

Table III. Analytical approximations of the reaction rates

$^1\text{H}(\text{p}, \nu \text{e}^+) ^2\text{H}$, $Q = 1.442$ MeV, (3%)

$$N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 4.08 \times 10^{-15} T_9^{-2/3} \exp(-3.381 T_9^{-1/3}) \times (1 + 3.82 T_9 + 1.51 T_9^2 + 0.144 T_9^3 - 1.14 \times 10^{-2} T_9^4)$$

$$N_{\text{A}} \langle \sigma v \rangle_{\text{tt}} = N_{\text{A}} \langle \sigma v \rangle_{\text{gs}}$$

$^2\text{H}(\text{p}, \gamma) ^3\text{He}$, $Q = 5.493$ MeV, (3%)

$$\text{For } T_9 \leq 0.11 : N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 1.81 \times 10^3 T_9^{-2/3} \exp(-3.721 T_9^{-1/3}) \times (1 + 14.3 T_9 - 90.5 T_9^2 + 395 T_9^3)$$

$$\text{For } T_9 > 0.11 : N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 2.58 \times 10^3 T_9^{-2/3} \exp(-3.721 T_9^{-1/3}) \times (1 + 3.96 T_9 + 0.116 T_9^2)$$

$$N_{\text{A}} \langle \sigma v \rangle_{\text{tt}} = N_{\text{A}} \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.630 \times 10^{10} T_9^{3/2} \exp(-63.749/T_9)$$

$^2\text{H}(\text{d}, \gamma) ^4\text{He}$, $Q = 23.847$ MeV, (3%)

$$N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 42.1 T_9^{-2/3} \exp(-4.259 T_9^{-1/3}) \times (1 + 0.514 T_9 + 0.339 T_9^2 - 1.18 \times 10^{-2} T_9^3)$$

$$N_{\text{A}} \langle \sigma v \rangle_{\text{tt}} = N_{\text{A}} \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 4.488 \times 10^{10} T_9^{3/2} \exp(-276.73/T_9)$$

$^2\text{H}(\text{d}, \text{n}) ^3\text{He}$, $Q = 3.269$ MeV, (4%)

$$N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 4.67 \times 10^8 T_9^{-2/3} \exp(-4.259 T_9^{-1/3}) \times (1 + 1.079 T_9 - 0.1124 T_9^2 + 5.68 \times 10^{-3} T_9^3)$$

$$N_{\text{A}} \langle \sigma v \rangle_{\text{tt}} = N_{\text{A}} \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.730 \exp(-37.935/T_9)$$

$^2\text{H}(\text{d}, \text{p}) ^3\text{H}$, $Q = 4.033$ MeV, (5%)

$$N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 4.66 \times 10^8 T_9^{-2/3} \exp(-4.259 T_9^{-1/3}) \times (1 + 0.759 T_9 - 0.0612 T_9^2 + 2.78 \times 10^{-3} T_9^3)$$

$$N_{\text{A}} \langle \sigma v \rangle_{\text{tt}} = N_{\text{A}} \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.732 \exp(-46.797/T_9)$$

$^2\text{H}(\alpha, \gamma) ^6\text{Li}$, $Q = 1.474$ MeV, (4%)

$$N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 14.82 T_9^{-2/3} \exp(-7.435 T_9^{-1/3}) \times (1 + 6.572 T_9 + 0.076 T_9^2 + 0.0248 T_9^3) \\ + 82.8 T_9^{-3/2} \exp(-7.904/T_9)$$

$$N_{\text{A}} \langle \sigma v \rangle_{\text{tt}} = N_{\text{A}} \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.531 \times 10^{10} T_9^{3/2} \exp(-17.108/T_9)$$

$^3\text{H}(\text{d}, \text{n}) ^4\text{He}$, $Q = 17.589$ MeV, (8%)

$$N_{\text{A}} \langle \sigma v \rangle_{\text{gs}} = 8.29 \times 10^{10} T_9^{-2/3} \exp(-4.524 T_9^{-1/3} - (T_9/0.08)^2) \times (1 + 17.2 T_9 + 175 T_9^2) \\ + 8.12 \times 10^8 T_9^{-0.712} \exp(-0.506/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 5.506 \exp(-204.12/T_9)$$

$${}^3\text{H}(\alpha, \gamma){}^7\text{Li}, Q = 2.467 \text{ MeV}, (5\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 8.20 \times 10^5 T_9^{-2/3} \exp(-8.081 T_9^{-1/3}) \times (1 - 0.389 T_9 + 0.134 T_9^2 - 1.81 \times 10^{-2} T_9^3 + 9.23 \times 10^{-4} T_9^4)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 1.113 \times 10^{10} T_9^{3/2} \exp(-28.629/T_9)$$

$${}^3\text{He}({}^3\text{He}, 2p){}^4\text{He}, Q = 12.859 \text{ MeV}, (2\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 5.59 \times 10^{10} T_9^{-2/3} \exp(-12.277 T_9^{-1/3}) \times (1 - 0.135 T_9 + 2.54 \times 10^{-2} T_9^2 - 1.29 \times 10^{-3} T_9^3)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 3.392 \times 10^{-10} T_9^{-3/2} \exp(-149.23/T_9)$$

$${}^3\text{He}(\alpha, \gamma){}^7\text{Be}, Q = 1.587 \text{ MeV}, (6\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 5.46 \times 10^6 T_9^{-2/3} \exp(-12.827 T_9^{-1/3}) \times (1 - 0.307 T_9 + 8.81 \times 10^{-2} T_9^2 - 1.06 \times 10^{-2} T_9^3 + 4.46 \times 10^{-4} T_9^4)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 1.113 \times 10^{10} T_9^{3/2} \exp(-18.412/T_9)$$

$${}^4\text{He}(\alpha n, \gamma){}^9\text{Be}^1, Q = 1.573 \text{ MeV}, (19\%)$$

$$N_A \langle \sigma v \rangle_{gs}^{\alpha\alpha} = 2.43 \times 10^9 T_9^{-2/3} \exp(-13.490 T_9^{-1/3} - (T_9/0.15)^2) \times (1 + 74.5 T_9) \\ + 6.09 \times 10^5 T_9^{-3/2} \exp(-1.054/T_9)$$

$$\text{For } T_9 \leq 0.03: N_A^2 \langle \sigma v \rangle_{gs}^{\alpha\alpha n} = N_A \langle \sigma v \rangle_{gs}^{\alpha\alpha} \times 6.69 \times 10^{-12} \\ \times (1 - 192 T_9 + 2.48 \times 10^4 T_9^2 - 1.50 \times 10^6 T_9^3 + 4.13 \times 10^7 T_9^4 - 3.90 \times 10^8 T_9^5)$$

$$\text{For } T_9 > 0.03: N_A^2 \langle \sigma v \rangle_{gs}^{\alpha\alpha n} = N_A \langle \sigma v \rangle_{gs}^{\alpha\alpha} \times 2.42 \times 10^{-12} \\ \times (1 - 1.52 \log_{10} T_9 + 0.448 (\log_{10} T_9)^2 + 0.435 (\log_{10} T_9)^3)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 5.844 \times 10^{19} T_9^3 \exp(-18.258/T_9)$$

$${}^4\text{He}(\alpha\alpha, \gamma){}^{12}\text{C}, Q = 7.274 \text{ MeV}, (23\%)$$

$$N_A \langle \sigma v \rangle_{gs}^{\alpha^8\text{Be}} = 2.76 \times 10^7 T_9^{-2/3} \exp(-23.570 T_9^{-1/3} - (T_9/0.4)^2) \times (1 + 5.47 T_9 + 326 T_9^2) \\ + 130.7 T_9^{-3/2} \exp(-3.338/T_9) + 2.51 \times 10^4 T_9^{-3/2} \exp(-20.307/T_9)$$

$$\text{For } T_9 \leq 0.03: N_A^2 \langle \sigma v \rangle_{gs}^{\alpha\alpha\alpha} = N_A \langle \sigma v \rangle_{gs}^{\alpha\alpha} \times N_A \langle \sigma v \rangle_{gs}^{\alpha^8\text{Be}} \times 3.07 \times 10^{-16} \times (1 - 29.1 T_9 + 1308 T_9^2)$$

$$\text{For } T_9 > 0.03: N_A^2 \langle \sigma v \rangle_{gs}^{\alpha\alpha\alpha} = N_A \langle \sigma v \rangle_{gs}^{\alpha\alpha} \times N_A \langle \sigma v \rangle_{gs}^{\alpha^8\text{Be}} \times 3.44 \times 10^{-16} \times (1 + 0.0158 T_9^{-0.65})$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 2.003 \times 10^{20} T_9^3 \exp(-84.415/T_9)$$

¹ The rate $N_A \langle \sigma v \rangle_{gs}^{\alpha\alpha}$ has no physical meaning but is convenient for the definitions of $N_A \langle \sigma v \rangle^{\alpha\alpha n}$ and $N_A \langle \sigma v \rangle^{\alpha\alpha\alpha}$.

