Table of *ft* Values in Beta-Decay*

ARNOLD M. FEINGOLD†
Palmer Physical Laboratory, Princeton University, Princeton, New Jersey

INTRODUCTION

SINCE the publication in 1943 of Konopinski's (K16)‡ review article on beta-decay, a large amount of further information on beta-decay energies and lifetimes has appeared. Djelepov and Kudryavtseva (D7) compiled a table of *ft* products based on the literature to the end of 1948. This table was analyzed by Djelepov (D8). The table of *ft* products, or comparative lifetimes which follows is based on the isotope compilation of Seaborg and Perlman (S1) and subsequent literature to June 1, 1950. An analysis of an essentially identical table will be found in the preceding paper by Feenberg and Trigg (F11).

For the definition of *f* and a general discussion of the significance of the *ft* product, where *t* is the partial half-life, the reader is referred to Konopinski's review article. Formulas and extensive charts of *f* as a function of nuclear charge and decay energy are given by Feenberg and Trigg (F11).

DESCRIPTION OF TABLE I

The first column is self-explanatory. The suffix *m* indicates that the transition starts from a metastable state. The second column, headed "Class," indicates the reliability of the isotopic identification, and follows the classification used by Seaborg and Perlman: A = isotope certain (mass number and element certain), B = isotope probable, element certain, C = one of a few isotopes, element certain, D = element certain, E = element probable, and F = insufficient evidence.

The third column lists the disintegration modes that are known experimentally to be present for each isotope. The symbols have the following meaning: β^- = negative beta-particles, β^+ = positive beta-particles (positrons), $K = K$ electron capture (or in more general terms, orbital electron capture), α = alpha-particles, and I.T. = isomeric transition (transition from upper to lower isomeric state).

Where several modes of disintegration occur for one isotope, branching ratios, where measured, are indicated in parentheses (in percent of total disintegrations).

The half-lives in the fourth column are total half-lives. If the disintegration scheme is complex, the partial half-life for each particle group may be found from the branching ratios given in the third and fifth columns.

In column five the maximum kinetic energy in Mev of the various electron and positron groups is given. In most cases, the most recent or what is considered the most accurate measurement is the one listed; but occasionally, an average value is used. In a few cases where the energies reported in the literature were determined from $K-U$ plots, they have been arbitrarily lowered 100 or 200 kv. For some of the mirror nuclei only the lifetimes are known. For these nuclei the disintegration energy was calculated from the theoretical coulomb energy (W14). Energy values determined in this manner are enclosed in parentheses. For Be^7, where only *K*-capture occurs, the energies listed are the energy differences of the initial and final nuclear levels. Where the disintegration scheme is complex and several groups of like particles are present (i.e., several electron groups or several positron groups), the percentage of decay by each group, when known, is given in parentheses.

The column headed "Final state" gives the nature of the state in the residual nucleus to which the transition goes. The notation is, g = ground state, e = excited state (in a few cases this is an isomeric level), and g' = no conclusive evidence that it is not the ground state. States are labeled g or e when the disintegration scheme is known sufficiently well to make a positive identification of the nature of the level.

The logarithm to the base 10 of the *ft* product is given in the next column for each positron and electron group and for the two *K*-capture groups of Be^7. The *f* charts used for determining the *ft* values were prepared by graphically integrating spectrum shapes using the curves given by Bleuler and Zünti (B26). The resultant *f* charts were later compared with the corresponding charts of Feenberg and Trigg, and were also compared with *f* tables kindly supplied by Professor John Blatt. The *f* values are believed to be accurate to within 10 percent over the entire range of nuclear charge and energy and to be accurate to within 5 percent over most of the range. For the positron emitters, when either *K*-capture or the *K*-capture branching ratio has not been reported, the theoretical *K*-capture/β^+ ratio, as given in Feenberg and Trigg's charts, has been used in determining the partial half-life, *t*. This will, in some cases, yield *ft* values that are too low, since more levels in the final nucleus are generally available for *K*-capture than for positron emission. In a few cases where the theoretical ratio of *K*-capture to β^+-emission is much greater than a rough experimental value, the theoretical branching ratio has been used in preference to the experimental one. When this has been done the *ft* product

* This work was supported in part by the joint program of the ONR and AEC.
† Now at Randal Morgan Laboratory of Physics, University of Pennsylvania, Philadelphia, Pennsylvania.
‡ References given in parentheses will be found in the bibliography at the end of this article.

TABLE I. *ft* values.

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	(%)	Final state	Log *ft*	References
0	n^1	A	β−	~15*m*	0.780		*g'*	3.21	R1, T1, T2, S31
1	H^3	A	β−	12.46*y*	0.0185		*g*	3.06	C1, H1, J1, S3, B1, C2
2	He^6	A	β−	0.823*s*	3.215		*g*	2.74	H2, P1, K1, A1
3	Li^8	A	β−	0.88*s*	12.7	(90)	*e*	5.60	H3
					~6	(10)	*e*	5.02	
4	Be^7	A	*K*	52.9*d*	0.863	(89)	*g*	3.36	T3, W1, S4
					0.383	(11)	*e*	3.56	
	Be^{10}	A	β−	2.7×10^6y	0.555		*g*	13.65	F1, H4, W2, F2, H5, B2
5	B^{12}	A	β−	0.027*s*	13.43		*g'*	4.18	H3
6	C^{10}	B	β+	19.1*s*	2.2		*e*	3.30	S5
	C^{11}	A	β+	20.5*m*	0.96		*g*	3.59	T7
	C^{14}	A	β−	6000*y*	0.156		*g*	9.05	E1, J2, A2, M1, F3
	C^{15}	B	β−	2.4*s*	8.8		*e*?	5.27	H6
7	N^{12}	A	β+	0.0125*s*	16.6		*g'*	4.18	A3
	N^{13}	A	β+	10.13*m*	1.202		*g*	3.67	H3
	N^{16}	A	β−	7.35*s*	10.5	(20)	*g*	6.84	
					4.3	(40)	*e*	4.72	
					3.8	(40)	*e*	4.48	
	N^{17}	A	β−	4.14*s*	3.7		*e*	3.78	A4
8	O^{14}	B	β+	76.5*s*	1.8		*e*	3.52	S5
	O^{15}	A	β+	118*s*	1.68		*g'*	3.57	P2
	O^{19}	A	β−	29.4*s*	4.5	(30)	*g*	5.55	
					2.9	(70)	*e*	4.33	
9	F^{17}	A	β+	66*s*	2.0		*g'*	3.64	B3
	F^{18}	A	β+	112*m*	0.635		*g*	3.57	B4, K1
	F^{20}	A	β−	10.7*s*	5.03	(89)	*e*	4.88	S6, J6
					4.22	(11)	*e*	5.43	
10	Ne^{19}	A	β+	20.3*s*	2.20		*g'*	3.29	
	Ne^{23}	A	β−	40.7*s*	4.1		*g'*	5.01	B3
11	Na^{21}	B	β+	23*s*	(2.5)		*g'*	3.58	
	Na^{22}	A	β+	2.60*y*	1.8	(0.005)	*g*	13.82	M3, L1, M2
					0.542	(~100)	*e*	7.40	
	Na^{24}	A	β−	14.90*h*	1.390		*e*	6.11	W3
	Na^{25}	B	β−	58.2*s*	3.4		*g*	4.82	
12	Mg^{23}	A	β+	11.6*s*	2.82		*g'*	3.50	
	Mg^{27}	A	β−	9.6*m*	1.80	(80)	*e*	4.73	
					0.79	(20)	*e*	3.90	
13	Al^{25}	A	β+	7.3*s*	(3.1)		*g'*	3.47	B5
	Al^{26}	A	β+	6.3*s*	2.99		*g'*	3.34	B5
	Al^{28}	A	β−	2.30*m*	3.01		*e*	4.98	
	Al^{29}	A	β−	6.56*m*	2.5	(75)	*e*	5.21	S7
					1.4	(25)	*e*	4.62	
14	Si^{27}	A	β+	4.9*s*	3.54		*g'*	3.55	
	Si^{31}	A	β−	170*m*	1.8		*g*	5.91	
15	P^{29}	A	β+	4.6*s*	3.63		*g'*	3.57	
	P^{30}	A	β+	2.55*m*	3.0		*g'*	4.71	
	P^{32}	A	β−	14.3*d*	1.70		*g*	7.90	L2, A5
	P^{34}	B	β−	12.4*s*	5.1	(75)	*g'*	5.11	
					3.2	(25)	*e*	4.68	
16	S^{31}	A	β+	3.2*s*	3.85		*g'*	3.52	
	S^{35}	A	β−	87.1*d*	0.167		*g*	5.01	G1, L3, C14
	S^{37}	B	β−	5.04*m*	4.3	(10)	*g*	7.04	
					1.6	(90)	*e*	4.23	
17	Cl^{33}	A	β+	2.8*s*	4.13		*g'*	3.60	
	Cl^{34}	A	β+	33*m*	2.5		?	5.46	
	Cl^{36}	A	β−	4.4×10^5y	0.713		*g*	13.49	W4, W5
	Cl^{38}	A	β−	38.5*m*	4.81	(53)	*g*	7.44	L4
					2.77	(16)	*e*	6.89	
					1.11	(31)	*e*	4.96	
	Cl^{39}	A	β−	55.5*m*	2.5		*g'*	6.06	H7
18	A^{35}	A	β+	1.84*s*	4.4		*g'*	3.53	
	A^{41}	A	β−	109*m*	2.55	(0.7)	*g*	8.56	B6
					1.245	(99.3)	*e*	5.11	
19	K^{37}	F	β+	1.3*s*	(4.7)		*g'*	3.51	
	K^{38}	A	β+	7.5*m*	2.53		*e*	4.82	
	K^{40}	A	β−(90), *K*(10)	1.1×10^9y	1.36		*g*	18.05	F4, S2, A6, F5, B7, F10
	K^{42}	A	β−	12.44*h*	3.58	(75)	*g*	8.02	
					2.04	(25)	*e*	7.44	
	K^{43}	B	β−	22.4*h*	0.81	(~80)	*e*	5.60	O1
					0.24	(~20)	*e*	4.32	
20	Ca^{39}	F	β+	1.06*s*	(4.9)		*g'*	3.49	
	Ca^{45}	A	β−	152*d*	0.254		*g*	5.98	M4, M5
	Ca^{47}	F	β−	5.8*d*	1.1		*e*	6.83	
	Ca^{49}	A	β−	2.5*h*	2.3		?	6.39	

