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Nuclear Energy Levels, Z-11 to 20

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INTRODUCTION

THE following compilation summarizes the present status of nuclear spectroscopy in the medium light elements from sodium to calcium. Above $Z=20$ it is still true that most of our information concerning nuclear excited states deals with (*a*) low-lying levels up to a few million volts above the ground level, studied by means of beta- and gamma-ray spectra of radioactive isotopes, and (*b*) levels just above the binding energy of the neutron, observed by means of neutron resonances. However, for the light nuclei there is available a much larger variety of information—the inelastic scattering of protons, neutrons, and deuterons, the discrete particle groups and gamma-ray lines emitted in such nuclear reactions as (dp) (αp) $(d\alpha)$ (αn) etc., as well as the study of proton, neutron, and alpha-particle resonances, and beta- and gamma-ray spectra. The task of critically coordinating this mass of data has become one of major concern to those working with nuclei in the region $Z<20$.

The initial attack on this problem was made in 1945 by Volz (VI) in a summary of nuclear energy levels up to $Z=20$. Energy levels in light nuclei below $Z=10$ were compiled by Hornyak and Lauritsen (H11, L4) in the first comprehensive postwar survey of this subject. This has now been expanded by Hornyak, Lauritsen, Morrison, and Fowler to include complete level information up to and including $Z=10$ and appears as the preceding article of this issue (H17). The need for a supplementary table of levels for the nuclei from $Z-11$ to 20 has become increasingly evident not only for presenting information already available but for indicating energy regions where data are lacking and where useful experiments might be performed. It is because of its possible value to nuclear physicists working in this field as well as to our own research program at Brookhaven that this compilation was undertaken. A preliminary survey was made early in 1949 (A7).

For most nuclei our knowledge of excited states is limited to their positions with respect to the ground level. The widths, angular momenta, and parity properties are, of course, of importance in attempting to formulate a suitable theory accounting for such states. Rather little conclusive information concerning these properties is available at present, although some experiments have been done on the angular dependence of collision processes, the relative yield of particle groups, and the line shape of resonance phenomena. The density of unresolved levels as a function of energy has been investigated in a few cases. Because of the indefinite nature of most of this other information only the level positions are given here.

Table I lists nuclear levels for isotopes from $Z=11$ up to and including $Z=20$ in order of increasing excitation energy. Observation of the ground state in a particular reaction is included only if an excited state is found in the same process, one exception being that of inelastic scattering levels. The elastically scattered peak, which is usually observed, has been omitted.

The concept of resonance levels corresponding to excitation of a compound nucleus at energies above the binding energy of the incoming particle is based on theoretical treatment of widths and level densities that have been obtained experimentally. The calculated lifetimes of these levels are of the order of 10^6 times as great as the transit time of nucleons across the nucleus, and it is therefore suspected that such virtual states are similar in nature to bound states. An excellent discussion of resonances and the compound nucleus has been given by Weisskopf (W13).

Representing the position of resonance levels above the ground state requires a knowledge of the binding energy of the incoming particle, a quantity which has not yet been measured directly in any of the cases considered here. Other processes must therefore be used to connect the initial and compound nuclei. For example the binding energy, or Q-value, of the $Na^{23}(p\gamma)Mg^{24}$ reaction is found by combining the relations

$$Na^{23}+d=Na^{24}+p+Q_0$$
$$Na^{24}=Mg^{24}+Q_1 \quad \text{(beta-decay)}$$

to obtain

$$Q\equiv(Na^{23}+p)-Mg^{24}$$
$$=2p-d+Q_0+Q_1,$$

where Q_0 and Q_1 are measured quantities, and masses have been converted to appropriate energy units. Table II shows the way in which the various resonance binding energies were obtained.

The position of a resonance above the ground level is then given by

$$E=Q+E_{cm},$$

where E_{cm} is the additional excitation in the center-of-mass system furnished by the kinetic energy of the incoming particle. If m is the mass of the bombarding particle and M is the mass of the compound nucleus then E_{cm} is obtained from the particle energy in laboratory coordinates, E_L, by using the relation

$$E_{cm}=\left(1-\frac{m}{M}\right)E_L=\frac{\text{mass of init. nucl.}}{\text{mass of comp. nucl.}}\times E_L.$$

* Under contract with the AEC.

TABLE I. Nuclear energy levels, Z—11 to 20.

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
11	Na^{23}	0	$Ne^{23}(\beta^-)Na^{23}$	β	$E_\beta=4.12$	B18
		3.0	$Ne^{23}(\beta^-)Na^{23}$	β	$E_\beta=1.18$	B18
				γ	$E_\gamma=2.5-3.5$	P15
		10.8+3.0	$F^{19}(\alpha p)Ne^{22}$	res.	$E_\alpha=3.7$	C5, C1
			$F^{19}(\alpha\alpha)F^{19}$	res.	$E_\alpha=3.5$	D8
		10.8+3.4	$F^{19}(\alpha p)Ne^{22}$	res.	$E_\alpha=4.1$	C5, C1
		10.8+3.9	$F^{19}(\alpha\alpha)F^{19}$	res.	$E_\alpha=4.7$	D8
		10.8+4.3	$F^{19}(\alpha p)Ne^{22}$	res.	$E_\alpha=5.25$	C1
	Na^{24}	0	$Na^{23}(dp)Na^{24}$	p	$Q=4.77$	W10, M10, L1, L6
		0.54	$Na^{23}(dp)Na^{24}$	p	$Q=4.23$	W10, M10
		1.32	$Na^{23}(dp)Na^{24}$	p	$Q=3.45$	W10, M10
		1.83	$Na^{23}(dp)Na^{24}$	p	$Q=2.94$	W10
		2.55	$Na^{23}(dp)Na^{24}$	p	$Q=2.22$	W10
		3.44	$Na^{23}(dp)Na^{24}$	p	$Q=1.33$	W10, M10, L1, L6
		3.81	$Na^{23}(dp)Na^{24}$	p	$Q=0.96$	W10
		3.99	$Na^{23}(dp)Na^{24}$	p	$Q=0.78$	W10
		4.27	$Na^{23}(dp)Na^{24}$	p	$Q=0.50$	W10
		4.65	$Na^{23}(dp)Na^{24}$	p	$Q=0.12$	W10
		7.00+0.00164	$Na^{23}+n$	σ res.	$E_n=0.00171$	L2
		7.00+0.0029	$Na^{23}+n$	σ res.	$E_n=0.003$	H15
		7.00+0.057	$Na^{23}+n$	σ res.	$E_n=0.060$	A4
		7.00+0.192	$Na^{23}+n$	σ res.	$E_n=0.200$	A4
		7.00+0.225	$Na^{23}+n$	σ res.	$E_n=0.235$	A4
		7.00+0.374	$Na^{23}+n$	σ res.	$E_n=0.390$	A4
		7.00+0.426	$Na^{23}+n$	σ res.	$E_n=0.445$	A4
		7.00+0.680	$Na^{23}+n$	σ res.	$E_n=0.710$	A4
		7.00+0.757	$Na^{23}+n$	σ res.	$E_n=0.790$	A4
		7.00+0.882	$Na^{23}+n$	σ res.	$E_n=0.920$	A4
12	Mg^{24}	0	$Na^{23}(dn)Mg^{24}$	n	$Q=9.2$	M13
		0.8	$Na^{23}(dn)Mg^{24}$	n	$Q=8.4$	M13
		1.38	$Na^{24}(\beta^-)Mg^{24}$	γ		S4, R4, E3, I1, W6, F4, L5, C4, M5, B8, M4
			$Mg^{24}(pp)Mg^{24}$	p		R6, R5, G5, D2, W7, F1, W11, D5
			$Mg^{24}(pp)Mg^{24}$	γ	$E_\gamma=1.35$	B12
			$Mg^{24}(dd)Mg^{24}$	d		H14, G5
			$Na^{23}(dn)Mg^{24}$	n	$Q=8.0$	M13
			$Mg^{24}(nn)Mg^{24}$	n		L3
		1.7	$Na^{23}(dn)Mg^{24}$	n	$Q=7.5$	M13
		4.14	$Na^{24}(\beta^-)Mg^{24}$	γ	$E_\gamma=1.38+2.76$	S4, R4, E3, I1, W6, F4, G2, L5, C4, W8, M5, B8, M4
			$Mg^{24}(pp)Mg^{24}$	p		D2, F1, W7
			$Na^{23}(dn)Mg^{24}$	n	$Q=5.1$	M13
		5.5	$Mg^{24}(pp)Mg^{24}$	p		F1
		7.5	$Na^{23}(dn)Mg^{24}$	n	$Q=1.5$	M13
			$Mg^{24}(pp)Mg^{24}$	p		F1
		8.5	$Na^{23}(dn)Mg^{24}$	n	$Q=0.6$	M13
			$Mg^{24}(pp)Mg^{24}$	p		F1
		11.74+0.244	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.255$	T1
		11.74+0.292	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.305$	G3, B10, T1, H1
		11.74+0.359	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.375$	T1
		11.74+0.407	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.425$	C2
		11.74+0.426	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.445$	T1
		11.74+0.494	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.515$	B10, C2, T1, H1
		11.74+0.552	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.576$	B10
		11.74+0.573	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.598$	B10, C2
		11.74+0.704	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.735$	B10, C2
		11.74+0.831	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=0.867$	B10, C2
		11.74+0.964	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.006$	B10
		11.74+1.03	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.08$	B10
		11.74+1.111	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.159$	B10
		11.74+1.156	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.206$	B10
		11.74+1.203	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.255$	B10
		11.74+1.228	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.281$	B10
		11.74+1.269	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.324$	B10
		11.74+1.334	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.392$	B10
		11.74+1.353	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.412$	B10
		11.74+1.393	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.454$	B10
		11.74+1.570	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.638$	B10
		11.74+1.660	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.732$	B10
		11.74+1.720	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.795$	B10
		11.74+1.753	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.829$	B10

