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核融合反応集

日本原子力研究所東海研究所物理部

深井 佑造*

(1992年12月7日受理)

核融合燃料となる原子核は放射性同位元素のトリチウムを含めて、次の10核種である。

p, D, T, ^3He , ^4He , ^6Li , ^7Li , ^9Be , ^{10}B , ^{11}B , (^{12}C , ^{13}C)

ここで括弧内の炭素はQ値の計算にのみ採用した。そこでこれらの核種により組み合わされた核融合反応の数は55になり、炭素を含めると78になる。それぞれの核融合反応はいくつかの分岐を持つ。反応生成物が2体および3体の分岐については計算機を用いて、Q値と反応しきい値を計算し、4体以上の場合はAjzenberg-Selove等の文献により分岐を調査した。そして得られた結果の分岐について、その分岐反応が観測されたことがあるか否かを同じ文献によって確認して分類した。その結果、

- | | |
|---|--------|
| (I) どの分岐でも $Q < 0$ の反応 | 3 |
| (II) $Q > 0$ の分岐はあるが、それは γ 線のみが発生で、他の分岐は全て $Q < 0$ の反応 | 7(3) |
| (III) $Q > 0$ の任意の分岐で中性子の発生がある反応 | 36(17) |
| (IV) $Q > 0$ のどの分岐でも中性子の発生がない反応 | 9(3) |

であった。括弧内の数字は炭素に関連した結果である。一般に(III)と(IV)の反応がエネルギー源として可能である。

^{11}B 以下の軽い核による55の核融合反応での反応生成物、Q値と反応しきい値、及び反応断面積を掲載している文献名、その他の問題を分類して表にまとめて示した。

本報告書はシグマ研究委員会で行った研究の成果である。

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Thermonuclear Reaction Listing

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The following 10 elements, including T, are well known as nuclear fusion fuels: p, D, T, ^3He , ^4He , ^6Li , ^7Li , ^9Be , ^{10}B , ^{11}B , (^{12}C , ^{13}C), where ^{12}C and ^{13}C are considered only in the calculation of Q value. Accordingly the number of the thermonuclear reactions is 55, and 78, if including carbon elements. The reactions have some branches. For the branches having two and three reaction products, the reaction products, Q value and threshold energy are calculated by using a computer. We have investigated those of the branches having more than three products from the papers of Ajzenberg-Selove and so on. And also, by the same papers, we check whether the above mentioned branch has been observed or not. The results are as follows:

- (I) the number of reactions which have $Q < 0$ in the all branches is 3,
- (II) that of reactions which have some $Q > 0$ branches only with γ ray production, and $Q < 0$ in the other branches is 7(3),
- (III) that of reactions which have some branches with $Q > 0$ and neutron production is 36(17), and
- (IV) that of reactions whose branch with $Q > 0$ does not produce neutrons is 9(3).

The value in the parentheses shows the number of the case of the carbon elements.

This work was performed as a part of activities of the Japanese Nuclear Data Committee.

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For 55 thermonuclear reactions induced by lighter nuclides than ^{11}B , the reaction products, the values of Q and threshold energy, and the papers with reaction cross section data are presented in the tables.

Keywords: Thermonuclear reaction, nuclear fusion fuel, branch, Q value, threshold energy, p , D , T , ^3He , ^4He , ^6Li , ^7Li , ^9Be , ^{10}B , ^{11}B

目 次

1. 緒 言	1
2. 核融合反応式の導出と核融合燃料	1
3. Q 値と反応生成物の計算・評価	5
4. ま と め	6
4.1 分岐反応数とQ 値	6
4.2 Q 値による分類	7
4.3 核融合反応式の表	8
4.4 核融合反応生成物の問題	9
4.5 反応断面積データ	10
謝 辞	10
参考文献	127
付録A L. T. Cox 報告批判	129
付録B 反応核種の核特性核種データ	134
付録C 核融合反応式を読むための手引	147

Contents

1. Introduction	1
2. Derivation of Thermonuclear Reaction and Fusion Fuels	1
3. Calculation of Q Value and Fusion Reaction Products	5
4. Some Remarks	6
4.1 Number of Branch and Q Value	6
4.2 Classification by Q Value	7
4.3 Tables of Fusion Reaction	8
4.4 On the Fusion Reaction Products	9
4.5 Reaction Cross Section Data	10
Acknowledgement	10
Reference	127
Appendix A Criticism for L.T. Cox Report	129
Appendix B Various Nuclear Data for Reaction Nucleus	134
Appendix C Manual for Reading the Tables of Fusion Reaction	147

1. 緒 言

ここでは ^{11}B より軽い原子核相互の核反応によって、核エネルギーを得る方法を核融合と称する。この原子核相互の核反応を具体的に表す核融合反応式及びその反応に伴って発生するエネルギー値 (Q 値) のデータは核融合研究の分野で関心が持たれている。核融合反応式と Q 値のデータは、最近では 1990 年に L. T. Cox et al. によって技術報告として公表されている⁽¹⁾。この Cox の技術報告では、核物理の分野で現在観測されていない (not observed 以下 n.o. と略称する) ことを確認されている分岐反応を含めて、観測されている核融合反応及びその分岐の総数の 60.2% しか収録されていない。更に核融合研究の分野で時々関心が持たれる負の Q 値の場合の反応しきい値 (E_{th}) や n.o. 核種である点の記述がなく、保存則が成立していない核融合反応式の掲載等の過誤やミスプリントが見られる。これらの詳細は付録 A に示した。

本報告では、F. Ajzenberg-Selove 等の核物理の分野での最新のデータを参照して⁽²⁾、確認されている n.o. 核種や n.o. 分岐反応を含めて、観測されている核融合反応及びその分岐を網羅して掲載した。更に保存則が成立していない反応式の記述を避けるために、反応式の導出には計算機を用いた。従って現状では本報告の内容はかなりの信頼性があると思われる。

なお付録 C には、核融合反応での各分岐の反応生成物、Q 値、反応しきい値、反応断面積データを掲載した論文等の情報を示した表 (Table 2~11) を読むための手引を示した。

2. 核融合反応式の導出と核融合燃料

一般に B イオン (B 原子核) と C イオン (C 原子核) が核反応すると、



の反応式 (Reaction) が成立する。ここで B および C の原子核がそれぞれ原子番号 Z_B 、 Z_C を、質量数 A_B 、 A_C を持つとすると、先ず原子番号 ($Z_B + Z_C$) と質量数 ($A_B + A_C$) を持つ励起された複合核 (compound nucleus) Y^* が生ずる。続いて Y^* の原子番号 ($Z_B + Z_C$) と質量数 ($A_B + A_C$) を分けあった反応生成物 E、F、G、……が生じ、この時核反応エネルギー Q MeV が発生する。

1. 結 言

ここでは ^{11}B より軽い原子核相互の核反応によって、核エネルギーを得る方法を核融合と称する。この原子核相互の核反応を具体的に表す核融合反応式及びその反応に伴って発生するエネルギー値 (Q 値) のデータは核融合研究の分野で関心が持たれている。核融合反応式と Q 値のデータは、最近では 1990 年に L. T. Cox et al. によって技術報告として公表されている⁽¹⁾。この Cox の技術報告では、核物理の分野で現在観測されていない (not observed 以下 n.o. と略称する) ことを確認されている分岐反応を含めて、観測されている核融合反応及びその分岐の総数の 60.2% しか収録されていない。更に核融合研究の分野で時々関心が持たれる負の Q 値の場合の反応しきい値 (E_{th}) や n.o. 核種である点の記述がなく、保存則が成立していない核融合反応式の掲載等の過誤やミスプリントが見られる。これらの詳細は付録 A に示した。

本報告では、F. Ajzenberg-Selove 等の核物理の分野での最新のデータを参照して⁽²⁾、確認されている n.o. 核種や n.o. 分岐反応を含めて、観測されている核融合反応及びその分岐を網羅して掲載した。更に保存則が成立していない反応式の記述を避けるために、反応式の導出には計算機を用いた。従って現状では本報告の内容はかなりの信頼性があると思われる。

なお付録 C には、核融合反応での各分岐の反応生成物、Q 値、反応しきい値、反応断面積データを掲載した論文等の情報を示した表 (Table 2~11) を読むための手引を示した。

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一般に Y^* からE、F、G、……への分けあいは一通りではなく、いくつかの種類が生ずる。これを分岐 (branch) と呼んでいる。従って各分岐での反応生成物はもちろんQ値もそれぞれ異にする。

各分岐のQ値は必ずしも常に正ではない。負のQ値の場合、BまたはCイオンのいずれかの原子核の持つエネルギーが負のQ値を打ち消す程高い時には、(1)式の反応は右辺に進行する。その際のBまたはCイオンのいずれかの原子核の持つエネルギー値を反応しきい値 (E_{th}) と呼ぶ。このE_{th}は次式で求められる。

$$E_{th} = \frac{M_B + M_C}{M_C} |Q| \quad (2)$$

(1)式では 原子番号と質量数の保存則が成立していなければならない。即ち

$$Z_B + Z_C = Z_E + Z_F + Z_G + \dots \quad (3)$$

$$A_B + A_C = A_E + A_F + A_G + \dots \quad (4)$$

一方Q値は各原子核の質量を M_B 、 M_C 、 M_E 、 M_F 、 M_G 、…… とすれば、質量とエネルギーの保存則から次式で与えられる。

$$Q = (M_B + M_C) - (M_E + M_F + M_G + \dots) \quad (5)$$

過剰質量 (mass excess) を ΔM とすれば、

$$\Delta M = M - A \quad (6)$$

であるから、(5)式に(4)式を用いて(5)式を次のように書き直すことが出来る。

$$Q = (\Delta M_B + \Delta M_C) - (\Delta M_E + \Delta M_F + \Delta M_G + \dots) \quad (7)$$

ΔM の値は主として実測値及び実測値から統計的に評価または予測されて数値表として与えられている。ここで用いられる核子及び核種に対する ΔM の値は付録Bの Table B.1 に示してある。

(1)式を核融合反応式とすると、(1)式左辺のBイオン (B原子核) とCイオン (C原子核) は核融合燃料原子核である。核融合燃料原子核は水素 (p)、重水素 (Dまたはd)、トリチウム (Tまたはt)、ヘリウム (^3He または τ

及び ^4He または α ）、リチウム (^6Li 及び ^7Li)、ベリリウム (^9Be) ボロン (^{10}B 及び ^{11}B) の 10 核種である。

これらの核融合燃料原子核はトリチウムを除いて、全て安定元素である。又 ^3He は地球では希少元素であるが、月面や土星、木星等には多量に存在する。更に核融合燃料原子核とは考えられていないが、ここでは炭素 (^{12}C 及び ^{13}C) をも検討対象とする。核融合燃料原子核の 2 核種が組み合わせられて核融合反応式が成り立っているから、10 核種の場合の検討すべき核融合反応の数は

5 5

で、炭素を含めて 12 核種になれば、反応の数は 78 になる。これらの反応を軽い核種で作用されている (induced) として分類すると、具体的な反応式は Table 1 のように与えられる。

Table 1 Fusion Reaction

induced	Fusion Reaction
p -	p p p D p T p ³ He p ⁴ He p ⁶ Li p ⁷ Li p ⁹ Be p ¹⁰ B p ¹¹ B (p ¹² C p ¹³ C)
D -	DD DT D ³ He D ⁴ He D ⁶ Li D ⁷ Li D ⁹ Be D ¹⁰ B D ¹¹ B (D ¹² C D ¹³ C)
T -	TT T ³ He T ⁴ He T ⁶ Li T ⁷ Li T ⁹ Be T ¹⁰ B T ¹¹ B (T ¹² C T ¹³ C)
³ He-	τ ³ He τ ⁴ He τ ⁶ Li τ ⁷ Li τ ⁹ Be τ ¹⁰ B τ ¹¹ B (τ ¹² C τ ¹³ C)
⁴ He-	α ⁴ He α ⁶ Li α ⁷ Li α ⁹ Be α ¹⁰ B α ¹¹ B (α ¹² C α ¹³ C)
⁶ Li-	⁶ Li ⁶ Li ⁶ Li ⁷ Li ⁶ Li ⁹ Be ⁶ Li ¹⁰ B ⁶ Li ¹¹ B (⁶ Li ¹² C ⁶ Li ¹³ C)
⁷ Li-	⁷ Li ⁷ Li ⁷ Li ⁹ Be ⁷ Li ¹⁰ B ⁷ Li ¹¹ B (⁷ Li ¹² C ⁷ Li ¹³ C)
⁹ Be-	⁹ Be ⁹ Be ⁹ Be ¹⁰ B ⁹ Be ¹¹ B (⁹ Be ¹² C ⁹ Be ¹³ C)
¹⁰ B -	¹⁰ B ¹⁰ B ¹⁰ B ¹¹ B (¹⁰ B ¹² C ¹⁰ B ¹³ C)
¹¹ B -	¹¹ B ¹¹ B (¹¹ B ¹² C ¹¹ B ¹³ C)
C -	(¹² C ¹² C ¹² C ¹³ C ¹³ C ¹³ C)

Reactions in the parentheses are related to the carbons, which are not generally considered to be a fusion reaction as an energy source.

3. Q 値と反応生成物の計算・評価

Table 1 に示した核融合反応の各々の反応に対して、いくつかの反応生成物、それに伴う Q 値と E_{th} 値 (Q < 0 の場合のみ、Q > 0 の場合は、E_{th} = 0 とする) を持つ分岐を求める。反応生成物 E、F、G、……の具体的な核子や核種等については次のように考える。

$$\begin{aligned} & \gamma \text{ 線} : Z = 0 \quad A = 0 \quad \Delta M = 0 \\ & n, p (=H), D, T, {}^3\text{He} (= \tau), {}^4\text{He} (= \alpha) \\ & \text{低質量数の核種で、Table B.1 に記載のある核種} \end{aligned}$$

(1) 2 体問題

各反応に対して、反応生成物の 1 つが γ 、n、p、D、T、 τ 、 α のいずれかであるとして決定し、生成した複合核 Y* の原子番号 ($Z_B + Z_C$) と質量数 ($A_B + A_C$) から決定した核子や核種等の原子番号と質量数をそれぞれ引き算する。残った原子番号と質量数の数値を Table B.1 に記載のある核種と比較して、該当する核種が Table B.1 に記載してあれば、その分岐は成立するとして (7) 式及び (2) 式に従って Q 値または E_{th} 値を計算する。もし引き算して残った原子番号と質量数を持つものが Table B.1 にない場合はその分岐は存在しないとする。

(2) 3 体問題

各反応に対して、反応生成物の 1 つが n、p、D、T、 τ 、 α のいずれかであるとして決定し、次の反応生成物も上記の核子や核種の順序に従って、前に決定した反応生成物を含めていずれかであるとして決定する。例えば、初めの 1 つに n を選べば、2 つめは n、p、D、T、 τ 、 α のいずれかから選ぶ。また初めの 1 つに T を選べば 2 つめは T、 τ 、 α のいずれかから選ぶ。こうして決定された 2 つの反応生成物の原子番号と質量数のそれぞれの和を生成した複合核 Y* の原子番号と質量数からそれぞれ引き算する。以下の手順は 2 体問題の場合と全く同様である。

(3) 4体以上の問題

反応生成物が4つ以上になる分岐については計算を実施しない。こうした分岐反応は極めて起こりにくいので、F. Ajzenberg-Selove等の核物理分野の文献を調査して観測された分岐反応式をのみ求めた⁽²⁾。

2体と3体問題で実施した計算による結果では完全に保存則が成立しているが、核融合反応の各分岐の反応の可能性を示しているに過ぎない。次の問題はこれらの分岐反応は現実に存在するかという点にある。現実に存在するか否かの判定は極めて困難である。それはその分岐反応が核物理の分野で興味を持たれているか否かに係っているからである。興味を持たれていても現状では観測されなかったという(n.o.)核種や分岐反応もある。そこでここでは2体と3体問題での計算結果をF. Ajzenberg-Selove等の文献⁽²⁾を参照して調査し、計算結果の全ての核融合反応の各分岐を次のように分類した。

- ◎ 観測されて各種の測定値の得られている分岐反応
- ◎ 興味を持たれていても現状では観測されなかったという分岐反応
(n.o.で示す)
- ◎ 上記以外の分岐反応。将来上記に分類されるかも知れないという可能性がある。

かようにして分類された結果を後に示す。

4. まとめ

前章で示した分類の内、最後の1項目を除く2項によって得られた結果のみが現状では興味のある点であるから、今後はこれらを中心に検討を加える。

4.1 分岐反応数とQ値

一般にエネルギー源として可能性があると考えられている10核種の核融合燃料原子核による核融合分岐反応で、現在観測が行われた総数は

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2体と3体問題で実施した計算による結果では完全に保存則が成立しているが、核融合反応の各分岐の反応の可能性を示しているに過ぎない。次の問題はこれらの分岐反応は現実に存在するかという点にある。現実に存在するか否かの判定は極めて困難である。それはその分岐反応が核物理の分野で興味を持たれているか否かに係っているからである。興味を持たれていても現状では観測されなかったという(n.o.)核種や分岐反応もある。そこでここでは2体と3体問題での計算結果をF. Ajzenberg-Selove等の文献⁽²⁾を参照して調査し、計算結果の全ての核融合反応の各分岐を次のように分類した。

- ◎ 観測されて各種の測定値の得られている分岐反応
- ◎ 興味を持たれていても現状では観測されなかったという分岐反応
(n.o.で示す)
- ◎ 上記以外の分岐反応。将来上記に分類されるかも知れないという可能性はある。

かようにして分類された結果を後に示す。

4. まとめ

前章で示した分類の内、最後の1項目を除く2項によって得られた結果のみが現状では興味のある点であるから、今後はこれらを中心に検討を加える。

4.1 分岐反応数とQ値

一般にエネルギー源として可能性があると考えられている10核種の核融合燃料原子核による核融合分岐反応で、現在観測が行われた総数は

である。内訳として、各核融合燃料原子核のより軽い核種により induced された分岐反応数は付録 A の Table A.1 に示されている。

これらの内で、Q 値が最高の値を示しているのは、



である。この Q 値は現在では実現性が最も高い D T 核融合反応の値の 1.5 倍である。 ${}^{10}\text{B}{}^{10}\text{B}$ 核融合反応では上記の反応は観測されて測定値が得られているが、Table 10 に示されているように、



の分岐があるので、 ${}^{10}\text{B}{}^{10}\text{B}$ 反応は中性子発生があると考えられる。

中性子発生が主反応にはないいわゆるアドバンスド燃料核融合（後に説明する）では、Q 値が最高の値を示しているのは、



である。

4. 2 Q 値による分類

Table 1 に示した炭素を含む 12 核種による 78 核融合反応を Q 値について次のように分類出来る。

- | | |
|---|---------|
| (I) どの分岐でも $Q < 0$ である。 | 3 |
| (II) $Q > 0$ の分岐はあるが、それは γ 線の発生であり、
他は全て $Q < 0$ である。 | 7 (3) |
| (III) $Q > 0$ のどこかの分岐で中性子発生がある。 | 36 (17) |
| (IV) $Q > 0$ の分岐では中性子の発生がない。 | 9 (3) |

数値は上記の方法で分類された反応数で、括弧内は炭素に関する反応数である。各分類項目に対する核融合反応式を次に示す。ここでも括弧内は炭素に関する反応である。

- (I) $p^3\text{He}$ $p^4\text{He}$ $\alpha^4\text{He}$
 (II) $p\text{D}$ $p\text{T}$ ($p^{12}\text{C}$ $p^{13}\text{C}$) D^4He T^4He $\tau^4\text{He}$ $\alpha^6\text{Li}$
 $\alpha^7\text{Li}$ ($\alpha^{12}\text{C}$)
 (III) DD DT D^6Li D^7Li D^9Be D^{10}B D^{11}B (D^{13}C)
 TT T^3He T^6Li T^7Li T^9Be T^{10}B T^{11}B
 (T^{12}C T^{13}C) $\tau^7\text{Li}$ $\tau^9\text{Be}$ $\tau^{10}\text{B}$ $\tau^{11}\text{B}$ ($\tau^{13}\text{C}$)
 $\alpha^9\text{Be}$ $\alpha^{10}\text{B}$ $\alpha^{11}\text{B}$ ($\alpha^{13}\text{C}$) ${}^6\text{Li}^6\text{Li}$ ${}^6\text{Li}^7\text{L}$
 ${}^6\text{Li}^9\text{Be}$ ${}^6\text{Li}^{10}\text{B}$ ${}^6\text{Li}^{11}\text{B}$ (${}^6\text{Li}^{12}\text{C}$ ${}^6\text{Li}^{13}\text{C}$)
 ${}^7\text{Li}^7\text{Li}$ ${}^7\text{Li}^9\text{Be}$ ${}^7\text{Li}^{10}\text{B}$ ${}^7\text{Li}^{11}\text{B}$ (${}^7\text{Li}^{12}\text{C}$ ${}^7\text{Li}^{13}\text{C}$)
 ${}^9\text{Be}^9\text{Be}$ ${}^9\text{Be}^{10}\text{B}$ ${}^9\text{Be}^{11}\text{B}$ (${}^9\text{Be}^{12}\text{C}$ ${}^9\text{Be}^{13}\text{C}$)
 ${}^{10}\text{B}^{10}\text{B}$ ${}^{10}\text{B}^{11}\text{B}$ (${}^{10}\text{B}^{12}\text{C}$ ${}^{10}\text{B}^{13}\text{C}$) ${}^{11}\text{B}^{11}\text{B}$ (${}^{11}\text{B}^{12}\text{C}$
 ${}^{11}\text{B}^{13}\text{C}$ ${}^{12}\text{C}^{13}\text{C}$ ${}^{13}\text{C}^{13}\text{C}$)
 (IV) $p\text{p}$ $p^6\text{Li}$ $p^7\text{Li}$ $p^9\text{Be}$ $p^{10}\text{B}$ $p^{11}\text{B}$ D^3He (D^{12}C)
 $\tau^3\text{He}$ $\tau^6\text{Li}$ ($\tau^{12}\text{C}$ ${}^{12}\text{C}^{12}\text{C}$)

ここで分類された (IV) の核融合反応で、 $p\text{p}$ 反応及び括弧内の炭素に関する反応を除いた 8 核融合反応をアドバンスド燃料核融合と称する。

4. 3 核融合反応式の表

一般にエネルギー源として可能性があると考えられている 10 核種の核融合燃料原子核 (炭素を除く) による核融合反応の全ての分岐の表を次に掲載する。

- Table 2 p -induced Fusion Reaction
 Table 3 D -induced Fusion Reaction
 Table 4 T -induced Fusion Reaction
 Table 5 ${}^3\text{He}$ -induced Fusion Reaction
 Table 6 ${}^4\text{He}$ -induced Fusion Reaction
 Table 7 ${}^6\text{Li}$ -induced Fusion Reaction
 Table 8 ${}^7\text{Li}$ -induced Fusion Reaction
 Table 9 ${}^9\text{Be}$ -induced Fusion Reaction
 Table 10 ${}^{10}\text{B}$ -induced Fusion Reaction
 Table 11 ${}^{11}\text{B}$ -induced Fusion Reaction

Table の番号は Table 1 に示したように、軽い核種で作用されている (induced) として分類された順序に従っている。各表中の各核融合反応毎に、第

3章の終わりで示した観測された結果の有無を基にした分類に従って、

- ◎ 観測されて各種の測定値の得られている分岐反応
表中の (s) は安定元素を示す。
- ◎ 興味を持たれていても現状では観測されなかったという分岐反応
表中 n.o. で示され、核種の次の # は n.o. の核種を示す。
- ◎ 上記以外の分岐反応
将来上記に分類されるかも知れないという可能性がある。

の順序で並べられている。

上記の分類項の前2項については、各分岐毎に番号をつけたが、最後の1項の分岐については番号をつけていない。また各核融合反応毎に、分岐の数として上記の分類項の最初の2項についての分岐数の和、括弧内に最後の1項の分岐数、そして複合核(compound nucleus)とその質量数Aと原子番号Zを表の初めに示した。表には、各分岐について反応生成物、Q値とE_{th}値、及び備考欄を設けて示した。

4. 4 核融合反応生成物の問題

Table 2~11の各分岐で発生する核融合反応生成物では、安定元素は問題ないが不安定核種の時間的変換は問題になる。Table B.1に掲載された全ての不安定核種の変換をTable B.2に示した。従ってTable 2~11に掲載されている不安定核種の核融合反応生成物の変換の過程はTable B.2によって解る。

Table B.2から、核融合反応で発生する放射性核種について考えることが出来る。半減期を1日以上とすれば問題となる長半減期の放射性核種は

T	半減期	12.33年	⁷ Be	半減期	53.29日
¹⁰ Be	半減期	1.6 × 10 ⁶ 年	¹⁴ C	半減期	5730年
²² Na	半減期	2.602年			

のみであることが解る。この内²²Naはエネルギー源として可能性があると考えられている10核種の核融合燃料による核融合反応では発生することはないので、結局核融合炉で問題となる長半減期の放射性核種はT、⁷Be、¹⁰Be、¹⁴Cの4核種のみである。

4. 5 反応断面積データ

核融合反応の観測された分岐でも、反応断面積の測定値が与えられているとは限らない。Table 2~11 に記載された分岐の一部でのみ、反応断面積データが収集または編集されてる。

現在入手可能な収集または編集された核データとして、

G.H. Miley et al. ⁽³⁾、
 W.A. Fowler et al. ⁽⁴⁾、
 J.R. McNally et al. ⁽⁵⁾、
 IAEA : Handbook ⁽⁶⁾、
 R. Feldbacher ⁽⁷⁾、
 S.N. Abramovich et al. ⁽⁸⁾、及び
 著者が収集したデータ ⁽⁹⁾

がある。ここで核データとは、反応粒子の入射エネルギー1点または数点のに対する測定された反応断面積値、ある範囲の入射エネルギーについて収集・評価・編集された反応断面積データ、反応粒子のエネルギー分布が Maxwell 速度分布に従うとして編集された反応断面積データを平均化した $\langle \sigma v \rangle$ 値である。Table 2~11 の備考欄に引用した数字はこれらの入手可能な核データの文献を示す。引用した文献には、ここに示したタイプの核データが "and/or" で収録されている。引用しなかったが、公表が予定されているシグマ研究委員会荷電粒子核データWGの報告書に収録されている数核種の (p, n), (α , n) 反応断面積データも参考になる。備考欄に指示のない分岐反応の核データについては、それぞれについて原論文を探さなければならない。その際に参考になるのは、F. Ajzenberg-Selove 等の文献 ⁽²⁾ である。

謝 辞

この報告書に対し、有用なコメントを戴いた住友原子力工業(株)松延廣幸氏及び参考文献の収集に助力を戴いた(株)東芝吉田正氏と安藤良平氏に謝意を表します。

4. 5 反応断面積データ

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 著者が収集したデータ ⁽⁹⁾

がある。ここで核データとは、反応粒子の入射エネルギー 1 点または数点のに対する測定された反応断面積値、ある範囲の入射エネルギーについて収集・評価・編集された反応断面積データ、反応粒子のエネルギー分布が Maxwell 速度分布に従うとして編集された反応断面積データを平均化した $\langle \sigma v \rangle$ 値である。Table 2~11 の備考欄に引用した数字はこれらの入手可能な核データの文献を示す。引用した文献には、ここに示したタイプの核データが "and/or" で収録されている。引用しなかったが、公表が予定されているシグマ研究委員会荷電粒子核データ W G の報告書に収録されている数核種の (p, n), (α , n) 反応断面積データも参考になる。備考欄に指示のない分岐反応の核データについては、それぞれについて原論文を探さなければならない。その際に参考になるのは、F. Ajzenberg-Selove 等の文献 ⁽²⁾ である。

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Table 2 p-induced Fusion Reaction

REACTION $p + p$ total branch 1			
compound nucleus D^* A=2 Z=2			
branch	Q(MeV)	Eth(MeV)	remarks
1	$D + \beta^+ + \nu$	1.192	0 (4)

REACTION $D + p$ total branch 2			
compound nucleus ${}^3\text{He}^*$ A=3 Z=2			
branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^3\text{He}(s)$	5.4935	0 (4, 7, 8)
2	$n + p + p$	-2.2246	3.3377 (4, 7, 8)

REACTION $T + p$ total branch 5			
compound nucleus ${}^4\text{He}^*$ A=4 Z=2			
branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^4\text{He}(s)$	19.814	0 (7, 8)
2	$n + {}^3\text{He}(s)$	-0.76375	1.019 (4, 6, 7, 8)
3	$D(s) + D(s)$	-4.0327	5.3803
4	$n + p + D(s)$	-6.2573	8.3482
5	$2n + 2p$	-8.48?	11.314

? ; This value is unable to be confirmed from F. Ajzenberg-Selove⁽²⁾.

REACTION ${}^3\text{He} + \text{p}$ total branch 4
 compound nucleus ${}^4\text{Li}^*$ A=4 Z=3

	branch	Q(MeV)	Eth(MeV)	remarks
1	p + p + D(s)	-5.4935	7.3292	
2	n + 3 p	-7.718	10.297	(9)
3	$\gamma + {}^4\text{Li}^\#$	-2.8997	3.8686	n. o.
4	n + ${}^3\text{Li}^\#$	- *	-	n. o.

* ; This can not be calculated due to uncertainty of ΔM of ${}^3\text{Li}$.

REACTION ${}^4\text{He} + \text{p}$ total branch 4(2)
 compound nucleus ${}^5\text{Li}^*$ A=5 Z=3

	branch	Q(MeV)	Eth(MeV)	remarks
1	D(s) + ${}^3\text{He}$ (s)	-18.353	22.974	
2	n + p + ${}^3\text{He}$ (s)	-20.578	25.759	
3	p + p + T	-19.814	24.803	
4	p + D(s) + D(s)	-23.847	29.851	
	$\gamma + {}^5\text{Li}$	-1.9661	2.4611	
	n + ${}^4\text{Li}^\#$	-23.477	29.389	

REACTION ${}^6\text{Li} + \text{p}$ total branch 11(3)compound nucleus ${}^7\text{Be}^*$ A=7 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^7\text{Be}$	5.6059	0	(4, 7, 8)
2	$\text{n} + {}^6\text{Be}$	-5.0707	5.9203	(8)
3	$\text{D}(\text{s}) + {}^5\text{Li}$	-3.4412	4.0178	
4	${}^3\text{He}(\text{s}) + {}^4\text{He}(\text{s})$	4.0184	0	(4, 5, 7, 8)
5	$\text{n} + \text{p} + {}^5\text{Li}$	-5.6658	6.6151	
6	$\text{n} + \text{D}(\text{s}) + {}^4\text{Li}\#$	-24.953	29.133	
7	$\text{p} + \text{p} + {}^5\text{He}$	-4.5934	5.3631	
8	$\text{p} + \text{D}(\text{s}) + {}^4\text{He}(\text{s})$	-1.4751	1.7223	
9	$\text{p} + \text{T} + {}^3\text{He}(\text{s})$	-15.796	18.442	
10	$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^3\text{He}(\text{s})$	-19.828	23.151	
11	$3\text{p} + {}^4\text{H}\#$	-26.1	30.474	
	$\text{T} + {}^4\text{Li}\#$	-18.695	21.828	
	$\text{n} + \text{n} + {}^6\text{Be}$	-28.468	33.238	
	$\text{n} + {}^3\text{He}(\text{s}) + {}^3\text{He}(\text{s})$	-16.559	19.334	

REACTION ${}^7\text{Li} + \text{p}$ total branch 14(5)compound nucleus ${}^8\text{Be}^*$ A=8 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^8\text{Be}$	17.254	0	(8, 9)
2	$\text{n} + {}^7\text{Be}$	-1.6442	1.8804	(4, 6, 7, 8, 9)
3	$\text{D}(\text{s}) + {}^6\text{Li}(\text{s})$	-5.0256	5.7475	
4	$\text{T} + {}^5\text{Li}$	-4.4341	5.071	
5	${}^3\text{He}(\text{s}) + {}^5\text{He}$	-4.1255	4.7181	
6	${}^4\text{He}(\text{s}) + {}^4\text{He}(\text{s})$	17.346	0	(4, 5, 7, 8)

(continued)

7	$n + p + {}^6\text{Li}(s)$	-7.2502	8.2916	(9)
8	$n + D(s) + {}^5\text{Li}$	-10.691	12.227	(9)
9	$p + p + {}^6\text{He}$	-9.9745	11.407	
10	$p + D(s) + {}^5\text{He}$	-9.619	11.001	
11	$p + T + {}^4\text{He}(s)$	-2.468	2.8226	
12	$D(s) + D(s) + {}^4\text{He}(s)$	-6.5007	7.4345	
13	$D(s) + T + {}^3\text{He}(s)$	-20.821	23.812	
14	$p + 2D(s) + T$	-26.3148	30.095	
	${}^4\text{H}\# + {}^4\text{Li}\#$	-28.764	32.896	
	$n + n + {}^6\text{Be}$	-12.321	14.091	
	$n + T + {}^4\text{Li}\#$	-25.945	29.672	
	$n + {}^3\text{He}(s) + {}^4\text{He}(s)$	-3.2318	3.696	
	$p + {}^3\text{He}(s) + {}^4\text{H}\#$	-25.865	29.58	

REACTION ${}^9\text{Be} + p$ total branch 16(17)
 compound nucleus ${}^{10}\text{B}^*$ A=10 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{10}\text{B}(s)$	6.586	0	(4, 7, 8, 9)
2	$n + {}^9\text{B}$	-1.8504	2.0574	(4, 8, 9)
3	$D(s) + {}^8\text{Be}$	0.55918	0	(4, 5, 7, 8)
4	$T + {}^7\text{Be}$	-12.082	13.433	(9)
5	${}^3\text{He}(s) + {}^7\text{Li}(s)$	-11.201	12.454	
6	${}^4\text{He}(s) + {}^6\text{Li}(s)$	2.1262	0	(4, 5, 7, 8)
7	${}^4\text{Li}\# + {}^6\text{He}$	-24.076	26.768	
8	$n + n + {}^8\text{B}$	-20.426	22.711	
9	$n + p + {}^8\text{Be}$	-1.6654	1.8516	(7, 9)
10	$p + p + {}^8\text{Li}$	-16.887	18.775	
11	$p + D(s) + {}^7\text{Li}(s)$	-16.695	18.562	
12	$p + T + {}^6\text{Li}(s)$	-17.688	19.666	

(continued)

13	$p + {}^3\text{H e (s)} + {}^6\text{H e}$	-21.176	23.544
14	$p + {}^4\text{H e (s)} + {}^5\text{H e}$	-2.4672	2.7431
15	$\text{D (s)} + {}^3\text{H e (s)} + {}^5\text{H e}$	-20.82	23.149
16	$\text{D (s)} + 2 {}^4\text{H e (s)}$	0.65107	0
	${}^4\text{H \#} + {}^6\text{B e}$	-25.577	28.438
	${}^5\text{H \#} + {}^5\text{B e}$	-48.853	54.316
	${}^5\text{H e} + {}^5\text{L i}$	-4.4333	4.929
	$n + \text{D (s)} + {}^7\text{B e}$	-18.339	20.39
	$n + \text{T} + {}^6\text{B e}$	-22.759	25.304
	$n + {}^3\text{H e (s)} + {}^6\text{L i (s)}$	-18.452	20.515
	$n + {}^4\text{H \#} + {}^5\text{B e}$	-48.975	54.451
	$n + {}^4\text{H e (s)} + {}^5\text{L i}$	-3.5396	3.9354
	$n + {}^4\text{L i \#} + {}^5\text{H e}$	-25.945	28.846
	$p + {}^4\text{H \#} + {}^5\text{L i}$	-26.172	29.099
	$p + {}^4\text{L i \#} + {}^5\text{H \#}$	-47.562	52.881
	$\text{D (s)} + \text{D (s)} + {}^6\text{L i (s)}$	-21.721	24.15
	$\text{D (s)} + \text{T} + {}^5\text{L i}$	-21.129	23.492
	$\text{D (s)} + {}^4\text{H \#} + {}^4\text{L i \#}$	-45.459	50.543
	$\text{T} + \text{T} + {}^4\text{L i \#}$	-36.383	40.452
	$\text{T} + {}^3\text{H e (s)} + {}^4\text{H e (s)}$	-13.669	15.198
	$\tau + {}^3\text{H e (s)} + {}^4\text{H \#}$	-37.066	41.211

REACTION ${}^{10}\text{B} + p$ total branch 9(32)compound nucleus ${}^{11}\text{C}^*$ A=11 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{11}\text{C}$	8.6897	0	(4, 7, 9)
2	$n + {}^{10}\text{C}$	-4.4333	4.8795	(7, 9)
3	$\text{D (s)} + {}^9\text{B}$	-6.2118	6.837	
4	$\text{T} + {}^8\text{B}$	-18.53	20.396	

(continued)

5	$^3\text{H e (s)} + ^8\text{B e}$	-0.53324	0.58691	(7)
6	$^4\text{H e (s)} + ^7\text{B e}$	1.1462	0	(4, 7, 9)
7	$\text{n} + \text{p} + ^9\text{B}$	-8.4364	9.2855	
8	$\text{p} + \text{p} + ^9\text{B e (s)}$	-6.586	7.2488	
9	$\text{p} + ^4\text{H e (s)} + ^6\text{L i (s)}$	-4.4597	4.9086	
	$^4\text{H \#} + ^7\text{B}$	-34.37	37.83	
	$^4\text{L i \#} + ^7\text{L i (s)}$	-20.687	22.769	
	$^5\text{H e} + ^6\text{B e}$	-10.424	11.473	
	$^5\text{L i} + ^6\text{L i (s)}$	-6.4258	7.0726	
	$^5\text{B e} + ^6\text{H e}$	-31.952	35.169	
	$\text{n} + \text{n} + ^9\text{C}$	-25.716	28.305	
	$\text{n} + \text{D (s)} + ^8\text{B}$	-24.788	27.283	
	$\text{n} + \text{T} + ^7\text{B}$	-31.551	34.727	
	$\text{n} + ^3\text{H e (s)} + ^7\text{B e}$	-19.432	21.387	
	$\text{n} + ^4\text{H e (s)} + ^6\text{B e}$	-9.5305	10.49	
	$\text{n} + ^4\text{L i \#} + ^6\text{L i (s)}$	-27.937	30.749	
	$\text{n} + ^5\text{H e} + ^5\text{B e}$	-33.822	37.226	
	$\text{n} + ^5\text{L i} + ^5\text{L i}$	-12.092	13.309	
	$\text{p} + \text{D (s)} + ^8\text{B e}$	-6.0268	6.6334	
	$\text{p} + \text{T} + ^7\text{B e}$	-18.668	20.547	
	$\text{p} + ^3\text{H e (s)} + ^7\text{L i (s)}$	-17.787	19.578	
	$\text{p} + ^4\text{H \#} + ^6\text{B e}$	-32.163	35.401	
	$\text{p} + ^4\text{L i \#} + ^6\text{H e}$	-30.662	33.748	
	$\text{p} + ^5\text{H \#} + ^5\text{B e}$	-55.439	61.019	
	$\text{p} + ^5\text{H e} + ^5\text{L i}$	-11.019	12.128	
	$\text{D (s)} + \text{D (s)} + ^7\text{B e}$	-22.701	24.985	
	$\text{D (s)} + \text{T} + ^6\text{B e}$	-27.12	29.85	
	$\text{D (s)} + ^3\text{H e (s)} + ^6\text{L i (s)}$	-22.813	25.109	
	$\text{D (s)} + ^4\text{H \#} + ^5\text{B e}$	-53.336	58.704	
	$\text{D (s)} + ^4\text{H e (s)} + ^5\text{L i}$	-7.9009	8.6962	
	$\text{D (s)} + ^4\text{L i \#} + ^5\text{H e}$	-30.306	33.356	
	$\text{T} + \text{T} + ^5\text{B e}$	-44.26	48.715	
	$\text{T} + ^3\text{H e (s)} + ^5\text{L i}$	-22.221	24.458	

(continued)

$T + {}^4\text{He}(s) + {}^4\text{Li}\#$	-23.155	25.486
$\tau + {}^3\text{He}(s) + {}^6\text{He}$	-21.913	24.118
$\tau + {}^4\text{H}\# + {}^4\text{Li}\#$	-46.552	51.237
$\tau + {}^4\text{He}(s) + {}^4\text{He}(s)$	-0.44135	0.48577

REACTION ${}^{11}\text{B} + p$ total branch 12(43)
 compound nucleus ${}^{12}\text{C}^*$ A=12 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{12}\text{C}(s)$	15.957	0	(4, 7, 9)
2	$n + {}^{11}\text{C}$	-2.7644	3.0175	(4, 6, 7, 9)
3	$D(s) + {}^{10}\text{B}(s)$	-9.2296	10.074	
4	$T + {}^9\text{B}$	-11.409	12.453	(9)
5	${}^3\text{He}(s) + {}^9\text{Be}(s)$	-10.322	11.267	
6	${}^4\text{He}(s) + {}^8\text{Be}$	8.5904	0	(3, 4, 5, 7, 9)
7	${}^6\text{Li}(s) + {}^6\text{Li}(s)$	-12.214	13.332	
8	$n + p + {}^{10}\text{B}(s)$	-11.454	12.503	
9	$p + p + {}^{10}\text{Be}$	-11.228	12.256	
10	$p + D(s) + {}^9\text{Be}(s)$	-15.816	17.263	
11	$p + {}^4\text{He}(s) + {}^7\text{Li}(s)$	-8.6637	9.4568	
12	$\alpha + {}^4\text{He}(s) + {}^4\text{He}(s)$	8.6823	0	(3, 4, 5, 7, 9)
	${}^4\text{H}\# + {}^8\text{B}$	-32.803	35.806	
	${}^4\text{Li}\# + {}^6\text{Li}$	-30.108	32.865	
	${}^5\text{H}\# + {}^7\text{B}$	-45.703	49.887	
	${}^5\text{He} + {}^7\text{Be}$	-11.202	12.227	
	${}^5\text{Li} + {}^7\text{Li}(s)$	-10.63	11.603	
	${}^5\text{Be} + {}^7\text{He}$	-43.853	47.867	
	${}^6\text{He} + {}^6\text{Be}$	-20.009	21.841	
	$n + n + {}^{10}\text{C}$	-15.887	17.342	
	$n + D(s) + {}^9\text{B}$	-17.666	19.283	

(continued)

$n + T + {}^8\text{B}$	-29.985	32.729
$n + {}^3\text{H e (s)} + {}^8\text{B e}$	-11.987	13.085
$n + {}^4\text{H \#} + {}^7\text{B}$	-45.824	50.019
$n + {}^4\text{H e (s)} + {}^7\text{B e}$	-10.308	11.252
$n + {}^4\text{L i \#} + {}^7\text{L i (s)}$	-32.141	35.083
$n + {}^6\text{H e} + {}^6\text{B e}$	-21.878	23.881
$n + {}^5\text{L i} + {}^6\text{L i (s)}$	-17.88	19.517
$n + {}^5\text{B e} + {}^6\text{H e}$	-43.407	47.38
$p + T + {}^8\text{B e}$	-11.224	12.251
$p + {}^3\text{H e (s)} + {}^8\text{L i}$	-27.209	29.699
$p + {}^4\text{H \#} + {}^7\text{B e}$	-32.941	35.956
$p + {}^4\text{L i \#} + {}^7\text{H e}$	-42.562	46.458
$p + {}^5\text{H \#} + {}^6\text{B e}$	-43.496	47.478
$p + {}^5\text{H e} + {}^6\text{L i (s)}$	-16.808	18.346
$p + {}^5\text{L i} + {}^6\text{H e}$	-20.604	22.49
$D (s) + D (s) + {}^8\text{B e}$	-15.256	16.653
$D (s) + T + {}^7\text{B e}$	-27.897	30.451
$D (s) + {}^3\text{H e (s)} + {}^7\text{L i (s)}$	-27.017	29.49
$D (s) + {}^4\text{H \#} + {}^6\text{B e}$	-41.393	45.182
$D (s) + {}^4\text{H e (s)} + {}^6\text{L i (s)}$	-13.689	14.942
$D (s) + {}^4\text{L i \#} + {}^6\text{H e}$	-39.891	43.543
$D (s) + {}^5\text{H \#} + {}^5\text{B e}$	-64.669	70.589
$D (s) + {}^5\text{H e} + {}^5\text{L i}$	-20.249	22.102
$T + T + {}^6\text{B e}$	-32.317	35.275
$T + {}^3\text{H e (s)} + {}^6\text{L i (s)}$	-28.01	30.574
$T + {}^4\text{H \#} + {}^5\text{B e}$	-58.533	63.891
$T + {}^4\text{H e (s)} + {}^5\text{L i}$	-13.098	14.297
$T + {}^4\text{L i \#} + {}^5\text{H e}$	-35.503	38.753
$\tau + p + {}^8\text{L i}$	-27.209	29.699
$\tau + {}^3\text{H e (s)} + {}^6\text{H e}$	-31.498	34.381
$\tau + {}^4\text{H \#} + {}^5\text{L i}$	-36.494	39.835
$\tau + {}^4\text{H e (s)} + {}^5\text{H e}$	-12.789	13.96

(continued)

$\tau + {}^4\text{Li} + {}^5\text{H}$	-57.884	63.183
$\alpha + {}^4\text{H} + {}^4\text{Li}$	-37.428	40.854

Table 3 D-induced Fusion Reaction

REACTION D + D total branch 5

compound nucleus ${}^4\text{He}^*$ A=4 Z=2

branch	Q(MeV)	Eth(MeV)	remarks
1 $\gamma + {}^4\text{He}(\text{s})$	23.847	0	(4, 8)
2 $\text{n} + {}^3\text{He}(\text{s})$	3.269	0	(3, 4, 5, 6, 7, 8)
3 $\text{p} + \text{T}$	4.0327	0	(3, 4, 5, 6, 7, 8)
4 $\text{n} + \text{p} + \text{D}(\text{s})$	-2.2246	4.4492	(8)
5 $2\text{n} + 2\text{p}$	-4.449	8.898	

REACTION T + D total branch 4(2)

compound nucleus ${}^5\text{He}^*$ A=5 Z=2

branch	Q(MeV)	Eth(MeV)	remarks
1 $\gamma + {}^5\text{He}$	16.696	0	(8)
2 $\text{n} + {}^4\text{He}(\text{s})$	17.589	0	(3, 4, 5, 6, 7)
3 $\text{n} + \text{n} + {}^3\text{He}(\text{s})$	-2.9883	4.9839	(8)
4 $\text{n} + \text{p} + \text{T}$	-2.2246	3.7101	(8)
$\text{p} + {}^4\text{He}\#$	-5.0433	8.4112	
$\text{n} + \text{D}(\text{s}) + \text{D}(\text{s})$	-6.2573	10.436	

REACTION $^3\text{He} + \text{D}$ total branch 6
 compound nucleus $^5\text{Li}^*$ A=5 Z=3

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^5\text{Li}$	16.387	0	(8)
2	$\text{p} + ^4\text{He}(\text{s})$	18.353	0	(3, 4, 5, 7, 8)
3	$\text{n} + \text{p} + ^3\text{He}(\text{s})$	-2.2246	3.7101	(8)
4	$\text{p} + \text{p} + \text{T}$	-1.4608	2.4364	
5	$\text{p} + \text{D}(\text{s}) + \text{D}(\text{s})$	-5.4935	9.1621	
6	$\text{n} + ^4\text{Li}\#$	-5.1242*	8.5462	n.o.

