Nuclear Disintegration Energies*†‡

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I. INTRODUCTION

THIS compilation of nuclear reaction energies was undertaken to provide a systematic and comprehensive survey of the present state of our experimental knowledge of the energy released in nuclear reactions. Table I also affords convenient reference to the large number of experimental results scattered throughout the literature. Somewhat similar tables have appeared previously;[1,2] in view of the rapid accumulation of new results, an up-to-date revision is felt to serve a useful purpose.

The Q values for the ground-state transitions are one source of information about the mass differences between the initial and final nuclei involved in the reaction. In the region of the light nuclei where the Q value measurements are sufficiently complete to relate all of the nuclei with $Z \leqq 16$ to O^{16} by successive reactions, it is possible to determine the masses of the light nuclei from Q value measurements alone.[3] For heavier nuclei the measurements are less abundant, and the results from nuclear spectroscopy must be used in conjunction with the information from mass spectroscopy and radio-frequency measurements. For both heavy and light nuclei, the most complete knowledge of nuclear masses will, of course, be achieved by combining the results from all of these different experimental techniques. Unfortunately, there are at present some discrepancies between the mass differences derived from nuclear reaction energies and those measured with the mass spectrograph. A first step toward the quantitative comparison, and eventual synthesis, of the results from the different experimental methods is a separate compilation and examination of the results from each of the different methods. This table was prepared with this end in view. Beta-decay measurements are not included; these have been excluded not because of inconsistency with the measurements of nuclear reaction energies but because the number and complexity of the measurements of beta spectra suggest that they be treated in a separate report.[4]

II. ARRANGEMENT OF THE TABLE

In Column 1 are listed the reactions for which energy measurements have been made. The experimental values are listed in Column 2. An attempt has been made to include all of the measurements that have appeared in journals received in this country up to May, 1954. In a few instances early results have been omitted when they are known to involve considerable experimental error or when several more recent determinations of substantially higher precision have been reported. Some of the experimental values, designated by the superscript "*a*," do not appear explicitly in the reference cited and have been calculated by the present authors from experimental data given in the reference. A frequent example is a Q value calculated from the published reaction threshold energy by multiplying by the factor $M_0/(M_0+M_1)$, where M_0 is the atomic mass of the target nucleus and M_1 is the mass of the bombarding particle.‖ When there is doubt that a reported Q value represents the ground-state transition, it has been enclosed in parentheses. It is quite possible that a few of the remaining Q values do not represent ground-state transitions, particularly in the region of the heavy nuclei where checks from reaction cycles are not available.

Column 3 indicates the method by which the measurement was made. A list of the abbreviations used to designate the experimental methods will be found at the end of Table I.

A great majority of the measurements of nuclear reaction energies are a comparison of the unknown energy with an established energy standard, and many measurements depend on an empirical range-energy relation. The energy standard employed, or reference to the range-energy relation used, is listed in Column 4. If separate energy standards were used for the bombard-

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‡ Reprints of this article combined with others on nuclear constants published at the suggestion of the Subcommittee on Nuclear Science of the National Research Council may be obtained from the Publications Office, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

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[1] D. M. Van Patter, Technical Report No. 57, Massachusetts Institute of Technology Laboratory of Nuclear Science and Engineering (1951).

[2] K. T. Bainbridge, in *Experimental Nuclear Physics*, I, by E. Segré (John Wiley and Sons, Inc., New York, 1953).

[3] Li, Whaling, Fowler, and Lauritsen, Phys. Rev. **83**, 512 (1951); C. W. Li, Phys. Rev. **88**, 1038 (1952).

[4] R. W. King, Revs. Modern Phys. **26**, 327 (1954).

‖ The masses used in these calculations are those given by K. T. Bainbridge in reference (2). If the mass M_0 is not known, the mass number has been used.

ing energy and the energy of the reaction products, both are listed. As the best values of these energy standards change with time, the results which depend on them must of course be altered also. Fortunately, recent changes in the commonly used energy standards have been small compared to other experimental uncertainty present in most measurements, and only a few results have had to be altered to establish conformity with the presently accepted values of the energy standards; any correction applied to such a measurement is explained in a footnote. Some of the (γ,n) threshold energies frequently employed as calibration points for betatron energy (e.g., the $Cu^{63}(\gamma,n)Cu^{62}$ threshold energy) are not yet well established. For these measurements the value assumed for the calibration energy is listed in Column 4, and no attempt has been made to correct such measurements to a common value of the calibration energy standard.

Column 5 gives a reference to the paper in which the measured value appears. When more than one measurement of a given reaction energy has been published by the same author or group of authors, the reference given refers to the latest published value. In the case where a correction has been reported in a later paper by another author, an additional reference with an asterisk has been added; for a subsequent revision of the error assigned to a measurement, the reference is designated with a double asterisk.

When several measurements of the same reaction have been reported by different authors, a weighted average value is listed in Column 6. The following procedure was used in calculating these weighted average values.

All published ± errors are treated as standard deviations. This assumption that all stated errors are of the same significance, regardless of the author's claim, is open to criticism but it appears to be the only practical method of combining results obtained by different methods in many different laboratories. Some authors do not specify how their published error is to be interpreted, and at best the assignment of an estimate of uncertainty to a Q value measurement involves subjective factors that vary from one individual to the next. In calculating the weighted average of several measurements, each measurement is weighted inversely as the square of the stated error. A measurement for which no error is given is necessarily omitted from the average. Range measurements have been omitted from the average if there are precise magnetic or electrostatic deflection measurements of the same reaction available. In addition, a few experimental results, designated by the superscript "c," have been omitted from the average because they appear to be statistically inconsistent with the other measurements of the same Q value. If all of the experimental measurements of a reaction energy appear to be inconsistent with each other, and there is no basis for choosing one of the measurements as most reliable, no average value has been calculated. Inverse and direct reactions have been averaged together, and the same average value, identified by a dagger superscript, has been listed for both reactions.

In assigning an error to the weighted average, both the internal error E_{int} and the external error E_{ext} have been calculated for each reaction:

$$\frac{1}{E_{\text{int}}^2}=\sum_i^n \frac{1}{E_i^2}$$

$$E_{\text{ext}}^2=\frac{\sum_i^n w_i(Q_i-\bar{Q})^2}{(n-1)\sum_i^n w_i};\quad w_i=\frac{1}{E_i^2};$$

where E_i is the error of the i'th measurement. The larger of the two errors, E_{int} or E_{ext}, is taken to be the error of the weighted average value. This method of calculating the error for the weighted average is justified only if the errors E_i are completely random. Although the E_i do contain systematic parts from the uncertainties in the fundamental constants and energy standards, the wide variety of different constants and standards used in the different measurements lends support for the above method of calculation.

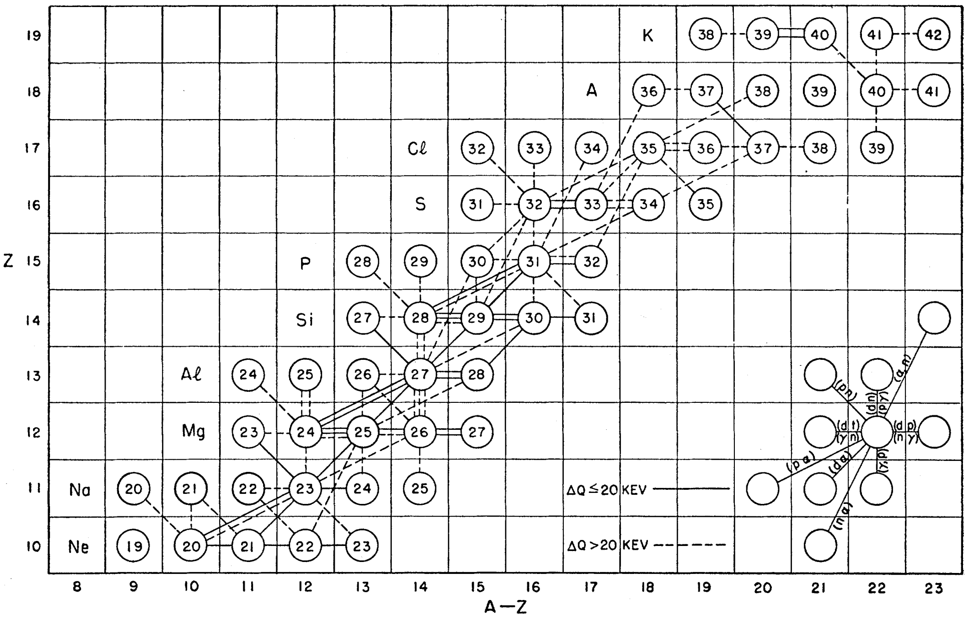
The mass difference between many of the nuclides appearing in Table I can be determined in more than one way, and some care should be taken to select the reaction or set of reactions which will determine the desired mass difference with minimum uncertainty. For example, the binding energy of the last neutron in P^{32} is given as 7.94±0.03 Mev by the $P^{31}(n,\gamma)P^{32}$ reaction energy: This same binding energy can be determined more accurately by adding the $P^{31}(d,p)P^{32}$ reaction energy and the binding energy of the deuteron $H^1(n,\gamma)D^2$,

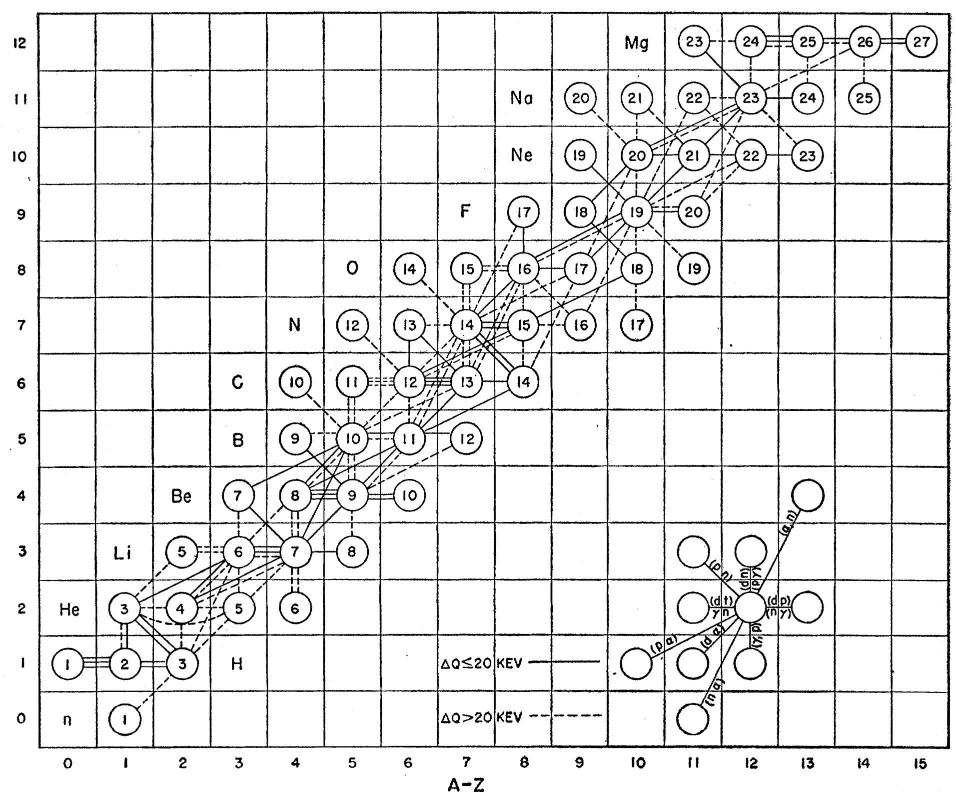
$$P^{31}+D^2=P^{32}+H^1+5.704\pm0.008\text{ Mev}$$

$$H^1+n=D^2+\gamma+2.227\pm0.002\text{ Mev}$$

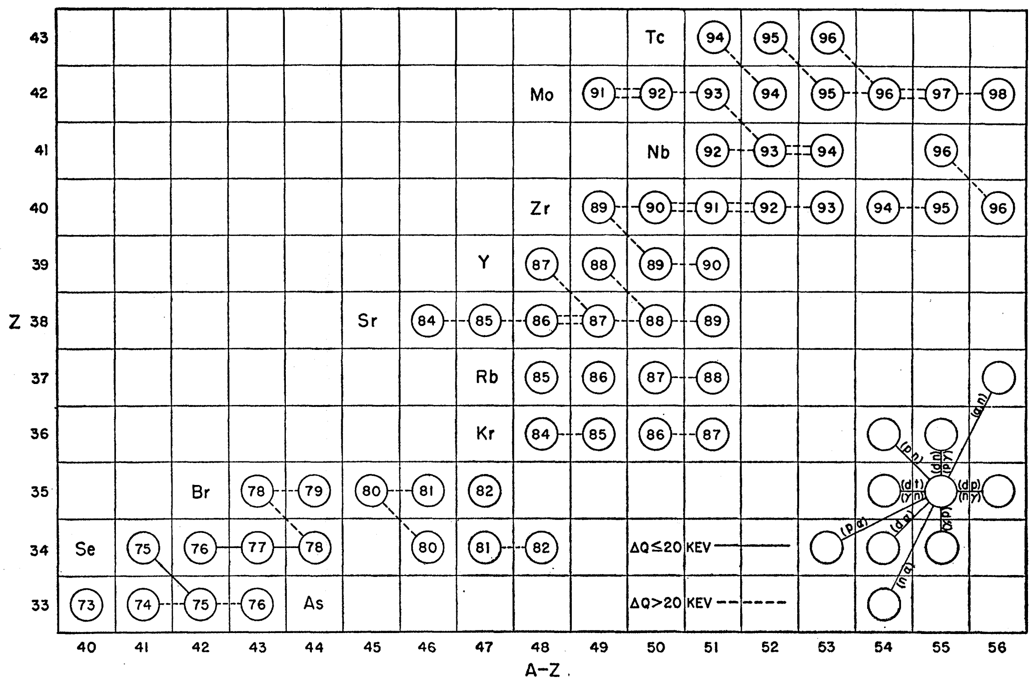
$$\overline{P^{31}+n=P^{32}+\gamma+7.931\pm0.008\text{ Mev}}$$

with an uncertainty of only 0.008 Mev. The charts at the end of Table I provide a convenient means of finding all of the reactions or reaction cycles that can give information about a particular mass difference. On the charts a link connecting two nuclides represents a reaction listed in the table, and the mass difference between any two nuclides which are connected by a link or chain of links can be determined from the information in the table. The more accurately measured reactions, $\Delta Q\leqq 20$ kev, are indicated by solid lines; dotted links indicate measurements with an uncertainty greater than 20 kev. A key in the corner of each figure identifies the type of reaction represented by different connecting links.

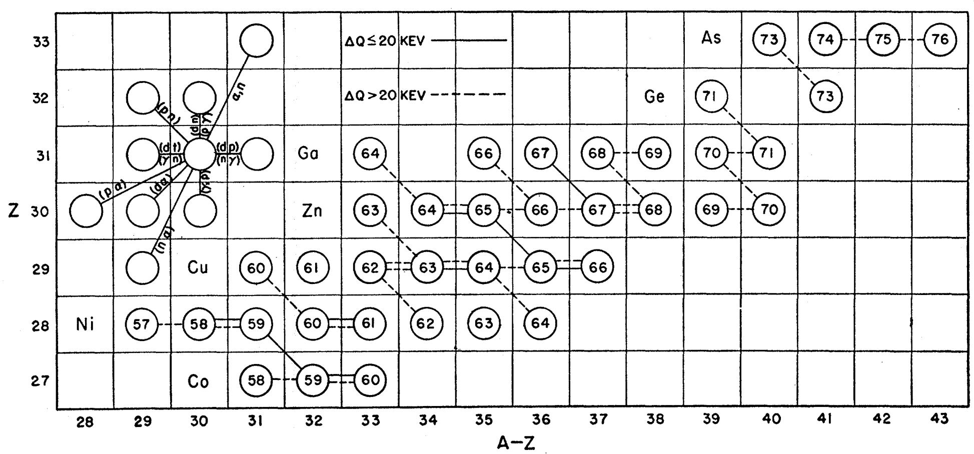




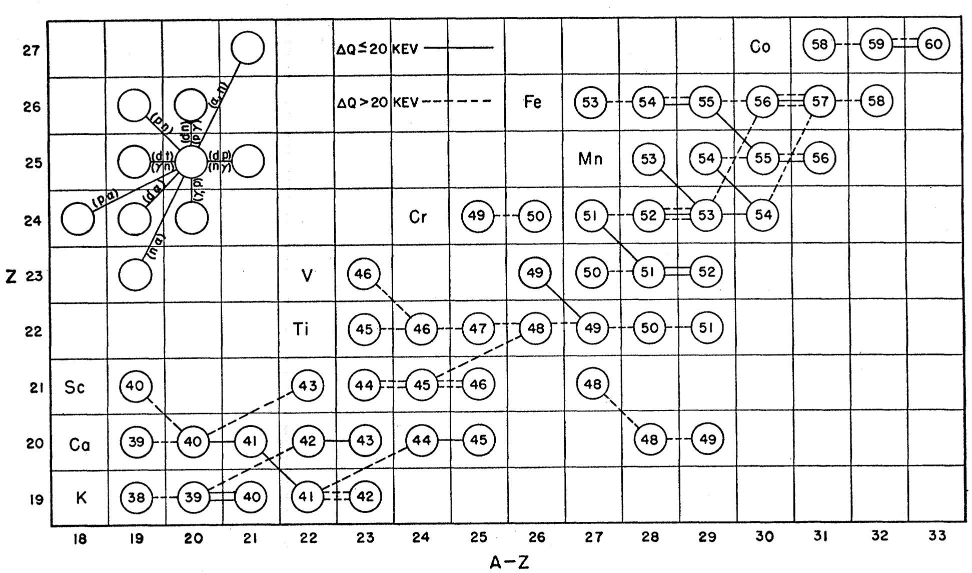
Nuclear reactions listed in the table are represented by links connecting target nucleus and residual nucleus. Q values with an error ≤ 20 kev are represented by solid links; dotted links are used for Q values with an error > 20 kev. The types of reactions represented by the different link configurations are indicated in the legend.



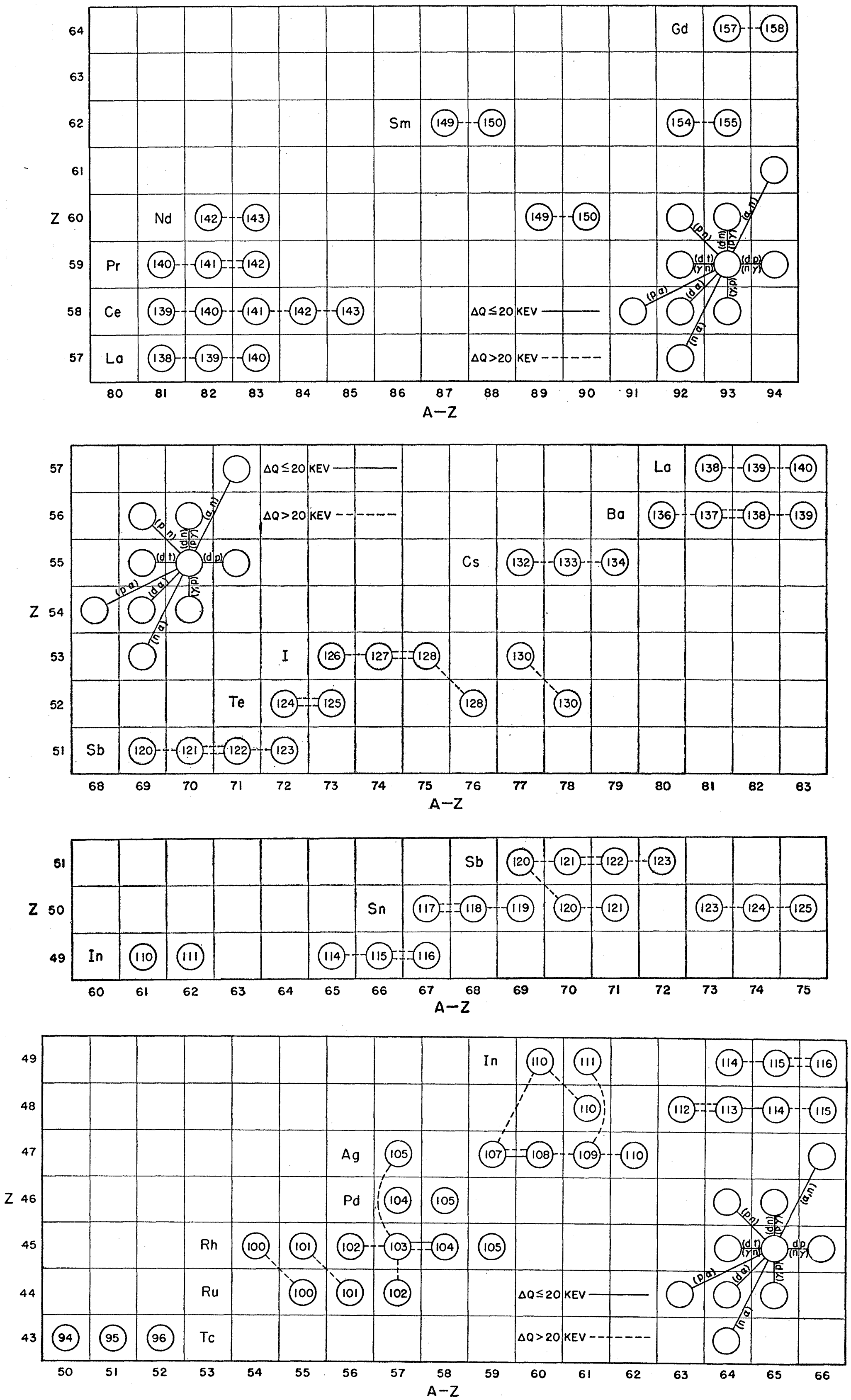
Z
A−Z
Tc
Mo
Nb
Zr
Y
Sr
Rb
Kr
Br
Se
As
ΔQ≤20 KEV
ΔQ>20 KEV
(d n)
(p γ)
(p n)
(d t)
(γ n)
(d p)
(n γ)
(d α)
(p α)
(n α)
(γ p)
(α n)