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	Mg^{24}	11.74+1.85	$Na^{23}(p\gamma)Mg^{24}$	res.	$E_p=1.93$	B10
		9.60+5.1	$Ne^{20}(\alpha\alpha)Ne^{20}$	res.	$E_\alpha=6.1$	B13
	Mg^{25}	0	$Mg^{24}(dp)Mg^{25}$	p	$Q=5.03$	A5, N2
			$Al^{27}(d\alpha)Mg^{25}$	α	$Q=6.52$	P7, L1, M6
			$Na^{25}(\beta^-)Mg^{25}$	β	$E_\beta=3.7$	B2
		0.58	$Mg^{24}(dp)Mg^{25}$	p	$Q=4.45$	A5, N2
		0.98	$Mg^{24}(dp)Mg^{25}$	p	$Q=4.05$	A5, N2
			$Al^{27}(d\alpha)Mg^{25}$	α	$Q=5.71$	P7, L1, M6
			$Na^{25}(\beta^-)Mg^{25}$	β	$E_\beta=2.7$	B2
		1.58	$Al^{27}(d\alpha)Mg^{25}$	α	$Q=4.94$	P7
			$Mg^{24}(dp)Mg^{25}$	p	—	N2
		2.54	$Al^{27}(d\alpha)Mg^{25}$	α	$Q=3.98$	P7
			$Mg^{24}(dp)Mg^{25}$	p	—	N2
		7.22+0.58	$Mg^{24}+n^{a}$	σ res.	$E_n=0.60$	F5
		7.22+0.69	$Mg^{24}+n^{a}$	σ res.	$E_n=0.72$	F5
		7.22+0.84	$Mg^{24}+n^{a}$	σ res.	$E_n=0.87$	F5
		7.22+1.09	$Mg^{24}+n^{a}$	σ res.	$E_n=1.14$	F5
		7.22+1.27	$Mg^{24}+n^{a}$	σ res.	$E_n=1.32$	F5
		7.22+1.60	$Mg^{24}+n^{a}$	σ res.	$E_n=1.60$	F5
		7.22+1.66	$Mg^{24}+n^{a}$	σ res.	$E_n=1.73$	F5
		7.22+2.44	$Mg^{24}+n^{a}$	σ res.	$E_n=2.54$	M14
	Mg^{26}	0	$Na^{23}(\alpha p)Mg^{26}$	p	$Q=1.72$	M7, K2, L1, M9, P8, H13
		0.44	$Na^{23}(\alpha p)Mg^{26}$	p	$Q=1.28$	M7
		1.91	$Na^{23}(\alpha p)Mg^{26}$	p	$Q=-0.19$	M7, H13, P8, L1, K2, M2, M9
		2.85	$Na^{23}(\alpha p)Mg^{26}$	p	$Q=-1.13$	M7, H13
		4.0	$Na^{23}(\alpha p)Mg^{26}$	p	$Q=-2.1$	L1, M2, K2, P8
		5.0	$Na^{23}(\alpha p)Mg^{26}$	p	$Q=-3.1$	L1, M2, K2
13	Al^{25}	−+0.213	$Mg^{24}(p\gamma)Al^{25}$	res. yield of Al^{25}	$E_p=0.222$	G4
		−+0.400	$Mg^{24}(p\gamma)Al^{25}$	res. yield of Al^{25}	$E=0.417$	G4
	Al^{26}	0	$Mg^{25}(dn)Al^{26}$	n	$Q=5.6$	S11
		2.0	$Mg^{25}(dn)Al^{26}$	n	$Q=3.6$	S11
		3.6	$Mg^{25}(dn)Al^{26}$	n	$Q=2.0$	S11
		5.1	$Mg^{25}(dn)Al^{26}$	n	$Q=0.5$	S11
		7.80+0.173	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.180$	C2
		7.80+0.298	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.310$	T1
		7.80+0.377	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.392$	T1
		7.80+0.473	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.492$	T1, C2
		7.80+0.488	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.508$	T1
		7.80+0.505	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.525$	T1
		7.80+0.553	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.575$	C2
		7.80+0.793	$Mg^{25}(p\gamma)Al^{26b}$	res.	$E_p=0.825$	C2
	Al^{27}	0	$Mg^{24}(\alpha p)Al^{27}$	p	$Q=-1.32^{c}$	L1, D1, H9
			$Mg^{26}(dn)Al^{27}$	n	$Q=5.7$	S14
		0.84	$Al^{27}(pp)Al^{27}$	p		H10, D2, F1, R6, R5, W12, B14, D5, G5
			$Al^{27}(dd)Al^{27}$	d		G5, H14
			$Mg^{26}(dn)Al^{27}$	n	$Q=4.8$	S14
			$Mg^{27}(\beta^-)Al^{27}$	γ	$E_\gamma=0.84$	B1, I1, R4
		1.02	$Al^{27}(pp)Al^{27}$	p		R6, R5, H10
			$Mg^{24}(\alpha p)Al^{27}$	p	$Q=-2.37^{d}$	L1, D1, H9
		1.85	$Al^{27}(pp)Al^{27}$	p		H10, D5
			$Mg^{27}(\beta^-)Al^{27}$	β, γ	$E_\gamma=0.84+1.01$	B1, I1
			$Mg^{26}(dn)Al^{27}$	n	$Q=3.8$	S14
		2.15	$Al^{27}(pp)Al^{27}$	p		R6, R5, G5, H10, D2, B14
			$Al^{27}(dd)Al^{27}$	d		G5, H14
		2.78	$Al^{27}(pp)Al^{27}$	p		H10, D2, D5, B14, F1
			$Mg^{26}(dn)Al^{27}$	n	$Q=2.9$	S14
		3.03	$Al^{27}(pp)Al^{27}$	p		H10, B14
		3.7	$Mg^{26}(dn)Al^{27}$	n	$Q=2.0$	S14
		4.3	$Mg^{26}(dn)Al^{27}$	n	$Q=1.4$	S14
		5.3	$Mg^{26}(dn)Al^{27}$	n	$Q=0.4$	S14
		5.8	$Mg^{26}(dn)Al^{27}$	n	$Q=-0.1$	S14
		8.29+0.279	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.290$	T1
		8.29+0.302	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.314$	T1
		8.29+0.324	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.336$	T1
		8.29+0.374	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.388$	T1
		8.29+0.414	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.430$	T1
		8.29+0.434	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.451$	T1
		8.29+0.476	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.494$	T1