* ; The value given in F. Ajzenberg-Selove⁽²⁾ is -2.225 MeV. Their estimated ΔM value of ^4Li would be different from the one shown in Appendix B.

REACTION $^4\text{He} + \text{D}$ total branch 7(3)
 compound nucleus $^6\text{Li}^*$ A=6 Z=3

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^6\text{Li}(\text{s})$	1.4751	0	(8)
2	$\text{n} + ^5\text{Li}$	-4.1906	6.2993	
3	$\text{p} + ^5\text{He}$	-3.1183	4.6874	
4	$\text{T} + ^3\text{He}(\text{s})$	-14.32	21.527	
5	$\text{n} + \text{p} + ^4\text{He}(\text{s})$	-2.2246	3.344	
6	$\text{p} + \text{D}(\text{s}) + \text{T}$	-19.814	29.784	
7	$\text{D}(\text{s}) + \text{D}(\text{s}) + \text{D}(\text{s})$	-23.847	35.846	
	$\text{n} + \text{n} + ^4\text{Li}\#$	-25.702	38.635	
	$\text{n} + \text{D}(\text{s}) + ^3\text{He}(\text{s})$	-20.578	30.932	
	$\text{p} + \text{p} + ^4\text{He}\#$	-24.857	37.365	

REACTION ${}^6\text{Li} + \text{D}$ total branch 11(7)
 compound nucleus ${}^8\text{Be}^*$ A=8 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^8\text{Be}$	22.28	0	
2	$n + {}^7\text{Be}$	3.3814	0	(5, 7, 8)
3	$p + {}^7\text{Li}(s)$	5.0256	0	(5, 7, 8)
4	$\text{T} + {}^6\text{Li}$	0.59151	0	(8)
5	${}^3\text{He}(s) + {}^5\text{He}$	0.9001	0	(8)
6	${}^4\text{He}(s) + {}^4\text{He}(s)$	22.372	0	(5, 7, 8)
7	$n + p + {}^6\text{Li}(s)$	-2.2246	2.9695	
8	$n + {}^3\text{He}(s) + {}^4\text{He}(s)$	1.7938	0	(5, 7)
9	$p + p + {}^6\text{He}$	-4.9489	6.606	
10	$p + \text{T} + {}^4\text{He}(s)$	2.5576	0	(5, 7)
11	$\text{D}(s) + \text{D}(s) + {}^4\text{He}(s)$	-1.4751	1.9691	
	${}^4\text{H}\# + {}^4\text{Li}\#$	-23.739	31.687	
	$n + n + {}^6\text{Be}$	-7.2953	9.7381	
	$n + \text{D}(s) + {}^6\text{Li}$	-5.6658	7.5629	
	$n + \text{T} + {}^4\text{Li}\#$	-20.92	27.925	
	$p + \text{D}(s) + {}^6\text{He}$	-4.5934	6.1315	
	$p + {}^3\text{He}(s) + {}^4\text{H}\#$	-20.839	27.817	
	$\text{D}(s) + \text{T} + {}^3\text{He}(s)$	-15.796	21.085	

REACTION ${}^7\text{Li} + \text{D}$ total branch 9(16)
 compound nucleus ${}^9\text{Be}^*$ A=9 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^9\text{Be}(s)$	16.695	0	
2	$n + {}^8\text{Be}$	15.03	0	(4, 5, 7, 8)
3	$p + {}^8\text{Li}$	-0.1918	0.24687	(7, 8)

(continued)

4	T + ⁶ Li (s)	-0.99288	1.2779	(7.8)
5	³ He (s) + ⁵ He	-4.481	5.7674	
6	⁴ He (s) + ⁵ He	14.228	0	
7	n + n + ⁷ B e	-3.8688	4.9794	(7.8)
8	n + ⁴ He (s) + ⁴ He (s)	15.121	0	(4.5)
9	3 n + ⁷ B e	-10.126	13.033	
	⁴ H # + ⁵ Li	-9.4774	12.198	
	⁴ Li # + ⁵ H #	-30.867	39.729	
	n + p + ⁷ Li (s)	-2.2246	2.8632	
	n + D (s) + ⁶ Li (s)	-7.2502	9.3315	
	n + T + ⁵ Li	-6.6587	8.5702	
	n + ³ He (s) + ⁵ He	-6.3501	8.173	
	n + ⁴ H # + ⁴ Li #	-30.989	39.885	
	p + p + ⁷ He	-12.645	16.276	
	p + D (s) + ⁶ He	-9.9745	12.838	
	p + T + ⁵ He	-5.5863	7.19	
	p + ³ He (s) + ⁵ H #	-27.968	35.996	
	p + ⁴ H # + ⁴ He (s)	-7.5113	9.6676	
	D (s) + D (s) + ⁵ He	-9.619	12.38	
	D (s) + T + ⁴ He (s)	-2.468	3.1765	
	D (s) + ³ He (s) + ⁴ H #	-25.865	33.29	
	T + T + ³ He (s)	-16.789	21.608	

REACTION ⁹B e + D total branch 8(33)
 compound nucleus ¹¹B * A=11 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	γ + ¹¹ B (s)	15.816	0	(8.9)
2	n + ¹⁰ B (s)	4.3614	0	(8.9)
3	p + ¹⁰ B e	4.5875	0	(8)

(continued)

4	T + ⁸ B e	4.5919	0	(8)
5	³ H e (s) + ⁸ L i	-11.393	13.939	
6	⁴ H e (s) + ⁷ L i (s)	7.1518	0	(8)
7	⁵ H e + ⁶ L i (s)	-0.99208	1.2138	
8	T + ⁴ H e (s) + ⁴ H e (s)	4.6838	0	(8)
	⁴ H # + ⁷ B e	-17.125	20.952	
	⁴ L i # + ⁷ H e	-26.746	32.724	
	⁵ H # + ⁶ B e	-27.68	33.867	
	⁶ L i + ⁶ H e	-4.7888	5.859	
	n + n + ⁹ B	-4.075	4.9857	
	n + p + ⁹ B e (s)	-2.2246	2.7217	
	n + D (s) + ⁸ B e	-1.6654	2.0376	
	n + T + ⁷ B e	-14.306	17.504	
	n + ³ H e (s) + ⁷ L i (s)	-13.426	16.426	
	n + ⁴ H # + ⁵ B e	-27.802	34.015	
	n + ⁴ H e (s) + ⁶ L i (s)	-0.098365	0.12035	
	n + ⁴ L i # + ⁶ H e	-26.3	32.178	
	n + ⁵ H # + ⁵ B e	-51.078	62.493	
	n + ⁵ H e + ⁵ L i	-6.6578	8.1458	
	p + p + ⁹ L i	-15.048	18.412	
	p + D (s) + ⁸ L i	-16.887	20.661	
	p + T + ⁷ L i (s)	-12.662	15.492	
	p + ³ H e (s) + ⁷ H e	-23.847	29.176	
	p + ⁴ H # + ⁶ L i (s)	-22.731	27.811	
	p + ⁴ H e (s) + ⁶ H e	-2.8227	3.4536	
	p + ⁵ H # + ⁵ L i	-28.276	34.595	
	p + ⁵ H e + ⁵ H e	-5.5855	6.8338	
	D (s) + D (s) + ⁷ L i (s)	-16.695	20.426	
	D (s) + T + ⁶ L i (s)	-17.688	21.641	
	D (s) + ³ H e (s) + ⁶ H e	-21.176	25.908	
	D (s) + ⁴ H # + ⁵ L i	-26.172	32.021	
	D (s) + ⁴ H e (s) + ⁵ H e	-2.4672	3.0186	
	D (s) + ⁴ L i # + ⁵ H #	-47.562	58.192	

(continued)

T + T + ⁵ Li	-17.096	20.917
T + ³ He(s) + ⁵ He	-16.788	20.54
T + ⁴ H# + ⁴ Li#	-41.426	50.685
τ + ³ He(s) + ⁵ H#	-39.169	47.923
τ + ⁴ H# + ⁴ He(s)	-18.713	22.895

REACTION ¹⁰B + D total branch 12(43)
 compound nucleus ¹²C* A=12 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	γ + ¹² C(s)	25.187	0	
2	n + ¹¹ C	6.4651	0	(6, 7, 9)
3	p + ¹¹ B(s)	9.2296	0	(7)
4	T + ⁹ B	-2.1791	2.6174	
5	³ He(s) + ⁹ Be(s)	-1.0924	1.3122	
6	⁴ He(s) + ⁸ Be	17.82	0	(7)
7	⁵ He + ⁷ Be	-1.9721	2.3688	
8	⁶ Li + ⁷ Li(s)	-1.4002	1.6818	
9	⁶ Li(s) + ⁶ Li(s)	-2.9846	3.5849	
10	p + p + ¹⁰ Be	-1.9985	2.4004	
11	D(s) + ⁴ He(s) + ⁶ Li(s)	-4.4597	5.3568	
12	α + ⁴ He(s) + ⁴ He(s)	17.912	0	(7)
	⁴ H# + ⁸ B	-23.574	28.316	
	⁴ Li# + ⁸ Li	-20.879	25.079	
	⁵ H# + ⁷ B	-36.473	43.81	
	⁵ Be + ⁷ He	-34.623	41.588	
	⁶ He + ⁶ Be	-10.78	12.948	
	n + n + ¹⁰ C	-6.6578	7.9971	
	n + p + ¹⁰ B(s)	-2.2246	2.6721	
	n + D(s) + ⁹ B	-8.4364	10.133	

(continued)

$n + T + {}^6\text{B}$	-20.755	24.93
$n + {}^3\text{H e (s)} + {}^6\text{B e}$	-2.7578	3.3126
$n + {}^4\text{H \#} + {}^7\text{B}$	-36.595	43.956
$n + {}^4\text{H e (s)} + {}^7\text{B e}$	-1.0784	1.2953
$n + {}^4\text{L i \#} + {}^7\text{L i (s)}$	-22.912	27.52
$n + {}^6\text{H e} + {}^6\text{B e}$	-12.649	15.193
$n + {}^5\text{L i} + {}^6\text{L i (s)}$	-8.6504	10.39
$n + {}^5\text{B e} + {}^6\text{H e}$	-34.177	41.052
$p + \text{D (s)} + {}^9\text{B e (s)}$	-6.586	7.9107
$p + T + {}^8\text{B e}$	-1.9941	2.3952
$p + {}^3\text{H e (s)} + {}^8\text{L i}$	-17.979	21.596
$p + {}^4\text{H \#} + {}^7\text{B e}$	-23.711	28.481
$p + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	0.56585	0
$p + {}^4\text{L i \#} + {}^7\text{H e}$	-33.332	40.037
$p + {}^5\text{H \#} + {}^6\text{B e}$	-34.266	41.159
$p + {}^5\text{H e} + {}^6\text{L i (s)}$	-7.578	9.1023
$p + {}^5\text{L i} + {}^6\text{H e}$	-11.375	13.663
$\text{D (s)} + \text{D (s)} + {}^8\text{B e}$	-6.0268	7.2391
$\text{D (s)} + T + {}^7\text{B e}$	-18.668	22.423
$\text{D (s)} + {}^3\text{H e (s)} + {}^7\text{L i (s)}$	-17.787	21.365
$\text{D (s)} + {}^4\text{H \#} + {}^6\text{B e}$	-32.163	38.633
$\text{D (s)} + {}^4\text{L i \#} + {}^6\text{H e}$	-30.662	36.829
$\text{D (s)} + {}^5\text{H \#} + {}^5\text{B e}$	-55.439	66.591
$\text{D (s)} + {}^5\text{H e} + {}^5\text{L i}$	-11.019	13.236
$T + n + {}^8\text{B}$	-20.755	24.93
$T + T + {}^6\text{B e}$	-23.087	27.731
$T + {}^3\text{H e (s)} + {}^6\text{L i (s)}$	-18.78	22.558
$T + {}^4\text{H \#} + {}^5\text{B e}$	-49.303	59.221
$T + {}^4\text{H e (s)} + {}^5\text{L i}$	-3.8682	4.6463
$T + {}^4\text{L i \#} + {}^5\text{H e}$	-26.273	31.558
$\tau + {}^3\text{H e (s)} + {}^6\text{H e}$	-22.268	26.748
$\tau + {}^4\text{H \#} + {}^5\text{L i}$	-27.265	32.749
$\tau + {}^4\text{H e (s)} + {}^5\text{H e}$	-3.5596	4.2757
$\tau + {}^4\text{L i \#} + {}^5\text{H \#}$	-48.655	58.442

(continued)

 $\alpha + {}^4\text{H}\# + {}^4\text{L i}\#$ -28.198 33.87

REACTION ${}^{11}\text{B} + \text{D}$ total branch 11(53)
 compound nucleus ${}^{13}\text{C}^*$ A=13 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{13}\text{C}(\text{s})$	18.679	0	
2	$\text{n} + {}^{12}\text{C}(\text{s})$	13.732	0	(7)
3	$\text{p} + {}^{12}\text{B}$	1.1453	0	(7)
4	$\text{T} + {}^{10}\text{B}(\text{s})$	-5.1969	6.1476	(9)
5	${}^3\text{H e}(\text{s}) + {}^{10}\text{B e}$	-5.7345	6.7836	(9)
6	${}^4\text{H e}(\text{s}) + {}^9\text{B e}(\text{s})$	8.0312	0	
7	${}^6\text{H e} + {}^7\text{B e}$	-11.557	13.672	
8	${}^6\text{L i}(\text{s}) + {}^7\text{L i}(\text{s})$	-7.1886	8.5037	
9	$\text{n} + \text{n} + {}^{11}\text{C}$	-4.989	5.9017	(6, 7)
10	$\text{n} + \text{p} + {}^{11}\text{B}(\text{s})$	-2.2246	2.6316	
11	$\text{n} + {}^4\text{H e}(\text{s}) + {}^8\text{B e}$	6.3658	0	
	${}^4\text{H}\# + {}^9\text{B}$	-16.452	19.462	
	${}^4\text{L i}\# + {}^9\text{L i}$	-28.27	33.442	
	${}^5\text{H}\# + {}^8\text{B}$	-34.906	41.292	
	${}^5\text{H e} + {}^8\text{B e}$	5.4721	0	
	${}^5\text{L i} + {}^8\text{L i}$	-10.822	12.801	
	${}^5\text{B e} + {}^8\text{H e}$	-43.494	51.451	
	${}^6\text{B e} + {}^7\text{H e}$	-22.68	26.829	
	$\text{n} + \text{D}(\text{s}) + {}^{10}\text{B}(\text{s})$	-11.454	13.55	
	$\text{n} + \text{T} + {}^9\text{B}$	-13.633	16.127	
	$\text{n} + {}^3\text{H e}(\text{s}) + {}^9\text{B e}(\text{s})$	-12.547	14.842	
	$\text{n} + {}^4\text{H}\# + {}^8\text{B}$	-35.028	41.436	
	$\text{n} + {}^4\text{L i}\# + {}^8\text{L i}$	-32.333	38.248	
	$\text{n} + {}^5\text{H}\# + {}^7\text{B}$	-47.928	56.696	

(continued)

$n + {}^5\text{H e} + {}^7\text{B e}$	-13.426	15.883
$n + {}^6\text{L i} + {}^7\text{L i (s)}$	-12.854	15.206
$n + {}^5\text{B e} + {}^7\text{H e}$	-46.078	54.507
$n + {}^6\text{H e} + {}^6\text{B e}$	-22.234	26.301
$n + {}^6\text{L i (s)} + {}^6\text{L i (s)}$	-14.439	17.08
$p + p + {}^{11}\text{B e}$	-12.948	15.317
$p + \text{D (s)} + {}^{10}\text{B e}$	-11.228	13.282
$p + \text{T} + {}^9\text{B e (s)}$	-11.783	13.938
$p + {}^3\text{H e (s)} + {}^9\text{L i}$	-25.37	30.012
$p + {}^4\text{H \#} + {}^8\text{B e}$	-16.267	19.243
$p + {}^4\text{H e (s)} + {}^8\text{L i}$	-8.8555	10.476
$p + {}^4\text{L i \#} + {}^8\text{H e}$	-42.203	49.924
$p + {}^5\text{H \#} + {}^7\text{B e}$	-35.044	41.455
$p + {}^5\text{H e} + {}^7\text{L i (s)}$	-11.782	13.937
$p + {}^5\text{L i} + {}^7\text{H e}$	-23.275	27.533
$p + {}^6\text{H e} + {}^6\text{L i (s)}$	-17.163	20.303
$\text{D (s)} + \text{D (s)} + {}^9\text{B e (s)}$	-15.816	18.709
$\text{D (s)} + \text{T} + {}^8\text{B e}$	-11.224	13.277
$\text{D (s)} + {}^3\text{H e (s)} + {}^8\text{L i}$	-27.209	32.186
$\text{D (s)} + {}^4\text{H \#} + {}^7\text{B e}$	-32.941	38.967
$\text{D (s)} + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	-8.6637	10.249
$\text{D (s)} + {}^4\text{L i \#} + {}^7\text{H e}$	-42.562	50.349
$\text{D (s)} + {}^5\text{H \#} + {}^6\text{B e}$	-43.496	51.453
$\text{D (s)} + {}^5\text{H e} + {}^6\text{L i (s)}$	-16.808	19.882
$\text{D (s)} + {}^5\text{L i} + {}^6\text{H e}$	-20.604	24.374
$\text{T} + \text{T} + {}^7\text{B e}$	-23.865	28.231
$\text{T} + {}^3\text{H e (s)} + {}^7\text{L i (s)}$	-22.984	27.189
$\text{T} + {}^4\text{H \#} + {}^6\text{B e}$	-37.36	44.195
$\text{T} + {}^4\text{H e (s)} + {}^6\text{L i (s)}$	-9.6566	11.423
$\text{T} + {}^4\text{L i \#} + {}^6\text{H e}$	-35.858	42.419
$\text{T} + {}^5\text{H \#} + {}^5\text{B e}$	-60.636	71.729
$\text{T} + {}^5\text{H e} + {}^5\text{L i}$	-16.216	19.183
$\tau + {}^3\text{H e (s)} + {}^7\text{H e}$	-34.169	40.42
$\tau + {}^4\text{H \#} + {}^6\text{L i (s)}$	-33.053	39.1

(continued)

$\tau + {}^4\text{He}(s) + {}^6\text{He}$	-13.145	15.549
$\tau + {}^5\text{H}\# + {}^6\text{Li}$	-38.597	45.659
$\tau + {}^5\text{He} + {}^5\text{He}$	-15.907	18.818
$\alpha + {}^4\text{H}\# + {}^6\text{Li}$	-18.141	21.46
$\alpha + {}^4\text{He}(s) + {}^5\text{He}$	5.564	0
$\alpha + {}^4\text{Li}\# + {}^5\text{H}\#$	-39.531	46.763

Table 4 T-induced Fusion Reaction

REACTION T + T total branch 5(3)
 compound nucleus ${}^6\text{He}^*$ A=6 Z=2

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^5\text{He}$	10.438	0	
2	$\text{D}(s) + {}^4\text{He}\#$	-9.076	18.152	
3	$n + n + {}^4\text{He}(s)$	11.332	0	(3, 4, 5, 7, 8)
4	$n + \text{D}(s) + \text{T}$	-6.2573	12.515	
5	$3n + {}^3\text{He}$	-9.2457	18.491	
	$\gamma + {}^6\text{He}$	12.308	0	
	$p + {}^5\text{He}\#$	-11.179	22.358	
	$n + p + {}^4\text{He}\#$	-11.301	22.601	

REACTION ${}^3\text{He} + \text{T}$ total branch 9(2)
 compound nucleus ${}^6\text{Li}^*$ A=6 Z=3

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^6\text{Li}(s)$	15.796	0	(8)
2	$n + {}^5\text{Li}$	10.13	0	(3, 8)
3	$p + {}^5\text{He}$	11.202	0	(3, 8)
4	$\text{D}(s) + {}^4\text{He}(s)$	14.32	0	(3, 4, 5, 7, 8)
5	$n + p + {}^4\text{He}(s)$	12.096	0	(3, 4, 5, 7, 8)
6	$n + \text{D}(s) + {}^3\text{He}(s)$	-6.2573	12.515	
7	$p + \text{D}(s) + \text{T}$	-5.4935	10.987	
8	$\text{D}(s) + \text{D}(s) + \text{D}(s)$	-9.5262	19.053	
9	$2n + p + {}^3\text{He}$	-8.4820	18.491	
	$n + n + {}^4\text{Li}\#$	-11.382	22.763	

(continued)

$p + p + {}^4\text{H}\#$ -10.537 21.074

REACTION ${}^4\text{H e} + \text{T}$ total branch 7(7)
 compound nucleus ${}^7\text{L i}^*$ A=7 Z=3

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^7\text{L i}(\text{s})$	2.468	0	(4, 7, 8)
2	$n + {}^6\text{L i}(\text{s})$	-4.7821	8.3856	(4, 7)
3	$p + {}^6\text{H e}$	-7.5065	13.163	
4	$\text{D}(\text{s}) + {}^5\text{H e}$	-7.151	12.539	
5	$n + n + {}^5\text{L i}$	-10.448	18.321	
6	$n + \text{D}(\text{s}) + {}^4\text{H e}(\text{s})$	-6.2573*	10.972	
7	$2n + p + {}^4\text{H e}$	-8.3820	14.698	
	${}^3\text{H e}(\text{s}) + {}^4\text{H}\#$	-23.396	41.026	
	$n + p + {}^5\text{H e}$	-9.3756	16.44	
	$n + \text{T} + {}^3\text{H e}(\text{s})$	-20.578	36.084	
	$p + p + {}^5\text{H}\#$	-30.993	54.347	
	$p + \text{D}(\text{s}) + {}^4\text{H}\#$	-28.89	50.659	
	$p + \text{T} + \text{T}$	-19.814	34.744	
	$\text{D}(\text{s}) + \text{D}(\text{s}) + \text{T}$	-23.847	41.816	

* ; F. Ajzenberg-Selove⁽²⁾ shows -0.4105 MeV. This might be erroneous.

REACTION ${}^6\text{Li} + \text{T}$ total branch 8(18)compound nucleus ${}^9\text{Be}^*$ A=9 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^9\text{Be}(s)$	17.688	0	
2	$n + {}^9\text{Be}$	16.022	0	(8)
3	$p + {}^6\text{Li}$	0.80108	0	(8)
4	$\text{D}(s) + {}^7\text{Li}(s)$	0.99289	0	(8)
5	${}^3\text{He}(s) + {}^6\text{He}$	-3.4881	5.2371	
6	${}^4\text{He}(s) + {}^5\text{He}$	15.221	0	
7	$n + n + {}^7\text{Be}$	-2.8759	4.318	(7, 8)
8	$n + {}^4\text{He}(s) + {}^4\text{He}(s)$	16.114	0	(8)
	${}^4\text{H}\# + {}^5\text{Li}$	-8.4845	12.739	
	${}^4\text{Li}\# + {}^5\text{H}\#$	-29.874	44.854	
	$n + p + {}^7\text{Li}(s)$	-1.2317	1.8493	
	$n + \text{D}(s) + {}^6\text{Li}(s)$	-6.2573	9.3948	
	$n + \text{T} + {}^5\text{Li}$	-5.6658	8.5067	
	$n + {}^3\text{He}(s) + {}^5\text{He}$	-5.3572	8.0433	
	$n + {}^4\text{H}\# + {}^4\text{Li}\#$	-29.996	45.036	
	$p + p + {}^7\text{He}$	-11.653	17.495	
	$p + \text{D}(s) + {}^6\text{He}$	-8.9816	13.485	
	$p + \text{T} + {}^5\text{He}$	-4.5934	6.8966	
	$p + {}^3\text{He}(s) + {}^5\text{H}\#$	-26.975	40.5	
	$p + {}^4\text{H}\# + {}^4\text{He}(s)$	-6.5184	9.7869	
	$\text{D}(s) + \text{D}(s) + {}^5\text{He}$	-8.6261	12.951	
	$\text{D}(s) + \text{T} + {}^4\text{He}(s)$	-1.4751	2.2148	
	$\text{D}(s) + {}^3\text{He}(s) + {}^4\text{H}\#$	-24.872	37.343	
	$\text{T} + \text{T} + {}^3\text{He}(s)$	-15.796	23.716	

REACTION ${}^7\text{Li} + \text{T}$ total branch 9(20)compound nucleus ${}^{10}\text{Be}^*$ A=10 Z=4

branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{10}\text{Be}$	17.25	0
2	$n + {}^9\text{Be}(s)$	10.438	0 (8, 9)
3	$p + {}^9\text{Li}$	-2.3862	3.412 (8)
4	$\text{D}(s) + {}^8\text{Li}$	-4.2245	6.0406 (8)
5	${}^3\text{He}(s) + {}^7\text{He}$	-11.185	15.993
6	${}^4\text{He}(s) + {}^6\text{He}$	9.8395	0 (8)
7	$n + n + {}^8\text{Be}$	8.7722	0 (4, 5, 7)
8	$n + {}^4\text{He}(s) + {}^5\text{He}$	7.9704	0
9	$3n + {}^7\text{Be}$	-10.126	14.479 (7)
	${}^4\text{H}\# + {}^6\text{Li}(s)$	-10.069	14.397
	${}^5\text{H}\# + {}^5\text{Li}$	-15.613	22.325
	${}^5\text{He} + {}^5\text{He}$	7.0767	0
	$n + p + {}^8\text{Li}$	-6.4491	9.2214
	$n + \text{D}(s) + {}^7\text{Li}(s)$	-6.2573	8.9472
	$n + \text{T} + {}^6\text{Li}(s)$	-7.2502	10.367
	$n + {}^3\text{He}(s) + {}^6\text{He}$	-10.738	15.354
	$n + {}^4\text{H}\# + {}^5\text{Li}$	-15.735	22.499
	$n + {}^4\text{Li}\# + {}^5\text{H}\#$	-37.125	53.084
	$p + p + {}^6\text{He}$	-16.319	23.335
	$p + \text{D}(s) + {}^7\text{He}$	-16.678	23.848
	$p + \text{T} + {}^6\text{He}$	-9.9745	14.262
	$p + {}^4\text{H}\# + {}^5\text{He}$	-14.662	20.965
	$p + {}^4\text{He}(s) + {}^5\text{H}\#$	-13.647	19.514
	$\text{D}(s) + \text{D}(s) + {}^6\text{He}$	-14.007	20.029
	$\text{D}(s) + \text{T} + {}^5\text{He}$	-9.618	13.754
	$\text{D}(s) + {}^3\text{He}(s) + {}^5\text{H}\#$	-32.0	45.757
	$\text{D}(s) + {}^4\text{H}\# + {}^4\text{He}(s)$	-11.544	16.507
	$\text{T} + \text{T} + {}^4\text{He}(s)$	-2.468	3.529

(continued)

 $T + {}^3\text{H e (s)} + {}^4\text{H \#}$ -25.865 36.983

REACTION ${}^9\text{B e} + \text{T}$ total branch 7(39)
 compound nucleus ${}^{12}\text{B}^*$ A=12 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^{11}\text{B (s)}$	9.5582	0	(8)
2	$p + {}^{11}\text{B e}$	-1.1654	1.5554	
3	$\text{D (s)} + {}^{10}\text{B e}$	0.55479	0	
4	${}^4\text{H e (s)} + {}^8\text{L i}$	2.9273	0	
5	${}^5\text{H e} + {}^7\text{L i (s)}$	0.00081062	0	
6	${}^6\text{H e} + {}^6\text{L i (s)}$	-5.3803	7.1809	
7	$n + \text{T} + {}^8\text{B e}$	-1.6654	2.2227	
	$\gamma + {}^{12}\text{B}$	12.928	0	
	${}^3\text{H e (s)} + {}^9\text{L i}$	-13.588	18.135	
	${}^4\text{H \#} + {}^8\text{B e}$	-4.4841	5.9848	
	${}^4\text{L i \#} + {}^8\text{H e}$	-30.42	40.601	
	${}^5\text{H \#} + {}^7\text{B e}$	-23.261	31.046	
	${}^6\text{L i} + {}^7\text{H e}$	-11.492	15.338	
	$n + n + {}^{10}\text{B (s)}$	-1.8959	2.5304	
	$n + p + {}^{10}\text{B e}$	-1.6698	2.2286	
	$n + \text{D (s)} + {}^9\text{B e (s)}$	-6.2573	8.3514	
	$n + {}^3\text{H e (s)} + {}^8\text{L i}$	-17.65	23.557	
	$n + {}^4\text{H \#} + {}^7\text{B e}$	-23.382	31.208	
	$n + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	0.89452	0	
	$n + {}^4\text{L i \#} + {}^7\text{H e}$	-33.004	44.049	
	$n + {}^5\text{H \#} + {}^6\text{B e}$	-33.938	45.296	
	$n + {}^5\text{H e} + {}^6\text{L i (s)}$	-7.2494	9.6755	
	$n + {}^5\text{L i} + {}^6\text{H e}$	-11.046	14.743	
	$p + p + {}^{10}\text{L i}$	-22.11	29.51	

(continued)

$p + D(s) + {}^9Li$	-19.081	25.467
$p + T + {}^8Li$	-16.887	22.538
$p + {}^3He(s) + {}^8He$	-27.521	36.731
$p + {}^4He\# + {}^7Li(s)$	-21.738	29.013
$p + {}^4He(s) + {}^7He$	-9.5263	12.714
$p + {}^5He\# + {}^6Li(s)$	-28.867	38.528
$p + {}^5He + {}^6He$	-9.9737	13.312
$D(s) + D(s) + {}^8Li$	-20.919	27.92
$D(s) + T + {}^7Li(s)$	-16.695	22.282
$D(s) + {}^3He(s) + {}^7He$	-27.88	37.21
$D(s) + {}^4He\# + {}^6Li(s)$	-26.764	35.721
$D(s) + {}^4He(s) + {}^6He$	-6.8554	9.1497
$D(s) + {}^5He\# + {}^5Li$	-32.308	43.121
$D(s) + {}^5He + {}^5He$	-9.61819	12.837
$T + T + {}^6Li(s)$	-17.688	23.607
$T + {}^3He(s) + {}^6He$	-21.176	28.263
$T + {}^4He\# + {}^5Li$	-26.172	34.931
$T + {}^4He(s) + {}^5He$	-2.4672	3.2929
$T + {}^4Li\# + {}^5He\#$	-47.562	63.48
$\tau + {}^4He\# + {}^5He$	-25.864	34.519
$\tau + {}^4He(s) + {}^5He\#$	-24.849	33.165
$\alpha + {}^4He\# + {}^4He(s)$	-4.3922	5.8621

REACTION ${}^{10}B + T$ total branch 6(58)
 compound nucleus ${}^{13}C^*$ A=13 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$p + {}^{12}B$	6.3422	0	
2	$D(s) + {}^{11}B(s)$	5.1969	0	
3	${}^4He(s) + {}^9Be(s)$	13.228	0	
4	${}^6He + {}^7Be$	-6.3603	8.2761	

(continued)

5	$p + {}^4\text{H e (s)} + {}^8\text{L i}$	-3.6587	4.7607
6	${}^3\text{H e (s)} + {}^{10}\text{B e}$	-0.53763	0.69957 not reported
	$\gamma + {}^{13}\text{C (s)}$	23.876	0
	$n + {}^{12}\text{C (s)}$	18.929	0
	${}^4\text{H \#} + {}^9\text{B}$	-11.255	14.645
	${}^4\text{L i \#} + {}^9\text{L i}$	-23.073	30.023
	${}^5\text{H \#} + {}^8\text{B}$	-29.71	38.659
	${}^5\text{H e} + {}^8\text{B e}$	10.669	0
	${}^5\text{L i} + {}^8\text{L i}$	-5.6247	7.319
	${}^5\text{B e} + {}^8\text{H e}$	-38.297	49.833
	${}^6\text{L i (s)} + {}^7\text{L i (s)}$	-1.9917	2.5916
	${}^6\text{B e} + {}^7\text{H e}$	-17.483	22.75
	$n + n + {}^{11}\text{C}$	0.20785	0
	$n + p + {}^{11}\text{B (s)}$	2.9723	0
	$n + \text{D (s)} + {}^{10}\text{B (s)}$	-6.2573	8.1421
	$n + \text{T} + {}^9\text{B}$	-8.4364	10.978
	$n + {}^3\text{H e (s)} + {}^9\text{B e (s)}$	-7.3497	9.5635
	$n + {}^4\text{H \#} + {}^8\text{B}$	-29.831	38.817
	$n + {}^4\text{H e (s)} + {}^8\text{B e}$	11.563	0
	$n + {}^4\text{L i \#} + {}^8\text{L i}$	-27.136	35.31
	$n + {}^5\text{H \#} + {}^7\text{B}$	-42.731	55.602
	$n + {}^6\text{H e} + {}^7\text{B e}$	-8.2294	10.708
	$n + {}^5\text{L i} + {}^7\text{L i (s)}$	-7.6575	9.964
	$n + {}^5\text{B e} + {}^7\text{H e}$	-40.881	53.195
	$n + {}^6\text{H e} + {}^6\text{B e}$	-17.037	22.169
	$n + {}^6\text{L i (s)} + {}^6\text{L i (s)}$	-9.2419	12.026
	$p + p + {}^{11}\text{B e}$	-7.7514	10.086
	$p + \text{D (s)} + {}^{10}\text{B e}$	-6.0312	7.8478
	$p + \text{T} + {}^9\text{B e (s)}$	-6.586	8.5697
	$p + {}^3\text{H e (s)} + {}^9\text{L i}$	-20.174	26.25
	$p + {}^4\text{H \#} + {}^8\text{B e}$	-11.07	14.405
	$p + {}^4\text{L i \#} + {}^8\text{H e}$	-37.006	48.153
	$p + {}^5\text{H \#} + {}^7\text{B e}$	-29.847	38.837

(continued)

$p + {}^5\text{H e} + {}^7\text{L i}(\text{s})$	-6.5851	8.5687
$p + {}^5\text{L i} + {}^7\text{H e}$	-18.078	23.524
$p + {}^6\text{H e} + {}^6\text{L i}(\text{s})$	-11.966	15.571
$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^9\text{B e}(\text{s})$	-10.619	13.817
$\text{D}(\text{s}) + \text{T} + {}^8\text{B e}$	-6.0268	7.8421
$\text{D}(\text{s}) + {}^3\text{H e}(\text{s}) + {}^6\text{L i}$	-22.012	28.642
$\text{D}(\text{s}) + {}^4\text{H}\# + {}^7\text{B e}$	-27.744	36.101
$\text{D}(\text{s}) + {}^4\text{H e}(\text{s}) + {}^7\text{L i}(\text{s})$	-3.4669	4.5111
$\text{D}(\text{s}) + {}^4\text{L i}\# + {}^7\text{H e}$	-37.365	48.62
$\text{D}(\text{s}) + {}^5\text{H}\# + {}^6\text{B e}$	-38.299	49.835
$\text{D}(\text{s}) + {}^5\text{H e} + {}^6\text{L i}(\text{s})$	-11.611	15.108
$\text{D}(\text{s}) + {}^5\text{L i} + {}^6\text{H e}$	-15.407	20.048
$\text{T} + \text{T} + {}^7\text{B e}$	-18.668	24.291
$\text{T} + {}^3\text{H e}(\text{s}) + {}^7\text{L i}(\text{s})$	-17.787	23.145
$\text{T} + {}^4\text{H}\# + {}^6\text{B e}$	-32.163	41.851
$\text{T} + {}^4\text{H e}(\text{s}) + {}^6\text{L i}(\text{s})$	-4.4597	5.8031
$\text{T} + {}^4\text{L i}\# + {}^6\text{H e}$	-30.662	39.897
$\text{T} + {}^5\text{H}\# + {}^5\text{B e}$	-55.439	72.138
$\text{T} + {}^5\text{H e} + {}^5\text{L i}$	-11.019	14.338
$\tau + {}^3\text{H e}(\text{s}) + {}^7\text{H e}$	-28.972	37.699
$\tau + {}^4\text{H}\# + {}^6\text{L i}(\text{s})$	-27.856	36.247
$\tau + {}^4\text{H e}(\text{s}) + {}^6\text{H e}$	-7.9478	10.342
$\tau + {}^5\text{H}\# + {}^5\text{L i}$	-33.401	43.461
$\tau + {}^5\text{H e} + {}^5\text{H e}$	-10.711	13.937
$\alpha + {}^4\text{H}\# + {}^5\text{L i}$	-12.944	16.843
$\alpha + {}^4\text{H e}(\text{s}) + {}^5\text{H e}$	10.761	0
$\alpha + {}^4\text{L i}\# + {}^5\text{H}\#$	-34.334	44.676

REACTION $^{11}\text{B} + \text{T}$ total branch 4(67)
 compound nucleus $^{14}\text{C}^*$ A=14 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + ^{13}\text{C}(\text{s})$	12.422	0	
2	$p + ^{13}\text{B}$	-0.23342	0.29737	
3	$^4\text{He}(\text{s}) + ^{10}\text{Be}$	8.586	0	
4	$\alpha + ^4\text{He}(\text{s}) + ^6\text{He}$	1.1758	0	
	$\gamma + ^{14}\text{C}$	20.598	0	
	$\text{D}(\text{s}) + ^{12}\text{B}$	-2.8874	3.6784	
	$^8\text{He}(\text{s}) + ^{11}\text{Be}$	-11.487	14.634	
	$^4\text{H}\# + ^{10}\text{B}(\text{s})$	-14.273	18.183	
	$^4\text{Li}\# + ^{10}\text{Li}$	-35.332	45.011	
	$^5\text{H}\# + ^9\text{B}$	-22.588	28.776	
	$^5\text{He} + ^9\text{Be}(\text{s})$	0.88021	0	
	$^5\text{Li} + ^9\text{Li}$	-13.016	16.582	
	$^5\text{Be} + ^9\text{He}$	-50.892	64.834	
	$^6\text{He} + ^8\text{Be}$	1.0839	0	
	$^6\text{Li}(\text{s}) + ^8\text{Li}$	-11.413	14.54	
	$^6\text{Be} + ^8\text{He}$	-26.354	33.574	
	$^7\text{He} + ^7\text{Be}$	-18.261	23.263	
	$^7\text{Li}(\text{s}) + ^7\text{Li}(\text{s})$	-6.1957	7.893	
	$n + n + ^{12}\text{C}(\text{s})$	7.4752	0	
	$n + p + ^{12}\text{B}$	-5.112	6.5124	
	$n + \text{D}(\text{s}) + ^{11}\text{B}(\text{s})$	-6.2573	7.9715	
	$n + \text{T} + ^{10}\text{B}(\text{s})$	-11.454	14.592	
	$n + ^3\text{He}(\text{s}) + ^{10}\text{Be}$	-11.992	15.277	
	$n + ^4\text{H}\# + ^9\text{B}$	-22.709	28.931	
	$n + ^4\text{He}(\text{s}) + ^9\text{Be}(\text{s})$	1.7739	0	
	$n + ^4\text{Li}\# + ^9\text{Li}$	-34.527	43.986	
	$n + ^5\text{H}\# + ^8\text{B}$	-41.164	52.441	
	$n + ^5\text{He} + ^8\text{Be}$	-0.78519	1.0003	
	$n + ^5\text{Li} + ^8\text{Li}$	-17.079	21.758	

(continued)

$n + {}^5\text{B e} + {}^8\text{H e}$	-49.751	63.381
$n + {}^6\text{H e} + {}^7\text{B e}$	-17.814	22.695
$n + {}^6\text{L i (s)} + {}^7\text{L i (s)}$	-13.446	17.129
$n + {}^6\text{B e} + {}^7\text{H e}$	-28.937	36.865
$p + p + {}^{12}\text{B e}$	-16.037	20.431
$p + \text{D (s)} + {}^{11}\text{B e}$	-16.981	21.633
$p + \text{T} + {}^{10}\text{B e}$	-11.228	14.304
$p + {}^3\text{H e (s)} + {}^{10}\text{L i}$	-32.432	41.317
$p + {}^4\text{H \#} + {}^9\text{B e (s)}$	-20.859	26.573
$p + {}^4\text{H e (s)} + {}^9\text{L i}$	-11.05	14.077
$p + {}^4\text{L i \#} + {}^9\text{H e}$	-49.601	63.19
$p + {}^5\text{H \#} + {}^8\text{B e}$	-22.403	28.54
$p + {}^5\text{H e} + {}^8\text{L i}$	-16.007	20.392
$p + {}^5\text{L i} + {}^8\text{H e}$	-26.949	34.332
$p + {}^6\text{H e} + {}^7\text{L i (s)}$	-16.17	20.6
$p + {}^6\text{L i (s)} + {}^7\text{H e}$	-23.867	30.405
$\text{D (s)} + \text{D (s)} + {}^{10}\text{B e}$	-15.261	19.441
$\text{D (s)} + \text{T} + {}^9\text{B e (s)}$	-15.816	20.148
$\text{D (s)} + {}^3\text{H e (s)} + {}^9\text{L i}$	-29.403	37.458
$\text{D (s)} + {}^4\text{H \#} + {}^8\text{B e}$	-20.3	25.861
$\text{D (s)} + {}^4\text{H e (s)} + {}^8\text{L i}$	-12.888	16.419
$\text{D (s)} + {}^4\text{L i \#} + {}^8\text{H e}$	-46.236	58.902
$\text{D (s)} + {}^5\text{H \#} + {}^7\text{B e}$	-39.077	49.782
$\text{D (s)} + {}^5\text{H e} + {}^7\text{L i (s)}$	-15.815	20.147
$\text{D (s)} + {}^5\text{L i} + {}^7\text{H e}$	-27.308	34.789
$\text{D (s)} + {}^6\text{H e} + {}^6\text{L i (s)}$	-21.196	27.003
$\text{T} + \text{T} + {}^8\text{B e}$	-11.224	14.298
$\text{T} + {}^3\text{H e (s)} + {}^8\text{L i}$	-27.209	34.663
$\text{T} + {}^4\text{H \#} + {}^7\text{B e}$	-32.941	41.965
$\text{T} + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	-8.6637	11.037
$\text{T} + {}^4\text{L i \#} + {}^7\text{H e}$	-42.562	54.222
$\text{T} + {}^5\text{H \#} + {}^6\text{B e}$	-43.496	55.412
$\text{T} + {}^5\text{H e} + {}^6\text{L i (s)}$	-16.808	21.412
$\text{T} + {}^5\text{L i} + {}^6\text{H e}$	-20.604	26.249

(continued)

$\tau + {}^3\text{H e (s)} + {}^8\text{H e}$	-37.843	48.21
$\tau + {}^4\text{H \#} + {}^7\text{L i (s)}$	-32.06	40.843
$\tau + {}^4\text{H e (s)} + {}^7\text{H e}$	-19.848	25.286
$\tau + {}^5\text{H \#} + {}^6\text{L i (s)}$	-39.189	49.925
$\tau + {}^5\text{H e} + {}^6\text{H e}$	-20.296	25.856
$\alpha + {}^4\text{H \#} + {}^6\text{L i (s)}$	-18.733	23.864
$\alpha + {}^5\text{H \#} + {}^5\text{L i}$	-24.277	30.928
$\alpha + {}^5\text{H e} + {}^5\text{H e}$	-1.587	2.0218

Table 5 ^3He -induced Fusion Reaction

REACTION $^3\text{He} + ^3\text{He}$ total branch 9(1)
compound nucleus $^6\text{Be}^*$ A=6 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^6\text{Be}$	11.489	0	(8, 9)
2	$n + ^6\text{Be}$	-11.909	23.817	(9)
3	$p + ^5\text{Li}$	10.894	0	
4	$D(s) + ^4\text{Li}^\#$	-8.3932	16.786	
5	$p + p + ^4\text{He}(s)$	12.86	0	(4, 5, 7, 8, 9)
6	$p + D(s) + ^3\text{He}(s)$	-5.4935	10.987	
7	$2p + 2D(s)$	-10.987	21.974	
8	$3p + T$	-6.955	13.909	unsuccessful
9	$T + ^3\text{Li}$	-*	-	n.o.
	$n + p + ^4\text{Li}^\#$	-10.618	21.236	

* ; This can not be calculated due to uncertainty of ΔM of ^3Li .

