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U S ARMY NATICK LABORATORIES

TECHNICAL REPORT

FD-I

HANDBOOK OF PHOTONUCLEAR REACTIONS

FOOD DIVISION

DECEMBER 1963

NATICK, MASSACHUSETTS

U. S. ARMY NATICK LABORATORIES

Natick, Massachusetts

FOOD DIVISION

Technical Report

FD - 1

HANDBOOK OF PHOTONUCLEAR REACTIONS

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FOREWORD

This Handbook has been compiled as a reference for scientists working with photonuclear reactions. It was intended to contain the known information required in the investigation of induced activity in foods. The photo cross sections, threshold values, and decay schemes presented here are the kind of information needed to calculate the activity produced in a food sample irradiated at a certain energy. Bremsstrahlung cross section curves are also included in the final section of the handbook in order to facilitate the calculation of radionuclide yields.

This collection of information is by no means complete. For this reason, space has been left to insert further information, remarks, and cross section curves. In this way, the individual can keep his photonuclear data up to date.

Although this information was compiled as part of the Food Irradiation Program of the U.S. Army, it is hoped that it will have wider application and will be used by those engaged in photonuclear research throughout the country.

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ABSTRACT

A compilation has been made of the data which would be most useful in calculating the activities produced in food by high energy electrons or gamma rays. The known isotopes of each element are listed with their atomic masses, half lives, and methods of decay. Photoneutron and photoproton cross sections are shown and both theoretical and experimental threshold values are listed. References are included for all data. The appendices include a short description of the bremsstrahlung cross sections and a list of the common radioactive isotopes found in food irradiated by high energy electrons.

INTRODUCTION

Purpose.

The purpose of this Handbook is to collect and make easily available the various data needed to calculate the activities produced in food and other materials by high energy electrons or gamma rays.

Arrangement of Contents.

The material is arranged by atomic number starting with Hydrogen and ending with element 103. The information is divided into three principal parts:

1. The Table. At the top of each page, the table gives pertinent information on the isotopes including the mass, half life, and type of decay.
2. The Cross Sections. At the bottom of each page are photoneutron and photoproton cross sections. Space has been provided for extra cross sections when they become available.
3. Threshold Values. On the back of each page, in the "Remarks" section are the threshold values for (γ, n) and (γ, p) reactions. Both theoretical and experimental values are listed where available for the major stable isotopes.

The Tables.

Source. The data for most of these tables are adapted from the Table of Isotopes of Strominger, Hollander, and Seeborg (Ref. 9). If another source is used, it is so indicated. Mass values in Column 2 are from the tables of Wapstra and Huizenga (Ref. 2).

Column Headings.

Column 1: This contains the atomic number, the name of the element, and the isotope number for each isotope.

Column 2: The atomic masses are listed here with the uncertainties in the measurement.

Column 3: This lists the relative isotopic abundance.

Column 4: The half life for radioactive isotopes are listed in this column.

Column 5: The type of decay is listed followed by the energy in Mev. The symbols used are:

B^- negative beta particle emission

B^+ positive beta particle emission

α alpha particle emission

γ gamma photon emission

K or EC orbital electron capture

Column 6: This refers to the references listed at the end of the Handbook.

Selection and Interpretation of Information.

The cross sections and data contained in this report are not meant to include all of the work which has been done. The bibliography of photonuclear reactions is quite large and increasing continuously. Thus the references used here were merely the ones known to the compilers of this report. This Handbook is considered only a place to start when photonuclear information is needed about a particular isotope.

No attempt has been made to be selective in determining which cross sections should be used. All (γ, n) and (γ, p) cross sections which could be found were included. The reader should return to the original papers to determine which most nearly fits his needs.

Space has been left in the Handbook for other remarks and information and for later cross sections.

Appendices.

Two appendices have been placed at the end of this Handbook. The first of these gives an introductory look at bremsstrahlung cross sections and the second lists some of the possible activities to be found in food irradiated by high energy gammas or electrons.

Alphabetical List of Elements.

The list which immediately follows is an index to the elements.

ALPHABETICAL LIST OF THE ELEMENTS

Element	Symbol	Atomic Number Z	Element	Smybol	Atomic Number Z
Actinium	Ac	89	Iridium	Ir	77
Aluminum	Al	13	Iron	Fe	26
Americium	Am	95	Krypton	Kr	36
Antimony	Sb	51	Lanthanum	La	57
Argon	A	18	Lead	Pb	82
Arsenic	As	33	Lithium	Li	3
Astatine	At	85	Lutecium	Lu	71
Barium	Ba	56	Magnesium	Mg	12
Berkelium	Bk	97	Manganese	Mn	25
Beryllium	Be	4	Mendeleevium	Mv	101
Bismuth	Bi	83	Mercury	Hg	80
Boron	B	5	Molybdenum	Mo	42
Bromine	Br	35	Neodymium	Nd	60
Cadmium	Cd	48	Neon	Ne	10
Calcium	Ca	20	Neptunium	Np	93
Californium	Cf	98	Nickel	Ni	28
Carbon	C	6	Niobium	Nb	41
Cerium	Ce	58	Nitrogen	N	7
Cesium	Cs	55	Osmium	Os	76
Chlorine	Cl	17	Oxygen	O	8
Chromium	Cr	24	Palladium	Pd	46
Cobalt	Co	27	Phosphorus	P	15
Copper	Cu	29	Platinum	Pt	78
Curium	Cm	96	Plutonium	Pu	94
Dysprosium	Dy	66	Polonium	Po	84
Einsteinium	E	99	Potassium	K	19
Erbium	Er	68	Praseodymium	Pr	59
Europium	Eu	63	Promethium	Pm	61
Fermium	Fm	100	Protactinium	Pa	91
Fluorine	F	9	Radium	Ra	88
Francium	Fr	87	Radon	Rn	86
Gadolinium	Gd	64	Rhenium	Re	75
Gallium	Ga	31	Rhodium	Rh	45
Germanium	Ge	32	Rubidium	Rb	37
Gold	Au	79	Ruthenium	Ru	44
Hafnium	Hf	72	Samarium	Sm	62
Helium	He	2	Scandium	Sc	21
Holmium	Ho	67	Selenium	Se	34
Hydrogen	H	1	Silicon	Si	14
Indium	In	49	Silver	Ag	47
Iodine	I	53	Sodium	Na	11

Element	Symbol	Atomic Number Z	Element	Symbol	Atomic Number Z
Strontium	Sr	38	Titanium	Ti	22
Sulphur	S	16	Tungsten (Wolfram)	W	74
Tantalum	Ta	73	Uranium	U	92
Technetium	Tc	43	Vanadium	V	23
Tellurium	Te	52	Xenon	Xe	54
Terbium	Tb	65	Ytterbium	Yb	70
Thallium	Tl	81	Yttrium	Y	39
Thorium	Th	90	Zinc	Zn	30
Thulium	Tm	69	Zirconium	Zr	40
Tin	Sn	50			

ACKNOWLEDGEMENT

This report is made possible by the fine work of all the authors listed in the references.

It was prepared under the supervision of Dr. Edward S. Josephson, Food Division Associate Director, in charge of Food Radiation, U. S. Army Radiation Laboratory, Natick.

The compilers are also indebted to Miss Carol Turner for her careful typing of the report.

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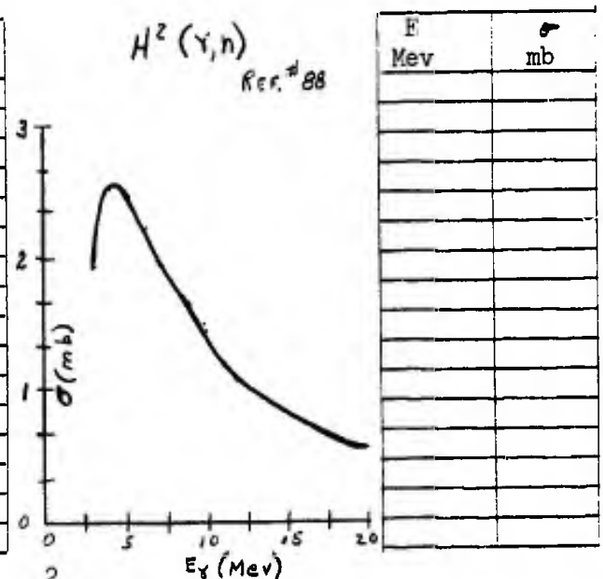
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
1	Hydrogen	- 1	1.008145	1	99.985			2
		- 2	2.014740	2	0.015			2
		- 3	3.017005	5		12.4 Y	B⁻0.019	2, 5

E Mev	σ mb
3	1.9
4	2.5
5	2.45
6	2.2
7	1.9
8	1.8
9	1.6
10	1.4
11	1.2
12	1.1
13	1.0
14	0.9
15	0.85
16	0.78
17	0.70



E Mev	σ mb

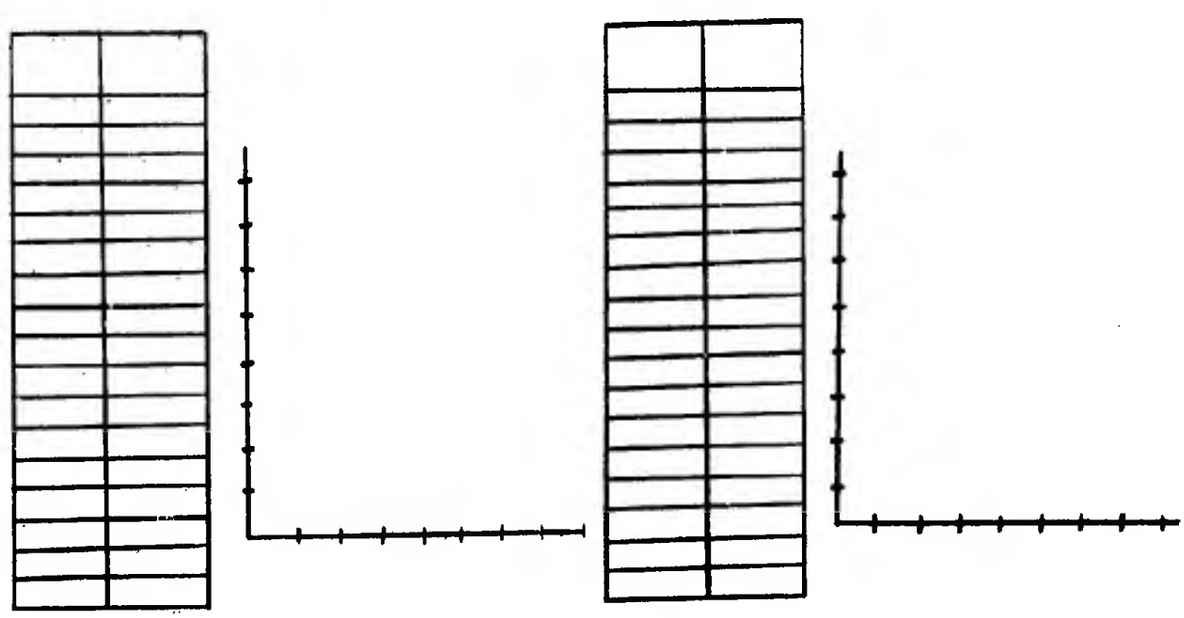
H^2 (γ, n)

E_{th} = 2.22471 ± 0.00040 Mev

Ref. #6

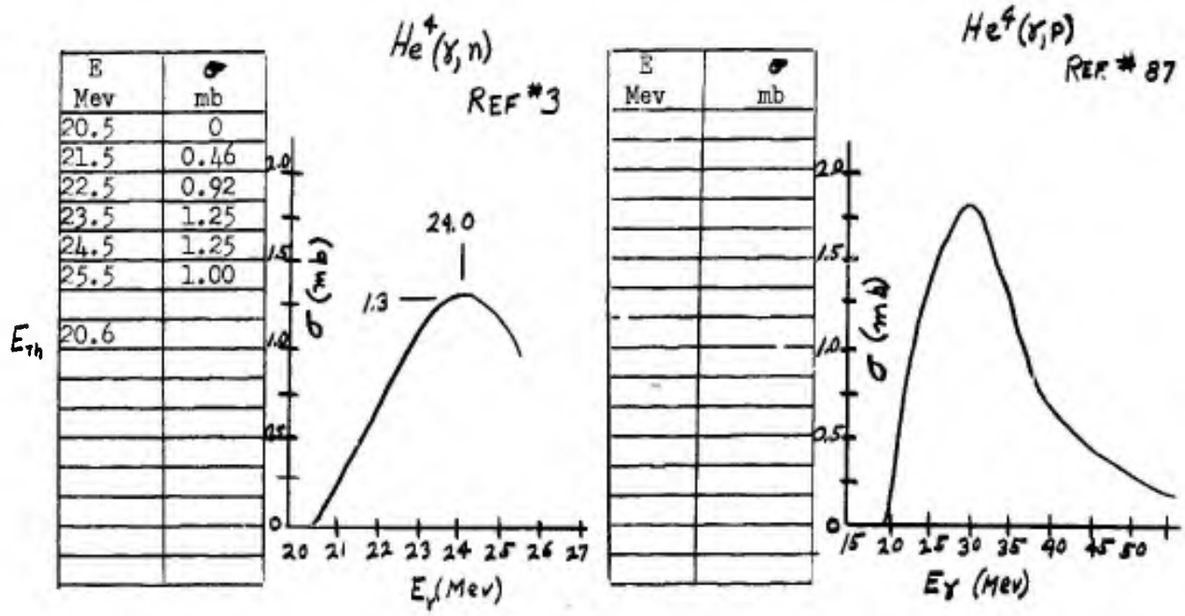
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	H^2	- 2.2247		6



$_2He$

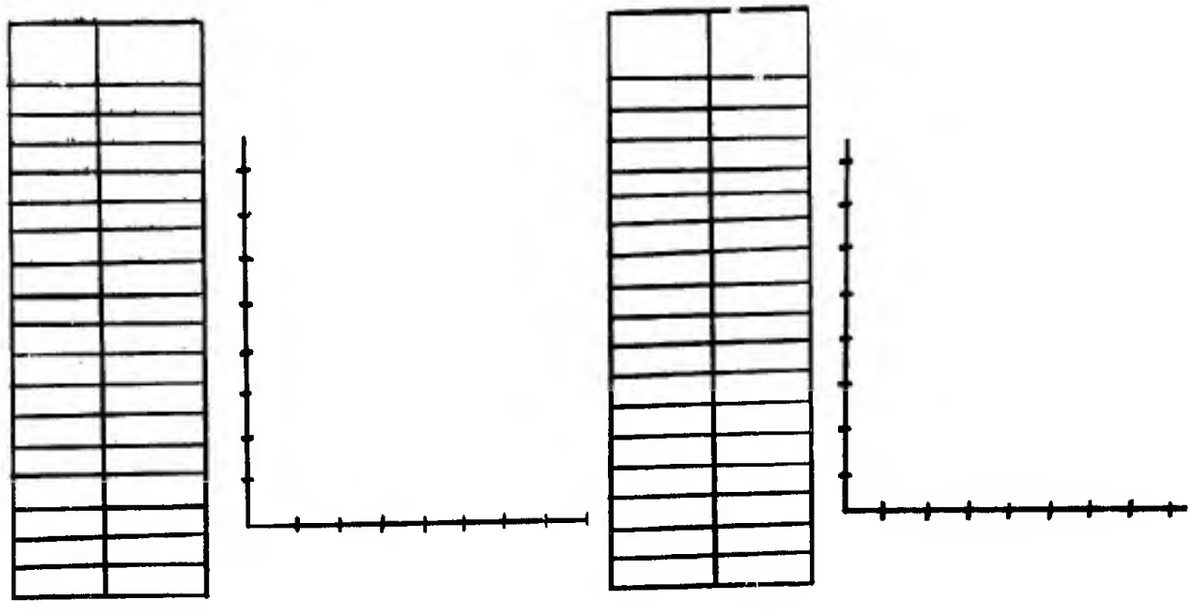
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF
2	Helium -	3	3.016986	5	0.00013			2
	-	4	4.003873	2	~ 100			2
	-	5	5.013888	32		2×10^{-21}s	n, α	2, 5
	-	6	6.020831	31		0.82	B⁻3.50	2, 5



$_2He$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Ref.
(γ, n)	He^4	- 20.577		6
(γ, p)	He^4	- 19.813		6

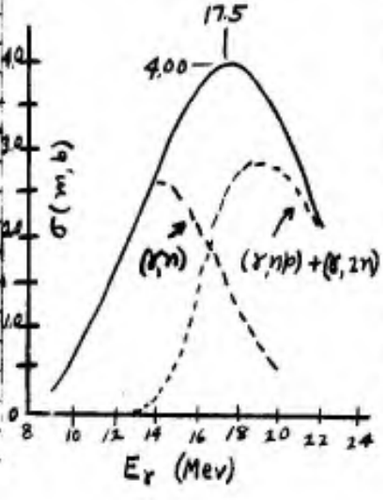


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
3	Lithium	-5	5.013948	220		10^{-21} s	p, α	2, 5
		-6	6.017034	5	7.5			2, 5
		-7	7.018232	6	92.5			2
		-8	8.025033	5		0.83 s	B^-13.4; 2α3	2
		-9				0.17 s	B^-; n + 2α	5

SUM

E Mev	σ mb
9	0.25
10	0.65
11	1.15
12	1.70
13	2.25
14	2.80
15	3.25
16	3.70
17	3.90
18	3.90
19	3.65
20	3.20
21	2.70
22	2.10

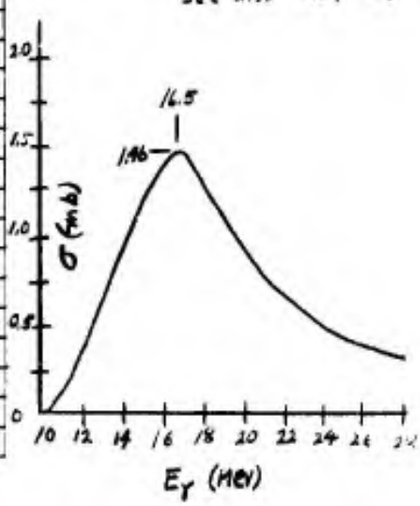
$Li^7(\gamma,n)$ REF #15



E Mev	σ mb

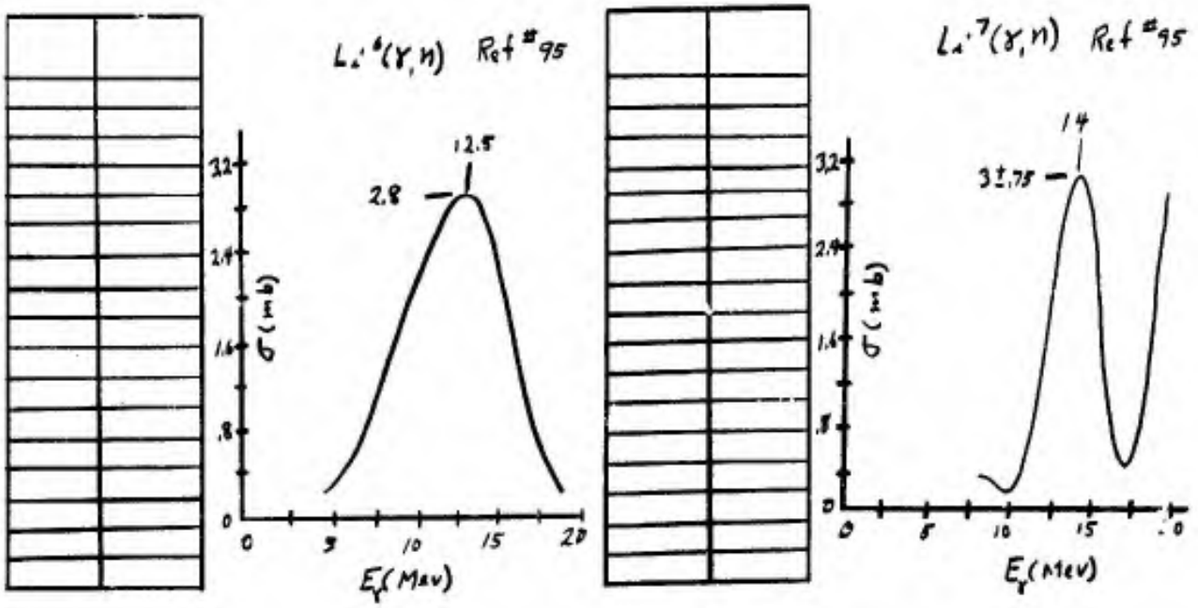
$Li^7(\gamma,p)$ REF #71

See also Ref #94



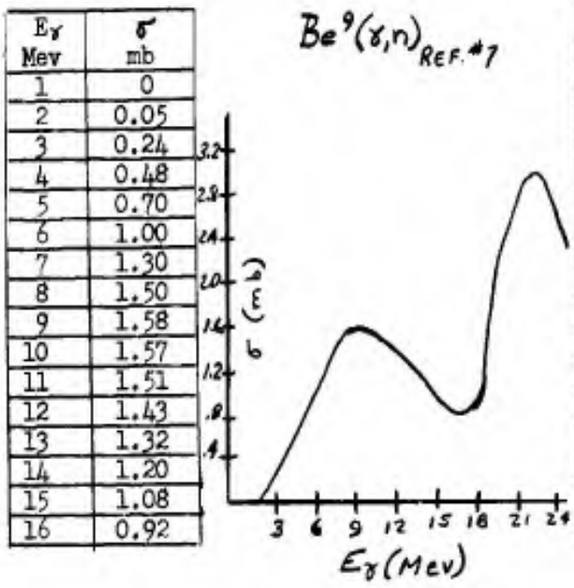
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Li^6	-5.663		6
	Li^7	-7.253		6
(γ,p)	Li^6	-4.653		6
	Li^7	-9.985		6

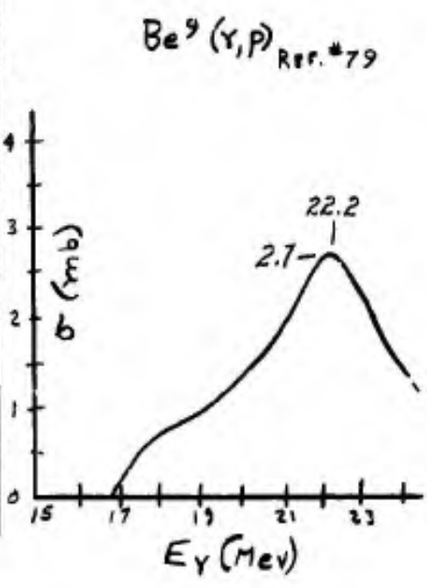


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
4	Beryllium-	7	7.019159	5		54 d	K;γ 0.48	2, 5
		-8	8.007849	5		$\sim 10^{-14}$ s	2α .08	2, 5
		-9	9.015046	6	100			2
		-10	10.016716	7		2.7×10^{6} Y	B⁻0.56	2

E_γ Mev	σ mb
1	0
2	0.05
3	0.24
4	0.48
5	0.70
6	1.00
7	1.30
8	1.50
9	1.58
10	1.57
11	1.51
12	1.43
13	1.32
14	1.20
15	1.08
16	0.92



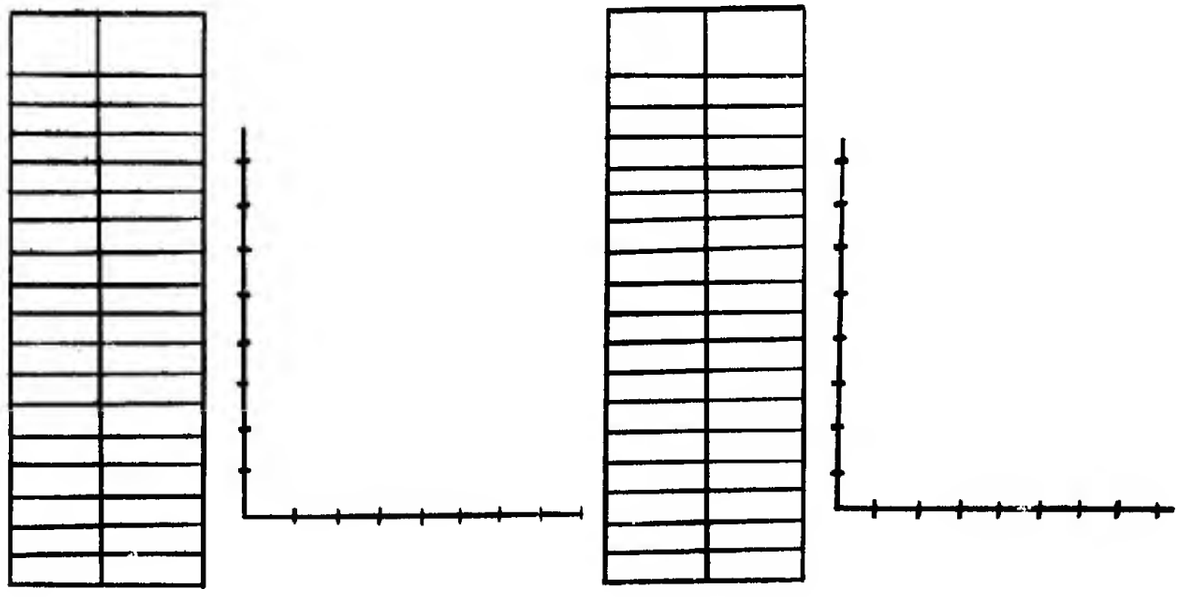
E_γ Mev	σ mb
16	0
17	0.10
18	0.70
19	1.00
20	1.40
21	1.95
22	2.70
23	2.50
24	1.60
25	1.00



$_4Be$

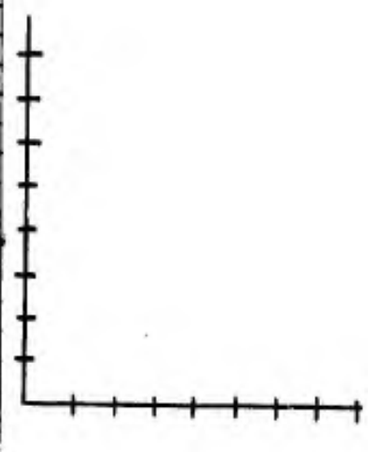
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Be^9	-1.665		6
(γ, p)	Be^9	-16.855		6
(γ, d)	Be^9	-2.528		6

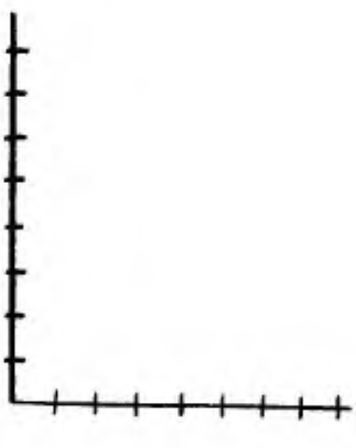


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
5	Boron	-8	8.026768	430		0.65 s	B+13.7;2α3	2,5
		-9	9.016195	6		$3x10^{-19}$ s	P,(2α)	2,5
		-10	10.016119	6	18.8			2,5
		-11	11.012795	6	81.2			2,5
		-12	12.018168	6		0.027 s	B⁻13.4~9;γ~ 4.5	2,5

E Mev	σ mb

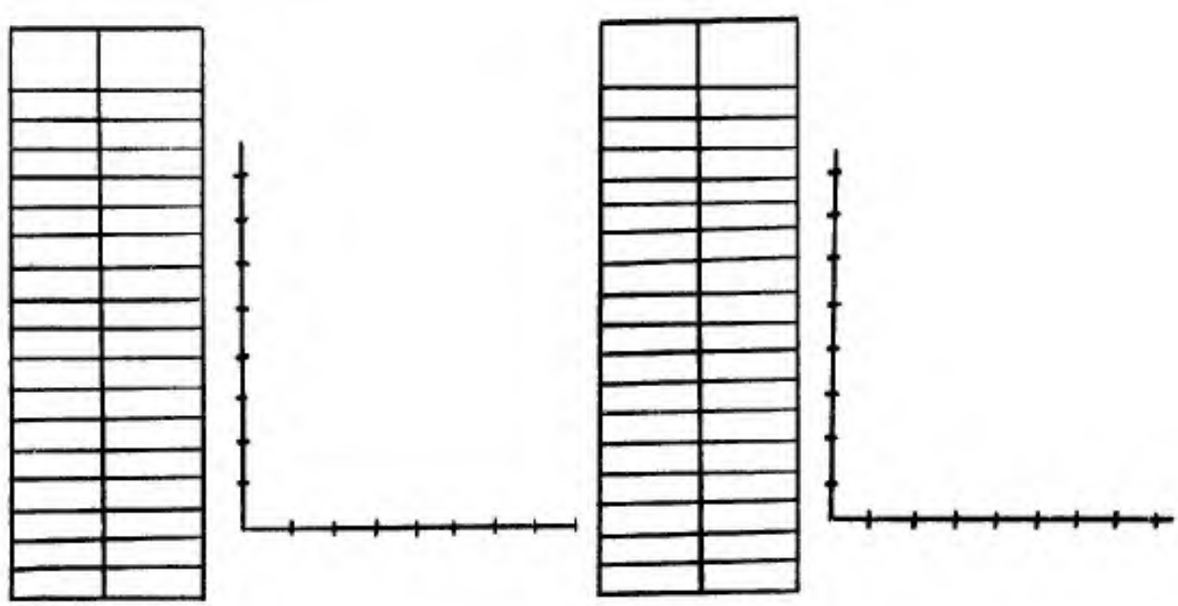


E Mev	σ mb



REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	B^{10}	- 8.440		6
	B^{11}	-11.456		6
(γ, p)	B^{10}	- 6.587		6
	B^{11}	-11.229		6



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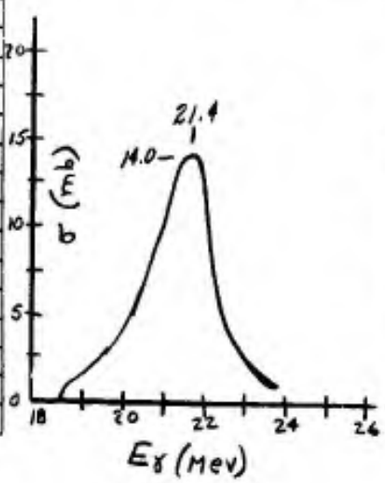
Z	CHEM. SYM.	A	Ref. #2 ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
6	Carbon	-10	10.020240	110		19.5s	B+2.2; γ .72, 1.04	2, 5
		-11	11.014922	7		20.5m	B+0.99	2, 5
		-12	12.003803	5	98.89			2
		-13	13.007478	5	1.11			2
		-14	14.007687	3		5580Y	B-0,155	2, 5
		-15	15.014162	50		2.4s	B⁻~ 9; γ 5.5	2, 5

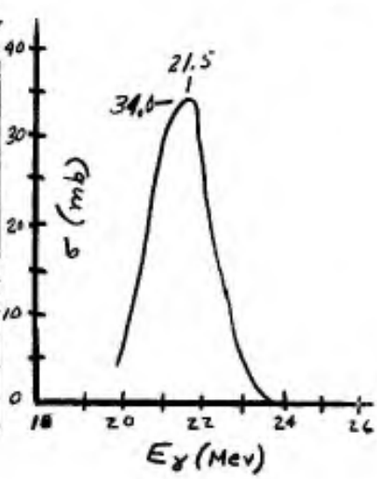
E Mev	σ mb
18.5	0
19.5	2.48
20.5	6.67
21.5	13.3
22.5	4.50
23.5	1.33

C (γ,n) REF. #1



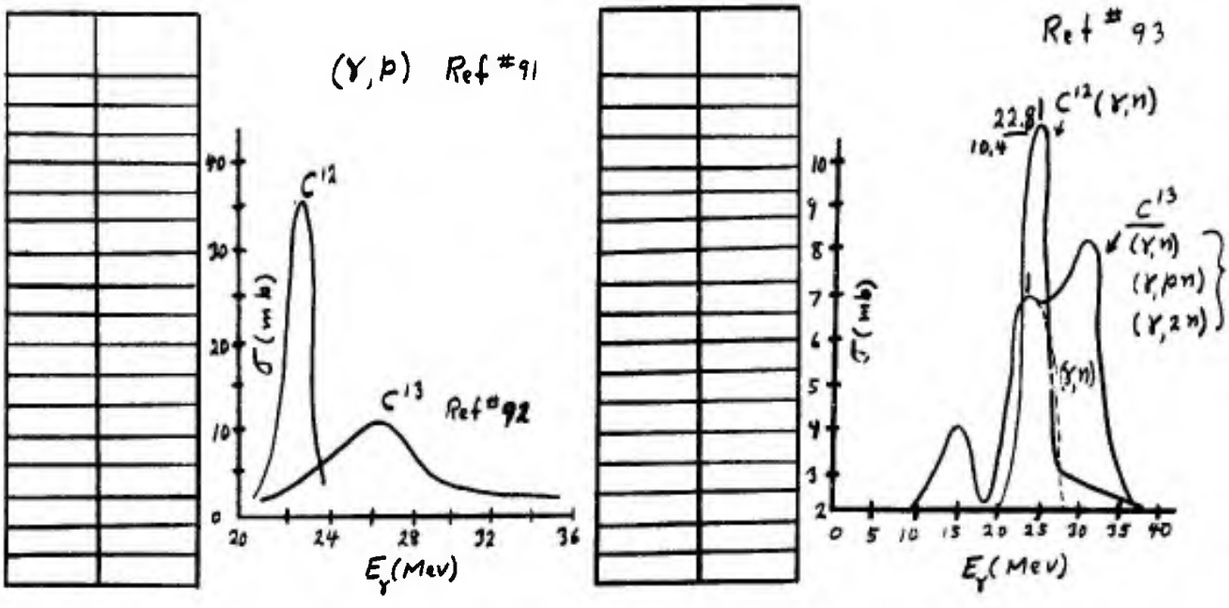
E Mev	σ mb
18	
19	~0
20	7.0
21	30.0
22	22.0
23	4.0
24	0

C (γ,P) REF #21



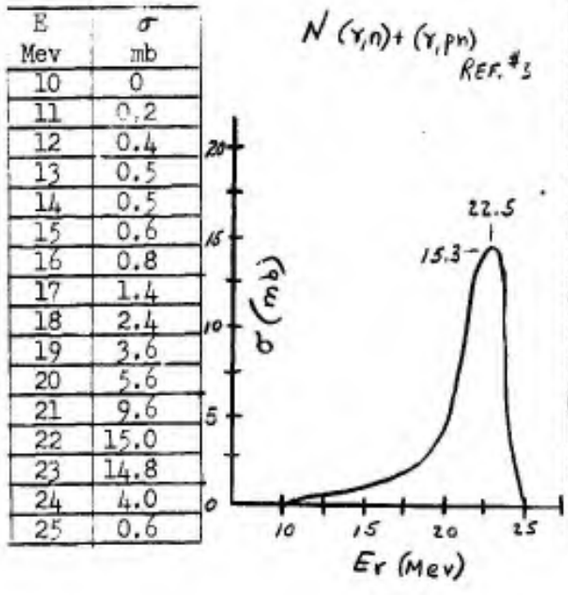
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	C^{12}	-18.721		6
	C^{13}	- 4.947		6
(γ, p)	C^{12}	-15.956		6
	C^{13}	-17.533		6
(γ, α)	C^{12}	- 7.3695		6

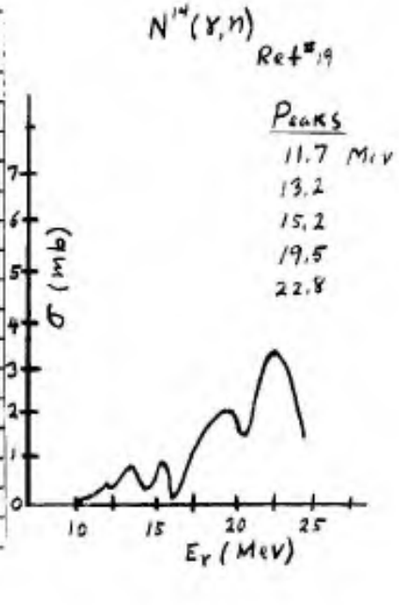


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
7	Nitrogen-	12	12.022776	110		0.013 s	B+17, 3α ~ 4	2, 5
		13	13.009864	5		10.1 m	B+1.20	2, 5
		14	14.007520	3	99.63			2
		15	15.004862	5	0.37			2
		16	16.011171	13		7.3 s	B⁻4,10, γ 1.72 γ 1.90,2.75,6.13, γ 7.11,8.85	2,5,6
		17	17.013984	210		4.14 s	B⁻3.7;(n 1.0)	2, 5

E Mev	σ mb
10	0
11	0.2
12	0.4
13	0.5
14	0.5
15	0.6
16	0.8
17	1.4
18	2.4
19	3.6
20	5.6
21	9.6
22	15.0
23	14.8
24	4.0
25	0.6



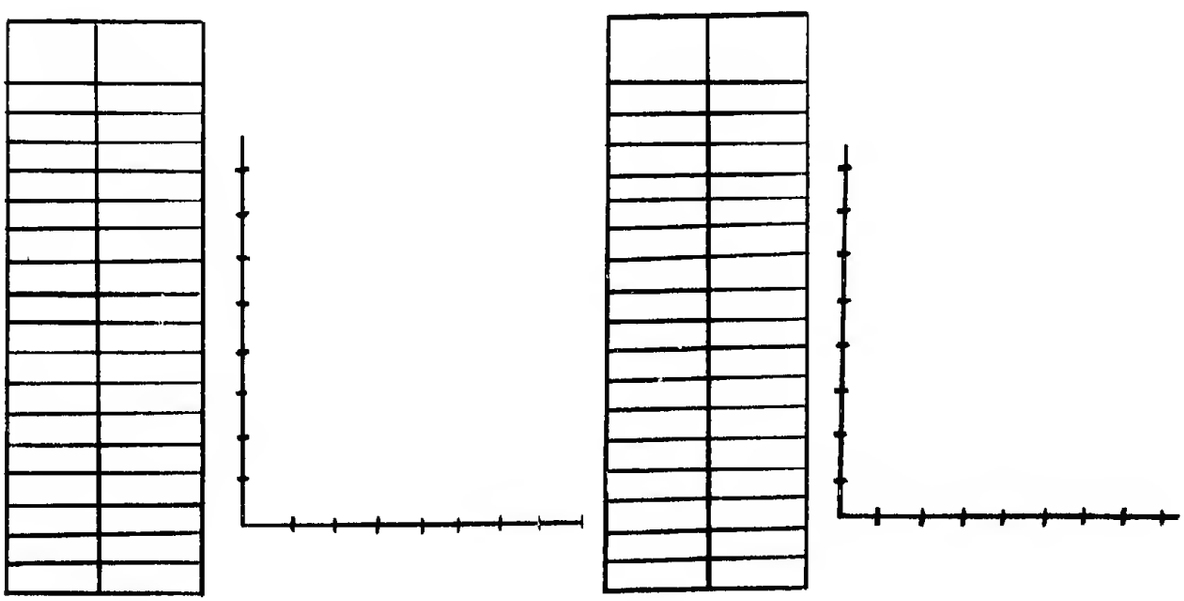
E Mev	σ mb



$_7N$

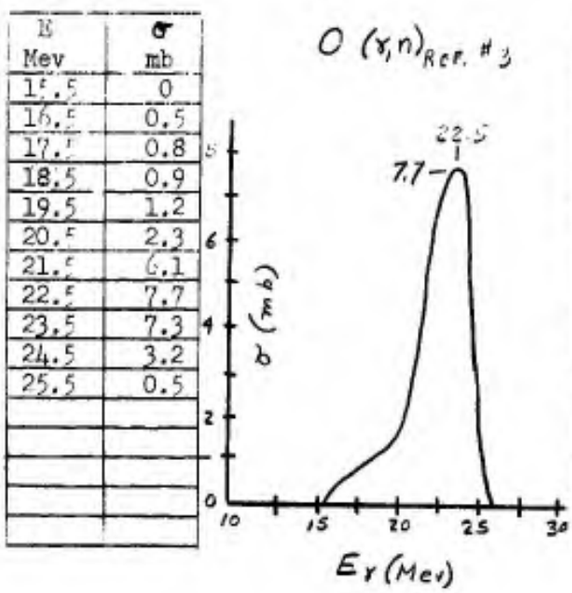
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	N^{14}	-10.553		6
	N^{15}	-10.834		6
(γ,p)	N^{14}	- 7.5494		6
	N^{15}	-10.2077		6

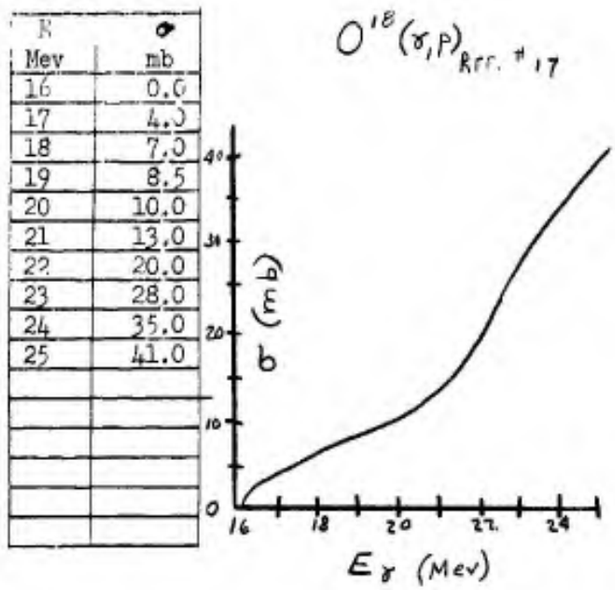


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
8	Oxygen	-14	14.013069	15		76 s	B+1.8; γ 2.3	2, 5
		-15	15.007767	6		2.1 m	B+1.66	2, 5
		-16	16.000000	0	99.76			2
		-17	17.004534	5	0.037			2
		-18	18.004855	8	0.20			2
		-19	19.009591	13		29 s	B⁻ 2.9, 4.5; γ .112,.200,1.366	2,5,6

E Mev	σ mb
15.5	0
16.5	0.5
17.5	0.8
18.5	0.9
19.5	1.2
20.5	2.3
21.5	6.1
22.5	7.7
23.5	7.3
24.5	3.2
25.5	0.5



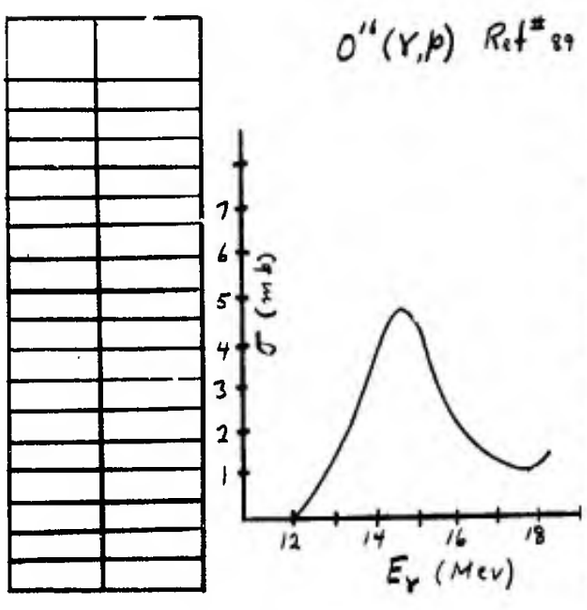
E Mev	σ mb
16	0.0
17	4.3
18	7.0
19	8.5
20	10.0
21	13.0
22	20.0
23	28.0
24	35.0
25	41.0

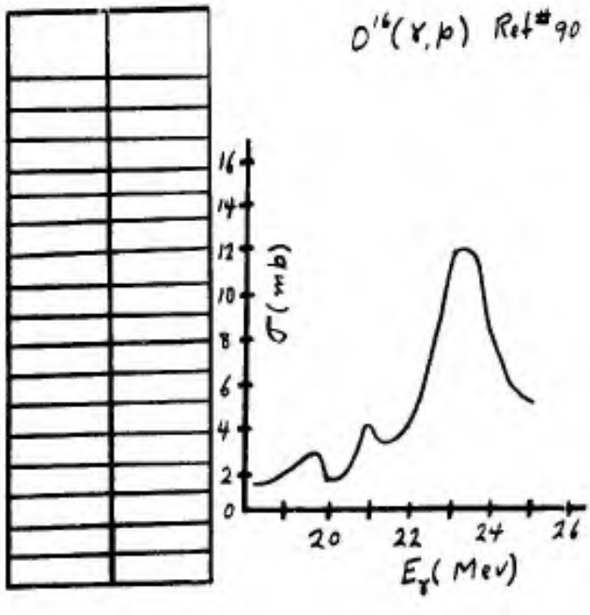


$_{8}O$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	O^{16}	-15.669		6
(γ,p)	O^{16}	- 12.126		6
(γ,α)	O^{16}	- 7.1615		6



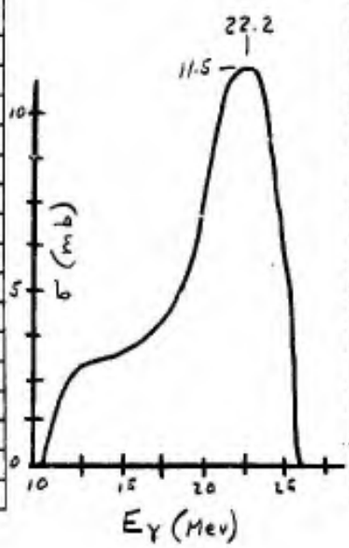


9 F

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
9	Fluorine	-17	17.007506	4		70 s	B+1.72	2, 5
		-18	18.006646	9		1.87 h	B+.65	2, 5
		-19	19.004448	7	100			2
		-20	20.006340	11		12 s	B⁻5.3, 6.7; γ 1.6	2, 5
		-21	21.					

E Mev	σ mb
10	0
11	1.5
12	2.6
13	3.0
14	3.25
15	3.4
16	3.8
17	4.3
18	5.0
19	6.1
20	8.2
21	10.8
22	11.3
23	11.1
24	7.9
25	4.9

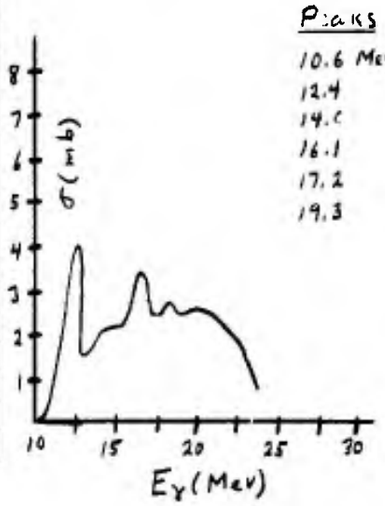
$F^{19}(\gamma,n)$ REF#5



E Mev	σ mb

$F^{19}(\gamma,n)$ Ref # 19

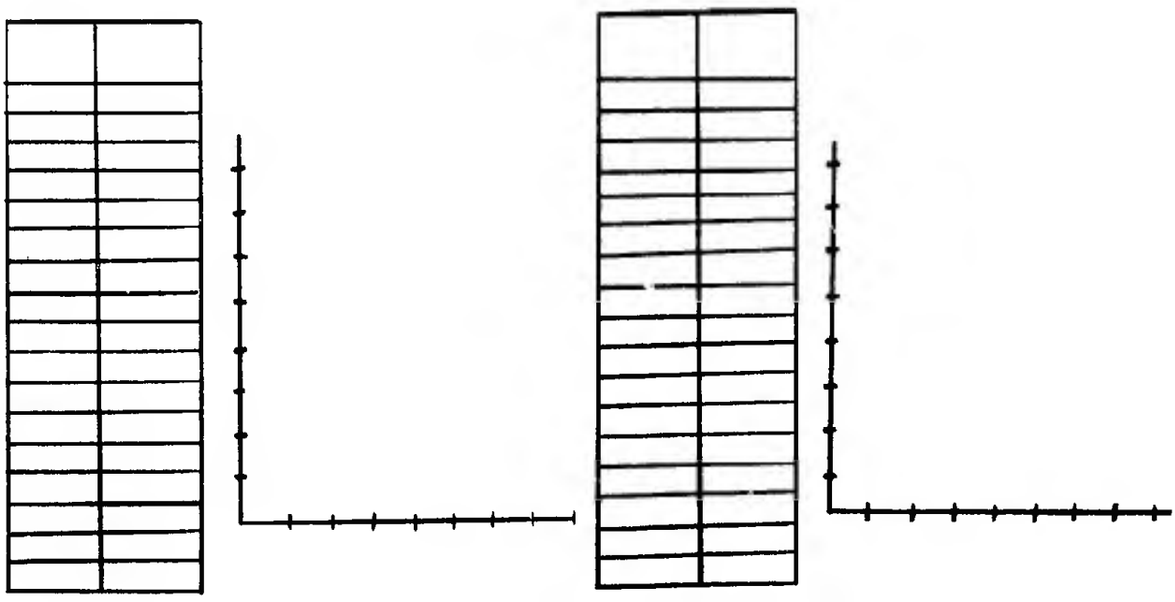
Peaks
10.6 Mev
12.4
14.0
16.1
17.2
19.3



$_{9}F$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	F^{19}	-10.442		6
(γ, p)	F^{19}	- 7.992		6

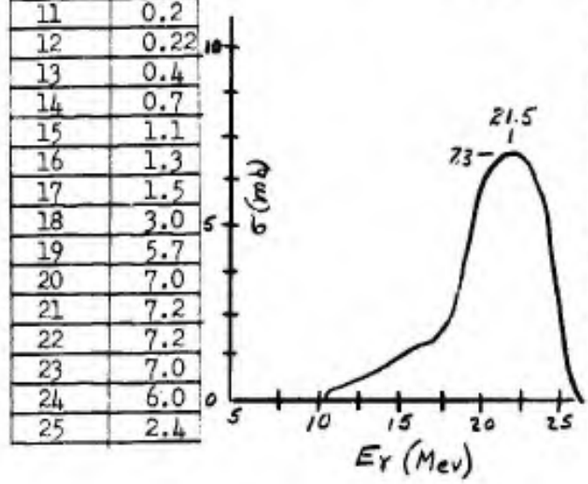


$_{10}Ne$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
10	Neon	-18	18.011185	220		1.6 s	B+3.2	2, 8
		-19	19.007945	9		18.5 s	B+2.18	2, 5
		-20	19.998769	9	90.9			9
		-21	21.000499	10	0.26			9
		-22	21.998354	12	8.8			9
		-23	23.001764	12		40 s	B^- 4.21, 1.18 γ 0.439, 1.65	2,5,6
		-24				3.4 m	B-1.95 γ 0.472,0.878	2,8,6

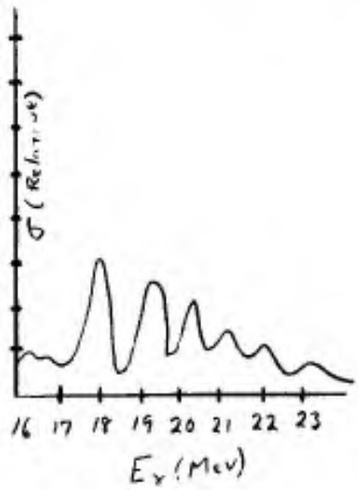
E Mev	σ mb
10	0
11	0.2
12	0.22
13	0.4
14	0.7
15	1.1
16	1.3
17	1.5
18	3.0
19	5.7
20	7.0
21	7.2
22	7.2
23	7.0
24	6.0
25	2.4

Ne (γ,n) Ref* 3

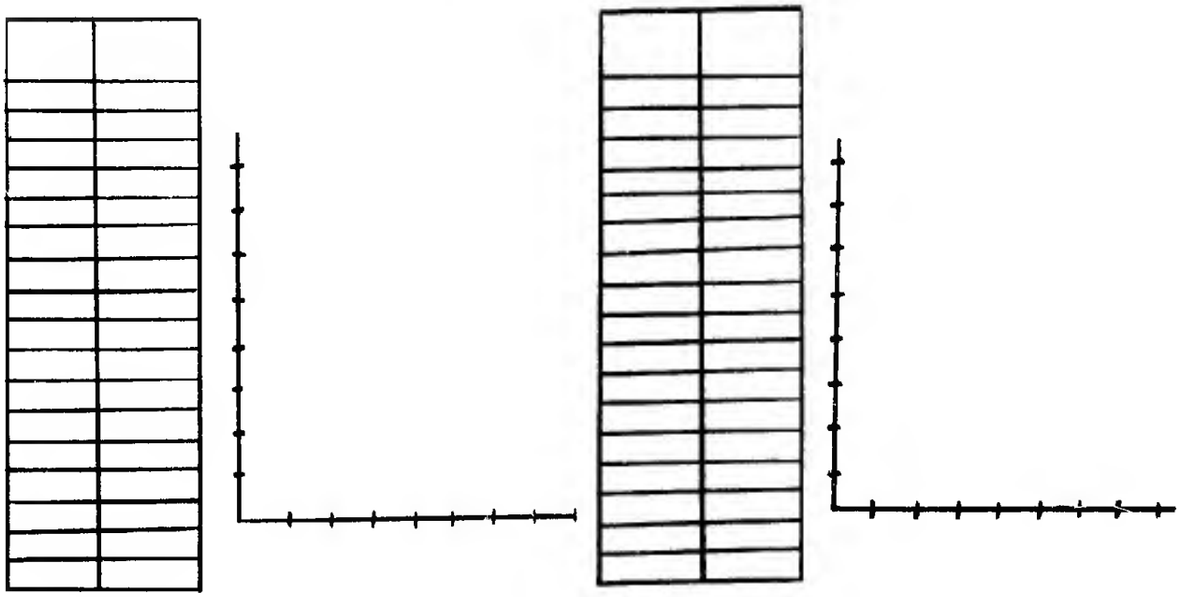


E Mev	σ mb

$Ne^{20}(\gamma p)$ Ref #99



Thresholds	Isotope	REMARKS		Reference
		Theoretical	Experimental	
(γ, n)	Ne^{20}	-16.875		6
	Ne^{22}	-10.367		6
(γ, p)	Ne^{20}	-12.844		6
	Ne^{22}	-15.288		6

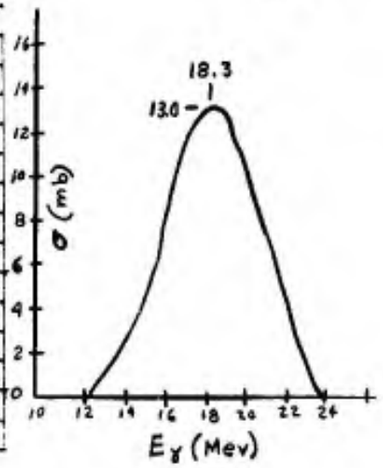


11 Na

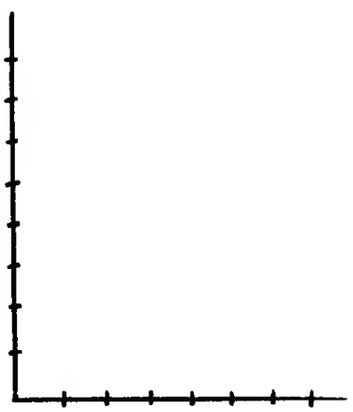
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
11	Sodium	- 20	20.015236	220		0.23 s	B+; 72	2, 5
		- 21	21.004281	35		23 s	B+2.50	2, 5
		- 22	22.001404	14		2.6 y	B+.54, ~1.8; γ 1.28	2, 5
		- 23	22.997053	11	100			2, 5
		- 24	23.998565	14		15.0 h	B⁻1.39, 4.2; γ 5.3 γ 2.755, 3.7, 1.38	2,5,6
		-25	24.997781	180		60 s	B⁻3.7, 2.7; γ0.39, γ 0.46, 0.58, 0.98, γ 1.61, 1.96	2,5,6

E Mev	σ mb
12	0
13	1.2
14	2.9
15	5.5
16	9.4
17	12.0
18	12.6
19	12.4
20	10.0
21	6.9
22	4.0
23	1.3
24	0

$Na^{23}(\gamma,n)$ Ref. #1



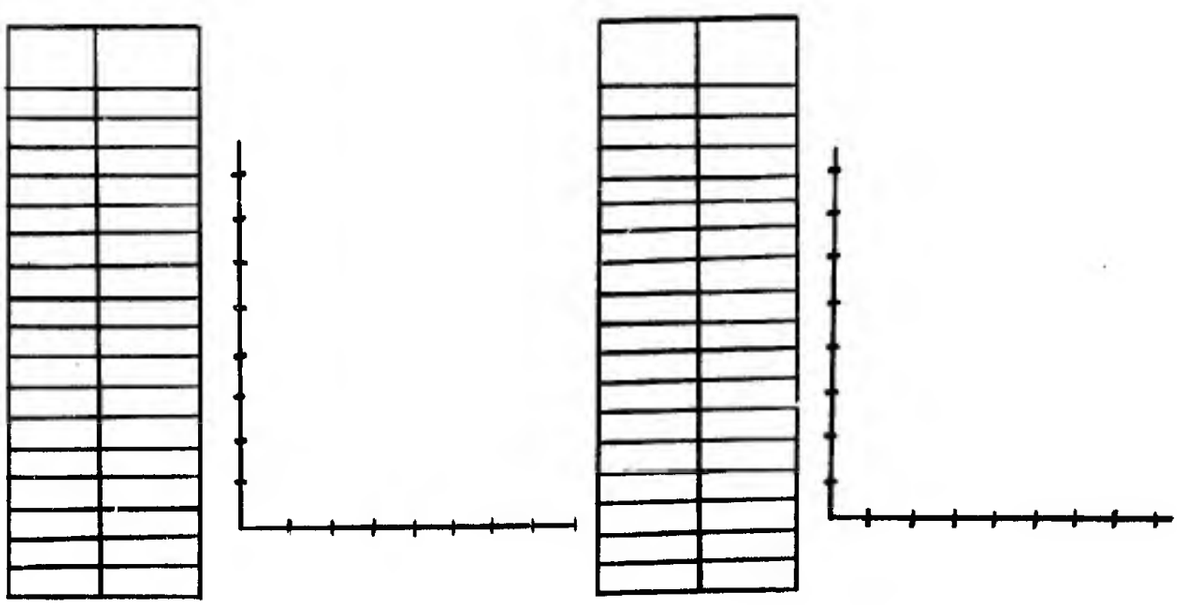
E Mev	σ mb



$_{11}Na$

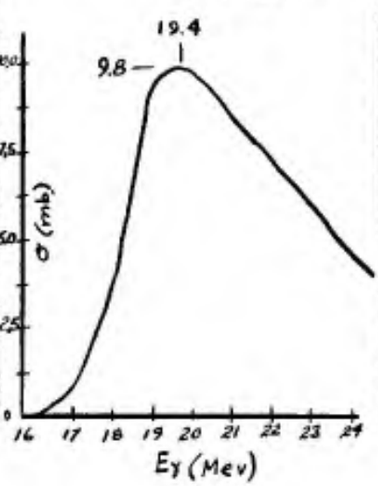
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Na^{23}	- 12.414		6
(γ, p)	Ne^{23}	- 8.790		6

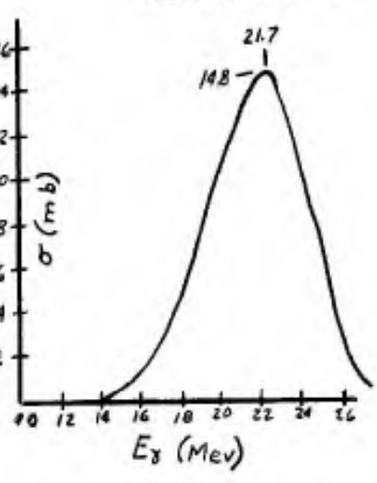


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
12	Magnesium	-23	23.001453	14		12 s	B-3.0	2, 5
		-24	23.992640	15	78.8			2, 5
		-25	24.993752	15	10.1			2, 5
		-26	25.990798	23	11.1			2, 5
		-27	26.992868	23		9.6 m	B-1.80, 0.79; γ 0.84, 0.180, 1.01	2,5,6
		-28	27.992714	32		21.3 h	B-0.45; γ 0.032, γ 0.396, 0.950, 1.35	2,8,6

E Mev	σ mb
16	0
17	0.4
18	4.3
19	9.4
20	9.6
21	8.5
22	7.2
23	5.9
24	4.6
25	3.3



E Mev	σ mb
13	0
14	0.2
15	0.7
16	1.9
17	3.9
18	6.5
19	9.1
20	11.8
21	14.1
22	14.5
23	12.2
24	9.4
25	6.6
26	3.6

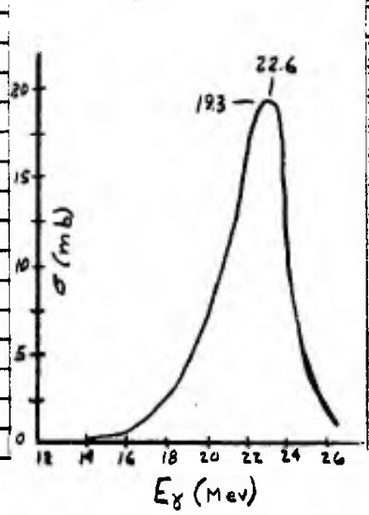


REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Mg^{24}	-16.535	-16.6	6,96
	Mg^{25}	-7.331	-7.2, -7.3	20,96
	Mg^{26}	-11.097	-11.1	20
(γ,p)	Mg^{24}	-11.693		6
	Mg^{25}	-12.064	-12.1	20
	Mg^{26}	-14.110	-14.3	20
(γ,α)	Mg^{24}	-9.314		6

E Mev	σ mb
14	0
15	0.05
16	0.5
17	1.4
18	2.8
19	4.8
20	7.5
21	11.6
22	17.8
23	18.2
24	9.1
25	4.3
26	2.3

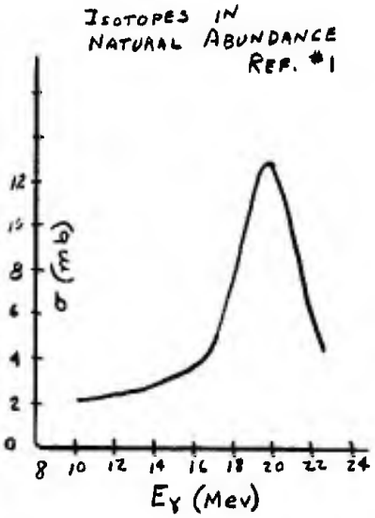
$Mg^{26}(\gamma,p)$ REF. #4



E Mev	σ mb
9	
10	2.1
11	2.3
12	2.5
13	2.7
14	3.0
15	3.3
16	4.0
17	5.0
18	9.0
19	12.2
20	10.2
21	7.8
22	5.0

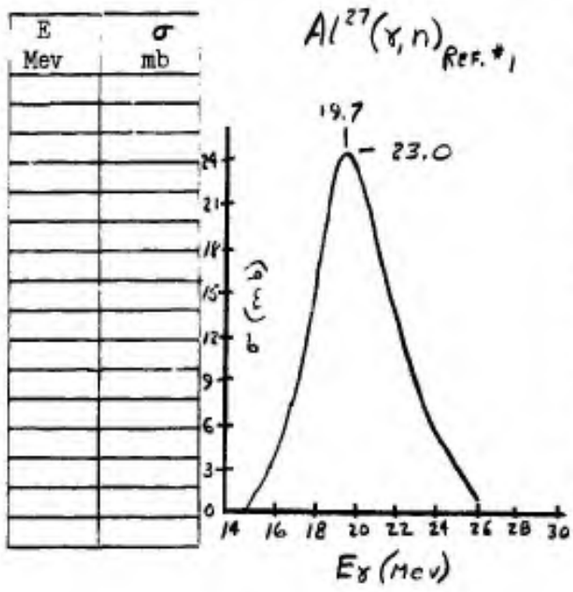
Mg (γ,n)

ISOTOPES IN NATURAL ABUNDANCE REF. #1

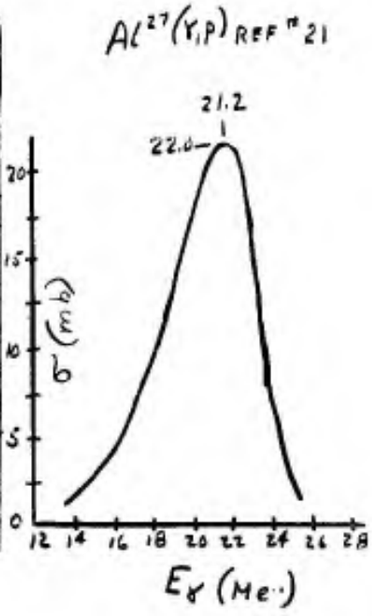


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
13	Aluminum	-24	24.007691	320		2.3 s	B+; γ 1.385, 2.72 4.20, 5.40, 5.70 7.05 ; α	2,5,6
		-25	24.998312	60		7.3 s	B+; γ 1.58	2,5,6
		-26	25.995120	23		6.5 s	B+3	2, 5
		-27	26.990081	16	100			2, 5
		-28	27.990771	16		2.30 m	B-2.87; γ 1.78	2, 5
		-29	28.989925	110		6.6 m	B-2.5, 1.4; γ 1.2, 2.3	2, 5

E Mev	σ mb

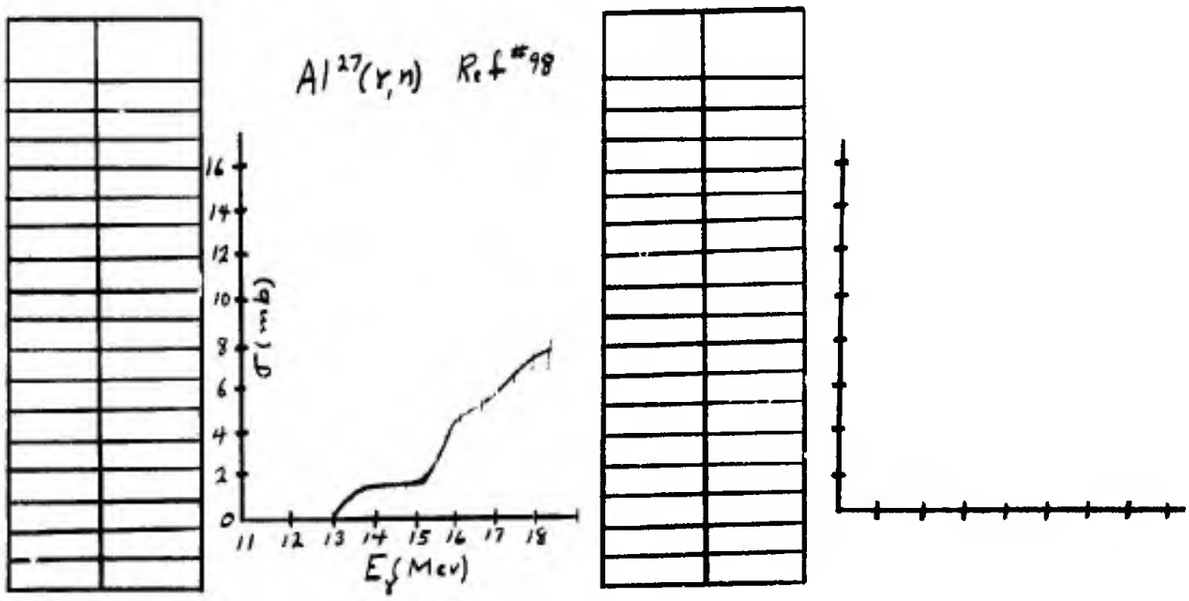


E Mev	σ mb
14	1.6
15	2.9
16	4.8
17	7.6
18	11.5
19	16.0
20	20.0
21	22.0
22	20.3
23	14.0
24	5.8
25	2.2



REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Al^{27}	- 13.069	- 13.4, -13.26	6, 39, 48
(γ, p)	Al^{27}	- 8.2724		6

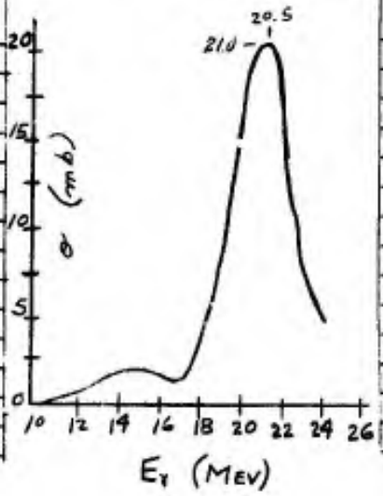


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
14	Silicon	-27	26.995265	19		5 s	B+3.5	2, 5
		-28	27.985775	19	92.21			2, 5
		-29	28.985660	20	4.70			2, 5
		-30	29.983252	19	3.09			2, 5
		-31	30.985153	23		2.6 h	B⁻1.47; γ 1.26	2,5,6
		-32	31.984134	60		300 y	B⁻0.1	2, 8

NAT.