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	Al^{27}	8.29+0.558	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.580$	C2
		8.29+0.655	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=0.680$	C2
		8.29+0.963	$Mg^{26}(p\gamma)Al^{27}$	res.	$E_p=1.000$	C2
		10.42+5.3	$Na^{23}(\alpha n)Al^{26}$	res.	$E_\alpha=6.2$	B9
		10.42+5.8	$Na^{23}(\alpha n)Al^{26}$	res.	$E_\alpha=6.8$	B9
		17.26+0.884	$Mg^{25}(dp)Mg^{26}$	res.	$E_d=0.955$	A1
	Al^{28}	0	$Al^{27}(dp)Al^{28}$	p	$Q=5.45$	P7, A1, A3, W10, N3, L1, M6
		1.02	$Al^{27}(dp)Al^{28}$	p	$Q=4.43$	P7, A1, A3, W10
		1.42	$Al^{27}(dp)Al^{28}$	p	$Q=4.03$	A1, W10
		1.61	$Al^{27}(dp)Al^{28}$	p	$Q=3.84$	P7, W10
		2.18	$Al^{27}(dp)Al^{28}$	p	$Q=3.27$	P7, A1, A3, W10
		2.64	$Al^{27}(dp)Al^{28}$	p	$Q=2.81$	P7, W10, N3, L1, M6
		3.00	$Al^{27}(dp)Al^{28}$	p	$Q=2.45$	P7, W10
		3.37	$Al^{27}(dp)Al^{28}$	p	$Q=2.08$	P7, W10
		3.64	$Al^{27}(dp)Al^{28}$	p	$Q=1.81$	W10, N3
		3.90	$Al^{27}(dp)Al^{28}$	p	$Q=1.55$	P7, L1, M6
		4.13	$Al^{27}(dp)Al^{28}$	p	$Q=1.32$	W10
		4.47	$Al^{27}(dp)Al^{28}$	p	$Q=0.98$	P7
		4.75	$Al^{27}(dp)Al^{28}$	p	$Q=0.70$	P7, W10
		4.95	$Al^{27}(dp)Al^{28}$	p	$Q=0.50$	P7, W10
		5.09	$Al^{27}(dp)Al^{28}$	p	$Q=0.36$	P7, W10, N3, L1, M6
		5.35	$Al^{27}(dp)Al^{28}$	p	$Q=0.10$	P7, W10
		5.72	$Al^{27}(dp)Al^{28}$	p	$Q=-0.27$	P7, W10
		7.68+0.0088	$Al^{27}+n$	σ res.	$E_n=0.0091$	L2
		7.68+0.039	$Al^{27}+n$	σ res.	$E_n=0.040$	H18, S3
				res. yield of Al^{28}	$E_n=0.040$	H18
		7.68+0.092	$Al^{27}+n$	σ res.	$E_n=0.095$	H18, S3
		7.68+0.140	$Al^{27}+n$	σ res.	$E_n=0.145$	H18, S3
				res. yield of Al^{28}	$E_n=0.145$	H18
		7.68+0.145	$Al^{27}+n$	σ res.	$E_n=0.155$	H18, S3
		7.68+0.203	$Al^{27}+n$	σ res.	$E_n=0.210$	H18, S3
				res. yield of Al^{28}	$E_n=0.210$	H18
		7.68+0.217	$Al^{27}+n$	res. yield of Al^{28}	$E_n=0.225$	H18
		7.68+0.256	$Al^{27}+n$	res. yield of Al^{28}	$E_n=0.265$	H18
		7.68+0.280	$Al^{27}+n$	σ res.	$E_n=0.290$	H18, S3
		7.68+0.304	$Al^{27}+n$	σ res.	$E_n=0.315$	H18, S3
				res. yield of Al^{28}	$E_n=0.315$	H18
		7.68+0.357	$Al^{27}+n$	σ res.	$E_n=0.370$	H18, S3
				res. yield of Al^{28}	$E_n=0.370$	H18
		7.68+0.410	$Al^{27}+n$	σ res.	$E_n=0.425$	H18, S3
				res. yield of Al^{28}	$E_n=0.425$	H18
		7.68+0.429	$Al^{27}+n$	res. yield of Al^{28}	$E_n=0.445$	H18
		7.68+0.463	$Al^{27}+n$	σ res.	$E_n=0.480$	H18
				res. yield of Al^{28}	$E_n=0.480$	H18
		7.68+0.482	$Al^{27}+n$	σ res.	$E_n=0.500$	H18
				res. yield of Al^{28}	$E_n=0.500$	H18
		7.68+0.511	$Al^{27}+n$	σ res.	$E_n=0.530$	H18, S3
		7.68+0.550	$Al^{27}+n$	σ res.	$E_n=0.570$	H18
		7.68+0.598	$Al^{27}+n$	σ res.	$E_n=0.620$	H18
		7.68+0.627	$Al^{27}+n$	σ res.	$E_n=0.650$	H18, S3
		7.68+0.680	$Al^{27}+n$	σ res.	$E_n=0.705$	H18
		7.68+0.767	$Al^{27}+n$	σ res.	$E_n=0.795$	S3
		7.68+2.3	$Al^{27}+n$	σ res.	$E_n=2.4$	A2
		7.68+2.8	$Al^{27}+n$	σ res.	$E_n=2.9$	A2
14	Si^{28}	0	$Al^{27}(dn)Si^{28}$	n	$Q=9.08$	P1
		1.80	$Al^{28}(\beta^-)Si^{28}$	γ		B1, B2, E1, I1
			$Al^{27}(dn)Si^{28}$	n	$Q=7.30$	P1
		4.47	$Al^{27}(dn)Si^{28}$	n	$Q=4.61$	P1
			$Si^{28}(pp)Si^{28}$	p		F1
		4.91	$Al^{27}(dn)Si^{28}$	n	$Q=4.17$	P1
		6.11	$Al^{27}(dn)Si^{28}$	n	$Q=2.97$	P1
		6.65	$Al^{27}(dn)Si^{28}$	n	$Q=2.43$	P1
		7.10	$Al^{27}(dn)Si^{28}$	n	$Q=1.98$	P1
		7.55	$Al^{27}(dn)Si^{28}$	n	$Q=1.53$	P1
		8.18	$Al^{27}(dn)Si^{28}$	n	$Q=0.90$	P1
		9.16	$Al^{27}(dn)Si^{28}$	n	$Q=-0.08$	P1
		11.69+0.217	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.225$	B3, T1
		11.69+0.284	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.295$	B3, T1
		11.69+0.313	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.325$	B3, H1, T1
		11.69+0.390	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.404$	B3, H1, T1
		11.69+0.427	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.443$	B3, H1, T1