REACTION $^4\text{He} + ^3\text{He}$ total branch 7(7)
compound nucleus $^7\text{Be}^*$ A=7 Z=4

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^7\text{Be}$	1.5875	0	(4, 7, 8, 9)
2	$n + ^6\text{Be}$	-9.0891	15.938	(9)
3	$p + ^6\text{Li}(s)$	-4.0184	7.0463	
4	$D(s) + ^5\text{Li}$	-7.4596	13.081	
5	$n + p + ^5\text{Li}$	-9.6842	16.981	
6	$p + D(s) + ^4\text{He}(s)$	-5.4935	9.633	

(continued)

7	$n + 2p + {}^4\text{He}(s)$	-7.7182	13.534
	$T + {}^4\text{Li}\#$	-22.714	39.829
	$n + n + {}^5\text{Be}$	-32.487	56.966
	$n + D(s) + {}^4\text{Li}\#$	-28.971	50.801
	$n + {}^3\text{He}(s) + {}^3\text{He}(s)$	-20.578	36.083
	$p + p + {}^5\text{He}$	-8.6118	15.101
	$p + T + {}^3\text{He}(s)$	-19.814	34.744
	$D(s) + D(s) + {}^3\text{He}(s)$	-23.847	41.816

REACTION ${}^6\text{Li} + {}^3\text{He}$ total branch 11(16)
 compound nucleus ${}^9\text{B}^*$ A=9 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^9\text{B}$	16.601	0	
2	$n + {}^9\text{B}$	-1.9748	2.9649	
3	$p + {}^9\text{Be}$	16.786	0	(5, 7, 8)
4	$D(s) + {}^7\text{Be}$	0.1124	0	(7, 8)
5	$T + {}^6\text{Be}$	-4.307	6.4665	
6	${}^4\text{He}(s) + {}^5\text{Li}$	14.912	0	
7	$p + {}^4\text{He}(s) + {}^4\text{He}(s)$	16.878	0	(5)
8	$T + {}^3\text{He}(s) + {}^3\text{He}(s)$	-15.796	23.716	
9	$\alpha + p + {}^4\text{He}(s)$	16.878	0	
10	$3p + {}^6\text{He}$	-10.442	15.663	
11	${}^6\text{He} + {}^3\text{Li}$	- *	-	n.o.
	${}^4\text{H}\# + {}^5\text{Be}$	-30.523	45.828	
	${}^4\text{Li}\# + {}^5\text{He}$	-7.4931	11.25	
	$n + n + {}^7\text{B}$	-14.996	22.515	
	$n + p + {}^7\text{Be}$	-2.1122	3.1712	

(continued)

$n + D(s) + {}^6\text{Be}$	-10.564	15.861
$n + T + {}^5\text{Be}$	-27.704	41.596
$n + {}^3\text{He}(s) + {}^5\text{Li}$	-5.6658	8.5066
$n + {}^4\text{He}(s) + {}^4\text{Li}\#$	-6.5994	9.9083
$p + p + {}^7\text{Li}(s)$	-0.46794	0.70257
$p + D(s) + {}^6\text{Li}(s)$	-5.4935	8.248
$p + T + {}^5\text{Li}$	-4.902	7.3599
$p + {}^3\text{He}(s) + {}^5\text{He}$	-4.5934	6.8966
$p + {}^4\text{H}\# + {}^4\text{Li}\#$	-29.232	43.889
$D(s) + D(s) + {}^5\text{Li}$	-8.9347	13.415
$D(s) + T + {}^4\text{Li}\#$	-24.189	36.317
$D(s) + {}^3\text{He}(s) + {}^4\text{He}(s)$	-1.4751	2.2148

* ; This can not be calculated due to uncertainty of ΔM of ${}^5\text{Li}$.

REACTION ${}^7\text{Li} + {}^3\text{He}$ total branch 17(16)
 compound nucleus ${}^{10}\text{B}^*$ A=10 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{10}\text{B}(s)$	17.787	0	
2	$n + {}^9\text{B}$	9.351	0	(8)
3	$p + {}^9\text{Be}(s)$	11.201	0	(8)
4	$D(s) + {}^8\text{Be}$	11.761	0	(8)
5	$T + {}^7\text{Be}$	-0.88049	1.259	(7, 8)
6	${}^4\text{He}(s) + {}^6\text{Li}(s)$	13.328	0	(8)
7	${}^4\text{Li}\# + {}^6\text{He}$	-12.874*	18.409	
8	$n + p + {}^8\text{Be}$	9.536	0	(4, 5, 7)
9	$n + {}^3\text{He}(s) + {}^6\text{Li}(s)$	-7.2502	10.367	
10	$p + D(s) + {}^7\text{Li}(s)$	-5.4935	7.8551	
11	$p + T + {}^6\text{Li}(s)$	-6.4864	9.2748	
12	$p + {}^3\text{He}(s) + {}^6\text{He}$	-9.9745	14.262	
13	$p + {}^4\text{He}(s) + {}^5\text{He}$	8.7342	0	

(continued)

14	D(s) + T + ⁵ Li	-9.9276	14.195
15	D(s) + ³ He(s) + ⁵ He	-9.619	13.754
16	D(s) + ⁴ He(s) + ⁴ He(s)	11.852	0
17	T + ³ He(s) + ⁴ He(s)	-2.468	3.529
	⁴ H# + ⁶ Be	-14.376	20.556
	⁶ H# + ⁵ Be	-37.652	53.838
	⁵ He + ⁵ Li	6.7681	0
	n + n + ⁸ B	-9.2249	13.191
	n + D(s) + ⁷ Be	-7.1378	10.206
	n + T + ⁶ Be	-11.557	16.525
	n + ⁴ H# + ⁵ Be	-37.773	54.011
	n + ⁴ He(s) + ⁵ Li	7.6618	0
	n + ⁴ Li# + ⁵ He	-14.743	21.081
	p + p + ⁸ Li	-5.6853	8.1293
	p + ⁴ H# + ⁵ Li	-14.971	21.407
	p + ⁴ Li# + ⁵ H#	-36.361	51.992
	D(s) + D(s) + ⁶ Li(s)	-10.519	15.041
	D(s) + ⁴ H# + ⁴ Li#	-34.258	48.984
	T + T + ⁴ Li#	-25.182	36.007
	τ + ³ He(s) + ⁴ H#	-25.865	36.983

* ; The value in F.Ajzenberg-Selove⁽²⁾ is -9.980 MeV. Their estimated ΔM value of ⁴Li would be then different from the one shown in Appendix B.

REACTION ⁹Be + ³He total branch 16(39)
 compound nucleus ¹²C* A=12 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	γ + ¹² C(s)	26.279	0	
2	n + ¹¹ C	7.5575	0	(6.8)

(continued)

3	$p + {}^{11}\text{B}(\text{s})$	10.322	0	(8)
4	$\text{D}(\text{s}) + {}^{10}\text{B}(\text{s})$	1.0924	0	
5	$\text{T} + {}^9\text{B}$	-1.0867	1.4504	
6	${}^4\text{H e}(\text{s}) + {}^8\text{B e}$	18.912	0	
7	${}^5\text{H e} + {}^7\text{B e}$	-0.87968	1.1741	
8	${}^5\text{L i} + {}^7\text{L i}(\text{s})$	-0.30778	0.41078	
9	${}^6\text{H e} + {}^6\text{B e}$	-9.6873	12.929	
10	${}^6\text{L i}(\text{s}) + {}^6\text{L i}(\text{s})$	-1.8922	2.5254	
11	$n + n + {}^{10}\text{C}$	-5.5654	7.428	
12	$n + {}^4\text{H e}(\text{s}) + {}^7\text{B e}$	0.01403	0	
13	$p + p + {}^{10}\text{B e}$	-0.90604	1.2093	
14	$p + {}^4\text{H e}(\text{s}) + {}^7\text{L i}(\text{s})$	1.6583	0	
15	$\tau + {}^4\text{H e}(\text{s}) + {}^5\text{H e}$	-2.4672	3.2929	
16	$\alpha + {}^4\text{H e}(\text{s}) + {}^4\text{H e}(\text{s})$	19.004	0	
	${}^4\text{H}\# + {}^8\text{B}$	-22.481	30.005	
	${}^4\text{L i}\# + {}^8\text{L i}$	-19.786	26.408	
	${}^5\text{H}\# + {}^7\text{B}$	-35.381	47.222	
	${}^5\text{B e} + {}^7\text{H e}$	-33.531	44.753	
	$n + p + {}^{10}\text{B}(\text{s})$	-1.1322	1.5111	
	$n + \text{D}(\text{s}) + {}^9\text{B}$	-7.344	9.8017	
	$n + \text{T} + {}^8\text{B}$	-19.663	26.243	
	$n + {}^3\text{H e}(\text{s}) + {}^8\text{B e}$	-1.6654	2.2227	
	$n + {}^4\text{H}\# + {}^7\text{B}$	-35.502	47.384	
	$n + {}^4\text{L i}\# + {}^7\text{L i}(\text{s})$	-21.819	29.121	
	$n + {}^5\text{H e} + {}^6\text{B e}$	-11.556	15.424	
	$n + {}^5\text{L i} + {}^6\text{L i}(\text{s})$	-7.558	10.087	
	$n + {}^5\text{B e} + {}^6\text{H e}$	-33.085	44.157	
	$p + \text{D}(\text{s}) + {}^9\text{B e}(\text{s})$	-5.4935	7.332	
	$p + \text{T} + {}^8\text{B e}$	-0.90165	1.2034	
	$p + {}^3\text{H e}(\text{s}) + {}^8\text{L i}$	-16.887	22.538	
	$p + {}^4\text{H}\# + {}^7\text{B e}$	-22.619	30.188	
	$p + {}^4\text{L i}\# + {}^7\text{H e}$	-32.24	43.03	
	$p + {}^5\text{H}\# + {}^6\text{B e}$	-33.174	44.276	

(continued)

$p + {}^5\text{H e} + {}^6\text{L i (s)}$	-6.4856	8.6561
$p + {}^6\text{L i} + {}^6\text{H e}$	-10.282	13.723
$\text{D (s)} + \text{D (s)} + {}^8\text{B e}$	-4.9344	6.5857
$\text{D (s)} + \text{T} + {}^7\text{B e}$	-17.575	23.457
$\text{D (s)} + {}^3\text{H e (s)} + {}^7\text{L i (s)}$	-16.695	22.282
$\text{D (s)} + {}^4\text{H \#} + {}^6\text{B e}$	-31.071	41.469
$\text{D (s)} + {}^4\text{H e (s)} + {}^6\text{L i (s)}$	-3.3673	4.4942
$\text{D (s)} + {}^4\text{L i \#} + {}^6\text{H e}$	-29.569	39.465
$\text{D (s)} + {}^5\text{H \#} + {}^5\text{B e}$	-54.347	72.535
$\text{D (s)} + {}^5\text{H e} + {}^5\text{L i}$	-9.9268	13.249
$\text{T} + \text{T} + {}^6\text{B e}$	-21.995	29.356
$\text{T} + {}^3\text{H e (s)} + {}^6\text{L i (s)}$	-17.688	23.607
$\text{T} + {}^4\text{H \#} + {}^5\text{B e}$	-48.211	64.345
$\text{T} + {}^4\text{H e (s)} + {}^5\text{L i}$	-2.7758	3.7048
$\text{T} + {}^4\text{L i \#} + {}^5\text{H e}$	-25.181	33.608
$\tau + n + {}^8\text{B e}$	-1.6654	2.2227
$\tau + {}^3\text{H e (s)} + {}^6\text{H e}$	-21.176	28.263
$\tau + {}^4\text{H \#} + {}^5\text{L i}$	-26.172	34.931
$\tau + {}^4\text{L i \#} + {}^5\text{H \#}$	-47.562	63.48
$\alpha + {}^4\text{H \#} + {}^4\text{L i \#}$	-27.106	36.177

REACTION ${}^1_0\text{B} + {}^3_2\text{H e}$ total branch 12(52)compound nucleus ${}^4_7\text{N}^*$ A=13 Z=7

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^1_7\text{N}$	21.637	0	
2	$n + {}^1_7\text{N}$	1.5726	0	
3	$p + {}^{12}_6\text{C (s)}$	19.693	0	
4	$\text{D (s)} + {}^{11}_6\text{C}$	3.1962	0	
5	$\text{T} + {}^{10}_6\text{C}$	-3.6695	4.7748	
6	${}^4_2\text{H e (s)} + {}^9_4\text{B}$	12.141	0	

(continued)			
7	${}^6\text{H e} + {}^7\text{B}$	-18.48	24.047
8	${}^6\text{L i (s)} + {}^7\text{B e}$	-2.8722	3.7373
9	$\text{n} + \text{p} + {}^{11}\text{C}$	0.9716	0
10	$\text{p} + \text{p} + {}^{11}\text{B (s)}$	3.736	0
11	$\text{p} + {}^4\text{H e (s)} + {}^8\text{B e}$	12.326	0
12	$\alpha + {}^4\text{H e (s)} + {}^5\text{L i}$	10.452	0
	${}^4\text{H \#} + {}^9\text{C}$	-27.771	36.136
	${}^4\text{L i \#} + {}^9\text{B e (s)}$	-9.4856	12.343
	${}^5\text{H \#} + {}^8\text{C}$	-41.903	54.525
	${}^5\text{H e} + {}^8\text{B}$	-7.3282	9.5355
	${}^5\text{L i} + {}^8\text{B e}$	10.36	0
	${}^5\text{B e} + {}^8\text{L i}$	-27.663	35.996
	${}^6\text{B e} + {}^7\text{L i (s)}$	-6.2987	8.196
	$\text{n} + \text{n} + {}^{11}\text{N}$	-14.071	18.309
	$\text{n} + \text{D (s)} + {}^{10}\text{C}$	-9.9268	12.917
	$\text{n} + \text{T} + {}^9\text{C}$	-24.952	32.468
	$\text{n} + {}^8\text{H e (s)} + {}^9\text{B}$	-8.4364	10.978
	$\text{n} + {}^4\text{H \#} + {}^8\text{C}$	-42.024	54.683
	$\text{n} + {}^4\text{H e (s)} + {}^8\text{B}$	-6.4345	8.3726
	$\text{n} + {}^4\text{L i \#} + {}^8\text{B e}$	-11.151	14.51
	$\text{n} + {}^5\text{H e} + {}^7\text{B}$	-20.349	26.479
	$\text{n} + {}^5\text{L i} + {}^7\text{B e}$	-8.538	11.11
	$\text{n} + {}^5\text{B e} + {}^7\text{L i (s)}$	-29.696	38.641
	$\text{n} + {}^6\text{L i (s)} + {}^6\text{B e}$	-13.549	17.63
	$\text{p} + \text{D (s)} + {}^{10}\text{B (s)}$	-5.4935	7.1483
	$\text{p} + \text{T} + {}^9\text{B}$	-7.6726	9.9837
	$\text{p} + {}^8\text{H e (s)} + {}^9\text{B e (s)}$	-6.5859	8.5697
	$\text{p} + {}^4\text{H \#} + {}^8\text{B}$	-29.067	37.823
	$\text{p} + {}^4\text{L i \#} + {}^8\text{L i}$	-26.372	34.316
	$\text{p} + {}^5\text{H \#} + {}^7\text{B}$	-41.967	54.608
	$\text{p} + {}^5\text{H e} + {}^7\text{B e}$	-7.4656	9.7144
	$\text{p} + {}^5\text{L i} + {}^7\text{L i (s)}$	-6.8937	8.9702
	$\text{p} + {}^5\text{B e} + {}^7\text{H e}$	-40.117	52.201

(6)

(continued)

$p + {}^6\text{H e} + {}^6\text{B e}$	-16.273	21.175
$p + {}^6\text{L i (s)} + {}^6\text{L i (s)}$	-8.4781	11.032
$\text{D (s)} + \text{D (s)} + {}^9\text{B}$	-11.705	15.231
$\text{D (s)} + \text{T} + {}^8\text{B}$	-24.024	31.26
$\text{D (s)} + {}^3\text{H e (s)} + {}^6\text{B e}$	-6.0268	7.8421
$\text{D (s)} + {}^4\text{H \#} + {}^7\text{B}$	-39.864	51.871
$\text{D (s)} + {}^4\text{H e (s)} + {}^7\text{B e}$	-4.3473	5.6568
$\text{D (s)} + {}^4\text{L i \#} + {}^7\text{L i (s)}$	-26.181	34.066
$\text{D (s)} + {}^5\text{H e} + {}^6\text{B e}$	-15.918	20.712
$\text{D (s)} + {}^5\text{L i} + {}^6\text{L i (s)}$	-11.919	15.51
$\text{D (s)} + {}^6\text{B e} + {}^6\text{H e}$	-37.446	48.725
$\text{T} + \text{T} + {}^7\text{B}$	-30.788	40.061
$\text{T} + {}^3\text{H e (s)} + {}^7\text{B e}$	-18.668	24.291
$\text{T} + {}^4\text{H e (s)} + {}^6\text{B e}$	-8.7667	11.407
$\text{T} + {}^4\text{L i \#} + {}^6\text{L i (s)}$	-27.173	35.358
$\text{T} + {}^5\text{H e} + {}^6\text{B e}$	-33.058	43.015
$\text{T} + {}^5\text{L i} + {}^5\text{L i}$	-11.328	14.74
$\tau + {}^3\text{H e (s)} + {}^7\text{L i (s)}$	-17.787	23.145
$\tau + {}^4\text{H \#} + {}^6\text{B e}$	-32.163	41.851
$\tau + {}^4\text{H e (s)} + {}^6\text{L i (s)}$	-4.4597	5.8031
$\tau + {}^4\text{L i \#} + {}^6\text{H e}$	-30.662	39.897
$\tau + {}^5\text{H \#} + {}^5\text{B e}$	-55.439	72.138
$\tau + {}^5\text{H e} + {}^5\text{L i}$	-11.019	14.338
$\alpha + {}^4\text{H \#} + {}^5\text{B e}$	-34.983	45.52
$\alpha + {}^4\text{L i \#} + {}^5\text{H e}$	-11.953	15.553

REACTION ${}^{11}\text{B} + {}^3\text{H e}$ total branch 11(67)compound nucleus ${}^{14}\text{N}^*$ A=14 Z=7

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{14}\text{N (s)}$	20.736	0	

		(continued)		
2	$n + {}^1_0\text{N}$	10.182	0	(6)
3	$p + {}^1_3\text{C (s)}$	13.185	0	
4	$\text{D (s)} + {}^1_2\text{C (s)}$	10.463	0	
5	$\text{T} + {}^1_1\text{C}$	-2.0007	2.5488	
6	${}^4_2\text{He (s)} + {}^1_0\text{B (s)}$	9.1236	0	
7	${}^6_3\text{He} + {}^8_4\text{B}$	-16.913	21.547	
8	${}^6_3\text{Li (s)} + {}^8_4\text{Be}$	4.572	0	
9	${}^7_3\text{Li (s)} + {}^7_4\text{Be}$	-7.0762	9.0147	
10	$n + p + {}^1_2\text{C (s)}$	8.2389	0	
11	$\alpha + {}^4_2\text{He (s)} + {}^6_3\text{Li (s)}$	4.6639	0	
	${}^4_2\text{He} + {}^1_0\text{C}$	-17.942	22.858	
	${}^4_3\text{Li} + {}^1_0\text{Be}$	-14.128	17.998	
	${}^5_1\text{H} + {}^9_4\text{C}$	-39.104	49.817	
	${}^5_2\text{He} + {}^9_4\text{B}$	-0.20648	0.26305	
	${}^6_3\text{Li} + {}^9_4\text{Be (s)}$	0.57162	0	
	${}^5_2\text{Be} + {}^9_4\text{Li}$	-35.055	44.658	
	${}^6_4\text{Be} + {}^8_3\text{Li}$	-15.72	20.027	
	${}^7_2\text{He} + {}^7_4\text{B}$	-30.381	38.704	
	$n + n + {}^1_2\text{N}$	-9.8815	12.589	
	$n + \text{D (s)} + {}^1_1\text{C}$	-8.258	10.52	
	$n + \text{T} + {}^1_0\text{C}$	-15.124	19.267	
	$n + {}^3_2\text{He (s)} + {}^1_0\text{B (s)}$	-11.454	14.592	
	$n + {}^4_1\text{H} + {}^9_4\text{C}$	-39.225	49.971	
	$n + {}^4_2\text{He (s)} + {}^9_4\text{B}$	0.68723	0	
	$n + {}^4_3\text{Li} + {}^9_4\text{Be (s)}$	-20.94	26.676	
	$n + {}^5_1\text{H} + {}^8_3\text{C}$	-53.357	67.974	
	$n + {}^5_2\text{He} + {}^8_4\text{B}$	-18.782	23.928	
	$n + {}^5_3\text{Li} + {}^8_4\text{Be}$	-1.0938	1.3934	
	$n + {}^5_4\text{Be} + {}^8_3\text{Li}$	-39.117	49.834	
	$n + {}^6_2\text{He} + {}^7_4\text{B}$	-29.934	38.135	
	$n + {}^6_3\text{Li (s)} + {}^7_4\text{Be}$	-14.326	18.251	
	$n + {}^6_4\text{Be} + {}^7_3\text{Li (s)}$	-17.753	22.616	
	$p + p + {}^1_2\text{B}$	-4.3482	5.5395	

(continued)

$p + D(s) + {}^{11}B(s)$	-5.4935	6.9985
$p + T + {}^1B(s)$	-10.69	13.619
$p + {}^3He(s) + {}^1Be$	-11.228	14.304
$p + {}^4H\# + {}^9B$	-21.946	27.958
$p + {}^4He(s) + {}^9Be(s)$	2.5377	0
$p + {}^4Li\# + {}^9Li$	-33.764	43.013
$p + {}^5H\# + {}^8B$	-40.4	51.468
$p + {}^5He + {}^8Be$	-0.021441	0.027315
$p + {}^5Li + {}^8Li$	-16.315	20.785
$p + {}^5Be + {}^8He$	-48.988	62.408
$p + {}^6He + {}^7Be$	-17.051	21.722
$p + {}^6Li(s) + {}^7Li(s)$	-12.682	16.156
$p + {}^6Be + {}^7He$	-28.174	35.892
$D(s) + D(s) + {}^1B(s)$	-14.723	18.757
$D(s) + T + {}^9B$	-16.902	21.533
$D(s) + {}^3He(s) + {}^9Be(s)$	-15.816	20.148
$D(s) + {}^4H\# + {}^8B$	-38.297	48.788
$D(s) + {}^4He(s) + {}^8Be$	3.0968	0
$D(s) + {}^4Li\# + {}^8Li$	-35.602	45.355
$D(s) + {}^5H\# + {}^7B$	-51.197	65.222
$D(s) + {}^5He + {}^7Be$	-16.695	21.269
$D(s) + {}^5Li + {}^7Li(s)$	-16.123	20.54
$D(s) + {}^5Be + {}^7He$	-49.347	62.865
$D(s) + {}^6He + {}^6Be$	-25.503	32.489
$D(s) + {}^6Li(s) + {}^6Li(s)$	-17.708	22.559
$T + T + {}^8B$	-29.221	37.226
$T + {}^3He(s) + {}^8Be$	-11.224	14.298
$T + {}^4H\# + {}^7B$	-45.061	57.405
$T + {}^4He(s) + {}^7Be$	-9.5442	12.159
$T + {}^4Li\# + {}^7Li(s)$	-31.377	39.973
$T + {}^5He + {}^6Be$	-21.115	26.899
$T + {}^5Li + {}^6Li(s)$	-17.116	21.805
$T + {}^5Be + {}^6He$	-42.643	54.325
$\tau + {}^3He(s) + {}^8Li$	-27.209	34.663

(continued)

$\tau + {}^4\text{H}\# + {}^7\text{B e}$	-32.941	41.965
$\tau + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	-8.6637	11.037
$\tau + {}^4\text{L i}\# + {}^7\text{H e}$	-42.562	54.222
$\tau + {}^5\text{H}\# + {}^6\text{B e}$	-43.496	55.412
$\tau + {}^5\text{H e} + {}^6\text{L i (s)}$	-16.808	21.412
$\tau + {}^5\text{L i} + {}^6\text{H e}$	-20.604	26.249
$\alpha + {}^4\text{H}\# + {}^6\text{B e}$	-23.04	29.351
$\alpha + {}^4\text{L i}\# + {}^6\text{H e}$	-21.538	27.438
$\alpha + {}^5\text{H}\# + {}^5\text{B e}$	-46.316	59.004
$\alpha + {}^5\text{H e} + {}^5\text{L i}$	-1.8956	2.4149

Table 6 ${}^4\text{He}$ -induced Fusion Reaction

REACTION ${}^4\text{He} + {}^4\text{He}$ total branch 6(9)
 compound nucleus ${}^8\text{Be}^*$ A=8 Z=4

branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^8\text{Be}$	-0.09189	0.18378
2	$n + {}^7\text{Be}$	-18.99	37.98
3	$p + {}^7\text{Li}(s)$	-17.346	34.692
4	$D(s) + {}^6\text{Li}(s)$	-22.372	44.743
5	$n + p + {}^6\text{Li}(s)$	-24.596	49.192
6	$n + {}^3\text{He}(s) + {}^4\text{He}(s)$	-20.578	41.156
7	$p + p + {}^6\text{He}$	-27.321	54.641
8	$p + T + {}^4\text{He}(s)$	-19.814	39.628
9	$D(s) + D(s) + {}^4\text{He}(s)$	-23.847	47.693
	$T + {}^5\text{Li}$	-21.78	43.56
	${}^3\text{He}(s) + {}^5\text{He}$	-21.471	42.943
	${}^4\text{He}\# + {}^4\text{Li}\#$	-46.11	92.22
	$n + n + {}^6\text{Be}$	-29.667	59.334
	$n + D(s) + {}^5\text{Li}$	-28.037	56.075
	$n + T + {}^4\text{Li}\#$	-43.291	86.583
	$p + D(s) + {}^5\text{He}$	-26.965	53.93
	$p + {}^3\text{He}(s) + {}^4\text{He}\#$	-43.211	86.421
	$D(s) + T + {}^3\text{He}(s)$	-38.167	76.334

REACTION ${}^6\text{Li} + {}^4\text{He}$ total branch 9(25)
 compound nucleus ${}^{10}\text{B}^*$ A=10 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{10}\text{B}(s)$	4.4597	0	(4, 7)
2	$n + {}^9\text{B}$	-3.9766	6.6228	
3	$p + {}^9\text{Be}(s)$	-2.1262	3.541	
4	$D(s) + {}^8\text{Be}$	-1.567	2.6098	
5	$T + {}^7\text{Be}$	-14.208	23.662	
6	${}^3\text{He}(s) + {}^7\text{Li}(s)$	-13.328	22.196	
7	$n + {}^4\text{He}(s) + {}^5\text{Li}$	-5.6658	9.4359	
8	$p + {}^4\text{He}(s) + {}^5\text{He}$	-4.5934	7.65	
9	$D(s) + {}^4\text{He}(s) + {}^4\text{He}(s)$	-1.4751	2.4567	
	${}^4\text{H}\# + {}^6\text{Be}$	-27.703	46.138	
	${}^4\text{Li}\# + {}^6\text{He}$	-26.202	43.637	
	${}^5\text{H}\# + {}^5\text{Be}$	-50.979	84.902	
	${}^5\text{He} + {}^6\text{Li}$	-6.5595	10.924	
	$n + n + {}^8\text{B}$	-22.553	37.559	
	$n + p + {}^8\text{Be}$	-3.7916	6.3146	
	$n + D(s) + {}^7\text{Be}$	-20.465	34.084	
	$n + T + {}^6\text{Be}$	-24.885	41.444	
	$n + {}^3\text{He}(s) + {}^6\text{Li}(s)$	-20.578	34.271	
	$n + {}^4\text{H}\# + {}^5\text{Be}$	-51.101	85.105	
	$n + {}^4\text{Li}\# + {}^5\text{He}$	-28.071	46.75	
	$p + p + {}^8\text{Li}$	-19.013	31.665	
	$p + D(s) + {}^7\text{Li}(s)$	-18.821	31.345	
	$p + T + {}^6\text{Li}(s)$	-19.814	32.999	
	$p + {}^3\text{He}(s) + {}^6\text{He}$	-23.302	38.808	
	$p + {}^4\text{H}\# + {}^5\text{Li}$	-28.299	47.129	
	$p + {}^4\text{Li}\# + {}^5\text{H}\#$	-49.689	82.752	
	$D(s) + D(s) + {}^6\text{Li}(s)$	-23.847	39.715	
	$D(s) + T + {}^5\text{Li}$	-23.255	38.73	
	$D(s) + {}^3\text{He}(s) + {}^5\text{He}$	-22.947	38.216	

(continued)

D(s) + $^4\text{H}\# + ^4\text{L i}\#$	-47.585	79.25
T + n + $^6\text{B e}$	-24.885	41.444
T + T + $^4\text{L i}\#$	-38.509	64.134
T + $^3\text{H e}(s) + ^4\text{H e}(s)$	-15.796	26.306
$\tau + ^3\text{H e}(s) + ^4\text{H}\#$	-39.192	65.271

REACTION $^7\text{L i} + ^4\text{H e}$ total branch 9(32)compound nucleus $^{11}\text{B}^*$ A=11 Z=5

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^{11}\text{B}(s)$	8.6637	0	(4, 7)
2	n + $^{10}\text{B}(s)$	-2.7904	4.3824	(4, 7, 8, 9)
3	p + $^{10}\text{B e}$	-2.5643	4.0272	
4	D(s) + $^9\text{B e}(s)$	-7.1518	11.232	
5	T + $^8\text{B e}$	-2.5599	4.0203	
6	$^6\text{H e} + ^6\text{L i}(s)$	-8.1439	12.79	
7	$^5\text{L i} + ^6\text{H e}$	-11.941	18.753	
8	n + $^4\text{H e}(s) + ^6\text{L i}(s)$	-7.2502	11.386	
9	T + $^4\text{H e}(s) + ^4\text{H e}(s)$	-2.468	3.876	
	$^3\text{H e}(s) + ^8\text{L i}$	-18.545	29.125	
	$^4\text{H}\# + ^7\text{B e}$	-24.277	38.127	
	$^4\text{L i}\# + ^7\text{H e}$	-33.898	53.237	
	$^5\text{H}\# + ^6\text{B e}$	-34.832	54.704	
	n + n + ^9B	-11.227	17.632	
	n + p + $^9\text{B e}(s)$	-9.3764	14.726	
	n + D(s) + $^8\text{B e}$	-8.8172	13.847	
	n + T + $^7\text{B e}$	-21.458	33.7	
	n + $^3\text{H e}(s) + ^7\text{L i}(s)$	-20.578	32.317	
	n + $^4\text{H}\# + ^6\text{B e}$	-34.954	54.895	
	n + $^4\text{L i}\# + ^6\text{H e}$	-33.452	52.536	

(continued)

$n + {}^5\text{H}\# + {}^5\text{B e}$	-58.23	91.449
$n + {}^5\text{H e} + {}^5\text{L i}$	-13.81	21.688
$p + p + {}^9\text{L i}$	-22.2	34.865
$p + \text{D}(\text{s}) + {}^6\text{L i}$	-24.039	37.752
$p + \text{T} + {}^7\text{L i}(\text{s})$	-19.814	31.118
$p + {}^3\text{H e}(\text{s}) + {}^7\text{H e}$	-30.999	48.683
$p + {}^4\text{H}\# + {}^6\text{L i}(\text{s})$	-29.883	46.931
$p + {}^4\text{H e}(\text{s}) + {}^6\text{H e}$	-9.9745	15.665
$p + {}^5\text{H}\# + {}^5\text{L i}$	-35.427	55.638
$p + {}^5\text{H e} + {}^5\text{H e}$	-12.737	20.004
$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^7\text{L i}(\text{s})$	-23.847	37.451
$\text{D}(\text{s}) + \text{T} + {}^6\text{L i}(\text{s})$	-24.84	39.011
$\text{D}(\text{s}) + {}^3\text{H e}(\text{s}) + {}^6\text{H e}$	-28.328	44.489
$\text{D}(\text{s}) + {}^4\text{H}\# + {}^5\text{L i}$	-33.324	52.335
$\text{D}(\text{s}) + {}^4\text{H e}(\text{s}) + {}^5\text{H e}$	-9.619	15.107
$\text{D}(\text{s}) + {}^4\text{L i}\# + {}^5\text{H}\#$	-54.714	85.928
$\text{T} + \text{T} + {}^5\text{L i}$	-24.248	38.082
$\text{T} + {}^3\text{H e}(\text{s}) + {}^5\text{H e}$	-23.94	37.597
$\text{T} + {}^4\text{H}\# + {}^4\text{L i}\#$	-48.578	76.292
$\tau + {}^3\text{H e}(\text{s}) + {}^5\text{H}\#$	-46.321	72.747
$\tau + {}^4\text{H}\# + {}^4\text{H e}(\text{s})$	-25.865	40.62

REACTION ${}^9\text{B e} + {}^4\text{H e}$ total branch 11(55)
 compound nucleus ${}^{13}\text{C}^*$ A=13 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{13}\text{C}(\text{s})$	10.648	0	
2	$n + {}^{12}\text{C}(\text{s})$	5.7013	0	(4, 5, 7, 8, 9)
3	$p + {}^{12}\text{B}$	-6.8859	9.9442	
4	$\text{D}(\text{s}) + {}^{11}\text{B}(\text{s})$	-8.0312	11.598	
5	$\text{T} + {}^{10}\text{B}(\text{s})$	-13.228	19.103	

(continued)

6	$^3\text{H e (s)} + ^{10}\text{B e}$	-13.766	19.879	
7	$^5\text{H e} + ^6\text{B e}$	-2.5591	3.6957	
8	$^5\text{L i} + ^8\text{L i}$	-18.853	27.226	
9	$n + n + ^{11}\text{C}$	-13.02	18.803	(6)
10	$n + ^4\text{H e (s)} + ^8\text{B e}$	-1.6654	2.4051	(7)
11	$\alpha + ^4\text{H e (s)} + ^5\text{H e}$	-2.4672	3.563	
	$^4\text{H \#} + ^9\text{B}$	-24.483	35.357	
	$^4\text{L i \#} + ^9\text{L i}$	-36.301	52.424	
	$^5\text{H \#} + ^8\text{B}$	-42.938	62.008	
	$^6\text{B e} + ^8\text{H e}$	-51.525	74.409	
	$^6\text{H e} + ^7\text{B e}$	-19.588	28.288	
	$^6\text{L i (s)} + ^7\text{L i (s)}$	-15.22	21.979	
	$^6\text{B e} + ^7\text{H e}$	-30.711	44.351	
	$n + p + ^{11}\text{B (s)}$	-10.256	14.811	
	$n + \text{D (s)} + ^{10}\text{B (s)}$	-19.485	28.139	
	$n + \text{T} + ^9\text{B}$	-21.664	31.286	
	$n + 3\text{H e (s)} + ^9\text{B e (s)}$	-20.578	29.717	
	$n + ^4\text{H \#} + ^8\text{B}$	-43.059	62.183	
	$n + ^4\text{L i \#} + ^8\text{L i}$	-40.364	58.291	
	$n + ^5\text{H \#} + ^7\text{B}$	-55.959	80.812	
	$n + ^6\text{H e} + ^7\text{B e}$	-21.457	30.987	
	$n + ^5\text{L i} + ^7\text{L i (s)}$	-20.886	30.162	
	$n + ^5\text{B e} + ^7\text{H e}$	-54.109	78.14	
	$n + ^6\text{H e} + ^6\text{B e}$	-30.265	43.707	
	$n + ^6\text{L i (s)} + ^6\text{L i (s)}$	-22.47	32.45	
	$p + p + ^{11}\text{B e}$	-20.979	30.297	
	$p + \text{D (s)} + ^{10}\text{B e}$	-19.259	27.813	
	$p + \text{T} + ^9\text{B e (s)}$	-19.814	28.614	
	$p + ^3\text{H e (s)} + ^9\text{L i}$	-33.402	48.236	
	$p + ^4\text{H \#} + ^8\text{B e}$	-24.298	35.09	
	$p + ^4\text{H e (s)} + ^8\text{L i}$	-16.887	24.387	
	$p + ^4\text{L i \#} + ^8\text{H e}$	-50.234	72.545	
	$p + ^5\text{H \#} + ^7\text{B e}$	-43.075	62.206	

(continued)

$p + {}^5\text{H e} + {}^7\text{L i}(\text{s})$	-19.813	28.613
$p + {}^5\text{L i} + {}^7\text{H e}$	-31.306	45.211
$p + {}^6\text{H e} + {}^6\text{L i}(\text{s})$	-25.194	36.384
$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^9\text{B e}(\text{s})$	-23.847	34.438
$\text{D}(\text{s}) + \text{T} + {}^8\text{B e}$	-19.255	27.807
$\text{D}(\text{s}) + {}^3\text{H e}(\text{s}) + {}^8\text{L i}$	-35.24	50.891
$\text{D}(\text{s}) + {}^4\text{H}\# + {}^7\text{B e}$	-40.972	59.169
$\text{D}(\text{s}) + {}^4\text{H e}(\text{s}) + {}^7\text{L i}(\text{s})$	-16.695	24.11
$\text{D}(\text{s}) + {}^4\text{L i}\# + {}^7\text{H e}$	-50.593	73.063
$\text{D}(\text{s}) + {}^6\text{H}\# + {}^6\text{B e}$	-51.527	74.412
$\text{D}(\text{s}) + {}^5\text{H e} + {}^6\text{L i}(\text{s})$	-24.839	35.871
$\text{D}(\text{s}) + {}^5\text{L i} + {}^6\text{H e}$	-28.636	41.353
$\text{T} + \text{T} + {}^7\text{B e}$	-31.896	46.062
$\text{T} + {}^3\text{H e}(\text{s}) + {}^7\text{L i}(\text{s})$	-31.015	44.79
$\text{T} + {}^4\text{H}\# + {}^6\text{B e}$	-45.391	65.551
$\text{T} + {}^4\text{H e}(\text{s}) + {}^6\text{L i}(\text{s})$	-17.688	25.544
$\text{T} + {}^4\text{L i}\# + {}^6\text{H e}$	-43.89	63.382
$\text{T} + {}^5\text{H}\# + {}^5\text{B e}$	-68.667	99.165
$\text{T} + {}^5\text{H e} + {}^5\text{L i}$	-24.247	35.016
$\tau + p + {}^9\text{L i}$	-33.402	48.236
$\tau + \text{D}(\text{s}) + {}^8\text{L i}$	-35.24	50.891
$\tau + {}^3\text{H e}(\text{s}) + {}^7\text{H e}$	-42.2	60.942
$\tau + {}^4\text{H}\# + {}^6\text{L i}(\text{s})$	-41.084	59.331
$\tau + {}^4\text{H e}(\text{s}) + {}^6\text{H e}$	-21.176	30.581
$\tau + {}^5\text{H}\# + {}^5\text{L i}$	-46.629	67.338
$\tau + {}^5\text{H e} + {}^5\text{H e}$	-23.939	34.571
$\alpha + {}^4\text{H}\# + {}^5\text{L i}$	-26.172	37.796
$\alpha + {}^4\text{L i}\# + {}^5\text{H}\#$	-47.562	68.686

REACTION ${}^1_0\text{B} + {}^4_2\text{He}$ total branch 9(69)
 compound nucleus ${}^{14}_7\text{N}^*$ A=14 Z=7

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^{13}_6\text{N}$	1.0588	0	(7)
2	$p + {}^{13}_6\text{C}(s)$	4.0616	0	
3	$D(s) + {}^{12}_6\text{C}(s)$	1.3399	0	
4	$T + {}^{11}_6\text{C}$	-11.124	15.571	
5	${}^3_2\text{He}(s) + {}^{11}_5\text{B}(s)$	-9.1236	12.771	
6	${}^6_3\text{Li} + {}^9_4\text{Be}(s)$	-8.552	11.971	
7	${}^6_3\text{Li}(s) + {}^8_4\text{Be}$	-4.5516	6.3711	
8	${}^7_3\text{Li}(s) + {}^7_4\text{Be}$	-16.2	22.676	
9	$\alpha + {}^4_2\text{He}(s) + {}^6_3\text{Li}(s)$	-4.4597	6.2425	
	$\gamma + {}^{14}_7\text{N}(s)$	11.612	0	
	${}^4_2\text{He} + {}^{10}_6\text{C}$	-27.066	37.885	
	${}^4_2\text{Li} + {}^{10}_5\text{Be}$	-23.251	32.546	
	${}^5_2\text{He} + {}^9_6\text{C}$	-48.228	67.506	
	${}^5_2\text{He} + {}^9_4\text{Be}$	-9.3301	13.06	
	${}^5_3\text{Be} + {}^9_3\text{Li}$	-44.178	61.838	
	${}^6_2\text{He} + {}^8_4\text{Be}$	-26.037	36.445	
	${}^6_3\text{Be} + {}^8_3\text{Li}$	-24.844	34.775	
	${}^7_2\text{He} + {}^7_4\text{Be}$	-39.504	55.296	
	$n + n + {}^{12}_7\text{N}$	-19.005	26.602	
	$n + p + {}^{12}_6\text{C}(s)$	-0.8847	1.2384	
	$n + D(s) + {}^{11}_6\text{C}$	-17.382	24.33	
	$n + T + {}^{10}_6\text{C}$	-24.247	33.94	
	$n + {}^3_2\text{He}(s) + {}^{10}_5\text{B}(s)$	-20.578	28.804	
	$n + {}^4_2\text{He} + {}^9_6\text{C}$	-48.349	67.676	
	$n + {}^4_2\text{He}(s) + {}^9_4\text{Be}$	-8.4364	11.809	
	$n + {}^4_3\text{Li} + {}^9_4\text{Be}(s)$	-30.063	42.081	
	$n + {}^5_2\text{He} + {}^8_6\text{C}$	-62.481	87.457	
	$n + {}^5_3\text{He} + {}^8_4\text{Be}$	-27.906	39.061	
	$n + {}^5_3\text{Li} + {}^8_4\text{Be}$	-10.217	14.302	

(continued)

$n + {}^5\text{B e} + {}^8\text{L i}$	-48.241	67.525
$n + {}^6\text{H e} + {}^7\text{B}$	-39.058	54.671
$n + {}^6\text{L i (s)} + {}^7\text{B e}$	-23.45	32.824
$n + {}^6\text{B e} + {}^7\text{L i (s)}$	-26.876	37.62
$p + p + {}^{12}\text{B}$	-13.472	18.857
$p + \text{D (s)} + {}^{11}\text{B (s)}$	-14.617	20.46
$p + \text{T} + {}^{10}\text{B (s)}$	-19.814	27.735
$p + {}^3\text{H e (s)} + {}^{10}\text{B e}$	-20.352	28.487
$p + {}^4\text{H \#} + {}^9\text{B}$	-31.069	43.489
$p + {}^4\text{H e (s)} + {}^9\text{B e (s)}$	-6.586	9.2186
$p + {}^4\text{L i \#} + {}^9\text{L i}$	-42.887	60.031
$p + {}^5\text{H \#} + {}^8\text{B}$	-49.524	69.32
$p + {}^5\text{H e} + {}^8\text{B e}$	-9.1451	12.801
$p + {}^5\text{L i} + {}^8\text{L i}$	-25.439	35.608
$p + {}^5\text{B e} + {}^8\text{H e}$	-58.111	81.341
$p + {}^6\text{H e} + {}^7\text{B e}$	-26.174	36.637
$p + {}^6\text{L i (s)} + {}^7\text{L i (s)}$	-21.806	30.522
$p + {}^6\text{B e} + {}^7\text{H e}$	-37.297	52.207
$\text{D (s)} + \text{D (s)} + {}^{10}\text{B (s)}$	-23.847	33.379
$\text{D (s)} + \text{T} + {}^9\text{B}$	-26.026	36.429
$\text{D (s)} + {}^3\text{H e (s)} + {}^9\text{B e (s)}$	-24.939	34.908
$\text{D (s)} + {}^4\text{H \#} + {}^8\text{B}$	-47.42	66.376
$\text{D (s)} + {}^4\text{H e (s)} + {}^8\text{B e}$	-6.0268	8.4359
$\text{D (s)} + {}^4\text{L i \#} + {}^8\text{L i}$	-44.726	62.604
$\text{D (s)} + {}^5\text{H \#} + {}^7\text{B}$	-60.32	84.433
$\text{D (s)} + {}^5\text{H e} + {}^7\text{B e}$	-25.819	36.14
$\text{D (s)} + {}^5\text{L i} + {}^7\text{L i (s)}$	-25.247	35.339
$\text{D (s)} + {}^5\text{B e} + {}^7\text{H e}$	-58.47	81.843
$\text{D (s)} + {}^6\text{H e} + {}^6\text{B e}$	-34.626	48.468
$\text{D (s)} + {}^6\text{L i (s)} + {}^6\text{L i (s)}$	-26.831	37.557
$\text{T} + \text{T} + {}^8\text{B}$	-38.344	53.672
$\text{T} + {}^3\text{H e (s)} + {}^8\text{B e}$	-20.347	28.481
$\text{T} + {}^4\text{H \#} + {}^7\text{B}$	-54.184	75.844
$\text{T} + {}^4\text{H e (s)} + {}^7\text{B e}$	-18.668	26.13

