Coefficients of different macro-microscopic mass formulae from the AME2012 atomic mass evaluation

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Abstract

The coefficients of different possible macro-microscopic mass formulae previously proposed have been adjusted on 2264 experimental atomic masses extracted from the AME2012 atomic mass evaluation [1] assuming N, Z $\geq$ 8 and the one standard deviation uncertainty on the mass lower than 150 keV. All the formulae include the volume and surface energies, the Coulomb energy, the diffuseness correction to the sharp radius Coulomb energy, the shell and pairing energies and take into account or not the curvature energy, different forms of the Wigner term, a free charge radius, the experimental equivalent rms charge radius or a fixed short central radius. Masses of 976 more exotic nuclei are extrapolated from the most accurate formula.

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1 Introduction

The binding energies of exotic nuclei close to the proton and neutron drip lines and in the superheavy element region are still poorly known and the different predictions do not fully agree completely. Therefore continuous efforts are still needed to improve the accuracy of the predictions from mass formulae. Recently, a semiempirical nuclear mass formula based on the macroscopic-microscopic method incorporating the isospin and mass dependence of the parameters and the mirror nuclei constraints have been adjusted on 2149 measured nuclear masses [2,3]. The nuclear mass predictions through the Garvey-Kelson relations have also been improved [4] while the ability of different liquid drop mass formulae and the Duflo-Zuker mass formula to describe the nuclear masses in various deformation regions has been analyzed [5,6].

In a previous paper [7] different formulae including the volume and surface energies, the Coulomb energy, the diffuseness correction to the sharp radius Coulomb energy and the shell and pairing energies and taking into account or not the curvature energy, different forms of the Wigner term, a free charge radius, the experimental equivalent rms charge radius or a fixed short central radius have been proposed. Their coefficients were adjusted on a mass data set of 2027 nuclei verifying the two conditions : N, Z $\geq$ 8 and the one standard deviation mass uncertainty $\leq$ 150 keV. The data were extracted from the 2003 atomic mass evaluation [8]. In the present paper, the same procedure has been applied using the updated AME2012 atomic mass evaluation [1]. The coefficients of these formulae have been adjusted on 2264 masses. One of these expressions leads to a rms deviation between the theoretical and experimental masses of 0.59 MeV. In a second part, the masses of 976 other nuclei appearing in the AME2012 but known with an higher uncertainty or extrapolated have been compared with the values calculated with this formula.

2 Macro-microscopic binding energy

The binding energy has been calculated using the following expansion in powers of $A^{-1/3}$ and $I = (N-Z)/A$:

$$B = a_v \left(1 - k_v I^2\right) A - a_s \left(1 - k_s I^2\right) A^{\frac{2}{3}} - a_k \left(1 - k_k I^2\right) A^{\frac{1}{3}} - \frac{3}{5}\frac{e^2 Z^2}{R_0}$$
$$+ f_p \frac{Z^2}{A} - E_{pair} - E_{shell} - E_{Wigner}. \quad (1)$$

The first term gives the volume energy. It incorporates the symmetry energy term of the Bethe-Weizsäcker mass formula. The second and third terms represent the surface and curvature energies. They depend also on the relative neutron excess or lack. The decrease of binding energy due to the Coulomb repulsion is given by the fourth term. Different charge radii will be assumed. The Z^2/A term is the diffuseness correction to the sharp radius Coulomb energy (also called proton form-factor correction). The shell energies of the Thomas-Fermi model [9,10] have been retained. They have been calculated from the Strutinsky shell-correction method and previously to the other coefficients of the TF model. As an example, the shell effects add 11.55 MeV to the binding energy of ^{132}Sn. It has been shown [11] that there is no correlation between the pairing term and any other term and, consequently, the pairing term of the TF model has been also retained. The Wigner energy depends on the number of identical neutron-proton pairs in the nucleus and then on I. The origin and meaning of this term are described in Ref. [12]. The binding energy is lower when $N \neq Z$. Three expressions of the Wigner term have been considered: the original linear version $k_1|I|$ and two terms proposed in [13,14] $k_2|N-Z| \times e^{-(A/50)^2}$ and $k_3 e^{-80I^2}$ with different coefficients. The second term is characteristic of Wigner's supermultiplet theory based on SU(4) spin-isospin symmetry while the third term represents the n-p pairing at T=0 [14].

3 Coefficients of different mass formulae

The coefficients of different possible mass formulae have been obtained by a least square fitting procedure on the masses of the 2264 nuclei given in the new AME2012 atomic mass evaluation [1] and verifying the two conditions : N and Z higher than 7 and the one standard deviation uncertainty on the mass lower than 150 keV. They are given in the Table 1.

The equations (1-5) in the table have been obtained assuming the linear approximation $R_0 = r_0 * A^{1/3}$, the reduced radius r_0 and the other coefficients being given by the adjustment to the experimental masses. The rms deviations are given in the last column. The curvature term depending on two parameters is less efficient than the Wigner term which depends on only one parameter. The different Wigner terms lead to higher values of r_0. The combination of two Wigner terms allows to reach an accuracy of 0.588 MeV. The combination of the three Wigner terms would lead to a rms deviation of 0.584 MeV. The adjustment leads always to a large value of the Coulomb reduced radius r_0 of around $1.21 - 1.24$ fm.

The equations (6-7) have been obtained assuming, a priori, a specific expression for the Coulomb energy. Experimentally, the equivalent rms relative charge radius $R_0/A^{1/3}$ decreases with the mass [15,16] and has an isospin

Table 1
Coefficient values and root mean square deviation (in MeV) between the theoretical and experimental binding energies. The theoretical shell and pairing energies are taken into account. The Coulomb reduced radius $r_0 = R_0/A^{1/3}$ is fixed to 1.2257 fm in eq (6) while the Coulomb radius is determined by $R_0 = 1.28A^{1/3} - 0.76 + 0.8A^{-1/3}$ in eq. (7).

(Eq.)	a_v	k_v	a_s	k_s	a_k	k_k	r_0	f_p	k_1	k_2	k_3	σ
(1)	15.4099	1.7173	17.5528	1.4359	-	-	1.2179	1.3961	-	-	-	0.668
(2)	15.3579	1.8028	17.0362	1.9315	-	-	1.2311	1.0080	19.9524	-	-	0.621
(3)	15.4926	1.7899	18.2494	2.0205	-1.349	19.	1.2141	1.4603	-	-	-	0.662
(4)	15.2854	1.7450	17.0067	1.5948	-	-	1.2364	1.1924	-	0.5023	-	0.625
(5)	15.4817	1.8005	17.5771	1.7913	-	-	1.2245	0.9216	-	0.3199	-2.79	0.588
(6)	15.3838	1.7848	17.2149	1.8258	-	-	-	1.1241	15.936	-	-	0.625
(7)	15.6031	1.8503	18.1213	1.9934	-	-	-	1.8456	-	0.45	-2.5228	0.613

dependence and a mean value of 1.2257 fm. This value is imposed in the equation (6). The coefficients of the equation (7) have been obtained assuming that the Coulomb radius follows the expression $R_0 = 1.28A^{1/3} - 0.76 + 0.8A^{-1/3}$ proposed in Ref. [17]. It comes from the Droplet model and the proximity energy and simulates rather a central radius for which $R_0/A^{1/3}$ increases slightly with the mass. This radius is much smaller than the equivalent rms radius. This more elaborated expression can also be used to reproduce accurately the fusion, fission and cluster and alpha-decay data [18–21]. So it it possible to obtain accurate mass formulae with a large constant reduced radius r_0 or with a more sophisticated central radius corresponding to a smaller value of r_0 increasing with the mass.

The range of variation of the rms deviation over these different fits is not very large which indicates that comparisons of other predicted quantities such as fission barrier heights, energy of mirror nuclei, ..may help to discriminate between the new added terms. Let us recall also that the Duflo-Zuker fits [22] to the same set of masses have a rms deviation of around 370 keV.

