ON ALPHA-DISINTEGRATION: PART I SOME USEFUL THEORETICAL TABULATIONS AND GRAPHICAL PLOTS

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ABSTRACT. Starting from the well-known mass defect formula

$$\Delta M = \alpha A - \beta \frac{(N-Z)^2}{A} - \gamma A^{2/3} - \delta \frac{Z^2}{A^{1/3}}$$

an expression has been deduced for the total energy released in an α-disintegration. The calculation has been confined to groups of nuclides with, $A = 44, 45, 46, 47, 48, 49, 50, 51, 52$, and 53. Useful theoretical data are given in ten tables. β, γ, δ and Q curves are plotted on ten separate graphs and their outstanding characteristics briefly discussed.

INTRODUCTION

It is well-known that when a nuclide $M(A, Z)$ disintegrates into the daughter nuclide $M(A-4, Z-2)$, emitting an α-particle $M(4, 2)$, we can write the reaction scheme as follows

$$M(A,Z) = M(A-4, Z-2) + M(4,2) + Q \qquad \ldots \quad (1).$$

where Q is the energy released in the α-disintegration process, including the recoil energy of the daughter nuclide. It is, of course, tacitly assumed that the resulting nuclide is in the ground state, so that there is no subsequent gamma ray emission. Whenever there is emission of a gamma photon following an α-disintegration the gamma energy has to be deducted from the theoretically possible value of Q to get the nearest approach to the experimentally observed value.

If by any means we can accurately measure the nuclear masses involved in the above reaction scheme, we can straightforward calculate the energy of disintegration. Unfortunately, the only practical means at our disposal of measuring nuclear masses accurately, namely, mass-spectrographic investigation, has not yet been much successful with heavy nuclei. However, using the Bethe-Weizsacker (1936) mass defect formula, we can theoretically calculate the possible energy release involved in an α-disintegration process.

Glueckauf (1948) has utilised the accurately known mass values of the lightest elements upto a mass number $A=40$, and with somewhat reduced accuracy upto $A=60$, to calculate directly the binding energy of the last alpha particle in the nucleus (which is the alpha disintegration energy with opposite sign). Although these nuclei are not radioactive in nature, the resulting plots are very interesting in that, the lines of constant α-energy values show qualitatively the same kind of fluctuations as are noticeable in similar experimental curves obtained for high atomic weight nuclei. Pryce (1950) has recently published some theoretical calculations on the energy of α-particles from radioactive bodies and has tabulated the results in the form of energy release from various isotopes (existing or hypothetical) of all the elements from Pt($Z=78$) to Cm ($Z=96$). Considering the fact that there are at present several collateral alpha decay chains of artificially produced radioactive nuclides (Seaborg and Perlman, 1950; Studier and Hyde, 1947; Meinke, Ghiorso and Seaborg, 1948) we have calculated the theoretical α-energy release from them with a view to extending the study of correlation between theoretical predictions and experimental findings. As the calculations are of an involved nature and hence time consuming; the final data have been supplied in tabular forms and relevant curves plotted for the different I values.

DERIVATION OF THE ENERGY RELEASE FORMULA

The exact nuclear mass of a nuclide $M(A, Z)$ can be expressed as

$$M(A,Z) = NM_n + ZM_p - \alpha A + \beta \frac{(N-Z)^2}{A} + \gamma A^{2/3} + \delta \frac{Z^2}{A^{1/3}}$$

from which, the mass defect ΔM is

$$\Delta M = \alpha A - \beta \frac{(N-Z)^2}{A} - \gamma A^{2/3} - \delta \frac{Z^2}{A^{1/3}} \quad .. \quad (2)$$

$$= \alpha A - \beta \frac{I^2}{A} - \gamma A^{2/3} - \delta \frac{Z^2}{A^{1/3}}$$

From (1), $\qquad Q = M(A, Z) - M(A-4, Z-2) - M(4, 2)$

or, in terms of $\Delta M(A, Z)$,

$\Delta M(A\text{-}4, Z\text{-}2)$ and $\Delta M(4, 2)$

$$Q = \Delta M(A-4, Z-2) + \Delta M(4,2) - \Delta M(A,Z).$$

Now, substituting for ΔM's their respective expressions involving the constants α, β, γ, and δ, we have, after slight rearrangements,

$$Q(\text{in Mev}) = -4\alpha + 28.16 - 4\beta \frac{I^2}{A(A-4)} + 13.08[A^{2/3} - (A-4)^{2/3}]$$

$$+ .58\left[\frac{Z^2}{A^{1/3}} - \frac{(Z-2)^2}{(A-4)^{1/3}}\right]$$

$$= -27.88 - 75.6 \frac{I^2}{A(A-4)} + 13.08[A^{2/3} - (A-4)^{2/3}] + .58\left[\frac{Z^2}{A^{1/3}} - \frac{(Z-2)^2}{(A-4)^{1/3}}\right]$$