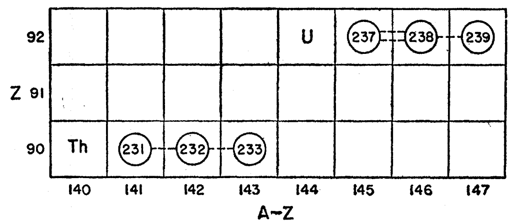


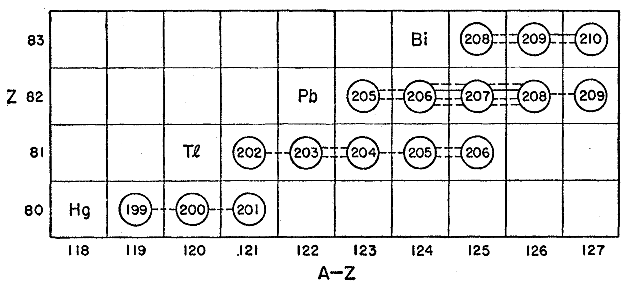
Z
A−Z
As
Ge
Ga
Zn
Cu
Ni
Co
ΔQ≤20 KEV
ΔQ>20 KEV

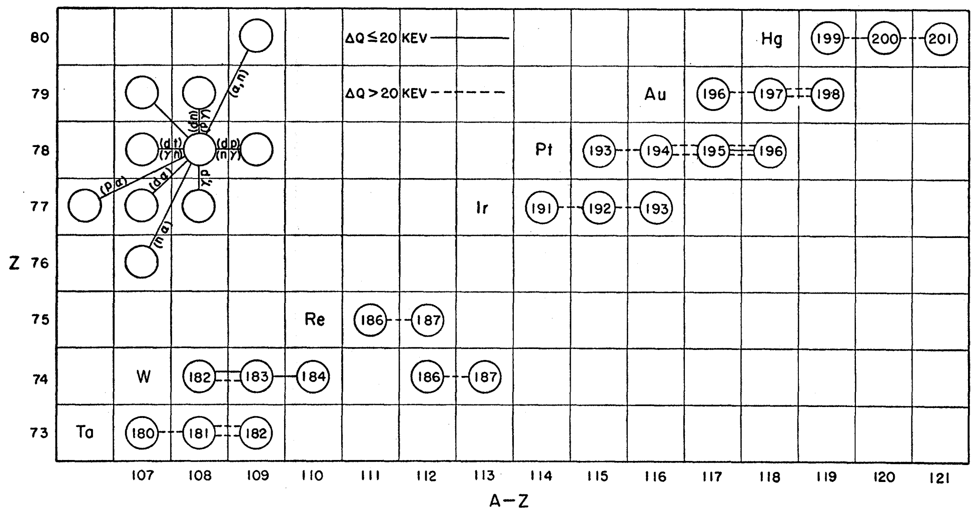


Z
A−Z
Co
Fe
Mn
Cr
V
Ti
Sc
Ca
K
ΔQ≤20 KEV
ΔQ>20 KEV


Z
A−Z
Gd
Sm
Nd
Pr
Ce
La
ΔQ≤20 KEV
ΔQ>20 KEV
Ba
Cs
I
Te
Sb
Sn
In
Ag
Pd
Rh
Ru
Tc
(p n)
(d n)
(p γ)
(α n)
(d t)
(γ n)
(d p)
(n γ)
(p α)
(d α)
(γ p)
(n α)


Z
92
91
90
U
237
238
239
Th
231
232
233
140 141 142 143 144 145 146 147
A−Z


Z
83
82
81
80
Bi
208
209
210
Pb
205
206
207
208
209
Tℓ
202
203
204
205
206
Hg
199
200
201
118 119 120 121 122 123 124 125 126 127
A−Z


Z
80 79 78 77 76 75 74 73
ΔQ≤20 KEV
ΔQ>20 KEV
(α,n)
(d,n)
(p,γ)
(d,t)
(γ,n)
(d,p)
(n,γ)
(p,α)
(d,α)
γ,p
(n,α)
Hg
199
200
201
Au
196
197
198
Pt
193
194
195
196
Ir
191
192
193
Re
186
187
W
182
183
184
186
187
Ta
180
181
182
107 108 109 110 111 112 113 114 115 116 117 118 119 120 121
A−Z

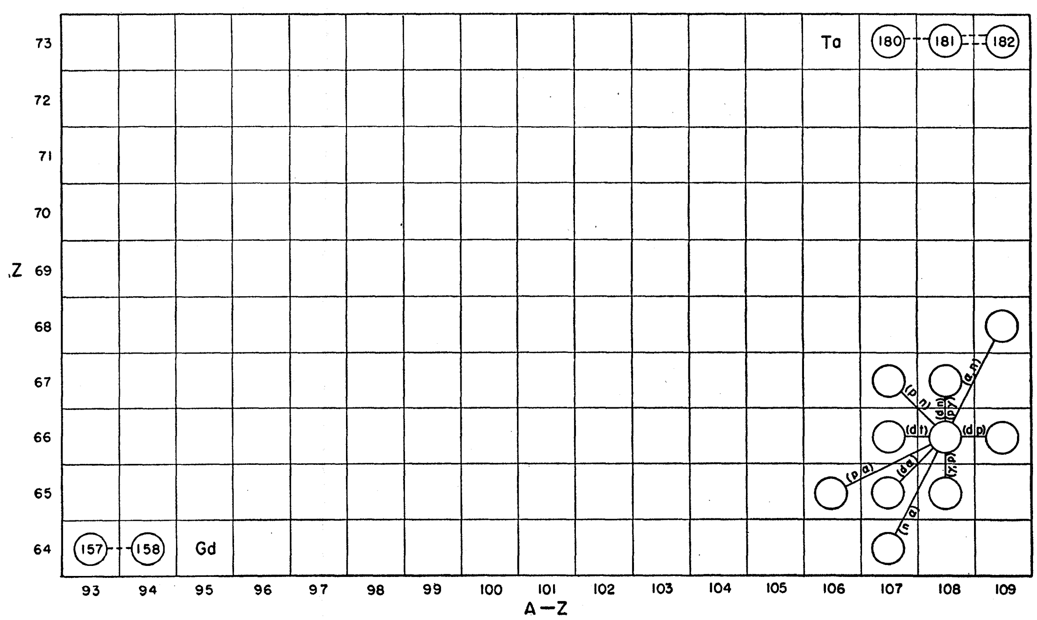

Z
73 72 71 70 69 68 67 66 65 64
Ta
180
181
182
(α,n)
(p,n)
(d,n)
(p,γ)
(d,t)
(d,p)
(p,α)
(d,α)
(γ,p)
(n,α)
157
158
Gd
93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109
A−Z

TABLE I. Nuclear reaction energies.

Reaction	Measured Q-Value (Mev.)	Method	Energy Calibration Standard	Reference	Average Q-Value (Mev.)
$H^1(n,\gamma)D^2$	2.26	abs co	Th C" γ	Fl 36	2.227 ± 0.002†
	2.230 ± 0.005	spec	Th C" γ	Be 50c, El 51b*	
	2.23	scint spec	Na^{24} γ	Ha 53a	
$D^2(\gamma,n)H^1$	-2.221 ± 0.013	pulse ht	$Li^7(p,n)Be^7$, Th C" γ	Ha 49b, Mo 50*	-2.227 ± 0.002†
	-2.226 ± 0.003	thresh	$Li^7(p,n)Be^7$	Mo 50	
	-2.227 ± 0.003	thresh	absolute	No 53	
$D^2(n,\gamma)T^3$	6.25 ± 0.008	pr spec	absolute	Ki 50b	
$D^2(p,n)2H^1$	-2.225 ± 0.010	thresh	$Li^7(p,n)Be^7$	Sm 50, Li 51a*	-2.227 ± 0.002†
$D^2(p,\gamma)He^3$	5.3 ± 0.3[a]	abs Al	$F^{19}(p,\alpha\gamma)O^{16}$	Fo 49	5.50 ± 0.03
	5.50 ± 0.03	scint spec		Gr 53	
$D^2(d,p)T^3$	3.98 ± 0.02	range	Th C'α, Li 37	Ol 35, Li 37*	4.031 ± 0.006
	3.96 ± 0.06	range		Co 36a	
	3.93 ± 0.10	range	Li 37	My 39	
	3.98 ± 0.07	range	α-energies	Ho 40a	
	4.036 ± 0.012	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	To 49, Li 51a**	
	3.96	mag spec	$Be^9(d,\alpha)Li^7$	In 50	
	4.030 ± 0.006	mag spec	Po α	St 51b	
$D^2(d,n)He^3$	3.27 ± 0.03	cl ch	Th C' α, Li 37	Bo 41, Ba 48*	3.265 ± 0.009
	3.30 ± 0.01[c]	el spec	absolute	Ar 48	
	3.23 ± 0.02	ph pl	Po α, Li 37	Li 48	
	3.265 ± 0.009	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	To 49, Li 51a**	
	3.24 ± 0.04	pulse ht	U^{234}, U^{238} α	Bi 52	
	3.25 ± 0.06	ph pl	El 51d, Ro 51c	Dy 53	
$T^3(p,n)He^3$	$-0.763_7 \pm 0.001$	thresh	$Al^{27}(p,\gamma)Si^{28}$, $F^{19}(p,\alpha\gamma)O^{16}$	Ta 49	-0.764 ± 0.001†
	$-0.764_7 \pm 0.001$	thresh	$Li^7(p,n)Be^7$	Bo 51	
$T^3(p,\gamma)He^4$	19.7 ± 0.3	pr spec	absolute	Ro 51b	19.7 ± 0.2
	19.7 ± 0.4	scint spec	$Li^7(p,\gamma)Be^8$	Wa 53 b	
$T^3(d,\alpha)n$	17.578 ± 0.030	el spec	$Li^7(p,n)Be^7$	Wi 51	
	17.7 ± 0.3	ph pl	La 47	Ro 53	
$T^3(He^3,p)He^5$	11.18 ± 0.07	range		Al 53	11.15 ± 0.05
	11.13 ± 0.07[a]	scint spec	$He^3(d,p)He^4$, Sm 47	Mo 53	
$He^3(n,p)T^3$	0.764 ± 0.025	cl ch	Je 49a	Hu 48a, Je 49a	0.764 ± 0.001†
	0.766 ± 0.010	pulse ht	Po α	Fr 50	

[a] This Q value has been calculated specifically for this compilation from the experimental data. In the calculation of Q values from published threshold energies, accurate masses have been used if they are known. Mass numbers have been used if the masses are not known.
[b] This Q value has been corrected for the $Li^7(p,n)Be^7$ threshold at 1.881 Mev.
[c] This Q value has been omitted from the weighted average.
[d] This Q value has been corrected for the $F^{19}(p,\alpha\gamma)$ resonance energy of 873.5 kev.
* This reference contains a later correction to the value originally reported.
** In this reference the quoted error for the Q value has been changed.
† This average value was calculated by including the measured Q value for the inverse reaction.

TABLE I.—*Continued.*

$He^3(d,p)He^4$	18.45 ± 0.17	range	Li 37	Wy 49a	
$He^3(d,\gamma)Li^5$	16.3 ± 0.2	scint spec	$Li^7(p,\gamma)Be^8$	Hi 54	
$He^3(He^3,p)Li^5$	10.86 ± 0.15	range		Al 53	
$He^4(d,p)He^5$	-2.9	ph pl	Po 43	Gu 47	
	-3.2	ph pl	Ro 51c	Bu 51c	
$He^5 \rightarrow He^4 + n$	~1.0	ph pl	Ro 51c	Bu 51c	0.95 ± 0.04
	0.9 ± 0.1	ph pl		Cu 53	
	0.90 ± 0.07	ph pl		Al 53	
	0.95 ± 0.07	scint spec	$D^2(d,p)T^3$, $He^3(d,p)He^4$	Mo 53	
	1.09 ± 0.10	ph pl	$Li^6(n,t)He^4$, $T^3(d,n)He^4$	Fr 54	
$Li^5 \rightarrow He^4 + H^1$	1.6 ± 0.5	ph pl		Ti 51	
$Li^6(\gamma,n)Li^5$	-5.4 ± 0.2	ph pl		Ti 51	-5.37 ± 0.14
	-5.35 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Li^6(n,\alpha)T^3$	4.86 ± 0.04[c]	range	Po α, Pa 37	Li 38	4.797 ± 0.022
	4.97	range	Po α, Ho 38	Ru 38	
	4.66	ph pl	La 47	Ch 49	
	4.69 ± 0.10	ph pl	Po 47a	Na 49	
	4.56, 4.92	range	Be 38, Ho 38	Bo 49	
	4.67 ± 0.21	ph pl	Pu α, La 47	Al 50	
	4.804 ± 0.022	pulse ht	U^{234}, U^{238} α	Fa 51	
$Li^6(n,d)He^5$	-2.57 ± 0.10	ph pl	$Li^6(n,t)He^4$, $T^3(d,n)He^4$	Fr 54	
$Li^6(p,\alpha)He^3$	3.72 ± 0.08	cl ch	Li 37	Ne 35, Li 37*	4.023 ± 0.002
	3.945 ± 0.06	range	$Be^9(p,\alpha)Li^6$	Pe 40	
	3.94 ± 0.08	range	$F^{19}(p,\alpha\gamma)O^{16}$, Po α	Mi 40	
	4.017 ± 0.012	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	To 49a, Li 51a**	
	3.97 ± 0.03[c]	mag spec	$Be^9(p,\alpha)Li^6$, $Be^9(p,d)Be^8$	Bu 50a	
	4.021 ± 0.006	mag spec	Po α	St 51b	
	4.023 ± 0.003	mag spec	absolute	Co 53	
	4.024 ± 0.005	el spec	$Li^7(p,n)Be^7$	Wi 51	
$Li^6(d,\alpha)He^4$	23.0	range	Li 37	Le 33, Li 37*	22.386 ± 0.011
	22.07 ± 0.07	range	Th C'α, Li 37	Ol 35, Li 37*	
	22.20 ± 0.04	range	Th C'α, Li 37	Sm 39	
	22.396 ± 0.012	mag spec	absolute	Co 53	
	22.375 ± 0.014	mag spec	absolute	Ph 53	
$Li^6(d,p)Li^7$	5.02 ± 0.12	range	Li 37	Co 34, Li 37*	5.027 ± 0.003
	5.019 ± 0.007	mag spec	Po α	St 51b	
	5.028 ± 0.003	mag spec	absolute	Co 53	

TABLE I.—*Continued.*

$Li^6(d,n)Be^7$	3.30	ph pl		Ma 49a	3.40 ± 0.05
	3.27	cl ch		Wh 50a	
	3.40 ± 0.05	ph pl	Ro 50	Gi 50	
$Li^6(d,t)Li^5$	0.9 ± 0.1	mag spec		Fr 53	preliminary
$Li^6(d,t)He^4+H^1$	2.51 ± 0.04	mag spec		Fr 53	preliminary
$Li^6(t,d)Li^7$	0.982 ± 0.007	mag spec	$Li^6(p,\alpha)He^3$	Pe 52	0.982 ± 0.007[+]
$Li^6(t,p)Li^8$	0.784 ± 0.015	mag spec	$Li^6(p,\alpha)He^3$	Pe 52	
$Li^6(He^3,p)Be^8$	16.60	scint spec	$D^2(He^3,p)He^4$	Ku 53	
$Li^7(\gamma,p)He^6$	-9.5 ± 0.3	thresh		Be 47	-9.6 ± 0.3
	-9.8 ± 0.5	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
$Li^7(p,\alpha)He^4$	17.1	range	Li 37	Li 33, Li 37*	17.346 ± 0.010
	17.13 ± 0.06	range	Th C'α	Ol 35, Li 37*	
	17.28 ± 0.03	range	Th C'α, Li 37	Sm 39	
	17.340 ± 0.014	mag spec	Po α	St 51b	
	17.338 ± 0.011	mag spec	Th C'α	Wh 51	
	17.352 ± 0.009	mag spec	absolute	Co 53	
	17.344 ± 0.013	mag spec	absolute	Fa 53	
$Li^7(p,n)Be^7$	-1.64 ± 0.02[d]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Ha 40a	$-1.645_3 \pm 0.000_4$
	-1.647 ± 0.005	thresh	absolute	Ha 44	
	$-1.645_7 \pm 0.001_6$	thresh	absolute	He 49	
	$-1.645_0 \pm 0.001_6$	thresh	absolute	Sh 49b	
	-1.65 ± 0.04	ph pl	La 47	Gr 50	
	$-1.645_1 \pm 0.000_6$	thresh	Ra C'α	St 51c	
	$-1.645_4 \pm 0.000_9$	thresh	$Mg^{24}(p,p')Mg^{24*}$, Na^{24} γ	Jo 53	
$Li^7(p,\gamma)Be^8$	17.1[a]	cl ch	absolute	Ga 37	17.1 ± 0.2
	16.7 ± 0.5[a]	cl ch	absolute	De 37	
	17.2 ± 0.2	pr spec	absolute	Wa 48	
$Li^7(d,\alpha)He^5$	14.3	range	Li 37	Wi 37, Li 37*	14.2 ± 0.1
	13.43	ph pl	α-energies	La 47	
	14.2 ± 0.1	range	Th(C + C')α	Fr 51c	
	14.2 ± 0.1	ph pl		Cu 53	
$Li^7(d,\alpha)He^4+n$	14.9 ± 0.3	range	Th C'α	Ol 35, Li 37*	
$Li^7(d,t)Li^6$	-1.00	range	$Al^{27}(d,p)Al^{28}$	Go 51a	-0.982 ± 0.007[+]
$Li^7(d,p)Li^8$	-0.3	thresh		Ba 37, Li 37*	-0.192 ± 0.001
	-0.20 ± 0.03	yield Li^8	$Li^7(p,\gamma)Be^8$	Ru 38	
	-0.187 ± 0.010	angle Li^8 recoil		Pa 50	

TABLE I.—*Continued.*

	−0.188 ± 0.007	mag spec	Po α	St 51b	
	−0.192 ± 0.001	el spec	$Li^7(p,n)Be^7$	Wi 51	
$Li^7(d,n)Be^8$	14.5 ± 0.5	cl ch	Li 37	Bo 35, Li 37*	15.0 ± 0.1
	15.05 ± 0.2	cl ch	Be 38	St 38	
	15.0 ± 0.15	ph pl	La 47	Gr 49a	
$Li^7(d,n)2He^4$	14.6	cl ch	Th C'α, Li 37	Bo 35, Li 37*	
$Li^7(t,\alpha)He^6$	9.79 ± 0.03	mag spec	$Cm^{242}\alpha$	De 52	
$Be^8 \rightarrow 2He^4$	0.101 ± 0.010	pulse ht	$Li^7(p,n)Be^7$, $Be^9(\gamma,n)Be^8$	He 48b, He 49b*	$0.094 \pm 0.001_3$
	0.089 ± 0.005	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	To 49a	
	0.085 ± 0.009	ph pl		Cr 50, Cr 50a	
	$0.094_5 \pm 0.001_4$	el spec	$Li^7(p,n)Be^7$, $B^{11}(p,\alpha)Be^8$	Jo 53a	
$Be^9(\gamma,p)Li^8$	≥ −18. ± 1	thresh		Og 47	−16.93 ± 0.15
	−16.93 ± 0.15	thresh		Tu 52	
$Be^9(\gamma,n)Be^8$	−1.681 ± 0.013	pulse ht	$Li^7(p,n)Be^7$, $Sb^{124}\gamma$	Ha 49b	−1.665 ± 0.002
	−1.666 ± 0.002	thresh	$Li^7(p,n)Be^7$	Mo 50	
	−1.662 ± 0.003	thresh	absolute	No 53	
$Be^9(n,\gamma)Be^{10}$	6.816 ± 0.006	pr spec	absolute	Ki 53b	
$Be^9(p,\alpha)Li^6$	2.115 ± 0.04[c]	el spec	absolute	Al 40	2.126 ± 0.002
	2.074 ± 0.03[c]	el spec	absolute	Ro 48	
	2.121 ± 0.007	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	To 49a, Li 51a**	
	2.142 ± 0.006[c]	mag spec	Po α	St 51b	
	2.130 ± 0.010	el spec	absolute	Ca 51	
	$2.126_5 \pm 0.004$	el spec	$Li^7(p,n)Be^7$	Wi 51, Cr 52*	
	2.126 ± 0.003	mag spec	absolute	Co 53	
$Be^9(p,d)Be^8$	0.547 ± 0.006[c]	el spec	absolute	Al 40	0.559 ± 0.001
	0.541 ± 0.003[c]	el spec	absolute	Ro 48	
	$0.557_7 \pm 0.003$	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	To 49a	
	0.562 ± 0.004	mag spec	Po α	St 51b	
	0.558 ± 0.005	el spec	absolute	Ca 51	
	0.558 ± 0.002	el spec	$Li^7(p,n)Be^7$	Wi 51	
	0.560 ± 0.013	mag spec	$Li^7(p,\gamma)Be^8$	Sa 51	
	0.560 ± 0.003	mag spec	absolute	Co 53	
$Be^9(p,n)B^9$	−1.85 ± 0.01[d]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Ha 40a	−1.852 ± 0.002
	−1.851 ± 0.006	thresh	$Li^7(p,n)Be^7$	Ha 44	
	−1.852 ± 0.002	thresh	$Li^7(p,n)Be^7$	Ri 50	
$Be^9(p,\gamma)B^{10}$	6.5 ± 0.2[a]	abs co	$F^{19}(p,\alpha\gamma)O^{16}$	Fo 48	6.5 ± 0.1
	6.50 ± 0.10[a]	pr spec	absolute	Wa 50b	
	6.48 ± 0.15	pulse ht	$F^{19}(p,\alpha\gamma)O^{16}$, $D^2(\gamma,p)n$	Ca 51a	

