The data file H2VIBR_DR: Additional Molecular Data for EIRENE: vibrationally resolved H_2(X;v) ground state

Since 2019 this particular version is modified by Detlev-Reiter-Consulting, Düren, under various specific contracts with IPP Greifswald and Aalto University, as well as under the auspices of the ITER ISFN fellowship network.

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5 Appendix **84**

I Introduction

This file contains some rate coefficients (cross-sections) supplementing the AMJUEL data. This area is the playground for ongoing FZ Juelich internal (EIRENE group) work, in parallel and supplementing the HYDKIN online database.
None of the material here has been prepared for external (3rd party) use. No documentation is planned either. All reaction rates in this file are for internal applications and testing of EIRENE code development needs at FZ Juelich.
Detlev Reiter

I.1 Record:

- update nov.00
  Nov.00: Stibbe-Tennyson Data for H2(v) $\rightarrow b_{triplet}$ additional to
  Janev-Greenland Data
  Note: Tennyson rates from v=8 on are identical (with the rate for v=7)

- update 12.1/02
  Hyd. atom: rates for radiation transfer, Form. I
  rates H.4, 2.1.5b, 2.1.5c, 2.1.5d, 2.1.5e
  rates H.4, 2.1.8b, 2.1.8c

- update 18.2/02
  Hyd. atom: rates for radiation transfer, Form. II
  rates H.4, 2.1.5a
  rates H.4, 2.1.8a

- update 12.6/02
  Hyd. atom: rates for radiation transfer, direct rad rec (phot.source)
  rates H.2, 2.1.8rr1

- update 6.7/02
  Hyd. atom: rates for radiation transfer, spont. decay 2$\rightarrow$1
  rates H.4, 2.1.5f

- update 5.5/03
  rates H.4, 2.1.5f removed, now in data file spectral,tex

- update 15.8/03
  rates H.2, 2.1.8rr1 new, also plot: hydrrs.eps

- update 15.12/15
  rates H.2, 2.0l4 ... 2.14l4 added, $H_2(v) \rightarrow H_2^+$, vibr. resolved, Janev-Reiter, JUEL report 4105 [4].

- update 11.10/16
  cross-sections H.1 and rate coeff. H.2, added, for 2.0l2 ... 2.14l2, p + $H_2(v)$ →H + H_2^+, vibr. resolved, These rate coefficients are for stationary H2. The previous ones, now called H.2 2.0l2th,...2.14l2th, have been for equilibrated temperatures T-H2 = T-p and for a reduced mass of 2/3. The new cross-section data for v=0 coincide with the HYDHEL data for v=0, and scaling to v=1,...14 is obtained by re-scaling by a single factor $g_2(v)$, i.e. adding increments to fit coeff. a0, or b0) according to the Greenland scaling in H2FUJI-Colrad routine.

- update 24.04/20
  al4 loss rates verified again, T1MIN, T1MAX added, Eth added (for better low Te extrapolation using exp(-Eth/T) dependence). Fits with this extra factor have been made, not included here yet)

- update Nov. 21
  H.1 and H.3 loss 2 (Ion conversion), Greenland scaling with saturation, added.

I.2 To be done:

- update 15.12/15
  for the al4 loss rates: still missing: fit error max err and rel.err: fits to be redone ?
  April 2020: No. The al4 Fits have been validated, with HYDKIN, are ok. But still no error bars
  Probably better use fits with b_{-1} term.

- update 11.10/16 al2 loss rate
  al2 loss rates are proton impact rates. So far we have H.1 and H.2 Still to be done: H.3, (Beam-Maxw. rates), scaled to higher v) Oct. 2021: Scaling done. Identical from v=5 onwards (higher). Missing pieces: full Greenland resonance scaling without saturation. So far we only have the saturated (near v=4.5) rates.

  Also: Greenland used thermal (TH2=Tp=Te) rates, derived from Janev H.3 rates. But the Janev H.3 rates are poor fits to the properly integrated cross sections, at low T (see note in original 1987 book). So: also scaled cross sections are not fully consistent with scaled H.3 rates. Tbd: first redo H.3 (and H.2) fits from H.1, with threshold Boltzmann factor. and scale them then!

- move H.2 e+ .. rates and H.2 p+ .. rates to separate subsections, for HYDKIN

- move 2.1.8rr1 to AMJUEL database

- add: al5: e + H2(v) to H + H*(n) (diss. ex), for v gt 0.

- The 2.al2T (Stibbe-Tennyson (Greenland fits) are probably not in correct format for EIRENE tex-file parser SLREAC.f

Below the following line do not use H.1,....H.12 in text, because EIRENE searches for theses section headers from here on.

I.3 End of preface

This next string is searched by EIRENE in subroutine SLREAC to initialize search for a particular set of fit coefficients. From here on, a character string **'H.n'**, with n an integer, must only appear in the section title, but not in the text. Likewise: identifiers p0, a0, b0, ...,h0, k0 are used in SLREAC and must not appear in the text elsewhere, from here on.

```
..........................................
.                                        .
.       ##BEGIN DATA HERE##              .
.                                        .
..........................................
```

1 H.1 : Fits for $\sigma(E)$

E is the "laboratory energy" (in eV) for the charged collision partner. In case of proton impact collisions this happens to coincide with the collision energy in eV/amu units. Eth is the threshold energy in center of mass.

1.1 Reaction 2.0l2 $p + H_2(v = 0) \rightarrow H(1s) + H_2^+$

Eth = 1.83 for H2(v=0) and H2+(v=0). But goes to H2+(v) Final distribution H2+(v) mentioned in Janev et al., 1987. Here now: same cross-section as 3.2.3 in HYDHEL.

```
a0 -8.965985910240e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  1.83
    Mcross 1.0E+00
```

1.2 Reaction 2.1l2 $p + H_2(v = 1) \rightarrow H(1s) + H_2^+$

scaled from cross-section from 3.2.3 in HYDHEL, Greenland resonance scaling [2] $g_2(v)$ incremented $a0$. But still incorrect Eth behaviour, due to use of const. scaling factor $g_2(v = 1)$

```
a0 -8.900261350000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  1.3144
    Mcross 1.0E+00
```

1.3 Reaction 2.2l2 $p + H_2(v = 2) \rightarrow H(1s) + H_2^+$

scaled from cross-section from 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ incremented $a0$. But incorrect Eth, due to use of const. scaling factor $g_2(v = 2)$

```
a0 -8.809585123000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.829
    Mcross 1.0E+00
```

1.4 Reaction 2.3l2 $p + H_2(v = 3) \rightarrow H(1s) + H_2^+$

scaled from cross-section from 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ but incorrect Eth, due to const. scaling factor $g_2(v = 3)$

```
a0 -8.660200911000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.3735
    Mcross 1.0E+00
```

1.5 Reaction 2.4l2 $p + H_2(v = 4) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ but incorrect Eth, due to const. scaling factor

```
a0 -8.468190770000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.0
    Mcross 1.0E+00
```

1.6 Reaction 2.5l2 $p + H_2(v = 5) \rightarrow H(1s) + H_2^+$

scaled from cross-section from 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance These cross section have not the proper exothermic low energy behaviour.

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.7 Reaction 2.6l2 $p + H_2(v = 6) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.8 Reaction 2.7l2 $p + H_2(v = 7) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.9 Reaction 2.8l2 $p + H_2(v = 8) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.10 Reaction 2.9l2 $p + H_2(v = 9) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.11 Reaction 2.10l2 $p + H_2(v = 10) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.12 Reaction 2.11l2 $p + H_2(v = 11) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.13 Reaction 2.12l2 $p + H_2(v = 12) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.14 Reaction 2.13l2 $p + H_2(v = 13) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

1.15 Reaction 2.14l2 $p + H_2(v = 14) \rightarrow H(1s) + H_2^+$

scaled from cross-section as 3.2.3 in HYDHEL, Greenland resonance scaling, [2] $g_2(v)$ Same cross-section for all v-levels above resonance around v=4–5

```
a0 -8.472331263000e+01    a1  1.057326823133e+02    a2 -8.364373343149e+01
a3  3.396650519934e+01    a4 -7.931279499027e+00    a5  1.110667708159e+00
a6 -9.213077375317e-02    a7  4.170940125995e-03    a8 -7.937779949951e-05
    Emin  2.72e+00   s(Emin)  1.00e-19   smax  1.03e-15   Error  2.46e-01
    Eth  0.00
    Mcross 1.0E+00
```

2 H.2 : Fits for $< \sigma v > (T)$

Maxwellian averaged rate coefficients $\langle \sigma v \rangle$ in this section are given as function of temperature T(eV).
If both collision partners (masses M_1, M_2) have a different temperature T_1 and T_2, respectively, then the rate coefficient has to be evaluated with $T_{eff} = \frac{M}{M_1} T_1 + \frac{M}{M_2} T_2$, were M is the mass used for definition of the rate coefficient. For electron impact collisions this was the electron mass: M_e, but since usually $M_2 \gg M_e$ we have $T_{eff} \simeq T_1 (= T_e)$

For proton impact collisions M is the proton mass, with the H_2 molecule at rest (here: 0.1 eV).
next: some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb

2.1 Reaction 2.0v1 $e + H_2(v = 0) \rightarrow e + H_2(v = 1)$

here: 2.avb rates for a=0
v= 0 → v= 1
$\Delta_{E_{elec}} = -0.515579$

```
b0 -2.019864904992D+01  b1  9.563689448046D-01  b2 -6.930432849672D-01
b3  1.672170464596D-01  b4 -3.218185446039D-02  b5  5.798138257523D-03
b6 -8.494785532438D-04  b7  7.361711570913D-05  b8 -2.624614104869D-06
Eth    0.515579
Max. rel. Error:    .0006 %
Mean rel. Error:    .0002 %
```

2.2 Reaction 2.1v2 $e + H_2(v = 1) \rightarrow e + H_2(v = 2)$

here: 2.avb rates for a=1
v= 1 $\rightarrow$ v= 2
$\Delta_{E_{elec}} = -0.485491$

```
b0 -1.977633757458D+01  b1  9.564088337422D-01  b2 -6.931762378599D-01
b3  1.673972558159D-01  b4 -3.230467170153D-02  b5  5.844010289469D-03
b6 -8.590099669139D-04  b7  7.465075798325D-05  b8 -2.670220415207D-06
Eth    0.485491
Max. rel. Error:    .0007 %
Mean rel. Error:    .0002 %
```

2.3 Reaction 2.1v0 $e + H_2(v = 1) \rightarrow e + H_2(v = 0)$

v= 1 $\rightarrow$ v= 0
exothermic $\Delta_{E_{elec}} = +0.515579$

```
b0 -1.968309407999D+01  b1  4.413866852302D-01  b2 -4.375491623531D-01
b3  8.481210871456D-02  b4 -1.352486343878D-02  b5  2.843664347044D-03
b6 -5.402568823255D-04  b7  5.462852926913D-05  b8 -2.112388028934D-06
Eth    0.0
Max. rel. Error:    .0024 %
Mean rel. Error:    .0010 %
```

2.4 Reaction 2.2v3 $e + H_2(v = 2) \rightarrow e + H_2(v = 3)$

here: 2.avb rates for a=2
v= 2 $\rightarrow$ v= 3
$\Delta_{E_{elec}} = -0.455403$

```
b0 -1.937087250675D+01  b1  9.563986318344D-01  b2 -6.931517460305D-01
b3  1.673706968047D-01  b4 -3.228932650184D-02  b5  5.839031940057D-03
b6 -8.581057840732D-04  b7  7.456526636728D-05  b8 -2.666952590194D-06
Eth    0.455403
Max. rel. Error:    .0006 %
Mean rel. Error:    .0002 %
```

2.5 Reaction 2.2v1 $e + H_2(v = 2) \rightarrow e + H_2(v = 1)$

v= 2 $\rightarrow$ v= 1
exotermic $\Delta_{E_{elec}} = +0.485491$

```
b0 -1.929086643028D+01  b1  4.714322317378D-01  b2 -4.524405833755D-01
b3  8.960512951965D-02  b4 -1.460778938439D-02  b5  3.015244916848D-03
b6 -5.583268044148D-04  b7  5.575453615114D-05  b8 -2.143550900856D-06
Eth    0.0
Max. rel. Error:    .0022 %
Mean rel. Error:    .0010 %
```

2.6 Reaction 2.3v4 $e + H_2(v = 3) \rightarrow e + H_2(v = 4)$

here: 2.avb rates for a=3
v= 3 $\rightarrow$ v= 4
$\Delta_{E_{elec}} = -0.425316$

```
b0 -1.898225633279D+01  b1  9.563960986163D-01  b2 -6.931501046560D-01
b3  1.673721101906D-01  b4 -3.229155089769D-02  b5  5.840130285792D-03
b6 -8.583629331346D-04  b7  7.459419549557D-05  b8 -2.668208705788D-06
Eth    0.425316
Max. rel. Error:    .0007 %
Mean rel. Error:    .0002 %
```

2.7 Reaction 2.3v2 $e + H_2(v = 3) \rightarrow e + H_2(v = 2)$

v= 3 $\rightarrow$ v= 2
exothermic $\Delta_{E_{elec}} = +0.455403$

```
b0 -1.891548879155D+01  b1  5.014966876811D-01  b2 -4.673877357801D-01
b3  9.445845395339D-02  b4 -1.572267323555D-02  b5  3.196101745851D-03
b6 -5.779051068742D-04  b7  5.700956841462D-05  b8 -2.179234175360D-06
Eth    0.0
Max. rel. Error:    .0021 %
Mean rel. Error:    .0009 %
```

some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb
here: rates for a=4
v= 4 → v= 5
$\Delta_{E_{elec}} = -0.395228$

2.8 Reaction 2.4v5 $e + H_2(v = 4) \to e + H_2(v = 5)$

```
b0 -1.861048995150D+01  b1  9.564054425438D-01  b2 -6.931632937811D-01
b3  1.673757235520D-01  b4 -3.228920035293D-02  b5  5.838397599024D-03
b6 -8.579289407995D-04  b7  7.454528969308D-05  b8 -2.666120439849D-06
Eth    0.395228
Max. rel. Error:    .0005 %
Mean rel. Error:    .0002 %
```

2.9 Reaction 2.4v3 $e + H_2(v = 4) \to e + H_2(v = 3)$

v= 4 → v= 3
exothermic $\Delta_{E_{elec}} = +0.425316$

```
b0 -1.855696064744D+01  b1  5.315597336002D-01  b2 -4.823196215528D-01
b3  9.928898010496D-02  b4 -1.682316262202D-02  b5  3.372255429641D-03
b6 -5.966471527998D-04  b7  5.818774150055D-05  b8 -2.212058870401D-06
Eth    0.0
Max. rel. Error:    .0020 %
Mean rel. Error:    .0009 %
```

2.10 Reaction 2.5v6 $e + H_2(v = 5) \rightarrow e + H_2(v = 6)$

here: 2.avb rates for a=5
v= 5 $\rightarrow$ v= 6
$\Delta_{E_{elec}} = -0.365140$

```
b0 -1.825557379755D+01  b1  9.563952515169D-01  b2 -6.931405419593D-01
b3  1.673575550930D-01  b4 -3.228237504688D-02  b5  5.837153522372D-03
b6 -8.578377390045D-04  b7  7.454622530191D-05  b8 -2.666430825622D-06
Eth    0.365140
Max. rel. Error:    .0008 %
Mean rel. Error:    .0002 %
```

2.11 Reaction 2.5v4 $e + H_2(v = 5) \rightarrow e + H_2(v = 4)$

v= 5 $\rightarrow$ v= 4
exothermic $\Delta_{E_{elec}} = 0.395228$

```
b0 -1.821527873038D+01  b1  5.616025125936D-01  b2 -4.972197892546D-01
b3  1.040933960955D-01  b4 -1.791074005428D-02  b5  3.544561563434D-03
b6 -6.147252831443D-04  b7  5.930529762302D-05  b8 -2.242624609668D-06
Eth    0.0
Max. rel. Error:    .0017 %
Mean rel. Error:    .0008 %
```

2.12 Reaction 2.6v7 $e + H_2(v = 6) \rightarrow e + H_2(v = 7)$

here: 2.avb rates for a=6
v= 6 $\rightarrow$ v= 7
$\Delta_{E_{elec}} = -0.335052$

```
b0 -1.791750176477D+01  b1  9.563765394068D-01  b2 -6.931114557277D-01
b3  1.673368982774D-01  b4 -3.227446851469D-02  b5  5.835380423171D-03
b6 -8.576013379817D-04  b7  7.452872287319D-05  b8 -2.665874601514D-06
Eth    0.335052
Max. rel. Error:    .0005 %
Mean rel. Error:    .0002 %
```

