD ₃ ⁺	5.7e-10	-0.15	1.3
3028	oD ₃ ⁺	oH ₂ oH ₂ D ⁺	2.3e-10	-1.01	324.3
3029	oD ₃ ⁺	oH ₂ oH ₂ D ⁺	1.3e-10	-0.67	227.0
3030	oD ₃ ⁺	oH ₂ pH ₂ D ⁺	1.1e-09	-0.21	71.6
3031	oD ₃ ⁺	oH ₂ oHD ₂ ⁺	5.8e-10	-0.13	18.7
3032	mD ₃ ⁺	oH ₂ oH ₂ D ⁺	8.8e-10	-0.52	270.7
3033	mD ₃ ⁺	oH ₂ oHD ₂ ⁺	3.7e-09	0.41	60.2
3034	mD ₃ ⁺	pH ₂ pH ₂ D ⁺	8.1e-10	-0.57	355.0

Table D6 – continued (part 42)

#	Reactants	Products	α	β	γ
3035	mD ₃ ⁺	pH ₂	oHD ₂ ⁺	HD	9.6e-09 -0.01 236.9
3036	pD ₃ ⁺	oH ₂	oH ₂ D ⁺	pD ₂	6.1e-10 -0.55 304.6
3037	pD ₃ ⁺	oH ₂	pHD ₂ ⁺	HD	2.3e-09 0.17 50.1
3038	oD ₃ ⁺	pH ₂	pH ₂ D ⁺	pD ₂	3.1e-10 -0.67 400.1
3039	oD ₃ ⁺	pH ₂	pH ₂ D ⁺	oD ₂	1.5e-10 -0.85 315.3
3040	oD ₃ ⁺	pH ₂	pHD ₂ ⁺	HD	1.3e-09 -0.75 253.9
3041	oD ₃ ⁺	pH ₂	oHD ₂ ⁺	HD	9.2e-10 -0.59 197.8
3042	pD ₃ ⁺	pH ₂	pH ₂ D ⁺	pD ₂	8.2e-10 -0.18 378.0
3043	pD ₃ ⁺	pH ₂	pHD ₂ ⁺	HD	3.5e-09 -0.34 233.0
3044	oD ₃ ⁺	HD	pHD ₂ ⁺	pD ₂	4.2e-10 -0.85 259.0
3045	oD ₃ ⁺	HD	pHD ₂ ⁺	oD ₂	3.8e-10 -0.56 166.4
3046	oD ₃ ⁺	HD	oHD ₂ ⁺	pD ₂	7.3e-10 -0.18 199.3
3047	oD ₃ ⁺	HD	oHD ₂ ⁺	oD ₂	3.6e-10 -0.24 114.1
3048	oD ₃ ⁺	HD	pD ₃ ⁺	HD	4.5e-11 -0.33 19.2
3049	oD ₃ ⁺	HD	mD ₃ ⁺	HD	2.1e-10 -0.07 0.4
3050	mD ₃ ⁺	HD	pHD ₂ ⁺	oD ₂	7.5e-10 -0.32 213.9
3051	mD ₃ ⁺	HD	oHD ₂ ⁺	pD ₂	2.0e-09 0.31 238.1
3052	mD ₃ ⁺	HD	oHD ₂ ⁺	oD ₂	2.9e-09 0.30 151.8
3053	mD ₃ ⁺	HD	oD ₃ ⁺	HD	1.1e-09 0.25 44.1
3054	pD ₃ ⁺	HD	pHD ₂ ⁺	pD ₂	1.6e-09 -0.13 232.6
3055	pD ₃ ⁺	HD	pHD ₂ ⁺	oD ₂	6.9e-10 -0.21 146.1
3056	pD ₃ ⁺	HD	oHD ₂ ⁺	pD ₂	8.9e-10 0.05 176.9
3057	pD ₃ ⁺	HD	oD ₃ ⁺	HD	9.5e-10 0.08 -0.7
3058	oD ₃ ⁺	oD ₂	pD ₂ ⁺	pD ₂	2.5e-11 -0.60 110.1
3059	oD ₃ ⁺	oD ₂	pD ₃ ⁺	oD ₂	2.0e-11 -0.57 20.8
3060	oD ₃ ⁺	oD ₂	oD ₃ ⁺	pD ₂	4.9e-10 -0.26 88.4
3061	oD ₃ ⁺	oD ₂	mD ₃ ⁺	pD ₂	2.2e-10 -0.23 41.9
3062	oD ₃ ⁺	oD ₂	mD ₃ ⁺	oD ₂	1.3e-10 -0.33 2.4
3063	oD ₃ ⁺	pD ₂	pD ₃ ⁺	pD ₂	3.2e-11 -0.24 18.1
3064	oD ₃ ⁺	pD ₂	pD ₃ ⁺	oD ₂	4.4e-11 -0.00 -0.3
3065	oD ₃ ⁺	pD ₂	oD ₃ ⁺	oD ₂	3.5e-10 -0.21 1.9
3066	oD ₃ ⁺	pD ₂	mD ₃ ⁺	pD ₂	3.7e-11 -0.06 0.1
3067	oD ₃ ⁺	pD ₂	mD ₃ ⁺	oD ₂	6.2e-10 0.99 -8.3
3068	mD ₃ ⁺	oD ₂	oD ₃ ⁺	pD ₂	3.4e-09 1.08 126.4
3069	mD ₃ ⁺	oD ₂	oD ₃ ⁺	oD ₂	6.5e-10 -0.02 46.2
3070	mD ₃ ⁺	oD ₂	mD ₃ ⁺	pD ₂	2.9e-10 0.11 84.5