${}^6\text{Li}(\text{p},\gamma){}^7\text{Be}$, $Q = 5.606$ MeV, (7%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 1.25 \times 10^6 T_9^{-2/3} \exp(-8.415 T_9^{-1/3}) \times (1 - 0.252 T_9 + 5.19 \times 10^{-2} T_9^2 - 2.92 \times 10^{-3} T_9^3)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.187 \times 10^{10} T_9^{3/2} \exp(-65.052/T_9)$$

${}^6\text{Li}(\text{p},\alpha){}^3\text{He}$, $Q = 4.019$ MeV, (2%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 3.54 \times 10^{10} T_9^{-2/3} \exp(-8.415 T_9^{-1/3}) \times (1 - 0.137 T_9 + 2.41 \times 10^{-2} T_9^2 - 1.28 \times 10^{-3} T_9^3)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.067 \exp(-46.641/T_9)$$

${}^7\text{Li}(\text{p},\gamma){}^8\text{Be}$, $Q = 17.255$ MeV, (11%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 1.75 \times 10^7 T_9^{-2/3} \exp(-8.473 T_9^{-1/3} - (T_9/0.8)^2) \times (1 - 1.47 T_9 + 4.43 T_9^2)$$

$$+ 1.60 \times 10^6 T_9^{-3/2} \exp(-4.441/T_9) + 4.32 \times 10^4 T_9^{0.309} \exp(-2.811/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 6.531 \times 10^{10} T_9^{3/2} \exp(-200.23/T_9)$$

${}^7\text{Li}(\text{p},\alpha){}^4\text{He}$, $Q = 17.347$ MeV, (6%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 7.20 \times 10^8 T_9^{-2/3} \exp(-8.473 T_9^{-1/3} - (T_9/6.5)^2) \times (1 + 1.05 T_9 - 0.653 T_9^2 + 0.185 T_9^3)$$

$$- 2.12 \times 10^{-2} T_9^4 + 9.30 \times 10^{-4} T_9^5) + 9.85 \times 10^6 T_9^{0.576} \exp(-10.415/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 4.676 \exp(-201.30/T_9)$$

${}^7\text{Li}(\alpha,\gamma){}^{11}\text{B}$, $Q = 8.664$ MeV, (17%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 9.72 \times 10^7 T_9^{-2/3} \exp(-19.163 T_9^{-1/3} - (T_9/0.4)^2) \times (1 + 2.84 T_9 - 7.89 T_9^2)$$

$$+ 3.35 \times 10^2 T_9^{-3/2} \exp(-2.959/T_9) + 1.04 \times 10^4 T_9^{-0.023} \exp(-4.922/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 4.015 \times 10^{10} T_9^{3/2} \exp(-100.55/T_9)$$

${}^7\text{Li}(\alpha,\text{n}){}^{10}\text{B}$, $Q = -2.790$ MeV, (5%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 1.66 \times 10^7 \exp(-32.371/T_9) \times (1 + 1.064 T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.325 \exp(32.371/T_9)$$

${}^7\text{Be}(\text{p},\gamma){}^8\text{B}$, $Q = 0.137$ MeV, (3%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 2.61 \times 10^5 T_9^{-2/3} \exp(-10.264 T_9^{-1/3}) \times (1 - 5.11 \times 10^{-2} T_9 + 4.68 \times 10^{-2} T_9^2 - 6.60 \times 10^{-3} T_9^3)$$

$$+ 3.12 \times 10^{-4} T_9^4) + 2.05 \times 10^3 T_9^{-3/2} \exp(-7.345/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 1.306 \times 10^{10} T_9^{3/2} \exp(-1.594/T_9)$$

$${}^7\text{Be}(\alpha, \gamma){}^{11}\text{C}, Q = 7.544 \text{ MeV}, (17\%)$$

$$\begin{aligned} \text{For } T_9 \leq 2: \quad N_A \langle \sigma v \rangle_{gs} = & 1.29 \times 10^{10} T_9^{-2/3} \exp(-23.214 T_9^{-1/3} - (T_9/0.8)^2) \times (1 - 6.47 T_9 + 19.5 T_9^2 - 19.3 T_9^3) \\ & + 1.25 \times 10^4 T_9^{-3/2} \exp(-6.498/T_9) + 1.44 \times 10^5 T_9^{-3/2} \exp(-10.177/T_9) \\ & + 1.63 \times 10^4 T_9^{0.178} \exp(-15.281/T_9) \end{aligned}$$

$$\text{For } T_9 > 2: \quad N_A \langle \sigma v \rangle_{gs} = 1.41 \times 10^3 T_9^{0.636} \exp(-3.015/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 4.016 \times 10^{10} T_9^{3/2} \exp(-87.541/T_9)$$

$${}^9\text{Be}(\text{p}, \gamma){}^{10}\text{B}, Q = 6.586 \text{ MeV}, (7\%)$$

$$\begin{aligned} N_A \langle \sigma v \rangle_{gs} = & 1.36 \times 10^7 T_9^{-2/3} \exp(-10.361 T_9^{-1/3} - (T_9/1.5)^2) \times (1 + 2.71 T_9 - 1.95 T_9^2 + 0.594 T_9^3) \\ & + 4.80 \times 10^3 T_9^{-3/2} \exp(-3.102/T_9) + 2.75 \times 10^6 T_9^{-3/2} \exp(-10.615/T_9) \end{aligned}$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 9.734 \times 10^9 T_9^{3/2} \exp(-76.424/T_9)$$

$${}^9\text{Be}(\text{p}, \text{n}){}^9\text{B}, Q = -1.851 \text{ MeV}, (4\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 5.06 \times 10^7 \exp(-21.474/T_9) \times (1 + 1.26 T_9 - 0.0302 T_9^2)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 9.989 \times 10^{-1} \exp(21.474/T_9)$$

$${}^9\text{Be}(\text{p}, \text{d})2\alpha, Q = 0.651 \text{ MeV}, (8\%)$$

$$\begin{aligned} N_A \langle \sigma v \rangle_{gs} = & 2.18 \times 10^{11} T_9^{-2/3} \exp(-10.361 T_9^{-1/3} - (T_9/0.42)^2) \times (1 - 0.427 T_9 + 34.055 T_9^2) \\ & + 6.24 \times 10^8 T_9^{-3/2} \exp(-3.446/T_9) + 3.53 \times 10^8 T_9^{-0.205} \exp(-3.889/T_9) \end{aligned}$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 8.071 \times 10^{-11} T_9^{-3/2} \exp(-7.556/T_9)$$

$${}^9\text{Be}(\text{p}, \alpha){}^6\text{Li}, Q = 2.125 \text{ MeV}, (9\%)$$

$$\begin{aligned} N_A \langle \sigma v \rangle_{gs} = & 2.11 \times 10^{11} T_9^{-2/3} \exp(-10.361 T_9^{-1/3} - (T_9/0.4)^2) \times (1 - 0.189 T_9 + 35.2 T_9^2) \\ & + 5.24 \times 10^8 T_9^{-3/2} \exp(-3.446/T_9) + 4.65 \times 10^8 T_9^{-0.293} \exp(-4.396/T_9) \end{aligned}$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 6.177 \times 10^{-1} \exp(-24.663/T_9)$$

$${}^9\text{Be}(\alpha, \text{n}){}^{12}\text{C}, Q = 5.701 \text{ MeV}, (10\%)$$

$$\begin{aligned} N_A \langle \sigma v \rangle_{gs} = & 5.00 \times 10^{13} T_9^{-2/3} \exp(-23.872 T_9^{-1/3} - (T_9/0.154)^2) \times (1 + 27.3 T_9 + 1632 T_9^2) \\ & + 0.70 T_9^{-3/2} \exp(-1.832/T_9) + 1.77 \times 10^5 T_9^{-3/2} \exp(-4.385/T_9) \\ & + 4.12 \times 10^7 T_9^{0.65} \exp(-10.060/T_9) \end{aligned}$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 10.28 \exp(-66.158/T_9)$$

$$^{10}\mathbf{B}(\mathbf{p},\gamma)^{11}\mathbf{C}, Q = 8.689 \text{ MeV}, (13\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 1.68 \times 10^6 T_9^{-2/3} \exp(-12.064 T_9^{-1/3}) \times ((T_9^{2/3} - 0.0273)^2 + 4.69 \times 10^{-4})^{-1} \\ \times (1 + 0.977 T_9 + 1.87 T_9^2 - 0.272 T_9^3 + 1.30 \times 10^{-2} T_9^4)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 3.026 \times 10^{10} T_9^{3/2} \exp(-100.83/T_9)$$

$$^{10}\mathbf{B}(\mathbf{p},\alpha)^7\mathbf{Be}, Q = 1.145 \text{ MeV}, (8\%)$$

$$\text{For } T_9 \leq 0.8 : N_A \langle \sigma v \rangle_{gs} = 2.56 \times 10^{10} T_9^{-2/3} \exp(-12.064 T_9^{-1/3}) \times ((T_9^{2/3} - 0.026)^2 + 4.70 \times 10^{-4})^{-1} \\ \times (1 + 5.95 T_9 + 29.2 T_9^2 - 316 T_9^3 + 914 T_9^4 - 1085 T_9^5 + 465 T_9^6)$$

$$\text{For } T_9 > 0.8 : N_A \langle \sigma v \rangle_{gs} = 1.01 \times 10^{10} T_9^{-2/3} \exp(-12.064 T_9^{-1/3}) \times (-1 + 15.8 T_9 - 2.60 T_9^2 + 0.125 T_9^3)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 7.537 \times 10^{-1} \exp(-13.291/T_9)$$

$$^{11}\mathbf{B}(\mathbf{p},\gamma)^{12}\mathbf{C}, Q = 15.957 \text{ MeV}, (5\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 4.58 \times 10^7 T_9^{-2/3} \exp(-12.097 T_9^{-1/3} - (T_9/0.6)^2) \times (1 + 0.353 T_9 + 0.842 T_9^2) \\ + 6.82 \times 10^3 T_9^{-3/2} \exp(-1.738/T_9) + 2.80 \times 10^4 T_9^{0.104} \exp(-3.892/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 7.004 \times 10^{10} T_9^{3/2} \exp(-185.17/T_9)$$