In working out the above expression for Q, we have used values of the constants α, β, γ, and δ, calculated with the help of up-to date mass data:

α	...	...	(14.01)
β	..	...	(18.9)
γ	.	...	(13.08)
δ	. .	.	(.58)

The binding energy of the α-particle has been taken as 28.16 Mev

Meanings of symbols used:

M = actual mass of the nuclide.

A = Mass number

N = The number of neutrons in the nuclide

Z = The ,, ,, protons ,, ,, ,,

I = Isotopic number = $(N-Z)$

M_p = Mass of the proton.

M_n = Mass of the neutron.

TABULATION AND GRAPHICAL PLOTS

With the help of the above expression we have calculated, term by term, the total energy release for the nuclear species characterised by $I = 44, 45, 46, 47, 48, 49, 50, 51, 52$, and 54. No series with $I = 53$ has yet been found. For convenience of tabulation, nuclides with the same I value have been divided into two groups from amongst the four possible ones, *viz*, even-even, even-odd, odd-odd and odd even—the first word referring to the number of protons in the nuclide and the second, to the number of neutrons.

The tabulated data have been presented in the form of graphical plots (Figs 1—10). On each graph for the same I, have been plotted the net contributions from the β, γ, and δ terms, as well as the theoretical energy Q, against the corresponding nuclide The scales of ordinates are necessarily different. This procedure has been adopted to present a comparative picture of the variations of the different quantities with the mass number.

Nuclides plotted immediately close to the abscissa denote class (A) of the tables, while those farther below or up denote class (B). The order of the ordinates, for all the plots, is respectively β, γ, δ, and Q, starting from the extreme right.

TABLE I

Nuclides : $I=44$

(A) Even-Even group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
				β-term	γ-term	δ-term	
$_{92}U^{228}$	0.03790720	0.437080	51.740	2.865790	5.726420	30.00920	4.990
$_{90}Th^{224}$	0.03928570	0.44030	50.940	2.97000	5.750120	29.54520	4.454
$_{88}Ra^{220}$	0.04074070	0.44310	50,130	3.08000	5.795740	29.07400	3.9[illegible]9
$_{86}Em^{216}$	0.04227810	0.44590	49.310	3.106220	5.832370	28.59980	3.356
$_{84}Po^{212}$	0.04390420	0.44860	48.500	3.319150	5.866768	28.13000	2.798

(B) Odd-Odd group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	β-term	γ-term	δ-term	Calc Q (in Mev)
$_{91}Pa^{226}$	0.03858720	0.43900	51.340	2.917190	5.74220	29.77920	4.724
$_{89}Ac^{222}$	0.04000330	0.44180	50.530	3,024250	5.778740	29.30739	4.182
$_{87}Fr^{218}$	0.04149770	0.44450	49.730	3.137300	5.814060	28.84340	3.640
$_{85}At^{214}$	0.04309950	0.44710	49.000	3.256820	5.848100	28.42000	3.131

TABLE II

Nuclides : $I=45$

(A) Even-Odd group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
				β-term	γ-term	δ-term	
$_{92}U^{229}$	0.03930130	0.43720	51.700	2.971193	5.718570	29.98600	4.853
$_{90}Th^{225}$	0.0407340	0.43970	50.899	3.078730	5.751270	29.52140	4.314
$_{88}Ra^{221}$	0.04222530	0.44240	50.081	3.192230	5.786580	29.04090	3.755
$_{86}Em^{217}$	0.04381120	0.44520	49.280	3.312130	5.82320	28.60210	3.233
$_{84}Po^{213}$	0.04548610	0.44790	48.450	3.438750	5.858530	28.10100	2.641

(B) Odd-Even group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	β-term	γ-term	δ-term	Calc Q (in Mev)
$_{91}Pa^{227}$	0.04000310	0.43500	51.300	3.024230	5.742390	29.75400	4.552
$_{89}Ac^{223}$	0.04146440	0.44110	50.490	3.134710	5.769580	29.28420	4.039
$_{87}Fr^{219}$	0.04300630	0.44370	49.689	3.251350	5.803590	28.81960	3.492
$_{85}At^{215}$	0.04463799	0.44660	48.861	3.374620	5.841520	28.33930	2.926
$_{83}Bi^{211}$	0.0463660	0.44930	48.040	3.505040	5.876400	27.86200	2.353