3071	mD ₃ ⁺	pD ₂	pD ₃ ⁺	oD ₂	3.2e-11 -0.42 3.5
3072	mD ₃ ⁺	pD ₂	oD ₃ ⁺	pD ₂	1.9e-10 0.24 43.9
3073	mD ₃ ⁺	pD ₂	oD ₃ ⁺	oD ₂	8.1e-10 0.11 -0.5
3074	mD ₃ ⁺	pD ₂	mD ₃ ⁺	oD ₂	2.2e-10 0.18 -2.6
3075	pD ₃ ⁺	oD ₂	oD ₃ ⁺	pD ₂	1.3e-09 0.35 66.1
3076	pD ₃ ⁺	oD ₂	oD ₃ ⁺	oD ₂	4.1e-10 -0.17 0.9
3077	pD ₃ ⁺	oD ₂	mD ₃ ⁺	pD ₂	1.8e-10 -0.36 25.9
3078	pD ₃ ⁺	pD ₂	oD ₃ ⁺	pD ₂	6.6e-10 0.15 -1.8
3079	pD ₃ ⁺	pD ₂	oD ₃ ⁺	oD ₂	4.7e-10 -0.00 0.6
3080	pH ₃ ⁺	e ⁻	pH ₂	H	9.2e-09 -0.73 1.0
3081	pH ₃ ⁺	e ⁻	oH ₂	H	9.2e-09 -0.73 1.0
3082	pH ₃ ⁺	e ⁻	H	H	3.6e-08 -0.73 1.0
3083	oH ₃ ⁺	e ⁻	oH ₂	H	2.5e-08 0.16 -1.0
3084	oH ₃ ⁺	e ⁻	H	H	4.9e-08 0.16 -1.0
3085	pH ₂ D ⁺	e ⁻	H	H	5.6e-07 0.44 -2.8
3086	pH ₂ D ⁺	e ⁻	HD	H	1.3e-07 0.44 -2.8
3087	pH ₂ D ⁺	e ⁻	pH ₂	D	5.2e-09 0.44 -2.8
3088	oH ₂ D ⁺	e ⁻	H	H	1.5e-07 -0.00 -3.5
3089	oH ₂ D ⁺	e ⁻	HD	H	3.7e-08 -0.00 -3.5
3090	oH ₂ D ⁺	e ⁻	oH ₂	D	1.4e-08 -0.00 -3.5
3091	pHD ₂ ⁺	e ⁻	D	D	1.7e-07 0.69 -9.4
3092	pHD ₂ ⁺	e ⁻	HD	D	2.2e-08 0.69 -9.4
3093	pHD ₂ ⁺	e ⁻	pD ₂	H	2.0e-08 0.69 -9.4
3094	oHD ₂ ⁺	e ⁻	D	D	9.4e-08 0.66 -12.5
3095	oHD ₂ ⁺	e ⁻	HD	D	1.2e-08 0.66 -12.5
3096	oHD ₂ ⁺	e ⁻	oD ₂	H	1.1e-08 0.66 -12.5
3097	pD ₂ ⁺	e ⁻	D	D	2.3e-08 -0.69 0.0
3098	oD ₂ ⁺	e ⁻	D	D	2.3e-08 -0.69 0.0
3099	pD ₃ ⁺	e ⁻	D	D	5.8e-08 -0.60 9.2
3100	pD ₃ ⁺	e ⁻	pD ₂	D	1.9e-08 -0.60 9.2
3101	mD ₃ ⁺	e ⁻	D	D	3.7e-08 -0.49 -2.8
3102	mD ₃ ⁺	e ⁻	oD ₂	D	1.2e-08 -0.49 -2.8
3103	oD ₃ ⁺	e ⁻	D	D	7.4e-08 -0.77 15.0
3104	oD ₃ ⁺	e ⁻	pD ₂	D	1.2e-08 -0.77 15.0
3105	oD ₃ ⁺	e ⁻	oD ₂	D	1.2e-08 -0.77 15.0
3106	oH ₂	H ⁺	pH ₂	H ⁺	1.8e-10 0.13 -0.0
3107	pH ₂	H ⁺	oH ₂	H ⁺	1.6e-09 0.13 170.5
3108	N ⁺	pH ₂	NH ₂ ⁺	H	8.4e-10 0.00 168.5

Table D6 – *continued* (part 43)

#	Reactants		Products			α	β	γ
3109	N ⁺	oH ₂	NH ⁺	H		4.2e-10	-0.15	44.1
3110	oH ₂	HCO ⁺	pH ₂	HCO ⁺		1.3e-10	0.00	0.0
3111	pH ₂	HCO ⁺	oH ₂	HCO ⁺		1.1e-09	0.00	170.7
3112	HD	H ⁺	D ⁺	pH ₂		4.4e-10	0.00	458.0
3113	HD	H ⁺	D ⁺	oH ₂		7.1e-10	0.00	628.7
3114	oD ₂	D ⁺	D ⁺	pD ₂		6.0e-10	0.00	86.0
3115	pD ₂	D ⁺	D ⁺	oD ₂		4.0e-10	0.00	0.0
3116	oD ₂	DCO ⁺	pD ₂	DCO ⁺		3.7e-10	0.00	86.0
3117	pD ₂	DCO ⁺	oD ₂	DCO ⁺		2.5e-10	0.00	0.0
3118	C ₂ H ₂ ⁺	pH ₂	C ₂ H ₃ ⁺	H		5.0e-10	0.00	800.0
3119	C ₂ H ₂ ⁺	oH ₂	C ₂ H ₃ ⁺	H		5.0e-10	0.00	629.3