$$^{11}\mathbf{B}(\mathbf{p},\mathbf{n})^{11}\mathbf{C}, Q = -2.765 \text{ MeV}, (4\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 1.36 \times 10^8 \exp(-32.085/T_9) \times (1 + 0.963 T_9 - 0.285 T_9^2 + 3.36 \times 10^{-2} T_9^3 - 1.37 \times 10^{-3} T_9^4)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 9.988 \times 10^{-1} \exp(32.085/T_9)$$

$$^{11}\mathbf{B}(\mathbf{p},\alpha)2\alpha, Q = 8.682 \text{ MeV}, (3\%)$$

$$\text{For } T_9 \leq 2 : N_A \langle \sigma v \rangle_{gs} = 2.68 \times 10^{12} T_9^{-2/3} \exp(-12.097 T_9^{-1/3}) \times (1 + 1.62 T_9 - 1.31 T_9^2 + 0.260 T_9^3) \\ + 2.12 \times 10^6 T_9^{-3/2} \exp(-1.724/T_9)$$

$$\text{For } T_9 > 2 : N_A \langle \sigma v \rangle_{gs} = 5.84 \times 10^{11} T_9^{-2/3} \exp(-12.097 T_9^{-1/3}) \times ((T_9^{2/3} - 1.47)^2 + 0.187)^{-1} \\ \times (-1 + 0.883 T_9 + 0.012 T_9^2)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 3.501 \times 10^{-10} T_9^{-3/2} \exp(-100.76/T_9)$$

$$^{12}\mathbf{C}(\mathbf{p},\gamma)^{13}\mathbf{N}, Q = 1.943 \text{ MeV}, (6\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 2.00 \times 10^7 T_9^{-2/3} \exp(-13.692 T_9^{-1/3} - (T_9/0.46)^2) \times (1 + 9.89 T_9 - 59.8 T_9^2 + 266 T_9^3) \\ + 1.00 \times 10^5 T_9^{-3/2} \exp(-4.913/T_9) + 4.24 \times 10^5 T_9^{-3/2} \exp(-21.62/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 8.847 \times 10^9 T_9^{3/2} \exp(-22.553/T_9)$$

$$^{12}\text{C}(\alpha, \gamma)^{16}\text{O}, Q = 7.162 \text{ MeV}, (17\%)$$

$$N_A \langle \sigma v \rangle_{gs} = N_A \langle \sigma v \rangle_{E1} + N_A \langle \sigma v \rangle_{E2} + N_A \langle \sigma v \rangle_{\text{res}}$$

$$N_A \langle \sigma v \rangle_{E1} = 6.66 \times 10^7 T_9^{-2} \exp(-32.123 T_9^{-1/3} - (T_9/4.6)^2) \times (1 + 2.54 T_9 + 1.04 T_9^2 - 0.226 T_9^3) \\ + 1.39 \times 10^3 T_9^{-3/2} \exp(-28.930/T_9)$$

$$N_A \langle \sigma v \rangle_{E2} = 6.56 \times 10^7 T_9^{-2} \exp(-32.123 T_9^{-1/3} - (T_9/1.3)^2) \times (1 + 9.23 T_9 - 13.7 T_9^2 + 7.4 T_9^3)$$

$$N_A \langle \sigma v \rangle_{\text{res}} = 19.2 T_9^2 \exp(-26.9/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 5.132 \times 10^{10} T_9^{3/2} \exp(-83.109/T_9)$$

$$^{13}\text{C}(\text{p}, \gamma)^{14}\text{N}, Q = 7.551 \text{ MeV}, (20\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 9.57 \times 10^7 T_9^{-2/3} (1 + 3.56 T_9) \exp(-13.720 T_9^{-1/3} - T_9^2) \\ + 1.50 \times 10^6 T_9^{-3/2} \exp(-5.930/T_9) + 6.83 \times 10^5 T_9^{-0.864} \exp(-12.057/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 2.070 \exp(-37.938/T_9))$$

$$\text{Rev. ratio} = 1.190 \times 10^{10} T_9^{3/2} \exp(-87.619/T_9)$$

$$^{13}\text{C}(\text{p}, \text{n})^{13}\text{N}, Q = -3.003 \text{ MeV}, (14\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 1.18 \times 10^8 \exp(-34.846/T_9) \times (1 + 0.336 T_9 - 3.79 \times 10^{-2} T_9^2 + 2.02 \times 10^{-3} T_9^3)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 1.131 \exp(-12.892/T_9 + 0.019 T_9))$$

$$\text{Rev. ratio} = 9.988 \times 10^{-1} \exp(34.846/T_9)$$

$$^{13}\text{C}(\alpha, \text{n})^{16}\text{O}, Q = 2.216 \text{ MeV}, (9\%)$$

$$\text{For } T_9 \leq 4.0: N_A \langle \sigma v \rangle_{gs} = 3.78 \times 10^{14} T_9^{-2} \exp(-32.333 T_9^{-1/3} - (T_9/0.71)^2) \times (1 + 46.8 T_9 - 292 T_9^2 + 738 T_9^3) \\ + 2.30 \times 10^7 T_9^{0.45} \exp(-13.03/T_9)$$

$$\text{For } T_9 > 4.0: N_A \langle \sigma v \rangle_{gs} = 7.59 \times 10^6 T_9^{1.078} \exp(-12.056/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 73.318 \exp(-58.176/T_9 - 0.198 T_9))$$

$$\text{Rev. ratio} = 5.793 \exp(-25.710/T_9)$$

$$^{13}\text{N}(\text{p}, \gamma)^{14}\text{O}, Q = 4.628 \text{ MeV}, (7\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 4.02 \times 10^7 T_9^{-2/3} \exp(-15.205 T_9^{-1/3} - (T_9/0.54)^2) \times (1 + 3.81 T_9 + 18.6 T_9^2 + 32.3 T_9^3) \\ + 3.25 \times 10^5 T_9^{-1.35} \exp(-5.926/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 3.571 \times 10^{10} T_9^{3/2} \exp(-53.705/T_9)$$

$$^{14}\text{N}(\text{p}, \gamma)^{15}\text{O}, Q = 7.297 \text{ MeV}, (10\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 4.83 \times 10^7 T_9^{-2/3} \exp(-15.231 T_9^{-1/3} - (T_9/0.8)^2)$$

$$\begin{aligned}
& \times (1 - 2.00 T_9 + 3.41 T_9^2 - 2.43 T_9^3) + 2.36 \times 10^3 T_9^{-3/2} \exp(-3.010/T_9) \\
& + 6.72 \times 10^3 T_9^{0.380} \exp(-9.530/T_9) \\
N_A \langle \sigma v \rangle_{tt} &= N_A \langle \sigma v \rangle_{gs} \\
\text{Rev. ratio} &= 2.699 \times 10^{10} T_9^{3/2} \exp(-84.677/T_9)
\end{aligned}$$

$$\begin{aligned}
^{14}\text{N}(\mathbf{p}, \mathbf{n})^{14}\text{O}, Q &= -5.925 \text{ MeV}, (2\%) \\
N_A \langle \sigma v \rangle_{gs} &= 6.40 \times 10^5 \exp(-68.761/T_9) \times (-1 + 8.74 T_9 - 0.431 T_9^2) \\
N_A \langle \sigma v \rangle_{tt} &= N_A \langle \sigma v \rangle_{gs} \times (1 + 1.206 \exp(0.007/T_9 + 0.046 T_9)) \\
\text{Rev. ratio} &= 2.996 \exp(68.761/T_9)
\end{aligned}$$

$$\begin{aligned}
^{14}\text{N}(\mathbf{p}, \alpha)^{11}\text{C}, Q &= -2.923 \text{ MeV}, (19\%) \\
N_A \langle \sigma v \rangle_{gs} &= 3.01 \times 10^{16} \exp(-31.884 T_9^{-1/3} - 33.920/T_9) \\
& \times \exp(-1.379 T_9 + 0.215 T_9^2 - 2.13 \times 10^{-2} T_9^3 + 8.00 \times 10^{-4} T_9^4) \\
N_A \langle \sigma v \rangle_{tt} &= N_A \langle \sigma v \rangle_{gs} \times (1 + 0.140 \exp(-0.275/T_9 - 0.210 T_9)) \\
\text{Rev. ratio} &= 2.719 \times 10^{-1} \exp(33.920/T_9)
\end{aligned}$$

$$\begin{aligned}
^{14}\text{N}(\alpha, \gamma)^{18}\text{F}, Q &= 4.415 \text{ MeV}, (5\%) \\
\text{For } T_9 \leq 2 : N_A \langle \sigma v \rangle_{gs} &= 7.93 \times 10^{11} T_9^{-2/3} \exp(-36.035 T_9^{-1/3} - (T_9/0.07)^2) \\
& + 1.85 \times 10^{-10} T_9^{-3/2} \exp(-2.750/T_9) + 2.62 T_9^{-3/2} \exp(-5.045/T_9) \\
& + 2.93 \times 10^3 T_9^{0.344} \exp(-10.561/T_9) \\
\text{For } T_9 > 2 : N_A \langle \sigma v \rangle_{gs} &= 1.52 \times 10^2 T_9^{1.567} \exp(-6.315/T_9) \\
N_A \langle \sigma v \rangle_{tt} &= N_A \langle \sigma v \rangle_{gs} \times (1 - 0.340 \exp(-26.885/T_9 - 0.012 T_9)) \\
\text{Rev. ratio} &= 5.420 \times 10^{10} T_9^{3/2} \exp(-51.231/T_9)
\end{aligned}$$