TABLE I.—*Continued.*

$Be^9(d,\alpha)Li^7$	7.19 ± 0.12	range	Po α	Ol 35a, Li37*	7.153 ± 0.003
	6.95	pulse ht	Th (C + C')α	Wi 37a	
	7.093 ± 0.022[c]	range	Po α, Ho 38	Gr 40	
	7.150 ± 0.008	mag spec	Po α	St 51b	
	7.151 ± 0.010	mag spec	Th C' α	Wh 51	
	7.159 ± 0.009	el spec	$Li^7(p,n)Be^7$	Wi 51	
	7.153 ± 0.004	mag spec	absolute	Co 53	
$Be^9(d,t)Be^8$	4.32 ± 0.06	pulse ht	Th (C + C') α	Wi 37a	4.598 ± 0.012
	4.597 ± 0.013	mag spec	Po α	St 51b	
	4.61 ± 0.04	mag spec	$Be^9(d,\alpha)Li^7$	Re 51	
	4.67 ± 0.03	ph pl	El 51c	El 51a	
	4.60 ± 0.03	ph pl		Ca 52	
$Be^9(d,p)Be^{10}$	4.59 ± 0.11	range	Po α	Ol 35a, Li 37*	4.588 ± 0.006
	4.52	range		Po 40	
	4.59 ± 0.05	range	Li 37	Al 48	
	4.68	mag spec	$Be^9(d,\alpha)Li^7$	In 50	
	4.585 ± 0.008	mag spec	Po α	St 51b	
	4.591 ± 0.008	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	Kl 51	
	4.55 ± 0.03	ph pl	$Li^7(p,\gamma)Be^8$, Ro 50	Sa 51	
$Be^9(d,n)B^{10}$	4.2 ± 0.2[c]	cl ch	Li 37	Bo 36a, Li37*	4.35 ± 0.02
	4.4	cl ch	$D^2(d,n)He^3$	St 39	
	4.39 ± 0.1	ph pl		Wh 50	
	4.35 ± 0.06	ph pl	Ri 51	Aj 52	
	4.44 ± 0.05[c]	ph pl	La 47	Pr 52	
	4.35 ± 0.02	ph pl	El 51d, Ro51c	Dy 53	
$Be^9(\alpha,d)B^{11}$	−8.01 ± 0.05	range	Th C' α, Be 50d	Mc 51	−8.018 ± 0.007[+]
$Be^9(\alpha,p)B^{12}$	−6.92 ± 0.05	range	Th C' α, Be 50d	Mc 51	
$Be^9(\alpha,n)C^{12}$	6.3	range recoil p	Li 37	Du 34, Li 37*	
	5.8			Be 37	
	5.7	ph pl	La 47	Br 50	
	5.68	ph pl	La 47	Gu 52	
$B^{10}(\gamma,n)B^9$	−8.55 ± 0.25	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$B^{10}(n,\alpha)Li^7$	2.75 ± 0.08	range	Po α, Bl 38	Li 38	2.786 ± 0.008
	2.90	pulse ht	Po α	Ma 39	
	2.8	pulse ht	Th (C + C') α	Wi 41	
	2.82	cl ch	Bl 38	Bo 45	
	2.78 ± 0.07	cl ch	Li 37	Gi 48	
	2.70 ± 0.02[c]	pulse ht	$U^{238}\alpha$	St 49	
	2.788 ± 0.010	pulse ht	Po α	Je 50, El 48	
	2.80 ± 0.05	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	Bu 50	
	2.85 ± 0.10	pulse ht	Po α	Fr 50c	
	2.793 ± 0.027	pulse ht	Pu α	Ha 50a	
	2.775 ± 0.02	pulse ht	U^{234}, $U^{238}\alpha$	Bi 52	
	2.781 ± 0.025	pulse ht	Po α	Ha 52c	

TABLE I.—*Continued.*

$B^{10}(p,\alpha)Be^{7}$	1.148 ± 0.006	mag spec	$Li^{7}(p,n)Be^{7}$, $F^{19}(p,\alpha)O^{16}$*	Ch 49a, Br 51a**	1.148 ± 0.002
	1.152 ± 0.004	mag spec	Po α	Va 50	
	1.147 ± 0.010	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	Bu 50	
	$1.147 \pm 0.002_5$	el spec	$Li^{7}(p,n)Be^{7}$	Cr 52	
$B^{10}(p,He^{3})Be^{8}$	-0.536 ± 0.003	el spec	$Li^{7}(p,n)Be^{7}$	Cr 52	-0.536 ± 0.003
$B^{10}(p,n)C^{10}$	-5.1	thresh		Ba 40	-4.35 ± 0.2
	-4.35 ± 0.2	ph pl		Aj 54a	preliminary
$B^{10}(p,\gamma)C^{11}$	$\geq 8.38 \pm 0.12$[a]	pr spec	absolute	Wa 50b	
$B^{10}(d,\alpha)Be^{8}$	17.76 ± 0.08	range	Li 37	Co 36, Li 37*	17.86 ± 0.04
	17.92 ± 0.15	range	Be 50	Wh 51a	
	17.91 ± 0.06	range	$F^{19}(p,\alpha\gamma)O^{16}$, Li 37	Tr 53a	
	17.87 ± 0.06	mag spec		Cu 53a	
$B^{10}(d,p)B^{11}$	9.14 ± 0.06	range	Li 37	Co 36, Li 37*	9.235 ± 0.011
	9.22 ± 0.20	range	Li 37, Be 38	Po 40b	
	9.18 ± 0.05	range	Li 37, Be 38	Ba 50	
	9.235 ± 0.011	mag spec	Po α	St 51b	
$B^{10}(d,n)C^{11}$	6.08 ± 0.2[c]	cl ch	Li 37	Bo 36a, Li 37*	6.6 ± 0.1
	6.6	ph pl		Sw 49	
	6.59 ± 0.1	ph pl	La 47	Gi 49	
$B^{10}(\alpha,d)C^{12}$	(1.55 ± 0.2)	range	Th (C + C') α, Li 37	Cr 49	
	1.39 ± 0.01	mag spec		Sh 53	
$B^{10}(\alpha,p)C^{13}$	4.16	cl ch		Zl 38	4.08 ± 0.10
	3.86	range		Je 40, Ho 50a*	
	3.85	ph pl	Th (C + C') α	Me 40	
	4.07 ± 0.2	range	Th (C + C') α, Li 37	Cr 49	
	4.08 ± 0.12	range		Pe 50a	
	4.13 ± 0.02[c]	mag spec		Sh 53	
$B^{11}(\gamma,n)B^{10}$	-11.50 ± 0.25	thresh	D^{2}, Li^{7}, $Be^{9}(\gamma,n)$thresholds	Sh 51	
$B^{11}(p,\alpha)Be^{8}$	8.60 ± 0.10	range	Th C'α	Ol 35a, Li 37*	8.585 ± 0.006
	8.567 ± 0.010	mag spec	Po α	St 51b	
	8.574 ± 0.014	mag spec	Po α	Li 51a	
	8.589 ± 0.004	mag spec	absolute	Co 53	
$B^{11}(p,\alpha)2He^{4}$	8.5 ± 0.6	range	Po α	Ol 35a	
	8.7 ± 0.2	cl ch		De 36	
$B^{11}(p,n)C^{11}$	-2.76 ± 0.01[d]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Ha 40a	-2.762 ± 0.003
	-2.762 ± 0.003	thresh	$Li^{7}(p,n)Be^{7}$	Ri 50	

TABLE I.—*Continued.*

$B^{11}(\alpha,p)C^{14}$	0.66 ± 0.30	range		Po 39	0.75 ± 0.01
	0.85 ± 0.2	range	Th (C + C') α, Li 37	Cr 49	
	0.75 ± 0.01	mag spec	Po α	Fr 51b	
	0.85 ± 0.02[c]	mag spec		Sh 53	
$B^{11}(\alpha,n)N^{14}$	0.4 ± 0.25[a]	pulse ht	Po α, Ra A α	Ma 37	0.27 ± 0.06[+]
$C^{12}(\gamma,n)C^{11}$	-19.0 ± 0.4	thresh	absolute	Ba 45	
	≥ -18.7	thresh	$Cu^{65}(\gamma,n)Cu^{64}$	Mc 49	
$C^{12}(n,2n)C^{11}$	≥ - 21	thresh	$Li^{7}(d,n)Be^{8}$	Sh 45	
$C^{12}(n,\gamma)C^{13}$	4.949 ± 0.006	pr spec	absolute	Ki 53 b	4.949 ± 0.006
	4.95 ± 0.05	pulse ht	$N^{14}(n,p)C^{14}$	Wi 50	
$C^{12}(p,d)C^{11}$	≥ -17.1 ± 0.3[a]	thresh	$B^{11}(p,n)C^{11}$	Pa 48	
	(-16.7)[a]	ph pl		Le 50	
$C^{12}(p,n)N^{12}$	-18.5 ± 0.1[a]	thresh	$C^{12}(p,d)C^{11}$, Sm 47	Al 49a	
$B^{11}(d,\alpha)Be^{9}$	8.13 ± 0.12	range	Li 37	Co 36, Li 37*	8.018 ± 0.007[+]
	8.018 ± 0.007	mag spec	Po α	Va 51	
$B^{11}(d,p)B^{12}$	(1.25)	ph pl		Hu 49a	1.137 ± 0.004
	1.136 ± 0.004	mag spec	Po α	Bu 50b	
	1.140 ± 0.008	mag spec	Po α	El 53	
$B^{11}(d,n)C^{12}$	13.4 ± 0.3	cl ch	Li 37	Bo 36a, Li 37*	13.8 ± 0.2
	13.92 ± 0.15	ph pl	La 47	Gi 49	
$C^{12}(d,p)C^{13}$	2.71 ± 0.05	range	Li 37	Co 36a, Li 37*	2.722 ± 0.003
	2.38 ± 0.15	range	Li 37	Hu 41	
	2.6	ph pl	Po 43	Gu 47	
	2.72	range	Pa 37, Li 37	He 49a	
	2.716 ± 0.005	mag spec	Po α	St 51b	
	2.70 ± 0.03	range	$Al^{27}(d,p)Al^{28}$	Ha 51	
	2.732 ± 0.006	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	Kl 51	
	2.722 ± 0.004	mag spec		Ha 51b	
	2.722 ± 0.004	mag spec	absolute	Fa 53	
$C^{12}(d,n)N^{13}$	-0.25 ± 0.03	cl ch	Pa 37	Bo 36a, Bo 38*	-0.281 ± 0.003
	-0.28	thresh	absolute	Co 36a, Li 37*	
	-0.281 ± 0.003	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Bo 49a	
$C^{12}(\alpha,p)N^{15}$	-4.84 ± 0.20	range	Sm 47, Li 37	Bu 51	-4.961 ± 0.003[+]
$C^{13}(p,n)N^{13}$	-3.01 ± 0.03[d]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Ha 40a	-3.003 ± 0.003
	-3.003 ± 0.003	thresh	$Li^{7}(p,n)Be^{7}$	Ri 50	

TABLE I.—*Continued.*

$C^{13}(p,\gamma)N^{14}$	7.6 ± 0.2[a]	cl ch	absolute	La 40	7.62 ± 0.08
	7.62 ± 0.08[a]	pulse ht	$F^{19}(p,\alpha\gamma)O^{16}$, $D^{2}(\gamma,p)n$	Ca 51a	
$C^{13}(d,\alpha)B^{11}$	5.24 ± 0.11	range	Li 37	Co 36a, Li 37*	5.164 ± 0.004
	5.160 ± 0.010	mag spec	Po α	St 51b	
	5.164 ± 0.006	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Po α	Li 51	
	5.166 ± 0.005	mag spec	absolute	Ph 53	
$C^{13}(d,t)C^{12}$	1.310 ± 0.006	mag spec	Po α	St 51b	1.310 ± 0.003
	1.310 ± 0.003	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Po α	Li 51	
$C^{13}(d,p)C^{14}$	6.1	cl ch		Bo 39	5.942 ± 0.004
	6.09 ± 0.2	range	Be 38	Be 41	
	5.82 ± 0.12	range	Li 37	Hu 41	
	5.91 ± 0.03	range	$Be^{9}(d,p)Be^{10}$	Cu 50	
	5.948 ± 0.008	mag spec	Po α	St 51b	
	5.940 ± 0.004	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Po α	Li 51	
$C^{13}(d,n)N^{14}$	5.2 ± 0.4	cl ch	Li 37	Bo 36a, Li 37*	
	5.17 ± 0.05	ph pl		Ma 50e	
$C^{13}(\alpha,n)O^{16}$	2.06 ± 0.16[a]	pulse ht	$D^{2}(\gamma,n)H^{1}$	Jo 51a	
$C^{14}(p,n)N^{14}$	-0.620 ± 0.009	thresh	$Li^{7}(p,n)Be^{7}$	Sh 49	-0.624 ± 0.004[+]
$C^{14}(d,n)N^{15}$	8.16	ph pl		Hu 50b	
$N^{14}(\gamma,n)N^{13}$	-11.1 ± 0.5	thresh	absolute	Ba 45	-10.7 ± 0.2
	-10.65 ± 0.2	thresh	$Cu^{65}(\gamma,n)Cu^{64}$	Mc 49	
	-10.8	thresh		Ho 51	
$N^{14}(n,\alpha)B^{11}$	-0.28	cl ch	$D(d,n)He^{3}$	Bo 36	-0.27 ± 0.06
	-0.43 ± 0.1[c]	pulse ht	Po α	Ba 39	
	-0.26	pulse ht	$Li^{7}(p,n)Be^{7}$	Ba 46	
	-0.50 ± 0.06[c]	pulse ht	Th (C +C') α	Bl 47b	
	-0.24 ± 0.08	pulse ht	U^{234}, U^{238} α	St 48	
	-0.28 ± 0.08	pulse ht		Bo 51a	
$N^{14}(n,p)C^{14}$	0.62	cl ch	Be 38	Bo 36, Li 37*	0.624 ± 0.004
	0.57 ± 0.04[c]	pulse ht	absolute	Hu 40, Hu 48*	
	0.60	cl ch	Li 37	Bo 45	
	0.71	pulse ht	$Li^{7}(p,n)Be^{7}$	Ba 46	
	0.60 ± 0.03	ph pl	Li 37	Cu 47	
	0.63 ± 0.01	pulse ht	Al 47	Hu 48	
	0.616 ± 0.025[a]	cl ch	Je 49a	Hu 48a, Je 49a	
	0.630 ± 0.006	pulse ht	Po α	Fr 50	
	0.610 ± 0.010	pulse ht	Th C α	Me 50	

TABLE I.—*Continued.*

$N^{14}(n,\gamma)N^{15}$	10.832 ± 0.008	pr spec	absolute	Ki 53b	
$N^{14}(p,n)O^{14}$	−6.0 ± 0.5	thresh	absolute	Sh 49a	−6.0 ± 0.2
	−6.03± 0.2	ph pl	Ro 51c	Aj 54	
$N^{14}(p,\gamma)O^{15}$	7.34 ± 0.13[a]	scint spec	Na^{22} γ, $F^{19}(p,\alpha)O^{16}$	Jo 52	
$N^{14}(d,\alpha)C^{12}$	13.40	range	Li 37	La 35a, Li 37*	
	13.40 ± 0.1	range	Li 37	Co 36a, Li 37*	
	13.39 ± 0.08	range	α-energies	Ho 40a	
$N^{14}(d,p)N^{15}$	8.55 ± 0.08	range	Li 37	Co 36a, Li 37*	8.614 ± 0.007
	8.51 ± 0.1	range	α energies	Ho 40a	
	8.65 ± 0.07	range		Da 47	
	8.55	ph pl	Po 43	Gu 47	
	8.61 ± 0.1	range		Wy 49	
	8.615 ± 0.009	mag spec	Po α	Ma 50d, St 51b**	
	8.63 ± 0.03	range	$Al^{27}(d,p)Al^{28}$	Ha 51	
	8.613 ± 0.011	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Th C α	Mi 52	
$N^{14}(d,n)O^{15}$	5.1 ± 0.2	cl ch	Ma 34	St 37	5.12 ± 0.04
	5.15 ± 0.10	ph pl	La 47	Gi 48a	
	5.11 ± 0.04	ph pl	Ri 51	Ma 52	
	5.1	ph pl		Ro 52	
	5.15 ± 0.16	ph pl	El 51c	Ev 53	
$N^{14}(\alpha,p)O^{17}$	−1.26	range		Ha 35	−1.16 ± 0.04
	−1.6 ± 0.2	range		St 35	
	−1.31	range		Po 47	
	−1.16 ± 0.04	ph pl		Ro 51a	
$N^{14}(\alpha,n)F^{17}$	≥ −5.5	thresh		Ha 35, Li 37*	
$N^{15}(p,\alpha)C^{12}$	5.00 ± 0.15	range		Bu 39	4.961 ± 0.003
	5.14[a]	range	α-energies	Ho 40	
	5.2	range		Co 49	
	4.96 ± 0.05	range	Th C α	Fr 50b	
	4.960 ± 0.007	mag spec	Po α	St 51b	
	4.961 ± 0.006	mag spec		Li 51a	
	4.962 ± 0.004	mag spec	absolute	Co 53	
$N^{15}(d,\alpha)C^{13}$	7.54 ± 0.07	range	α-energies	Ho 40a	7.681 ± 0.009
	7.681 ± 0.009	mag spec	Po α	Ma 51	
$N^{15}(d,p)N^{16}$	0.23 ± 0.15	range		Wy 49	
$N^{15}(d,n)O^{16}$	11.3	ph pl		Hu 49	
	10.9 ± 0.5	range recoil p		Wo 50a	

TABLE I.—*Continued.*

$O^{16}(\gamma,\alpha)3He^4$	14.6	ph pl		Go 49	
$O^{16}(\gamma,n)O^{15}$	-16.3 ± 0.4	thresh	absolute	Ba 45	-15.8 ± 0.2
	-15.6 ± 0.2	thresh	(γ,n)thresholds	St 51a	
$O^{16}(n,\alpha)C^{13}$	-2.38 ± 0.16	pulse ht	$D^2(d,n)He^3$, U α	Hu 51	
$O^{16}(n,p)N^{16}$	> -11.7[a]	thresh	$Be^9(d,n)B^{10}$	So 46	
$O^{16}(n,2n)O^{15}$	≥ -17	thresh	$Li^7(d,n)Be^8$	Je 44	
$O^{16}(d,\alpha)N^{14}$	3.13 ± 0.13	range	Li 37	Co 36a, Li 37*	$3.115 \pm 0.002_5$
	3.112 ± 0.006	mag spec	Po α	St 51b	
	3.119 ± 0.005	mag spec	Po α	Li 51a	
	3.09 ± 0.02[c]	ph pl	Ro 51c	Bu 51a	
	$3.113 \pm 0.003_5$	el spec	$Li^7(p,n)Be^7$	Cr 52	
	3.119 ± 0.005	mag spec	absolute	Fa 53	
$O^{16}(d,p)O^{17}$	1.95 ± 0.06	range	Li 37	Co 36a, Li 37*	1.919 ± 0.004
	1.8	ph pl	Po 43	Gu 47	
	1.75	range		Po 47	
	1.9	ph pl		Ne 49a	
	1.90 ± 0.2	range	Pa 37, Li 37	He 49a	
	1.94 ± 0.08	range	Li 37	Sa 50	
	1.917 ± 0.005	mag spec	Po α	St 51b	
	1.918 ± 0.008	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	Kl 51	
	1.928 ± 0.010	ph pl	Ro 51c	Bu 51a	
$O^{16}(d,n)F^{17}$	-1.7	thresh		Ne 35a, Li 37*	-1.630 ± 0.004
	-1.3	angle F^{17}		Ne 35a	
	-1.615 ± 0.010	thresh	Ha 44	He 48	
	-1.51 ± 0.05[c]	ph pl		El 51	
	-1.631 ± 0.003	thresh	$Li^7(p,n)Be^7$	Bo 51	
$O^{16}(\alpha,p)F^{19}$	-8.08 ± 0.10	range	Sm 47, Li 37	Bu 51b	-8.117 ± 0.009[+]
$O^{17}(n,\alpha)C^{14}$	1.6	pulse ht	$N^{14}(n,p)C^{14}$	Ma 47a	
$O^{18}(\gamma,p)N^{17}$	$\geq -16.35 \pm 0.2$	thresh	(γ,n)thresholds	St 51a	
$O^{18}(p,\alpha)N^{15}$	3.96 ± 0.15	range		Bu 39	3.961 ± 0.009
	3.97 ± 0.05	range	Th C α	Fr 50b	
	3.96 ± 0.04	mag spec	$Be^9(d,\alpha)Li^7$, $C^{12}(d,p)C^{13}$	Se 51	
	3.961 ± 0.009	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$, $N^{15}(p,\alpha)C^{12}$	Mi 54	
$O^{18}(p,n)F^{18}$	-2.42 ± 0.04	thresh		Du 38	-2.453 ± 0.004
	-2.4[a]	thresh		Bl 49	
	-2.453 ± 0.004	thresh	$Li^7(p,n)Be^7$	Ri 50	