E Mev	σ mb
10	0
11	0.3
12	0.5
13	1.0
14	1.4
15	1.8
16	1.5
17	1.2
18	3.4
19	9.4
20	17.0
21	21.0
22	13.0
23	7.4
24	5.0

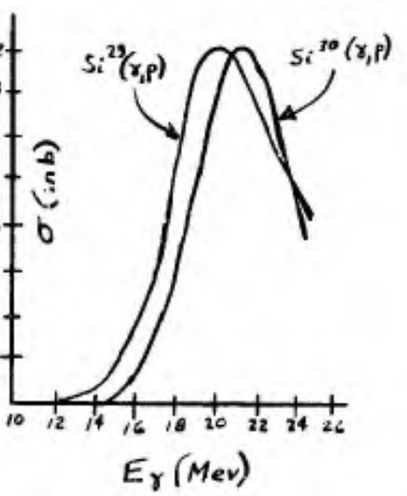
$Si^{nat.}(\gamma,n)$ REF *20



Si^{29}

E Mev	σ mb
12	0
13	0.3
14	1.4
15	3.5
16	7.0
17	12.0
18	22.0
19	30.2
20	33.0
21	29.8
22	26.0
23	22.4
24	19.0

$Si^{29}(\gamma,P) - Si^{30}(\gamma,P)$ REF *20



$_{14}Si$

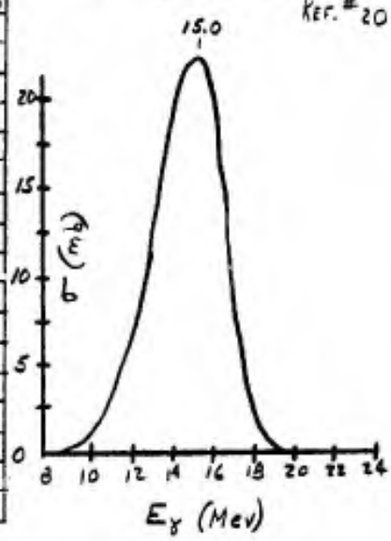
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.

REMARKS

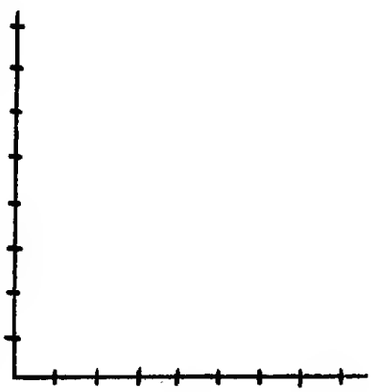
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Si^{28}	-17.179		6
	Si^{29}	- 8.479		6
	Si^{30}	- 10.614		6
(γ, p)	Si^{28}	- 11.581		6
	Si^{29}	-12.335		6
	Si^{30}	- 13.590		6
(γ, α)	Si^{28}	- 9.986		

E Mev	σ_{mb}
8	0
9	~0
10	1.0
11	3.0
12	6.5
13	12.0
14	19.0
15	23.0
16	17.5
17	8.0
18	3.0
19	0.8

$Si^{29}(\gamma,n) + Si^{30}(\gamma,n)$ Ref. #20

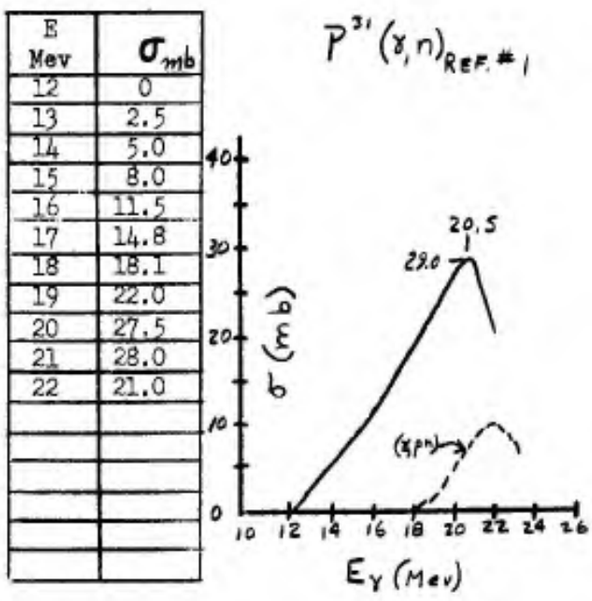


E Mev	σ

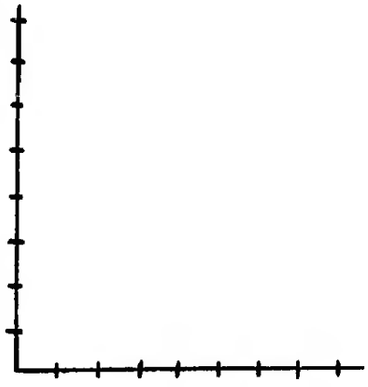


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
15	Phosphorus	-28	28.000585	300		0.28 s	B+10.6; γ	2, 9
		-29	28.990994	23		4.45 s	B+3.9; γ 1.28, 2.42	2, 9, 6
		-30	29.987885	48		2.5 m	B+3.2; γ 2.16	2, 9
		-31	30.983561	24	100			9
		-32	31.984028	26		14.2 d	B-1.7	2, 9
		-33	32.982156	30		25 d	B-0.25	2, 9
		-34	33.984120	230		12.4 s	B-5.1, 3.2, γ 2.10, 4.0	2, 9

E Mev	σ_{mb}
12	0
13	2.5
14	5.0
15	8.0
16	11.5
17	14.8
18	18.1
19	22.0
20	27.5
21	28.0
22	21.0



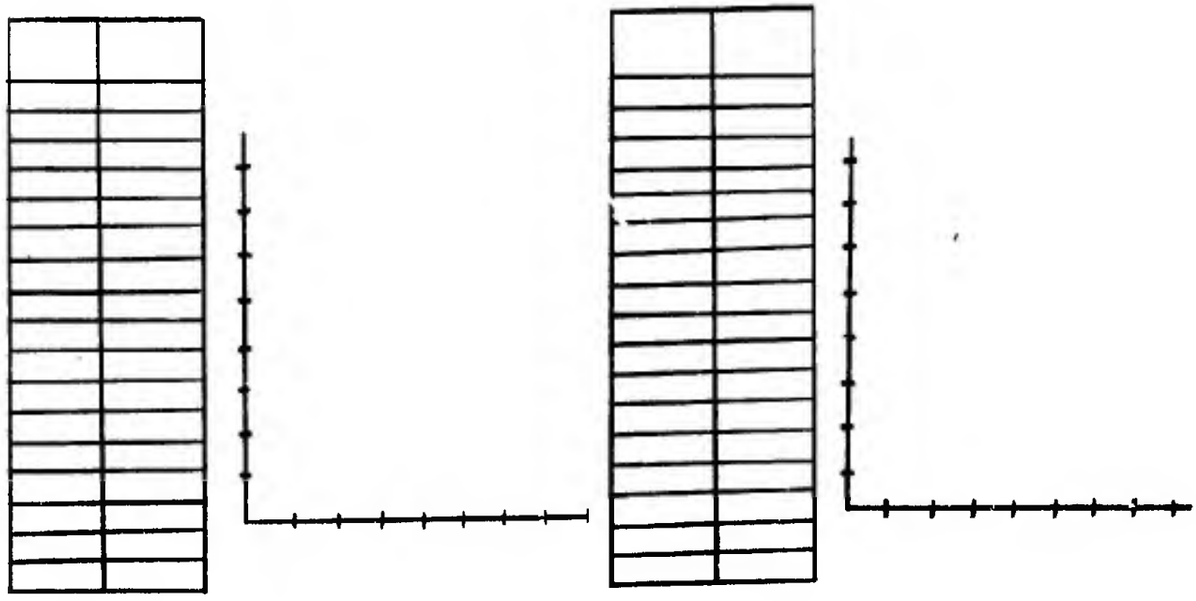
E Mev	σ



$_{15}P$

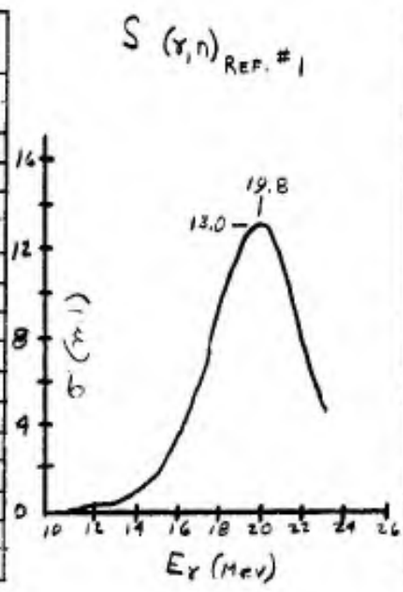
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	P^{31}	- 12.316	- 12.33, -12.39	6, 39, 48
(γ, p)	P^{31}	- 7.286		6

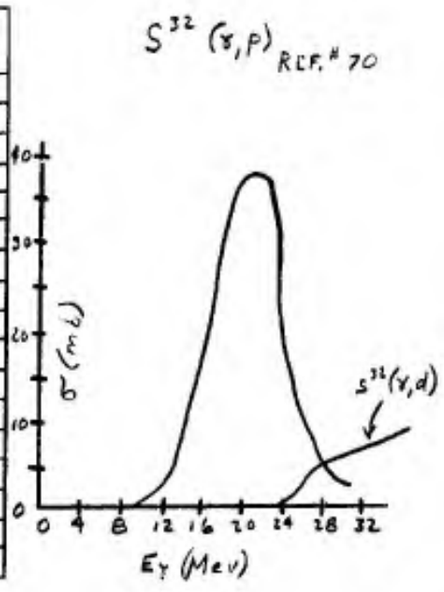


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
16	Sulfur	-31	30.989405	80		2.4 s	B+4.5	2, 9
		-32	31.982196	26	95.018			9
		-33	32.981889	30	0.750			9
		-34	33.978640	50	4.215			9
		-35	34.980085	35		87 d	B^-0.17	2, 9
		-36	35.978440	120	0.017			9
		-37	36.982050	330		5.04 m	B^-1.6; γ3.1	2, 9
		-38				2.87 h	B^-1.1; γ1.88	9, 6

E Mev	$\sigma_{mb.}$
11	0
12	0.05
13	0.3
14	0.9
15	1.9
16	4.0
17	6.5
18	9.7
19	12.5
20	13.0
21	10.6
22	7.4
23	5.0

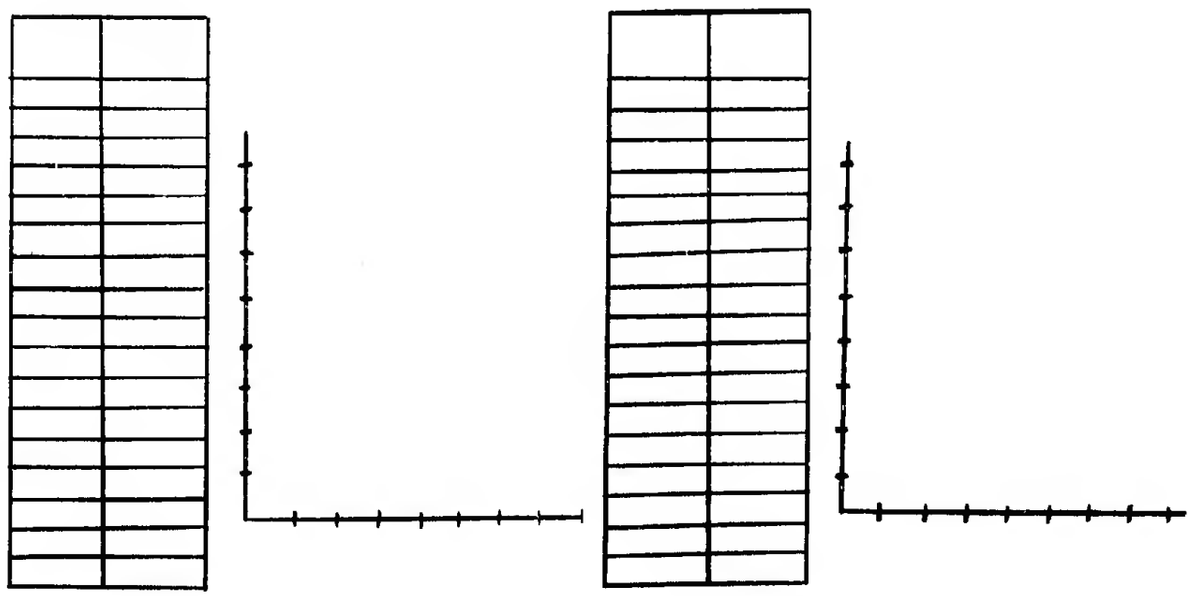


E Mev	σ



REMARKS

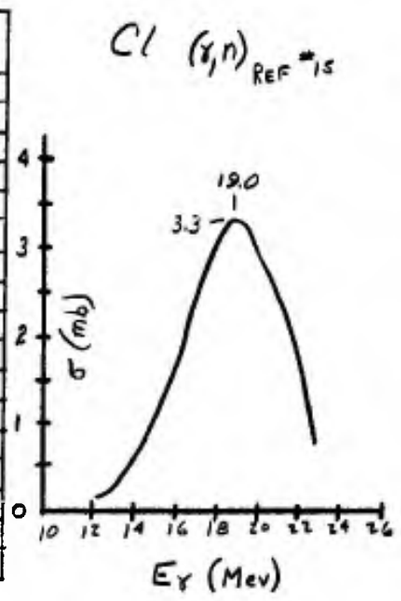
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	S^{32}	-15.081		6
	S^{34}	-11.421		6
(γ, p)	S^{32}	- 8.8626		6
	S^{34}	-10.8872		6



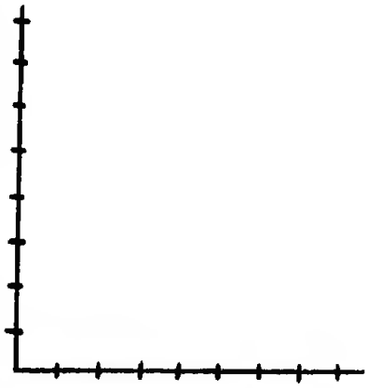
$_{17}Cl$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
17	Chlorine	-32	31.996186	430		0.32 s	B+9.5; γ 2.23, 3.79 γ 4.30, 4.80	2,9,6
		-33	32.987744	140		1.8 s	B+4.2; γ 2.9	2,9
		-34	33.984570	60		1.5 s	B+4.45;	2,9
		-35	34.979905	35	75.53			2,9
		-36	35.979688	40		3.1×10^5 y	B⁻0.714;	2,9
		-37	36.977540	45	24.47			2,9
		-38	37.979965	60		37.5 m	B⁻4.81,2.77,1.11; γ 2.15, 1.60	2,9
		-39	38.979820	80		55.5 m	B⁻1.91,2.18,3.45; γ 0.246,0.35,1.27, 1.35, 1.52	2,9
		-40				1.4 m	B⁻3.2, 7.5; γ 1.46 γ 2.75, 6.0	9

E Mev	mb σ
12	
13	0.3
14	0.7
15	1.1
16	1.5
17	2.2
18	2.8
19	3.3
20	3.0
21	2.5
22	1.7
23	0.9



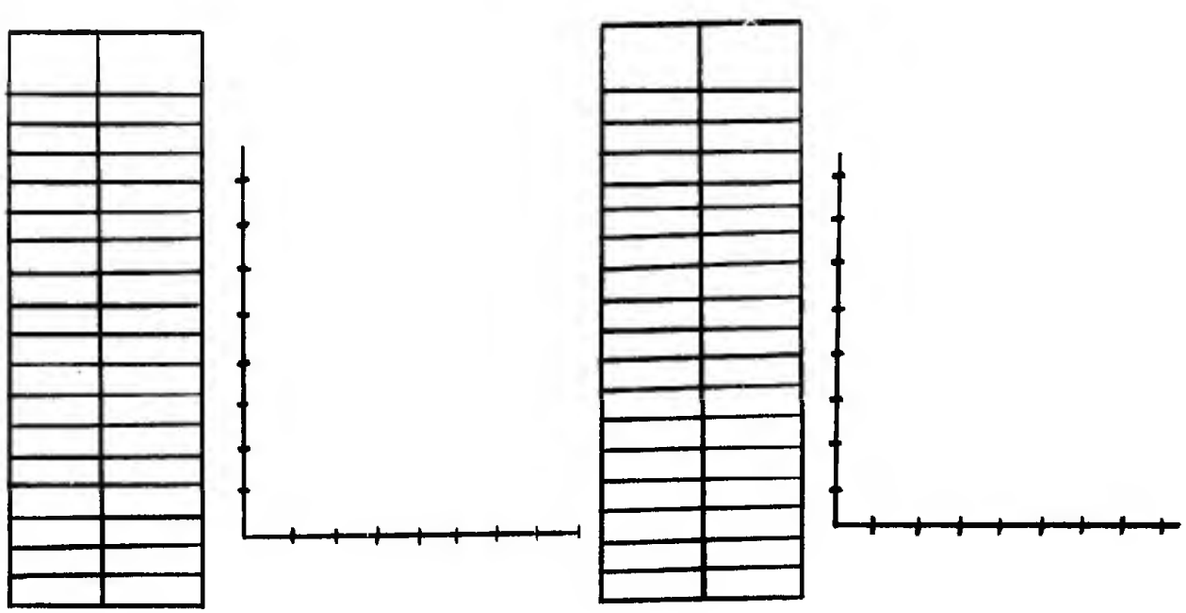
E Mev	σ



$_{17}Cl$

REMARKS

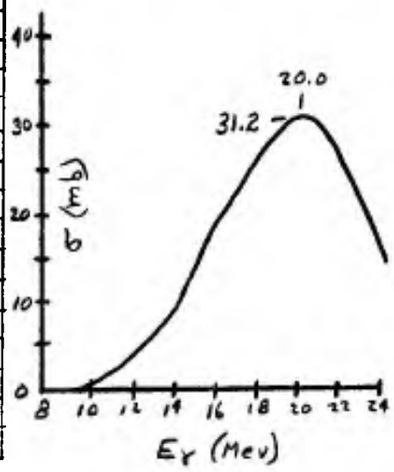
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Cl^{35}	- 12.569		6
	Cl^{37}	- 10.322	- 10.307	6,48
(γ,p)	Cl^{35}	- 6.366		6
	Cl^{37}	- 8.4014		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
18	Argon	-35	34.985715	65		1.83 s	B+4.96; γ 1.19,1.73	2,9,6
		-36	35.978921	40	0.337			2,9
		-37	36.978416	45		35 d	EC	2,9
		-38	37.974790	50	0.063			2,9
		-39	38.976644	70		~ 265 y	B⁻0.565	2,9
		-40	39.975050	50	99.6			2,9
		-41	40.977530	60		110 m	B⁻1.25; γ 1.3	2,9
		-42				≥3.5 y	B⁻	9

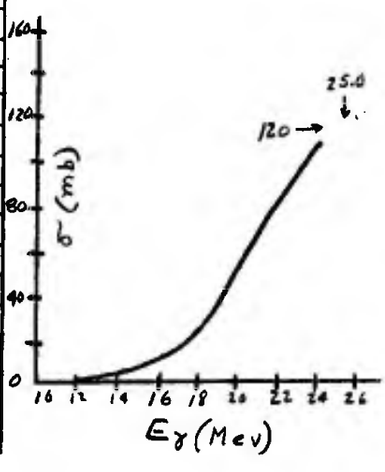
E Mev	σ_{mb}
9	0
10	1.0
11	2.0
12	4.0
13	7.0
14	10.0
15	14.5
16	19.0
17	23.0
18	26.5
19	29.5
20	31.2
21	30.0
22	26.2
23	21.0
24	14.0

A $(\gamma,n)_{REF\#3}$



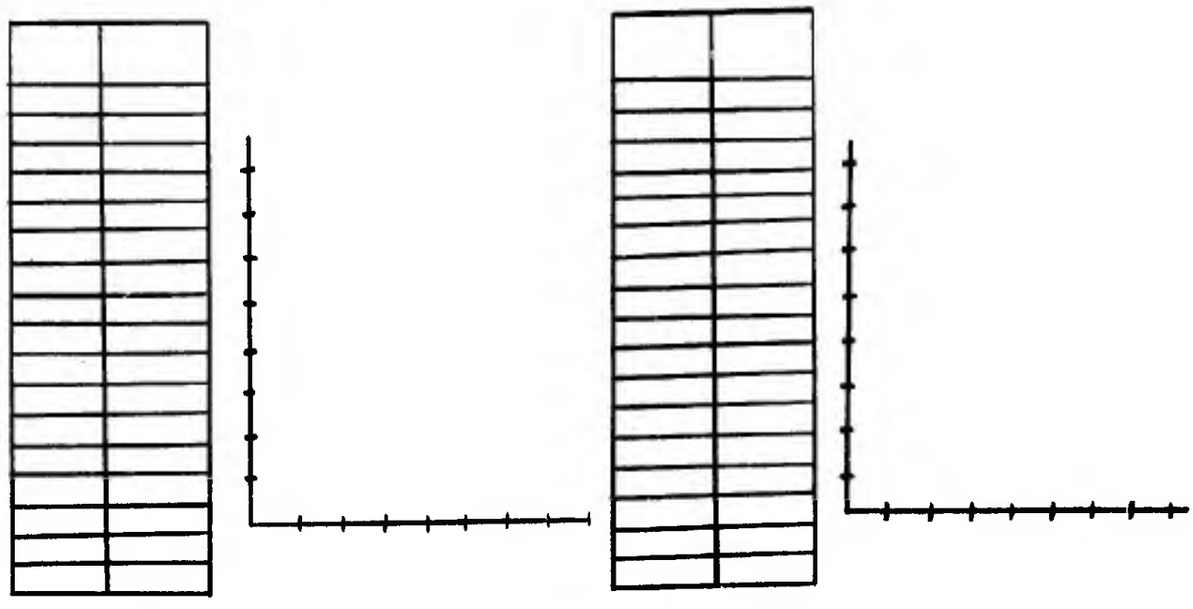
E Mev	σ_{mb}
14	1.5
15	3.4
16	6.8
17	13.0
18	21.0
19	33.0
20	49.0
21	68.0
22	84.0
23	97.0
24	107.0

A $(\gamma,p)_{REF\#16}$



REMARKS

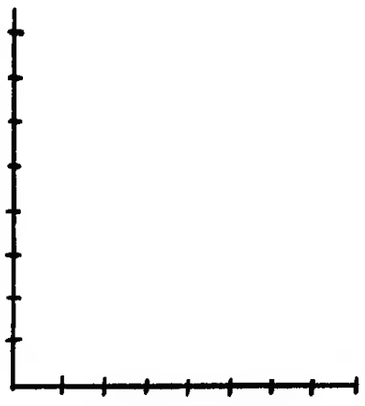
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	A^{40}	- 9.875		6
(γ, p)	A^{40}	- 12.523		6
(γ, α)	A^{40}	- 6.809		6



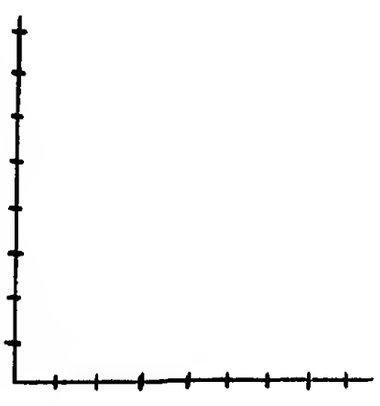
$_{19}K$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
19	Potassium	-37	36.985000	300		1.2 s	B+5.1	2,9
		-38	37.981100	60		7.7 m	B+2.68; γ 2.2	2,9
		-39	38.976037	70	93.08			2,9
		-40	39.976653	60	0.0118	1.39×10^9 y	B-1.3; γ 1.5	2,9
		-41	40.974760	60	6.91			2,9
		-42	41.975830	70		12.5 h	B-3.55,1.99; γ 0.315, 1.516	2,9
		-43	42.974330	80		22.0 h	B-0.83,0.24,0.46; γ 0.219,0.373,0.388 0.393,0.591,0.617	2,9
		-44	43.975900	230		22.0 m	B-1.5, 4.9; γ 1.13, 2.07, 2.48, 3.6	2,9
		-45				34 m	E	9

E Mev	σ



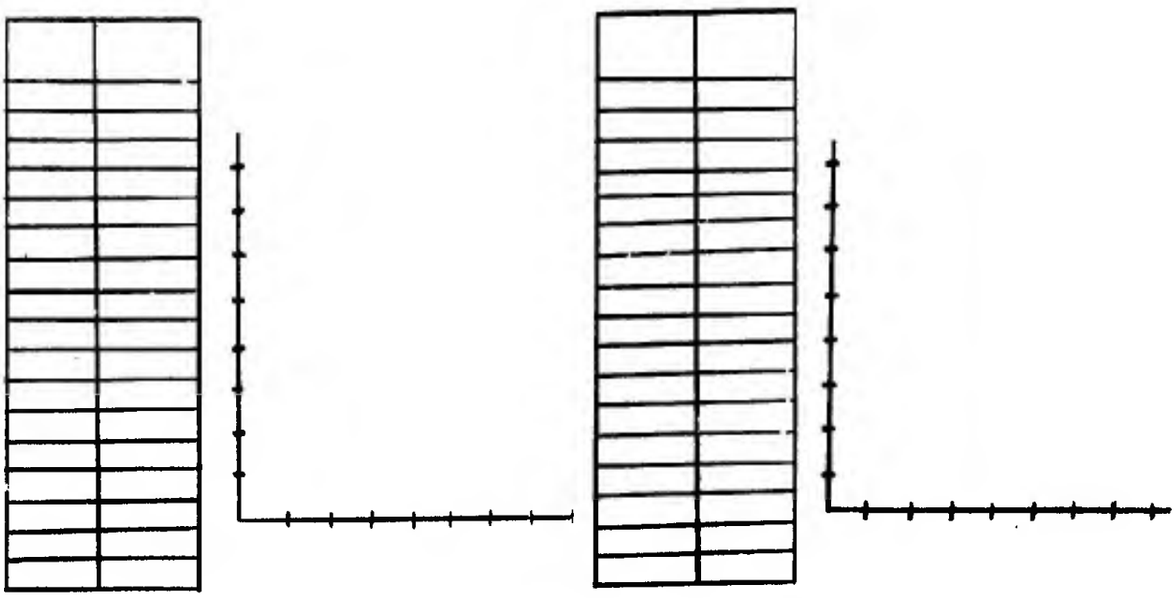
E Mev	σ



$_{19}K$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	K^{39}	-13.079	-13.125	6, 48
	K^{40}	-10.095		6
(γ, p)	K^{39}	-6.3672		6
	K^{41}	-7.7998		6

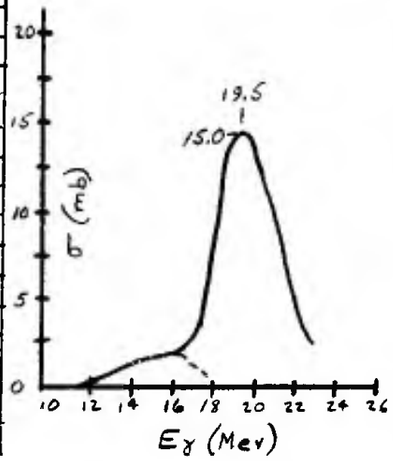


$_{20}Ca$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
20	Calcium	-38				0.66 s	B+ , γ3.5	6
		-39	38.983400	400		1.0 s	B+6.1	2,9
		-40	39.975230	60	96.97			2,9
		-41	40.975230	60		$1.1x10^5$y	EC	2,9
		-42	41.971890	60	0.64			2,9
		-43	42.972350	80	0.145			2,9
		-44	43.969340	80	2.06			2,9
		-45	44.970350	80		153 d	B⁻0.26	2,9
		-46			0.0033			9
		-47	46.969460	100		4.7 d	B⁻1.94,0.66; γ0.150,0.234, 0.392,0.81,1.30	2,9,6
		-48	47.967700	200	0.185			2,9
		-49	48.971160	200		8.8 m	B⁻1.95;γ3.08,4.04	2,9,6

E Mev	σ_{mb}
11	~ 0
12	+
13	0.8
14	1.2
15	1.2
16	1.8
17	3.0
18	7.0
19	14.0
20	13.0
21	9.8
22	5.0
23	2.0

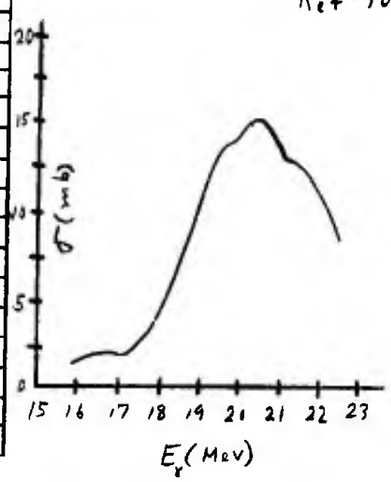
$Ca(\gamma,n)_{REF\#15}$



E Mev	σ

$Ca^{40}[(\gamma,n)+(\gamma,pn)]$

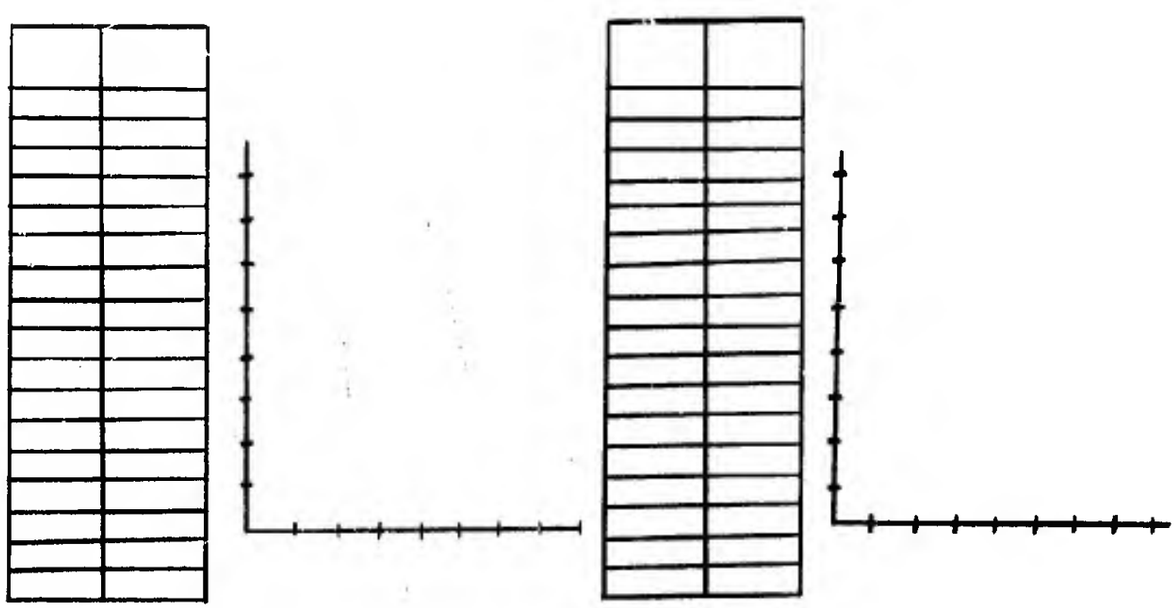
Ref# 104



$_{20}Ca$

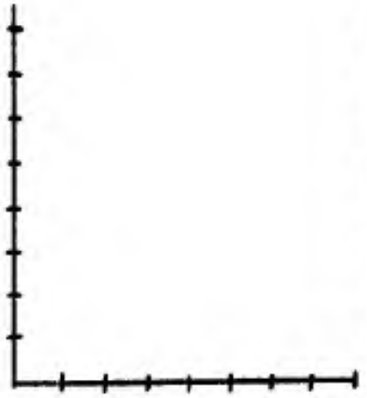
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ca^{40}	- 15.729		6
(γ, p)	Ca^{40}	- 8.3364		6

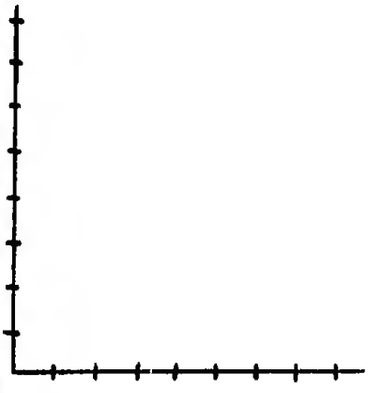


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
21	Scandium	-40	39.990250	500		0.22 s	B+9.0; γ 3.75,3.348	2, 9, 6
		-41	40.981630	70		0.87 s	B+4.94	2, 9
		-42				0.68 s	B+4.8	9
		-43	42.974730	80		3.9 h	B+1.2,0.8,0.4; γ 0.25 γ 0.371,0.627,0.8,1.2	2, 6, 9
		-44	43.973260	80		3.9 h	B+1.5; EC; γ 1.2,2.54	2, 9
		-45	44.970075	80	100			2, 9
		-46	45.969490	80		84 d	B⁻.36,1.2; γ 1.12, 0.888	2, 9
		-47	46.967240	95		3.4 d	B⁻0.6; γ 0.161	2, 9, 5
		-48	47.967410	90		44 h	B⁻0.65; γ 1.0,0.987, 1.329	2, 9
		-49	48.965540	100		57 m	B⁻2.0	2, 9
		-50				1.5 m	B⁻ ~3.5; γ 1.56	9

E Mev	σ



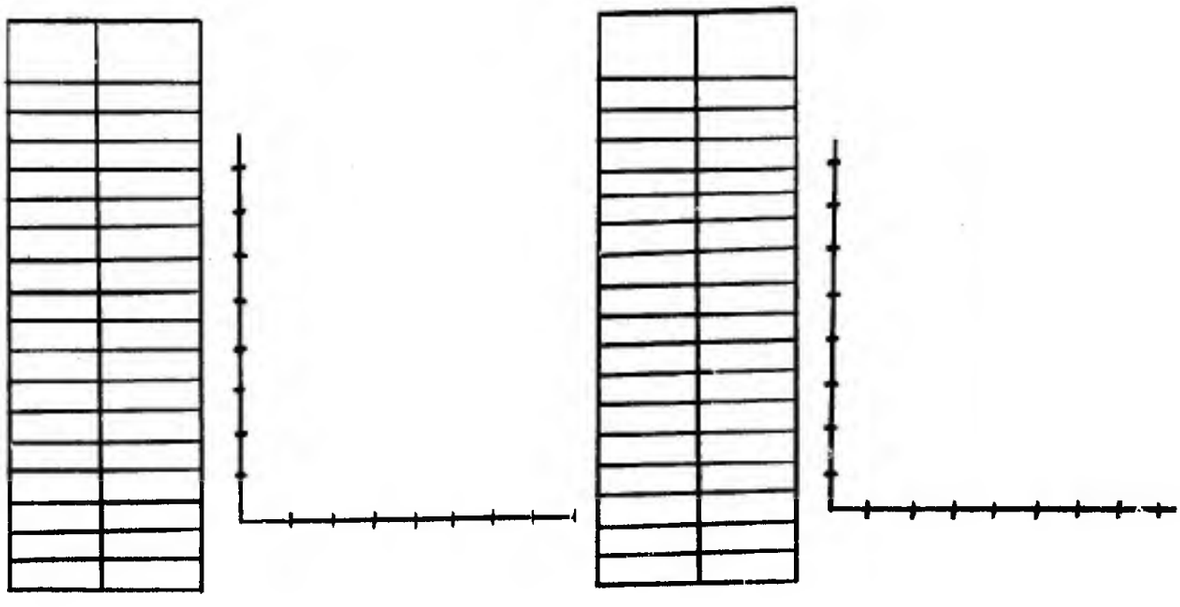
E Mev	σ



$_{21}Sc$

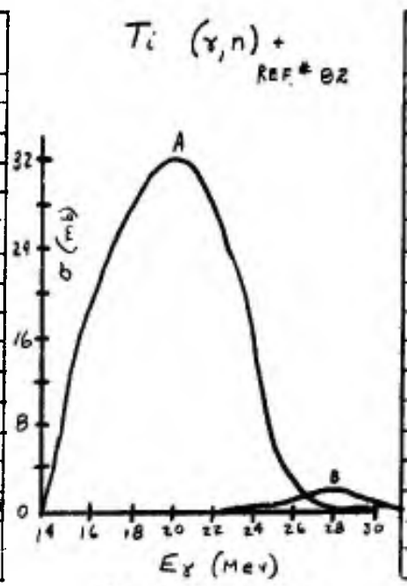
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Sc^{45}	-11.320		6
(γ, p)	Sc^{45}	- 6.889		6



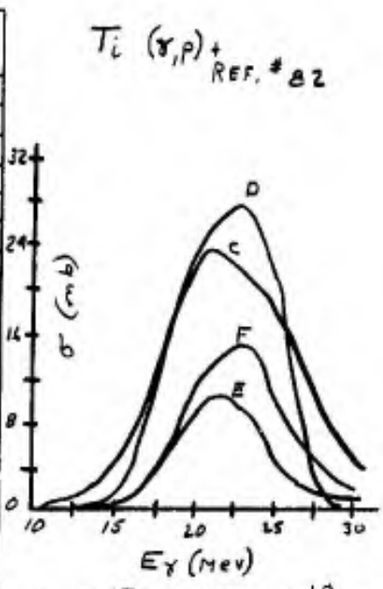
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
22	Titanium	-43				0.6 s		9
		-44				~10^3 y	EC ; γ0.072, 0.16	9
		-45	44.972270	80		3.1 h	B+1.0; γ0.45, 0.80	2, 9
		-46	45.966954	80	7.99			2, 9
		-47	46.966500	80	7.32			2, 9
		-48	47.963120	80	73.99			2, 9
		-49	48.963390	80	5.46			2, 9
		-50	49.960580	80	5.25			2, 9
		-51	50.962660	120		5.8 m	B-2.1, 1.5; γ 0.323, 0.608, 0.93	2, 9

E Mev	σ



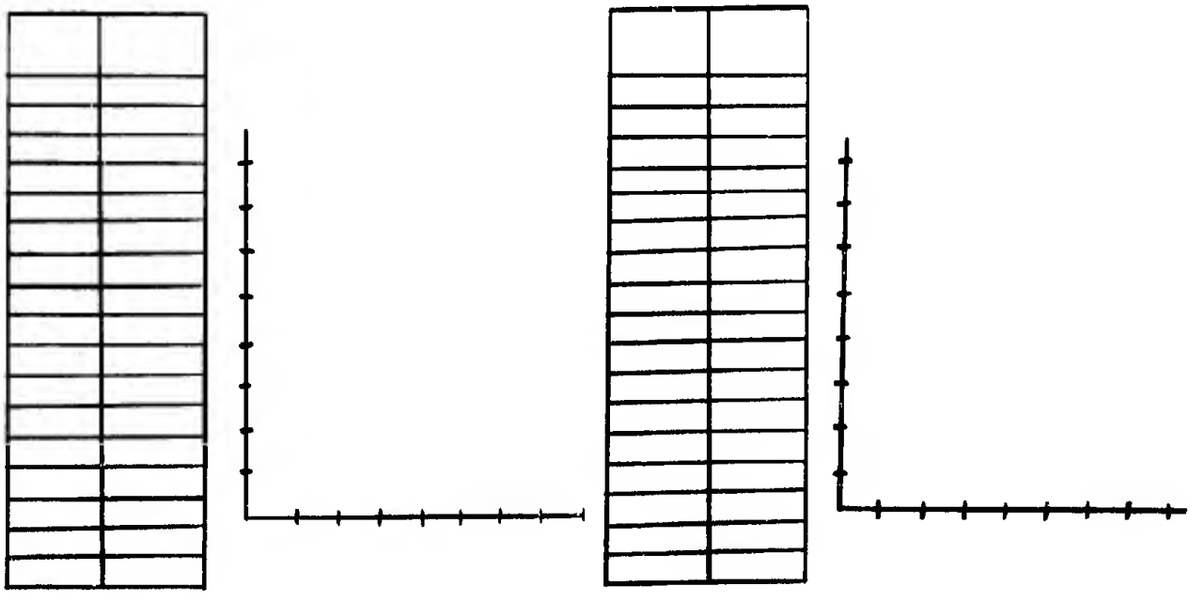
A - (γ,n) + (γ,2n)
B - (γ,np)

E Mev	σ



C: $Ti^{47}(\gamma,p)$+10.1 $Ti^{48}(\gamma,np)$
D: $Ti^{48}(\gamma,p)$+0.07 $Ti^{49}(\gamma,np)$
E: $Ti^{49}(\gamma,p)$+0.96 $Ti^{50}(\gamma,np)$
F: $Ti^{50}(\gamma,p)$

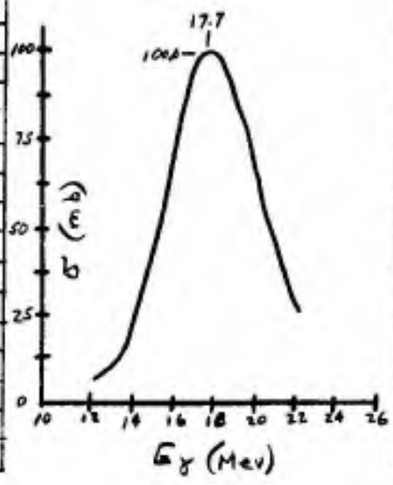
		REMARKS		$_{22}Ti$
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ti^{46}	-13.190		6
	Ti^{47}	- 8.887		6
	Ti^{48}	-11.620		6
	Ti^{49}	- 8.1469		6
(γ, p)	Ti^{46}	-10.349		6
	Ti^{47}	-10.469		6
	Ti^{48}	-11.438		6
	Ti^{49}	-11.354		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
23	Vanadium-	46	45.974900	400		0.4 s	B+ ≥ 6.0	2, 9
		-47	46.969627	80		31.1 m	B+1.9	2, 9
		-48	47.967453	80		16 d	B+0.7; γ 0.983, γ 1.321, 2.25	2, 9, 6
		-49	48.964043	80		330 d	EC	2, 9
		-50	49.963120	180	0.25	4×10^{14} y	γ	2, 9
		-51	50.960040	120	99.75			2, 9
		-52	51.961184	120		3.8 m	B⁻2.5, γ 1.440	2, 9
		-53				2 m	B⁻2.5; γ 1.0	9
		-54				55 s	B⁻3.3; γ 0.835, γ 0.99, 2.21	9

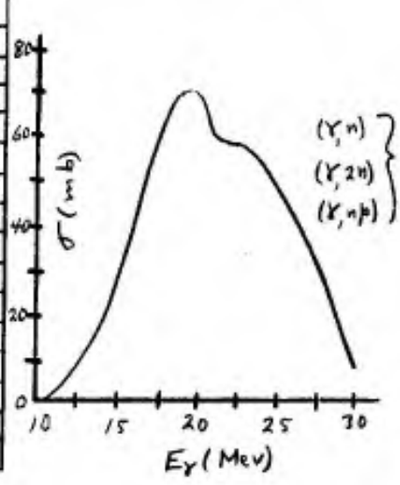
E Mev	σ_{mb}
13	0
14	22
15	40
16	65
17	95
18	100
19	83
20	63
21	47
22	32

V (γ,n) Ref. #15



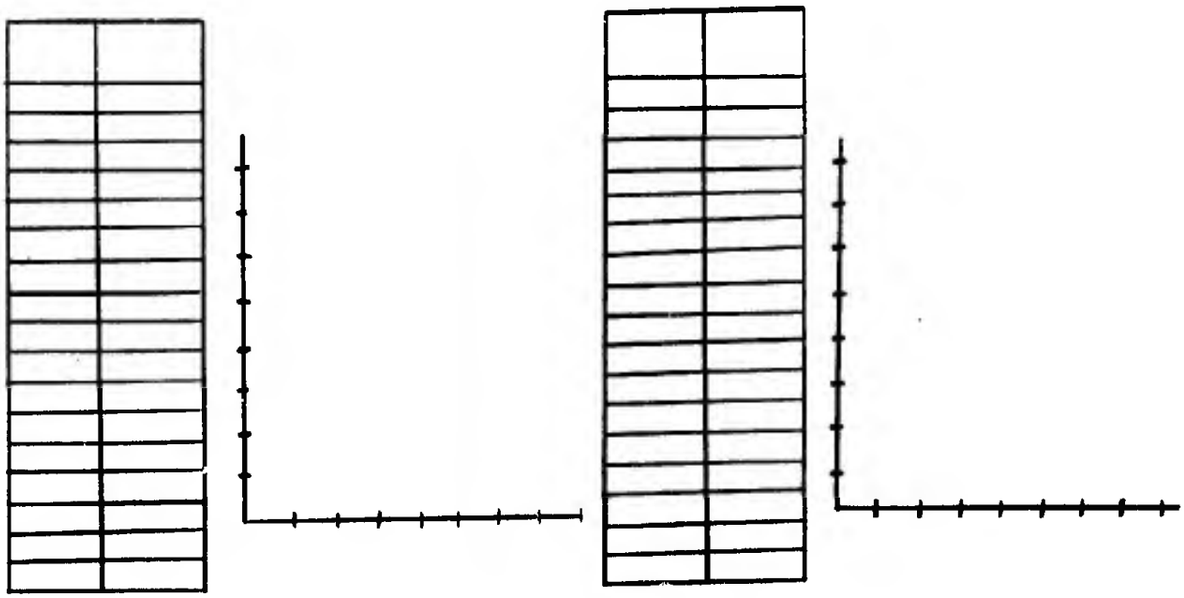
E Mev	σ

V^{51} Ref #101



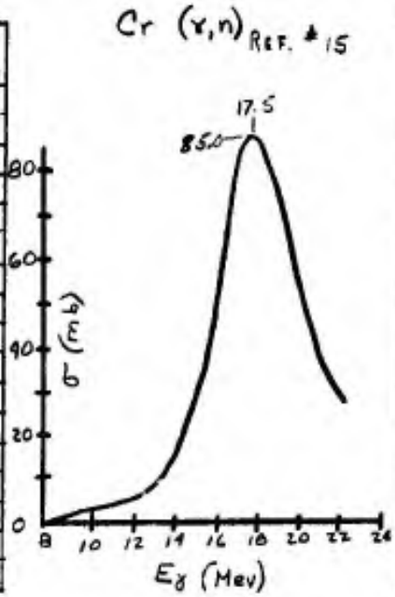
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	V^{51}	-11.040		6
(γ, p)	V^{51}	- 8.044		6

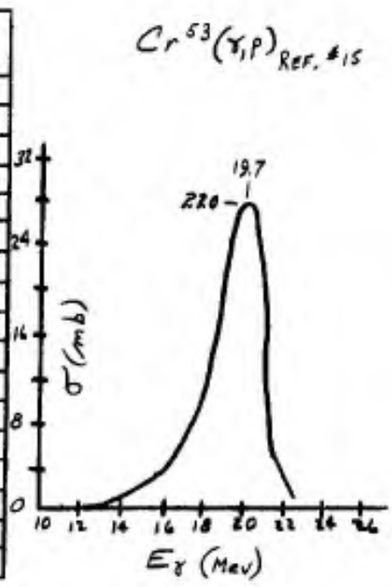


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
24	Chromium	-46				1.1 s	F	9
		-47				0.4 s	F	9
		-48				23 h	EC ; γ 0.117, 0.310	9, 6
		-49	48.966794	80		42 m	B+1.54, 1.39, 0.73 γ 0.063, 0.089, 0.152	2, 9, 6
		-50	49.961640	150	4.31			2, 9
		-51	50.960844	120		28 d	EC; γ 0.320, 0.324, γ 0.624, 0.650	2, 9, 6
		-52	51.956990	130	83.76			2, 9
		-53	52.957460	130	9.55			2, 9
		-54	53.956020	130	2.38			2, 9
		-55	54.958430	180		3.6 m	B-2.8	2, 9

E Mev	σ_{mb}
9	1.0
10	2.0
11	3.0
12	4.0
13	9.0
14	19.0
15	35.0
16	60.0
17	84.0
18	85.0
19	66.0
20	48.0
21	35.0
22	30.0



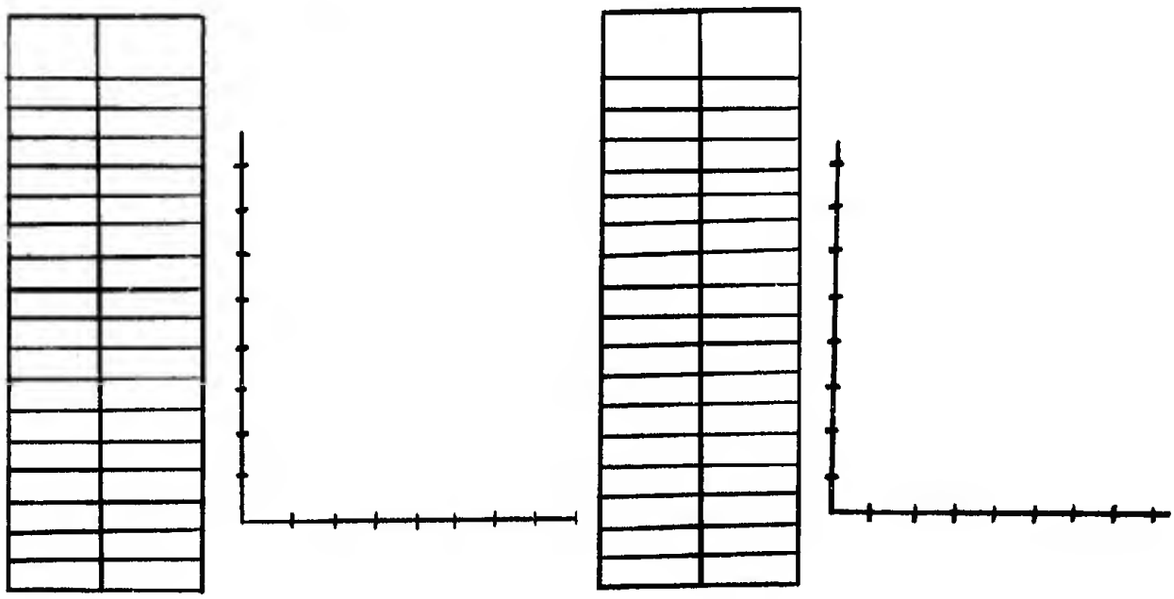
E Mev	σ



REMARKS

$_{24}Cr$

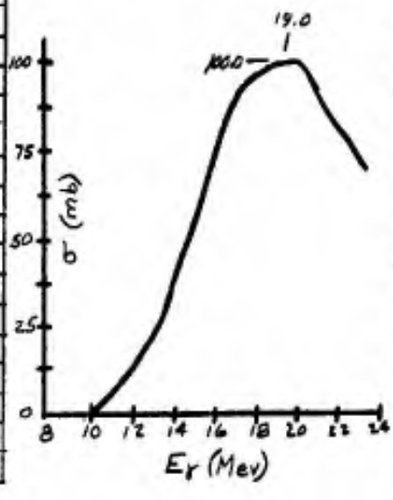
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Cr^{50}	-12.934	-13.4	6, 15
	Cr^{52}	-12.051	-12.18	6, 48
	Cr^{53}	- 7.943	- 7.92	6, 48
	Cr^{54}	- 9.7216	-10.20	6, 15
(γ, p)	Cr^{50}	- 9.592		6
	Cr^{52}	-10.515		6
	Cr^{53}	-11.155		6
	Cr^{54}	-11.470		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
25	Manganese	-49				0.4 s	F	9
		-50	49.970000	500		0.3 s	B+?6.3	2, 9
		-51	50.964300	140		45 m	B+2.2	2, 9
		-52	51.962070	140		5.7 d	B+0.6; γ 0.73, 0.94 γ 1.46	2, 9, 6
		-53	52.958100	130		~2x10^6 y	EC	2, 9
		-54	53.957310	200		300 d	EC ; γ 0.840	2, 9
		-55	54.955400	150	100			2, 9
		-56	55.956590	160		2.6 h	B-2.8, 1.0, 0.6; γ 0.84, 1.80, 2.11 2.52, 2.66, 2.98 3.39	2, 9, 6
		-57				1.7 m	B-2.6; γ 0.117, γ 0.134, 0.69, γ 0.220, 0.350	9, 6

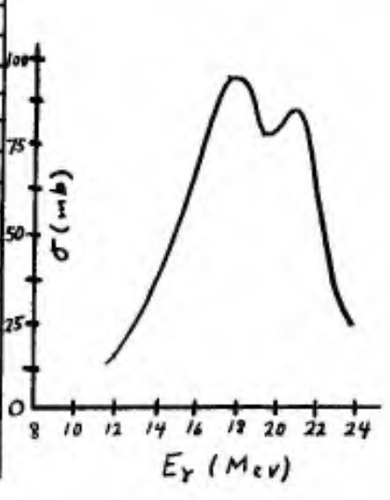
E Mev	σ_{mb}
10	1.0
11	6.0
12	13.0
13	22.0
14	39.0
15	62.0
16	84.0
17	90.0
18	95.0
19	100.0
20	98.0
21	90.0
22	88.0
23	77.0
24	66.0

$Mn^{55}(\gamma,n)_{REF\ \#1}$



E Mev	σ

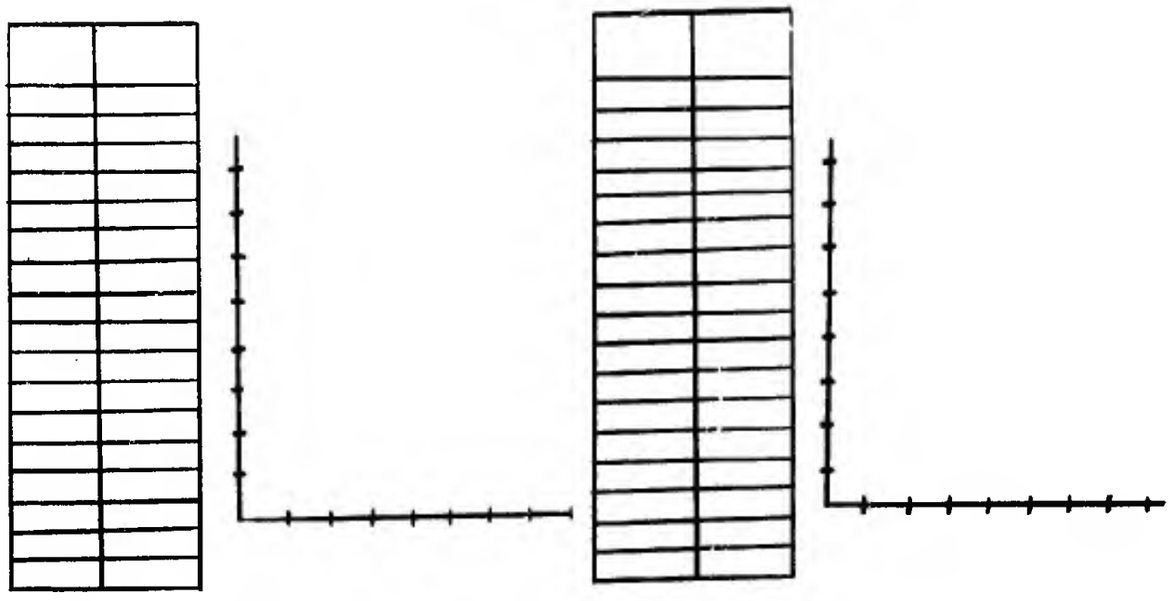
$Mn^{55}(\gamma,n)$ REF. #49



$_{25}Mn$

REMARKS

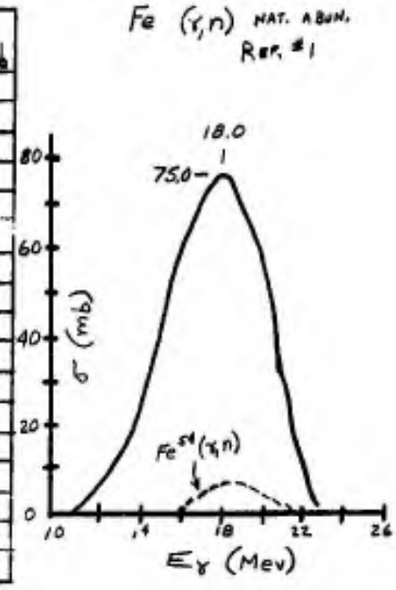
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Mn^{55}	- 10,220		6
(γ, p)	Mn^{55}	- 8,058		6