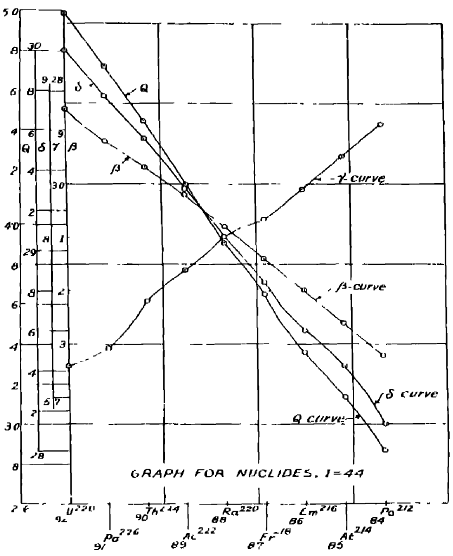
GRAPH FOR NUCLIDES. I=44
Q curve
δ curve
β-curve
γ-curve

FIG. 1

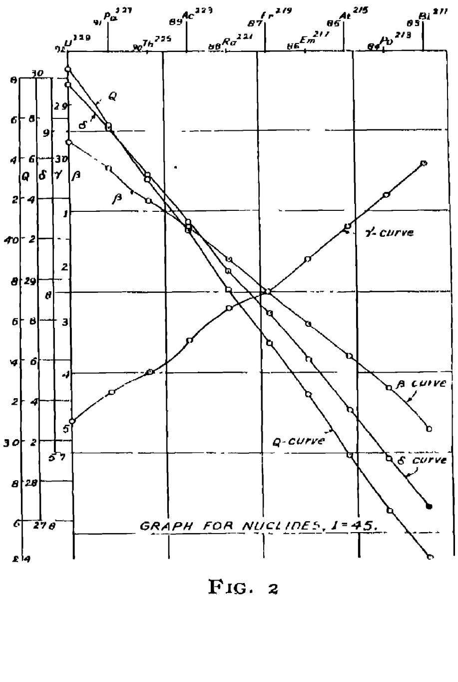
GRAPH FOR NUCLIDES. I=45.
Q-curve
δ curve
β curve
γ-curve

FIG. 2

TABLE III

Nuclides : $I = 46$

(*A*) *Even-Even group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc. Q in Mev).
				β term	γ-term	δ-term	
$_{92}U^{230}$	0 04070790	0 43660	51 660	3 077520	5.710720	29 96280	4.716
$_{90}Th^{226}$	0.04121490	0 43910	50 850	3 188420		29 49300	4.168
$_{88}Ra^{222}$	0 04372260	0 44180	50.110	3 305430	5 778740	29 06371	3.657
$_{86}Em^{218}$	0 0453571	0 44440	49.170	3.428990	5.812750	28.51860	
$_{84}RaC'^{214}$	0.047085	0.44720	48.410	3 559620	5 849370	28 07780	2 48

(*B*) *Odd-Odd group*

$_{91}Pa^{228}$	0.04143170	0 43770	51 260	3 12230	5.725110	29 75180	4.434
$_{89}Ac^{224}$	0 04203830	0 44040	50 440	3 246130	5.760430	29.25520	3 890
$_{87}Fr^{220}$	0 04452850	0 44300	49 650	3.366360	5.795740	28 79700	3 346
$_{85}At^{216}$	0.04620890	0 44590	48 820	3.493390	5 831060	28 31560	2 773
$_{83}Bi^{212}$	0.04798620	0 44860	48.000	3 627740	5 867680	27 84000	2 200

TABLE IV

Nuclides : $I = 47$

(*A*) *Even-Odd group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc. Q (in Mev)
				β-term	γ-term	δ-term	
$_{96}Cm^{239}$	0.03933054	0 43091	53 199	2 973900	5 636302	30 85542	6.038
$_{94}Pu^{235}$	0.04069264	0 43335	52 411	3.076363	5 68216	30.39837	5 124
$_{92}U^{231}$	0.04212673	0 43587	51.606	3 184781	5.70177	29.93148	4 568
$_{90}RaAc^{227}$	0 04363799	0.43845	50.822	3 299034	5 734917	29 47674	4.033
$_{88}AcX^{223}$	0.04523210	0 44108	50.006	3 419547	5 769326	28 93619	3.406
$_{86}An^{219}$	0 04691516	0.44375	49.192	3 446785	5 804140	28.53350	3.011
$_{84}AcA^{295}$	0.04869354	0 44653	48.371	3.681260	5 84061	28.05517	2.335
$_{82}AcB^{211}$	0.05057581	0 44936	47.543	3.823532	5.877601	27.57493	1.749