A decrease of the radius coefficient r_0 and an increase of the surface coefficient a_s is observed when comparing the present adjustments on 2264 nuclear masses to the ones obtained previously on 2027 nuclei [7]. All the rms deviations between the theoretical and experimental masses are higher than the previous ones by around $0.04 - 0.05$ MeV but the conclusion on the range of the main parameter values remains roughly identical : $a_v = 15.3 - 15.7$ MeV, $a_s = 16.8 - 18.3$ MeV, $k_v = 1.7 - 1.9$, $k_s = 1.4 - 2.8$, $r_0 = 1.21 - 1.24$ fm and $f_p = 0.9 - 2.0$. The correlations between the different terms of the LDM mass formulae have been deeply investigated in Ref. [11] using correlation and error matrix but starting directly from the four basic terms of the Bethe-Weizsäcker mass formula (see also [7]).

The difference (in absolute value) between the theoretical masses calculated with the equations (1-5,7) and the experimental masses of the 2264 nuclei are given from the top left to the bottom right on the Figure 1. The structures observed are about the same for the different formulae. They come mainly from the assumed shell and pairing energies. The errors are much more important for the lighter nuclei. If only the nuclei verifying A≥55 are taken into account then the equation (5) becomes :

$$B = 15.3982\left(1-1.7546I^2\right)A - 17.3401\left(1-1.5981I^2\right)A^{\frac{2}{3}} - 0.6\frac{e^2Z^2}{1.2271A^{\frac{1}{3}}}$$
$$+1.0867\frac{Z^2}{A} - 0.356|N-Z| \times e^{-(A/50)^2} + 1.359 \times e^{-80I^2} - E_{pair} - E_{shell}. \quad (2)$$

and the rms deviation is only 0.478 MeV for these 2010 nuclei. The Figure 2 displays the difference between the theoretical masses calculated with the above mentioned formula and the experimental masses of these 2010 nuclei.

As an illustration, the difference between the theoretical masses obtained with the equation (5) and the experimental masses of the 2264 nuclei is shown in Figure 3. The other formulae lead to similar figures.

The distribution and the number of the nuclei in each error range is given explicitly in Figure 4. The larger errors for the lighter nuclei come perhaps from the inadequacy of the shell effects to describe the cluster and halo formation.

4 Mass predictions for 976 exotic nuclei

Mass predictions from the equation (5) (not readjusted) are given in the Table 2 for 976 more exotic nuclei for which the mass is still unknown or known with an uncertainty higher or equal to 150 keV and lower than 800 keV. They are compared with the data given in the AME2012. The location of these 976 nuclei around the known valley of isotopes and the difference between the theoretical and empirical values are displayed in Figure 5. The rms deviation is 1.35 MeV. For about 45% of nuclei the difference is lower than 0.5 MeV and for 80% of nuclei the difference is lower than 1 MeV. These comparisons seem to confirm that this is the microscopic part of the mass formulae which induces these structures in ΔE. The distribution of the 976 nuclei in each error range is indicated in Figure 6.

When the coefficients of the equation (5) are readjusted on the whole 3240 masses the rms deviation reaches σ =0.769 MeV, which justifies the adjustment on the 2264 best known nuclear masses.

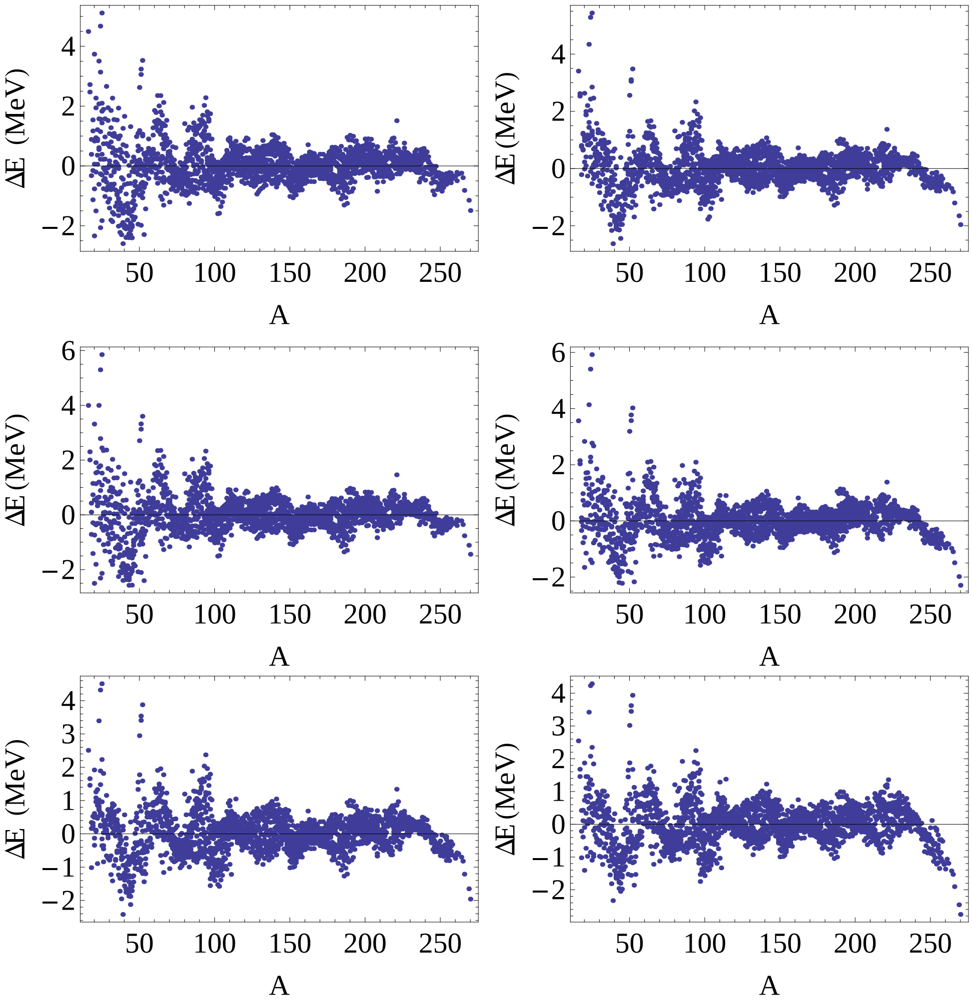

Fig. 1. Difference between the theoretical and experimental masses of the 2264 selected nuclei for the formulas (1-5) and (7) from the top left to the bottom right versus the mass number.

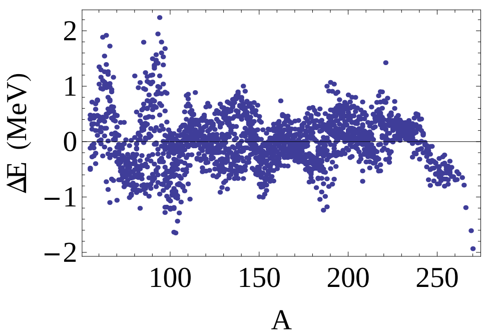

Fig. 2. Difference between the theoretical and experimental masses calculated from the formula (2) given in the text for the 2010 nuclei verifying A≥55.