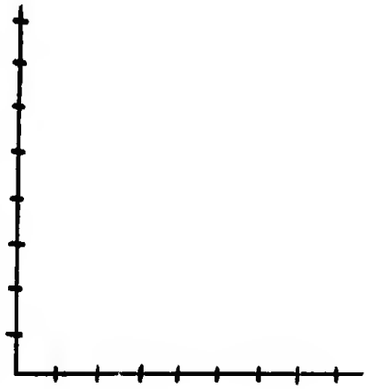
$_{26}Fe$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
26	Iron	-52	51.964210	150		8.3 h	B+0.8; γ0.163	2, 9
		-53	52.962250	200		8.9 m	B+2.5; γ0.370	2, 9
		-54	53.956640	150	5.84			2, 9
		-55	54.955646	150		2.6 y	EC	2, 9
		-56	55.952640	150	91.68			2, 9
		-57	56.953420	150	2.17			2, 9
		-58	57.951470	160	0.31			2, 9
		-59	58.953615	250		45 d	B⁻0.27, 0.46; γ0.191, 0.337, 1.102, 1.290	2, 9
		-60				$\sim 3\times10^5$ y	B⁻	9
		-61				5.5 m	B⁻ ; γ0.29	9

E Mev	σ_{mb}
11	0
12	5.0
13	13.0
14	25.0
15	39.0
16	57.0
17	68.0
18	75.0
19	68.0
20	57.0
21	35.0
22	13.0
23	~3.0
24	~0



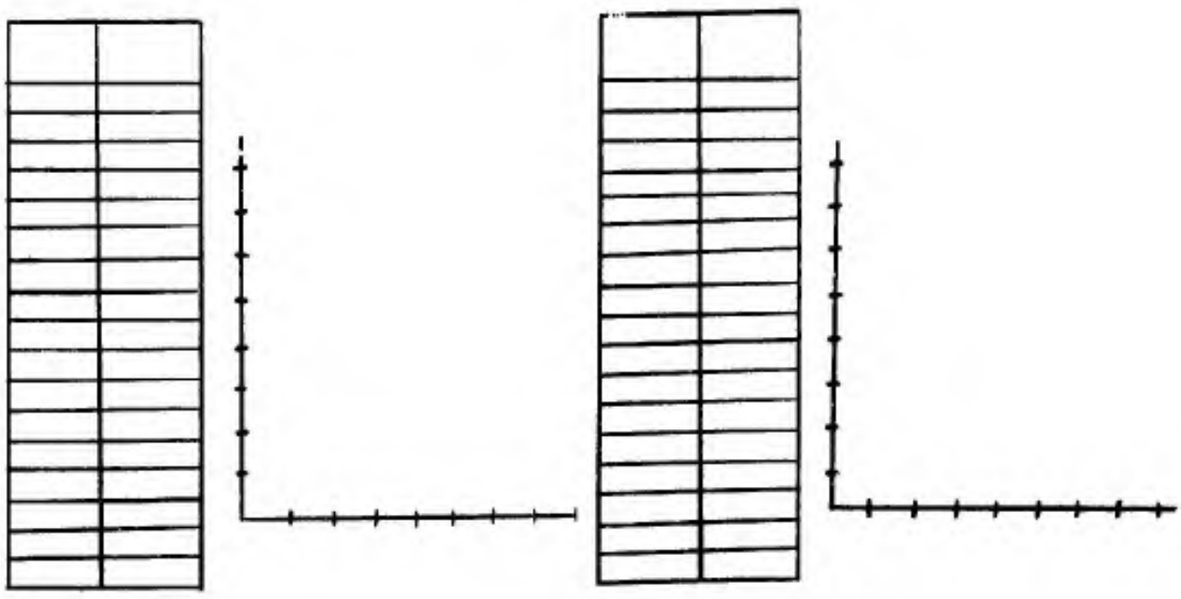
E Mev	σ



REMARKS

$_{26}Fe$

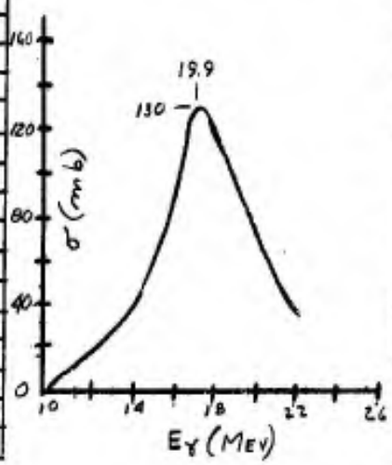
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Fe^{54}	-13.620	-13.7	6, 39
	Fe^{56}	-11.211	-11.34	6, 23
	Fe^{57}	- 7.641	- 7.85	6, 23
(γ, p)	Fe^{54}	- 8.846		6
	Fe^{56}	-10.196		6
	Fe^{57}	-10.567		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
27	Cobalt	- 54	53.966200	700		0.18 s	$B^+ > 7.4$	2, 9
		-55	54.959360	150		18.2 h	B+1.5,1.0,.5; γ 0.250,0.477, 0.936, 1.410	2, 9
		-56	55.957610	150		77.3 d	EC; B+; γ 0.845, 1.26,1.74,2.01, 2.55,3.25,	6, 2, 9
		-57	56.953980	330		270 d	EC; γ 0.01437, 0.12205,0.13640	2, 9, 6
		-58	57.953940	160		71.3 d	EC; B+0.[illegible]; γ 0.808, 1.64, ~0.81, 0.025	2, 9, 6
		-59	58.951940	250	100			2, 9
		-60	59.952868	250		5.2 y	B^- ; γ 1.17, 1.33, 2.158	2, 9, 6
		-61	60.951290	250		99 m	B^- 1.22; γ 0.072	2, 9
		-62	61.952940	400		1.6 m	B^- ; γ 1.0, 1.170, 1.49, 1.72,2.02, 2.50	2, 9, 6
		-62				14 m	B^- 0.88,2.88; γ 1.3	9
		-64				~5 m		9

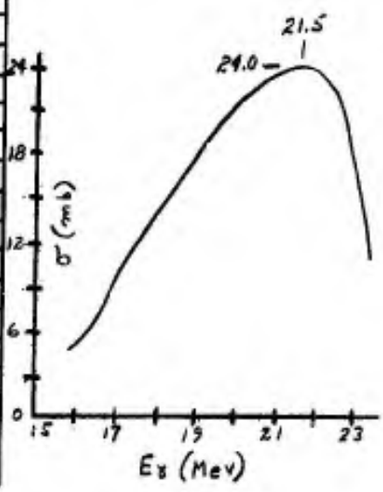
E Mev	σ_{mb}
10	0
11	9.0
12	16.0
13	26.0
14	40.0
15	60.0
16	96.0
17	129.0
18	112.0
19	94.0
20	74.0
21	52.0
22	34.0

$Co^{59}(\gamma,n)$ Ref #1



E Mev	σ_{mb}
15	
16	5.5
17	9.0
18	13.0
19	17.0
20	21.0
21	23.0
22	24.0
23	20.0

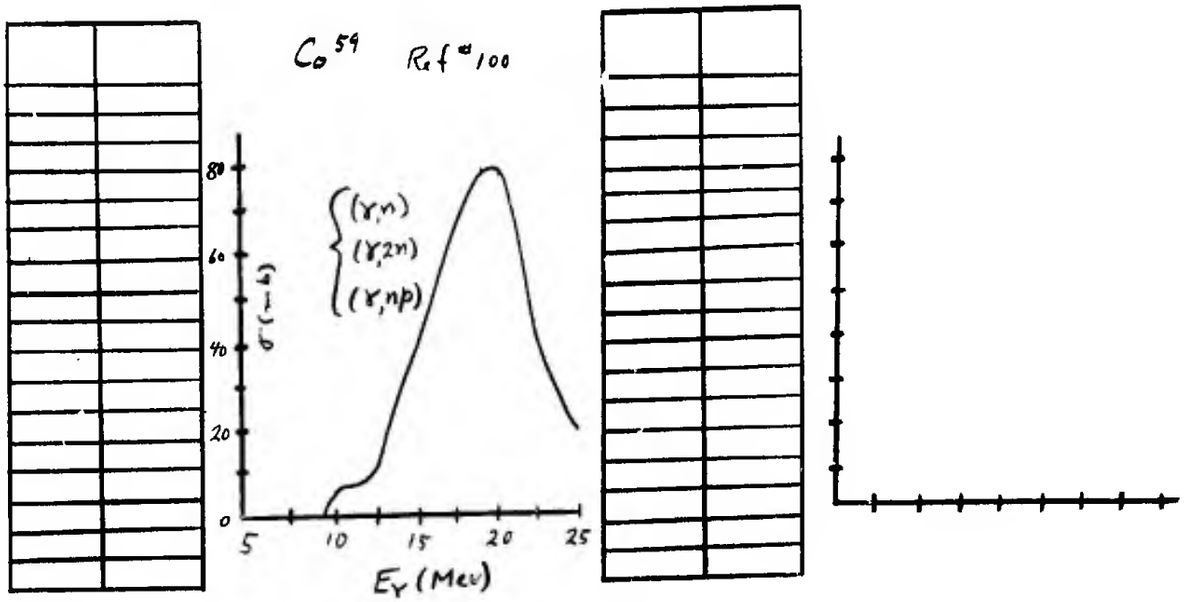
$Co^{59}(\gamma,p)$ Ref. #21



$_{27}Co$

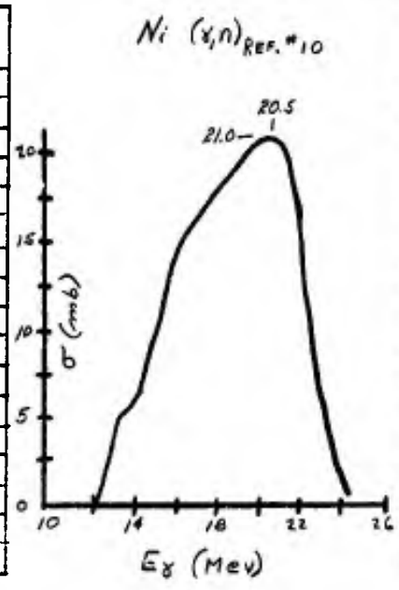
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Co^{59}	-10.460	-10.44	6, 22
(γ,p)	Co^{59}	-7.366		6

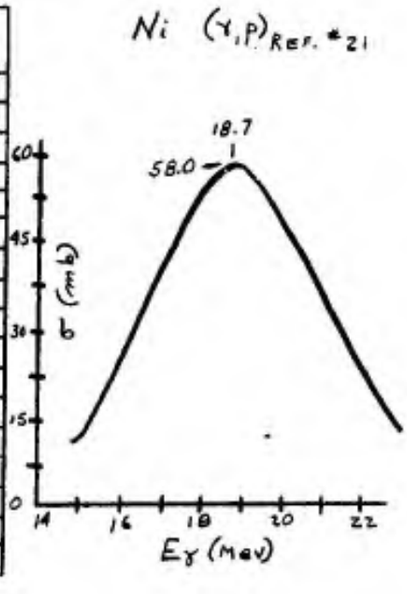


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
28	Nickel	-56				6.4 d	EC ; γ 0.16,0.28, 0.48,0.79,0.96, 1.33,1.58,1.75	9, 6
		-57	56.957460	330		31.1 h#10 36 h#9	β+0.8,0.7,0.4; γ 0.125,1.38,1.90	2,9,10
		-58	57.953770	250	67.76			2, 9
		-59	58.953093	250		10^5 y	EC	2, 9
		-60	59.949840	250	26.16			2, 9
		-61	60.949690	250	1.25			2, 9
		-62	61.947570	250	3.66			2, 9
		-63	62.949508	200		125 y	β⁻0.067	2, 9
		-64	63.948130	200	1.16			2, 9
		-65	64.950650	200		2.6 h	β⁻2.1, 1.0, 0.6; γ 0.37, 1.12, 1.49	2, 9

E Mev	σ_{mb}
12	0
13	5.0
14	7.0
15	10.5
16	14.0
17	16.0
18	17.8
19	20.0
20	20.4
21	20.4
22	13.0
23	7.0
24	2.0



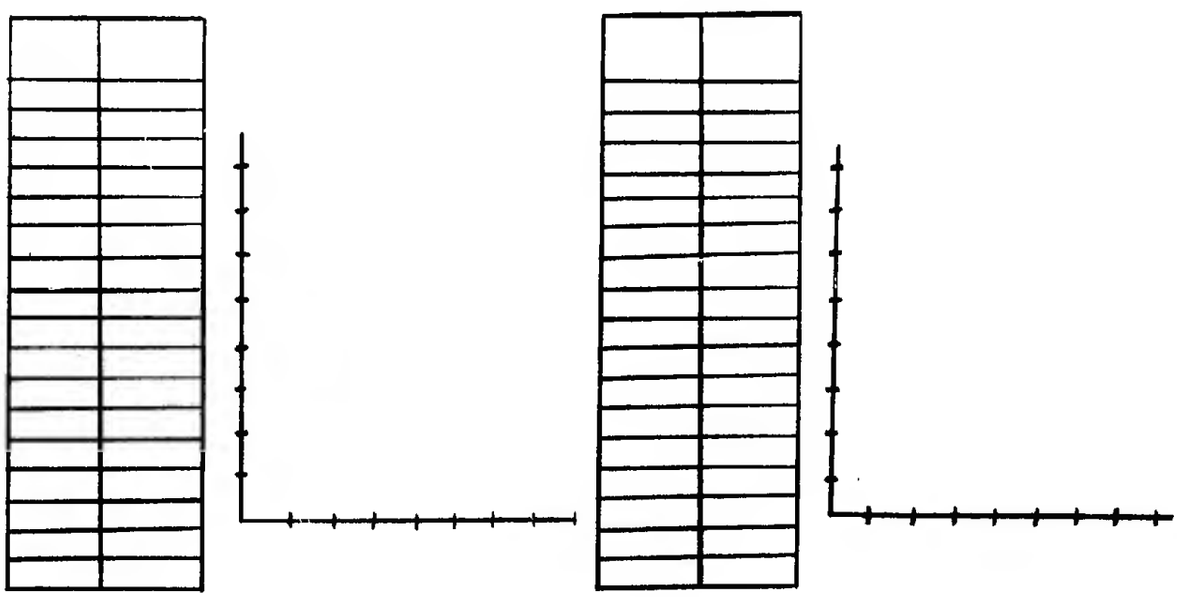
E Mev	σ_{mb}
12	
13	
14	
15	12.0
16	26.0
17	40.0
18	52.0
19	58.0
20	48.0
21	37.0
22	25.0
23	14.0



REMARKS

$_{28}Ni$

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Ni^{58}	-11.924		6
	Ni^{60}	-11.389		6
	Ni^{62}	-10.590		6
(γ,p)	Ni^{58}	- 7.907		6
	Ni^{60}	- 9.530		6
	Ni^{62}	-11.097		6

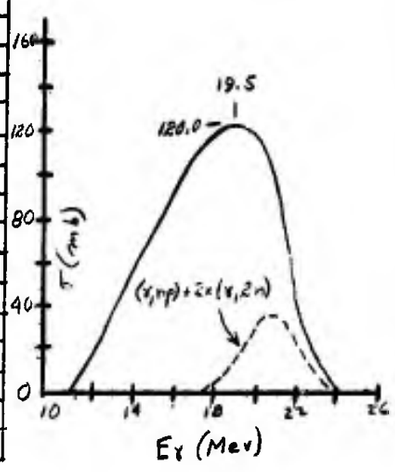


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
29	Copper	-57				0.18s		9
		-58	57.964000	900		3.0 s	B+ 7.5	9
						9.5 m	B+	2, 9
		-59				81 s	B+3.7; γ0.34,0.42, 0.463,0.872,1.30, 1.69,2.07	9, 6
		-60	59.956580	250		23.4 m	B+2.0,3.0,4.0; γ0.85,1.33,1.76, 2.13,2.64,3.13, 3.52,4.0	9, 6
		-61	60.952084	250		3.3 h	B+1.2,0.9,0.6; γ0.072,0.281,0.380 0.580,0.656,0.94, 1.15,1.22	9, 6
		-62	61.951793	250		10.0 m	B+2.9; γ0.67,0.87, 1.18,1.35,1.46, 1.98,2.24	9, 6
		-63	62.949440	200	69.1			9
		-64	63.949934	200		12.8 h	B-0.6;EC; γ1.35	9, 6
		-65	64.948100	200	30.9			9
		-66	65.949760	200		5.1 m	B-2.6,1.5; γ0.83, 1.04	9, 6
		-67	66.949114	200		59.0 h	B-0.4,0.5,0.6; γ 0.094,0.186,0.300 0.391	9, 6

Continued on next page

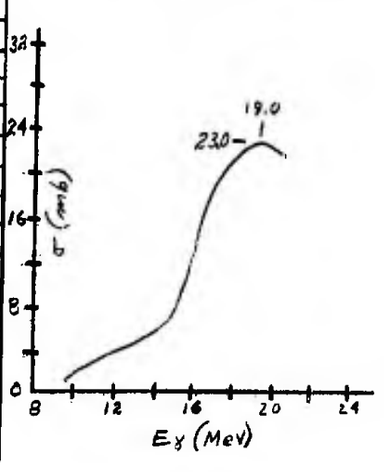
E Mev	σ_{mb}
10	0
11	0+
12	18.0
13	36.0
14	54.0
15	70.0
16	85.0
17	100.0
18	113.0
19	120.0
20	119.0
21	95.0
22	66.0
23	18.0
24	1.0

Cu $(\gamma,n)_{REF.\#1}$



E Mev	σ_{mb}
9	0
10	1.8
11	2.4
12	3.2
13	4.2
14	5.0
15	6.0
16	13.0
17	18.0
18	21.0
19	23.0
20	22.5

Cu $(\gamma,P)_{REF.\#50}$



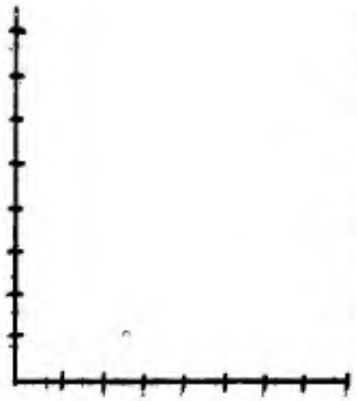
$_{29}Cu$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
29	Copper	-68				32 s	β^- ~3.0; γ	9

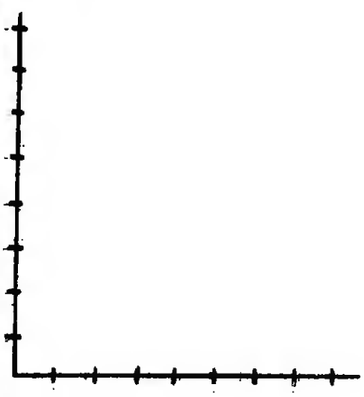
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Cu^{63}	- 10.838	- 10.78	39
	Cu^{65}	- 9.910	- 9.94	39
(γ,p)	Cu^{63}	- 6.126		6
	Cu^{65}	- 7.450		6

E Mev	σ



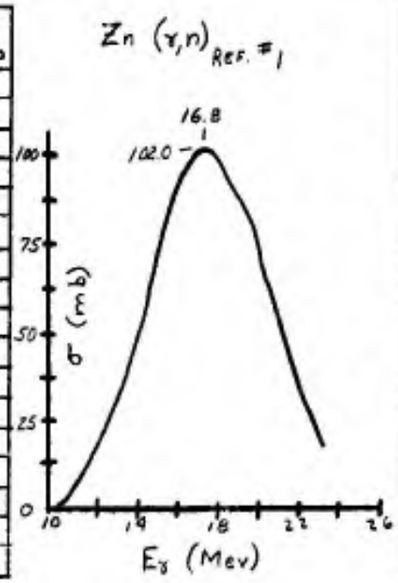
E Mev	σ



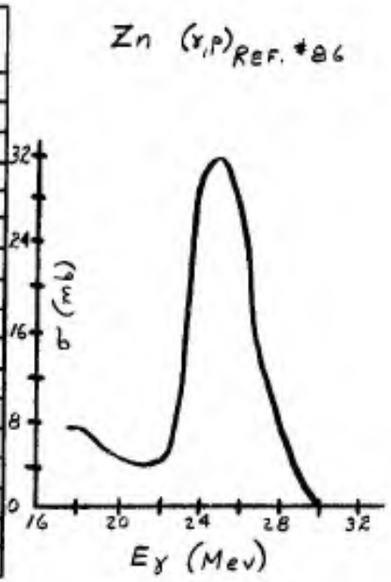
30 Zn

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
30	Zinc	-60				32 s	β^- ~3.0	9
		-61				1.5 m	B+4.3	9
		-62	61.953615	250		9.3 h	EC; B+0.66;γ0.04, γ.25,.36,.40,.51, .595	2,9,6
		-63	62.953029	200		38.3 m	B+2.36, 1.4, 0.5 γ	2,9
		-64	63.949320	200	48.49	$>8\times10^{15}$y		2,9
		-65	64.949847	200		245 d	EC;B+0.3;γ 1.119	2,9,6
		-66	65.946940	200	27.81			2,9
		-67	66.948500	200	4.11			2,9
		-68	67.946520	200	18.56			2,9
		-69	68.948533	200		52 m	β^-0.9	2,9
		-70	69.947430	200	0.62			2,9
		-71	70.949840	300		2.2 m	β^-2.4;γ0.12,0.51, 0.90,1.09	2,9,6
		-72				49.0 h	β^-~0.3, ~1.6	9

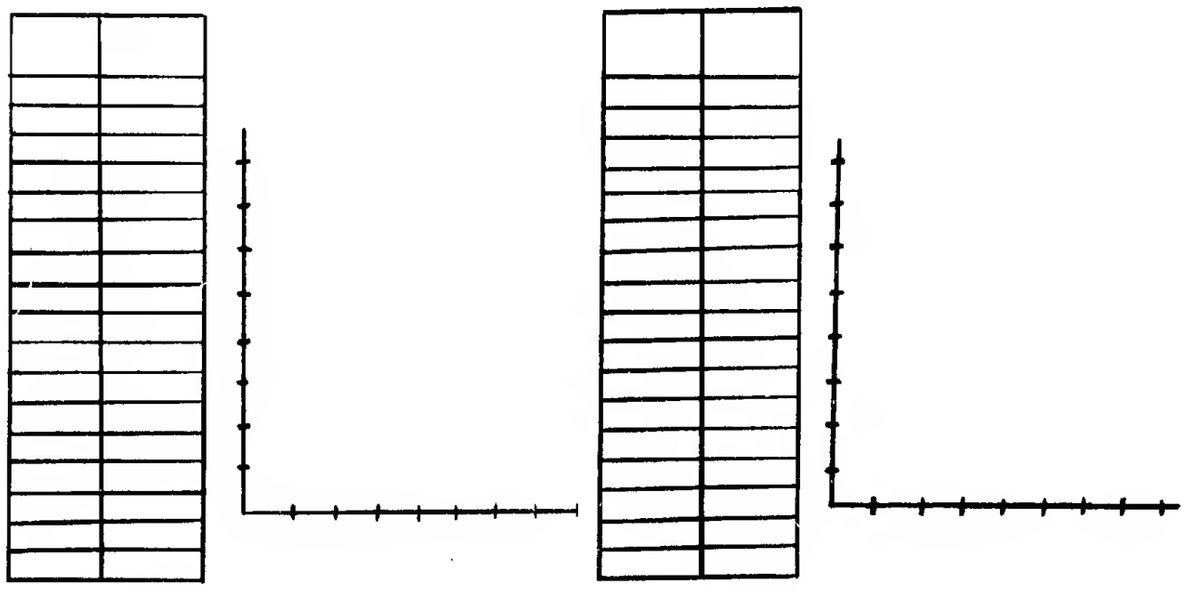
E Mev	σ_{mb}
10	0
11	6.0
12	18.0
13	34.0
14	55.0
15	80.0
16	96.0
17	102.0
18	95.0
19	82.0
20	65.0
21	50.0
22	34.0
23	20.0



E Mev	σ

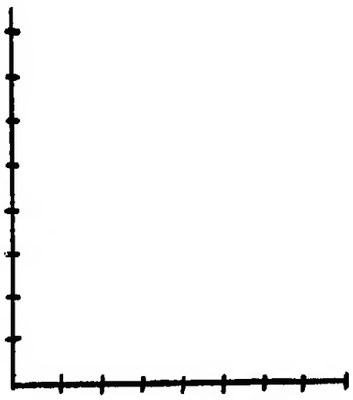


Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference
(γ, n)	Zn^{64}	-11.856		6
	Zn^{66}	-11.039		6
	Zn^{68}	-10.199		6
(γ, p)	Zn^{64}	- 7.7067		6
	Zn^{66}	- 8.908		6
	Zn^{68}	- 9.988		6

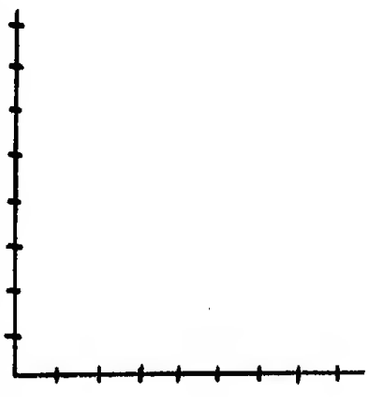


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
31	Gallium	-64	63.957100	600		2.6 m	B+6.1,2.8; γ 0.975 1.30,2.225,3.25	2, 9, 6
		-65	64.953200	220		15.2 m	EC; B+ ; γ 0.054,0.117	2, 9, 6
		-66	65.952490	200		9.4 h	B+4.1,1.4,0.88; γ 1.05,1.7,2.2,2.75 3.3,4.25,4.8	2, 9, 6
		-67	66.949576	200		78 h	EC ; γ 0.090,0.092, 0.182,0.206,0.296, 0.388,0.496,0.790, 0.880	2, 9, 6
		-68	67.949640	200		68 m	B+1.9,0.8; γ 0.81, 1.06,1.24,1.88	2, 9, 6
		-69	68.947570	200	60.5			2, 9
		-70	69.948140	200		21.1 m	B⁻1.65,0.6,0.44; γ 0.1735,1.039,1.215	2, 9, 6
		-71	70.947370	200	39.5			2, 9
		-72	71.948900	250		14.3 h	B⁻0.64,0.96,1.5; γ 2.491, 2.508	
		-73 -74	72.947950	150		5.0 h 7.8 m	B⁻1.4; B⁻2.65,2.0,1.1; γ 0.30,0.50,0.59, 0.88,1.1,1.5,1.9, 2.30, 2.7	2, 9 9, 6

E Mev	σ



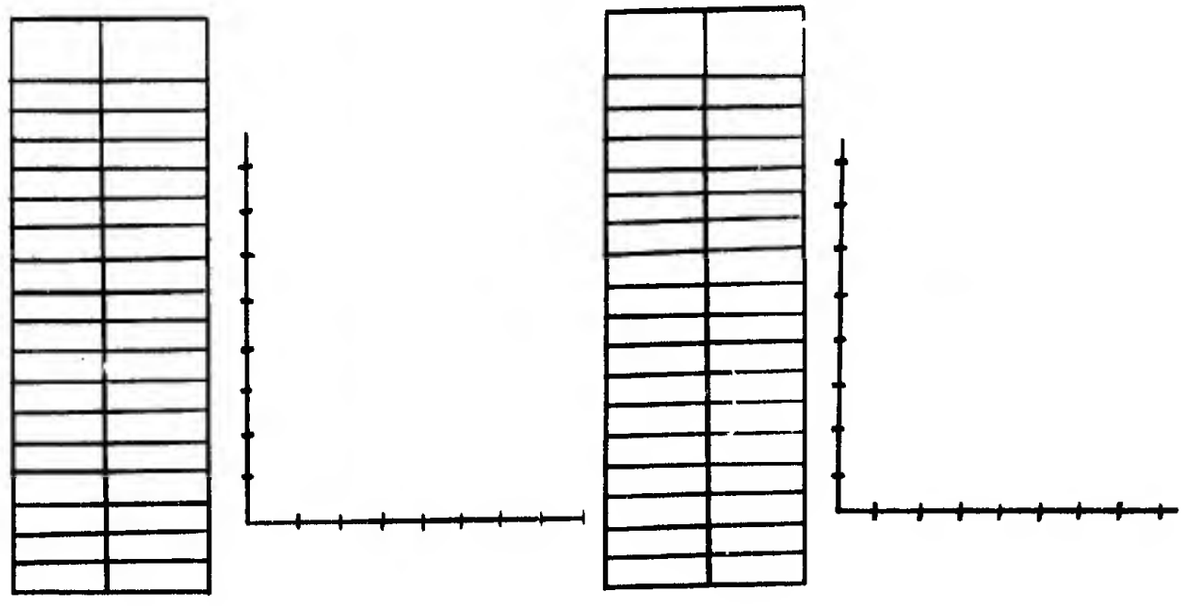
E Mev	σ



31 Ga

REMARKS

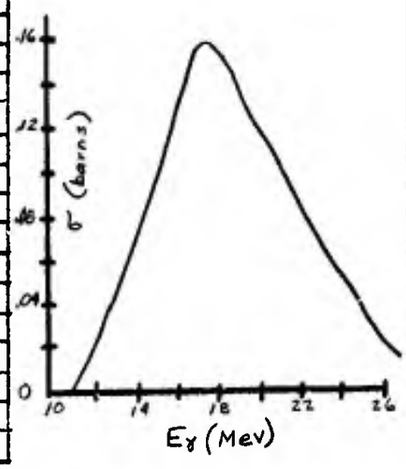
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ga^{69}	- 10,228		6
	Ga^{71}	- 9,195		6
(γ, p)	Ga^{69}	- 6,528		6
	Ga^{71}	- 7,760		6



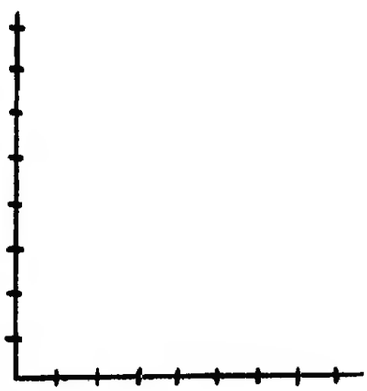
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
32	Germanium	-66				150 m	B^+ ; γ0.045,0.070 γ0.114, 0.186	2, 9
		-67	66.954330	400		21 m	B^+2.9; γ0.170, 0.68 0.86, 1.47	2, 9
		-68				280 d	EC	9
		-69	68.949970	200		40 h	EC ; β^+1.2, 0.6; γ1.61,1.34,1.12, 0.87,0.576,0.388, 0.090	2, 9
		-70	69.946370	200	20.55			
		-71	70.947634	200		11 d	EC	2, 9
		-72	71.944600	250	27.37			2, 9
		-73	72.946450	100	7.67			2, 9
		-74	73.944590	100	36.74			2, 9
	Ge75m Ref 6&9	-75	74.946620	100		82 m	B-1.14, 0.6; γ0.066 γ0.199,0.2645,0.918 0.427,0.477,0.572 0.628	2,9,6
		-76	75.945330	150	7.67			2, 9
	Ge^{77m} Ref 2	-77	76.948020	140		11.3 h	B-2.2,1.4,0.7; γ0.042,0.073,0.213 0.264,0.368,0.418 0.564,1.105,1.75	2,9,6
		-78				86 m	B-~0.9	9

E Mev	σ

$Ge^{70}(\gamma,n)_{REF.\#84}$



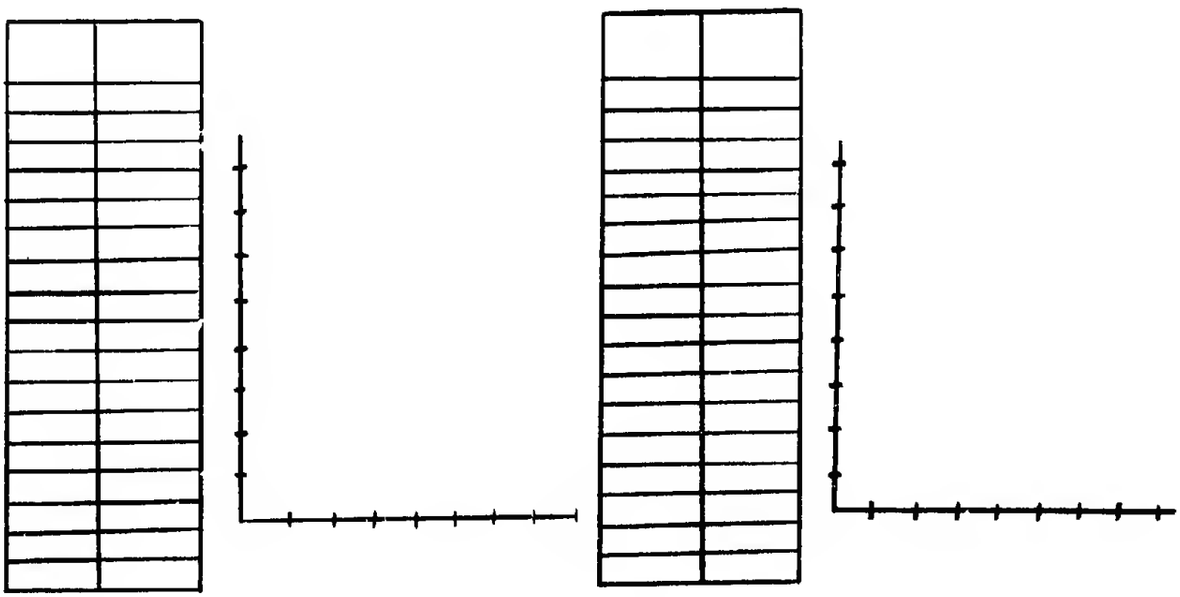
E Mev	σ



REMARKS

$_{32}Ge$

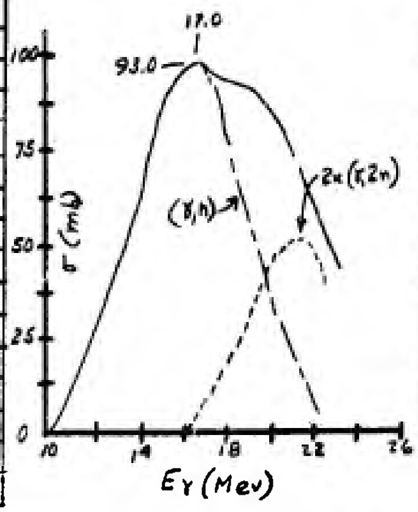
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Ge^{70}	-11.617	-11.56	6, 23
	Ge^{72}	-11.190	-11.3	6, 23
	Ge^{73}	- 6.570	- 6.4	6, 23
	Ge^{74}	-10.120	-10.14	6, 23
	Ge^{76}	- 9.450	- 9.6	6, 23
(γ,p)	Ge^{70}	- 8.597		6
	Ge^{72}	-10.174		6
	Ge^{73}	- 9.780		6
	Ge^{74}	-10.890		6
	Ge^{76}			



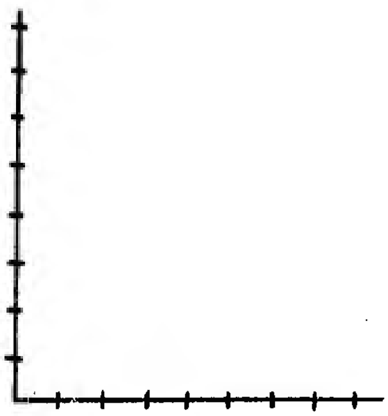
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
33	Arsenic	-68				~7 m		9
		-69				15 m	B^+2.9; γ0.23	9
		-70				52 m	B^+1.35,2.45;γ0.18 γ1.065,1.36,1.5, 1.74,2.04,2.15, 2.75,3.25	9, 6
		-71	70.949690	230		62 h	EC(K);B^+0.81,0.25; γ0.0232,0.1748	9, 2, 6
		-72	71.949280	250		26 h	EC; B^+ ; γ0.835	9, 2
		-73	72.946850	110		76 d	EC;γ0.0133,0.0535	9, 2, 6
		-74	73.947345	100		17.5 d	B^-1.36,0.7;B^+1.53, 0.9;γ0.593,0.633, 1.25	9, 2, 6
		-75	74.945400	100	100			9, 2
		-76	75.946530	100		26.4 h	B^-2.97,2.41,1.76; γ0.5605,0.646, 1.205,1.405,2.05	9, 2
		-77	76.945095	100		38.7 h	B^-0.68;	9, 2
		-78	77.946490	150		91.0 m ~40 m	B^-4.1,1.4;γ0.615	9, 2, 6
		-79	78.946050	180		9.0 m	B^-2.3	9
		-80				~36 s		9
		-85				0.43 s	n	9

E Mev	σ_{mb}
10	0
11	12.0
12	29.0
13	45.0
14	68.0
15	88.0
16	92.0
17	93.0
18	88.0
19	86.0
20	81.0
21	69.0
22	52.0
23	39.0

$As^{75}(\gamma,n)_{Ref. \#1}$



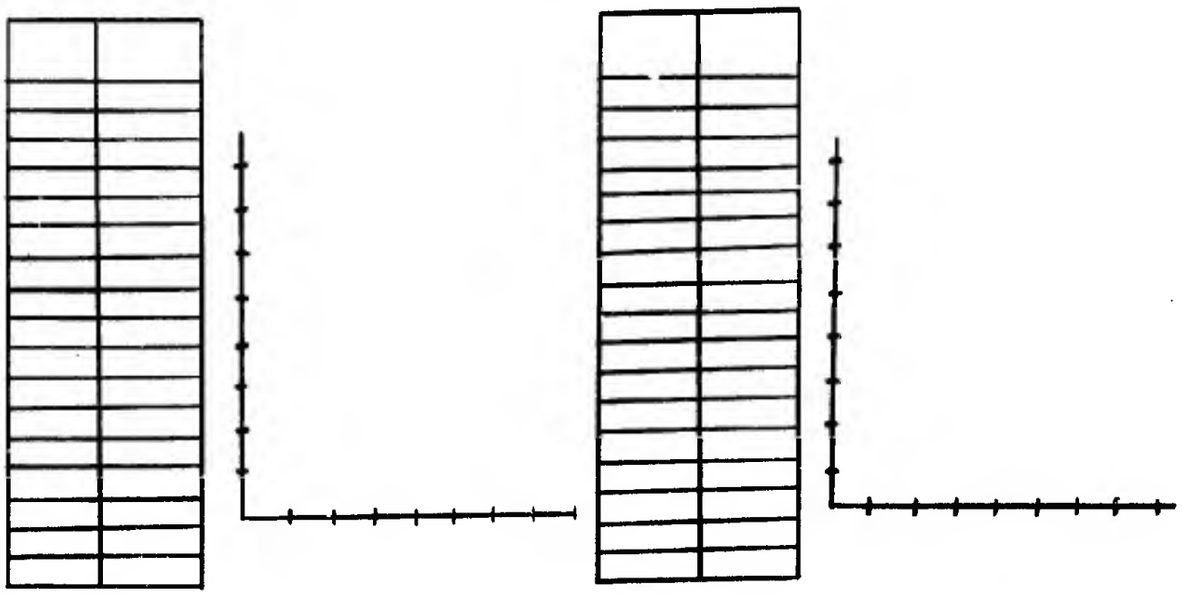
E Mev	σ



$_{33}As$

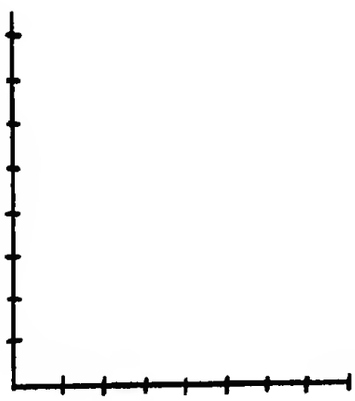
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	As^{75}	- 10.241	- 10.24	6, 22
(γ, p)	As^{75}	- 6.894		6

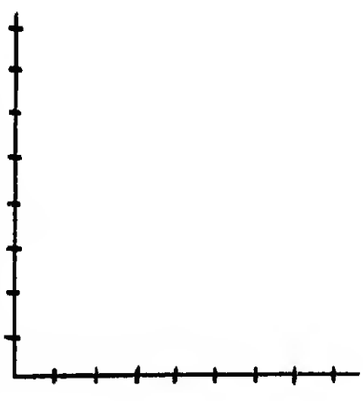


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
34	Selenium	-70				~44 m	B^+	9
		-71				4.5 m	B^+ 3.4; γ 0.160	9, 6
		-72				8.4 d	EC; γ 0.048	9, 6
		-73	72.949830	110		7.1 h	B^+; γ 0.0665, 0.360	2, 9
						44 m	B^+ 1.7	2, 9
		-74	73.945890	100	0.87			2, 9
		-75	74.946333	100		121 d	EC; γ 0.067, 0.077, 0.098, 0.124, 0.138, 0.203, 0.269, 0.281, 0.308, 0.405	2, 9, 6
		-76	75.943340	100	9.02			2, 9
		-77	76.944360	100	7.58			2, 9
		-78	77.942090	100	23.52			2, 9
		-79	78.943580	150		$\leq 6.5 \times 10^4$ y	B^- 0.16	2, 9
		-80	79.941980	200	49.82			2, 9
		-81	80.943580	210		18.2 m	B^- 1.38	2, 9
		-82	81.942610	150	9.19	$>10^{17}$ y		
		-83				25 m	B^- 1.5; γ 0.04, 0.061, 0.173, 0.36, 0.950, 1.1	9, 6
						70 s	B^- 3.4; γ 0.35, 0.650, 1.01, 2.02	9
		-84				3.3 m	B^-	9
		-85				40 s	B^-	9
		-86 -87				17 s	B^-	9

E Mev	σ

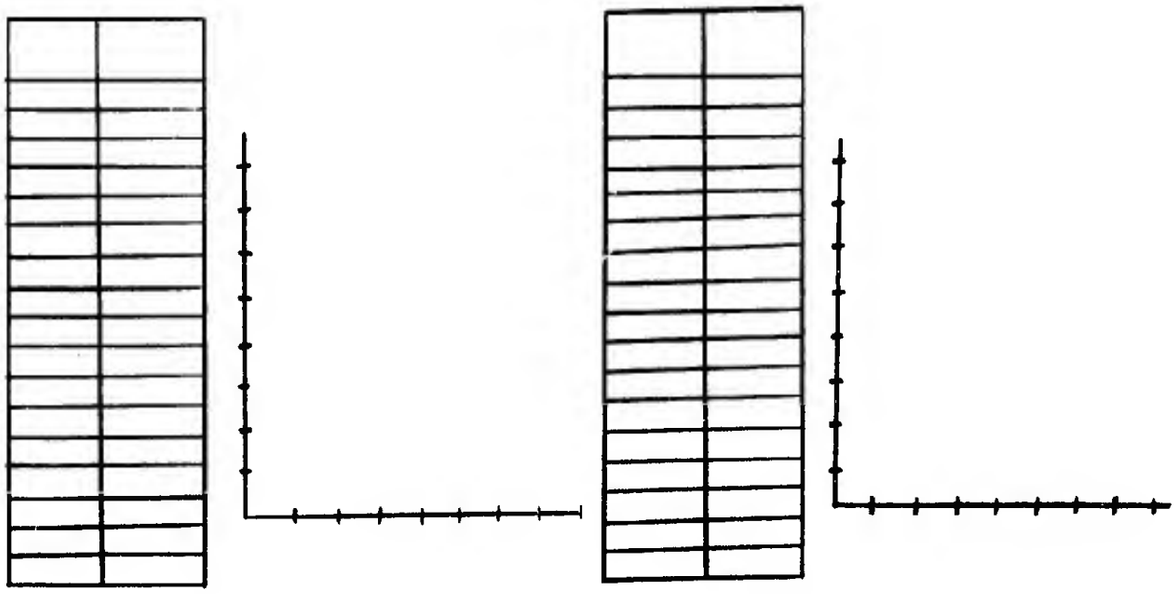


E Mev	σ



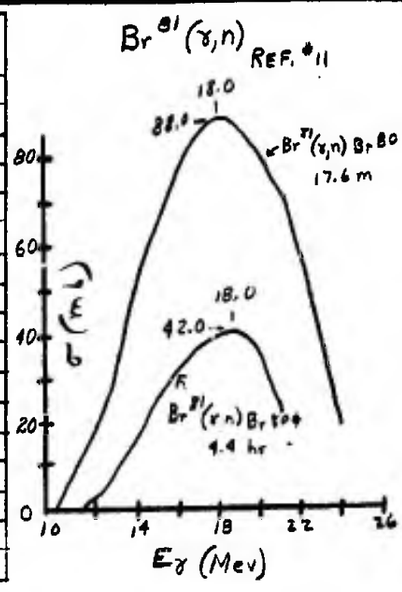
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Se^{76}	-11.126		6
	Se^{77}	- 7.415		6
	Se^{78}	-10.480		6
	Se^{80}	- 9.942		6
	Se^{82}	- 9.190		6
(γ, p)	Se^{76}	- 9.477		6
	Se^{77}	- 9.602		6
	Se^{78}	-10.381		6
	Se^{80}	-11.460		6
	Se^{82}			

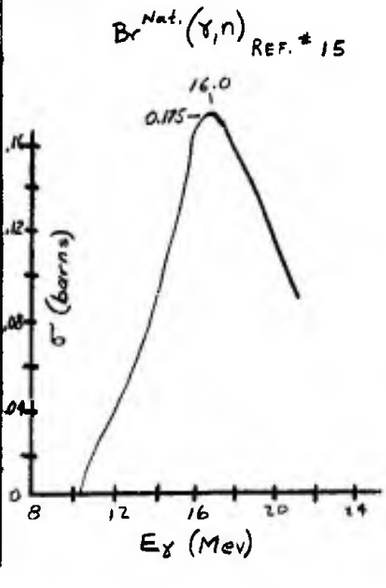


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
35	Bromine	-74				36 m	B+; γ 0.64	9
		-75	74.949260	100		1.6 h	B+1.7,0.8,0.6,0.3; γ 0.29	2, 9
		-76	75.948270	130		17.2 h	B+3.57,1.7,1.1,0.8, 0.6; γ 0.25,0.33,0.37 0.42,0.56,0.67,0.75 0.96,1.20	2, 9, 6
		-77	76.945818	100		57 h	EC; B+0.34; γ 0.237, 0.520,0.641,0.813	2, 9, 6
		-78	77.945850	180		< 6 m	B+2.4	2, 9
		-79	78.943410	150	50.52			2, 9
		-80	79.944010	200		17.6 m	B-1.99; B+0.87; γ 0.62	2, 9
		-81	80.942080	200	49.48			2, 9
		-82	81.942680	210		36 h	B-0.44; γ 0.55,0.611, 0.69,0.76,0.822, 1.030,1.3,1.46	2, 9, 6
		-83	82.941392	200		2.3 h	B-0.940; γ 0.048	2, 9, 6
		-84	83.943085	200		31.8 m	B-4.68,3.56,2.53, 1.72; γ 0.89,1.89	2, 9
		-85	84.942610	230		3.0 m	B-2.5	2, 9
		-87	86.949870	600		55.6 s	B-2.6; n 0.25; γ 5.4	2, 9
		-88				15.5 s	B-	9
		-89				4.51 s	B-; B-n 0.43	9
		-90				1.4 s	n	9

E Mev	σ_{mb}
10	0
11	8
12	19
13	32
14	51
15	65
16	79
17	84
18	88
19	83
20	78
21	68
22	51
23	36
24	20



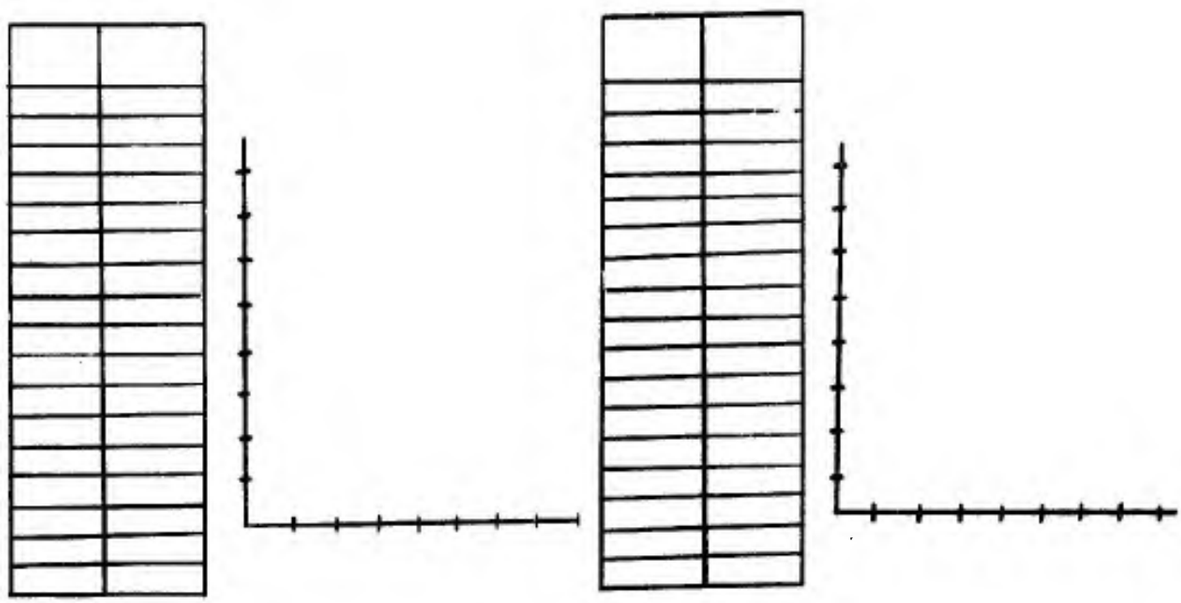
E Mev	σ_{barns}
10	0
11	0.02
12	0.04
13	0.06
14	0.095
15	0.13
16	0.17
17	0.162
18	0.15
19	0.132
20	0.11
21	0.09



$_{35}Br$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Br^{79}	-10,600		6
	Br^{81}	-10.117		6
(γ, p)	Br^{79}	-6.357		6
	Br^{81}	-7.445		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
36	Krypton	-76				9.7 h	EC; γ 0.028,0.093, 0.267, 0.316,0.4	9, 6
		-77	76.948910	100		1.1 h	EC;B+1.86,1.67;γ	2, 9
		-78	77.944890	200	0.354			2, 9
		-79	78.945150	150		34.5 h	EC;B+0.6; γ 0.263, 0.044	2, 9, 6
		-80	79.941860	200	2.27			2, 9
		-81	80.942250	270		2.1×10^5 y	EC; γ 0.012	2, 9
		-82	81.939400	200	11.56			2, 9
		-83	82.940340	200	11.55			2, 9
		-84	83.938060	200	56.90			2, 9
		-85	84.939600	200		10.3 y	B-0.67; γ 0.517	2, 9
		-86	85.938210	200	17.37			2, 9
		-87	86.941280	180		78 m	B-3.8,~3.3,1.3; γ 0.4,0.85	2, 9, 6
		-88	87.942470	240		2.8 h	B-2.8; γ 0.191, 0.85, 2.40	2, 9, 6
		-89	88.944790	360		3.18 m	B-4.0	9,
		-90				33 s	B-3.2	9
		-91				9.8 s	B- ~3.6	9
		-92				3.0 s	B-	9
		-93				2.0 s	B-	9
		-94				1.4 s	B-	9

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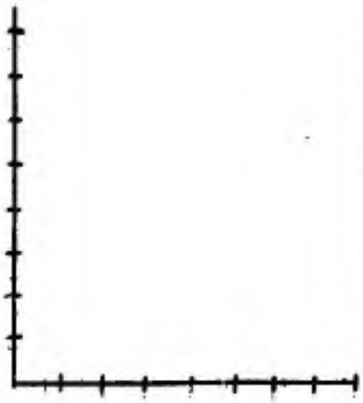
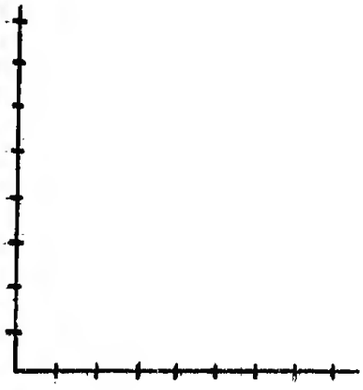
E Mev	σ



E Mev	σ



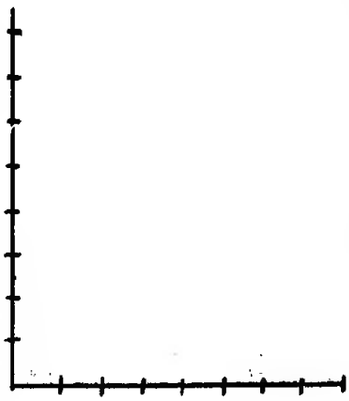
$_{36}Kr$

Z	CHEM. SYM.	A	ATOMIC MASS AMU ±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
36	Krypton	-95			Short	B-	9
		-97			~1 s	B-	9

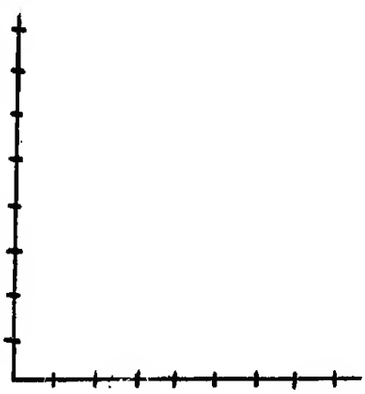
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Kr^{84}	- 10.518		6
	Kr^{86}	- 9.760		6
(γ,p)	Kr^{84}	- 10.735		6
	Kr^{86}	- 11.780		6
(γ,α)	Kr^{84}	- 7.090		6

E Mev	σ



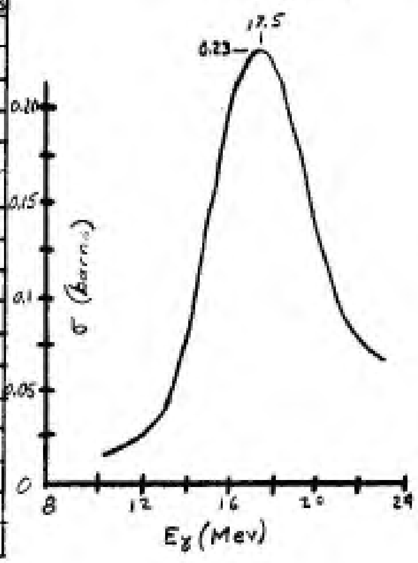
E Mev	σ



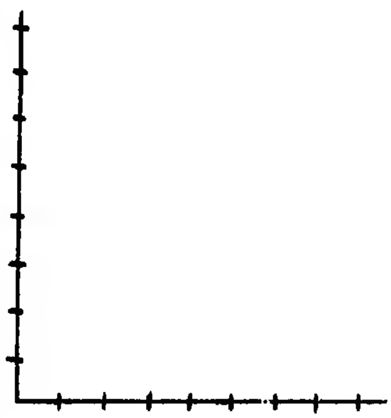
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
37	Fubidium	-79				24 m	B+; γ0.15	9
		-80				8 d		9
81m	Fef 9 0.085	-81	80.944610	280		4.7 h	EC; B+; γ0.253, 0.450, 1.03	2, 9, 6
82m	Ref. #9	-82	81.943550	500		1.25 m	B+3.15	2, 9
		-83				83 d	EC; γ0.525	9
84m	Fef. #9	-84	83.940900	200		33 d	EC; B+; B-0.91; γ0.89	2, 9
		-85	84.938880	200	72.15			2, 9
86m	Ref. #9	-86	85.938521	200		18.66 d	B-1.78; γ0.527, 1.080	2, 9, 6
		-87	86.936870	150	27.85	$5x10^{10}$y	B-0.275	2, 9
		-88	87.939300	210		17.8 m	B-5.3, 3.6, 2.5; γ2.8, 1.86, 0.9	2, 9
		-89	88.940490	350		15.4 m	B-3.92, 2.8; γ0.663, 1.05, 1.26	2, 9, 6
		-90	89.941900	350		2.74 m	B-5.7; γ	2, 9
		-91				1.67 m	B-4.6	
						14 m	B-3.0	9
		-92				80 s	B-	9
		-93				Short	B-	9
		-94				Short	B-	9
		-95				Short	B-	9
		-97				Short	B-	9

E Mev	σ barns
10	
11	0.02
12	0.025
13	0.04
14	0.07
15	0.125
16	0.18
17	0.225
18	0.225
19	0.19
20	0.14
21	0.10
22	0.08
23	0.07

$Rb^{87}(\gamma,n)$ Ref. #12



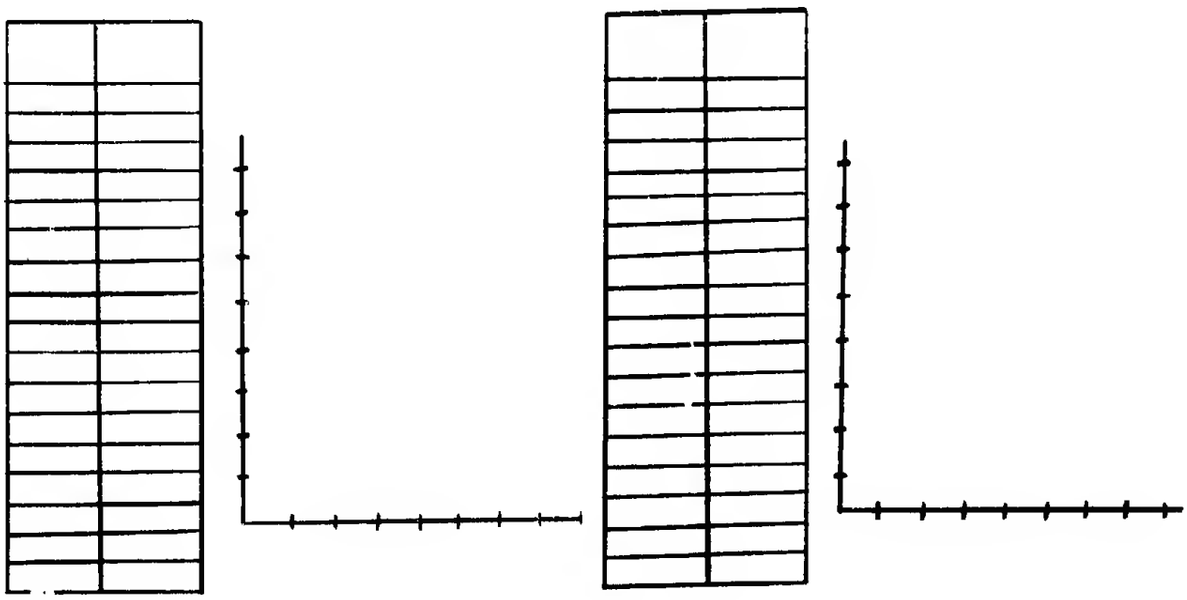
E Mev	σ



$_{37}Rb$

REMARKS

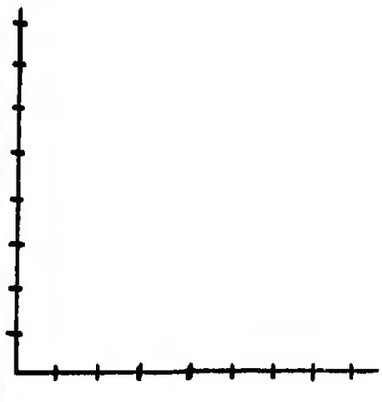
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Rb^{85}	-10.530	- 10.26	6, 23
	Rb^{87}	- 9.918	- 9.91	6, 23
(γ, p)	Rb^{85}	- 7.100		6
	Rb^{87}	- 8.630		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
38	Strontium	-81				29 m	EC; B+	9
		-82				25.5 d	EC; γ0.95, .4, .15	9
		-83				33 h	EC; B+1.15; γ0.040 0.074,0.101,0.151 0.165	9, 6
		-84	83.939860	250	0.56			2, 9
	85^m Ref. #9	-85	84.940000	500		64.0 d	EC; γ0.5133	2,9,6
		-86	85.936620	200	9.86			2, 9
	87^m Ref. 9	-87	86.936576	150	7.02			2, 9
		-88	87.933750	200	82.56			2, 9
	89^m Ref. #9	-89	88.935655	200		50.5 d	B-1.463	2, 9
		-90	89.935773	200		27.7 y	B-0.545	2, 9
		-91	90.938667	200		9.67 h	B-2.67,2.03,1.36, 1.09; γ0.551,0.645 0.748,0.93,1.025, 1.913	2,9,6
		-92	91.939650	240		2.6 h	B-0.55; γ0.23,0.44, 1.37	2,9,6
		-93				8.2 m	B⁻	9
		-94				1.3 m	B⁻	9
		-95				~0.7 m	B⁻	9
		-97				Short	B⁻	9