TABLE I.—*Continued.*

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	(%)	Final state	Log *ft*	References
21	Sc^{41}	A	$\beta+$	0.87*s*	4.94		*g'*	3.40	
	Sc^{43}	A	$\beta+$	3.92*h*	1.12		*g'*	4.81	
	Sc^{44}	A	$\beta+$, *K*	3.92*h*	1.478		*g*	>5.27	B8
					0.955		*e*	>4.47	
	Sc^{46}	A	$\beta-$	85*d*	1.49	(2)	*e*	10.22	P3
					0.36	(98)	*e*	6.23	
	Sc^{47}	B	$\beta-$	3.43*d*	0.61		*g*	5.65	K2
	Sc^{48}	A	$\beta-$	44*h*	0.57		*e*	5.26	K2
	Sc^{49}	A	$\beta-$	57*m*	1.8		*g*	5.54	
22	Ti^{43}	E	$\beta+$	0.58*s*	(5.4)		*g'*	3.40	
	Ti^{45}	A	$\beta+$	3.08*h*	1.00		*g*	4.51	K3
	Ti^{51m}	A	$\beta-$	6*m*	1.6		?	4.36	
	Ti^{51}	A	$\beta-$	72*d*	0.45		*e*	6.51	
23	V^{47}	B	$\beta+$	33.0*m*	1.65		?	4.64	K2
	V^{48}	A	$\beta+(58)$, *K*(42)	16*d*	0.72		*e*	6.16	
	V^{52}	A	$\beta-$	3.74*m*	2.05		*e*	4.60	
24	Cr^{49}	A	$\beta+$	43*m*	1.45		*e*	4.50	
25	Mn^{51}	A	$\beta+$	46*m*	2.0		*g'*	5.11	
	Mn^{52m}	A	$\beta+$	21*m*	2.66		*e*	5.32	
	Mn^{52}	A	$\beta+(35)$, *K*(65)	6.5*d*	0.58		*e*	5.58	
	Mn^{54}	A	*K*, $\beta-(<0.1)$	310*d*	1.0		*g'*	>11.47	K4, E2
	Mn^{56}	A	$\beta-$	2.59*h*	2.81	(50)	*e*	7.19	
					1.04	(30)	*e*	5.64	
					0.75	(20)	*e*	5.24	
26	Fe^{52}	A	$\beta+$	7.8*h*	0.55		*g'*	4.29	
	Fe^{59}	A	$\beta-$	46*d*	0.46	(50)	*e*	6.72	
					0.26	(50)	*e*	5.86	
27	Co^{55}	A	$\beta+$	18.2*h*	1.50	(50)	*e*	6.31	D1
					1.01	(50)	*e*	5.57	
	Co^{56}	A	$\beta+(25)$, *K*(75)	72*d*	1.50		*e*	8.49	
	Co^{57}	A	$\beta+$, *K*	270*d*	0.26		?	6.97	
	Co^{58}	A	$\beta+(15)$, *K*(85)	72*d*	0.470		*e*	6.57	
	Co^{60}	A	$\beta-$	5.3*y*	0.319		*e*	7.51	W6
	Co^{60m}	A	$\beta-(<10)$, I.T.(>90)	10.7*m*	1.4?		*e*	>5.44	
	Co^{61}	A	$\beta-$	1.75*h*	1.3		*g*	5.30	P4
	Co^{62}	B	$\beta-$	13.9*m*	2.3		*e*	5.44	P4
28	Ni^{57}	A	$\beta+$, *K*	35.7*h*	0.72		*e*	5.22	M6
	Ni^{63}	B	$\beta-$	~300*y*	0.063		*g*	7.06	W7
	Ni^{65}	A	$\beta-$	2.564*h*	2.10	(57)	*g*	6.57	S8, M6, S9
					1.01	(14)	*e*	5.91	
					0.60	(29)	*e*	4.76	
29	Cu^{60}	A	$\beta+$	24.6*m*	3.3	(<5)	*g*	>7.07	
					1.8		*e*	4.65	
	Cu^{61}	A	$\beta+(70)$, *K*(30)	3.4*h*	1.205	(97)	*g*	4.92	B9, O2, B10, K15, H15,
					0.53	(~3)	*e*	4.90	C13, B24
	Cu^{62}	A	$\beta+$	10.1*m*	2.92		*e*?	5.15	H8, B11
	Cu^{64}	A	$\beta-(38)$, $\beta+(19)$, *K*(43)	12.88*h*	0.571($\beta-$)		*g*	5.29	W8, L5, O3, R2, S9, H15
					0.657($\beta+$)		*g*	4.94	
	Cu^{66}	A	$\beta-$	4.34*m*	2.6		*e*	5.19	S9
	Cu^{67}	B	$\beta-$	2.44*d*	0.54		*e*	5.44	K15
30	Zn^{62}	A	$\beta+(10)$, *K*(90)	9.2*h*	0.665		*e*	5.08	H8
	Zn^{63}	A	$\beta+(93)$, *K*(7)	38*m*	2.36	(85)	*g*	5.37	
					1.40	(7)	*e*	5.46	
					0.47	(1)	*e*	4.28	
	Zn^{65}	A	$\beta+(1.3)$, *K*(98.7)	250*d*	0.325		*e*	7.46	M7
	Zn^{69}	A	$\beta-$	57*m*	1.0		*g*	4.65	
	Zn^{71}	B	$\beta-$	2.2*m*	2.1		*g'*	4.52	
	Zn^{72}	A	$\beta-$	49*h*	1.6	(5)	*g'*	8.47	
					0.3	(95)	*e*	4.54	
31	Ga^{66}	A	$\beta+$	9.4*h*	4.14	(87)	*e*	7.77	M8
					1.4	(4.3)	*e*	6.97	
					0.88	(6.9)	*e*	5.90	
					0.40	(1.7)	*e*	5.05	
	Ga^{68}	A	$\beta+$	68*m*	1.9		*g'*	5.17	
	Ga^{70}	A	$\beta-$	20.3*m*	1.65		*g'*	5.08	
	Ga^{72}	A	$\beta-$	14.3*h*	3.15	(9.5)	*e*	8.90	
					2.52	(8)	*e*	8.55	
					1.48	(10.5)	*e*	7.49	
					0.955	(32)	*e*	6.26	
					0.64	(40)	*e*	5.47	
	Ga^{73}	B	$\beta-$	5*h*	1.4		*g*	5.96	
32	Ge^{69}	B	$\beta+(\sim33)$, *K*($\sim$67)	1.65*d*	1.0		*g'*	5.93	M9
	Ge^{75}	A	$\beta-$	82*m*	1.1		*g*	5.00	M9
	Ge^{77}	A	$\beta-$	12*h*	1.74		*e*	6.73	M10