3120	HD ⁺	H	pH ₂ ⁺	D		1.0e-09	0.00	285.0
3121	pH ₂ D ⁺	H	pH ₃ ⁺	D		1.0e-09	0.00	644.2
3122	oH ₂ D ⁺	H	pH ₃ ⁺	D		1.0e-09	0.00	644.2
3123	pHD ₂ ⁺	H	pH ₂ D ⁺	D		1.0e-09	0.00	599.6
3124	oHD ₂ ⁺	H	pH ₂ D ⁺	D		1.0e-09	0.00	599.6
3125	pD ₃ ⁺	H	pHD ₂ ⁺	D		1.0e-09	0.00	646.2
3126	mD ₃ ⁺	H	pHD ₂ ⁺	D		1.0e-09	0.00	646.2
3127	oD ₃ ⁺	H	pHD ₂ ⁺	D		1.0e-09	0.00	646.2
3128	pNH ₃	OH	pNH ₂	pH ₂ O		3.5e-12	0.00	925.0
3129	oNH ₃	OH	pNH ₂	pH ₂ O		3.5e-12	0.00	925.0
3130	pH ₂ S	OH	SH	pH ₂ O		6.1e-12	0.00	80.0
3131	oH ₂ S	OH	SH	pH ₂ O		6.1e-12	0.00	80.0
3132	oCH ₄	He ⁺	CH ⁺	oH ₂	H He	1.7e-10	0.00	0.0
3133	oCH ₄	He ⁺	CH ⁺	pH ₂	H He	8.5e-11	0.00	0.0
3134	mCH ₄	He ⁺	CH ⁺	oH ₂	H He	2.6e-10	0.00	0.0
3135	pCH ₄	He ⁺	CH ⁺	oH ₂	H He	1.3e-10	0.00	0.0
3136	pCH ₄	He ⁺	CH ⁺	pH ₂	H He	1.3e-10	0.00	0.0
3137	oCH ₄ ⁺	e ⁻	oCH ₂	H	H	2.0e-07	-0.60	0.0
3138	oCH ₄ ⁺	e ⁻	pCH ₂	H	H	1.0e-07	-0.60	0.0
3139	mCH ₄ ⁺	e ⁻	oCH ₂	H	H	3.0e-07	-0.60	0.0
3140	pCH ₄ ⁺	e ⁻	oCH ₂	H	H	1.5e-07	-0.60	0.0
3141	pCH ₄ ⁺	e ⁻	pCH ₂	H	H	1.5e-07	-0.60	0.0
3142	oCH ₅ ⁺	e ⁻	CH	oH ₂	oH ₂	4.4e-08	-0.30	0.0
3143	oCH ₅ ⁺	e ⁻	CH	oH ₂	pH ₂	4.4e-08	-0.30	0.0
3144	mCH ₅ ⁺	e ⁻	CH	oH ₂	oH ₂	3.5e-08	-0.30	0.0
3145	mCH ₅ ⁺	e ⁻	CH	pH ₂	oH ₂	3.5e-08	-0.30	0.0
3146	mCH ₅ ⁺	e ⁻	CH	pH ₂	pH ₂	1.8e-08	-0.30	0.0
3147	pCH ₅ ⁺	e ⁻	CH	oH ₂	oH ₂	8.7e-08	-0.30	0.0
3148	oCH ₅ ⁺	e ⁻	oCH ₂	oH ₂	H	4.4e-08	-0.30	0.0
3149	oCH ₅ ⁺	e ⁻	oCH ₂	pH ₂	H	2.2e-08	-0.30	0.0
3150	oCH ₅ ⁺	e ⁻	pCH ₂	oH ₂	H	2.2e-08	-0.30	0.0
3151	mCH ₅ ⁺	e ⁻	oCH ₂	oH ₂	H	3.5e-08	-0.30	0.0
3152	mCH ₅ ⁺	e ⁻	oCH ₂	pH ₂	H	1.8e-08	-0.30	0.0
3153	mCH ₅ ⁺	e ⁻	pCH ₂	oH ₂	H	1.8e-08	-0.30	0.0
3154	mCH ₅ ⁺	e ⁻	pCH ₂	pH ₂	H	1.8e-08	-0.30	0.0
3155	pCH ₅ ⁺	e ⁻	oCH ₂	oH ₂	H	8.7e-08	-0.30	0.0
3156	oNH ₄ ⁺	e ⁻	oNH ₂	H	H	8.1e-08	-0.60	0.0
3157	oNH ₄ ⁺	e ⁻	pNH ₂	H	H	4.1e-08	-0.60	0.0
3158	mNH ₄ ⁺	e ⁻	oNH ₂	H	H	1.2e-07	-0.60	0.0
3159	pNH ₄ ⁺	e ⁻	oNH ₂	H	H	6.1e-08	-0.60	0.0
3160	pNH ₄ ⁺	e ⁻	pNH ₂	H	H	6.1e-08	-0.60	0.0
3161	CH ₃ OH	γ	pCH ₃	OH		3.0e+03	0.00	0.0
3162	Gr	γ	Gr ⁺	e ⁻		6.3e+07	0.00	0.0
3163	Gr ⁻	γ	Gr	e ⁻		4.2e+08	0.00	0.0
3164	Gr	e ⁻	Gr ⁻	γ		6.9e-05	0.50	0.0
3165	Gr ⁺	e ⁻	Gr	γ		6.9e-05	0.50	0.0
3166	Fe	γ	Fe ⁺	e ⁻		4.8e+02	0.00	0.0