(continued)

$T + {}^4\text{Li}\# + {}^7\text{Li}(s)$	-40.501	56.691
$T + {}^5\text{He} + {}^6\text{Be}$	-30.238	42.326
$T + {}^5\text{Li} + {}^6\text{Li}(s)$	-26.24	36.729
$T + {}^5\text{Be} + {}^6\text{He}$	-51.767	72.46
$\tau + {}^3\text{He}(s) + {}^8\text{Li}$	-36.332	50.856
$\tau + {}^4\text{H}\# + {}^7\text{Be}$	-42.064	58.879
$\tau + {}^4\text{He}(s) + {}^7\text{Li}(s)$	-17.787	24.898
$\tau + {}^4\text{Li}\# + {}^7\text{He}$	-51.686	72.347
$\tau + {}^5\text{H}\# + {}^6\text{Be}$	-52.62	73.654
$\tau + {}^5\text{He} + {}^6\text{Li}(s)$	-25.931	36.297
$\tau + {}^5\text{Li} + {}^6\text{He}$	-29.728	41.611
$\alpha + {}^4\text{H}\# + {}^6\text{Be}$	-32.163	45.02
$\alpha + {}^4\text{Li}\# + {}^6\text{He}$	-30.662	42.918
$\alpha + {}^5\text{H}\# + {}^5\text{Be}$	-55.439	77.601
$\alpha + {}^5\text{He} + {}^5\text{Li}$	-11.019	15.424

REACTION ${}^{11}\text{B} + {}^4\text{He}$ total branch 8(82)
 compound nucleus ${}^{15}\text{N}^*$ A=15 Z=7

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{15}\text{N}(s)$	10.991	0	
2	$n + {}^{14}\text{N}(s)$	0.15811	0	(7.9)
3	$p + {}^{14}\text{C}$	0.78398	0	(7.9)
4	$D(s) + {}^{13}\text{C}(s)$	-5.1679	7.0468	
5	$T + {}^{12}\text{C}(s)$	-3.857	5.2593	
6	${}^3\text{He}(s) + {}^{12}\text{B}$	-17.208	23.464	
7	${}^7\text{Li}(s) + {}^8\text{Be}$	-8.7556	11.939	
8	$\alpha + {}^4\text{He}(s) + {}^7\text{Li}(s)$	-8.6637	11.814	
	${}^4\text{H}\# + {}^{11}\text{C}$	-25.397	34.631	
	${}^4\text{Li}\# + {}^{11}\text{Be}$	-34.201	46.635	

(continued)

${}^5\text{H}\# + {}^1\text{O}\text{C}$	-38.399	52.359
${}^5\text{H}\text{e} + {}^1\text{O}\text{B}(\text{s})$	-12.348	16.837
${}^5\text{L}\text{i} + {}^1\text{O}\text{B}\text{e}$	-13.194	17.991
${}^5\text{B}\text{e} + {}^1\text{O}\text{L}\text{i}$	-56.437	76.956
${}^6\text{H}\text{e} + {}^9\text{B}$	-18.915	25.792
${}^6\text{L}\text{i}(\text{s}) + {}^9\text{B}\text{e}(\text{s})$	-14.34	19.554
${}^6\text{B}\text{e} + {}^9\text{L}\text{i}$	-32.235	43.955
${}^7\text{H}\text{e} + {}^8\text{B}$	-37.937	51.73
${}^7\text{L}\text{i}(\text{s}) + {}^8\text{B}\text{e}$	-8.7556	11.939
${}^7\text{B}\text{e} + {}^8\text{L}\text{i}$	-25.621	34.936
${}^7\text{B} + {}^8\text{H}\text{e}$	-48.375	65.963
$\text{n} + \text{n} + {}^{13}\text{N}$	-10.395	14.175
$\text{n} + \text{p} + {}^{13}\text{C}(\text{s})$	-7.3925	10.08
$\text{n} + \text{D}(\text{s}) + {}^{12}\text{C}(\text{s})$	-10.114	13.791
$\text{n} + \text{T} + {}^{11}\text{C}$	-22.578	30.787
$\text{n} + {}^8\text{H}\text{e}(\text{s}) + {}^{11}\text{B}(\text{s})$	-20.578	28.059
$\text{n} + {}^4\text{H}\# + {}^1\text{O}\text{C}$	-38.52	52.525
$\text{n} + {}^4\text{H}\text{e}(\text{s}) + {}^1\text{O}\text{B}(\text{s})$	-11.454	15.618
$\text{n} + {}^4\text{L}\text{i}\# + {}^1\text{O}\text{B}\text{e}$	-34.705	47.323
$\text{n} + {}^5\text{H}\# + {}^9\text{C}$	-59.682	81.38
$\text{n} + {}^5\text{H}\text{e} + {}^9\text{B}$	-20.784	28.341
$\text{n} + {}^5\text{L}\text{i} + {}^9\text{B}\text{e}(\text{s})$	-20.006	27.28
$\text{n} + {}^5\text{B}\text{e} + {}^9\text{L}\text{i}$	-55.632	75.858
$\text{n} + {}^6\text{H}\text{e} + {}^8\text{B}$	-37.491	51.122
$\text{n} + {}^6\text{L}\text{i}(\text{s}) + {}^8\text{B}\text{e}$	-16.006	21.825
$\text{n} + {}^6\text{B}\text{e} + {}^8\text{L}\text{i}$	-36.298	49.494
$\text{n} + {}^7\text{H}\text{e} + {}^7\text{B}$	-50.958	69.485
$\text{n} + {}^7\text{L}\text{i}(\text{s}) + {}^7\text{B}\text{e}$	-27.654	37.708
$\text{p} + \text{p} + {}^{13}\text{B}$	-20.047	27.336
$\text{p} + \text{D}(\text{s}) + {}^{12}\text{B}$	-22.701	30.955
$\text{p} + \text{T} + {}^{11}\text{B}(\text{s})$	-19.814	27.018
$\text{p} + {}^8\text{H}\text{e}(\text{s}) + {}^{11}\text{B}\text{e}$	-31.301	42.682
$\text{p} + {}^4\text{H}\# + {}^1\text{O}\text{B}(\text{s})$	-34.087	46.48
$\text{p} + {}^4\text{H}\text{e}(\text{s}) + {}^1\text{O}\text{B}\text{e}$	-11.228	15.31

(continued)

$p + {}^4\text{Li}\# + {}^{10}\text{Li}$	-55.146	75.195
$p + {}^5\text{H}\# + {}^9\text{B}$	-42.402	57.818
$p + {}^5\text{He} + {}^9\text{Be}(s)$	-18.934	25.817
$p + {}^5\text{Li} + {}^9\text{Li}$	-32.83	44.766
$p + {}^5\text{Be} + {}^9\text{He}$	-70.706	96.412
$p + {}^6\text{He} + {}^8\text{Be}$	-18.73	25.54
$p + {}^6\text{Li}(s) + {}^8\text{Li}$	-31.227	42.58
$p + {}^6\text{Be} + {}^8\text{He}$	-46.168	62.953
$p + {}^7\text{He} + {}^7\text{Be}$	-38.075	51.917
$p + {}^7\text{Li}(s) + {}^7\text{Li}(s)$	-26.01	35.466
$D(s) + D(s) + {}^{11}\text{B}(s)$	-23.847	32.517
$D(s) + T + {}^{10}\text{B}(s)$	-29.044	39.603
$D(s) + {}^3\text{He}(s) + {}^{10}\text{Be}$	-29.581	40.336
$D(s) + {}^4\text{H}\# + {}^9\text{B}$	-40.299	54.95
$D(s) + {}^4\text{He}(s) + {}^9\text{Be}(s)$	-15.816	21.566
$D(s) + {}^4\text{Li}\# + {}^9\text{Li}$	-52.117	71.065
$D(s) + {}^5\text{H}\# + {}^8\text{B}$	-58.753	80.114
$D(s) + {}^5\text{He} + {}^8\text{Be}$	-18.375	25.055
$D(s) + {}^5\text{Li} + {}^8\text{Li}$	-34.668	47.273
$D(s) + {}^5\text{Be} + {}^8\text{He}$	-67.341	91.824
$D(s) + {}^6\text{He} + {}^7\text{Be}$	-35.404	48.276
$D(s) + {}^6\text{Li}(s) + {}^7\text{Li}(s)$	-31.035	42.319
$D(s) + {}^6\text{Be} + {}^7\text{He}$	-46.527	63.442
$T + T + {}^9\text{B}$	-31.223	42.574
$T + {}^3\text{He}(s) + {}^9\text{Be}(s)$	-30.136	41.092
$T + {}^4\text{H}\# + {}^8\text{B}$	-52.617	71.747
$T + {}^4\text{He}(s) + {}^8\text{Be}$	-11.224	15.304
$T + {}^4\text{Li}\# + {}^8\text{Li}$	-49.922	68.072
$T + {}^5\text{H}\# + {}^7\text{B}$	-65.517	89.337
$T + {}^5\text{He} + {}^7\text{Be}$	-31.016	42.292
$T + {}^5\text{Li} + {}^7\text{Li}(s)$	-30.444	41.512
$T + {}^5\text{Be} + {}^7\text{He}$	-63.667	86.814
$T + {}^6\text{He} + {}^6\text{Be}$	-39.823	54.302
$T + {}^6\text{Li}(s) + {}^6\text{Li}(s)$	-32.028	43.673

(continued)

$\tau + {}^3\text{H e (s)} + {}^9\text{L i}$	-43.724	59.62
$\tau + {}^4\text{H \#} + {}^8\text{B e}$	-34.62	47.207
$\tau + {}^4\text{H e (s)} + {}^8\text{L i}$	-27.209	37.101
$\tau + {}^4\text{L i \#} + {}^8\text{H e}$	-60.556	82.573
$\tau + {}^5\text{H \#} + {}^7\text{B e}$	-53.397	72.81
$\tau + {}^5\text{H e} + {}^7\text{L i (s)}$	-30.135	41.091
$\tau + {}^5\text{L i} + {}^7\text{H e}$	-41.628	56.763
$\tau + {}^6\text{H e} + {}^6\text{L i (s)}$	-35.516	48.429
$\alpha + {}^4\text{H \#} + {}^7\text{B e}$	-32.941	44.917
$\alpha + {}^4\text{L i \#} + {}^7\text{H e}$	-42.562	58.036
$\alpha + {}^5\text{H \#} + {}^6\text{B e}$	-43.496	59.31
$\alpha + {}^5\text{H e} + {}^6\text{L i (s)}$	-16.808	22.918
$\alpha + {}^5\text{L i} + {}^6\text{H e}$	-20.604	28.095

Table 7 ${}^6\text{Li}$ -induced Fusion Reaction

REACTION ${}^6\text{Li} + {}^6\text{Li}$ total branch 18(37)
 compound nucleus ${}^{12}\text{C}^*$ A=12 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{12}\text{C}(\text{s})$	28.171	0	
2	$\text{n} + {}^{11}\text{C}$	9.4497	0	(5, 7)
3	$\text{p} + {}^{11}\text{B}(\text{s})$	12.214	0	(5, 7)
4	$\text{D}(\text{s}) + {}^{10}\text{B}(\text{s})$	2.9846	0	(5, 7)
5	$\text{T} + {}^9\text{B}$	0.80549	0	(5)
6	${}^3\text{He}(\text{s}) + {}^9\text{Be}(\text{s})$	1.8922	0	
7	${}^4\text{He}(\text{s}) + {}^8\text{Be}$	20.805	0	
8	${}^5\text{He} + {}^7\text{Be}$	1.0125	0	
9	${}^5\text{Li} + {}^7\text{Li}(\text{s})$	1.5844	0	
10	${}^6\text{He} + {}^6\text{Be}$	-7.7951	15.59	
11	$\text{n} + \text{p} + {}^{10}\text{B}(\text{s})$	0.76002	0	
12	$\text{n} + {}^3\text{He}(\text{s}) + {}^8\text{Be}$	0.22678	0	
13	$\text{n} + {}^4\text{He}(\text{s}) + {}^7\text{Be}$	1.9062	0	(5, 7)
14	$\text{p} + \text{p} + {}^{10}\text{Be}$	0.98614	0	
15	$\text{p} + \text{T} + {}^8\text{Be}$	0.99053	0	(7)
16	$\text{p} + {}^4\text{He}(\text{s}) + {}^7\text{Li}(\text{s})$	3.5505	0	
17	$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^8\text{Be}$	-3.0422	6.0844	
18	$\alpha + {}^4\text{He}(\text{s}) + {}^4\text{He}(\text{s})$	20.896	0	(5, 7)
	${}^4\text{H}\# + {}^8\text{B}$	-20.589	41.178	
	${}^4\text{Li}\# + {}^8\text{Li}$	-17.894	35.788	
	${}^6\text{H}\# + {}^7\text{B}$	-33.489	66.978	
	${}^6\text{Be} + {}^7\text{He}$	-31.639	63.278	
	$\text{n} + \text{n} + {}^{10}\text{C}$	-3.6732	7.3465	
	$\text{n} + \text{D}(\text{s}) + {}^9\text{B}$	-5.4518	10.904	
	$\text{n} + \text{T} + {}^8\text{B}$	-17.77	35.541	
	$\text{n} + {}^4\text{H}\# + {}^7\text{B}$	-33.61	67.22	

(continued)

$n + {}^4\text{Li} + {}^7\text{Li}(s)$	-19.927	39.854
$n + {}^5\text{He} + {}^6\text{Be}$	-9.6642	19.328
$n + {}^5\text{Li} + {}^6\text{Li}(s)$	-5.6658	11.332
$n + {}^5\text{Be} + {}^6\text{He}$	-31.192	62.385
$p + \text{D}(s) + {}^9\text{Be}(s)$	-3.6014	7.2027
$p + {}^3\text{He}(s) + {}^6\text{Li}$	-14.995	29.989
$p + {}^4\text{H} + {}^7\text{Be}$	-20.727	41.453
$p + {}^4\text{Li} + {}^7\text{He}$	-30.348	60.696
$p + {}^5\text{H} + {}^6\text{Be}$	-31.282	62.564
$p + {}^5\text{He} + {}^6\text{Li}(s)$	-4.5934	9.1869
$p + {}^5\text{Li} + {}^6\text{He}$	-8.3901	16.78
$\text{D}(s) + \text{T} + {}^7\text{Be}$	-15.683	31.366
$\text{D}(s) + {}^3\text{He}(s) + {}^7\text{Li}(s)$	-14.803	29.605
$\text{D}(s) + {}^4\text{H} + {}^6\text{Be}$	-29.179	58.357
$\text{D}(s) + {}^4\text{He}(s) + {}^6\text{Li}(s)$	-1.4751	2.9503
$\text{D}(s) + {}^4\text{Li} + {}^6\text{He}$	-27.677	55.354
$\text{D}(s) + {}^5\text{H} + {}^5\text{Be}$	-52.455	104.91
$\text{D}(s) + {}^5\text{He} + {}^5\text{Li}$	-8.0346	16.069
$\text{T} + n + {}^8\text{B}$	-17.77	35.541
$\text{T} + \text{T} + {}^6\text{Be}$	-20.103	40.205
$\text{T} + {}^3\text{He}(s) + {}^6\text{Li}(s)$	-15.796	31.591
$\text{T} + {}^4\text{H} + {}^5\text{Be}$	-46.319	92.637
$\text{T} + {}^4\text{He}(s) + {}^5\text{Li}$	-0.88363	1.7673
$\text{T} + {}^4\text{Li} + {}^5\text{He}$	-23.289	46.577
$\tau + {}^3\text{He}(s) + {}^6\text{He}$	-19.284	38.567
$\tau + {}^4\text{H} + {}^5\text{Li}$	-24.28	48.56
$\tau + {}^4\text{He}(s) + {}^5\text{He}$	-0.57504	1.1501
$\tau + {}^4\text{Li} + {}^5\text{H}$	-45.67	91.34
$\alpha + {}^4\text{H} + {}^4\text{Li}$	-25.214	50.427

REACTION ${}^7\text{Li} + {}^6\text{Li}$ total branch 9(55)
 compound nucleus ${}^{13}\text{C}^*$ A=13 Z=6

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{13}\text{C}(\text{s})$	25.867	0	
2	$\text{n} + {}^{12}\text{C}(\text{s})$	20.921	0	
3	$\text{p} + {}^{12}\text{B}$	8.3339	0	
4	$\text{D}(\text{s}) + {}^{11}\text{B}(\text{s})$	7.1886	0	
5	$\text{T} + {}^{10}\text{B}(\text{s})$	1.9917	0	
6	${}^4\text{He}(\text{s}) + {}^9\text{Be}(\text{s})$	15.22	0	
7	${}^5\text{Li} + {}^6\text{Li}$	-3.633	6.7477	
8	${}^6\text{He} + {}^7\text{Be}$	-4.3686	8.114	
9	$\text{n} + \text{n} + {}^{11}\text{C}$	2.1996	0	
	${}^3\text{He}(\text{s}) + {}^{10}\text{Be}$	1.4541	0	
	${}^4\text{H}\# + {}^9\text{B}$	-9.2634	17.205	
	${}^4\text{Li}\# + {}^9\text{Li}$	-21.082	39.156	
	${}^5\text{H}\# + {}^8\text{B}$	-27.718	51.482	
	${}^5\text{He} + {}^8\text{Be}$	12.661	0	
	${}^5\text{Be} + {}^8\text{He}$	-36.306	67.432	
	${}^6\text{Be} + {}^7\text{He}$	-15.492	28.773	
	$\text{n} + \text{p} + {}^{11}\text{B}(\text{s})$	4.964	0	
	$\text{n} + \text{D}(\text{s}) + {}^{10}\text{B}(\text{s})$	-4.2656	7.9226	
	$\text{n} + \text{T} + {}^9\text{B}$	-6.4447	11.97	
	$\text{n} + {}^3\text{He}(\text{s}) + {}^9\text{Be}(\text{s})$	-5.358	9.9516	
	$\text{n} + {}^4\text{H}\# + {}^8\text{B}$	-27.839	51.707	
	$\text{n} + {}^4\text{He}(\text{s}) + {}^8\text{Be}$	13.554	0	
	$\text{n} + {}^4\text{Li}\# + {}^6\text{Li}$	-25.144	46.702	
	$\text{n} + {}^5\text{H}\# + {}^7\text{B}$	-40.739	75.666	
	$\text{n} + {}^5\text{He} + {}^7\text{Be}$	-6.2377	11.585	
	$\text{n} + {}^5\text{Li} + {}^7\text{Li}(\text{s})$	-5.6658	10.523	
	$\text{n} + {}^5\text{Be} + {}^7\text{He}$	-38.889	72.23	
	$\text{n} + {}^6\text{He} + {}^6\text{Be}$	-15.045	27.944	
	$\text{n} + {}^6\text{Li}(\text{s}) + {}^6\text{Li}(\text{s})$	-7.2502	13.466	

(continued)

$p + p + {}^{11}\text{B e}$	-5.7597	10.698
$p + \text{D (s)} + {}^{10}\text{B e}$	-4.0395	7.5027
$p + \text{T} + {}^9\text{B e (s)}$	-4.5942	8.5331
$p + {}^3\text{H e (s)} + {}^9\text{L i}$	-18.182	33.77
$p + {}^4\text{H \#} + {}^8\text{B e}$	-9.0784	16.862
$p + {}^4\text{H e (s)} + {}^8\text{L i}$	-1.6669	3.0961
$p + {}^4\text{L i \#} + {}^8\text{H e}$	-35.015	65.034
$p + {}^5\text{H \#} + {}^7\text{B e}$	-27.855	51.737
$p + {}^5\text{H e} + {}^7\text{L i (s)}$	-4.5934	8.5316
$p + {}^5\text{L i} + {}^7\text{H e}$	-16.087	29.878
$p + {}^6\text{H e} + {}^6\text{L i (s)}$	-9.9745	18.526
$\text{D (s)} + \text{D (s)} + {}^9\text{B e (s)}$	-8.6269	16.023
$\text{D (s)} + \text{T} + {}^8\text{B e}$	-4.0351	7.4945
$\text{D (s)} + {}^3\text{H e (s)} + {}^8\text{L i}$	-20.02	37.184
$\text{D (s)} + {}^4\text{H \#} + {}^7\text{B e}$	-25.752	47.831
$\text{D (s)} + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	-1.4751	2.7398
$\text{D (s)} + {}^4\text{L i \#} + {}^7\text{H e}$	-35.373	65.701
$\text{D (s)} + {}^5\text{H \#} + {}^6\text{B e}$	-36.307	67.435
$\text{D (s)} + {}^5\text{H e} + {}^6\text{L i (s)}$	-9.619	17.866
$\text{D (s)} + {}^5\text{L i} + {}^6\text{H e}$	-13.416	24.918
$\text{T} + \text{T} + {}^7\text{B e}$	-16.676	30.973
$\text{T} + {}^3\text{H e (s)} + {}^7\text{L i (s)}$	-15.796	29.338
$\text{T} + {}^4\text{H \#} + {}^6\text{B e}$	-30.172	56.039
$\text{T} + {}^4\text{H e (s)} + {}^6\text{L i (s)}$	-2.468	4.584
$\text{T} + {}^4\text{L i \#} + {}^6\text{H e}$	-28.67	53.25
$\text{T} + {}^5\text{H \#} + {}^5\text{B e}$	-53.448	99.269
$\text{T} + {}^5\text{H e} + {}^5\text{L i}$	-9.0275	16.767
$\tau + {}^3\text{H e (s)} + {}^7\text{H e}$	-26.98	50.112
$\tau + {}^4\text{H \#} + {}^6\text{L i (s)}$	-25.865	48.039
$\tau + {}^4\text{H e (s)} + {}^6\text{H e}$	-5.9561	11.063
$\tau + {}^5\text{H \#} + {}^5\text{L i}$	-31.409	58.337
$\tau + {}^5\text{H e} + {}^5\text{H e}$	-8.7189	16.194
$\alpha + {}^4\text{H \#} + {}^5\text{L i}$	-10.953	20.343
$\alpha + {}^4\text{H e (s)} + {}^5\text{H e}$	12.753	0

(continued)

 $\alpha + {}^4\text{Li} + {}^5\text{H}\#$

-32.343

60.071

REACTION ${}^9\text{Be} + {}^6\text{Li}$ total branch 14(76)
 compound nucleus ${}^{15}\text{N}^*$ A=15 Z=7

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^{14}\text{N}(s)$	14.498	0	
2	$p + {}^{14}\text{C}$	15.124	0	
3	$\text{D}(s) + {}^{13}\text{C}(s)$	9.1725	0	
4	$\text{T} + {}^{12}\text{C}(s)$	10.483	0	
5	${}^3\text{He}(s) + {}^{12}\text{B}$	-2.8675	4.7814	
6	${}^4\text{He}(s) + {}^{11}\text{B}(s)$	14.34	0	
7	${}^5\text{He} + {}^{10}\text{B}(s)$	1.9925	0	
8	${}^6\text{He} + {}^9\text{B}$	-4.5748	7.6282	
9	${}^7\text{He} + {}^8\text{B}$	-23.597	39.347	
10	${}^7\text{Li}(s) + {}^8\text{Be}$	5.5848	0	
11	$n + n + {}^{13}\text{N}$	3.945	0	
12	$p + {}^4\text{He}(s) + {}^{10}\text{Be}$	3.1124	0	
13	$\text{T} + {}^4\text{He}(s) + {}^8\text{Be}$	3.1167	0	
14	$\alpha + {}^4\text{He}(s) + {}^7\text{Li}(s)$	5.6767	0	
	$\gamma + {}^{15}\text{N}(s)$	25.332	0	
	${}^4\text{H}\# + {}^{11}\text{C}$	-11.057	18.437	
	${}^4\text{Li}\# + {}^{11}\text{Be}$	-19.861	33.117	
	${}^5\text{H}\# + {}^{10}\text{C}$	-24.058	40.116	
	${}^5\text{Li} + {}^{10}\text{Be}$	1.1463	0	
	${}^5\text{Be} + {}^{10}\text{Li}$	-42.097	70.194	
	${}^6\text{Be} + {}^9\text{Li}$	-17.895	29.838	
	${}^7\text{Be} + {}^8\text{Li}$	-11.281	18.81	
	${}^7\text{B} + {}^8\text{He}$	-34.035	56.751	
	$n + p + {}^{13}\text{C}(s)$	6.9479	0	

(continued)

$n + D(s) + {}^{12}C(s)$	4.2261	0
$n + T + {}^{11}C$	-8.2381	13.737
$n + {}^3He(s) + {}^{11}B(s)$	-6.2374	10.4
$n + {}^4H\# + {}^{10}C$	-24.18	40.318
$n + {}^4He(s) + {}^{10}B(s)$	2.8862	0
$n + {}^4Li\# + {}^{10}Be$	-20.365	33.958
$n + {}^5H\# + {}^9C$	-45.341	75.604
$n + {}^5He + {}^9B$	-6.4439	10.745
$n + {}^5Li + {}^9Be(s)$	-5.6658	9.4474
$n + {}^5Be + {}^9Li$	-41.292	68.852
$n + {}^6He + {}^8B$	-23.151	38.602
$n + {}^6Li(s) + {}^8Be$	-1.6654	2.777
$n + {}^6Be + {}^8Li$	-21.957	36.613
$n + {}^7He + {}^7B$	-36.618	61.059
$n + {}^7Li(s) + {}^7Be$	-13.314	22.2
$p + p + {}^{13}B$	-5.7071	9.5162
$p + D(s) + {}^{12}B$	-8.3611	13.942
$p + T + {}^{11}B(s)$	-5.4736	9.127
$p + {}^3He(s) + {}^{11}Be$	-16.961	28.282
$p + {}^4H\# + {}^{10}B(s)$	-19.747	32.926
$p + {}^4Li\# + {}^{10}Li$	-40.806	68.041
$p + {}^5H\# + {}^9B$	-28.062	46.791
$p + {}^5He + {}^9Be(s)$	-4.5934	7.6593
$p + {}^5Li + {}^9Li$	-18.49	30.83
$p + {}^5Be + {}^9He$	-56.366	93.987
$p + {}^6He + {}^8Be$	-4.3898	7.3197
$p + {}^6Li(s) + {}^8Li$	-16.887	28.158
$p + {}^6Be + {}^8He$	-31.828	53.071
$p + {}^7He + {}^7Be$	-23.734	39.576
$p + {}^7Li(s) + {}^7Li(s)$	-11.669	19.458
$D(s) + D(s) + {}^{11}B(s)$	-9.5063	15.851
$D(s) + T + {}^{10}B(s)$	-14.703	24.517
$D(s) + {}^3He(s) + {}^{10}Be$	-15.241	25.413
$D(s) + {}^4H\# + {}^9B$	-25.958	43.284

(continued)

$D(s) + {}^4\text{H e}(s) + {}^9\text{B e}(s)$	-1.4751	2.4597
$D(s) + {}^4\text{L i}\# + {}^9\text{L i}$	-37.776	62.99
$D(s) + {}^5\text{H}\# + {}^8\text{B}$	-44.413	74.056
$D(s) + {}^5\text{H e} + {}^8\text{B e}$	-4.0343	6.7269
$D(s) + {}^5\text{L i} + {}^8\text{L i}$	-20.328	33.896
$D(s) + {}^6\text{B e} + {}^8\text{H e}$	-53.001	88.375
$D(s) + {}^6\text{H e} + {}^7\text{B e}$	-21.064	35.122
$D(s) + {}^6\text{L i}(s) + {}^7\text{L i}(s)$	-16.695	27.838
$D(s) + {}^6\text{B e} + {}^7\text{H e}$	-32.187	53.669
$T + T + {}^9\text{B}$	-16.882	28.15
$T + {}^3\text{H e}(s) + {}^9\text{B e}(s)$	-15.796	26.338
$T + {}^4\text{H}\# + {}^8\text{B}$	-38.277	63.825
$T + {}^4\text{L i}\# + {}^8\text{L i}$	-35.582	59.331
$T + {}^5\text{H}\# + {}^7\text{B}$	-51.177	85.334
$T + {}^5\text{H e} + {}^7\text{B e}$	-16.675	27.805
$T + {}^5\text{L i} + {}^7\text{L i}(s)$	-16.103	26.852
$T + {}^5\text{B e} + {}^7\text{H e}$	-49.327	82.249
$T + {}^6\text{H e} + {}^6\text{B e}$	-25.483	42.491
$T + {}^6\text{L i}(s) + {}^6\text{L i}(s)$	-17.688	29.493
$\tau + {}^3\text{H e}(s) + {}^9\text{L i}$	-29.383	48.995
$\tau + {}^4\text{H}\# + {}^8\text{B e}$	-20.28	33.815
$\tau + {}^4\text{H e}(s) + {}^8\text{L i}$	-12.868	21.457
$\tau + {}^4\text{L i}\# + {}^8\text{H e}$	-46.216	77.063
$\tau + {}^5\text{H}\# + {}^7\text{B e}$	-39.057	65.125
$\tau + {}^5\text{H e} + {}^7\text{L i}(s)$	-15.795	26.337
$\tau + {}^5\text{L i} + {}^7\text{H e}$	-27.288	45.501
$\tau + {}^6\text{H e} + {}^6\text{L i}(s)$	-21.176	35.31
$\alpha + {}^4\text{H}\# + {}^7\text{B e}$	-18.6	31.015
$\alpha + {}^4\text{L i}\# + {}^7\text{H e}$	-28.222	47.058
$\alpha + {}^5\text{H}\# + {}^6\text{B e}$	-29.156	48.615
$\alpha + {}^5\text{H e} + {}^6\text{L i}(s)$	-2.4672	4.114
$\alpha + {}^5\text{L i} + {}^6\text{H e}$	-6.2639	10.445

REACTION ${}^1_0\text{B} + {}^6_3\text{Li}$ total branch 12(94)
 compound nucleus ${}^{16}_8\text{O}^*$ A=16 Z=8

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{16}_8\text{O}(\text{s})$	30.873	0	
2	$\text{n} + {}^{15}_8\text{O}$	15.21	0	
3	$\text{p} + {}^{15}_7\text{N}(\text{s})$	18.746	0	
4	$\text{D}(\text{s}) + {}^{14}_7\text{N}(\text{s})$	10.137	0	
5	$\text{T} + {}^{13}_7\text{N}$	5.8409	0	
6	${}^3_2\text{He}(\text{s}) + {}^{13}_6\text{C}(\text{s})$	8.08	0	
7	${}^4_2\text{He}(\text{s}) + {}^{12}_6\text{C}(\text{s})$	23.711	0	
8	${}^5_2\text{He} + {}^{11}_6\text{C}$	4.0963	0	
9	${}^5_3\text{Li} + {}^{11}_5\text{B}(\text{s})$	5.7884	0	
10	${}^6_2\text{He} + {}^{10}_6\text{C}$	-7.1576	11.457	
11	${}^8_3\text{Li} + {}^8_4\text{B}$	-17.729	28.38	
12	$\text{n} + \text{n} + {}^{14}_8\text{O}$	1.9871	0	
	${}^4_2\text{He}\# + {}^{12}_7\text{N}$	-17.042	27.279	
	${}^4_2\text{He}(\text{s}) + {}^{12}_6\text{C}(\text{s})$	23.711	0	
	${}^4_3\text{Li}\# + {}^{12}_5\text{B}$	-12.353	19.774	
	${}^5_2\text{He}\# + {}^{11}_7\text{N}$	-32.564	52.126	
	${}^5_2\text{He} + {}^{11}_6\text{C}$	4.0963	0	
	${}^5_3\text{Li} + {}^{11}_5\text{B}(\text{s})$	5.7884	0	
	${}^6_4\text{Be} + {}^{11}_5\text{B e}$	-27.738	44.401	
	${}^6_2\text{He} + {}^{10}_6\text{C}$	-7.1576	11.457	
	${}^6_4\text{Be} + {}^{10}_5\text{B e}$	-4.8446	7.755	
	${}^7_2\text{He} + {}^9_6\text{C}$	-28.887	46.24	
	${}^7_3\text{Li}(\text{s}) + {}^9_4\text{B}$	-1.1862	1.8988	
	${}^7_4\text{Be} + {}^9_5\text{B e}(\text{s})$	-0.98002	1.5688	
	${}^7_5\text{B} + {}^9_3\text{Li}$	-26.688	42.72	
	${}^8_2\text{He} + {}^8_6\text{C}$	-40.557	64.92	
	${}^8_3\text{Li} + {}^8_4\text{B}$	-17.729	28.38	
	${}^8_4\text{Be} + {}^8_5\text{B e}$	16.253	0	
	$\text{n} + \text{n} + {}^{14}_8\text{O}$	1.9871	0	

(continued)

$n + p + {}^{14}\text{N}(\text{s})$	7.9125	0
$n + \text{D}(\text{s}) + {}^{13}\text{N}$	-0.41634	0.66644
$n + \text{T} + {}^{12}\text{N}$	-14.223	22.767
$n + {}^3\text{H e}(\text{s}) + {}^{12}\text{C}(\text{s})$	3.1337	0
$n + {}^4\text{H}\# + {}^{11}\text{N}$	-32.685	52.32
$n + {}^4\text{H e}(\text{s}) + {}^{11}\text{C}$	4.99	0
$n + {}^4\text{L i}\# + {}^{11}\text{B}(\text{s})$	-15.723	25.168
$n + {}^5\text{H}\# + {}^{10}\text{N}\#$	-55.425	88.721
$n + {}^5\text{H e} + {}^{10}\text{C}$	-9.0267	14.449
$n + {}^6\text{L i} + {}^{10}\text{B}(\text{s})$	-5.6658	9.0694
$n + {}^5\text{B e} + {}^{10}\text{B e}$	-28.242	45.208
$n + {}^6\text{H e} + {}^9\text{C}$	-28.44	45.526
$n + {}^6\text{L i}(\text{s}) + {}^9\text{B}$	-8.4364	13.504
$n + {}^6\text{B e} + {}^9\text{B e}(\text{s})$	-11.657	18.659
$n + {}^7\text{H e} + {}^8\text{C}$	-43.14	69.056
$n + {}^7\text{L i}(\text{s}) + {}^8\text{B}$	-19.762	31.634
$n + {}^7\text{B e} + {}^8\text{B e}$	-2.6454	4.2346
$n + {}^7\text{B} + {}^8\text{L i}$	-30.75	49.223
$p + p + {}^{14}\text{C}$	8.5384	0
$p + \text{D}(\text{s}) + {}^{13}\text{C}(\text{s})$	2.5865	0
$p + \text{T} + {}^{12}\text{C}(\text{s})$	3.8974	0
$p + {}^3\text{H e}(\text{s}) + {}^{12}\text{B}$	-9.4535	15.133
$p + {}^4\text{H}\# + {}^{11}\text{C}$	-17.643	28.241
$p + {}^4\text{H e}(\text{s}) + {}^{11}\text{B}(\text{s})$	7.7544	0
$p + {}^4\text{L i}\# + {}^{11}\text{B e}$	-26.447	42.334
$p + {}^5\text{H}\# + {}^{10}\text{C}$	-30.644	49.053
$p + {}^5\text{H e} + {}^{10}\text{B}(\text{s})$	-4.5934	7.3529
$p + {}^5\text{L i} + {}^{10}\text{B e}$	-5.4397	8.7074
$p + {}^5\text{B e} + {}^{10}\text{L i}$	-48.683	77.928
$p + {}^6\text{H e} + {}^9\text{B}$	-11.161	17.865
$p + {}^6\text{L i}(\text{s}) + {}^9\text{B e}(\text{s})$	-6.586	10.542
$p + {}^6\text{B e} + {}^9\text{L i}$	-24.481	39.187
$p + {}^7\text{H e} + {}^8\text{B}$	-30.183	48.315
$p + {}^7\text{L i}(\text{s}) + {}^8\text{B e}$	-1.0012	1.6026

(continued)

$p + {}^7\text{B}e + {}^8\text{Li}$	-17.867	28.6
$p + {}^7\text{B} + {}^8\text{He}$	-40.621	65.023
$D(s) + D(s) + {}^{12}\text{C}(s)$	-0.13527	0.21653
$D(s) + T + {}^{11}\text{C}$	-12.599	20.168
$D(s) + {}^3\text{He}(s) + {}^{11}\text{B}(s)$	-10.599	16.966
$D(s) + {}^4\text{H}\# + {}^{10}\text{C}$	-28.541	45.687
$D(s) + {}^4\text{He}(s) + {}^{10}\text{B}(s)$	-1.4751	2.3613
$D(s) + {}^4\text{Li}\# + {}^{10}\text{Be}$	-24.726	39.58
$D(s) + {}^5\text{H}\# + {}^9\text{C}$	-49.703	79.561
$D(s) + {}^5\text{He} + {}^9\text{B}$	-10.805	17.296
$D(s) + {}^5\text{Li} + {}^9\text{Be}(s)$	-10.027	16.051
$D(s) + {}^5\text{Be} + {}^9\text{Li}$	-45.653	73.079
$D(s) + {}^6\text{He} + {}^8\text{B}$	-27.512	44.039
$D(s) + {}^6\text{Li}(s) + {}^8\text{Be}$	-6.0268	9.6473
$D(s) + {}^6\text{Be} + {}^8\text{Li}$	-26.319	42.13
$D(s) + {}^7\text{He} + {}^7\text{B}$	-40.979	65.597
$D(s) + {}^7\text{Li}(s) + {}^7\text{Be}$	-17.675	28.293
$T + T + {}^{10}\text{C}$	-19.465	31.159
$T + {}^3\text{He}(s) + {}^{10}\text{B}(s)$	-15.796	25.285
$T + {}^4\text{H}\# + {}^9\text{C}$	-43.567	69.739
$T + {}^4\text{He}(s) + {}^9\text{B}$	-3.6543	5.8495
$T + {}^4\text{Li}\# + {}^9\text{Be}(s)$	-25.281	40.469
$T + {}^5\text{H}\# + {}^8\text{C}$	-57.699	92.36
$T + {}^5\text{He} + {}^8\text{B}$	-23.124	37.015
$T + {}^5\text{Li} + {}^8\text{Be}$	-5.4353	8.7004
$T + {}^5\text{Be} + {}^8\text{Li}$	-43.459	69.566
$T + {}^6\text{He} + {}^7\text{B}$	-34.276	54.867
$T + {}^6\text{Li}(s) + {}^7\text{Be}$	-18.668	29.882
$T + {}^6\text{Be} + {}^7\text{Li}(s)$	-22.094	35.367
$\tau + {}^3\text{He}(s) + {}^{10}\text{Be}$	-16.333	26.145
$\tau + {}^4\text{H}\# + {}^9\text{B}$	-27.051	43.301
$\tau + {}^4\text{He}(s) + {}^9\text{Be}(s)$	-2.5676	4.11
$\tau + {}^4\text{Li}\# + {}^9\text{Li}$	-38.869	62.219
$\tau + {}^5\text{H}\# + {}^8\text{B}$	-45.505	72.842

(continued)

$\tau + {}^5\text{He} + {}^8\text{Be}$	-5.1267	8.2064
$\tau + {}^6\text{Li} + {}^8\text{Li}$	-21.42	34.288
$\tau + {}^5\text{Be} + {}^8\text{He}$	-54.093	86.588
$\tau + {}^6\text{He} + {}^7\text{Be}$	-22.156	35.466
$\tau + {}^6\text{Li}(s) + {}^7\text{Li}(s)$	-17.787	28.473
$\tau + {}^6\text{Be} + {}^7\text{He}$	-33.279	53.271
$\alpha + {}^4\text{H}\# + {}^8\text{B}$	-25.049	40.097
$\alpha + {}^4\text{He}(s) + {}^8\text{Be}$	16.345	0
$\alpha + {}^4\text{Li}\# + {}^8\text{Li}$	-22.354	35.783
$\alpha + {}^5\text{H}\# + {}^7\text{B}$	-37.949	60.746
$\alpha + {}^5\text{He} + {}^7\text{Be}$	-3.4472	5.5181
$\alpha + {}^5\text{Li} + {}^7\text{Li}(s)$	-2.8753	4.6027
$\alpha + {}^5\text{Be} + {}^7\text{He}$	-36.099	57.784
$\alpha + {}^6\text{He} + {}^6\text{Be}$	-12.255	19.617
$\alpha + {}^6\text{Li}(s) + {}^6\text{Li}(s)$	-4.4597	7.1389

REACTION ${}^{11}\text{B} + {}^6\text{Li}$ total branch 11(109)compound nucleus ${}^{17}\text{O}^*$ A=17 Z=8

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + {}^{17}\text{O}(s)$	23.563	0	
2	$n + {}^{16}\text{O}(s)$	19.419	0	
3	$p + {}^{16}\text{N}$	9.7825	0	
4	$\text{D}(s) + {}^{15}\text{N}(s)$	9.5163	0	
5	$\text{T} + {}^{14}\text{N}(s)$	4.9403	0	
6	$3\text{He}(s) + {}^{14}\text{C}$	4.8024	0	
7	${}^4\text{He}(s) + {}^{13}\text{C}(s)$	17.204	0	
8	${}^5\text{Li} + {}^{12}\text{B}$	-2.2959	3.5503	
9	${}^6\text{He} + {}^{11}\text{C}$	-5.4888	8.4877	
10	${}^8\text{B} + {}^9\text{Li}$	-25.121	38.846	
11	$n + n + {}^{16}\text{O}$	3.7554	0	

(continued)

${}^4\text{H}\# + {}^{13}\text{N}$	-8.4319	13.039
${}^4\text{L i}\# + {}^{13}\text{B}$	-18.929	29.271
${}^5\text{H}\# + {}^{12}\text{N}$	-28.375	43.877
${}^5\text{H e} + {}^{12}\text{C}(\text{s})$	11.364	0
${}^5\text{B e} + {}^{12}\text{B e}$	-36.023	55.705
${}^6\text{B e} + {}^{11}\text{B e}$	-15.794	24.424
${}^7\text{H e} + {}^{10}\text{C}$	-19.058	29.471
${}^7\text{L i}(\text{s}) + {}^{10}\text{B}(\text{s})$	-4.204	6.5009
${}^7\text{B e} + {}^{10}\text{B e}$	-5.6221	8.6938
${}^7\text{B} + {}^{10}\text{L i}$	-38.946	60.225
${}^8\text{H e} + {}^9\text{C}$	-37.758	58.387
${}^8\text{L i} + {}^9\text{B}$	-10.608	16.403
${}^8\text{B e} + {}^9\text{B e}(\text{s})$	6.4642	0
${}^8\text{C} + {}^9\text{H e}$	-53.151	82.192
$\text{n} + \text{p} + {}^{15}\text{N}(\text{s})$	7.2917	0
$\text{n} + \text{D}(\text{s}) + {}^{14}\text{N}(\text{s})$	-1.317	2.0366
$\text{n} + \text{T} + {}^{13}\text{N}$	-5.6132	8.6801
$\text{n} + {}^3\text{H e}(\text{s}) + {}^{13}\text{C}(\text{s})$	-3.3741	5.2176
$\text{n} + {}^4\text{H}\# + {}^{12}\text{N}$	-28.496	44.065
$\text{n} + {}^4\text{H e}(\text{s}) + {}^{12}\text{C}(\text{s})$	12.257	0
$\text{n} + {}^4\text{L i}\# + {}^{12}\text{B}$	-23.807	36.815
$\text{n} + {}^5\text{H}\# + {}^{11}\text{N}$	-44.018	68.068
$\text{n} + {}^5\text{H e} + {}^{11}\text{C}$	-7.3579	11.378
$\text{n} + {}^5\text{L i} + {}^{11}\text{B}(\text{s})$	-5.6658	8.7614
$\text{n} + {}^5\text{B e} + {}^{11}\text{B e}$	-39.192	60.605
$\text{n} + {}^6\text{H e} + {}^{10}\text{C}$	-18.612	28.781
$\text{n} + {}^6\text{L i}(\text{s}) + {}^{10}\text{B}(\text{s})$	-11.454	17.712
$\text{n} + {}^6\text{B e} + {}^{10}\text{B e}$	-16.299	25.204
$\text{n} + {}^7\text{H e} + {}^9\text{C}$	-40.341	62.382
$\text{n} + {}^7\text{L i}(\text{s}) + {}^9\text{B}$	-12.64	19.547
$\text{n} + {}^7\text{B e} + {}^9\text{B e}(\text{s})$	-12.434	19.228
$\text{n} + {}^7\text{B} + {}^9\text{L i}$	-38.142	58.981
$\text{n} + {}^8\text{H e} + {}^8\text{C}$	-52.011	80.428
$\text{n} + {}^8\text{L i} + {}^8\text{B}$	-29.183	45.128

(continued)