2.13 Reaction 2.6v5 $e + H_2(v = 6) \rightarrow e + H_2(v = 5)$

v= 6 $\rightarrow$ v= 5
exothermic $\Delta_{E_{elec}} = 0.365140$

```
b0 -1.789045229732D+01  b1  5.916679551165D-01  b2 -5.121311260976D-01
b3  1.088929406027D-01  b4 -1.899317907912D-02  b5  3.715356909481D-03
b6 -6.326073845628D-04  b7  6.041245844855D-05  b8 -2.273084411033D-06
Eth    0.0
Max. rel. Error:    .0017 %
Mean rel. Error:    .0008 %
```

some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb
here: rates for a=7
v= 7 → v= 8
$\Delta_{E_{elec}} = -0.304965$

2.14 Reaction 2.7v8 $e + H_2(v = 7) \rightarrow e + H_2(v = 8)$

```
b0 -1.759628608401D+01  b1  9.563983633040D-01  b2 -6.931605371434D-01
b3  1.673841318657D-01  b4 -3.229793458739D-02  b5  5.841905872641D-03
b6 -8.586273568756D-04  b7  7.461395545659D-05  b8 -2.668781967500D-06
Eth    0.304965
Max. rel. Error:    .0007 %
Mean rel. Error:    .0002 %
```

v= 7 → v= 6
$\Delta_{E_{elec}} = 0.335052$

2.15 Reaction 2.7v6 $e + H_2(v = 7) \rightarrow e + H_2(v = 6)$

```
b0 -1.758246610521D+01  b1  6.217013182816D-01  b2 -5.270198573168D-01
b3  1.136959682626D-01  b4 -2.008484626390D-02  b5  3.890088095849D-03
b6 -6.512593562470D-04  b7  6.159274114022D-05  b8 -2.306271203184D-06
Eth    0.0
Max. rel. Error:    .0016 %
Mean rel. Error:    .0007 %
```

some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb
here: rates for a=8
v= 8 → v= 9
$\Delta_{E_{elec}} = -0.274877$

2.16 Reaction 2.8v9 $e + H_2(v = 8) \rightarrow e + H_2(v = 9)$

```
b0 -1.729191776727D+01  b1  9.563989054428D-01  b2 -6.931519633782D-01
b3  1.673705751835D-01  b4 -3.228922221813D-02  b5  5.839034598316D-03
b6 -8.581172796755D-04  b7  7.456750118724D-05  b8 -2.667079597271D-06
Eth    0.274877
Max. rel. Error:    .0006 %
Mean rel. Error:    .0002 %
```

v= 8 → v= 7
$\Delta_{E_{elec}} = 0.304965$

2.17 Reaction 2.8v7 $e + H_2(v = 8) \rightarrow e + H_2(v = 7)$

```
b0 -1.729133660481D+01  b1  6.517705262809D-01  b2 -5.419663946532D-01
b3  1.185434245879D-01  b4 -2.119497413881D-02  b5  4.069161805933D-03
b6 -6.704842512069D-04  b7  6.281213480116D-05  b8 -2.340519067726D-06
Eth    0.0
Max. rel. Error:    .0014 %
Mean rel. Error:    .0006 %
```

some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb
here: rates for a=9
v= 9 → v= 10
$\Delta_{E_{elec}} = -0.244789$

2.18 Reaction 2.9v10 $e + H_2(v = 9) \rightarrow e + H_2(v = 10)$

```
b0 -1.700439591879D+01  b1  9.563966363060D-01  b2 -6.931545806421D-01
b3  1.673772422216D-01  b4 -3.229410770597D-02  b5  5.840774704551D-03
b6 -8.584454021545D-04  b7  7.459890305585D-05  b8 -2.668279554488D-06
Eth    0.244789
Max. rel. Error:    .0004 %
Mean rel. Error:    .0002 %
```

v= 9 → v= 8
$\Delta_{E_{elec}} = 0.274877$

2.19 Reaction 2.9v8 $e + H_2(v = 9) \rightarrow e + H_2(v = 8)$

```
b0 -1.701705270991D+01  b1  6.818229076298D-01  b2 -5.568766608948D-01
b3  1.233520134745D-01  b4 -2.228308672033D-02  b5  4.241333829446D-03
b6 -6.885065289214D-04  b7  6.392253596930D-05  b8 -2.370763006793D-06
Eth    0.0
Max. rel. Error:    .0013 %
Mean rel. Error:    .0006 %
```

2.20 Reaction 2.10v11 $e + H_2(v = 10) \rightarrow e + H_2(v = 11)$

here: 2.avb rates for a=10
v= 10 $\rightarrow$ v= 11
$\Delta_{E_{elec}} = -0.214702$

```
b0 -1.673372508418D+01  b1  9.563998411687D-01  b2 -6.931596706102D-01
b3  1.673810041199D-01  b4 -3.229557291606D-02  b5  5.841081184989D-03
b6 -8.584786020792D-04  b7  7.460053737379D-05  b8 -2.668303594568D-06
Eth    0.214702
Max. rel. Error:    .0006 %
Mean rel. Error:    .0002 %
```

2.21 Reaction 2.10v9 $e + H_2(v = 10) \rightarrow e + H_2(v = 9)$

v= 10 $\rightarrow$ v= 9
exothermic $\Delta_{E_{elec}} = 0.244789$

```
b0 -1.675961815373D+01  b1  7.118728751530D-01  b2 -5.717787651021D-01
b3  1.281546365117D-01  b4 -2.337029834941D-02  b5  4.413997789718D-03
b6 -7.067371443254D-04  b7  6.506166104935D-05  b8 -2.402379846582D-06
Eth    0.0
Max. rel. Error:    .0013 %
Mean rel. Error:    .0005 %
```

some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb
here: rates for a=11
v= 11 → v= 12
$\Delta_{E_{elec}} = -0.184614$

2.22 Reaction 2.11v12 $e + H_2(v = 11) \rightarrow e + H_2(v = 12)$

```
b0 -1.647990244033D+01  b1  9.563942800918D-01  b2 -6.931463277701D-01
b3  1.673666305699D-01  b4 -3.228729006747D-02  b5  5.838404584005D-03
b6 -8.579952062156D-04  b7  7.455506941211D-05  b8 -2.666570149968D-06
Eth    0.184614
Max. rel. Error:    .0005 %
Mean rel. Error:    .0002 %
```

v= 11 → v= 10
$\Delta_{E_{elec}} = 0.214702$

2.23 Reaction 2.11v10 $e + H_2(v = 11) \rightarrow e + H_2(v = 10)$

```
b0 -1.651903291691D+01  b1  7.419356436913D-01  b2 -5.867236119235D-01
b3  1.330066833462D-01  b4 -2.448489265837D-02  b5  4.594825648293D-03
b6 -7.263126191158D-04  b7  6.631624303442D-05  b8 -2.438034077292D-06
Eth    0.0
Max. rel. Error:    .0011 %
Mean rel. Error:    .0005 %
```

some rates: e + H2(v=a)→e + H2(v=b). notation: 2.avb

2.24 Reaction 2.12v13 $e + H_2(v = 12) \rightarrow e + H_2(v = 13)$

here: 2.avb rates for a=12
v= 12 → v= 13
$\Delta_{E_{elec}} = -0.154526$

```
b0 -1.624292843520D+01  b1  9.563916527161D-01  b2 -6.931504230185D-01
b3  1.673790359310D-01  b4 -3.229737072252D-02  b5  5.842257704388D-03
b6 -8.587623572024D-04  b7  7.463197605980D-05  b8 -2.669637421005D-06
Eth    0.154526
Max. rel. Error:    .0005 %
Mean rel. Error:    .0002 %
```

2.25 Reaction 2.12v11 $e + H_2(v = 12) \rightarrow e + H_2(v = 11)$

v= 12 → v= 11
exothermic $\Delta_{E_{elec}} = 0.184614$

```
b0 -1.629529739854D+01  b1  7.719833979882D-01  b2 -6.016188325834D-01
b3  1.378008352063D-01  b4 -2.556674781785D-02  b5  4.765655849285D-03
b6 -7.442009918713D-04  b7  6.742272668084D-05  b8 -2.468409663873D-06
Eth    0.0
Max. rel. Error:    .0010 %
Mean rel. Error:    .0004 %
```

2.26 Reaction 2.13v14 $e + H_2(v = 13) \rightarrow e + H_2(v = 14)$

here: 2.avb rates for a=13
v= 13 $\rightarrow$ v= 14
$\Delta_{E_{elec}} = -0.124438$

```
b0 -1.602280495131D+01  b1  9.563875619739D-01  b2 -6.931229785638D-01
b3  1.673414501519D-01  b4 -3.227464611562D-02  b5  5.835033363511D-03
b6 -8.575055981320D-04  b7  7.451875835329D-05  b8 -2.665505460091D-06
Eth    0.124438
Max. rel. Error:    .0006 %
Mean rel. Error:    .0002 %
```

2.27 Reaction 2.13v12 $e + H_2(v = 13) \rightarrow e + H_2(v = 12)$

v= 13 $\rightarrow$ v= 12
exothermic $\Delta_{E_{elec}} = 0.154526$

```
b0 -1.608840990302D+01  b1  8.020394394303D-01  b2 -6.165440945034D-01
b3  1.426308983770D-01  b4 -2.666919821799D-02  b5  4.942829173728D-03
b6 -7.631622155716D-04  b7  6.862293543371D-05  b8 -2.502085216731D-06
Eth    0.0
Max. rel. Error:    .0010 %
Mean rel. Error:    .0004 %
```

2.28 Reaction 2.14v13 $e + H_2(v = 14) \rightarrow e + H_2(v = 13)$

here: 2.avb rates for a=14
v= 14 $\rightarrow$ v= 13
exothermic $\Delta_{E_{elec}} = 0.124438$

```
b0 -1.589837154244D+01  b1  8.320824642517D-01  b2 -6.314283588817D-01
b3  1.474153520168D-01  b4 -2.774686223813D-02  b5  5.112667638941D-03
b6 -7.809186117202D-04  b7  6.972006006944D-05  b8 -2.532180981291D-06
Eth    0.0
Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.29 losses from v-Population

now: loss from vibrational state v: loss channel $a = 1, a = 2, a = 3, a = 4$. Notation: ..2.vla,

- a=1: $e + H_2(v)$ to repulsive triplet state $b^3\Sigma \rightarrow H + H$

  currently available: Hydhel 2.2.5 (v=0) and Greenland scaling [2], $g_1(v)$

  or, as alternative: Stibbe-Tennyson and Rescignio-Schneider rate coefficient (Greenland, CRMOL Manual, 2001, [3], individual fits for each v)

- a=2: ion conversion $p + H_2(v) \rightarrow H_2^+ + H$

  currently available: Hydhel 3.2.3 $(v = 0)$ and Greenland resonance scaling [2], $g_2(v)$ i.e.:

  Cross-sections are as in Hydhel, with incremented a0 coefficient for Greenland scaling.

  The "thermal" rate coeff. data labeled 2.al2th given here are evaluated from HYDHEL, 3.2.3, at $E_{H_2} = 0.37 \approx 0.0$ eV. The temperature scale here is $T = T_{H_2} = T_p$. I.e. to obtain this Maxwellian (single temperature) rate coefficient the HYDHEL Beam-Maxwellian rate fit is first evaluated at $E_{H_2} = 0.0$ eV.

  Greenland actually had used $E_{H_2} = 0.37 \approx 0.0$. The resulting fit for cold molecules vs. T_p/m_p is then rescaled to a fit vs.

  $T_{eff} = m/m_1 T_1 + m/m_2 T_2 = 1.5T$, with $m = 1, m_1 = 1, m_2 = 2$ and $T_1 = T_p, T_2 = T_{H_2}$.

  The rate coeff. data labeled 2.al2 (without "th") are for stationary H2 molecules (taken at $E_{H_2} = 0.1 \approx 0.0$ eV), same as for v=0 in HYDHEL, and then have been scaled (incremented fit coeff. b0) to higher vibr. states.

  The same scaling $g_2(v)$ has also been applied to the full Beam-Maxwellian (H.3) rates 2.al2

- a=3: dissociative attachment $e + H_2(v) \rightarrow H_2^- \rightarrow H(n) + H^-$,

  orig: Bardsley and Wadehra; [2]

- a=4: ionization $e + H_2(v) \rightarrow H_2^+ + e$,

  Janev, Reiter report, JUEL, [4]. Corresponds to reaction 2.2.9 in HYDHEL and AMJUEL

- a=5: dissociative excitation/ionisation $e + H_2(v) \rightarrow H + H * + e$, or $\rightarrow H + H^+ + 2e$

  Janev, Reiter report, JUEL, [4], to be done, not yet here.

  Corresponds to reaction 2.2.10 in HYDHEL and AMJUEL

2.30 Reaction 2.0l1 $e + H_2(v = 0) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

(HYDHEL 2.2.5, and Greenland scaling)

```
b0 -2.785523959742D+01  b1  1.052255591937D+01  b2 -4.973297770708D+00
b3  1.451288296907D+00  b4 -3.063256693791D-01  b5  4.434701866973D-02
b6 -4.098442028674D-03  b7  2.161417112329D-04  b8 -4.934489173929D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.31 Reaction 2.0l1T $e + H_2(v = 0) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

Stibbe-Tennyson Rescignio-Schneider rate coeff. (Greenland fit):

```
b0      -27.737228809932  b1      11.4261099558375  b2     -7.10684878187016
b3      2.91291925736074  b4    -0.813578474322528  b5     0.143951459534869
b6   -0.0152728085858885  b7   0.00088343832658218  b8 -2.13827792172883e-05

Max. rel. Error: 8.159e-05 %
Mean rel. Error: 7.611e-06 %
```

2.32 Reaction 2.0l2th $p + H_2(v = 0) \rightarrow H + H_2^+$ (ion conversion)

Thermal rate coeff.: Original HYDHEL fit vs. T_p and $E(H_2)$, taken at $E(H_2) = 0.37 \approx 0.0$ eV. Then rescaled (and refitted) for effective temperature $T_p = T_{H_2} = T$, T/m with $m = m_{red} = 2/3$.

```
b0 -2.358503880904D+01  b1  1.287800684831D+00  b2 -1.477574532576D+00
b3  6.341267609262D-01  b4 -7.940548870324D-02  b5 -3.856752713590D-03
b6  1.747919751930D-03  b7 -1.472692136643D-04  b8  4.122891606416D-06

Max. rel. Error:    .0007 %
Mean rel. Error:    .0003 %
```

2.33 Reaction 2.0l2 $p + H_2(v = 0) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest, derived from HYDHEL rate coeff. data. Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -2.440996809955E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.34 Reaction 2.0l3 $e + H_2(v = 0) \rightarrow H_2^- \rightarrow H + H^-$

```
  b0 -3.274002188165D+01  b1  2.669321144749D+00  b2 -1.988587518396D+00
  b3  6.103750530912D-01  b4 -1.312496951350D-01  b5  1.990432011373D-02
  b6 -2.026189571957D-03  b7  1.232520842300D-04  b8 -3.355796773264D-06

  Max. rel. Error:    .0145 %
  Mean rel. Error:    .0071 %
```

2.35 Reaction 2.0l4 $e + H_2(v = 0) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. 4105 [4] eth 1.542000E+01

```
  b0 -3.540823398177E+01  b1  1.657145033166E+01  b2 -7.228943029682E+00
  b3  2.032462219400E+00  b4 -3.938257813639E-01  b5  5.235094832810E-02
  b6 -4.578745995938E-03  b7  2.369472437341E-04  b8 -5.461691892092E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
      Eth  15.42
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.36 Reaction 2.0l4ar $e + H_2(v = 0) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. 4105 [4], eth 1.542000E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.542000000000E+01
  b0 -1.999480681654E+01  b1  1.255127602054E+00  b2  2.014963920740E-01
  b3 -2.280390412519E-01  b4  6.511763952242E-02  b5 -9.534117648640E-03
  b6  7.120466801526E-04  b7 -2.131371338727E-05  b8 -1.214366936845E-19

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
      Eth  15.42
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.37 Reaction 2.1l1 $e+H_2(v=1) \rightarrow e+H_2(b_{triplet}) \rightarrow e+H+H$ (Greenl.)