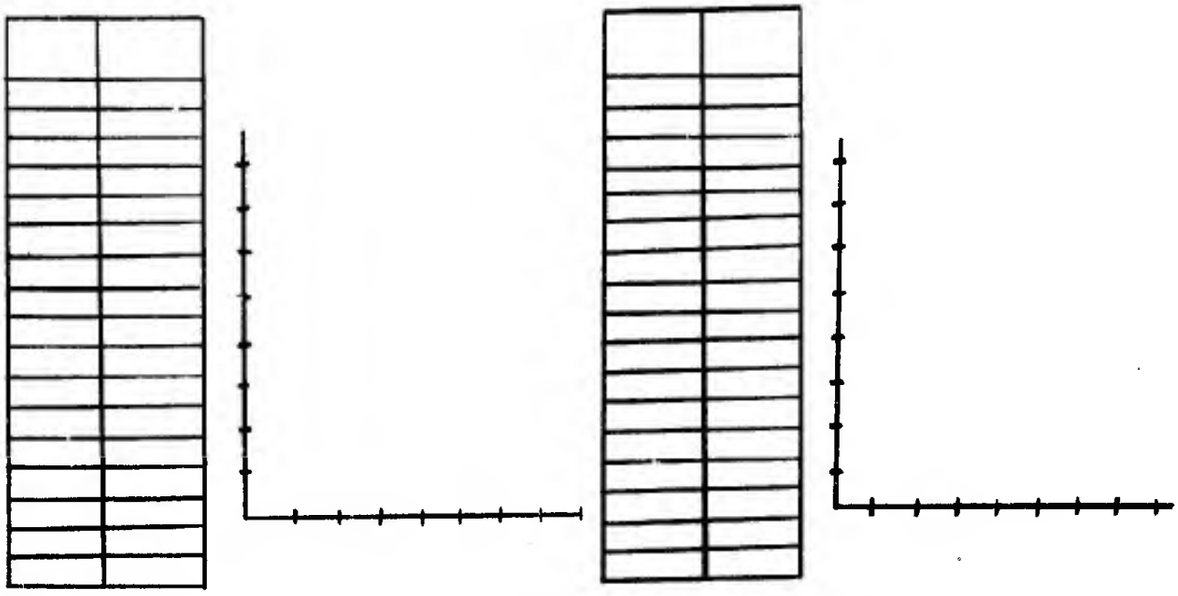
E Mev	σ

E Mev	σ



REMARKS

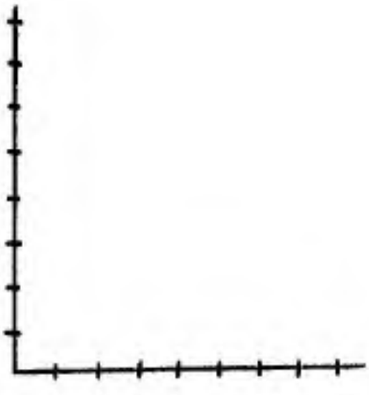
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Sr^{86}	-11.460	-11.5	6, 39
	Sr^{87}	- 8.418		6
	Sr^{88}	-11.124		6
(γ,p)	Sr^{86}	- 9.570		6
	Sr^{87}	- 9.408		6
	Sr^{88}	-10.614		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
39	Yttrium	-82				70 m		9
		-83				3.5 h		9
		-84				3.7 h	B+2.0	9
		-85				5 h		9
		-86	85.941130	230		14.6 h	B+1.8,1.19;δ0.18 0.635,1.08,1.93	2,9,6
87m	Ref.9	0.384	-87	86.938390	270		80 h	EC;B+0.7;δ0.388, 0.484	2,9,6
		-88	87.937770	200		104 d	EC; B+0.58; δ0.9082,1.87,2.76	2, 9
89m	Ref.9	0.914	-89	88.934080	200	100			2, 9
		-90	89.935200	200		64.2 h	B-2.26; δ1.739	2, 9
91m	Ref.9	0.551	-91	90.935805	200		57.5 d	B-1.537; δ1.21	2, 9
		-92	91.937580	240		3.60 h	B-3.60,2.7,1.3; 0.21,0.48,0.94, 1.45,1.9,2.4	2,9,6
		-93	92.938660	330		10.4 h	B-2.88;δ0.7	2, 9
		-94	93.941600	480		16.5 m	B-5.4; δ1.4	9
		-95				10.5 m	B-	
		-97				Short	B-	9

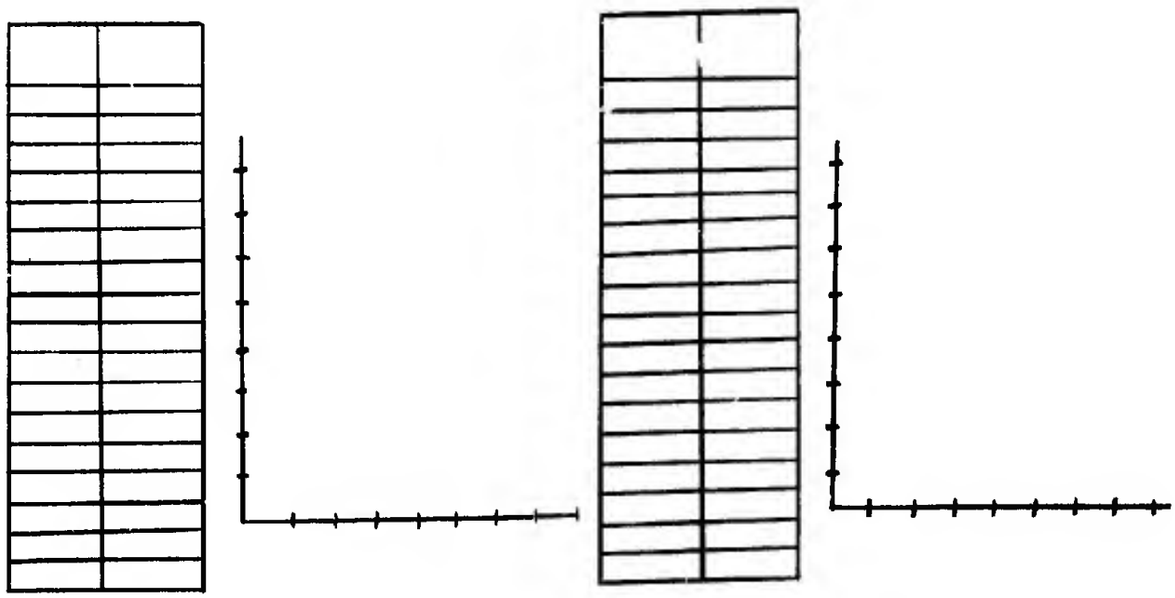
E Mev	σ

E Mev	σ



REMARKS

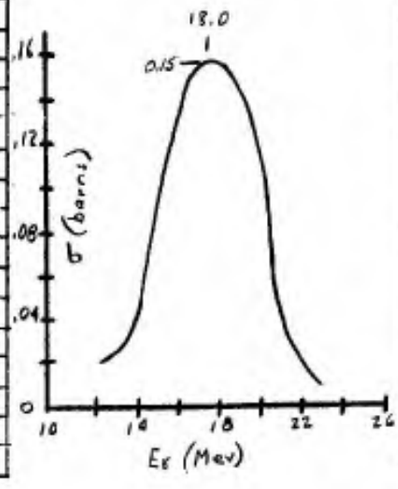
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Y^{89}	- 11.686	- 11.82	6, 22
(γ, p)	Y^{89}	- 7.456		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
40	Zirconium	-86				17 h	EC; γ 0.241	9
		-87	86.942160	270		94 m	B^+ 2.10; γ 0.65, 0.35	9, 2
		-88				85 d	EC; γ 0.394	9
89m Ref. 9 0.588, 1.53		-89	88.937131	200		79.3 h	IT; EC; B^+; γ	2, 9
90m Ref. 9		-90	89.932840	200	51.46			2, 9
		-91	90.934140	200	11.23			2, 9
		-92	91.833820	210	17.11			2, 9
		-93	92.935327	240		1.1×10^6 y	B- 0.056	2, 9
		-94	93.935800	350	17.40			2, 9
		-95	94.937906	400		65 d	B- 0.360, 0.396; γ 0.723, 0.757	2, 9, 6
		-96	95.938530	500	2.80			2, 9
		-97	96.941420	500		17.0h	B- 1.91; γ 0.747	2, 9
		-99				30 s	B-	9

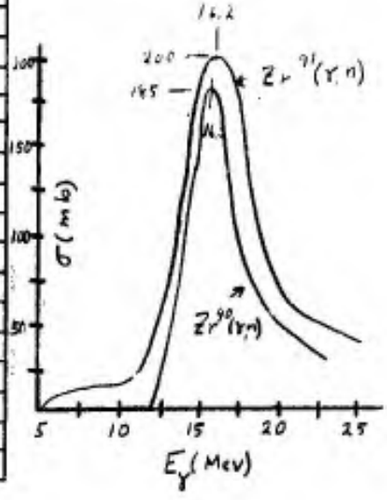
E Mev	σ_{barns}
12	
13	0.025
14	0.045
15	0.08
16	0.13
17	0.15
18	0.15
19	0.14
20	0.10
21	0.04
22	0.02
23	0.01

$Zr^{90}(\gamma,n)Zr^{89*}$ Ref.* 12



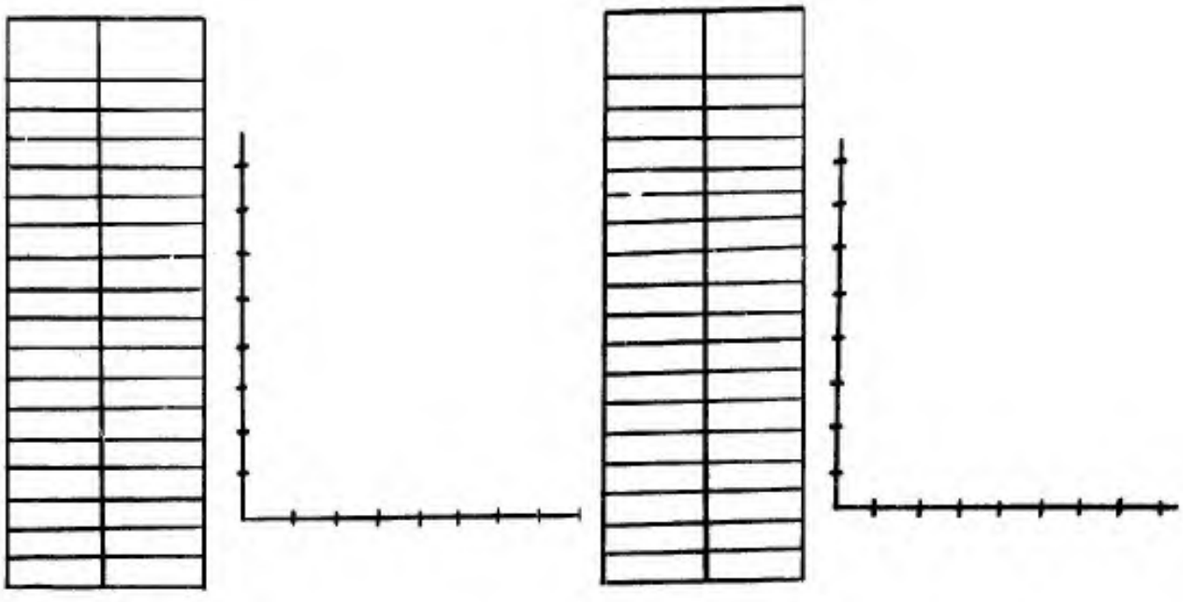
E Mev	σ

Ref* 96



$_{40}Zr$

Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference
(γ, n)	Zr^{90}	-11.949	-11.78	6, 39
	Zr^{91}	- 7.205	-7.2	6, 96
	Zr^{92}	- 8.683		6
	Zr^{94}	- 8.020		6
(γ, p)	Zr^{90}	- 8.324		6
	Zr^{91}	- 8.680		6
	Zr^{92}	- 9.450		6
	Zr^{94}	-10.130		6

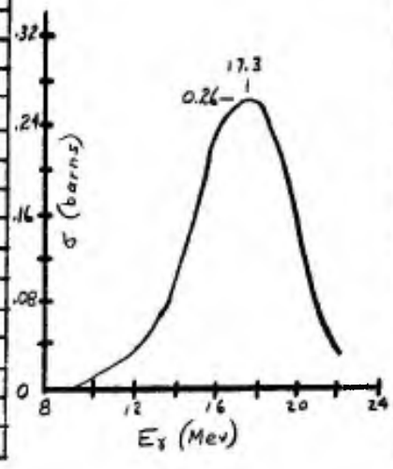


41 Nb

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
41	Niobium	-89				1.9 h	B+2.9	9
	Columbium	-90	89.937610	220		14.6 h	B+; γ 0.1',1.14,2.23	2, 9, 6
		-91	90.935630	320		Long	EC	2, 9
		-92	91.935610	300		10.1 d	EC; γ 0.90,0.931, 1.835	2, 9, 6
		-93	92.935260	240	100			2, 9
		-94	93.936520	250		1.8×10^4y	B⁻0.50; γ 0.71,0.89 1.61	2, 9, 6
		-95	94.936700	400		35 d	B⁻0.158; γ 0.768	2, 9
		-96	95.938261	430		23.35 h	B⁻0.750, 0.37; γ 0.453, 0.55, 0.76 1.06	2, 9, 6
		-97	96.938550	500		72.1 m	B⁻1.27; γ 0.665,1.02	2,9,6
		-98				26.0 m	B⁻	9
		-99				3.8 m	B⁻3.2	9

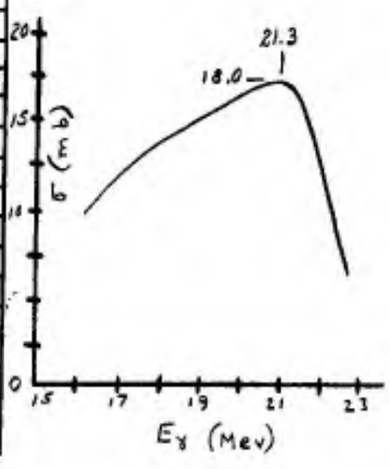
E Mev	σ barns
8	0
9	0+
10	0.01
11	0.03
12	0.04
13	0.07
14	0.12
15	0.17
16	0.24
17	0.255
18	0.25
19	0.22
20	0.15
21	0.08
22	0.03

$Nb^{93}(\gamma,n)_{REF.\ \#1}$



E Mev	σ mb
14	
15	
16	9.5
17	12.0
18	13.5
19	15.0
20	17.0
21	18.0
22	13.0

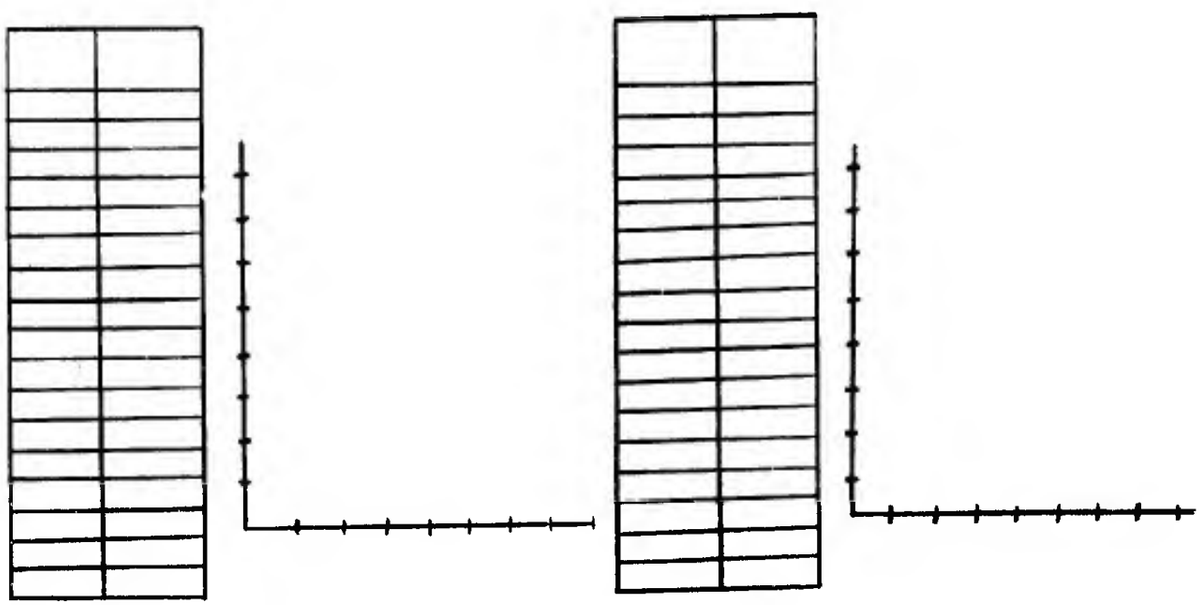
$Nb^{93}(\gamma,P)_{REF.\ \#21}$



$_{41}Nb$

REMARKS

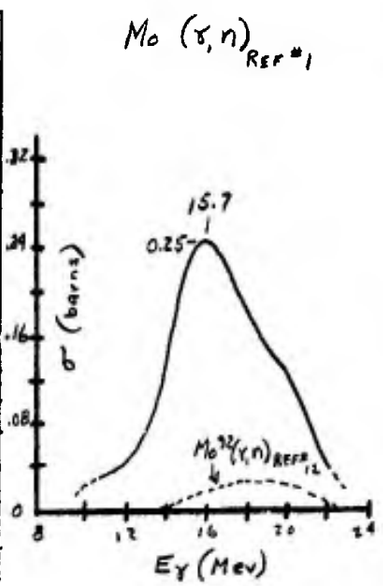
Thresholds	Isotope	Theoretical	Experimental	Reference
(Y,n)	Nb^{93}	- 8.818	- 8.86	6, 22
(Y,p)	Nb^{93}	- 5.962		6



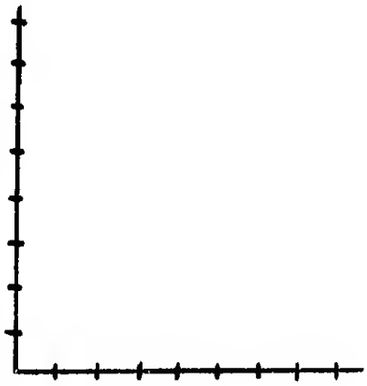
42 Mo

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
42	Molybdenum	-90	89.940600	280		5.7 h	B+1.2;EC;γ0.12,0.25	2,9,6
		-91	90.939490	340		15.5 m	B+3.44	2,9
		-92	91.935210	290	15.86			2,9
		-93	92.935730	290		> 2 y	EC;	2,9
		-94	93.934330	270	9.12			2,9
		-95	94.935700	400	15.70			2,9
		-96	95.934900	430	16.50			2,9
		-97	96.936470	500	9.45			2,9
		-98	97.936560	500	23.75			2,9
		-99	98.939997	400		66.0 h	B-1.18,0.8,0.41; γ0.140,0.181,0.739	2,9,6
		-100	99.938280	500	9.62			2,9
		-101				14.6 m	B-2.23; γ0.191, 0.960	9,6
		-102				11.5 m	B-	9
		-105				< 2 m	B-	9

E Mev	σ_{mb}
10	25.0
11	32.0
12	48.0
13	70.0
14	140.0
15	220.0
16	245.0
17	220.0
18	180.0
19	150.0
20	125.0
21	90.0
22	50.0

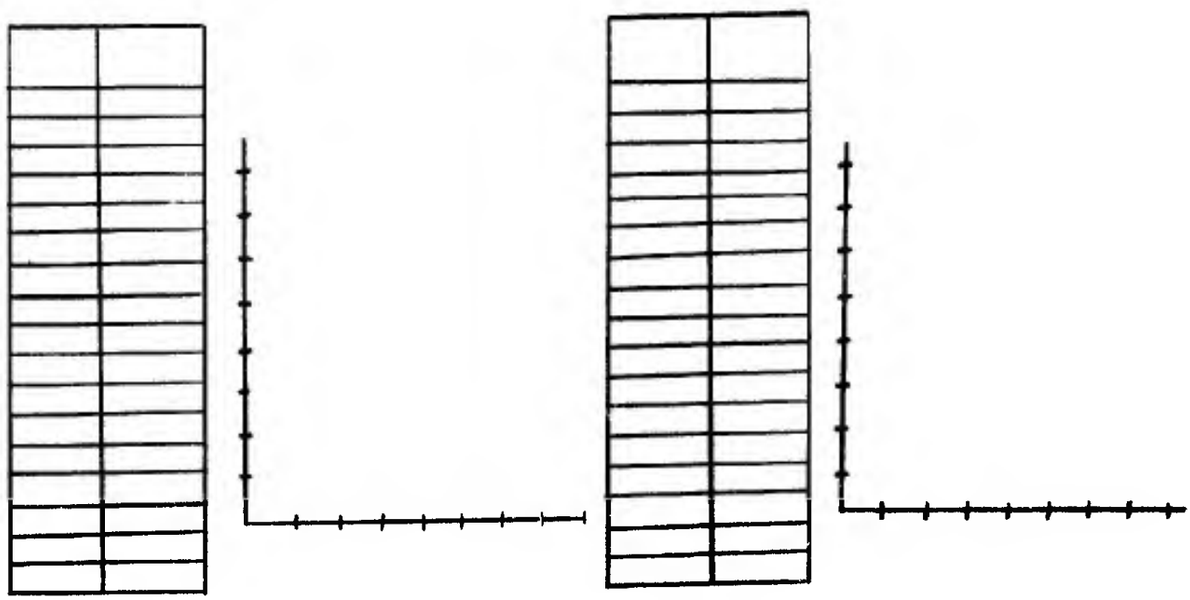


E Mev	σ



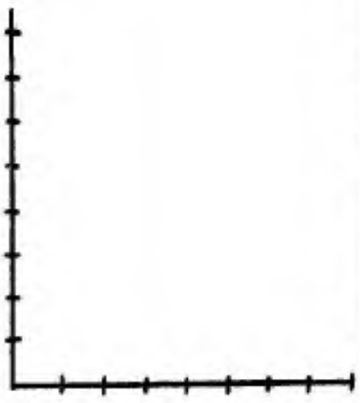
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Mo^{92}	-13.140	-13.1	6, 1
	Mo^{95}	- 7.160		6
	Mo^{96}	- 9.160		6
	Mo^{98}	- 8.296		6
(γ, p)	Mo^{92}	- 7.910		6
	Mo^{95}	- 8.450		6
	Mo^{96}	- 9.304		6
	Mo^{98}	- 9.440		6

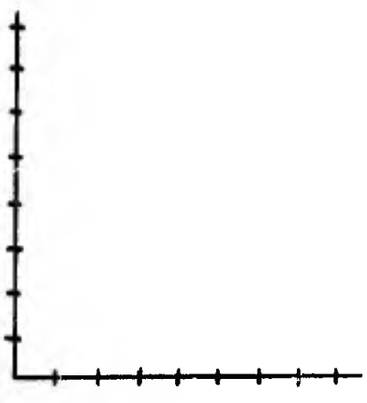


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
43	Technetium	-92	91.942080	750		4.3 m	B+4.1; γ 1.3	2, 9
		-93	92.939100	290		2.75 h	B+0.8; γ 1.35, 1.5, 2.0	2, 9
		-94	93.938980	400		53 m	B+2.41; γ	2, 9
		-95	94.937451	400		20.0 h	γ 0.762, 0.932, 1.071	2, 9
		-96	95.938230	60		4.20 d	γ 0.312, 0.770, 0.809 0.841, 1.118, 1.65, 1.89, 2.39	2, 9, 6
		-97				2.6×10^6 y		2, 9
		-98				1.5×10^6 y	B- 0.30; γ 0.655, 0.745	2, 9, 6
		-99	98.938515	900		2.12×10^5 y	B- 0.29	2, 9
		-100				15.8 s	B- ; γ 0.55	2, 9
		-101				14.0 m	B- ; γ 0.307	2, 9
		-102				5 s	B- 4.4; γ 0.47	2, 9, 6
		-102				4.5 m	B- 2	
		-103				1.2 m		2, 9
		-104				18 m	B- ~3.02; γ 0.310 0.360, 0.490, 0.680, 0.870	2, 9, 6
		-105				10 m	B-	2, 9
		-107				<1.5 m	B-	2, 9

E Mev	σ



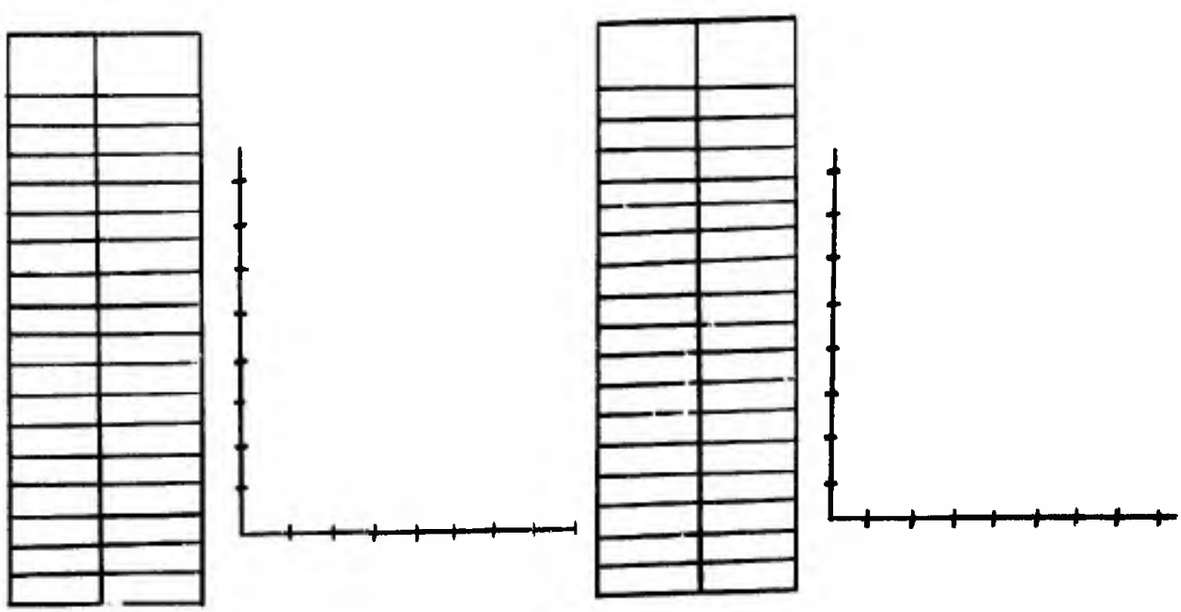
E Mev	σ



$_{43}Tc$

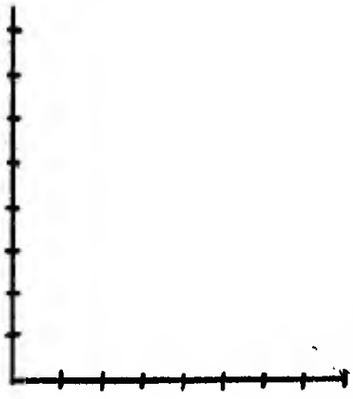
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Tc^{98}			
	Tc^{99}	-8.900		6
(γ, p)	Tc^{98}	-5.800		6
	Tc^{99}	-6.500		6

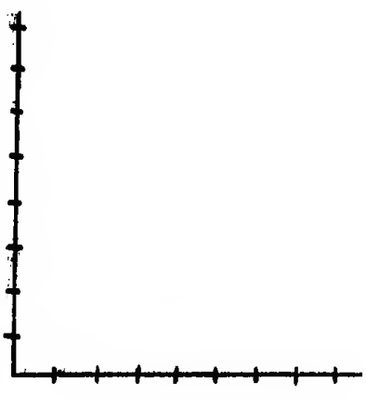


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
44	Ruthenium	-93						
		-94				~57 m	EC	2
		-95	94.939700	450		1.65 h	EC; B+1.1; γ 0.145, 0.340, 0.640, 1.053	2, 6
		-96	95.937920	500	5.57			2, 9
		-97				2.8 d	EC; γ 0.1091, 0.2180, 0.325, 0.567	2, 6
		-98	97.937130	650	1.91			9
		-99	98.938200	900	12.7			9
		-100			12.7			9
		-101			17.0			9
		-102	101.936410	500	31.5			9
		-103	102.938704	500		39.8 d	B⁻0.217, 0.698, 0.497, 0.610	2, 6
		-104	103.937800	700	18.5			9
		-105	104.940845	500		4.5 h	B⁻1.150; γ 0.265, 0.315, 0.400, 0.670, 0.725, 0.870, 0.960	2
		-106	105.940232	500		1.0 y	B⁻0.0392	2
		-107				4 m	B⁻~4; 0.22	9
		-108						

E Mev	σ



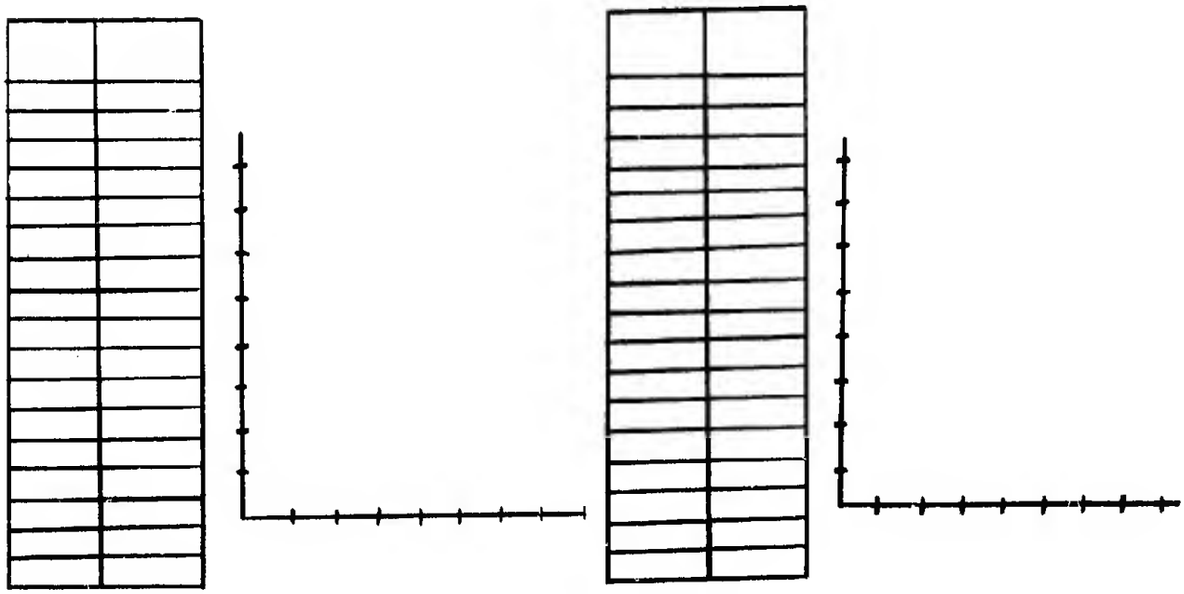
E Mev	σ



$_{44}Ru$

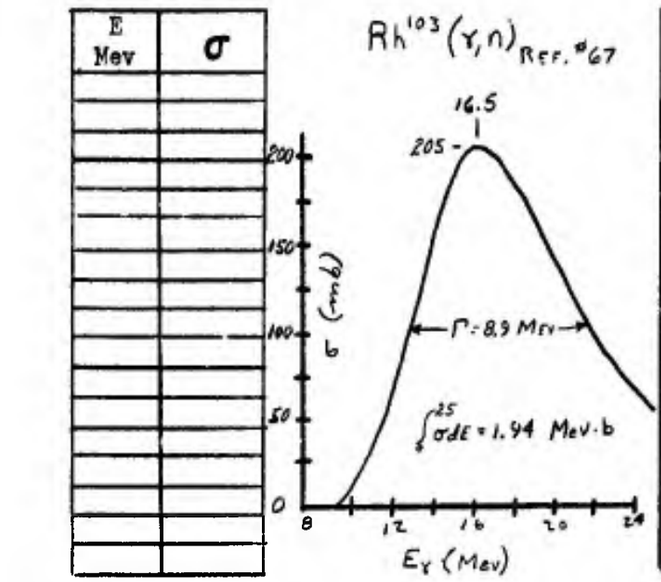
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ru^{96}	- 10,200		6
	Ru^{104}	- 8,150		6
(γ, p)	Ru^{96}	- 7,200		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
45	Rhodium	-97						
		-98					B^+ ; γ0.650	2, 6
		-99				4.5 h	B^+0.74;EC; γ0.286 0.34,0.62,0.89, 1.26,1.41	2, 6
		-100				9.4 h	EC; B^+3.0; γ1.2	2, 6
		-101				4.3 d	EC; γ0.146;0.30	2, 6
		-102	101.938750	500		210 d	B^-1.0;B^+1.1; γ	2
		-103	102.937900	500	100			
		-104	103.939600	700		44 s	B^-2.6; γ0.555,1.18	
		-105	104.938692	500		36.5 h	B^-0.570,0.25; γ0.08 0.16,0.22,0.31, 0.316,0.415,0.550	2, 6
		-106	105.940190	500		30 s	B^-3.53,3.1,2.44,2.0; γ0.513, 0.624	2
		-107	106.940240	410		26 m	B^-1.2; γ0.305,0.388	6
		-108					B^- ; γ0.43	6
		-109				<1 h	B^-	

E Mev	σ

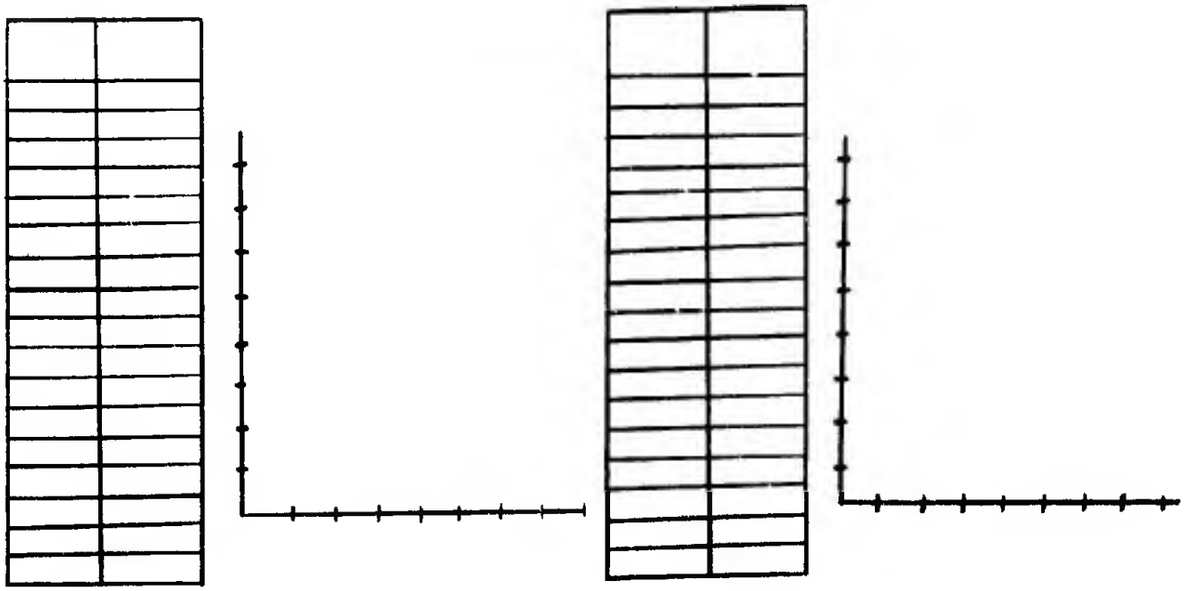


E Mev	σ

$_{45}Rh$

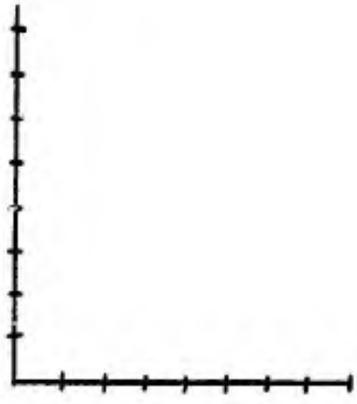
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Rh^{103}	- 9.327		6
(γ, p)	Rh^{103}	- 6.274		6

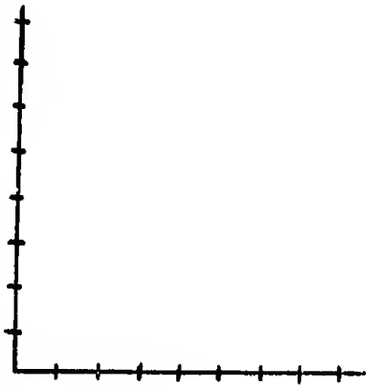


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
46	Palladium	-98					EC; γ0.132	6
		-99					B+ ; γ0.140,0.275, 0.420, 0.670	6
		-100				4.0 d	EC; γ0.085	2, 6
		-101				8 h	EC,B+2.3; γ0.288, 0.590,0.720,1.19, 1.28	2, 6
		-102	101.937530	500	0.96			9
		-103	102.938500	500		17.0 d	EC; γ0.324,0.364, 0.402	6
		-104	103.936370	500	10.97			9
		-105	104.938080	500	22.2			9
		-106	105.936400	500	27.3			9
		-107	106.938948	400		$\sim 7 \times 10^6$ y	B $\sim$0.04	9
		-108	107.937800	400	26.7			9
		-109	108.940510	400		13.6 h	B-0.961; γ0.314, 0.412,0.640,0.770	6
		-110	109.939600	500	11.8			9
		-111	110.942890	530		22 m	B-2.13	2
		-112	111.942770	510		21 h	B-0.2; γ0.018	6
		-113						
		-114						
		-115						

E Mev	σ



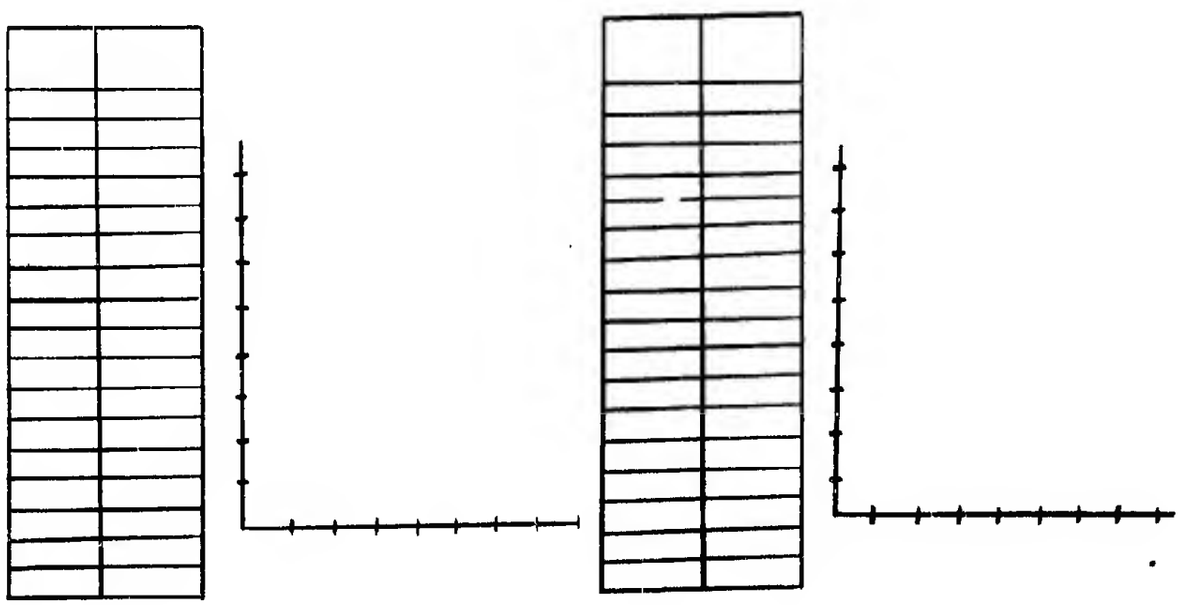
E Mev	σ



REMARKS

$_{46}Pd$

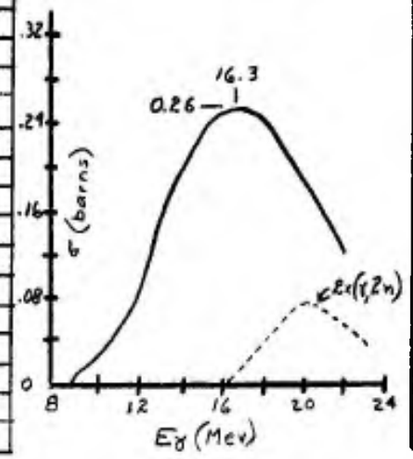
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Pd^{104}	-9.790		6
	Pd^{105}	-7.070		6
	Pd^{106}	-9.410		6
	Pd^{108}	-9.080		6
	Pd^{110}	-9.370		6
(γ, p)	Pd^{104}	-8.448		6
	Pd^{105}	-8.720		6
	Pd^{106}	-9.190		6
	Pd^{108}	-9.800		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
47	Silver	-102				16 m		9
		-103				66 m	B+1.3;EC;γ0.549, 0.764	9, 6
		-104	103.910870	510		1.2 h	B+	2, 9
						27 m	B+2.7;γ0.1184, 0.5562	2, 9, 6
		-105	104.940500	750		40 d	EC;γ0.0625,0.280, 0.343,0.440	2, 9, 6
		-106	105.939590	500		8.2 d	EC;γ0.220,0.409, 0.511,0.620,0.717, 0.815	9
						24.0 m	B+1.95;B-0.36;γ0.512	2, 9, 6
		-107	106.938910	400	51.35			2, 9
		-108	107.910090	400		2.3 m	B-1.77;EC;γ0.42, 0.62	2, 9, 6
		-109	108.939340	400	48.65			2, 9
		-110	109.911390	400		253 d	B-;γ0.66,0.72,0.81 0.88,0.95	2, 9, 6
		-111	110.940580	520		7.6 d	B-1.04,0.79,0.69; γ0.245,0.337	2, 9, 6
		-112	111.942450	510		3.2 h	B-4.1,3.5,2.7,1.0; γ0.618, 1.39	2, 9, 6
		-113	112.942280	510		5.3 h	B-2.0;γ	2, 9
		-114				5 s	B-4.6; γ0.57	2, 9, 6
						2 m	B-	9

E Mev	σ

$Ag^{n}(\gamma,n)_{REF.\ \#1}$



E Mev	σ

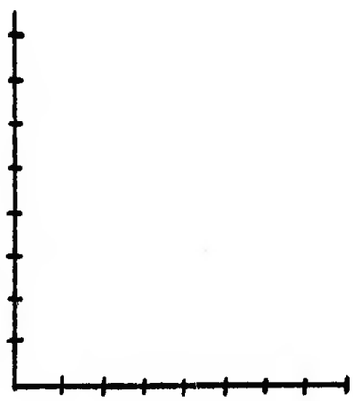
E_{th} $(\gamma,n)Ag^{107}$=9.5 Mev.
E_{th} $(\gamma,n)Ag^{109}$=9.0 Mev.

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
47	Silver	-115	114.945280	.50		21.1 m	β^- 2.9; γ 0.138, 0.227	2, 9, 6
	(Cont'd)	-116				2.5 m	β^- 5.0; γ 0.70, 0.52	9
		-117				1.1 m	β^-	9

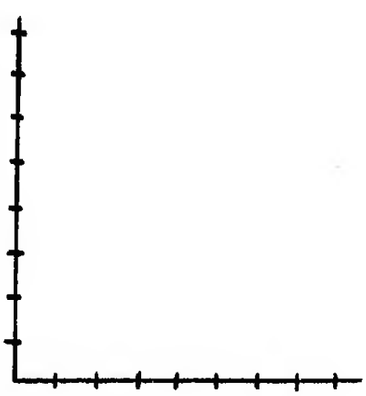
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ag^{107}	-9.391	-9.353	6, 48
	Ag^{109}	-9.180	-9.196	6, 48
(γ, p)	Ag^{107}	-5.638		6
	Ag^{109}	-6.560		6

E Mev	σ



E Mev	σ

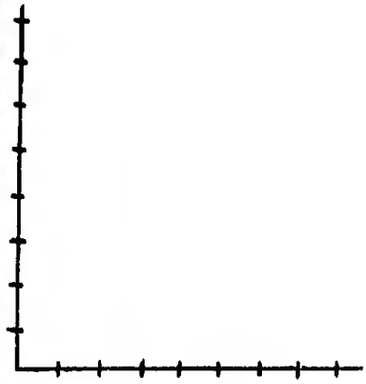


$_{48}Cd$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
48	Cadmium	-104	103.943020	520		59 m	EC; 0.0667	2, 9, 6
		-105	104.943720	800		55 m	EC; B+1.69,0.8;	2, 9
		-106	105.939520	500	1.22			2, 9
		-107	106.940451	400		6.7 h	EC;B+0.32; 0.846	2, 9
		-108	107.938200	400	0.88			2, 9
		-109	108.939510	410		470 d	EC; 0.0875	2, 9, 6
		-110	109.938300	400	12.39			2, 9
		-111	110.939450	500	12.75			2, 9
		-112	111.938230	500	24.07			2, 9
		-113	112.940280	500	12.26			2, 9
		-114	113.939550	500	28.86			2, 9
		-115	114.942060	500		53 h	B^-1.11,0.58; 0.335,0.360, 0.500, 0.525	2, 9, 6
		-116	115.941850	500	7.58			2, 9
		-117	116.944800	600		50 m	B^- ; 0.267,0.281, 0.331, 0.83, 1.27, 1.53, 2.25	2, 9, 6
		-118				50 m	B^-	9
		-119				10 m	B^-	9
						2.9 m	B^-	9

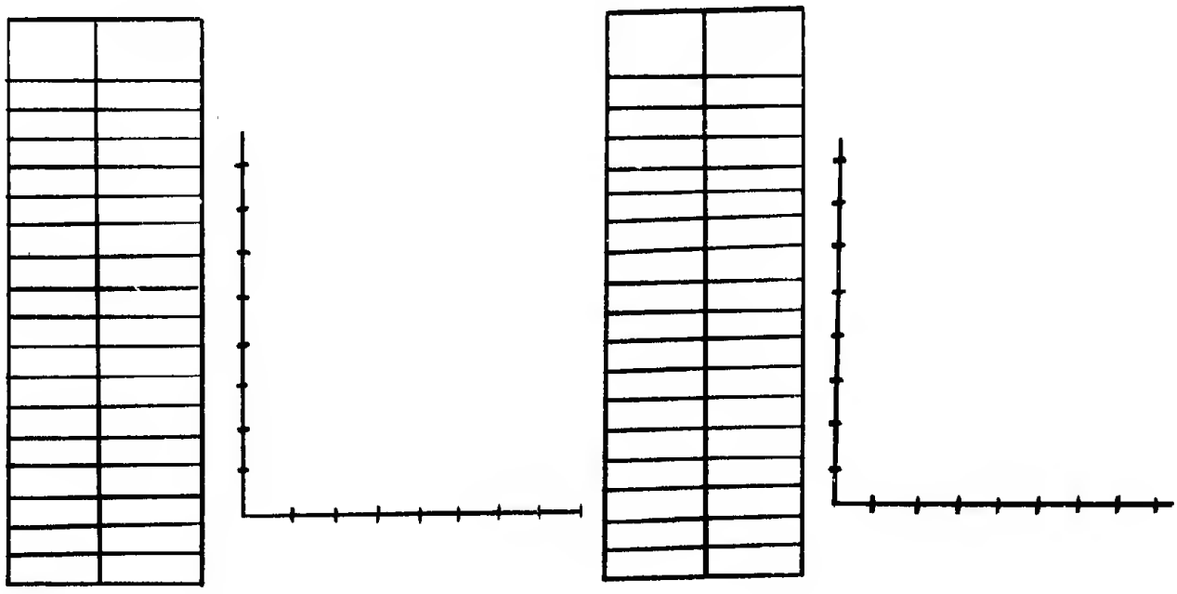
E Mev	σ

E Mev	σ



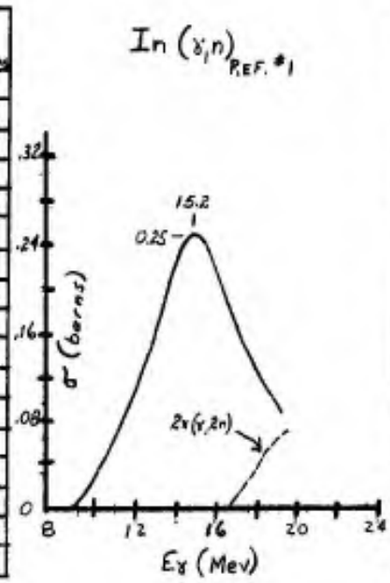
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Cd^{110}	-9.847		6
	Cd^{111}	-6.970		6
	Cd^{112}	-9.300		6
	Cd^{113}	-6.420		6
	Cd^{114}	-9.046		6
(γ, p)	Cd^{110}	-8.907		6
	Cd^{111}	-9.060		6
	Cd^{112}	-9.560		6
	Cd^{113}	-9.670		6
	Cd^{114}	-10.263		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
49	Indium	-107	106.944030	450		30 m	B+-2; γ0.22	2, 9
		-108				40 m	B+3.5; 0.637	9
		-109	108.941410	420		4.3 h	EC; B+0.80, ~0.3; γ	2, 9
		-110	109.942520	400		66 m	B+2.25; γ0.656	2, 9
		-111	110.940400	750		2.81 d	EC; γ0.172, 0.2465	2, 9, 6
		-112	111.940960	510		15 m	B-0.656; B+1.52	2, 9
		-113	112.940120	500	4.23			2, 9
		-114	113.941600	600		72 s	B-1.984, 0.71; B+0.40; γ0.311, 1.29	2, 9, 6
		-115	114.940500	500	95.77	6×10^{14} y	B-0.63; γ0.52	2, 9
		-116	115.942530	500		13 s	B-3.29	2, 9
		-117	116.941790	500		1.1 h	B-0.74; γ0.161, 0.565	2, 9
		-118				4.5 m 5.5 s	B-1.5; γ B-4.4	9 9
		-119				~2 m 17.5 m	B-2.7; γ0.4	9
		-120				~55 s	B-; γ~1	9
		-122				7.5±0.8 s	B-4.5; γ1.14, .995	64

E Mev	σ barns
9	0
10	0.03
11	0.06
12	0.10
13	0.15
14	0.21
15	0.25
16	0.22
17	0.17
18	0.13
19	0.09

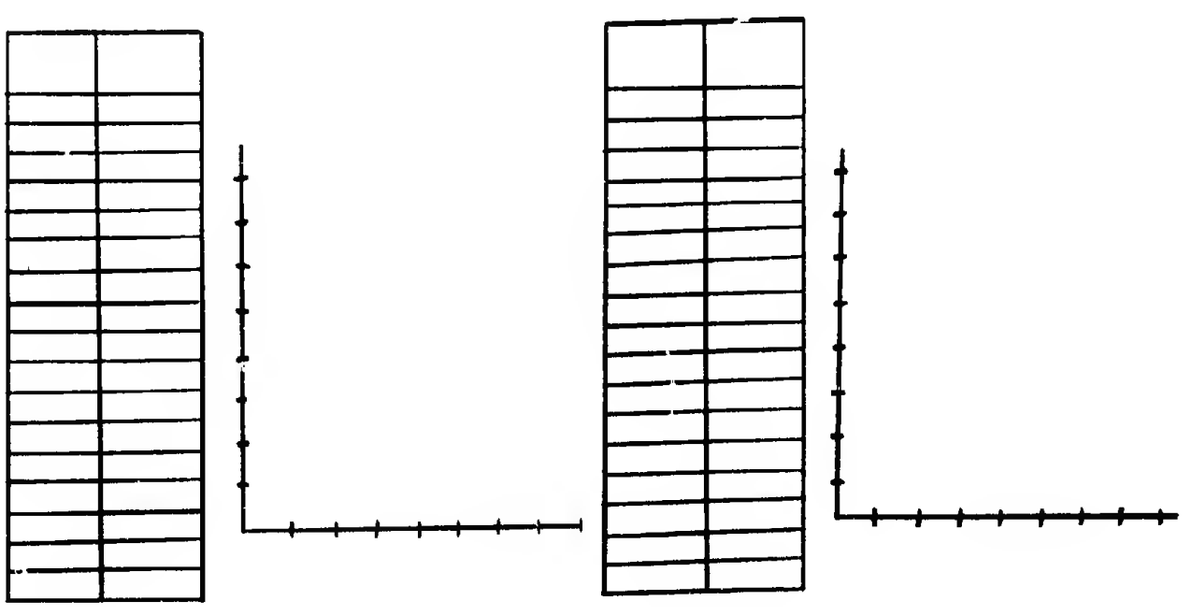


E Mev	σ

$_{49}In$

REMARKS

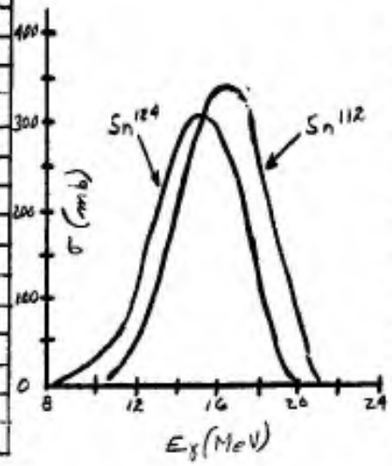
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	In^{113}	- 9.340		6
	In^{115}	- 9.025		6
(γ, p)	In^{113}	- 5.940		6
	In^{115}	- 6.822		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
50	Tin	-108				9 m	EC	9
		-109				18.1 m	EC; B+1.6; γ0.335	9, 6
		-110				4.0 h	EC; γ0.283	9
		-111	110.94311	750		35 m	EC; B+1.51	2, 9
		-112	111.940256	510	0.95			2, 9
		-113				119 d	EC; γ0.256,0.392, 0.605	9, 6
		-114	113.939468	600	0.65			2, 9
		-115	114.939960	500	0.34			2, 9
		-116	115.938970	500	14.24			2, 9
		-117	116.940200	500	7.57			2, 9
		-118	117.939300	500	24.01			2, 9
		-119	118.941000	500	8.58			2, 9
		-120	119.940060	500	32.97			2, 9
		-121	120.942411	500		27.5 h	B-0.383	2, 9
		-122	121.942100	500	4.71			2, 9
		-123	122.944620	500		39.5 m	B-1.26; γ0.153	2, 9
		-124	123.944540	500	5.98			2, 9
		-125	124.947420	500		9.5 m	B-2.04,1.17,0.51; γ0.326	2, 9
		-126				~50 m	B-	9
		-127				2.1 h	B-	9
		-128				57 m	B-	9
		-130				2.6 m	B-	9
		-131				3.4 m	B-	9
		-132				2.2 m	B-	9

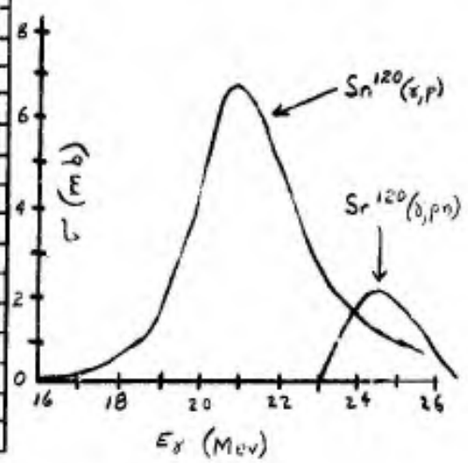
E Mev	σ

Sn $(\gamma,n)_{REF.\ \#26}$

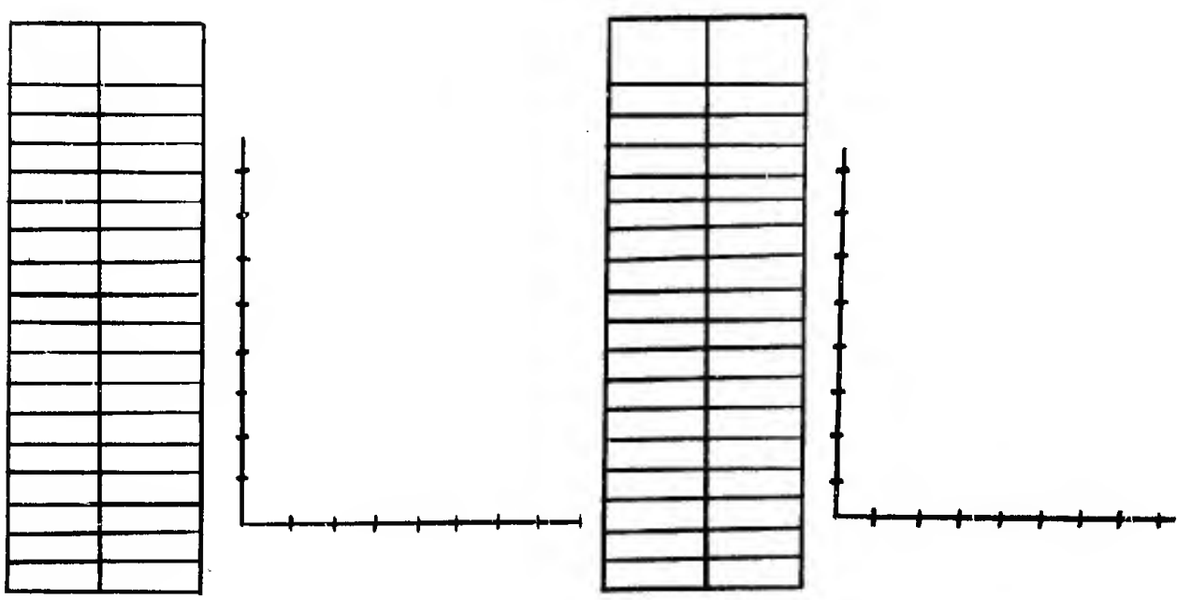


E Mev	σ

Sn $(\gamma,P)_{REF.\ \#66}$

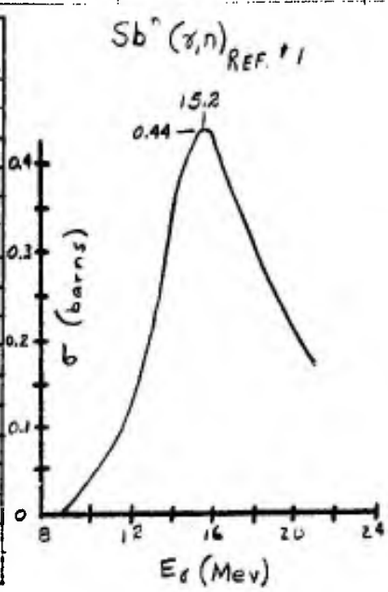


		REMARKS		$_{50}Sn$
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Sn^{116}	-9.390		6
	Sn^{117}	-7.190		6
	Sn^{118}	-9.250		6
	Sn^{119}	-6.590		6
	Sn^{120}	-9.240		6
(γ,p)	Sn^{116}	-9.110		6
	Sn^{117}	-9.690		6
	Sn^{118}	-9.940		6
	Sn^{119}			
	Sn^{120}			

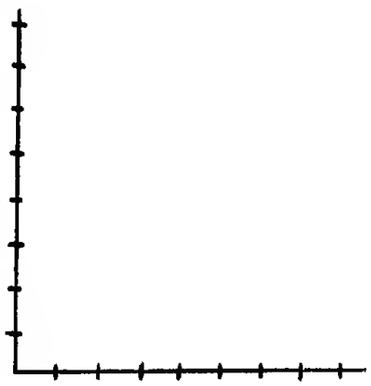


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
51	Antimony	-115					B+ ; 0.060,0.090	6
		-116				60 m	B+ ; 0.90,1.3,2.21	6
		-117				2.8 h	EC;B+ ;γ0.159	6
		-118				5.1 h	EC;γ0.040,0.257, 1.06, 1.25	6
						3.5 m	EC	
		-119				39 h	EC; γ0.0238	6
		-120	119.942980	500		5.8 d	EC;	9
						16.4 d	B+1.70;EC; γ1.18	2, 9
		-121	120.942000	500	57.25			
		-122	121.943680	500		2.8 d	B- ;EC;γ0.564,0.691 1.13	6
		-123	122.943100	500	42.75			
		-124				60 d	B- ; γ0.121,0.607, 0.653,0.730,1.708, 2.04	6
		-125				2.7 y	B- ;γ0.637,0.601, 0.465,0.425,0.175, 0.035	6
		-126				9 h	B- ;	6
		-127				93 h	B- ; γ0.244,0.460, 0.768	6
		-128				9.6 h	B- ;γ0.32,0.4,0.75 0.90	6

E Mev	σ_{barns}
9	0
10	0.03
11	0.08
12	0.13
13	0.20
14	0.33
15	0.44
16	0.41
17	0.36
18	0.31
19	0.26
20	0.21
21	0.17



E Mev	σ

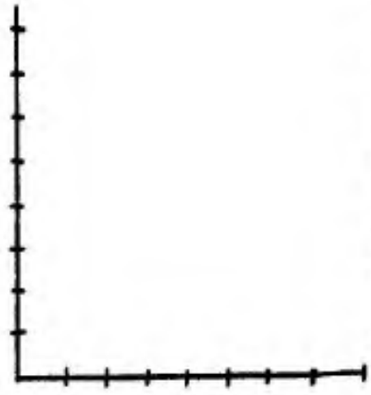


Z	CHEM. SYM.	A	ATOMIC MASS AMU ±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
51	Antimony Cont'd	-129			4.2 h	β^- ;0.165,0.308, 0.534, 0.79	6
		-130			12 m	β^-	2
		-131			23.1 m	β^-	2
		-132			2 m	β^-	2
		-133			4.4 m	β^-	2
		-134 - 135			~50 s	β^-	2

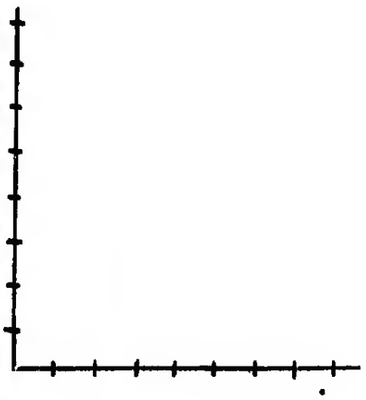
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Sb^{121}	-9.284		6
	Sb^{123}	-8.976		6
(γ,p)	Sb^{121}	-5.779		6
	Sb^{123}	-6.600		6

E Mev	σ



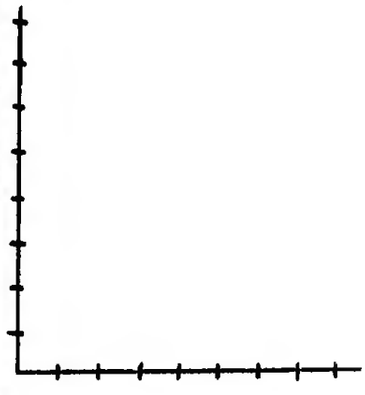
E Mev	σ



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
52	Tellurium	-118				6.0 d	EC; γ 0.108	9
		-119				4.5 d	EC; γ 0.53	9
		-120	119.942520	500	0.089			2, 9
		-121				17 d	EC; γ 0.506,0.573	9
		-122	121.941560	500	2.46			2, 9
		-123	122.943300	400	0.87			2, 9
		-124	123.942110	500	4.61			2, 9
		-125	124.944080	500	6.99			2, 9
		-126	125.943600	500	18.71			2, 9
		-127	126.945660	520		9.4 h	B-0.70; γ 0.0585, 0.145,0.360,0.418	2, 9
		-128	127.946100	500	31.79			2, 9
		-129	128.947080	520		72 m	B-0.29,1.45; γ 0.45 1.09	2, 9,6
		-130	129.947800	500	34.49			2, 9
		-131	130.950020	520		24.8 m	B-1.35,1.69,2.14; γ 0.15,0.448	2, 9,6
		-132	131.950260	510		77.7 h	B-0.22; γ 0.231, 0.053	2, 9,6
		-133	132.952850	720		2.0 m	B-2.4,1.3; γ 0.6,1.0	
		-134				44 m	B-	9
		-135				< 2 m	B-	9