$$\begin{aligned}
^{14}\text{N}(\alpha, \mathbf{n})^{17}\text{F}, Q &= -4.735 \text{ MeV}, (8\%) \\
N_A \langle \sigma v \rangle_{gs} &= 1.38 \times 10^8 T_9^{0.053} \exp(-55.0/T_9) \\
N_A \langle \sigma v \rangle_{tt} &= N_A \langle \sigma v \rangle_{gs} \times (1 + 0.039 \exp(-0.012/T_9 + 0.217 T_9)) \\
\text{Rev. ratio} &= 1.478 \exp(54.943/T_9)
\end{aligned}$$

$$\begin{aligned}
^{15}\text{N}(\mathbf{p}, \gamma)^{16}\text{O}, Q &= 12.127 \text{ MeV}, (15\%) \\
\text{For } T_9 \leq 3.5 : N_A \langle \sigma v \rangle_{gs} &= 1.08 \times 10^9 T_9^{-2/3} \exp(-15.254 T_9^{-1/3} - (T_9/0.34)^2) \times (1 + 6.15 T_9 + 16.4 T_9^2) \\
& + 9.23 \times 10^3 T_9^{-3/2} \exp(-3.597/T_9) + 3.27 \times 10^6 T_9^{-3/2} \exp(-11.024/T_9) \\
\text{For } T_9 > 3.5 : N_A \langle \sigma v \rangle_{gs} &= 3.54 \times 10^4 T_9^{0.095} \exp(-2.306/T_9) \\
N_A \langle \sigma v \rangle_{tt} &= N_A \langle \sigma v \rangle_{gs} \\
\text{Rev. ratio} &= 3.622 \times 10^{10} T_9^{3/2} \exp(-140.73/T_9)
\end{aligned}$$

$$\begin{aligned}
^{15}\text{N}(\mathbf{p}, \mathbf{n})^{15}\text{O}, Q &= -3.536 \text{ MeV}, (4\%) \\
N_A \langle \sigma v \rangle_{gs} &= 1.16 \times 10^8 \exp(-41.037/T_9) \times (1 + 0.219 T_9 - 0.029 T_9^2 + 1.73 \times 10^{-3} T_9^3)
\end{aligned}$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 0.387 \exp(-26.171/T_9 + 0.118 T_9))$$

$$\text{Rev. ratio} = 9.988 \times 10^{-1} \exp(41.037/T_9)$$

$$^{15}\mathbf{N}(\mathbf{p},\alpha)^{12}\mathbf{C}, Q = 4.966 \text{ MeV}, (13\%)$$

$$\text{For } T_9 \leq 2.5 : N_A \langle \sigma v \rangle_{gs} = 1.12 \times 10^{12} T_9^{-2/3} \exp(-15.253 T_9^{-1/3} - (T_9/0.28)^2) \times (1 + 4.95 T_9 + 143 T_9^2)$$

$$+ 1.01 \times 10^8 T_9^{-3/2} \exp(-3.643/T_9) + 1.19 \times 10^9 T_9^{-3/2} \exp(-7.406/T_9)$$

$$\text{For } T_9 > 2.5 : N_A \langle \sigma v \rangle_{gs} = 4.17 \times 10^7 T_9^{0.917} \exp(-3.292/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 7.060 \times 10^{-1} \exp(-57.622/T_9)$$

$$^{15}\mathbf{N}(\alpha,\gamma)^{19}\mathbf{F}, Q = 4.014 \text{ MeV}, (13\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 1.10 \times 10^{11} T_9^{-2/3} \exp(-36.214 T_9^{-1/3} - (T_9/0.6)^2) + 1.65 \times 10^{-4} T_9^{-3/2} \exp(-4.224/T_9)$$

$$+ 2.66 T_9^{-3/2} \exp(-6.220/T_9) + 1.56 \times 10^2 T_9^{-3/2} \exp(-7.764/T_9)$$

$$+ 3.92 \times 10^4 T_9^{-0.333} \exp(-14.522/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 5.542 \times 10^{10} T_9^{3/2} \exp(-46.577/T_9)$$

$$^{16}\mathbf{O}(\mathbf{p},\gamma)^{17}\mathbf{F}, Q = 0.600 \text{ MeV}, (10\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 7.37 \times 10^7 \exp(-16.696 T_9^{-1/3}) \times T_9^{-0.82}$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 202 \exp(-70.348/T_9 - 0.161 T_9))$$

$$\text{Rev. ratio} = 3.037 \times 10^9 T_9^{3/2} \exp(-6.966/T_9)$$

$$^{16}\mathbf{O}(\alpha,\gamma)^{20}\mathbf{Ne}, Q = 4.730 \text{ MeV}, (3\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 2.68 \times 10^{10} T_9^{-2/3} \exp(-39.760 T_9^{-1/3} - (T_9/1.6)^2)$$

$$+ 51.1 T_9^{-3/2} \exp(-10.32/T_9) + 616.1 T_9^{-3/2} \exp(-12.200/T_9) + 0.41 T_9^{2.966} \exp(-11.900/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 5.653 \times 10^{10} T_9^{3/2} \exp(-54.886/T_9)$$

$$^{17}\mathbf{O}(\mathbf{p},\gamma)^{18}\mathbf{F}, Q = 5.606 \text{ MeV}, (10\%)$$

$$\text{For } T_9 \leq 3 : N_A \langle \sigma v \rangle_{gs} = 1.50 \times 10^8 T_9^{-2/3} \exp(-16.710 T_9^{-1/3} - (T_9/0.2)^2) + 9.79 \times 10^{-6} T_9^{-3/2} \exp(-0.7659/T_9)$$

$$+ 4.15 T_9^{-3/2} \exp(-2.083/T_9) + 7.74 \times 10^4 T_9^{1.16} \exp(-6.342/T_9)$$

$$\text{For } T_9 > 3 : N_A \langle \sigma v \rangle_{gs} = 1.74 \times 10^3 T_9^{0.700} \exp(-1.072/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 0.287 \exp(-10.011/T_9 - 0.062 T_9))$$

$$\text{Rev. ratio} = 3.663 \times 10^{10} T_9^{3/2} \exp(-65.060/T_9)$$

$$^{17}\mathbf{O}(\mathbf{p},\alpha)^{14}\mathbf{N}, Q = 1.192 \text{ MeV}, (11\%)$$

$$\text{For } T_9 \leq 6 : N_A \langle \sigma v \rangle_{gs} = 9.20 \times 10^8 T_9^{-2/3} \exp(-16.715 T_9^{-1/3} - (T_9/0.06)^2) \times (1 - 80.31 T_9 + 2211 T_9^2)$$

$$+9.13 \times 10^{-4} T_9^{-3/2} \exp(-0.7667/T_9) + 9.68 T_9^{-3/2} \exp(-2.083/T_9) \\ +8.13 \times 10^6 T_9^{-3/2} \exp(-5.685/T_9) + 1.85 \times 10^6 T_9^{1.591} \exp(-4.848/T_9)$$

$$\text{For } T_9 > 6 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 8.73 \times 10^6 T_9^{0.950} \exp(-7.508/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 + 1.033 \exp(-10.034/T_9 - 0.165 T_9))$$

$$\text{Rev. ratio} = 6.759 \times 10^{-1} \exp(-13.829/T_9)$$

$$^{17}\text{O}(\alpha, \mathbf{n})^{20}\text{Ne}, Q = 0.586 \text{ MeV}, (6\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 4.38 \times 10^{17} T_9^{-2/3} \exp(-39.918 T_9^{-1/3} - (T_9/1.1)^2) \\ +1.73 \times 10^3 T_9^{-3/2} \exp(-8.55/T_9) + 7.50 \times 10^5 T_9^{1.83} \exp(-13.8/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 18.59 \exp(-6.806/T_9)$$

$$^{18}\text{O}(\mathbf{p}, \gamma)^{19}\text{F}, Q = 7.994 \text{ MeV}, (15\%)$$

$$\text{For } T_9 \leq 2 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 4.59 \times 10^8 T_9^{-2/3} \exp(-16.732 T_9^{-1/3} - (T_9/0.15)^2) \times (1 - 9.02 T_9 + 506 T_9^2 - 2400 T_9^3) \\ +9.91 \times 10^{-17} T_9^{-3/2} \exp(-0.232/T_9) + 3.30 \times 10^{-3} T_9^{-3/2} \exp(-1.033/T_9) \\ +1.61 \times 10^2 T_9^{-3/2} \exp(-1.665/T_9) + 1.25 \times 10^4 T_9^{0.458} \exp(-5.297/T_9)$$

$$\text{For } T_9 > 2 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 1.38 \times 10^4 T_9^{0.829} \exp(-5.919/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 0.475 \exp(-15.513/T_9 - 0.102 T_9))$$