```
b0 -2.781915029226D+01  b1  1.052255333317D+01  b2 -4.973289320743D+00
b3  1.451280690096D+00  b4 -3.063222749058D-01  b5  4.434616127142D-02
b6 -4.098317261058D-03  b7  2.161319529412D-04  b8 -4.934171143115D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.38 Reaction 2.1l1T $e+H_2(v=1) \rightarrow e+H_2(b_{triplet}) \rightarrow e+H+H$ (Ten.)

```
b0     -25.8958840785285  b1      9.30878084516833  b2     -6.11169315867176
b3      2.71647639013235  b4    -0.815302111062534  b5     0.151728705958444
b6   -0.0166681283588793  b7  0.000988401852658999  b8 -2.43697308162397e-05

Max. rel. Error: 6.975e-05 %
Mean rel. Error: 6.714e-06 %
```

2.39 Reaction 2.1l2th $p+H_2(v=1) \rightarrow H+H_2^+$ (ion conversion)

Thermal rate coeff., Tp=TH2, Greenland scaling, T/m with $m=m_{red}=2/3$.

```
b0 -2.292919657678D+01  b1  1.287794638677D+00  b2 -1.477559046391D+00
b3  6.341102406704D-01  b4 -7.939676653935D-02  b5 -3.859256113224D-03
b6  1.748319409629D-03  b7 -1.473026714030D-04  b8  4.124039577804D-06

Max. rel. Error:    .0010 %
Mean rel. Error:    .0003 %
```

2.40 Reaction 2.1l2 $p+H_2(v=1) \rightarrow H+H_2^+$ (ion conversion)

Rate coeff. for H2 at rest, derived from HYDHEL data. Greenland resonance scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -2.375269260000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.41 Reaction 2.1l3 $e+H_2(v=1) \rightarrow H_2^- \rightarrow H+H^-$

```
b0 -2.865748279758D+01  b1  2.055737192965D+00  b2 -1.716700156229D+00
b3  5.343326950875D-01  b4 -1.164300433732D-01  b5  1.783787331708D-02
b6 -1.827247029733D-03  b7  1.114651687003D-04  b8 -3.036205962969D-06

Max. rel. Error:    .0118 %
Mean rel. Error:    .0050 %
```

2.42 Reaction 2.1l4 $e + H_2(v = 1) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. 4105 [4], eth 1.490400E+01

```
  b0 -3.481334039125E+01  b1  1.624419918008E+01  b2 -7.360715783239E+00
  b3  2.218244862146E+00  b4 -4.664334315731E-01  b5  6.642982009994E-02
  b6 -6.050396486944E-03  b7  3.160608551072E-04  b8 -7.173333297668E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
      Eth 14.904
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.43 Reaction 2.1l4ar $e + H_2(v = 1) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep., eth 1.490400E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.490400000000E+01
  b0 -1.991308015095E+01  b1  1.409524377881E+00  b2 -1.138311156908E-01
  b3 -2.079323340873E-02  b4 -2.848006524890E-04  b5  1.458463887853E-03
  b6 -2.793669335691E-04  b7  2.264011168061E-05  b8 -7.053467780789E-07
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
      Eth 14.904
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.44 Reaction 2.2l1 $e + H_2(v = 2) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.778516522635D+01  b1  1.052255988601D+01  b2 -4.973303177704D+00
b3  1.451291629987D+00  b4 -3.063269628723D-01  b5  4.434736776129D-02
b6 -4.098503003982D-03  b7  2.161476054735D-04  b8 -4.934722807335D-06

Max. rel. Error:    .0006 %
Mean rel. Error:    .0003 %
```

2.45 Reaction 2.2l1T $e + H_2(v = 2) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -24.4090557080575  b1      7.30549186675227  b2     -4.71605572033619
b3      2.14487780148394  b4    -0.672580354751647  b5     0.129887611959617
b6   -0.0146741596125013  b7  0.000888897227320994  b8 -2.22839862046592e-05

Max. rel. Error: 5.79e-05 %
Mean rel. Error: 5.914e-06 %
```

2.46 Reaction 2.2l2th $p + H_2(v = 2) \rightarrow H + H_2^+$ (ion conversion)

thermal Rate coeff. for T(p) = T(H2), Greenland scaling, T/m with $m = m_{red} = 2/3$.

```
b0 -2.202529493081D+01  b1  1.287806068192D+00  b2 -1.477582420825D+00
b3  6.341309771234D-01  b4 -7.940646003829D-02  b5 -3.856669758778D-03
b6  1.747921326823D-03  b7 -1.472696464009D-04  b8  4.122893523274D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0002 %
```

2.47 Reaction 2.2l2 $p + H_2(v = 2) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest, derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -2.284596033000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.48 Reaction 2.2l3 $e + H_2(v = 2) \rightarrow H_2^- \rightarrow H + H^-$

```
b0 -2.591866933510D+01  b1  1.621906764170D+00  b2 -1.488240863403D+00
b3  4.555468112070D-01  b4 -9.740404663324D-02  b5  1.465136339309D-02
b6 -1.477453193987D-03  b7  8.903066054810D-05  b8 -2.403332587604D-06

Max. rel. Error:    .0097 %
Mean rel. Error:    .0039 %
```

2.49 Reaction 2.2l4 $e + H_2(v = 2) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep.4105 [4], eth 1.441700E+01

```
  b0 -3.428836104964E+01 b1  1.565808679005E+01 b2 -6.893018168570E+00
  b3  1.955837175253E+00 b4 -3.753879507425E-01 b5  4.764687790230E-02
  b6 -3.813417228001E-03 b7  1.743203731125E-04 b8 -3.478720752808E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
    Eth 14.417
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.50 Reaction 2.2l4ar $e + H_2(v = 2) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep., eth 1.441700E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.441700000000E+01
  b0 -1.988108861624E+01  b1  1.380327454118E+00  b2 -3.504017357917E-02
  b3 -8.343722550589E-02  b4  2.281006518055E-02  b5 -3.152175094877E-03
  b6  2.333984036075E-04  b7 -7.178754747349E-06  b8 -4.851195132529E-20

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
    Eth 14.417
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.51 Reaction 2.3l1 $e + H_2(v = 3) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.775328717144D+01  b1  1.052255367692D+01  b2 -4.973289555946D+00
b3  1.451278907194D+00  b4 -3.063199285155D-01  b5  4.434504336931D-02
b6 -4.098065267946D-03  b7  2.161046623371D-04  b8 -4.933024950567D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.52 Reaction 2.3l1T $e + H_2(v = 3) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -23.2471490990366  b1      5.82920685290242  b2     -3.74467798716235
b3      1.75797373751848  b4    -0.576480269917161  b5     0.115092345155716
b6   -0.0133095657860856  b7  0.000820052834830402  b8 -2.08263077082272e-05

Max. rel. Error: 4.832e-05 %
Mean rel. Error: 5.314e-06 %
```

2.53 Reaction 2.3l2th $p + H_2(v = 3) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.053940214067D+01  b1  1.287794934319D+00  b2 -1.477562410575D+00
b3  6.341146465792D-01  b4 -7.939962165046D-02  b5 -3.858201085727D-03
b6  1.748100436976D-03  b7 -1.472792368815D-04  b8  4.123039365518D-06


Max. rel. Error:    .0010 %
Mean rel. Error:    .0003 %
```

2.54 Reaction 2.3l2 $p + H_2(v = 3) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest, derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -2.135211821000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.55 Reaction 2.3l3 $e + H_2(v = 3) \rightarrow H_2^- \rightarrow H + H^-$

```
b0 -2.380889883947D+01  b1  1.145593802336D+00  b2 -1.262299189883D+00
b3  3.864542801636D-01  b4 -8.254357837871D-02  b5  1.238650827308D-02
b6 -1.244892294017D-03  b7  7.473447446431D-05  b8 -2.009848790756D-06

Max. rel. Error:    .0076 %
Mean rel. Error:    .0032 %
```

2.56 Reaction 2.3l4 $e + H_2(v = 3) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep., eth 1.395900E+01

```
  b0 -3.378879447664E+01 b1  1.523672637854E+01 b2 -6.745590257052E+00
  b3  1.974828926502E+00 b4 -4.098427218451E-01 b5  5.919650377042E-02
  b6 -5.603508387710E-03 b7  3.087429479944E-04 b8 -7.428722816433E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
      Eth  13.959

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.57 Reaction 2.3l4ar $e + H_2(v = 3) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep., eth 1.395900E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.395900000000E+01
  b0 -1.983329774434E+01  b1  1.342656584583E+00  b2  4.179960502647E-02
  b3 -1.222410791273E-01  b4  2.674936384095E-02  b5 -1.655289063249E-03
  b6 -1.983958074452E-04  b7  3.392679310612E-05  b8 -1.370844411435E-06

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
      Eth  13.959

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.58 Reaction 2.4l1 $e + H_2(v = 4) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.772351621954D+01  b1  1.052256821107D+01  b2 -4.973321696839D+00
b3  1.451310462218D+00  b4 -3.063368639725D-01  b5  4.435025569759D-02
b6 -4.098974811888D-03  b7  2.161879690469D-04  b8 -4.936128529736D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.59 Reaction 2.4l1T $e + H_2(v = 4) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0 -22.3116918809814    b1  4.66004285894235    b2 -2.898825531842D+00
b3  1.37064885936369    b4 -0.4659672655505     b5  9.578476315815D-02
b6 -0.0113104860539474  b7  7.076399119603D-04  b8 -1.818375382571D-05

Max. rel. Error: 4.04e-05 %
Mean rel. Error: 4.864e-06 %
```

2.60 Reaction 2.4l2th $p + H_2(v = 4) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -1.858781180352D+01  b1  1.287785079093D+00  b2 -1.477535830536D+00
b3  6.340894181665D-01  b4 -7.938783234796D-02  b5 -3.861258099902D-03
b6  1.748551617180D-03  b7 -1.473148894596D-04  b8  4.124214571833D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.61 Reaction 2.4l2 $p + H_2(v = 4) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest, derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.943201680000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.62 Reaction 2.4l3 $e + H_2(v = 4) \rightarrow H_2^- \rightarrow H + H^-$

```
  b0 -2.181958767840D+01  b1  7.062174347527D-01  b2 -1.042070002229D+00
  b3  3.144348543370D-01  b4 -6.595818350289D-02  b5  9.707201256601D-03
  b6 -9.578202173189D-04  b7  5.659613126477D-05  b8 -1.502596517836D-06

  Max. rel. Error:    .0056 %
  Mean rel. Error:    .0023 %
```

2.63 Reaction 2.4l4 $e + H_2(v = 4) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep.4105 [4] eth 1.352900E+01

```
  b0 -3.330086528303E+01 b1  1.491564676374E+01 b2 -6.802923904629E+00
  b3  2.110712395565E+00 b4 -4.678815789295E-01 b5  7.099619985562E-02
  b6 -6.872951706756E-03 b7  3.778766156092E-04 b8 -8.915811243923E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
    Eth 13.529

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.64 Reaction 2.4l4ar $e + H_2(v = 4) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.352900E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.352900000000E+01
  b0 -1.977525999726E+01  b1  1.449576193073E+00  b2 -2.246158761824E-01
  b3  7.824148486684E-02  b4 -4.473847373276E-02  b5  1.201891322904E-02
  b6 -1.634340664249E-03  b7  1.115260221152E-04  b8 -3.044542471029E-06

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
    Eth 13.529

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.65 Reaction 2.5l1 $e + H_2(v = 5) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.769585006151D+01  b1  1.052254581896D+01  b2 -4.973265511463D+00
b3  1.451254555062D+00  b4 -3.063085889212D-01  b5  4.434230078384D-02
b6 -4.097713187510D-03  b7  2.160824161522D-04  b8 -4.932505061094D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.66 Reaction 2.5l1T $e + H_2(v = 5) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.6765406590837  b1      3.96287802270257  b2     -2.40258564400747
b3      1.12173673874494  b4    -0.386820176842012  b5    0.0806339479146663
b6  -0.00962479211187377  b7  0.000607325967190121  b8   -1.5716017024353e-05

Max. rel. Error: 3.548e-05 %
Mean rel. Error: 4.595e-06 %
```

2.67 Reaction 2.5l2th $p + H_2(v = 5) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.085159225482D+01  b1  1.287785621840D+00  b2 -1.477538158990D+00
b3  6.340918458670D-01  b4 -7.938847940329D-02  b5 -3.861353657325D-03
b6  1.748621163219D-03  b7 -1.473257018073D-04  b8  4.124762918375D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.68 Reaction 2.5l2 $p + H_2(v = 5) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.69 Reaction 2.5l3 $e + H_2(v = 5) \rightarrow H_2^- \rightarrow H + H^-$

```
b0 -2.044203459604D+01  b1  3.289282407147D-01  b2 -8.502098907687D-01
b3  2.506415915048D-01  b4 -5.103166869055D-02  b5  7.264584648861D-03
b6 -6.936883240811D-04  b7  3.980653731245D-05  b8 -1.031327104843D-06

Max. rel. Error:    .0038 %
Mean rel. Error:    .0014 %
```

2.70 Reaction 2.5l4 $e + H_2(v = 5) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 13.127

```
  b0 -3.281190667595E+01 b1  1.451688819145E+01 b2 -6.829388255185E+00
  b3  2.300762824373E+00 b4 -5.727472024827E-01 b5  9.761110682421E-02
  b6 -1.043168740981E-02 b7  6.208936382936E-04 b8 -1.560452675954E-05
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
    Eth 13.127

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.71 Reaction 2.5l4ar $e + H_2(v = 5) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 13.127, with separated exponential Arrhenius pre-factor

```
  b-1 13.12700000000E+00
  b0 -1.968820093858E+01  b1  1.450948155910E+00  b2 -4.465479318758E-01
  b3  3.286847111773E-01  b4 -1.621773625324E-01  b5  4.038627004057E-02
  b6 -5.348736344615E-03  b7  3.624573806803E-04  b8 -9.907716742314E-06

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
    Eth 13.127

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.72 Reaction 2.6l1 $e+H_2(v=6) \rightarrow e+H_2(b_{triplet}) \rightarrow e+H+H$ (Greenl.)

```
b0 -2.767028933904D+01  b1  1.052255117744D+01  b2 -4.973278873545D+00
b3  1.451265302500D+00  b4 -3.063125679682D-01  b5  4.434303316421D-02
b6 -4.097774935546D-03  b7  2.160836790142D-04  b8 -4.932435984375D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.73 Reaction 2.6l1T $e+H_2(v=6) \rightarrow e+H_2(b_{triplet}) \rightarrow e+H+H$ (Ten.)

```
b0     -21.3121502328226  b1      3.67180595146767  b2     -2.16627223962433
b3     0.955708249141364  b4     -0.32072282880924  b5    0.0661715411325917
b6  -0.00787337152084188  b7  0.000496850449448679  b8  -1.2879247141546e-05

Max. rel. Error: 3.356e-05 %
Mean rel. Error: 4.513e-06 %
```

2.74 Reaction 2.6l2th $p + H_2(v=6) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.198120878181D+01  b1  1.287800277418D+00  b2 -1.477569386898D+00
b3  6.341199961692D-01  b4 -7.940196845073D-02  b5 -3.857656591908D-03
b6  1.748040548337D-03  b7 -1.472771995563D-04  b8  4.123096000888D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.75 Reaction 2.6l2 $p + H_2(v=6) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest, derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.76 Reaction 2.6l3 $e + H_2(v = 6) \to H_2^- \to H + H^-$

```
b0 -1.927528972571D+01  b1 -5.457126038696D-02  b2 -6.576593507257D-01
b3  1.874931378235D-01  b4 -3.643480518488D-02  b5  4.897128398432D-03
b6 -4.390980935440D-04  b7  2.367076011992D-05  b8 -5.789590362768D-07

Max. rel. Error:    .0020 %
Mean rel. Error:    .0007 %
```

2.77 Reaction 2.6l4 $e + H_2(v = 6) \to e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.275300E+01

```
  b0 -3.241016595549E+01 b1  1.388073863431E+01 b2 -5.922094220968E+00
  b3  1.604395247906E+00 b4 -2.946889149200E-01 b5  3.654977851345E-02
  b6 -2.968203805941E-03 b7  1.443221949914E-04 b8 -3.204695160354E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
   Eth  12.753
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.78 Reaction 2.6l4ar $e + H_2(v = 6) \to e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.275300E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.275300000000E+01
  b0 -1.966549000393E+01  b1  1.247595496620E+00  b2  1.513213490020E-01
  b3 -2.053174899209E-01  b4  5.996873386256E-02  b5 -8.939051925029E-03
  b6  6.820053065774E-04  b7 -2.092478358000E-05  b8 -1.855204539636E-20

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
   Eth  12.753
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.79 Reaction 2.7l1 $e + H_2(v = 7) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.764683592986D+01  b1  1.052256124887D+01  b2 -4.973309833709D+00
b3  1.451299433487D+00  b4 -3.063306982504D-01  b5  4.434828583212D-02
b6 -4.098628142788D-03  b7  2.161567917415D-04  b8 -4.935011253373D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.80 Reaction 2.7l1T $e + H_2(v = 7) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.81 Reaction 2.7l2th $p + H_2(v = 7) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.265768563070D+01  b1  1.287790813817D+00  b2 -1.477557104204D+00
b3  6.341128293460D-01  b4 -7.940032254390D-02  b5 -3.857581842174D-03
b6  1.747941965381D-03  b7 -1.472615566830D-04  b8  4.122302064791D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.82 Reaction 2.7l2 $p + H_2(v = 7) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.83 Reaction 2.7l3 $e + H_2(v = 7) \to H_2^- \to H + H^-$

```
  b0 -1.929224252337D+01  b1 -3.590154847244D-01  b2 -4.966611701523D-01
  b3  1.315458104960D-01  b4 -2.278676033674D-02  b5  2.586659978513D-03
  b6 -1.829570469995D-04  b7  7.105733698367D-06  b8 -1.085295608434D-07

  Max. rel. Error:    .0013 %
  Mean rel. Error:    .0005 %
```

2.84 Reaction 2.7l4 $e + H_2(v = 7) \to e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.240800E+01

```
  b0 -3.199508030297E+01 b1  1.365940877532E+01 b2 -6.049963928526E+00
  b3  1.751601536116E+00 b4 -3.473823631818E-01 b5  4.594389870428E-02
  b6 -3.858383561780E-03 b7  1.863363584155E-04 b8 -3.953846213463E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
    Eth  12.408
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.85 Reaction 2.7l4ar $e + H_2(v = 7) \to e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.240800E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.240800000000E+01
  b0 -1.959334081278E+01  b1  1.346303283762E+00  b2 -9.507879818493E-02
  b3 -4.724842256587E-02  b4  1.354385837415E-02  b5 -1.939915619011E-03
  b6  1.551407654363E-04  b7 -5.231574049420E-06  b8 -1.118438651688E-18
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
    Eth  12.408
  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.86 Reaction 2.8l1 $e+H_2(v=8) \rightarrow e+H_2(b_{triplet}) \rightarrow e+H+H$ (Greenl.)