TABLE I.—*Continued.*

$O^{18}(d,n)F^{19}$	5.7 ± 0.1	ph pl	La 47	Se 53	
$F^{19}(n,\alpha)N^{16}$	−0.73 ± 0.25	pulse ht	Th (C + C') α	Bl 47b	
	−1.2 ± 0.9	thresh	calculated	Je 50a	
$F^{19}(n,p)O^{19}$	−3.9 ± 0.75	thresh	calculated	Je 50a	
$F^{19}(n,\gamma)F^{20}$	6.63 ± 0.03	pr spec	absolute	Ki 51a	
$F^{19}(p,\alpha)O^{16}$	8.15 ± 0.12	range	Li 37	Li 37	8.117 ± 0.009⁺
	7.95	range	$Li^6(p,\alpha)He^3$	Bu 38	
	8.113± 0.030	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$	Ch 50	
	8.06 ± 0.04	mag spec	Th C, $C^{13}(d,\alpha)B^{11}$	Fr 50b	
	8.118± 0.009	mag spec	Po α	St 51b	
$F^{19}(p,n)Ne^{19}$	−3.97 ± 0.25[a]	thresh		Wh 39	−4.039 ± 0.005
	−4.1	thresh	Sm 47	Bl 51	
	−4.039 ± 0.005	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Wi 52	
$F^{19}(d,\alpha)O^{17}$	9.84	range	$Li^6(p,\alpha)He^3$	Bu 38	10.039 ± 0.010
	10.050 ± 0.010	mag spec	Po α	St 51c	
	10.042 ± 0.020	ph pl	Ro 51c	Bu 51a	
	10.028	mag spec	Po α	Wa 52	
$F^{19}(d,p)F^{20}$	4.3	cl ch		Bo 39	4.373 ± 0.007
	4.48 ± 0.04	range	$C^{12}(d,p)C^{13}$, $Be^9(d,p)Be^{10}$	Je 50b	
	4.16 ± 0.08	range		Al 51	
	4.373± 0.007	mag spec	Po α	St 51b	
	4.55	mag spec		Sh 51b	
	4.39 ± 0.05	ph pl	Ro 51c	Bu 51a	
$F^{19}(d,n)Ne^{20}$	10.80 ± 0.20	cl ch	Ho 38	Bo 40	
$F^{19}(\alpha,p)Ne^{22}$	1.58	range	Li 37	Ch 32, Li 37*	
	1.4 ± 0.2	range	Du 34b	Ma 36	
	1.57	ph pl	Po α, La 47	Hj 52	
$F^{19}(\alpha,n)Na^{22}$	(−2.3)	cl ch	Bl 32	Bo 34, Li 37*	
$Ne^{20}(n,\alpha)O^{17}$	−0.7	cl ch		Ja 35	−0.75 ± 0.05
	−0.80 to −0.85	pulse ht	$D^2(d,n)He^3$	Gr 46, Jo 51*	
	−0.75 ± 0.05	pulse ht	Po α	Jo 51	
$Ne^{20}(d,\alpha)F^{18}$	2.78 ± 0.02	ph pl	Ro 51c	Mi 51a	2.791 ± 0.009
	2.791± 0.009	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$, $O^{16}(d,p)O^{17}$	Mi 54a	
$Ne^{20}(d,n)Na^{21}$	(−0.17 ± 0.05)	ph pl		Sw 52	

TABLE I.—*Continued.*

$Ne^{20}(p,n)Na^{20}$	-16.1[a]	thresh	$C^{12}(p,n)N^{12}$	Al 50c	
$Ne^{20}(d,p)Ne^{21}$	4.48 ± 0.10	range		El 47	4.528 ± 0.006
	4.50 ± 0.09	range		Zu 50	
	4.54	ph pl		Am 50	
	4.54 ± 0.04	ph pl	Ro 51c	Mi 51a	
	4.529 ± 0.007	mag spec	Po α	Va 52	
	4.526 ± 0.009	mag spec	$F^{19}(p,\alpha\gamma)O^{16}$, $Be^9(d,p)Be^{10}$	Ah 54	
$Ne^{20}(\alpha,p)Na^{23}$	-2.54 ± 0.20	range	Li 37	Po 37, Li 37*	-2.378 ± 0.003
$Ne^{21}(d,\alpha)F^{19}$	6.432 ± 0.010	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Th C α	Mi 52	
$Ne^{21}(d,p)Ne^{22}$	8.34	ph pl		Am 50	8.137 ± 0.011
	8.137 ± 0.011	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Th C α	Mi 52	
$Ne^{22}(d,\alpha)F^{20}$	2.62 ± 0.10	ph pl	Ro 51c	Mi 51a	
$Ne^{22}(d,p)Ne^{23}$	2.89 ± 0.11	range		El 47	2.964 ± 0.007
	2.88 ± 0.06	range		Zu 50	
	2.96	ph pl		Am 50	
	2.964 ± 0.007	mag spec	Po α	Va 52	
$Ne^{22}(\alpha,n)Mg^{25}$	-0.916 ± 0.07	ph pl		Ol 51	
$Na^{23}(\gamma,n)Na^{22}$	-12.05 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Na^{23}(n,\alpha)F^{20}$	-5.4 ± 0.3	thresh	calculated	Je 50a	
$Na^{23}(n,p)Ne^{23}$	-3.6 ± 0.8	thresh	calculated	Je 50a	
$Na^{23}(p,\alpha)Ne^{20}$	2.37 ± 0.045	range	$F^{19}(p,\alpha)O^{16}$*, Hu 38	Fr 48, Fr 50b*	2.378 ± 0.003*
	2.34 ± 0.04	mag spec	$Be^9(p,\alpha)Li^6$, $Li^6(p,\alpha)He^3$	Fr 50b	
	2.372 ± 0.008	mag spec	Po α	Va 52	
	2.379 ± 0.003	el spec	$Li^7(p,n)Be^7$	Do 53	
$Na^{23}(p,n)Mg^{23}$	-4.58 ± 0.3	thresh		Wh 39	-4.88 ± 0.01
	-5.0	thresh	Sm 47	Bl 51	
	-4.88 ± 0.01	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Wi 52a	
$Na^{23}(d,\alpha)Ne^{21}$	6.85 ± 0.1	range	Li 37	La 35, Li 37*	6.902 ± 0.010
	6.75 ± 0.1	range	$C^{13}(d,\alpha)B^{11}$	Mu 39	
	6.902 ± 0.010	mag spec	Po α	St 51b	
	6.84 ± 0.05	range	α-energies, Be 50	Fr 51	

TABLE I.—*Continued.*

$Na^{23}(d,p)Na^{24}$	4.92 ± 0.30	range	Li 37	La 35, Li 37*	4.727 ± 0.005
	4.76	range	$D^2(d,p)T^3$, $Li^6(d,p)Li^7$	Mu 39	
	4.69 to 4.81	range		Wh 50b	
	4.731 ± 0.007	mag spec	Po α	St 51b, Sp 52**	
	4.723 ± 0.008	mag spec	$Al^{27}(p,\gamma)Si^{28}$, Th C α	Mi 52	
$Na^{23}(d,n)Mg^{24}$	9.23	ph pl	Po 47a	Ma 49	
$Na^{23}(\alpha,p)Mg^{26}$	1.91	range		Ko 34, Li 37*	
	1.64	ph pl	Th (C + C') α	Me 40	
	1.44	range	Th C' α	Mo 48	
	1.55	ph pl	Po α, La 47	Hj 52	
$Mg^{24}(\gamma,n)Mg^{23}$	−16.4 ± 0.3	thresh		Be 47	−16.4 ± 0.2
	−16.2 ± 0.3	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
	−16.55± 0.25	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Mg^{24}(n,\gamma)Mg^{25}$	7.334 ± 0.007	pr spec	absolute	Ki 51a, Ki 53e*	7.334 ± 0.007⁺
$Mg^{24}(p,n)Al^{24}$	−14.8 ± 0.3	thresh		Bi 52a	
$Mg^{24}(p,\gamma)Al^{25}$	2.14 ± 0.1[a]	scint spec	$F^{19}(p,\alpha\gamma)O^{16}$, Na^{22} γ	Ca 53a	
$Mg^{24}(d,p)Mg^{25}$	5.03 ± 0.05	range	Li 37	Al 48	5.097 ± 0.007
	5.097± 0.007	mag spec	Po α	St 51b, Va 52*	
	4.99 ± 0.10	ph pl		Am 52	
$Mg^{24}(d,n)Al^{25}$	0.07 ± 0.06	ph pl	$O^{16}(d,n)F^{17}$, Ro 51c	Go 53	
$Mg^{24}(\alpha,p)Al^{27}$	−1.82	range	Li 37	Du 34a, Li 37*	−1.595 ± 0.002⁺
	−1.613 ± 0.010	mag spec		Ka 52	
$Mg^{25}(\gamma,p)Na^{24}$	−11.5 ± 1.0	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
$Mg^{25}(\gamma,n)Mg^{24}$	−7.25 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	−7.334 ± 0.007⁺
$Mg^{25}(d,\alpha)Na^{23}$	7.2	range	Li 37	Le 33, Li 37*	7.019 ± 0.013
	7.019 ± 0.013	mag spec	Po α	Va 52	
$Mg^{25}(d,p)Mg^{26}$	8.880 ± 0.012	mag spec	Po α	Va 52	8.880 ± 0.010
	8.86 ± 0.10	ph pl		Am 52	
$Mg^{25}(d,n)Al^{26}$	5.58 ± 0.10	ph pl		Sw 50	
$Mg^{25}(\alpha,p)Al^{28}$	−1.05	range	Li 37	Du 34a, Li 37*	

TABLE I.—*Continued.*

$Mg^{26}(\gamma,n)Mg^{25}$	-11.15 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Mg^{26}(\gamma,p)Na^{25}$	-14.0 ± 1.0	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
$Mg^{26}(n,\gamma)Mg^{27}$	6.440 ± 0.008	pr spec	absolute	Ki 53e	
$Mg^{26}(p,n)Al^{26}$	(-5.1)	thresh	Sm 47	Bl 51	
$Mg^{26}(p,\gamma)Al^{27}$	8.3 ± 0.4[a]	scint spec	$F^{19}(p,\alpha\gamma)O^{16}$, Na^{22} γ	Ca 53	8.4 ± 0.3[+]
$Mg^{26}(d,p)Mg^{27}$	4.21 ± 0.10	range		Al 49b	4.207 ± 0.006
	4.207± 0.006	mag spec	Po α	Va 52	
	4.16 ± 0.10	ph pl		Am 52	
$Mg^{26}(d,n)Al^{27}$	5.68 ± 0.05	ph pl		Sw 50	
$Al^{27}(\gamma,p)Mg^{26}$	-8.6 ± 0.5	ph pl	La 47	Di 50	-8.4 ± 0.3[+]
$Al^{27}(\gamma,n)Al^{26}$	-14.4 ± 0.3	thresh		Be 47	
	-14.0 ± 0.1	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
	-12.75± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Al^{27}(n,\gamma)Al^{28}$	7.724 ± 0.006	pr spec	absolute	Ki 53b	
$Al^{27}(p,\alpha)Mg^{24}$	1.57 ± 0.03	range	$F^{19}(p,\alpha)O^{16}$, Ho 38	Fr 48, Fr 50b*	1.595 ± 0.002[+]
	1.585 ± 0.015	mag spec	$Be^9(p,\alpha)Li^6$, $Li^6(p,\alpha)He^3$	Fr 50b	
	1.595 ± 0.007	mag spec	Po α	Va 52	
	1.594 ± 0.002	el spec	$Li^7(p,n)Be^7$	Do 53	
	1.61 ± 0.02	mag spec	$F^{19}(p,\alpha)O^{16}$*	Ru 53	
$Al^{27}(p,n)Si^{27}$	-5.8 ± 0.1	thresh		Mc 40	-5.610 ± 0.010
	-5.4	ph pl	La 47	Gu 51	
	-5.71	thresh	Sm 47	Bl 51	
	-5.610 ± 0.10	thresh	$F^{19}(p,\alpha\gamma)O^{16}$	Ki 53d	
$Al^{27}(p,\gamma)Si^{28}$	11.51 ± 0.20	pr spec	$Li^7(p,\gamma)Be^8$, $F^{19}(p,\alpha\gamma)O^{16}$	Ru 51a	11.60 ± 0.09
	11.63 ± 0.10	scint spec	$B^{11}(p,\gamma)C^{12}$, $C^{13}(p,\gamma)N^{14}$	Ru 54	
$Al^{27}(d,\alpha)Mg^{25}$	6.46 ± 0.14	range	Li 37	Mc 35, Li 37*	6.694 ± 0.010
	6.52 ± 0.06	range	Li 37	Po 49	
	6.58 ± 0.03	range	Th C' α, Li 37	Sc 50	
	6.62 ± 0.05	range	$C^{13}(d,\alpha)B^{11}$, Ho 38	Fr 50a	
	6.694 ± 0.010	mag spec	Po α	En 51	

TABLE I.—*Continued.*

$Al^{27}(d,p)Al^{28}$	5.79 ± 0.3	range	Li 37	Mc 35, Li 37*	5.494 ± 0.010
	5.46 ± 0.06	range	Li 37	Al 48	
	5.45 ± 0.05	range	Li 37	Po 49	
	5.47 ± 0.15	ph pl		Ne 49	
	5.72	range		Wh 50b	
	5.494 ± 0.010	mag spec	Po α	En 51	
	5.53 ± 0.2	mag spec	Po α	Ke 51	
$Al^{27}(d,n)Si^{28}$	9.08 ± 0.20	ph pl	$B^{10}(d,p)B^{11}$, Li 37	Pe 49	
$Al^{27}(\alpha,p)Si^{30}$	2.3	range	Bl 32	Ch 32	2.27 ± 0.05
	2.3	range	Bl 32	Ha 33	
	2.26	range	Li 37	Du 34a, Li 37*	
	2.25	ph pl	Th (C +C') α	Me 40	
	2.22	range		Be 48	
	2.38 ± 0.2	range		La 50b	
	2.30	ph pl	Po α, La 47	Sl 51, Sl 52	
	2.26 ± 0.05	ph pl		Ro 51d	
$Al^{27}(\alpha,n)P^{30}$	-2.8[a]	thresh		Sa 35	-2.9 ± 0.2
	-3.0[a]	thresh		Wa 36	
	-3.2[a]	thresh		Po 38	
	-3.4[a]	thresh		Fu 38	
	-2.93 ± 0.17	ph pl	Pe 47a	Pe 48	
$Si^{28}(\gamma,n)Si^{27}$	-16.9 ± 0.3	thresh		Be 47	-16.9 ± 0.2
	-16.8 ± 0.4	thresh	$Be^{9}(\gamma,n)Be^{8}$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
	-16.9 ± 0.2	thresh	absolute	Su 53	
$Si^{28}(n,\gamma)Si^{29}$	8.468 ± 0.008	pr spec	absolute	Ki 53b	8.468 ± 0.008⁺
$Si^{28}(p,n)P^{28}$	-15.1 ± 0.5	thresh	$Mg^{24}(p,n)Al^{24}$	Gl 53	-14.9 ± 0.4
	-14.8 ± 0.5	thresh	$Mg^{24}(p,n)Al^{24}$	Br 54a	
$Si^{28}(d,p)Si^{29}$	6.16 ± 0.06	range	Li 37	Al 48	6.246 ± 0.010
	6.12 ± 0.15	ph pl		Ne 49	
	6.18 ± 0.09	range		Mo 50a	
	6.246 ± 0.010	mag spec	Po α	En 51a	
$Si^{28}(d,n)P^{29}$	(-0.80 ± 0.10)	ph pl	Pe 47a	Pe 48	
	0.29 ± 0.04	ph pl	Ri 51	Ma 52	
$Si^{28}(\alpha,p)P^{31}$	-2.23	range	Li 37	Ha 35a, Li 37*	-1.909 ± 0.010⁺
$Si^{29}(\gamma,n)Si^{28}$	-8.45 ± 0.20	thresh	D^{2}, Li^{7}, $Be^{9}(\gamma,n)$thresholds	Sh 51	-8.468 ± 0.008⁺
$Si^{29}(n,\gamma)Si^{30}$	10.601 ± 0.011	pr spec	absolute	Ki 53b	

TABLE I.—*Continued.*

$Si^{29}(d,\alpha)Al^{27}$	5.994 ± 0.011	mag spec	Po α	Va 51a, Va 52*	
$Si^{29}(d,p)Si^{30}$	8.36 ± 0.10	range		Mo 50a	8.388 ± 0.013
	8.388 ± 0.013	mag spec	Po α	Va 51a, Va 52*	
$Si^{29}(d,n)P^{30}$	(3.38 ± 0.17)	ph pl	Pe 47a	Pe 48	3.27 ± 0.04
	3.27 ± 0.04	ph pl	Ri 51	Ma 52	
$Si^{30}(d,\alpha)Al^{28}$	3.120 ± 0.010	mag spec	Po α	St 51b	
$Si^{30}(d,p)Si^{31}$	4.33 ± 0.15	range		Mo 50a	4.364 ± 0.007
	4.364 ± 0.007	mag spec	Po α	St 51b, Va 52**	
$Si^{30}(d,n)P^{31}$	(4.56 ± 0.13)	ph pl	Pe 47a	Pe 48	
	4.92 ± 0.04	ph pl	Ri 51	Ma 52	
$P^{31}(\gamma,n)P^{30}$	-12.35 ± 0.2	thresh	$Be^{9}(\gamma,n)Be^{8}$, $C^{12}(\gamma,n)C^{11}$	Mc 49	-12.27 ± 0.12
	-12.4 ± 0.2	thresh	$C^{12}(\gamma,n)C^{11}$, $Cu^{65}(\gamma,n)Cu^{64}$	Ka 51a	
	-12.05 ± 0.20	thresh	D^{2}, Li^{7}, $Be^{9}($,n)thresholds	Sh 51	
$P^{31}(n,p)Si^{31}$	-0.94 ± 0.13	pulse ht	$U^{234}\alpha$	Me 48	
$P^{31}(n,\gamma)P^{32}$	7.94 ± 0.03	pr spec	absolute	Ki 52	
$P^{31}(p,\alpha)Si^{28}$	1.85 ± 0.02	mag spec	$F^{19}(p,\alpha)O^{16*}$	Fr 51a	1.909 ± 0.010^{+}
	1.909 ± 0.010	mag spec	Po α	Va 52	
$P^{31}(d,\alpha)Si^{29}$	8.158 ± 0.011	mag spec	Po α	En 51a, Va 52*	
$P^{31}(d,p)P^{32}$	5.9 ± 0.3	range		Po 40a	5.704 ± 0.009
	5.52 ± 0.10	range		Al 51	
	5.704± 0.008	mag spec	Po α	St 51b, Va 52**	
$P^{31}(d,n)S^{32}$	6.81 ± 0.08	ph pl		El 52	
	6.2 ± 0.2	ph pl		Sn 52, Sn 52a*	
$P^{31}(\alpha,p)S^{34}$	0.31	compiled	Li 37	Li 37	
	(1.3)	ph pl	Th (C +C') α	Me 40	
$P^{31}(\alpha,n)Cl^{34}$	-5.6[a]	thresh		Br 38	
$S^{32}(\gamma,d)P^{30}$	-19.15 ± 0.20	thresh	$C^{12}(\gamma,n)C^{11}$, $Cu^{65}(\gamma,n)Cu^{64}$	Ka 51a	

TABLE I.—*Continued.*

$S^{32}(\gamma,n)S^{31}$	-15.0 ± 0.3	thresh		Be 47	-15.0 ± 0.1
	-14.8 ± 0.4	thresh	$Be^{9}(\gamma,n)Be^{8}$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
	-15.0 ± 0.1	thresh		Ha 52	
$S^{32}(n,\alpha)Si^{29}$	1.16 ± 0.15	pulse ht	$U^{238}\alpha$	St 48	
$S^{32}(n,p)P^{32}$	-0.93 ± 0.10	pulse ht	absolute	Hu 41a	
$S^{32}(n,\gamma)S^{33}$	8.64 ± 0.02	pr spec	absolute	Ki 50a, Ki 52*	
$S^{32}(p,n)Cl^{32}$	-13.9 ± 0.5	thresh	$Mg^{24}(p,n)Al^{24}$	Gl 53	-14.0 ± 0.4
	-14.1 ± 0.6	thresh	$Mg^{24}(p,n)Al^{24}$	Br 54a	
$S^{32}(d,p)S^{33}$	6.62	range		Sm 41	6.422 ± 0.011
	6.48 ± 0.11	range	Li 37	Da 49	
	6.422 ± 0.011	mag spec	Po α	St 51b	
$S^{32}(d,n)Cl^{33}$	0.25	ph pl	El 51c	Mi 53	
$S^{32}(\alpha,p)Cl^{35}$	-2.10 ± 0.20	compiled	Li 37	Ha 35a, Br 36, Li 37*	2.04 ± 0.10
	-2.02 ± 0.11	ph pl	Th C'α	Fo 52	
$S^{33}(d,p)S^{34}$	8.67 ± 0.25	range	Li 37	Da 49	
$S^{34}(\gamma,n)S^{33}$	-10.85 ± 0.20	thresh	D^{2}, Li^{7}, $Be^{9}(\gamma,n)$thresholds	Sh 51	
$Cl^{35}(n,p)S^{35}$	0.52 ± 0.04	pulse ht	$D^{2}(d,n)He^{3}$, Po α	Gi 44	
$Cl^{35}(n,\gamma)Cl^{36}$	8.56 ± 0.03	pr spec	absolute	Ki 52	8.57 ± 0.03
	8.57 ± 0.03	scint spec	Au^{198}, Cs^{137}, Na^{24} γ	Ha 52b	
$Cl^{35}(n,\alpha)P^{32}$	1.07 ± 0.15	pulse ht	$D^{2}(d,n)He^{3}$, Th(B + C)	Fo 52	1.02 ± 0.11
	0.97 ± 0.16	pulse ht	Po α	Ad 53	
$Cl^{35}(d,\alpha)S^{33}$	9.1	range		Sh 41	
$Cl^{35}(d,p)Cl^{36}$	6.31	range		Sh 41	6.28 ± 0.10
	6.26 ± 0.10	range		En 51b	
$Cl^{35}(\alpha,p)A^{38}$	0.81 ± 0.08	range		Kr 53	
$Cl^{37}(\gamma,n)Cl^{36}$	(-9.95 ± 0.20)	thresh	D^{2}, Li^{7}, $Be^{9}(\gamma,n)$thresholds	Sh 51	tgt. isotope uncertain
$Cl^{37}(p,\alpha)S^{34}$	3.2	pulse ht		Br 51	