E Mev	σ

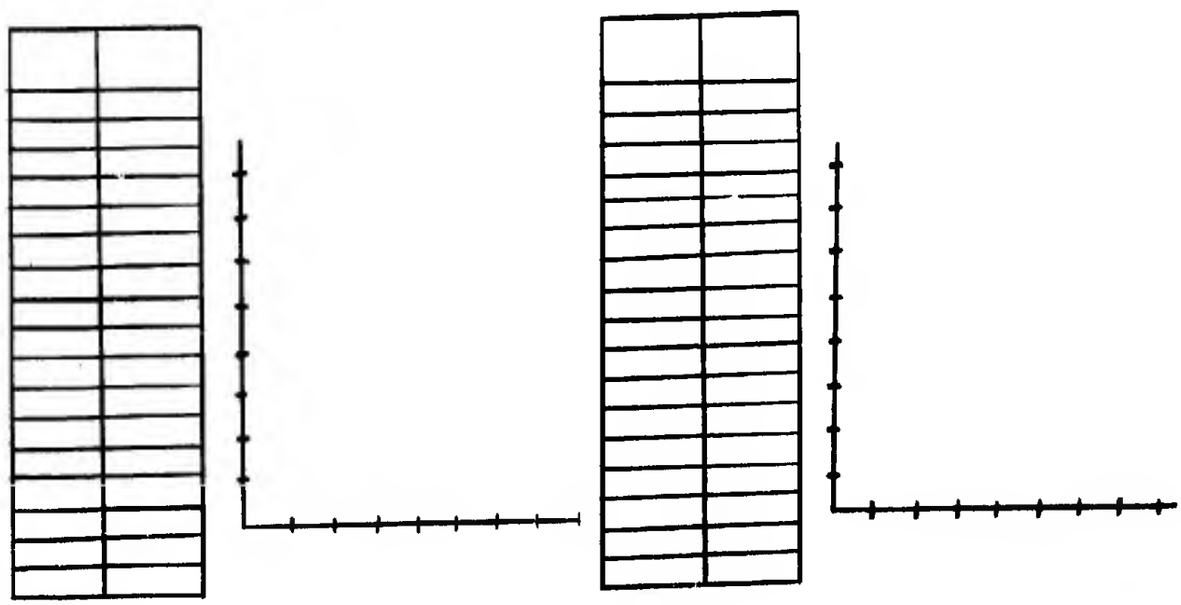
E Mev	σ



52 Te

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Te^{126}	- 9.170	- 8.84	6, 48
	Te^{128}	- 8.430	- 8.41	6, 48
	Te^{130}	- 7.960		6
(γ, p)	Te^{126}	- 9.140		6
	Te^{128}	- 7.740		6
	Te^{130}			



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
53	Iodine	-118				~10 m		9
		-119				18 m	B+4.0	9
		-120				1.4 h	EC	9
		-121				2.0 h	B+1.2; γ 0.210	9
		-122	121.946010	510		3.5 m	B+3.12	2, 9
		-123				13.0 h	EC; γ 0.159	9
		-124	123.945570	500		4.5 d	EC; B+2.20,1.5,0.7; γ 0.603,0.73,1.72, 1.95,2.24	2, 9,6
		-125	124.944240	510		60.0 d	EC; γ 0.0354	2, 9
		-126	125.945850	500		2.6 h		
						13.3 d	EC; B-; B+; γ 0.65, 0.745,0.384	2, 9,6
		-127	126.944800	500	100			2, 9
		-128	127.946670	500		25 m	B-2.12,1.67; γ 0.44, 0.53	2, 9,6
		-129	128.945752	500		1.72×10^7 y	B-0.450,0.188; γ 0.039	2, 9,6
		-130	129.947810	500		12.6 h	B-0.6,1.02; γ 0.413, 0.532,0.664,0.744, 1.15	2, 9,6
		-131	130.947660	500		8.08 d	B-0.608,0.335; γ 0.284,0.364, 0.638	2, 9,6

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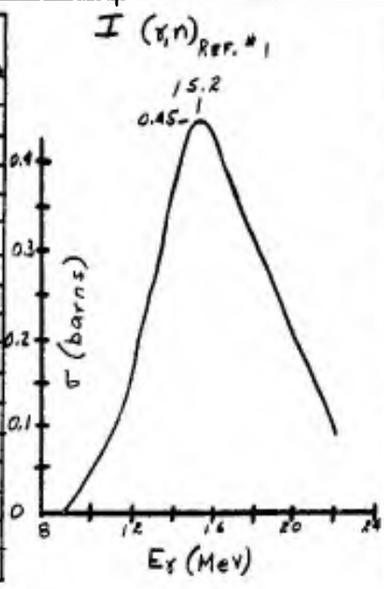
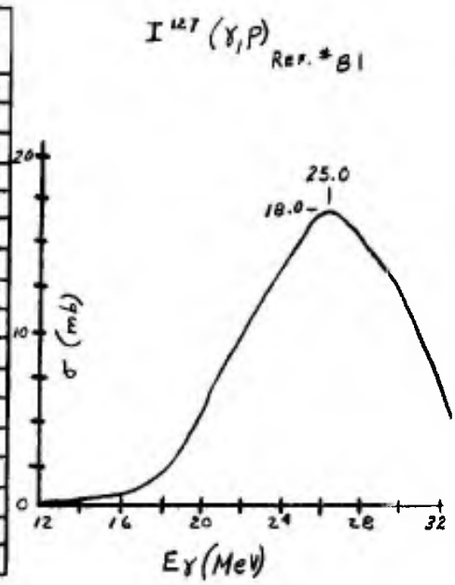
E Mev	σ_{barns}
9	0
10	0.04
11	0.08
12	0.15
13	0.25
14	0.35
15	0.45
16	0.42
17	0.36
18	0.30
19	0.26
20	0.20
21	0.15
22	0.08



E Mev	σ

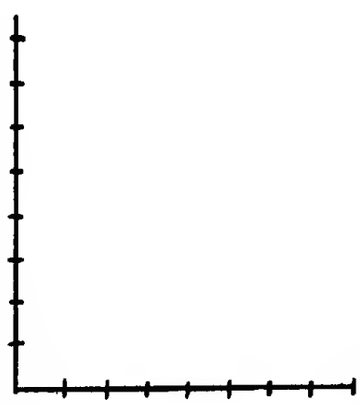


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
53	Iodine	-132	131.949820	510		2.26 h	β^-;δ0.528,0.677, 0.778,1.1	2, 9,6
		-133	132.949630	710		20.8 h	β^-1.3,0.4;δ0.53, 0.85	2, 9
		-134	133.951270	650		52.5 m	β^-2.5,1.5;δ0.12, 0.20,0.86,1.10, 1.78	2, 9,6
		-135				6.68 h	β^- ;δ0.42,0.86, 1.04,1.14,1.275, 1.46,1.72,1.80	9, 6
		-136	135.956920	540		86 s	β^- ;δ1.4,2.9	2, 9
		-137				22.0 s	β^- ; β^- n 0.56	9
		-138				5.9 s	β^-	9
		-139				2.7 s	β^-	9

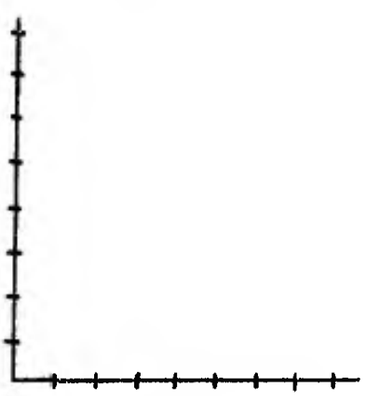
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	I^{127}	-9.152		6
(γ,p)	I^{127}	-6.254		6

E Mev	σ



E Mev	σ



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
54	Xenon	-121				40 m	B+ ; γ 0.096	9
		-122				19.5 h	EC; γ 0.182, 0.235	9
		-123				2.1 h	EC; B+1.7; γ 0.148	9
		-124	123.945390	500	0.096			2, 9
		-125				18.0 h	EC; γ 0.055, 0.096, 0.106, 0.187, 0.243, 0.460	9, 6
		-126	125.944500	500	0.090			2, 9
		-127	126.945880	900		36.41 d	EC; γ 0.565, 0.1450 0.1700, 0.202, 0.367	2, 9, 6
		-128	127.944500	500	1.919			2, 9
		-129	128.945550	500	26.44			2, 9
		-130	129.944620	500	4.08			2, 9
		-131	130.946620	500	21.18			2, 9
		-132	131.946000	500	26.89			2, 9
		-133	132.947660	700		5.27 d	B-0.347; γ 0.0809	2, 9
		-134	133.947620	500	10.44			2, 9
		-135				9.13 h	B-0.91; γ 0.249, 0.36, 0.607	9, 6
		-136	135.950050	500	8.87			9
		-137	136.955200	1400		3.9 m	B-3.5	9
		-138				17 m	B-2.4; γ 0.42, 0.51	6
		-139				41 s	B-	9

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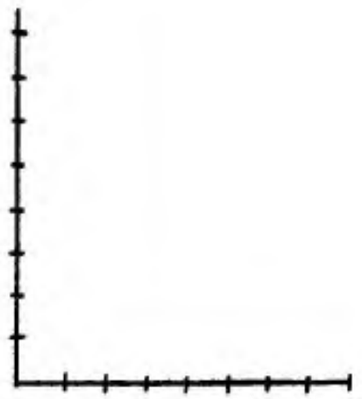
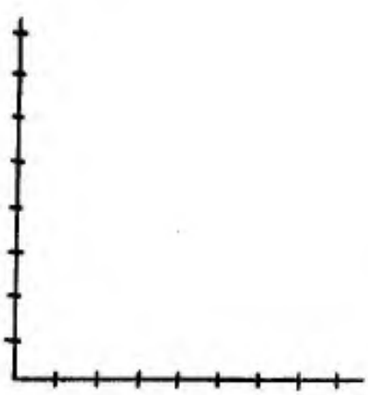
E Mev	σ



E Mev	σ



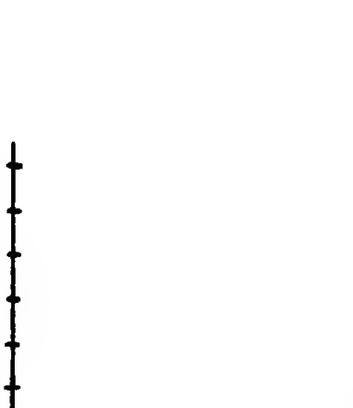
54 Xe

Z	CHEM. SYM.	A	ATOMIC MASS AMU ±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
54	Xenon	-140			16.0 s	β^-	9
		-141			1.7 s	β^-	9
		-143			1.0 s	β^-	9
		-144			~1 s	β^-	9

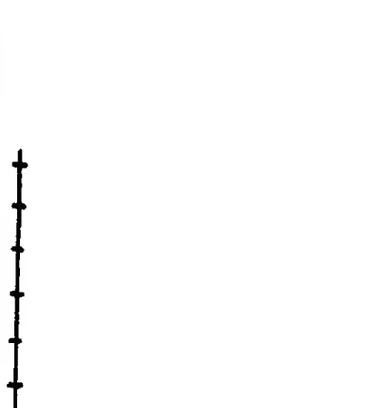
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Xe^{129}	- 6.910		6
	Xe^{131}	- 6.603		6
	Xe^{132}	- 8.932		6
(γ,p)	Xe^{129}	- 8.251		6
	Xe^{131}	- 8.777		6
	Xe^{132}	- 9.120		6
(γ,d)	Xe^{132}	- 2.940		6

E Mev	σ



E Mev	σ

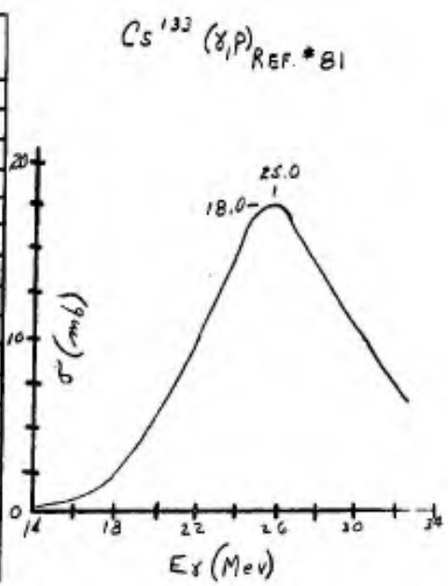


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
55	Cesium	- 123				6 m	B+	9
		-125				45 m	B+2.05;γ 0.112	9
		-126	125.949660	650		1.6 m	B+3.8; γ 0.385	2, 9
		-127	126.948160	900		6.3 h	EC;B+;γ0.1245,0.406	2, 9, 6
		-128	127.948900	650		3.8 m	B+3.0,2.5;γ0.44,098	2, 9
		-129	128.946740	750		30.7 h	EC; γ 0.040,0.092, 0.174,0.283,0.315, 0.373,0.415,0.55, 0.585	2, 9, 6
		-130	129.947830	500		30 m	B+1.97; B-0.442	2, 9
		-131	130.946996	500		9.6 d	EC	2, 9
		-132	131.947930	650		6.2 d	EC; γ 0.67	2, 9
		-133	132.947200	700	100			2, 9
		-134	133.948960	800		2.07y	B- ;γ0.561,0.567 0.601,0.794	2, 9, 6
		-135	136.950899	1010		3.0×10^6y	B-0.21;	2, 9
		-136	137.953900	1000		12.9 d	B-0.341,0.657;γ1.2	2, 9, 6
		-137				26.6 y	B-0.514; γ 0.6616	9, 6
		-138				32.2 m	B-3.40; γ 0.463, 0.98, 1.44	9, 6
		-139				9.5 m	B-	9
		-140				66 s	B-	9
		-141				Short	B-	9

Continued on next page

E Mev	σ

E Mev	σ



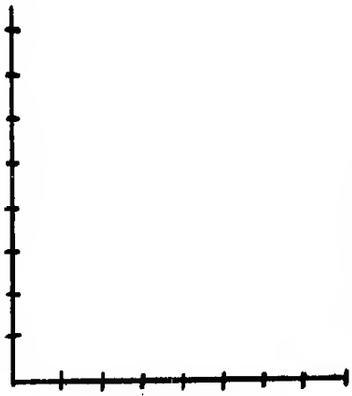
$_{55}Cs$

Z	CHEM. SYM.	A	ATOMIC MASS AMU ±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
55	Cesium	-142			~1 m	B-	9
		-143			Short	B-	9
		-144			Short	B-	9

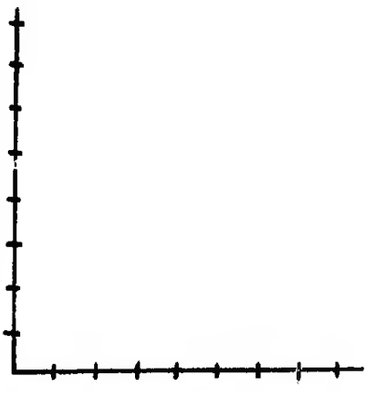
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Cs^{133}	- 9.026	- 8.988	6, 48
(γ, p)	Cs^{133}	- 6.430		6

E Mev	σ

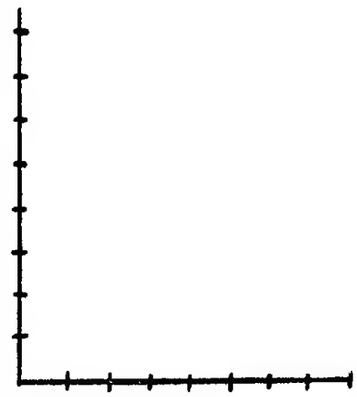


E Mev	σ

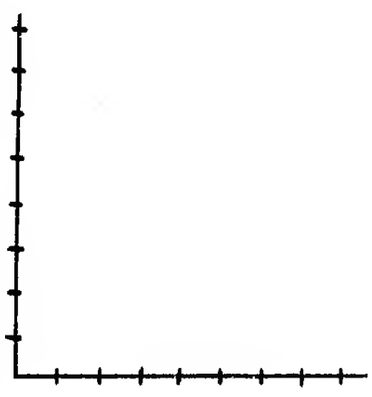


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
56	Barium	-126				97 m	EC;γ0.225,0.70,0.9	9, 6
		-127				12 m	B+	9
		-128				2.4 d	EC;γ0.270,0.135	9, 6
		-129	128.949530	800		2.45 h	B+1.6; 0.127,0.18, 0.210,1.45	2,9,6
		-130	129.947355	500	0.101			2, 9
		-131				11.5 d	EC;γ 0.122,0.214, 0.241,0.370,0.494	9, 6
		-132			0.097			9
		-133				7.2 y	EC;γ 0.080,0.298, 0.357	9, 6
		-134	133.946757	800	2.42			2, 9
		-135			6.59			9
		-136			7.81			9
		-137	136.949630	1010	11.32			2, 9
		-138	137.948700	1000	71.66			2, 9
		-139	138.952060	1000		84 m	B⁻2.38,2.23,0.82; γ 0.164	2, 9, 6
		-140	139.954370	1050		12.8 d	B⁻1.02,0.48;γ 0.03 0.16,0.5	2, 9, 6
		-141				18 m	B⁻2.8;γ	9
		-142				6 m	B⁻	9
		-143				<0.5 m	B⁻	9
		-144				Short	B⁻	9

E Mev	σ



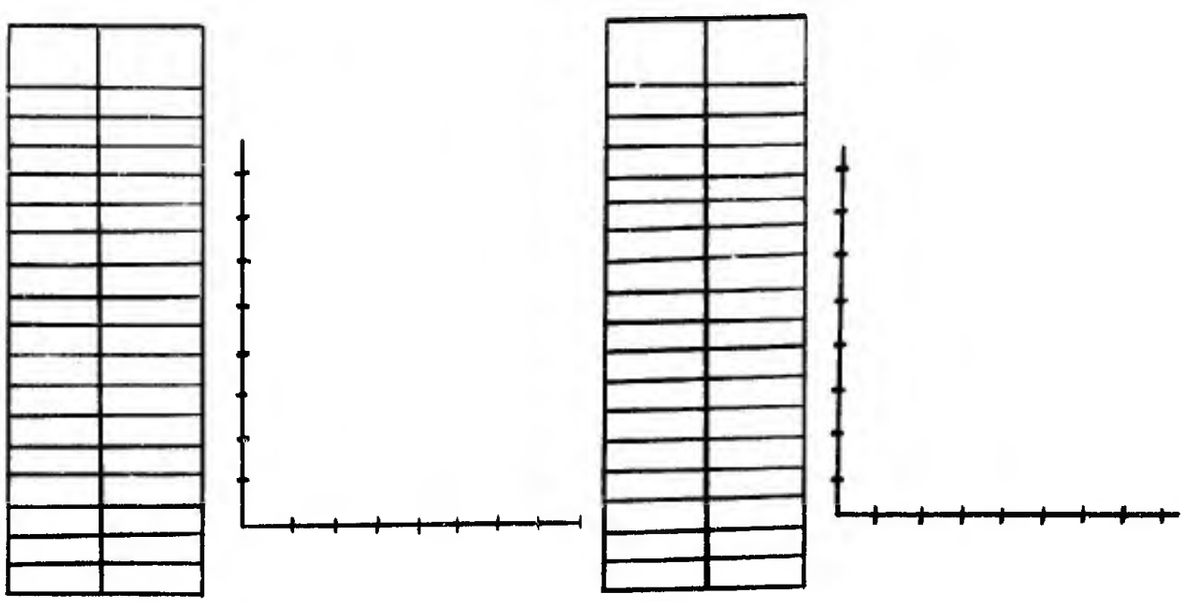
E Mev	σ



$_{56}Ba$

REMARKS

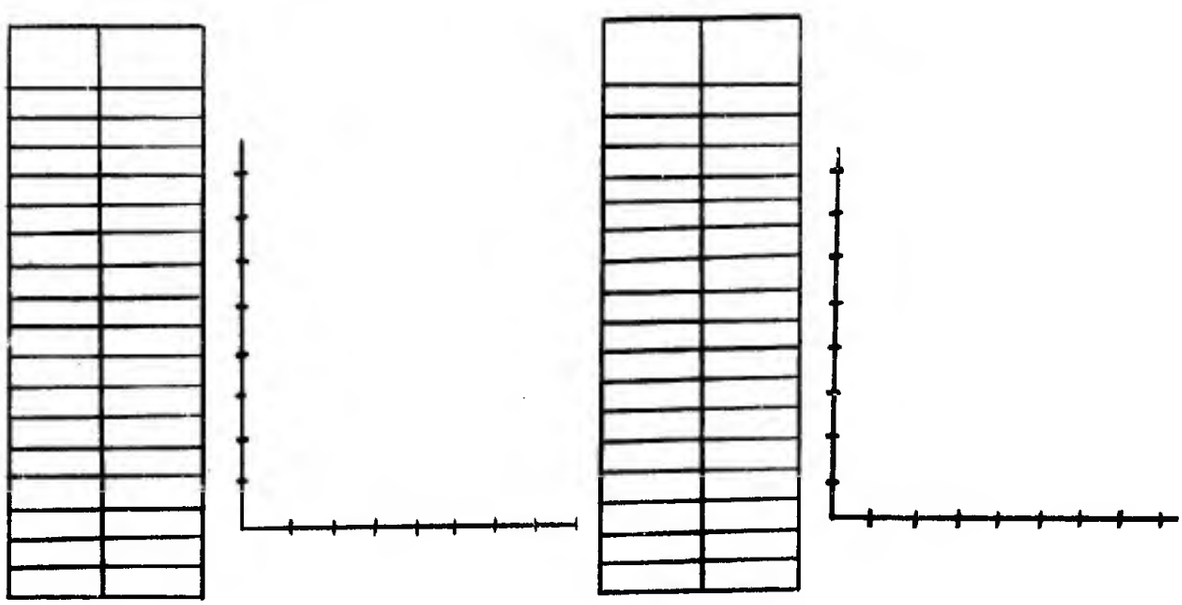
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ba^{137}	-6.450	-6.949	6, 48
	Ba^{138}	-8.580		6
(γ, p)	Ba^{137}	-8.747		6
	Ba^{138}	-8.970		6



$_{56}Ba$

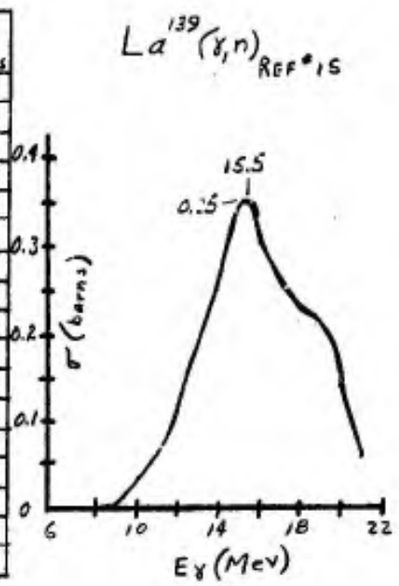
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ba^{137}	-6.950	-6.949	6, 48
	Ba^{138}	-8.580		6
(γ, p)	Ba^{137}	-8.747		6
	Ba^{138}	-8.970		6

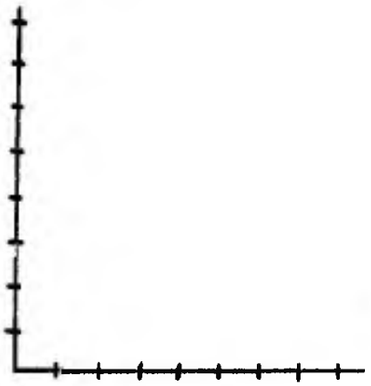


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
57	Lathanum	-131				58 m	B+1.6	9
		-132				4.5 h	B+3.8; γ 1.0	9
		-133				4.0 h	EC; B+ ~1.2; γ 0.8	9
		-134	133.950730	820		6.5 m	B+2.7	2, 9
		-135				19.5 h	EC; γ 0.104,0.218, 0.265,0.295,0.367, 0.483,0.588,0.65, 0.86	9, 6
		-136				9.5 m	EC; B+2.1	9
		-137				$6x10^4$y	EC;	9
		-138	137.950100	1020	0.089	10^{11}y	EC; B⁻0.21; γ 0.54, 0.81, 1.42	2,9,6
		-139	138.949500	1000	99.911			2,9
		-140	139.952970	1000		40.22 h	B⁻; γ 0.3286, 0.4867,0.81[F1], 1.596	2, 9
		-141	140.954330	1000		3.8 h	B⁻2.43,0.9; γ 1.3, 1.6	2, 9
		-142				77 m	B⁻ 2.5; γ 0.630, 0.870,1.0,1.8,2.0, 2.4,2.9	9, 6
		-143				~19 m	B⁻	9
		-144				Short	B⁻	9

E Mev	σ_{barns}
8	0
9	0.01
10	0.03
11	0.07
12	0.12
13	0.18
14	0.25
15	0.34
16	0.31
17	0.26
18	0.23
19	0.21
20	0.14
21	0.06



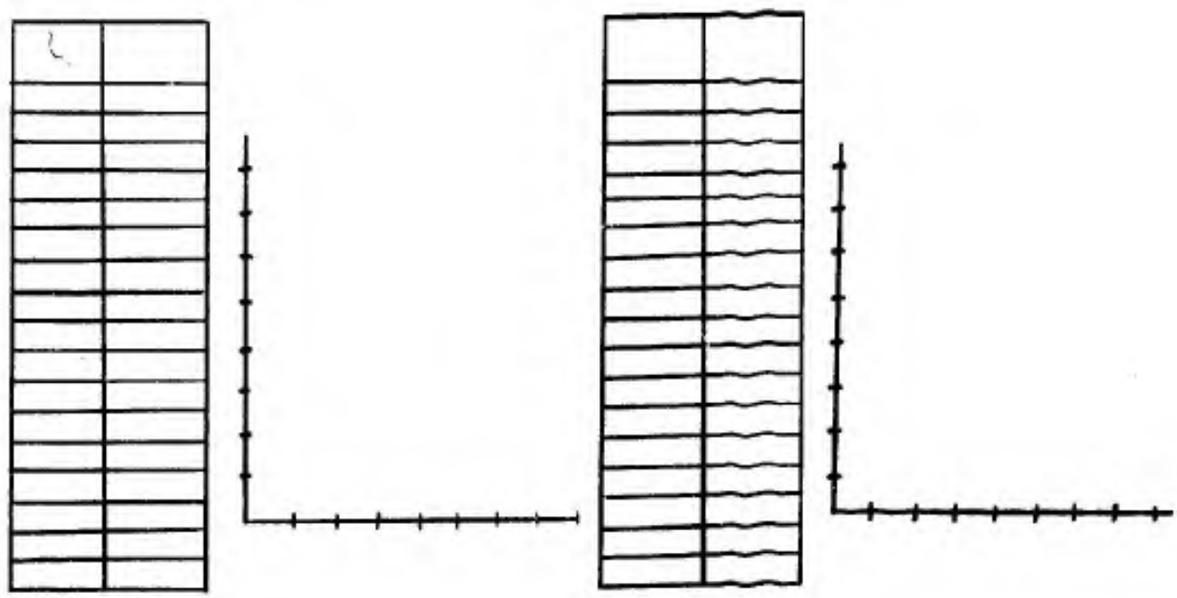
E Mev	σ



$_{57}La$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	La^{139}	- 8,777	- 8.81	6, 22
(γ, p)	La^{139}	- 6,318		6

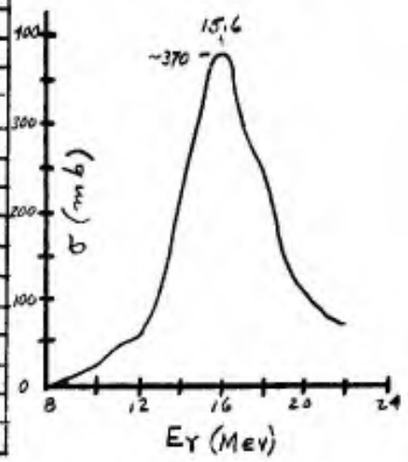


$_{58}Ce$

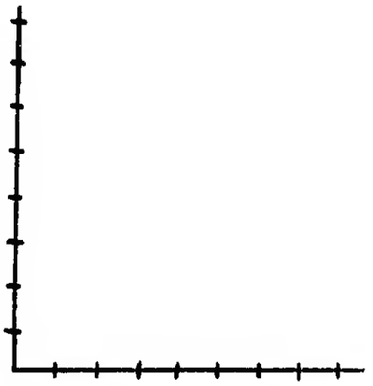
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
58	Cerium	-131				30 m	B+4.2	9
		-132				4.2 h	B+	9
		-133				6.3 h	B+1.3; γ1.8	9
		-134				72.0 h	EC	9
		-135				22 h	EC; B+0.81	9
		-136			0.193			9
		-137				8.7 h	EC; γ0.443	9
		-138	137.949030	1040	0.250			2, 9
		-139	138.949630	1020		140 d	EC;	2, 9
		-140	139.948900	1000	88.48			2, 9
		-141	140.951724	1000		33.1 d	B-0.581,0.442; γ0.144	2, 9
		-142	141.953020	1000	11.07	$5x10^{15}$y	α 1.5	2, 9
		-143	142.956538	1000		33 h	B- ; γ0.035, 0.126,0.160,0.289, 0.356,0.660,0.720	2, 9, 6
		-144	143.958445	1000		285 d	B- ; γ0.0337, 0.054,0.0807,0.100 0.134	2, 9
		-145				3 m	B- ~2.0;	9
		-146	145.963210	1010		13.9 m	B-0.7; γ0.11,0.142 0.22,0.27,0.32	

E Mev	σ

$Ce^{140,142}$ $\sigma(\gamma,n)+\sigma(\gamma,pn)+2\sigma(\gamma,2n)$. REF. #72



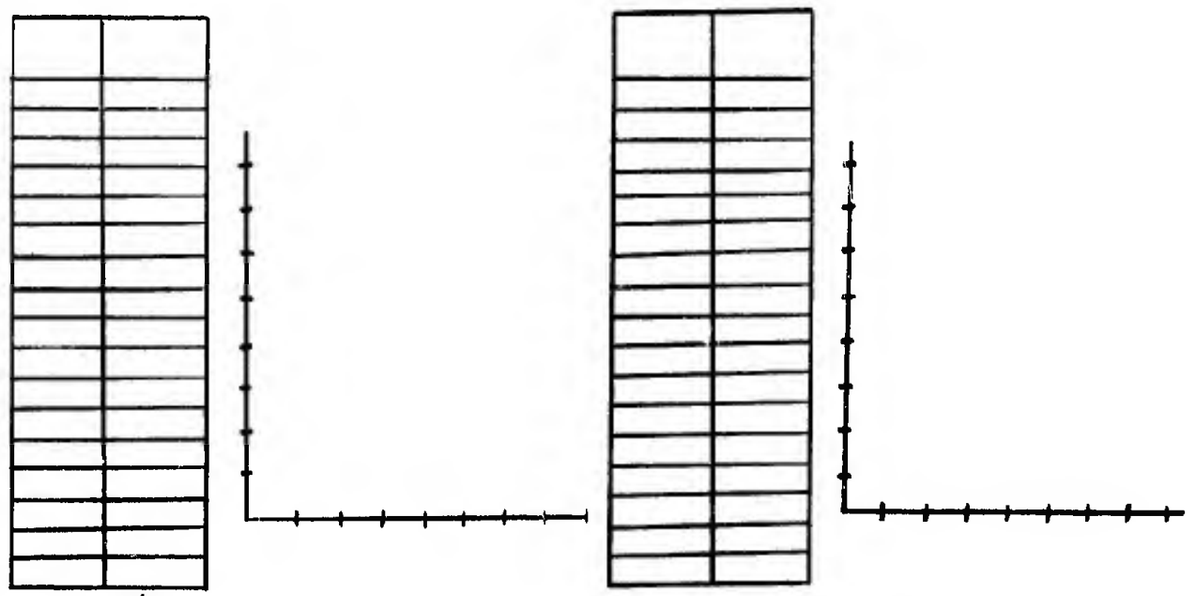
E Mev	σ



$_{58}Ce$

REMARKS

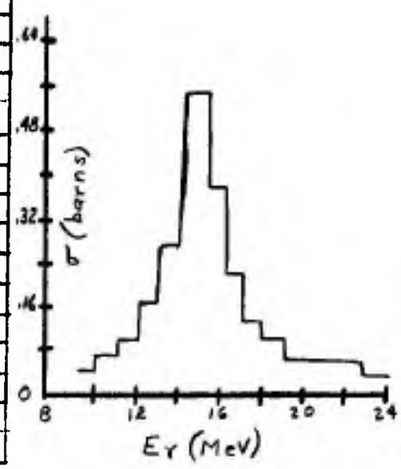
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Ce^{140}	-9.060		6
	Ce^{142}	-7.120	-7.24	6, 48
(γ,p)	Ce^{140}	-8.010		6
	Ce^{142}	-8.760		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
59	Praseodymium	135				22 m	B+2.5;γ 0.08,0.22, 0.3	9
		-136				70 m	B+2.0;γ 0.17,0.8,1.1	9, 6
		-137				1.4 h	EC; B+1.8	9
		-138	137.952790	1060		2.0 h	EC; B+1.4;γ 0.30, 0.80,1.05,1.4,1.7	2,9,6
		-139				4.5 h	EC; B+1.0; γ 1.3,1.6	9
		-140	139.952390	1000		3.4 m	B+2.23	2, 9
		-141	140.951100	1000	100			2, 9
		-142	141.953836	1000		19.2 h	B⁻2.17,0.59;γ 1.572	2, 9
		-143	142.955050	1000		13.76 d	B⁻0.932	2, 9
		-144	143.958120	1000		17.27 m	B⁻2.98,2.3,0.8; γ 0.691,1.488, 2.182	2,9,6
		-145				5.95 h	B⁻~1.7	9
		-146	145.963210	1010		24.4 m	B⁻3.7,2.3;γ 0.455, 0.59, 0.75, 1.49	2,9,6

E Mev	σ

$Pr^{141}(\gamma,n)_{Ref\ \#83}$

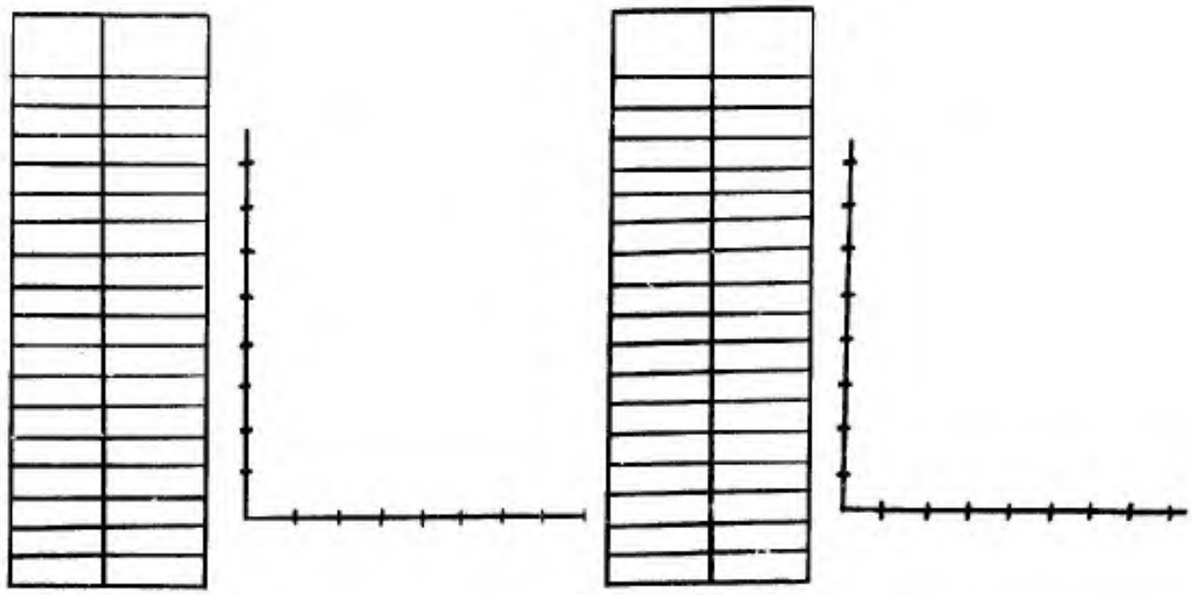


E Mev	σ

$_{59}Pr$

REMARKS

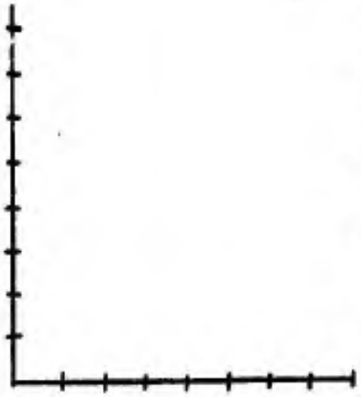
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Pr^{141}	-9.368		6
(γ,p)	Pr^{141}	-5.326		6



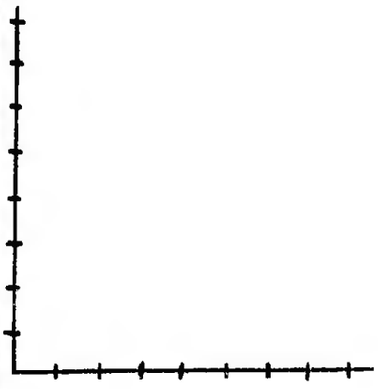
$_{60}$Nd

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
60	Neodymium	-138				22 m	B+ ~ 2.4	9
		-139				5.5 h	EC; B+3.1; γ 1.3	9
		-140	139.952500	1010		3.3 d	EC	2, 9
		-141	140.952980	1000		2.42 h	EC; B+0.7; γ 0.14, 1.295	2, 9, 6
		-142	141.951510	1000	27.13			2, 9
		-143	142.954052	1000	12.20			2, 9
		-144	143.954930	1000	23.87	5×10^{15} y	α 1.9	2, 9
		-145			8.29			9
		-146	145.958700	1000	17.18			2, 9
		-147	146.961530	1000		11.06 d	B^- ; γ 0.091	2, 9
		-148	147.964000	1000	5.72			2, 9
		-149	148.966700	1000		2.0 h	B-1.5,1.1,0.95; γ 0.30,0.097,0.112, 0.114,0.124,0.188, 0.198, 0.21	2, 9
		-150	149.967900	1000	5.60			2, 9
		-151				15 m	B-1.93; γ 0.085, 0.110 0.117, 0.421, 0.73, 1.14	9

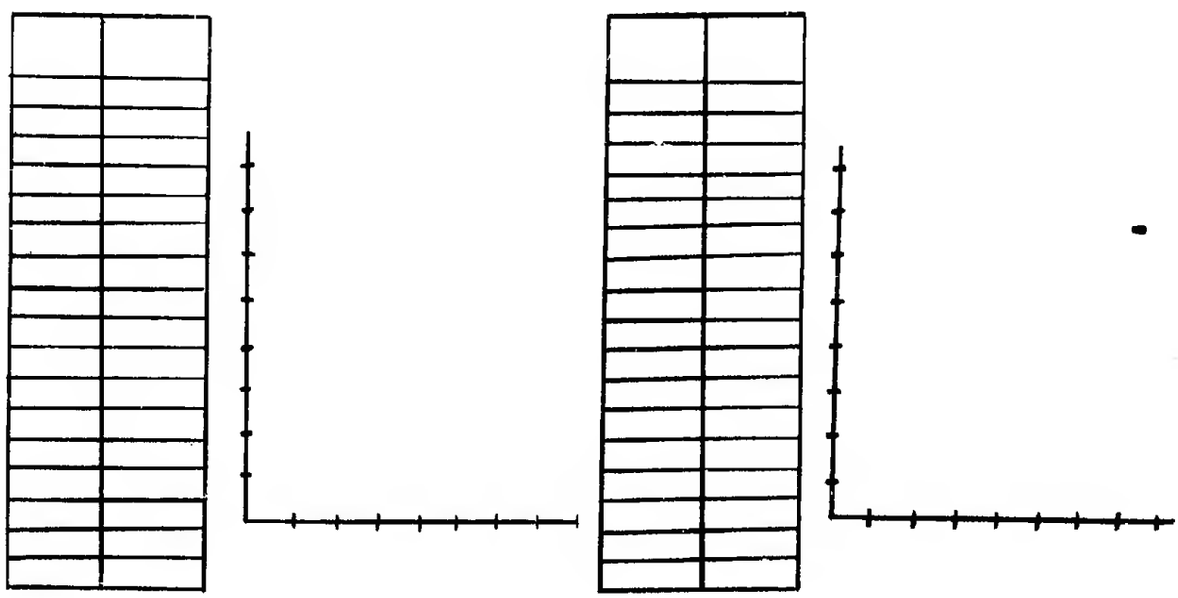
E Mev	σ



E Mev	σ

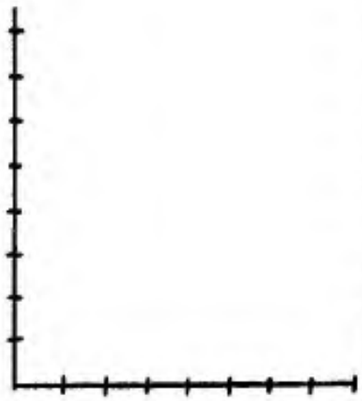


		REMARKS		$_{60}Nd$
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Nd^{142}	-9.789		6
	Nd^{143}	-6.070		6
	Nd^{144}	-7.814		6
	Nd^{145}	-5.970	-6.38	6
	Nd^{146}	-7.580		6
(γ, p)	Nd^{142}	-7.206		6
	Nd^{143}	-7.440		6
	Nd^{144}	-7.965		6
	Nd^{145}	-8.160		6
	Nd^{146}	-8.602		6

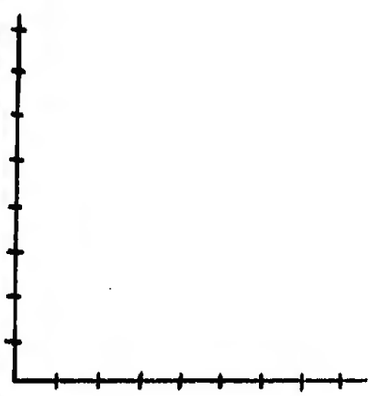


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
61	Prometheum	-141				20 m	B+2.6	9
		-142				~30 s	B+3.78;EC	9
		-143				270 d	EC;γ 0.95,0.740	9, 6
		-144				300 d	EC;γ 0.65,0.44,0.17	9
		-145				16 d	B+0.45	
						18 y	EC;γ 0.064,0.0725	9, 6
		-146	145.958950	1010		~1 y	B-0.7	2, 9
		-147	146.960552	1000		2.64 y	B-0.223;γ 0.121	2, 9
		-148	147.964200	1050		5.3 d	B⁻ 2.5;γ 0.8	
						42 d	B-2.4;γ 0.54,0.95	2, 9,6
		-149	148.964900	1000		54 h	B-1.05;γ 0.285,1.2	2, 9,6
		-150	149.969100	1010		2.7 h	B-3.05,2.01;γ 0.34 0.40,0.57,0.70, 0.82,1.17,1.33,1.68, 1.95,2.75	2, 9,6
		-151				27.5 h	B-1.1;γ 0.065,0.070 0.100,0.116,0.144, 0.163,0.177,0.208	9, 6
		Pm?				12.5 h	B⁻	

E Mev	σ



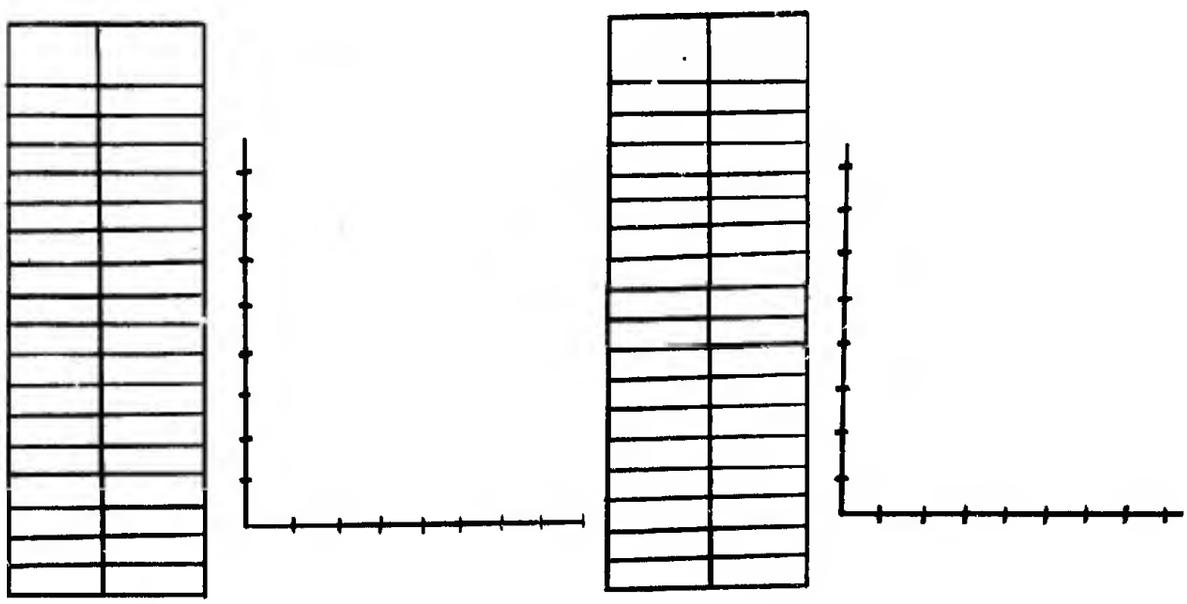
E Mev	σ



$_{61}Pm$

REMARKS

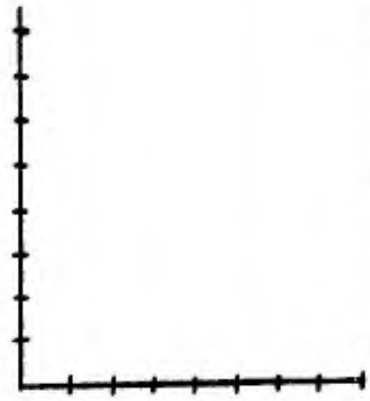
Thresholds	Isotope	Theoretical	Experimental	Reference



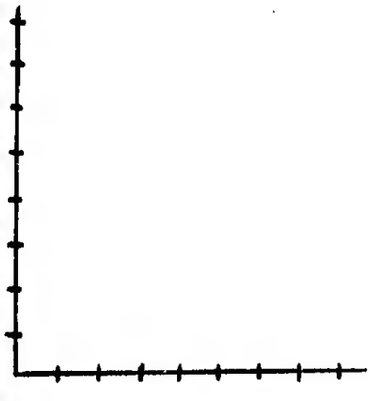
62 Sm

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
62	Samarium	-142				72 m	B+	9
		-143				9 m	B+2.3	9
		-144	143.956000	1600	3.16			2, 9
		-145				340 d	EC; γ 0.0613	9, 6
		-146	145.958200	1000		5x10⁷ y	α 2.55	2, 9
		-147	146.960310	1000	15.07	1.3x10¹¹ y	α 2.18	2, 9
		-148	147.961300	1000	11.27			2, 9
		-149	148.963460	1000	13.82			2, 9
		-150	149.963400	1000	7.47			2, 9
		-151				93 y	B⁻0.076; γ 0.021	9
		-152	151.967300	1000	26.63			2, 9
		-153				47.1	B⁻ ; γ 0.103, 0.53	9, 6
		-154	153.970520	1000	22.53			2, 9
		-155	154.973510	1050		23.5 m	B⁻1.8; γ 0.105, 0.248	2, 9, 6
		-156	155.975050	1020		9.0 h	B⁻0.9	2, 9

E Mev	σ

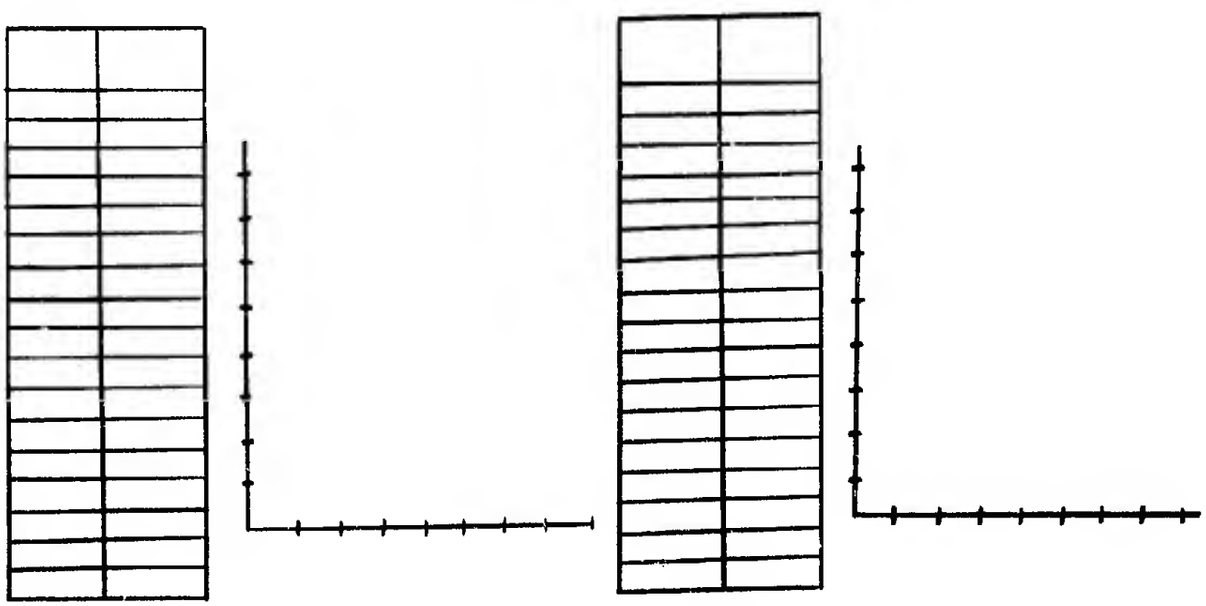


E Mev	σ



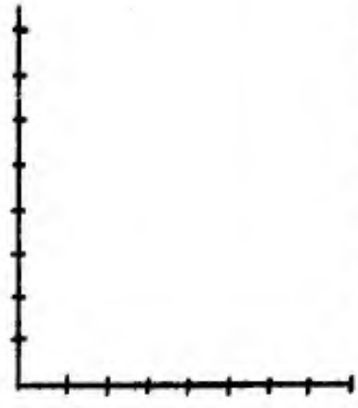
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Sm^{147}	-6.470		6
	Sm^{148}	-8.130		6
	Sm^{149}	-5.860		6
	Sm^{152}	-8.410		6
	Sm^{154}			
(γ, p)	Sm^{147}	-6.440		6
	Sm^{148}	-7.570		6
	Sm^{149}			
	Sm^{152}	-9.430		6
	Sm^{154}			

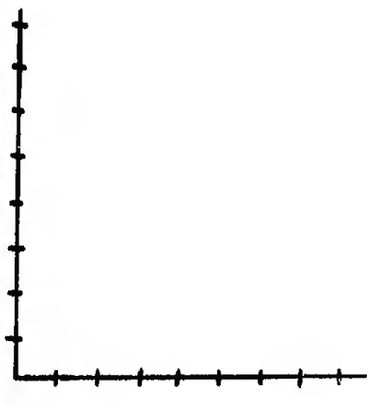


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
63	Europium	-144				18 m	B+2.4	9
		-145				5 d	EC; γ 0.63, 0.66, 0.75, 0.89	9, 6
		-146				38 h	EC; γ	9
		-147				24 d	EC; 2.9; γ 0.038	9, 6
		-148				54 d	EC; γ 0.58, 0.41, 1.00	9
		-149				120 d	0.4	9
		-150	149.966200	1000		15.0 h	B⁻ 1.07	2, 9
		-151			47.77			9
		-152				12.7 y 9.2 h	EC; B⁻; EC; B⁻ 1.88, 0.55; B+; γ 0.122	9, 6
		-153			52.23			9
		-154	153.972920	1010		16 y	B⁻ ; γ 0.336, 0.778, 1.116	2, 9, 6
		-155	154.971146	1060		1.7 y	B⁻ ; γ	2, 9
		-156	155.974080	1010		15.4 h	B⁻ ; γ	2, 9
		-157	156.973030	1010		15.4 h	B⁻ ; γ	2, 9
		-158				60 m	B⁻ 2.6 ; γ	9
		-159				20 m		9

E Mev	σ



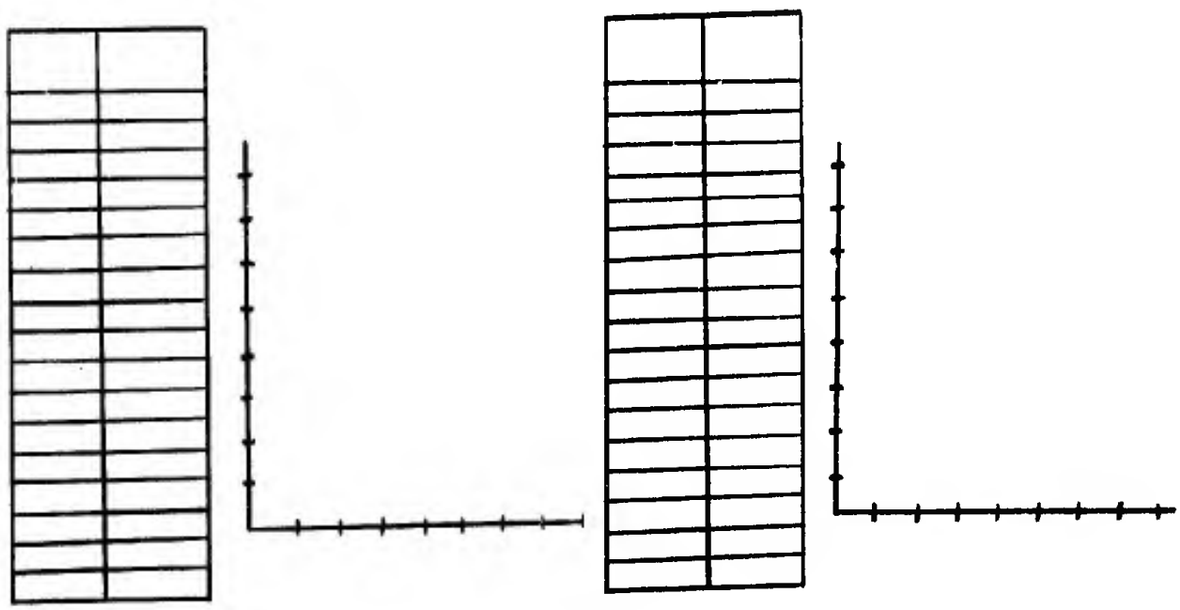
E Mev	σ



$_{63}Eu$

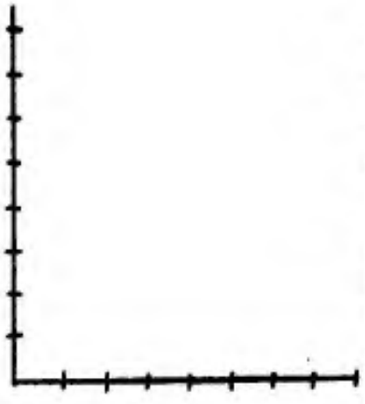
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Eu^{151}	-8.050	- 8.04	6, 48
	Eu^{153}	- 8.650	- 8.65	6, 48
(γ, p)	Eu^{151}	- 4.850		6
	Eu^{153}	- 6.010		6

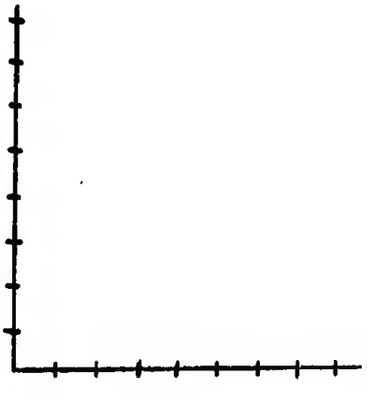


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
64	Gadolinium	-147				29.0 h	EC;γ	9
		-148	147.963370	1600		~130 y	α 3.2	2, 9
		-149				9.3 d	EC; 3.0;	9
		-150	149.965050	1000		>10^5 y	α 2.7	2, 9
		-151				150 d	EC;γ 0.0215,0.1531 0.1753, 0.242, 0.305	9, 6
		-152			0.20			9
		-153				236 d	EC;γ	9
		-154	153.969720	1000	2.15			2, 9
		-155	154.970880	1050	14.7			2, 9
		-156	155.971500	1000	20.47			2,9
		-157	156.971200	1000	15.68			2, 9
		-158	157.973420	1000	24.9			2, 9
		-159				18.0 h	β^- 0.95;0.60;γ	9
		-160	159.577750	1000	21.9			2, 9
		-161				3.6 m	β^- 1.5;γ	9

E Mev	σ

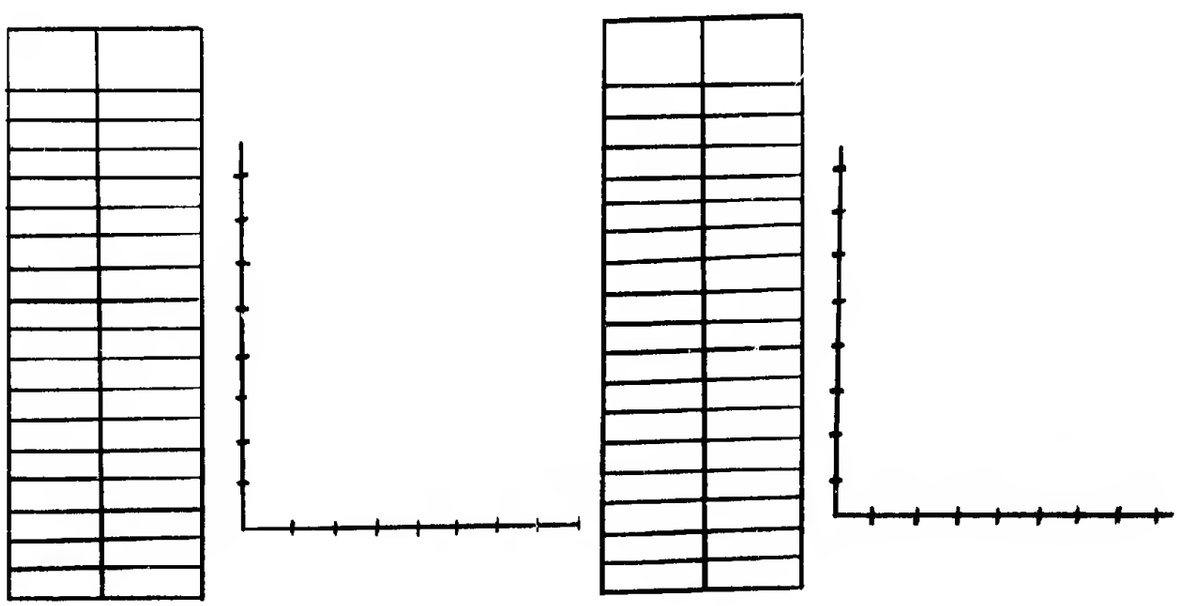


E Mev	σ



$_{64}Gd$

Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference
(γ, n)	Gd^{155}	-6.420		6
	Gd^{156}	-7.859		6
	Gd^{157}	-6.390	-6.39	6, 48
	Gd^{158}	-7.926		6
	Gd^{160}	-6.200		6
(γ, p)	Gd^{155}	-7.600		6
	Gd^{156}	-7.319		6
	Gd^{157}	-8.150		6
	Gd^{158}	-8.840		6
	Gd^{159}			



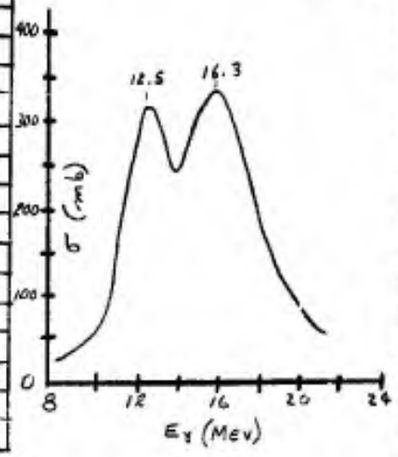
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
65	Terbium	-149				4.1 h	EC;α 3.95; γ 0.17, 0.23,0.36,0.50, 0.64	9, 6
		-151				19 h	EC;α 3.4; γ 0.108, 0.180,0.192,0.252, 0.271,0.287,0.344, 0.432,0.615	9, 6
		-153				62 h	EC; γ 0.0 .15,0.0517, 0.0681,0.0875,0.102 0.110,0.174,0.195, 0.212,0.250	9, 6
		-154				8 h	EC; γ	9
						17.2 h	EC;B+2.75; γ	9
		-155				5.6 d	EC; γ 1.4	9
		-156				5.6 d	EC;B⁻0.2,0.6; γ 1.3	9
		-157						
		-158				11.0 s	IT; γ 0.111	9
		-159			100			9
		-160	159.977755	2000		72.3 d	B⁻; γ 0.970,0.886, 0.300,0.200,0.085	2,9,6
		-161				6.88 d	B⁻; γ 0.0256,0.0489, 0.078	9, 6
		-162				14 m		9
		-163				6.5 h		9

Continued on next page.