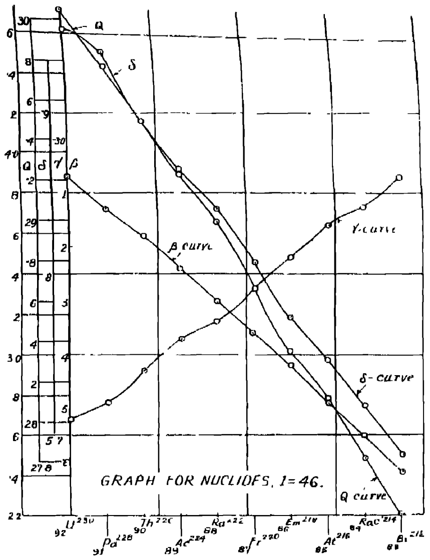
GRAPH FOR NUCLIDES, I=46.
Q
δ
β curve
γ-curve
δ- curve
Q curve
Q δ γ β

FIG 3

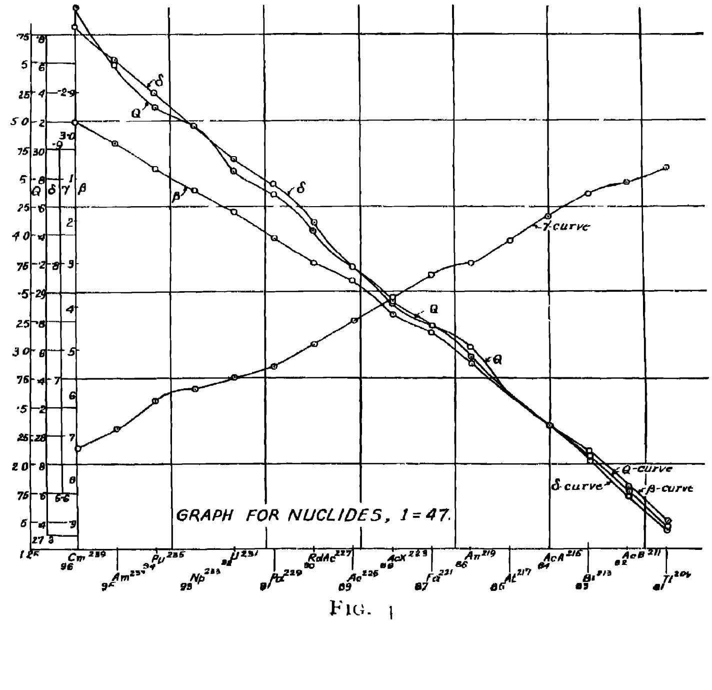
GRAPH FOR NUCLIDES, I=47.
δ
Q
β
γ-curve
Q-curve
δ-curve
β-curve
Q δ γ β

FIG. 1

TABLE IV (*contd.*)

(*B*) *Odd-Even group*

$_{95}Am^{237}$	0 04000290	0 43095	52 806	3.024220	5 657754	30.627470	5 491
$_{93}Np^{233}$	0 04140034	0 43458	52 012	3 129862	5.684338	30 166960	4 961
$_{91}Pa^{229}$	0 04287233	0 43718	51 316	3 241153	5 718314	29 76330	4 360
$_{89}Ac^{225}$	0 04442431	0 43973	50 310	3 335880	5 751666	29 17985	3 716
$_{87}Fa^{221}$	0 04610150	0 44243	49 600	3.460497	5 786983	28 76800	3 214
$_{85}At^{217}$	0 04779214	0.44512	48 782	3.613086	5 822169	28 29357	2 623
$_{83}Bi^{213}$	0 04962150	0 44791	47 958	3 751386	5 859054	27,81565	2 043
$_{81}Tl^{209}$	0 05155793	0 45082	47 126	3 897800	5.883640	27 33308	1.439