TABLE I.—*Continued.*

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	(%)	Final state	Log *ft*	References
32	Ge^{77m}	B	$\beta-$	59*s*	2.8		*g'*	4.72	
	Ge^{78}	D	$\beta-$	2.1*h*	~0.9		?	4.85	
33	As^{72}	B	$\beta+(33), K(67)$	26*h*	3.38		*e*?	>8.07	M11, M12
					2.486		*e*	>7.46	
					1.849		*e*	>6.90	
					0.669		*e*	>4.69	
					0.225		*e*	>4.20	
	As^{74}	A	$\beta-(46), \beta+(54), K$	17.5*d*	1.1($\beta-$)		*g'*	8.16	M11
					0.8($\beta+$)		*g'*	6.64	
	As^{76}	A	$\beta-$	26.8*h*	3.1	(60)	*g*	8.36	P5, M13
					2.5	(25)	*e*	8.35	
					1.3	(15)	*e*	7.41	
	As^{77}	A	$\beta-$	40*h*	0.8		*g'*	5.96	
	As^{78}	A	$\beta-$	65*m*	1.2		*e*	5.16	
	As^{78}	D	$\beta-$	90*m*	4.1	(70)	*g'*	7.58	
					1.4	(30)	*e*	5.99	
34	Se^{73}	B	$\beta+(50), K(50)$	7.1*h*	1.29		*g*	5.46	
	Se^{81}	B	$\beta-$	17*m*	1.5		*g*	4.88	
	Se^{83m}	A	$\beta-$	67*s*	3.4		*g'*	5.17	
	Se^{83}	A	$\beta-$	25*m*	1.5		*g'*	5.04	
35	Br^{75}	B	$\beta+(18), K(82)$	1.7*h*	1.6		*g*	5.69	
	Br^{76}	D	$\beta+, K$	15.7*h*	3.15		*g'*	7.23	
	Br^{77}	B	$\beta+(5), K(95)$	57.2*h*	0.36		*e*	5.35*	
	Br^{78}	A	$\beta+$	6.4*m*	2.3		*e*?	4.47	
	Br^{80}	A	$\beta-(89), \beta+(3), K(8)$	18*m*	2.0($\beta-$)		*g*	5.49	C3, R2
					0.73($\beta+$)		*g'*	4.26	
	Br^{82}	A	$\beta-$	36.0*h*	0.447		*e*	>5.07	S10, S11, B12, R2
					0.323		*e*	>4.59	
					0.181		*e*	>3.78	
	Br^{83}	A	$\beta-$	140*m*	1.0		*g*	5.13	
	Br^{84}	A	$\beta-$	33*m*	5.3		*g'*	7.53	
	Br^{85}	A	$\beta-$	3.00*m*	2.5		*g*	5.06	S32
36	Kr^{77}	B	$\beta+(30), K(70)$	1.1*h*	1.7		*g'*	5.39	
	Kr^{79}	A	$\beta+(2), K(98)$	34*h*	0.9	(30)	*g*	7.37	
					0.6	(70)	*e*	6.24	
	Kr^{85}	A	$\beta-$	4.36*h*	0.75		*g'*	4.96	K5
	Kr^{85}	B	$\beta-$	9.4*y*	0.74		*g*	9.22	
	Kr^{87}	B	$\beta-$	1.30*h*	3.2		*g'*	6.95	K5
	Kr^{88}	A	$\beta-$	2.77*h*	2.4 (weak)		*g'*	>6.74	K5
					0.5		*e*	>4.14	
37	Rb^{81}	A	$\beta+(\sim 30), K(\sim 70)$	5.0*h*	0.9		*e*?	4.83	
	Rb^{82}	D	$\beta+(\sim 15), K(\sim 85)$	6.3*h*	0.9		*e*?	5.23	
	Rb^{86}	A	$\beta-$	19.5*d*	1.822	(80)	*g*	8.59	M14
					0.716	(20)	*e*	7.63	
	Rb^{87}	A	$\beta-$	$6\times 10^{10}y$	0.13		*g*	16.52	K17
	Rb^{88}	A	$\beta-$	17.5*m*	4.8		*g'*	7.08	
	Rb^{89}	A	$\beta-$	15*m*	3.8		*g'*	6.56	
38	Sr^{89}	A	$\beta-$	55*d*	1.48		*g*	8.59	S12, L2
	Sr^{90}	A	$\beta-$	25*y*	0.54		*g*	9.20	J3, B13
	Sr^{91}	A	$\beta-$	9.7*h*	3.2	(60)	*g*	8.06	
					1.3	(40)	*e*	6.63	
39	Y^{84}	B	$\beta+, K$	3.7*h*	2.0		*g'*	5.76	R3
	Y^{87m}	A	$\beta+, K$	14*h*	1.1		*g'*	5.51	R4
	Y^{87}	A	$\beta+, K$	3.3*d*	0.7		*g'*	5.86	R4
	Y^{88}	C	$\beta+$	2.0*h*	1.65		*g'*	5.19	R3
	Y^{88}	A	$\beta+(0.19), K(99.8)$	105*d*	0.83		*e*	9.56	
	Y^{90}	A	$\beta-$	62*h*	2.20		*g*	7.98	J3, B13, L2
	Y^{91}	A	$\beta-$	57*d*	1.53		*g*	8.68	L6, O4, L2, W9, A5
	Y^{92}	A	$\beta-$	3.5*h*	3.5		*g'*	7.58	
	Y^{93}	A	$\beta-$	10*h*	3.1		*g'*	7.83	
	Y^{94}	B	$\beta-$	16.5*m*	5.4		*g'*	7.32	B25
40	Zr^{87}	B	$\beta+, K$	2.0*h*	2.0		*g'*	5.50	R3
	Zr^{89}	A	$\beta+, K$	80.1*h*	1.07		*g*	6.26	
	Zr^{93}	B	$\beta-$	$\sim 5\times 10^{6}y$	0.060		*g'*	11.48	S29
	Zr^{95}	A	$\beta-$	65*d*	1.0	(1.4)	*e*?	9.90	
					0.394	(98.6)	*e*	6.62	
	Zr^{97}	B	$\beta-$	17.0*h*	2.2		*g'*	7.43	
	Zr	F	$\beta-$	90*m*	1.5		*g'*	5.71	
	Zr	E	$\beta-$	70*h*	1.1		*g'*	6.86	
41	Nb^{90}	B	$\beta+, K$	15.0*h*	1.2		*e*	5.67	K6
	Nb^{92}	A	$\beta-$	10.1*d*	1.38		*g'*	7.79	
	Nb^{92}	A	$\beta-$	21.6*h*	1.2		*g'*	6.50	
	Nb^{94m}	A	$\beta-(0.01)$, I.T.	6.6*m*	1.3		*g'*	8.34	
	Nb^{95}	A	$\beta-$	35*d*	0.146		*e*	4.97	H9

TABLE I.—*Continued.*

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	Energy (%)	Final state	Log *ft*	References
41	Nb^{96}	A	β−	23.35*h*	0.67		*e*	5.61	K7
	Nb^{97}	A	β−	68*m*	1.4		*g'*	5.49	
42	Mo^{91m}	A	β+	15.5*m*	3.7		*g*	5.72	D9
	Mo^{91}	A	β+	75*s*	2.6		?	3.97	D9
	Mo^{99}	A	β−	67*h*	1.215	(75)	*e*	7.15	M38
					0.490	(25)	*e*	6.22	
	Mo^{101}	A	β−	14.6*m*	∼2.2	(∼30)	*e*	6.14	
					∼1.0	(∼70)	*e*	4.43	
43	Tc^{93m}	B	β+	4.5*m*	4.3		*g'*	5.47	K8
	Tc^{93}	B	β+(7), *K*(93)	2.7*h*	0.83		*e*	4.98	K8
	Tc^{94}	A	β+(76), *K*(24)	52.5*m*	2.41	(∼75)	*e*	5.51	M37
					0.56	(∼1)	*e*	4.58	
	Tc^{95m}	A	β+(∼0.4), *K*(99.6)	60*d*	0.40		*g*	7.56	M37
	Tc^{98}	F	β−	2.8*d*	1.3		*g'*	7.15	M37
	Tc^{99}	A	β−	5×10⁵*y*	0.30		*g*	12.74	K9
	Tc^{100}	B	β−	80*s*	2.3		*g'*	4.67	
	Tc^{101}	A	β−	14.0*m*	1.3		*e*	4.69	
44	Ru^{95}	A	β+(∼50), *K*(∼50)	1.65*h*	1.1		*g'*	4.72*	
	Ru^{103}	A	β−	42*d*	0.680	(10)	*g*	8.31	H10, M14, M15, S13
					0.205	(90)	*e*	5.61	
	Ru^{105}	B	β−	4.4*h*	1.3		*g'*	5.99	
	Ru^{106}	A	β−	1.0*y*	0.0392		*g*	4.29	A5
	Ru^{107}	D	β−	4*m*	4		*g'*	6.18	
45	Rh	E	β+	32*m*	1.86		*g'*	4.85	E3
	Rh	E	β+, β−?	5*h*	0.6		*g'*	4.83	E3
	Rh^{100}	B	β+(5), *K*(95)	19.4*h*	3.0		*g'*	8.44	
	Rh^{100}	B	β+(25), *K*(75)	21*h*	1.3		*e*?	6.16	E3
	Rh^{102}	A	β−(50), β+(50), *K*	210*d*	1.04(β−)		*g'*	9.37	M16
					1.13(β+)		*g'*	8.36	
	Rh^{104}	A	β−	44*s*	2.6		*e*?	4.67	
	Rh^{105}	A	β−	36*h*	0.78		*g'*	6.11	
	Rh^{106}	A	β−	30*s*	3.55	(82)	*g*	5.16	J4
					2.30	(18)	*e*	5.02	
	Rh	E	β−	9*h*	1.3		*g'*	6.32	
	Rh^{107}	D	β−	24*m*	1.2		*g'*	4.84	
					{2.3		*g*	{7.29	
46	Pd^{101}	B	β+(10), *K*(90)	9*h*	or 0.53}		*g'*	5.08*	E3
	Pd^{109}	A	β−	13*h*	0.950		*e*?	5.98	S14
	Pd^{111}	A	β−	26*m*	3.5		*g'*	6.78	
	Pd^{112}	A	β−	21*h*	0.2		*g*	3.89	
47	Ag^{106}	A	β+	24.5*m*	2.04		*g*	4.87	
	Ag^{108}	A	β−	2.3*m*	2.8		*g'*	5.32	
	Ag^{110}	A	β−	24*s*	2.86		*g*	4.60	S15
	Ag^{110m}	A	β−	270*d*	0.530	(∼38)	*e*	8.26	S15, M6, E4, G2, R5
					0.087	(∼58)	*e*	5.52	
	Ag^{111}	A	β−	7.5*d*	1.06		*g*	7.32	H11
	Ag^{112}	A	β−	3.2*h*	3.6		*g'*	7.72	
	Ag^{113}	A	β−	5.3*h*	2.1		*g*	6.95	D2
	Ag^{115}	A	β−	20*m*	∼3		*g*	6.39	D2
48	Cd^{105}	B	β+	57*m*	1.5		*g'*	4.85	G2
	Cd^{107}	A	β+(0.3), *K*(99.7)	6.7*h*	0.32		*e*	4.84	
	Cd^{115}	A	β−	2.5*d*	1.13	(∼80)	*e*	7.07	C4, M17, H12, C5
					0.6	(∼20)	*e*	6.67	
	Cd^{115m}	A	β−	43*d*	1.67		*g*	8.86	H12, S16, C5
	Cd^{117}	A	β−	2.72*h*	∼1.5		*g'*	6.09	
49	In^{107}	B	β+	33*m*	2		*g'*	4.99	M18
	In^{108}	B	β+	55*m*	2		*g'*	5.22	M18
	In^{109}	B	β+(4), *K*(96)	5.2*h*	2.7		*g*	7.74	T8
	In^{109}	B	β+(∼11), *K*(∼89)	4.30*h*	0.75		*g'*	4.75	M18
	In^{110}	A	β+, *K*	65*m*	2.3		*e*	5.49	T8
	In^{112}	B	β+(16), *K*(25),	9*m*	1.45(β+)		*g*	4.40	T8
			β−(59)		1.0(β−)		*g*	4.42	
	In^{114}	A	β−(96), *K*(4)	72*s*	1.98		*g*	4.48	B22, M6, M19, M20
	In^{115m}	A	β−(10), I.T.(90)	4.5*h*	0.830		*g*	6.36	B14
	In^{116}	A	β−	13*s*	2.8		*g*	4.33	
	In^{116m}	A	β−	53.93*m*	1.00	(51)	*e*	5.26	S9, S28
					0.87	(28)	*e*	5.29	
					0.60	(21)	*e*	4.85	
	In^{117}	A	β−	117*m*	1.73		*g*	6.22	
	In^{118}	A	β−	4.5*m*	1.5		*g'*	4.55	D3
	In^{119}	A	β−	17.5*m*	2.7		*g*	6.17	D3
50	Sn^{111}	A	β+(3.7), *K*(96.3)	35.0*m*	1.45		*g'*	5.62	H13
	Sn^{121}	A	β−	28*h*	0.383		*g*	5.03	L7, D4
	Sn^{121}	B	β−	36*m*	∼2.5		*g*	6.37	N1