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	Si^{28}	11.69+0.486	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.504$	B3, P2, H1, T1
		11.69+0.587	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.609$	B3
		11.69+0.607	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.630$	B3, P2
		11.69+0.630	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.653$	B3, P2
		11.69+0.653	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.677$	B3, P2
		11.69+0.702	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.728$	B3
		11.69+0.707	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.733$	B3, P2
		11.69+0.712	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.738$	B3
		11.69+0.730	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.757$	B3
		11.69+0.737	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.764$	B3
		11.69+0.743	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.771$	B3, P2
		11.69+0.848	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.880$	B3
		11.69+0.885	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.918$	B3
		11.69+0.899	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.932$	B3
		11.69+0.951	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.986$	B3, P2
		11.69+0.958	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=0.994$	B3
		11.69+0.983	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.019$	B3, P2
		11.69+1.044	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.083$	B3
		11.69+1.052	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.091$	B3
		11.69+1.076	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.116$	B3, P2
		11.69+1.124	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.166$	B3, P2
		11.69+1.134	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.176$	B3
		11.69+1.147	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.190$	B3, P2
		11.69+1.160	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.203$	B3, P2
		11.69+1.210	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.255$	B3, P2
		11.69+1.223	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.268$	B3
		11.69+1.261	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.308$	B3, P2
		11.69+1.273	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.320$	B3
		11.69+1.306	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.355$	B3
		11.69+1.321	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.370$	B3, P2
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.370$	S15
		11.69+1.336	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.385$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.385$	S15
		11.69+1.343	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.393$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.393$	S15
		11.69+1.393	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=1.445$	S15
		11.69+1.409	$Al^{27}(pp)Al^{27}$	res.	$E_p=1.461$	S15
		11.69+1.454	$Al^{27}(pp)Al^{27}$	res.	$E_p=1.508$	S15
		11.69+1.469	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.523$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.523$	S15
		11.69+1.526	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=1.583$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.583$	S15
		11.69+1.536	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.593$	S15
		11.69+1.610	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.670$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.670$	S15
		11.69+1.628	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.688$	S15
		11.69+1.647	$Al^{27}(pp)Al^{27}$	res.	$E_p=1.708$	S15
		11.69+1.667	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.729$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=1.729$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.729$	S15
		11.69+1.690	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.753$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.753$	S15
		11.69+1.741	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.806$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.806$	S15
		11.69+1.842	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.910$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=1.910$	S15
		11.69+1.903	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=1.973$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=1.973$	S15
		11.69+1.966	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.039$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.039$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.039$	S15
		11.69+1.978	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.051$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.051$	S15
		11.69+2.037	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.112$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.112$	S15
		11.69+2.056	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.132$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.132$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.132$	S15
		11.69+2.084	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.161$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.161$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.161$	S15
		11.69+2.097	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.175$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.175$	S15

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	Si^{28}	11.69+2.106	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.184$	S15
		11.69+2.127	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.206$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.206$	S15
		11.69+2.206	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.288$	S15
		11.69+2.233	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.316$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.316$	S15
		11.69+2.250	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.333$	S15
		11.69+2.281	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.365$	S15
		11.69+2.292	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.377$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.377$	S15
		11.69+2.319	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.405$	S15
		11.69+2.358	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.445$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.445$	S15
		11.69+2.391	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.480$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.480$	S15
		11.69+2.402	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.491$	S15
		11.69+2.445	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=2.536$	S15
		11.69+2.468	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.559$	S15
		11.69+2.486	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.578$	S15
		11.69+2.514	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.607$	S15
		11.69+2.719	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.820$	S15
		11.69+2.747	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.849$	S15
		11.69+2.767	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.869$	S15
		11.69+2.777	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=2.880$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=2.880$	S15
		11.69+2.892	$Al^{27}(pp)Al^{27}$	res.	$E_p=2.999$	S15
		11.69+2.912	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.020$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.020$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=3.020$	S15
		11.69+2.936	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.045$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.045$	S15
		11.69+2.960	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.070$	S15
		11.69+2.970	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.080$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.080$	S15
		11.69+2.995	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.106$	S15
			$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.106$	S15
		11.69+3.071	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.185$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=3.185$	S15
		11.69+3.148	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.265$	S15
		11.69+3.279	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.400$	S15
			$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.400$	S15
		11.69+3.343	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.467$	S15
		11.69+3.405	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.531$	S15
		11.69+3.425	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.552$	S15
		11.69+3.439	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.566$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=3.566$	S15
		11.69+3.471	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.599$	S15
		11.69+3.494	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.623$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.623$	S15
			$Al^{27}(pp)Al^{27}$	res.	$E_p=3.623$	S15
		11.69+3.531	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.662$	S15
		11.69+3.573	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.705$	S15
		11.69+3.684	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=3.820$	S15
		11.69+3.713	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.850$	S15
		11.69+3.837	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=3.979$	S15
		11.69+3.910	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=4.055$	S15
			$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=4.055$	S15
		11.69+3.954	$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=4.100$	S15
			$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=4.100$	S15
		11.69+3.965	$Al^{27}(p\alpha)Mg^{24}$	res.	$E_p=4.112$	S15
			$Al^{27}(p\gamma)Si^{28}$	res.	$E_p=4.112$	S15
		10.37+4.8[e]	$Mg^{24}(\alpha p)Al^{27}$	res.	$E_\alpha=5.7$	D1
			$Mg^{24}(\alpha n)Si^{27}$	res. yield of Si^{27}	$E_\alpha=5.6$	M15
		10.37+5.3[e]	$Mg^{24}(\alpha p)Al^{27}$	res.	$E_\alpha=6.3$	D1
			$Mg^{24}(\alpha n)Si^{27}$	res. yield of Si^{27}	$E_\alpha=6.2$	M15
	Si^{29}	0	$Si^{28}(dp)Si^{29}$	p	$Q=6.18$	M8, A1, N3
		1.29	$Si^{28}(dp)Si^{29}$	p	$Q=4.89$	M8, A1, N3
			$Al^{29}(\beta^-)Si^{29}$	γ	$E_\gamma=1.25$	S12
		2.06	$Si^{28}(dp)Si^{29}$	p	$Q=4.12$	M8, N3
		2.43	$Si^{28}(dp)Si^{29}$	p	$Q=3.75$	M8, A1
			$Al^{29}(\beta^-)Si^{29}$	γ	$E_\gamma=2.35$	S12
		3.08	$Si^{28}(dp)Si^{29}$	p	$Q=3.10$	M8