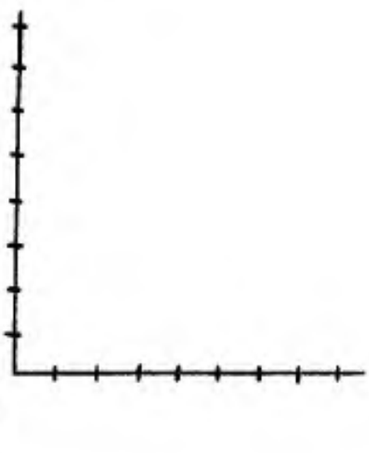
E Mev	σ

$Tb^{159}\ \sigma_n = \sigma(\gamma,n)+\sigma(\gamma,2n)+\sigma(\gamma,pn)$

REF. ^{65}



E Mev	σ



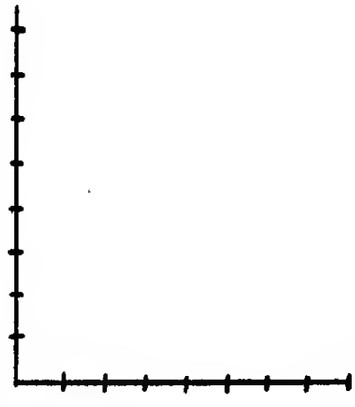
$_{65}Tb$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
65	Terbium	-164				23 h		9
	Tb?					217 h	B+3.1	9

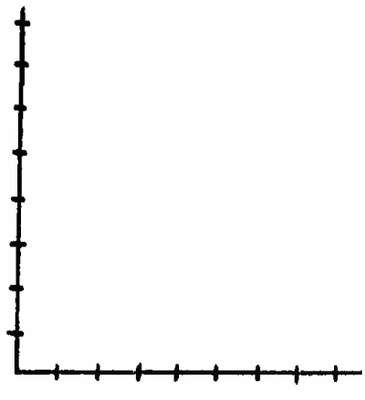
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Tb^{159}	- 8.148		6
(γ, p)	Tb^{159}	- 7.200		6

E Mev	σ

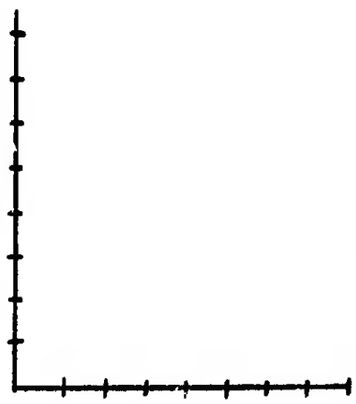


E Mev	σ

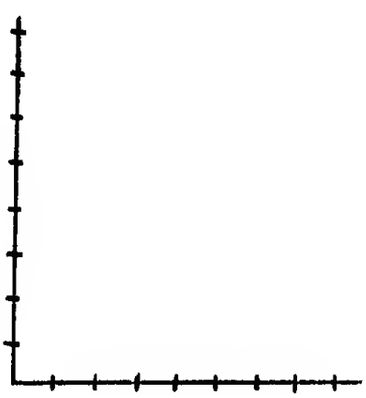


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
66	Dysprosium	-149				8 m	EC	9
		-153				7 m	α 4.2	9
		-153				19 m	α 4.1	9
		-152				2.3 h	α 3.66	9
		-153				5.0 h	α 3.48	9
		-154				13 h	α 3.37	9
		-155				10 h	EC; γ 0.0654,0.0904 0.1154,0.1558, 0.1614,0.2057, 0.2270,0.2714	9, 6
		-156			0.0524			9
		-157				8.2 h	EC; γ 0.0608, 0.0830,0.1439, 0.1825,0.2655, 0.3266	9
		-158			0.0902			9
		-159				134 d	EC; γ 0.058	9
		-160	159.975800	2000	2.294			2, 9
		-161			18.88			9
		-162	161.976960	2000	25.53			2, 9
		-163			24.97			9
		-164	163.980420	2000	28.18			2, 9
		-165	164.982440	2000		139.2 m	β^- ; γ 0.095,0.175 0.274, 0.360	2, 9
		-166				82 h	β 0.2; γ 0.05	9

E Mev	σ

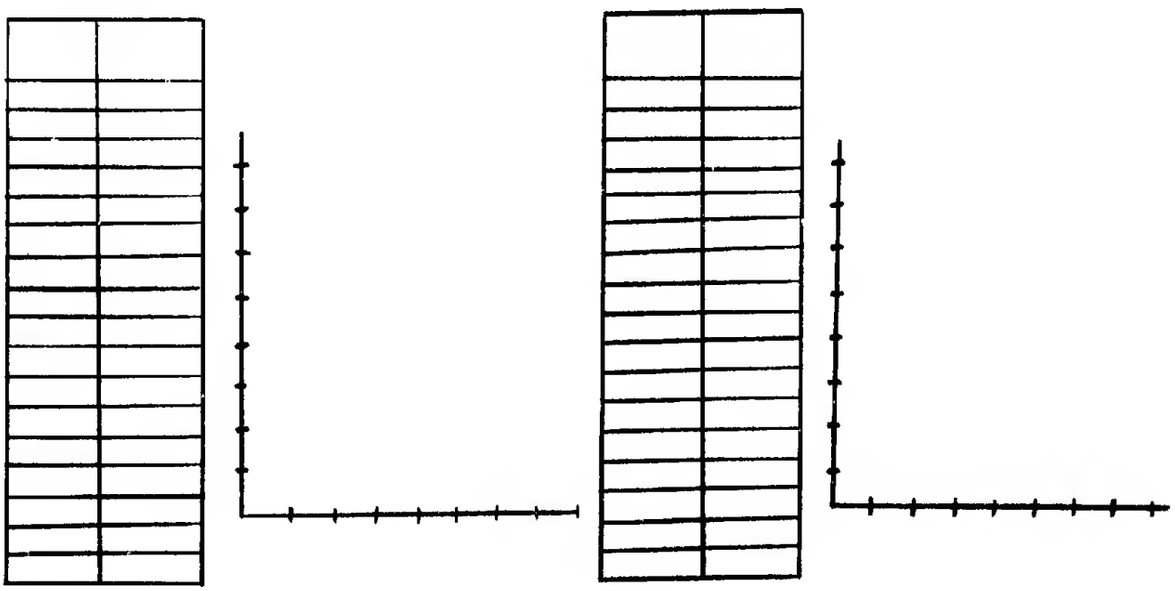


E Mev	σ

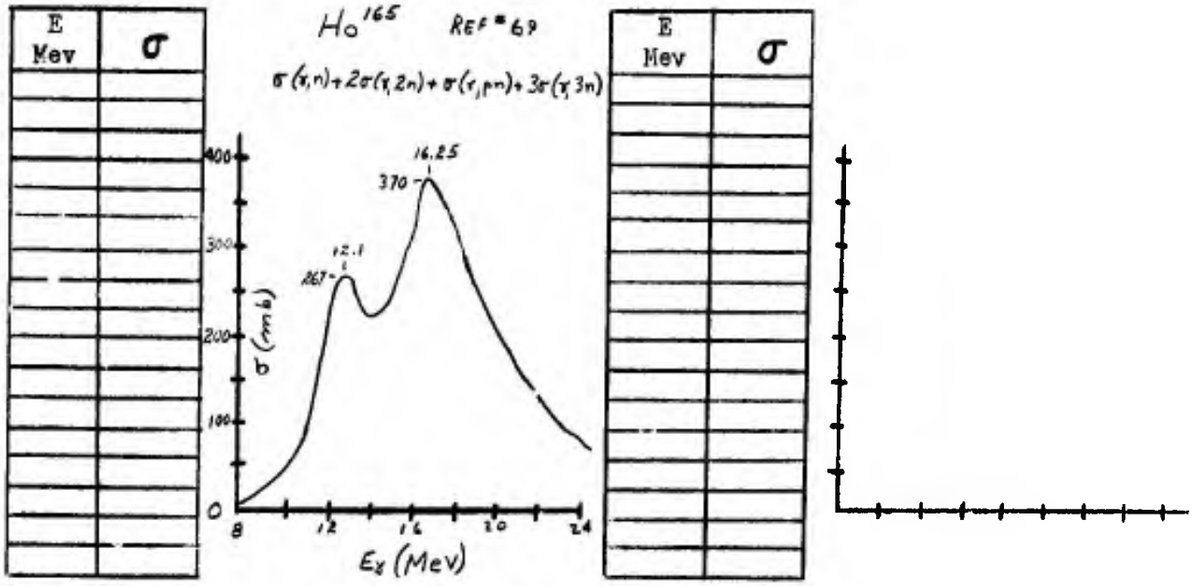


REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Dy^{161}	-6.410		6
	Dy^{162}	-8.170		6
	Dy^{163}	-6.300	-6.32	6, 48
	Dy^{164}	-7.620		6
(γ, p)	Dy^{161}	-7.450		6
	Dy^{162}	-7.970		6
	Dy^{163}			
	Dy^{164}			

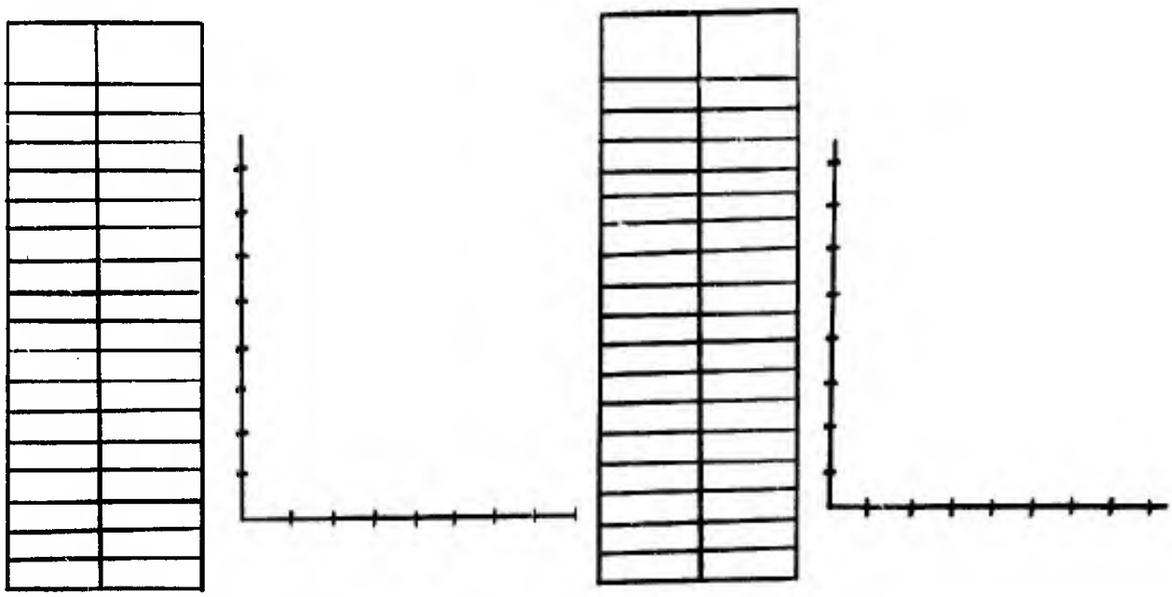


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
67	Holmium	-156				~4 m	α 4.2	9
		-156				~1 h	α 0.1381	9
		-159				33 m	EC; γ	9
		-160				28 m	EC; B+1.3; γ 0.090 0.20, 0.65, 0.73, 0.89, 0.97	9, 6
		-161				2.5 h	EC; γ 0.0256, 0.0775 0.103, 0.175	9, 6
		-162				67 m	EC; γ 0.0382, 0.0577 0.0808, 0.1848, 0.2828	9, 6
		-163				0.8 s	0.305	9
		-164	163.982770	1000		36.7 m	EC; B⁻ 0.99; γ 0.0373, 0.0729, 0.0909	2, 9, 6
		-165	164.981100	2000	100			2, 9
		-166				27.3 h	B⁻; γ 0.08, 1.37, 1.56	6
						>30 y	B⁻; γ 0.084, 0.185, 0.212	9, 6
		-167				3.0 h	B⁻ 0.28, 0.96; γ 0.35, 0.70	9, 6
		-169				96 m		9



REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Ho^{165}	-8.119		6
(γ, p)	Ho^{165}	-5.900		6

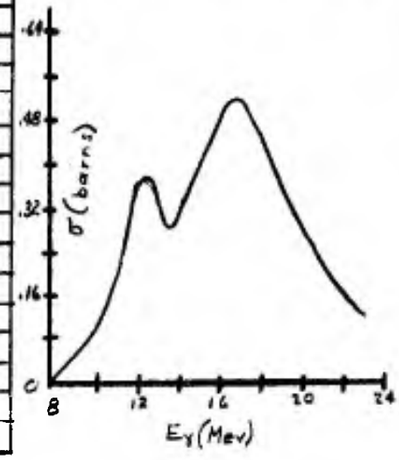


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
68	Erbium	-160				29 h	EC	9
		-161				3.1 h	EC; B+1.2;γ	9
		-162			0.136			9
		-163				75 m	EC; γ 0.43, 1.10	9
		-164	163.981720	1000	1.56			2, 9
		-165				10.0 h	EC; γ 1.1	9
		-166			33.41			9
		-167			22.94			9
		-168	167.983920	1000	27.07			2, 9
		-169				9.4 d	B⁻ 0.33; γ 0.0084	9
		-170	169.989360	2000	14.88			2, 9
		-171				7.8 h	B⁻ ; γ 0.113, 0.118, 0.126, 0.176, 0.295, 0.308, 0.420	9, 6
		-172				50 h	B⁻	9

E Mev	σ

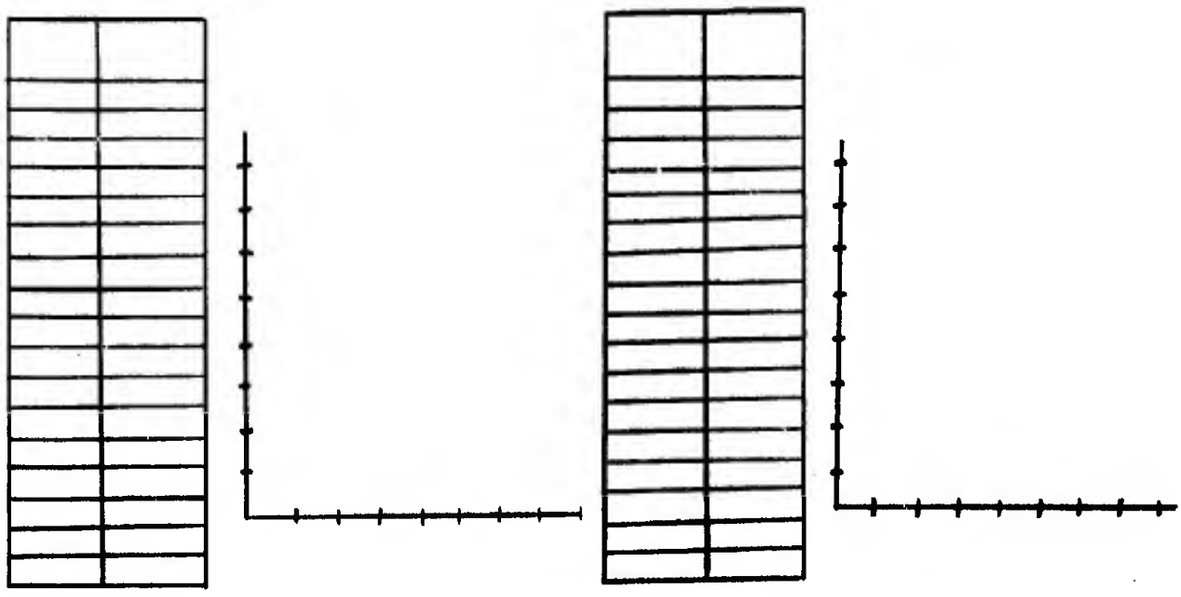
Er (γ,n)

Approximated From Ref. #73



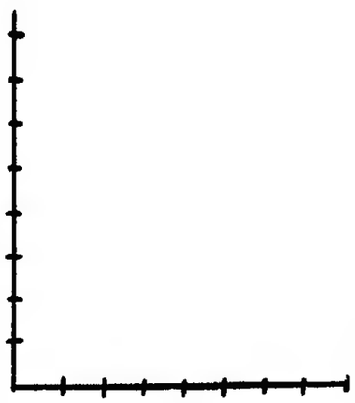
E Mev	σ

Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference
(γ, n)	Er^{166}			
	Er^{167}	-6.540	-6.64	6, 48
	Er^{168}	-7.780		6
(γ, p)	Er^{166}	-7.430		6
	Er^{167}	-7.600		6
	Er^{168}	-8.000		6

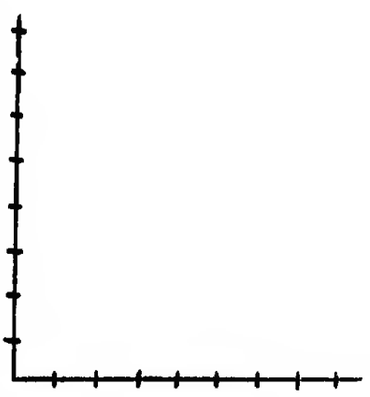


Z	CHEM. SYM.	A	ATOMIC MASS AMU ±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
69	Thulium	-165			29 h	EC; γ	9
		-166			7.7 h	EC; B+2.1; γ 1.7	9, 6
		-167			9.6 d	EC; γ 0.057	9, 6
		-168			85 d	EC; B^- ; γ 0.21, 0.85	9, 6
		-169		100			9
		-170			129 d	B^- 0.968, 0.884; γ 0.0842	9, 6
		▶171			19 m		9,
		-171			680 d	B^- 0.097, ~0.03; γ 0.0667	9, 6
		-172			63.6 h	B^- 1.5; γ 0.076, 1.09, 1.49, 1.79	9, 6

E Mev	σ



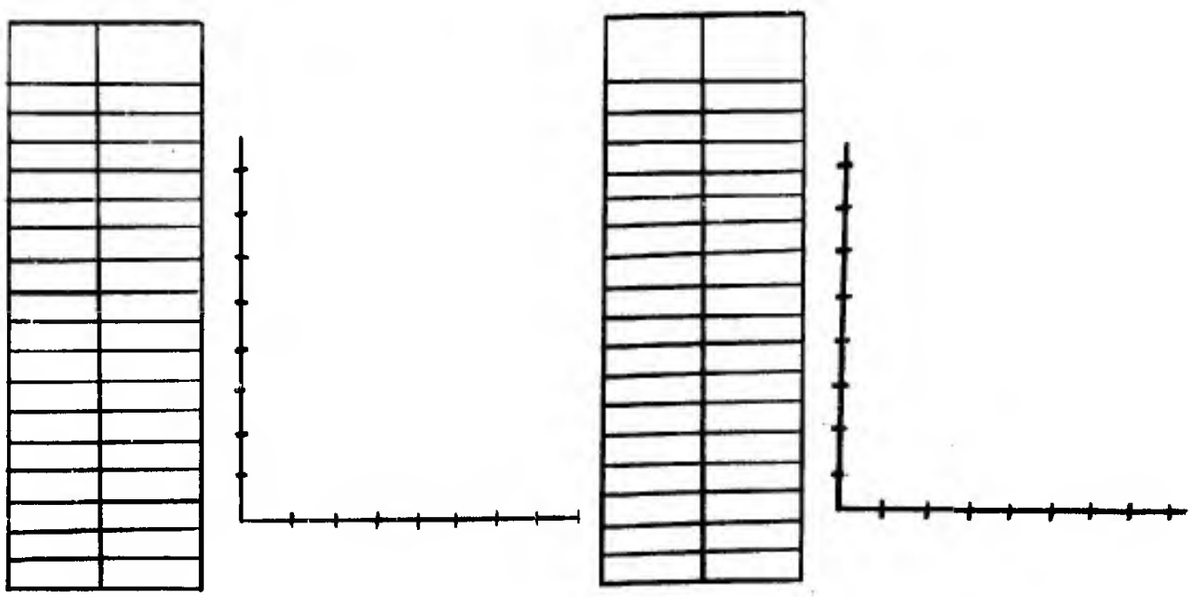
E Mev	σ



^{69}Tm

REMARKS

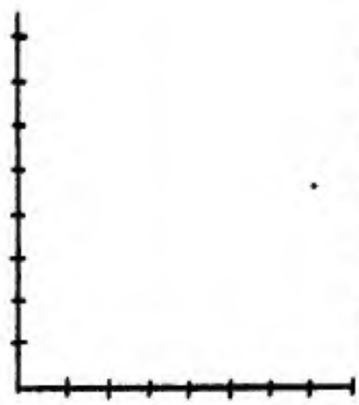
Thresholds	Isotope	Theoretical	Experimental	Reference



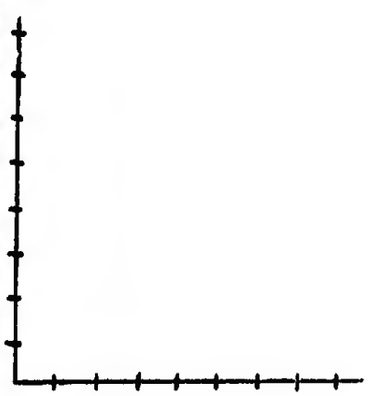
$_{70}Yb$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
70	Ytterbium	-166				54 h	EC;γ 0.112,0.140	9
		-167				74 m	B+2.4	
						19 m	EC;γ 0.118,0.18,0.33	9, 6
		-168			0.140			9
		-169				31.8 d	EC; γ 0.064,0.110, 0.133,0.178,0.198	9, 6
		-170			3.03			9
		-171			14.31			9
		-172	171.983480	3000	21.82			2, 9
		-173			16.13			9
		-174	173.980750	3000	31.84			2, 9
		-175				101 h	B^- ;γ 0.1138, 0.2826, 0.3961	9, 6
		-176			12.73			9
		-177				1.9 h	B-1.30;γ 0.1185, 0.147,1.085,1.235	9, 6
		Yb^m				6 s	IT; 0.212,0.104	9
		Yb^m				50 s	IT; ~0.025	9
		Yb^m				0.15 s		9

E Mev	σ



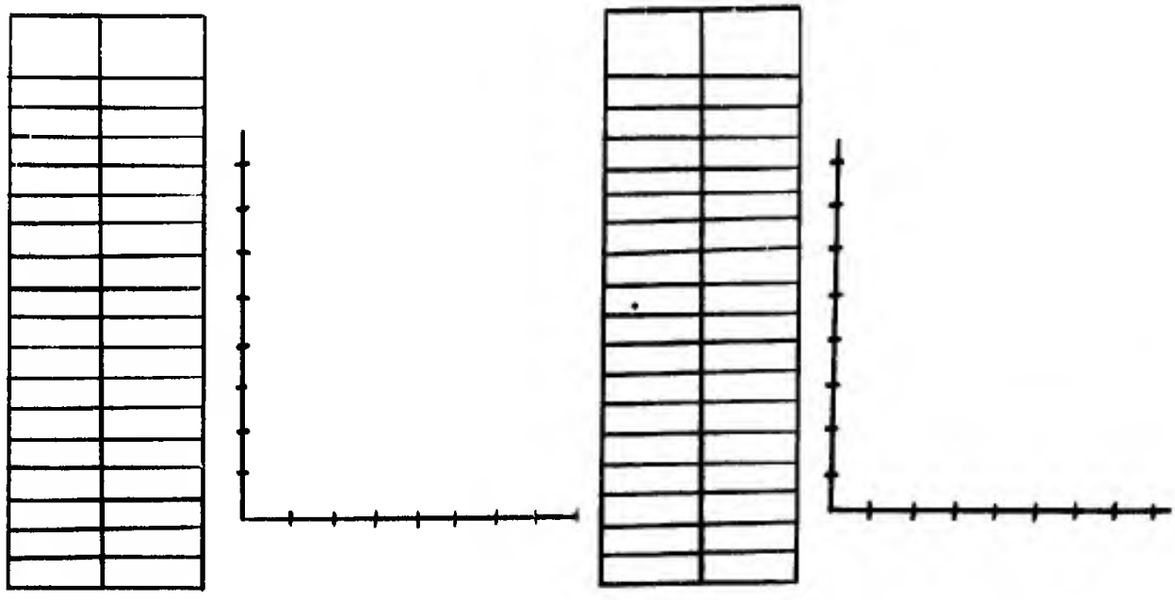
E Mev	σ



$_{70}Yb$

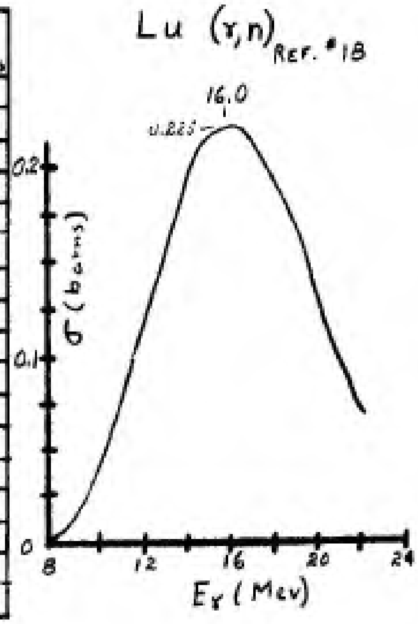
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Yb^{173}		-6.50	48

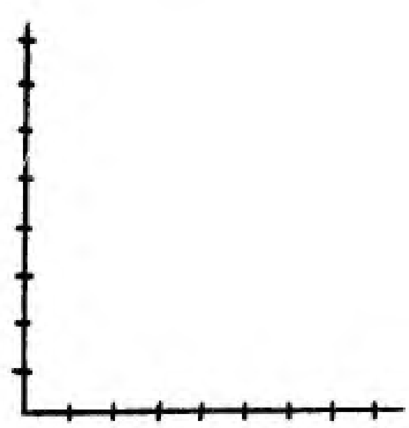


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
71	Lutecium	-169				~2 d	EC	9
		-170				1.7 d	EC; γ 0.0842,0.1935	9, 6
		-171				8.5 d	EC; γ	9
		-171				600 d	EC; γ~1	9
		-172				6.7 d	EC; γ	9
		-172				4.0 h	B+1.2;EC; γ 0.0787, 0.0906,0.1128, 0.1815,0.203?, 0.2705,0.3246, 0.3731	9, 6
		-173				1.4 y	EC; γ 0.0788,0.1009, 0,1715, 0.2727	9, 6
		-174				165 d	EC; B^-0.6; γ 0.0766, ~1	9, 6
		-175			97.40			9
		-176	175.997370	2000	2.60	2.4×10^{10}	B^-0.43; γ0.089, 0.20, 0.309	2,9,6
		-177				6.75 d	B^- ; γ 0.113, 0.208	9
		-178				18.7 m	γ 0.342;0.445	9

E Mev	σ barns
7	0
8	0.005
9	0.020
10	0.040
11	0.078
12	0.120
13	0.160
14	0.190
15	0.215
16	0.225
17	0.218
18	0.185
19	0.160
20	0.120
21	0.095
22	0.065



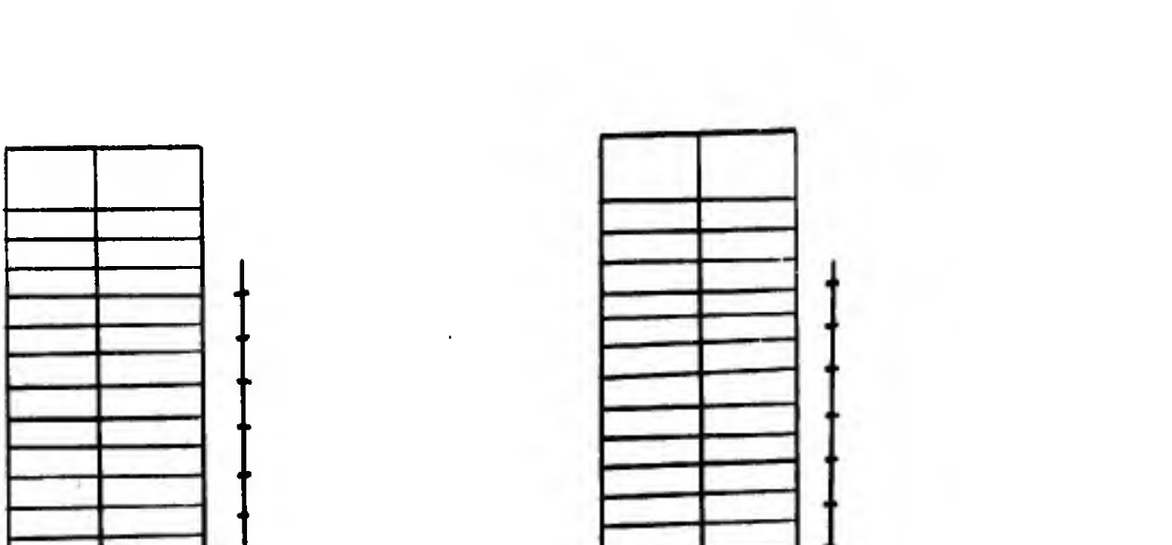
E Mev	σ



71 Lu

REMARKS

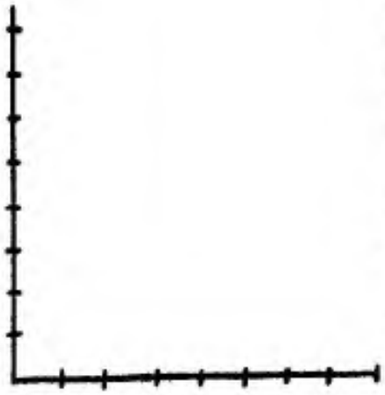
Thresholds	Isotope	Theoretical	Experimental	Reference



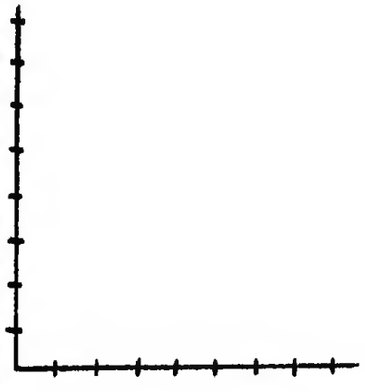
$_{72}Hf$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
72	Hafnium	-170				112 m	B+2.4	9
		-171				16.0 h	EC;γ0.18,1.4	9, 6
		-172				5 y	EC;γ~ 0.28,0.8	9
		-173				23.6 h	EC; γ 0.123,0.2985	9, 3
		-174			0.163			9
		-175				70 d	EC; γ0.089,0.3434, 0.433	9, 6
		-176	175.996300	2000	5.21			9, 2
		-177			18.56			9
		-178	177.999760	2000	27.1			9, 2
		-179			13.75			9
		-180	179.998000	2000	35.22			9, 2
		-181	181.004000	2000		44.6 d	B⁻0.408; γ 0.133, 0.136,0.346,0.482	9,2,6
		-183				64 m	B⁻1.4;γ	9

E Mev	σ

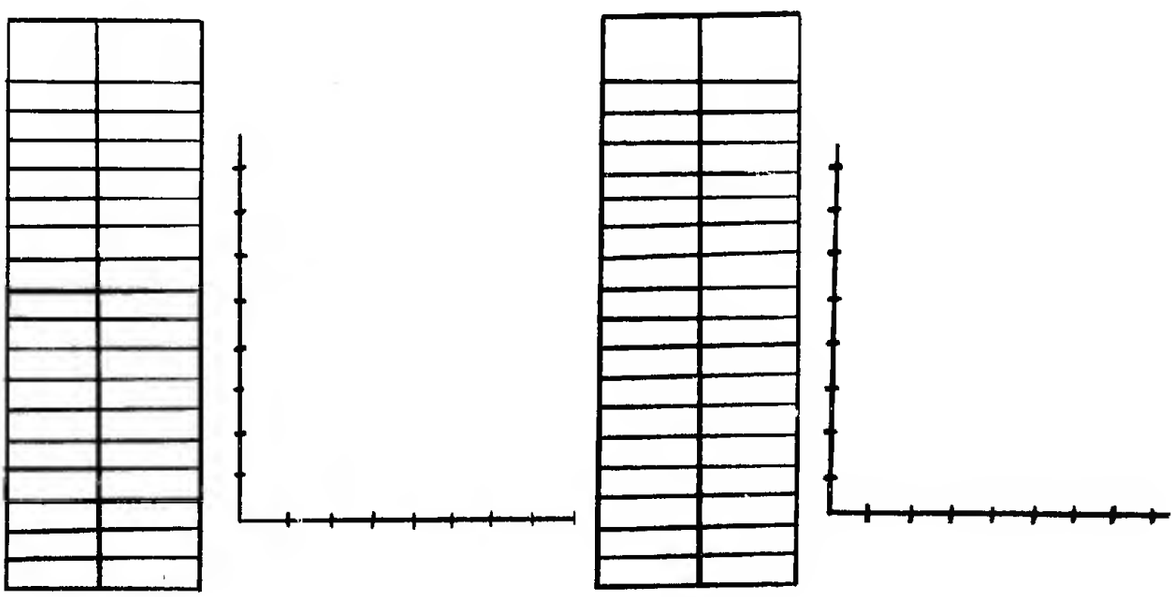


E Mev	σ



$_{72}Hf$

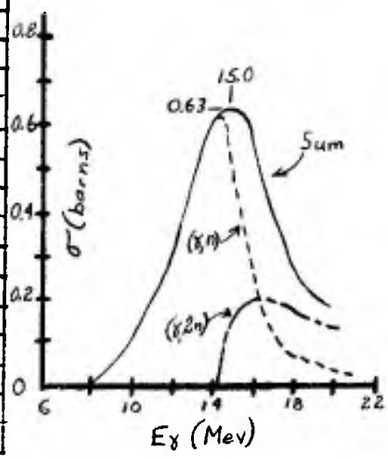
Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference.
(γ, n)	Hf^{177}	-6.602	-6.38	6, 23
	Hf^{178}	-7.540	-7.61	6, 23
	Hf^{179}	-6.270	-6.09	6, 23
	Hf^{180}	-7.420	-7.31	6, 23
(γ, p)	Hf^{177}	-6.840		6
	Hf^{178}	-7.260		6
	Hf^{179}			



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
73	Tantalum	-176				8.0 h	EC; γ0.0883,0.202	9, 6
		-177				53 h	EC; γ0.113,0.208, 0.321,0.425,0.510, 0.63,0.75,0.96, 1.07	9, 6
		-178				2.1 h	EC;B+ 1;γ 0.332, 1.4	9, 6
		-178				9.35 m	EC;B+1.06; γ0.093, 1.35, 1.5	9, 6
		-179				~600 d	EC;	9
		-180	180.002200	2000	0.0123			2, 9
		-181	181.002900	2000	99.9877			2, 9
		-182	182.005370	2000		115.1 d	B⁻ ;γ0.068,0.100, 0.152,0.222,0.229 0.264, 1.12, 1.19, 1.22	2,9,6
		-183				5.0 d	B⁻0.62;γ0.24	9, 6
		-184				8.7 h	B⁻1.26,0.15; γ0.110,0.24,0.30, 0.41,0.89,1.18	9, 6
		-185				50 m	B⁻1.7,~0.15;γ0.125 0.175,0.235	9, 6
		-186				10.5 m	B⁻2.2;γ0.125,0.20, 0.30,0.41,0.51, 0.61,0.73,0.94	9, 6

E Mev	σ_{barns}
8	0
9	0.04
10	0.10
11	0.18
12	0.30
13	0.44
14	0.60
15	0.63
16	0.53
17	0.36
18	0.26
19	0.21
20	0.18

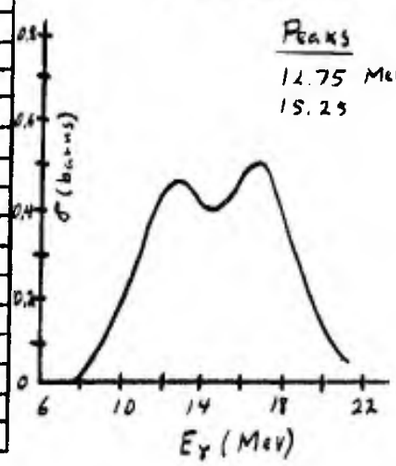
Ta (γ,n) Ref. #15



E Mev	σ

Ta 181 (γ, n)

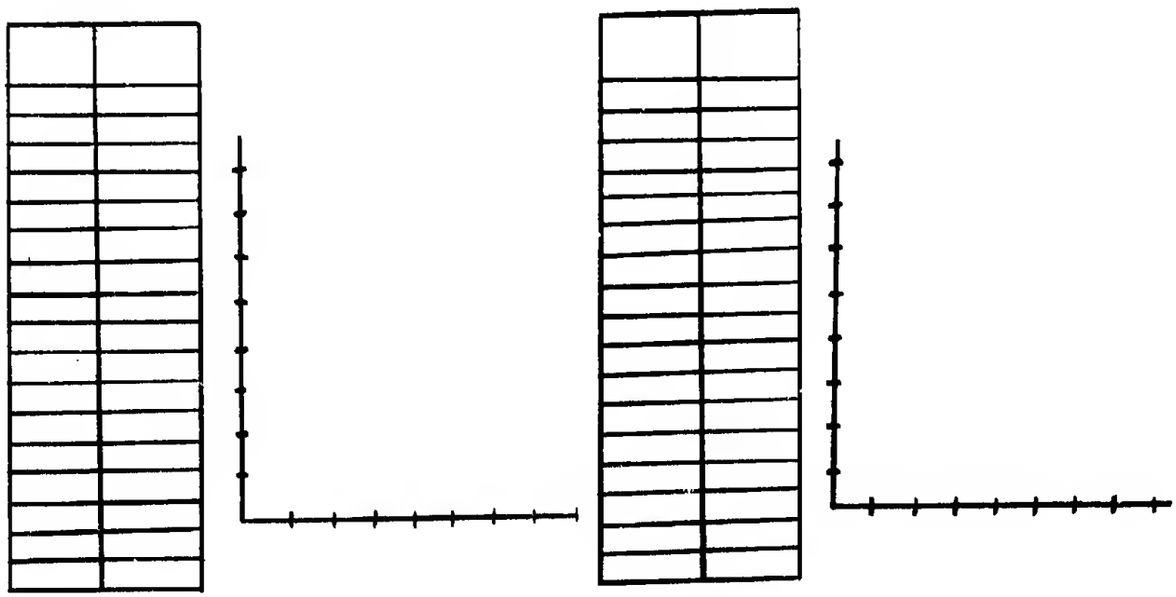
Peaks
12.75 Mev
15.25



$_{73}Ta$

REMARKS

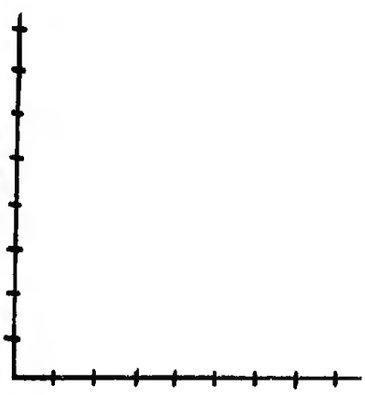
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Ta^{181}	-7 645		6
(γ,p)	Ta^{181}	-6.300		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
74	Tungsten	-176				80 m	EC;B+ ~2,~1.3	9
		-177				130 m	EC;γ~0.5, 1.2	9
		W?				Long	α 3.0	9
		-178				21.5 d	EC;γ~0.3	9
		-179				30 m	EC; γ 0.030	9
		-179				5.2 m	EC or IT; γ 0.22	9
		-180	180.001450	2000	0.135			2, 9
		-181				145 d	EC;γ	9
		-182	182.003510	2000	26.4			2, 9
		-183	183.005300	2000	14.4			2, 9
		-184	184.006300	2000	30.6			2, 9
		-185				75.8 d	B-0.430; γ 0.052, 0.134	9, 6
		-186	186.010400	2000	28.4			2, 9
		-187	187.012460	2200		24.0 h	B⁻ ; γ 0.072, 0.134,0.479,0.62, 0.69	2, 9,6
		-188				69.5 d	B⁻	9

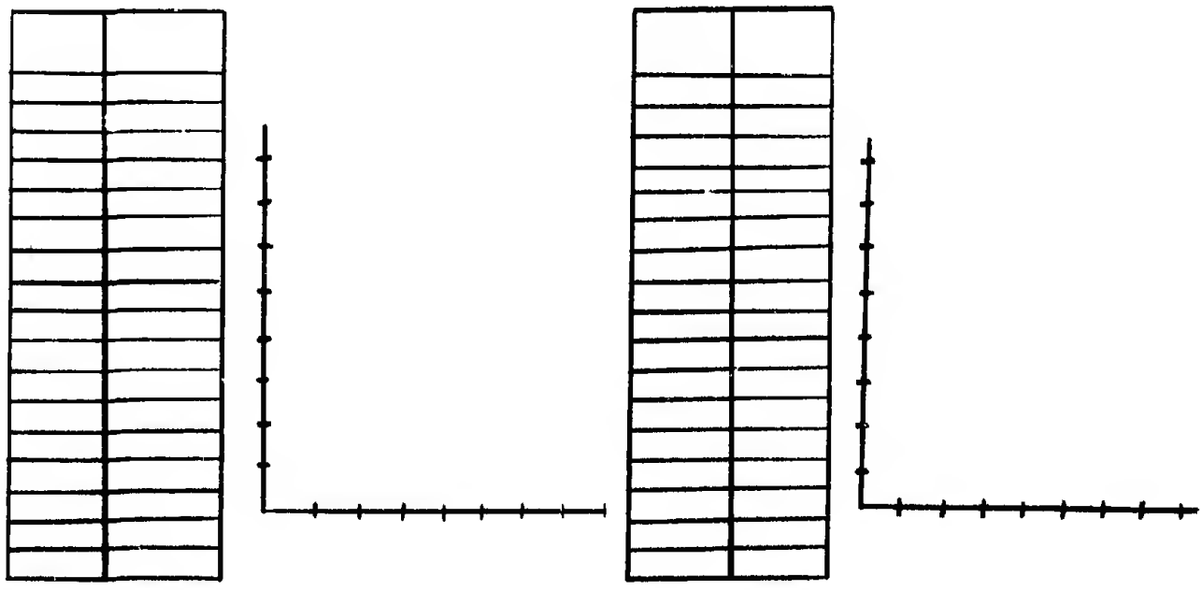
E Mev	σ

E Mev	σ



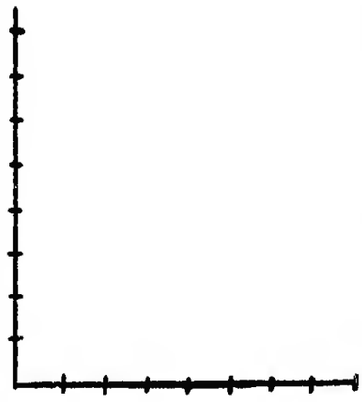
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	W^{182}	-8.000		6
	W^{183}	-6.185	-6.29	6, 48
	W^{184}	-7.460		6
	W^{186}	-7.280	-7.28	6, 48
(γ, p)	W^{182}	-7.021		6
	W^{183}	-7.135		6
	W^{184}	-7.740		6
	W^{186}	-8.200		6

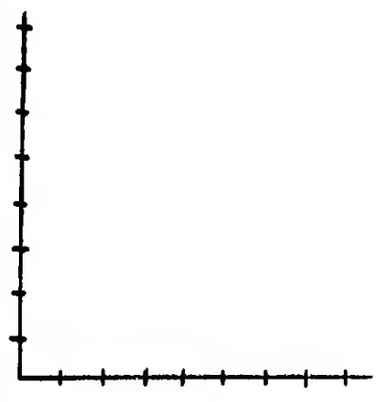


Z	CHEM. SYM.	A	ATOMIC MASS AMU ±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
75	Rhenium	-177			17 m	B+	9
		-178			15 m	B+3.1	9
		-180			2.4 m	B+1.1; γ0.11, 0.88	9
		-180			18 m	EC; γ0.227,0.212	9
					20 h	B+1.9	9
		-181			20 h	EC; γ	9
		-182			12.7h	EC;γ0.110,0.127, 0.222,0.250,0.346	9, 6
					64.0 h	EC;γ0.110,0.127, 0.222,0.250,0.346	9, 6
		-183			71 d	EC ;γ0.081,0.252	9, 6
		-184			50 d	EC ;γ0.159,0.206, 0.244,0.784,0.89	9, 6
					2.2 d	EC or IT; γ0.43, 0.159	9,
		-185		37.07			9
		-186	186.010697 2300		88.9 h	B- ; γ0.137,0.628	2,9,6
		-187	187.011052 2200	62.93	$\sim 5\times10^{10}$ y	B- 0.008; γ0.1342	2
		-188	188.016330 2000		16.7 h	B-2.12,1.96; γ0.152 0.476,0.638,1.13	2, 6
		-189			150 d	B-0.2; γ1.0	9
		Fe?			9.8 m	B-1.8	9
		-190			2.8 m	B-1.7;γ0.191,0.392 0.57,0.83	9, 6
		Fe?			≥25 y	B-0.75	9

E Mev	σ

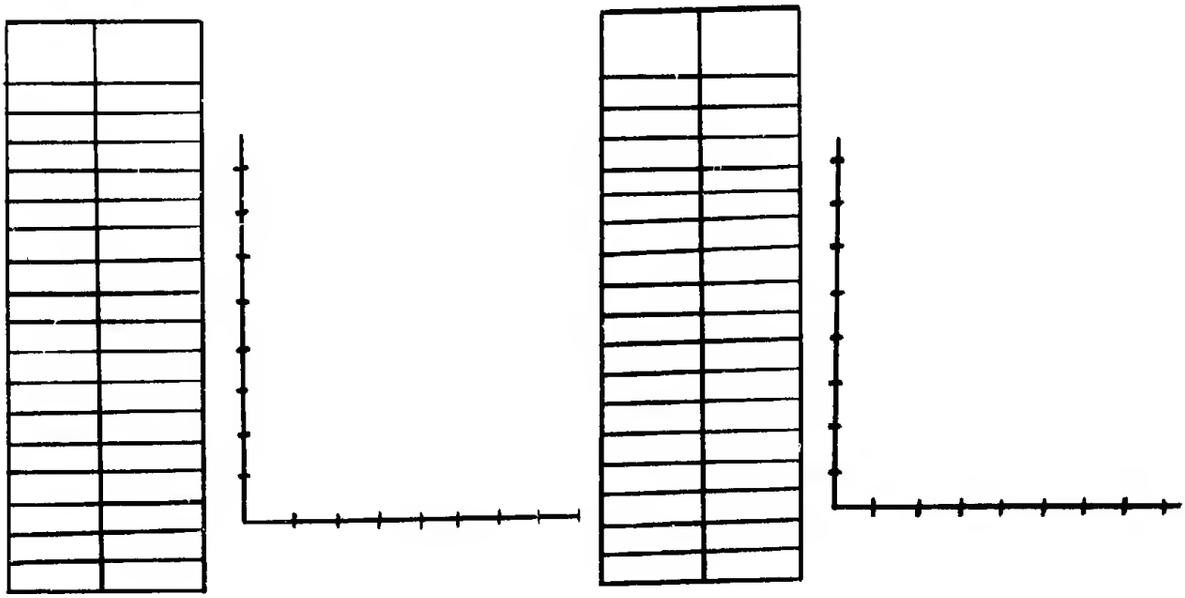


E Mev	σ



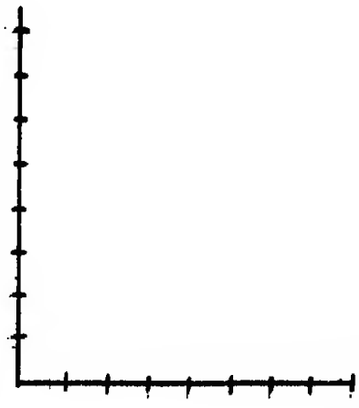
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Re^{185}			
	Re^{187}	-7,240	-7,18	6, 48
(γ, p)	Re^{185}	-6.400		6
	Re^{187}	-3.900		6

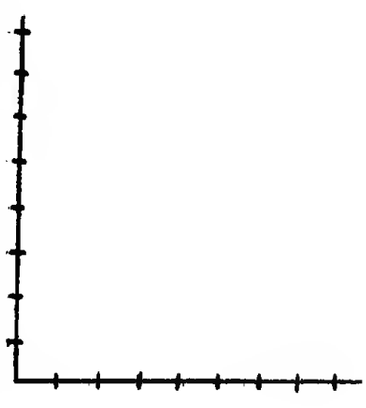


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
76	Osmium	-181				23 m	EC; γ 0.166, 0.174	9, 6
		-182				21.9 h	EC; γ 0.0276, 0.0555, 0.1805, 0.510	9, 6
		-183				13.5 h	EC; γ 0.3, 1.6	9
		-184			0.018			9
		-185				93.6 d	EC; γ 0.648, 0.878	9
		-186	186.009550	2300	1.59			2, 9
		-187	187.011045	2200	1.64			2, 9
		-188	188.014100	200	13.3			2, 9
		-189	189.018120	2000	16.1			2, 9
		-190	190.017400	2000	26.4			2, 9
		-191	191.021500	2100		16.0 d	B^- 0.143; γ 0.1858	2, 9, 6
		-192	192.022500	3000	41.0			2, 9
		-193	193.026370			30.6 h	B^- ; γ 0.072, 0.137, 0.2507, 0.2806	2, 9, 6
		-194				~700 d	B^-	9
		-195				6.5 m	B^- 2	9

E Mev	σ

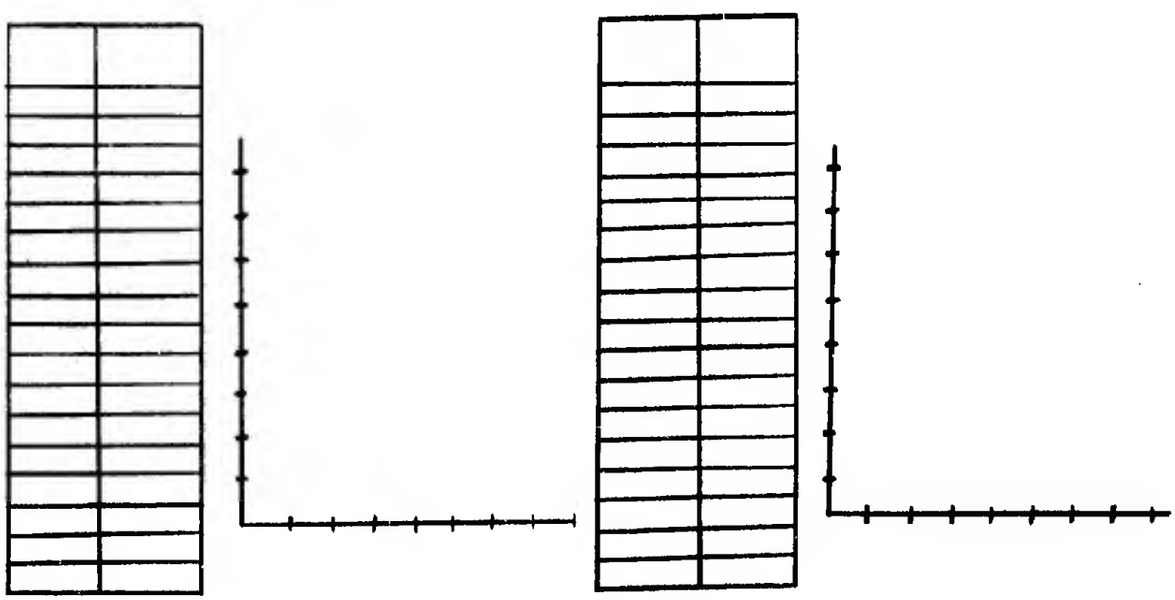


E Mev	σ



$_{76}Os$

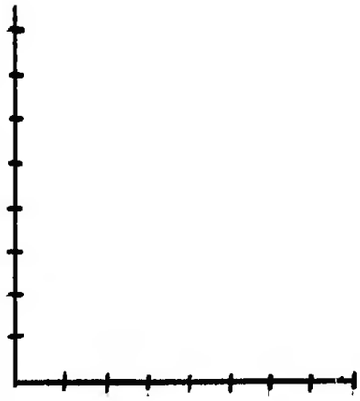
Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference
(γ, n)	Os^{188}	-8.060		6
	Os^{189}	-5.990		6
	Os^{190}	-7.880		6
	Os^{192}	-7.810		6
(γ, p)	Os^{188}	-7.280		6
	Os^{189}	-7.320		6
	Os^{190}			
	Os^{192}			



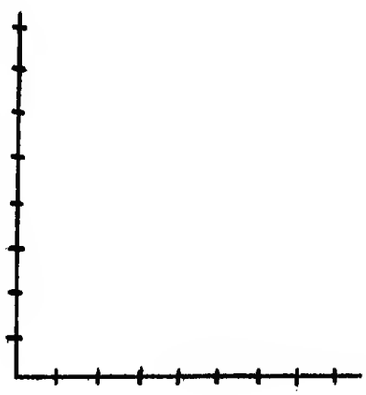
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
77	Iridium	-185				1.5 h	EC; γ 0.0374, 0.0599, 0.0973, 0.1008, 0.1044, 0.2544	9, 6
		-186				15 h	EC; B+; γ 0.138, 0.298, 0.436	9, 6
		-187				13 h	EC; γ > 10 γ's	9, 6
		-188				41.5 h	EC; B+ 2.0, γ > 10 γ's	9, 6
		-189				11 d	EC; γ > 10 γ's	9, 6
		-190				3.2 h	EC; B+ 2.0; γ 0.186, 0.36, 0.56, 0.62	9, 6
						11 d	EC; γ 0.1865, 0.359, 0.404, 0.558, 0.80	9, 6
		-191	191.021240	2100	38.5			2, 9
		-192	192.024700	2050		74.37 d	B- 0.67; γ 0.206, 0.296, 0.308, 0.316 0.468	2, 9
		-193	193.025200	2000	61.5			2, 9
		-194	194.026400	1510		19.0 h	B- ; γ 0.29, 0.326, 1.51	2, 9
		-195	195.028660	1510		2.3 h	B- 2.1, 1.3; γ 0.070, 0.42, 0.66, 0.88	2, 9, 6
		-196				9.7 d	B- 0.08; γ 0.58, 0.76 ~1	9, 6

Continued on next page

E Mev	σ



E Mev	σ



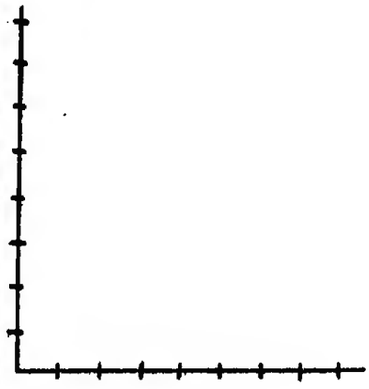
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
77	Iridium	- 197				7 m	B-1.6; γ 1.8	9
		- 198	198.033700	2010		50 s	B-3.6 ; γ 0.78	2, 9

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Ref.
(γ, n)	Ir^{191}			
	Ir^{193}	- 7.786		6
(γ, p)	Ir^{191}	- 4.980		6
	Ir^{193}	- 5.590		6

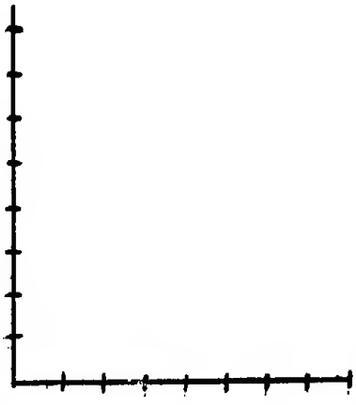
E Mev	σ

E Mev	σ

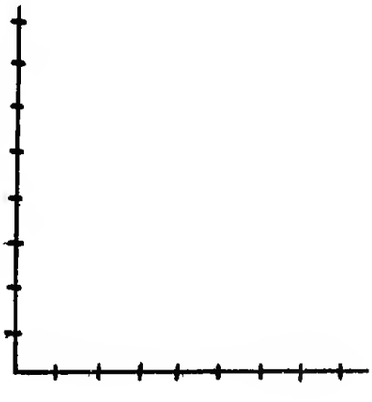


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
78	Platinum	-186				2.5 h	EC	9
		-188				10.0 d	EC; γ 0.20,0.28, 0.40	9, 6
		-189				11.0 h	EC; γ 0.14,0.55,0.70	9, 6
		-190			0.0127	5.9×10^{11} y	α 3.30	9
		-191				3.00 d	EC; γ 0.083,0.096, 0.173	9, 6
		-192	192.023100	2050	0.78	$\sim 10^{15}$ y	α 2.6	2, 9
		-193	193.025300	1550			EC; no γ	2, 9
		-194	194.024000	1500	32.9			2, 9
		-195	195.026400	1500	33.8			2, 9
		-196	196.026880	1500	25.2			2, 9
		-197	197.029280	1000		18 h	β^- 0.670; γ 0.0771, 0.1910,0.279	2,9,6
		-198	198.029000	2000	7.19			2, 9
		-199				31 m	β^- ; γ 0.074, 0.197,0.246,0.318, 0.475,0.540,0.715, 0.790,0.960	9, 6
		-200				11.5 h	β^-	2, 9

E Mev	σ



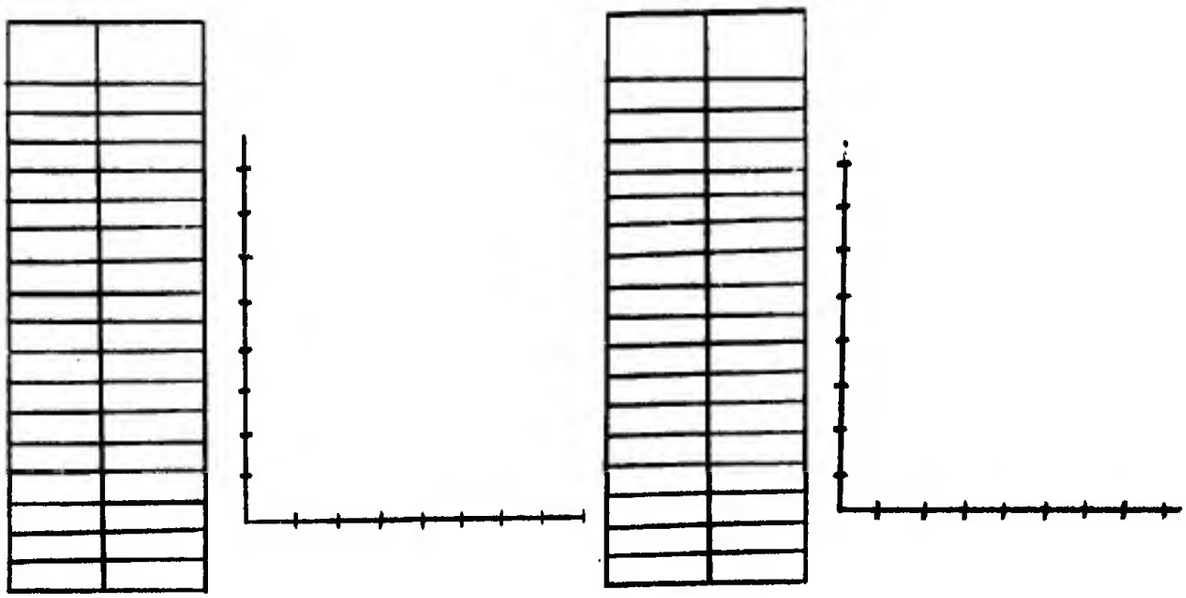
E Mev	σ



REMARKS

$_{78}Pt$

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Pt^{194}	-8.030		6
	Pt^{195}	-6.178	-6.205	6, 48
	Pt^{196}	-7.922	-8.29	6, 48
	Pt^{198}	-7.910		6
(γ,p)	Pt^{194}	-7.200		6
	Pt^{195}	-7.631		6
	Pt^{196}			
	Pt^{198}			

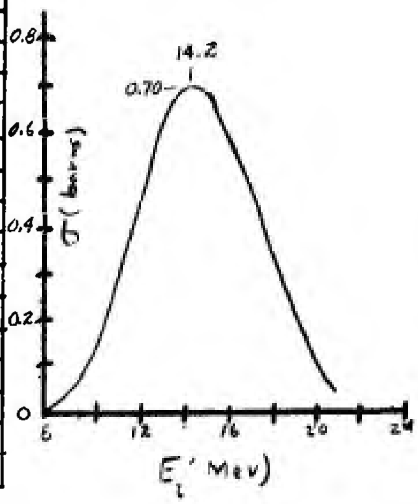


Z	CHEM. SYM. A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
79	Gold 183-187				4.3 m	EC;B+ γ5.07	9
	-186				~15 m	EC	9
	-188				4.5 m	EC	9
	-189				42 m	EC; γ0.135, 0.29	9, 6
	191-193				2.0 s		9
	-191				3.0 h	EC;γ0.135,0.300, 0.390,0.475,0.600	9
	-192				4.7 h	EC;B+~1.9;γ2.3	9
	-193				15.8 h	EC;γ0.051,0.060, 0.084,0.093,0.109, 0.165,0.177,0.235	9
	-194				39.5 h	EC;B+1.21,1.55; γ0.291,0.328,1.48 2.1	9
	-195				180 d	EC;γ0.0303,0.0987, 0.128	9, 6
	-196	196.028100	3010		14.0 h 5.55 d	EC or IT; EC; B^-0.27;γ0.331, 0.356	9 2, 9
	-197	197.028470	3000	100			2, 9
	-198	198.030480	3000		2.697 d	B^-0.960;γ0.418, 0.676, 1.086	2,9,6
	-199	199.031033	3050		3.14 d	B^- ;γ0.050, 0.158, 0.208	2,9,6

Continued on next page

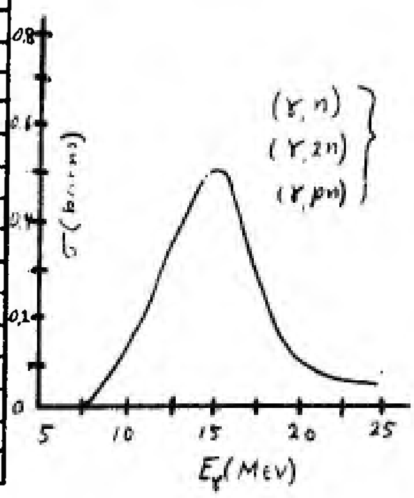
E Mev	σ_{barns}
8	0.[illegible]
9	0.04
10	0.11
11	0.28
12	0.45
13	0.64
14	0.70
15	0.67
16	0.57
17	0.42
18	0.34
19	0.21
20	0.12
21	.02

$Au^{197}(\gamma,n)$ REF. #1



E Mev	σ

Au^{197} Ref # 102

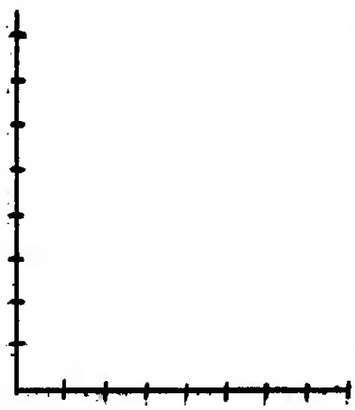


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
79	Gold	-200	200.034380	3030		48 m	B-2.18,0.6; γ0.39, 1.13,1.23	2, 9, 6
		-201	201.035600	3010		26 m	B-1.5; γ0.55	2, 9
	202	-204				~25 s	B⁻ or IT	9
		-203				55 s	B-1.9; γ0.69	9

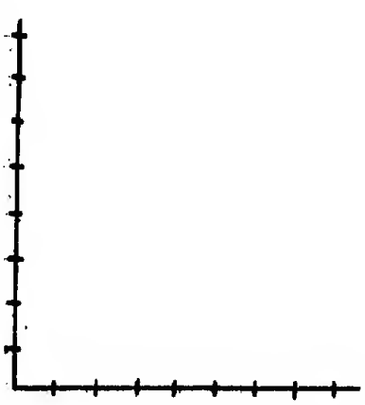
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Au^{197}	- 8.067	- 7.96	6, 22
(γ,p)	Au^{197}	- 5.490		6