TABLE I.—*Continued.*

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	Energy (%)	Final state	Log *ft*	References
50	Sn^{123}	A	β−	136*d*	1.42		*g*	9.10	L7, K10
	Sn^{123}	A	β−	39.5*m*	1.26		*e*	5.22	D4, L7
	$Sn^{>120}$	D	β−	∼80*h*	0.76		*g'*	6.49	
	$Sn^{>120}$	E	β−	17.5*d*	1.7		*g'*	8.54	
	$Sn^{>120}$	E	β−	7.0*d*	1.8		*g'*	8.24	
	Sn^{125}	B	β−	9.9*d*	2.33		*g*	8.84	L7, K10
	Sn^{125}	A	β−	9.8*m*	2.04		*e*?	>5.44	L7, D5
					1.17		*e*	>4.49	
	Sn^{126}	D	β−	70*m*	{0.7 or 2.8		*g'*	{4.54 or 6.87	
51	Sb^{116}	A	β+, *K*	60*m*	1.45		*g'*	4.90	T4
	Sb^{118}	B	β+	3.3*m*	3.1		*g'*	4.70	
	Sb^{120}	A	β+	17*m*	1.5		*g'*	4.38	
	Sb^{122}	A	β−	2.8*d*	1.94		*g*	>7.99	
					1.36		*e*	>7.37	
	Sb^{124}	A	β−	60*d*	2.37	(21)	*e*	10.35	
					1.62	(8)	*e*	10.09	
					1.00	(9)	*e*	9.26	
					0.65	(44)	*e*	7.89	
					0.48	(18)	*e*	7.84	
	Sb^{124m}	A	β−	1.3*m*	3.2		*g*	5.37	
	Sb^{125}	A	β−	2.7*y*	0.616	(18)	*e*	9.41	K11, S17, M22, J4
					0.299	(49)	*e*	7.93	
					0.128	(33)	*e*	6.93	
	Sb^{126}	D	β−	60*m*	{2.8 or 0.7		*g'*	{6.82 or 4.49	
	$Sb^{>125}$	E	β−	28*d*	1.86		*g'*	8.92	
	Sb^{127}	A	β−	90*h*	1.2		*g'*	7.29	
52	Te^{127}	A	β−	9.3*h*	0.76		*g*	5.61	
	Te^{129}	A	β−	72*m*	1.8		*g'*	6.13	
	Te^{132}	B	β−	77*h*	0.36		*e*?	5.42	
53	I^{120}	C	β+	30*m*	4.0		*g'*	6.12	M24
	I^{121}	A	β+	1.8*h*	1.2		*g'*	5.03	M24
	I^{122}	B	β+, *K*	4*m*	2.9		*g'*	4.67	M24
	I^{124}	A	β+(30), *K*(70)	4.5*d*	2.20	(51)	*e*	8.05	M23, M24
					1.50	(44)	*e*	7.39	
					0.67	(5)	*e*	6.75	
	I^{126}	A	β−	13.0*d*	1.268	(27)	*g*	8.52	M23
					0.85	(73)	*e*	7.46	
	I^{128}	A	β−(95), *K*(5)	24.99*m*	2.02	(93)	*g*	5.94	R2
					1.59	(7)	*e*	6.65	
	I^{130}	A	β−	12.6*h*	1.03	(60)	*e*	6.45	
					0.61	(40)	*e*	5.82	
	I^{131}	A	β−	8.0*d*	0.606	(85)	*e*	6.66	K11, M25, F6, O5
					0.306	(15)	*e*	6.42	
	I^{132}	B	β−	2.4*h*	2.2		*e*	>6.79	
					0.9		*e*	>5.30	
	I^{133}	A	β−	22*h*	1.4		*g'*	6.98	
	I^{135}	A	β−	6.7*h*	1.40	(25)	*e*	7.07	
					1.00	(40)	*e*	6.30	
					0.47	(35)	*e*	5.22	
	I^{136}	D	β−	86*s*	6.5		*e*?	6.81	S18
54	Xe^{133}	A	β−	5.27*d*	0.315		*g'*	5.48	M26, T5
	Xe^{135}	A	β−	9.1*h*	0.93		*g'*	5.94	T5
	Xe^{137}	B	β−	3.8*m*	4		*g'*	6.31	
55	Cs^{127}	A	β+	5.5*h*	1.2		*g'*	5.56	F7
	Cs^{134m}	A	β−, I.T.	3.15*h*	2.4		*g*	>7.10	
	Cs^{134}	A	β−	2*y*	0.66	(70)	*e*	8.88	M4
					0.09	(30)	*e*	6.47	
	Cs^{135}	B	β−	2.1×10^{6}*y*	0.21		*g*	13.09	S19
	Cs^{136}	A	β−	13*d*	∼0.3		*e*	5.83	
	Cs^{137}	A	β−	33*y*	1.18	(5)	*g*	12.16	P6, O4, L2, A5
					0.52	(95)	*e*	9.62	
	Cs^{138}	A	β−	33*m*	2.68		*g'*	6.53	T5
56	Ba^{139}	A	β−	84*m*	2.27		*g'*	6.66	
	Ba^{140}	A	β−	12.8*d*	1.022	(60)	*g*	7.88	M19, B15
					0.48	(40)	*e*	6.91	
57	La^{133}	A	β+, *K*	4.0*h*	1.2		*g'*	5.48	N2
	La^{136}	A	β+(33), *K*(67)	9.5*m*	2.1		*g'*	4.78	N2, R6
	La^{140}	A	β−	40*h*	2.26	(10)	*e*	9.13	B15, C6
					1.67	(20)	*e*	8.32	
					1.32	(70)	*e*	7.36	
	La^{141}	A	β−	3.7*h*	2.9		*g*	7.54	