$$\text{Rev. ratio} = 9.201 \times 10^9 T_9^{3/2} \exp(-92.769/T_9)$$

$$^{18}\text{O}(\mathbf{p}, \alpha)^{15}\text{N}, Q = 3.981 \text{ MeV}, (10\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 5.58 \times 10^{11} T_9^{-2/3} \exp(-16.732 T_9^{-1/3} - (T_9/0.51)^2) \times (1 + 3.2 T_9 + 21.8 T_9^2) \\ +9.91 \times 10^{-14} T_9^{-3/2} \exp(-0.232/T_9) + 2.58 \times 10^4 T_9^{-3/2} \exp(-1.665/T_9) \\ +3.24 \times 10^8 T_9^{-0.378} \exp(-6.395/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 1.968 \exp(-25.673/T_9 - 0.083 T_9))$$

$$\text{Rev. ratio} = 1.660 \times 10^{-1} \exp(-46.192/T_9)$$

$$^{18}\text{O}(\alpha, \gamma)^{22}\text{Ne}, Q = 9.667 \text{ MeV}, (19\%)$$

$$\text{For } T_9 \leq 6 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 1.95 \times 10^{-13} T_9^{-3/2} \exp(-2.069/T_9) + 1.56 \times 10^{-2} T_9^{-3/2} \exp(-4.462/T_9) \\ +10.1 T_9^{-3/2} \exp(-6.391/T_9) + 44.1 T_9^{-3/2} \exp(-7.389/T_9) \\ +3.44 \times 10^5 T_9^{-0.5} \exp(-22.103/T_9)$$

$$\text{For } T_9 > 6 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 3.31 \times 10^5 T_9^{-0.221} \exp(-24.990/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 1.411 \exp(-20.533/T_9 - 0.038 T_9))$$

$$\text{Rev. ratio} = 5.847 \times 10^{10} T_9^{3/2} \exp(-112.18/T_9)$$

$$^{18}\text{O}(\alpha, \mathbf{n})^{21}\text{Ne}, Q = -0.697 \text{ MeV}, (12\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 49.1 \exp(-8.085/T_9) \times (-1 + 18.7 T_9 - 85.6 T_9^2 + 146.8 T_9^3) \\ +6.94 \times 10^5 T_9^{2.24} \exp(-15.444/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 + 0.427 \exp(-22.836/T_9 - 0.009 T_9))$$

$$\text{Rev. ratio} = 7.845 \times 10^{-1} \exp(8.085/T_9)$$

$$^{19}\text{F}(\text{p}, \gamma)^{20}\text{Ne}, Q = 12.843 \text{ MeV}, (11\%)$$

$$\text{For } T_9 \leq 1.5: N_A \langle \sigma v \rangle_{\text{gs}} = 6.37 \times 10^7 T_9^{-2/3} \exp(-18.116 T_9^{-1/3}) \times (1 + 0.775 T_9 + 36.1 T_9^2)$$

$$+ 8.27 \times 10^2 T_9^{-3/2} \exp(-3.752/T_9) + 1.28 \times 10^6 T_9^{-3.667} \exp(-9.120/T_9)$$

$$\text{For } T_9 > 1.5: N_A \langle \sigma v \rangle_{\text{gs}} = 3.66 \times 10^3 T_9^{0.947} \exp(-2.245/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 0.990 \exp(-1.207/T_9 - 0.0886 T_9))$$

$$\text{Rev. ratio} = 3.696 \times 10^{10} T_9^{3/2} \exp(-149.04/T_9)$$

$$^{19}\text{F}(\text{p}, \text{n})^{19}\text{Ne}, Q = -4.021 \text{ MeV}, (7\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 4.42 \times 10^7 \exp(-46.659/T_9) \times (1 + 1.19 T_9 - 0.150 T_9^2 + 6.68 \times 10^{-3} T_9^3)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1.536 + 2.848 \times \exp(-0.0331/T_9 - 0.943 T_9))$$

$$\text{Rev. ratio} = 9.988 \times 10^{-1} \exp(46.659/T_9)$$

$$^{19}\text{F}(\text{p}, \alpha)^{16}\text{O}, Q = 8.114 \text{ MeV}, (18\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 2.62 \times 10^{11} T_9^{-2/3} \exp(-18.116 T_9^{1/3} - (T_9/0.185)^2)$$

$$\times (1 + 6.26 \times 10^{-2} T_9 + 0.285 T_9^2 + 4.94 \times 10^{-3} T_9^3 + 11.5 T_9^4 + 7.40 \times 10^4 T_9^5)$$

$$+ 3.80 \times 10^6 T_9^{-3/2} \exp(-3.752/T_9) + 3.27 \times 10^7 T_9^{-0.193} \exp(-6.587/T_9)$$

$$+ 7.30 \times 10^8 T_9^{-0.201} \exp(-16.249/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 + 0.755 \exp(-1.755/T_9 - 0.174 T_9))$$

$$\text{Rev. ratio} = 6.538 \times 10^{-1} \exp(-94.154/T_9)$$

$$^{20}\text{Ne}(\text{p}, \gamma)^{21}\text{Na}, Q = 2.431 \text{ MeV}, (12\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 2.35 \times 10^7 T_9^{-1.84} \exp(-19.451 T_9^{-1/3}) \times (1 + 10.80 T_9) + 18.0 T_9^{-3/2} \exp(-4.247/T_9)$$

$$+ 9.83 T_9^{-3/2} \exp(-4.619/T_9) + 6.76 \times 10^4 T_9^{-0.641} \exp(-11.922/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 7.929 \exp(-20.108/T_9 - 0.327 T_9))$$

$$\text{Rev. ratio} = 4.637 \times 10^9 T_9^{3/2} \exp(-28.214/T_9)$$

$$^{20}\text{Ne}(\text{p}, \alpha)^{17}\text{F}, Q = -4.130 \text{ MeV}, (6\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 3.75 \times 10^{18} T_9^{-2/3} \exp(-43.180 T_9^{-1/3} - 47.920/T_9) \times$$

$$\exp(-1.40 \times 10^{-3} T_9^4 + 3.44 \times 10^{-2} T_9^3 - 0.278 T_9^2 + 0.354 T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (5.341 - 0.549 T_9 + 0.363 T_9^2 - 0.0603 T_9^3 + 2.90 \times 10^{-3} T_9^4)$$

$$\text{Rev. ratio} = 5.372 \times 10^{-2} \exp(47.920/T_9)$$

$$^{20}\text{Ne}(\alpha, \gamma)^{24}\text{Mg}, Q = 9.316 \text{ MeV}, (12\%)$$

$$\text{For } T_9 \leq 1: N_A \langle \sigma v \rangle_{\text{gs}} = 8.72 T_9^{-0.532} \exp(-8.995/T_9)$$

$$\text{For } T_9 > 1: N_A \langle \sigma v \rangle_{\text{gs}} = 3.74 \times 10^2 T_9^{2.229} \exp(-12.681/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 7.787 \exp(-19.821/T_9 - 0.114 T_9))$$

$$\text{Rev. ratio} = 6.010 \times 10^{10} T_9^{3/2} \exp(-108.11/T_9)$$

$$^{21}\text{Ne}(\mathbf{p},\gamma)^{22}\text{Na}, Q = 6.739 \text{ MeV}, (5\%)$$

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_A \langle \sigma v \rangle_{gs} = & 4.68 \times 10^8 T_9^{-2/3} \exp(-19.465 T_9^{-1/3} - (T_9/0.2)^2) \\ & + 8.18 \times 10^{-4} T_9^{-3/2} \exp(-1.085/T_9) + 6.11 T_9^{-3/2} \exp(-1.399/T_9) \\ & + 1.34 \times 10^4 T_9^{-3/2} \exp(-3.009/T_9) + 1.26 \times 10^5 T_9^{-0.128} \exp(-4.962/T_9) \end{aligned}$$

$$\text{For } T_9 > 2 : \quad N_A \langle \sigma v \rangle_{gs} = 3.04 \times 10^4 T_9^{0.420} \exp(-2.650/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 0.708 \exp(-3.851/T_9 - 0.156 T_9))$$

$$\text{Rev. ratio} = 1.064 \times 10^{10} T_9^{3/2} \exp(-78.205/T_9)$$

$$^{21}\text{Ne}(\alpha, \mathbf{n})^{24}\text{Mg}, Q = 2.555 \text{ MeV}, (7\%)$$

$$\begin{aligned} \text{For } T_9 \leq 2.5 : \quad N_A \langle \sigma v \rangle_{gs} = & 1.00 \times 10^{19} T_9^{-2/3} \exp(-46.880 T_9^{-1/3} - (T_9/1.5)^2) \times (1 - 0.15 T_9) \\ & + 7.00 \times 10^5 T_9^{-3/2} \exp(-16.9/T_9) + 3.7 \times 10^6 T_9^{1.61} \exp(-20.20/T_9) \end{aligned}$$

$$\text{For } T_9 > 2.5 : \quad N_A \langle \sigma v \rangle_{gs} = 7.50 \times 10^6 T_9^{1.511} \exp(-21.764/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs}$$

$$\text{Rev. ratio} = 12.94 \exp(-29.651/T_9)$$

$$^{22}\text{Ne}(\mathbf{p},\gamma)^{23}\text{Na}, Q = 8.794 \text{ MeV}, (12\%)$$