E Mev	σ

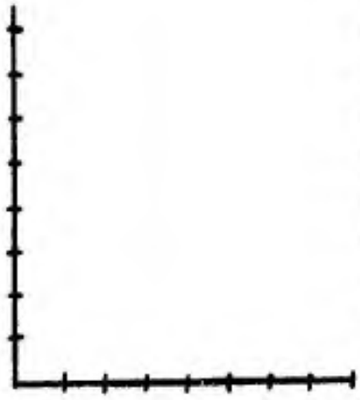


E Mev	σ

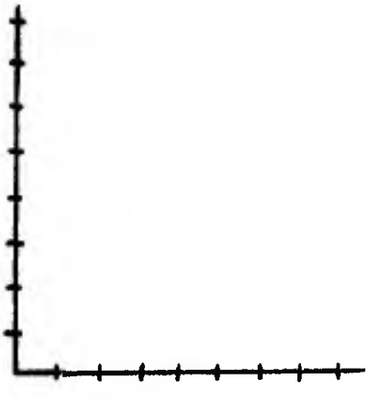


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
80	Mercury	-189				23 m	EC; γ 0.0286	9
		-191				90 m		9
						3 h		9
		-19'				0.7 m	α 5.60	9
		-191				57 m	EC; γ 0.2526,0.2741	9, 6
		-192				5.7 h	EC; B+1.18; γ 1.4	9
		-193				~6 h	EC; γ 0.0379,0.1865, 0.570, 0.860	9
		-194				0.4 s	γ	
						~130 d	EC;	9
		-195				9.5 h	EC; γ 0.061,0.197, 0.600, 0.780	9, 6
		-196	196.027350	3010	0.146			2, 9
		-197				65 h	EC; γ 0.0775,0.1916	9, 6
		-198	198.029000	3000	10.02			2, 9
		-199	199.030550	3050	16.84			2, 9
		-200	200.031910	3010	23.13			2, 9
		-201	201.034000	3000	13.22			2, 9
		-202	202.035341	620	29.80			2, 9
		-203	203.036474	400		46.9 d	B⁻0.208; γ 0.280	2, 9
		-204	204.037323	230	6.85			2, 9
		-205	205.040359	160		5.5 m	B⁻1.8; γ 0.203	2, 9
		-206					B⁻	9

E Mev	σ



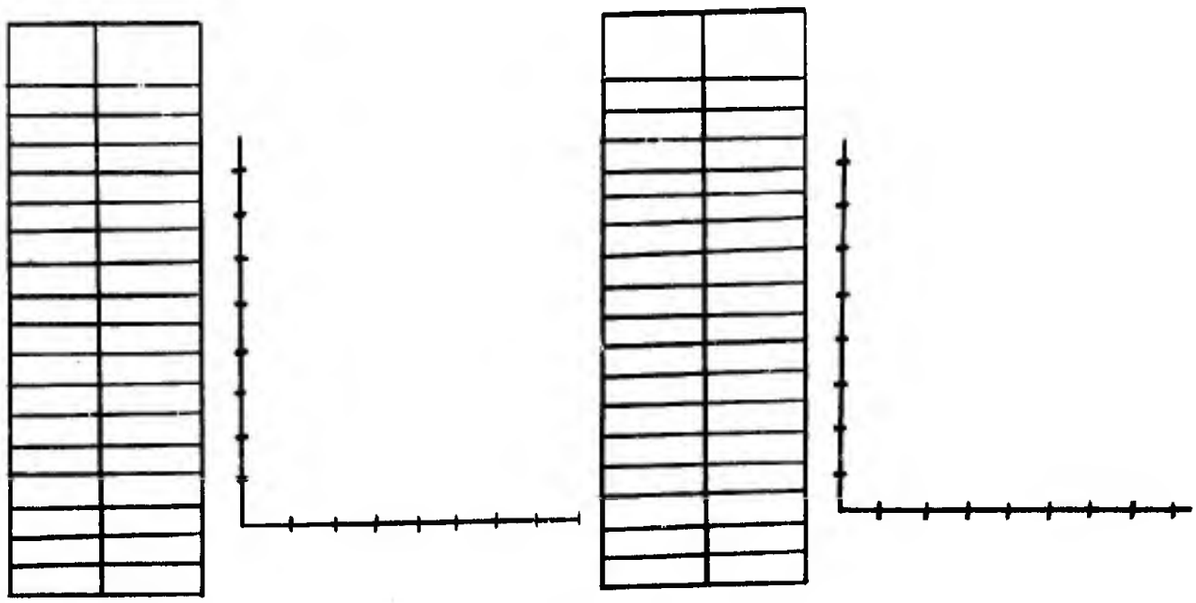
E Mev	σ



$_{80}Hg$

REMARKS

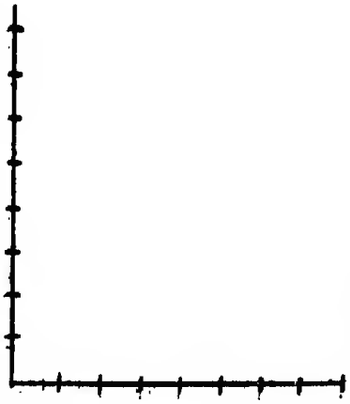
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Hg^{198}			
	Hg^{199}	-6.686	-6.59	6, 48
	Hg^{201}		-6.21	48
(γ, p)	Hg^{198}	-7.087		6
	Hg^{199}	-7.275		6



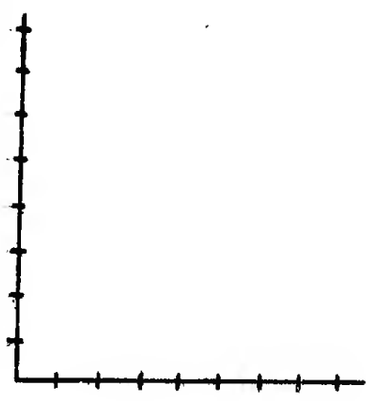
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
81	Thallium	-195				1.2 h	EC; γ0.037	9
		-196				1.8 h	EC; γ0.426	9
		-197				2.7 h	EC; γ0.1335,0.1521 0.1731,0.269,0.425	9
		-198				5.3 h	EC; γ~1.075,~1.23, 1.44	9, 6
		-199				7.4 h	EC; γ0.0495,0.078, 0.103,0.158,0.207, 0.246,0.333,0.454, 0.490	9, 6
		-200				26.1 h	EC;B+ ; γ0.365, 0.577,0.622,0.829, 1.210,1.360	9, 3
		-201				72 h	EC; γ0.0306,0.0321, 0.135,0.1672,0.210	9, 6
		-202	202.036415	450		12.0 h	EC; γ0.440	2,9,6
		-203	203.035951	400	29.50			2, 9
		-204	204.037678	130		3.56 y	B-0.764;EC;	2, 9
		-205	205.038480	130	70.50			2, 9
		-206	206.040447	20		4.19 m	B-1.51;	2, 9
		-207	207.042138	40		4.79 m	B-1.44; γ0.870	2, 9
		-208	208.047006	20		3.10 m	B-1.792; γ2.62, 0.859,0.582,0.510 0.277	2, 9, 6

Continued on next page

E Mev	σ



E Mev	σ



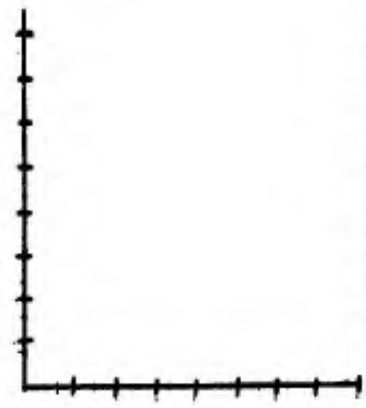
81 Tl

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
81	Thallium	-209	209.050676	60		2.2 m	β^- 1.99; γ 0.120, 0.45, 1.56	2, 9, 6
		-210	210.055615	30		1.32 m	β^- 1.96; γ 0.297, 0.783, ~1.1, ~1.3 2.36	2, 9, 6

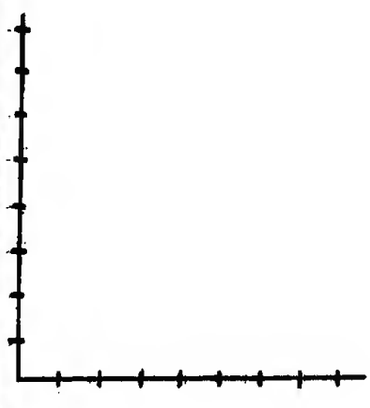
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	Tl^{205}		-7.515	48

E Mev	σ



E Mev	σ

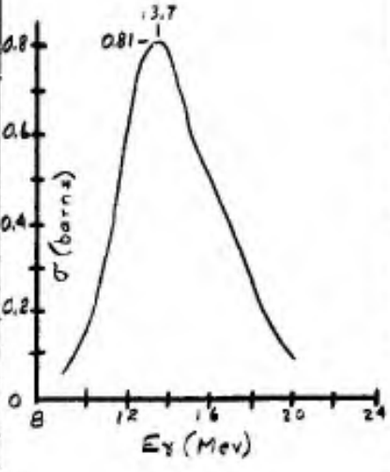


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
82	Lead	-195				17 m	EC;γ	9
		-196				37 m	EC;γ0.191,0.24,0.25	9, 6
		-197				42 m	EC; IT;γ	9
		-198				25 m	EC	
						2.4 h	EC;γ0.117,0.173, 0.259,0.290,0.365, 0.382	9, 6
		-199				90 m	EC;B+2.8;γ0.267, 0.353,0.367,0.721, 1.132	9, 6
		-200				21.5 h	EC;γ0.0328,0.109, 0.142,0.148,0.159, 0.235,0.257,0.268, 0.289, 0.450	9, 6
		-201				9.4 h	EC;B+~2.5;γ ? 10δ's	9
		-202	202.036501	460		~3x10⁵ y	EC;γ	2, 9
		-203	203.037347	530		52.1 h	EC;γ0.2795,0.401	2, 9, 6
		-204	204.036859	130	1.40			2, 9
		-205	205.038539	50		~5x10⁷ y	EC;γ	2, 9
		-206	206.038826	10	25.1			2, 9
		-207	207.040580	10	21.7			2, 9
		-208	208.041640	0	52.3			2, 9
		-209	209.046471	50		3.30 h	B-0.635	2, 9

Continued on next page

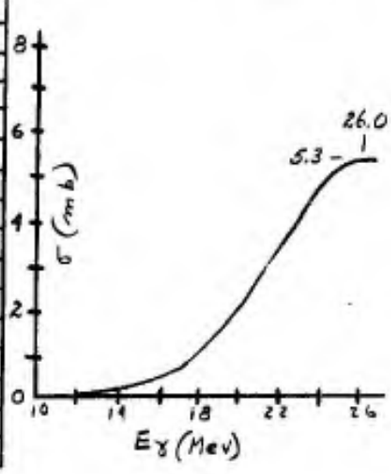
E Mev	σ_{barns}
9	0.06
10	0.15
11	0.32
12	0.56
13	0.77
14	0.80
15	0.67
16	0.50
17	0.37
18	0.23
19	0.14
20	0.07

Pb (γ,n) Ref. #1



E Mev	σ_{mb}
12	0
13	0+
14	0.1
15	0.2
16	0.4
17	0.7
18	1.0
19	1.4
20	2.1
21	2.7
22	3.5
23	4.2
24	4.8
25	5.3
26	5.3

Pb (γ,p) Ref. #14



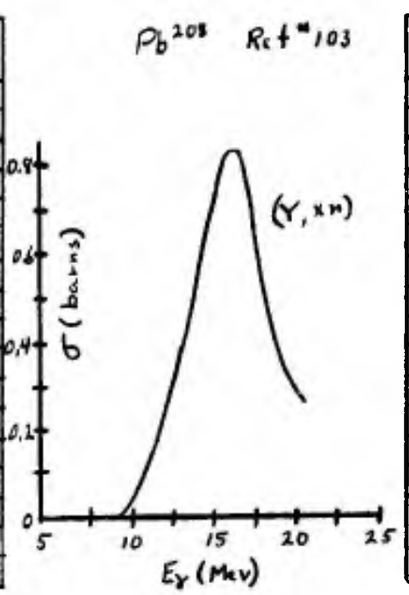
$_{82}Pb$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
82	Lead	-210	210.049830	20		19.4 y	B-0.017; γ0.0465	2,9,6
		-211	211.054754	100		36.1 m	B-1.3?, ~0.5; γ0.065,0.083,0.404	2, 9, 6
		-212	212.058170	30		10.64 h	B-0.355,0.589; γ0.238, 0.300	2, 9, 6
		-213	213.063028	390				2
		-214	214.066581	80		26.8 m	B- ; γ 0.242, 0.295, 0.352	2, 9, 6

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference
(γ,n)	Pb^{206}		-8.09	48
	Pb^{207}		-6.790	48
	Pb^{208}		-7.404	48

E Mev	σ



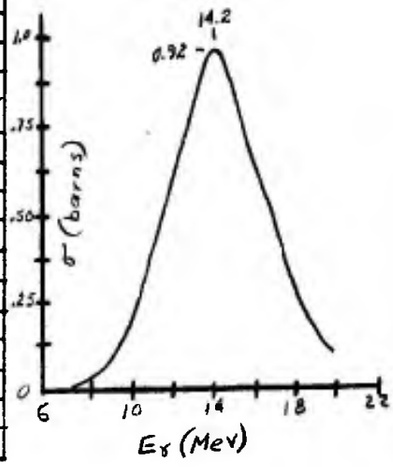
E Mev	σ

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
83	Bismuth	>198				1.7 m	α 6.2	9
		-198				7 m	EC; α 5.83	9
		-199				~25 m	EC; α 5.47	9
		-200				35 m	EC; γ 0.462, 1.027	9, 6
		-201				62 m	EC; α 5.15	9
						1.85 h	EC; γ	9
		-202				95 m	EC; γ 0.422, 0.961	9
		-203				12.3 h	EC; α 4.85; B+1.35, 0.74; γ 10's	9
		-204				11.6 h	EC; γ 0.217	9
		-205				14.5 d	EC, B+0.98; γ 0.431, 0.527, 0.550, 0.746 1.84	9, 6
		-206	206.042692	210		6.4 d	EC; γ 10's	2, 9
		-207	207.043160	40		8.0 y	EC; γ 0.567, 1.064, 1.766	2, 9, 6
		-208	208.044787	70		~3x10^4 y	EC; γ 2.61, 0.50, 0.93	2, 9, 6
		-209	209.045794	50	100	>2x10^{18} y	α 3.0?;	2, 9
		-210	210.049761	20		5.013 d 2.6x10^6 y	B-1.155; α 4.94; B-	2, 9
		-211	211.053261	50		2.16 m	α 6.617, 6.273; B- γ 0.351	2, 9
		-212	212.057545	30		60.5 m	B-2.250; α ; γ 10's	2, 9

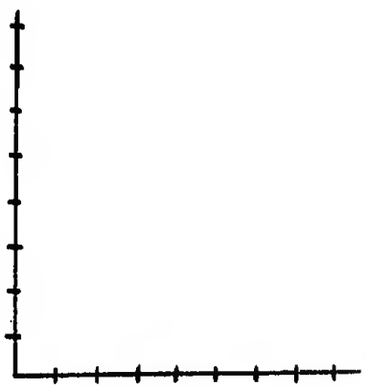
Continued on next page

E Mev	σ_{barns}
7	0
8	0.04
9	0.10
10	0.22
11	0.38
12	0.58
13	0.80
14	0.91
15	0.85
16	0.62
17	0.42
18	0.33
19	0.21
20	0.10

$Bi^{209}(\gamma,n)$ REF. #1

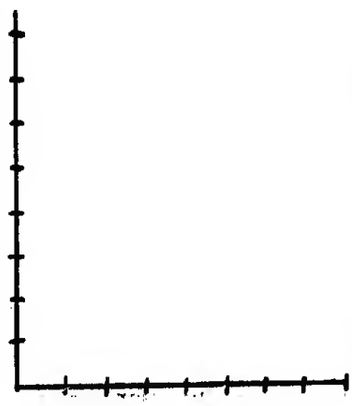


E Mev	σ

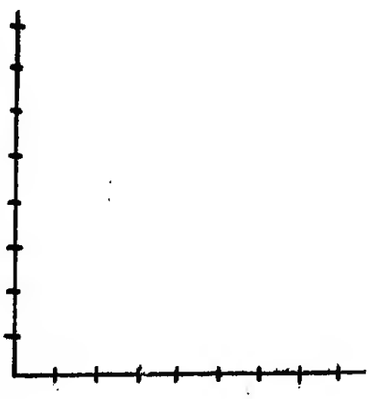


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
83	Bismuth	-213	213.060966	60		47 m	B-1.39,0.96; α5.86; γ0.44	2, 9,6
		-214	214.065518	40		19.7 m	B- ; α ; γ10's	2, 9
		-215	215.068911	250		8 m	B-	2, 9
		-216	216.073802	350				2

E Mev	σ



E Mev	σ



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
84	Polonium	-196				1.9 m	α6.14	9
		-197				~4 m	α6.04	9
		-198				~6 m	α5.935; 5.933	9, 6
		-199				~11 m	α5.846	9
		-200				11 m	EC;α5.770	9
		-201				18 m	EC;α5.671	9
		-202				51 m	EC;α5.575	9
		-203				42 m	EC;	9
		-204				3.8 h	EC;α5.370	9
		-205				1.8 h	EC;α5.2	9
		-206				8.8 d	EC;α5.218; γ0.8, 0.0599	9
		-207				5.7 h	EC;α5.10;γ0.1,1.3	9
		-208	208.046330	120		2.93 y	α5.108;γ	2, 9
		-209	209.047756	90		103 y	α4.877;γ0.260, 0.91	2, 9, 6
		-210	210.048505	20		138.4 d	α5.305;γ0.79	2, 9
		-211	211.052605	20		0.52 s	α7.442; γ0.562, 0.88	2, 9, 6
		-212	212.055129	10		3.04×10^{-7}s	α8.78	2, 9
		-213	213.059473	60		4.2×10^{-6}s	~8.35	2, 9
		-214	214.062114	30		1.64×10^{-4}s	~7.68	2, 9
		-215	215.066711	100		1.83×10^{-3}s	α7.36	2, 9

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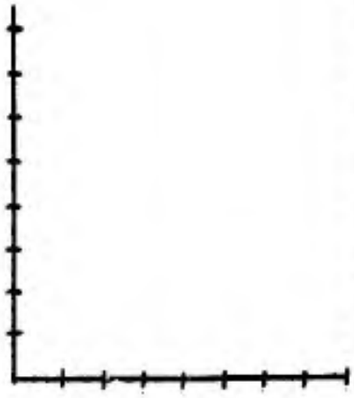
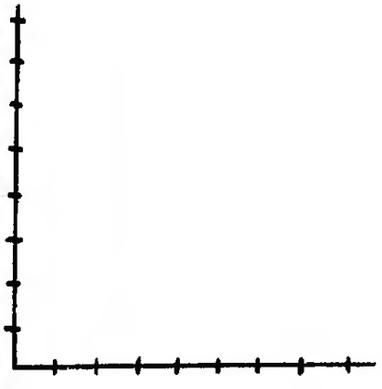
E Mev	σ



E Mev	σ



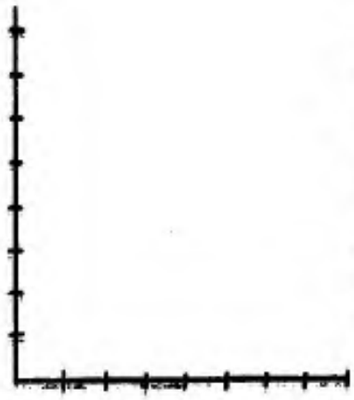
84 Po

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
84	Polonium	-216	216.069462	30		0.158 s	$\mathcal{E}$6.775	2, 9
		-217	217.074058	320		<10 s	$\mathcal{E}$6.54	2, 9
		-218	218.077021	80		3.05 m	$\mathcal{E}$5.998, β^-	2, 9
		-219	219.082111	340				2
		-220	220.085026	320				2

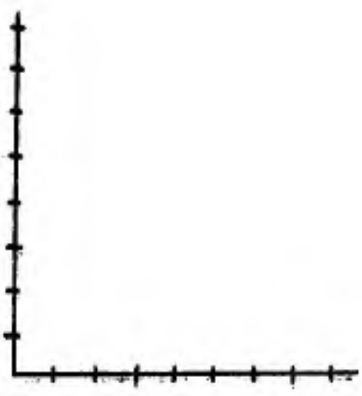
REMARKS

Thresholds Isotope Theoretical Experimental Reference

E Mev	σ

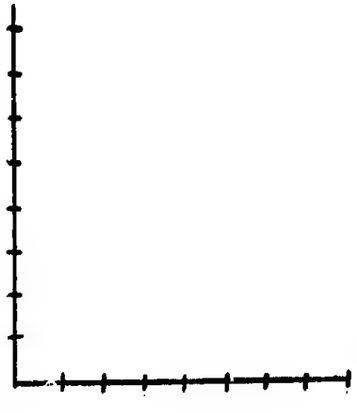


E Mev	σ

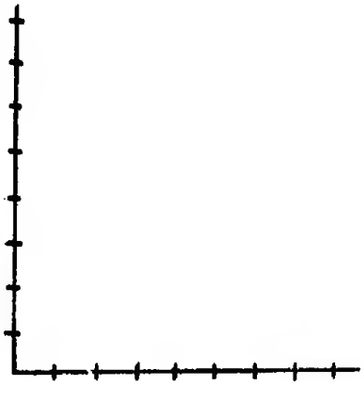


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
85	Astatine	202				43 s	α6.50	9
		203				1.7 m	α6.35	9
		203				7 m	α 6.10	9
		204				~25 m	EC	9
		205				25 m	α5.90	9
		206				2.9 h	EC	9
		207				1.8 h	EC; α5.75	9
		208				6.3 h	EC;	9
						1.6 h	EC; α5.65; γ0.120, 0.175, 0.250, 0.660	9, 6
		209				5.5 h	EC; α5.642; γ0.195, 0.547, 0.782	9, 6
		210	210.052611	230		8.3 h	EC; α5.519, 5.437, 5.355, >10 γ's	2, 9
		211	211.053543	50		7.20 h	α5.862; EC; γ0.67, >10 γ's	2, 9
		212	212.056934	550		0.22 s	α	2, 9
		213	213.059746	130			α9.2	2, 9
		214	214.063251	60		~2x10-6s	α8.78	2, 9
		215	215.065892	60		~10-4 s	α8.00	2, 9
		216	216.069950	50		~3x10-4s	α7.79	2, 9
		217	217.072512	80		0.018 s	α7.05	2, 9
		218	218.076645	240		1.5-2.0s	α6.63	2, 9
		219	219.079651	260		0.9 m	α6.27; β^-	2, 9
		220	220.084124	290				2

E Mev	σ

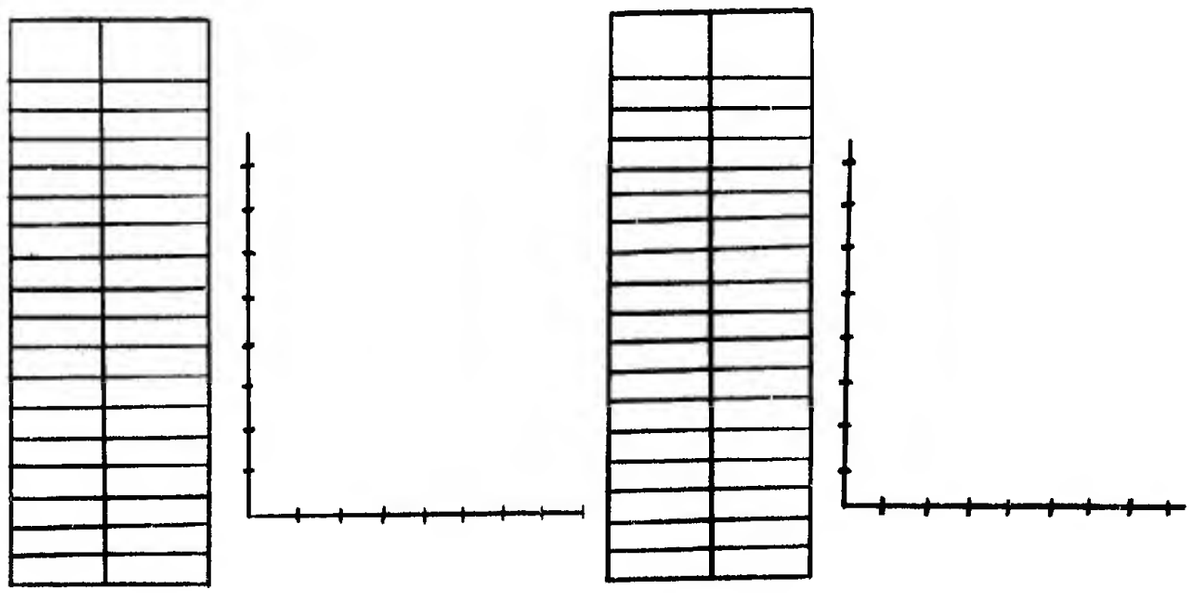


E Mev	σ



$_{85}At$

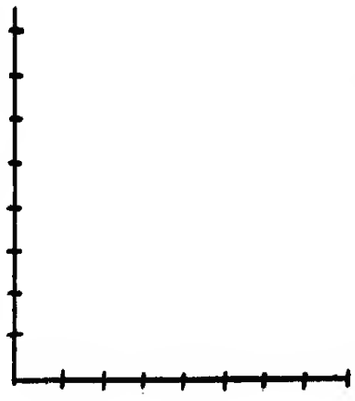
Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference



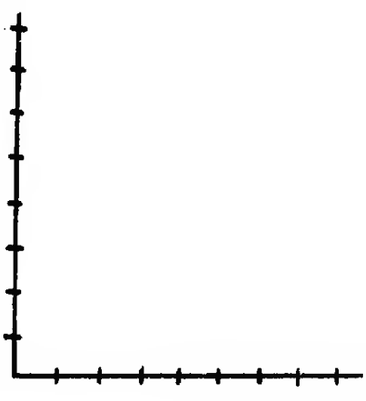
86 Rn

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
86	Radon	-204				3 m	α 6.28	9
		-206				6.5 m	α 6.25	9
		-207				11 m	EC; α 6.14	9
		-208				23 m	EC; α 6.141	9
		-209				30 m	EC; α 6.037	9
		-210				2.7 h	α 6.037	9
		-211				16 h	EC; α ; ≈10 γ's	9, 6
		-212				23 m	α 6.264	9
		-213	213.057062	120				2
		-214	214.062370	330				2
		-215	215.065891	120		~10^{-6} s	α 8.6	2, 9
		-216	216.067770	40		~10^{-4} s	α 8.01	2, 9
		-217	217.071824	80		~10^{-3} s	α 7.74	2, 9
		-218	218.073788	40		0.019 s	α 7.13; γ 0.609	2, 9
		-219	219.078036	110		3.92 s	α ; γ 0.198, 0.270, 0.399	2, 9, 6
		-220	220.080211	40		51.5 s	α 6.282; γ 0.542	2, 9, 6
		-221	221.084508	250		25 m	B^- ; 6.0	2, 9
		-222	222.086899	80		3.8229 d	α 5.486; γ 0.510	2, 9, 6
		-223	223.091574	260				2
		-224	224.094113	250				2

E Mev	σ



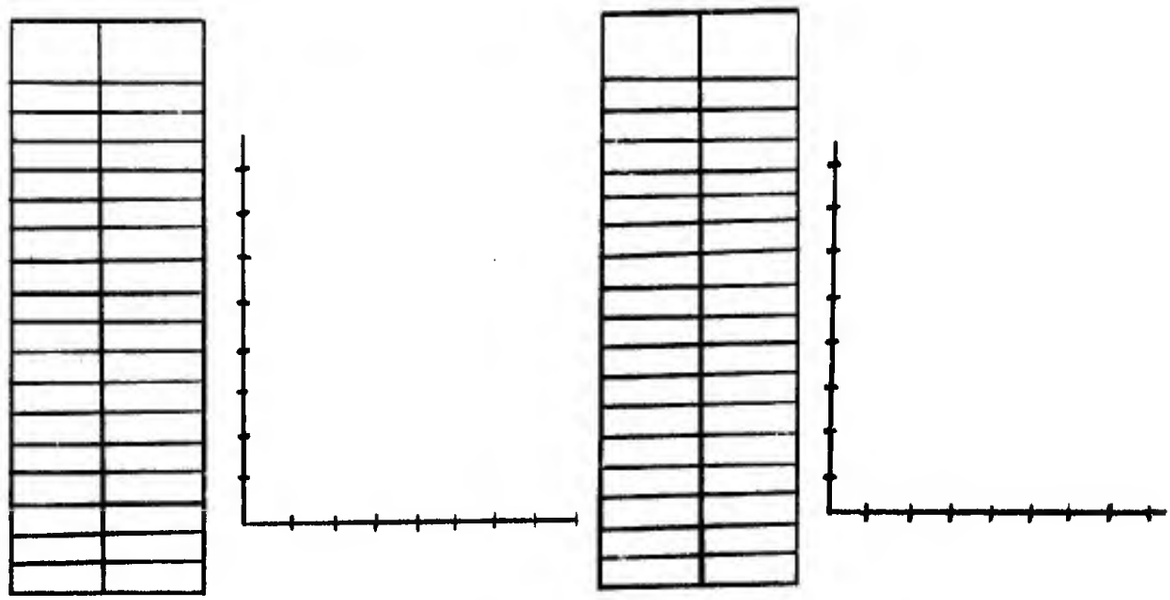
E Mev	σ



$_{86}Rn$

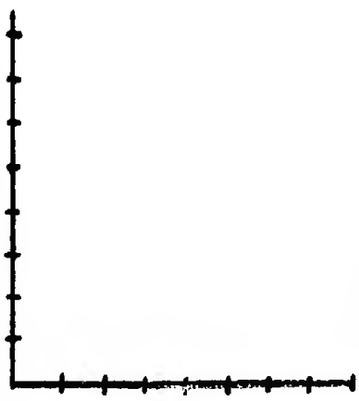
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

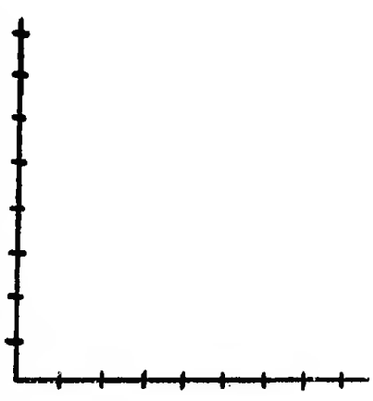


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
87	Francium	-212				19.3 m	EC; α 6.342	9
		-217	217.072709	170			α 8.3	2, 9
		-218	218.075720	100		5×10^{-3} s	α 7.85	2, 9
		-219	219.077760	80		0.02 s	α 7.30	2, 9
		-220	220.081142	60		27.5 s	α 6.69	2, 9
		-221	221.083240	90		4.8 m	α ; γ 0.218	2, 9, 6
		-222	222.087074	290		14.8 m	B^-	2, 9
		-223	223.089597	130		22 m	B^- 1.15; α 5.34; γ 0.049, 0.080	2, 9
		-224	224.093586	180				2
		-225	225.095933	380				2
		-226	226.100005	590				2
		-227	227.102867	480				2
		-228	228.107115	270				2

E Mev	σ



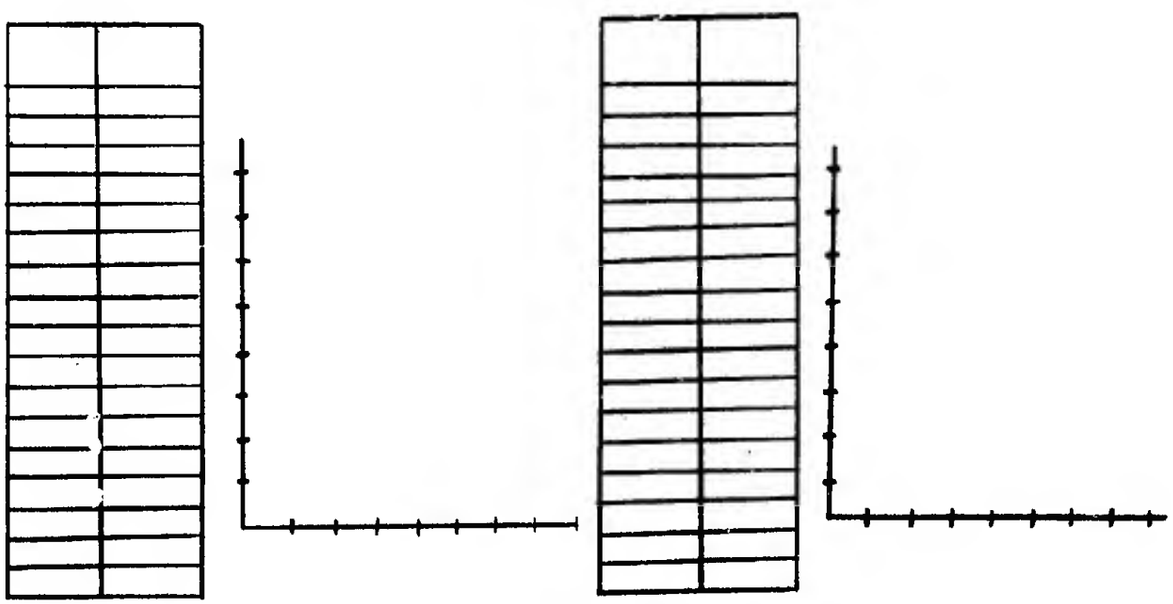
E Mev	σ



^{87}Fr

REMARKS

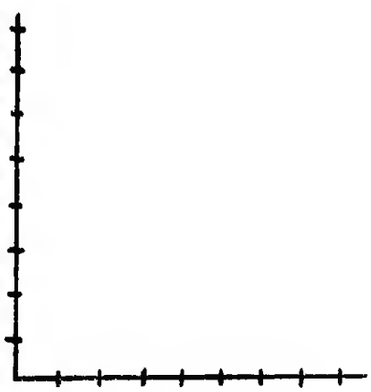
Thresholds	Isctope	Theoretical	Experimental	Reference



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
88	Radium	-213				2.7 m	α 6.90	9 2
		-218	218.075506	370				
		-219	219.078521	170		~10-3 s	α 8.0	2, 9
		-220	220.079778	50		0.03 s	α 7.43	2, 9
		-221	221.083037	90		30 s	α 6.71	2, 9
		-222	222.084834	50		38 s	α 6.55; γ 0.325, 0.80	2, 9, 6
		-223	223.088322	120		11.68d	α; γ 0.144,0.155, 0.180,0.270,0.340	2, 9, 6
		-224	224.090300	40		3.64d	α; γ 0.241	2, 9, 6
		-225	225.093885	100		14.8 d	β-0.32; γ 0.040	2, 9
		-226	226.959990	90		1622 y	α 4.777; γ 0.187, 0.260	2, 9, 6
		-227	227.100177	130		41.2 m	β-1.31; γ 0.0275, 0.295, 0.499	2, 9, 6
		-228	228.102555	90		6.7 y	β-~0.012; γ ~0.03	2, 9, 6
		-229	229.106415	210		Short	β-	2, 9
		-230	230.109141	260		1 h	β-1.2	2, 9
		-231	231.113457	350				2

E Mev	σ

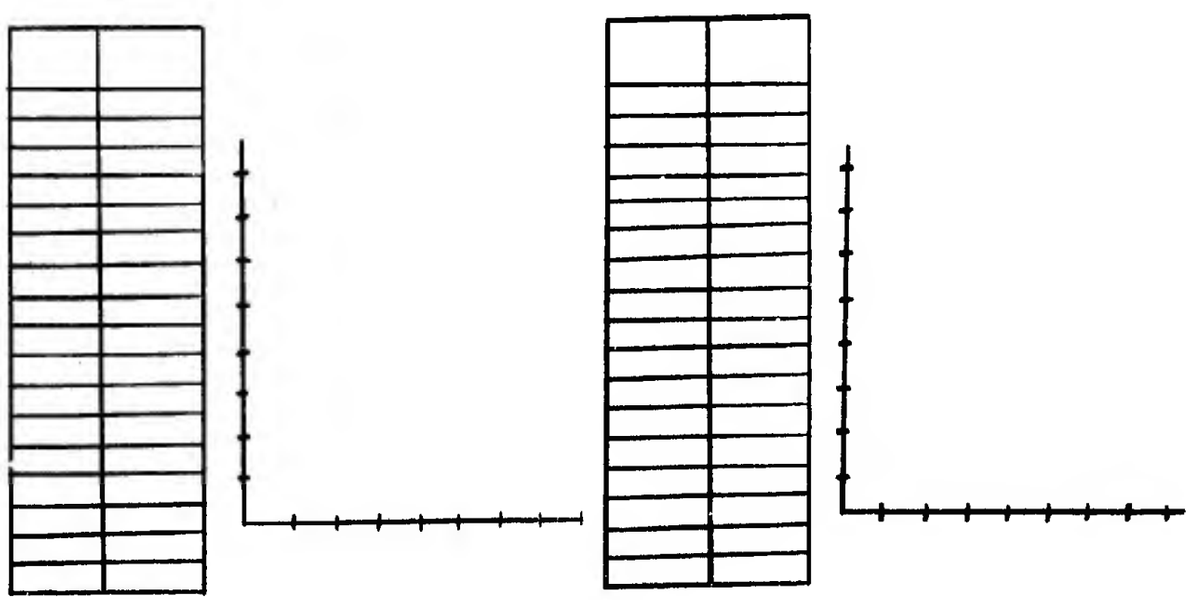
E Mev	σ



$_{88}Ra$

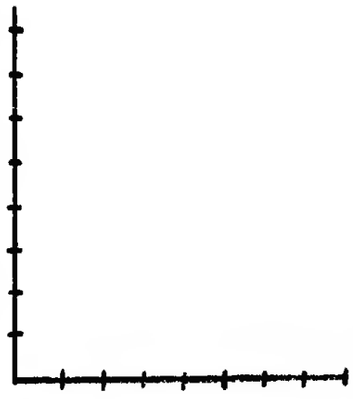
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

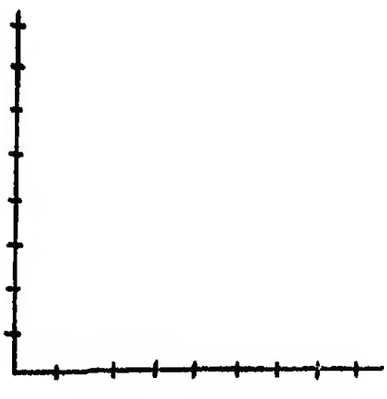


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
89	Actinium	-221	221.084899	230			α7.6	2, 9
		-222	222.087213	120		5.5 s	α6.96	2, 9
		-223	223.088898	90		2.2 m	α6.64	2, 9
		-224	224.091764	90		2.9 h	EC;α6.17;γ0.133, 0.217	2, 9, 6
		-225	225.093498	90		10.0 d	α; γ0.0366,0.0384 0.0628,0.0873, 0.0944,0.150,0.187	2, 9, 6
		-226	226.096891	340		29 h	β^-1.2; γ0.158, 0.185,0.230,0.253	2, 9, 6
		-227	227.988780	130		21.6 y	β^-0.046;α4.492; γ0.037	2, 9, 6
		-228	228.102512	60		6.13 h	β^-2.18,1.85,1.72, 1.15,0.66,0.46; γ0.058,0.129, 0.184,0.338,0.462, 0.914,0.969	2, 9
		-229	229.104482	270		66 m	β^-	2, 9
		-230	230.108179	490		>1 m	β^-2.2	2, 9
		-231	231.110826	350				2
		-232	232.114859	420				2

E Mev	σ

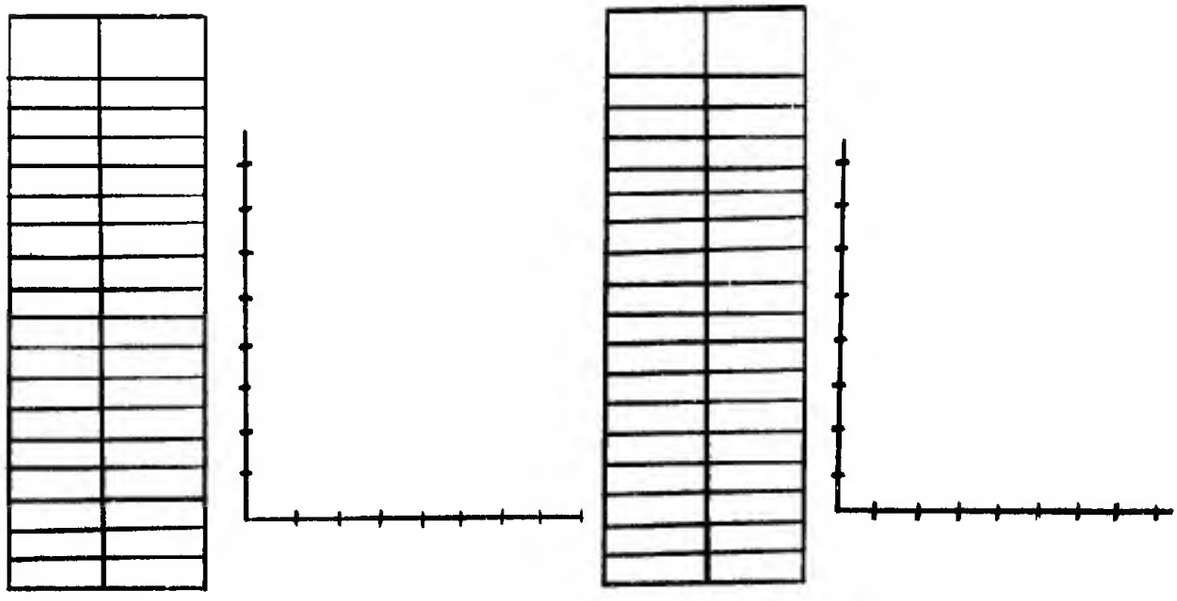


E Mev	σ



REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

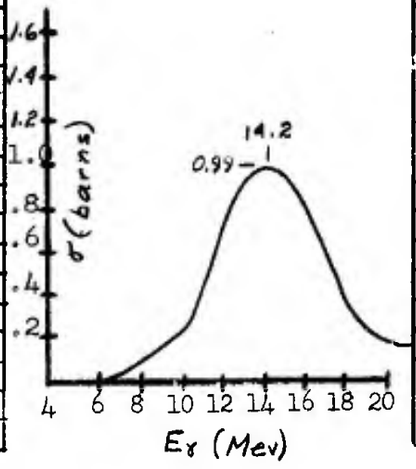


90 Th

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
90	Thorium	-222	222.088082	460				2
		-223	223.090658	200		~0.1 s	α 7.55	2, 9
		-224	224.091452	60		~1 s	α 7.13	2, 9
		-225	225.094143	100		8 m	α 6.57	2, 9
		-226	226.095639	60		30.9 m	α ; γ 0.1116, 0.131, 0.20, 0.242	2, 9, 6
		-227	227.098792	120		18.17 d	α ; γ 0.050, 0.080, 0.101, 0.129, 0.208, 0.240	2, 9, 6
		-228	228.100106	50		1.910 y	α ; γ 0.085, 0.134, 0.205	2, 9, 6
		-229	229.103251	210		7340 y	α ; γ 0.0677, 0.144	2, 9, 6
		-230	230.104995	100		8×10^4 y	α ; γ 0.059, 0.063, 0.085, 0.136	2, 9, 6
		-231	231.108614	130		25.64 h	β^- ; γ 0.059, 0.063, 0.085, 0.136	2, 9, 6
		-232	232.110797	60	100	1.39×10^{10} y	α 4.007 ; γ 0.059	2, 9
		-233	233.114321	130		22.12 m	β^- 1.23 ; γ 0.098, 0.448	2, 9
		-234	234.116778	110		24.10 d	β^- ; γ 0.029, 0.054, 0.092	2, 9, 6
		-235	235.120933	280		410 m	β	2, 9
		-236	236.123795	370				2

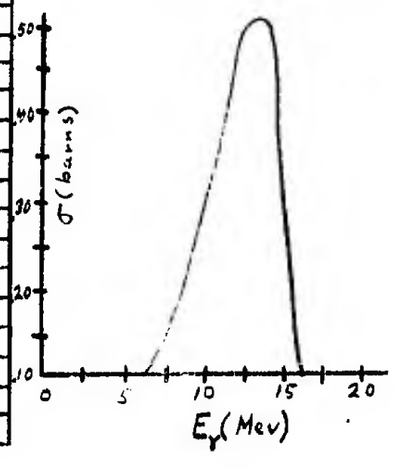
E Mev	σ_{barns}
6	0
7	.07
8	.10
9	.15
10	.25
11	.50
12	.70
13	.90
14	.99
15	.93
16	.75
17	.55
18	.35
19	.25
20	.20
21	.20

$Th^{232}(\gamma,n)_{Ref.\#29}$



E Mev	σ

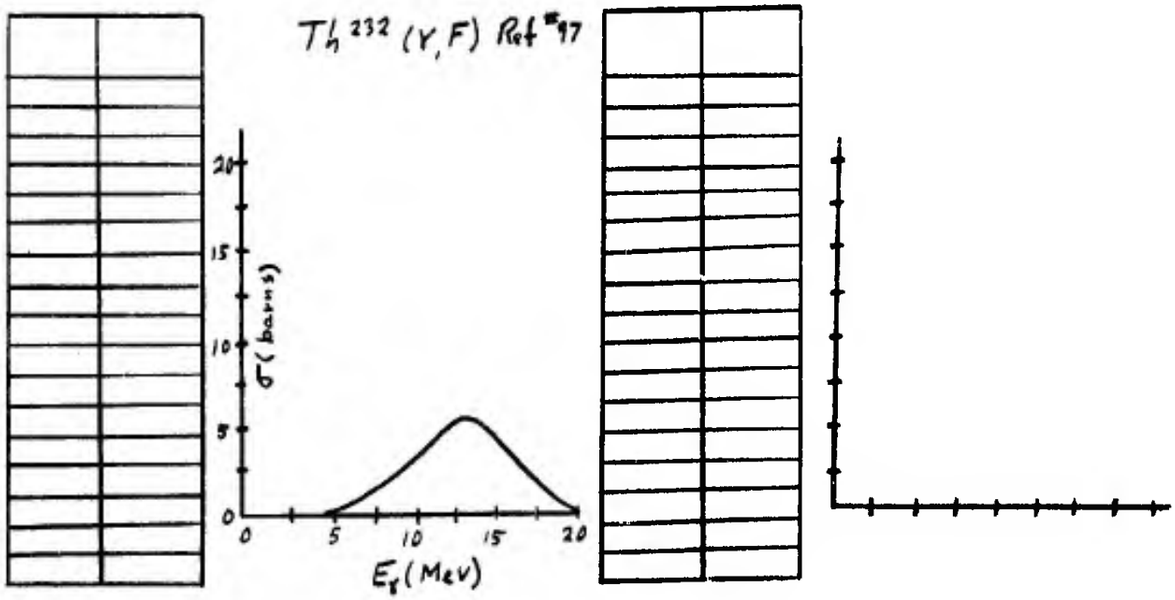
$Th^{232}(\gamma,n)$ Ref # 97



$_{90}Th$

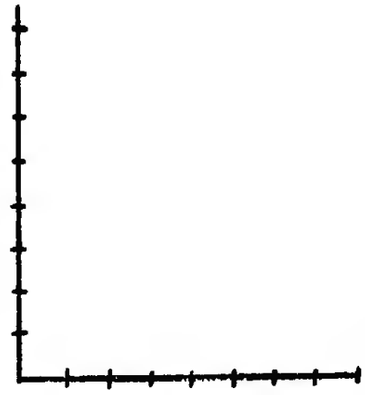
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

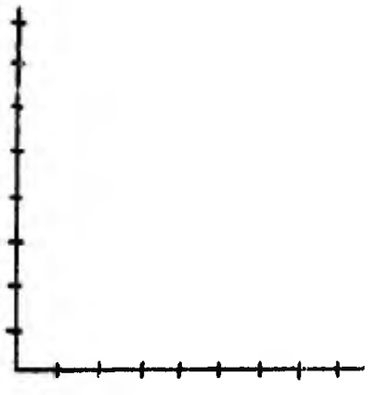


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
91	Protactinium	-225	225.096617	280		2.0 s	α	2, 9
		-226	226.098533	140		1.8 m	α 6.81	2, 9
		-227	227.099842	90		38.3 m	α 6.46	2, 9
		-228	228.102300	90		22 h	EC;α ; $\gamma > 10\gamma$'s	2, 9, 6
		-229	229.103594	110		1.5 d	EC;α5.69	2, 9
		-230	230.106622	390		17.7 d	EC; β^-0.41;γ0.94	2, 9
		-231	231.108266	130		3.4×10^4 y	α ; $\gamma > 10\gamma$'s	2, 9
		-232	232.111180	60		1.31 d	β^- ; $\gamma > 10\gamma$'s	2, 9
		-233	233.113000	130		27.0 d	β^- ; $\gamma > 10\gamma$'s	2, 9
		-234	234.116567	370		6.66 h	β^- ; $\gamma > 10\gamma$'s	2, 9
		-235	235.119000	280		23.7 m	β^-1.4 ;	2, 9
		-236	236.122871	260				2
		-237	237.125145	450		11 m	β^-	2, 9
		-238	238.129444	570				2

E Mev	σ



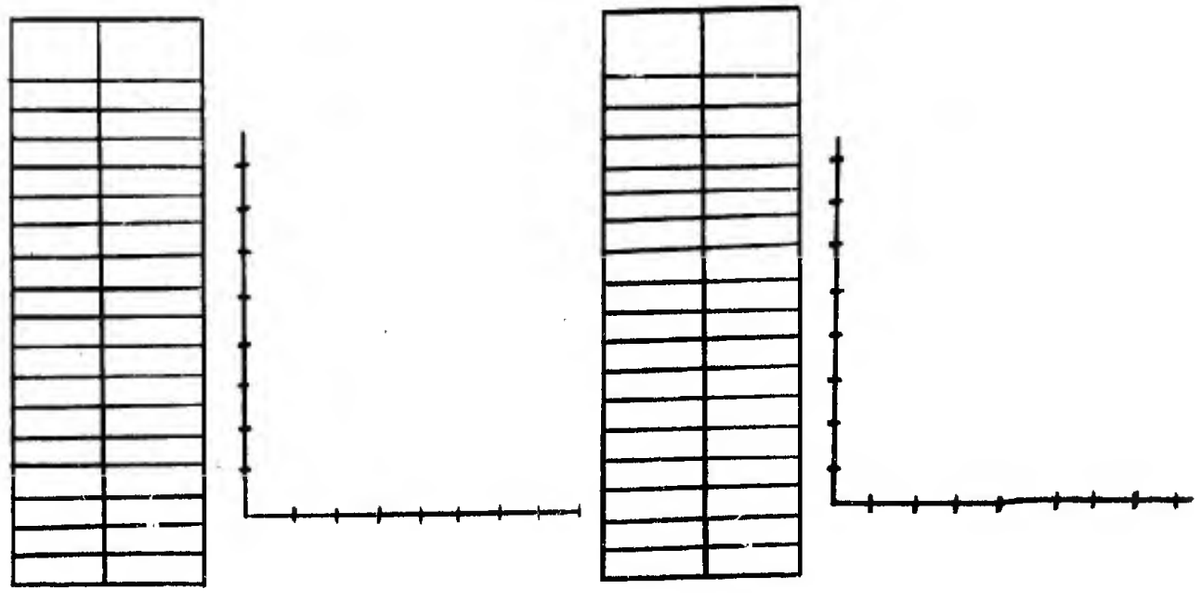
E Mev	σ



91 Pa

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

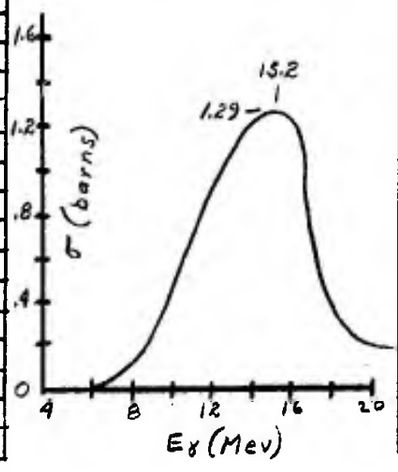


$_{92}U$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
92	Uranium	-226	226.099907	580				2
		-227	227.101967	250		1.3 m	α 6.8	2, 9
		-228	228.102622	80		9.3 m	α 6.67	2, 9
		-229	229.104990	110		58 m	EC; α 6.42	2, 9
		-230	230.105951	60		20.8 d	α ; γ 0.0721, 0.1543, 0.158, 0.232	2, 9
		-231	231.108630	140		4.3 d	EC; α 5.45; γ 0.051, 0.064, 0.076	2, 9
		-232	232.109795	50		74 y	α ; γ 0.059, 0.130 0.328	2, 9, 6
		-233	233.112398	120		1.62×10^5 y	α ; γ 0.0429, 0.056, 0.099	2, 9, 6
		-234	234.114076	100	0.0056	2.48×10^5 y	α ; γ 0.052, 0.1175	2, 9, 6
		-235	235.117496	140	0.720	7.1×10^8 y	α ; γ 0.094, 0.109, 0.144, 0.165, 0.185, 0.203	2, 9, 6
		-236	236.119590	100		2.39×10^7 y	α 4.499; γ 0.050	2, 9, 6
		-237	237.122752	150		6.75 d	β^- ; γ 10's	2, 9, 6
		-238	238.125223	110	99.276	4.51×10^9 y	α 4.195; γ 0.0447	2, 9, 6
		-239	239.129160	150		23.54 m	β^- 1.21; γ	2, 9, 6
		-240	240.131807	110		14.1 h	β^- 0.36	2, 9
		-241	241.135466	550				2
		-242	242.138444	710				2
		-243	243.142876	970				2
		-244	244.146650	1070				2

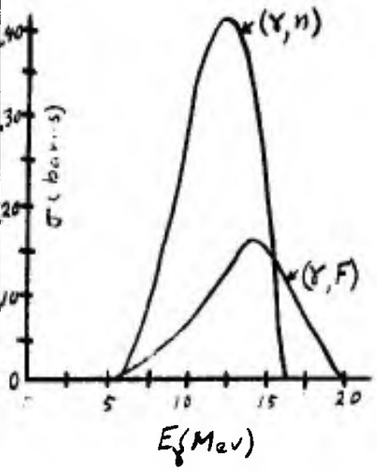
E Mev	σ_{barns}
6	0
7	.05
8	.10
9	.25
10	.48
11	.70
12	.95
13	1.10
14	1.25
15	1.29
16	1.20
17	.60
18	.35
19	.31
20	.30
21	.30

U^{238} (γ, n) REF. #29



E Mev	σ

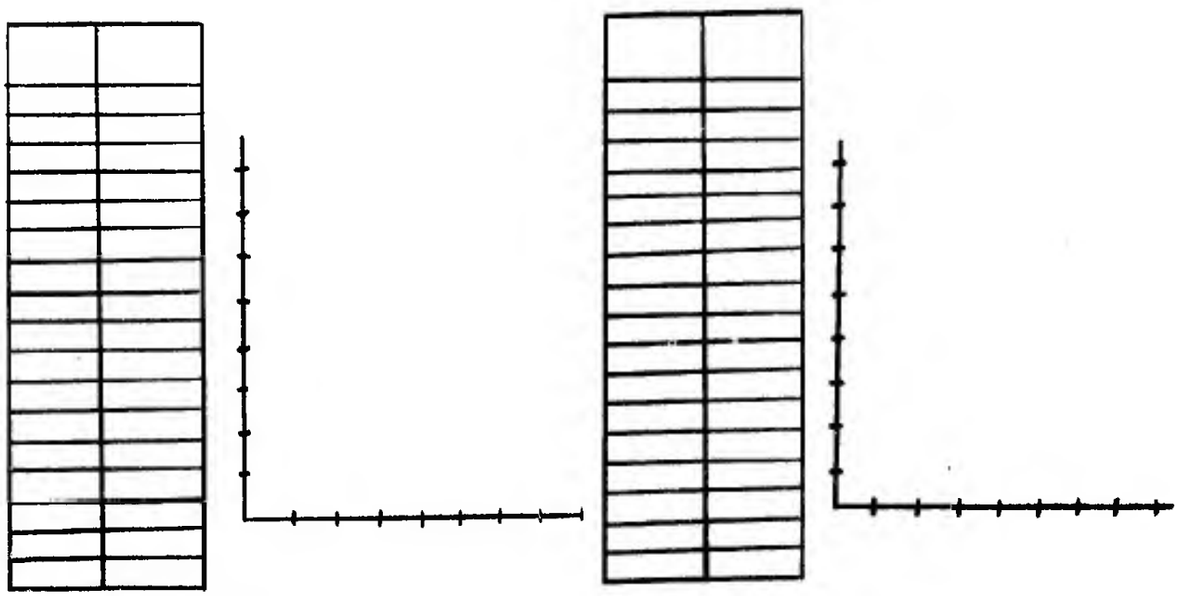
U^{238} Ref # 97



92 U

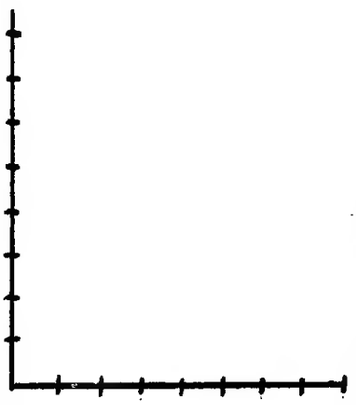
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

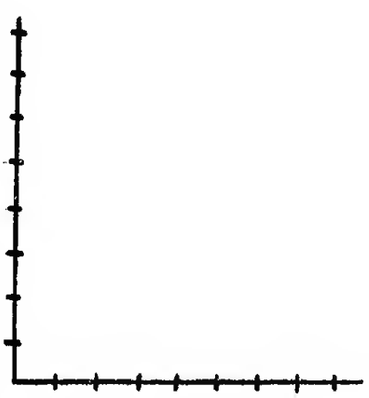


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
93	Neptunium	-229	229.108088	440				2
		-230	230.109660	270				2
		-231	231.110580	120		~50 m	α 6.28	2, 9
		-232	232.112643	160		~13 m	EC; γ (hard)	2, 9
		-233	233.113518	130		35 m	EC; α 5.53	2, 9
		-234	234.116352	430		4.4 d	EC; B+~0.8; γ>10⁵ s	2, 9, 6
		-235	235.117674	140		410 d	EC; α 5.06; γ 0.026 0.086	2, 9, 6
		-236	236.120503	80		22 h	EC; B⁻0.52; γ 0.0443 0.0453, 0.150	2, 9, 6
		-237	237.122204	150		2.2×10^6 y	α ; γ 0.0296 0.0870	2, 9, 6
		-238	238.125356	110		2.1 d	B⁻ ; γ>10⁵ s	2, 9, 6
		-239	239.127769	150		2.346 d	B⁻ ; γ>10⁵ s	2, 9, 6
		-240	240.131421	100		7.3 m	B⁻ ; γ	2, 9
						60 m	B⁻0.89; γ>10⁵ s	2, 9, 6
		-241	241.133555	300				2
		-242	242.137746	460				2
		-243	243.140213	810				2
		-244	244.144943	1050				2
		-245	245.147399	1040				2
		-246	246.152320	1090				2

E Mev	σ



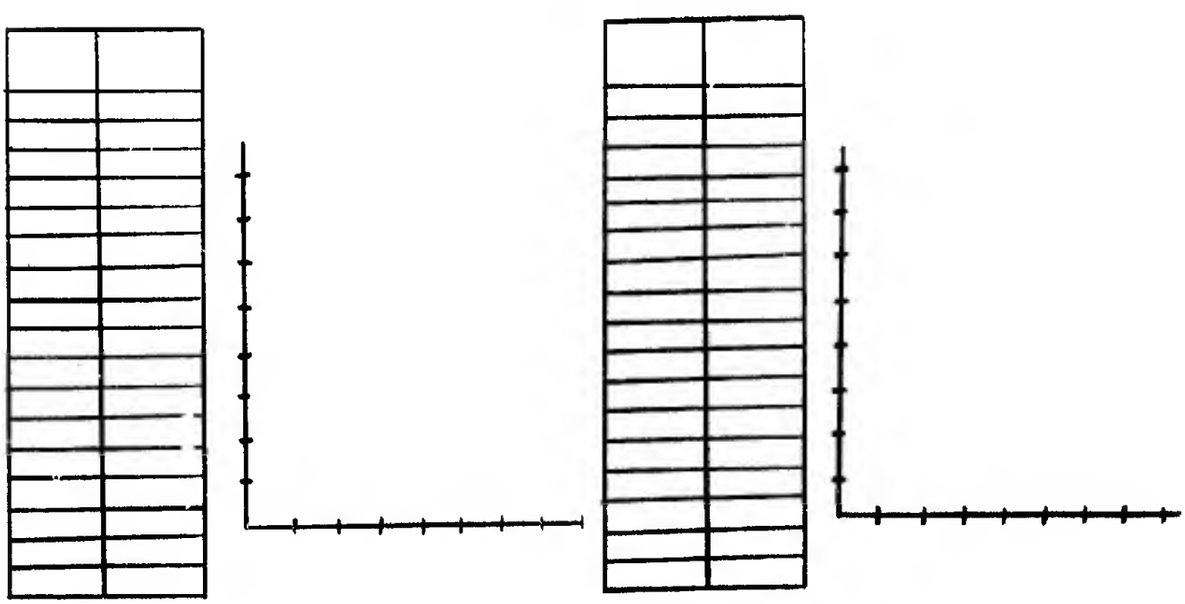
E Mev	σ



$_{93}Np$

REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

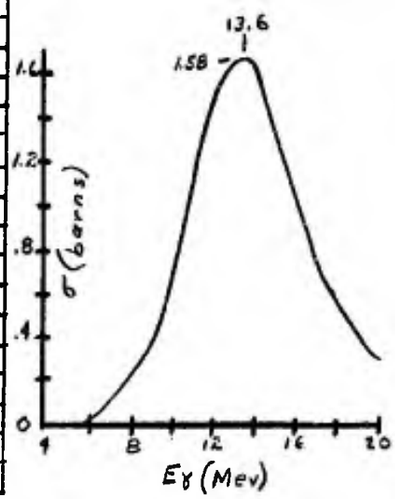


94 Pu

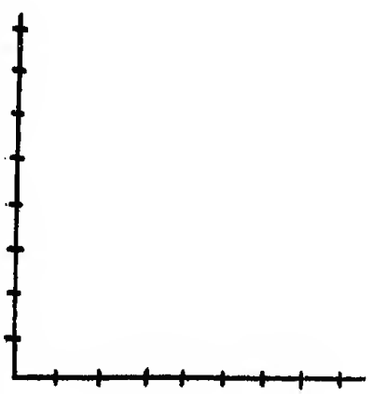
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
94	Plutonium	-230	230.111571	640				2
		-231	231.113416	330				2
		-232	232.113696	110		36 m	α 6.58; EC	2, 9
		-233	233.115849	170		20 m	EC; α 6.30	2, 9
		-234	234.116595	100		9.0 h	EC; α 6.19	2, 9
		-235	235.118898	160		26 m	EC; α 5.85	2, 9
		-236	236.119955	80		2.85 y	α ; γ 0.046, 0.110	2, 9, 6
		-237	237.122430	170		45.6 d	EC; α ; γ 0.026, 0.033, 0.044, 0.056, 0.064, 0.076	2, 9, 6
		-238	238.123956	110		86.4 y	α ; γ 0.044, 0.100, 0.152	2, 9, 6
		-239	239.126999	150		24,360 y	α ; γ 0.052, 0.121, 0.207, 0.340, 0.380, 0.420	2, 9, 6
		-240	240.129105	100		6580 y	α ; γ 0.047	2, 9, 6
		-241	241.132148	150		13.0 y	β^-; α ; γ 0.100, 0.145	2, 9, 6
		-242	242.134449	120		3.79×10^5 y	α ; γ	2, 9
		-243	243.138087	160		4.98 h	β^- ; γ 7 10 γ's	2, 9, 6
		-244	244.140647	270		$\sim 7.6 \times 10^7$ y		2, 9
		-245	245.144123	500		10.1 h	β^-	2, 9
		-246	246.147123	560		10.85 d	β^- ; γ	2, 9
		-247	247.151587	860				2
		-248	248.155414	980				2
		-249	249.159847	1040				2
		-250	250.163501	1270				2