TABLE V

Nuclides, $I = 48$

(*A*) *Even-Even group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc *Q* in Mev.
				β-term	γ-term	δ-term	
$_{96}Cm^{240}$	0 04067796	0 43029	53.150	3 075253	5.628193	30 82922	5 502
$_{94}Pu^{236}$	0 04208064	0 43276	52.371	3.181296	5 660492	30 37518	4 974
$_{92}U^{232}$	0 04355716	0 43425	51.562	3 292922	5 679981	29 92915	4 436
$_{90}Th^{228}$	0 04583525	0 43877	50.784	3 465133	5.739110	29 45471	3 849
$_{88}Thx^{224}$	0 04675323	3 44039	49 965	3 354544	5 76030	28 97970	3 325
$_{86}ThEm^{220}$	0.04848483	0 44310	49 150	3 665420	5 795847	28.50700	2 757
$_{84}ThA^{216}$	0.05031455	0 44583	48 329	3 803771	5.831465	28.03827	2 186
$_{82}ThB^{212}$	0 05224062	0 44866	47 501	3 950070	5.868472	27 55058	1 589
$_{80}Hg^{208}$	0 5429863	0 45151	46 670	4 104976	5 90575	27 06859	0.989

(*B*) *Odd-Odd group*

$_{95}Am^{238}$	0 04137037	0 43150	52 769	3.12760	5 64420	30 60600	5 248
$_{93}Np^{34}$	0 04280936	0 43400	51 972	3 236385	5.676711	30 14375	4.704
$_{91}Pa^{230}$	0 04132464	0 43650	51 369	3 350950	5 709420	29 69150	3 880
$_{89}Ac^{226}$	0 0459220	0 43908	50.369	3.471700	5 743164	29.21400	3.605
$_{87}Fa^{222}$	0 04760722	0 44182	49 559	3.599000	5 779000	28.67810	2.978
$_{85}At^{218}$	0 0493870	0 44438	48.471	3 735851	5.812490	28.11317	2 312
$_{83}RaC^{214}$	0 05126833	0 44722	47 916	3.875886	5.849636	27 79128	1.885
$_{81}RaC^{210}$	0 05325934	0 45009	47 082	4 026407	5 887076	27.30755	1.288

TABLE VI

Nuclides : $I=49$

(A) *Even-Odd group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
				β-term	γ-term	δ-term	
$_{96}Cm^{241}$	0.04203052	0.42972	53.119	3.177062	5.620737	30.80902	5.372
$_{94}Pu^{237}$	0.04347985	0.43211	52.330	3.287076	5.652291	30.35139	4.837
$_{92}U^{233}$	0.0449978	0.43460	51.534	3.401908	5.681566	29.88972	4.292
$_{90}Th^{229}$	0.04659873	0.43713	50.731	3.521864	5.718050	29.42400	3.739
$_{88}Ra^{225}$	0.04828557	0.43973	49.921	3.650380	5.751665	28.95591	3.177

(B) *Odd-Even group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	β-term	γ-term	δ-term	Calc Q (in Mev)
$_{95}Am^{239}$	0.04271003	0.43091	52.727	3.231827	5.636302	30.5132	5.038
$_{93}Np^{235}$	0.04422953	0.43335	51.916	3.343752	5.668216	30.11302	4.557
$_{91}Pa^{231}$	0.04578827	0.43580	51.148	3.461591	5.701410	29.66830	4.028
$_{89}Ac^{227}$	0.04743000	0.43843	50.429	3.585776	5.734660	29.30019	3.578
$_{87}AcK^{223}$	0.04916353	0.44108	49.405	3.716761	5.769326	28.65257	2.825

TABLE VII

Nuclides : $I=50$

(A) *Even Even group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
				β-term	γ-term	δ-term	
$_{96}Cm^{242}$	0.04340578	0.42912	53.084	3.281770	5.612890	30.78871	5.240
$_{94}Pu^{238}$	0.04489974	0.43150	52.284	3.393663	5.614020	30.32468	4.695
$_{92}U^{234}$	0.04539377	0.43400	51.475	3.51170	5.676720	29.79841	4.083
$_{90}Io^{230}$	0.04809543	0.43650	50.690	3.636010	5.709420	29.40021	3.594
$_{88}Ra^{226}$	0.04982856	0.43910	49.881	3.767410	5.743426	28.93100	3.027
$_{86}Rn^{222}$	0.0516452	0.44617	49.160	3.904376	5.765100	28.51280	2.434
$_{84}RaA^{218}$	0.05235640	0.45101	48.150	4.050340	5.799210	27.92600	1.895
$_{82}RaB^{214}$	0.05562970	0.45622	47.417	4.205606	5.836556	27.50286	1.254