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_A \langle \sigma v \rangle_{gs} = & 1.11 \times 10^{-9} T_9^{-3/2} \exp(-0.422/T_9) + 6.83 \times 10^{-5} T_9^{-3/2} \exp(-0.810/T_9) \\ & + 9.76 \times 10^{-3} T_9^{-3/2} \exp(-1.187/T_9) + 1.06 \times 10^{-1} T_9^{-3/2} \exp(-1.775/T_9) \\ & + 8.51 \times 10^4 T_9^{0.725} \exp(-4.315/T_9) \end{aligned}$$

$$\text{For } T_9 > 2 : \quad N_A \langle \sigma v \rangle_{gs} = 6.30 \times 10^4 T_9^{0.816} \exp(-3.910/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 1.410 \exp(-14.651/T_9 - 0.020 T_9))$$

$$\text{Rev. ratio} = 4.668 \times 10^9 T_9^{3/2} \exp(-102.05/T_9)$$

$$^{22}\text{Ne}(\alpha, \gamma)^{26}\text{Mg}, Q = 10.615 \text{ MeV}, (22\%)$$

$$\begin{aligned} \text{For } T_9 \leq 1.25 : \quad N_A \langle \sigma v \rangle_{gs} = & 3.55 \times 10^{-9} T_9^{-3/2} \exp(-3.927/T_9) + 7.07 \times 10^{-1} T_9^{-1.064} \exp(-7.759/T_9) \\ & + 1.27 \times 10^{-3} T_9^{-2.556} \exp(-6.555/T_9) \end{aligned}$$

$$\text{For } T_9 > 1.25 : \quad N_A \langle \sigma v \rangle_{gs} = 1.76 T_9^{3.322} \exp(-12.412/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 0.005 \exp(-5.109/T_9 + 0.373 T_9))$$

$$\text{Rev. ratio} = 6.150 \times 10^{10} T_9^{3/2} \exp(-123.18/T_9)$$

$$^{22}\text{Ne}(\alpha, \mathbf{n})^{25}\text{Mg}, Q = -0.478 \text{ MeV}, (4\%)$$

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_A \langle \sigma v \rangle_{gs} = & 7.40 \exp(-7.79/T_9) + 1.30 \times 10^{-4} T_9^{0.83} \exp(-5.52/T_9) \\ & + 9.41 \times 10^3 T_9^{2.78} \exp(-11.7/T_9) + 8.59 \times 10^6 T_9^{0.892} \exp(-24.4/T_9) \end{aligned}$$

$$\text{For } T_9 > 2 : \quad N_A \langle \sigma v \rangle_{gs} = 1.51 \times 10^5 T_9^{2.879} \exp(-16.717/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 2.674 \exp(-15.025/T_9 - 0.321 T_9))$$

$$\text{Rev. ratio} = 5.440 \times 10^{-1} \exp(5.547/T_9)$$

$$^{22}\text{Na}(\text{p},\gamma)^{23}\text{Mg}, Q = 7.579 \text{ MeV}, (11\%)$$

$$\begin{aligned} \text{For } T_9 \leq 1 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = & 1.12 \times 10^{-10} T_9^{-3/2} \exp(-0.483/T_9) + 4.51 \times 10^{-7} T_9^{-3/2} \exp(-0.715/T_9) \\ & + 2.80 \times 10^2 T_9^{-3/2} \exp(-2.369/T_9) + 4.15 \times 10^3 T_9^{0.152} \exp(-2.775/T_9) \end{aligned}$$

$$\text{For } T_9 > 1 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 7.55 \times 10^3 T_9^{0.744} \exp(-3.299/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 0.769 \exp(-7.854/T_9 + 0.016 T_9))$$

$$\text{Rev. ratio} = 3.268 \times 10^{10} T_9^{3/2} \exp(-87.955/T_9)$$

$$^{23}\text{Na}(\text{p},\gamma)^{24}\text{Mg}, Q = 11.693 \text{ MeV}, (7\%)$$

$$\begin{aligned} \text{For } T_9 \leq 5 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = & 9.55 \times 10^7 T_9^{-2/3} \exp(-20.770 T_9^{-1/3} - (T_9/0.3)^2) \times (1 - 10.80 T_9 + 61.08 T_9^2) \\ & + 8.20 \times 10^{-2} T_9^{-3/2} \exp(-1.601/T_9) + 85.2 T_9^{-3/2} \exp(-2.808/T_9) \\ & + 1.70 \times 10^4 T_9^{-3/2} \exp(-3.458/T_9) + 5.94 \times 10^4 \exp(-5.734/T_9) \end{aligned}$$

$$\text{For } T_9 > 5 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 5.60 \times 10^3 T_9^{1.112} \exp(-2.337/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 - 0.560 \exp(-5.119/T_9 - 0.050 T_9))$$

$$\text{Rev. ratio} = 7.490 \times 10^{10} T_9^{3/2} \exp(-135.69/T_9)$$

$$^{23}\text{Na}(\text{p},\text{n})^{23}\text{Mg}, Q = -4.839 \text{ MeV}, (3\%)$$

$$N_A \langle \sigma v \rangle_{\text{gs}} = 2.26 \times 10^8 \exp(-56.156/T_9) \times (1 + 0.071 T_9 - 2.26 \times 10^{-3} T_9^2)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}} \times (1 + 1.651 \exp(-0.014/T_9 - 0.054 T_9))$$

$$\text{Rev. ratio} = 9.988 \times 10^{-1} \exp(56.156/T_9)$$

$$^{23}\text{Na}(\text{p},\alpha)^{20}\text{Ne}, Q = 2.377 \text{ MeV}, (12\%)$$

$$\begin{aligned} \text{For } T_9 \leq 5 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = & 8.39 \times 10^9 T_9^{-2/3} \exp(-20.770 T_9^{-1/3} - (T_9/0.1)^2) \times (1 + 45.2 T_9) \\ & + 3.09 \times 10^{-13} T_9^{-3/2} \exp(-0.420/T_9) + 8.12 \times 10^{-3} T_9^{-3/2} \exp(-1.601/T_9) \\ & + 4.37 T_9^{-3/2} \exp(-1.934/T_9) + 7.50 \times 10^3 T_9^{-1.48} \exp(-3.150/T_9) \\ & + 1.05 \times 10^6 T_9^{1.456} \exp(-4.482/T_9) \end{aligned}$$

$$\text{For } T_9 > 5 : \quad N_A \langle \sigma v \rangle_{\text{gs}} = 3.96 \times 10^6 T_9^{1.291} \exp(-9.277/T_9)$$

$$N_A \langle \sigma v \rangle_{\text{tt}} = N_A \langle \sigma v \rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.246 \exp(-27.578/T_9)$$

$$^{23}\text{Na}(\alpha,\text{n})^{26}\text{Al}^{\text{g}}, Q = -2.966 \text{ MeV} (6\%)$$

$$\begin{aligned} N_A \langle \sigma v \rangle_{\text{gs}}^{\text{g}} = & 2.74 \times 10^6 T_9^{-2/3} \exp(-34.440/T_9) (1 + 2.86 T_9 + 0.38 T_9^2 - 3.00 \times 10^{-2} T_9^3) \\ & + 1.45 \times 10^{10} T_9^{-1.36} \exp(-74.00/T_9) \end{aligned}$$

$$N_A \langle \sigma v \rangle_{\text{tt}}^{\text{g}} = N_A \langle \sigma v \rangle_{\text{gs}}^{\text{g}} \times (1 + 1.14 \exp(-0.0097/T_9 - 0.246 T_9))$$

$$\text{Rev. ratio} = 1.196 \exp(34.414/T_9)$$

$^{23}\mathbf{Na}(\alpha, \mathbf{n})^{26}\mathbf{Al}^{\mathbf{m}}, Q = -3.194 \text{ MeV} \text{ (5\%)}$

$$\begin{aligned} N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{m}} &= 5.55 \times 10^2 T_9^{-2/3} \exp(-37.090/T_9) (1 + 1.80 \times 10^3 T_9 + 5.40 \times 10^2 T_9^2 - 1.50 \times 10^2 T_9^3) \\ &\quad + 1.38 \times 10^6 T_9^{1.5} \exp(-48.00/T_9) \\ N_A \langle \sigma v \rangle_{\text{tt}}^{\mathbf{m}} &= N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{m}} \times (1 + 1.14 \exp(-0.0097/T_9 - 0.246 T_9)) \\ \text{Rev. ratio} &= 13.16 \exp(37.062/T_9) \end{aligned}$$

$^{23}\mathbf{Na}(\alpha, \mathbf{n})^{26}\mathbf{Al}^{\mathbf{t}}, \text{ (6\%)}$

$$\begin{aligned} N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{t}} &= 1.30 \times 10^4 T_9^{-2/3} \exp(-34.440/T_9) (1 - 20.0 T_9^2 + 7.80 T_9^3) \\ &\quad + 1.17 \times 10^7 T_9^{0.35} \exp(-34.350/T_9) \\ N_A \langle \sigma v \rangle_{\text{tt}}^{\mathbf{t}} &= N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{t}} \times (1 + 1.14 \exp(-0.0097/T_9 - 0.246 T_9)) \end{aligned}$$

$^{24}\mathbf{Mg}(\mathbf{p}, \gamma)^{25}\mathbf{Al}, Q = 2.271 \text{ MeV}, \text{ (12\%)}$

$$\begin{aligned} \text{For } T_9 \leq 7 : \quad N_A \langle \sigma v \rangle_{\text{gs}} &= 5.97 \times 10^8 T_9^{-2/3} \exp(-22.023 T_9^{-1/3} - (T_9/0.1)^2) + 1.59 \times 10^3 T_9^{-3/2} \exp(-2.483/T_9) \\ &\quad + 3.33 \times 10^3 T_9^{0.122} \exp(-3.981/T_9) \\ \text{For } T_9 > 7 : \quad N_A \langle \sigma v \rangle_{\text{gs}} &= 3.81 \times 10^1 T_9^{2.113} \exp(0.860/T_9) \\ N_A \langle \sigma v \rangle_{\text{tt}}^{\mathbf{t}} &= N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{t}} \\ \text{Rev. ratio} &= 3.129 \times 10^9 T_9^{3/2} \exp(-26.357/T_9) \end{aligned}$$