$n + {}^8\text{Be} + {}^8\text{Be}$	4.7988	0
$p + p + {}^{15}\text{C}$	-1.6977	2.6252
$p + \text{D}(\text{s}) + {}^{14}\text{C}$	-0.69116	1.0688
$p + \text{T} + {}^{13}\text{C}(\text{s})$	-2.6104	4.0366
$p + {}^3\text{He}(\text{s}) + {}^{13}\text{B}$	-16.029	24.787
$p + {}^4\text{H}\# + {}^{12}\text{C}(\text{s})$	-10.375	16.044
$p + {}^4\text{He}(\text{s}) + {}^{12}\text{B}$	-0.32985	0.51007
$p + {}^4\text{Li}\# + {}^{12}\text{Be}$	-34.732	53.709
$p + {}^5\text{H}\# + {}^{11}\text{C}$	-28.976	44.807
$p + {}^5\text{He} + {}^{11}\text{B}(\text{s})$	-4.5934	7.1031
$p + {}^5\text{Li} + {}^{11}\text{Be}$	-16.389	25.344
$p + {}^5\text{Be} + {}^{11}\text{Li}$	-59.135	91.445
$p + {}^6\text{He} + {}^{10}\text{B}(\text{s})$	-14.179	21.925
$p + {}^6\text{Li}(\text{s}) + {}^{10}\text{Be}$	-11.228	17.363
$p + {}^6\text{Be} + {}^{10}\text{Li}$	-36.739	56.813
$p + {}^7\text{He} + {}^9\text{B}$	-23.061	35.661
$p + {}^7\text{Li}(\text{s}) + {}^9\text{Be}(\text{s})$	-10.79	16.685
$p + {}^7\text{Be} + {}^9\text{Li}$	-25.258	39.058
$p + {}^7\text{B} + {}^9\text{He}$	-53.215	82.291
$p + {}^8\text{He} + {}^8\text{B}$	-39.054	60.391
$p + {}^8\text{Li} + {}^8\text{Be}$	-10.423	16.117
$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^{13}\text{C}(\text{s})$	-6.6431	10.273
$\text{D}(\text{s}) + \text{T} + {}^{12}\text{C}(\text{s})$	-5.3321	8.2454
$\text{D}(\text{s}) + {}^3\text{He}(\text{s}) + {}^{12}\text{B}$	-18.683	28.891
$\text{D}(\text{s}) + {}^4\text{H}\# + {}^{11}\text{C}$	-26.872	41.554
$\text{D}(\text{s}) + {}^4\text{He}(\text{s}) + {}^{11}\text{B}(\text{s})$	-1.4751	2.2811
$\text{D}(\text{s}) + {}^4\text{Li}\# + {}^{11}\text{Be}$	-35.676	55.169
$\text{D}(\text{s}) + {}^5\text{H}\# + {}^{10}\text{C}$	-39.874	61.66
$\text{D}(\text{s}) + {}^5\text{He} + {}^{10}\text{B}(\text{s})$	-13.823	21.375
$\text{D}(\text{s}) + {}^5\text{Li} + {}^{10}\text{Be}$	-14.669	22.684
$\text{D}(\text{s}) + {}^5\text{Be} + {}^{10}\text{Li}$	-57.912	89.554
$\text{D}(\text{s}) + {}^6\text{He} + {}^9\text{B}$	-20.39	31.531
$\text{D}(\text{s}) + {}^6\text{Li}(\text{s}) + {}^9\text{Be}(\text{s})$	-15.816	24.457
$\text{D}(\text{s}) + {}^6\text{Be} + {}^9\text{Li}$	-33.71	52.128

(continued)

D(s)+ ⁷ He + ⁸ B	-39.413	60.946
D(s)+ ⁷ Li(s) + ⁸ Be	-10.231	15.82
D(s)+ ⁷ Be + ⁸ Li	-27.096	41.901
D(s)+ ⁷ B + ⁸ He	-49.85	77.087
T + T + ¹¹ C	-17.796	27.52
T + ³ He(s) + ¹¹ B(s)	-15.796	24.426
T + ⁴ H# + ¹⁰ C	-33.738	52.171
T + ⁴ He(s) + ¹⁰ B(s)	-6.672	10.317
T + ⁴ Li# + ¹⁰ Be	-29.923	46.272
T + ⁵ H# + ⁹ C	-54.9	84.895
T + ⁵ He + ⁹ B	-16.002	24.745
T + ⁵ Li + ⁹ Be(s)	-15.224	23.542
T + ⁵ Be + ⁹ Li	-50.85	78.633
T + ⁶ He + ⁸ B	-32.709	50.58
T + ⁶ Li(s) + ⁸ Be	-11.224	17.356
T + ⁶ Be + ⁸ Li	-31.516	48.735
T + ⁷ He + ⁷ B	-46.176	71.406
T + ⁷ Li(s) + ⁷ Be	-22.872	35.368
τ + ³ He(s) + ¹¹ Be	-27.283	42.19
τ + ⁴ H# + ¹⁰ B(s)	-30.069	46.497
τ + ⁴ He(s) + ¹⁰ Be	-7.2096	11.149
τ + ⁴ Li# + ¹⁰ Li	-51.128	79.062
τ + ⁵ H# + ⁹ B	-38.384	59.355
τ + ⁵ He + ⁹ Be(s)	-14.915	23.065
τ + ⁵ Li + ⁹ Li	-28.812	44.553
τ + ⁵ Be + ⁹ He	-66.688	103.12
τ + ⁶ He + ⁸ Be	-14.712	22.75
τ + ⁶ Li(s) + ⁸ Li	-27.209	42.075
τ + ⁶ Be + ⁸ He	-42.15	65.179
τ + ⁷ He + ⁷ Be	-34.056	52.664
τ + ⁷ Li(s) + ⁷ Li(s)	-21.991	34.007
α + ⁴ H# + ⁹ B	-17.927	27.722
α + ⁴ He(s) + ⁹ Be(s)	6.5561	0
α + ⁴ Li# + ⁹ Li	-29.745	45.997

(continued)

$\alpha + {}^5\text{H} + {}^8\text{B}$	-36.382	56.259
$\alpha + {}^5\text{He} + {}^8\text{Be}$	3.997	0
$\alpha + {}^5\text{Li} + {}^8\text{Li}$	-12.297	19.015
$\alpha + {}^5\text{Be} + {}^8\text{He}$	-44.969	69.539
$\alpha + {}^6\text{He} + {}^7\text{Be}$	-13.032	20.153
$\alpha + {}^6\text{Li}(s) + {}^7\text{Li}(s)$	-8.6637	13.397
$\alpha + {}^6\text{Be} + {}^7\text{He}$	-24.155	37.353

Table 8 ${}^7\text{Li}$ -induced Fusion Reaction

REACTION ${}^7\text{Li} + {}^7\text{Li}$ total branch 13(61)			
compound nucleus ${}^{14}\text{C}^*$ A=14 Z=6			
branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^{13}\text{C}(\text{s})$	18.617	0 (9)
2	$p + {}^{13}\text{B}$	5.9623	0
3	$\text{D}(\text{s}) + {}^{12}\text{B}$	3.3083	0
4	$\text{T} + {}^{11}\text{B}(\text{s})$	6.1957	0
5	${}^4\text{He}(\text{s}) + {}^{10}\text{Be}$	14.782	0
6	${}^6\text{He} + {}^6\text{Be}$	7.2796	0
7	${}^6\text{Li}(\text{s}) + {}^8\text{Li}$	-5.2174	10.435
8	${}^7\text{He} + {}^7\text{Be}$	-12.065	24.13
9	$n + n + {}^{12}\text{C}(\text{s})$	13.671	0 (9)
10	$p + p + {}^{12}\text{Be}$	-9.84149	19.683
11	$3n + {}^{11}\text{C}$	-5.050	10.10
12	$4n + {}^{10}\text{C}$	-18.172	36.344
13	${}^8\text{B} + {}^6\text{H}\#$	-35.01*	70.02 n. o.
	$\gamma + {}^{14}\text{C}$	26.794	0
	${}^8\text{He}(\text{s}) + {}^{11}\text{Be}$	-5.2917	10.583
	${}^4\text{H}\# + {}^{10}\text{B}(\text{s})$	-8.0772	16.154
	${}^4\text{Li}\# + {}^{10}\text{Li}$	-29.136	58.273
	${}^5\text{H}\# + {}^9\text{B}$	-16.392	32.784
	${}^5\text{He} + {}^9\text{Be}(\text{s})$	7.0759	0
	${}^5\text{Li} + {}^9\text{Li}$	-6.8203	13.641
	${}^5\text{Be} + {}^9\text{He}$	-44.696	89.393
	${}^6\text{Be} + {}^8\text{He}$	-20.158	40.317
	$n + p + {}^{12}\text{B}$	1.0837	0
	$n + \text{D}(\text{s}) + {}^{11}\text{B}(\text{s})$	-0.061594	0.12319
	$n + \text{T} + {}^{10}\text{B}(\text{s})$	-5.2585	10.517

(continued)

$n + {}^3\text{H e (s)} + {}^{10}\text{B e}$	-5.7961	11.592
$n + {}^4\text{H \#} + {}^9\text{B}$	-16.514	33.027
$n + {}^4\text{H e (s)} + {}^9\text{B e (s)}$	7.9696	0
$n + {}^4\text{L i \#} + {}^9\text{L i}$	-28.332	56.663
$n + {}^5\text{H \#} + {}^8\text{B}$	-34.968	69.936
$n + {}^5\text{H e} + {}^8\text{B e}$	5.4105	0
$n + {}^5\text{L i} + {}^8\text{L i}$	-10.883	21.766
$n + {}^5\text{B e} + {}^8\text{H e}$	-43.556	87.112
$n + {}^6\text{H e} + {}^7\text{B e}$	-11.619	23.238
$n + {}^6\text{L i (s)} + {}^7\text{L i (s)}$	-7.2502	14.5
$n + {}^6\text{B e} + {}^7\text{H e}$	-22.742	45.484
$p + \text{D (s)} + {}^{11}\text{B e}$	-10.785	21.571
$p + \text{T} + {}^{10}\text{B e}$	-5.0323	10.065
$p + {}^3\text{H e (s)} + {}^{10}\text{L i}$	-26.237	52.474
$p + {}^4\text{H \#} + {}^9\text{B e (s)}$	-14.663	29.326
$p + {}^4\text{H e (s)} + {}^9\text{L i}$	-4.8543	9.7085
$p + {}^4\text{L i \#} + {}^9\text{H e}$	-43.405	86.811
$p + {}^5\text{H \#} + {}^8\text{B e}$	-16.207	32.414
$p + {}^5\text{H e} + {}^8\text{L i}$	-9.81079	19.622
$p + {}^5\text{L i} + {}^8\text{H e}$	-20.753	41.507
$p + {}^6\text{H e} + {}^7\text{L i (s)}$	-9.9745	19.949
$p + {}^6\text{L i (s)} + {}^7\text{H e}$	-17.671	35.342
$\text{D (s)} + \text{D (s)} + {}^{10}\text{B e}$	-9.065	18.13
$\text{D (s)} + \text{T} + {}^9\text{B e (s)}$	-9.6198	19.24
$\text{D (s)} + {}^3\text{H e (s)} + {}^9\text{L i}$	-23.207	46.415
$\text{D (s)} + {}^4\text{H \#} + {}^8\text{B e}$	-14.104	28.208
$\text{D (s)} + {}^4\text{H e (s)} + {}^8\text{L i}$	-6.6925	13.385
$\text{D (s)} + {}^4\text{L i \#} + {}^8\text{H e}$	-40.04	80.08
$\text{D (s)} + {}^5\text{H \#} + {}^7\text{B e}$	-32.881	65.762
$\text{D (s)} + {}^5\text{H e} + {}^7\text{L i (s)}$	-9.619	19.238
$\text{D (s)} + {}^5\text{L i} + {}^7\text{H e}$	-21.112	42.224
$\text{D (s)} + {}^6\text{H e} + {}^6\text{L i (s)}$	-15.0	30.0
$\text{T} + \text{T} + {}^8\text{B e}$	-5.0279	10.056
$\text{T} + {}^3\text{H e (s)} + {}^8\text{L i}$	-21.013	42.026

(continued)

$T + {}^4\text{H}\# + {}^7\text{B e}$	-26.745	53.49
$T + {}^4\text{H e (s)} + {}^7\text{L i (s)}$	-2.468	4.9361
$T + {}^4\text{L i}\# + {}^7\text{H e}$	-36.366	72.733
$T + {}^5\text{H}\# + {}^6\text{B e}$	-37.3	74.601
$T + {}^5\text{H e} + {}^6\text{L i (s)}$	-10.612	21.224
$T + {}^5\text{L i} + {}^6\text{H e}$	-14.409	28.817
$\tau + {}^3\text{H e (s)} + {}^8\text{H e}$	-31.647	63.294
$\tau + {}^4\text{H}\# + {}^7\text{L i (s)}$	-25.865	51.729
$\tau + {}^4\text{H e (s)} + {}^7\text{H e}$	-13.653	27.305
$\tau + {}^5\text{H}\# + {}^6\text{L i (s)}$	-32.993	65.987
$\tau + {}^5\text{H e} + {}^6\text{H e}$	-14.1	28.2
$\alpha + {}^4\text{H}\# + {}^6\text{L i (s)}$	-12.537	25.074
$\alpha + {}^4\text{H e (s)} + {}^6\text{H e}$	7.3715	0
$\alpha + {}^5\text{H}\# + {}^5\text{L i}$	-18.081	36.163
$\alpha + {}^5\text{H e} + {}^5\text{H e}$	4.6087	0

* ; ΔM of ${}^6\text{H}$ is based on $\Delta M = 41.9$ MeV. This ΔM value is not shown in Appendix B.

REACTION ${}^6\text{B e} + {}^7\text{L i}$ total branch 13(87)
compound nucleus ${}^{16}\text{N}^*$ A=16 Z=7

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^{16}\text{N (s)}$	18.082	0	
2	$p + {}^{15}\text{C}$	9.0923	0	
3	$\text{D (s)} + {}^{14}\text{C}$	10.099	0	
4	$\text{T} + {}^{13}\text{C (s)}$	8.1796	0	
5	${}^4\text{H e (s)} + {}^{12}\text{B}$	10.46	0	
6	${}^6\text{H e} + {}^{10}\text{B (s)}$	-3.3886	6.0266	
7	${}^6\text{L i (s)} + {}^{10}\text{B e}$	-0.4381	0.77916	
8	${}^7\text{B e} + {}^9\text{L i}$	-14.468	25.732	
9	${}^8\text{H e} + {}^8\text{B}$	-28.264	50.267	

(continued)

10	${}^8\text{Li} + {}^8\text{Be}$	0.36737	0	
11	$n + n + {}^{14}\text{N}(s)$	7.2483	0	
12	$n + {}^4\text{He}(s) + {}^{11}\text{B}(s)$	7.0902	0	
13	${}^4\text{He} + {}^{12}\text{C}(s)$	0.4145*	0	n. o.
	$\gamma + {}^{16}\text{N}$	20.572	0	
	${}^8\text{He}(s) + {}^{18}\text{B}$	-5.2391	9.3178	
	${}^4\text{Li} + {}^{12}\text{Be}$	-23.943	42.582	
	${}^5\text{He} + {}^{11}\text{C}$	-18.186	32.343	
	${}^5\text{He} + {}^{11}\text{B}(s)$	6.1965	0	
	${}^5\text{Li} + {}^{11}\text{Be}$	-5.5995	9.9587	
	${}^5\text{Be} + {}^{11}\text{Li}$	-48.346	85.983	
	${}^6\text{Be} + {}^{10}\text{Li}$	-25.95	46.151	
	${}^7\text{He} + {}^9\text{B}$	-12.271	21.825	
	${}^7\text{B} + {}^9\text{He}$	-42.426	75.454	
	$n + p + {}^{14}\text{C}$	7.8742	0	
	$n + \text{D}(s) + {}^{13}\text{C}(s)$	1.9223	0	
	$n + \text{T} + {}^{12}\text{C}(s)$	3.2332	0	
	$n + {}^8\text{He}(s) + {}^{12}\text{B}$	-10.118	17.994	
	$n + {}^4\text{He} + {}^{11}\text{C}$	-18.307	32.559	
	$n + {}^4\text{Li} + {}^{11}\text{Be}$	-27.111	48.217	
	$n + {}^5\text{He} + {}^{10}\text{C}$	-31.309	55.682	
	$n + {}^5\text{He} + {}^{10}\text{B}(s)$	-5.2576	9.3507	
	$n + {}^5\text{Li} + {}^{10}\text{Be}$	-6.1039	10.856	
	$n + {}^5\text{Be} + {}^{10}\text{Li}$	-49.347	87.764	
	$n + {}^6\text{He} + {}^9\text{B}$	-11.825	21.031	
	$n + {}^6\text{Li}(s) + {}^9\text{Be}(s)$	-7.2502	12.894	
	$n + {}^6\text{Be} + {}^9\text{Li}$	-25.145	44.72	
	$n + {}^7\text{He} + {}^8\text{B}$	-30.847	54.862	
	$n + {}^7\text{Li}(s) + {}^8\text{Be}$	-1.6654	2.9619	
	$n + {}^7\text{Be} + {}^8\text{Li}$	-18.531	32.957	
	$n + {}^7\text{B} + {}^8\text{He}$	-41.285	73.425	
	$p + p + {}^{14}\text{B}$	-11.988	21.32	

(continued)

$p + D(s) + {}^1_3B$	-10.733	19.088
$p + T + {}^1_2B$	-9.3539	16.636
$p + {}^3He(s) + {}^1_2Be$	-21.043	37.425
$p + {}^4H\# + {}^1_1B(s)$	-15.543	27.642
$p + {}^4He(s) + {}^1_1Be$	-3.6334	6.4621
$p + {}^4Li\# + {}^1_1Li$	-47.055	83.687
$p + {}^5H\# + {}^1_0B(s)$	-26.875	47.798
$p + {}^5He + {}^1_0Be$	-5.0315	8.9486
$p + {}^6Li + {}^1_0Li$	-26.545	47.21
$p + {}^6Be + {}^1_0He\#$	-64.135	114.06
$p + {}^6He + {}^9Be(s)$	-9.9745	17.74
$p + {}^6Li(s) + {}^9Li$	-20.074	35.702
$p + {}^6Be + {}^9He$	-40.219	71.529
$p + {}^7He + {}^8Be$	-12.086	21.495
$p + {}^7Li(s) + {}^8Li$	-16.887	30.033
$p + {}^7Be + {}^8He$	-28.401	50.512
$D(s) + D(s) + {}^1_2B$	-13.387	23.808
$D(s) + T + {}^1_1B(s)$	-10.499	18.673
$D(s) + {}^3He(s) + {}^1_1Be$	-21.987	39.103
$D(s) + {}^4H\# + {}^1_0B(s)$	-24.772	44.057
$D(s) + {}^4He(s) + {}^1_0Be$	-1.9132	3.4027
$D(s) + {}^4Li\# + {}^1_0Li$	-45.831	81.511
$D(s) + {}^5H\# + {}^9B$	-33.087	58.846
$D(s) + {}^5He + {}^9Be(s)$	-9.619	17.107
$D(s) + {}^6Li + {}^9Li$	-23.515	41.822
$D(s) + {}^6Be + {}^9He$	-61.391	109.18
$D(s) + {}^6He + {}^8Be$	-9.4154	16.745
$D(s) + {}^6Li(s) + {}^8Li$	-21.912	38.971
$D(s) + {}^6Be + {}^8He$	-36.853	65.544
$D(s) + {}^7He + {}^7Be$	-28.76	51.15
$D(s) + {}^7Li(s) + {}^7Li(s)$	-16.695	29.692
$T + T + {}^1_0B(s)$	-15.696	27.916
$T + {}^3He(s) + {}^1_0Be$	-16.234	28.872
$T + {}^4H\# + {}^9B$	-26.951	47.933

(continued)

$T + {}^4\text{H e (s)} + {}^9\text{B e (s)}$	-2.468	4.3894
$T + {}^4\text{L i \#} + {}^9\text{L i}$	-38.769	68.951
$T + {}^5\text{H \#} + {}^8\text{B}$	-45.406	80.754
$T + {}^5\text{H e} + {}^8\text{B e}$	-5.0271	8.9408
$T + {}^5\text{L i} + {}^8\text{L i}$	-21.321	37.919
$T + {}^5\text{B e} + {}^8\text{H e}$	-53.993	96.027
$T + {}^6\text{H e} + {}^7\text{B e}$	-22.056	39.227
$T + {}^6\text{L i (s)} + {}^7\text{L i (s)}$	-17.688	31.458
$T + {}^6\text{B e} + {}^7\text{H e}$	-33.179	59.01
$\tau + {}^3\text{H e (s)} + {}^{10}\text{L i}$	-37.438	66.584
$\tau + {}^4\text{H \#} + {}^9\text{B e (s)}$	-25.865	46.0
$\tau + {}^4\text{H e (s)} + {}^9\text{L i}$	-16.056	28.555
$\tau + {}^4\text{L i \#} + {}^9\text{H e}$	-54.607	97.118
$\tau + {}^5\text{H \#} + {}^8\text{B e}$	-27.409	48.746
$\tau + {}^5\text{H e} + {}^8\text{L i}$	-21.012	37.37
$\tau + {}^5\text{L i} + {}^8\text{H e}$	-31.955	56.832
$\tau + {}^6\text{H e} + {}^7\text{L i (s)}$	-21.176	37.661
$\tau + {}^6\text{L i (s)} + {}^7\text{H e}$	-28.872	51.35
$\alpha + {}^4\text{H \#} + {}^8\text{B e}$	-6.9521	12.364
$\alpha + {}^4\text{H e (s)} + {}^8\text{L i}$	0.45926	0
$\alpha + {}^4\text{L i \#} + {}^8\text{H e}$	-32.888	58.492
$\alpha + {}^5\text{H \#} + {}^7\text{B e}$	-25.729	45.759
$\alpha + {}^5\text{H e} + {}^7\text{L i (s)}$	-2.4672	4.388
$\alpha + {}^5\text{L i} + {}^7\text{H e}$	-13.96	24.829
$\alpha + {}^6\text{H e} + {}^6\text{L i (s)}$	-7.8483	13.958

* ; The value in F. Ajzenberg-Selove⁽²⁾ is 3.237 MeV. Their estimated ΔM value of ${}^4\text{H}$ would be then different from the one shown in Appendix B..

REACTION $^{10}\text{B} + ^7\text{Li}$ total branch 11(109)
 compound nucleus $^{17}\text{O}^*$ A=17 Z=8

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^{17}\text{O}(\text{s})$	27.767	0	
2	$\text{p} + ^{16}\text{N}$	13.986	0	
3	$\text{D}(\text{s}) + ^{15}\text{N}(\text{s})$	13.72	0	
4	$\text{T} + ^{14}\text{N}(\text{s})$	9.1442	0	
5	$^4\text{He}(\text{s}) + ^{13}\text{C}(\text{s})$	21.408	0	
6	$^6\text{He} + ^{11}\text{C}$	-1.2848	2.1851	
7	$^6\text{Li}(\text{s}) + ^{11}\text{B}(\text{s})$	4.204	0	
8	$^7\text{Be} + ^{10}\text{Be}$	-1.4181	2.4118	
9	$^8\text{Be} + ^9\text{Be}(\text{s})$	10.668	0	
10	$\text{n} + \text{n} + ^{15}\text{O}$	7.9593	0	
11	$^4\text{H}\# + ^{13}\text{N}$	-4.2279*	7.1904	n. o.
	$\text{n} + ^{16}\text{O}(\text{s})$	23.623	0	
	$^3\text{He}(\text{s}) + ^{14}\text{C}$	9.0064	0	
	$^4\text{Li}\# + ^{13}\text{B}$	-14.725	25.042	
	$^5\text{H}\# + ^{12}\text{N}$	-24.171	41.107	
	$^5\text{He} + ^{12}\text{C}(\text{s})$	15.568	0	
	$^5\text{Li} + ^{12}\text{B}$	1.9081	0	
	$^5\text{Be} + ^{12}\text{Be}$	-31.819	54.115	
	$^6\text{Be} + ^{11}\text{Be}$	-11.59	19.712	
	$^7\text{He} + ^{10}\text{C}$	-14.854	25.262	
	$^7\text{B} + ^{10}\text{Li}$	-34.742	59.086	
	$^8\text{He} + ^9\text{C}$	-33.554	57.064	
	$^8\text{Li} + ^9\text{B}$	-6.4036	10.891	
	$^8\text{B} + ^9\text{Li}$	-20.917	35.573	
	$^8\text{C} + ^9\text{He}$	-48.947	83.245	
	$\text{n} + \text{p} + ^{15}\text{N}(\text{s})$	11.496	0	
	$\text{n} + \text{D}(\text{s}) + ^{14}\text{N}(\text{s})$	2.887	0	
	$\text{n} + \text{T} + ^{13}\text{N}$	-1.4092	2.3967	

(continued)

$n + {}^3\text{H e (s)} + {}^{13}\text{C (s)}$	0.82987	0
$n + {}^4\text{H \#} + {}^{12}\text{N}$	-24.292	41.313
$n + {}^4\text{H e (s)} + {}^{12}\text{C (s)}$	16.461	0
$n + {}^4\text{L i \#} + {}^{12}\text{B}$	-19.603	33.339
$n + {}^5\text{H \#} + {}^{11}\text{N}$	-39.814	67.711
$n + {}^5\text{H e} + {}^{11}\text{C}$	-3.1539	5.3638
$n + {}^5\text{L i} + {}^{11}\text{B (s)}$	-1.4618	2.4861
$n + {}^5\text{B e} + {}^{11}\text{B e}$	-34.988	59.504
$n + {}^6\text{H e} + {}^{10}\text{C}$	-14.408	24.503
$n + {}^6\text{L i (s)} + {}^{10}\text{B (s)}$	-7.2502	12.33
$n + {}^6\text{B e} + {}^{10}\text{B e}$	-12.095	20.57
$n + {}^7\text{H e} + {}^9\text{C}$	-36.137	61.458
$n + {}^7\text{L i (s)} + {}^9\text{B}$	-8.4364	14.348
$n + {}^7\text{B e} + {}^9\text{B e (s)}$	-8.2302	13.997
$n + {}^7\text{B} + {}^9\text{L i}$	-33.938	57.718
$n + {}^8\text{H e} + {}^8\text{C}$	-47.807	81.305
$n + {}^8\text{L i} + {}^8\text{B}$	-24.979	42.482
$n + {}^8\text{B e} + {}^8\text{B e}$	9.0027	0
$p + p + {}^{15}\text{C}$	2.5063	0
$p + \text{D (s)} + {}^{14}\text{C}$	3.5128	0
$p + \text{T} + {}^{13}\text{C (s)}$	1.5936	0
$p + {}^3\text{H e (s)} + {}^{13}\text{B}$	-11.825	20.111
$p + {}^4\text{H \#} + {}^{12}\text{C (s)}$	-6.1714	10.496
$p + {}^4\text{H e (s)} + {}^{12}\text{B}$	3.8741	0
$p + {}^4\text{L i \#} + {}^{12}\text{B e}$	-30.528	51.92
$p + {}^5\text{H \#} + {}^{11}\text{C}$	-24.772	42.129
$p + {}^5\text{H e} + {}^{11}\text{B (s)}$	-0.38945	0.66234
$p + {}^5\text{L i} + {}^{11}\text{B e}$	-12.185	20.724
$p + {}^5\text{B e} + {}^{11}\text{L i}$	-54.931	93.422
$p + {}^6\text{H e} + {}^{10}\text{B (s)}$	-9.9745	16.964
$p + {}^6\text{L i (s)} + {}^{10}\text{B e}$	-7.0241	11.946
$p + {}^6\text{B e} + {}^{10}\text{L i}$	-32.535	55.333
$p + {}^7\text{H e} + {}^9\text{B}$	-18.857	32.07
$p + {}^7\text{L i (s)} + {}^9\text{B e (s)}$	-6.586	11.201

(continued)

$p + {}^7\text{B}e + {}^9\text{Li}$	-21.054	35.806
$p + {}^7\text{B} + {}^9\text{He}$	-49.011	83.353
$p + {}^8\text{He} + {}^8\text{B}$	-34.85	59.269
$p + {}^8\text{Li} + {}^8\text{Be}$	-6.2186	10.576
$D(s) + D(s) + {}^{13}\text{C}(s)$	-2.4391	4.1482
$D(s) + T + {}^{12}\text{C}(s)$	-1.1282	1.9186
$D(s) + {}^8\text{He}(s) + {}^{12}\text{B}$	-14.479	24.624
$D(s) + {}^4\text{H}\# + {}^{11}\text{C}$	-22.668	38.552
$D(s) + {}^4\text{He}(s) + {}^{11}\text{B}(s)$	2.7288	0
$D(s) + {}^4\text{Li}\# + {}^{11}\text{Be}$	-31.472	53.525
$D(s) + {}^5\text{H}\# + {}^{10}\text{C}$	-35.67	60.664
$D(s) + {}^5\text{He} + {}^{10}\text{B}(s)$	-9.619	16.359
$D(s) + {}^5\text{Li} + {}^{10}\text{Be}$	-10.465	17.798
$D(s) + {}^5\text{Be} + {}^{10}\text{Li}$	-53.708	91.341
$D(s) + {}^6\text{He} + {}^9\text{B}$	-16.186	27.528
$D(s) + {}^6\text{Li}(s) + {}^9\text{Be}(s)$	-11.612	19.748
$D(s) + {}^6\text{Be} + {}^9\text{Li}$	-29.506	50.181
$D(s) + {}^7\text{He} + {}^8\text{B}$	-35.209	59.879
$D(s) + {}^7\text{Li}(s) + {}^8\text{Be}$	-6.0268	10.25
$D(s) + {}^7\text{Be} + {}^8\text{Li}$	-22.892	38.933
$D(s) + {}^7\text{B} + {}^8\text{He}$	-45.646	77.63
$T + T + {}^{11}\text{C}$	-13.592	23.116
$T + {}^8\text{He}(s) + {}^{11}\text{B}(s)$	-11.592	19.714
$T + {}^4\text{H}\# + {}^{10}\text{C}$	-29.534	50.228
$T + {}^4\text{He}(s) + {}^{10}\text{B}(s)$	-2.468	4.1974
$T + {}^4\text{Li}\# + {}^{10}\text{Be}$	-25.719	43.741
$T + {}^5\text{H}\# + {}^9\text{C}$	-50.696	86.218
$T + {}^5\text{He} + {}^9\text{B}$	-11.798	20.065
$T + {}^5\text{Li} + {}^9\text{Be}(s)$	-11.02	18.742
$T + {}^5\text{Be} + {}^9\text{Li}$	-46.646	79.331
$T + {}^6\text{He} + {}^8\text{B}$	-28.505	48.478
$T + {}^6\text{Li}(s) + {}^8\text{Be}$	-7.0197	11.938
$T + {}^6\text{Be} + {}^8\text{Li}$	-27.312	46.449
$T + {}^7\text{He} + {}^7\text{B}$	-41.972	71.382

(continued)

$\tau + {}^7\text{Li}(\text{s}) + {}^7\text{Be}$	-18.668	31.748
$\tau + {}^8\text{He}(\text{s}) + {}^{11}\text{Be}$	-23.079	39.25
$\tau + {}^4\text{H}\# + {}^{10}\text{B}(\text{s})$	-25.865	43.988
$\tau + {}^4\text{He}(\text{s}) + {}^{10}\text{Be}$	-3.0057	5.1117
$\tau + {}^4\text{Li}\# + {}^{10}\text{Li}$	-46.924	79.803
$\tau + {}^5\text{H}\# + {}^9\text{B}$	-34.18	58.129
$\tau + {}^5\text{He} + {}^9\text{Be}(\text{s})$	-10.711	18.217
$\tau + {}^5\text{Li} + {}^9\text{Li}$	-24.608	41.85
$\tau + {}^5\text{Be} + {}^9\text{He}$	-62.484	106.27
$\tau + {}^6\text{He} + {}^8\text{Be}$	-10.508	17.871
$\tau + {}^6\text{Li}(\text{s}) + {}^8\text{Li}$	-23.005	39.124
$\tau + {}^6\text{Be} + {}^8\text{He}$	-37.946	64.534
$\tau + {}^7\text{He} + {}^7\text{Be}$	-29.852	50.77
$\tau + {}^7\text{Li}(\text{s}) + {}^7\text{Li}(\text{s})$	-17.787	30.251
$\alpha + {}^4\text{H}\# + {}^9\text{B}$	-13.723	23.339
$\alpha + {}^4\text{He}(\text{s}) + {}^9\text{Be}(\text{s})$	10.76	0
$\alpha + {}^4\text{Li}\# + {}^9\text{Li}$	-25.541	43.438
$\alpha + {}^5\text{H}\# + {}^8\text{B}$	-32.178	54.724
$\alpha + {}^5\text{He} + {}^8\text{Be}$	8.2009	0
$\alpha + {}^5\text{Li} + {}^8\text{Li}$	-8.0927	13.763
$\alpha + {}^5\text{Be} + {}^8\text{He}$	-40.765	69.329
$\alpha + {}^6\text{He} + {}^7\text{Be}$	-8.8283	15.014
$\alpha + {}^6\text{Li}(\text{s}) + {}^7\text{Li}(\text{s})$	-4.4597	7.5847
$\alpha + {}^6\text{Be} + {}^7\text{He}$	-19.951	33.931

* ; The value in F.Ajzenberg-Selove⁽²⁾ is -1.407 MeV. Their estimated ΔM value of ${}^4\text{H}$ would be then different from the one shown in Appendix B.

REACTION $^{11}\text{B} + ^7\text{Li}$ total branch 15(120)compound nucleus $^{18}\text{O}^*$ A=18 Z=8

	branch	Q(MeV)	Eth(MeV)	remarks
1	$\gamma + ^{18}\text{O}(\text{s})$	24.357	0	
2	$\text{p} + ^{17}\text{N}$	8.4148	0	
3	$\text{D}(\text{s}) + ^{16}\text{N}$	4.7569	0	
4	$\text{T} + ^{15}\text{N}(\text{s})$	8.5234	0	
5	$^4\text{He}(\text{s}) + ^{14}\text{C}$	18.13	0	
6	$^5\text{He} + ^{13}\text{C}(\text{s})$	9.0598	0	
7	$^6\text{He} + ^{12}\text{C}(\text{s})$	5.9825	0	
8	$^6\text{Li}(\text{s}) + ^{12}\text{B}$	-3.8803	6.3531	
9	$^7\text{He} + ^{11}\text{C}$	-13.185	21.588	
10	$^8\text{He} + ^{10}\text{C}$	-23.725	38.844	
11	$^8\text{Li} + ^{10}\text{B}(\text{s})$	-9.4214	15.425	
12	$\text{n} + \text{p} + ^{16}\text{N}$	2.5323	0	
13	$\text{n} + ^4\text{He}(\text{s}) + ^{13}\text{C}(\text{s})$	9.9535	0	
14	$\text{p} + \text{p} + ^{16}\text{C}$	-4.6973	7.6907	
15	$3\text{n} + ^{15}\text{O}$	-3.494	5.720	
	$\text{n} + ^{17}\text{O}(\text{s})$	16.313	0	
	$^3\text{He}(\text{s}) + ^{15}\text{C}$	-1.2297	2.0134	
	$^4\text{He}\# + ^{14}\text{N}(\text{s})$	-5.1286	8.397	
	$^4\text{Li}\# + ^{14}\text{B}$	-25.209	41.275	
	$^5\text{He}\# + ^{13}\text{N}$	-15.561	25.477	
	$^6\text{Li} + ^{13}\text{B}$	-4.6675	7.642	
	$^6\text{Be} + ^{13}\text{Be}\#$	-45.075	73.801	
	$^6\text{Be} + ^{12}\text{Be}$	-19.876	32.543	
	$^7\text{Be} + ^{11}\text{Be}$	-12.368	20.25	
	$^7\text{B} + ^{11}\text{Li}$	-45.195	73.997	
	$^8\text{Be} + ^{10}\text{Be}$	6.0261	0	
	$^8\text{B} + ^{10}\text{Li}$	-33.176	54.318	
	$^8\text{C} + ^{10}\text{He}\#$	-60.92	99.743	
	$^9\text{He} + ^9\text{C}$	-46.148	75.558	

(continued)

${}^9\text{Li} + {}^9\text{B}$	-13.795	22.586
${}^9\text{Be}(\text{s}) + {}^9\text{Be}(\text{s})$	0.8794	0
$\text{n} + \text{n} + {}^{16}\text{O}(\text{s})$	12.169	0
$\text{n} + \text{D}(\text{s}) + {}^{15}\text{N}(\text{s})$	2.2661	0
$\text{n} + \text{T} + {}^{14}\text{N}(\text{s})$	-2.3099	3.782
$\text{n} + {}^3\text{He}(\text{s}) + {}^{14}\text{C}$	-2.4478	4.0077
$\text{n} + {}^4\text{He} + {}^{13}\text{N}$	-15.682	25.676
$\text{n} + {}^4\text{Li} + {}^{13}\text{B}$	-26.179	42.862
$\text{n} + {}^5\text{He} + {}^{12}\text{N}$	-35.625	58.328
$\text{n} + {}^5\text{He} + {}^{12}\text{C}(\text{s})$	4.1134	0
$\text{n} + {}^5\text{Li} + {}^{12}\text{B}$	-9.5461	15.63
$\text{n} + {}^5\text{Be} + {}^{12}\text{Be}$	-43.274	70.851
$\text{n} + {}^6\text{He} + {}^{11}\text{C}$	-12.739	20.857
$\text{n} + {}^6\text{Li}(\text{s}) + {}^{11}\text{B}(\text{s})$	-7.2502	11.871
$\text{n} + {}^6\text{Be} + {}^{11}\text{Be}$	-23.045	37.73
$\text{n} + {}^7\text{He} + {}^{10}\text{C}$	-26.308	43.074
$\text{n} + {}^7\text{Li}(\text{s}) + {}^{10}\text{B}(\text{s})$	-11.454	18.754
$\text{n} + {}^7\text{Be} + {}^{10}\text{Be}$	-12.872	21.076
$\text{n} + {}^7\text{B} + {}^{10}\text{Li}$	-46.197	75.637
$\text{n} + {}^8\text{He} + {}^9\text{C}$	-45.008	73.69
$\text{n} + {}^8\text{Li} + {}^9\text{B}$	-17.858	29.238
$\text{n} + {}^8\text{Be} + {}^9\text{Be}(\text{s})$	-0.786	1.2869
$\text{n} + {}^8\text{B} + {}^9\text{Li}$	-32.371	53.0
$\text{n} + {}^8\text{C} + {}^9\text{He}$	-60.402	98.894
$\text{p} + \text{D}(\text{s}) + {}^{15}\text{C}$	-6.7233	11.008
$\text{p} + \text{T} + {}^{14}\text{C}$	-1.684	2.7573
$\text{p} + {}^3\text{He}(\text{s}) + {}^{14}\text{B}$	-22.31	36.527
$\text{p} + {}^4\text{He} + {}^{13}\text{C}(\text{s})$	-12.679	20.759
$\text{p} + {}^4\text{He}(\text{s}) + {}^{13}\text{B}$	-2.7015	4.423
$\text{p} + {}^4\text{Li} + {}^{13}\text{Be} \#$	-43.784	71.687
$\text{p} + {}^5\text{He} + {}^{12}\text{C}(\text{s})$	-17.504	28.659
$\text{p} + {}^5\text{He} + {}^{12}\text{B}$	-8.4737	13.874
$\text{p} + {}^5\text{Li} + {}^{12}\text{Be}$	-20.471	33.517
$\text{p} + {}^5\text{Be} + {}^{12}\text{Li} \#$	-70.334	115.16

(continued)

$p + {}^6\text{H e} + {}^{11}\text{B}(\text{s})$	-9.9745	16.331
$p + {}^6\text{L i}(\text{s}) + {}^{11}\text{B e}$	-17.974	29.428
$p + {}^6\text{B e} + {}^{11}\text{L i}$	-42.988	70.384
$p + {}^7\text{H e} + {}^{10}\text{B}(\text{s})$	-21.875	35.816
$p + {}^7\text{L i}(\text{s}) + {}^{10}\text{B e}$	-11.228	18.383
$p + {}^7\text{B e} + {}^{10}\text{L i}$	-33.313	54.543
$p + {}^7\text{B} + {}^{10}\text{H e}\#$	-60.984	99.848
$p + {}^8\text{H e} + {}^9\text{B}$	-27.728	45.399
$p + {}^8\text{L i} + {}^9\text{B e}(\text{s})$	-16.007	26.208
$p + {}^8\text{B e} + {}^9\text{L i}$	-13.61	22.283
$p + {}^8\text{B} + {}^9\text{H e}$	-47.445	77.68
$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^{14}\text{C}$	-5.7168	9.3599
$\text{D}(\text{s}) + \text{T} + {}^{13}\text{C}(\text{s})$	-7.636	12.502
$\text{D}(\text{s}) + {}^3\text{H e}(\text{s}) + {}^{13}\text{B}$	-21.055	34.472
$\text{D}(\text{s}) + {}^4\text{H}\# + {}^{12}\text{C}(\text{s})$	-15.401	25.216
$\text{D}(\text{s}) + {}^4\text{H e}(\text{s}) + {}^{12}\text{B}$	-5.3554	8.7684
$\text{D}(\text{s}) + {}^4\text{L i}\# + {}^{12}\text{B e}$	-39.758	65.095
$\text{D}(\text{s}) + {}^5\text{H}\# + {}^{11}\text{C}$	-34.001	55.669
$\text{D}(\text{s}) + {}^5\text{H e} + {}^{11}\text{B}(\text{s})$	-9.619	15.749
$\text{D}(\text{s}) + {}^5\text{L i} + {}^{11}\text{B e}$	-21.415	35.062
$\text{D}(\text{s}) + {}^5\text{B e} + {}^{11}\text{L i}$	-64.161	105.05
$\text{D}(\text{s}) + {}^6\text{H e} + {}^{10}\text{B}(\text{s})$	-19.204	31.442
$\text{D}(\text{s}) + {}^6\text{L i}(\text{s}) + {}^{10}\text{B e}$	-16.254	26.612
$\text{D}(\text{s}) + {}^6\text{B e} + {}^{10}\text{L i}$	-41.765	68.381
$\text{D}(\text{s}) + {}^7\text{H e} + {}^9\text{B}$	-28.087	45.986
$\text{D}(\text{s}) + {}^7\text{L i}(\text{s}) + {}^9\text{B e}(\text{s})$	-15.816	25.894
$\text{D}(\text{s}) + {}^7\text{B e} + {}^9\text{L i}$	-30.284	49.583
$\text{D}(\text{s}) + {}^7\text{B} + {}^9\text{H e}$	-58.241	95.357
$\text{D}(\text{s}) + {}^8\text{H e} + {}^8\text{B}$	-44.079	72.17
$\text{D}(\text{s}) + {}^8\text{L i} + {}^8\text{B e}$	-15.448	25.293
$\text{T} + \text{T} + {}^{12}\text{C}(\text{s})$	-6.325	10.356
$\text{T} + {}^3\text{H e}(\text{s}) + {}^{12}\text{B}$	-19.676	32.215
$\text{T} + {}^4\text{H}\# + {}^{11}\text{C}$	-27.865	45.623
$\text{T} + {}^4\text{H e}(\text{s}) + {}^{11}\text{B}(\text{s})$	-2.468	4.0409

(continued)

$T + {}^4\text{Li} \# + {}^{11}\text{Be}$	-36.669	60.038
$T + {}^5\text{H} \# + {}^{10}\text{C}$	-40.867	66.910
$T + {}^5\text{He} + {}^{10}\text{B}(\text{s})$	-14.816	24.258
$T + {}^5\text{Li} + {}^{10}\text{Be}$	-15.662	25.643
$T + {}^5\text{Be} + {}^{10}\text{Li}$	-58.905	96.444
$T + {}^6\text{He} + {}^9\text{B}$	-21.383	35.01
$T + {}^6\text{Li}(\text{s}) + {}^9\text{Be}(\text{s})$	-16.808	27.662
$T + {}^6\text{Be} + {}^9\text{Li}$	-34.703	56.819
$T + {}^7\text{He} + {}^8\text{B}$	-40.405	66.155
$T + {}^7\text{Li}(\text{s}) + {}^8\text{Be}$	-11.224	18.376
$T + {}^7\text{Be} + {}^8\text{Li}$	-28.089	45.99
$T + {}^7\text{B} + {}^8\text{He}$	-50.843	83.244
$\tau + {}^8\text{He}(\text{s}) + {}^{12}\text{Be}$	-31.365	51.353
$\tau + {}^4\text{H} \# + {}^{11}\text{B}(\text{s})$	-25.865	42.347
$\tau + {}^4\text{He}(\text{s}) + {}^{11}\text{Be}$	-13.955	22.849
$\tau + {}^4\text{Li} \# + {}^{11}\text{Li}$	-57.377	93.941
$\tau + {}^5\text{H} \# + {}^{10}\text{B}(\text{s})$	-37.197	60.902
$\tau + {}^5\text{He} + {}^{10}\text{Be}$	-15.354	25.138
$\tau + {}^5\text{Li} + {}^{10}\text{Li}$	-36.867	60.361
$\tau + {}^5\text{Be} + {}^{10}\text{He} \#$	-74.457	121.91
$\tau + {}^6\text{He} + {}^9\text{Be}(\text{s})$	-20.297	33.231
$\tau + {}^6\text{Li}(\text{s}) + {}^9\text{Li}$	-30.396	49.767
$\tau + {}^6\text{Be} + {}^9\text{He}$	-50.541	82.749
$\tau + {}^7\text{He} + {}^8\text{Be}$	-22.408	36.689
$\tau + {}^7\text{Li}(\text{s}) + {}^8\text{Li}$	-27.209	44.548
$\tau + {}^7\text{Be} + {}^8\text{He}$	-38.723	63.401
$\alpha + {}^4\text{H} \# + {}^{10}\text{B}(\text{s})$	-16.741	27.41
$\alpha + {}^4\text{He}(\text{s}) + {}^{10}\text{Be}$	6.118	0
$\alpha + {}^4\text{Li} \# + {}^{10}\text{Li}$	-37.8	61.889
$\alpha + {}^5\text{H} \# + {}^9\text{B}$	-25.056	41.024
$\alpha + {}^5\text{He} + {}^9\text{Be}(\text{s})$	-1.5878	2.5997
$\alpha + {}^5\text{Li} + {}^9\text{Li}$	-15.484	25.352
$\alpha + {}^5\text{Be} + {}^9\text{He}$	-53.36	87.365
$\alpha + {}^6\text{He} + {}^8\text{Be}$	-1.3842	2.2662