Table D7. Species-to-species rates for the inter-conversion reactions of H_3^+ with HD, H_2 , and D_2 . The rates have been fitted, in the 5 to 50 K temperature range, by a modified Arrhenius function of the form $k(T) = \alpha(T/300)^\beta \exp(-\gamma/T)$ in $\text{cm}^3 \text{s}^{-1}$. Elastic channels are not reported. Rates at 10 K are also listed.

#	Reactants	Products	α $\text{cm}^3 \text{s}^{-1}$	β	γ K	$k(10)$ $\text{cm}^3 \text{s}^{-1}$		
1	oH_3^+	HD	pH_3^+	HD	7.7e-11	0.44	-4.8	2.8e-11
2	oH_3^+	HD	pH_2D^+	oH_2	1.6e-10	-0.02	-0.4	1.8e-10
3	oH_3^+	HD	oH_2D^+	pH_2	1.5e-10	-0.16	1.1	2.3e-10
4	oH_3^+	HD	oH_2D^+	oH_2	1.1e-09	0.01	0.3	1.0e-09
5	pH_3^+	HD	oH_3^+	HD	1.2e-10	0.33	29.2	2.1e-12
6	pH_3^+	HD	pH_2D^+	pH_2	1.1e-10	-0.41	2.9	3.3e-10
7	pH_3^+	HD	pH_2D^+	oH_2	2.5e-10	-0.27	3.3	4.5e-10
8	pH_3^+	HD	oH_2D^+	pH_2	2.8e-10	-0.32	1.9	6.9e-10
9	pH_3^+	HD	oH_2D^+	oH_2	1.2e-09	0.30	22.8	4.4e-11
10	oH_3^+	oH_2	pH_3^+	pH_2	1.3e-10	0.08	-0.7	1.1e-10
11	oH_3^+	oH_2	oH_3^+	pH_2	9.7e-11	0.00	-0.2	9.9e-11
12	oH_3^+	pH_2	pH_3^+	oH_2	3.5e-10	-0.90	154.2	1.5e-15
13	oH_3^+	pH_2	oH_3^+	oH_2	5.0e-10	-0.42	180.4	3.1e-17
14	oH_3^+	oH_2	pH_3^+	oH_2	4.1e-10	0.02	-0.5	4.0e-10
15	pH_3^+	oH_2	pH_3^+	pH_2	1.9e-10	-0.18	1.1	3.1e-10
16	pH_3^+	oH_2	oH_3^+	pH_2	1.7e-10	-0.28	1.7	3.7e-10
17	pH_3^+	oH_2	oH_3^+	oH_2	6.7e-10	-0.07	33.3	3.0e-11
18	pH_3^+	pH_2	pH_3^+	oH_2	1.0e-09	-0.57	180.4	1.0e-16
19	pH_3^+	pH_2	oH_3^+	oH_2	9.2e-10	-0.54	216.9	2.2e-18
20	oH_3^+	oD_2	oH_2D^+	HD	1.2e-09	0.34	-0.8	4.1e-10
21	oH_3^+	oD_2	oHD_2^+	oH_2	6.2e-10	-0.22	1.2	1.2e-09
22	oH_3^+	pD_2	oH_2D^+	HD	9.1e-10	0.05	-0.4	8.0e-10
23	oH_3^+	pD_2	pHD_2^+	oH_2	6.5e-10	-0.06	0.5	7.6e-10
24	pH_3^+	oD_2	pH_2D^+	HD	5.3e-10	0.24	-1.6	2.7e-10
25	pH_3^+	oD_2	oH_2D^+	HD	5.8e-10	0.38	-3.7	2.3e-10
26	pH_3^+	oD_2	oHD_2^+	pH_2	2.6e-10	-0.27	2.2	5.2e-10
27	pH_3^+	oD_2	oHD_2^+	oH_2	4.0e-10	-0.13	1.3	5.5e-10
28	pH_3^+	pD_2	pH_2D^+	HD	4.0e-10	0.06	-1.1	3.6e-10
29	pH_3^+	pD_2	oH_2D^+	HD	4.7e-10	-0.03	0.2	5.1e-10
30	pH_3^+	pD_2	pHD_2^+	pH_2	2.6e-10	-0.06	0.5	3.0e-10
31	pH_3^+	pD_2	pHD_2^+	oH_2	4.1e-10	0.00	0.6	3.9e-10

Table D8. Same as Table D7 for reactions involving H_2D^+ .