```
b0 -2.762548922048D+01  b1  1.052257612473D+01  b2 -4.973350220434D+00
b3  1.451343133232D+00  b4 -3.063544627643D-01  b5  4.435536964224D-02
b6 -4.099802397676D-03  b7  2.162583361807D-04  b8 -4.938582991498D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.87 Reaction 2.8l1T $e+H_2(v=8) \rightarrow e+H_2(b_{triplet}) \rightarrow e+H+H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.88 Reaction 2.8l2th $p + H_2(v=8) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.312377572562D+01  b1  1.287797017082D+00  b2 -1.477563048344D+00
b3  6.341171844357D-01  b4 -7.940241959935D-02  b5 -3.857038385376D-03
b6  1.747872038635D-03  b7 -1.472577477196D-04  b8  4.122258391283D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.89 Reaction 2.8l2 $p + H_2(v=8) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.90 Reaction 2.8l3 $e + H_2(v = 8) \rightarrow H_2^- \rightarrow H + H^-$

```
b0 -1.958440259728D+01  b1 -6.441357547219D-01  b2 -3.509251619114D-01
b3  8.250967928444D-02  b4 -1.110578372126D-02  b5  6.353035206263D-04
b6  3.230666138956D-05  b7 -6.817667604373D-06  b8  2.879302754787D-07

Max. rel. Error:    .0024 %
Mean rel. Error:    .0012 %
```

2.91 Reaction 2.8l4 $e + H_2(v = 8) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.209300E+01

```
  b0 -3.161209981241E+01 b1  1.315443924925E+01 b2 -5.565861497924E+00
  b3  1.466628707574E+00 b4 -2.498209080604E-01 b5  2.622910410308E-02
  b6 -1.531860781957E-03 b7  3.792496165572E-05 b8 -9.865107527778E-09
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
   Eth 12.093

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.92 Reaction 2.8l4ar $e + H_2(v = 8) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.209300E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.209300000000E+01
  b0 -1.953368145316E+01  b1  1.254084488062E+00  b2  2.680074687430E-02
  b3 -1.109101081211E-01  b4  2.880495513269E-02  b5 -3.723481850850E-03
  b6  2.494848782952E-04  b7 -6.821937535592E-06  b8 -2.684744901126E-19

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
   Eth 12.093

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.93 Reaction 2.9l1 $e + H_2(v = 9) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.760624341071D+01  b1  1.052252684188D+01  b2 -4.973238725352D+00
b3  1.451236614115D+00  b4 -3.063019800822D-01  b5  4.434089612595D-02
b6 -4.097543054859D-03  b7  2.160716334553D-04  b8 -4.932231997412D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.94 Reaction 2.9l1T $e + H_2(v = 9) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.95 Reaction 2.9l2th $p + H_2(v = 9) \rightarrow H + H_2^+$ (ion conversion)

thermal Rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.346789836907D+01  b1  1.287805383903D+00  b2 -1.477588720367D+00
b3  6.341441719511D-01  b4 -7.941608618199D-02  b5 -3.853256143552D-03
b6  1.747283304462D-03  b7 -1.472092156357D-04  b8  4.120607671872D-06

Max. rel. Error:    .0007 %
Mean rel. Error:    .0002 %
```

2.96 Reaction 2.9l2 $p + H_2(v = 9) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.97 Reaction 2.9l3 $e + H_2(v = 9) \rightarrow H_2^- \rightarrow H + H^-$

```
b0 -1.939772885025D+01  b1 -8.253817970642D-01  b2 -2.434784692591D-01
b3  4.045157332450D-02  b4  2.913895811381D-04  b5 -1.459971700840D-03
b6  2.791086540504D-04  b7 -2.348958212881D-05  b8  7.765205565247D-07

Max. rel. Error:    .0046 %
Mean rel. Error:    .0022 %
```

2.98 Reaction 2.9l4 $e + H_2(v = 9) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.180900E+01

```
  b0 -3.129110031970E+01 b1  1.299658870009E+01 b2 -5.666154017553E+00
  b3  1.584294271614E+00 b4 -2.941981567042E-01 b5  3.467135918621E-02
  b6 -2.401613093175E-03 b7  8.406824396275E-05 b8 -9.845880388168E-07
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
   Eth 11.809

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.99 Reaction 2.9l4ar $e + H_2(v = 9) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.180900E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.180900000000E+01
  b0 -1.949416843703E+01  b1  1.350090118753E+00  b2 -1.508710919706E-01
  b3 -1.096485880940E-03  b4 -3.422486390747E-03  b5  1.150343034735E-03
  b6 -1.177308166450E-04  b7  4.099019404424E-06  b8 -1.304715779986E-21

T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
   Eth 11.809

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.100 Reaction 2.10l1 $e + H_2(v = 10) \rightarrow e + e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.758911407569D+01  b1  1.052257675919D+01  b2 -4.973341819629D+00
b3  1.451330880965D+00  b4 -3.063476040789D-01  b5  4.435342752538D-02
b6 -4.099505380607D-03  b7  2.162348682406D-04  b8 -4.937828839451D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.101 Reaction 2.10l1T $e + H_2(v = 10) \rightarrow e + e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.102 Reaction 2.10l2th $p + H_2(v = 10) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.373156447008D+01  b1  1.287797144053D+00  b2 -1.477569836046D+00
b3  6.341249292595D-01  b4 -7.940617689847D-02  b5 -3.856048097769D-03
b6  1.747721542109D-03  b7 -1.472452386033D-04  b8  4.121817056481D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0002 %
```

2.103 Reaction 2.10l2 $p + H_2(v = 10) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.104 Reaction 2.10l3 $e + H_2(v = 10) \rightarrow H_2^- \rightarrow H + H^-$

```
  b0 -1.961343230561D+01  b1 -8.639443544811D-01  b2 -2.205710582788D-01
  b3  3.126712865456D-02  b4  2.879930125755D-03  b5 -1.957216223866D-03
  b6  3.401585912652D-04  b7 -2.776571437959D-05  b8  9.057334076982D-07

  Max. rel. Error:    .0054 %
  Mean rel. Error:    .0026 %
```

2.105 Reaction 2.10l4 $e + H_2(v = 10) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 11.557

```
  b0 -3.100582302649E+01 b1  1.274999381088E+01 b2 -5.673204141782E+00
  b3  1.689291367906E+00 b4 -3.519487708149E-01 b5  4.915723567388E-02
  b6 -4.314196523316E-03 b7  2.129587027608E-04 b8 -4.482246060660E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
   Eth 11.557

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.106 Reaction 2.10l4ar $e + H_2(v = 10) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 11.557, with separated exponential Arrhenius pre-factor

```
  b-1 11.55700000000E+00
  b0 -1.945289532879E+01  b1  1.260603191167E+00  b2 -8.295052464082E-02
  b3 -2.262541851055E-02  b4 -6.022500746933E-04  b5  1.089319137439E-03
  b6 -1.339304891776E-04  b7  5.074412449086E-06  b8 -2.077788243221E-22
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
   Eth 11.557

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.107 Reaction 2.11l1 $e + H_2(v = 11) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.757408595229D+01  b1  1.052257439706D+01  b2 -4.973330731558D+00
b3  1.451319844531D+00  b4 -3.063427260066D-01  b5  4.435228299508D-02
b6 -4.099356745512D-03  b7  2.162248248938D-04  b8 -4.937557673448D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.108 Reaction 2.11l1T $e + H_2(v = 11) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.109 Reaction 2.11l2th $p + H_2(v = 11) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.393739736481D+01  b1  1.287787931375D+00  b2 -1.477544702789D+00
b3  6.340970104750D-01  b4 -7.939032683233D-02  b5 -3.861042924976D-03
b6  1.748603370756D-03  b7 -1.473267134353D-04  b8  4.124879550605D-06

Max. rel. Error:    .0007 %
Mean rel. Error:    .0002 %
```

2.110 Reaction 2.11l2 $p + H_2(v = 11) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.111 Reaction 2.11l3 $e + H_2(v = 11) \rightarrow H_2^- \rightarrow H + H^-$

```
  b0 -1.961343230561D+01  b1 -8.639443544811D-01  b2 -2.205710582788D-01
  b3  3.126712865456D-02  b4  2.879930125755D-03  b5 -1.957216223866D-03
  b6  3.401585912652D-04  b7 -2.776571437959D-05  b8  9.057334076982D-07

  Max. rel. Error:    .0054 %
  Mean rel. Error:    .0026 %
```

2.112 Reaction 2.11l4 $e + H_2(v = 11) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.133400E+01

```
  b0 -3.079446327037E+01 b1  1.259121133842E+01 b2 -5.554414001000E+00
  b3  1.627653615551E+00 b4 -3.364988459532E-01 b5  4.759783628804E-02
  b6 -4.327984150924E-03 b7  2.256855418333E-04 b8 -5.093163873610E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
  Eth  11.334

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.113 Reaction 2.11l4ar $e + H_2(v = 11) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.133400E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.133400000000E+01
  b0 -1.946330781490E+01  b1  1.309931441017E+00  b2 -4.339772265708E-02
  b3 -7.506085535637E-02  b4  1.799178153471E-02  b5 -1.810732791932E-03
  b6  6.069309047168E-05  b7  2.548764084991E-06  b8 -1.744738940036E-07
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
  Eth  11.334

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.114 Reaction 2.12l1 $e + H_2(v = 12) \to e + H_2(b_{triplet}) \to e + H + H$ (Greenl.)

```
b0 -2.756116092185D+01  b1  1.052255091496D+01  b2 -4.973277908964D+00
b3  1.451269199285D+00  b4 -3.063172671814D-01  b5  4.434507032384D-02
b6 -4.098198643285D-03  b7  2.161264523859D-04  b8 -4.934121004497D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.115 Reaction 2.12l1T $e + H_2(v = 12) \to e + H_2(b_{triplet}) \to e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.116 Reaction 2.12l2th $p + H_2(v = 12) \to H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.409894660398D+01  b1  1.287796545437D+00  b2 -1.477563283235D+00
b3  6.341166151596D-01  b4 -7.940179418730D-02  b5 -3.857236994575D-03
b6  1.747896331887D-03  b7 -1.472584557526D-04  b8  4.122218513563D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.117 Reaction 2.12l2 $p + H_2(v = 12) \to H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.118 Reaction 2.12l3 $e + H_2(v = 12) \rightarrow H_2^- \rightarrow H + H^-$

```
  b0 -1.961343230561D+01  b1 -8.639443544811D-01  b2 -2.205710582788D-01
  b3  3.126712865456D-02  b4  2.879930125755D-03  b5 -1.957216223866D-03
  b6  3.401585912652D-04  b7 -2.776571437959D-05  b8  9.057334076982D-07

  Max. rel. Error:    .0054 %
  Mean rel. Error:    .0026 %
```

2.119 Reaction 2.12l4 $e + H_2(v = 12) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 11.166

```
  b0 -3.059332240574E+01 b1  1.235407166829E+01 b2 -5.305620831066E+00
  b3  1.453071037647E+00 b4 -2.664731004959E-01 b5  3.162021399547E-02
  b6 -2.272804513332E-03 b7  8.697749637266E-05 b8 -1.276410280092E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
  Eth 11.166

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.120 Reaction 2.12l4ar $e + H_2(v = 12) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 11.166, with separated exponential Arrhenius pre-factor

```
  b-1 11.16600000000E+00
  b0 -1.924850182249E+01  b1  1.010238647984E+00  b2  1.631937799994E-01
  b3 -1.464660799314E-01  b4  3.144628167956E-02  b5 -3.315668366658E-03
  b6  1.726199235661E-04  b7 -3.431227743517E-06  b8 -6.669682946895E-19
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
  Eth 11.166

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.121 Reaction 2.13l1 $e + H_2(v = 13) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.755034619316D+01  b1  1.052258385150D+01  b2 -4.973360506789D+00
b3  1.451350903493D+00  b4 -3.063580178328D-01  b5  4.435636964964D-02
b6 -4.099970713992D-03  b7  2.162737880270D-04  b8 -4.939174367895D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.122 Reaction 2.13l1T $e + H_2(v = 13) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6    -0.006119396039219  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.123 Reaction 2.13l2th $p + H_2(v = 13) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.422483601892D+01  b1  1.287790908632D+00  b2 -1.477549007523D+00
b3  6.341005887109D-01  b4 -7.939255849820D-02  b5 -3.860134331857D-03
b6  1.748395205906D-03  b7 -1.473026752126D-04  b8  4.123793755724D-06

Max. rel. Error:    .0009 %
Mean rel. Error:    .0003 %
```

2.124 Reaction 2.13l2 $p + H_2(v = 13) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.125 Reaction 2.13l3 $e + H_2(v = 13) \rightarrow H_2^- \rightarrow H + H^-$

```
  b0 -1.961343230561D+01  b1 -8.639443544811D-01  b2 -2.205710582788D-01
  b3  3.126712865456D-02  b4  2.879930125755D-03  b5 -1.957216223866D-03
  b6  3.401585912652D-04  b7 -2.776571437959D-05  b8  9.057334076982D-07

  Max. rel. Error:    .0054 %
  Mean rel. Error:    .0026 %
```

2.126 Reaction 2.13l4 $e + H_2(v = 13) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.103600E+01

```
  b0 -3.040637628145E+01 b1  1.206139604914E+01 b2 -5.133567877491E+00
  b3  1.420670602666E+00 b4 -2.718421480963E-01 b5  3.485869586564E-02
  b6 -2.812572602589E-03 b7  1.272053775577E-04 b8 -2.424574709641E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
   Eth  11.036

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.127 Reaction 2.13l4ar $e + H_2(v = 13) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 1.103600E+01, with separated exponential Arrhenius pre-factor

```
  b-1 1.103600000000E+01
  b0 -1.937834529948E+01  b1  1.138168549504E+00  b2  1.030714963736E-01
  b3 -1.295069297668E-01  b4  2.845088774605E-02  b5 -2.993653782248E-03
  b6  1.534686508642E-04  b7 -2.950144939001E-06  b8 -6.585824084197E-22
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
   Eth  11.036

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.128 Reaction 2.14l1 $e + H_2(v = 14) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Greenl.)

```
b0 -2.754163096543D+01  b1  1.052254544931D+01  b2 -4.973269874009D+00
b3  1.451261590180D+00  b4 -3.063130130080D-01  b5  4.434371585649D-02
b6 -4.097959650066D-03  b7  2.161048253687D-04  b8 -4.933341800181D-06

Max. rel. Error:    .0008 %
Mean rel. Error:    .0003 %
```

2.129 Reaction 2.14l1T $e + H_2(v = 14) \rightarrow e + H_2(b_{triplet}) \rightarrow e + H + H$ (Ten.)

```
b0     -21.2234451158395  b1      3.79779548996827  b2     -2.20485191961662
b3     0.881816655859811  b4    -0.270729873773876  b5    0.0529758947071274
b6   -0.00611939603921 9  b7  0.000379920833744922  b8 -9.76407488585707e-06

Max. rel. Error: 3.49e-05 %
Mean rel. Error: 4.631e-06 %
```