TABLE I.—*Continued.*

$Cl^{37}(p,n)A^{37}$	-1.598 ± 0.004	thresh	$Li^7(p,n)Be^7$	Ri 50	-1.598 ± 0.002
	-1.598 ± 0.002[a]	thresh	$Li^7(p,n)Be^7$	Sc 52	
	-1.58	ph pl		St 52	
$Cl^{37}(d,p)Cl^{38}$	4.0 ± 0.3	range		Po 40a	4.0 ± 0.2
	4.02	range		Sh 41	
$A^{36}(n,\alpha)S^{33}$	2.0 ± 0.1	pulse ht	$D^2(d,n)He^3$	To 53	preliminary
$A^{36}(d,p)A^{37}$	6.59 ± 0.03	range		Da 49a	6.58 ± 0.03
	6.49 ± 0.08	range		Zu 50a	
$A^{40}(\gamma,p)Cl^{39}$	-10.8 ± 0.1	pulse ht	Po α	Wi 51a	
$A^{40}(p,n)K^{40}$	≥ -2.3	thresh		Ri 48, Ri 50	
$A^{40}(d,p)A^{41}$	3.84 ± 0.03	range		Da 49a	3.84 ± 0.03
	3.80 ± 0.06	range	Li 37	Sa 49	
	3.90 ± 0.08	ph pl	Ro 51c	Gi 52	
$A^{40}(d,n)K^{41}$	5.97 ± 0.25	range recoil p		Wo 50a	
$K^{39}(\gamma,n)K^{38}$	-13.2 ± 0.2	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
$K^{39}(n,\gamma)K^{40}$	7.789 ± 0.008	pr spec	absolute	Ba 53b, Bu 53	
$K^{39}(d,p)K^{40}$	5.6 ± 0.3	range		Po 40a	5.576 ± 0.010
	5.48± 0.08	range	Li 37	Sa 50	
	5.576± 0.010	mag spec	Po α	Bu 53	
$K^{39}(\alpha,p)Ca^{42}$	≥ 0.18	range		Sc 53	
$K^{41}(n,\gamma)K^{42}$	(7.34 ± 0.02)	pr spec	absolute	Ba 53b	tgt. isotope uncertain
$K^{41}(p,n)Ca^{41}$	-1.22 ± 0.02	thresh	$Li^7(p,n)Be^7$	Ri 50	
$K^{41}(d,p)K^{42}$	5.12 ± 0.10	range	Li 37	Sa 50	
$K^{41}(\alpha,p)Ca^{44}$	1.20	range		Sc 53	
$Ca^{40}(\gamma,n)Ca^{39}$	-16.0 ± 0.3	thresh		Be 47	-15.8 ± 0.1
	-15.9 ± 0.4	thresh	$Be^9(\gamma,n)Be^8$, $C^{12}(\gamma,n)C^{11}$	Mc 49	
	-15.8 ± 0.1	thresh	absolute	Su 53	
$Ca^{40}(p,n)Sc^{40}$	-15.5 ± 1.0[a]	thresh		Gl 53a	

TABLE I.—*Continued.*

$Ca^{40}(d,p)Ca^{41}$	6.30	range		Da 39	6.138 ± 0.010
	6.17 ± 0.05	range	Li 37	Sa 49	
	6.14 ± 0.05	range	$O^{16}(d,p)O^{17}$	Ho 53	
	6.138 ± 0.010	mag spec	Po α	Br 54	
$Ca^{40}(\alpha,p)Sc^{43}$	−4.3 ± 0.2	range	Li 37	Po 37, Li 37*	
$Ca^{42}(d,p)Ca^{43}$	5.70 ± 0.02	mag spec	Po α	Br 54b	
$Ca^{44}(d,p)Ca^{45}$	5.19 ± 0.02	mag spec	Po α	Br 54b	
$Ca^{48}(p,n)Sc^{48}$	≥ −0.64	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	
$Ca^{48}(d,p)Ca^{49}$	2.80 ± 0.30	scint spec		Wa 54	
$Sc^{45}(n,2n)Sc^{44}$	−11.05 ± 0.3[a]	thresh		Ba 53c	
$Sc^{45}(n,\gamma)Sc^{46}$	(8.85 ± 0.08)	pr spec	absolute	Ba 53	
$Sc^{45}(d,p)Sc^{46}$	6.78 ± 0.3	range Al		Da 39	
$Sc^{45}(\alpha,p)Ti^{48}$	−0.3 ± 0.3	range		Po 38a	
$Ti^{46}(\gamma,n)Ti^{45}$	−13.3 ± 0.2	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.85	Og 50	
$Ti^{46}(p,n)V^{46}$	−10 ± 2	thresh		Ma 52a	
$Ti^{46}(d,p)Ti^{47}$	6.51 ± 0.10	range	$Al^{27}(d,p)Al^{28}$, Q = 5.50, Sm 47	Ha 51	6.46 ± 0.04
	6.45 ± 0.05	range	Li 37, $O^{16}(d,p)O^{17}$	Pi 52a	
$Ti^{47}(d,p)Ti^{48}$	8.82 ± 0.04	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
	8.14 ± 0.05	range	Li 37, $O^{16}(d,p)O^{17}$	Pi 52a	
$Ti^{48}(d,p)Ti^{49}$	5.92 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	5.85 ± 0.05
	5.81 ± 0.04	range	Li 37, $O^{16}(d,p)O^{17}$	Pi 52, Pi 52a*	
$Ti^{49}(p,n)V^{49}$	−1.391 ± 0.005[a]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	
$Ti^{49}(d,p)Ti^{50}$	8.62 ± 0.05	range	Li 37, $O^{16}(d,p)O^{17}$	Pi 52a	
$Ti^{50}(d,p)Ti^{51}$	4.11 ± 0.07	range	Li 37, $O^{16}(d,p)O^{17}$	Pi 52a	
$V^{51}(\gamma,n)V^{50}$	−11.15 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	11.15 ± 0.20

TABLE I.—*Continued.*

$V^{51}(n,\gamma)V^{52}$	7.305 ± 0.007	pr spec	absolute	Ba 53	
	7.4	scint spec	Au^{198}, Cs^{137}, Na^{24} γ	Ha 52b	
$V^{51}(p,n)Cr^{51}$	-1.532 ± 0.006	thresh	$Li^7(p,n)Be^7$	Ri 50	-1.532 ± 0.006
	-1.54	ph pl		St 50	
$V^{51}(d,p)V^{52}$	5.02 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	5.072 ± 0.008
	5.42 ± 0.15[a]	range		Ab 50	
	6.25	range		Ho 51a	
	5.0			Ki 53a	
	5.072 ± 0.008	mag spec	Po α	Sc 53a	
$Cr^{50}(\gamma,n)Cr^{49}$	-13.4 ± 0.2	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.85	Og 50	
$Cr^{52}(\gamma,n)Cr^{51}$	-11.80 ± 0.25	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	-11.80 ± 0.25 tgt. isotope "probable"
$Cr^{52}(n,\gamma)Cr^{53}$	7.929 ± 0.008	pr spec	absolute	Ki 53	7.929 ± 0.008⁺
$Cr^{52}(d,p)Cr^{53}$	5.70	mag spec		Mc 53a	
$Cr^{53}(\gamma,n)Cr^{52}$	-7.75 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	-7.929 ± 0.008⁺ tgt. isotope "probable"
$Cr^{53}(n,\gamma)Cr^{54}$	9.716 ± 0.007	pr spec	absolute	Ki 53	
$Cr^{53}(p,n)Mn^{53}$	-1.380 ± 0.008[a]	thresh	$Li^7(p,n)Be^7$	Lo 52	-1.380 ± 0.008
	-1.37 ± 0.05	res. n scatt.		St 51e	
$Cr^{54}(p,n)Mn^{54}$	-1.985 ± 0.005[a]	thresh	$Li^7(p,n)Be^7$	Lo 52	
$Mn^{55}(\gamma,n)Mn^{54}$	-10.15 ± 0.20	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.9 Mev.	Ha 49a	-10.07 ± 0.14
	-10.00 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Mn^{55}(n,\gamma)Mn^{56}$	7.2	scint spec	Au^{198}, Cs^{137}, Na^{24} γ	Ha 51c	7.261 ± 0.006
	7.16 ± 0.05	scint spec	C^{12*} γ = 4.5 Mev.	Pr 51	
	7.261 ± 0.006	pr spec	absolute	Ba 53	
$Mn^{55}(d,p)Mn^{56}$	6.57 ± 0.30[c]	range Al		Da 39a	5.09 ± 0.15
	5.61	range Al	$Be^9(p,n)B^9$, $Li^7(p,n)Be^7$, $F^{19}(p,\alpha\gamma)O^{16}$	Wh 50b	
	4.76 ± 0.11[c]	range Al		Ma 50	
	5.09 ± 0.15	ph pl		Ab 50	
$Mn^{55}(p,n)Fe^{55}$	-1.16 ± 0.01[c]	thresh	See $V^{51}(p,n)Cr^{51}$	Ri 50	-1.017 ± 0.006
	-1.006 ± 0.010	res. n scatt.	$Li^7(p,n)Be^7$	St 51e	
	-1.00			Mc 51b	
	-1.05 ± 0.05	ph pl	$Li^7(p,n)Be^7$	St 51d	
	-1.020 ± 0.005[a]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	

TABLE I.—*Continued.*

$Fe^{54}(\gamma,n)Fe^{53}$	-14.2 ± 0.4	thresh	absolute	Ba 45	-13.8 ± 0.2
	-13.8 ± 0.2	thresh	$Be^9(\gamma,n)Be^8$, $E_t = 1.63$	Mc 49	
			$C^{12}(\gamma,n)C^{11}$, $E_t = 18.7$		
$Fe^{54}(n,\gamma)Fe^{55}$	9.298 ± 0.007	pr spec	absolute	Ki 53	
$Fe^{54}(d,p)Fe^{55}$	7.11 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Fe^{56}(\gamma,n)Fe^{55}$	-11.15 ± 0.25	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Fe^{56}(n,\gamma)Fe^{57}$	(7.639 ± 0.004)	pr spec	absolute	Ki 53	$7.639 \pm 0.004^+$
	7.8 ± 0.7	abs Al		Ku 49	
$Fe^{56}(n,\alpha)Cr^{53}$	4.5 ± 0.5	range		Ha 52a	tgt. isotope uncertain
$Fe^{56}(d,p)Fe^{57}$	5.42 ± 0.10	range Al	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Fe^{57}(\gamma,n)Fe^{56}$	-7.75 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	$-7.639 \pm 0.004^+$
$Fe^{57}(n,\gamma)Fe^{58}$	10.16 ± 0.04	pr spec	absolute	Ki 53	10.16 ± 0.04
$Fe^{57}(n,\alpha)Cr^{54}$	5.7 ± 0.3	range		Ha 52a	
$Co^{59}(\gamma,n)Co^{58}$	-10.25 ± 0.20	thresh	D^2, Li^7, $Be^8(\gamma,n)$thresholds	Sh 51	-10.25 ± 0.20
$Co^{59}(n,\gamma)Co^{60}$	7.7 ± 0.2	abs Al		Ku 49	
	7.0	scint spec	Au^{198}, Cs^{137}, Na^{24} γ	Ha 52b	
	(7.486 ± 0.006)	pr spec	absolute	Ba 53	
$Co^{59}(p,n)Ni^{59}$	-1.857 ± 0.003	thresh	$Li^7(p,n)Be^7$	Mc 51a	
$Co^{59}(d,p)Co^{60}$	5.43 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	5.43 ± 0.2
	5.19			Ba 50a	
	5.30	range Al		Ho 52	
$Ni^{58}(\gamma,n)Ni^{57}$	-11.7 ± 0.2	thresh	$N^{14}(\gamma,n)N^{13}$, $E_t = 10.54$	Og 50a	
			$F^{19}(\gamma,n)F^{18}$, $E_t = 10.4$		
$Ni^{58}(n,\gamma)Ni^{59}$	8.997 ± 0.005	pr spec	absolute	Ki 53	
$Ni^{58}(d,p)Ni^{59}$	6.78 ± 0.10	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	6.78 ± 0.10
	6.77	mag spec		Mc 53a	
$Ni^{60}(n,\gamma)Ni^{61}$	8.532 ± 0.008	pr spec	absolute	Ki 53	

TABLE I.—*Continued.*

$Ni^{60}(p,n)Cu^{60}$	-5.0 ± 0.2^{a}	thresh		Le 47	
$Ni^{60}(d,p)Ni^{61}$	6.30 ± 0.04	range		Ho 52	
$Ni^{62}(p,n)Cu^{62}$	-4.62 ± 0.1^{a}	thresh	Sm 47	Bl 51a	
$Ni^{64}(p,n)Cu^{64}$	-2.46 ± 0.2^{a}	thresh	Sm 47	Bl 51a.	
$Cu^{63}(\gamma,n)Cu^{62}$	-10.9 ± 0.3	thresh	absolute	Ba 45	-10.65 ± 0.05
	-10.9 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	
	-10.8 ± 0.2	thresh	$\{N^{14}(\gamma,n)N^{13}$, $E_t = 10.54$ $\{F^{19}(\gamma,n)F^{18}$, $E_t = 10.40$	Mc 50	
	-10.85 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
	-10.61 ± 0.05	thresh	O^{16}, N^{14}, $C^{12}(\gamma,n)$thresholds	Bi 53, Bi 54	
	-10.72	thresh	$F^{19}(\gamma,n)F^{18}$, $E_t = 10.41$	Ta 54	
$Cu^{63}(n,2n)Cu^{62}$	-11.2 ± 0.3	thresh		Fo 50	
$Cu^{63}(n,\gamma)Cu^{64}$	7.7 ± 0.4	abs Al		Ku 49	7.914 ± 0.006
	7.914 ± 0.006	pr spec	absolute	Ba 53	
$Cu^{63}(p,n)Zn^{63}$	-4.04 ± 0.17^{a}	thresh		St 38a	-4.19 ± 0.03
	-4.14 ± 0.1^{a}	thresh	Sm 47	Bl 51a	
	-4.21 ± 0.03^{a}	thresh		Co 54	preliminary
$Cu^{63}(d,p)Cu^{64}$	5.55 ± 0.20	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	5.60 ± 0.17
	5.70 ± 0.30	range		Da 39	
	5.66	range		Ho 52	
$Cu^{65}(\gamma,n)Cu^{64}$	-10.2 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	-9.97 ± 0.22
	-9.75 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
	-10.2	thresh	$\{Cu^{63}(\gamma,n)Cu^{62}$, $E_t = 10.9$ $\{C^{12}(\gamma,n)C^{11}$, $E_t = 18.7$	Jo 50	
$Cu^{65}(p,n)Zn^{65}$	-2.166 ± 0.010^{b}	thresh	$Li^7(p,n)Be^7$	Sh 48	
	-2.12 ± 0.03	thresh		Co 54	preliminary
$Cu^{65}(n,\gamma)Cu^{66}$	7.634 ± 0.006	pr spec	absolute	Ba 53	tgt. isotope uncertain
$Cu^{65}(d,p)Cu^{66}$	6.35 ± 0.30	range		Da 39	
$Zn^{64}(p,n)Ga^{64}$	-8.0 ± 0.5	thresh	$Cu^{63}(p,n)Zn^{63}$	Co 53a	
$Zn^{64}(d,p)Zn^{65}$	5.69 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Zn^{66}(\gamma,n)Zn^{65}$	-11.15 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"

TABLE I.—*Continued.*

$Zn^{64}(\gamma,n)Zn^{63}$	−11.6 ± 0.4	thresh	absolute	Ba 45	11.72 ± 0.16
	−11.80 ± 0.20	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
	−11.65 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Zn^{64}(n,\gamma)Zn^{65}$	(7.876 ± 0.007)	pr spec	absolute	Ki 53c	tgt. isotope uncertain
$Zn^{66}(p,n)Ga^{66}$	−5.96 ± 0.5[a]	thresh	Sm 47	Bl 51a	
$Zn^{67}(n,\gamma)Zn^{68}$	9.51 ± 0.03	pr spec	absolute	Ki 53c	9.52 ± 0.09[+]
$Zn^{67}(\gamma,n)Zn^{66}$	−7.00 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh51	
$Zn^{67}(p,n)Ga^{67}$	−1.785 ± 0.005	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	
$Zn^{68}(\gamma,n)Zn^{67}$	−10.15 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
					−9.52 ± 0.09
$Zn^{68}(p,n)Ga^{68}$	−3.35 ± 0.3[a]	thresh	Sm 47	Bl 51a	
$Zn^{68}(d,p)Zn^{69}$	4.16 ± 0.15	scint spec		Eb 54	
$Zn^{70}(\gamma,n)Zn^{69}$	−9.20 ± 0.20	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
$Zn^{70}(p,n)Ga^{70}$	−1.45 ± 0.03[a]	thresh	$F^{19}(p,\alpha\gamma)$, $Li^7(p,n)Be^7$	Tr 53	
$Ga^{69}(\gamma,n)Ga^{68}$	−10.10 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Ga^{71}(\gamma,n)Ga^{70}$	−9.05 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Ga^{71}(p,n)Ge^{71}$	−1.026 ± 0.03[a]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	
$Ge^{70}(n,2n)Ge^{69}$	−11.6 ± 0.3	thresh		Ba 53c	
$Ge^{73}(p,n)As^{73}$	−1.154 ± 0.03[a]	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	
$As^{75}(\gamma,n)As^{74}$	−10.3 ± 0.2	thresh	See $Ni^{58}(\gamma,n)Ni^{57}$	Og 50a	−10.2 ± 0.14
	−10.10 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$As^{75}(p,n)Se^{75}$	−1.652 ± 0.005	thresh	$F^{19}(p,\alpha\gamma)O^{16}$, $Li^7(p,n)Be^7$	Tr 53	
$As^{75}(n,\gamma)As^{76}$	7.30 ± 0.04	pr spec	absolute	Ki 53c	
$Se^{76}(n,\gamma)Se^{77}$	7.416 ± 0.009	pr spec	absolute	Ki 53c	

TABLE I.—*Continued.*

$Se^{77}(n,\gamma)Se^{78}$	10.483 ± 0.014	pr spec	absolute	Ki 53c	
$Se^{78}(p,n)Br^{78}$	-4.45 ± 0.2[a]	thresh	Sm 47	Bl 51a	
$Se^{80}(p,n)Br^{80}$	-2.57 ± 0.2[a]	thresh	Sm 47	Bl 51a	
$Se^{82}(\gamma,n)Se^{81}$	-9.8 ± 0.5	thresh	absolute	Ba 45	
$Br^{79}(\gamma,n)Br^{78}$	-10.7 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	-10.65 ± 0.14
	-10.6 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$ thresholds	Sh 51	
$Br^{81}(\gamma,n)Br^{80}$	-10.2 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	-10.07 ± 0.14
	- 9.95 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Kr^{84}(d,p)Kr^{85}$	3.72 ± 0.05	range		Wh 53	
$Kr^{86}(d,p)Kr^{87}$	3.30 ± 0.05	range		Wh 53	
$Sr^{84}(d,p)Sr^{85}$	5.25 ± 0.30	scint spec		Wa 54	
$Sr^{86}(\gamma,n)Sr^{85}$	-9.50 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Sr^{86}(d,p)Sr^{87}$	6.29 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	6.275 ± 0.16
	6.26 ± 0.2	scint spec		Wa 54	
$Sr^{87}(\gamma,n)Sr^{86}$	-8.40 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Sr^{87}(p,n)Y^{87}$	-2.47 ± 0.2[a]	thresh	Sm 47	Bl 51a	
$Sr^{88}(\gamma,n)Sr^{87}$	-11.15 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Sr^{88}(p,n)Y^{88}$	- 4.7 ± 0.2	thresh	Sm 47	Bl 51a	
$Sr^{88}(d,p)Sr^{89}$	4.32 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	4.30 ± 0.06
	4.29 ± 0.15	scint spec		Wa 54	
	4.33 ± 0.1	mag spec	$C^{12}(d,p)C^{13}$, $O^{16}(d,p)O^{17}$	Mc 53	
	4.18 ± 0.08	range	$O^{16}(d,p)O^{17}$	Ho 53	
$Y^{89}(p,n)Zr^{89}$	-3.46 ± 0.2[a]	thresh	Sm 47	Bl 51a	
$Y^{89}(d,p)Y^{90}$	4.41 ± 0.20	scint spec		Wa 54	
$Zr^{90}(\gamma,n)Zr^{89}$	-12.0 ± 0.2	thresh	See $Ni^{58}(\gamma,n)Ni^{57}$	Og 50a	-12.30 ± 0.23
	-12.48 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	