TABLE I.—*Continued.*

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	Energy (%)	Final state	Log *ft*	References
58	Ce^{141}	A	$\beta-$	33.1*d*	0.56	(30)	*g*	7.72	S20, T6, M27, W10
					0.42	(70)	*e*	6.93	
	Ce^{143}	A	$\beta-$	33*h*	1.1		*e*	6.86	S21
	Ce^{144}	A	$\beta-$	300*d*	0.36		*g*	7.51	M28
59	Pr^{140}	A	$\beta+(40)$, $K(60)$	1.5*m*	2.4		*g'*	4.15	W11
	Pr^{142}	A	$\beta-$	19.3*h*	2.23	(80)	*g*	7.93	M29, J4, R7
					0.66	(20)	*e*	6.55	
	Pr^{143}	A	$\beta-$	13.7*d*	0.932		*g*	7.61	T6, S20, B16, F8, M27
	Pr^{144}	A	$\beta-$	17*m*	2.9		*g'*	6.46	M28
	Pr^{145}	D	$\beta-$	4.5*h*	3.2		*g*	7.84	
	Pr^{146}	D	$\beta-$	25*m*	3		*g'*	6.69	
60	Nd^{141}	B	$\beta+(2)$, $K(98)$	145*m*	0.7		*g'*	5.02	W11
	Nd^{147}	A	$\beta-$	11*d*	0.78	(67)	*e*	7.43	M30
					0.17	(33)	*e*	5.55	
	Nd^{149}	B	$\beta-$	2.0*h*	1.6		*g'*	6.30	
	Nd^{150}	E	$\beta-$	$\sim 5\times 10^{10}y$	0.011		*g'*	13.73	
61	Pm	E	$\beta-$	2.7*h*	2		*g'*	6.83	
	Pm	E	$\beta-$	16*d*	1.7		*g'*	8.70	
	Pm^{147}	A	$\beta-$	3.7*y*	0.227		*g*	7.58	L8, A5, L3
	Pm^{148}	A	$\beta-$	5.3*d*	2.5		*g'*	8.89	
	Pm^{149}	A	$\beta-$	47*h*	1.1		*e*	7.07	M31
62	Sm^{151}	A	$\beta-$	$\sim 500y$	0.076		*g*?	8.27	K12, A5
	Sm^{153}	A	$\beta-$	47*h*	0.80	(33)	*g*	7.09	H16
					0.68	(67)	*e*	6.52	
	Sm^{155}	B	$\beta-$	21*m*	1.8		*g'*	5.79	
	Sm^{156}	A	$\beta-$	$\sim 10h$	~ 0.8		*g'*	5.93	
63	Eu^{152}	A	$\beta-(82)$, $K(18)$	9.2*h*	1.88		*g*	7.39	H14, H16
	Eu^{152}	A	$\beta-(26)$, $K(74)$	5.3*y*	0.75		*g'*	10.23	H14
	Eu^{154}	A	$\beta-(>95)$, $K(<5)$	5.4*y*	1.58		*g'*	10.74	H14, H16
	Eu^{155}	A	$\beta-$	1.7*y*	0.20		*g'*	7.10	H14
	Eu^{156}	A	$\beta-$	15.4*d*	2.5	(40)	*g*	9.78	
					0.5	(60)	*e*	7.03	
	Eu^{157}	D	$\beta-$	15.4*h*	~ 1.8	(~ 25)	*g*	8.04	
					~ 1.0	(~ 75)	*e*	6.60	
	$Eu^{>154}$	D	$\beta-$	60*m*	~ 2.5		*g'*	6.82	
64	Gd^{159}	B	$\beta-$	18.0*h*	0.95		*g'*	6.48	B17
	Gd^{161}	B	$\beta-$	3.6*m*	1.5		*g'*	4.74	B17
65	Tb^{154}	D	$\beta+$, K	17.2*h*	2.6		*g'*	7.03	
	Tb^{160}	A	$\beta-$	76*d*	0.860	(43)	*e*	8.68	B18, C7
					0.521	(41)	*e*	7.99	
					0.396	(16)	*e*	8.00	
	Tb^{161}	F	$\beta-$	420*d*	0.23		*e*	7.18	
	Tb^{161}	B	$\beta-$	6.7*d*	0.5		*g'*	6.49	B17
66	Dy^{165}	A	$\beta-$	145*m*	1.25	(~ 80)	*g*	6.18	
					0.88	(~ 10)	*e*	6.52	
					0.42	(~ 10)	*e*	5.44	
	Dy^{166}	A	$\beta-$	80*h*	0.4		*g'*	5.90	K13, B23
67	$Ho^{162,161}$	C	$\beta+$, K	4.5*h*	2.0		*g'*	6.22	
	Ho^{164}	D	$\beta-$	35*m*	0.7		*g'*	4.59	
	Ho^{166}	A	$\beta-$	27.7*h*	1.84	(89)	*e*?	7.87	C8, K13, A7, G6, S30
					0.55	(11)	*e*	6.88	
68	Er^{169}	B	$\beta-$	9.4*d*	0.33		*g*	6.10	
	Er^{171}	B	$\beta-$	7.5*h*	1.49	(6)	*g*	8.14	
					1.05	(71)	*e*	6.50	
					0.67	(22)	*e*	6.31	
	Er^{171}	F	$\beta-$	20*h*	0.6		*g'*	5.92	
69	Tm^{166}	B	$\beta+(0.5)$, $K(99.5)$	7.7*h*	2.1		*g'*	8.25	W12
	Tm^{170}	A	$\beta-$	127*d*	0.970	(90)	*g*	8.90	G3, F9, A5, S22, G4
					0.886	(10)	*e*	9.71	
	Tm^{171}	B	$\beta-$	500*d*	0.10		*g'*	6.23	
	Yb^{175}	A	$\beta-$	99*h*	0.50		*g*	>6.39	
					0.13		*e*	>4.52	
	Yb^{177}	B	$\beta-$	2.4*h*	1.2		*g'*	6.11	
71	Lu^{170}	B	$\beta+$, K	2.15*d*	1.7		*g'*	7.24	
	Lu^{176}	A	$\beta-(33)$, $K(67)$	$2.4\times 10^{10}y$	{0.215 or 0.4		*g'*	{18.02 or 18.91	
	Lu^{176m}	A	$\beta-$	3.4*h*	1.15		*g*	6.22	
	Lu^{177}	A	$\beta-$	6.9*d*	0.495	(65)	*g*	6.80	D6, C8, A8
					0.366	(17)	*e*	6.95	
					0.169	(18)	*e*	5.86	
72	Hf^{181}	A	$\beta-$	46*d*	0.405		*e*	7.19	C9, M17, B19, C10, J5, L9
	Hf^{181}	B	$\beta-$	5.5*h*	0.45		*e*	5.04	B19
73	Ta^{182}	A	$\beta-$	123*d*	0.53		*e*	8.01	C11, B20, J7

TABLE I.—*Continued.*

Z	Isotope A	Class	Decay	Half-life	Energy (Mev)	(%)	Final state	Log *ft*	References
74	W^{185}	A	$\beta-$	73.2	0.428		*g*	7.50	
	W^{187}	A	$\beta-$	24.1*h*	1.33	(30)	*g*	7.88	B21
					0.63	(70)	*e*	6.35	
75	Re^{184}	A	$\beta-$, *K*	50*d*	0.22		*g′*	>6.43	
	Re^{186}	A	$\beta-$	91*h*	1.073		*e*	7.62	L2, G3, B20
	Re^{187}	A	$\beta-$	$4\times10^{12}y$	0.043		*g′*	17.73	
	Re^{188}	A	$\beta-$	18*h*	2.10		*e*?	8.00	B20
76	Os^{191}	B	$\beta-$	15*d*	0.142		*e*	5.34	
	Os^{193}	A	$\beta-$	32*h*	1.15		*e*	7.29	
77	Ir^{192}	A	$\beta-$	70*d*	0.67		*e*	8.20	
	Ir^{194}	A	$\beta-$	19*h*	2.2		*g*?	8.14	
78	Pt^{197,199}	C	$\beta-$	82*d*	0.54		*e*	7.96	C12
	Pt^{197}	B	$\beta-$	18*h*	0.7		*e*	6.30	C12
	Pt^{199}	A	$\beta-$	31*m*	1.8		*g′*	6.26	
79	Au^{192}	B	$\beta+(\sim1)$, $K(\sim99)$	4.0*h*	1.9		*g′*	7.45	W13
	Au^{194}	B	$\beta+(3?)$, $K(97?)$	39.5*h*	1.8		*g′*	7.86	W13, S23
	Au^{196}	A	$\beta-(4.5)$, $K(95.5)$	5.6*d*	0.30		*e*	7.34	W13, S23
	Au^{198}	A	$\beta-(82)$, $K(18)$	2.69*d*	0.960		*e*	7.46	S23, S24, L10, L2, S9, D10
	Au^{199}	A	$\beta-$	3.3*d*	0.32		*e*	5.86	M4, B20
	Au^{200,202}	D	$\beta-$	48*m*	2.5		*g′*	7.03	
80	Hg^{203}	A	$\beta-$	43.5*d*	0.208		*e*	6.40	S25, S26
	Hg^{205}	A	$\beta-$	5.5*m*	1.62		*g*	5.39	
81	Tl^{204}	B	$\beta-$	2.7*y*	0.783		*g*	9.69	S27
	Tl^{206}	A	$\beta-$	4.23*m*	1.7		*g*	5.38	
	AcC″^{207}	A	$\beta-$	4.76*m*	1.47		*g′*	5.18	
	ThC″^{208}	A	$\beta-$	3.1*m*	1.792		*e*	5.33	M32
	Tl^{209}	A	$\beta-$	2.2*m*	1.8		*g′*	5.19	
	RaC″^{210}	A	$\beta-$	1.32*m*	1.7		*g′*	4.87	
82	Pb^{209}	A	$\beta-$	3.32*h*	0.68		*g*	5.64	
	RaD^{210}	A	$\beta-$	22*y*	0.027		*e*	6.02	
	AcB^{211}	A	$\beta-$	36.1*m*	1.40	(85)	*g*	6.09	
					0.5	(15)	*e*	5.28	
	ThB^{212}	A	$\beta-$	10.6*h*	0.569	(12)	*g*	6.81	M33, G7
					0.331	(88)	*e*	5.17	
	RaB^{214}	A	$\beta-$	26.8*m*	0.65		*e*?	4.71	
83	RaE^{210}	A	$\beta-(\sim100)$, $\alpha(\sim0)$	5.0*d*	1.17		*g*	8.05	L2, M34
	ThC^{212}	A	$\beta-(66)$, $\alpha(34)$	60.5*m*	2.251		*g*	7.22	M33
	Bi^{213}	A	$\beta-(98)$, $\alpha(2)$	47*m*	1.3		*g′*	6.03	
	RaC^{214}	A	$\beta-(\sim100)$, $\alpha(\sim0)$	19.7*m*	3.15		*g′*	7.12	
87	AcK^{223}	A	$\beta-$	21*m*	1.20		*e*	5.65	
88	Ra^{225}	A	$\beta-$	14.5*d*	{~0.2 or <0.05		*g′*	{6.08 or <4.24	
	MsTh$_1$^{228}	A	$\beta-$	6.7*y*	0.053?		*g′*	6.54	L11
89	Ac^{227}	A	$\beta-(99)$, $\alpha(1)$	21.7*y*	<0.01		*g′*	<4.98	
	MsTh$_2$^{228}	A	$\beta-$	6.13*h*	1.55		*e*	7.35	L11
90	UY^{231}	A	$\beta-$	25.5*h*	0.21		*e*	5.07	K14
	Th^{233}	A	$\beta-$	23.5*m*	1.2		*g*	5.77	
	UX$_1$^{234}	A	$\beta-$	24.1*d*	0.205	(80)	*g*	6.49	
					0.110	(20)	*e*	6.26	
91	Pa^{230}	A	$\beta-(\sim10)$, $K(\sim90)$, $\alpha(\sim0)$	17*d*	1.1		*g′*	9.68	
	Pa^{232}	A	$\beta-$	1.4*d*	~0.28		*e*	5.64	
	Pa^{233}	A	$\beta-$	27.4*d*	0.23		*e*	6.63	
	UZ^{234}	A	$\beta-$	6.7*h*	1.2	(10)	*g*	8.03	
					0.45	(90)	*e*	5.62	
	UX$_2$^{234m}	A	$\beta-$	1.2*m*	2.32	(95)	*g*	5.59	
					1.52	(5)	*e*	6.17	
	Pa^{235}	A	$\beta-$	23.7*m*	1.4		*g′*	6.04	M36
92	U^{237}	A	$\beta-$	6.63*d*	0.23		*e*	6.04	M35
	U^{239}	A	$\beta-$	23.5*m*	2.06	(3)	*g*	8.21	
					1.12	(97)	*e*	5.72	
93	Np^{236}	A	$\beta-$	22*h*	0.5		*g′*	6.28	
	Np^{238}	A	$\beta-$	2.10*d*	1.39		*e*	>8.18	
					0.22		*e*	>5.50	
	Np^{239}	A	$\beta-$	2.3*d*	1.179	(1)	*g*	9.97	
					0.676	(6)	*e*	8.33	
					0.403	(42)	*e*	6.76	
					0.288	(51)	*e*	6.20	
94	Pu^{241}	A	$\beta-$	~10*y*	~0.015		*g′*	5.24	
95	Am^{242}	A	$\beta-$	16*h*	0.63		*g′*	6.52	G5
	Am^{242}	A	$\beta-(\sim100)$, $\alpha(\sim0)$	~400*y*	~0.5		*g′*	11.53	