2.130 Reaction 2.14l2th $p + H_2(v = 14) \rightarrow H + H_2^+$ (ion conversion)

thermal rate coeff. for T(p) = T(H2), T/m with $m = m_{red} = 2/3$.

```
b0 -2.432076996732D+01  b1  1.287803404369D+00  b2 -1.477573884680D+00
b3  6.341217583821D-01  b4 -7.940186237537D-02  b5 -3.857829177957D-03
b6  1.748067715781D-03  b7 -1.472776363802D-04  b8  4.122991462534D-06

Max. rel. Error:    .0007 %
Mean rel. Error:    .0003 %
```

2.131 Reaction 2.14l2 $p + H_2(v = 14) \rightarrow H + H_2^+$ (ion conversion)

Rate coeff. for H2 at rest (0.1 eV), derived from HYDHEL data. Greenland scaling Taken at $E(H_2) = 0.1 \approx 0.0$ eV, and fit is for temperature $T_p = T$ with H_2 at rest, T/m with $m = m_p = 1$.

```
b0 -1.947342173000E+01  b1  2.552627389749E+00  b2 -2.608194219039E+00
b3  1.347571390219E+00  b4 -3.646182244708E-01  b5  5.938400660590E-02
b6 -5.795480327782E-03  b7  3.075899232458E-04  b8 -6.769294455276E-06
```

2.132 Reaction 2.14l3 $e + H_2(v = 14) \rightarrow H_2^- \rightarrow H + H^-$

```
b0 -1.961343230561D+01  b1 -8.639443544811D-01  b2 -2.205710582788D-01
b3  3.126712865456D-02  b4  2.879930125755D-03  b5 -1.957216223866D-03
b6  3.401585912652D-04  b7 -2.776571437959D-05  b8  9.057334076982D-07
```

```
  Max. rel. Error:    .0054 %
  Mean rel. Error:    .0026 %
```

2.133 Reaction 2.14l4 $e + H_2(v = 14) \rightarrow e + H_2^+ + e$

Janev-Reiter, JUEL-rep. eth 10.959

```
  b0 -3.032266556048E+01 b1  1.230019998846E+01 b2 -5.638800771953E+00
  b3  1.795709971225E+00 b4 -4.147784008872E-01 b5  6.552622885626E-02
  b6 -6.544169502584E-03 b7  3.672791438275E-04 b8 -8.764761530765E-06
T1MIN =   1.00000D-01 EV
T1MAX =   1.00000D 03 EV
   Eth  10.959

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.134 Reaction 2.14l4ar $e + H_2(v = 14) \rightarrow e + H_2^+ + e$

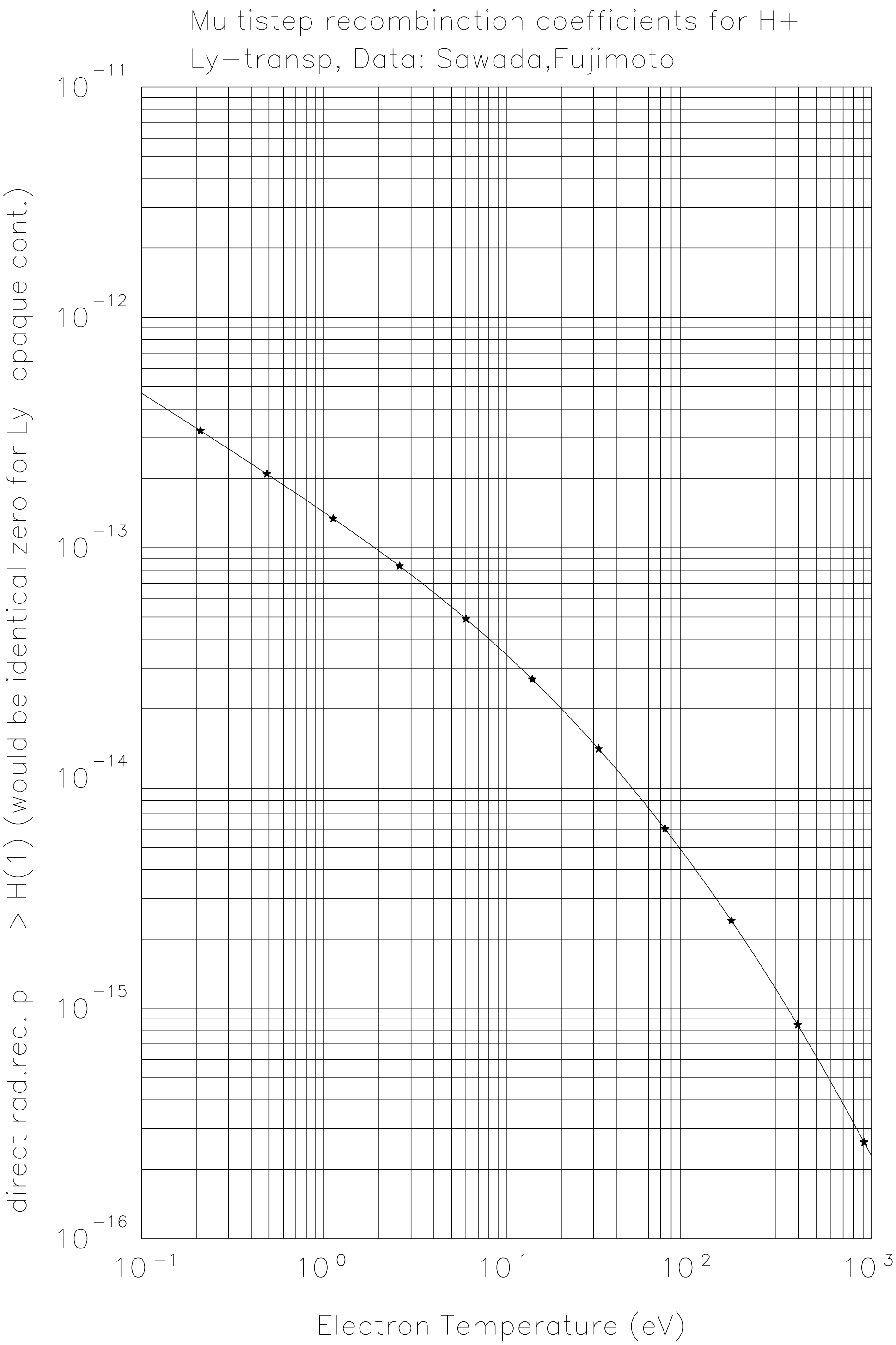
Janev-Reiter, JUEL-rep. eth 10.959, with separated exponential Arrhenius pre-factor

```
  b-1 10.95900000000E+00
  b0 -1.936641600171E+01  b1  1.392175790560E+00  b2 -3.101235770021E-01
  b3  1.493320052789E-01  b4 -7.201655314234E-02  b5  1.775240602694E-02
  b6 -2.300697309614E-03  b7  1.515251342432E-04  b8  2.002201976529E-03
T1MIN =   1.00000D-03 EV
T1MAX =   1.00000D 03 EV
   Eth  10.959

  Max. rel. Error:    .xxx %
  Mean rel. Error:    .xxx %
```

2.135 Reaction 2.1.8rr1 $p + e \rightarrow H(n = 1) + h\nu$, direct rad.rec

Sawada-Fujimoto, single step rate, for Lyman rad.rec. continuum emission to be used as Lyman-cont. source rate. Tbd.: Find H.1 cross section and H.8 rate for electron energy loss, sample electron from sigma(v) v fmax, (sigma: corresponding H.1 cross section, and then find Lyman cont. frequency, e.g. for photo-ionisation.

```
  b0 -2.957888914571D+01  b1 -5.407764512982D-01  b2 -1.887782807843D-02
  b3 -5.957963562133D-03  b4 -6.689096738611D-04  b5  1.798038419103D-04
  b6  5.588505208658D-06  b7 -4.618096511047D-06  b8  3.313570987992D-07
T1MIN =   1.00000D-01
T1MAX =   1.00000D 03

  Max. rel. Error:    .0700 %
  Mean rel. Error:    .0372 %
```



Multistep recombination coefficients for H+
Ly−transp, Data: Sawada,Fujimoto
direct rad.rec. p −−> H(1) (would be identical zero for Ly−opaque cont.)
Electron Temperature (eV)

3 H.3 : Fits for $< \sigma v > (E_b, T)$

3.1 Reaction 2.0l2 $p + H_2(v = 0) \rightarrow H(1s) + H_2^+$

same as in HYDHEL 3.2.3, for $v = 0$. Then from here: scaling to other init. vibr. states v, see below.

T Index \ E Index	0	1	2
0	-2.393090018673e+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.2 Reaction 2.1l2 $p + H_2(v = 1) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 1$. Scaled cross section, Greenland: $g_2(v)$ Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-2.327365458433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.3 Reaction 2.2l2 $p + H_2(v = 2) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 2$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-2.236689231433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.4 Reaction 2.3l2 $p + H_2(v = 3) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 3$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-2.087305019433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.5 Reaction 2.4l2 $p + H_2(v=4) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 4$. Scaled cross section, Greenland: [2] $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.895294878433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.6 Reaction 2.5l2 $p + H_2(v = 5) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 5$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.7 Reaction 2.6l2 $p + H_2(v = 6) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 6$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.8 Reaction 2.7l2 $p + H_2(v = 7) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 7$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.9 Reaction 2.8l2 $p + H_2(v = 8) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 8$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.10 Reaction 2.9l2 $p + H_2(v = 9) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 9$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.11 Reaction 2.10l2 $p + H_2(v = 10) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 10$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.12 Reaction 2.11l2 $p + H_2(v = 11) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 11$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.13 Reaction 2.12l2 $p + H_2(v = 12) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 12$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.14 Reaction 2.13l2 $p + H_2(v = 13) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 13$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

3.15 Reaction 2.14l2 $p + H_2(v = 14) \rightarrow H(1s) + H_2^+$

scaled from HYDHEL 3.2.3, to $v = 14$. Scaled cross section, Greenland: $g_2(v)$ tbd: Only the 00 coefficient (constant factor) is scaled.

T Index \ E Index	0	1	2
0	-1.899435371433E+01	6.248759475696e-01	4.860672617319e-02
1	1.497880823202e+00	-1.321184618254e+00	1.610180305377e-01
2	-1.108848312589e+00	1.026939763848e+00	-2.764437632008e-01
3	2.723796545755e-01	-3.349189897157e-01	1.525831234833e-01
4	2.721877464232e-02	4.328258310611e-02	-4.172607648071e-02
5	-1.779177173774e-02	4.465034873018e-04	6.494173133750e-03
6	2.547195398346e-03	-6.602886969983e-04	-5.936946344163e-04
7	-1.581068390892e-04	6.000753124589e-05	2.989789198510e-05
8	3.720016363224e-06	-1.724843689004e-06	-6.403267693113e-07

T Index \ E Index	3	4	5
0	-1.200688114292e-01	8.087736504737e-03	9.460417081363e-03
1	1.165310493854e-01	-3.963918450387e-02	4.451468403951e-03
2	-3.948109106588e-02	3.853676685634e-02	-9.097709483121e-03
3	-9.592981926094e-03	-1.131614493158e-02	3.519316476081e-03
4	1.001163900824e-02	3.016020168360e-04	-4.649867654705e-04
5	-2.726517864643e-03	3.947434451322e-04	-3.560364682888e-06
6	3.516907384191e-04	-7.253981468239e-05	6.007588925145e-06
7	-2.210901325776e-05	5.074761954649e-06	-4.890225279817e-07
8	5.443461456508e-07	-1.285040546716e-07	1.225908917355e-08

T Index \ E Index	6	7	8
0	-2.128651089328e-03	1.685181886244e-04	-4.665309226730e-06
1	-1.304738719348e-04	-8.714697396102e-06	4.796574269551e-07
2	1.042066219239e-03	-5.955686719189e-05	1.358749516236e-06
3	-4.463914380371e-04	2.672110767494e-05	-6.218012239798e-07
4	7.356430658399e-05	-4.797055206851e-06	1.159195338618e-07
5	-4.585211534749e-06	4.292978331848e-07	-1.209703556619e-08
6	-1.866842996766e-08	-2.383240469589e-08	9.353713300206e-10
7	1.067090708836e-08	1.188959741308e-09	-5.741789281748e-11
8	-1.967393094286e-10	-3.854014407618e-11	1.748544462760e-12

Error 7.17e-03 (D)

Error is improved to 2.24e-03 (C) if only values of <sv> for T > 1 eV are considered.

4 H.4 : Fits for $< \sigma v > (n_e, T)$

4.1 Reaction 2.1.5a $H + e \rightarrow H^+ + 2e, Ly_\alpha$-removed

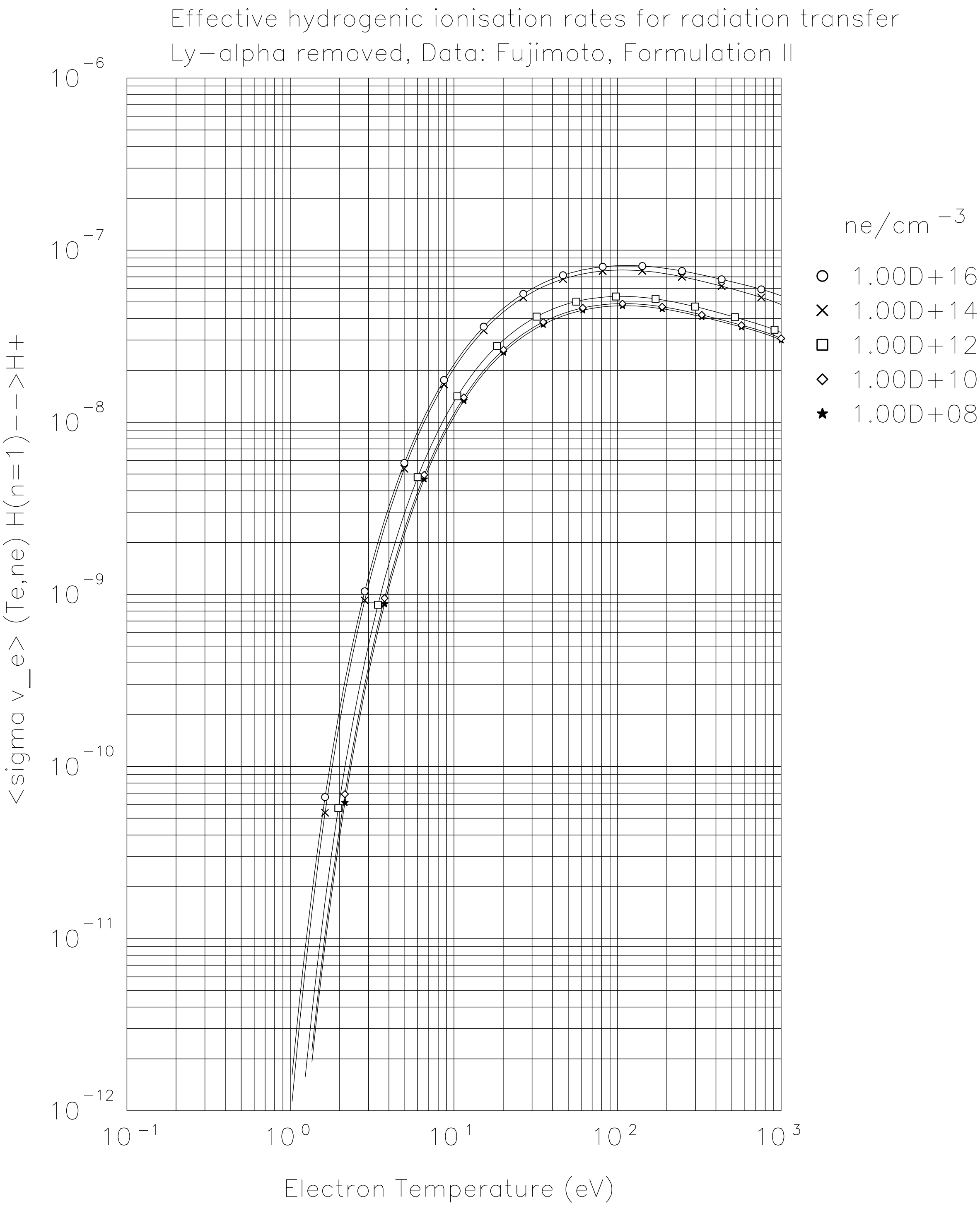
Effective hydrogenic ionisation rate. Data: T.Fujimoto Ly-alpha removed, Formulation II, data for radiation transfer, or Lyman-alpha opaque case, with all other Lyman lines transparent.

T-Index \ E-Index:	0	1	2
0	-3.022431884192D+01	1.477880772147D-01	-1.572672172571D-01
1	1.242533748190D+01	-5.470384149249D-02	4.116202175547D-02
2	-6.314277246192D+00	1.905661825335D-03	9.229826010107D-03
3	2.480577766986D+00	-3.451067142808D-03	-6.534524280156D-03
4	-7.568906138410D-01	8.939631300339D-03	-4.808204401856D-04
5	1.622115446335D-01	-5.049963529433D-03	1.361061125082D-03
6	-2.217192152793D-02	1.265865423492D-03	-4.644904483405D-04
7	1.708676750718D-03	-1.492409336441D-04	6.493737984557D-05
8	-5.606702924248D-05	6.725450104229D-06	-3.287579398592D-06

T-Index \ E-Index:	3	4	5
0	7.280879238421D-02	-1.589318183128D-02	1.852697229106D-03
1	-1.657408268822D-02	2.773389081609D-03	-2.141817737737D-04
2	-4.332842725523D-03	1.275573319668D-03	-2.024812982595D-04
3	2.608112513447D-03	-4.901649510295D-04	5.094138248796D-05
4	-3.763269379389D-04	6.624466844459D-05	1.844157708971D-08
5	-9.804636464500D-05	-7.983757512249D-06	3.247109732244D-07
6	6.214782620914D-05	-1.464396038380D-06	-1.969168432781D-07
7	-1.111120948999D-05	7.068350505865D-07	-4.104806461655D-09
8	6.547564256484D-07	-5.847945540489D-08	2.361191962969D-09

T-Index \ E-Index:	6	7	8
0	-1.157875780788D-04	3.647982620347D-06	-4.547088373770D-08
1	5.128377308193D-06	1.544090527203D-07	-6.641974919482D-09
2	1.695387091392D-05	-6.958582121645D-07	1.099951417209D-08
3	-2.845927207874D-06	7.475887055081D-08	-6.422897849582D-10
4	-7.173410358984D-07	5.250774467977D-08	-1.131242699174D-09
5	1.514582937665D-07	-1.315107905875D-08	3.017774523710D-10
6	2.021803051693D-09	8.863805177302D-10	-2.875901203141D-11
7	-7.327880180666D-10	-1.432779345041D-11	1.214953547643D-12
8	-4.482535378130D-11	1.201150148690D-12	-3.597174268523D-14

