THERMONUCLEAR FUSION[26]

Natural abundance of isotopes:

hydrogen	$n_D/n_H = 1.5 \times 10^{-4}$
helium	$n_{\mathrm{He}^3}/n_{\mathrm{He}^4} = 1.3 \times 10^{-6}$
lithium	$n_{\mathrm{Li}^6}/n_{\mathrm{Li}^7} = 0.08$

Mass ratios:

$$m_e/m_D = 2.72 \times 10^{-4} = 1/3670$$
$$(m_e/m_D)^{1/2} = 1.65 \times 10^{-2} = 1/60.6$$
$$m_e/m_T = 1.82 \times 10^{-4} = 1/5496$$
$$(m_e/m_T)^{1/2} = 1.35 \times 10^{-2} = 1/74.1$$

Absorbed radiation dose is measured in rads: 1 rad $= 10^2\,\mathrm{erg\,g^{-1}}$. The curie (abbreviated Ci) is a measure of radioactivity: 1 curie $= 3.7\times10^{10}$ counts sec^{-1}.

Fusion reactions (branching ratios are correct for energies near the cross section peaks; a negative yield means the reaction is endothermic):[27]

(1a)	D + D	$\xrightarrow[50\%]{}$ T(1.01 MeV) + p(3.02 MeV)
(1b)		$\xrightarrow[50\%]{}$ He^3(0.82 MeV) + n(2.45 MeV)
(2)	D + T	$\longrightarrow$ He^4(3.5 MeV) + n(14.1 MeV)
(3)	D + He^3	$\longrightarrow$ He^4(3.6 MeV) + p(14.7 MeV)
(4)	T + T	$\longrightarrow$ He^4 + 2n + 11.3 MeV
(5a)	He^3 + T	$\xrightarrow[51\%]{}$ He^4 + p + n + 12.1 MeV
(5b)		$\xrightarrow[43\%]{}$ He^4(4.8 MeV) + D(9.5 MeV)
(5c)		$\xrightarrow[6\%]{}$ He^5(2.4 MeV) + p(11.9 MeV)
(6)	p + Li^6	$\longrightarrow$ He^4(1.7 MeV) + He^3(2.3 MeV)
(7a)	p + Li^7	$\xrightarrow[20\%]{}$ 2 He^4 + 17.3 MeV
(7b)		$\xrightarrow[80\%]{}$ Be^7 + n − 1.6 MeV
(8)	D + Li^6	$\longrightarrow$ 2He^4 + 22.4 MeV
(9)	p + B^{11}	$\longrightarrow$ 3 He^4 + 8.7 MeV
(10)	n + Li^6	$\longrightarrow$ He^4(2.1 MeV) + T(2.7 MeV)

The total cross section in barns (1 barn $= 10^{-24}\,\mathrm{cm}^2$) as a function of E, the energy in keV of the incident particle [the first ion on the left side of Eqs. (1)–(5)], assuming the target ion at rest, can be fitted by[28]

$$\sigma_T(E) = \frac{A_5 + \left[(A_4 - A_3E)^2 + 1\right]^{-1} A_2}{E\left[\exp(A_1E^{-1/2}) - 1\right]}$$

where the Duane coefficients A_j for the principle fusion reactions are as follows:

	D–D (1a)	D–D (1b)	D–T (2)	D–He^3 (3)	T–T (4)	T–He^3 (5a–c)
A_1	46.097	47.88	45.95	89.27	38.39	123.1
A_2	372	482	50200	25900	448	11250
A_3	4.36×10^{-4}	3.08×10^{-4}	1.368×10^{-2}	3.98×10^{-3}	1.02×10^{-3}	0
A_4	1.220	1.177	1.076	1.297	2.09	0
A_5	0	0	409	647	0	0

Reaction rates $\overline{\sigma v}$ (in cm^3 sec^{-1}), averaged over Maxwellian distributions:

Temperature (keV)	D–D (1a + 1b)	D–T (2)	D–He^3 (3)	T–T (4)	T–He^3 (5a–c)
1.0	1.5×10^{-22}	5.5×10^{-21}	10^{-26}	3.3×10^{-22}	10^{-28}
2.0	5.4×10^{-21}	2.6×10^{-19}	1.4×10^{-23}	7.1×10^{-21}	10^{-25}
5.0	1.8×10^{-19}	1.3×10^{-17}	6.7×10^{-21}	1.4×10^{-19}	2.1×10^{-22}
10.0	1.2×10^{-18}	1.1×10^{-16}	2.3×10^{-19}	7.2×10^{-19}	1.2×10^{-20}
20.0	5.2×10^{-18}	4.2×10^{-16}	3.8×10^{-18}	2.5×10^{-18}	2.6×10^{-19}
50.0	2.1×10^{-17}	8.7×10^{-16}	5.4×10^{-17}	8.7×10^{-18}	5.3×10^{-18}
100.0	4.5×10^{-17}	8.5×10^{-16}	1.6×10^{-16}	1.9×10^{-17}	2.7×10^{-17}
200.0	8.8×10^{-17}	6.3×10^{-16}	2.4×10^{-16}	4.2×10^{-17}	9.2×10^{-17}
500.0	1.8×10^{-16}	3.7×10^{-16}	2.3×10^{-16}	8.4×10^{-17}	2.9×10^{-16}
1000.0	2.2×10^{-16}	2.7×10^{-16}	1.8×10^{-16}	8.0×10^{-17}	5.2×10^{-16}

For low energies ($T \lesssim 25\,\mathrm{keV}$) the data may be represented by

$$(\overline{\sigma v})_{DD} = 2.33 \times 10^{-14} T^{-2/3} \exp(-18.76 T^{-1/3})\ \mathrm{cm^3\,sec^{-1}};$$

$$(\overline{\sigma v})_{DT} = 3.68 \times 10^{-12} T^{-2/3} \exp(-19.94 T^{-1/3})\ \mathrm{cm^3\,sec^{-1}},$$

where T is measured in keV.

The power density released in the form of charged particles is

$$P_{DD} = 3.3 \times 10^{-13} {n_D}^2 (\overline{\sigma v})_{DD}\ \mathrm{watt\,cm^{-3}}$$ (including the subsequent D–T reaction);

$$P_{DT} = 5.6 \times 10^{-13} n_D n_T (\overline{\sigma v})_{DT}\ \mathrm{watt\,cm^{-3}};$$

$$P_{D\mathrm{He}^3} = 2.9 \times 10^{-12} n_D n_{\mathrm{He}^3} (\overline{\sigma v})_{D\mathrm{He}^3}\ \mathrm{watt\,cm^{-3}}.$$