(continued)

$\alpha + {}^6\text{Li}(s) + {}^8\text{Li}$	-13.881	22.727
$\alpha + {}^6\text{Be} + {}^8\text{He}$	-28.822	47.19
$\alpha + {}^7\text{He} + {}^7\text{Be}$	-20.729	33.939
$\alpha + {}^7\text{Li}(s) + {}^7\text{Li}(s)$	-8.6637	14.185

Table 9 ${}^9\text{Be}$ -induced Fusion Reaction

REACTION ${}^9\text{Be} + {}^9\text{Be}$ total branch 9(125)
 compound nucleus ${}^{18}\text{O}^*$ A=18 Z=8

branch	Q(MeV)	Eth(MeV)	remarks
1	T + ${}^{15}\text{N}$ (s)	7.644	0
2	${}^4\text{He}$ (s) + ${}^{14}\text{C}$	17.251	0
3	${}^6\text{He}$ + ${}^{12}\text{C}$ (s)	5.1031	0
4	${}^7\text{He}$ + ${}^{11}\text{C}$	-14.065	28.129
5	${}^7\text{Li}$ (s) + ${}^{11}\text{B}$ (s)	-0.8794	1.7588
6	${}^8\text{He}$ + ${}^{10}\text{C}$	-24.604	49.209
7	${}^8\text{Be}$ + ${}^{10}\text{Be}$	5.1467	0
8	${}^8\text{B}$ + ${}^{10}\text{Li}$	-34.055	68.11
9	n + 4 ${}^4\text{He}$ (s) + ${}^{13}\text{C}$ (s)	9.0741	0
	γ + ${}^{18}\text{O}$ (s)	23.478	0
	n + ${}^{17}\text{O}$ (s)	15.433	0
	p + ${}^{17}\text{N}$	7.5354	0
	D(s) + ${}^{16}\text{N}$	3.8775	0
	${}^3\text{He}$ (s) + ${}^{15}\text{C}$	-2.1091	4.2182
	${}^4\text{He}\#$ + ${}^{14}\text{N}$ (s)	-6.008	12.016
	${}^4\text{Li}\#$ + ${}^{14}\text{B}$	-26.089	52.177
	${}^5\text{He}\#$ + ${}^{13}\text{N}$	-16.44	32.88
	${}^5\text{He}$ + ${}^{13}\text{C}$ (s)	8.1804	0
	${}^5\text{Li}$ + ${}^{13}\text{B}$	-5.5469	11.094
	${}^5\text{Be}$ + ${}^{13}\text{Be}\#$	-45.955	91.909
	${}^6\text{Li}$ (s) + ${}^{12}\text{B}$	-4.7597	9.5194
	${}^6\text{Be}$ + ${}^{12}\text{Be}$	-20.756	41.511
	${}^7\text{Be}$ + ${}^{11}\text{Be}$	-13.247	26.495
	${}^7\text{B}$ + ${}^{11}\text{Li}$	-46.075	92.149
	${}^8\text{Li}$ + ${}^{10}\text{B}$ (s)	-10.301	20.602
	${}^8\text{C}$ + ${}^{10}\text{He}\#$	-61.8	123.6

(continued)

${}^0\text{H e} + {}^0\text{C}$	-47.028	94.056
${}^0\text{L i} + {}^0\text{B}$	-14.674	29.349
$\text{n} + \text{n} + {}^{16}\text{O}(\text{s})$	11.29	0
$\text{n} + \text{p} + {}^{16}\text{N}$	1.6529	0
$\text{n} + \text{D}(\text{s}) + {}^{15}\text{N}(\text{s})$	1.3867	0
$\text{n} + \text{T} + {}^{14}\text{N}(\text{s})$	-3.1893	6.3786
$\text{n} + {}^3\text{H e}(\text{s}) + {}^{14}\text{C}$	-3.3272	6.6544
$\text{n} + {}^4\text{H}\# + {}^{13}\text{N}$	-16.561	33.123
$\text{n} + {}^4\text{L i}\# + {}^{13}\text{B}$	-27.058	54.117
$\text{n} + {}^5\text{H}\# + {}^{12}\text{N}$	-36.504	73.008
$\text{n} + {}^5\text{H e} + {}^{12}\text{C}(\text{s})$	3.234	0
$\text{n} + {}^5\text{L i} + {}^{12}\text{B}$	-10.425	20.851
$\text{n} + {}^6\text{B e} + {}^{12}\text{B e}$	-44.153	88.306
$\text{n} + {}^6\text{H e} + {}^{11}\text{C}$	-13.618	27.237
$\text{n} + {}^6\text{L i}(\text{s}) + {}^{11}\text{B}(\text{s})$	-8.1296	16.259
$\text{n} + {}^6\text{B e} + {}^{11}\text{B e}$	-23.924	47.848
$\text{n} + {}^7\text{H e} + {}^{10}\text{C}$	-27.188	54.375
$\text{n} + {}^7\text{L i}(\text{s}) + {}^{10}\text{B}(\text{s})$	-12.334	24.667
$\text{n} + {}^7\text{B e} + {}^{10}\text{B e}$	-13.752	27.503
$\text{n} + {}^7\text{B} + {}^{10}\text{L i}$	-47.076	94.152
$\text{n} + {}^8\text{H e} + {}^9\text{C}$	-45.887	91.774
$\text{n} + {}^8\text{L i} + {}^9\text{B}$	-18.737	37.474
$\text{n} + {}^8\text{B e} + {}^9\text{B e}(\text{s})$	-1.6654	3.3308
$\text{n} + {}^8\text{B} + {}^9\text{L i}$	-33.25	66.5
$\text{n} + {}^8\text{C} + {}^9\text{H e}$	-61.281	122.56
$\text{p} + \text{p} + {}^{16}\text{C}$	-5.5767	11.153
$\text{p} + \text{D}(\text{s}) + {}^{15}\text{C}$	-7.6027	15.205
$\text{p} + \text{T} + {}^{14}\text{C}$	-2.5634	5.1269
$\text{p} + {}^3\text{H e}(\text{s}) + {}^{14}\text{B}$	-23.189	46.378
$\text{p} + {}^4\text{H}\# + {}^{13}\text{C}(\text{s})$	-13.559	27.117
$\text{p} + {}^4\text{H e}(\text{s}) + {}^{13}\text{B}$	-3.5808	7.1617
$\text{p} + {}^4\text{L i}\# + {}^{13}\text{B e}\#$	-44.664	89.327
$\text{p} + {}^5\text{H}\# + {}^{12}\text{C}(\text{s})$	-18.384	36.767
$\text{p} + {}^5\text{H e} + {}^{12}\text{B}$	-9.3531	18.706

(continued)

$p + {}^5\text{Li} + {}^{12}\text{Be}$	-21.351	42.701
$p + {}^5\text{Be} + {}^{12}\text{Li}\#$	-71.214	142.43
$p + {}^6\text{He} + {}^{11}\text{B}(s)$	-10.854	21.708
$p + {}^6\text{Li}(s) + {}^{11}\text{Be}$	-18.853	37.706
$p + {}^6\text{Be} + {}^{11}\text{Li}$	-43.868	87.735
$p + {}^7\text{He} + {}^{10}\text{B}(s)$	-22.754	45.509
$p + {}^7\text{Li}(s) + {}^{10}\text{Be}$	-12.107	24.215
$p + {}^7\text{Be} + {}^{10}\text{Li}$	-34.192	68.385
$p + {}^7\text{B} + {}^{10}\text{He}\#$	-61.864	123.73
$p + {}^8\text{He} + {}^9\text{B}$	-28.607	57.215
$p + {}^8\text{Li} + {}^9\text{Be}(s)$	-16.887	33.773
$p + {}^8\text{Be} + {}^9\text{Li}$	-14.489	28.979
$p + {}^8\text{B} + {}^9\text{He}$	-48.324	96.648
$D(s) + D(s) + {}^{14}\text{C}$	-6.5962	13.192
$D(s) + T + {}^{13}\text{C}(s)$	-8.5154	17.031
$D(s) + {}^3\text{He}(s) + {}^{13}\text{B}$	-21.934	43.868
$D(s) + {}^4\text{H}\# + {}^{12}\text{C}(s)$	-16.28	32.561
$D(s) + {}^4\text{He}(s) + {}^{12}\text{B}$	-6.2348	12.47
$D(s) + {}^4\text{Li}\# + {}^{12}\text{Be}$	-40.637	81.275
$D(s) + {}^5\text{H}\# + {}^{11}\text{C}$	-34.881	69.761
$D(s) + {}^5\text{He} + {}^{11}\text{B}(s)$	-10.498	20.997
$D(s) + {}^5\text{Li} + {}^{11}\text{Be}$	-22.294	44.589
$D(s) + {}^5\text{Be} + {}^{11}\text{Li}$	-65.04	130.08
$D(s) + {}^6\text{He} + {}^{10}\text{B}(s)$	-20.084	40.167
$D(s) + {}^6\text{Li}(s) + {}^{10}\text{Be}$	-17.133	34.266
$D(s) + {}^6\text{Be} + {}^{10}\text{Li}$	-42.644	85.289
$D(s) + {}^7\text{He} + {}^9\text{B}$	-28.966	57.932
$D(s) + {}^7\text{Li}(s) + {}^9\text{Be}(s)$	-16.695	33.39
$D(s) + {}^7\text{Be} + {}^9\text{Li}$	-31.163	62.326
$D(s) + {}^7\text{B} + {}^9\text{He}$	-59.12	118.24
$D(s) + {}^8\text{He} + {}^8\text{B}$	-44.959	89.917
$D(s) + {}^8\text{Li} + {}^8\text{Be}$	-16.328	32.655
$T + T + {}^{12}\text{C}(s)$	-7.2044	14.409
$T + {}^3\text{He}(s) + {}^{12}\text{B}$	-20.555	41.111

(continued)

T + $^4\text{H}\# + ^{11}\text{C}$	-28.745	57.489
T + $^4\text{H e (s)} + ^{11}\text{B (s)}$	-3.3474	6.6949
T + $^4\text{L i}\# + ^{11}\text{B e}$	-37.549	75.097
T + $^5\text{H}\# + ^{10}\text{C}$	-41.746	83.492
T + $^5\text{H e} + ^{10}\text{B (s)}$	-15.695	31.391
T + $^5\text{L i} + ^{10}\text{B e}$	-16.542	33.083
T + $^5\text{B e} + ^{10}\text{L i}$	-59.785	119.57
T + $^6\text{H e} + ^9\text{B}$	-22.263	44.525
T + $^6\text{L i (s)} + ^9\text{B e (s)}$	-17.688	35.376
T + $^6\text{B e} + ^9\text{L i}$	-35.582	71.165
T + $^7\text{H e} + ^8\text{B}$	-41.285	82.57
T + $^7\text{L i (s)} + ^8\text{B e}$	-12.103	24.206
T + $^7\text{B e} + ^8\text{L i}$	-28.969	57.937
T + $^7\text{B} + ^8\text{H e}$	-51.723	103.45
$\tau + ^8\text{H e (s)} + ^{12}\text{B e}$	-32.244	64.488
$\tau + ^4\text{H}\# + ^{11}\text{B (s)}$	-26.744	53.488
$\tau + ^4\text{H e (s)} + ^{11}\text{B e}$	-14.835	29.67
$\tau + ^4\text{L i}\# + ^{11}\text{L i}$	-58.256	116.51
$\tau + ^5\text{H}\# + ^{10}\text{B (s)}$	-38.077	76.153
$\tau + ^5\text{H e} + ^{10}\text{B e}$	-16.233	32.466
$\tau + ^5\text{L i} + ^{10}\text{L i}$	-37.746	75.492
$\tau + ^5\text{B e} + ^{10}\text{H e}\#$	-75.336	150.67
$\tau + ^6\text{H e} + ^9\text{B e (s)}$	-21.176	42.352
$\tau + ^6\text{L i (s)} + ^9\text{L i}$	-31.275	62.551
$\tau + ^6\text{B e} + ^9\text{H e}$	-51.42	102.84
$\tau + ^7\text{H e} + ^8\text{B e}$	-23.288	46.575
$\tau + ^7\text{L i (s)} + ^8\text{L i}$	-28.088	56.176
$\tau + ^7\text{B e} + ^8\text{H e}$	-39.603	79.205
$\alpha + ^4\text{H}\# + ^{10}\text{B (s)}$	-17.62	35.241
$\alpha + ^4\text{H e (s)} + ^{10}\text{B e}$	5.2386	0
$\alpha + ^4\text{L i}\# + ^{10}\text{L i}$	-38.68	77.359
$\alpha + ^5\text{H}\# + ^9\text{B}$	-25.935	51.871
$\alpha + ^5\text{H e} + ^9\text{B e (s)}$	-2.4672	4.9344
$\alpha + ^5\text{L i} + ^9\text{L i}$	-16.363	32.727

(continued)

$\alpha + {}^5\text{B e} + {}^9\text{H e}$	-54.24	108.48
$\alpha + {}^6\text{H e} + {}^8\text{B e}$	-2.2636	4.5271
$\alpha + {}^6\text{L i (s)} + {}^8\text{L i}$	-14.761	29.521
$\alpha + {}^6\text{B e} + {}^8\text{H e}$	-29.702	59.403
$\alpha + {}^7\text{H e} + {}^7\text{B e}$	-21.608	43.216
$\alpha + {}^7\text{L i (s)} + {}^7\text{L i (s)}$	-9.5431	19.086

REACTION ${}^{10}\text{B} + {}^9\text{B e}$ total branch 5(148)compound nucleus ${}^{19}\text{F}^*$ A=19 Z=9

	branch	Q(MeV)	Eth(MeV)	remarks
1	$n + {}^{18}\text{F}$	14.454	0	
2	$p + {}^{18}\text{O (s)}$	16.892	0	
3	${}^6\text{H e} + {}^{13}\text{N}$	0.46066	0	
4	${}^8\text{B e} + {}^{11}\text{B (s)}$	9.7887	0	
5	$n + {}^4\text{H e (s)} + {}^{14}\text{N (s)}$	10.039	0	
	$\gamma + {}^{19}\text{F (s)}$	24.886	0	
	$\text{D (s)} + {}^{17}\text{O (s)}$	11.072	0	
	$\text{T} + {}^{16}\text{O (s)}$	13.186	0	
	${}^3\text{H e (s)} + {}^{16}\text{N}$	2.7851	0	
	${}^4\text{H \#} + {}^{15}\text{O}$	-5.297	10.065	
	${}^4\text{H e (s)} + {}^{15}\text{N (s)}$	20.872	0	
	${}^4\text{L i \#} + {}^{15}\text{C}$	-11.595	22.031	
	${}^6\text{H \#} + {}^{14}\text{O}$	-18.398	34.957	
	${}^5\text{H e} + {}^{14}\text{N (s)}$	9.145	0	
	${}^5\text{L i} + {}^{14}\text{C}$	8.6986	0	
	${}^5\text{B e} + {}^{14}\text{B}$	-33.966	64.536	
	${}^6\text{L i (s)} + {}^{13}\text{C (s)}$	6.1879	0	
	${}^6\text{B e} + {}^{13}\text{B}$	-11.538	21.922	
	${}^7\text{H e} + {}^{12}\text{N}$	-20.05	38.095	

(continued)

${}^7\text{Li}(\text{s}) + {}^{12}\text{C}(\text{s})$	8.4917	0
${}^7\text{Be} + {}^{12}\text{B}$	-5.7397	10.906
${}^7\text{B} + {}^{12}\text{Be}$	-29.549	56.144
${}^8\text{He} + {}^{11}\text{N}$	-33.11	62.91
${}^8\text{Li} + {}^{11}\text{C}$	-8.197	15.575
${}^8\text{B} + {}^{11}\text{Be}$	-19.696	37.423
${}^8\text{C} + {}^{11}\text{Li}$	-52.597	99.936
${}^9\text{He} + {}^{10}\text{N}\#$	-57.112	108.51
${}^9\text{Li} + {}^{10}\text{C}$	-17.257	32.789
${}^9\text{B} + {}^{10}\text{Be}$	-1.6243	3.0863
${}^9\text{C} + {}^{10}\text{Li}$	-39.345	74.757
$\text{n} + \text{n} + {}^{17}\text{F}$	5.3042	0
$\text{n} + \text{p} + {}^{17}\text{O}(\text{s})$	8.8474	0
$\text{n} + \text{D}(\text{s}) + {}^{16}\text{O}(\text{s})$	6.9283	0
$\text{n} + \text{T} + {}^{15}\text{O}$	-2.4783	4.7089
$\text{n} + {}^3\text{He}(\text{s}) + {}^{15}\text{N}(\text{s})$	0.29429	0
$\text{n} + {}^4\text{H}\# + {}^{14}\text{O}$	-18.519	35.188
$\text{n} + {}^4\text{Li}\# + {}^{14}\text{C}$	-12.813	24.345
$\text{n} + {}^5\text{H}\# + {}^{13}\text{O}$	-41.574	78.993
$\text{n} + {}^5\text{He} + {}^{13}\text{N}$	-1.4084	2.6761
$\text{n} + {}^5\text{Li} + {}^{13}\text{C}(\text{s})$	0.52208	0
$\text{n} + {}^5\text{Be} + {}^{13}\text{B}$	-34.935	66.379
$\text{n} + {}^6\text{He} + {}^{12}\text{N}$	-19.603	37.247
$\text{n} + {}^6\text{Li}(\text{s}) + {}^{12}\text{C}(\text{s})$	1.2415	0
$\text{n} + {}^6\text{Be} + {}^{12}\text{B}$	-16.416	31.192
$\text{n} + {}^7\text{He} + {}^{11}\text{N}$	-35.693	67.818
$\text{n} + {}^7\text{Li}(\text{s}) + {}^{11}\text{C}$	-10.23	19.437
$\text{n} + {}^7\text{Be} + {}^{11}\text{B}(\text{s})$	-9.1096	17.309
$\text{n} + {}^7\text{B} + {}^{11}\text{Be}$	-32.717	62.164
$\text{n} + {}^8\text{He} + {}^{10}\text{N}\#$	-55.971	106.35
$\text{n} + {}^8\text{Li} + {}^{10}\text{C}$	-21.32	40.509
$\text{n} + {}^8\text{Be} + {}^{10}\text{B}(\text{s})$	-1.6654	3.1644
$\text{n} + {}^8\text{B} + {}^{10}\text{Be}$	-20.2	38.381
$\text{n} + {}^8\text{C} + {}^{10}\text{Li}$	-53.598	101.84

(continued)

$n + {}^9\text{Li} + {}^9\text{C}$	-38.54	73.228
$n + {}^9\text{Be}(s) + {}^9\text{B}$	-8.4364	16.03
$p + p + {}^{17}\text{N}$	0.94942	0
$p + \text{D}(s) + {}^{16}\text{N}$	-2.7085	5.1462
$p + \text{T} + {}^{15}\text{N}(s)$	1.058	0
$p + {}^3\text{He}(s) + {}^{15}\text{C}$	-8.6951	16.521
$p + {}^4\text{H}\# + {}^{14}\text{N}(s)$	-12.594	23.929
$p + {}^4\text{He}(s) + {}^{14}\text{C}$	10.665	0
$p + {}^4\text{Li}\# + {}^{14}\text{B}$	-32.675	62.083
$p + {}^5\text{H}\# + {}^{13}\text{N}$	-23.026	43.751
$p + {}^5\text{He} + {}^{13}\text{C}(s)$	1.5944	0
$p + {}^5\text{Li} + {}^{13}\text{B}$	-12.133	23.053
$p + {}^5\text{Be} + {}^{13}\text{Be}\#$	-52.541	99.830
$p + {}^6\text{He} + {}^{12}\text{C}(s)$	-1.4829	2.8175
$p + {}^6\text{Li}(s) + {}^{12}\text{B}$	-11.346	21.557
$p + {}^6\text{Be} + {}^{12}\text{Be}$	-27.342	51.95
$p + {}^7\text{He} + {}^{11}\text{C}$	-20.651	39.237
$p + {}^7\text{Li}(s) + {}^{11}\text{B}(s)$	-7.4654	14.185
$p + {}^7\text{Be} + {}^{11}\text{Be}$	-19.833	37.684
$p + {}^7\text{B} + {}^{11}\text{Li}$	-52.661	100.06
$p + {}^8\text{He} + {}^{10}\text{C}$	-31.19	59.263
$p + {}^8\text{Li} + {}^{10}\text{B}(s)$	-16.887	32.086
$p + {}^8\text{Be} + {}^{10}\text{Be}$	-1.4393	2.7347
$p + {}^8\text{B} + {}^{10}\text{Li}$	-40.641	77.22
$p + {}^8\text{C} + {}^{10}\text{He}\#$	-68.386	129.94
$p + {}^9\text{He} + {}^9\text{C}$	-53.614	101.87
$p + {}^9\text{Li} + {}^9\text{B}$	-21.26	40.396
$p + {}^9\text{Be}(s) + {}^9\text{Be}(s)$	-6.586	12.514
$\text{D}(s) + \text{D}(s) + {}^{15}\text{N}(s)$	-2.9747	5.652
$\text{D}(s) + \text{T} + {}^{14}\text{N}(s)$	-7.5507	14.347
$\text{D}(s) + {}^3\text{He}(s) + {}^{14}\text{C}$	-7.6886	14.609
$\text{D}(s) + {}^4\text{H}\# + {}^{13}\text{N}$	-20.923	39.755
$\text{D}(s) + {}^4\text{He}(s) + {}^{13}\text{C}(s)$	4.7127	0
$\text{D}(s) + {}^4\text{Li}\# + {}^{13}\text{B}$	-31.42	59.699

(continued)

D(s) + $^5\text{H}\# + ^{12}\text{N}$	-40.865	77.647
D(s) + $^5\text{H e} + ^{12}\text{C}(s)$	-1.1273	2.142
D(s) + $^5\text{L i} + ^{12}\text{B}$	-14.787	28.096
D(s) + $^5\text{B e} + ^{12}\text{B e}$	-48.514	92.18
D(s) + $^6\text{H e} + ^{11}\text{C}$	-17.98	34.162
D(s) + $^6\text{L i}(s) + ^{11}\text{B}(s)$	-12.491	23.733
D(s) + $^6\text{B e} + ^{11}\text{B e}$	-28.285	53.744
D(s) + $^7\text{H e} + ^{10}\text{C}$	-31.549	59.945
D(s) + $^7\text{L i}(s) + ^{10}\text{B}(s)$	-16.695	31.721
D(s) + $^7\text{B e} + ^{10}\text{B e}$	-18.113	34.416
D(s) + $^7\text{B} + ^{10}\text{L i}$	-51.437	97.734
D(s) + $^8\text{H e} + ^9\text{C}$	-50.249	95.475
D(s) + $^8\text{L i} + ^9\text{B}$	-23.099	43.888
D(s) + $^8\text{B e} + ^9\text{B e}(s)$	-6.0268	11.451
D(s) + $^8\text{B} + ^9\text{L i}$	-37.612	71.464
D(s) + $^8\text{C} + ^9\text{H e}$	-65.642	124.72
T + T + ^{13}N	-11.847	22.51
T + $^3\text{H e}(s) + ^{13}\text{C}(s)$	-9.6078	18.255
T + $^4\text{H}\# + ^{12}\text{N}$	-34.73	65.988
T + $^4\text{H e}(s) + ^{12}\text{C}(s)$	6.0237	0
T + $^4\text{L i}\# + ^{12}\text{B}$	-30.041	57.079
T + $^5\text{H}\# + ^{11}\text{N}$	-50.251	95.480
T + $^5\text{H e} + ^{11}\text{C}$	-13.592	25.825
T + $^5\text{L i} + ^{11}\text{B}(s)$	-11.899	22.61
T + $^5\text{B e} + ^{11}\text{B e}$	-45.425	86.311
T + $^6\text{H e} + ^{10}\text{C}$	-24.845	47.208
T + $^6\text{L i}(s) + ^{10}\text{B}(s)$	-17.688	33.608
T + $^6\text{B e} + ^{10}\text{B e}$	-22.532	42.813
T + $^7\text{H e} + ^9\text{C}$	-46.575	88.494
T + $^7\text{L i}(s) + ^9\text{B}$	-18.874	35.862
T + $^7\text{B e} + ^9\text{B e}(s)$	-18.668	35.47
T + $^7\text{B} + ^9\text{L i}$	-44.375	84.316
T + $^8\text{H e} + ^8\text{C}$	-58.244	110.67
T + $^8\text{L i} + ^8\text{B}$	-35.417	67.294

(continued)

$T + {}^8\text{B e} + {}^8\text{B e}$	-1.4349	2.7264
$\tau + {}^3\text{H e (s)} + {}^{13}\text{B}$	-23.026	43.752
$\tau + {}^4\text{H \#} + {}^{12}\text{C (s)}$	-17.373	33.009
$\tau + {}^4\text{H e (s)} + {}^{12}\text{B}$	-7.3273	13.922
$\tau + {}^4\text{L i \#} + {}^{12}\text{B e}$	-41.73	79.289
$\tau + {}^5\text{H \#} + {}^{11}\text{C}$	-35.973	68.351
$\tau + {}^5\text{H e} + {}^{11}\text{B (s)}$	-11.591	22.023
$\tau + {}^5\text{L i} + {}^{11}\text{B e}$	-23.387	44.436
$\tau + {}^5\text{B e} + {}^{11}\text{L i}$	-66.133	125.66
$\tau + {}^6\text{H e} + {}^{10}\text{B (s)}$	-21.176	40.235
$\tau + {}^6\text{L i (s)} + {}^{10}\text{B e}$	-18.225	34.629
$\tau + {}^6\text{B e} + {}^{10}\text{L i}$	-43.737	83.102
$\tau + {}^7\text{H e} + {}^9\text{B}$	-30.059	57.113
$\tau + {}^7\text{L i (s)} + {}^9\text{B e (s)}$	-17.787	33.797
$\tau + {}^7\text{B e} + {}^9\text{L i}$	-32.255	61.287
$\tau + {}^7\text{B} + {}^9\text{H e}$	-60.213	114.41
$\tau + {}^8\text{H e} + {}^8\text{B}$	-46.051	87.5
$\tau + {}^8\text{L i} + {}^8\text{B e}$	-17.42	33.099
$\alpha + {}^4\text{H \#} + {}^{11}\text{C}$	-15.517	29.482
$\alpha + {}^4\text{H e (s)} + {}^{11}\text{B (s)}$	9.8806	0
$\alpha + {}^4\text{L i \#} + {}^{11}\text{B e}$	-24.32	46.21
$\alpha + {}^5\text{H \#} + {}^{10}\text{C}$	-28.518	54.186
$\alpha + {}^5\text{H e} + {}^{10}\text{B (s)}$	-2.4672	4.6879
$\alpha + {}^5\text{L i} + {}^{10}\text{B e}$	-3.3134	6.2957
$\alpha + {}^5\text{B e} + {}^{10}\text{L i}$	-46.556	88.46
$\alpha + {}^6\text{H e} + {}^9\text{B}$	-9.0345	17.166
$\alpha + {}^6\text{L i (s)} + {}^9\text{B e (s)}$	-4.4597	8.4737
$\alpha + {}^6\text{B e} + {}^9\text{L i}$	-22.354	42.474
$\alpha + {}^7\text{H e} + {}^8\text{B}$	-28.057	53.309
$\alpha + {}^7\text{L i (s)} + {}^8\text{B e}$	1.125	0
$\alpha + {}^7\text{B e} + {}^8\text{L i}$	-15.741	29.908
$\alpha + {}^7\text{B} + {}^8\text{H e}$	-38.494	73.142

REACTION $^{11}\text{B} + ^9\text{Be}$ total branch 10(162)
 compound nucleus $^{20}\text{F}^*$ A=20 Z=9

	branch	Q(MeV)	Eth(MeV)	remarks
1	D(s) + ^{18}O (s)	7.6621	0	
2	^5He + ^{15}N (s)	8.5242	0	
3	^7He + ^{13}N	-11.44	20.804	
4	^8Li + ^{12}C (s)	-0.9297	1.6907	
5	^8Be + ^{12}B	1.7045	0	
6	n + n + ^{18}F	2.9998	0	
7	n + ^4He (s) + ^{15}N (s)	9.4179	0	
8	2 n + T + ^{15}O	-13.932	25.336	
9	$^5\text{H}\#$ + ^{15}O	-16.63	30.243	n. o.
10	$^6\text{H}\#$ + ^{14}O	-29.89*	54.36	n. o.
	γ + ^{20}F	20.033	0	
	n + ^{19}F (s)	13.432	0	
	p + ^{19}O	9.3945	0	
	T + ^{17}O (s)	5.8751	0	
	^3He (s) + ^{17}N	-2.7866	5.0677	
	$^4\text{H}\#$ + ^{16}O (s)	-1.0873	1.9773	
	^4He (s) + ^{16}N	11.909	0	
	$^4\text{Li}\#$ + ^{16}C	-18.798	34.187	
	^5Li + ^{15}C	-1.5375	2.7961	
	^5Be + ^{15}B	-42.654	77.571	
	^6He + ^{14}N (s)	-0.44004	0.80025	
	^6Li (s) + ^{14}C	2.9102	0	
	^6Be + ^{14}B	-22.022	40.05	
	^7Li (s) + ^{13}C (s)	1.9839	0	
	^7Be + ^{13}B	-12.315	22.397	
	^7B + $^{13}\text{Be}\#$	-42.804	77.844	
	^8He + ^{12}N	-28.92	52.595	
	^8B + ^{12}Be	-27.982	50.887	

(continued)

$^6\text{C} + ^{12}\text{Li}\#$	-67.999	123.66
$^9\text{He} + ^{11}\text{N}$	-45.704	83.118
$^9\text{Li} + ^{11}\text{C}$	-15.588	28.349
$^9\text{B} + ^{11}\text{Be}$	-12.574	22.867
$^9\text{C} + ^{11}\text{Li}$	-49.798	90.562
$^{10}\text{He}\# + ^{10}\text{N}\#$	-69.084	125.64
$^{10}\text{Li} + ^{10}\text{C}$	-29.516	53.678
$^{10}\text{Be} + ^{10}\text{B}(s)$	-4.6421	8.4421
$n + p + ^{18}\text{O}(s)$	5.4375	0
$n + \text{D}(s) + ^{17}\text{O}(s)$	-0.38219	0.69506
$n + \text{T} + ^{16}\text{O}(s)$	1.7315	0
$n + ^3\text{He}(s) + ^{16}\text{N}$	-8.6691	15.766
$n + ^4\text{He}\# + ^{15}\text{O}$	-16.751	30.464
$n + ^4\text{Li}\# + ^{15}\text{C}$	-23.049	41.917
$n + ^5\text{He}\# + ^{14}\text{O}$	-29.852	54.289
$n + ^5\text{He} + ^{14}\text{N}(s)$	-2.3091	4.1993
$n + ^5\text{Li} + ^{14}\text{C}$	-2.7556	5.0113
$n + ^5\text{Be} + ^{14}\text{B}$	-45.42	82.6
$n + ^6\text{He} + ^{13}\text{N}$	-10.993	19.993
$n + ^6\text{Li}(s) + ^{13}\text{C}(s)$	-5.2663	9.5773
$n + ^6\text{Be} + ^{13}\text{B}$	-22.992	41.813
$n + ^7\text{He} + ^{12}\text{N}$	-31.504	57.293
$n + ^7\text{Li}(s) + ^{12}\text{C}(s)$	-2.9625	5.3875
$n + ^7\text{Be} + ^{12}\text{B}$	-17.194	31.269
$n + ^7\text{B} + ^{12}\text{Be}$	-41.003	74.567
$n + ^8\text{He} + ^{11}\text{N}$	-44.564	81.043
$n + ^8\text{Li} + ^{11}\text{C}$	-19.651	35.738
$n + ^8\text{Be} + ^{11}\text{B}(s)$	-1.6654	3.0287
$n + ^8\text{B} + ^{11}\text{Be}$	-31.15	56.649
$n + ^9\text{C} + ^{11}\text{Li}$	-64.051	116.48
$n + ^9\text{He} + ^{10}\text{N}\#$	-68.566	124.69
$n + ^9\text{Li} + ^{10}\text{C}$	-28.711	52.214
$n + ^9\text{Be}(s) + ^{10}\text{B}(s)$	-11.454	20.83
$n + ^9\text{B} + ^{10}\text{Be}$	-13.078	23.784

(continued)

$n + {}^9\text{C} + {}^{10}\text{Li}$	-50.799	92.383
$p + p + {}^{18}\text{N}$	-7.6794	13.966
$p + \text{D}(\text{s}) + {}^{17}\text{N}$	-8.2802	15.058
$p + \text{T} + {}^{16}\text{N}$	-7.9053	14.377
$p + {}^8\text{He}(\text{s}) + {}^{16}\text{C}$	-15.899	28.913
$p + {}^4\text{H}\# + {}^{15}\text{N}(\text{s})$	-13.215	24.032
$p + {}^4\text{He}(\text{s}) + {}^{15}\text{C}$	0.42855	0
$p + {}^4\text{Li}\# + {}^{15}\text{B}$	-41.363	75.223
$p + {}^5\text{H}\# + {}^{14}\text{N}(\text{s})$	-23.927	43.513
$p + {}^5\text{He} + {}^{14}\text{C}$	-1.6832	3.0611
$p + {}^5\text{Li} + {}^{14}\text{B}$	-22.617	41.132
$p + {}^5\text{Be} + {}^{14}\text{Be}$	-61.993	112.74
$p + {}^6\text{He} + {}^{13}\text{C}(\text{s})$	-7.9907	14.532
$p + {}^6\text{Li}(\text{s}) + {}^{13}\text{B}$	-17.921	32.591
$p + {}^6\text{Be} + {}^{13}\text{Be}\#$	-40.597	73.83
$p + {}^7\text{He} + {}^{12}\text{C}(\text{s})$	-13.383	24.339
$p + {}^7\text{Li}(\text{s}) + {}^{12}\text{B}$	-15.55	28.279
$p + {}^7\text{Be} + {}^{12}\text{Be}$	-28.119	51.137
$p + {}^7\text{B} + {}^{12}\text{Li}\#$	-68.063	123.78
$p + {}^8\text{He} + {}^{11}\text{C}$	-29.521	53.688
$p + {}^8\text{Li} + {}^{11}\text{B}(\text{s})$	-16.887	30.71
$p + {}^8\text{Be} + {}^{11}\text{Be}$	-12.389	22.531
$p + {}^8\text{B} + {}^{11}\text{Li}$	-51.094	92.919
$p + {}^9\text{He} + {}^{10}\text{C}$	-43.785	79.627
$p + {}^9\text{Li} + {}^{10}\text{B}(\text{s})$	-24.278	44.152
$p + {}^9\text{Be}(\text{s}) + {}^{10}\text{Be}$	-11.228	20.419
$p + {}^9\text{B} + {}^{10}\text{Li}$	-33.519	60.958
$p + {}^9\text{C} + {}^{10}\text{He}\#$	-65.587	119.28
$\text{D}(\text{s}) + \text{D}(\text{s}) + {}^{16}\text{N}$	-11.938	21.71
$\text{D}(\text{s}) + \text{T} + {}^{15}\text{N}(\text{s})$	-8.1715	14.861
$\text{D}(\text{s}) + {}^8\text{He}(\text{s}) + {}^{15}\text{C}$	-17.925	32.598
$\text{D}(\text{s}) + {}^4\text{H}\# + {}^{14}\text{N}(\text{s})$	-21.824	39.688
$\text{D}(\text{s}) + {}^4\text{He}(\text{s}) + {}^{14}\text{C}$	1.435	0
$\text{D}(\text{s}) + {}^4\text{Li}\# + {}^{14}\text{B}$	-41.904	76.207

(continued)

D (s) + $^5\text{H}\# + ^{13}\text{N}$	-32.256	58.660
D (s) + $^5\text{H e} + ^{13}\text{C (s)}$	-7.6351	13.885
D (s) + $^5\text{L i} + ^{13}\text{B}$	-21.362	38.85
D (s) + $^5\text{B e} + ^{13}\text{B e}\#$	-61.77	112.33
D (s) + $^6\text{H e} + ^{12}\text{C (s)}$	-10.712	19.482
D (s) + $^6\text{L i (s)} + ^{12}\text{B}$	-20.575	37.418
D (s) + $^6\text{B e} + ^{12}\text{B e}$	-36.571	66.508
D (s) + $^7\text{H e} + ^{11}\text{C}$	-29.88	54.34
D (s) + $^7\text{L i (s)} + ^{11}\text{B (s)}$	-16.695	30.361
D (s) + $^7\text{B e} + ^{11}\text{B e}$	-29.063	52.854
D (s) + $^7\text{B} + ^{11}\text{L i}$	-61.89	112.55
D (s) + $^8\text{H e} + ^{10}\text{C}$	-40.42	73.507
D (s) + $^8\text{L i} + ^{10}\text{B (s)}$	-26.116	47.495
D (s) + $^8\text{B e} + ^{10}\text{B e}$	-10.669	19.402
D (s) + $^8\text{B} + ^{10}\text{L i}$	-49.87	90.694
D (s) + $^8\text{C} + ^{10}\text{H e}\#$	-77.615	141.15
D (s) + $^9\text{H e} + ^9\text{C}$	-62.843	114.29
D (s) + $^9\text{L i} + ^9\text{B}$	-30.49	55.449
D (s) + $^9\text{B e (s)} + ^9\text{B e (s)}$	-15.816	28.762
T + T + $^{14}\text{N (s)}$	-12.748	23.183
T + $^8\text{H e (s)} + ^{14}\text{C}$	-12.885	23.433
T + $^4\text{H}\# + ^{13}\text{N}$	-26.12	47.501
T + $^4\text{H e (s)} + ^{13}\text{C (s)}$	-0.48415	0.88048
T + $^4\text{L i}\# + ^{13}\text{B}$	-36.617	66.591
T + $^5\text{H}\# + ^{12}\text{N}$	-46.062	83.769
T + $^5\text{H e} + ^{12}\text{C (s)}$	-6.3242	11.501
T + $^6\text{L i} + ^{12}\text{B}$	-19.984	36.342
T + $^5\text{B e} + ^{12}\text{B e}$	-53.711	97.679
T + $^6\text{H e} + ^{11}\text{C}$	-23.177	42.149
T + $^6\text{L i (s)} + ^{11}\text{B (s)}$	-17.688	32.167
T + $^6\text{B e} + ^{11}\text{B e}$	-33.482	60.891
T + $^7\text{H e} + ^{10}\text{C}$	-36.746	66.826
T + $^7\text{L i (s)} + ^{10}\text{B (s)}$	-21.892	39.812
T + $^7\text{B e} + ^{10}\text{B e}$	-23.31	42.391

(continued)

$T + {}^7\text{B} + {}^{10}\text{L i}$	-56.634	102.99
$T + {}^8\text{H e} + {}^9\text{C}$	-55.445	100.83
$T + {}^8\text{L i} + {}^9\text{B}$	-28.295	51.458
$T + {}^8\text{B e} + {}^9\text{B e (s)}$	-11.224	20.411
$T + {}^8\text{B} + {}^9\text{L i}$	-42.808	77.851
$T + {}^9\text{C} + {}^9\text{H e}$	-70.839	128.83
$\tau + {}^8\text{H e (s)} + {}^{14}\text{B}$	-33.511	60.943
$\tau + {}^4\text{H \#} + {}^{13}\text{C (s)}$	-23.881	43.429
$\tau + {}^4\text{H e (s)} + {}^{13}\text{B}$	-13.903	25.284
$\tau + {}^4\text{L i \#} + {}^{13}\text{B e \#}$	-54.986	99.997
$\tau + {}^5\text{H \#} + {}^{12}\text{C (s)}$	-28.706	52.204
$\tau + {}^6\text{H e} + {}^{12}\text{B}$	-19.675	35.781
$\tau + {}^6\text{L i} + {}^{12}\text{B e}$	-31.673	57.6
$\tau + {}^6\text{B e} + {}^{12}\text{L i \#}$	-81.536	148.28
$\tau + {}^6\text{H e} + {}^{11}\text{B (s)}$	-21.176	38.51
$\tau + {}^6\text{L i (s)} + {}^{11}\text{B e}$	-29.175	53.058
$\tau + {}^6\text{B e} + {}^{11}\text{L i}$	-54.19	98.549
$\tau + {}^7\text{H e} + {}^{10}\text{B (s)}$	-33.076	60.153
$\tau + {}^7\text{L i (s)} + {}^{10}\text{B e}$	-22.429	40.79
$\tau + {}^7\text{B e} + {}^{10}\text{L i}$	-44.514	80.954
$\tau + {}^7\text{B} + {}^{10}\text{H e \#}$	-72.186	131.28
$\tau + {}^8\text{H e} + {}^9\text{B}$	-38.929	70.797
$\tau + {}^8\text{L i} + {}^9\text{B e (s)}$	-27.209	49.482
$\tau + {}^8\text{B e} + {}^9\text{L i}$	-24.811	45.122
$\tau + {}^8\text{B} + {}^9\text{H e}$	-58.646	106.65
$\alpha + n + {}^{15}\text{N (s)}$	9.4179	0
$\alpha + {}^4\text{H \#} + {}^{12}\text{C (s)}$	-8.2492	15.002
$\alpha + {}^4\text{H e (s)} + {}^{12}\text{B}$	1.7964	0
$\alpha + {}^4\text{L i \#} + {}^{12}\text{B e}$	-32.606	59.298
$\alpha + {}^5\text{H \#} + {}^{11}\text{C}$	-26.849	48.828
$\alpha + {}^5\text{H e} + {}^{11}\text{B (s)}$	-2.4672	4.4869
$\alpha + {}^5\text{L i} + {}^{11}\text{B e}$	-14.263	25.939
$\alpha + {}^5\text{B e} + {}^{11}\text{L i}$	-57.009	103.68
$\alpha + {}^6\text{H e} + {}^{10}\text{B (s)}$	-12.052	21.918

(continued)

$\alpha + {}^6\text{Li}(s) + {}^{10}\text{Be}$	-9.1018	16.553
$\alpha + {}^6\text{Be} + {}^{10}\text{Li}$	-34.613	62.948
$\alpha + {}^7\text{He} + {}^9\text{B}$	-20.935	38.072
$\alpha + {}^7\text{Li}(s) + {}^9\text{Be}(s)$	-8.6637	15.756
$\alpha + {}^7\text{Be} + {}^9\text{Li}$	-23.132	42.067
$\alpha + {}^7\text{B} + {}^9\text{He}$	-51.089	92.911
$\alpha + {}^8\text{He} + {}^8\text{B}$	-36.928	67.156
$\alpha + {}^8\text{Li} + {}^8\text{Be}$	-8.2963	15.088

* ; ΔM value of ${}^6\text{H}$ is based on $\Delta M = 41.9$ MeV. This ΔM value is not shown in Appendix B.