is followed by an asterisk. For a great number of the nuclei tabulated, the particle spectrum has not been analyzed for complexity, and only the end point of the spectrum has been reported. For these nuclei, therefore, the *ft* values really represent lower limits to the true values.

The last column in the table contains the references consulted, which have appeared after Seaborg and Perlman's isotope compilation. These references are listed in the bibliography. It is hoped that the bibliography is reasonably complete to June 1, 1950.

ACKNOWLEDGMENTS

I wish to express my appreciation to Professor E. P. Wigner, who suggested the preparation of this table, for his continued interest and kindly encouragement during the course of this work. I am deeply indebted to Professor E. Feenberg and Dr. G. Trigg of Washington University for furnishing me with a copy of their own *ft* table in addition to a copy of their manuscript, and also for much invaluable advice and criticism. I would also like to thank Professor John Blatt of the University of Illinois for supplying me with a table of *f*-values.

BIBLIOGRAPHY

A1. Allen, Paneth, and Morrish, Phys. Rev. **75**, 570 (1949).
A2. Angus, Cockroft, and Curran, Phil. Mag. **40**, 522 (1949).
A3. A. W. Alvarez, Phys. Rev. **75**, 1815 (1949).
A4. A. W. Alvarez, Phys. Rev. **75**, 1127 (1949).
A5. H. M. Agnew, Phys. Rev. **77**, 655 (1950).
A6. D. E. Alburger, Phys. Rev. **78**, 629 (1950).
A7. Antonieva, Bashilov, Djelepov, and Zolotavin, Doklady Akad. Nauk S.S.S.R. **70**, 397 (1950).
A8. Antonieva, Bashilov, Djelepov, and Zolotavin, Doklady Akad. Nauk S.S.S.R. **70**, 597 (1950).

B1. Byatt, Rogers, and Waltner, Phys. Rev. **75**, 909 (1949).
B2. P. R. Bell and J. M. Cassidy, Phys. Rev. **77**, 301 (1950).
B3. H. Brown and V. Perez-Mendez, Phys. Rev. **75**, 1286(A) (1949).
B4. Blaser, Boehm, and Marmier, Phys. Rev. **75**, 1953 (1949).
B5. H. Bradner and J. D. Gow, Phys. Rev. **74**, 1559(A) (1948).
B6. H. Brown and V. Perez-Mendez, Phys. Rev. **75**, 1276 (1949).
B7. Bell, Weaver, and Cassidy, Phys. Rev. **77**, 399 (1950).
B8. A. Bruner and M. Langer, Phys. Rev. **79**, 236(A) (1950).
B9. R. Bouchez and G. Kayas, J. phys. radium **10**, 110 (1949).
B10. Boehm, Blaser, Marmier, and Preiswerk, Phys. Rev. **77**, 295 (1950).
B11. R. A. Becker and F. S. Kirn, Phys. Rev. **76**, 182(A) (1949).
B12. E. Berne, Phys. Rev. **77**, 568 (1950).
B13. Braden, Slack, and Shull, Phys. Rev. **75**, 1964 (1949).
B14. Bell, Ketelle, and Cassidy, Phys. Rev. **76**, 574 (1949).
B15. Beach, Peacock, and Wilkinson, Phys. Rev. **76**, 1624 (1949).
B16. Bruner, Langer, and Moffat, Phys. Rev. **77**, 747(A) (1950).
B17. F. D. S. Butement, Phys. Rev. **75**, 1276 (1949).
B18. Buɪson, Blair, and Saxon, Phys. Rev. **77**, 403 (1950).
B19. S. B. Burson and K. W. Blair, Phys. Rev. **78**, 89(A) (1950).
B20. Beach, Peacock, and Wilkinson, Phys. Rev. **76**, 1585 (1949).
B21. Beach, Peacock, and Wilkinson, Phys. Rev. **75**, 211 (1949).
B22. F. Boehm and P. Preiswerk, Helv. Phys. Acta **22**, 331 (1949).
B23. F. D. S. Butement, Proc. Phys. Soc. (London) **A63**, 532 (1950).
B24. Bouchez, de Groot, Nataf, and Tolhoek, Physica **15**, 863 (1949).
B25. L. J. Brown and S. Katcoff, J. Chem. Phys. **17**, 497 (1949).
B26. E. Bleuler and W. Zünti, Helv. Phys. Acta **19**, 375 (1946).

C1. Curran, Angus, and Cockroft, Phil. Mag. **40**, 53 (1949).
C2. Curran, Angus, and Cockroft, Phys. Rev. **76**, 853 (1949).
C3. S. D. Chatterjee and N. K. Saha, Indian J. Phys. **22**, 515 (1948).
C4. Cork, Shreffler, and Fowler, Phys. Rev. **74**, 1657 (1948).
C5. Cork, Rutledge, Stoddard, Branyan, and LeBlanc, Phys. Rev. **79**, 238(A) (1950).
C6. Cork, Keller, Rutledge, and Stoddard, Phys. Rev. **76**, 1886 (1949).
C7. Cork, Branyan, Rutledge, Stoddard, and LeBlanc, Phys. Rev. **78**, 304 (1950).
C8. Cork, Keller, and Stoddard, Phys. Rev. **76**, 986 (1949).
C9. K. Y. Chu and M. L. Wiedenbeck, Phys. Rev. **75**, 226 (1949).
C10. Cork, Stoddard, Rutledge, Branyan, and LeBlanc, Phys. Rev. **78**, 299 (1950).
C11. Cork, Keller, Sazynski, Rutledge, and Stoddard, Phys. Rev. **75**, 1778 (1949).
C12. Cork, Stoddard, Rutledge, Branyan, and LeBlanc, Phys. Rev. **77**, 843 (1950).
C13. C. S. Cook and G. E. Owen, private communication by E. Feenberg and G. Trigg.
C14. A. L. Cockroft and G. M. Insch, Phil. Mag. **40**, 1014 (1949).

D1. M. Deutsch and A. Hedgran, Phys. Rev. **75**, 1443 (1949).
D2. R. B. Duffield and J. D. Knight, Phys. Rev. **75**, 1613 (1949).
D3. R. B. Duffield and J. D. Knight, Phys. Rev. **75**, 1967 (1949).
D4. R. B. Duffield and L. M. Langer, Phys. Rev. **76**, 1272 (1949).
D5. R. B. Duffield and L. M. Langer, Phys. Rev. **77**, 743(A) (1950).
D6. D. G. Douglas, Phys. Rev. **75**, 1960 (1949).
D7. B. C. Djelepov and A. V. Kudryavtseva, Zhur. Eksp. i Teoret. Fiz. **19**, 761 (1949).
D8. B. C. Djelepov, Zhur. Eksp. i Teoret. Fiz. **19**, 784 (1949).
D9. R. B. Duffield and J. D. Knight, Phys. Rev. **76**, 573 (1949).
D10. Djelepov, Bashilov, Zolotavin, and Antonieva, Doklady Akad. Nauk S.S.S.R. **64**, 803 (1949).

