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## **Tcalc**

**A tool for calculation of reaction Q-values and threshold energies**

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### **Abstract**

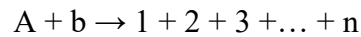
Tcalc calculates reaction Q-values and threshold energies for a given projectile and target with the mass table prepared by the Atomic Mass Data Center (AMDC). The users can additionally specify the combination of the outgoing particles and/or the residual nuclide. The package is available on request from the authors. Its web interface is also available at <http://www.jcprg.org/tcalc/>.

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## 1. Introduction

Tcalc calculates reaction Q-values and threshold energies for a given projectile particle or nuclide and target nuclide. The ejectile particle combination and residual nuclide are optional. Consider the case where a projectile with laboratory energy  $E_b$  and mass  $m_b$  interacts with the target nuclide with mass  $m_A$  at rest to produce particles 1 to n:



Tcalc calculates the reaction Q-values  $Q$  and threshold energies  $E_{b,\text{thr}}$  by

$$Q = (m_A + m_b) - \sum_{i=1}^n m_i$$

$$E_{b,\text{thr}} = \left[ \left( \sum_{i=1}^n m_i \right)^2 - (m_A + m_b)^2 \right] / 2m_A$$

with the light velocity  $c=1$  and the Q-values, threshold energy and masses in keV.

## 2. Input specification

### 2.1. Mass table (mass.mas.txt)

Columns	Description
10-14	Atomic number
15-19	Mass number
21-23	Elemental symbol
29-43	Mass excess

This is the format adopted in AME2020 file (mass\_1.mas20).

Note: If the AME file is renamed to mass.mas.txt and used, the head lines must be commented out by # at the first column of each header line.

### 2.2. Standard input

Lines	Description	Example - $^{27}\text{Al}(n,\alpha)^{24}\text{Na}$
1	Target atomic and mass numbers	2 3
2	Projectile atomic and mass numbers	0 1
3*	Residual nuclide	11 24
4*	Number of outgoing particles: photon (g), neutron (n), proton (p), deuteron (d), triton (t), helion (h), alpha (a)	0 0 0 0 0 0 1

\*One of these lines is optional, but must be filled by zeros (0) if not specified.

Note: Integers on the same line must be separated by one or more space.

### 3. Output specification

Lines	Columns	Description	Example - $^{27}\text{Al}(n,\alpha)^{24}\text{Na}$
1	1-5	Target atomic number	13
	6-10	Target mass number	27
	11-15	Target elemental symbol	Al
	16-30	Target mass (MeV)	25133.143890
	32-34	Target mass unit	MeV
2	1-5	Projectile atomic number	0
	6-10	Projectile mass number	1
	11-15	Projectile elemental symbol	N
	16-30	Projectile mass (MeV)	939.565420
	32-34	Projectile mass unit	MeV
3	1-5	Product atomic number	11
	6-10	Product mass number	24
	11-15	Product elemental symbol	Na
	16-30	Product mass (MeV)	22347.440547
	32-34	Product mass unit	MeV
4	1-5	Number of channels n (0 when there is an error)	6
5	1-40	Error message	
6	1-65	Header line	
7	1-5	Number of outgoing photon in channel 1	0
	6-10	Number of outgoing neutron in channel 1	0
	11-15	Number of outgoing proton in channel 1	0
	16-20	Number of outgoing deuteron in channel 1	0
	21-25	Number of outgoing triton in channel 1	0
	26-30	Number of outgoing helion in channel 1	0
	31-35	Number of outgoing alpha in channel 1	1
8	1-5	Number of outgoing photon in channel 2	0
...	...	...	...
7+n	1-65	Footer line	

## 4. Input/Output Examples

### 4.1. Target= $^{27}\text{Al}$ , Projectile= $\text{n}$ , Product= $^{24}\text{Na}$

Input

13	27							
0	1							
11	24							
0	0	0	0	0	0	0	0	0

Output

13	27	Al	25133.143890	MeV					
0	1	n	939.565420	MeV					
11	24	Na	22347.440547	MeV					
6									
	g	n	p	d	t	h	a	Qval (MeV)	Ethr (MeV)
	0	0	0	0	0	0	1	-3.132561	3.249862
	0	0	1	0	1	0	0	-22.946427	23.814720
	0	1	0	0	0	1	0	-23.710182	24.607736
	0	0	0	2	0	0	0	-26.979091	28.002144
	0	1	1	1	0	0	0	-29.203657	30.312359
	0	2	2	0	0	0	0	-31.428223	32.622771
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### 4.2. Target= $^{27}\text{Al}$ , Projectile= $\text{n}$ , Ejectile= $\alpha$

Input

13	27							
0	1							
0	0							
0	0	0	0	0	0	0	1	

Output

13	27	Al	25133.143890	MeV					
0	1	n	939.565420	MeV					
11	24	Na	22347.440547	MeV					
1									
	g	n	p	d	t	h	a	Qval (MeV)	Ethr (MeV)
	0	0	0	0	0	0	1	-3.132561	3.249862
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