TABLE I.—*Continued.*

$Zr^{90}(d,p)Zr^{91}$	4.93 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	4.93 ± 0.05
	5.03	mag spec		Sh 52	preliminary
$Zr^{91}(\gamma,n)Zr^{90}$	-7.20 ± 0.4	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
$Zr^{91}(d,p)Zr^{92}$	6.50 ± 0.10	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Zr^{91}(n,\gamma)Zr^{92}$	8.66 ± 0.04	pr spec	absolute	Ki 53c	
$Zr^{92}(d,p)Zr^{93}$	4.33 ± 0.10	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	4.43 ± 0.05
	4.46 ± 0.05	scint spec		Wa 54	
$Zr^{94}(d,p)Zr^{95}$	4.19 ± 0.05	scint spec		Wa 54	
$Zr^{96}(p,n)Nb^{96}$	-2.58 ± 0.2[a]	thresh	Sm 47	Bl 51a	
$Nb^{93}(\gamma,n)Nb^{92}$	-8.70 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Nb^{93}(n,\gamma)Nb^{94}$	(7.19 ± 0.03)	pr spec	absolute	Ba 53a	May be transition to 41 kev state.
$Nb^{93}(p,n)Mo^{93}$	-3.66 ± 0.2[a]	thresh	Sm 47	Bl 51a	
$Nb^{93}(d,p)Nb^{94}$	5.03 ± 0.10	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Mo^{92}(\gamma,n)Mo^{91}$	-13.5 ± 0.4	thresh	absolute	Ba 45	-13.17 ± 0.08
	-13.28 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
	-13.1 ± 0.1	thresh		Ka 53	
$Mo^{92}(n,2n)Mo^{91}$	-12.35	thresh		Ba 53c	
$Mo^{92}(d,p)Mo^{93}$	6.08 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	5.66 ± 0.10
	6.50	mag spec		Sh 52	preliminary
	5.63 ± 0.05	scint spec		Wa 54	
$Mo^{94}(p,n)Tc^{94}$	-5.05 ± 0.10[a]	thresh	Sm 47	Bl 51a	
$Mo^{95}(n,\gamma)Mo^{96}$	9.15 ± 0.05	pr spec	absolute	Ki 53c	
$Mo^{95}(p,n)Tc^{95}$	-3.56 ± 0.3[a]	thresh	Sm 47	Bl 51a	
$Mo^{96}(p,n)Tc^{96}$	-3.76 ± 0.3[a]	thresh	Sm 47	Bl 51a	
$Mo^{96}(d,p)Mo^{97}$	4.51 ± 0.30	scint spec		Wa 54	

TABLE I.—*Continued.*

$Mo^{97}(\gamma,n)Mo^{96}$	-7.10 ± 0.30	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
$Mo^{97}(d,p)Mo^{98}$	6.06 ± 0.10	scint spec		Wa 54	
$Ru^{100}(p,n)Rh^{100}$	-4.06 ± 0.2^{a}	thresh	Sm 47	Bl 51a	
$Ru^{101}(p,n)Rh^{101}$	-2.58 ± 0.3^{a}	thresh	Sm 47	Bl 51a	
$Rh^{103}(\gamma,n)Rh^{102}$	-9.35 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Rh^{103}(\gamma,p)Ru^{102}$	-8 ± 1	ph pl		Cu 50a	
$Rh^{103}(\alpha,2n)Ag^{105}$	-15.6 ± 0.5	thresh		Br 47	
$Rh^{103}(n,\gamma)Rh^{104}$	(6.792 ± 0.014)	pr spec	absolute	Ba 53a	
$Rh^{103}(d,p)Rh^{104}$	4.58 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Ag^{107}(n,\gamma)Ag^{108}$	7.27 ± 0.02	pr spec	absolute	Ba 53a	
$Ag^{107}(d,p)Ag^{108}$	4.78 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Ag^{107}(\alpha,n)In^{110}$	-10.6^{a}	thresh		Gh 48	
$Ag^{109}(\gamma,n)Ag^{108}$	-9.3 ± 0.5	thresh	absolute	Ba 45	-9.07 ± 0.07
	-9.05 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
	-9.07 ± 0.07	thresh	O^{16}, N^{14}, $C^{12}(\gamma,n)$thresholds	Bi 53, Bi 54	
$Ag^{109}(n,\gamma)Ag^{110}$	6.5 ± 0.7	abs Al		Ku 49	tgt. isotope uncertain
$Ag^{109}(\alpha,2n)In^{111}$	-14.95 ± 0.5^{a}	thresh		Te 47	
	-14.3 ± 0.2^{a}	thresh		Bl 53	
$Cd^{110}(p,n)In^{110}$	-4.46 ± 0.2^{a}	thresh	Sm 47	Bl 51a	
$Cd^{112}(d,p)Cd^{113}$	4.10 ± 0.09	scint spec		Wa 54	
$Cd^{113}(\gamma,n)Cd^{112}$	-6.44 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	-6.48 ± 0.12
	-6.55 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Cd^{113}(n,\gamma)Cd^{114}$	8.5 ± 0.5	cl ch	$N^{14}(n,p)C^{14}$	Wi 50	9.046 ± 0.008
	7.0 ± 0.2	abs Al		Ku 49	tgt. isotope probable
	9.046 ± 0.008	pr spec	absolute	Ki 53c	

TABLE I.—*Continued.*

$Cd^{114}(d,p)Cd^{115}$	3.52 ± 0.15	scint spec		Wa 54	
$In^{115}(\gamma,n)In^{114}$	−9.05 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope probable
$In^{115}(n,\gamma)In^{116}$	≥ 6.27 ± 0.16	pr spec	absolute	Ba 53a	
$In^{115}(d,p)In^{116}$	4.36 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Sn^{117}(d,p)Sn^{118}$	7.14 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Sn^{118}(\gamma,n)Sn^{117}$	−9.10 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope probable
$Sn^{119}(\gamma,n)Sn^{118}$	−6.51 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	−6.54 ± 0.12
	−6.60 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope probable
$Sn^{120}(p,n)Sb^{120}$	−3.47 ± 0.3[a]	thresh	Sm 47	Bl 51a	
$Sn^{120}(d,p)Sn^{121}$	4.0 ± 0.3	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	3.92 ± 0.07
	3.92± 0.07	scint spec		Wa 54	
$Sn^{124}(\gamma,n)Sn^{123}$	−8.50 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
$Sn^{124}(d,p)Sn^{125}$	3.52 ± 0.07	scint spec		Wa 54	
$Sb^{121}(\gamma,n)Sb^{120}$	−9.25 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	
	−9.3	thresh	See $Cu^{65}(\gamma,n)Cu^{64}$	Jo 50	
$Sb^{121}(n,\gamma)Sb^{122}$	6.80 ± 0.04	pr spec	absolute	Ba 53a	tgt. isotope uncertain
$Sb^{121}(d,p)Sb^{122}$	4.41 ± 0.20	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Sb^{123}(\gamma,n)Sb^{122}$	−9.3	thresh	See $Cu^{65}(\gamma,n)Cu^{64}$	Jo 50	
$Te^{124}(d,p)Te^{125}$	4.25 ± 0.07	scint spec		Wa 54	
$Te^{128}(p,n)I^{128}$	−3.8 ± 0.3[a]	thresh	Sm 47	Bl 51a	
$Te^{130}(p,n)I^{130}$	−3.27 ± 0.3[a]	thresh	Sm 47	Bl 51a	
$I^{127}(\gamma,n)I^{126}$	−9.3 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	−9.28 ± 0.12
	−9.45± 0.2	thresh	See $Ni^{58}(\gamma,n)Ni^{57}$	Og 50a	
	−9.10± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	

TABLE I.—*Continued.*

$I^{127}(n,\gamma)I^{128}$	7.0 ± 0.4	abs Al		Ku 49	
$I^{127}(d,p)I^{128}$	4.35 ± 0.05	scint spec		Wa 54	
$Cs^{133}(\gamma,n)Cs^{132}$	-9.05 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Cs^{133}(d,p)Cs^{134}$	4.50 ± 0.1	scint spec		Wa 54	
$Ba^{137}(n,\gamma)Ba^{138}$	9.23 ± 0.07	pr spec	absolute	Ki 53c	
$Ba^{138}(d,p)Ba^{139}$	3.0 ± 0.3	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$La^{139}(\gamma,n)La^{138}$	-8.80 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$La^{139}(d,p)La^{140}$	2.87 ± 0.1	scint spec		Wa 54	
$Ce^{140}(\gamma,n)Ce^{139}$	-9.05 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Ce^{140}(d,p)Ce^{141}$	3.17 ± 0.10	scint spec		Wa 54	
$Ce^{142}(\gamma,n)Ce^{141}$	-7.15 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Ce^{142}(d,p)Ce^{143}$	2.86 ± 0.07	scint spec		Wa 54	
$Pr^{141}(\gamma,n)Pr^{140}$	-9.8 ± 0.3	thresh	See $Ni^{58}(\gamma,n)Ni^{57}$	Og 50a	-9.44 ± 0.12
	-9.40± 0.10	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
$Pr^{141}(n,\gamma)Pr^{142}$	≥ 5.83 ± 0.03	pr spec	absolute	Ba 53a	
$Pr^{141}(d,p)Pr^{142}$	3.42 ± 0.20	scint spec		Wa 54	
$Nd^{142}(d,p)Nd^{143}$	3.79 ± 0.08	scint spec		Wa 54	
$Nd^{150}(\gamma,n)Nd^{149}$	-7.40 ± 0.20	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	
$Sm^{149}(n,\gamma)Sm^{150}$	6.6 ± 0.3	abs Al		Ku 49	tgt. isotope "probable"
	≥ 7.89 ± 0.06	pr spec		Ki 53c	
$Sm^{154}(d,p)Sm^{155}$	3.36 ± 0.30	scint spec		Wa 54	
$Gd^{157}(n,\gamma)Gd^{158}$	6.3 ± 0.4	abs Al		Ku 49	tgt. isotope "probable"

TABLE I.—*Continued.*

$Ta^{181}(\gamma,n)Ta^{180}$	-7.7 ± 0.20	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	-7.62 ± 0.14
	-7.55± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
	-8.0	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.9; $C^{12}(\gamma,n)C^{11}$, E_t = 18.7	Jo 50	
$Ta^{181}(n,\gamma)Ta^{182}$	6.07 ± 0.03	pr spec	absolute	Ba 53a	
$Ta^{181}(d,p)Ta^{182}$	3.80 ± 0.15	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$W^{182}(n,\gamma)W^{183}$	(6.182 ± 0.008)	pr spec	absolute	Ki 53c	tgt. isotope uncertain
$W^{183}(\gamma,n)W^{182}$	-6.25 ± 0.3	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope uncertain
$W^{183}(n,\gamma)W^{184}$	7.42 ± 0.02	pr spec	absolute	Ki 53c	tgt. isotope "probable"
$W^{186}(n,\gamma)W^{187}$	7.1 ± 0.3	abs Al		Ku 49	tgt. isotope "probable"
$Re^{187}(\gamma,n)Re^{186}$	-7.30 ± 0.30	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Ir^{191}(n,\gamma)Ir^{192}$	5.15 ± 0.2	abs Al		Ku 49	tgt. isotope "probable"
$Ir^{193}(\gamma,n)Ir^{192}$	-7.80 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Pt^{194}(\gamma,n)Pt^{193}$	-9.50 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable"
$Pt^{194}(d,p)Pt^{195}$	3.91 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Pt^{195}(\gamma,n)Pt^{194}$	-6.1 ± 0.1	thresh	absolute	Pa 50a	tgt. isotope uncertain
	-6.1 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	-6.1 ± 0.9
$Pt^{195}(n,\gamma)Pt^{196}$	7.920 ± 0.012	pr spec	absolute	Ki 53c	tgt. isotope "probable" 7.920 ± 0.012⁺
$Pt^{195}(d,p)Pt^{196}$	5.74 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	tgt. isotope uncertain
$Pt^{196}(\gamma,n)Pt^{195}$	-8.20 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	tgt. isotope "probable" 7.920 ± 0.012⁺
$Au^{197}(\gamma,n)Au^{196}$	-8.00 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	-8.05 ± 0.08
	-8.1 ± 0.1	thresh	absolute	Pa 50a	
	-7.90 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Au^{197}(n,\gamma)Au^{198}$	(6.494 ± 0.008)	pr spec	absolute	Ba 53a	
	7.3 ± 0.4	abs Al		Ku 49	

TABLE I.—*Continued.*

$Au^{197}(d,p)Au^{198}$	4.12 ± 0.15	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Hg^{199}(n,\gamma)Hg^{200}$	7.1 ± 0.4	abs Al		Ku 49	tgt. isotope "probable" See also Ki 53c
$Hg^{201}(\gamma,n)Hg^{200}$	-6.25 ± 0.20	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	-6.42 ± 0.18
	-6.6 ± 0.2	thresh	absolute	Pa 50a	tgt. isotope uncertain
$Tl^{203}(\gamma,n)Tl^{202}$	-8.80 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Tl^{203}(n,\gamma)Tl^{204}$	6.54 ± 0.03	pr spec	absolute	Ba 53a	
$Tl^{203}(d,p)Tl^{204}$	4.29 ± 0.15	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Tl^{205}(\gamma,n)Tl^{204}$	-7.48 ± 0.15	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	-7.46 ± 0.11
	-7.3 ± 0.25	thresh	absolute	Pa 50a	tgt. isotope uncertain
	-7.55 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Tl^{205}(n,\gamma)Tl^{206}$	(6.20 ± 0.03)	pr spec	absolute	Ba 53a	
$Tl^{205}(d,p)Tl^{206}$	3.93 ± 0.15	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Pb^{206}(\gamma,n)Pb^{205}$	-8.25 ± 0.10	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.9	Pa 50b	
$Pb^{206}(n,\gamma)Pb^{207}$	6.734 ± 0.008	pr spec	absolute	Ki 51b	
$Pb^{206}(d,p)Pb^{207}$	4.48 ± 0.03	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Pb^{206}(d,t)Pb^{205}$	-1.83 ± 0.100	range	$Pb^{208}(d,t)Pb^{207}$	Ha 53	
$Pb^{207}(\gamma,n)Pb^{206}$	-6.85 ± 0.20	thresh	See $Mn^{55}(\gamma,n)Mn^{54}$	Ha 49a	6.91 ± 0.07
	-6.95 ± 0.10	thresh	See $Pb^{206}(\gamma,n)Pb^{205}$	Pa 50b	(n,γ)Q-value not included in average
	-6.75 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
	-6.9 ± 0.1	thresh	absolute	Pa 50a	
$Pb^{207}(n,\gamma)Pb^{208}$	7.380 ± 0.008	pr spec	absolute	Ki 51b	7.380 ± 0.008*
$Pb^{207}(d,t)Pb^{206}$	-0.42 ± 0.05	range	$Pb^{208}(d,t)Pb^{207}$	Ha 53	
$Pb^{207}(d,p)Pb^{208}$	5.14 ± 0.03	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Pb^{208}(\gamma,n)Pb^{207}$	-7.44 ± 0.10	thresh	See $Pb^{206}(\gamma,n)Pb^{205}$	Pa 50b	-7.380 ± 0.008*
	-8.1 ± 0.3	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.9	Pa 50a, Pa 50c	
	-7.30 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	

TABLE I.—*Continued.*

$Pb^{208}(d,t)Pb^{207}$	-1.10 ± 0.05	range		Ha 53	
$Pb^{208}(d,p)Pb^{209}$	1.64 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$Bi^{209}(\gamma,n)Bi^{208}$	-7.45 ± 0.2	thresh	See $Fe^{54}(\gamma,n)Fe^{53}$	Mc 49	-7.28 ± 0.08
	-7.2 ± 0.1	thresh	absolute	Pa 50a	
	-7.40 ± 0.20	thresh	D^2, Li^7, $Be^9(\gamma,n)$thresholds	Sh 51	
$Bi^{209}(d,t)Bi^{208}$	-1.17 ± 0.05	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51, Ha 53	
$Bi^{209}(n,\gamma)Bi^{210}$	4.170 ± 0.015	pr spec	absolute	Ki 50a	
$Bi^{209}(d,p)Bi^{210}$	(1.91 ± 0.3)	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	1.94 ± 0.03
	1.94 ± 0.03	scint spec		Wa 53, Wa 54*	
$Th^{232}(\gamma,n)Th^{231}$	-6.0 ± 0.15	thresh	absolute	Pa 50a	-6.34 ± 0.09
	-6.35 ± 0.04	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.9	Ma 51a	
$Th^{232}(d,p)Th^{233}$	2.65 ± 0.20	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$U^{238}(\gamma,n)U^{237}$	-5.8 ± 0.15	thresh	absolute	Pa 50a	-5.88 ± 0.11
	-5.97 ± 0.15	thresh	$Cu^{63}(\gamma,n)Cu^{62}$, E_t = 10.9	Hu 51a	
$U^{238}(d,t)U^{237}$	0.4 ± 0.2	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	
$U^{238}(d,p)U^{239}$	2.40 ± 0.15	range	See $Ti^{46}(d,p)Ti^{47}$	Ha 51	

[a] This Q value has been calculated specifically for this compilation from the experimental data. In the calculation of Q values from published threshold energies, accurate masses have been used if they are known. Mass numbers have been used if the masses are not known.
[b] This Q value has been corrected for the $Li^7(p,n)Be^7$ threshold at 1.881 Mev.
[c] This Q value has been omitted from the weighted average.
[d] This Q value has been corrected for the $F^{19}(p,\alpha\gamma)$ resonance energy of 873.5 kev.
* This reference contains a later correction to the value originally reported.
** In this reference the quoted error for the Q value has been changed.
† This average value was calculated by including the measured Q value for the inverse reaction.

Note added in proof.—On page 408, the third line of the table should read

$D^2(n,\gamma)T^3$	6.251 ±0.008 Mev	pr spec	absolute	Ki 50b

Note added in proof.—On page 431 of Table I add

$Rb^{87}(d,p)Rb^{88}$	−3.75 ±0.20 Mev	scint spec	Wa[54]

List of Abbreviations Used for Experimental Methods

abs Al	absorption in aluminum
abs co	absorption of secondary electrons using coincidences
cl ch	cloud chamber
el spec	electrostatic spectrometer
mag spec	magnetic spectrograph or spectrometer
ph pl	photographic plate
pr spec	pair spectrometer
res. n scatt	resonant neutron scattering
pulse ht	pulse height
scint spec	scintillation spectrometer
spec	spectrograph or spectrometer
tgt	target
thresh	threshold

BIBLIOGRAPHY

Ab 50 A. Abramov, Doklady Akad. Nauk SSSR **73**, 921 (1950).

Ad 53 Adler, Huber, and Halg, Helv. Phys. Acta **26**, 349 (1953).

Ah 54 K. Ahnlund, Arkiv Fysik **7**, 155 (1954).

Aj 52 F. Ajzenberg, Phys. Rev. **88**, 298 (1952).

Aj 54 F. Ajzenberg and W. Franzen, Phys. Rev. **94**, 409 (1954).

Aj 54a Ajzenberg, Franzen, and Likely, Phys. Rev. **95**, 641 (1954).

Al 40 Allison, Skaggs, and Smith, Phys. Rev. **57**, 550 (1940).

Al 47 Alder, Huber, and Metzger, Helv. Phys. Acta **20**, 234 (1947).

Al 48 H. R. Allan and C. A. Wilkinson, Proc. Roy. Soc. (London) **A194**, 131 (1948).

Al 49a L. Alvarez, Phys. Rev. **75**, 1815 (1949).

Al 49b Allan, Wilkinson, Burcham, and Curling, Nature **163**, 210 (1949).

Al 50 Allred, Phillips, Rosen, and Tallmadge, Rev. Sci. Instr. **21**, 225 (1950).

Al 50c L. Alvarez, Phys. Rev. **80**, 519 (1950).

Al 51 R. Allen and W. Rall, Phys. Rev. **81**, 60 (1951).

Al 53 Almqvist, Allen, Dewan, and Pepper, Phys. Rev. **91**, 1022 (1953).

Am 50 J. Ambrosen and K. M. Bisgaard, Nature **165**, 888 (1950).

Am 52 J. Ambrosen, Nature **169**, 408 (1952).

Ar 48 H. Argo, Phys. Rev. **74**, 1293 (1948).

Ba 37 D. S. Bayley and H. R. Crane, Phys. Rev. **51**, 1012 (1937).

Ba 39 E. Baldinger and P. Huber, Helv. Phys. Acta **12**, 330 (1939).

Ba 40 Barkas, Creutz, Delsasso, Fox, and White, Phys. Rev. **57**, 562 (1940).

Ba 45 G. C. Baldwin and H. W. Koch, Phys. Rev. **67**, 1 (1945).

Ba 46 H. H. Barschall and M. E. Battat, Phys. Rev. **70**, 245 (1946).

Ba 48 K. T. Bainbridge, Preliminary Report No. 1, National Research Council Nuclear Sci. Ser. (1948).

Ba 50 W. O. Bateson, Phys. Rev. **80**, 982 (1950).

Ba 50a W. O. Bateson and E. Pollard, Phys. Rev. **79**, 241 (1950).

Ba 53 G. A. Bartholomew and B. B. Kinsey, Phys. Rev. **89**, 386 (1953).

Ba 53a G. A. Bartholomew and B. B. Kinsey, Can. J. Phys. **31**, 1025 (1953).

Ba 53b G. A. Bartholomew and B. B. Kinsey, Can. J. Phys. **31**, 927 (1953).

Ba 53c S. J. Bame, Jr., Phys. Rev. **92**, 1096 (1953).

Be 37 G. Bernardini, Ricerca sci. **8**, 33 (1937).

Be 38 H. Bethe, Phys. Rev. **53**, 313 (1938).

Be 41 Bennett, Bonner, Hudspeth, Richards, and Watt, Phys. Rev. **59**, 781 (1941).

Be 47 Becker, Hanson, and Diven, Phys. Rev. **71**, 466 (1947).

Be 48 B. B. Benson, Phys. Rev. **73**, 7 (1948).

Be 50 P. R. Bell and J. M. Cassidy, Phys. Rev. **77**, 301 (1950).

Be 50c R. E. Bell and L. G. Elliott, Phys. Rev. **79**, 282 (1950).

Be 50d H. Bethe, Revs. Modern Phys. **20**, 213 (1950).