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	Si^{29}	3.60	$Si^{28}(dp)Si^{29}$	p	$Q=2.58$	M8, N3
		4.09	$Si^{28}(dp)Si^{29}$	p	$Q=2.09$	M8
		4.87	$Si^{28}(dp)Si^{29}$	p	$Q=1.31$	M8, N3
		8.40+0.58	$Si^{28}+n$	σ res.	$E_n=0.60$	F5
		8.40+0.80	$Si^{28}+n$	σ res.	$E_n=0.83$	F5
		8.40+0.96	$Si^{28}+n$	σ res.	$E_n=0.99$	F5
		8.40+1.18	$Si^{28}+n$	σ res.	$E_n=1.22$	F5
		8.40+1.26	$Si^{28}+n$	σ res.	$E_n=1.30$	F5
		8.40+1.39	$Si^{28}+n$	σ res.	$E_n=1.44$	F5
		8.40+1.61	$Si^{28}+n$	σ res.	$E_n=1.67$	F5
		8.40+1.82	$Si^{28}+n$	σ res.	$E_n=1.88$	F5
		11.20+4.8	$Mg^{25}(\alpha p)Al^{28}$	res. yield of Al^{28}	$E_\alpha=5.6$	C6, F2, M15, E2
		11.20+5.4	$Mg^{25}(\alpha p)Al^{28}$	res. yield of Al^{28}	$E_\alpha=6.3$	C6, F2, M15, E2
	Si^{30}	0	$Si^{29}(dp)Si^{30}$	p	$Q=8.36$	M8
			$Al^{27}(\alpha p)Si^{30}$	p	$Q=2.26$	L1, B4, D1, H2, M1, P8, L7
		2.28	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-0.02$	L1, B4, D1, H2, M1, P8, L7
			$Si^{29}(dp)Si^{30}$	p	$Q=6.0$	M8
		3.58	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-1.32$	L1, D1, M1, H2, B4, P8, B14
			$Si^{29}(dp)Si^{30}$	p	$Q=4.45$	M8, P8
		4.75	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-2.49$	L1, B4, D1, H2, P8, L7
			$Si^{29}(dp)Si^{30}$	p	$Q=3.36$	M8
		5.7	$Si^{29}(dp)Si^{30}$	p	$Q=2.7$	M8
			$Al^{27}(\alpha p)Si^{30}$	p	$Q=-3.22$	B14
		7.18	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-4.96$	B14
		8.20	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-5.98$	B14
		9.26	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-7.04$	B14
		9.87	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-7.65$	B14
		10.86	$Al^{27}(\alpha p)Si^{30}$	p	$Q=-8.64$	B14
	Si^{31}	0	$Si^{30}(dp)Si^{31}$	p	$Q=4.33$	M8
			$P^{31}(np)Si^{31}$	p	$Q=-0.97$	M11
		0.73	$Si^{30}(dp)Si^{31}$	p	$Q=3.60$	M8
			$P^{31}(np)Si^{31}$	p	$Q\sim-1.7$	M11
		1.23	$Si^{30}(dp)Si^{31}$	p	$Q=3.10$	M8
		1.73	$Si^{30}(dp)Si^{31}$	p	$Q=2.60$	M8
		2.33	$Si^{30}(dp)Si^{31}$	p	$Q=2.00$	M8
15	P^{30}	0	$Al^{27}(\alpha n)P^{30}$	n	$Q=-2.93$	P4
			$Si^{29}(dn)P^{30}$	n	$Q=3.38$	P4
		1.02	$Al^{27}(\alpha n)P^{30}$	n	$Q=-3.91$	P4
			$Si^{29}(dn)P^{30}$	n	$Q=2.11$	P4
		5.63+0.315	$Si^{29}(p\gamma)P^{30}$	res. yield of P^{30}	$E_p=0.326$	T1
		5.63+0.400	$Si^{29}(p\gamma)P^{30}$	res. yield of P^{30}	$E_p=0.414$	T1
	P^{31}	0	$Si^{30}(dn)P^{31}$	n	$Q=4.56$	P4
			$Si^{28}(\alpha p)P^{31}$	p	$Q=-2.23$	L1, H2, H3
		0.44	$Si^{30}(dn)P^{31}$	n	$Q=4.12$	P4
		1.02	$Si^{30}(dn)P^{31}$	n	$Q=3.57$	P4
			$Si^{28}(\alpha p)P^{31}$	p	$Q=-3.28$	L1, H3, H9, H2
		1.74	$Si^{30}(dn)P^{31}$	n	$Q=2.78$	P4
			$Si^{28}(\alpha p)P^{31}$	p	$Q=-3.92$	L1, H3, H9, H2
		7.46+0.355	$Si^{30}(p\gamma)P^{31}$	res.	$E_p=0.367$	T1, H1
		7.46+0.483	$Si^{30}(p\gamma)P^{31}$	res.	$E_p=0.499$	T1, H1
		9.72+3.41	$Al^{27}(\alpha p)Si^{30}$	res.	$E_\alpha=3.92$	M1, C1, D1, K1
			$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=4.0$	W1
		9.72+3.81	$Al^{27}(\alpha p)Si^{30}$	res.	$E_\alpha=4.37$	M1, C1, D1, K1
			$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=4.51$	W1
		9.72+4.09	$Al^{27}(\alpha p)Si^{30}$	res.	$E_\alpha=4.70$	M1, C1, D1, K1
			$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=5.0$	W1, F3
		9.72+4.48	$Al^{27}(\alpha p)Si^{30}$	res.	$E_\alpha=5.14$	M1, C1, D1
			$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=5.3$	W1
		9.72+5.1	$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=5.9$	W1, Y1
			$Al^{27}(\alpha p)Si^{30}$	res.	$E_\alpha=5.75$	D1
		9.72+5.8	$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=6.7$	F3, W1, Y1
			$Al^{27}(\alpha p)Si^{30}$	res.	$E_\alpha=6.61$	D1
		9.72+6.8	$Al^{27}(\alpha n)P^{30}$	res. yield of P^{30}	$E_\alpha=7.80$	F3
16	S^{32}	2.25	$S^{32}(pp)S^{32}$	p		D2
			$S^{32}(pp)S^{32}$	γ	$E_\gamma=2.35$	B12
		4.34	$S^{32}(pp)S^{32}$	p		D2
		9.93+0.344	$P^{31}(p\gamma)S^{32}$	res.	$E_p=0.355$	T1, H1
		9.93+0.426	$P^{31}(p\gamma)S^{32}$	res.	$E_p=0.440$	T1, H1, C2