#	Reactants	Products	α $\text{cm}^3 \text{s}^{-1}$	β	γ K	$k(10)$ $\text{cm}^3 \text{s}^{-1}$
1	oH_2D^+	oH_2 pH_3^+ HD	7.9e-11	0.27	-4.0	4.7e-11
2	oH_2D^+	oH_2 oH_3^+ HD	1.3e-10	-0.12	7.4	9.3e-11
3	oH_2D^+	oH_2 pH_2D^+ pH_2	7.6e-11	-0.00	-1.3	8.7e-11
4	oH_2D^+	oH_2 pH_2D^+ oH_2	1.5e-10	-0.04	-0.7	1.8e-10
5	oH_2D^+	oH_2 oH_2D^+ pH_2	1.4e-10	-0.16	0.6	2.3e-10
6	oH_2D^+	pH_2 pH_3^+ HD	9.4e-11	-0.79	154.6	2.7e-16
7	oH_2D^+	pH_2 oH_3^+ HD	1.1e-10	-0.52	184.4	6.3e-18
8	oH_2D^+	pH_2 pH_2D^+ oH_2	8.2e-10	-0.04	82.2	2.5e-13
9	oH_2D^+	pH_2 oH_2D^+ oH_2	9.3e-10	-0.41	177.1	7.6e-17
10	pH_2D^+	oH_2 pH_3^+ HD	9.0e-11	-0.69	68.2	1.0e-12
11	pH_2D^+	oH_2 oH_3^+ HD	8.7e-11	-0.58	99.6	3.0e-14
12	pH_2D^+	oH_2 oH_2D^+ pH_2	4.9e-10	-0.40	3.8	1.3e-09
13	pH_2D^+	oH_2 oH_2D^+ oH_2	7.5e-10	-0.43	91.3	3.5e-13
14	pH_2D^+	pH_2 pH_3^+ HD	2.7e-10	-1.08	245.4	2.3e-19
15	pH_2D^+	pH_2 oH_2D^+ oH_2	3.1e-09	-0.55	267.1	5.1e-20
16	oH_2D^+	HD pH_3^+ pD_2	4.8e-12	-0.61	155.0	7.1e-18
17	oH_2D^+	HD pH_3^+ oD_2	4.7e-12	-0.10	65.3	9.6e-15
18	oH_2D^+	HD oH_3^+ pD_2	1.5e-11	-0.61	188.4	7.9e-19
19	oH_2D^+	HD oH_3^+ oD_2	1.1e-11	-0.49	106.9	1.3e-15
20	oH_2D^+	HD pH_2D^+ HD	1.7e-10	0.31	-3.5	8.4e-11
21	oH_2D^+	HD pHD_2^+ pH_2	3.2e-11	-0.30	3.2	6.4e-11
22	oH_2D^+	HD pHD_2^+ oH_2	2.0e-10	-0.16	0.8	3.2e-10
23	oH_2D^+	HD oHD_2^+ pH_2	6.0e-11	-0.39	3.7	1.6e-10
24	oH_2D^+	HD oHD_2^+ oH_2	4.7e-10	-0.04	-0.3	5.5e-10
25	pH_2D^+	HD pH_3^+ pD_2	2.5e-11	-0.49	218.2	4.4e-20
26	pH_2D^+	HD pH_3^+ oD_2	2.2e-11	-0.40	140.6	6.7e-17
27	pH_2D^+	HD oH_2D^+ HD	8.4e-10	-0.11	88.8	1.7e-13
28	pH_2D^+	HD pHD_2^+ pH_2	8.6e-11	-0.65	5.4	4.6e-10
29	pH_2D^+	HD pHD_2^+ oH_2	1.0e-10	-0.76	53.4	6.4e-12
30	pH_2D^+	HD oHD_2^+ pH_2	2.3e-10	-0.48	4.9	7.2e-10
31	pH_2D^+	HD oHD_2^+ oH_2	4.7e-10	0.35	-3.5	2.0e-10
32	oH_2D^+	oD_2 oH_2D^+ pD_2	1.1e-10	0.27	83.4	1.0e-14
33	oH_2D^+	oD_2 pHD_2^+ HD	2.7e-10	-0.02	-0.1	2.9e-10
34	oH_2D^+	oD_2 oHD_2^+ HD	9.3e-10	0.02	0.3	8.4e-10
35	oH_2D^+	oD_2 oD_3^+ oH_2	6.0e-11	-0.10	-0.2	8.6e-11
36	oH_2D^+	oD_2 mD_3^+ oH_2	7.2e-11	-0.32	1.2	1.9e-10