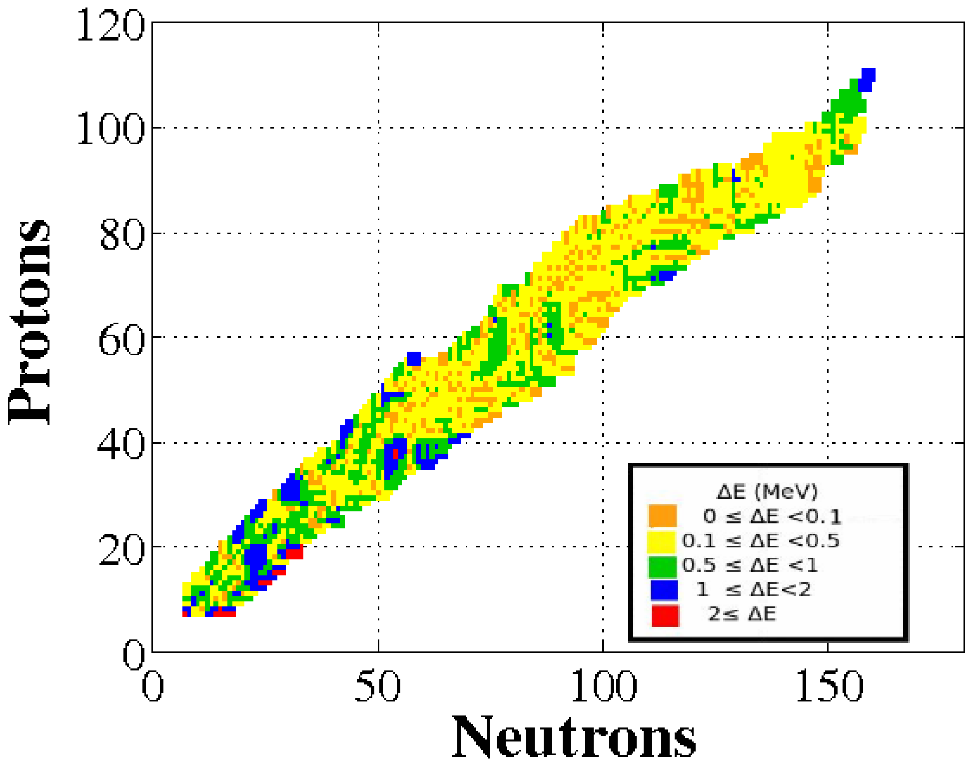

Fig. 3. Difference between the theoretical masses calculated from the equation (5) and the experimental masses of the 2264 selected nuclei.

5 Summary and conclusion

The coefficients of different macro-microscopic mass formulae including the pairing and shell energies of the Thomas-Fermi model have been determined by an adjustment to 2264 experimental atomic masses given in the recent AME2012 atomic mass evaluation. The usual Wigner term is more efficient than the curvature energy term to improve the accuracy of the formulae. The coefficients of these two terms are very unstable. Other exponential forms of the Wigner terms are more stable and efficient. A rms deviation of 0.59 MeV can be reached between the experimental and theoretical masses. The remaining differences come probably mainly from the determination of the shell and pairing energies. A large constant coefficient $r_0 = 1.22 - 1.23$ fm or a small central radius increasing with the mass can be used. The different fits lead rather to a low value of the surface energy coefficient of around 17-18 MeV. Predictions are advanced for masses of 976 selected more exotic nuclei.

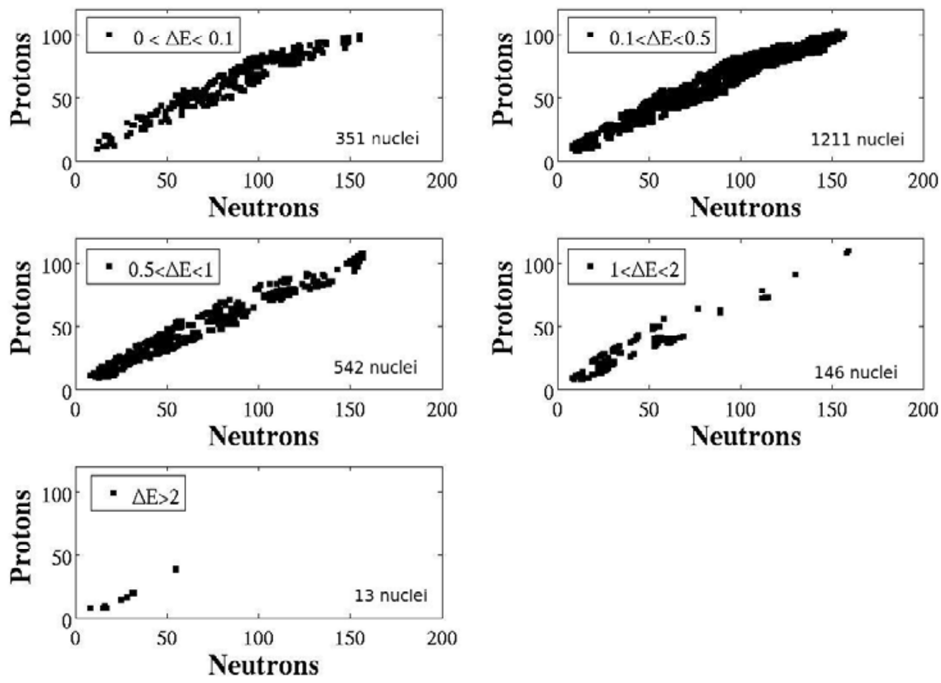

Fig. 4. Distribution of the 2264 nuclei in each error range.

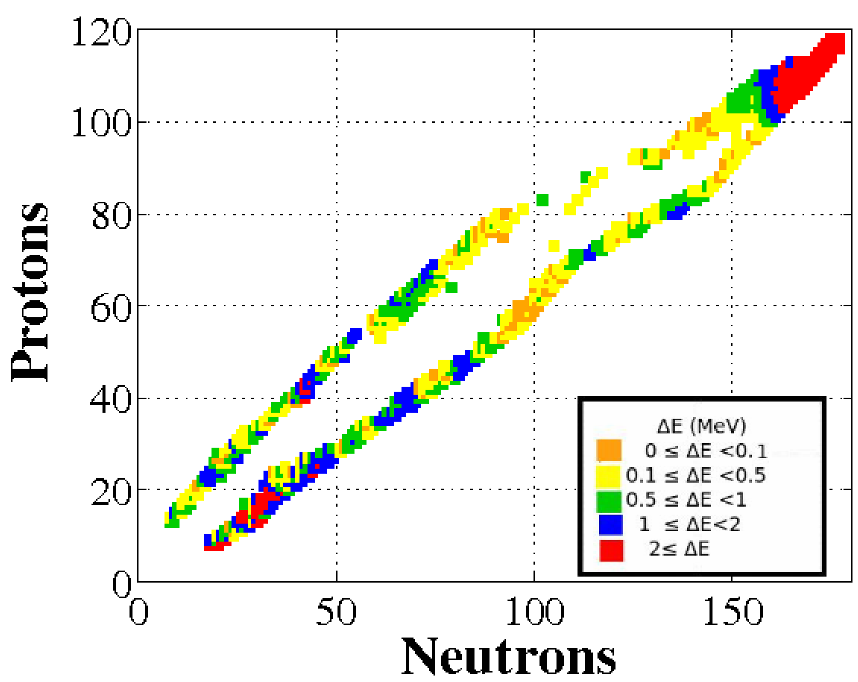

Fig. 5. Difference between the theoretical masses obtained from the equation (5) and 976 poorly known or extrapolated masses extracted from the AME2012 table.

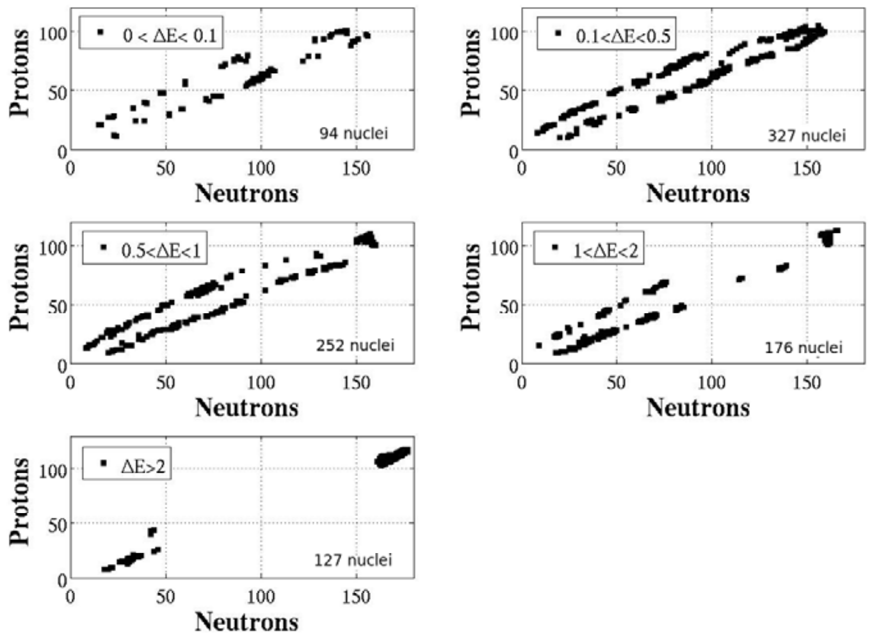

Fig. 6. Distribution of the 976 nuclei in each error range.