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	S^{32}	9.93+0.523	$P^{31}(p\gamma)S^{32}$	res.	$E_p=0.540$	T1, H1, C2
		9.93+0.68	$P^{31}(p\gamma)S^{32}$	res.	$E_p=0.70$	C2
		9.93+0.92	$P^{31}(p\gamma)S^{32}$	res.	$E_p=0.95$	C2
		9.93+1.05	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.08$	G6
		9.93+1.08	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.11$	G6
		9.93+1.10	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.14$	G6
		9.93+1.13	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.17$	G6
		9.93+1.23	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.27$	G6
		9.93+1.39	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.43$	G6
		9.93+1.42	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.47$	G6
		9.93+1.45	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.50$	G6
		9.93+1.49	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.54$	G6
		9.93+1.54	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.59$	G6
		9.93+1.57	$P^{31}(p\gamma)S^{32}$	res.	$E_p=1.62$	G6
	S^{33}	0	$S^{32}(dp)S^{33}$	p	$Q=6.48$	D3, S6
		0.79	$S^{32}(dp)S^{33}$	p	$Q=5.69$	D3, S6
		1.90	$S^{32}(dp)S^{33}$	p	$Q=4.58$	D3
		2.17	$S^{32}(dp)S^{33}$	p	$Q=4.31$	D3, S6
		2.85	$S^{32}(dp)S^{33}$	p	$Q=3.63$	D3
		3.15	$S^{32}(dp)S^{33}$	p	$Q=3.33$	D3, S6
		3.88	$S^{32}(dp)S^{33}$	p	$Q=2.60$	D3
		4.15	$S^{32}(dp)S^{33}$	p	$Q=2.33$	D3
		4.42	$S^{32}(dp)S^{33}$	p	$Q=2.06$	D3, S6
		4.70	$S^{32}(dp)S^{33}$	p	$Q=1.78$	D3
		5.11	$S^{32}(dp)S^{33}$	p	$Q=1.37$	D3, S6
		5.63	$S^{32}(dp)S^{33}$	p	$Q=0.85$	D3
		6.30	$S^{32}(dp)S^{33}$	p	$Q=0.18$	D3
		8.71+0.108	$S^{32}+n$	σ res.	$E_n=0.111$	P14, A6, P13
		8.71+0.199	$S^{32}+n$	σ res.	$E_n=0.205$	P14, A6
		8.71+0.267	$S^{32}+n$	σ res.	$E_n=0.275$	P14
		8.71+0.281	$S^{32}+n$	σ res.	$E_n=0.290$	P14
		8.71+0.364	$S^{32}+n$	σ res.	$E_n=0.375$	P14, P13
		8.71+0.567	$S^{32}+n$	σ res.	$E_n=0.585$	P14, P13, F5
		8.71+0.674	$S^{32}+n$	σ res.	$E_n=0.695$	P14, P13, F5
		8.71+0.703	$S^{32}+n$	σ res.	$E_n=0.725$	P14
		8.71+0.718	$S^{32}+n$	σ res.	$E_n=0.740$	P14
		8.71+0.761	$S^{32}+n$	σ res.	$E_n=0.785$	P14
		8.71+0.800	$S^{32}+n$	σ res.	$E_n=0.825$	P14
		8.71+0.892	$S^{32}+n$	σ res.	$E_n=0.920$	P14, F5
		8.71+0.926	$S^{32}+n$	σ res.	$E_n=0.955$	P14
		8.71+0.960	$S^{32}+n$	σ res.	$E_n=0.990$	P14, F5
		8.71+1.03	$S^{32}+n$	σ res.	$E_n=1.06$	P14, F5
		8.71+1.10	$S^{32}+n$	σ res.	$E_n=1.13$	P14
		8.71+1.12	$S^{32}+n$	σ res.	$E_n=1.15$	P14
		8.71+1.14	$S^{32}+n$	σ res.	$E_n=1.18$	P14
		8.71+1.16	$S^{32}+n$	σ res.	$E_n=1.20$	P14
		8.71+1.18	$S^{32}+n$	σ res.	$E_n=1.22$	P14
		8.71+1.21	$S^{32}+n$	σ res.	$E_n=1.25$	P14, F5
		8.71+1.24	$S^{32}+n$	σ res.	$E_n=1.28$	P14
		8.71+1.26	$S^{32}+n$	σ res.	$E_n=1.30$	P14
		8.71+1.30	$S^{32}+n$	σ res.	$E_n=1.33$	P14, F5
		8.71+1.32	$S^{32}+n$	σ res.	$E_n=1.36$	P14
		8.71+1.35	$S^{32}+n$	σ res.	$E_n=1.39$	P14, F5
		8.71+1.39	$S^{32}+n$	σ res.	$E_n=1.43$	F5
		8.71+1.50	$S^{32}+n$	σ res.	$E_n=1.55$	F5
		8.71+1.57	$S^{32}+n$	σ res.	$E_n=1.62$	F5
		8.71+1.72	$S^{32}+n$	σ res.	$E_n=1.77$	F5
	S^{34}	0	$S^{33}(dp)S^{34}$	p	$Q=8.67$	D3
			$P^{31}(\alpha p)S^{34}$	p	$Q=1.3$	M9
			$P^{34}(\beta^-)S^{34}$	β	$E_\beta=5.0$	B6, Z1
			$Cl^{34}(\beta^+)S^{34}$	β	$E_\beta=5.1$	H4
		0.82	$S^{33}(dp)S^{34}$	p	$Q=7.85$	D3
			$P^{31}(\alpha p)S^{34}$	p	$Q=0.4$	M9, L1, M2, P5, P6
		1.8	$P^{34}(\beta^-)S^{34}$	β	$E_\beta=3.2$	B6, Z1
				γ	$E_\gamma=1.9$	B6
		2.5	$P^{31}(\alpha p)S^{34}$	p	$Q=-1.2$	M9, L1, M2, P5, P6
			$Cl^{34}(\beta^+)S^{34}$	β	$E_\beta=2.4$	H4
				γ	$E_\gamma=3.4$	H4
		3.8	$P^{31}(\alpha p)S^{34}$	p	$Q=-2.5$	L1, M2, P5, P6
		5.8	$P^{31}(\alpha p)S^{34}$	p	$Q=-4.5$	L1, P5

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
17	Cl^{35}	0	$S^{32}(\alpha p)Cl^{35}$	p	$Q=-2.1$	L1, B5, H9
		0.6	$S^{32}(\alpha p)Cl^{35}$	p	$Q=-2.7$	L1, B5, H9
		1.5	$S^{32}(\alpha p)Cl^{35}$	p	$Q=-3.6$	L1, B5, H9
	Cl^{36}	0	$Cl^{35}(dp)Cl^{36}$	p	$Q=6.31$	S5
		0.96	$Cl^{35}(dp(Cl^{36}$	p	$Q=5.35$	S5
		4.81	$Cl^{35}(dp)Cl^{36}$	p	$Q=1.50$	S5
		8.54−0.000073	$Cl^{35}+n$	σ res.	$E_n=-0.000075$ (calculated)	H16
	Cl^{37}	0	$S^{37}(\beta^-)Cl^{37}$	β	$E_\beta=4.1$	H5, Z1, B6
		2.7	$S^{37}(\beta^-)Cl^{37}$	β	$E_\beta=1.5$	H5, Z1, B6
			$S^{37}(\beta^-)Cl^{37}$	γ	$E_\gamma=2.7$	H5, Z1, B6
	Cl^{38}	0	$Cl^{37}(dp)Cl^{38}$	p	$Q=4.02$	S5
		1.00	$Cl^{37}(dp)Cl^{38}$	p	$Q=3.02$	S5
		1.92	$Cl^{37}(dp)Cl^{38}$	p	$Q=2.10$	S5
		6.25+0.0018	$Cl^{37}+n$	σ res.	$E_n=0.0018$	L2
18	A^{37}	0	$A^{36}(dp)A^{37}$	p	$Q=6.54$	Z2, D6
		1.49	$A^{36}(dp)A^{37}$	p	$Q=5.05$	Z2, D6
		2.56	$A^{36}(dp)A^{37}$	p	$Q=3.98$	Z2, D6
		3.50	$A^{36}(dp)A^{37}$	p	$Q=3.04$	Z2, D6
		4.40	$A^{36}(dp)A^{37}$	p	$Q=2.14$	Z2
		4.63	$A^{36}(dp)A^{37}$	p	$Q=1.91$	Z2
		5.04	$A^{36}(dp)A^{37}$	p	$Q=1.50$	Z2, D6
		5.85	$A^{36}(dp)A^{37}$	p	$Q=0.69$	Z2
	A^{38}	0	$Cl^{38}(\beta^-)A^{38}$	β	$E_\beta=4.81$	L8, H6, S8, W2, W3
			$Cl^{35}(\alpha p)A^{38}$	p	$Q=0.1$	P5
		2.10	$Cl^{38}(\beta^-)A^{38}$	γ	$E_\gamma=2.15$	H6, S8, I1
			$Cl^{38}(\beta^-)A^{38}$	β	$E_\beta=2.77$	L8, H6, S8, W2, W3
			$K^{38}(\beta^+)A^{38}$	γ	$E_\gamma=2.0-2.15$	R2
		2.6	$Cl^{35}(\alpha p)A^{38}$	p	$Q=-2.5$	P5
		3.70	$Cl^{38}(\beta^-)A^{38}$	γ	$E_\gamma=2.15+1.60$	S8, H6, I1, C3
			$Cl^{38}(\beta^-)A^{38}$	β	$E_\beta=1.11$	L8, H6, W2, W3
		4.3	$Cl^{35}(\alpha p)A^{38}$	p	$Q=-4.2$	P5
		10.28+0.416	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=0.427$	T1
		10.28+0.435	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=0.447$	T1
		10.28+0.487	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=0.500$	T1
		10.28+0.518	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=0.532$	T1
		10.28+0.63	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=0.65$	C2
		10.28+0.78	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=0.80$	C2
		10.28+0.97	$Cl^{37}(p\gamma)A^{38}$	res.	$E_p=1.00$	C2
	A^{40}	1.46	$K^{40}(K)A^{40}$	γ		B16, B11, P12, G1, H7, M3
			$A^{40}(pp)A^{40}$	p		H12
		2.4	$A^{40}(pp)A^{40}$	p		H12
	A^{41}	0	$A^{40}(dp)A^{41}$	p	$Q=3.84$	D6, P9, D7
		0.66	$A^{40}(dp)A^{41}$	p	$Q=3.18$	D6, P9
		1.21	$A^{40}(dp)A^{41}$	p	$Q=2.63$	D6, P9
		1.34	$A^{40}(dp)A^{41}$	p	$Q=2.50$	D6, D7
		1.94	$A^{40}(dp)A^{41}$	p	$Q=1.90$	D6, P9
		2.27	$A^{40}(dp)A^{41}$	p	$Q=1.57$	D6, P9, D7
		2.80	$A^{40}(dp)A^{41}$	p	$Q=1.04$	D6, P9
		3.29	$A^{40}(dp)A^{41}$	p	$Q=0.55$	D6
		3.69	$A^{40}(dp)A^{41}$	p	$Q=0.15$	D6
		4.01	$A^{40}(dp)A^{41}$	p	$Q=-0.17$	D6
19	K^{40}	0	$K^{39}(dp)K^{40}$	p	$Q=5.48$	S10, P10
		0.81	$K^{39}(dp)K^{40}$	p	$Q=4.67$	S10, P10
		2.01	$K^{39}(dp)K^{40}$	p	$Q=3.47$	S10, P10
		2.56	$K^{39}(dp)K^{40}$	p	$Q=2.92$	S10
		3.3	$K^{39}(dp)K^{40}$	p	$Q=2.18$	S10
		3.7	$K^{39}(dp)K^{40}$	p	$Q=1.78$	S10
		4.2	$K^{39}(dp)K^{40}$	p	$Q=1.28$	S10
		4.8	$K^{39}(dp)K^{40}$	p	$Q=0.68$	S10
		7.71+0.020	$K^{39}+n$	σ res.	$E_n=0.020$	P11
		7.71+0.068	$K^{39}+n$	σ res.	$E_n=0.070$	P11
		7.71+0.107	$K^{39}+n$	σ res.	$E_n=0.110$	P11
		7.71+0.156	$K^{39}+n$	σ res.	$E_n=0.160$	P11
		7.71+0.299	$K^{39}+n$	σ res.	$E_n=0.305$	P11