```
N2MIN =   1.00000D 08 1/CM3
N2MAX =   1.00000D 16 1/CM3

  Max. rel. Error:   2.5098 %
  Mean rel. Error:    .6261 %
```



Effective hydrogenic ionisation rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation II
<sigma v_e> (Te,ne) H(n=1)−−>H+
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

4.2 Reaction 2.1.5b $H(n=1)+e \rightarrow H^{+}+2e, Ly_{\alpha}$-removed

Effective hydrogenic ionisation rate. Ly-alpha removed, Formulation I, data for radiation transfer or for Lyman-alpha opaque case, all other Lyman lines transparent, and n=2 state meta-stable

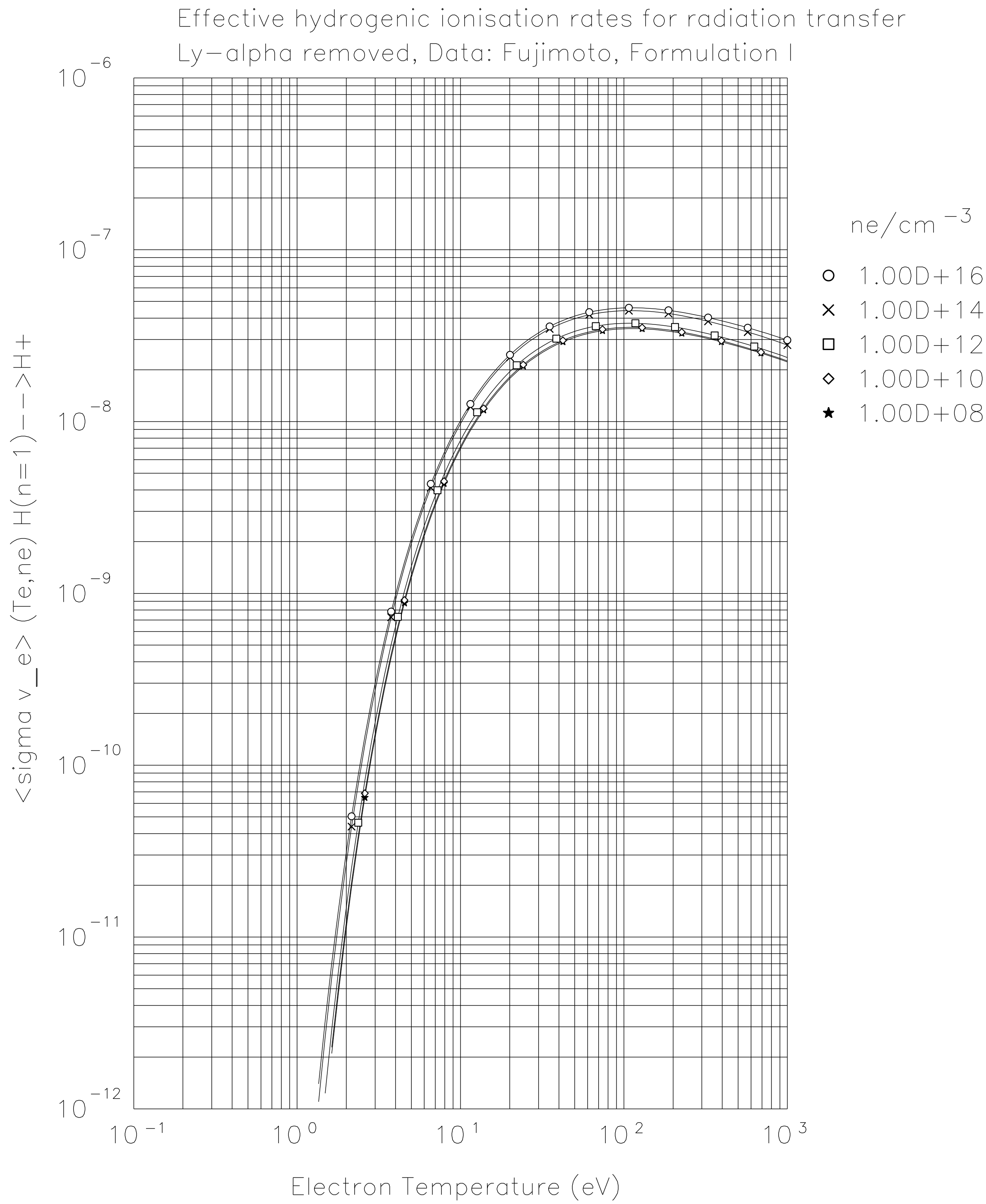
T-Index \ E-Index:	0	1	2
0	-3.248384445230D+01	7.293410610463D-02	-6.942352986508D-02
1	1.427809037474D+01	-3.887286473033D-02	2.478859076894D-02
2	-6.726972866893D+00	1.092594330815D-02	-3.336487886830D-03
3	2.176674919017D+00	1.764246675785D-03	1.751409035955D-04
4	-5.090338523044D-01	-4.306390407210D-03	8.874703074411D-04
5	8.295947264795D-02	1.983243222211D-03	-5.602463387149D-04
6	-8.856746653956D-03	-4.038613669733D-04	1.187401531764D-04
7	5.537696204476D-04	3.808747081131D-05	-9.719861669731D-06
8	-1.531161137972D-05	-1.348551160867D-06	2.265271054600D-07

T-Index \ E-Index:	3	4	5
0	3.041032169286D-02	-6.086012592412D-03	6.363019817757D-04
1	-9.020148697515D-03	1.210856135948D-03	-4.699101677556D-05
2	3.569852431711D-04	3.110102668251D-04	-7.721118867758D-05
3	-2.411363042853D-04	-3.598459978140D-05	1.139983285471D-05
4	6.476148410259D-05	-1.872619765692D-05	2.076737885855D-06
5	4.201414598449D-05	-1.540245625626D-06	1.104351486597D-07
6	-1.039945546008D-05	5.786742392780D-07	-8.808085434566D-08
7	1.567590362684D-07	1.201707880062D-07	-7.880947976248D-09
8	5.836470567764D-08	-1.779395134379D-08	1.679753858814D-09

T-Index \ E-Index:	6	7	8
0	-3.435664297628D-05	8.802267580237D-07	-7.995819111051D-09
1	-4.007687273585D-06	3.873206604671D-07	-8.671626429538D-09
2	7.393467613764D-06	-3.187206713399D-07	5.125213569428D-09
3	-8.125224526149D-07	1.822044547356D-08	-1.061236415891D-11
4	-2.614672116853D-07	1.734774242072D-08	-3.884613855226D-10
5	1.463109045635D-08	-2.002994443576D-09	5.379365821640D-11
6	7.092931520645D-09	-2.134940156380D-10	2.032057312592D-12
7	-8.584512206848D-11	1.997928983568D-11	-4.790497915314D-13
8	-7.083680798821D-11	1.139617384842D-12	7.735673361710D-16

N2MIN = 1.00000D 08 1/CM3
N2MAX = 1.00000D 16 1/CM3

Max. rel. Error: 1.6577 %
Mean rel. Error: .2764 %



Effective hydrogenic ionisation rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation I
<sigma v_e> (Te,ne) H(n=1)−−>H+
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08
10 −6
10 −7
10 −8
10 −9
10 −10
10 −11
10 −12
10 −1
10 0
10 1
10 2
10 3

4.3 Reaction 2.1.5c $H(n=1)+e \rightarrow H(n=2)+e, Ly_{\alpha}$-removed

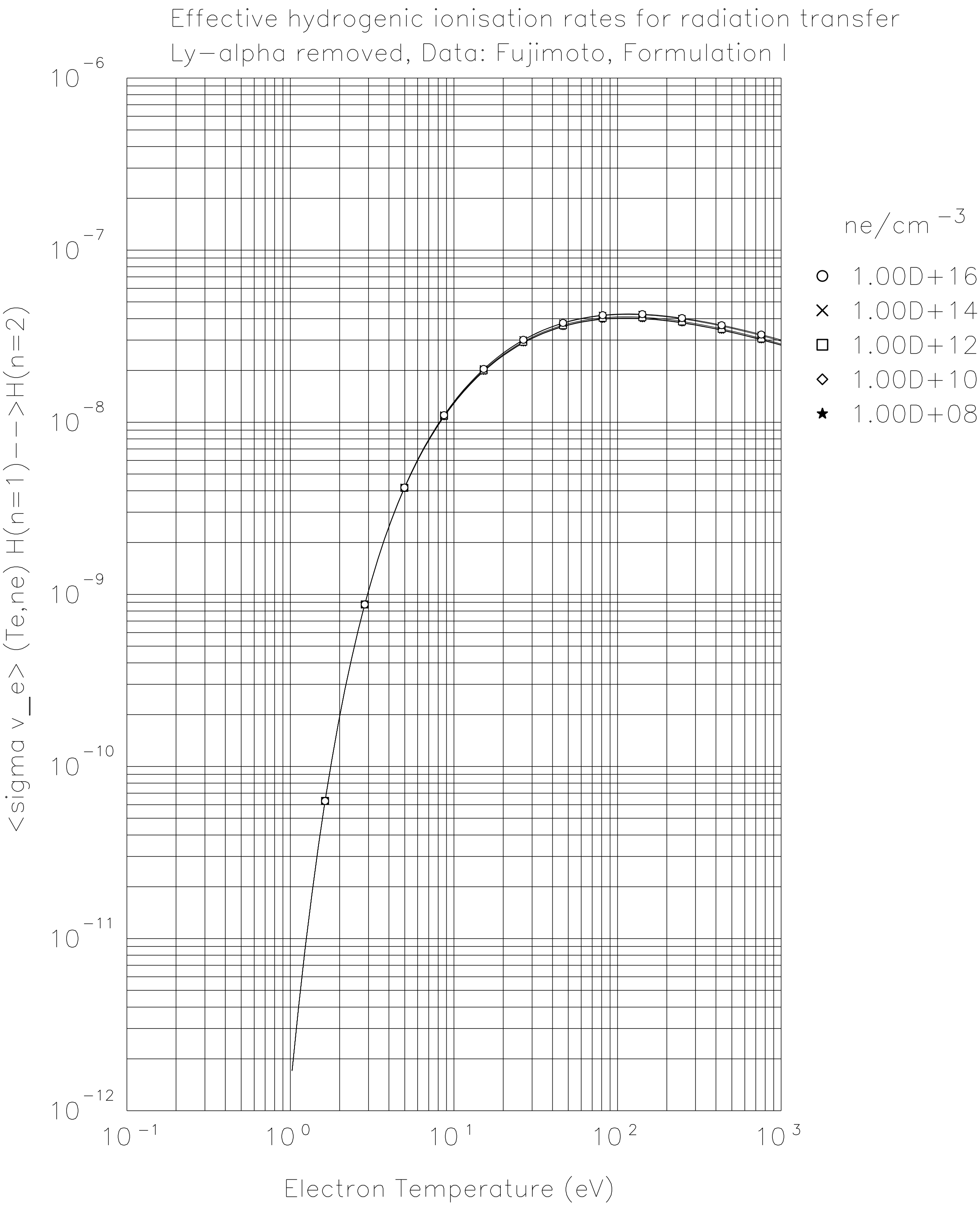
Effective hydrogenic ionisation rate. Ly-alpha removed, Formulation I, and n=2 state meta-stable data for radiation transfer simulations

T-Index \ E-Index	0	1	2
0	-2.732702422613D+01	-1.508576131264D-04	1.872353272462D-04
1	9.942867847868D+00	-2.632841887401D-04	3.452012251367D-04
2	-4.997530269473D+00	6.559282602805D-04	-5.797337934145D-04
3	1.683052423447D+00	1.254342763651D-04	8.545926767443D-05
4	-3.836337745154D-01	-3.185827629333D-04	1.009778672991D-04
5	5.720695520317D-02	1.400592671321D-04	-5.978401828728D-05
6	-5.358955217722D-03	-2.746966330902D-05	1.277061974502D-05
7	2.888347792841D-04	2.516940058093D-06	-1.158570567442D-06
8	-6.915074509856D-06	-8.703714842321D-08	3.633724963304D-08

T-Index \ E-Index	3	4	5
0	-7.629473588333D-05	1.550097510180D-05	-1.731418238339D-06
1	-1.326555904790D-04	2.509311823554D-05	-2.554298250891D-06
2	2.250648741189D-04	-4.119998836569D-05	4.069891413295D-06
3	-4.537015062412D-05	9.220799309537D-06	-8.411676927015D-07
4	-1.517153942255D-05	-3.043173799395D-08	1.407410168855D-07
5	1.180861422945D-05	-8.317621018664D-07	6.141225578357D-09
6	-2.551548640525D-06	1.942510874330D-07	-3.606869466105D-09
7	2.052211011805D-07	-1.010930204187D-08	-5.682582207333D-10
8	-4.322115492549D-09	-3.244269571886D-10	9.764976297168D-11

T-Index \ E-Index	6	7	8
0	1.074805789263D-07	-3.470606438007D-09	4.542480946192D-11
1	1.394047301654D-07	-3.818799358166D-09	4.101078748816D-11
2	-2.262349426703D-07	6.695796328753D-09	-8.223791846038D-11
3	3.804347055718D-08	-7.715880618270D-10	3.936358646223D-12
4	-7.722574474149D-09	-2.434863248973D-11	6.531045548972D-12
5	2.666455817423D-10	9.825348918612D-11	-4.050855928030D-12
6	1.171036715797D-10	-2.809228870343D-11	9.792621302229D-13
7	3.746419877493D-11	1.529859104815D-12	-8.525738644768D-14
8	-5.810958440786D-12	6.995905890738D-14	1.757130683111D-15