37	oH_2D^+	pD_2 oH_2D^+ oD_2	8.1e-11	0.30	-2.5	3.7e-11
38	oH_2D^+	pD_2 pHD_2^+ HD	5.8e-10	-0.05	0.7	6.4e-10
39	oH_2D^+	pD_2 oHD_2^+ HD	5.1e-10	-0.01	-0.4	5.5e-10
40	oH_2D^+	pD_2 pD_3^+ oH_2	1.4e-11	-0.03	-0.2	1.6e-11
41	oH_2D^+	pD_2 oD_3^+ oH_2	1.1e-10	-0.10	1.4	1.3e-10
42	pH_2D^+	oD_2 pH_2D^+ pD_2	8.5e-11	0.28	73.5	2.1e-14
43	pH_2D^+	oD_2 pHD_2^+ HD	2.7e-10	0.02	-0.8	2.7e-10
44	pH_2D^+	oD_2 oHD_2^+ HD	1.2e-09	0.21	-1.2	6.6e-10
45	pH_2D^+	oD_2 oD_3^+ pH_2	4.6e-11	-0.52	5.0	1.6e-10
46	pH_2D^+	oD_2 mD_3^+ pH_2	3.8e-11	-0.74	5.8	2.6e-10
47	pH_2D^+	pD_2 pH_2D^+ oD_2	3.5e-11	-0.11	-0.4	5.3e-11
48	pH_2D^+	pD_2 pHD_2^+ HD	6.9e-10	0.01	-0.2	6.8e-10
49	pH_2D^+	pD_2 oHD_2^+ HD	5.6e-10	0.01	0.7	5.0e-10
50	pH_2D^+	pD_2 pD_3^+ pH_2	5.6e-12	-0.45	3.4	1.8e-11
51	pH_2D^+	pD_2 oD_3^+ pH_2	5.7e-11	-0.37	2.2	1.6e-10

Table D9. Same as Table D7 for reactions involving D_2H^+ .

#	Reactants	Products	α $cm^3 s^{-1}$	β	γ K	$k(10)$ $cm^3 s^{-1}$
1	oHD_2^+	oH_2 pH_3^+ oD_2	7.1e-12	-1.09	182.4	3.5e-18
2	oHD_2^+	oH_2 oH_3^+ oD_2	1.9e-11	-1.24	215.7	5.5e-19
3	oHD_2^+	oH_2 pH_2D^+ HD	2.6e-10	0.44	12.3	1.7e-11
4	oHD_2^+	oH_2 oH_2D^+ HD	1.2e-09	-0.42	109.4	8.9e-14
5	oHD_2^+	oH_2 oHD_2^+ pH_2	1.4e-10	-0.47	4.2	4.5e-10
6	oHD_2^+	pH_2 pH_3^+ oD_2	4.0e-11	-1.29	357.6	9.5e-25
7	oHD_2^+	pH_2 pH_2D^+ HD	8.1e-10	-0.64	196.4	2.1e-17
8	oHD_2^+	pH_2 oH_2D^+ HD	1.2e-09	-0.92	288.2	8.4e-21
9	oHD_2^+	pH_2 oHD_2^+ oH_2	9.2e-10	-0.68	178.8	1.6e-16
10	pHD_2^+	oH_2 pH_3^+ pD_2	9.8e-12	-0.87	220.4	5.1e-20
11	pHD_2^+	oH_2 oH_3^+ pD_2	3.5e-11	-0.82	249.9	8.0e-21
12	pHD_2^+	oH_2 pH_2D^+ HD	1.9e-10	0.37	-1.4	6.2e-11
13	pHD_2^+	oH_2 oH_2D^+ HD	8.1e-10	-0.06	53.5	4.7e-12
14	pHD_2^+	oH_2 pHD_2^+ pH_2	1.3e-10	-0.31	2.1	3.0e-10
15	pHD_2^+	pH_2 pH_3^+ pD_2	9.3e-11	-0.68	388.7	1.2e-26
16	pHD_2^+	pH_2 pH_2D^+ HD	3.3e-10	-0.55	144.3	1.2e-15
17	pHD_2^+	pH_2 oH_2D^+ HD	7.0e-10	-0.59	236.4	2.8e-19
18	pHD_2^+	pH_2 pHD_2^+ oH_2	6.5e-10	-0.73	182.4	9.3e-17
19	oHD_2^+	HD pH_2D^+ pD_2	4.3e-11	-0.49	200.3	4.6e-19
20	oHD_2^+	HD pH_2D^+ oD_2	6.8e-11	-0.27	113.0	2.1e-15
21	oHD_2^+	HD oH_2D^+ pD_2	2.2e-10	-0.85	290.0	1.0e-21