TABLE I—*Continued.*

Z	Isotope	Level (Mev)	Process	Observation	Energetics (Mev)	References
	K^{40}	7.71+0.351	$K^{39}+n$	σ res.	$E_n=0.360$	P11
		7.71+0.419	$K^{39}+n$	σ res.	$E_n=0.430$	P11
		7.71+0.478	$K^{39}+n$	σ res.	$E_n=0.490$	P11
		7.71+0.546	$K^{39}+n$	σ res.	$E_n=0.560$	P11
	K^{41}	0	$A^{41}(\beta^-)K^{41}$	β	$E_\beta=2.55$	B7
			$A^{40}(dn)K^{41}$	n	$Q=6.0$	W7
		1.35	$A^{41}(\beta^-)K^{41}$	β	$E_\beta=1.18$	B7
			$A^{41}(\beta^-)K^{41}$	γ	$E_\gamma=1.37$	R1, B7
			$A^{40}(dn)K^{41}$	n	$Q=4.6$	W9
			$Ca^{41}(K)K^{41}$	γ	$E_\gamma=1.1$	W4
		3.1	$A^{40}(dn)K^{41}$	n	$Q=2.9$	W9
		4.4	$A^{40}(dn)K^{41}$	n	$Q=1.6$	W9
		7.84+0.878	$A^{40}(p\gamma)K^{41}$	res.	$E_p=0.900$	B19
		7.84+1.024	$A^{40}(p\gamma)K^{41}$	res.	$E_p=1.050$	B19
		7.84+1.054	$A^{40}(p\gamma)K^{41}$	res.	$E_p=1.080$	B19
		7.84+1.073	$A^{40}(p\gamma)K^{41}$	res.	$E_p=1.100$	B19
		7.84+1.205	$A^{40}(p\gamma)K^{41}$	res.	$E_p=1.235$	B19
	K^{42}	0	$K^{41}(dp)K^{42}$	p	$Q=5.12$	S10
		0.62	$K^{41}(dp)K^{42}$	p	$Q=4.50$	S10
		1.18	$K^{41}(dp)K^{42}$	p	$Q=3.94$	S10
		1.97	$K^{41}(dp)K^{42}$	p	$Q=3.15$	S10
		2.29	$K^{41}(dp)K^{42}$	p	$Q=2.83$	S10
20	Ca^{41}	0	$Ca^{40}(dp)Ca^{41}$	p	$Q=6.09$	S9, S1, D4
		1.95	$Ca^{40}(dp)Ca^{41}$	p	$Q=4.14$	S9, S1, D4
		2.41	$Ca^{40}(dp)Ca^{41}$	p	$Q=3.68$	S9, S1
		2.96	$Ca^{40}(dp)Ca^{41}$	p	$Q=3.13$	S9, S1
		3.23	$Ca^{40}(dp)Ca^{41}$	p	$Q=2.86$	S9, S1
		3.49	$Ca^{40}(dp)Ca^{41}$	p	$Q=2.60$	S9, S1
		3.67	$Ca^{40}(dp)Ca^{41}$	p	$Q=2.42$	S9, S1
		3.86	$Ca^{40}(dp)Ca^{41}$	p	$Q=2.23$	S9, S1
		8.32+0.137	$Ca^{40}+n$	σ res.	$E_n=0.140$	B17, A4
		8.32+0.166	$Ca^{40}+n$	σ res.	$E_n=0.170$	B17
		8.32+0.215	$Ca^{40}+n$	σ res.	$E_n=0.220$	B17, A4
		8.32+0.249	$Ca^{40}+n$	σ res.	$E_n=0.255$	B17, A4
		8.32+0.288	$Ca^{40}+n$	σ res.	$E_n=0.295$	B17
		8.32+0.327	$Ca^{40}+n$	σ res.	$E_n=0.335$	B17, A4
		8.32+0.429	$Ca^{40}+n$	σ res.	$E_n=0.440$	B17, A4
		8.32+0.498	$Ca^{40}+n$	σ res.	$E_n=0.510$	B17, A4
		8.32+0.590	$Ca^{40}+n$	σ res.	$E_n=0.605$	B17
	Ca^{42}	0	$K^{42}(\beta^-)Ca^{42}$	β	$E_\beta=3.58$	S2, S13, B2
			$K^{39}(\alpha p)Ca^{42}$	p	$Q=-0.89$	L1, P5
		1.51	$K^{42}(\beta^-)Ca^{42}$	β	$E_\beta=2.07$	S2, S13, B2
			$K^{42}(\beta^-)Ca^{42}$	γ	$E_\gamma=1.51$	S2, S13, B2
			$K^{39}(\alpha p)Ca^{42}$	p	$Q=-2.3$	L1, P5
		2.6	$K^{39}(\alpha p)Ca^{42}$	p	$Q=-3.5$	L1, P5
		10.15+1.56	$K^{41}(pn)Ca^{41}$	res.	$E_p=1.60$	B15
		10.15+1.85	$K^{41}(pn)Ca^{41}$	res.	$E_p=1.90$	B15
		10.15+2.19	$K^{41}(pn)Ca^{41}$	res.	$E_p=2.24$	B15
		10.15+2.40	$K^{41}(pn)Ca^{41}$	res.	$E_p=2.46$	B15
		10.15+2.54	$K^{41}(pn)Ca^{41}$	res.	$E_p=2.60$	B15
		10.15+2.73	$K^{41}(pn)Ca^{41}$	res.	$E_p=2.80$	B15
		10.15+2.89	$K^{41}(pn)Ca^{41}$	res.	$E_p=2.96$	B15
		10.15+3.05	$K^{41}(pn)Ca^{41}$	res.	$E_p=3.12$	B15
	Ca^{43}	0.56	$K^{43}(\beta^-)Ca^{43}$	β	$E_\beta=0.81, 0.24$	O1
			$K^{43}(\beta^-)Ca^{43}$	γ	$E_\gamma\sim 0.4$	O1
		1.0	$Sc^{43}(\beta^+)Ca^{43}$	β	$E_\beta=1.4, 0.4$	W5
			$Sc^{43}(\beta^+)Ca^{43}$	γ	$E_\gamma=1.0$	W5
		1.65	$Sc^{43}(\beta^+)Ca^{43}$	γ		H8
	Ca^{44}	1.33	$Sc^{44}(K)Ca^{44}$	γ		H8