E1. Engelkemeier, Hamill, Inghram, and Libby, Phys. Rev. **75**, 1825 (1949).
E2. Emmerich, Ballweg, and Kurbatov, Phys. Rev. **76**, 1891(A) (1949).
E3. D. T. Eggen and M. L. Pool, Phys. Rev. **75**, 1464(A) (1949).
E4. W. S. Emmerich and J. D. Kurbatov, Phys. Rev. **75**, 1446 (1949).

F1 H. W. Fulbright and J. C. D. Milton, Phys. Rev. **76**, 1271 (1949).
F2. L. Feldman and C. S. Wu, Phys. Rev. **78**, 318(A) (1950).
F3. L. Feldman and C. S. Wu, Phys. Rev. **75**, 1286(A) (1949).
F4. J. J. Floyd and L. B. Borst, Phys. Rev. **75**, 1106 (1949).
F5. L. Feldman and C. S. Wu, Phys. Rev. **76**, 697 (1949).
F6. I. Feister and L. F. Curtis, Phys. Rev. **78**, 179 (1950).
F7. Fink, Reynolds, and Templeton, Phys. Rev. **77**, 614 (1950).
F8. Feldman, Lidofsky, Macklin, and Wu, Phys. Rev. **76**, 1888 (1949).
F9. J. S. Fraser, Phys. Rev. **76**, 1540 (1949).
F10. W. R. Faust, Phys. Rev. **78**, 624 (1950).
F11. E. Feenberg and G. Trigg, Revs. Modern Phys. **22**, 399 (1950).

G1. L. Gross and D. R. Hamilton, Phys. Rev. **78**, 318(A) (1950).
G2. Gum, Thompson, and Pool, Phys. Rev. **76**, 184(A) (1949).
G3. P. J. Grant and R. Richmond, Proc. Phys. Soc. (London) **A62**, 573 (1949).
G4. R. L. Graham and G. H. Tomlin, Nature **164**, 278 (1949).

G5. Grundlund, Harvey, Moss, and Yaffe, Phys. Rev. **78**, 69 (1950).
G6. P. J. Grant and J. M. Hill, Nature **163**, 524 (1949).
G7. L. V. Groshev and L. Ya. Shavtvalov, Doklady Akad. Nauk S.S.S.R. **68**, 257 (1949).

H1. G. C. Hanna and B. Pontecorvo, Phys. Rev. **75**, 983 (1949).
H2. J. E. R. Holmes, Proc. Phys. Soc. (London) **A62**, 293 (1949).
H3. W. F. Hornyak and T. Lauritsen, Phys. Rev. **77**, 160 (1950).
H4. Hughes, Eggler, and Huddleston, Phys. Rev. **75**, 515 (1949).
H5. Hughes, Eggler, and Alburger, Phys. Rev. **77**, 726 (1950).
H6. Hudspeth, Swann, and Heydenburg, Phys. Rev. **77**, 736 (1950).
H7. Haslam, Katz, Johns, and Moody, Phys. Rev. **76**, 704 (1949).
H8. R. W. Hayward, Phys. Rev. **78**, 87(A) (1950).
H9. J. E. Hudgens, Jr., and W. S. Lyon, Phys. Rev. **75**, 206 (1949).
H10. N. Hole, Arkiv Mat., Astron. Fysik **36A**, No. 2 (1948).
H11. Helmholz, Hayward, and McGinnis, Phys. Rev. **75**, 1469(A) (1949).
H12. R. W. Hayward and A. C. Helmholz, Phys. Rev. **75**, 1469(A) (1949).
H13. R. A. Hinshaw and M. L. Pool, Phys. Rev. **76**, 358 (1949).
H14. Hayden, Reynolds, and Inghram, Phys. Rev. **75**, 1500 (1949).
H15. Huber, Rüetschi, and Scherrer, Helv. Phys. Acta **22**, 375 (1949).
H16. J. M. Hill and L. R. Shepherd, Proc. Phys. Soc. (London) **A63**, 126 (1950).

J1. Jenks, Ghormley, and Sweeton, Phys. Rev. **75**, 701 (1949).
J2. W. M. Jones, Phys. Rev. **76**, 855 (1949).
J3. E. N. Jensen and L. S. Laslett, Phys. Rev. **75**, 1949 (1949).
J4. E. T. Journey, Phys. Rev. **76**, 290 (1949).
J5. E. N. Jensen, Phys. Rev. **76**, 958 (1949).
J6. J. V. Jelley, Proc. Phys. Soc. (London) **A63**, 538 (1950).
J7. S. Jnanananda, J. Sci. Ind. Research (India) **8B**, 147 (1949).

K1. W. J. Knox, Phys. Rev. **74**, 1192 (1948).
K2. N. L. Krisberg and M. L. Pool, Phys. Rev. **75**, 1693 (1949).
K3. Kubitschek, Longacre, and Goldhaber, Phys. Rev. **77**, 742(A) (1950).
K4. J. D. Kurbatov and D. Gideon, Phys. Rev. **75**, 328(A) (1949).
K5. Koch, Kofoed-Hansen, Kristensen, and Drost-Hansen, Phys. Rev. **76**, 279 (1949).
K6. D. N. Kundu and M. L. Pool, Phys. Rev. **76**, 183(A) (1949).
K7. D. N. Kundu and M. L. Pool, Phys. Rev. **75**, 1690 (1949).
K8. D. N. Kundu and M. L. Pool, Phys. Rev. **74**, 1775 (1948).
K9. B. H. Ketelle and J. W. Ruch, Phys. Rev. **77**, 565 (1950).
K10. Ketelle, Nelson, and Boyd, Phys. Rev. **79**, 242(A) (1950).
K11. Kern, Mitchell, and Zaffarano, Phys. Rev. **76**, 94 (1949).
K12. B. H. Ketelle and G. W. Parker, Phys. Rev. **76**, 1416 (1949).
K13. B. H. Ketelle, Phys. Rev. **76**, 1256 (1949).
K14. G. B. Knight and R. L. Macklin, Phys. Rev. **75**, 34 (1949).
K15. D. N. Kundu and M. L. Pool, Phys. Rev. **78**, 488 (1950).
K16. E. J. Konopinski, Revs. Modern Phys. **15**, 209 (1943).
K17. M. Kemmerich, Z. Physik **126**, 399 (1949).

L1. L. J. Laslett, Phys. Rev. **76**, 858 (1949).
L2. L. M. Langer and H. C. Price, Jr., Phys. Rev. **76**, 641 (1949).
L3. Langer, Motz, and Price, Phys. Rev. **77**, 798 (1950).
L4. L. M. Langer, Phys. Rev. **77**, 50 (1950).
L5. Langer, Moffat, and Price, Phys. Rev. **76**, 1725 (1949).
L6. L. M. Langer and H. C. Price, Phys. Rev. **75**, 1109 (1949).
L7. J. C. Lee and M. L. Pool, Phys. Rev. **76**, 606 (1949).
L8. Lidofsky, Macklin, and Wu, Phys. Rev. **76**, 1888 (1949).
L9. A. Lundby, Phys. Rev. **76**, 1809 (1949).
L10. P. W. Levy and E. Greuling, Phys. Rev. **75**, 819 (1949).
L11. Lecoin, Perey, and Teillac, J. phys. radium **10**, 37 (1949).