$^{24}\mathbf{Mg}(\mathbf{p}, \alpha)^{21}\mathbf{Na}, Q = -6.885 \text{ MeV} \text{ (5\%)}$

$$\begin{aligned} N_A \langle \sigma v \rangle_{\text{gs}} &= 3.72 \times 10^{16} T_9^{-2/3} \exp(-44.480 T_9^{-1/3} - 79.897/T_9) \times \\ &\quad \exp(1.88 T_9 - 0.516 T_9^2 + 5.17 \times 10^{-2} T_9^3 - 1.86 \times 10^{-3} T_9^4) \\ N_A \langle \sigma v \rangle_{\text{tt}} &= N_A \langle \sigma v \rangle_{\text{gs}} \times (4.555 + 2.790 T_9 - 0.127 T_9^2) \\ \text{Rev. ratio} &= 7.716 \times 10^{-2} \exp(79.897/T_9) \end{aligned}$$

$^{25}\mathbf{Mg}(\mathbf{p}, \gamma)^{26}\mathbf{Al}^{\mathbf{g}}, Q = 6.306 \text{ MeV}, \text{ (16\%)}$

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_A \langle \sigma v \rangle_{\text{gs}} &= 3.07 \times 10^{-16} T_9^{-3/2} \exp(-0.435/T_9) + 3.70 \times 10^{-8} T_9^{-3/2} \exp(-0.673/T_9) \\ &\quad + 1.60 \times 10^{-5} T_9^{-3/2} \exp(-1.074/T_9) + 1.27 \times 10^4 T_9^{0.647} \exp(-3.055/T_9) \\ \text{For } T_9 > 2 : \quad N_A \langle \sigma v \rangle_{\text{gs}} &= 8.75 \times 10^3 T_9 \exp(-2.997/T_9) \\ N_A \langle \sigma v \rangle_{\text{tt}}^{\mathbf{g}} &= N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{g}} \times (1 - 0.352 \exp(-7.221/T_9 + 0.068 T_9)) \\ \text{Rev. ratio} &= 1.026 \times 10^{11} T_9^{3/2} \exp(-73.183/T_9) \end{aligned}$$

$^{25}\mathbf{Mg}(\mathbf{p}, \gamma)^{26}\mathbf{Al}^{\mathbf{m}}, Q = 6.078 \text{ MeV}, \text{ (28\%)}$

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_A \langle \sigma v \rangle_{\text{gs}} &= 8.15 \times 10^{-17} T_9^{-3/2} \exp(-0.435/T_9) + 8.68 \times 10^{-9} T_9^{-3/2} \exp(-0.673/T_9) \\ &\quad + 2.82 \times 10^{-6} T_9^{-3/2} \exp(-1.074/T_9) + 3.48 \times 10^3 T_9^{1.362} \exp(-2.906/T_9) \\ \text{For } T_9 > 2 : \quad N_A \langle \sigma v \rangle_{\text{gs}} &= 3.91 \times 10^3 T_9^{1.262} \exp(-3.229/T_9) \\ N_A \langle \sigma v \rangle_{\text{tt}}^{\mathbf{m}} &= N_A \langle \sigma v \rangle_{\text{gs}}^{\mathbf{m}} \times (1 - 0.352 \exp(-7.221/T_9 + 0.068 T_9)) \\ \text{Rev. ratio} &= 1.129 \times 10^{11} T_9^{3/2} \exp(-70.535/T_9) \end{aligned}$$

$^{25}\text{Mg}(\text{p},\gamma)^{26}\text{Al}^{\text{t}}$, (16%)

$$N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}^{\text{t}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}^{\text{g}} + N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}^{\text{m}}$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}}^{\text{t}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}^{\text{t}} \times (1 - 0.352 \exp(-7.221/T_9 + 0.068 T_9))$$

$^{25}\text{Mg}(\alpha,\text{n})^{28}\text{Si}$, $Q = 2.654$ MeV, (9%)

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = & 3.84 \times 10^{19} T_9^{-2/3} \exp(-53.415 T_9^{-1/3}) \\ & \times (1 + 6.993 \times 10^{-1} T_9 - 4.538 \times 10^{-1} T_9^2 + 8.853 \times 10^{-2} T_9^3 - 7.387 \times 10^{-3} T_9^4 \\ & + 2.276 \times 10^{-4} T_9^5) \end{aligned}$$

$$\text{For } T_9 > 2 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 5.37 \times 10^4 T_9^{2.852} \exp(-21.052/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} \times (1 - 0.397 \exp(-12.153/T_9 - 0.093 T_9))$$

$$\text{Rev. ratio} = 20.01 \exp(-30.794/T_9)$$

$^{26}\text{Mg}(\text{p},\gamma)^{27}\text{Al}$, $Q = 8.271$ MeV, (21%)

$$\begin{aligned} \text{For } T_9 \leq 3.5 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = & 8.54 \times 10^{-12} T_9^{-3/2} \exp(-0.605/T_9) + 1.93 \times 10^{-6} T_9^{-3/2} \exp(-1.044/T_9) \\ & + 9.67 \times 10^{-3} T_9^{-3/2} \exp(-1.726/T_9) + 9.50 \times 10^4 T_9^{-3/2} \exp(-3.781/T_9) \\ & + 10.2 T_9^{-1.565} \exp(-2.521/T_9) + 7.07 \times 10^4 T_9^{0.215} \exp(-3.947/T_9) \end{aligned}$$

$$\text{For } T_9 > 3.5 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 3.95 \times 10^4 T_9^{1.068} \exp(-4.990/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} \times (1 - 1.259 \exp(-20.076/T_9 + 0.069 T_9))$$

$$\text{Rev. ratio} = 3.144 \times 10^9 T_9^{3/2} \exp(-95.983/T_9)$$

$^{26}\text{Mg}(\alpha,\text{n})^{29}\text{Si}$, $Q = 0.034$ MeV, (7%)

$$\begin{aligned} \text{For } T_9 \leq 2 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = & 8.09 \times 10^{19} T_9^{-2/3} \exp(-53.505 T_9^{-1/3} - (T_9/7.3)^2) \\ & \times (1 - 0.17 T_9 + 8.9 \times 10^{-3} T_9^2) + 2.80 \times 10^4 T_9^{-0.43} \exp(-18.73/T_9) \end{aligned}$$

$$\text{For } T_9 > 2 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 4.92 \times 10^4 T_9^{3.117} \exp(-20.864/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}}$$

$$\text{Rev. ratio} = 1.678 \exp(-0.396/T_9)$$

$^{26}\text{Al}^{\text{g}}(\text{p},\gamma)^{27}\text{Si}$, $Q = 7.463$ MeV, (10%)

$$\begin{aligned} \text{For } T_9 \leq 0.9 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = & 3.54 \times 10^{-9} T_9^{-3/2} \exp(-0.789/T_9) + 8.54 \times 10^{-7} T_9^{-3/2} \exp(-1.079/T_9) \\ & + 10.3 T_9^{-3/2} \exp(-2.182/T_9) + 6.12 \times 10^2 T_9^{-3/2} \exp(-3.203/T_9) \\ & + 1.05 \times 10^4 T_9^{-3/2} \exp(-4.213/T_9) \end{aligned}$$

$$\text{For } T_9 > 0.9 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} = 1.63 \times 10^4 T_9^{0.348} \exp(-4.285/T_9)$$

$$N_{\text{A}}\langle\sigma v\rangle_{\text{tt}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} \times (1 + 2.17 \exp(-4.616/T_9 - 0.076 T_9))$$

$$\text{Rev. ratio} = 3.459 \times 10^{10} T_9^{3/2} \exp(-86.608/T_9)$$

$^{26}\text{Al}^{\text{ms}}(\text{p},\gamma)^{27}\text{Si}$, $Q = 7.691$ MeV, (10%)

$$\text{For } T_9 \leq 0.4 : \quad N_{\text{A}}\langle\sigma v\rangle_{\text{ms}} = N_{\text{A}}\langle\sigma v\rangle_{\text{gs}} \times (1 + 7.80 \exp(-0.854/T_9 - 0.019 T_9))$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 2.17 \exp(-4.616/T_9 - 0.076 T_9))$$

$$\text{Rev. ratio} = 3.459 \times 10^{10} T_9^{3/2} \exp(-89.254/T_9)$$

$$^{27}\text{Al}(\mathbf{p}, \gamma)^{28}\text{Si}, Q = 11.585 \text{ MeV}, (10\%)$$

$$\begin{aligned} \text{For } T_9 \leq 6 : \quad N_A \langle \sigma v \rangle_{gs} = & 2.51 \times 10^{-11} T_9^{-3/2} \exp(-0.839/T_9) + 48.2 T_9^{-0.2} \exp(-2.223/T_9) \\ & + 1.76 \times 10^3 T_9^{1.12} \exp(-3.196/T_9) + 3.25 \times 10^4 T_9^{0.251} \exp(-5.805/T_9) \end{aligned}$$

$$\text{For } T_9 > 6 : \quad N_A \langle \sigma v \rangle_{gs} = 1.62 \times 10^5 T_9^{0.549} \exp(-17.222/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 0.669 \exp(-10.426/T_9 + 0.008 T_9))$$