22	oHD_2^+	HD oH_2D^+ oD_2	2.7e-10	-0.82	205.4	5.3e-18
23	oHD_2^+	HD pHD_2^+ HD	6.7e-10	0.03	53.0	3.0e-12
24	oHD_2^+	HD oD_3^+ pH_2	1.3e-11	-0.93	8.6	1.3e-10
25	oHD_2^+	HD oD_3^+ oH_2	4.7e-11	-0.77	7.0	3.2e-10
26	oHD_2^+	HD mD_3^+ pH_2	2.0e-11	-0.84	8.1	1.5e-10
27	oHD_2^+	HD mD_3^+ oH_2	5.9e-11	-0.52	4.7	2.2e-10
28	pHD_2^+	HD pH_2D^+ pD_2	7.3e-11	-0.11	143.7	6.1e-17
29	pHD_2^+	HD pH_2D^+ oD_2	2.5e-11	0.05	56.0	7.8e-14
30	pHD_2^+	HD oH_2D^+ pD_2	2.9e-10	-0.64	238.6	1.1e-19
31	pHD_2^+	HD oH_2D^+ oD_2	1.0e-10	-0.49	149.5	1.7e-16
32	pHD_2^+	HD oHD_2^+ HD	9.0e-10	0.40	-1.7	2.7e-10
33	pHD_2^+	HD pD_3^+ pH_2	3.6e-12	-0.58	4.6	1.6e-11
34	pHD_2^+	HD pD_3^+ oH_2	1.2e-11	-0.49	3.6	4.4e-11
35	pHD_2^+	HD oD_3^+ pH_2	3.2e-11	-0.51	3.9	1.2e-10
36	pHD_2^+	HD oD_3^+ oH_2	1.2e-10	-0.48	5.1	3.7e-10
37	oHD_2^+	oD_2 pHD_2^+ pD_2	1.8e-10	-0.36	143.7	3.5e-16
38	oHD_2^+	oD_2 pHD_2^+ oD_2	1.6e-10	-0.05	55.6	7.3e-13
39	oHD_2^+	oD_2 oHD_2^+ pD_2	2.5e-10	0.17	83.8	3.2e-14
40	oHD_2^+	oD_2 oD_3^+ HD	3.3e-10	-0.24	2.7	5.7e-10
41	oHD_2^+	oD_2 mD_3^+ HD	4.7e-10	-0.09	0.9	5.8e-10
42	oHD_2^+	pD_2 pHD_2^+ pD_2	1.0e-10	0.07	54.2	3.5e-13
43	oHD_2^+	pD_2 pHD_2^+ oD_2	1.3e-10	-0.14	0.5	2.0e-10
44	oHD_2^+	pD_2 oHD_2^+ oD_2	1.8e-10	0.22	-2.6	1.1e-10
45	oHD_2^+	pD_2 pD_3^+ HD	2.3e-11	-0.45	3.2	7.7e-11
46	oHD_2^+	pD_2 oD_3^+ HD	4.9e-10	-0.13	2.3	6.1e-10
47	oHD_2^+	pD_2 mD_3^+ HD	1.9e-10	-0.15	0.6	3.0e-10
48	pHD_2^+	oD_2 pHD_2^+ pD_2	7.8e-11	-0.01	86.3	1.4e-14
49	pHD_2^+	oD_2 oHD_2^+ pD_2	2.6e-10	0.20	31.9	5.4e-12
50	pHD_2^+	oD_2 oHD_2^+ oD_2	2.1e-10	0.32	0.8	6.5e-11
51	pHD_2^+	oD_2 pD_3^+ HD	4.1e-11	-0.26	2.7	7.6e-11
52	pHD_2^+	oD_2 oD_3^+ HD	5.0e-10	-0.16	0.8	8.0e-10
53	pHD_2^+	oD_2 mD_3^+ HD	2.2e-10	-0.12	1.4	2.9e-10
54	pHD_2^+	pD_2 pHD_2^+ oD_2	5.7e-11	0.04	-0.3	5.1e-11
55	pHD_2^+	pD_2 oHD_2^+ pD_2	1.4e-10	0.44	-0.7	3.4e-11
56	pHD_2^+	pD_2 oHD_2^+ oD_2	2.1e-10	0.17	-0.4	1.2e-10
57	pHD_2^+	pD_2 pD_3^+ HD	7.0e-11	-0.08	-0.5	9.7e-11
58	pHD_2^+	pD_2 oD_3^+ HD	5.7e-10	-0.15	1.3	8.3e-10

Table D10. Same as Table D7 for reactions involving D_3^+ .