Table 10 ^{10}B -induced Fusion Reaction

REACTION $^{10}\text{B} + ^{10}\text{B}$ total branch 8(160)
 compound nucleus $^{20}\text{Ne}^*$ A=20 Z=10

	branch	Q(MeV)	Eth(MeV)	remarks
1	$^4\text{He}(s) + ^{16}\text{O}(s)$	26.414	0	(10)
2	$n + ^{19}\text{Ne}$	14.279	0	(10)
3	$p + ^{19}\text{F}(s)$	18.3	0	(10)
4	$^8\text{Be} + ^{12}\text{C}(s)$	19.16	0	(10)
5	$n + p + ^{18}\text{F}$	7.868	0	(10)
6	$n + ^4\text{He}(s) + ^{15}\text{O}$	10.75	0	(10)
7	$p + ^4\text{He}(s) + ^{15}\text{N}(s)$	14.286	0	(10)
8	$n + p + \alpha + ^{14}\text{N}(s)$	3.4528	0	(10)
	$\gamma + ^{20}\text{Ne}(s)$	31.148	0	
	$\text{D}(s) + ^{18}\text{F}$	10.093	0	
	$\text{T} + ^{17}\text{F}$	7.2001	0	
	$^3\text{He}(s) + ^{17}\text{O}(s)$	9.9795	0	
	$^4\text{He}\# + ^{16}\text{F}$	-12.418	24.837	
	$^4\text{Li}\# + ^{16}\text{N}$	-6.7005	13.401	
	$^5\text{He}\# + ^{15}\text{F}\#$	-26.458	52.917	
	$^5\text{He} + ^{15}\text{O}$	9.8561	0	
	$^5\text{Li} + ^{15}\text{N}(s)$	12.32	0	
	$^5\text{Be} + ^{15}\text{C}$	-19.472	38.943	
	$^6\text{He} + ^{14}\text{O}$	-1.4973	2.9946	
	$^6\text{Li}(s) + ^{14}\text{N}(s)$	7.1525	0	
	$^6\text{Be} + ^{14}\text{C}$	2.7077	0	
	$^7\text{He} + ^{13}\text{O}$	-25.119	50.239	
	$^7\text{Li}(s) + ^{13}\text{N}$	3.8492	0	
	$^7\text{Be} + ^{13}\text{C}(s)$	5.2078	0	
	$^7\text{B} + ^{13}\text{B}$	-20.331	40.661	
	$^8\text{He} + ^{12}\text{O}$	-39.556	79.113	

(continued)

${}^6\text{Li} + {}^{12}\text{N}$	-14.182	28.364
${}^8\text{B} + {}^{12}\text{B}$	-12.188	24.376
${}^8\text{C} + {}^{12}\text{Be}$	-36.07	72.141
${}^9\text{Li} + {}^{11}\text{N}$	-25.762	51.525
${}^9\text{Be(s)} + {}^{11}\text{C}$	2.1038	0
${}^9\text{B} + {}^{11}\text{B(s)}$	3.0178	0
${}^9\text{C} + {}^{11}\text{Be}$	-24.986	49.971
${}^{10}\text{Li} + {}^{10}\text{N}\#$	-49.428	98.857
${}^{10}\text{Be} + {}^{10}\text{C}$	-4.2071	8.4143
$n+n+{}^{18}\text{Ne}$	2.6398	0
$n+\text{D(s)}+{}^{17}\text{F}$	0.94283	0
$n+\text{T}+{}^{16}\text{F}$	-9.5997	19.199
$n+{}^3\text{He(s)}+{}^{16}\text{O(s)}$	5.8359	0
$n+{}^4\text{H}\#+{}^{15}\text{F}\#$	-26.58	53.16
$n+{}^4\text{Li}\#+{}^{15}\text{N(s)}$	-9.1913	18.383
$n+{}^5\text{H}\#+{}^{14}\text{F}\#$	-51.37	102.74
$n+{}^5\text{He}+{}^{14}\text{O}$	-3.3664	6.7327
$n+{}^5\text{Li}+{}^{14}\text{N(s)}$	1.4868	0
$n+{}^5\text{Be}+{}^{14}\text{C}$	-20.69	41.379
$n+{}^6\text{He}+{}^{13}\text{O}$	-24.673	49.346
$n+{}^6\text{Li(s)}+{}^{13}\text{N}$	-3.4009	6.8019
$n+{}^6\text{Be}+{}^{13}\text{C(s)}$	-5.4688	10.938
$n+{}^7\text{He}+{}^{12}\text{O}$	-42.14	84.28
$n+{}^7\text{Li(s)}+{}^{12}\text{N}$	-16.215	32.429
$n+{}^7\text{Be}+{}^{12}\text{C(s)}$	0.26149	0
$n+{}^7\text{B}+{}^{12}\text{B}$	-25.209	50.419
$n+{}^8\text{Li}+{}^{11}\text{N}$	-29.825	59.65
$n+{}^8\text{Be}+{}^{11}\text{C}$	0.43836	0
$n+{}^8\text{B}+{}^{11}\text{B(s)}$	-15.558	31.116
$n+{}^8\text{C}+{}^{11}\text{Be}$	-39.239	78.478
$n+{}^9\text{Li}+{}^{10}\text{N}\#$	-48.624	97.247
$n+{}^9\text{Be(s)}+{}^{10}\text{C}$	-11.019	22.038
$n+{}^9\text{B}+{}^{10}\text{B(s)}$	-8.4364	16.873
$n+{}^9\text{C}+{}^{10}\text{Be}$	-25.49	50.98

(continued)

p + p + ^{18}O (s)	10.306	0
p + D (s) + ^{17}O (s)	4.486	0
p + T + ^{16}O (s)	6.5997	0
p + $^3\text{H e}$ (s) + ^{16}N	-3.8009	7.6018
p + $^4\text{H \#}$ + ^{15}O	-11.883	23.766
p + $^4\text{L i \#}$ + ^{15}C	-18.181	36.361
p + $^5\text{H \#}$ + ^{14}O	-24.984	49.968
p + $^5\text{H e}$ + ^{14}N (s)	2.5591	0
p + $^5\text{L i}$ + ^{14}C	2.1126	0
p + $^5\text{B e}$ + ^{14}B	-40.551	81.103
p + $^6\text{H e}$ + ^{13}N	-6.1253	12.251
p + $^6\text{L i}$ (s) + ^{13}C (s)	-0.39809	0.79619
p + $^6\text{B e}$ + ^{13}B	-18.124	36.248
p + $^7\text{H e}$ + ^{12}N	-26.636	53.271
p + $^7\text{L i}$ (s) + ^{12}C (s)	1.9057	0
p + $^7\text{B e}$ + ^{12}B	-12.326	24.651
p + ^7B + $^{12}\text{B e}$	-36.134	72.269
p + $^8\text{H e}$ + ^{11}N	-39.695	79.391
p + $^8\text{L i}$ + ^{11}C	-14.783	29.566
p + $^8\text{B e}$ + ^{11}B (s)	3.2028	0
p + ^8B + $^{11}\text{B e}$	-26.282	52.564
p + ^8C + $^{11}\text{L i}$	-59.182	118.36
p + $^9\text{H e}$ + $^{10}\text{N \#}$	-63.697	127.39
p + $^9\text{L i}$ + ^{10}C	-23.843	47.686
p + $^9\text{B e}$ (s) + ^{10}B (s)	-6.586	13.172
p + ^9B + $^{10}\text{B e}$	-8.2103	16.421
p + ^9C + $^{10}\text{L i}$	-45.931	91.861
D (s) + D (s) + ^{16}O (s)	2.5669	0
D (s) + T + ^{15}O	-6.8397	13.679
D (s) + $^3\text{H e}$ (s) + ^{15}N (s)	-4.0671	8.1342
D (s) + $^4\text{H \#}$ + ^{14}O	-22.881	45.762
D (s) + $^4\text{H e}$ (s) + ^{14}N (s)	5.6774	0
D (s) + $^4\text{L i \#}$ + ^{14}C	-17.174	34.348
D (s) + $^5\text{H \#}$ + ^{13}O	-45.935	91.871

(continued)

D(s) + ⁵ He + ¹³ N	-5.7698	11.54
D(s) + ⁵ Li + ¹³ C(s)	-3.8393	7.6786
D(s) + ⁵ Be + ¹³ B	-39.297	78.593
D(s) + ⁶ He + ¹² N	-23.965	47.929
D(s) + ⁶ Li(s) + ¹² C(s)	-3.1199	6.2397
D(s) + ⁶ Be + ¹² B	-20.778	41.556
D(s) + ⁷ He + ¹¹ N	-40.054	80.109
D(s) + ⁷ Li(s) + ¹¹ C	-14.591	29.182
D(s) + ⁷ Be + ¹¹ B(s)	-13.471	26.942
D(s) + ⁷ B + ¹¹ Be	-37.078	74.157
D(s) + ⁸ He + ¹⁰ N#	-60.332	120.66
D(s) + ⁸ Li + ¹⁰ C	-25.681	51.363
D(s) + ⁸ Be + ¹⁰ B(s)	-6.0268	12.054
D(s) + ⁸ B + ¹⁰ Be	-24.562	49.123
D(s) + ⁸ C + ¹⁰ Li	-57.959	115.92
D(s) + ⁹ Li + ⁹ C	-42.901	85.803
D(s) + ⁹ Be(s) + ⁹ B	-12.798	25.596
T + T + ¹⁴ O	-13.805	27.61
T + ³ He(s) + ¹⁴ N(s)	-8.6431	17.286
T + ⁴ H# + ¹³ O	-39.799	79.599
T + ⁴ He(s) + ¹³ N	1.3812	0
T + ⁴ Li# + ¹³ C(s)	-19.093	38.187
T + ⁵ H# + ¹² O	-56.698	113.4
T + ⁵ He + ¹² N	-19.576	39.153
T + ⁵ Li + ¹² C(s)	-2.5283	5.0567
T + ⁵ Be + ¹² B	-37.918	75.836
T + ⁶ He + ¹¹ N	-33.351	66.701
T + ⁶ Li(s) + ¹¹ C	-15.584	31.168
T + ⁶ Be + ¹¹ B(s)	-17.89	35.781
T + ⁷ He + ¹⁰ N#	-56.658	113.32
T + ⁷ Li(s) + ¹⁰ C	-21.457	42.914
T + ⁷ Be + ¹⁰ B(s)	-18.668	37.336
T + ⁷ B + ¹⁰ Be	-31.325	62.651
T + ⁸ Li + ⁹ C	-40.707	81.414

(continued)

$T + {}^8\text{B}e + {}^9\text{B}$	-8.2059	16.412
$T + {}^8\text{B} + {}^9\text{B}e(s)$	-25.116	50.233
$T + {}^6\text{C} + {}^9\text{Li}$	-50.897	101.79
$\tau + {}^3\text{He}(s) + {}^{14}\text{C}$	-8.781	17.562
$\tau + {}^4\text{H}\# + {}^{15}\text{N}$	-22.015	44.031
$\tau + {}^4\text{He}(s) + {}^{13}\text{C}(s)$	3.6203	0
$\tau + {}^4\text{Li}\# + {}^{13}\text{B}$	-32.512	65.024
$\tau + {}^5\text{H}\# + {}^{12}\text{N}$	-41.958	83.916
$\tau + {}^5\text{He} + {}^{12}\text{C}(s)$	-2.2198	4.4395
$\tau + {}^5\text{Li} + {}^{12}\text{B}$	-15.879	31.759
$\tau + {}^5\text{Be} + {}^{12}\text{Be}$	-49.607	99.214
$\tau + {}^6\text{He} + {}^{11}\text{C}$	-19.072	38.144
$\tau + {}^6\text{Li}(s) + {}^{11}\text{B}(s)$	-13.583	27.167
$\tau + {}^6\text{Be} + {}^{11}\text{Be}$	-29.378	58.756
$\tau + {}^7\text{He} + {}^{10}\text{C}$	-32.641	65.283
$\tau + {}^7\text{Li}(s) + {}^{10}\text{B}(s)$	-17.787	35.575
$\tau + {}^7\text{Be} + {}^{10}\text{Be}$	-19.205	38.411
$\tau + {}^7\text{B} + {}^{10}\text{Li}$	-52.53	105.06
$\tau + {}^8\text{He} + {}^9\text{C}$	-51.341	102.68
$\tau + {}^8\text{Li} + {}^9\text{B}$	-24.191	48.382
$\tau + {}^8\text{Be} + {}^9\text{Be}(s)$	-7.1192	14.238
$\tau + {}^8\text{B} + {}^9\text{Li}$	-38.704	77.408
$\tau + {}^8\text{C} + {}^9\text{He}$	-66.735	133.47
$\alpha + {}^4\text{H}\# + {}^{12}\text{N}$	-21.501	43.003
$\alpha + {}^4\text{He}(s) + {}^{12}\text{C}(s)$	19.252	0
$\alpha + {}^4\text{Li}\# + {}^{12}\text{B}$	-16.813	33.626
$\alpha + {}^5\text{H}\# + {}^{11}\text{N}$	-37.023	74.047
$\alpha + {}^5\text{He} + {}^{11}\text{C}$	-0.36346	0.72692
$\alpha + {}^5\text{Li} + {}^{11}\text{B}(s)$	1.3286	0
$\alpha + {}^5\text{Be} + {}^{11}\text{Be}$	-32.197	64.395
$\alpha + {}^6\text{He} + {}^{10}\text{C}$	-11.617	23.235
$\alpha + {}^6\text{Li}(s) + {}^{10}\text{B}(s)$	-4.4597	8.9195
$\alpha + {}^6\text{Be} + {}^{10}\text{Be}$	-9.3044	18.609
$\alpha + {}^7\text{He} + {}^9\text{C}$	-33.347	66.693

(continued)

$\alpha + {}^7\text{Li}(s) + {}^9\text{B}$	-5.646	11.292
$\alpha + {}^7\text{Be} + {}^9\text{Be}(s)$	-5.4398	10.88
$\alpha + {}^7\text{B} + {}^9\text{Li}$	-31.147	62.295
$\alpha + {}^8\text{He} + {}^8\text{C}$	-45.016	90.033
$\alpha + {}^8\text{Li} + {}^8\text{B}$	-22.189	44.378
$\alpha + {}^8\text{Be} + {}^8\text{Be}$	11.793	0

REACTION ${}^{11}\text{B} + {}^{10}\text{B}$ total branch 7(180)compound nucleus ${}^{21}\text{Ne}^*$ A=21 Z=10

	branch	Q(MeV)	Eth(MeV)	remarks
1	${}^4\text{He}(s) + {}^{17}\text{O}(s)$	19.103	0	(10)
2	${}^8\text{Be} + {}^{13}\text{C}(s)$	12.652	0	(10)
3	${}^9\text{Be}(s) + {}^{12}\text{C}(s)$	9.3711	0	(10)
4	$n + n + {}^{19}\text{Ne}$	2.825	0	(10)
5	$n + p + {}^{19}\text{F}(s)$	6.8458	0	(10)
6	$n + {}^4\text{He}(s) + {}^{16}\text{O}(s)$	14.96	0	(10)
7	$n + {}^8\text{Be} + {}^{12}\text{C}(s)$	7.7057	0	(10)
	$\gamma + {}^{21}\text{Ne}(s)$	26.454	0	
	$n + {}^{20}\text{Ne}(s)$	19.694	0	
	$p + {}^{20}\text{F}$	13.447	0	
	$\text{D}(s) + {}^{19}\text{F}(s)$	9.0704	0	
	$\text{T} + {}^{18}\text{F}$	4.8957	0	
	${}^8\text{He}(s) + {}^{18}\text{O}(s)$	6.5697	0	
	${}^4\text{He} + {}^{17}\text{F}$	-7.0728	13.505	
	${}^4\text{Li} + {}^{17}\text{N}$	-12.272	23.434	
	${}^5\text{He} + {}^{16}\text{F}$	-23.751	45.353	
	${}^5\text{He} + {}^{16}\text{O}(s)$	14.066	0	
	${}^5\text{Li} + {}^{16}\text{N}$	3.3567	0	
	${}^5\text{Be} + {}^{16}\text{C}$	-26.675	50.936	

(continued)

${}^6\text{He} + {}^{15}\text{O}$	0.27098	0
${}^6\text{Li}(\text{s}) + {}^{15}\text{N}(\text{s})$	6.5317	0
${}^6\text{Be} + {}^{15}\text{C}$	-7.5284	14.376
${}^7\text{He} + {}^{14}\text{O}$	-13.398	25.583
${}^7\text{Li}(\text{s}) + {}^{14}\text{N}(\text{s})$	2.9485	0
${}^7\text{Be} + {}^{14}\text{C}$	1.9302	0
${}^7\text{B} + {}^{14}\text{B}$	-30.815	58.842
${}^8\text{He} + {}^{13}\text{O}$	-33.99	64.904
${}^8\text{Li} + {}^{13}\text{N}$	-5.5721	10.64
${}^8\text{B} + {}^{13}\text{B}$	-18.764	35.829
${}^8\text{C} + {}^{13}\text{Be}\#$	-49.326	94.188
${}^9\text{He} + {}^{12}\text{O}$	-52.151	99.583
${}^9\text{Li} + {}^{12}\text{N}$	-21.573	41.194
${}^9\text{B} + {}^{12}\text{B}$	-5.0665	9.6745
${}^9\text{C} + {}^{12}\text{Be}$	-33.271	63.532
${}^{10}\text{Li} + {}^{11}\text{N}$	-38.021	72.601
${}^{10}\text{Be} + {}^{11}\text{C}$	-2.5383	4.8469
${}^{10}\text{C} + {}^{11}\text{Be}$	-15.157	28.942
${}^{10}\text{N}\# + {}^{11}\text{Li}$	-59.881	114.34
$\text{n} + \text{D}(\text{s}) + {}^{18}\text{F}$	-1.3616	2.6
$\text{n} + \text{T} + {}^{17}\text{F}$	-4.254	8.1231
$\text{n} + {}^8\text{He}(\text{s}) + {}^{17}\text{O}(\text{s})$	-1.4746	2.8158
$\text{n} + {}^4\text{H}\# + {}^{16}\text{F}$	-23.873	45.585
$\text{n} + {}^4\text{Li}\# + {}^{16}\text{N}$	-18.155	34.666
$\text{n} + {}^5\text{H}\# + {}^{16}\text{F}\#$	-37.913	72.394
$\text{n} + {}^5\text{He} + {}^{15}\text{O}$	-1.5981	3.0515
$\text{n} + {}^5\text{Li} + {}^{15}\text{N}(\text{s})$	0.86591	0
$\text{n} + {}^5\text{Be} + {}^{15}\text{C}$	-30.926	59.053
$\text{n} + {}^6\text{He} + {}^{14}\text{O}$	-12.951	24.731
$\text{n} + {}^6\text{Li}(\text{s}) + {}^{14}\text{N}(\text{s})$	-4.3016	8.2139
$\text{n} + {}^6\text{Be} + {}^{14}\text{C}$	-8.7465	16.701
$\text{n} + {}^7\text{He} + {}^{13}\text{O}$	-36.574	69.837
$\text{n} + {}^7\text{Li}(\text{s}) + {}^{13}\text{N}$	-7.6049	14.522
$\text{n} + {}^7\text{Be} + {}^{13}\text{C}(\text{s})$	-6.2463	11.927

(continued)

$n + {}^7\text{B} + {}^{13}\text{B}$	-31.785	60.693
$n + {}^8\text{He} + {}^{12}\text{O}$	-51.011	97.405
$n + {}^8\text{Li} + {}^{12}\text{N}$	-25.636	48.952
$n + {}^8\text{B} + {}^{12}\text{B}$	-23.642	45.145
$n + {}^8\text{C} + {}^{12}\text{Be}$	-47.525	90.748
$n + {}^9\text{Li} + {}^{11}\text{N}$	-37.216	71.065
$n + {}^9\text{Be}(s) + {}^{11}\text{C}$	-9.3504	17.855
$n + {}^9\text{B} + {}^{11}\text{B}(s)$	-8.4364	16.109
$n + {}^9\text{C} + {}^{11}\text{Be}$	-36.44	69.582
$n + {}^{10}\text{Li} + {}^{10}\text{N}\#$	-60.883	116.26
$n + {}^{10}\text{Be} + {}^{10}\text{C}$	-15.661	29.905
$n + {}^{10}\text{B}(s) + {}^{10}\text{B}(s)$	-11.454	21.872
$p + p + {}^{19}\text{O}$	2.8085	0
$p + \text{D}(s) + {}^{18}\text{O}(s)$	1.0761	0
$p + \text{T} + {}^{17}\text{O}(s)$	-0.71086	1.3574
$p + {}^3\text{He}(s) + {}^{17}\text{N}$	-9.3726	17.897
$p + {}^4\text{H}\# + {}^{16}\text{O}(s)$	-7.6732	14.652
$p + {}^4\text{He}(s) + {}^{16}\text{N}$	5.3227	0
$p + {}^4\text{Li}\# + {}^{16}\text{C}$	-25.384	48.471
$p + {}^5\text{H}\# + {}^{15}\text{O}$	-23.216	44.33
$p + {}^5\text{He} + {}^{15}\text{N}(s)$	1.9382	0
$p + {}^5\text{Li} + {}^{15}\text{C}$	-8.1235	15.512
$p + {}^5\text{Be} + {}^{15}\text{B}$	-49.24	94.024
$p + {}^6\text{He} + {}^{14}\text{N}(s)$	-7.026	13.416
$p + {}^6\text{Li}(s) + {}^{14}\text{C}$	-3.6758	7.0189
$p + {}^6\text{Be} + {}^{14}\text{B}$	-28.608	54.627
$p + {}^7\text{He} + {}^{13}\text{N}$	-18.026	34.42
$p + {}^7\text{Li}(s) + {}^{13}\text{C}(s)$	-4.6021	8.7877
$p + {}^7\text{Be} + {}^{13}\text{B}$	-18.901	36.092
$p + {}^7\text{B} + {}^{13}\text{Be}\#$	-49.39	94.311
$p + {}^8\text{He} + {}^{12}\text{N}$	-35.506	67.799
$p + {}^8\text{Li} + {}^{12}\text{C}(s)$	-7.5157	14.351
$p + {}^8\text{Be} + {}^{12}\text{B}$	-4.8815	9.3217
$p + {}^8\text{B} + {}^{12}\text{Be}$	-34.568	66.007

(continued)

$p + {}^3\text{C} + {}^{12}\text{Li}\#$	-74.585	142.42
$p + {}^9\text{He} + {}^{11}\text{N}$	-52.29	99.848
$p + {}^9\text{Li} + {}^{11}\text{C}$	-22.174	42.342
$p + {}^9\text{Be}(s) + {}^{11}\text{B}(s)$	-6.586	12.576
$p + {}^9\text{B} + {}^{11}\text{Be}$	-19.16	36.586
$p + {}^9\text{C} + {}^{11}\text{Li}$	-56.383	107.66
$p + {}^{10}\text{He}\# + {}^{10}\text{N}\#$	-75.67	144.49
$p + {}^{10}\text{Li} + {}^{10}\text{C}$	-36.102	68.937
$p + {}^{10}\text{Be} + {}^{10}\text{B}(s)$	-11.228	21.44
$\text{D}(s) + \text{D}(s) + {}^{17}\text{O}(s)$	-4.7436	9.0578
$\text{D}(s) + \text{T} + {}^{16}\text{O}(s)$	-2.6299	5.0218
$\text{D}(s) + {}^3\text{He}(s) + {}^{16}\text{N}$	-13.03	24.882
$\text{D}(s) + {}^4\text{H}\# + {}^{15}\text{O}$	-21.113	40.314
$\text{D}(s) + {}^4\text{He}(s) + {}^{15}\text{N}(s)$	5.0565	0
$\text{D}(s) + {}^4\text{Li}\# + {}^{15}\text{C}$	-27.41	52.34
$\text{D}(s) + {}^5\text{H}\# + {}^{14}\text{O}$	-34.214	65.331
$\text{D}(s) + {}^5\text{He} + {}^{14}\text{N}(s)$	-6.6705	12.737
$\text{D}(s) + {}^5\text{Li} + {}^{14}\text{C}$	-7.117	13.59
$\text{D}(s) + {}^5\text{Be} + {}^{14}\text{B}$	-49.781	95.057
$\text{D}(s) + {}^6\text{He} + {}^{13}\text{N}$	-15.355	29.32
$\text{D}(s) + {}^6\text{Li}(s) + {}^{13}\text{C}(s)$	-9.6277	18.384
$\text{D}(s) + {}^6\text{Be} + {}^{13}\text{B}$	-27.353	52.231
$\text{D}(s) + {}^7\text{He} + {}^{12}\text{N}$	-35.865	68.484
$\text{D}(s) + {}^7\text{Li}(s) + {}^{12}\text{C}(s)$	-7.3238	13.985
$\text{D}(s) + {}^7\text{Be} + {}^{12}\text{B}$	-21.555	41.16
$\text{D}(s) + {}^7\text{B} + {}^{12}\text{Be}$	-45.364	86.623
$\text{D}(s) + {}^8\text{He} + {}^{11}\text{N}$	-48.925	93.422
$\text{D}(s) + {}^8\text{Li} + {}^{11}\text{C}$	-24.013	45.852
$\text{D}(s) + {}^8\text{Be} + {}^{11}\text{B}(s)$	-6.0268	11.508
$\text{D}(s) + {}^8\text{B} + {}^{11}\text{Be}$	-35.511	67.809
$\text{D}(s) + {}^8\text{C} + {}^{11}\text{Li}$	-68.412	130.63
$\text{D}(s) + {}^9\text{He} + {}^{10}\text{N}\#$	-72.927	139.25
$\text{D}(s) + {}^9\text{Li} + {}^{10}\text{C}$	-33.073	63.152
$\text{D}(s) + {}^9\text{Be}(s) + {}^{10}\text{B}(s)$	-15.816	30.2

(continued)

D(s) + $^9\text{B} + ^{10}\text{B e}$	-17.44	33.301
D(s) + $^9\text{C} + ^{10}\text{L i}$	-55.16	105.33
T + T + ^{15}O	-12.037	22.984
T + $^3\text{H e (s)} + ^{15}\text{N (s)}$	-9.264	17.689
T + $^4\text{H \#} + ^{14}\text{O}$	-28.078	53.614
T + $^4\text{H e (s)} + ^{14}\text{N (s)}$	0.48052	0
T + $^4\text{L i \#} + ^{14}\text{C}$	-22.371	42.717
T + $^5\text{H \#} + ^{13}\text{O}$	-51.132	97.637
T + $^5\text{H e} + ^{13}\text{N}$	-10.967	20.941
T + $^5\text{L i} + ^{13}\text{C (s)}$	-9.0362	17.255
T + $^5\text{B e} + ^{13}\text{B}$	-44.493	84.96
T + $^6\text{H e} + ^{12}\text{N}$	-29.162	55.684
T + $^6\text{L i (s)} + ^{12}\text{C (s)}$	-8.3167	15.881
T + $^6\text{B e} + ^{12}\text{B}$	-25.975	49.598
T + $^7\text{H e} + ^{11}\text{N}$	-45.251	86.407
T + $^7\text{L i (s)} + ^{11}\text{C}$	-19.788	37.785
T + $^7\text{B e} + ^{11}\text{B (s)}$	-18.668	35.646
T + $^7\text{B} + ^{11}\text{B e}$	-42.275	80.724
T + $^8\text{H e} + ^{10}\text{N \#}$	-65.529	125.13
T + $^8\text{L i} + ^{10}\text{C}$	-30.878	58.962
T + $^8\text{B e} + ^{10}\text{B (s)}$	-11.224	21.432
T + $^8\text{B} + ^{10}\text{B e}$	-29.758	56.824
T + $^8\text{C} + ^{10}\text{L i}$	-63.156	120.6
T + $^9\text{L i} + ^9\text{C}$	-48.098	91.843
T + $^9\text{B e (s)} + ^9\text{B}$	-17.995	34.361
$\tau + ^8\text{H e (s)} + ^{15}\text{C}$	-19.017	36.313
$\tau + ^4\text{H \#} + ^{14}\text{N (s)}$	-22.916	43.758
$\tau + ^4\text{H e (s)} + ^{14}\text{C}$	0.34263	0
$\tau + ^4\text{L i \#} + ^{14}\text{B}$	-42.997	82.102
$\tau + ^5\text{H \#} + ^{13}\text{N}$	-33.348	63.678
$\tau + ^5\text{H e} + ^{13}\text{C (s)}$	-8.7276	16.665
$\tau + ^5\text{L i} + ^{13}\text{B}$	-22.455	42.877
$\tau + ^5\text{B e} + ^{13}\text{B e \#}$	-62.863	120.04
$\tau + ^6\text{H e} + ^{12}\text{C (s)}$	-11.805	22.541

(continued)

$\tau + {}^6\text{Li}(s) + {}^{12}\text{B}$	-21.668	41.374
$\tau + {}^6\text{Be} + {}^{12}\text{Be}$	-37.664	71.918
$\tau + {}^7\text{He} + {}^{11}\text{C}$	-30.973	59.142
$\tau + {}^7\text{Li}(s) + {}^{11}\text{B}(s)$	-17.787	33.965
$\tau + {}^7\text{Be} + {}^{11}\text{Be}$	-30.155	57.581
$\tau + {}^7\text{B} + {}^{11}\text{Li}$	-62.983	120.27
$\tau + {}^8\text{He} + {}^{10}\text{C}$	-41.512	79.268
$\tau + {}^8\text{Li} + {}^{10}\text{B}(s)$	-27.209	51.955
$\tau + {}^8\text{Be} + {}^{10}\text{Be}$	-11.761	22.458
$\tau + {}^8\text{B} + {}^{10}\text{Li}$	-50.963	97.313
$\tau + {}^8\text{C} + {}^{10}\text{He}\#$	-78.708	150.29
$\tau + {}^9\text{He} + {}^9\text{C}$	-63.936	122.09
$\tau + {}^9\text{Li} + {}^9\text{B}$	-31.582	60.306
$\tau + {}^9\text{Be}(s) + {}^9\text{Be}(s)$	-16.908	32.286
$\alpha + {}^4\text{H}\# + {}^{13}\text{N}$	-12.892	24.617
$\alpha + {}^4\text{Li}\# + {}^{13}\text{B}$	-23.388	44.66
$\alpha + {}^5\text{H}\# + {}^{12}\text{N}$	-32.834	62.697
$\alpha + {}^5\text{He} + {}^{12}\text{C}(s)$	6.9039	0
$\alpha + {}^5\text{Li} + {}^{12}\text{B}$	-6.7556	12.9
$\alpha + {}^5\text{Be} + {}^{12}\text{Be}$	-40.483	77.302
$\alpha + {}^6\text{He} + {}^{11}\text{C}$	-9.9485	18.997
$\alpha + {}^6\text{Li}(s) + {}^{11}\text{B}(s)$	-4.4597	8.5159
$\alpha + {}^6\text{Be} + {}^{11}\text{Be}$	-20.254	38.675
$\alpha + {}^7\text{He} + {}^{10}\text{C}$	-23.518	44.907
$\alpha + {}^7\text{Li}(s) + {}^{10}\text{B}(s)$	-8.6637	16.543
$\alpha + {}^7\text{Be} + {}^{10}\text{Be}$	-10.082	19.251
$\alpha + {}^7\text{B} + {}^{10}\text{Li}$	-43.406	82.884
$\alpha + {}^8\text{He} + {}^9\text{C}$	-42.217	80.614
$\alpha + {}^8\text{Li} + {}^9\text{B}$	-15.067	28.771
$\alpha + {}^8\text{Be} + {}^9\text{Be}(s)$	2.0044	0
$\alpha + {}^8\text{B} + {}^9\text{Li}$	-29.58	56.484
$\alpha + {}^8\text{C} + {}^9\text{He}$	-57.611	110.01

Table 11 ^{11}B -induced Fusion Reaction

REACTION $^{11}\text{B} + ^{11}\text{B}$ total branch 9(199)
 compound nucleus $^{22}\text{Ne}^*$ A=22 Z=10

branch	Q(MeV)	Eth(MeV)	remarks
1 $^7\text{Li}(s) + ^{15}\text{N}(s)$	2.3277	0	(7)
2 $^8\text{Li} + ^{14}\text{N}(s)$	-6.4728	12.946	(7)
3 $^9\text{Li} + ^{13}\text{N}$	-12.963	25.927	(7)
4 $^{10}\text{Be} + ^{12}\text{C}(s)$	4.729	0	(7, 10)
5 $p + ^{21}\text{F}$	10.095	0	(10)
6 $n + n + ^{20}\text{Ne}(s)$	8.2395	0	(10)
7 $n + p + ^{20}\text{F}$	1.9929	0	(10)
8 $n + ^4\text{He}(s) + ^{17}\text{O}(s)$	7.649	0	(10)
9 $2n + p + ^{19}\text{F}(s)$	-4.6084*	9.2168	(10)
$\gamma + ^{22}\text{Ne}(s)$	25.363	0	
$n + ^{21}\text{Ne}(s)$	15.0	0	
$\text{D}(s) + ^{20}\text{F}$	4.2175	0	
$\text{T} + ^{19}\text{F}(s)$	3.8735	0	
$^3\text{He}(s) + ^{19}\text{O}$	-0.92752	1.855	
$^4\text{He} + ^{18}\text{F}$	-9.3772	18.754	
$^4\text{He}(s) + ^{18}\text{O}(s)$	15.693	0	
$^4\text{Li} + ^{18}\text{N}$	-20.901	41.802	
$^5\text{He} + ^{17}\text{F}$	-18.406	36.811	
$^5\text{He} + ^{17}\text{O}(s)$	6.7553	0	
$^5\text{Li} + ^{17}\text{N}$	-2.215	4.43	
$^6\text{Be} + ^{17}\text{C}$	-37.394	74.788	
$^6\text{He} + ^{16}\text{O}(s)$	4.4807	0	
$^6\text{Li}(s) + ^{16}\text{N}$	-2.4317	4.8634	
$^6\text{Be} + ^{16}\text{C}$	-14.732	29.464	
$^7\text{He} + ^{15}\text{O}$	-11.63	23.259	
$^7\text{Be} + ^{15}\text{C}$	-8.3059	16.612	

(continued)

${}^7\text{B} + {}^{15}\text{B}$	-39.504	79.008
${}^8\text{H e} + {}^{14}\text{O}$	-22.269	44.537
${}^8\text{B e} + {}^{14}\text{C}$	9.3744	0
${}^8\text{B} + {}^{14}\text{B}$	-29.248	58.497
${}^8\text{C} + {}^{14}\text{B e}$	-58.779	117.56
${}^9\text{H e} + {}^{18}\text{O}$	-46.585	93.17
${}^9\text{B e}(\text{s}) + {}^{18}\text{C}(\text{s})$	2.8633	0
${}^9\text{B} + {}^{18}\text{B}$	-11.642	23.284
${}^9\text{C} + {}^{18}\text{B e}\#$	-46.527	93.054
${}^{10}\text{H e}\# + {}^{12}\text{O}$	-64.124	128.25
${}^{10}\text{L i} + {}^{12}\text{N}$	-33.832	67.664
${}^{10}\text{B}(\text{s}) + {}^{12}\text{B}$	-8.0843	16.169
${}^{10}\text{C} + {}^{12}\text{B e}$	-23.443	46.885
${}^{10}\text{N}\# + {}^{12}\text{L i}\#$	-75.284	150.57
${}^{11}\text{L i} + {}^{11}\text{N}$	-48.474	96.948
${}^{11}\text{B e} + {}^{11}\text{C}$	-13.488	26.976
$\text{n} + \text{D}(\text{s}) + {}^{19}\text{F}(\text{s})$	-2.3838	4.7676
$\text{n} + \text{T} + {}^{18}\text{F}$	-6.5585	13.117
$\text{n} + {}^3\text{H e}(\text{s}) + {}^{18}\text{O}(\text{s})$	-4.8845	9.769
$\text{n} + {}^4\text{H}\# + {}^{17}\text{F}$	-18.527	37.054
$\text{n} + {}^4\text{L i}\# + {}^{17}\text{N}$	-23.726	47.453
$\text{n} + {}^5\text{H}\# + {}^{16}\text{F}$	-35.205	70.411
$\text{n} + {}^5\text{H e} + {}^{16}\text{O}(\text{s})$	2.6117	0
$\text{n} + {}^5\text{L i} + {}^{16}\text{N}$	-8.0975	16.195
$\text{n} + {}^5\text{B e} + {}^{16}\text{C}$	-38.129	76.259
$\text{n} + {}^6\text{H e} + {}^{15}\text{O}$	-11.183	22.366
$\text{n} + {}^6\text{L i}(\text{s}) + {}^{15}\text{N}(\text{s})$	-4.9225	9.8449
$\text{n} + {}^6\text{B e} + {}^{15}\text{C}$	-18.983	37.965
$\text{n} + {}^7\text{H e} + {}^{14}\text{O}$	-24.852	49.704
$\text{n} + {}^7\text{L i}(\text{s}) + {}^{14}\text{N}(\text{s})$	-8.5056	17.011
$\text{n} + {}^7\text{B e} + {}^{14}\text{C}$	-9.524	19.048
$\text{n} + {}^7\text{B} + {}^{14}\text{B}$	-42.269	84.539
$\text{n} + {}^8\text{H e} + {}^{18}\text{O}$	-45.444	90.889
$\text{n} + {}^8\text{L i} + {}^{18}\text{N}$	-17.026	34.053

(continued)

$n + {}^8\text{B} e + {}^{13}\text{C}(\text{s})$	1.1979	0
$n + {}^8\text{B} + {}^{13}\text{B}$	-30.218	60.436
$n + {}^8\text{C} + {}^{13}\text{B} e \#$	-60.78	121.56
$n + {}^9\text{H} e + {}^{12}\text{O}$	-63.605	127.21
$n + {}^9\text{L} i + {}^{12}\text{N}$	-33.027	66.055
$n + {}^9\text{B} e(\text{s}) + {}^{12}\text{C}(\text{s})$	-2.0831	4.1661
$n + {}^9\text{B} + {}^{12}\text{B}$	-16.521	33.041
$n + {}^9\text{C} + {}^{12}\text{B} e$	-44.726	89.451
$n + {}^{10}\text{L} i + {}^{11}\text{N}$	-49.475	98.951
$n + {}^{10}\text{B} e + {}^{11}\text{C}$	-13.992	27.985
$n + {}^{10}\text{B}(\text{s}) + {}^{11}\text{B}(\text{s})$	-11.454	22.908
$n + {}^{10}\text{C} + {}^{11}\text{B} e$	-26.611	53.222
$n + {}^{10}\text{N}\# + {}^{11}\text{L} i$	-71.335	142.67
$p + p + {}^{20}\text{O}$	-1.0384	2.0767
$p + \text{D}(\text{s}) + {}^{19}\text{O}$	-6.4211	12.842
$p + \text{T} + {}^{18}\text{O}(\text{s})$	-4.1207	8.2415
$p + {}^3\text{H} e(\text{s}) + {}^{18}\text{N}$	-18.001	36.003
$p + {}^4\text{H}\# + {}^{17}\text{O}(\text{s})$	-14.984	29.967
$p + {}^4\text{H} e(\text{s}) + {}^{17}\text{N}$	-0.24895	0.4979
$p + {}^4\text{L} i\# + {}^{17}\text{C}$	-36.103	72.206
$p + {}^5\text{H}\# + {}^{16}\text{O}(\text{s})$	-19.006	38.012
$p + {}^5\text{H} e + {}^{16}\text{N}$	-7.0251	14.05
$p + {}^5\text{L} i + {}^{16}\text{C}$	-15.327	30.654
$p + {}^5\text{B} e + {}^{16}\text{B}\#$	-61.293	122.59
$p + {}^6\text{H} e + {}^{15}\text{N}(\text{s})$	-7.6468	15.294
$p + {}^6\text{L} i(\text{s}) + {}^{15}\text{C}$	-13.912	27.824
$p + {}^6\text{B} e + {}^{15}\text{B}$	-37.297	74.594
$p + {}^7\text{H} e + {}^{14}\text{N}(\text{s})$	-18.926	37.853
$p + {}^7\text{L} i(\text{s}) + {}^{14}\text{C}$	-7.8797	15.759
$p + {}^7\text{B} e + {}^{14}\text{B}$	-29.386	58.771
$p + {}^7\text{B} + {}^{14}\text{B} e$	-58.843	117.69
$p + {}^8\text{H} e + {}^{13}\text{N}$	-26.897	53.793
$p + {}^8\text{L} i + {}^{13}\text{C}(\text{s})$	-14.023	28.047
$p + {}^8\text{B} e + {}^{13}\text{B}$	-11.457	22.914

(continued)

$p + {}^8\text{B} + {}^{13}\text{B e} \#$	-47.823	95.647
$p + {}^8\text{C} + {}^{13}\text{L i} \#$	-86.608	173.22
$p + {}^9\text{H e} + {}^{12}\text{N}$	-48.101	96.202
$p + {}^9\text{L i} + {}^{12}\text{C (s)}$	-14.907	29.814
$p + {}^9\text{B e (s)} + {}^{12}\text{B}$	-14.67	29.34
$p + {}^9\text{B} + {}^{12}\text{B e}$	-27.446	54.892
$p + {}^9\text{C} + {}^{12}\text{L i} \#$	-71.786	143.57
$p + {}^{10}\text{H e} \# + {}^{11}\text{N}$	-64.263	128.53
$p + {}^{10}\text{L i} + {}^{11}\text{C}$	-34.433	68.866
$p + {}^{10}\text{B e} + {}^{11}\text{B (s)}$	-11.228	22.456
$p + {}^{10}\text{B (s)} + {}^{11}\text{B e}$	-22.178	44.356
$p + {}^{10}\text{C} + {}^{11}\text{L i}$	-46.555	93.109
$\text{D (s)} + \text{D (s)} + {}^{18}\text{O (s)}$	-8.1534	16.307
$\text{D (s)} + \text{T} + {}^{17}\text{O (s)}$	-9.9404	19.881
$\text{D (s)} + {}^3\text{H e (s)} + {}^{17}\text{N}$	-18.602	37.204
$\text{D (s)} + {}^4\text{H} \# + {}^{16}\text{O (s)}$	-16.903	33.806
$\text{D (s)} + {}^4\text{H e (s)} + {}^{16}\text{N}$	-3.9068	7.8137
$\text{D (s)} + {}^4\text{L i} \# + {}^{16}\text{C}$	-34.614	69.228
$\text{D (s)} + {}^5\text{H} \# + {}^{15}\text{O}$	-32.445	64.891
$\text{D (s)} + {}^5\text{H e} + {}^{15}\text{N (s)}$	-7.2913	14.583
$\text{D (s)} + {}^5\text{L i} + {}^{15}\text{C}$	-17.353	34.706
$\text{D (s)} + {}^5\text{B e} + {}^{15}\text{B}$	-58.47	116.94
$\text{D (s)} + {}^6\text{H e} + {}^{14}\text{N (s)}$	-16.256	32.511
$\text{D (s)} + {}^6\text{L i (s)} + {}^{14}\text{C}$	-12.905	25.811
$\text{D (s)} + {}^6\text{B e} + {}^{14}\text{B}$	-37.838	75.676
$\text{D (s)} + {}^7\text{H e} + {}^{13}\text{N}$	-27.255	54.511
$\text{D (s)} + {}^7\text{L i (s)} + {}^{13}\text{C (s)}$	-13.832	27.663
$\text{D (s)} + {}^7\text{B e} + {}^{13}\text{B}$	-28.131	56.262
$\text{D (s)} + {}^7\text{B} + {}^{13}\text{B e} \#$	-58.62	117.24
$\text{D (s)} + {}^8\text{H e} + {}^{12}\text{N}$	-44.736	89.472
$\text{D (s)} + {}^8\text{L i} + {}^{12}\text{C (s)}$	-16.745	33.49
$\text{D (s)} + {}^8\text{B e} + {}^{12}\text{B}$	-14.111	28.222
$\text{D (s)} + {}^8\text{B} + {}^{12}\text{B e}$	-43.797	87.594
$\text{D (s)} + {}^8\text{C} + {}^{12}\text{L i} \#$	-83.815	167.63

(continued)

D(s) + $^9\text{He} + ^{11}\text{N}$	-61.52	123.04
D(s) + $^9\text{Li} + ^{11}\text{C}$	-31.404	62.808
D(s) + $^9\text{Be}(s) + ^{11}\text{B}(s)$	-15.816	31.631
D(s) + $^9\text{B} + ^{11}\text{Be}$	-28.39	56.779
D(s) + $^9\text{C} + ^{11}\text{Li}$	-65.613	131.23
D(s) + $^{10}\text{He}\# + ^{10}\text{N}\#$	-84.9	169.8
D(s) + $^{10}\text{Li} + ^{10}\text{C}$	-45.332	90.663
D(s) + $^{10}\text{Be} + ^{10}\text{B}(s)$	-20.458	40.915
T + T + $^{16}\text{O}(s)$	-7.8268	15.654
T + $^3\text{He}(s) + ^{16}\text{N}$	-18.227	36.455
T + $^4\text{He}\# + ^{16}\text{O}$	-26.309	52.619
T + $^4\text{He}(s) + ^{15}\text{N}(s)$	-0.14033	0.28066
T + $^4\text{Li}\# + ^{16}\text{C}$	-32.607	65.214
T + $^5\text{He}\# + ^{14}\text{O}$	-39.41	78.821
T + $^5\text{He} + ^{14}\text{N}(s)$	-11.867	23.735
T + $^5\text{Li} + ^{14}\text{C}$	-12.314	24.628
T + $^5\text{Be} + ^{14}\text{B}$	-54.978	109.96
T + $^6\text{He} + ^{13}\text{N}$	-20.552	41.103
T + $^6\text{Li}(s) + ^{13}\text{C}(s)$	-14.825	29.649
T + $^6\text{Be} + ^{13}\text{B}$	-32.55	65.1
T + $^7\text{He} + ^{12}\text{N}$	-41.062	82.124
T + $^7\text{Li}(s) + ^{12}\text{C}(s)$	-12.521	25.041
T + $^7\text{Be} + ^{12}\text{B}$	-26.752	53.504
T + $^7\text{B} + ^{12}\text{Be}$	-50.561	101.12
T + $^8\text{He} + ^{11}\text{N}$	-54.122	108.24
T + $^8\text{Li} + ^{11}\text{C}$	-29.209	58.419
T + $^8\text{Be} + ^{11}\text{B}(s)$	-11.224	22.447
T + $^8\text{B} + ^{11}\text{Be}$	-40.708	81.416
T + $^8\text{C} + ^{11}\text{Li}$	-73.609	147.22
T + $^9\text{He} + ^{10}\text{N}\#$	-78.124	156.25
T + $^9\text{Li} + ^{10}\text{C}$	-38.27	76.539
T + $^9\text{Be}(s) + ^{10}\text{B}(s)$	-21.012	42.025
T + $^9\text{B} + ^{10}\text{Be}$	-22.637	45.273
T + $^9\text{C} + ^{10}\text{Li}$	-60.357	120.71

(continued)

$\tau + {}^3\text{H e (s)} + {}^{16}\text{C}$	-26.221	52.441
$\tau + {}^4\text{H \#} + {}^{15}\text{N (s)}$	-23.537	47.074
$\tau + {}^4\text{H e (s)} + {}^{15}\text{C}$	-9.8934	19.787
$\tau + {}^4\text{L i \#} + {}^{15}\text{B}$	-51.685	103.37
$\tau + {}^5\text{H \#} + {}^{14}\text{N (s)}$	-34.249	68.498
$\tau + {}^5\text{H e} + {}^{14}\text{C}$	-12.005	24.01
$\tau + {}^5\text{L i} + {}^{14}\text{B}$	-32.939	65.879
$\tau + {}^5\text{B e} + {}^{14}\text{B e}$	-72.315	144.63
$\tau + {}^6\text{H e} + {}^{13}\text{C (s)}$	-18.313	36.625
$\tau + {}^6\text{L i (s)} + {}^{13}\text{B}$	-28.243	56.486
$\tau + {}^6\text{B e} + {}^{13}\text{B e \#}$	-50.919	101.84
$\tau + {}^7\text{H e} + {}^{12}\text{C (s)}$	-23.705	47.411
$\tau + {}^7\text{L i (s)} + {}^{12}\text{B}$	-25.872	51.743
$\tau + {}^7\text{B e} + {}^{12}\text{B e}$	-38.441	76.882
$\tau + {}^7\text{B} + {}^{12}\text{L i \#}$	-78.385	156.77
$\tau + {}^8\text{H e} + {}^{11}\text{C}$	-39.843	79.687
$\tau + {}^8\text{L i} + {}^{11}\text{B (s)}$	-27.209	54.417
$\tau + {}^8\text{B e} + {}^{11}\text{B e}$	-22.711	45.422
$\tau + {}^8\text{B} + {}^{11}\text{L i}$	-61.416	122.83
$\tau + {}^9\text{H e} + {}^{10}\text{C}$	-54.107	108.21
$\tau + {}^9\text{L i} + {}^{10}\text{B (s)}$	-34.6	69.2
$\tau + {}^9\text{B e (s)} + {}^{10}\text{B e}$	-21.55	43.1
$\tau + {}^9\text{B} + {}^{10}\text{L i}$	-43.841	87.682
$\tau + {}^9\text{C} + {}^{10}\text{H e \#}$	-75.909	151.82
$\alpha + {}^4\text{H \#} + {}^{14}\text{N (s)}$	-13.792	27.585
$\alpha + {}^4\text{H e (s)} + {}^{14}\text{C}$	9.4663	0
$\alpha + {}^4\text{L i \#} + {}^{14}\text{B}$	-33.873	67.746
$\alpha + {}^5\text{H \#} + {}^{13}\text{N}$	-24.224	48.449
$\alpha + {}^5\text{H e} + {}^{13}\text{C (s)}$	0.39606	0
$\alpha + {}^5\text{L i} + {}^{13}\text{B}$	-13.331	26.662
$\alpha + {}^5\text{B e} + {}^{13}\text{B e \#}$	-53.739	107.48
$\alpha + {}^6\text{H e} + {}^{12}\text{C (s)}$	-2.6812	5.3624
$\alpha + {}^6\text{L i (s)} + {}^{12}\text{B}$	-12.544	25.088
$\alpha + {}^6\text{B e} + {}^{12}\text{B e}$	-28.54	57.08

(continued)

$\alpha + {}^7\text{H e} + {}^{11}\text{C}$	-21.849	43.698
$\alpha + {}^7\text{L i}(\text{s}) + {}^{11}\text{B}(\text{s})$	-8.6637	17.327
$\alpha + {}^7\text{B e} + {}^{11}\text{B e}$	-21.032	42.063
$\alpha + {}^7\text{B} + {}^{11}\text{L i}$	-53.859	107.72
$\alpha + {}^8\text{H e} + {}^{10}\text{C}$	-32.389	64.777
$\alpha + {}^8\text{L i} + {}^{10}\text{B}(\text{s})$	-18.085	36.17
$\alpha + {}^8\text{B e} + {}^{10}\text{B e}$	-2.6377	5.2753
$\alpha + {}^8\text{B} + {}^{10}\text{L i}$	-41.839	83.678
$\alpha + {}^8\text{C} + {}^{10}\text{H e} \#$	-69.584	139.17
$\alpha + {}^9\text{H e} + {}^9\text{C}$	-54.812	109.62
$\alpha + {}^9\text{L i} + {}^9\text{B}$	-22.459	44.917
$\alpha + {}^9\text{B e}(\text{s}) + {}^9\text{B e}(\text{s})$	-7.7843	15.569

*; M.D. High⁽¹⁰⁾ shows a positive value, which is unaccountable.