$$\text{Rev. ratio} = 1.134 \times 10^{11} T_9^{3/2} \exp(-134.440/T_9)$$

$$^{27}\text{Al}(\mathbf{p}, \alpha)^{24}\text{Mg}, Q = 1.601 \text{ MeV}, (11\%)$$

$$\begin{aligned} \text{For } T_9 \leq 6 : \quad N_A \langle \sigma v \rangle_{gs} = & 4.76 \times 10^{10} T_9^{-2/3} \exp(-23.265 T_9^{-1/3} - (T_9/0.15)^2) \times (1 - 22.3 T_9 + 126.7 T_9^2) \\ & + 9.65 \times 10^{-11} T_9^{-3/2} \exp(-0.834/T_9) + 2.09 \times 10^{-3} T_9^{-3/2} \exp(-2.269/T_9) \\ & + 1.17 \times 10^{-2} T_9^{-3/2} \exp(-3.273/T_9) + 2.84 \times 10^4 \exp(-5.623/T_9)/T_9 \\ & + 1.38 \times 10^6 T_9 \exp(-10.01/T_9) \end{aligned}$$

$$\text{For } T_9 > 6 : \quad N_A \langle \sigma v \rangle_{gs} = 6.02 \times 10^5 T_9^{1.862} \exp(-14.352/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 3.471 \exp(-11.091/T_9 - 0.129 T_9))$$

$$\text{Rev. ratio} = 1.809 \exp(-18.574/T_9)$$

$$^{27}\text{Al}(\alpha, \mathbf{n})^{30}\text{P}, Q = -2.643 \text{ MeV}, (3\%)$$

$$N_A \langle \sigma v \rangle_{gs} = 8.15 \times 10^4 \exp(-30.667/T_9) (1 - 1.351 T_9 + 1.086 T_9^2 + 0.354 T_9^3 + 0.014 T_9^4 - 2.13 \times 10^{-3} T_9^5)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 + 0.227 \exp(-3.588/T_9 + 0.0172 T_9))$$

$$\text{Rev. ratio} = 6.751 \exp(30.677/T_9)$$

$$^{28}\text{Si}(\mathbf{p}, \gamma)^{29}\text{P}, Q = 2.748 \text{ MeV}, (1\%)$$

$$\begin{aligned} \text{For } T_9 \leq 3 : \quad N_A \langle \sigma v \rangle_{gs} = & 8.71 \times 10^8 T_9^{-2/3} \exp(-24.453 T_9^{-1/3} - (T_9/1.1)^2) \\ & \times (1 + 0.301 T_9 + 0.069 T_9^2) + 3.37 \times 10^2 T_9^{-3/2} \exp(-4.155/T_9) \\ & + 1.14 \times 10^3 T_9^{1.654} \exp(-11.055/T_9) \end{aligned}$$

$$\text{For } T_9 > 3 : \quad N_A \langle \sigma v \rangle_{gs} = 32.4 T_9^{2.052} \exp(-1.525/T_9)$$

$$N_A \langle \sigma v \rangle_{tt} = N_A \langle \sigma v \rangle_{gs} \times (1 - 23.813 \exp(-22.872/T_9 - 0.353 T_9))$$

$$\text{Rev. ratio} = 9.468 \times 10^9 T_9^{3/2} \exp(-31.889/T_9)$$

Table IV. Analytical approximations of the partition functions

$G(T_9) = 1 + a_1 T_9^{a_2} \exp(a_3/T_9 + a_4 T_9 + a_5 T_9^{2/3})$ $G(T_9) = 1 \text{ for H and He isotopes, as well as for } {}^8\text{B and } {}^9\text{B}$					
isotope	a_1	a_2	a_3	a_4	a_5
${}^6\text{Li}$	3.47×10^0	-3.43×10^{-1}	-2.59×10^1	5.58×10^{-2}	—
${}^7\text{Li}$	5.20×10^{-1}	-5.75×10^{-2}	-5.59×10^0	1.27×10^{-2}	—
${}^7\text{Be}$	5.16×10^{-1}	-5.18×10^{-2}	-5.02×10^0	1.20×10^{-2}	—
${}^8\text{Be}$	4.52×10^0	5.29×10^{-2}	-3.51×10^1	-3.79×10^{-3}	—
${}^9\text{Be}$	1.73×10^{-2}	2.25×10^0	-1.54×10^1	-1.08×10^{-1}	—
${}^{10}\text{B}$	5.04×10^{-1}	-3.19×10^{-1}	-8.59×10^0	9.40×10^{-2}	—
${}^{11}\text{B}$	2.16×10^0	-1.19×10^0	-2.67×10^1	1.74×10^{-1}	—
${}^{11}\text{C}$	2.89×10^0	-1.38×10^0	-2.57×10^1	1.95×10^{-1}	—
${}^{12}\text{C}$	4.55×10^0	1.64×10^{-2}	-5.13×10^1	3.91×10^{-3}	—
${}^{13}\text{C}$	4.44×10^{-1}	1.06×10^0	-3.57×10^1	-4.57×10^{-2}	—
${}^{13}\text{N}$	4.68×10^{-2}	1.69×10^0	-2.33×10^1	-3.84×10^{-2}	—
${}^{14}\text{N}$	1.23×10^0	-1.48×10^0	-2.85×10^1	2.97×10^{-1}	—
${}^{15}\text{N}$	1.61×10^0	1.60×10^{-1}	-5.94×10^1	7.03×10^{-2}	—
${}^{14}\text{O}$	3.16×10^{-1}	1.38×10^0	-5.75×10^1	-4.25×10^{-2}	—
${}^{15}\text{O}$	2.95×10^0	-3.40×10^{-2}	-6.04×10^1	7.82×10^{-2}	—
${}^{16}\text{O}$	2.38×10^0	5.15×10^{-1}	-6.87×10^1	1.53×10^{-2}	—
${}^{17}\text{O}$	6.47×10^{-1}	-7.03×10^{-1}	-1.10×10^1	1.29×10^{-1}	—
${}^{18}\text{O}$	8.11×10^0	-6.71×10^{-1}	-2.37×10^1	1.59×10^{-1}	—
${}^{17}\text{F}$	4.16×10^{-1}	-3.07×10^{-1}	-6.03×10^0	6.64×10^{-2}	—
${}^{18}\text{F}$	4.36×10^0	6.46×10^{-2}	-1.14×10^1	4.81×10^{-2}	—
${}^{19}\text{F}$	9.05×10^0	1.66×10^0	-1.05×10^0	6.81×10^{-1}	-2.39×10^0
${}^{19}\text{Ne}$	3.73×10^0	-1.33×10^{-1}	-2.87×10^0	7.61×10^{-2}	—
${}^{20}\text{Ne}$	1.02×10^1	-6.02×10^{-1}	-1.99×10^1	8.95×10^{-2}	—
${}^{21}\text{Ne}$	2.98×10^0	4.86×10^{-1}	-3.97×10^0	4.16×10^{-1}	-1.20×10^0
${}^{22}\text{Ne}$	1.00×10^1	-6.92×10^{-1}	-1.57×10^1	1.22×10^{-1}	—
${}^{21}\text{Na}$	1.58×10^0	-2.51×10^{-1}	-3.99×10^0	8.92×10^{-2}	—
${}^{22}\text{Na}$	3.24×10^{-1}	7.64×10^{-1}	-6.32×10^0	3.87×10^{-2}	—
${}^{23}\text{Na}$	1.80×10^0	-4.17×10^{-1}	-5.40×10^0	1.20×10^{-1}	—
${}^{23}\text{Mg}$	4.30×10^0	8.89×10^{-1}	-5.00×10^0	6.16×10^{-1}	-1.90×10^0
${}^{24}\text{Mg}$	8.23×10^0	-4.74×10^{-1}	-1.65×10^1	7.87×10^{-2}	—
${}^{25}\text{Mg}$	1.51×10^{-1}	6.37×10^{-1}	-6.07×10^0	9.59×10^{-2}	—
${}^{26}\text{Mg}$	1.15×10^1	-9.90×10^{-1}	-2.22×10^1	2.17×10^{-1}	—
${}^{25}\text{Al}$	5.26×10^{-2}	-1.91×10^0	-5.78×10^0	-5.96×10^{-1}	2.99×10^0
${}^{26}\text{Al}$	2.26×10^0	3.98×10^0	-1.58×10^0	1.39×10^0	-5.09×10^0
${}^{27}\text{Al}$	9.52×10^{-1}	-4.51×10^{-1}	-1.08×10^1	1.69×10^{-1}	—
${}^{27}\text{Si}$	9.24×10^{-1}	-4.28×10^{-1}	-1.01×10^1	1.63×10^{-1}	—
${}^{28}\text{Si}$	9.87×10^0	-5.50×10^{-1}	-2.16×10^1	7.73×10^{-2}	—
${}^{29}\text{Si}$	1.31×10^0	1.27×10^{-3}	-1.44×10^1	1.32×10^{-1}	—
${}^{30}\text{Si}$	1.87×10^1	-1.28×10^0	-2.78×10^1	2.38×10^{-1}	—
${}^{29}\text{P}$	1.46×10^0	2.90×10^{-2}	-1.59×10^1	1.33×10^{-1}	—
${}^{30}\text{P}$	1.41×10^0	-5.33×10^{-1}	-8.41×10^0	2.36×10^{-1}	—
${}^{31}\text{P}$	4.05×10^0	-1.03×10^0	-1.57×10^1	2.69×10^{-1}	—

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