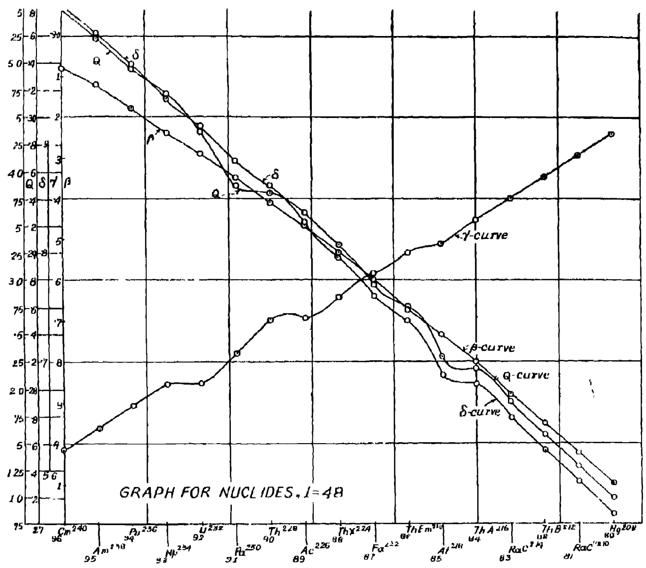
GRAPH FOR NUCLIDES, I=48
γ-curve
β-curve
Q-curve
δ-curve

FIG. 5

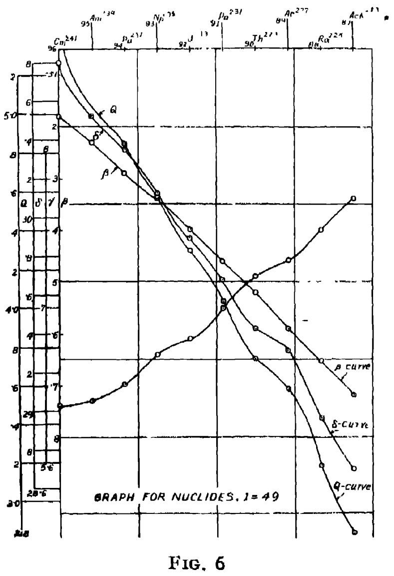
GRAPH FOR NUCLIDES, I = 49
β curve
δ-curve
Q-curve

FIG. 6

TABLE VII (*contd.*)

(*B*) *Odd-Odd group*

$_{95}Am^{240}$	0.04413842	0.43041	52.687	3.336864	5.629762	30.55847	4.971
$_{93}Np^{236}$	0.04566043	0.43273	51.890	3.451928	5.660500	30.10200	4.431
$_{91}Pa^{232}$	0.04618672	0.43525	51.153	3.573050	5.693070	29.66874	3.008
$_{89}MsTh_2^{228}$	0.0489505	0.43777	50.227	3.700558	5.726030	29.13165	3.277
$_{87}Fa^{224}$	0.05073051	0.44040	49.028	3.835327	5.760439	28.43629	2.481
$_{85}At^{220}$	0.05260942	0.44309	48.072	3.977271	5.795615	27.88059	1.919
$_{83}Bi^{216}$	0.05459468	0.44583	47.866	4.127357	5.831456	27.71048	1.574
$_{81}Tl^{212}$	0.05660447	0.44866	47.003	4.286102	5.868469	27.36000	0.962

TABLE VIII

Nuclides. $I=51$

(*A*) *Even-Odd group*

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
				β term	γ-term	δ-term	
$_{96}Cm^{243}$	0.04178537	0.42852	53.039	3.385766	5.605040	30.76261	5.102
$_{94}Pu^{239}$	0.04631000	0.43001	52.240	3.501034	5.636302	30.31022	1.565
$_{92}U^{235}$	0.0479177	0.43335	51.452	3.622281	5.666910	29.84216	4.007
$_{90}UY^{231}$	0.04960237	0.43587	50.651	3.749049	5.701177	29.37758	3.449
$_{88}Ra^{227}$	0.05138182	0.43845	49.841	3.884467	5.731046	28.90777	2.873

(*B*) *Odd-Even group*

$_{95}Am^{241}$	0.04553820	0.42952	52.645	3.442680	5.618133	30.35110	4.650
$_{93}Np^{237}$	0.04710165	0.43234	51.851	3.560884	5.655006	30.07510	4.290
$_{91}Pa^{239}$	0.04874712	0.43460	51.052	3.686980	5.684566	29.54206	3.660
$_{89}Ac^{229}$	0.0504835	0.43716	50.247	3.816323	5.718050	29.02208	3.144