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付録 A L. T. C o x 報告批判

L. T. Cox et al: "Thermonuclear Reaction Listing with Cross-section Data for Four Advanced Reactions", FUSION TECHNOLOGY, 18, 325(1990) に核融合反応式のリストが与えられている⁽¹⁾。しかしこの技術報告に記載されているリストの内容には次の点で問題及び我々が調査した結果との相違がある。

- (1) 反応及び反応の分岐の調査が不十分で、本文に我々が調査した件数の 60.2% しか収録されていない。
- (2) 核融合燃料原子核としては利用されない ${}^7\text{Be}$ と ${}^{10}\text{Be}$ をも対象にしている。しかしこれらのデータは本文にはないので利用価値があると思われる。
- (3) 明らかに過誤及びミスプリントと思われる点が 21 箇所ある。
- (4) その他の問題として、
 - 負の Q 値の場合にはしきい値 E_{th}
 - まだ観察されていない "n.o.:not observed" 核種の情報が必要である。

A. 1 反応及び反応の分岐数の比較

核融合反応で軽い原子核が作用する（ここでは induced を翻訳した）反応を基にして分類して、反応及び反応の分岐数の Cox のデータとの比較を Table A.1 に示した。なお括弧内の数字は本文の計算で得られた分岐のうち、観測値のない分岐で将来観測がされる可能性がある分岐数である。まとめると次のようになる。

- Cox データは $p\text{-}{}^3\text{He}$ と $p\text{-}{}^4\text{He}$ 反応を無視している。
- Cox データは ${}^9\text{Be}\text{-}{}^9\text{Be}$ 反応以上の multi-channel 反応を無視している。
- Cox データは 重い原子核に関する反応になると、いくつかの分岐が無視されている。
 - 例えば、無視される分岐の割合は $p\text{-}T$ -induced 反応で 10~20% であるが、 ${}^7\text{Li}$ -induced 反応では ~80% になっている。
- 本文の収録件数に占める Cox データの割合は全体では 60.2% であるが、 ${}^7\text{Li}$ より軽い核種との induced 反応では 66.4% である。

Table A.1 Comparison of number of branches

induced	this report	COX	ratio
p -	7 8 (1 0 2)	6 3	8 0 . 8 %
D -	7 3 (1 5 7)	6 3	8 6 . 3 %
T -	5 5 (2 1 4)	4 8	8 7 . 3 %
³ He -	8 3 (1 9 8)	5 8	6 9 . 9 %
⁴ He -	5 2 (2 7 2)	3 6	6 9 . 2 %
⁶ Li -	6 4 (3 7 1)	2 6	4 0 . 6 %
⁷ Li -	5 2 (3 7 7)	1 0	1 9 . 2 %
⁹ Be -	2 4 (4 3 5)	0	0
¹⁰ B, ¹¹ B -	5 (5 5 6)	0	0
計	5 0 5 (2 6 6 5)	3 0 4	6 0 . 2 %

A. 2 不安定核種についての反応及び反応の分岐

本文には記載のない ⁷Be、¹⁰Be と ⁶Li についての反応及び反応の分岐データを Table A.2 に示す。⁷Be と ¹⁰Be は Cox 及びその他の研究者からのデータ、⁶Li は谷畑勇夫:日本物理学会誌, 47, 814(1992) による。

備考欄の数字は各分岐の核反応断面積データの文献の引用を示す。引用された数字は本文の参考文献を示す。⁶Li の核反応断面積データは谷畑勇夫:日本物理学会誌に記載されている。

Table A.2 Reaction of Radioactive Nuclei

REACTION	branch	Q(MeV)	Eth(MeV)	remarks
${}^7\text{Be} + p$	$\gamma + {}^6\text{B}$	0.113 ~ 0.137	0	(4, 7, 9)
${}^7\text{Be} + \text{D}$	$p + 2 {}^4\text{He}$	16.7 ~ 16.766	0	(4, 5, 7)
${}^7\text{Be} + \text{T}$	$n + p + 2 {}^4\text{He}$	10.510	0	(4, 5, 7)
${}^7\text{Be} + \tau$	$p + p + 2 {}^4\text{He}$	11.274	0	(4, 5, 7)
${}^7\text{Be} + \alpha$	$\gamma + {}^{11}\text{C}$	7.545	0	(4, 7)
${}^{10}\text{Be} + p$	$\text{T} + {}^8\text{Be}$	0.0049	0	
	${}^3\text{He} + {}^8\text{Li}$	-15.982	17.59	
	${}^4\text{He} + {}^7\text{Li}$	2.563	0	
${}^{10}\text{Be} + \text{D}$	$\text{T} + {}^9\text{Be}$	-0.5545	0.666	
	${}^3\text{He} + {}^9\text{Li}$	-14.143	16.987	
	${}^4\text{He} + {}^8\text{Li}$	2.372	0	
${}^{10}\text{Be} + {}^{11}\text{B}$	${}^6\text{Li} + {}^{12}\text{C}$	-3.680	7.73	
${}^8\text{Li} + {}^4\text{He}$	$n + {}^{11}\text{B}$	6.631	0	

A. 3 過誤及びミスプリントと思われる点

Cox の技術報告での過誤及びミスプリントと思われる点を分類すると、次の3点になる。

○原子番号及び質量数の保存則が成立していない(7箇所)。

Table A.3

○Q値の間違い(8箇所)。

Table A.4

○Q値が記載されていない(6箇所)。

Table A.5

以上の3点をそれぞれ表に示したが、表中に波線で指示した部分が誤りである。

Table A.3 Reactions Violating Conservation Law in COX paper

COX	corrected	remarks
<p><u>$p+t \rightarrow 2p+{}^5\text{He}-4.59\text{MeV}$</u></p> <p>$t+{}^6\text{Li} \rightarrow \gamma + p+{}^8\text{Li} \rightarrow 2{}^4\text{He}$</p> <p>$t+{}^7\text{Li} \rightarrow \gamma + d+{}^8\text{Li} \rightarrow 2{}^4\text{He}$</p> <p><u>${}^3\text{He}+{}^7\text{Li} \rightarrow 2p+2{}^4\text{He}$</u></p> <p><u>${}^3\text{He}+{}^9\text{Be} \rightarrow n+{}^9\text{C}-6.282$</u></p> <p><u>${}^3\text{He}+{}^9\text{Be} \rightarrow p+3{}^4\text{He}$</u></p> <p><u>${}^4\text{He}+{}^9\text{Be} \rightarrow {}^6\text{He}+{}^8\text{Be}-2.56\text{MeV}$</u></p>	<p>${}^8\text{Li} \rightarrow e^-+{}^8\text{Be} \rightarrow 2{}^4\text{He}$</p> <p>${}^8\text{Li} \rightarrow e^-+{}^8\text{Be} \rightarrow 2{}^4\text{He}$</p>	typographical error

Table A.4 Reactions whose Q values are not correct

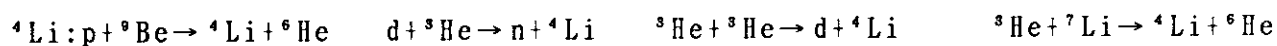
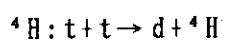
COX	correct	remarks
$p+{}^10\text{B} \rightarrow d+{}^9\text{B}-\underline{2.179\text{MeV}}$	6.2118	
$p+{}^11\text{B} \rightarrow {}^3\text{He}+{}^9\text{Be}-\underline{15.8159\text{MeV}}$	10.322	
$d+{}^3\text{He} \rightarrow n+{}^4\text{Li}+\underline{16.39\text{MeV}}$	-5.1242	-2.225 is correct?
$d+{}^11\text{B} \rightarrow {}^6\text{He}+{}^7\text{Be}+\underline{11.560\text{MeV}}$	-11.560	negative value
$t+{}^4\text{He} \rightarrow n+d+{}^4\text{He}-\underline{0.4105\text{MeV}}$	6.2573	due to the error in quoted paper
$t+{}^9\text{Be} \rightarrow {}^5\text{He}+{}^7\text{Li}+\underline{0.0\text{MeV}}$	0.00081	
${}^3\text{He}+{}^11\text{B} \rightarrow {}^6\text{He}+{}^8\text{B}-\underline{17.730\text{MeV}}$	16.913	
${}^6\text{Li}+{}^10\text{B} \rightarrow {}^10\text{C}+{}^6\text{He}-\underline{31.846\text{MeV}}$	7.1576	

Table A.5 Reactions whose Q Value are not given in COX paper

COX errors	Q value
$t+{}^1_0\text{B} \rightarrow p+{}^4_2\text{He}+{}^8_3\text{Li}$	-3.6587MeV
$t+{}^1_0\text{B} \rightarrow {}^7_4\text{Be}+{}^6_2\text{He}$	-6.3603MeV
$t+{}^1_1\text{B} \rightarrow 2{}^4_2\text{He}+{}^6_2\text{He}$	+1.1758MeV
${}^3_2\text{He}+{}^9_4\text{Be} \rightarrow n+{}^{11}_6\text{C}$	+7.5575MeV
${}^3_2\text{He}+{}^9_4\text{Be} \rightarrow 2n+{}^{10}_6\text{C}$	-5.5654MeV
${}^3_2\text{He}+{}^1_0\text{B} \rightarrow d+{}^{11}_6\text{C}$	+3.1962MeV

A. 4 その他の問題

次の反応の生成物 ${}^4_3\text{H}$ と ${}^4_3\text{Li}$ は "n.o.:not observed" 核種である。



付録 B 反応核種の核特性各種データ

B. 1 反応核種の ΔM 値のデータ

原子核間の反応でのQ値は反応前後における原子核の質量差から求められる。一般には、次のように定義された過剰質量 ΔM 値から計算する。

$$\Delta M = (M - A) \text{ MeV}$$

ここでMは原子核の質量、Aは質量数であり、 $1 \text{ amu} = 931.49433 \text{ MeV}$ として換算したものである。この ΔM 値は主として実測値及び実測値から統計的に評価または予測されて、数値表として古くから公表されている。ここでは1985年にWapstra & Audiが公表した数値データ^(B1)を主に用いる。

本文での計算に必要な1～26の質量数、0～12の原子番号の核種の ΔM 値をTable B.1に示した。なお表中の(s)は安定な元素、核種の右の#は現在「観測されていない n.o. (not observed)」元素を示す。

Wapstra & Audiの文献にない核種の ΔM 値も表に掲載したが、これらは次に示す文献から採用した。

⁵H : Wapstra & Bosの値である^(B2)。Ajzenberg-Seloveはこの核種について $>33.200 \text{ MeV}$ としている^(B3)。

⁵Be : Ajzenberg-Selove^(B3)またはAdelberger^(B4)によれば、 $>33.700 \text{ MeV}$ であるが、ここでは 33.700 MeV とした。最近のshell modelによる評価では 33.47 MeV である^(B5)。

¹⁰He : Ajzenberg-Seloveによる評価値^(B3)である。なお¹⁰Nの値も同じく提案値である。

¹²Li : $>49.000 \text{ MeV}$ であるが、ここでは評価値の 52.920 MeV を用いる^(B6)。

¹³Li : Ajzenberg-Seloveによる予測値^(B7)である。

¹⁴Li : Ajzenberg-Seloveによる評価値^(B7)である。なお¹⁴Fの値も同じく予測値である。

- ¹⁵ L i : Ajzenberg-Seloveによる評価値^(B⁷)である。
- ¹⁵ B e : Ajzenberg-Seloveによる評価値^(B⁷)である。
- ¹⁶ B e : Ajzenberg-Seloveによる評価値^(B⁸)である。
- ¹⁷ B e : Ajzenberg-Seloveによる評価値^(B⁸)である。
- ¹⁸ B e : Ajzenberg-Seloveによる予測値^(B⁹)である。
- ¹⁸ B : Ajzenberg-Seloveによる予測値^(B⁹)である。
- ¹⁹ B : Ajzenberg-Seloveによる予測値^(B⁹)である。
- ²⁰ B : Ajzenberg-Seloveによる予測値^(B⁹)である。

Table B.1 ΔM Value (Unit:MeV)

mass	nuclide	ΔM	nuclide	ΔM	nuclide	ΔM
1	n	8.071369	H(s)	7.289030		
2	D(s)	13.135824				
3	T	14.94991	³ He(s)	14.93132		
4	⁴ H#	25.840	⁴ He(s)	2.42492	⁴ Li#	25.120
5	⁵ H#	33.790	⁵ He	11.390	⁵ Li	11.680
	⁵ Be	33.700				
6	⁶ He	17.5923	⁶ Li(s)	14.0856	⁶ Be	18.374
7	⁷ He	26.110	⁷ Li(s)	14.9068	⁷ Be	15.7687
	⁷ B	27.870				
8	⁸ He	31.598	⁸ Li	20.9454	⁸ Be	4.94173
	⁸ B	22.9203	⁸ C	35.095		
9	⁹ He	40.810	⁹ Li	24.9539	⁹ Be(s)	11.3477
	⁹ B	12.4158	⁹ C	28.9132		
10	¹⁰ He#	49.400	¹⁰ Li	33.830	¹⁰ Be	12.6070
	¹⁰ B(s)	12.05078	¹⁰ C	15.7017	¹⁰ N	39.700
11	¹¹ Li	40.900	¹¹ Be	20.174	¹¹ B(s)	8.6680
	¹¹ C	10.6501	¹¹ N	24.910		
12	¹² Li#	52.920	¹² Be	25.077	¹² B	13.3695
	¹² C(s)	0.	¹² N	17.3381	¹² O	32.060

Table B.1 ΔM Value (Unit:MeV) continue-1

mass	nuclide	ΔM	nuclide	ΔM	nuclide	ΔM
1 3	${}^3\text{Li}\#$	61.560	${}^3\text{Be}\#$	34.950	${}^3\text{B}$	16.5623
	${}^3\text{C(s)}$	3.125025	${}^3\text{N}$	5.34552	${}^3\text{O}$	23.111
1 4	${}^4\text{Li}\#$	72.290	${}^4\text{Be}$	41.020	${}^4\text{B}$	23.664
	${}^4\text{C}$	3.019910	${}^4\text{N(s)}$	2.863436	${}^4\text{O}$	8.00656
	${}^4\text{F}\#$	33.610				
1 5	${}^5\text{Li}\#$	81.600	${}^5\text{Be}\#$	51.180	${}^5\text{B}$	28.970
	${}^5\text{C}$	9.8732	${}^5\text{N(s)}$	0.10150	${}^5\text{O}$	2.8555
	${}^5\text{F}\#$	16.770				
1 6	${}^6\text{Be}\#$	59.220	${}^6\text{B}\#$	37.640	${}^6\text{C}$	13.694
	${}^6\text{N}$	5.6821	${}^6\text{O(s)}$	-4.73703	${}^6\text{F}$	10.680
	${}^6\text{Ne}\#$	23.989				
1 7	${}^7\text{Be}\#$	70.670	${}^7\text{B}$	44.010	${}^7\text{C}$	21.030
	${}^7\text{N}$	7.871	${}^7\text{O(s)}$	-0.8093	${}^7\text{F}$	1.95154
	${}^7\text{Ne}$	16.480				
1 8	${}^8\text{Be}\#$	78.430	${}^8\text{B}\#$	53.850	${}^8\text{C}$	24.890
	${}^8\text{N}$	13.117	${}^8\text{O(s)}$	-0.7822	${}^8\text{F}$	0.8732
	${}^8\text{Ne}$	5.319	${}^8\text{Na}$	25.320		
1 9	${}^9\text{B}\#$	60.100	${}^9\text{C}$	32.760	${}^9\text{N}$	15.873
	${}^9\text{O}$	3.3322	${}^9\text{F(s)}$	-1.48740	${}^9\text{Ne}$	1.7510
	${}^9\text{Na}$	12.929				
2 0	${}^{20}\text{B}\#$	69.080	${}^{20}\text{C}\#$	38.030	${}^{20}\text{N}$	22.100
	${}^{20}\text{O}$	3.7963	${}^{20}\text{F}$	-0.01733	${}^{20}\text{Ne(s)}$	-7.0462
	${}^{20}\text{Na}$	6.841	${}^{20}\text{Mg}$	17.572		

Table B.1 ΔM Value (Unit:MeV) continue-2

mass	nuclide	ΔM	nuclide	ΔM	nuclide	ΔM
2 1	^{21}N	26.050	^{21}O	8.130	^{21}F	-0.048
	$^{21}\text{Ne(s)}$	-5.7354	^{21}Na	-2.1886	^{21}Mg	10.914
2 2	^{22}O	9.440	^{22}F	2.830	$^{22}\text{Ne(s)}$	-8.0266
	^{22}Na	-5.1846	^{22}Mg	-0.3966		
2 3	^{23}O	17.460	^{23}F	3.350	^{23}Ne	-5.1555
	$^{23}\text{Na(s)}$	-9.5314	^{23}Mg	-5.4731		
2 4	^{24}F	8.750	^{24}Ne	-5.950	^{24}Na	-8.4195
	$^{24}\text{Mg(s)}$	-13.9331				
2 5	^{25}F	12.540	^{25}Ne	-2.160	^{25}Na	-9.359
	$^{25}\text{Mg(s)}$	-13.1925				
2 6	^{26}Ne	0.440	^{26}Na	-6.906	$^{26}\text{Mg(s)}$	-16.2140

B.2 反応後の生成不安定核種の変換

本文で検討されている核融合反応で、原子核間の反応が起こった後に生成した核種は全て Table B.1 に示された核種であるが、表中に(s)で示されていない核種は不安定な核種である。不安定核種は崩壊、あるいは break up によって異なった核種に変換する。

原子核の崩壊としては α 、 β^- 、 β^+ 、EC 崩壊があり、それぞれ固有の半減期を持っている。break up では drip line を超えた中性子や陽子の過剰の核種が殆ど瞬間的に中性子や陽子を放出して、異なった核種に変換する。場合によっては同様の反応で次々に中性子や陽子を放出し、更に異なった核種に変換する。

Table B.2 は Table B.1 の不安定核種の変換を示す。表では放出粒子、変換後の核種、半減期、放出粒子のエネルギーを掲載する。備考欄の“数字”は数字の番号の変換を、“n.o.”は「観測されていない(not observed)」、「p.s.”は particle stable を示す。放出粒子のエネルギーの値は主として Ajzenberg-Selove により^(B8)~^(B9)、半減期の値は主として Table of Isotopes^(B10) から採用したが、一部(*印)は E. Browne and R. B. Firestone による^(B11)。

なお表中の(s)は安定な元素を、s は秒、m は分、h は時間、d は日、y は年を示す。

例えば、Table B.2 の no.10 の ${}^7\text{He}$ は 2.9×10^{-21} 秒で break up し、中性子を放出し、no.8 の ${}^6\text{He}$ に変換する。更に no.8 の ${}^6\text{He}$ は半減期 0.8054 秒の β 崩壊によって、安定な ${}^6\text{Li}$ に変換する。

Table B.2 Transmutation (A=3~8)

NO.	nuclide	released particle	transmuted nuclide	half life energy(MeV)		remarks
1	T	β^-	$^3\text{He}(s)$	12.33y	0.01861	
2	^4H	β^-	$^4\text{He}(s)$		20.6	n. o.
		n	^3H		2.82	$\Rightarrow 1$
3	^4Li	β^+	$^4\text{He}(s)$		19.8	n. o.
		p	$^3\text{He}(s)$		2.9	
4	^5H	2 n	^3H		2.7	$\Rightarrow 1$ n. o.
5	^5He	n	$^4\text{He}(s)$		0.89	
6	^5Li	p	$^4\text{He}(s)$		1.97	
7	^6Be	2 p	$^3\text{He}(s)$		4.2	
8	^6He	β^-	$^6\text{Li}(s)$	0.8054s	3.507	
9	^6Be	2 p	$^4\text{He}(s)$	$5.0 \times 10^{-21}\text{s}^*$	1.37 4.288*	
10	^7He	n	^6He	$2.9 \times 10^{-21}\text{s}^*$	0.44 11.203*	$\Rightarrow 8$
11	^7Be	EC	$^7\text{Li}(s)$	53.29d	0.862	
12	^7B	p	^6Be		2.21	$\Rightarrow 9$
		2 p	^5Li		1.61	$\Rightarrow 6$
		3 p	$^4\text{He}(s)$	$3.5 \times 10^{-22}\text{s}^*$	3.58	
13	^8He	β^-	^8Li	0.119s	10.648	$\Rightarrow 14$
14	^8Li	β^-	^8Be	0.836s	16.0037	$\Rightarrow 15$
15	^8Be	α	$^4\text{He}(s)$	$6.7 \times 10^{-17}\text{s}$	0.09178	
16	^8B	β^+	^8Be	0.770s	17.979	$\Rightarrow 15$
17	^8C	2 p	^6Be		2.14	$\Rightarrow 9$
		3 p	^5Li		1.55	$\Rightarrow 6$
		4 p	$^4\text{He}(s)$	$2.0 \times 10^{-21}\text{s}^*$	3.51	

Table B.2 Transmutation (A=9~12) (continued)

NO.	nuclide	released particle	transmuted nuclide	half life energy(MeV)	remarks
18	${}^9\text{He}$	n	${}^8\text{He}$	1.14	$\Rightarrow 13$
19	${}^9\text{Li}$	β^-	${}^9\text{Be}(s)$	0.1783s 13.606	
20	${}^9\text{B}$	p	${}^8\text{Be}$	$8.0 \times 10^{-19}\text{s}^*$ 0.185	$\Rightarrow 15$
		α	${}^5\text{Li}$?	$\Rightarrow 6$
21	${}^9\text{C}$	β^+	${}^9\text{B}$	0.1265s 16.682	$\Rightarrow 20$
22	${}^{10}\text{He}$	n	${}^9\text{He}$	0.52	$\Rightarrow 18\text{n.o.}$
		2 n	${}^8\text{He}$	1.66	$\Rightarrow 13\text{n.o.}$
23	${}^{10}\text{Li}$	n	${}^9\text{Li}$	0.8	$\Rightarrow 19$
24	${}^{10}\text{Be}$	β^-	${}^{10}\text{B}(s)$	$1.6 \times 10^6\text{y}$ 0.5568	
25	${}^{10}\text{C}$	β^+	${}^{10}\text{B}(s)$	19.255s 3.6488	
26	${}^{10}\text{N}$	p	${}^9\text{C}$	3.5	$\Rightarrow 21\text{n.o.}$
27	${}^{11}\text{Li}$	β^-	${}^{11}\text{Be}$	0.0085s 20.76	$\Rightarrow 28$
		n	${}^{10}\text{Li}$	0.158	$\Rightarrow 23$
		2 n	${}^9\text{Li}$	0.96	$\Rightarrow 19$
28	${}^{11}\text{Be}$	β^-	${}^{11}\text{B}(s)$	13.81s 11.508	
29	${}^{11}\text{C}$	β^+	${}^{11}\text{B}(s)$	20.385m 1.982	
30	${}^{11}\text{N}$	p	${}^{10}\text{C}$	2.24	$\Rightarrow 25$
31	${}^{12}\text{Li}$	n	${}^{11}\text{Li}$	3.92	$\Rightarrow 27\text{n.o.}$
		2 n	${}^{10}\text{Li}$	2.96	$\Rightarrow 23\text{n.o.}$
		3 n	${}^9\text{Li}$	3.76	$\Rightarrow 19\text{n.o.}$
32	${}^{12}\text{Be}$	β^-	${}^{12}\text{B}$	0.0244s 11.708	$\Rightarrow 33$
33	${}^{12}\text{B}$	β^-	${}^{12}\text{C}(s)$	0.0202s 13.370	
34	${}^{12}\text{N}$	β^+	${}^{12}\text{C}(s)$	0.0110s 17.338	
35	${}^{12}\text{O}$	p	${}^{11}\text{N}^*$	0.41	$\Rightarrow 30$
		2 p	${}^{10}\text{C}$	1.83	$\Rightarrow 25$

Table B.2 Transmutation (A=13~15) (continued)

NO.	nuclide	released particle	transmuted nuclide	half life	energy(MeV)	remarks
36	^{13}Li	n	^{12}Li		0.6	\Rightarrow 31n. o.
		2 n	^{11}Li		4.5	\Rightarrow 27n. o.
37	^{13}Be	n	^{12}Be		2.32	\Rightarrow 32n. o.
38	^{13}B	β^-	^{13}C (s)	0.01736s	13.437	
39	^{13}N	β^+	^{13}C (s)	0.009961s	2.221	
40	^{13}O	\Rightarrow 39**	^{12}C (s)			**
		β^+	^{13}N	0.0089s	15.816	\Rightarrow 39**
41	^{14}Li	n	^{13}Li		2.66	\Rightarrow 36n. o.
		2 n	^{12}Li		-3.23	\Rightarrow 31n. o.
42	^{14}Be	n	^{13}Be		-2.73	p. s.
		2 n	^{12}Be		-0.41	p. s.
43	^{14}B	β^-	^{14}C	0.0161s	20.64	\Rightarrow 44
44	^{14}C	β^-	^{14}N (s)	5730y	0.1561	
45	^{14}O	β^+	^{14}N (s)	70.599s	5.1448	
46	^{14}F	p	^{13}O		\sim 3	\Rightarrow 40n. o.
47	^{15}Li	n	^{14}Li		1.24	\Rightarrow 41n. o.
		2 n	^{13}Li		3.90	\Rightarrow 36n. o.
48	^{15}Be	n	^{14}Be		2.42	\Rightarrow 42n. o.
		2 n	^{13}Be		0.31	\Rightarrow 37n. o.
49	^{15}B	n	^{14}B		-1.84	p. s.
		2 n	^{13}B		-2.82	p. s.
50	^{15}C	β^-	^{15}N (s)	2.449s	9.772	
51	^{15}O	β^+	^{15}N (s)	122.24s	2.7538	
52	^{15}F	p	^{14}O		2.32	\Rightarrow 45n. o.

** : delayed proton emitter

Table B.2 Transmutation (A=16~18) (continued)

NO.	nuclide	released particle	transmuted nuclide	half life	energy(MeV)	remarks
53	^{16}Be	2 n	^{14}Be		2.4	\Rightarrow 42n. o.
54	^{16}B	n	^{15}B		1.1	\Rightarrow 49n. o.
55	^{16}C	β^-	^{16}N	0.747s	8.011	\Rightarrow 56
56	^{16}N	β^-	$^{16}\text{O}(\text{s})$	7.13s	10.418	
57	^{16}F	p	^{15}O		0.548	\Rightarrow 51
58	^{16}Ne	2 p	^{14}O		2.6	\Rightarrow 45n. o.
59	^{17}Be	n	^{16}Be		3.37	\Rightarrow 53n. o.
		2 n	^{15}Be		3.34	\Rightarrow 48n. o.
60	^{17}B	β^-	^{17}C		β max 23.1	\Rightarrow 61
61	^{17}C	β^-	^{17}N		β max 13.4	\Rightarrow 62
		n	^{16}C		-0.5	p. s.
62	^{17}N	β^-	$^{17}\text{O}(\text{s})$	4.169s	8.682	
63	^{17}F	β^+	$^{17}\text{O}(\text{s})$	64.50s	2.762	
64	^{17}Ne	β^+	^{17}F	0.1080s	14.53	\Rightarrow 63
65	^{18}Be	2 n	^{16}Be		3.02	\Rightarrow 53n. o.
		3 n	^{15}Be		3.01	\Rightarrow 48n. o.
		4 n	^{14}Be		5.42	\Rightarrow 42n. o.
		5 n	^{13}Be		2.88	\Rightarrow 37n. o.
		6 n	^{12}Be		4.99	\Rightarrow 32n. o.
		7 n	^{11}Be		1.75	\Rightarrow 28n. o.
		8 n	^{10}Be		1.25	\Rightarrow 24n. o.
66	^{18}B	n	^{17}B		1.39	\Rightarrow 60n. o.
67	^{18}C	n	^{17}C		-3.76	\Rightarrow 61p. s.
		2 n	^{16}C		-4.46	\Rightarrow 55p. s.
68	^{18}N	β^-	$^{18}\text{O}(\text{s})$	0.63s	β max 9.4	
69	^{18}F	β^+	$^{18}\text{O}(\text{s})$	109.77m	1.6555	
70	^{18}Ne	β^+	^{18}F	1.672s	4.447	\Rightarrow 69
71	^{18}Na	p	^{17}Ne		1.55	\Rightarrow 64n. o.

Table B.2 Transmutation (A=19~21) (continued)

NO.	nuclide	released particle	transmuted nuclide	half life	energy(MeV)	remarks
72	^{19}B	n	^{18}B		-1.8	$\Rightarrow 66$ n. o. p. s.
		2 n	^{17}B		-0.4	$\Rightarrow 60$ n. o. p. s.
73	^{19}C	n	^{18}C		-1.0	$\Rightarrow 67\text{p. s.}$
		2 n	^{17}C		-5.0	$\Rightarrow 61\text{p. s.}$
74	^{19}N	n	^{18}N		-5.5	$\Rightarrow 68\text{p. s.}$
75	^{19}O	β^-	$^{19}\text{F}(\text{s})$	26.91s	4.819	
76	^{19}Ne	β^+	$^{19}\text{F}(\text{s})$	17.22s	3.2383	
77	^{19}Na	p	^{18}Ne		0.320	$\Rightarrow 70$
78	^{20}B	n	^{19}B		0.9	$\Rightarrow 72\text{n. o.}$
79	^{20}C	n	^{19}C		-3.2	$\Rightarrow 70$ n. o. p. s.
		2 n	^{18}C		-4.2	$\Rightarrow 67$ n. o. p. s.
80	^{20}N	n	^{19}N		-1.9	$\Rightarrow 74\text{p. s.}$
81	^{20}O	β^-	^{20}F	13.57s	3.816	$\Rightarrow 80$
82	^{20}F	β^-	$^{20}\text{Ne}(\text{s})$	11.00s	7.0259	
83	^{20}Na	β^+	$^{20}\text{Ne}(\text{s})$	0.446s	13.887	
84	^{20}Mg	p	^{19}Na		-2.65	$\Rightarrow 77\text{p. s.}$
		2 p	^{18}Ne		-2.33	$\Rightarrow 70\text{p. s.}$
85	^{21}N	n	^{20}N		-4.1	$\Rightarrow 80\text{p. s.}$
86	^{21}O	β^-	^{21}F	3.4s*	8.19	$\Rightarrow 87 \dagger$
87	^{21}F	β^-	$^{21}\text{Ne}(\text{s})$	4.32s	5.686	
88	^{21}Na	β^+	$^{21}\text{Ne}(\text{s})$	22.48s	3.5473	
89	^{21}Mg	β^+	^{21}Na	0.121s	13.098	$\Rightarrow 88$

† : According to P.M. Endt et al. ^(B12), this reaction is n.o.

Table B.2 Transmutation (A=22~26)

(continued)

NO.	nuclide	released particle	transmuted nuclide	half life	energy(MeV)	remarks
90	^{22}O	β^-	^{22}F	0.910s*	6.600	$\Rightarrow 91 \dagger$
91	^{22}F	β^-	$^{22}\text{Ne(s)}$	4.23s	10.853	
92	^{22}Na	β^+	$^{22}\text{Ne(s)}$	2.602y	2.8421	
93	^{22}Mg	β^+	^{22}Na	3.857s	4.7899	$\Rightarrow 92$
94	^{23}O	—	—	—	—	p. s.
95	^{23}F	β^-	^{23}Ne	2.23s	8.510	$\Rightarrow 96$
96	^{23}Ne	β^-	$^{23}\text{Na(s)}$	37.24s	4.3745	
97	^{23}Mg	β^+	$^{23}\text{Na(s)}$	11.317s	4.0589	
98	^{24}F	—	—	—	—	p. s.
99	^{24}Ne	β^-	^{24}Na	3.38m	2.468	
100	^{24}Na	β^-	$^{24}\text{Mg(s)}$	15.020h	5.5130	
101	^{25}F	—	—	—	—	p. s.
102	^{25}Ne	β^-	^{25}Na	0.602s	7.200	$\Rightarrow 103$
103	^{25}Na	β^-	$^{25}\text{Mg(s)}$	59.6s	3.833	
104	^{26}Ne	—	—	—	—	p. s.
105	^{26}Na	β^-	$^{26}\text{Mg(s)}$	1.072s	9.325	

† : According to P.M.Endt et al. ^(B12), this reaction is n.o.

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付録 C 核融合反応式を読むための手引

核融合燃料原子核（イオン） ^{11}B 以下の軽い核による核融合反応について

反応生成物とその分岐のQ値、反応しきい値（ E_{th} ）、反応断面積データの出典

の一覧をTable 2~11に掲載した。そこに示した分岐は、主として現在観測で確認されている反応である。Table 2~11より、目的とする核融合反応に関連した全ての分岐についての上記の情報を得る手順を次に説明する。

(1) 目的とする核融合反応の上記の情報を得る

目的とする核融合反応を主反応と定義する。主反応の上記の情報を収録している表の番号とその表を掲載している本文の頁を次頁のTable Cから探す。

例えば、DD核融合反応は次頁のTable Cから、
本文のTable 3で p.20 に掲載されていることが解る。
この反応は次の5分岐を持つ。

branch	Q(MeV)	E_{th} (MeV)
$\gamma + {}^4\text{He}$	23.847	0
$n + {}^3\text{He}$	3.269	0
$p + \text{T}$	4.0327	0
$n + p + \text{D}$	-2.2246	4.4492
$2n + 2p$	-4.449	8.898

Table C Page of Fusion Reaction Tables in the Text

p-induced		D-induced		T-induced		^3He -induced	
pp	p. 11	DD	p. 20	TT	p. 30	τ ^3He	p. 41
pD	p. 11	DT	p. 20	T ^3He	p. 30	τ ^4He	p. 41
pT	p. 11	D ^3He	p. 21	T ^4He	p. 31	τ ^6Li	p. 42
p ^3He	p. 12	D ^4He	p. 21	T ^6Li	p. 32	τ ^7Li	p. 43
p ^4He	p. 12	D ^6Li	p. 22	T ^7Li	p. 33	τ ^9Be	p. 44
p ^6Li	p. 13	D ^7Li	p. 22	T ^9Be	p. 34	τ ^{10}B	p. 46
p ^7Li	p. 13	D ^9Be	p. 23	T ^{10}B	p. 35	τ ^{11}B	p. 48
p ^9Be	p. 14	D ^{10}B	p. 25	T ^{11}B	p. 38		
p ^{10}B	p. 15	D ^{11}B	p. 27				
p ^{11}B	p. 17						
^4He -induced		^6Li -induced		^7Li -induced		^9Be -induced	
α ^4He	p. 52	^6Li ^6Li	p. 64	^7Li ^7Li	p. 79	^9Be ^9Be	p. 94
α ^6Li	p. 53	^6Li ^7Li	p. 66	^7Li ^9Be	p. 81	^9Be ^{10}B	p. 98
α ^7Li	p. 54	^6Li ^9Be	p. 68	^7Li ^{10}B	p. 85	^9Be ^{11}B	p. 103
α ^9Be	p. 55	^6Li ^{10}B	p. 71	^7Li ^{11}B	p. 89		
α ^{10}B	p. 58	^6Li ^{11}B	p. 74				
α ^{11}B	p. 60						
^{10}B -induced		^{11}B -induced					
^{10}B ^{10}B	p. 109	^{11}B ^{11}B	p. 120				
^{10}B ^{11}B	p. 114						

 $\tau = ^3\text{He}$ $\alpha = ^4\text{He}$

前々頁の表から γ 線発生 の分岐を除いて、 $Q > 0$ の $n + {}^3\text{He}$ と $p + \text{T}$ の 2 分岐が核融合反応プラズマ内で生成して、核融合エネルギー源となる。プラズマ内のイオン温度が低い場合は、 $n + p + \text{D}$ と $2n + 2p$ の分岐は問題にならない。

(2) 主反応の反応生成物の発生エネルギー値を求める

次の 2 次反応を評価するために、主反応の反応生成物の発生エネルギー値を知る必要がある。一般には文献で測定値を調査せねばならないが、反応生成物が 2 核種の場合 (2 体問題) には、近似的に次のように計算出来る。

$$\text{ある反応生成物の発生エネルギー値} = \frac{\text{他方の反応生成物の質量数}}{\text{発生反応生成物の質量数の和}} \times Q \text{ 値}$$

例えば、 D D 核融合反応では上の結果から、 $n + {}^3\text{He}$ と $p + \text{T}$ の 2 分岐の n 、 ${}^3\text{He}$ 、 p 、 T はそれぞれ次のようになる。

$$\begin{aligned} n \text{ の発生エネルギー値} &= 3.269 \times (3/4) = 2.452 \text{ MeV} \\ {}^3\text{He} \text{ の発生エネルギー値} &= 3.269 \times (1/4) = 0.817 \text{ MeV} \\ p \text{ の発生エネルギー値} &= 4.0327 \times (3/4) = 3.025 \text{ MeV} \\ \text{T} \text{ の発生エネルギー値} &= 4.0327 \times (3/4) = 1.008 \text{ MeV} \end{aligned}$$

(3) 2 次反応での反応生成物と Q 値及び E th 値等の情報を得る

プラズマ内では、中性子が反応を起こすことは考えられない。中性子以外の主反応の反応生成物と核融合燃料原子核との間の反応 (2 次反応) についての情報を、2 次反応を主反応と読み替えて、(1) と同様の手順によって反応生成物とその分岐の Q 値及び E th 値等の情報を得る。

この際、もし主反応の反応生成物が ${}^7\text{Be}$ 、 ${}^{10}\text{Be}$ 、 ${}^8\text{Li}$ の場合は付録 A の Table A.2 p.131 を参照にする。

例えば、 D D 核融合反応では上の結果から、核融合燃料原子核である D と p 、 T 、 ${}^3\text{He}$ との反応が問題になる。

$p\text{D}$ 反応は、本文の Table 2 で p.11 に掲載されている。

branch	Q(MeV)	Eth(MeV)
$\gamma + {}^3\text{He}$	5.4935	0
$n + p + p$	-2.2246	3.3377

主反応での p の発生エネルギー値は 3.025 MeV であるから、プラズマ内での $D(p, n)2p$ は生起しない。

D T 反応は、本文の Table 3 で p.20 に掲載されている。

branch	Q(MeV)	Eth(MeV)
$\gamma + {}^3\text{He}$	16.696	0
$n + {}^4\text{He}$	17.589	0
$2n + {}^3\text{He}$	-2.9883	4.9839
$n + p + T$	-2.2246	3.7101

主反応での T の発生エネルギー値は 1.008 MeV であるから、上表の後者 2 分岐の反応は起こらないが、 $T(d, n){}^4\text{He}$ は生起する。

$D{}^3\text{He}$ 反応は、本文の Table 3 で p.21 に掲載されている。

branch	Q(MeV)	Eth(MeV)
$\gamma + {}^6\text{Li}$	16.387	0
$p + {}^4\text{He}$	18.353	0
$n + p + {}^3\text{He}$	-2.2246	3.7101
$2p + T$	-1.4608	2.4364
$p + 2D$	-5.4935	9.1621
$n + {}^6\text{Li}\#$	-5.1242	8.5462 n.o.

主反応での ${}^3\text{He}$ の発生エネルギー値は 0.817 MeV であるから、上表の後者 4 分岐の反応は起こらない。

(4) 2次反応より高次の反応は無視する

一般に、主反応の反応生成物の発生率は数%程度であるから、プラズマ内での核融合燃料原子核に対する反応生成物の割合は低い。従って主反応の反応生成物同士及び2次反応の反応生成物と核融合燃料原子核との間の反応は無視出来る。プラズマ内に反応生成物が蓄積することも考えられない。

(5) 放射性反応生成物の問題

表に示された核融合反応で発生する反応生成物核種で、(s)印は安定元素であり、#印は観察されていない(n.o.)核種を示す。反応生成物核種のかなりの部分は放射性核種である。従ってそれらの放射性と時間的変換が問題になる。核融合反応の各分岐に現れている全ての放射性核種の変換形態、放出粒子、半減期、放出粒子のエネルギー値等を付録BのTable B.2 p.140に掲載した。この表を用いることによって、核融合反応で発生する全ての放射性生成核種は安定な元素になるまでの変換過程を辿ることが出来る。これは付録Bのp.139の末尾に例示してある。

(6) γ 線放出反応の問題

殆どの核融合反応は γ 線放出反応の分岐を持っている。この γ 線は高いエネルギーで発生するので、プラズマ内で反応を起こすことはないが、プラズマ容器の構造材を照射して(γ, n)反応を起こすことが考えられる。一般に構造材の(γ, n)反応しきい値は10 MeV以上であるから、 γ 線放出反応の分岐のQ値が10 MeVを超えていなければ問題は無い。10 MeVを超えている場合には、文献を調査して必要な検討を加えることが大切である。

(7) 反応断面積データ

この報告書では、反応断面積データ値そのものは掲載していないが、核融合反応Table 2~11の備考欄に核データ値を収録している文献の引用番号を記載している。具体的な文献名は参考文献の頁p.127を参照のこと。参考文献は反応断面積値 and/or $\langle \sigma v \rangle$ 値が収録され、入手可能である。