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Table 2
Theoretical mass excess (in MeV) predicted from the equation (5) and from the AME2012 table for 976 very exotic nuclei.

Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}
^{21}Al	26.99	27.65	^{22}Al	18.2	18.99	^{22}Si	33.34	33.62	^{23}Si	23.7	24.33	^{24}P	33.32	34.45
^{25}P	19.74	20.54	^{26}P	10.97	11.12	^{26}O	34.73	37.89	^{26}S	27.08	27.82	^{27}O	44.45	48.05
^{27}F	24.63	25.94	^{27}S	17.03	17.92	^{28}O	52.08	54.86	^{28}F	32.92	34.11	^{28}S	4.07	4.61
^{28}Cl	27.52	27.87	^{29}F	39.63	40.41	^{29}Cl	13.77	14.14	^{30}F	48.11	50.45	^{30}Ne	23.04	22.68
^{30}Cl	4.44	5.17	^{30}Ar	21.49	21.02	^{31}F	55.62	57.92	^{31}Ne	30.82	32.24	^{31}Ar	11.29	11.67
^{32}Ne	37.	37.93	^{32}K	21.1	21.36	^{33}Ne	46.	47.15	^{33}Na	23.97	24.61	^{33}K	7.04	7.72
^{34}Ne	52.84	53.30	^{34}Na	31.29	32.15	^{34}K	-1.22	-1.08	^{34}Ca	13.85	14.17	^{35}Na	37.84	37.93
^{35}Mg	15.64	15.71	^{35}Ca	4.79	5.04	^{36}Na	45.91	46.22	^{36}Mg	20.38	19.85	^{36}Sc	15.35	15.31
^{37}Na	53.14	52.87	^{37}Mg	28.29	27.80	^{37}Sc	3.48	3.46	^{38}Mg	34.07	32.90	^{38}Al	16.21	14.86
^{38}Sc	-4.55	-4.91	^{38}Ti	10.67	9.99	^{39}Mg	42.28	41.54	^{39}Al	21.	19.62	^{39}Ti	2.2	1.30
^{40}Mg	48.61	47.14	^{40}Al	27.97	26.79	^{40}Si	5.43	3.16	^{40}Ti	-8.85	-10.02	^{40}V	11.89	10.33
^{41}Al	33.89	32.08	^{41}Si	12.12	10.01	^{41}V	0.2	-1.30	^{42}Al	40.84	41.15	^{42}Si	16.56	13.87
^{42}P	1.01	-1.32	^{42}V	-7.62	-9.46	^{42}Cr	6.24	4.78	^{43}Al	47.94	50.57	^{43}Si	23.1	22.64
^{43}P	4.68	2.21	^{43}Cr	-2.3	-3.67	^{43}Si	28.51	30.12	^{44}P	10.44	9.59	^{44}Cl	-20.61	-21.45
^{44}V	-24.12	-24.91	^{44}Cr	-13.64	-14.99	^{44}Mn	6.66	5.19	^{45}Si	37.21	39.48	^{45}P	15.32	18.02
^{45}S	-3.99	-4.28	^{45}Mn	-5.13	-6.42	^{45}Fe	13.43	12.64	^{46}P	22.78	25.76	^{46}S	0.04	2.50
^{46}Cl	-13.81	-13.97	^{46}Mn	-12.96	-13.79	^{46}Fe	0.59	-0.28	^{47}P	29.24	30.15	^{47}S	7.41	10.02
^{47}Cl	-10.1	-7.88	^{47}Fe	-7.59	-7.95	^{47}Co	9.85	9.77	^{48}S	12.76	14.88	^{48}Cl	-4.06	-1.32
^{48}Ar	-22.44	-20.47	^{48}Mn	-29.32	-29.89	^{48}Fe	-18.42	-18.90	^{48}Co	0.87	0.82	^{48}Ni	16.48	17.18
^{49}S	21.2	23.15	^{49}Cl	1.15	3.37	^{49}Ar	-16.86	-14.16	^{49}Co	-10.33	-10.41	^{49}Ni	7.17	7.97
^{50}Cl	8.43	10.66	^{50}Ar	-12.92	-10.78	^{50}Co	-17.78	-18.61	^{50}Ni	-4.9	-4.51	^{51}Cl	14.48	16.10
^{51}Ar	-5.87	-3.79	^{51}Ni	-12.94	-13.00	^{52}Ar	-0.97	0.42	^{52}K	-16.54	-13.12	^{52}Co	-33.99	-35.02
^{52}Ni	-23.47	-24.11	^{52}Cu	-3.07	-3.20	^{53}Ar	6.79	8.30	^{53}K	-11.68	-8.89	^{53}Ca	-28.46	-24.77
^{53}Sc	-38.11	-36.13	^{53}Cu	-14.35	-14.60	^{54}K	-5.	-2.04	^{54}Ca	-24.78	-21.86	^{54}Sc	-33.6	-31.39
^{54}Cu	-21.74	-22.80	^{54}Zn	-7.42	-6.25	^{54}K	0.71	3.19	^{55}Ca	-18.35	-15.67	^{55}Sc	-29.98	-28.58
^{55}Ti	-41.67	-40.55	^{55}Cu	-31.64	-32.52	^{55}Zn	-14.92	-14.28	^{56}K	7.93	9.63	^{56}Ca	-13.9	-12.24
^{56}Sc	-24.73	-23.29	^{56}V	-46.12	-45.10	^{56}Cu	-38.24	-39.17	^{56}Zn	-25.58	-25.71	^{56}Ga	-4.32	-4.04
^{57}Ca	-6.87	-4.69	^{57}Sc	-20.71	-19.92	^{57}Ti	-33.87	-33.72	^{57}V	-44.23	-43.84	^{57}Zn	-32.55	-32.69
^{57}Ga	-15.65	-15.48	^{58}Ca	-1.92	-1.36	^{58}Sc	-14.88	-14.08	^{58}Ti	-31.11	-31.62	^{58}Cr	-51.83	-51.89
^{58}Ga	-23.49	-23.67	^{58}Ge	-7.71	-8.10	^{59}Sc	-10.3	-10.46	^{59}Ti	-25.64	-26.01	^{59}V	-37.83	-38.01
^{59}Cr	-47.89	-48.14	^{59}Ga	-33.97	-33.65	^{59}Ge	-16.31	-16.43	^{60}Sc	-4.05	-4.27	^{60}Ti	-22.33	-23.49
^{60}V	-33.24	-33.12	^{60}Cr	-46.5	-47.43	^{60}Ga	-39.78	-38.83	^{60}Ge	-27.61	-27.29	^{60}As	-5.7	-6.06
^{61}Sc	0.93	-0.43	^{61}Ti	-16.35	-17.54	^{61}V	-30.51	-30.76	^{61}Ge	-33.73	-33.15	^{61}As	-17.59	-17.18

Table 3
continued...

Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}
^{62}Ti	-12.57	-14.21	^{62}V	-25.48	-25.77	^{62}Mn	-48.48	-47.99	^{62}Ge	-41.9	-41.21	^{62}As	-24.58	-24.02
^{63}Ti	-5.82	-7.03	^{63}V	-21.99	-22.89	^{63}Cr	-35.72	-35.66	^{63}As	-33.63	-32.70	^{64}V	-16.17	-16.47
^{64}Cr	-33.46	-34.61	^{64}As	-39.65	-38.24	^{64}Se	-26.93	-26.69	^{65}V	-11.64	-13.04	^{65}Cr	-27.98	-28.40
^{65}Se	-33.16	-32.60	^{65}V	-5.61	-7.33	^{66}Cr	-24.54	-25.98	^{66}Se	-41.37	-41.11	^{67}Cr	-18.48	-20.12
^{67}Mn	-33.31	-34.20	^{67}Fe	-46.07	-46.25	^{67}Br	-32.93	-32.55	^{68}Cr	-14.88	-16.93	^{68}Mn	-28.3	-29.00
^{68}Fe	-43.83	-45.11	^{68}Br	-38.44	-38.40	^{69}Mn	-24.54	-26.08	^{69}Fe	-39.06	-39.99	^{69}Co	-50.17	-51.21
^{69}Kr	-32.44	-32.67	^{70}Mn	-19.22	-20.60	^{70}Fe	-36.31	-38.01	^{70}Co	-46.92	-47.17	^{70}Kr	-40.95	-41.50
^{71}Mn	-15.2	-17.05	^{71}Fe	-31.	-32.83	^{71}Co	-44.37	-45.31	^{71}Rb	-32.3	-32.66	^{72}Fe	-28.1	-30.27
^{72}Co	-39.78	-41.02	^{72}Rb	-38.12	-38.33	^{73}Fe	-22.62	-24.41	^{73}Co	-36.9	-38.62	^{73}Rb	-46.08	-46.23
^{73}Sr	-31.95	-32.55	^{74}Fe	-19.24	-21.23	^{74}Co	-32.46	-33.79	^{74}Ni	-48.46	-49.36	^{74}Sr	-40.83	-41.67
^{75}Co	-29.1	-30.90	^{75}Ni	-44.25	-44.97	^{75}Sr	-46.62	-46.86	^{76}Co	-24.1	-25.75	^{76}Ni	-41.61	-42.94
^{76}Y	-38.6	-39.24	^{77}Ni	-36.75	-37.91	^{77}Cu	-48.51	-49.56	^{77}Y	-46.78	-47.26	^{78}Ni	-34.13	-35.79
^{78}Cu	-44.5	-45.38	^{78}Y	-52.53	-52.41	^{78}Zr	-41.3	-41.90	^{79}Ni	-27.71	-28.18	^{79}Cu	-41.9	-42.78
^{79}Y	-58.36	-58.34	^{79}Zr	-47.06	-47.04	^{80}Cu	-36.43	-36.60	^{80}Zr	-55.52	-54.39	^{81} Cu	-31.79	-31.88
^{81}Zr	-58.4	-57.86	^{81}Nb	-46.95	-46.42	^{82}Cu	-25.67	-24.98	^{82}Zn	-42.61	-42.63	^{82}Zr	-63.94	-61.81
^{82}Nb	-52.2	-51.32	^{83}Zn	-36.74	-36.04	^{83}Nb	-58.41	-56.75	^{83}Mo	-46.69	-44.87	^{84}Zn	-32.41	-31.91
^{84}Ga	-44.28	-43.42	^{84}Nb	-61.02	-59.33	^{84}Mo	-54.5	-51.41	^{85}Zn	-25.84	-24.93	^{85}Ga	-40.06	-39.41
^{85}Tc	-46.03	-43.77	^{86}Ga	-34.46	-33.15	^{86}Ge	-49.76	-49.23	^{86}Tc	-51.3	-49.30	^{87}Ga	-29.58	-28.66
^{87}Ge	-44.08	-43.18	^{87}Ru	-45.93	-43.98	^{88}Ge	-40.14	-39.45	^{88}As	-50.72	49.81	^{88}Ru	-54.4	-52.37
^{89}Ge	-33.73	-32.96	^{89}As	-46.8	-46.26	^{89}Ru	-58.11	-56.97	^{89}Rh	-46.03	-44.88	^{90}Ge	-29.22	-28.76
^{90}As	-41.33	-40.60	^{90}Se	-55.8	-55.38	^{90}Rh	-51.96	-50.69	^{91}As	-36.9	-36.61	^{91}Se	-50.34	-49.82
^{91}Rh	-58.8	-58.00	^{91}Pd	-46.28	-45.05	^{92}As	-30.98	-30.49	^{92}Se	-46.72	-46.69	^{92}Pd	-55.07	-53.63
^{93}Se	-40.72	-40.75	^{93}Br	-52.97	-52.75	^{93}Pd	-59.14	-58.55	^{93}Ag	-46.27	-46.13	^{94}Se	-36.8	-37.25
^{94}Br	-47.6	-47.92	^{94}Ag	-52.41	-52.26	^{95}Se	-30.46	-31.19	^{95}Br	-43.77	-44.55	^{95}Ag	-59.6	-59.81
^{95}Cd	-46.63	-46.55	^{96}Br	-38.16	-39.29	^{96}Cd	-55.57	-55.45	^{97}Br	-34.06	-35.43	^{97}Cd	-60.45	-60.38
^{97}In	-47.19	-48.09	^{98}Br	-28.45	-29.48	^{98}Kr	-44.31	-45.85	^{98}In	-53.9	-54.33	^{99}Kr	-38.76	-40.06
^{99}In	-61.38	-62.03	^{99}Sn	-47.94	-48.59	^{100}Kr	-35.05	-36.39	^{100}Rb	-46.55	-47.47	^{100}In	-64.31	-65.02
^{100}Sn	-57.28	-57.45	^{101}Kr	-29.13	-30.32	^{101}Rb	-42.81	-43.90	^{101}In	-68.61	-69.75	^{101}Sn	-60.31	-60.84
^{102}Rb	-37.71	-38.57	^{103}Rb	-33.61	-34.75	^{103}Sr	-47.42	-48.30	^{103}Sb	-56.18	-56.33	^{104}Sr	-44.11	-45.18
^{104}Y	-54.06	-54.73	^{105}Sr	-38.61	-39.70	^{105}Y	-50.82	-51.69	^{105}Te	-52.81	-52.08	^{106}Sr	-34.79	-36.32
^{106}Y	-46.05	-46.91	^{106}Zr	-58.91	-60.02	^{107}Sr	-28.9	-30.37	^{107}Y	-42.36	-43.60	^{107}Zr	-54.27	-55.38
^{107}I	-49.57	-48.32	^{108}Y	-37.3	-38.39	^{108}Zr	-51.35	-52.73	^{109}Y	-33.2	-34.36	^{109}Zr	-46.19	-47.67
^{109}Nb	-56.62	-58.06	^{109}Xe	-46.17	-44.82	^{110}Zr	-42.89	-44.25	^{110}Nb	-52.14	-53.68	^{111}Zr	-37.56	-38.43

Table 4
continued...

Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}
^{111}Nb	-48.88	-50.42	^{112}Zr	-33.81	-34.35	^{112}Nb	-44.27	-45.29	^{112}Mo	-57.46	-58.56	^{113}Nb	-40.51	-40.79
^{113}Mo	-52.77	-52.87	^{114}Nb	-35.39	-35.38	^{114}Mo	-49.81	-50.15	^{114}Tc	-58.77	-58.68	^{114}I	-72.8	-72.91
^{115}Nb	-31.35	-31.66	^{115}Mo	-44.75	-45.14	^{115}Tc	-55.91	-56.05	^{115}Cs	-59.7	-59.78	^{115}Ba	-49.03	-48.59
^{116}Mo	-41.5	-42.09	^{116}Tc	-51.46	-51.66	^{116}Cs	-62.06	-62.52	^{116}Ba	-54.7	-54.58	^{116}La	-40.7	-40.46
^{117}Mo	-36.17	-36.90	^{117}Tc	-48.38	-48.67	^{117}Ru	-59.52	-59.80	^{117}Ba	-57.62	-57.50	^{117}La	-46.59	-46.66
^{118}Tc	-43.79	-44.17	^{118}Ru	-57.26	-57.51	^{118}Ba	-62.35	-62.46	^{118}La	-49.62	-50.28	^{119}Tc	-40.37	-40.88
^{119}Ru	-52.56	-53.05	^{119}Ba	-64.59	-64.70	^{119}La	-54.97	-55.40	^{119}Ce	-44.05	-44.32	^{120}Tc	-35.52	-36.10
^{120}Ru	-50.01	-50.43	^{120}Rh	-58.82	-58.90	^{120}Ba	-68.89	-69.01	^{120}La	-57.69	-58.21	^{120}Ce	-49.8	-50.17
^{121}Ru	-45.05	-45.82	^{121}Rh	-56.43	-56.45	^{121}La	-62.27	-62.63	^{121}Ce	-52.77	-53.18	^{121}Pr	-41.62	-42.21
^{122}Ru	-42.41	-42.81	^{122}Rh	-52.17	-52.43	^{122}La	-64.54	-65.00	^{122}Ce	-57.87	-58.26	^{122}Pr	-44.95	-45.89
^{123}Ru	-37.36	-37.81	^{123}Rh	-49.51	-49.59	^{123}Pd	-60.42	-60.52	^{123}La	-68.65	-68.95	^{123}Ce	-60.29	-60.72
^{123}Pr	-50.34	-51.04	^{124}Ru	-34.42	-35.09	^{124}Rh	-45.17	-45.18	^{124}Pd	-58.55	-58.66	^{124}Ag	-66.2	-66.05
^{124}Ce	-64.92	-65.24	^{124}Pr	-53.15	-54.11	^{124}Nd	-44.53	-45.41	^{125}Rh	-42.21	-42.56	^{125}Pd	-54.22	-54.72
^{125}Ag	-64.23	-64.58	^{125}Ce	-66.66	-67.18	^{125}Pr	-58.03	-58.70	^{125}Nd	-47.6	-48.55	^{126}Rh	-37.76	-38.88
^{126}Pd	-52.02	-52.86	^{126}Ag	-60.78	-61.14	^{126}Pr	-60.32	-61.22	^{126}Nd	-52.99	-53.78	^{126}Pm	-39.2	-40.57
^{127}Pd	-47.44	-48.88	^{127}Ag	-58.58	-59.24	^{127}Pr	-64.54	-65.24	^{127}Nd	-55.54	-56.40	^{127}Pm	-44.79	-45.89
^{128}Pd	-44.87	-46.19	^{128}Ag	-54.9	-55.83	^{128}Nd	-60.31	-61.02	^{128}Pm	-47.79	-49.12	^{128}Sm	-38.73	-39.50
^{129}Ag	-52.21	-53.27	^{129}Cd	-63.51	-64.63	^{129}Nd	-62.32	-63.08	^{129}Pm	-52.88	-53.85	^{129}Sm	-42.14	-42.82
^{130}Ag	-45.92	-47.13	^{130}Cd	-61.53	-62.66	^{130}Pm	-55.4	-56.53	^{130}Sm	-47.51	-48.24	^{130}Eu	-33.82	-34.24
^{131}Cd	-55.33	-56.56	^{131}Pm	-59.92	-60.56	^{131}Sm	-50.13	-50.99	^{131}Eu	-39.27	-39.86	^{132}Cd	-50.26	-52.09
^{132}Pm	-61.63	-62.61	^{132}Sm	-55.08	-55.80	^{132}Eu	-42.23	-43.31	^{133}Cd	-43.92	-45.28	^{133}In	-57.46	-58.53
^{133}Sm	-57.23	-57.85	^{133}Eu	-47.24	-48.22	^{133}Gd	-36.02	-36.76	^{134}In	-51.66	-52.17	^{134}Sm	-61.38	-61.81
^{134}Eu	-49.93	-50.87	^{134}Gd	-41.3	-42.33	^{135}In	-46.53	-47.29	^{135}Eu	-54.15	-54.95	^{135}Gd	-44.29	-45.11
^{135}Tb	-32.83	-33.81	^{136}Sn	-55.9	-56.13	^{136}Eu	-56.24	-56.94	^{136}Gd	-49.09	-49.79	^{136}Tb	-36.06	-37.22
^{137}Sn	-49.79	-49.62	^{137}Sb	-60.03	-60.23	^{137}Eu	-60.12	-60.41	^{137}Gd	-51.21	-51.90	^{137}Tb	-40.97	-41.94
^{138}Sn	-44.86	-45.04	^{138}Sb	-54.54	-53.58	^{138}Gd	-55.66	-56.18	^{138}Tb	-43.67	-44.64	^{138}Dy	-34.93	-35.86
^{139}Sb	-49.79	-49.30	^{139}Gd	-57.63	-57.85	^{139}Tb	-48.13	-48.82	^{139}Dy	-37.64	-38.74	^{140}Sb	-43.94	-43.10
^{140}I	-63.6	-62.76	^{140}Tb	-50.48	-51.31	^{140}Dy	-42.83	-43.60	^{140}Ho	-29.26	-30.57	^{141}Te	-50.49	-49.57
^{141}I	-59.9	-59.26	^{141}Dy	-45.38	-45.99	^{141}Ho	-34.36	-35.37	^{142}Te	-46.37	-45.76	^{142}I	-54.77	-53.88
^{142}Tb	-56.56	-56.09	^{142}Dy	-50.12	-50.43	^{142}Ho	-37.25	-38.54	^{142}Er	-27.85	-28.89	^{143}Te	-40.28	-39.73
^{143}Eu	-50.63	-50.25	^{143}Gd	-68.23	-67.70	^{143}Ho	-42.05	-42.97	^{143}Er	-31.09	-32.01	^{144}I	-45.28	-44.80
^{144}Er	-36.61	-37.01	^{144}Tm	-22.09	-23.58	^{145}I	-40.94	-40.93	^{145}Er	-39.08	-38.61	^{145}Tm	-27.58	-28.65
^{146}Tm	-30.89	-30.67	^{147}Xe	-42.61	-42.79	^{148}Xe	-39.	-39.14	^{148}Cs	-47.3	-47.28	^{148}Yb	-30.2	-29.96

Table 5
continued...

Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}
^{149}Cs	-43.76	-43.66	^{149}Ba	-53.02	-53.33	^{149}La	-60.22	-60.76	^{149}Tm	-43.88	-44.09	^{149}Yb	-33.2	-33.26
^{150}Cs	-38.82	-38.58	^{150}Ba	-50.25	-50.33	^{150}La	-56.38	-56.83	^{150}Tm	-46.49	-46.67	^{150}Yb	-38.64	-38.67
^{150}Lu	-24.64	-24.91	^{151}Cs	-34.86	-34.68	^{151}Ba	-45.39	-45.40	^{151}La	-53.73	-53.93	^{151}Yb	-41.54	-41.32
^{151}Lu	-30.11	-30.35	^{152}Ba	-42.09	-42.01	^{152}La	-49.54	-49.54	^{152}Ce	-59.06	-59.40	^{152}Yb	-46.32	-46.58
^{152}Lu	-33.42	-33.55	^{153}Ba	-36.92	-36.81	^{153}La	-46.24	-46.26	^{153}Ce	-55.02	-55.14	^{153}Yb	-47.21	-47.31
^{153}Lu	-38.42	-38.86	^{153}Hf	-27.3	-27.24	^{154}La	-41.76	-41.59	^{154}Ce	-52.35	-52.45	^{154}Lu	-39.72	-40.16
^{154}Hf	-32.73	-33.24	^{155}La	-38.18	-38.03	^{155}Ce	-47.93	-47.89	^{155}Hf	-34.36	-34.51	^{155}Ta	-23.99	-24.81
^{156}Ce	-44.87	-44.88	^{156}Pr	-51.57	-51.48	^{156}Nd	-60.47	-60.47	^{156}Hf	-37.87	-37.97	^{156}Ta	-26.05	-26.59
^{157}Ce	-40.01	-39.99	^{157}Pr	-48.54	-48.53	^{157}Hf	-38.9	-38.79	^{157}Ta	-29.64	-30.18	^{157}W	-19.71	-20.07
^{158}Pr	-44.33	-44.13	^{158}Nd	-54.06	-54.13	^{158}Ta	-31.17	-31.40	^{158}W	-23.7	-24.21	^{159}Pr	-41.09	-40.99
^{159}Nd	-49.81	-49.83	^{159}W	-25.49	-25.35	^{159}Re	-14.74	-15.58	^{160}Nd	-47.13	-47.18	^{160}Pm	-53.	-52.92
^{160}W	-29.38	-28.97	^{160}Re	-16.93	-17.36	^{161}Nd	-42.59	-42.67	^{161}Pm	-50.24	-50.34	^{161}W	-30.56	-30.35
^{161}Re	-20.89	-20.93	^{161}Os	-10.22	-10.54	^{162}Pm	-46.37	-46.33	^{162}Sm	-54.53	-54.98	^{162}Re	-22.5	-22.86
^{162}Os	-14.5	-14.55	^{163}Pm	-43.25	-43.37	^{163}Sm	-50.72	-51.05	^{163}Os	-16.39	-16.27	^{164}Sm	-48.1	-48.61
^{164}Eu	-53.33	-53.20	^{164}Gd	-59.77	-59.87	^{164}Os	-20.47	-20.11	^{164}Ir	-7.54	-7.98	^{165}Sm	-43.81	-44.12
^{165}Eu	-50.69	-50.87	^{165}Gd	-56.49	-56.54	^{165}Tb	-60.57	-60.34	^{165}Os	-21.8	-21.71	^{165}Ir	-11.64	-11.70
^{166}Eu	-46.93	-46.93	^{166}Gd	-54.53	-54.69	^{166}Ir	-13.35	-13.66	^{166}Pt	-4.79	-4.78	^{167}Eu	-43.88	-43.94
^{167}Gd	-50.81	-50.87	^{167}Tb	-55.93	-55.82	^{167}Re	-34.84	-34.88	^{167}Pt	-6.81	-6.56	^{168}Gd	-48.36	-48.41
^{168}Tb	-52.72	-52.51	^{168}Pt	-11.06	-10.43	^{169}Gd	-44.15	-43.99	^{169}Tb	-50.33	-50.18	^{169}Dy	-55.6	-55.46
^{169}Pt	-12.51	-12.32	^{169}Au	-1.79	-2.11	^{170}Tb	-46.72	-46.36	^{170}Dy	-53.66	-53.64	^{170}Ir	-23.36	-23.57
^{170}Au	-3.75	-4.05	^{171}Tb	-44.03	-43.74	^{171}Dy	-50.19	-49.95	^{171}Ho	-54.52	-54.36	^{171}Hg	3.29	3.17
^{172}Dy	-48.01	-47.87	^{172}Ho	-51.48	-51.23	^{172}Hg	-1.11	-0.89	^{173}Dy	-43.94	-43.87	^{173}Ho	-49.35	-49.29
^{173}Er	-53.65	-53.64	^{173}Hg	-2.71	-2.61	^{174}Ho	-45.69	-45.86	^{174}Er	-51.95	-52.22	^{174}Au	-14.24	-14.05
^{175}Ho	-43.2	-43.49	^{175}Er	-48.65	-48.90	^{176}Er	-46.63	-47.08	^{177}Er	-42.86	-43.29	^{177}Tm	-47.47	-47.92
^{178}Tm	-44.12	-44.63	^{178}Ta	-50.6	-50.88	^{178}Tl	-4.79	-4.56	^{179}Tm	-41.6	-42.41	^{179}Yb	-46.54	-47.02
^{180}Yb	-44.6	-45.32	^{181}Yb	-41.09	-41.79	^{181}Lu	-44.8	-45.41	^{182}Lu	-41.88	-42.40	^{184}Lu	-36.41	-37.23
^{185}Lu	-33.89	-34.91	^{185}Bi	-2.24	-1.54	^{187}Hf	-32.82	-34.15	^{188}Hf	-30.88	-32.02	^{189}Hf	-27.16	-28.02
^{189}Ta	-31.83	-32.78	^{190}Ta	-28.51	-29.27	^{190}Tl	-24.38	-24.49	^{191}Ta	-26.49	-27.21	^{192}Ta	-23.16	-22.89
^{192}W	-29.65	-30.24	^{193}W	-26.29	-25.93	^{194}W	-24.53	-24.32	^{194}Re	-27.24	-27.38	^{194}Bi	-16.04	-15.93
^{195}Re	-25.58	-25.20	^{196}Re	-22.54	-22.12	^{197}Re	-20.5	-20.45	^{197}Os	-25.31	-24.90	^{198}Re	-17.14	-17.32
^{198}Os	-23.84	-23.71	^{198}Ir	-25.82	-25.59	^{198}At	-6.72	-6.26	^{199}Os	-20.48	-20.67	^{200}Os	-18.78	-19.11
^{200}Ir	-21.61	-21.72	^{201}Os	-15.24	-15.96	^{201}Ir	-19.9	-20.22	^{201}Ra	11.84	12.43	^{202}Os	-13.09	-13.73
^{202}Ir	-16.78	-17.46	^{202}Fr	3.09	3.48	^{203}Ir	-14.69	-15.28	^{203}Pt	-19.63	-20.21	^{204}Ir	-9.69	-10.29

Table 6
continued...

Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}
^{204}Pt	-17.92	-18.41	^{204}Au	-20.65	-20.72	^{205}Pt	-12.97	-13.58	^{205}Au	-18.77	-19.06	^{206}Pt	-9.63	-10.31
^{206}Au	-14.22	-14.50	^{206}Ac	13.46	13.79	^{207}Au	-10.81	-11.37	^{208}Au	-6.1	-6.30	^{209}Au	-2.47	-2.52
^{209}Hg	-8.64	-8.87	^{210}Au	2.33	2.76	^{210}Hg	-5.37	-5.51	^{211}Hg	-0.62	-0.28	^{212}Hg	2.76	3.17
^{212}Tl	-1.55	-1.19	^{213}Hg	7.67	8.53	^{214}Hg	11.18	12.03	^{214}Tl	6.47	7.21	^{215}Hg	16.21	17.64
^{215}Tl	9.91	10.78	^{215}Pb	4.42	5.31	^{216}Hg	19.86	21.34	^{216}Tl	14.72	15.96	^{216}Pb	7.48	8.32
^{217}Tl	18.31	19.56	^{217}Pb	12.24	13.23	^{217}U	22.97	22.66	^{218}Tl	23.09	24.44	^{218}Pb	15.45	16.42
^{219}Pb	20.28	21.53	^{219}Bi	16.28	17.11	^{219}Np	29.28	28.80	^{220}Pb	23.67	24.91	^{220}Bi	20.82	21.73
^{220}Pa	20.22	21.02	^{220}U	22.93	22.90	^{220}Np	30.31	30.19	^{221}Bi	24.1	24.97	^{221}U	24.48	24.35
^{221}Np	29.85	29.92	^{221}Bi	28.67	29.77	^{222}Pa	22.16	21.51	^{222}U	24.22	24.46	^{222}Np	31.02	31.90
^{223}Bi	32.14	33.04	^{223}Po	27.08	27.85	^{223}Np	30.6	30.18	^{224}Bi	36.77	37.57	^{224}Po	29.91	30.73
^{224}Np	31.88	31.44	^{225}Po	34.53	35.17	^{225}At	30.4	30.73	^{226}Po	37.55	38.25	^{226}At	34.61	34.76
^{226}Np	32.78	32.73	^{227}Po	42.28	42.89	^{227}At	37.48	37.76	^{228}At	41.68	42.01	^{229}At	44.82	45.07
^{230}Rn	42.05	42.59	^{230}Am	42.93	42.80	^{231}Rn	46.45	46.86	^{231}Am	42.44	42.43	^{232}Fr	45.99	46.43
^{232}Np	37.36	37.60	^{232}Am	43.27	43.49	^{232}Cm	46.4	46.51	^{233}Fr	49.03	49.33	^{233}Am	43.26	43.42
^{234}Am	44.46	44.72	^{234}Bk	53.34	53.39	^{235}Ra	51.2	51.26	^{235}Cm	48.01	48.32	^{235}Bk	52.7	52.84
^{236}Am	46.04	46.50	^{236}Bk	53.54	53.72	^{237}Ac	54.28	54.06	^{237}Am	46.57	47.01	^{237}Bk	53.19	53.42
^{238}Th	52.63	52.45	^{238}Bk	54.22	54.63	^{238}Cf	57.28	57.48	^{239}Th	56.61	56.38	^{239}Pa	53.34	53.30
^{239}Bk	54.25	54.62	^{239}Cf	58.25	58.66	^{239}Es	63.56	63.57	^{240}Pa	56.8	56.88	^{240}Bk	55.67	55.98
^{240}Es	64.2	64.36	^{241}Pa	59.69	59.52	^{241}U	56.2	56.19	^{241}Bk	56.03	56.42	^{241}Cf	59.33	59.54
^{241}Es	63.86	63.84	^{241}Fm	69.13	69.26	^{242}U	58.62	58.45	^{242}Np	57.42	57.52	^{242}Bk	57.74	58.18
^{242}Es	64.8	64.88	^{242}Fm	68.4	68.38	^{243}U	62.4	62.26	^{243}Np	59.88	59.73	^{243}Cf	60.99	61.05
^{243}Es	64.75	64.85	^{243}Fm	69.36	69.36	^{244}Np	63.2	63.20	^{244}Es	66.03	65.93	^{244}Fm	68.97	68.92
^{245}Np	65.95	65.50	^{245}Es	66.37	66.19	^{245}Fm	70.19	69.94	^{245}Md	75.27	75.30	^{246}Am	64.99	64.56
^{246}Es	67.9	67.74	^{246}Md	76.12	76.22	^{247}Pu	69.11	68.80	^{247}Am	67.15	66.69	^{247}Fm	71.67	71.31
^{247}Md	75.94	75.77	^{248}Am	70.56	70.21	^{248}Bk	68.08	67.83	^{248}Es	70.3	70.08	^{248}Md	77.15	76.85
^{248}No	80.62	80.36	^{249}Am	73.1	72.30	^{249}Es	71.18	70.88	^{249}Md	77.23	76.92	^{249}No	81.78	81.43
^{250}Es	73.23	72.80	^{250}Md	78.63	78.27	^{250}No	81.56	81.10	^{251}No	82.85	82.40	^{251}Lr	87.73	87.33
^{252}Cm	79.06	79.03	^{252}Bk	78.54	78.47	^{252}Md	80.51	80.05	^{252}Lr	88.74	88.28	^{253}Bk	80.93	80.79
^{253}Md	81.18	80.77	^{253}Lr	88.58	88.02	^{253}Rf	93.56	93.22	^{254}Bk	84.39	84.52	^{254}Md	83.45	83.21
^{254}Lr	89.87	89.21	^{254}Rf	93.2	92.59	^{255}Cf	84.81	84.69	^{255}Rf	94.33	93.61	^{255}Db	99.73	99.13
^{256}Cf	87.04	86.94	^{256}Es	87.19	86.99	^{256}Md	87.46	87.03	^{256}Db	100.5	99.79	^{257}Es	89.4	89.07
^{257}Lr	92.61	92.08	^{257}Db	100.21	99.57	^{258}Es	92.7	92.42	^{258}Fm	90.43	89.95	^{258}No	91.48	91.82
^{258}Lr	94.78	94.24	^{258}Db	101.8	101.08	^{258}Sg	105.24	104.52	^{259}Fm	93.71	93.08	^{259}Md	93.63	93.03