[a] Isotopic assignment not certain.
[b] Isotopic assignment uncertain—possibly $Mg^{25}(p\gamma)Al^{25}$ on basis of reference G4.
[c] Q-value taken from $Al^{27}(p\alpha)Mg^{24}$ reaction (F6).
[d] Corrected to agree with ground state $(p\alpha)$ Q-value.
[e] Level numerically out of order.

Thus, E_{cm} is less than E_L by a few percent for proton and neutron resonances in this mass region; for alpha-particle resonances E_{cm} may be lower than E_L by as much as 15 percent.

In most resonance work the value of E_{cm} is much more accurately determined than the corresponding calculation of Q. Proton resonances are often known to a few kev and slow neutron resonances to the order of electron volts. On the other hand the value of Q is seldom good to better than 0.05 Mev. Resonance levels have therefore been listed as the sum of Q and E_{cm} in order that the location of their positions not be misleading and to allow the Q-values to be changed easily with improved data.

The observation of a resonance generally refers to the yield of the reaction product found in the "Process" column unless special note is made otherwise. All cases in which gamma-radiation is the observed product are listed as $(p\gamma)$ although it is probable that in many of the measurements the radiation arose from the decay of the residual nucleus in a $(p\alpha)$ process or in inelastic scattering of energetic protons. The experimental separation of these processes has rarely been attempted; the Wisconsin data on Si^{28} (S15) form a notable exception.

The value listed in Table I for a given level has been obtained by comparing the data of various processes leading to this level and selecting a best average value. The relative weight of a particular reference depends on such features as the techniques employed, whether isotopically enriched samples were used, and an over-all estimation of the results. The assumption is made that the same level is observed in two different processes if the limits of error appear to overlap. Such correlations may in some cases later prove incorrect. Some of the results of very early work have been omitted entirely because, in our opinion, the nature of the experiment did not justify the data.

To widen the usefulness of Table I a separate column is devoted to energy characteristics of the various processes, including Q-values, resonance energies, and disintegration energies. Facts pertaining to particular experiments, such as bombarding energies in non-resonant reactions, beam energy spread, type and resolution of measuring equipment, angle of observation, etc., have been omitted. The energetics column may be used, to some extent, for noting how the data of various processes leading to a given level compare. Limits of error have not been stated in much of the literature and for uniformity it has been decided to omit those which have been specified. Instead, the number of significant figures may be taken as a fairly reliable guide to the approximate accuracy of measurement. In a few cases the data in the literature have been rounded off to fewer significant figures, if, in our opinion, the probable errors of the results appear to justify such a procedure.

TABLE II. Binding energies of incident particles.

Q[a]	Mass differences[a]
$F^{19}+\alpha-Na^{23}=10.8$	$Ne^{20}-F^{19}=-5.4$ $Na^{23}-Ne^{20}=-1.80$
$Na^{23}+n-Na^{24}=7.00$	$Na^{24}-Na^{23}=1.36$
$Na^{23}+p-Mg^{24}=11.74$	$Na^{24}-Na^{23}=1.36$ $Mg^{24}-Na^{24}=-5.52$
$Ne^{20}+\alpha-Mg^{24}=9.60$	$Na^{23}-Ne^{20}=-1.80$ $Na^{24}-Na^{23}=1.36$ $Mg^{24}-Na^{24}=-5.52$
$Mg^{24}+n-Mg^{25}=7.22$	$Mg^{25}-Mg^{24}=1.10$
$Mg^{24}+p-Al^{25}$	(no information on Al^{25})
$Mg^{25}+p-Al^{26}=7.80$	$Al^{26}-Mg^{25}=-0.23$
$Mg^{26}+p-Al^{27}=8.29$	$Mg^{27}-Mg^{26}=1.93$ $Al^{27}-Mg^{27}=-2.64$
$Na^{23}+\alpha-Al^{27}=10.42$	$Na^{24}-Na^{23}=1.36$ $Mg^{24}-Na^{24}=-5.52$ $Al^{27}-Mg^{24}=-2.62$
$Mg^{25}+d-Al^{27}=17.26$	$Al^{27}-Mg^{25}=-3.55$
$Al^{27}+n-Al^{28}=7.68$	$Al^{28}-Al^{27}=0.68$
$Al^{27}+p-Si^{28}=11.69$	$Al^{28}-Al^{27}=0.68$ $Si^{28}-Al^{28}=-4.79$
$Mg^{24}+\alpha-Si^{28}=10.37$	$Al^{27}-Mg^{24}=-2.62$ $Al^{28}-Al^{27}=0.68$ $Si^{28}-Al^{28}=-4.79$
$Si^{28}+n-Si^{29}=8.40$	$Si^{29}-Si^{28}=-0.05$
$Mg^{25}+\alpha-Si^{29}=11.20$	$Al^{27}-Mg^{25}=-3.55$ $Si^{29}-Al^{27}=-4.01$
$Si^{29}+p-P^{30}=5.63$	$Si^{30}-Si^{29}=-2.22$ $P^{30}-Si^{30}=4.17$
$Si^{30}+p-P^{31}=7.46$	$Si^{31}-Si^{30}=1.80$ $P^{31}-Si^{31}=-1.68$
$Al^{27}+\alpha-P^{31}=9.72$	$Si^{30}-Al^{27}=-6.20$ $Si^{31}-Si^{30}=1.80$ $P^{31}-Si^{31}=-1.68$
$P^{31}+p-S^{32}=9.93$	$S^{34}-P^{31}=-5.24$ $S^{34}-S^{33}=-2.54$ $S^{33}-S^{32}=-0.35$
$S^{32}+n-S^{33}=8.71$	$S^{33}-S^{32}=-0.35$
$Cl^{35}+n-Cl^{36}=8.54$	$Cl^{36}-Cl^{35}=-0.18$
$Cl^{37}+n-Cl^{38}=6.25$	$Cl^{38}-Cl^{37}=2.11$
$C^{37}+p-A^{38}=10.28$	$Cl^{38}-Cl^{37}=2.11$ $A^{38}-Cl^{38}=-4.81$
$K^{39}+n-K^{40}=7.71$	$K^{40}-K^{39}=0.65$
$A^{40}+p-K^{41}=7.84$	$A^{41}-A^{40}=2.29$ $K^{41}-A^{41}=-2.55$
$Ca^{40}+n-Ca^{41}=8.32$	$Ca^{41}-Ca^{40}=0.04$
$K^{41}+p-Ca^{42}=10.15$	$K^{42}-K^{41}=1.01$ $Ca^{42}-K^{42}=-3.58$

[a] All values in Mev. $n=8.358$, $p=7.576$, $d=13.710$, $\alpha=3.640$.

In addition to the original papers, the following summaries contain useful reference material: L1, M12, N1, P3, S7, V1, and K3.

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