```
N2MIN =   1.00000D 08 1/CM3
N2MAX =   1.00000D 16 1/CM3

  Max. rel. Error:    .1532 %
  Mean rel. Error:    .0592 %
```



Effective hydrogenic ionisation rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation I
10 −6
10 −7
10 −8
10 −9
10 −10
10 −11
10 −12
<sigma v_e> (Te,ne) H(n=1)−−>H(n=2)
10 −1
10 0
10 1
10 2
10 3
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

4.4 Reaction 2.1.5d $H(n=2) + e \rightarrow H(n=1) + e, Ly_\alpha$-removed

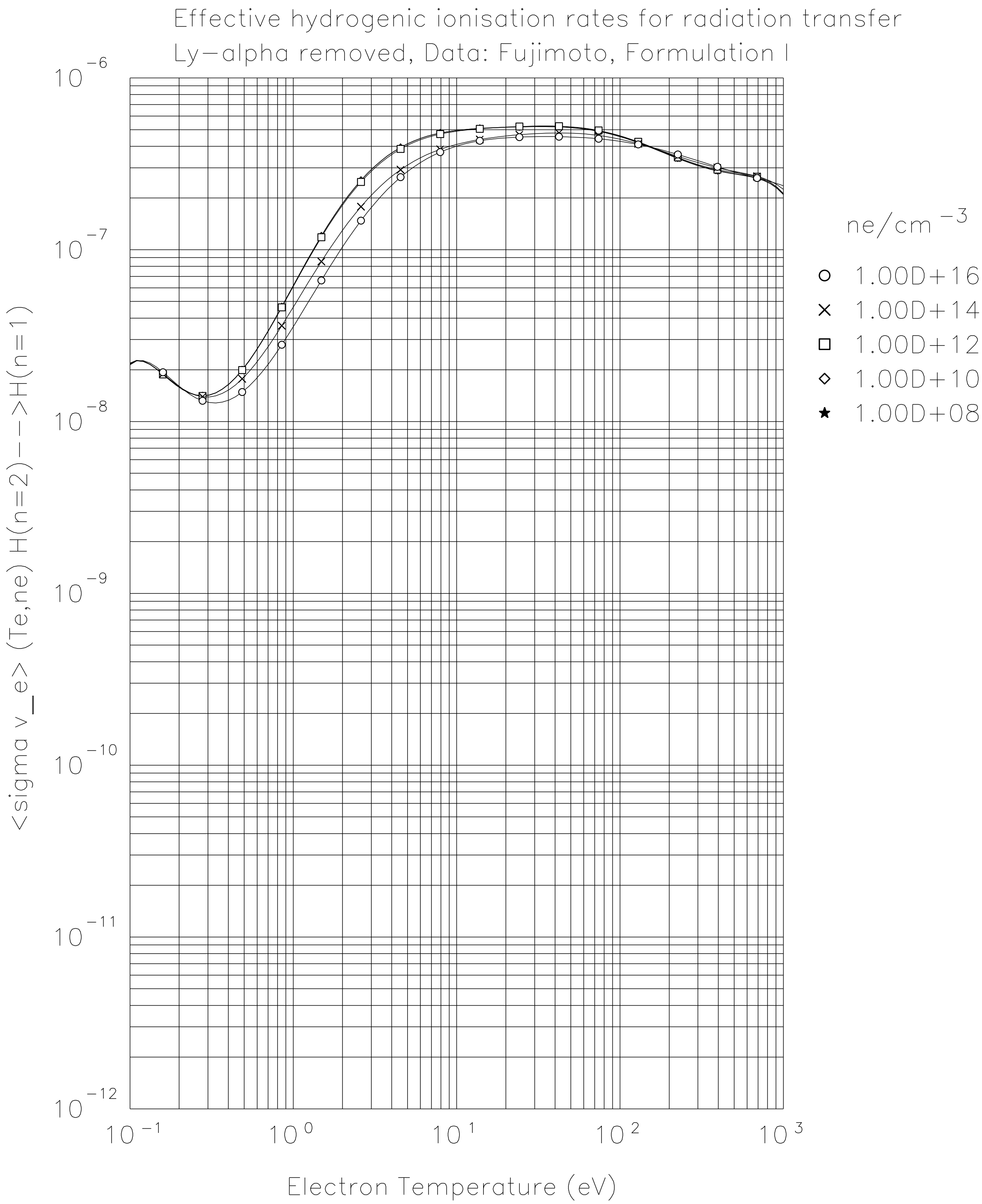
Effective hydrogenic ionisation rate. Ly-alpha removed, Formulation I, and n=2 state meta-stable data for radiation transfer simulations

T-Index \ E-Index:	0	1	2
0	-1.659818649793D+01	1.429484983203D-02	-2.100141042578D-02
1	1.742330959484D+00	-5.997846101940D-03	6.059773560752D-03
2	-3.422017214424D-02	-7.679301781651D-03	9.535509218740D-03
3	-3.392525402761D-01	3.605303852806D-03	-2.919305119896D-03
4	7.948143827542D-02	-2.943088253866D-04	2.234196372195D-04
5	1.867182206299D-02	-6.654726528785D-04	5.292004513132D-04
6	-9.962095099418D-03	3.385340695970D-04	-3.160633510540D-04
7	1.414704279202D-03	-5.868922497053D-05	5.981393236066D-05
8	-6.778145294630D-05	3.399096070717D-06	-3.648373573909D-06

T-Index \ E-Index:	3	4	5
0	1.152299446960D-02	-3.077712244622D-03	4.375850699659D-04
1	-1.693723561537D-03	7.833198105940D-05	3.273993894179D-05
2	-4.932008159215D-03	1.299912776071D-03	-1.842176089711D-04
3	6.571581162102D-04	-4.079964162940D-06	-1.609954859886D-05
4	1.138934671427D-04	-8.745345049058D-05	1.853247621903D-05
5	-1.465380906612D-04	1.715005769551D-05	-6.057079632044D-07
6	9.486307883572D-05	-1.082995210965D-05	1.743274221470D-07
7	-1.993485945346D-05	2.808826990812D-06	-1.549916526132D-07
8	1.297479669764D-06	-2.047939003690D-07	1.510643098784D-08

T-Index \ E-Index:	6	7	8
0	-3.356465680433D-05	1.296836422250D-06	-1.971818325611D-08
1	-5.346970160704D-06	2.977637393971D-07	-5.689256722171D-09
2	1.404096288049D-05	-5.366619323826D-07	8.046595868836D-09
3	2.175371740624D-06	-1.124395092099D-07	2.066437244946D-09
4	-1.751213305596D-06	7.634570384085D-08	-1.251382124144D-09
5	-4.466867192030D-08	4.307746584152D-09	-9.756692581883D-11
6	5.666724942724D-08	-4.040606638396D-09	8.160750637647D-11
7	-7.619004757300D-10	3.585200856379D-10	-8.907451129040D-12
8	-4.285833264589D-10	-2.317364247767D-12	2.299707584654D-13