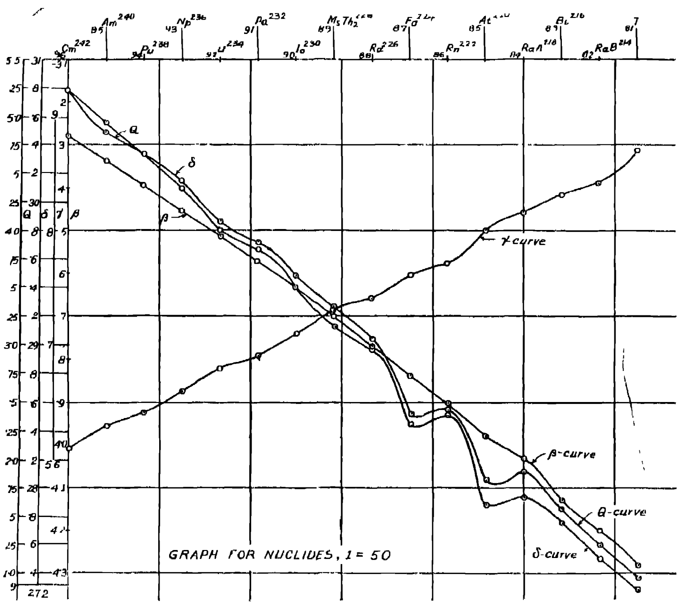
GRAPH FOR NUCLIDES, 1 = 50
γ-curve
β-curve
Q-curve
δ-curve

FIG. 7

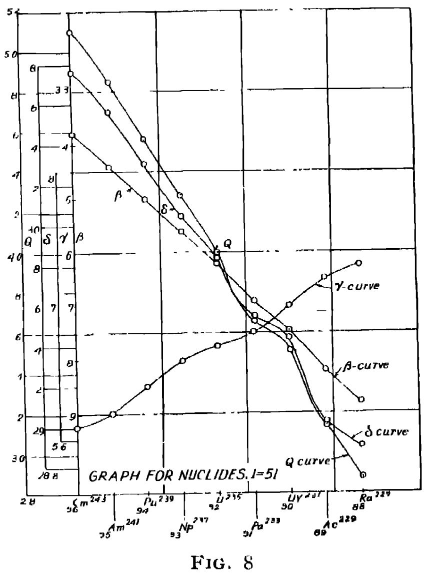
GRAPH FOR NUCLIDES, 1=51
γ curve
β-curve
δ curve
Q curve

FIG. 8

TABLE IX

Nuclides : $I = 52$

(A) Even-Even group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
				β-term	γ-term	δ-term	
$_{96}Cm^{244}$	0.04617486	0.42791	52.909	3.490818	5.59761	30.7394[illegible]	4.966
$_{94}Pu^{240}$	0.04774010	0.43031	52.208	3.609152	5.628152	30.28064	4.1[illegible]0
$_{92}U^{236}$	0.04938631	0.43276	51.413	3.733605	5.66050	29.81932	3.806
$_{90}Th^{232}$	0.05111916	0.43523	50.609	3.864910	5.69287	29.27897	3.227
$_{88}MsTh_1^{228}$	0.05306790	0.43778	49.801	4.011058	5.725135	28.88457	2.718
$_{86}Rn^{224}$	0.05487010	0.44041	48.983	4.148180	5.7605[illegible]	28.41014	2.143

(B) Odd-Odd group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	β-term	γ-term	δ-term	Calc Q (in Mev)
$_{95}Am^{242}$	0.04694768	0.42912	52.605	3.549244	5.61289	30.44712	4.631
$_{93}Np^{238}$	0.04855274	0.43270	51.811	3.670586	5.659515	30.05037	4.159
$_{91}Pa^{234}$	0.05024152	0.43279	51.019	3.798[illegible]60	5.660892	29.58579	3.568
$_{89}Ac^{230}$	0.052020	0.43651	50.198	3.932701	5.70965	29.11483	3.01[illegible]
$_{87}Fa^{226}$	0.05389158	0.43998	49.393	4.074430	5.752584	28.64940	2.448

TABLE X

Nuclides . $I = 54$

(A) Even-Even group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$	Net contribution from			Calc Q (in Mev)
					γ term	δ term	
$_{96}Cm^{246}$	0.04901581	0.42668	52.922	3.703044	5.58359	30.70475	4.705
$_{94}Pu^{242}$	0.05062840	0.42918	52.129	3.827524	5.604176	30.23482	4.321
$_{92}U^{238}$	0.05235940	0.43152	51.452	3.958370	5.63160	29.84216	3.635
$_{90}UX_1^{234}$	0.05418060	0.43400	50.506	4.096054	5.676732	29.29348	2.994
$_{88}Ra^{230}$	0.0567682	0.43752	50.028	4.241047	5.72575[illegible]	28.97582	2.650