Bi 52 Bichsel, Halg, Huber, and Stebler, Helv. Phys. Acta **25**, 119 (1952).

Bi 52a A. C. Birge, Phys. Rev. **85**, 753 (1952).

Bi 53 Birnbaum, Harth, Seren, and Tobin, Phys. Rev. **91**, 474 (1953).

Bi 54 M. Birnbaum, Phys. Rev. **93**, 146 (1954).

Bl 32 P. M. S. Blackett, Proc. Roy. Soc. (London) **A135**, 132 (1932).

Bl 38 J. H. Blewett and M. H. Blewett, private communication to Livingston and Hoffman, Phys. Rev. **53**, 227 (1938).

Bi 47b E. Bleuler and J. Rossel, Helv. Phys. Acta **20**, 445 (1947).

Bl 49 Blaser, Boehm, Marmier, Preiswerk, and Scherrer, Helv. Phys. Acta **22**, 598 (1949).

Bl 51 Blaser, Boehm, Marmier, and Scherrer, Helv. Phys. Acta **24**, 465 (1951).

Bl 51a Blaser, Boehm, Marmier, and Scherrer, Helv. Phys. Acta **24**, 441 (1951).

Bl 53 Bleuler, Stebbins, and Tendam, Phys. Rev. **90**, 460 (1953).

Bo 34 T. W. Bonner and L. M. Mott-Smith, Phys. Rev. **46**, 258 (1934).

Bo 35 T. W. Bonner and W. M. Brubaker, Phys. Rev. **48**, 742 (1935).

Bo 36 T. W. Bonner and W. M. Brubaker, Phys. Rev. **49**, 778 (1936).

Bo 36a T. W. Bonner and W. M. Brubaker, Phys. Rev. **50**, 308 (1936).

Bo 38 T. W. Bonner, Phys. Rev. **53**, 496 (1938).

Bo 39 J. C. Bower and W. E. Burcham, Proc. Roy. Soc. (London) **A173**, 379 (1939).

Bo 39 T. W. Bonner, Proc. Roy. Soc. (London) **A174**, 339 (1940).

Bo 41 T. W. Bonner, Phys. Rev. **59**, 237 (1941).

Bo 45 J. K. Bøggild, Kgl. Danske. Videnskab. Selsk. Mat.-fys. Medd. **23**, No. 4 (1945).

Bo 49 J. K. Bøggild and L. Minnhagen, Phys. Rev. **75**, 782 (1949).

Bo 49a Bonner, Evans, and Hill, Phys. Rev. **75**, 1401 (1949).

Bo 51 T. W. Bonner and J. W. Butler, Phys. Rev. **83**, 1091 (1951).

Bo 51a W. Bollman and W. Zünti, Helv. Phys. Acta **24**, 517 (1951).

Br 36 C. J. Brasefield and E. Pollard, Phys. Rev. **50**, 296 (1936).

Br 38 Brandt, Z. Physik **108**, 726 (1938).

Br 47 H. Bradt and D. J. Tendam, Phys. Rev. **72**, 1117 (1947).

Br 50 C. E. Bradford and W. E. Bennett, Phys. Rev. **78**, 302 (1950).

Br 51 Brostrom, Madsen, and Madsen, Phys. Rev. **83**, 1265 (1951).

Br 51a Brown, Snyder, Fowler, and Lauritsen, Phys. Rev. **82**, 159 (1951).

Br 54 C. M. Braams, Phys. Rev. **94**, 763 (1954).

Br 54a Breckon, Henrikson, Martin, and Foster, Can. J. Phys. **32**, 223 (1954).

Br 54b C. M. Braams, Phys. Rev. **95**, 650 (1954).

Bu 38 W. E. Burcham and C. L. Smith, Proc. Roy. Soc. (London) **A168**, 176 (1938).

Bu 39 W. E. Burcham and C. L. Smith, Nature **143**, 795 (1939).

Bu 50 W. E. Burcham and J. M. Freeman, Phil. Mag. **41**, 337 (1950).

Bu 50a W. E. Burcham and J. M. Freeman, Phil. Mag. **41**, 921 (1950).

Bu 50b Buechner, Van Patter, Strait, and Sperduto, Phys. Rev. **79**, 262 (1950).

Bu 51 Bullock, McMinn, Rasmussen, and Sampson, Phys. Rev. **83**, 212 (1951).

Bu 51a Burrows, Powell, and Rotblat, Proc. Roy. Soc. (London) **A209**, 478 (1951).

Bu 51b M. L. Bullock and M. B. Sampson, Phys. Rev. **84**, 967 (1951).

Bu 51c Burge, Burrows, Gibson, and Rotblat, Proc. Roy. Soc. (London) **A210**, 534 (1951).

Bu 53 Buechner, Sperduto, Browne, and Bockelman, Phys. Rev. **91**, 1502 (1953).

Ca 51 R. R. Carlson, Phys. Rev. **84**, 749 (1951).

Ca 51a J. H. Carver and D. H. Wilkinson, Proc. Phys. Soc. (London) **64A**, 199 (1951).

Ca 52 Catala, Selent, and Casanova, Anales real soc. espan. fis. y quim. (Madrid) **48A**, 323 (1952).

Ca 53 H. Casson, Phys. Rev. **89**, 809 (1953).

Ch 32 J. Chadwick and J. E. R. Constable, Proc. Roy. Soc. (London) **A135**, 48 (1932).

Ch 49 R. Chastel, Compt. rend. **228**, 1725 (1949).

Ch 49a Chao, Lauritsen, and Tollestrup, Phys. Rev. **76**, 586 (1949).

Ch 50 Chao, Tollestrup, Fowler, and Lauritsen, Phys. Rev. **79**, 108 (1950).

Co 34 J. D. Cockcroft and E. T. S. Walton, Proc. Roy. Soc. (London) **A144**, 704 (1934).

Co 36 J. D. Cockcroft and W. B. Lewis, Proc. Roy. Soc. (London) **A154**, 246 (1936).

Co 36a J. D. Cockcroft and W. B. Lewis, Proc. Roy. Soc. (London) **A154**, 261 (1936).
Co 49 W. Cochrane and A. G. Hester, Proc. Roy. Soc. (London) **A199**, 458 (1949).
Co 53 Collins, McKenzie, and Ramm, Proc. Roy. Soc. (London) **A216**, 242 (1953).
Co 53a B. L. Cohen, Phys. Rev. **91**, 74 (1953).
Co 54 C. F. Cook and T. W. Bonner, Phys. Rev. **94**, 807 (1954).
Cr 49 R. J. Creagan, Phys. Rev. **76**, 1769 (1949).
Cr 50 J. Crussard, Nature **166**, 825 (1950).
Cr 50a J. Crussard, Compt. rend. **231**, 141 (1950).
Cr 52 Craig, Donahue, and Jones, Phys. Rev. **88**, 808 (1952).
Cu 39 Curran, Dee, and Petrzilka, Proc. Roy. Soc. (London) **A169**, 269 (1939).
Cu 47 P. Cuer, J. phys. et radium **8**, 83 (1947).
Cu 50 C. D. Curling and J. O. Newton, Nature **165**, 609 (1950).
Cu 50a Curtis, Hornbostel, Lee, and Salant, Phys. Rev. **77**, 290 (1950).
Cu 53 P. Cuer and J. Jung, Compt. rend. **236**, 1252 (1953).
Cu 53 P. Cuer and P. Jung, Compt. rend. **236**, 1252 (1953).
Da 39 W. L. Davidson, Jr., Phys. Rev. **56**, 1061 (1939).
Da 39a W. L. Davidson, Jr., Phys. Rev. **56**, 1062 (1939).
Da 47 P. W. Davison and E. Pollard, Phys. Rev. **72**, 162 (1947).
Da 49 P. W. Davison, Phys. Rev. **75**, 757 (1949).
Da 49a Davison, Buchanan, and Pollard, Phys. Rev. **76**, 890 (1949).
De 36 P. I. Dee and C. W. Gilbert, Proc. Roy. Soc. (London) **A154**, 279 (1936).
De 37 Delsasso, Fowler, and Lauritsen, Phys. Rev. **51**, 391 (1937).
De 52 Dewan, Pepper, Allen, and Almqvist, Phys. Rev. **86**, 416 (1952).
Di 50 B. C. Diven and G. M. Almy, Phys. Rev. **80**, 407 (1950).
Do 53 Donahue, Jones, McEllistrem, and Richards, Phys. Rev. **89**, 824 (1953).
Du 34 J. R. Dunning, Phys. Rev. **45**, 586 (1934).
Du 34a W. E. Duncanson and H. Miller, Proc. Roy. Soc. (London) **A146**, 396 (1934).
Du 34b W. E. Duncanson, Proc. Cambridge Phil. Soc. **30**, 102 (1934).
Du 38 DuBridge, Barnes, Buck, and Strain, Phys. Rev. **53**, 447 (1938).
Dy 53 Dyer and Bird, Australian J. Phys. **6**, 45 (1953).
Eb 54 Eby, Hill, and Jentschke, Phys. Rev. **93**, 925 (1954).
El 47 Elder, Motz, and Davison, Phys. Rev. **71**, 917 (1947).
El 48 L. G. Elliott and R. E. Bell, Phys. Rev. **74**, 1869 (1948).
El 51 El-Bedewi, Middleton, and Tai, Proc. Phys. Soc. (London) **64A**, 756 (1951).
El 51a F. A. El-Bedewi, Proc. Phys. Soc. (London) **64A**, 947 (1951).
El 51b L. G. Elliott (private communication).
El 51c F. A. El-Bedewi, Proc. Phys. Soc. (London) **64A**, 1079 (1951).
El 51d F. A. El-Bedewi, Proc. Roy. Soc. (London) **64A**, 584 (1951).
El 52 El-Bedewi, Middleton, and Tai, Nature **169**, 235 (1952).
El 53 M. M. Elkind, Phys. Rev. **92**, 127 (1953).
En 51 Enge, Buechner, Sperduto, and Van Patter, Phys. Rev. **83**, 31 (1951).
En 51a Endt, Van Patter, Buechner, and Sperduto, Phys. Rev. **83**, 491 (1951).
En 51b W. W. Ennis, Phys. Rev. **82**, 304 (1951).
Ev 53 Evans, Green, and Middleton, Proc. Phys. Soc. (London), **66A**, 108 (1953).
Fa 48 H. Faraggi, Compt. rend. **227**, 527 (1948).
Fa 51 Facchini, Galti, and Germagnoli, Nuovo cimento **8**, 145 (1951).
Fa 53 K. F. Famularo and G. C. Phillips, Phys. Rev. **91**, 1195 (1953).
Fl 36 R. Fleischmann, Z. Physik **103**, 113 (1936).
Fo 48 Fowler, Lauritsen, and Lauritsen, Revs. Modern Phys. **20**, 236 (1948).
Fo 49 Fowler, Lauritsen, and Tollestrup, Phys. Rev. **76**, 1767 (1949).
Fo 50 J. L. Fowler and J. M. Slye, Jr., Phys. Rev. **77**, 787 (1950).
Fo 52 A. Folkierski, Proc. Phys. Soc. (London) **65A**, 1006 (1952).
Fr 48 J. M. Freeman and A. S. Baxter, Nature **162**, 696 (1948).
Fr 50 Franzen, Halpern, and Stephens, Phys. Rev. **77**, 641 (1950).
Fr 50a A. P. French and P. B. Treacy, Proc. Phys. Soc. (London) **63A**, 665 (1950).
Fr 50b J. M. Freeman, Proc. Phys. Soc. (London) **63A**, 668 (1950).
Fr 50c H. Franz and H. Westmeyer, Z. Physik **128**, 617 (1950).
Fr 51 A. P. French and D. M. Thomson, Proc. Phys. Soc. (London) **64A**, 203 (1951).
Fr 51a J. M. Freeman and J. Seed, Proc. Phys. Soc. (London) **64A**, 314 (1951).
Fr 51b G. M. Frye, Jr., and W. L. Weidenbeck, Phys. Rev. **82**, 960 (1951).
Fr 51c A. P. French and P. B. Treacy, Proc. Phys. Soc. (London) **64A**, 452 (1951).
Fr 53 R. T. Frost and S. S. Hanna, Phys. Rev. **91**, 462 (1953).
Fr 54 G. M. Frye, Jr., Phys. Rev. **93**, 1086 (1954).
Fu 38 E. Fünfer, Ann. Physik **32**, 313 (1938).
Ga 37 E. R. Gaerttner and H. R. Crane, Phys. Rev. **51**, 49 (1937).
Gh 48 S. N. Ghoshal, Phys. Rev. **73**, 417 (1948).
Gi 44 Gibert, Roggen, and Rossel, Helv. Phys. Acta **17**, 97 (1944).
Gi 48 C. W. Gilbert, Proc. Cambridge Phil. Soc. **44**, 447 (1948).
Gi 48a W. M. Gibson and D. L. Livesey, Proc. Phys. Soc. (London) **60A**, 523 (1948).
Gi 49 W. M. Gibson, Proc. Phys. Soc. (London) **62A**, 586 (1949).
Gi 50 W. M. Gibson and L. L. Green, Proc. Phys. Soc. (London) **63A**, 494 (1950).
Gi 52 W. M. Gibson and E. E. Thomas, Proc. Roy. Soc. (London) **A120**, 543 (1952).
Gl 53 Glass, Jensen, and Richardson, Phys. Rev. **90**, 320 (1953).
Gl 53a N. W. Glass and J. R. Richardson, Phys. Rev. **93**, 942 (1954).
Go 49 Goward, Titterton, and Wilkins, Proc. Phys. Soc. (London) **62A**, 460 (1949).
Go 51a H. E. Gove and J. A. Harvey, Phys. Rev. **82**, 658 (1951).
Go 53 E. Goldberg, Phys. Rev. **89**, 760 (1953).
Gr 40 E. R. Graves, Phys. Rev. **57**, 855 (1940).
Gr 49a L. L. Green and W. M. Gibson, Proc. Phys. Soc. (London) **62A**, 407 (1949).
Gr 50 J. C. Grosskreutz and K. B. Mather, Phys. Rev. **77**, 580 (1950).
Gr 53 G. M. Griffiths and J. B. Warren, Phys. Rev. **92**, 1084 (1953).
Gu 47 Guggenheimer, Heitler, and Powell, Proc. Roy. Soc. (London) **A190**, 196 (1947).
Gu 51 P. C. Gugelot, Phys. Rev. **81**, 51 (1951).
Gu 52 Guier, Bertini, and Roberts, Phys. Rev. **85**, 426 (1952).
Ha 33 O. Haxel, Z. Physik **83**, 323 (1933).
Ha 35 O. Haxel, Z. Physik **93**, 400 (1935).
Ha 35a O. Haxel, Physik. Z. **36**, 804 (1935).
Ha 40a Haxby, Shoupp, and Wells, Phys. Rev. **58**, 1035 (1940).
Ha 44 A. O. Hanson and D. L. Benedict, Phys. Rev. **65**, 33 (1944).
Ha 49a Hanson, Duffield, Knight, Diven, and Palevsky, Phys. Rev. **76**, 578 (1949).
Ha 49b A. O. Hanson, Phys. Rev. **75**, 1794 (1949).
Ha 50a G. C. Hanna, Phys. Rev. **80**, 530 (1950).
Ha 51 J. A. Harvey, Phys. Rev. **81**, 353 (1951).
Ha 51b E. M. Hafner, Quart. Progr. Rept. Brookhaven National Laboratory, BNL 117 (August, 1951).
Ha 51c B. Hamermesh and V. Hummel, Phys. Rev. **83**, 663 (1951).
Ha 52 Haslam, Summers-Gill, and Crosby, Can. J. Phys. **30**, 257 (1952).
Ha 52a H. Hanni and J. Rossel, Helv. Phys. Acta **25**, 521 (1952).
Ha 52b B. Hamermesh and V. Hummel, Phys. Rev. **88**, 916 (1952).

Ha 52c U. H. Hauser, Z. Naturforsch. **7A**, 781 (1952).
Ha 53 J. A. Harvey, Can. J. Phys. **31**, 278 (1953).
Ha 53a B. Hamermesh and V. Hummel, Phys. Rev. **92**, 211 (1953).
He 48 N. P. Heydenburg and D. R. Inglis, Phys. Rev. **73**, 230 (1948).
He 48b A. Hemmendinger, Phys. Rev. **73**, 806 (1948).
He 49 Herb, Snowden, and Sala, Phys. Rev. **75**, 246 (1949).
He 49a Heydenburg, Inglis, Whitehead, and Hafner, Phys. Rev. **75**, 1147 (1949).
He 49b A. Hemmendinger, Phys. Rev. **75**, 1267 (1949).
Hi 54 Hintz, Blair, and Van Patter, Phys. Rev. **93**, 924 (1954).
Hj 52 E. Hjalmar and H. Slätis, Arkiv Fysik **4**, 323 (1952).
Hj 53 E. Hjalmar and H. Slätis, Arkiv Fysik **6**, 451 (1953).
Ho 38 M. G. Holloway and M. S. Livingston, Phys. Rev. **54**, 18 (1938).
Ho 40 M. G. Holloway and H. A. Bethe, Phys. Rev. **57**, 747 (1940).
Ho 40a M. G. Holloway and B. L. Moore, Phys. Rev. **58**, 847 (1940).
Ho 50a Hornyak, Lauritsen, Morrison, and Fowler, Revs. Modern Phys. **22**, 291 (1950).
Ho 51 Horsley, Johns, and Haslam, Phys. Rev. **83**, 886 (1951).
Ho 51a D. C. Hoesterey, Science **114**, 481A (1951).
Ho 52 D. C. Hoesterey, Phys. Rev. **87**, 216 (1952).
Ho 53 J. R. Holt and T. N. Marsham, Proc. Phys. Soc. (London) **66A**, 565 (1953).
Hu 40 Huber, Huber, and Scherrer, Helv. Phys. Acta **13**, 209 (1940).
Hu 41 C. J. Humphreys and W. W. Watson, Phys. Rev. **60**, 542 (1941).
Hu 41a P. Huber, Helv. Phys. Acta **14**, 163 (1941).
Hu 48 P. Huber and A. Stebler, Phys. Rev. **73**, 85 (1948).
Hu 48a D. J. Hughes and C. Eggler, Phys. Rev. **73**, 809 (1948).
Hu 49 E. Hudspeth and C. P. Swann, Phys. Rev. **76**, 464 (1949).
Hu 49a E. Hudspeth and C. P. Swann, Phys. Rev. **76**, 1150 (1949).
Hu 50b Hudspeth, Swann, and Heydenburg, Phys. Rev. **80**, 643 (1950).
Hu 51 Huber, Baldinger, and Proctor, Helv. Phys. Acta **24**, 302 (1951).
Hu 51a Huizenga, Magnusson, Fields, Studier, and Duffield, Phys. Rev. **82**, 561 (1951).
In 50 D. R. Inglis, Phys. Rev. **78**, 104 (1950).
Ja 35 R. Jaeckel, Z. Physik **96**, 151 (1935).
Je 40 W. Jentske, Physik. Z. **41**, 524 (1940).
Je 44 P. Jensen, Z. Physik **122**, 387 (1944).
Je 49a W. P. Jesse and J. Sadaukis, Phys. Rev. **75**, 1110 (1949).
Je 50 Jesse, Forstat, and Sadaukis, Phys. Rev. **77**, 782 (1950).
Je 50a J. V. Jelley and E. B. Paul, Proc. Phys. Soc. (London) **63A**, 112 (1950).
Je 50b J. V. Jelley, Phil. Mag. **41**, 1199 (1950).
Jo 50 Johns, Katz, Douglas, and Haslam, Phys. Rev. **80**, 1062 (1950).
Jo 51 Johnson, Bockelman, and Barschall, Phys. Rev. **82**, 117 (1951).
Jo 51a G. A. Jones and D. H. Wilkinson, Proc. Phys. Soc. (London) **64A**, 756 (1951).
Jo 52 Johnson, Robinson, and Moak, Phys. Rev. **85**, 931 (1952).
Jo 53 Jones, McEllistrem, Douglas, and Richards, Phys. Rev. **91**, 482 (1953).
Jo 53a Jones, Donahue, McEllistrem, Douglas, and Richards, Phys. Rev. **91**, 879 (1953).
Ka 51a L. Katz and A. S. Penfold, Phys. Rev. **81**, 815 (1951).
Ka 52 Kaufmann, Goldberg, Koester, and Mooring, Phys. Rev. **88**, 673 (1952).
Ka 53 Katz, Baker, and Montalbatti, Can. J. Phys. **31**, 250 (1953).
Ke 51 K. K. Keller, Phys. Rev. **84**, 884 (1951).
Ki 50 Kinsey, Bartholomew, and Walker, Phys. Rev. **77**, 723 (1950).
Ki 50a Kinsey, Bartholomew, and Walker, Phys. Rev. **78**, 481 (1950).
Ki 50b B. B. Kinsey and G. A. Bartholomew, Phys. Rev. **80**, 918 (1950).
Ki 51 Kinsey, Bartholomew, and Walker, Can. J. Phys. **29**, 1 (1951).
Ki 51a Kinsey, Bartholomew, and Walker, Phys. Rev. **83**, 519 (1951).
Ki 51b Kinsey, Bartholomew, and Walker, Phys. Rev. **82**, 380 (1951).
Ki 52 Kinsey, Bartholomew, and Walker, Phys. Rev. **85**, 1012 (1952).
Ki 53 B. B. Kinsey and G. A. Bartholomew, Phys. Rev. **89**, 375 (1953).
Ki 53a J. S. King and W. C. Parkinson, Phys. Rev. **89**, 1080 (1953).
Ki 53b B. B. Kinsey and G. H. Bartholomew, Can. J. Phys. **31**, 537 (1953).
Ki 53c B. B. Kinsey and G. A. Bartholomew, Can. J. Phys. **31**, 1051 (1953).
Ki 53d Kington, Bair, Carlson, and Willard, Phys. Rev. **89**, 530 (1953).
Ki 53e B. B. Kinsey and G. A. Bartholomew, Can. J. Phys. **31**, 901 (1953).
Kl 51 E. D. Klema and G. C. Phillips, Phys. Rev. **83**, 212 (1951).
Ko 34 A. König, Z. Physik **90**, 197 (1934).
Kr 53 A. Z. Kranz and W. W. Watson, Phys. Rev. **91**, 1472 (1953).
Ku 49 H. Kubitschek and S. M. Dancoff, Phys. Rev. **76**, 531 (1949).
Ku 53 Kunz, Moak, and Good, Phys. Rev. **91**, 676 (1953).
La 35 E. Lawrence, Phys. Rev. **47**, 17 (1935).
La 35a Lawrence, McMillan, and Henderson, Phys. Rev. **47**, 273 (1935).
La 40 C. C. Lauritsen and W. A. Fowler, Phys. Rev. **58**, 193 (1940).
La 47 Lattes, Fowler, and Cuer, Proc. Phys. Soc. (London) **59A**, 883 (1947).
La 50b H. H. Landon, Phys. Rev. **78**, 338 (1950).
Le 33 Lewis, Livingston, and Lawrence, Phys. Rev. **44**, 55 (1933).
Le 47 Leith, Bratenahl, and Moyer, Phys. Rev. **72**, 732 (1947).
Le 50 Levinthal, Martinelli, and Silverman, Phys. Rev. **78**, 199 (1950).
Li 33 Livingston, Henderson, and Lawrence, Phys. Rev. **44**, 316 (1933).
Li 37 M. S. Livingston and H. A. Bethe, Revs. Modern Phys. **9**, 245 (1937).
Li 38 M. S. Livingston and J. G. Hoffman, Phys. Rev. **53**, 227 (1938).
Li 48 D. L. Livesey and D. H. Wilkinson, Proc. Roy. Soc. (London) **A195**, 123 (1948).
Li 51 C. W. Li and W. Whaling, Phys. Rev. **82**, 122 (1951).
Li 51a Li, Whaling, Fowler, and Lauritsen, Phys. Rev. **83**, 512 (1951).
Lo 52 Lovington, McCue, and Preston, Phys. Rev. **85**, 585 (1952).
Ma 34 G. Mano, J. phys. et radium **5**, 628 (1934).
Ma 36 A. N. May and R. Vaidyanathan, Proc. Roy. Soc. (London) **A155**, 519 (1936).
Ma 37 W. Maurer, Z. Physik **107**, 721 (1937).
Ma 39 W. Maurer and J. B. Fisk, Z. Physik **112**, 436 (1939).
Ma 47 A. B. Martin, Phys. Rev. **72**, 378 (1947).
Ma 47a A. N. May and E. P. Hincks, Can. J. Research **A25**, 77 (1947).
Ma 49 C. E. Mandeville, Phys. Rev. **76**, 436 (1949).
Ma 49a Mandeville, Swann, and Snowden, Phys. Rev. **76**, 980 (1949).
Ma 49b J. Mattauch and A. Flammersfeld, *Isotopenbericht*, (Verlagder Zeitschrift für Naturforschung, Tübingen, 1949).
Ma 50d R. Malm and W. W. Buechner, Phys. Rev. **80**, 771 (1950).
Ma 50e C. E. Mandeville and C. P. Swann, Phys. Rev. **79**, 787 (1950).
Ma 51 R. Malm and W. W. Buechner, Phys. Rev. **81**, 519 (1951).
Ma 51a Magnusson, Huizenga, Fields, Studier, and Duffield, Phys. Rev. **84**, 166 (1951).
Ma 52 Mandeville, Swann, Chatterjee, and Van Patter, Phys. Rev. **85**, 193 (1952).