```
N2MIN =   1.00000D 08 1/CM3
N2MAX =   1.00000D 16 1/CM3

  Max. rel. Error:   9.1628 %
  Mean rel. Error:   3.6082 %
```


Effective hydrogenic ionisation rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation I
<sigma v_e> (Te,ne) H(n=2)−−>H(n=1)
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

4.5 Reaction 2.1.5e $H(n = 2) + e \rightarrow H^{+} + 2e, Ly_{\alpha}$-removed

Effective hydrogenic ionisation rate. Ly-alpha removed, Formulation I, and n=2 state meta-stable data for radiation transfer simulations

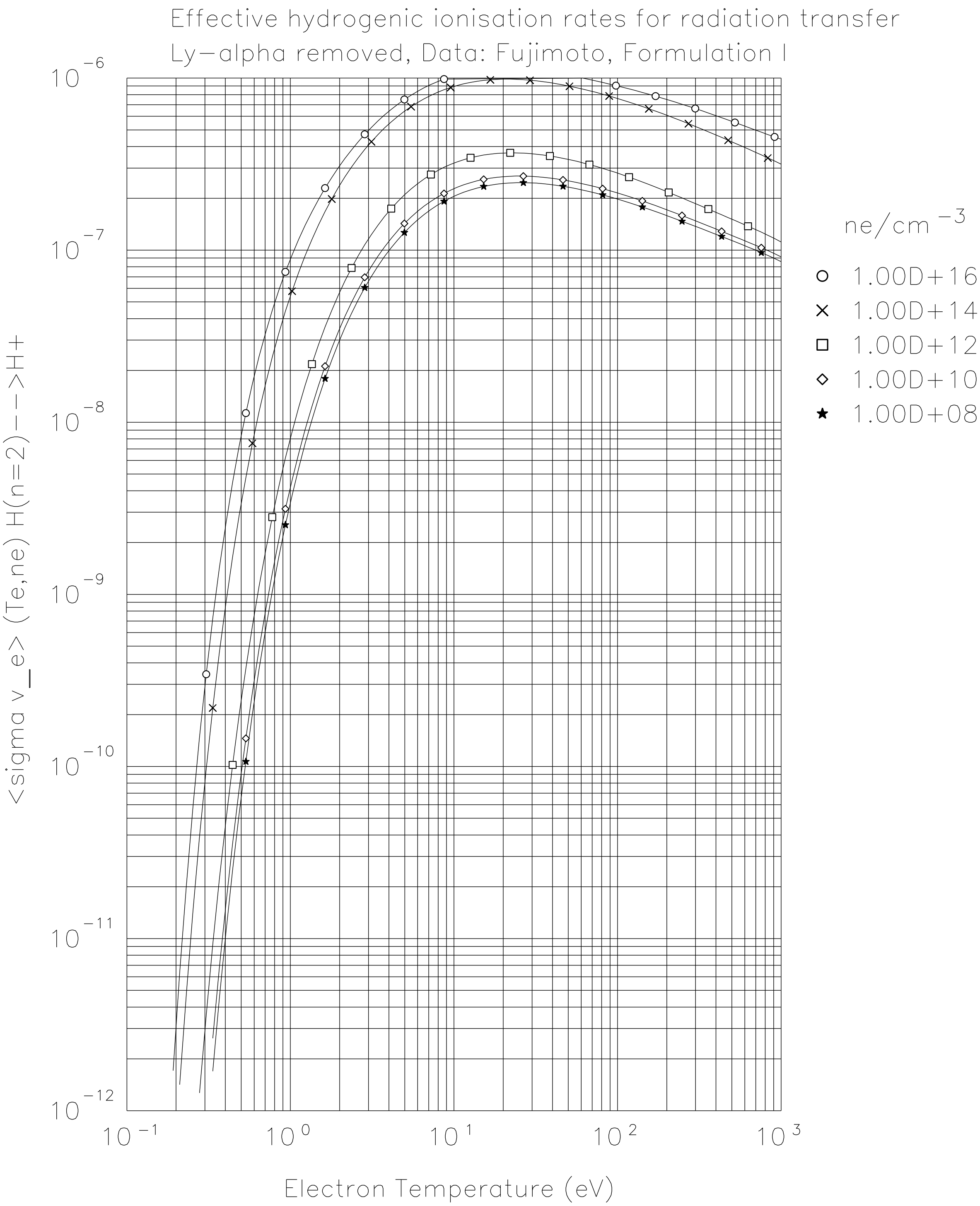
T-Index \ E-Index	0	1	2
0	-1.949602962418D+01	1.572379381689D-01	-1.672687958682D-01
1	4.151579585185D+00	1.556233836878D-02	-3.245367410506D-02
2	-1.773155597615D+00	1.371251582122D-02	-2.968766720555D-03
3	5.318599536087D-01	-2.157101198306D-02	1.634450838611D-02
4	-1.405207852240D-01	2.865675278552D-03	-2.159292629010D-03
5	2.964617574118D-02	1.926302090118D-03	-1.444026989600D-03
6	-4.236696509078D-03	-6.231773237818D-04	4.167286753002D-04
7	3.477708693863D-04	6.423694857182D-05	-3.477587053445D-05
8	-1.218787732227D-05	-2.124219526300D-06	6.673464438778D-07

T-Index \ E-Index	3	4	5
0	7.714528275367D-02	-1.668245359835D-02	1.918023565068D-03
1	1.413987396431D-02	-3.508873991240D-03	4.794032041305D-04
2	8.412201007766D-04	-2.584848991331D-05	-7.643710148594D-06
3	-6.250045783812D-03	1.236161025217D-03	-1.405279759171D-04
4	9.407657488399D-04	-2.085162968365D-04	2.527049237995D-05
5	4.170317752366D-04	-6.005016591723D-05	4.962988065563D-06
6	-1.113639199877D-04	1.451094245195D-05	-1.040996593967D-06
7	6.389730706016D-06	-2.193260195502D-07	-5.493878229105D-08
8	9.777130038298D-08	-7.137568289626D-08	1.185846172382D-08

T-Index \ E-Index	6	7	8
0	-1.177118883477D-04	3.626797574496D-06	-4.401597343578D-08
1	-3.653292205533D-05	1.430913561828D-06	-2.222952832799D-08
2	9.533973070265D-07	-4.156400550013D-08	6.067986475434D-10
3	9.182767471549D-06	-3.177805341251D-07	4.488049880822D-09
4	-1.688503865789D-06	5.760613277956D-08	-7.777721186164D-10
5	-2.498439288842D-07	7.498373582042D-09	-1.045833850715D-10
6	4.359165697592D-08	-1.067795658171D-09	1.258171671672D-11
7	6.582775573429D-09	-2.790931932103D-10	4.242120120127D-12
8	-9.022658909532D-10	3.311018546718D-11	-4.760695087298D-13

N2MIN = 1.00000D 08 1/CM3
N2MAX = 1.00000D 16 1/CM3

Max. rel. Error: 3.8493 %
Mean rel. Error: 1.2476 %



Effective hydrogenic ionisation rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation I
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
<sigma v_e> (Te,ne) H(n=2)−−>H+
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Electron Temperature (eV)
ne/cm $^{-3}$
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

4.6 Reaction 2.1.8a $H^+ + e \rightarrow H, Ly_\alpha$-removed

Effective hydrogenic recombination rate. Ly-alpha removed, Formulation II, data for radiation transfer simulations

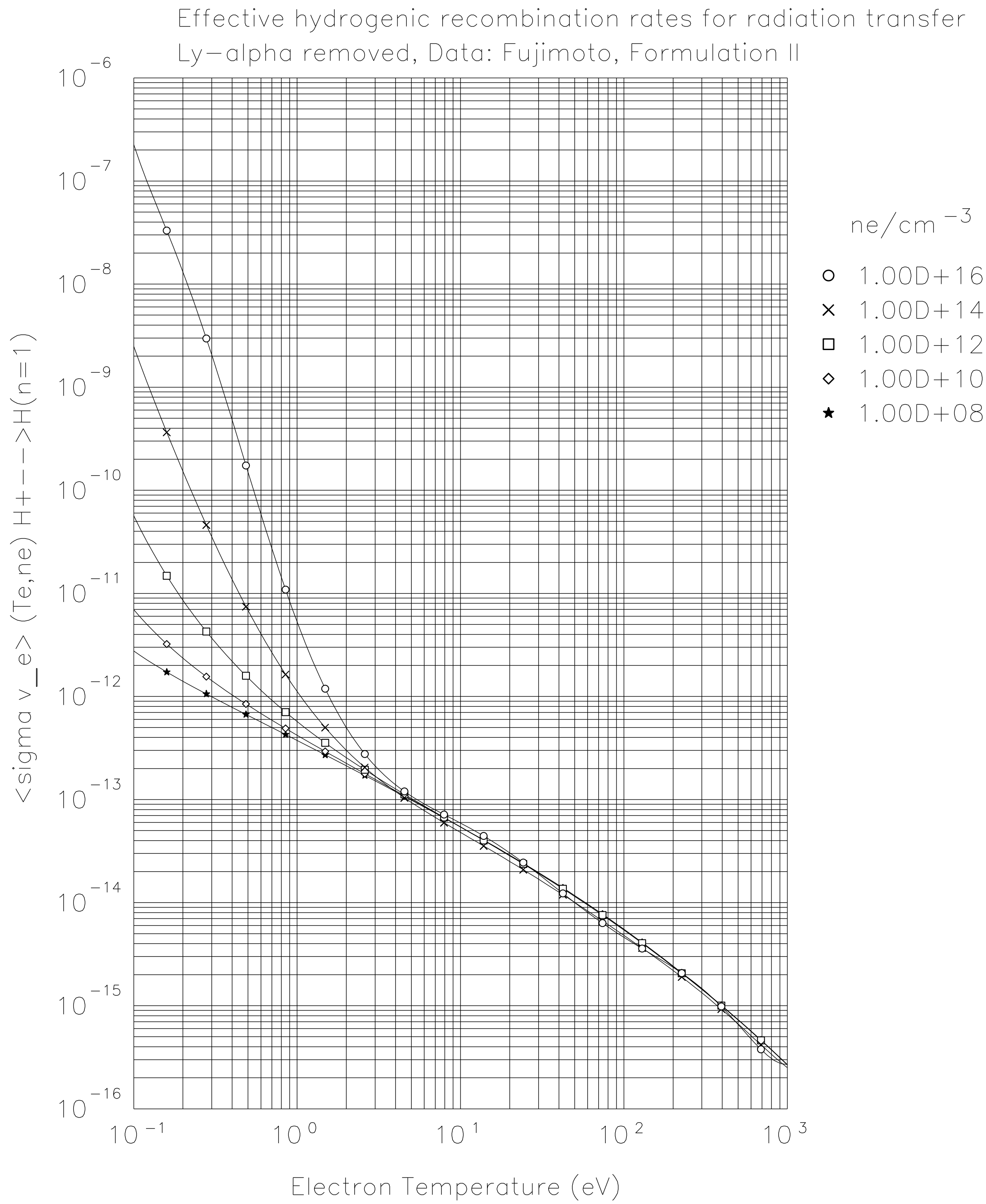
T-Index \ E-Index	0	1	2
0	-2.861405005821D+01	4.620699582138D-02	-4.310217977998D-02
1	-8.096253665929D-01	-1.982600180666D-02	5.149269267498D-03
2	-8.680053705955D-03	-2.774347690614D-03	1.830331540352D-02
3	-3.423620117720D-03	-2.253517011392D-03	2.534802275545D-04
4	2.217386625472D-03	3.906239156966D-05	-9.640084691630D-04
5	-9.133957716113D-04	2.188487676863D-04	-1.894817112935D-04
6	1.127654792924D-04	8.251873666618D-05	6.950956334568D-06
7	-2.221558155667D-06	-3.343798848899D-05	1.629103970917D-05
8	-2.648237167503D-07	2.619826393182D-06	-1.692290353860D-06

T-Index \ E-Index	3	4	5
0	2.163633746471D-02	-4.934198508671D-03	6.014239865534D-04
1	-3.536319884091D-03	8.646305436282D-04	-1.214633770778D-04
2	-9.539656849598D-03	2.351276617334D-03	-2.945300396974D-04
3	5.105273834881D-05	-1.019011295818D-04	2.446793338056D-05
4	7.935740272598D-04	-2.112574864114D-04	2.585778679511D-05
5	6.790154677976D-06	1.502804342818D-05	-3.491112930467D-06
6	-1.686519524158D-05	3.081981220261D-06	-2.409573774776D-08
7	-2.458338620147D-06	2.081151821523D-07	-4.465203160706D-08
8	4.266346328712D-07	-6.316991307367D-08	7.438508336626D-09

T-Index \ E-Index	6	7	8
0	-3.939661867048D-05	1.301454523149D-06	-1.687548001227D-08
1	9.228401211596D-06	-3.669772782966D-07	5.952644052228D-09
2	1.942957459134D-05	-6.324186846600D-07	7.888547656643D-09
3	-2.461588471260D-06	1.143263146679D-07	-1.989303560372D-09
4	-1.536800069369D-06	3.976903638756D-08	-2.941649864993D-10
5	3.176407704657D-07	-1.283821134880D-08	1.899998044740D-10
6	-3.323808525611D-08	2.634978856800D-09	-5.944238126509D-11
7	7.217991219922D-09	-4.756643628740D-10	1.051833018767D-11
8	-6.664003260557D-10	3.399636029899D-11	-6.762717749689D-13

N2MIN = 1.00000D 08 1/CM3
N2MAX = 1.00000D 16 1/CM3

Max. rel. Error: 15.1059 %
Mean rel. Error: 1.7676 %



Effective hydrogenic recombination rates for radiation transfer
Ly—alpha removed, Data: Fujimoto, Formulation II
<sigma v_e> (Te,ne) H+——>H(n=1)
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

4.7 Reaction 2.1.8b $H^{+} + e \rightarrow H(n=1), Ly_{\alpha}$-removed

Effective hydrogenic recombination rate. Ly-alpha removed, Formulation I, and n=2 state meta-stable data for radiation transfer simulations

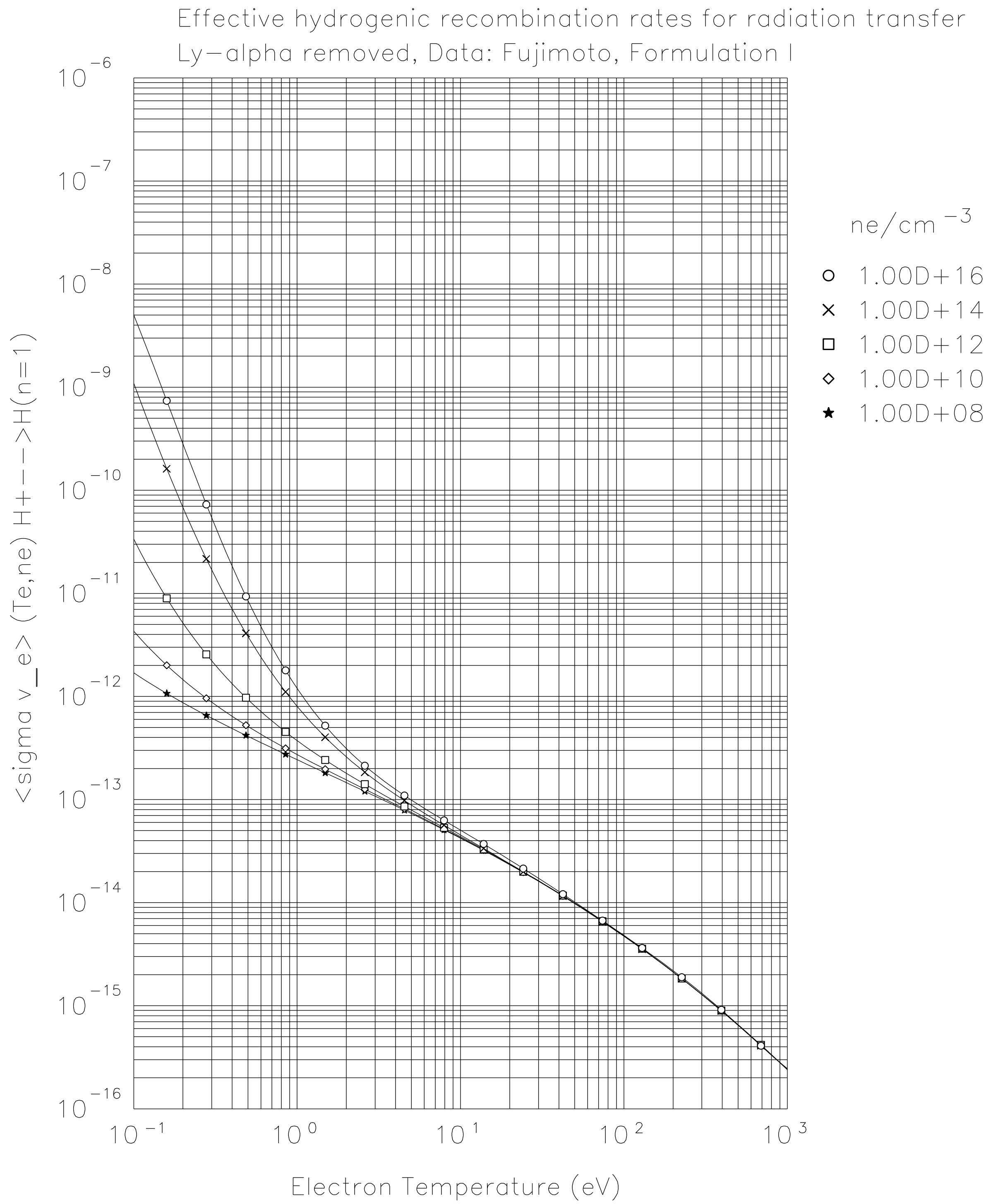
T-Index \ E-Index:	0	1	2
0	-2.904392824956D+01	4.748380595941D-02	-3.885509978119D-02
1	-7.413152839270D-01	-1.624618836039D-02	-6.527747741468D-03
2	1.008500503247D-02	1.085273506172D-02	1.887705494629D-04
3	-9.877231300575D-03	-2.738218262627D-03	3.784783831386D-03
4	1.228935647219D-03	-2.341814733406D-03	1.484146074200D-03
5	-3.001711248224D-04	9.023695534517D-05	-3.075667894504D-04
6	3.740127557627D-05	4.135859674382D-04	-2.862610500727D-04
7	-1.100007463011D-06	-9.739599957078D-05	7.956179072838D-05
8	-6.623669500573D-08	6.278503216096D-06	-5.468707947925D-06

T-Index \ E-Index:	3	4	5
0	1.712927469063D-02	-3.361241945480D-03	3.438926027645D-04
1	5.658551260601D-03	-2.030634326153D-03	3.289693006643D-04
2	-1.281958835325D-03	5.920743039417D-04	-1.008055485423D-04
3	-3.014406755608D-03	8.818315221189D-04	-1.270611978746D-04
4	4.771092031069D-05	-1.376014146835D-04	2.882374587156D-05
5	1.813694194025D-04	-4.661737833573D-05	6.158134640331D-06
6	5.298162697377D-05	1.508573031919D-06	-1.429821922438D-06
7	-2.187415032423D-05	2.379088649469D-06	-5.219696847870D-08
8	1.679719615032D-06	-2.327142241096D-07	1.472211001966D-08

T-Index \ E-Index:	6	7	8
0	-1.791747341723D-05	4.272872174542D-07	-3.244985957631D-09
1	-2.741532450191D-05	1.127790526767D-06	-1.802383606427D-08
2	8.378952723411D-06	-3.376132910878D-07	5.253174205221D-09
3	9.562069331749D-06	-3.593850777871D-07	5.323191995381D-09
4	-2.561738074337D-06	1.052502490482D-07	-1.640172707727D-09
5	-4.346985316250D-07	1.567372870851D-08	-2.272881976447D-10
6	1.589481882484D-07	-7.158954160829D-09	1.176279052424D-10
7	-8.575444723676D-09	6.123179214785D-10	-1.187879809144D-11
8	-2.932846221875D-10	-7.940750343776D-12	3.012879621855D-13

N2MIN = 1.00000D 08 1/CM3
N2MAX = 1.00000D 16 1/CM3

Max. rel. Error: 2.5149 %
Mean rel. Error: .5219 %


Effective hydrogenic recombination rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation I
<sigma v_e> (Te,ne) H+−−>H(n=1)
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

4.8 Reaction 2.1.8c $H^+ + e \rightarrow H(n=2), Ly_\alpha$-removed

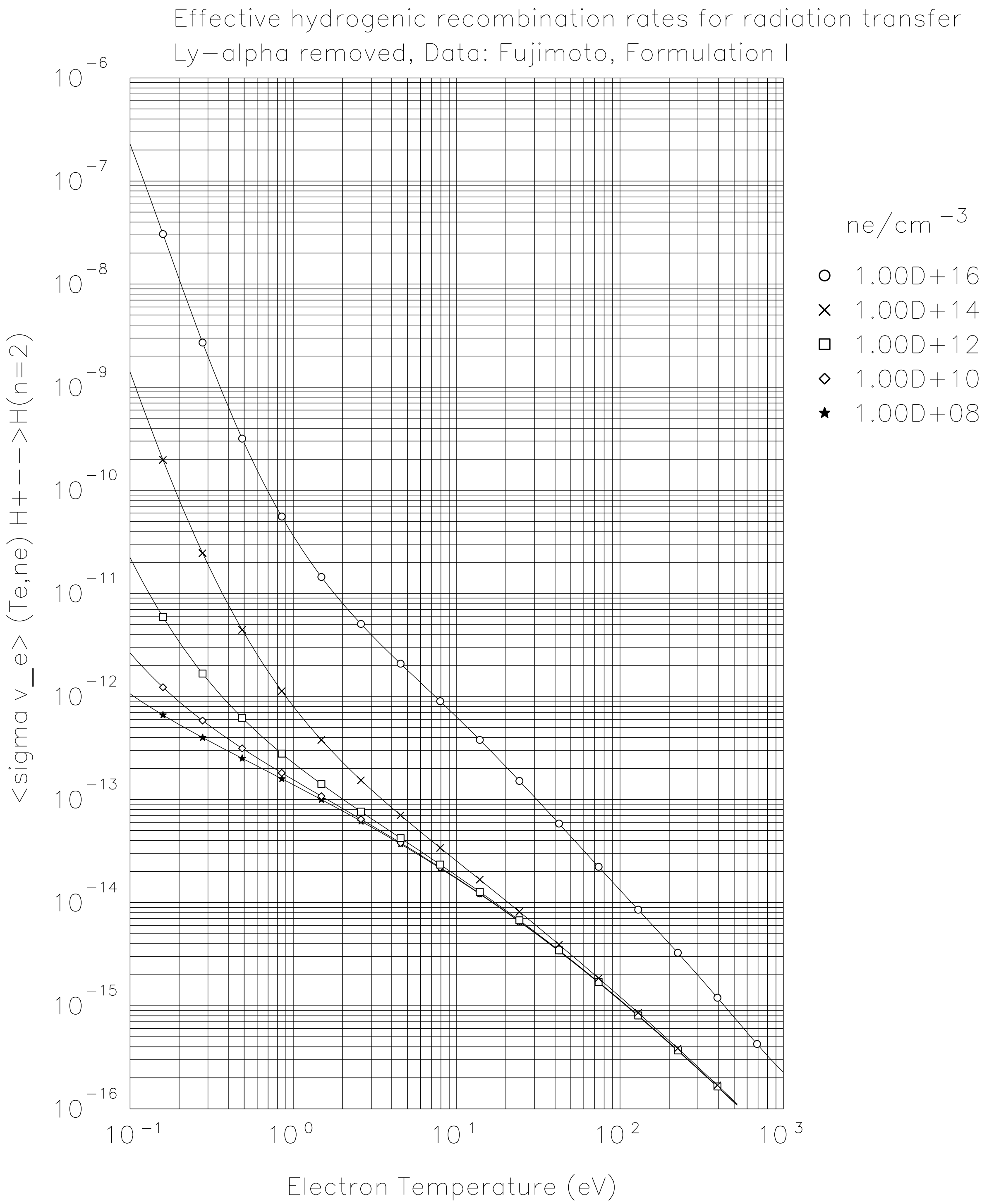
Effective hydrogenic recombination rate. Ly-alpha removed, Formulation I, and n=2 state meta-stable data for radiation transfer simulations

T-Index \ E-Index	0	1	2
0	-2.960304455412D+01	-6.024281511757D-02	9.194777261188D-02
1	-8.255954605093D-01	-1.059347367199D-02	-8.897748584135D-03
2	-2.049851775797D-02	1.210884622564D-02	-1.639618703650D-05
3	-1.131520438019D-02	1.036367999042D-03	-4.552983427899D-03
4	2.618464046931D-03	-1.104301146490D-03	5.697755633356D-04
5	-4.632238103475D-04	-1.350103571232D-04	3.926250234735D-04
6	3.828369069689D-06	1.614159561983D-04	-1.494540585461D-04
7	9.786336636781D-06	-3.043853986174D-05	2.086521383726D-05
8	-8.078260754039D-07	1.777045842963D-06	-1.058881685100D-06

T-Index \ E-Index	3	4	5
0	-3.993740839764D-02	8.671366680674D-03	-1.005626441360D-03
1	5.582328043677D-03	-1.867055064403D-03	2.982196188632D-04
2	-1.369889136652D-03	6.132950791357D-04	-1.013519534168D-04
3	1.830974908065D-03	-3.588456542352D-04	3.670103811047D-05
4	2.000759347085D-04	-1.205008259199D-04	2.147857229656D-05
5	-2.459714435516D-04	6.403906157425D-05	-8.440570754674D-06
6	4.714824850786D-05	-6.679116746805D-06	4.429838046009D-07
7	-3.730974398628D-06	-1.399848707717D-07	1.044288516493D-07
8	1.128105892342D-07	3.549913345546D-08	-9.660977795422D-09

T-Index \ E-Index	6	7	8
0	6.365495678023D-05	-2.047562769978D-06	2.611485123919D-08
1	-2.485712379918D-05	1.024080695104D-06	-1.635316914657D-08
2	8.186804434437D-06	-3.211255631268D-07	4.870951413670D-09
3	-2.030958351106D-06	5.796735092413D-08	-6.705716269527D-10
4	-1.769810818327D-06	6.892843390956D-08	-1.025703945606D-09
5	5.936246712296D-07	-2.111031099839D-08	2.975783504596D-10
6	-1.203033234183D-08	6.720414281142D-12	3.583291567817D-12
7	-1.107938818946D-08	4.764505739843D-10	-7.448416706593D-12
8	8.952403415503D-10	-3.662329587020D-11	5.594497105623D-13

```
N2MIN =   1.00000D 08 1/CM3
N2MAX =   1.00000D 16 1/CM3

  Max. rel. Error:   2.8117 %
  Mean rel. Error:    .7203 %
```


Effective hydrogenic recombination rates for radiation transfer
Ly−alpha removed, Data: Fujimoto, Formulation I
<sigma v_e> (Te,ne) H+−−>H(n=2)
Electron Temperature (eV)
ne/cm −3
1.00D+16
1.00D+14
1.00D+12
1.00D+10
1.00D+08

5 Appendix

References

[1] Sawada,K., Fujimoto,T., J. Appl. Phys.78 (5), (1995), p2913

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