M1. Miller, Ballentine, Bernstein, Friedman, Nier, and Evans, Phys. Rev. **77**, 714 (1950).
M2. K. H. Morganstern and K. P. W. Wolf, Phys. Rev. **76**, 1261 (1949).
M3. Macklin, Lidofsky, and Wu, Phys. Rev. **78**, 318(A) (1950).
M4. J. L. Meem, Jr., and F. Maienschein, Phys. Rev. **76**, 328 (1949).
M5. Macklin, Feldman, Lidofsky, and Wu, Phys. Rev. **77**, 137 (1950).
M6. F. Maienschein and J. L. Meem, Jr., Phys. Rev. **76**, 899 (1949).
M7. Mann, Rankin, and Daykin, Phys. Rev. **76**, 1719 (1949).
M8. R. D. Moffat and L. M. Langer, Phys. Rev. **79**, 237(A) (1950).
M9. McCowan, Woodward, Pool, Phys. Rev. **74**, 1311 (1948).
M10. Mandeville, Woo, Scherb, Keighton, and Shapiro, Phys. Rev. **75**, 1528 (1949).
M11. McCown, Woodward, Pool, Phys. Rev. **74**, 1315 (1948).
M12. Mei, Mitchell, and Huddleston, Phys. Rev. **79**, 237(A) (1950).
M13. Marty, Labeyrigue, and Langevin, Compt. rend. **228**, 1722 (1949).
M14. C. E. Mandeville and E. Shapiro, Phys. Rev. **77**, 439 (1950).
M15. Mei, Huddleston, and Mitchell, Phys. Rev. **79**, 237(A) (1950).
M16. O. Minakawa, Sci. Papers Inst. Phys. Chem. Research (Tokyo) **42**, 139 (1944).
M17. Mandeville, Scherb, and Keighton, Phys. Rev. **75**, 221 (1949).
M18. E. C. Mallory and M. L. Pool, Phys. Rev. **76**, 1454 (1949).
M19. C. E. Mandeville and E. Shapiro, Phys. Rev. **76**, 718 (1949).
M20. Mei, Mitchell, and Zaffarano, Phys. Rev. **76**, 1883 (1949).
M21. A. C. G. Mitchell, Revs. Modern Phys. **22**, 36 (1950).
M22. C. E. Mandeville and E. Shapiro, Phys. Rev. **75**, 897 (1949).
M23. Mitchell, Mei, Maienschein, and Peacock, Phys. Rev. **76**, 1450 (1949).
M24. L. Marquez and I. Perlman, Phys. Rev. **78**, 189 (1950).
M25. F. Metzger and M. Deutsch, Phys. Rev. **74**, 1640 (1948).
M26. Macnamara, Collins, and Thode, Phys. Rev. **75**, 532 (1949).
M27. C. E. Mandeville and E. Shapiro, Phys. Rev. **75**, 1834 (1949).
M28. C. E. Mandeville and E. Shapiro, Phys. Rev. **79**, 243(A) (1950).
M29. C. E. Mandeville, Phys. Rev. **75**, 1017 (1949).
M30. C. E. Mandeville, Phys. Rev. **78**, 319(A) (1950).
M31. C. E. Mandeville and M. V. Scherb, Phys. Rev. **76**, 186(A) (1949).
M32. Martin, Richardson, and Hsü, Proc. Phys. Soc. (London) **60**, 466 (1948).
M33. D. G. E. Martin and H. O. W. Richardson, Proc. Roy. Soc. (London) **A195**, 287 (1949).
M34. R. Morrissey and C. S. Wu, Phys. Rev. **75**, 1288 (1949).
M35. L. Melander and H. Slätis, Arkiv Mat., Astron. Fysik **36A**, No. 15 (1949).
M36. W. W. Meinke and G. T. Seaborg, Phys. Rev. **78**, 475 (1950).
M37. Medicus, Preiswerk, and Scherrer, Helv. Phys. Acta **23**, 299 (1950).
M38. Medicus, Maeder, and Schneider, Helv. Phys. Acta **22**, 603 (1949).

N1. A. Newton, as reported in S16.
N2. Naumann, Reynolds, and Perlman, Phys. Rev. **77**, 398 (1950).

O1. Overstreet, Jacobson, and Stout, Phys. Rev. **75**, 231 (1949).
O2. G. E. Owen and C. S. Cook, Phys. Rev. **76**, 1536 (1949).

O3. G. E. Owen and C. S. Cook, Phys. Rev. **76**, 1726 (1949).
O4. J. S. Osoba, Phys. Rev. **76**, 345 (1949).
O5. Owen, Moe, and Cook, Phys. Rev. **74**, 1879 (1948).

P1. V. Perez-Mendez and H. Brown, Phys. Rev. **77**, 404 (1950).
P2. V. Perez-Mendez and H. Brown, Phys. Rev. **76**, 689 (1949).
P3. C. L. Peacock and R. G. Wilkinson, Phys. Rev. **74**, 297 (1948).
P4. Parmley, Moyer, and Lilly, Phys. Rev. **75**, 619 (1949).
P5. K. Philipp and P. Rehbein, Z. Physik **124**, 225 (1948).
P6. C. L. Peacock and A. C. G. Mitchell, Phys. Rev. **75**, 1272 (1949).

R1. J. M. Robson, Phys. Rev. **78**, 311 (1950).
R2. J. H. Reynolds, Phys. Rev. **79**, 243(A) (1950).
R3. Robertson, Scott, and Pool, Phys. Rev. **76**, 1649 (1949).
R4. Robertson, Scott, and Pool, Phys. Rev. **78**, 318(A) (1950).
R.5 Rutledge, Stoddard, Branyan, LeBlanc, and Cork, Phys. Rev. **79**, 237(A) (1950).
R6. Robertson, Carss, and Pool, Phys. Rev. **77**, 747(A) (1950).
R7. E. R. Rae, Proc. Phys. Soc. (London) **A63**, 292 (1950).

S1. G. T. Seaborg and I. Perlman, Revs. Modern Phys. **20**, 585 (1948).
S2. R. W. Stout, Phys. Rev. **75**, 1107 (1949).
S3. Slack, Owen, and Primakoff, Phys. Rev. **75**, 1448 (1949).
S4. E. Segrè and C. E. Wiegand, Phys. Rev. **75**, 43 (1949).
S5. Sherr, Muether, White, Phys. Rev. **75**, 282 (1949).
S6. S. C. Snowdon, Phys. Rev. **78**, 299 (1950).
S7. Seidlitz, Bleuler, and Tendam, Phys. Rev. **76**, 861 (1949).
S8. K. Siegbahn and A. Ghosh, Arkiv Mat., Astron. Fysik **36A**, No. 19 (1949); Phys. Rev. **76**, 307 (1949).
S9. L. M. Silver, Phys. Rev. **76**, 589(A) (1949).
S10. Siegbahn, Hedgran, and Deutsch, Phys. Rev. **76**, 1263 (1949).
S11. K. Siegbahn, as reported in M21.
S12 Slack, Braden, and Shull, Phys. Rev. **75**, 1965 (1949).
S13. Saur, Axel, Mann, and Ovadia, Phys. Rev. **79**, 237(A) (1950).
S14. Siegbahn, Kondaiah, and Johannsson, Nature **164**, 405 (1949).
S15. K. Siegbahn, Phys. Rev. **77**, 233 (1950).
S16. E. Segrè and A. C. Helmholz, Revs. Modern Phys. **21**, 271 (1949).
S17. K. Siegbahn and W. Forsling, Arkiv. Fysik **1**, 505 (1950).
S18. C. W. Stanley and S. Katcoff, J. Chem. Phys. **17**, 653 (1949).
S19. N. Sugarman, Phys. Rev. **75**, 1473 (1949).
S20. L. R. Shepherd, Research **1**, 671 (1948).
S21. E. Shapiro and C. E. Mandeville, Phys. Rev. **78**, 319(A) (1950).
S22. D. Saxon and J. Richards, Phys. Rev. **76**, 186(A) (1949).
S23. Steffen, Huber, and Humbel, Helv. Phys. Acta **22**, 167 (1949).
S24. D. Saxon and R. Heller, Phys. Rev. **75**, 909 (1949).
S25. H. Slätis and K. Siegbahn, Phys. Rev. **75**, 318 (1949).
S26. H. Slätis and K. Siegbahn, Arkiv Mat., Astron. Fysik **36A**, No. 21 (1949).
S27. D. Saxon and J. Richards, Phys. Rev. **76**, 982 (1949).
S28. Slätis, du Toit, and Siegbahn, Phys. Rev. **78**, 498 (1950).
S29. E. P. Steinberg and L. E. Glendenin, Phys. Rev. **78**, 624 (1950).
S30. K. Siegbahn and H. Slätis, Arkiv. Fysik **1**, 559 (1950).
S31. Snell, Pleasonton, and McCord, Phys. Rev. **78**, 310(A) (1950).
S32. N. Sugarman, J. Chem. Phys. **17**, 11 (1949).

T1. Tollestrup, Jenkins, Fowler, and Lauritsen, Phys. Rev. **75**, 1947 (1949).
T2. Taschek, Argo, Hemmendinger, and Jarvis, Phys. Rev. **76**, 325 (1949).
T3. C. M. Turner, Phys. Rev. **76**, 148 (1949).
T4. G. M. Temmer, Phys. Rev. **76**, 424 (1949).
T5. Thulin, Bergström, and Hedgran, Phys. Rev. **76**, 871 (1949).
T6. Ter-Pogossian, Cook, Goddard, and Robinson, Phys. Rev. **76**, 909 (1949).
T7. Tollestrup, Fowler, and Lauritsen, Phys. Rev. **78**, 372 (1950).
T8. D. J. Tendam, Private communication by E. Feenberg and G. L. Trigg.

W1. R. M. Williamson and H. T. Richards, Phys. Rev. **76**, 614 (1949).
W2. C. S. Wu and L. Feldman, Phys. Rev. **76**, 698 (1949).
W3. R. Wilson and G. R. Bishop, Proc. Phys. Soc. (London) **A62**, 457 (1949).
W4. Wu, Townes, and Feldman, Phys. Rev. **76**, 692 (1949).
W5. C. S. Wu and L. Feldman, Phys. Rev. **76**, 693 (1949).
W6. Waggoner, Moon, and Roberts, Phys. Rev. **79**, 236(A) (1950).
W7. H. W. Wilson and S. C. Curran, Phil. Mag. **40**, 631 (1949).
W8. C. S. Wu and R. D. Albert, Phys. Rev. **75**, 315, 1107 (1949).
W9. C. S. Wu and L. Feldman, Phys. Rev. **76**, 696 (1949).
W10. D. Walker, Proc. Phys. Soc. (London) **A62**, 799 (1949).
W11. G. Wilkinson and H. G. Hicks, Phys. Rev. **75**, 1687 (1949).
W12. G. Wilkinson and H. G. Hicks, Phys. Rev. **75**, 1370 (1949).
W13. G. Wilkinson, Phys. Rev. **75**, 1019 (1949).
W14. E. P. Wigner, Phys. Rev. **56**, 519 (1939).