(B) Odd-Odd group

Nuclides	$\frac{I^2}{A(A-4)}$	$[A^{2/3}-(A-4)^{2/3}]$	$\left[\frac{Z^2}{A^{1/3}}-\frac{(Z-2)^2}{(A-4)^{1/3}}\right]$		γ term	δ term	Calc Q (in Mev)
$_{95}Am^{244}$	0.04979518	0.42792	52.516	3.764510	5.59720	30.45927	4.412
$_{93}Np^{240}$	0.05148307	0.42931	51.730	3.892120	5.617653	30.03400	3.760
$_{91}Pa^{236}$	0.05325832	0.44276	50.933	4.026330	5.65130	29.54114	3.426
$_{89}Ac^{232}$	0.05512705	0.44389	50.121	4.167605	5.67227	29.07180	2.894

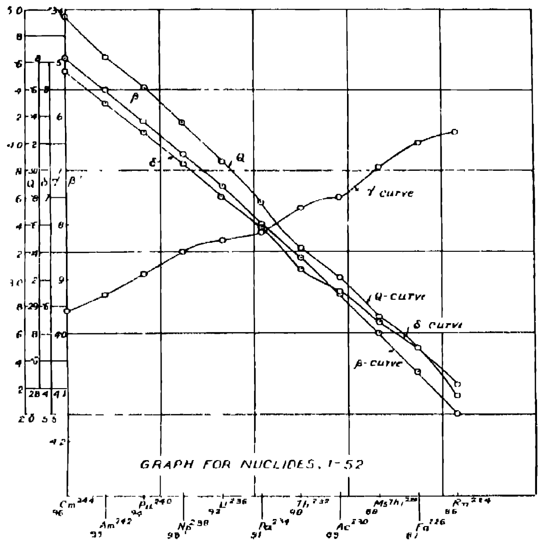
GRAPH FOR NUCLIDES, I=52
γ curve
Q-curve
δ curve
β-curve
Q δ γ β

FIG. 9

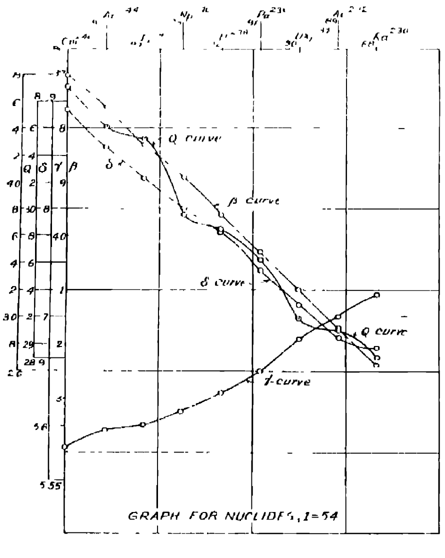
Q curve
β curve
δ curve
Q curve
γ-curve
GRAPH FOR NUCLIDES, I=54
Q δ γ β

FIG. 10

DISCUSSION

It will be seen from the plots that the β-curves have almost a constant slope, the net contribution of the β-terms to the α-energy Q diminishing monotonically with decreasing mass number. The average slope of these curves, considering the straightest portion of each, is about ·035 per mass unit.

Most of the γ-curves are characterised by undulations—flat maxima and minima occurring alternately. This feature is very prominent for $I=44$, 45, 46, 48, 49, 50, 51, and 54 Another peculiarity of these curves is that even in the same curve the undulations do not occur with any regularity with respect to mass number. On the other hand, for $I=44$, 45, and 48 there is practically no undulation for a considerable run of the curves towards the ends

The δ and Q curves show a pronounced tendency to run more or less parallel. This is specially true for curves with increasing I values. Also, with increase of I there is a tendency for the occurrence of undulations. This is very marked for $I=47$, 48, 49, 50 and 51. We can infer from this that the main contribution toward the energy release comes from δ-term This is also apparent from the tables, in which the leading contributor is the δ-term. Another interesting fact is that when the Q-points belonging to the same class (A) or (B) are joined separately, the resulting mean curve is more or less straight. This theoretical prediction of irregularity in the energy release curves of nuclides with the same I value is in qualitative agreement with experimentally obtained curves (Perlman, Ghiorso and Seaborg, 1950). In any similar theoretical plots the relative trend of the curves will not change by altering the constants β, γ, and δ because, such an alteration will introduce only a change in the scale of the ordinates in the ratio of the altered values of the constants to their respective values used here. The full significance of these theoretical plots in relation to experimental findings will be dealt with subsequently

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