Table 7
continued...

Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}	Nucleus	E_{th}	E_{AME}
^{259}No	94.11	93.67	^{259}Lr	95.85	95.47	^{259}Rf	98.36	97.85	^{259}Sg	106.56	105.86	^{260}Fm	95.77	94.93
^{260}Md	96.55	95.78	^{260}No	95.61	94.88	^{260}Lr	98.28	97.66	^{260}Rf	99.15	98.64	^{260}Db	103.67	103.05
^{260}Bh	113.32	112.53	^{261}Md	98.58	97.60	^{261}No	98.46	97.66	^{261}Lr	99.56	98.79	^{261}Db	104.25	103.76
^{261}Bh	113.14	112.38	^{262}Md	101.63	100.53	^{262}No	100.1	98.94	^{262}Lr	102.1	101.19	^{262}Rf	102.39	101.49
^{262}Db	106.26	105.51	^{262} Bh	114.54	113.61	^{263}No	103.13	101.81	^{263}Lr	103.73	102.40	^{263}Rf	104.79	103.71
^{263}Db	107.11	106.19	^{263}Sg	110.19	109.50	^{263}Bh	114.5	113.76	^{263}Hs	119.72	119.05	^{264}No	105.01	103.34
^{264}Lr	106.38	104.93	^{264}Rf	106.08	104.64	^{264}Db	109.36	108.03	^{264}Sg	110.78	109.80	^{264}Bh	116.06	115.16
^{265}Lr	108.23	106.40	^{265}Rf	108.69	107.08	^{265}Db	110.49	108.8	^{265}Sg	112.8	111.57	^{265}Bh	116.36	115.38
^{265}Mt	126.68	126.00	^{266}Lr	111.62	109.34	^{266}Rf	110.08	108.1	^{266}Db	112.74	110.99	^{266}Sg	113.62	111.96
^{266}Bh	118.11	116.78	^{266}Mt	127.96	126.87	^{267}Rf	113.45	111.07	^{267}Db	114.08	111.92	^{267}Sg	115.84	114.01
^{267}Bh	118.77	117.12	^{267}Hs	122.65	121.31	^{267}Mt	127.79	126.73	^{267}Ds	133.92	132.95	^{268}Rf	115.48	112.91
^{268}Db	117.06	114.55	^{268}Sg	116.8	114.67	^{268}Bh	120.81	118.78	^{268}Hs	122.83	121.26	^{268}Mt	129.15	127.67
^{268}Ds	133.65	132.34	^{269}Db	119.15	116.40	^{269}Sg	119.82	117.25	^{269}Bh	121.48	119.38	^{269}Hs	124.59	122.88
^{269}Mt	129.31	127.48	^{270}Db	122.36	119.60	^{270}Sg	121.49	118.70	^{270}Bh	124.23	121.61	^{270}Hs	125.09	123.11
^{270}Mt	130.71	128.77	^{271}Sg	124.76	121.91	^{271}Bh	125.99	123.03	^{271}Hs	127.77	125.28	^{271}Mt	131.1	128.87
^{271}Ds	135.95	133.96	^{272}Sg	126.58	123.72	^{272}Bh	128.79	125.88	^{272}Hs	129.01	126.32	^{272}Mt	133.58	130.66
^{272}Ds	136.02	133.77	^{272}Rg	142.77	141.05	^{273}Sg	130.02	127.17	^{273}Bh	130.63	127.66	^{273}Hs	131.97	129.12
^{273}Mt	134.51	131.66	^{273}Ds	138.38	135.43	^{273}Rg	142.64	140.84	^{274}Bh	133.71	130.74	^{274}Hs	133.49	130.60
^{274}Mt	137.16	134.12	^{274}Ds	139.18	136.09	^{274}Rg	144.62	142.11	^{275}Bh	135.69	132.98	^{275}Hs	136.62	133.73
^{275}Mt	138.63	135.54	^{275}Ds	141.62	138.47	^{275}Rg	145.26	142.67	^{276}Hs	138.29	135.48	^{276}Mt	141.21	138.24
^{276}Ds	142.54	139.51	^{276}Rg	147.49	144.65	^{276}Cp	150.35	148.08	^{277}Hs	141.49	138.34	^{277}Mt	142.77	139.95
^{277}Ds	145.23	142.26	^{277}Rg	148.17	145.62	^{277}Cp	152.43	150.00	^{278}Rg	145.6	142.55	^{278}Ds	146.28	143.46
^{278}Rg	150.43	147.97	^{278}Cp	152.91	150.85	^{278}113	158.89	157.15	^{279}Mt	147.25	144.34	^{279}Ds	149.13	145.87
^{279}Rg	151.57	148.92	^{279}Cp	155.13	152.76	^{279}113	159.24	157.77	^{280}Rg	153.83	150.83	^{280}Cp	155.7	153.10
^{280}113	161.08	158.59	^{281}Ds	153.24	149.32	^{281}Cp	158.12	154.87	^{281}113	161.6	158.79	^{282}Rg	157.53	153.79
^{282}Cp	158.82	155.33	^{282}113	163.64	160.23	^{283}Rg	158.86	154.88	^{283}Cp	161.4	157.33	^{283}113	164.48	160.73
^{284}113	166.48	162.45	^{285}Cp	164.98	160.36	^{285}Fl	171.06	166.67	^{286}113	169.73	165.14	^{286}Fl	171.61	167.19
^{287}113	170.83	166.15	^{287}Fl	173.99	169.11	^{287}115	177.64	173.46	^{288}115	179.54	175.04	^{289}Fl	177.37	171.68
^{289}Lv	184.59	180.43	^{290}115	182.55	177.53	^{290}Lv	185.03	180.79	^{291}Lv	187.3	182.69	^{291}117	191.45	187.66
^{292}117	193.25	189.22	^{292}Lv	190.48	185.08	^{293}118	198.93	195.18	^{294}117	196.04	191.68	^{294}118	199.27	195.55
^{295}118	201.43	197.36												