Ma 52a W. M. Martin and S. W. Breckon, Can. J. Phys. **30**, 643 (1952).
Mc 35 E. McMillan and E. O. Lawrence, Phys. Rev. **47**, 343 (1935).
Mc 40 McCreary, Kuerti, and Van Voorhis, Phys. Rev. **57**, 351 (1940).
Mc 49 McElhinney, Hanson, Becker, Duffield, and Diven, Phys. Rev. **75**, 542 (1949).
Mc 50 J. McElhinney and W. E. Ogle, Phys. Rev. **78**, 63 (1950).
Mc 51 McMinn, Sampson, and Rasmussen, Phys. Rev. **84**, 963 (1951).
Mc 51a J. J. G. McCue and W. M. Preston, Phys. Rev. **84**, 384 (1951).
Mc 51b J. J. G. McCue and W. M. Preston, quoted in St 51c.
Mc 53 C. E. McFarland and F. B. Shull, Phys. Rev. **89**,489 (1953).
Mc 53a McFarland, Bretscher, and Shull, Phys. Rev. **89**, 892 (1953).
Me 40 O. Merhaut, Physik. Z. **41**, 528 (1940).
Me 48 Metzger, Alder, and Huber, Helv. Phys. Acta **21**, 278 (1948).
Me 50 P. Meyer, Z. Physik **128**, 451 (1950).
Mi 40 L. C. Miller, Phys. Rev. **58**, 935 (1940).
Mi 51a R. Middleton and C. T. Tai, Proc. Phys. Soc. (London) **64A**, 801 (1951).
Mi 52 C. Mileikowsky and W. Whaling, Phys. Rev. **88**, 1254 (1952).
Mi 53 Middleton, El-Bedewi, and Tai, Proc. Phys. Soc. (London) **66A**, 95 (1953).
Mi 54 C. Mileikowsky, Arkiv Fysik **7**, 89 (1954).
Mi 54a C. Mileikowsky, Arkiv Fysik **7**, 117 (1954).
Mo 48 H. T. Motz and R. F. Humphreys, Phys. Rev. **74**, 1232 (1948).
Mo 50 R. C. Mobley and R. A. Laubenstein, Phys. Rev. **80**, 309 (1950).
Mo 50a H. T. Motz and R. F. Humphreys, Phys. Rev. **80**, 595 (1950).
Mo 53 C. D. Moak, Phys. Rev. **92**, 383 (1953).
Mo 53a C. D. Moak, Phys. Rev. **91**, 462 (1953).
Mu 39 E. B. M. Murrell and C. L. Smith, Proc. Roy. Soc. (London) **A173**, 410 (1939).
My 39 Myers, Huntoon, Shull, and Crenshaw, Phys. Rev. **56**, 1104 (1939).
Na 49 L. Natanson, Compt. rend. **229**, 588 (1949).
Ne 35 H. Neuert, Physik. Z. **36**, 629 (1935).
Ne 35a H. W. Newson, Phys. Rev. **48**, 790 (1935).
Ne 49 A. Nemilov, Doklady Akad. Nauk SSSR **66**, 369 (1949).
Ne 49a A. Nemilov and B. L. Funshtein, Doklady Akad. Nauk SSSR **66**, 609 (1949).
No 53 Noyes, Van Hoomissen, Miller, and Waldman, Technical Report No. 3, University of Notre Dame (November, 1953).
Og 47 Ogle, Brown, and Conklin, Phys. Rev. **71**, 378 (1947).
Og 50 W. E. Ogle and R. E. England, Phys. Rev. **78**, 63 (1950).
Og 50a Ogle, Brown, and Carson, Phys. Rev. **78**, 63 (1950).
Ol 35 Oliphant, Kempton, and Rutherford, Proc. Roy. Soc. (London) **A149**, 406 (1935).
Ol 35a Oliphant, Kempton, and Rutherford, Proc. Roy. Soc. (London) **A150**, 241 (1935).
Ol 51 M. I. Ollano and R. R. Roy, Nuovo cimento **8**, 77 (1951).
Pa 37 Parkinson, Herb, Bellamy, and Hudson, Phys. Rev. **52**, 75 (1937).
Pa 48 W. K. H. Panofsky and R. Phillips, Phys. Rev. **74**, 1732 (1948).
Pa 50 E. B. Paul, Phil. Mag. **41**, 942 (1950).
Pa 50a R. W. Parsons and C. H. Collie, Proc. Phys. Soc. (London) **63A**, 839 (1950).
Pa 50b H. Palevsky and A. O. Hanson, Phys. Rev. **79**, 242 (1950).
Pa 50c Parsons, Lees, and Collie, Proc. Phys. Soc. (London) **63A**, 915 (1950).
Pe 40 G. J. Perlow, Phys. Rev. **58**, 218 (1940).
Pe 47a R. A. Peck, Jr., Phys. Rev. **72**, 1121 (1947).
Pe 48 R. A. Peck, Jr., Phys. Rev. **73**, 947 (1948).
Pe 49 R. A. Peck, Jr., Phys. Rev. **76**, 1279 (1949).
Pe 50a J. L. Perkin, Phys. Rev. **79**, 175 (1950).
Pe 52 Pepper, Allen, Almqvist, and Dewan, Phys. Rev. **85**, 155 (1951).
Pi 52 G. F. Pieper, Phys. Rev. **87**, 215 (1952).
Pi 52a G. F. Pieper, Phys. Rev. **88**, 1299 (1952).
Po 37 E. Pollard and C. J. Brasefield, Phys. Rev. **51**, 8 (1937).
Po 38 Pollard, Schultz, and Brubaker, Phys. Rev. **53**, 351 (1938).
Po 38a E. Pollard, Phys. Rev. **54**, 411 (1938).
Po 39 E. Pollard, Phys. Rev. **56**, 1168 (1939).
Po 40 E. Pollard, Phys. Rev. **57**, 241 (1940).
Po 40a E. Pollard, Phys. Rev. **57**, 1086 (1940).
Po 40b Pollard, Davidson, and Schultz, Phys. Rev. **57**, 1117 (1940).
Po 43 C. F. Powell, Proc. Roy. Soc. (London) **A181**, 344 (1943).
Po 47 E. Pollard and P. W. Davison, Phys. Rev. **72**, 736 (1947).
Po 47a C. F. Powell and G. P. S. Ochialini, *Nuclear Physics in Photographs* (Oxford University Press, London, (1947).
Po 49 Pollard, Sailor, and Wyly, Phys. Rev. **75**, 725 (1949).
Pr 51 R. W. Pringle and G. Isford, Phys. Rev. **83**, 467 (1951).
Pr 52 Pruitt, Hanna, and Swartz, Phys. Rev. **87**, 534 (1952).
Re 51 I. Resnick and S. S. Hanna, Phys. Rev. **82**, 463 (1951).
Ri 48 H. T. Richards and R. V. Smith, Phys. Rev. **74**, 1870 (1948).
Ri 50 Richards, Smith, and Browne, Phys. Rev. **80**, 524 (1950).
Ri 51 Richards, Johnson, Ajzenberg, and Laubenstein, Phys. Rev. **83**, 994 (1951).
Ro 48 L. del Rosario, Phys. Rev. **74**, 304 (1948).
Ro 50 J. Rotblat, Nature **165**, 387 (1950).
Ro 51a R. R. Roy, Phys. Rev. **82**, 227 (1951).
Ro 51b R. S. Rochlin, Phys. Rev. **84**, 165 (1951).
Ro 51d R. R. Roy, Bull. centre phys. nucléaire univ. libre Bruxelles **31**, 9 (1951).
Ro 51c J. Rotblat, Nature **167**, 550 (1951).
Ro 52 Rose, Hudspeth, and Heydenburg, Phys. Rev. **87**, 382 (1952).
Ro 53 L. Rosen, Nucleonics **11**, No. 8, 38 (1953).
Ru 38 Rumbaugh, Roberts, and Hafstad, Phys. Rev. **54**, 657 (1938).
Ru 51a Rutherglen, Rae, and Smith, Proc. Phys. Soc. (London) **64A**, 906 (1951).
Ru 53 J. D. Rutherglen and R. D. Smith, Proc. Phys. Soc. (London) **66A**, 800 (1953).
Ru 54 Rutherglen, Grant, Flack, and Deuchars, Proc. Phys. Soc. (London) **67A**, 101 (1954).
Sa 35 P. Savel, Ann. phys. **4**, 88 (1935).
Sa 49 V. L. Sailor, Phys. Rev. **75**, 1836 (1949).
Sa 50 V. L. Sailor, Phys. Rev. **77**, 794 (1950).
Sa 51 A. J. Salmon, Proc. Phys. Soc. (London) **64A**, 848 (1951).
Sc 50 Schelburg, Sampson, and Cochrane, Phys. Rev. **80**, 574 (1950).
Sc 52 Schoenfeld, Duborg, Preston, and Goodman, Phys. Rev. **85**, 873 (1952).
Sc 53 J. P. Schiffer and E. Pollard, Phys. Rev. **91**, 474 (1953).
Sc 53a J. E. Schwager and L. A. Cox, Phys. Rev. **92**, 102 (1953).
Se 51 J. Seed, Phil. Mag. **42**, 566 (1951).
Se 53 R. L. Seale, Phys. Rev. **92**, 389 (1953).
Sh 41 E. F. Shrader and E. Pollard, Phys. Rev. **59**, 277 (1941).
Sh 45 R. Sherr, Phys. Rev. **68**, 240 (1945).
Sh 48 Shoupp, Jennings, and Jones, Phys. Rev. **73**, 421 (1948).
Sh 49 Shoupp, Jennings, and Sun, Phys. Rev. **75**, 1 (1949).
Sh 49a Sherr, Muether, and White, Phys. Rev. **75**, 282 (1949).
Sh 49b Shoupp, Jennings, and Jones, Phys. Rev. **76**, 502 (1949).
Sh 51 Sher, Halpern, and Mann, Phys. Rev. **84**, 387 (1951).
Sh 51a Sher, Halpern, and Stephens, Phys. Rev. **81**, 154 (1951).
Sh 51b F. B. Shull, Phys. Rev. **83**, 875 (1951).
Sh 52 F. B. Shull and C. E. McFarland, Phys. Rev. **87**, 216 (1952).
Sh 53 Shire, Wormald, Lindsay-Jones, Lunden, and Stanley, Phil. Mag. **44**, 1197 (1953).
Sl 51 Slätis, Hjalmar, and Carlsson, Phys. Rev. **81**, 641 (1951).

Sl 52 H. Slätis, Arkiv Fysik **3**, 315 (1952).
Sm 39 N. M. Smith, Jr., Phys. Rev. **56**, 548 (1939).
Sm 41 E. C. Smith and E. Pollard, Phys. Rev. **59**, 942 (1941).
Sm 47 J. H. Smith, Phys. Rev. **71**, 32 (1947).
Sm 50 R. V. Smith and D. H. Martin, Phys. Rev. **77**, 752 (1950).
Sn 52 S. C. Snowden, Phys. Rev. **86**, 630 (1952).
Sn 52a S. C. Snowden, Phys. Rev. **87**, 1022 (1952).
So 46 H. S. Sommers, Jr., and R. Sherr, Phys. Rev. **69**, 21 (1946).
Sp 52 A. Sperduto and W. W. Buechner, Phys. Rev. **88**, 574 (1952).
St 35 H. Stegmann, Z. Physik **95**, 72 (1935).
St 37 Stephens, Djanab, and Bonner, Phys. Rev. **52**, 1079 (1937).
St 38 W. E. Stephens, Phys. Rev. **53**, 223 (1938).
St 38a C. V. Strain, Phys. Rev. **54**, 1021 (1938).
St 39 H. Staub and W. E. Stephens, Phys. Rev. **55**, 131 (1939).
St 48 A. Stebler and P. Huber, Helv. Phys. Acta **21**, 59 (1948).
St 49 Stebler, Huber, and Bichsel, Helv. Phys. Acta **22**, 362 (1949).
St 50 Stelson, Preston, and Goodman, Phys. Rev. **80**, 287 (1950).
St 51a Stephens, Halpern, and Sher, Phys. Rev. **82**, 511 (1951).
St 51b Strait, Van Patter, Buechner, and Sperduto, Phys. Rev. 81, 747 (1951).
St 51c W. J. Sturm and J. Johnson, Phys. Rev. **83**, 542 (1951).
St 51d P. H. Stelson and W. M. Preston, Phys. Rev. **82**, 655 (1951).
St 51e P. H. Stelson and W. M. Preston, Phys. Rev. **83**, 469 (1951).
St 52 P. H. Stelson and W. M. Preston, Phys. Rev. **86**, 807 (1952).
Su 53 Summers-Gill, Haslam, and Katz, Can. J. Phys. **31**, 70 (1953).
Sw 49 C. P. Swann and E. L. Hudspeth, Phys. Rev. **76**, 168 (1949).
Sw 50 Swann, Mandeville, and Whitehead, Phys. Rev. **79**, 598 (1950).
Sw 51 C. P. Swann and C. E. Mandeville, Phys. Rev. **82**, 772 (1951).
Sw 52 C. P. Swann and C. E. Mandeville, Phys. Rev. **87**, 214 (1952).
Ta 49 Taschek, Argo, Hemmendinger, and Jarvis, Phys. Rev. **76**, 325 (1949).
Ta 54 Taylor, Robinson, and Haslam, Can. J. Phys. **32**, 238 (1954).
Te 47 D. J. Tendam and H. L. Bradt, Phys. Rev. **72**, 1118 (1947).
Ti 51 E. W. Titterton and T. A. Brinkley, Proc. Phys. Soc. (London) **64A**, 212 (1951).
To 49 Tollestrup, Jenkins, Fowler, and Lauritsen, Phys. Rev. **75**, 1947 (1949).
To 49a Tollestrup, Fowler, and Lauritsen, Phys. Rev. **76**, 428 (1949).
To 53 B. J. Toppel and S. D. Bloom, Phys. Rev. **91**, 473 (1953).
Tr 53 C. C. Trail and C. H. Johnson, Phys. Rev. **91**, 474 (1953).
Tr 53a P. B. Treacy, Phil. Mag. **44**, 325 (1953).
Tu 52 B. L. Tucker and E. C. Gregg, Phys. Rev. **87**, 907 (1952).
Va 50 Van Patter, Sperduto, Strait, and Buechner, Phys. Rev. **79**, 900 (1950).
Va 51 Van Patter, Sperduto, Huang, Strait, and Buechner, Phys. Rev. **81**, 233 (1951).
Va 51a Van Patter, Sperduto, and Enge, Phys. Rev. **83**, 212 (1951).
Va 52 Van Patter, Sperduto, Endt, Buechner, and Enge, Phys. Rev. **85**, 142 (1952).
Va 52a D. M. Van Patter, Massachusetts Institute of Technology Technical Report No. 57 (January 15, 1952).
Ve 51 G. Vendryes, Compt. rend. **233**, 391 (1951).
Wa 36 J. R. S. Waring and W. Y. Chang, Proc. Roy. Soc. (London) **A157**, 652 (1936).
Wa 40a W. W. Watson and E. Pollard, Phys. Rev. **57**, 1082 (1940).
Wa 48 R. L. Walker and B. D. McDaniel, Phys. Rev. **74**, 315 (1948).
Wa 50b R. L. Walker, Phys. Rev. **79**, 172 (1950).
Wa 52 H. A. Watson and W. W. Buechner, Phys. Rev. **88**, 1324 (1952).
Wa 52a Way, Fuller, Wood, Thew, and Justus, Supplement 3 to Natl. Bur. Standards Circular (1952).
Wa 53 N. S. Wall, Phys. Rev. **91**, 485 (1953).
Wa 53a N. S. Wall, Phys. Rev. **92**, 1526 (1953).
Wa 53b J. B. Warren and G. M. Griffiths, Phys. Rev. **92**, 1084 (1953).
Wa 54 N. S. Wall, Ph.D. thesis, Massachusetts Institute of Technology (1953) and private communication.
Wh 39 White, Delsasso, Fox, and Creutz, Phys. Rev. **56**, 512 (1939).
Wh 50 W. D. Whitehead and C. E. Mandeville, Phys. Rev. **77**, 732 (1950).
Wh 50a W. Whaling and J. W. Butler, Phys. Rev. **78**, 72 (1950).
Wh 50b W. D. Whitehead and M. P. Heydenburg, Phys. Rev. **79**, 99 (1950).
Wh 51 W. Whaling and C. W. Li, Phys. Rev. **81**, 150 (1951).
Wh 51a W. D. Whitehead, Phys. Rev. **82**, 553 (1951).
Wh 53 Wheeler, Schwartz, and Watson, Phys. Rev. **92**, 121 (1953).
Wi 37 Williams, Shepherd, and Haxby, Phys. Rev. **51**, 888 (1937).
Wi 37a Williams, Haxby, and Shepherd, Phys. Rev. **52**, 1031 (1937).
Wi 41 R. S. Wilson, Proc. Roy. Soc. (London) **A177**, 382 (1940–1941).
Wi 50 R. R. Wilson, Phys. Rev. **80**, 90 (1950).
Wi 51 Williamson, Browne, Craig, and Donahue, Phys. Rev. **84**, 731 (1951).
Wi 51a D. H. Wilkinson and J. H. Carver, Phys. Rev. **83**, 466 (1951).
Wi 52 Willard, Bair, Kington, Hahn, and Green, Phys. Rev. **85**, 849 (1952).
Wi 52a Willard, Kington, and Bair, Phys. Rev. **86**, 259 (1952).
Wo 50a Donald C. Worth, Phys. Rev. **78**, 378 (1950).
Wy 49 L. D. Wyly, Phys. Rev. **76**, 316 (1949).
Wy 49a Wyly, Sailor, and Ott, Phys. Rev. **76**, 1532 (1949).
Zl 38 I. Zlotowski, Compt. rend. **207**, 148 (1938).
Zu 50 A. Zucker and W. W. Watson, Phys. Rev. **78**, 14 (1950).
Zu 50a A. Zucker and W. W. Watson, Phys. Rev. **80**, 966 (1950).