#	Reactants	Products	α $\text{cm}^3 \text{s}^{-1}$	β	γ K	$k(10)$ $\text{cm}^3 \text{s}^{-1}$
1	oD_3^+	oH_2 oH_2D^+ pD_2	2.3e-10	-1.01	324.3	5.9e-23
2	oD_3^+	oH_2 oH_2D^+ oD_2	1.3e-10	-0.67	227.0	1.8e-19
3	oD_3^+	oH_2 pHD_2^+ HD	1.1e-09	-0.21	71.6	1.7e-12
4	oD_3^+	oH_2 oHD_2^+ HD	5.8e-10	-0.13	18.7	1.4e-10
5	mD_3^+	oH_2 oH_2D^+ oD_2	8.8e-10	-0.52	270.7	9.0e-21
6	mD_3^+	oH_2 oHD_2^+ HD	3.7e-09	0.41	60.2	2.2e-12
7	mD_3^+	pH_2 pH_2D^+ oD_2	8.1e-10	-0.57	355.0	2.2e-24
8	mD_3^+	pH_2 oHD_2^+ HD	9.6e-09	-0.01	236.9	5.1e-19
9	pD_3^+	oH_2 oH_2D^+ pD_2	6.1e-10	-0.55	304.6	2.3e-22
10	pD_3^+	oH_2 pHD_2^+ HD	2.3e-09	0.17	50.1	8.6e-12
11	oD_3^+	pH_2 pH_2D^+ pD_2	3.1e-10	-0.67	400.1	1.3e-26
12	oD_3^+	pH_2 pH_2D^+ oD_2	1.5e-10	-0.85	315.3	5.5e-23
13	oD_3^+	pH_2 pHD_2^+ HD	1.3e-09	-0.75	253.9	1.6e-19
14	oD_3^+	pH_2 oHD_2^+ HD	9.2e-10	-0.59	197.8	1.8e-17
15	pD_3^+	pH_2 pH_2D^+ pD_2	8.2e-10	-0.18	378.0	5.8e-26
16	pD_3^+	pH_2 pHD_2^+ HD	3.5e-09	-0.34	233.0	8.5e-19
17	oD_3^+	HD pHD_2^+ pD_2	4.2e-10	-0.85	259.0	4.3e-20
18	oD_3^+	HD pHD_2^+ oD_2	3.8e-10	-0.56	166.4	1.5e-16
19	oD_3^+	HD oHD_2^+ pD_2	7.3e-10	-0.18	199.3	3.0e-18
20	oD_3^+	HD oHD_2^+ oD_2	3.6e-10	-0.24	114.1	9.0e-15
21	oD_3^+	HD pD_3^+ HD	4.5e-11	-0.33	19.2	2.0e-11
22	oD_3^+	HD mD_3^+ HD	2.1e-10	-0.07	0.4	2.6e-10
23	mD_3^+	HD pHD_2^+ oD_2	7.5e-10	-0.32	213.9	1.1e-18
24	mD_3^+	HD oHD_2^+ pD_2	2.0e-09	0.31	238.1	3.2e-20
25	mD_3^+	HD oHD_2^+ oD_2	2.9e-09	0.30	151.8	2.7e-16
26	mD_3^+	HD oD_3^+ HD	1.1e-09	0.25	44.1	5.7e-12
27	pD_3^+	HD pHD_2^+ pD_2	1.6e-09	-0.13	232.6	2.0e-19
28	pD_3^+	HD pHD_2^+ oD_2	6.9e-10	-0.21	146.1	6.4e-16
29	pD_3^+	HD oHD_2^+ pD_2	8.9e-10	0.05	176.9	1.6e-17
30	pD_3^+	HD oD_3^+ HD	9.5e-10	0.08	-0.7	7.8e-10
31	oD_3^+	oD_2 pD_3^+ pD_2	2.5e-11	-0.60	110.1	3.2e-15
32	oD_3^+	oD_2 pD_3^+ oD_2	2.0e-11	-0.57	20.8	1.7e-11
33	oD_3^+	oD_2 oD_3^+ pD_2	4.9e-10	-0.26	88.4	1.7e-13
34	oD_3^+	oD_2 mD_3^+ pD_2	2.2e-10	-0.23	41.9	7.3e-12
35	oD_3^+	oD_2 mD_3^+ oD_2	1.3e-10	-0.33	2.4	3.1e-10
36	oD_3^+	pD_2 pD_3^+ pD_2	3.2e-11	-0.24	18.1	1.2e-11
37	oD_3^+	pD_2 pD_3^+ oD_2	4.4e-11	-0.00	-0.3	4.5e-11
38	oD_3^+	pD_2 oD_3^+ oD_2	3.5e-10	-0.21	1.9	5.9e-10
39	oD_3^+	pD_2 mD_3^+ pD_2	3.7e-11	-0.06	0.1	4.5e-11
40	oD_3^+	pD_2 mD_3^+ oD_2	6.2e-10	0.99	-8.3	4.9e-11
41	mD_3^+	oD_2 oD_3^+ pD_2	3.4e-09	1.08	126.4	2.8e-16
42	mD_3^+	oD_2 oD_3^+ oD_2	6.5e-10	-0.02	46.2	6.9e-12
43	mD_3^+	oD_2 mD_3^+ pD_2	2.9e-10	0.11	84.5	4.3e-14
44	mD_3^+	pD_2 pD_3^+ oD_2	3.2e-11	-0.42	3.5	9.4e-11
45	mD_3^+	pD_2 oD_3^+ pD_2	1.9e-10	0.24	43.9	1.0e-12
46	mD_3^+	pD_2 oD_3^+ oD_2	8.1e-10	0.11	-0.5	5.9e-10
47	mD_3^+	pD_2 mD_3^+ oD_2	2.2e-10	0.18	-2.6	1.5e-10
48	pD_3^+	oD_2 oD_3^+ pD_2	1.3e-09	0.35	66.1	5.3e-13
49	pD_3^+	oD_2 oD_3^+ oD_2	4.1e-10	-0.17	0.9	6.7e-10
50	pD_3^+	oD_2 mD_3^+ pD_2	1.8e-10	-0.36	25.9	4.6e-11
51	pD_3^+	pD_2 oD_3^+ pD_2	6.6e-10	0.15	-1.8	4.7e-10
52	pD_3^+	pD_2 oD_3^+ oD_2	4.7e-10	-0.00	0.6	4.4e-10