E Mev	σ_{barns}
6	0
7	.10
8	.20
9	.40
10	.60
11	1.00
12	1.35
13	1.55
14	1.55
15	1.30
16	1.00
17	.70
18	.55
19	.38
20	.25
21	.21

$Pu^{239}(\gamma,n)$ REF. #29



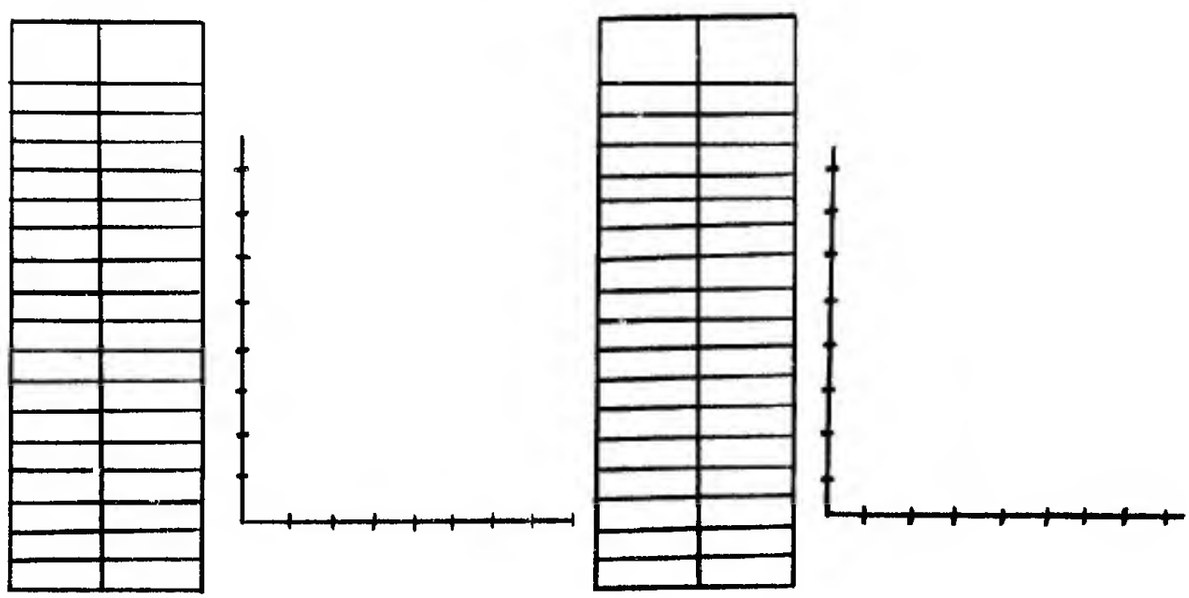
E Mev	σ



$_{94}Pu$

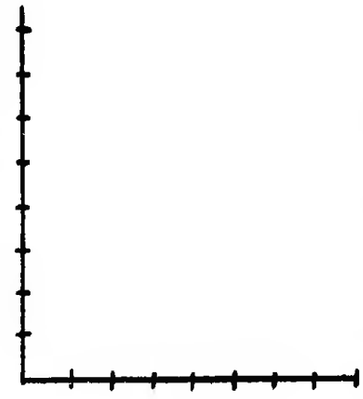
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

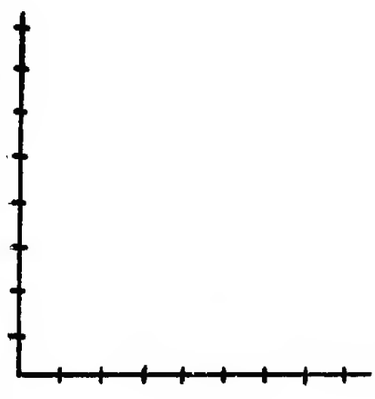


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
95	Americium	~235	235.121600	270				2
		~236	236.123394	250				2
		~237	237.123958	150		~1.3 h	EC; ϵ6.01	2, 9
		~238	238.126642	450		1.9 h	EC; γ0.58, 0.98	2
		~239	239.127835	160		12 h	EC; ϵ5.75; γ 0.3	2
		~240	240.130556	160		51 h	EC; γ0.92, 1.02, 1.40	2, 6
		~241	241.132126	150		458 y	ϵ ; γ10 r's	2, 6
		~242	242.135187	110		~100 y	B⁻0.59	2
		~243	243.137479	150		7.95×10^3	ϵ ; γ 0.0748	2, 6
		~244	244.140925	170		26 m	B⁻1.5	2
		~245	245.142834	190		1.98 h	B⁻0.91; γ 0.036, 0.06, 0.78, 0.140, 0.153, 0.23, 0.25	2, 6
		~246	246.146800	310		25 m	B⁻ ; γ0.035, 0.245, 0.78, 1.06	2, 6
		~247	247.149299	680				2
		~248	248.154051	960				2
		~249	249.156539	950				2
		~250	250.161300	1010				2
		~251	251.164776	1070				2
		~252	252.169860	990				2

E Mev	σ



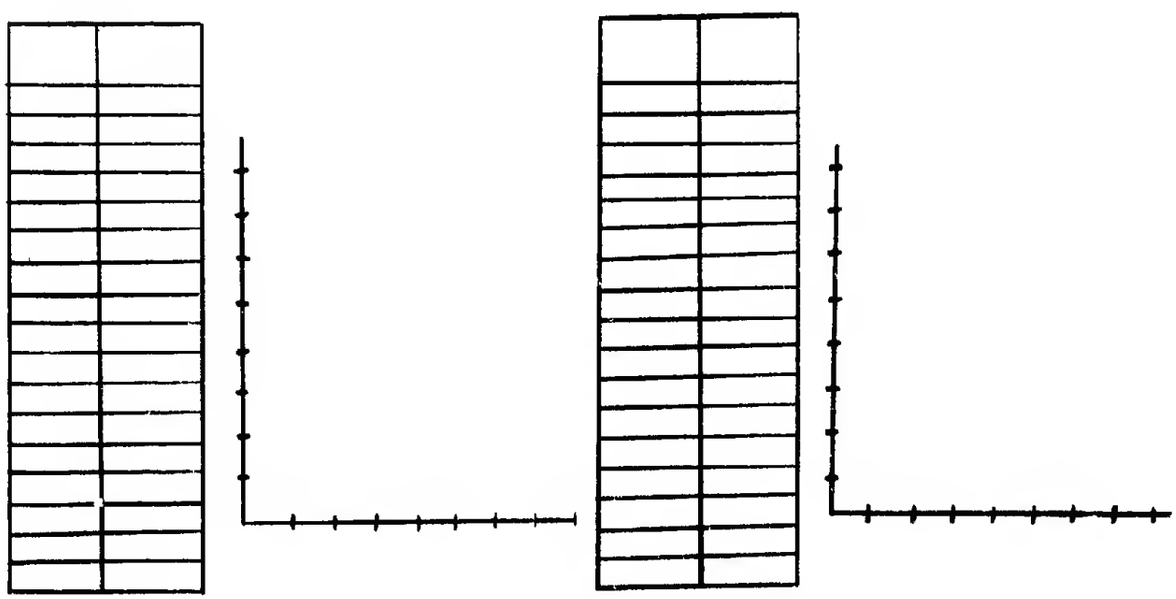
E Mev	σ



^{95}Am

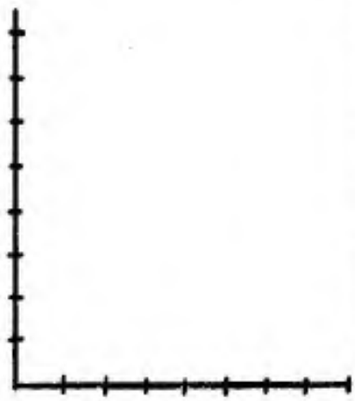
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

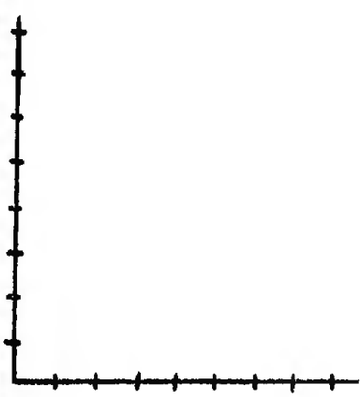


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
96	Curium	-236	236.125359	270				2
		-237	237.127158	250				2
		-238	238.127572	140		2.5 h	EC; α 6.50	2, 9
		-239	239.129756	200		2.9 h	EC; γ 0.188	2
		-240	240.130664	110		26.8 d	α 6.25	2
		-241	241.133074	210		35 d	EC; α 5.95; γ 0.47, ~0.60	2, 6
		-242	242.134506	110		162.5 d	α ; γ 0.044, 0.101, 0.157	2, 6
		-243	243.137483	150		35 y	α ; γ 0.210, 0.228, 0.277	2, 6
		-244	244.139314	110		17.9 y	α ; γ 0.043, 0.100, 0.150	2, 6
		-245	245.142093	290		8×10^3 y	α ; γ 0.13, 0.173	2, 6
		-246	246.144126	140		6600 y	α 5.37	2
		-247	247.147495	340		6×10^7 y	α	2
		-248	248.150088	450		4.7×10^5 y	α 5.05	2
		-249	249.153586	690		64 m	B-0.9	2
		-250	250.156639	310		Sp. Fission	Sp. Fission	2
		-251	251.160910	740				2
		-252	252.164522	880				2
		-253	253.168740	960				2
		-254	254.172179	1190				2
		-255	255.177320	1250				2

E Mev	σ



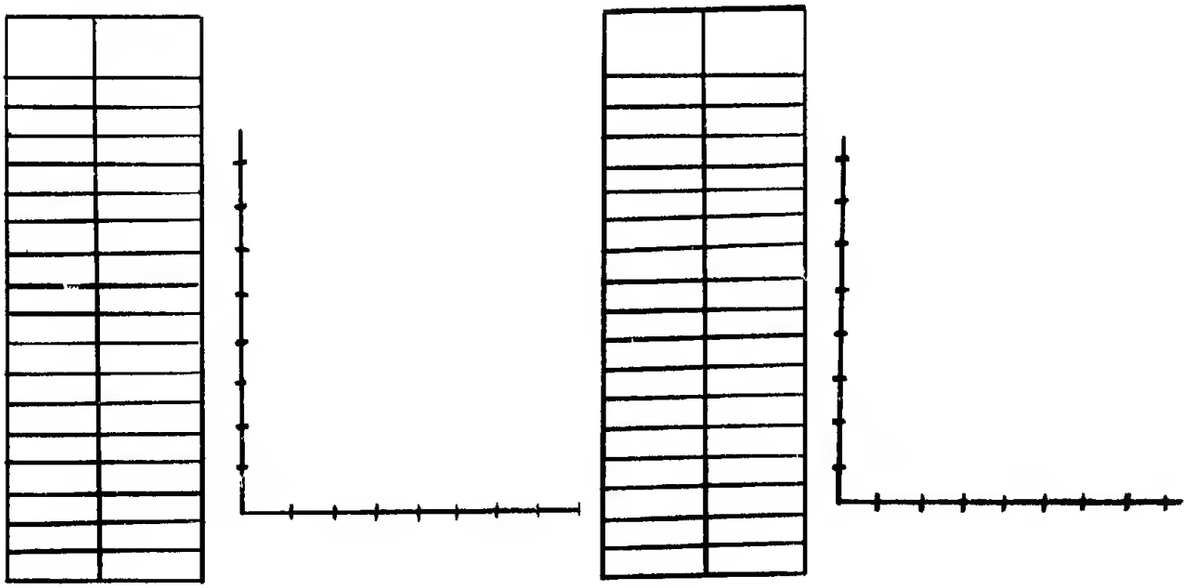
E Mev	σ



96 Cm

REMARKS

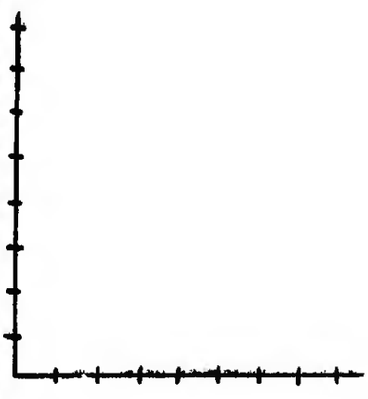
Thresholds	Isotope	Theoretical	Experimental	Reference



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
97	Berkelium	-240	240.135273	340				2
		-241	241.135590	390				2
		-242	242.138059	480				2
		-243	243.139048	180		4.5 h	EC; α ; γ 0.74, 0.84 0.96	2, 9, 6
		-244	244.141544	200		4.4 h	EC; α 6.67; γ 0.90, 1.06, 1.16	2, 6
		-245	245.142920	170		4.98 d	EC; α ; γ 0.251, 0.380	2, 6
		-246	246.145723	280		1.8 d	EC; γ 0.81, 1.09	2, 6
		-247	247.147639	390		$\sim 10^4$ y	α ; γ 0.084, 0.27	2, 6
		-248	248.150677	400		16 h	β^- 0.65	2
		-249	249.152608	190		314 d	β^- 0.11; α ; γ 0.32	2, 6
		-250	250.156639	190		3.13 h	β^- ; γ 0.94	2, 6
		-251	251.159191	590				2
		-252	252.163749	860				2
		-253	253.166055	940				2
		-254	254.170547	910				2
		-255	255.173830	980				2
		-256	256.178710	890				2

E Mev	σ

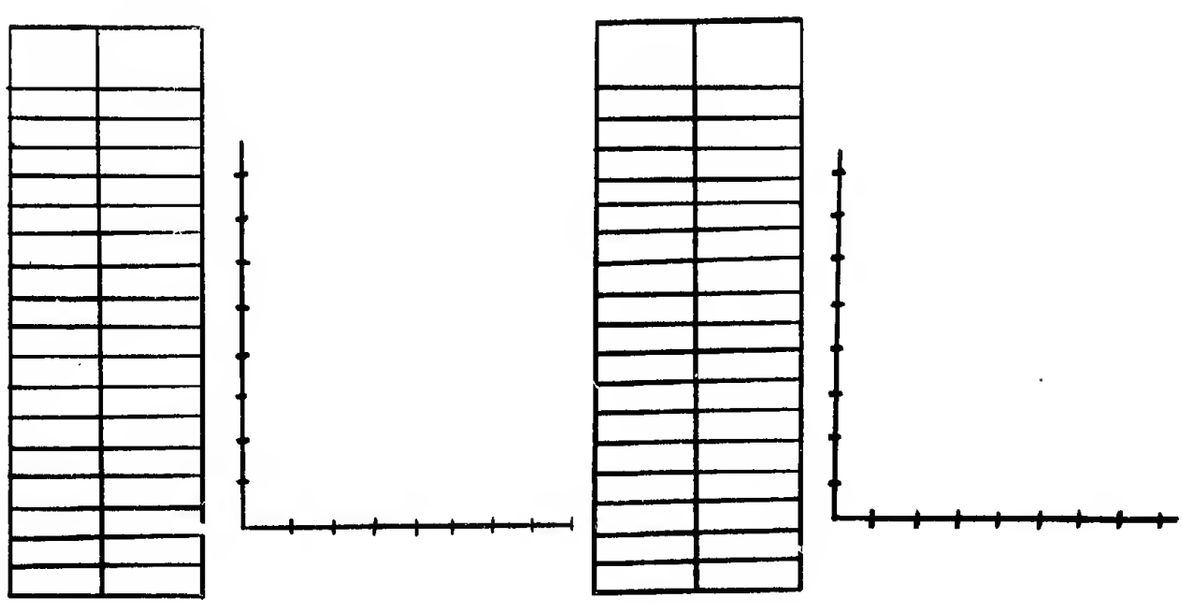
E Mev	σ



^{97}Bk

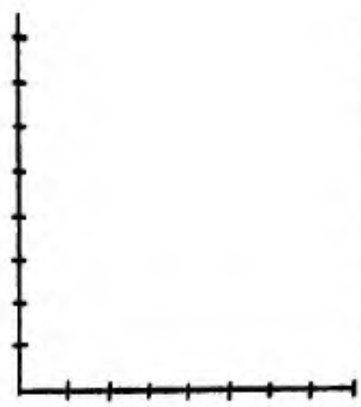
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

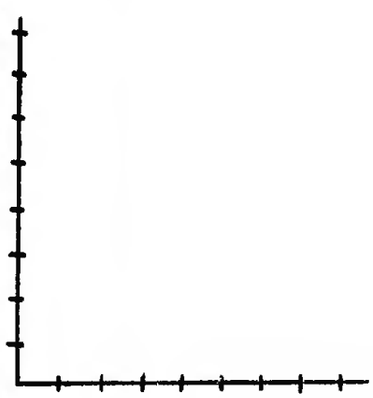


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
98	Californium	-241	241.139520	430				2
		-242	242.139687	280				2
		-243	243.141689	280				2
		-244	244.142349	130		25 m	α 7.17	2, 9
		-245	245.144576	260		44 m	EC; α 7.11	2, 9
		-246	246.145757	120		35.7 h	α ; γ 0.042, 0.046, 0.146	2, 9,6
		-247	247.148470	290		2.5 h	EC; γ 0.295, 0.417, 0.460	2, 9,6
		-248	248.150022	130		350 d	α 6.26	2, 9
		-249	249.152522	300		360 y	α ; γ 0.265, 0.340 0.40	2, 9,6
		-250	250.154598	150		10.9 y	α ; γ 0.0429	2, 9,6
		-251	251.158010	370		~800 y	α ; γ 0.180, .	2, 9,6
		-252	252.160656	450		2.2 y	α ; γ 0.043, 0.100	2, 9,6
		-253	253.163907	710		17 d	β^- 0.27, 0.17	2, 9
		-254	254.166756	470		Sp. Fission	Sp. Fission	2, 9
		-255	255.170823	870				2
		-256	256.174200	760				2
		-257	257.178224	1050				2
		-258	258.181449	1120				2
		-259	259.186375	1170				2

E Mev	σ



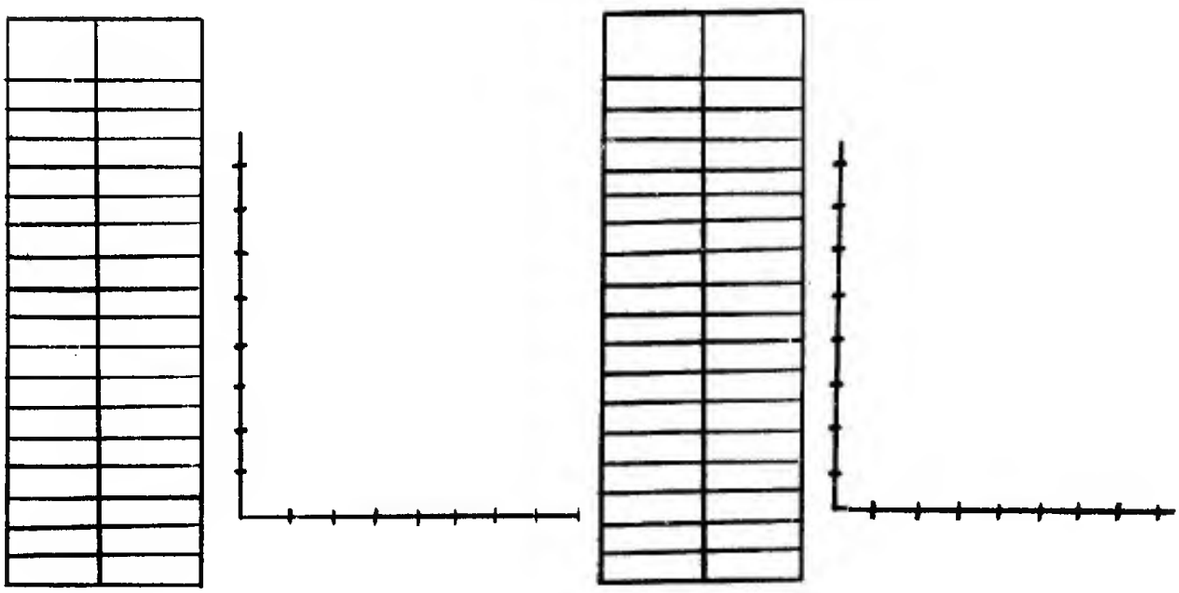
E Mev	σ



$_{98}Cf$

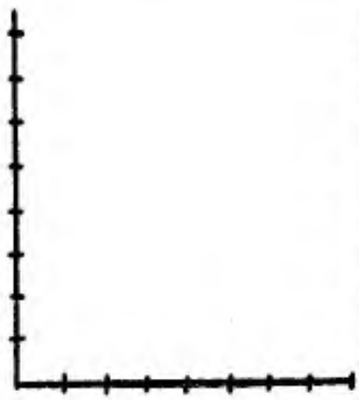
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

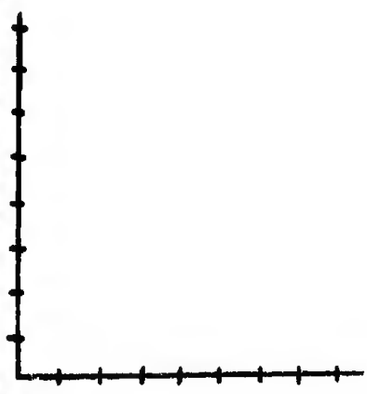


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
99	Einsteinium	-244	244.147796	570				2
		-245	245.147898	600				2
		-246	246.150174	570		7.3 m	EC; α 7.35	2,9
		-247	247.150894	230				2
		-248	248.153122	410		25 m	EC; α 6.87	2,9
		-249	249.154187	410		2 h	EC; α 6.76	9
		-250	250.156689	450		8 h	EC;	9
		-251	251.158627	530		1.5 d	EC; α 6.48	9
		-252	252.161718	200		~140 d	α 6.64	9
		-253	253.163714	200		20.03 d	α ; γ 0.0419, 0.051,0.398,0.422	2,9,6
		-254	254.167508	210		480 d	α 6.42; γ 0.062	9
		-255	255.169835	660		37 h	B^- 1.04; γ 0.66	9
		-256	256.174200	730		Short	B^-	9
		-257	257.176323	960				
		-258	258.180600	810				
		-259	259.183690	1080				
		-260	260.188355	1000				

E Mev	σ

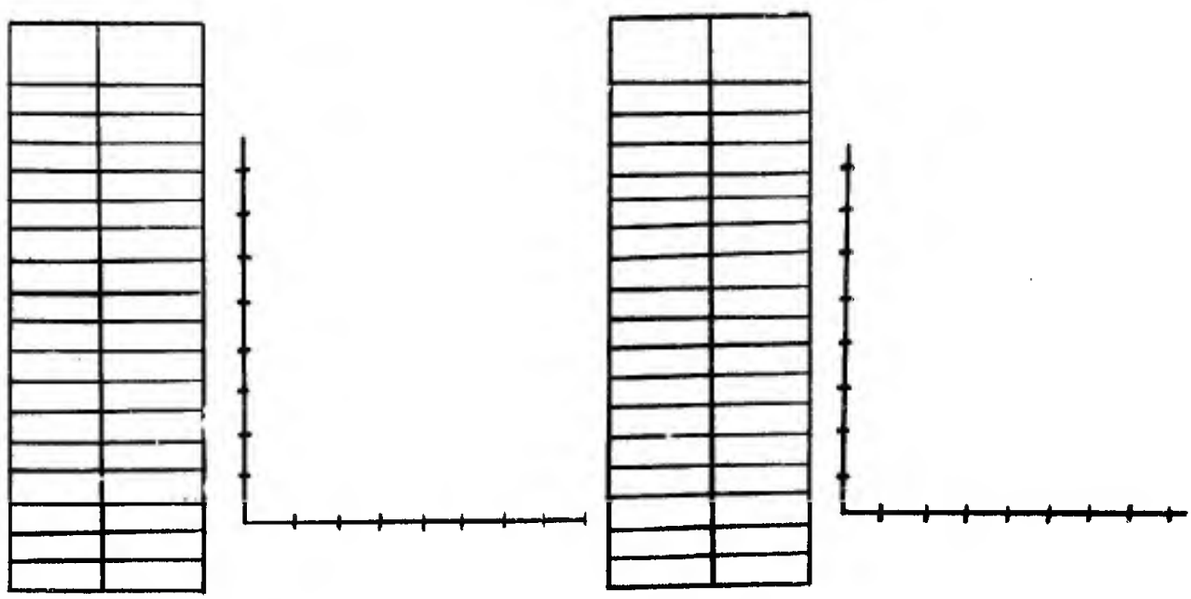


E Mev	σ



REMARKS

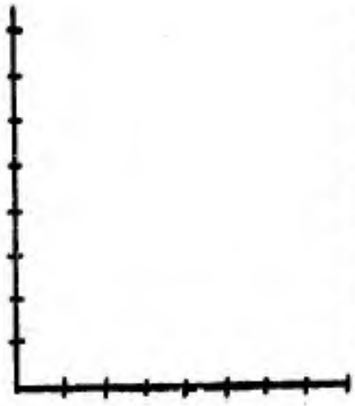
Thresholds	Isotope	Theoretical	Experimental	Reference



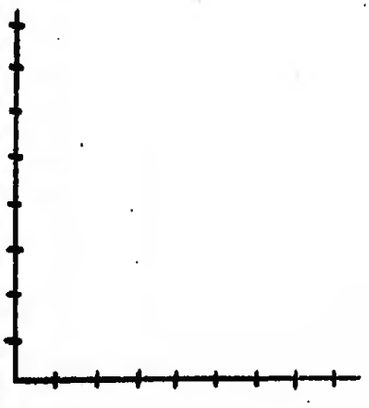
100 Fm

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
100	Fermium	-246	246.152586	540				2
		-247	247.154373	540				2
		-248	248.154818	490		Short	α	2, 9
		-249	249.156863	350		Short	α	2, 9
		-250	250.157689	490		30 m	α 7.43	2, 9
		-251	251.160027	550		7 h	EC; 6.89	2, 9
		-252	252.161632	490		22.7 h	α 7.04	2, 9
		-253	253.164165	390		~4.5 d	EC; α 6.85	2, 9
		-254	254.166327	170		3.24 h	α ; γ 0.041,0.048	2,9,6
		-255	255.169631	390		21.5 h	α 7.03; γ 0.082, ~0.055	2,9,6
		-256	256.172052	570		s.f. ~3.4 h	Sp. Fission	2, 9
		-257	257.175088	790				2
		-258	258.177701	670				2
		-259	259.181542	990				2
		-260	260.184704	890				2
		-261	261.188545	1150				2
		-262	262.191534	1030				2
		-263	263.196234	1260				2

E Mev	σ



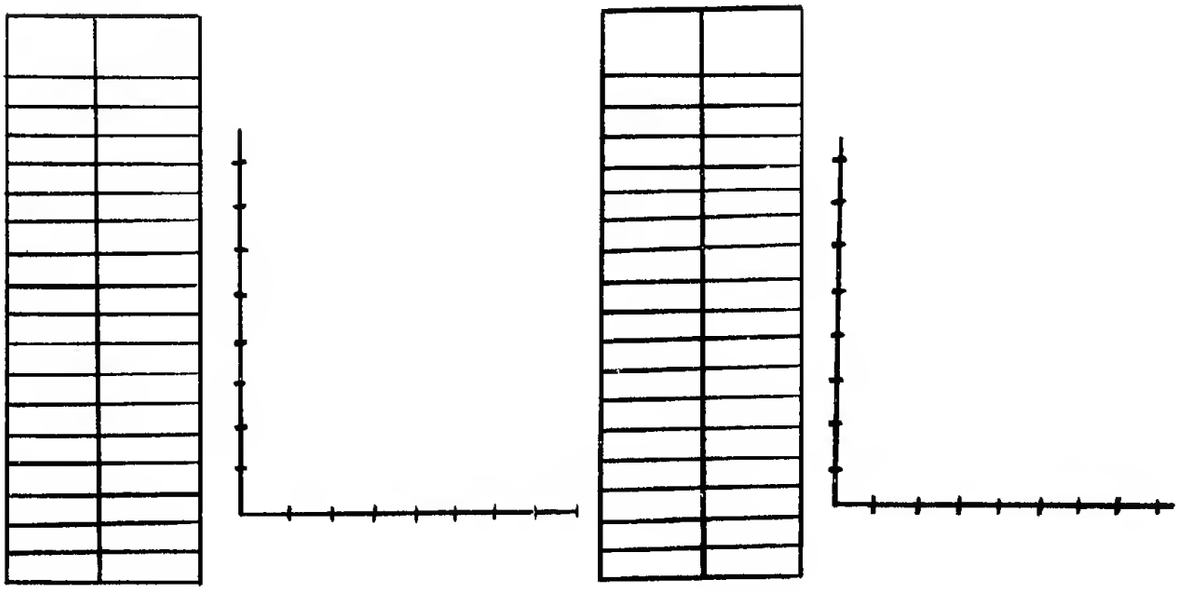
E Mev	σ



$_{100}Fm$

REMARKS

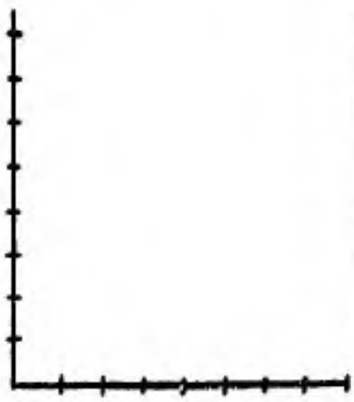
Thresholds	Isotope	Theoretical	Experimental	Reference



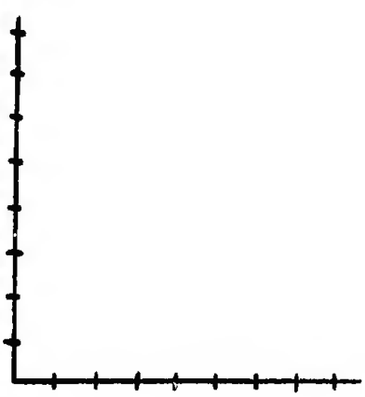
101 Mv

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
101	Mendeleevium	-250	250.162912	730				2
		-251	251.163364	530				2
		-252	252.165322	620				2
		-253	253.166420	610				2
		-254	254.168965	640				2
		-255	255.170935	700				2
		-256	256.173833	710		~30 m	EC	2, 9
		-257	257.175646	680				2
		-258	258.179247	530				2
		-259	259.181370	810				2
		-260	260.185541	860				2
		-261	261.187450	1060				2
		-262	262.191534	423				2
		-263	263.194409	1170				2
		-264	264.198891	1100				2

E Mev	σ



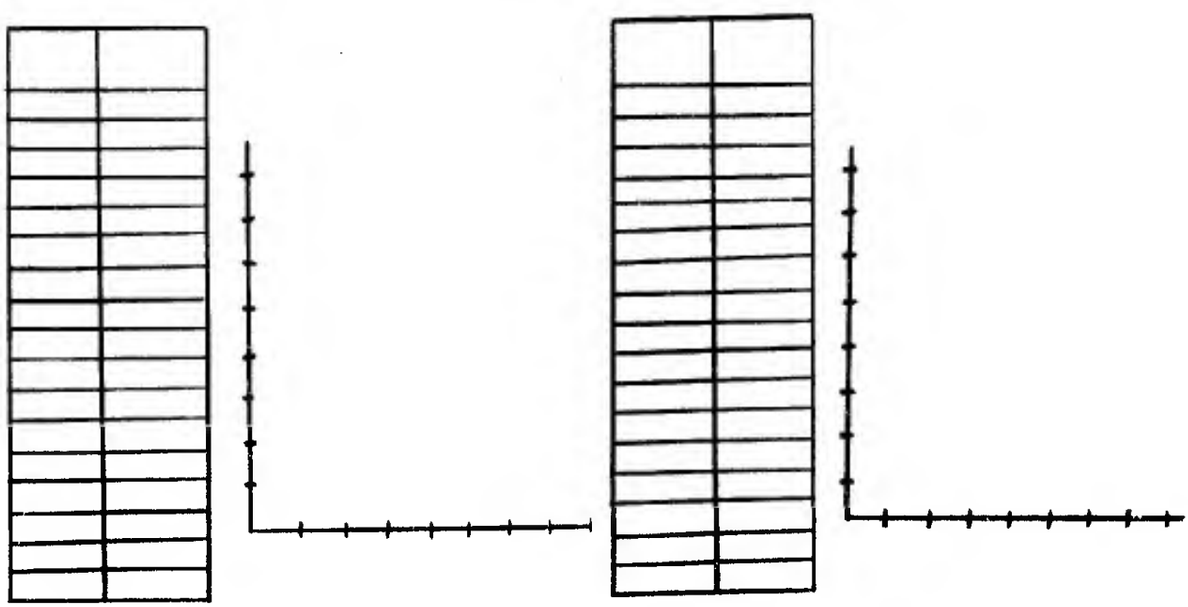
E Mev	σ



101 Mv

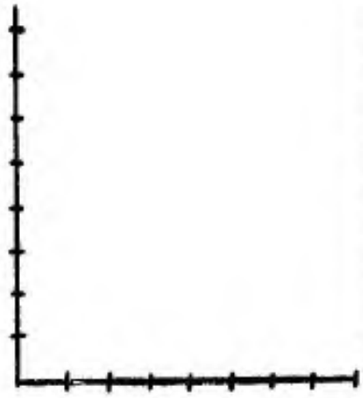
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

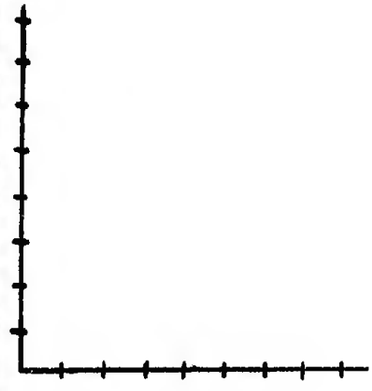


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
102		-252	252.167771	670				2
		-253	253.169655	580				2
		-254	254.170534	680		3 s	ε	2, 9
		-255	255.172926	720				2
		-256	256.174585	680				2
		-257	257.176903	610				2
		-258	258.173903	520				2
		-259	259.182015	610				2
		-260	260.184253	730				2
		-261	261.187095	910				2
		-262	262.189504	810				2
		-263	263.193174	1080				2
		-264	264.196153	1060				2
		-265	265.199779	1240				2
		-266	266.202586	1130				2
		-267	267.207093	1330				2

E Mev	σ

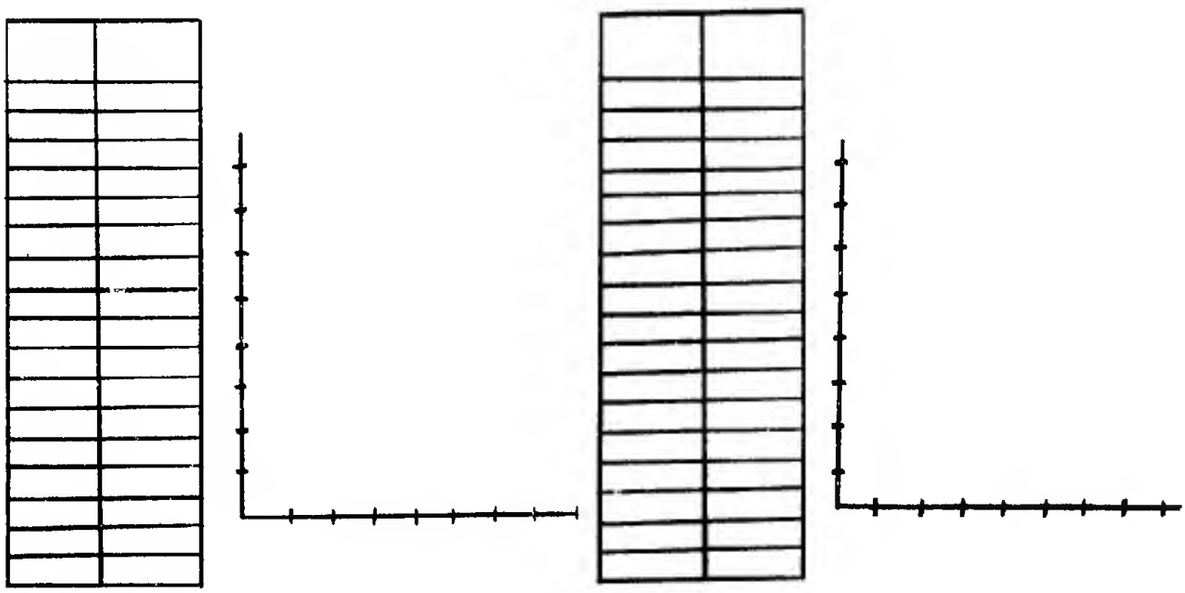


E Mev	σ



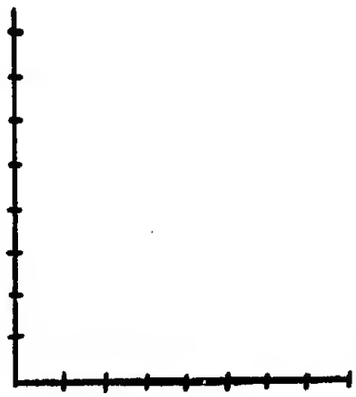
REMARKS

Thresholds	Isotope	Theoretical	Experimental	Reference

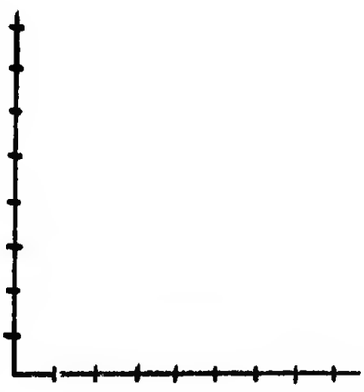


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
103		-264	264.197871	980				
		-265	265.199597	1160				
		-266	266.203498	1030				
		-267	267.206180	1260				

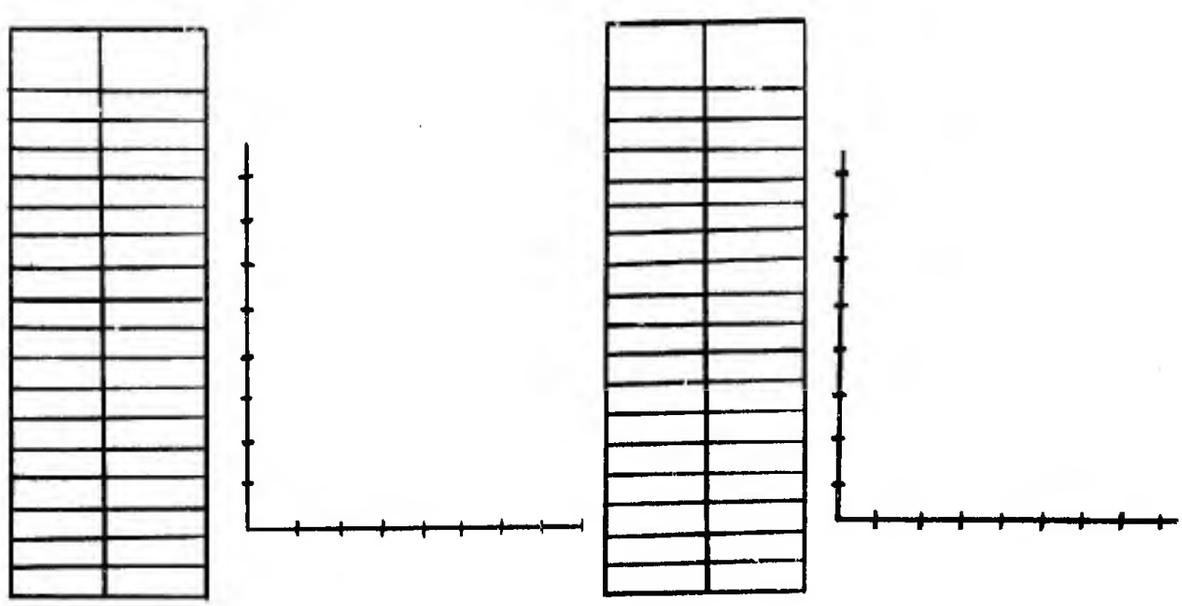
E Mev	σ



E Mev	σ



Thresholds	Isotope	REMARKS Theoretical	Experimental	Reference



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APPENDIX A

Bremsstrahlung Cross Sections

In the field of photonuclear research almost everyone is forced by circumstances to make use of bremsstrahlung gammas. Although recent application has been made of monoenergetic photons from high energy positron annihilation and from nuclear de-excitation, bremsstrahlung radiation is and will continue to be widely used.

Energetic electrons stopped in a food sample interact with the nucleus as if they were virtual gamma rays. Thus rather than being monoenergetic, their interaction cross section is the same as the bremsstrahlung cross section.

The yield of a radioisotope due to photonuclear disintegration is given by:

$$Y(E) = N_s \int_0^{\infty} B(E_o, E)\, \sigma(E)\, dE$$

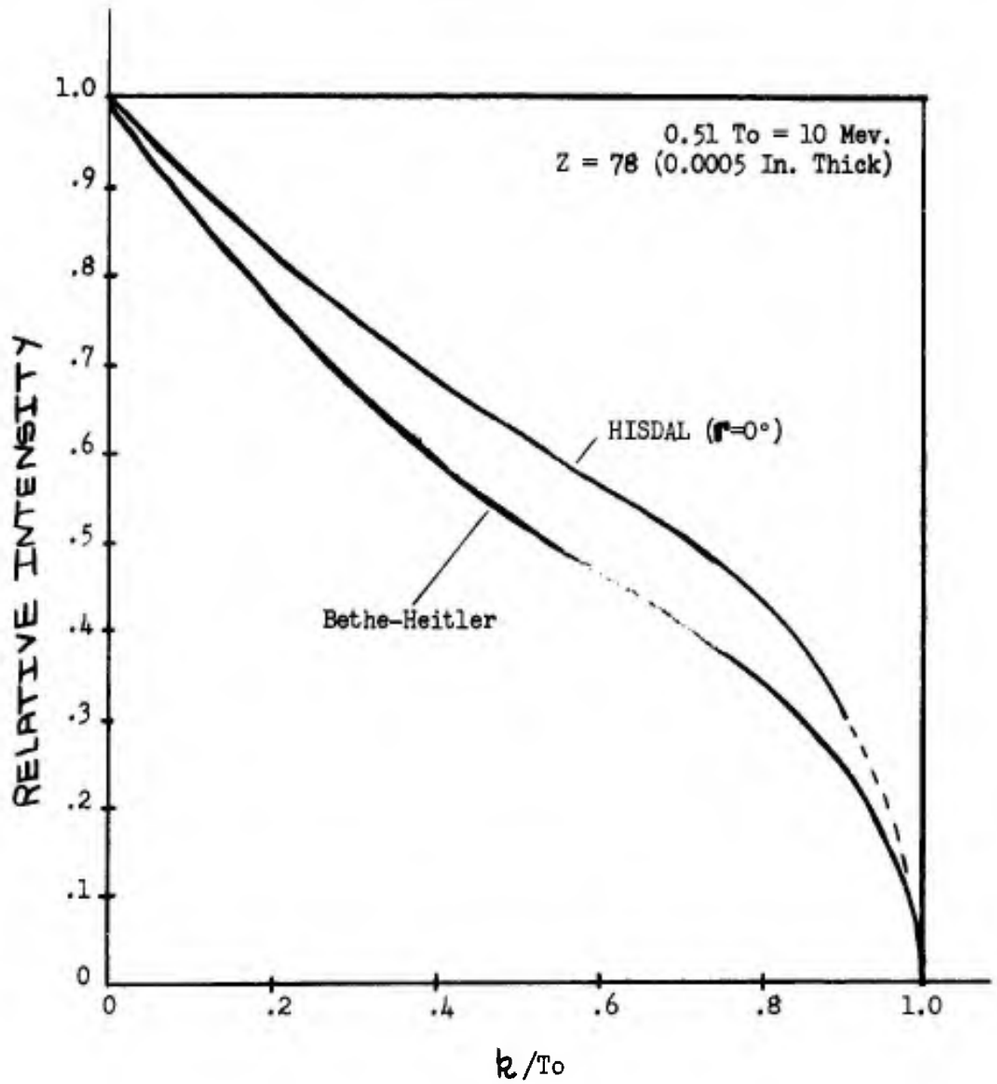
where N_s is the number of nuclei of the appropriate type per cm^2, $\sigma(E)$ is the photo cross section and $B(E_o, E)$ is the number of photons of energy between E and E + dE due to bremsstrahlung of maximum energy E_o. Therefore to calculate the amount of activity produced under particular conditions, the bremsstrahlung cross section must be known.

The most widely used approximations to the bremsstrahlung spectrum are due to Schiff and Bethe-Heitler for thin targets and to Hisdal for thick targets. Koch and Motz (Reference 62) give a very complete discussion of the theoretical and the small amount of experimental work which has been done on production of bremsstrahlung.

Included here for ready reference are the thin and thick target spectra for 10, 20, and 40 Mev electrons incident on platinum. The Bethe-Heitler and the Schiff integrated over angle curves for thin targets are very nearly the same,

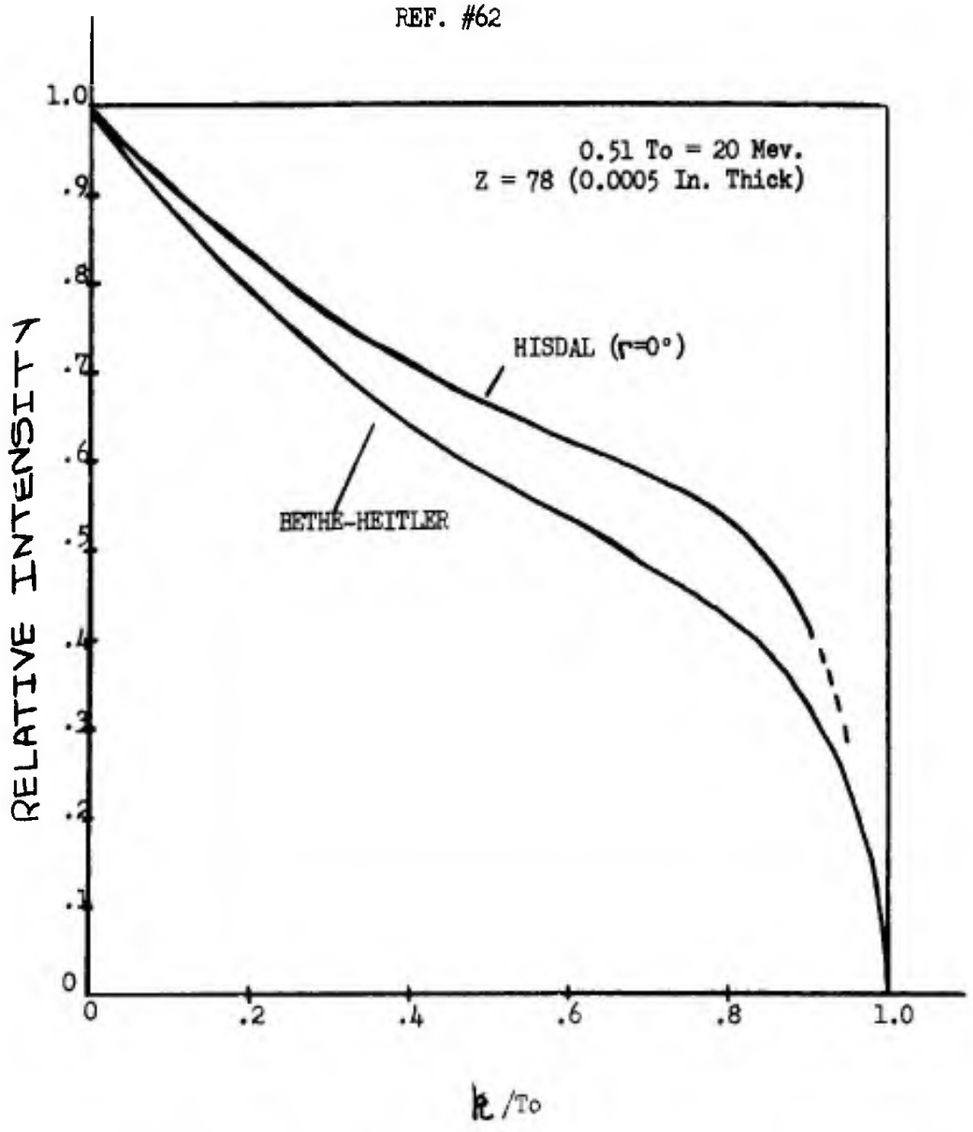
so only the Bethe-Heitler curves are shown. Also included is a tabulation showing the relative number of photons at each energy for bremsstrahlung spectra due to electrons with energy between 9 and 30 Mev. This should simplify the numerical integration of the equation for the yield given above.

REF. #62



10 MEV BREMSSTRAHLUNG SPECTRA

REF. #62



20 MEV. BREMSSTRAHLUNG SPECTRA

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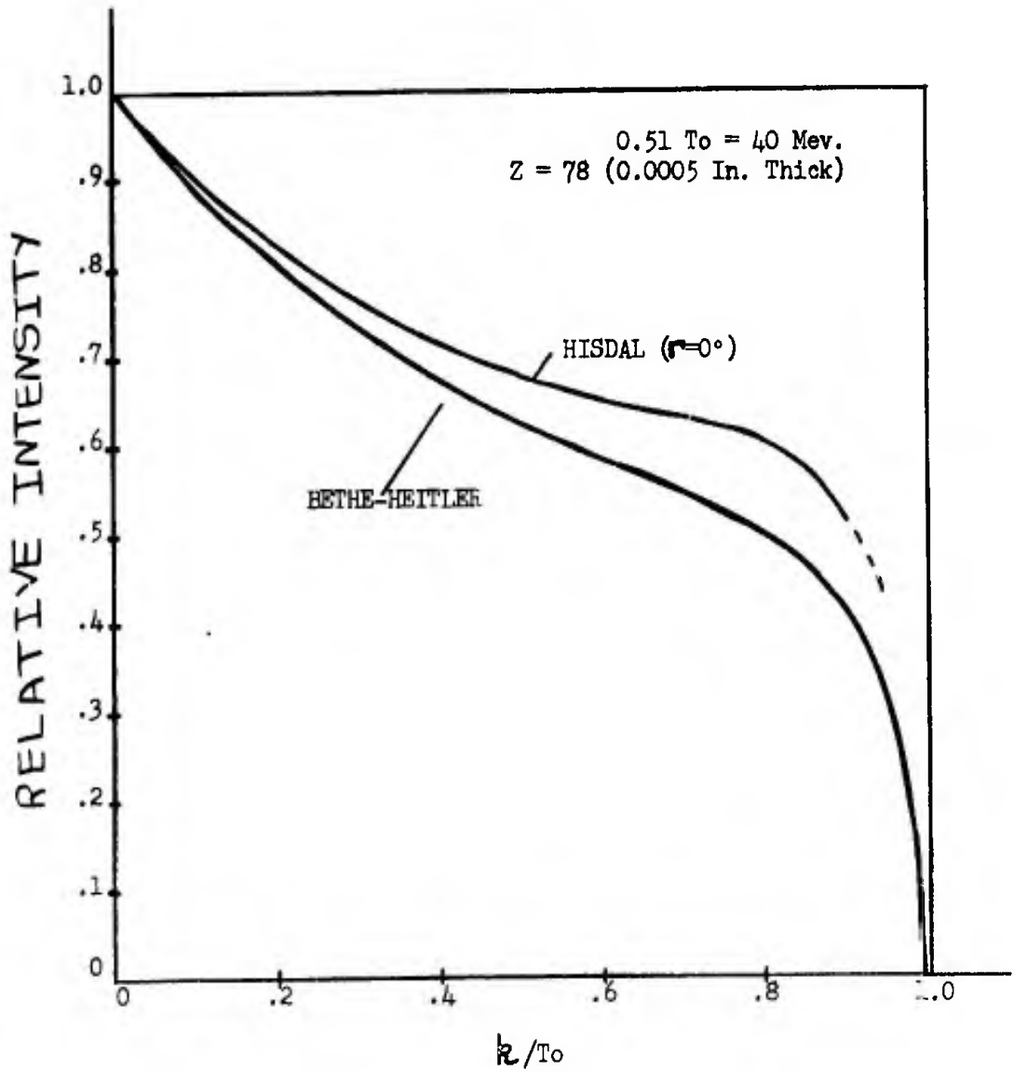

40 MEV. BREMSSTRAHLUNG SPECTRA

RELATIVE NUMBERS OF PHOTONS OF VARIOUS ENERGIES

ELECTRON ENERGY, Eo, IN MEV

X-Ray Photon Energy (K) In Mev	9.51	10.51	11.51	12.51	13.51	14.51	15.51	16.51	17.51	18.51	19.51
2	169	208	256	304	418	418	481	550	625	700	784
3	118	147	182	217	258	300	347	397	452	508	570
4	68.1	86.2	108	130	157	183	213	245	280	316	356
5	51.4	66.4	84.4	102.3	124	145	169	196	224	253	285
6	34.7	46.6	60.6	74.7	91.2	108	126	147	169	191	216
7	24.0	35.9	48.4	60.9	78.9	89.7	105.4	123	132	161	182
8	11.7	25.2	36.1	47.1	59.2	71.4	84.8	99.1	115	131	149
9	1.86	13.6	25.5	37.5	51.3	60.2	72.4	85.2	98.6	112	128
10		2.10	15.0	28.0	38.5	49.1	60.1	71.4	83.6	95.9	109
11			2.29	12.5	26.3	40.0	50.9	61.3	70.0	84.5	96.9
12				2.47	16.6	31.0	41.6	52.0	62.5	73.0	84.3
13					2.65	16.9	31.7	43.0	53.6	64.0	74.5
14						2.84	21.7	34.1	44.7	55.3	65.4
15							3.03	18.6	31.8	45.0	56.7
16								3.22	20.0	37.3	48.0
17									3.41	20.3	36.0
18										3.58	22.1
19											3.78

Continued on next page

(Continued)

X-Ray Photon Energy (K) In Mev	20.51	21.51	22.51	23.51	24.51	25.51	26.51	27.51	28.51	29.51	30.51
2	869	962	1056	1158	1261	1370	1484	1604	1725	1854	1984
3	632	676	720	826	932	1002	1087	1153	1260	1358	1457
4	396	440	485	534	583	635	690	748	806	868	931
5	318	354	391	431	471	514	559	606	654	705	757
6	241	269	298	329	360	393	428	465	503	543	583
7	204	228	252	278	305	334	364	396	428	462	497
8	167	187	207	229	251	275	300	327	354	383	412
9	145	162	180	200	220	240	263	287	311	336	362
10	123	138	154	171	188	206	226	246	267	289	312
11	109	123	137	152	167	184	201	219	238	258	279
12	95.5	108	120	133	147	162	177	193	210	228	246
13	85.5	96.9	108.3	121	133	147	160	175	190	206	223
14	75.5	86.0	96.6	108	119	132	144	157	171	186	201
15	67.3	77.5	87.6	98.2	109	120	132	145	158	171	184
16	58.8	68.7	78.6	88.6	98.7	109	120	131	143	155	168
17	49.7	60.4	70.6	80.5	90.4	100	110	121	132	144	156
18	40.6	51.6	62.6	72.3	82.1	91.7	101	111	122	133	144
19	22.3	37.8	53.3	64.2	74.3	84.0	93.0	103	113	123	134
20	3.97	24.0	43.9	55.2	66.5	76.3	85.9	95.4	105	114	124
21		4.19	24.0	40.5	56.9	67.9	78.1	87.7	97.4	106	116
22			4.34	25.8	47.3	59.6	70.4	80.3	89.8	98.9	108
23				4.53	26.0	46.8	60.5	71.3	82.1	91.5	101
24					4.72	34.0	50.6	62.5	74.4	84.1	93.9
25						4.91	27.8	46.0	64.2	75.2	86.2
26							5.10	29.5	54.0	66.2	78.5
27								5.28	29.6	48.7	67.9
28									5.47	31.4	57.3
29										5.66	32.5
30											5.85

NOTE: ODD TERMS INTERPOLATED

REFERENCE: NATIONAL BUREAU OF STANDARDS' HANDBOOK 55 (1954)

APPENDIX B (Ref 105)

POSSIBLE LONG-LIVED RADIOACTIVITIES PRODUCED IN FOODS

Element	Atomic Number	% in Food	Isotope	Half Life	Photonuclear Reaction	Estimated Radioactivity (μcuries/g/5 Mrads)
Hydrogen	1	9.3	None			
Boron	5	6×10^{-6}	None			
Carbon	6	18	None			
Nitrogen	7	1.[illegible]	None			
Oxygen	8	70	None			
Sodium	11	6.6×10^{-2}	$Na^{22}(\gamma)$	2.58y	γ,n	2×10^{-7}
Magnesium	12	3.2×10^{-2}	$Na^{22}(\gamma)$	2.58y	γ,d	2×10^{-10}
Aluminum	13	1×10^{-6}	None			
Silicon	14	6×10^{-6}	None			
Phosphorus	15	0.198	$P^{32}(\bar{B})$	14.2d	n,γ	6×10^{-8}
Sulfur	16	0.221	$P^{32}(\bar{B})$	14.2d	γ,p	1×10^{-7}
"	"	"	$P^{32}(\bar{B})$	14.2d	γ,d	6×10^{-9}
"	"	"	$P^{33}(\bar{B})$	24.4d	γ,p	6×10^{-7}
"	"	"	$S^{35}(\bar{B})$	87d	γ,n	9×10^{-10}
"	"	"	$S^{35}(\bar{B})$	87d	n,γ	5×10^{-10}
Chlorine	17	5.6×10^{-2}	$S^{35}(\bar{B})$	87d	γ,d	2×10^{-9}
Potassium	19	0.382	$A^{37}(x)$	35.0d	γ,d	1×10^{-7}
Calcium	20	1.4×10^{-2}	$Ca^{45}(\bar{B})$	164d	γ,n	7×10^{-12}
"	"	"	$Ca^{45}(\bar{B})$	164d	n,γ	1×10^{-11}
Chromium	24	3×10^{-7}	$V^{48}(\gamma)$	16.0d	γ,d	1×10^{-12}
"	"	"	$Cr^{51}(\gamma)$	27d	γ,n	3×10^{-11}
"	"	"	$Cr^{51}(\gamma)$	27d	γ,2n	2×10^{-14}
"	"	"	$Cr^{51}(\gamma)$	27d	n,γ	3×10^{-17}

Appendix B (Continued)

Element	Atomic Number	% in Food	Isotope	Half Life	Photonuclear Reaction	Estimated Radioactivity (μcuries/g/5Mrads)
Manganese	25	$2x10^{-5}$	$Mn^{54}(\gamma)$	291d	γ,n	$2x10^{-10}$
Iron	26	$4.2x10^{-3}$	$Mn^{54}(\gamma)$	291d	γ,d	$2x10^{-10}$
"	"	"	$Fe^{55}(x)$	2.9y	γ,n	$1x10^{-8}$
"	"	"	$Fe^{55}(x)$	2.9y	γ,2n	$1x10^{-12}$
"	"	"	$Fe^{55}(x)$	2.9y	n,γ	$2x10^{-12}$
"	"	"	$Fe^{59}(\gamma)$	45.1d	n,γ	$2x10^{-12}$
Cobalt	27	$2x10^{-7}$	$Co^{57}(\gamma)$	270d	γ,2n	$1x10^{-14}$
"	"	"	$Co^{58}(\gamma)$	71d	γ,n	$1x10^{-11}$
"	"	"	$Co^{60}(\gamma)$	5.24y	n,γ	$9x10^{-16}$
Nickel	28	$3x10^{-7}$	$Co^{56}(\gamma)$	77.3d	γ,d	$4x10^{-14}$
"	"	"	$Co^{57}(\gamma)$	270d	γ,p	$1x10^{-12}$
"	"	"	$Co^{58}(\gamma)$	71d	γ,d	$2x10^{-13}$
Copper	29	$5x10^{-5}$	None			
Zinc	30	$1.5x10^{-3}$	$Zn^{65}(\gamma)$	245d	γ,n	$4x10^{-9}$
"	"	"	$Zn^{65}(\gamma)$	245d	γ,2n	$5x10^{-14}$
"	"	"	$Zn^{65}(\gamma)$	245d	n,γ	$3x10^{-13}$
Molybdenum	42	$1.5x10^{-6}$	$Nb^{91}(\gamma)$	64d	γ,p	$1x10^{-11}$
"	"	"	$Nb^{92}(\gamma)$	10.1d	γ,d	$4x10^{-13}$
"	"	"	$Nb^{95}(\gamma)$	35d	γ,p	$2x10^{-11}$
"	"	"	$Nb^{95}(\gamma)$	35d	γ,d	$1x10^{-13}$
"	"	"	$Mo^{93}(x)$	>2y	γ,n	$1x10^{-12}$
"	"	"	$Mo^{93}(x)$	>2y	γ,2n	$9x10^{-15}$
Silver	47	$1.4x10^{-6}$	$Ag^{105}(\gamma)$	40d	γ,2n	$5x10^{-13}$
"	"	"	$Ag^{110m}(\gamma)$	253d	n,γ	$4x10^{-14}$

Appendix B (Continued)

Element	Atomic Number	% in Food	Isotope	Half Life	Photonuclear Reaction	Estimated Radioactivity (μcuries/g/5Mrads)
Tin	50	2×10^{-7}	$In^{114m}(\gamma)$	50.0d	γ,p	4×10^{-14}
"	"	"	$In^{114m}(\gamma)$	50.0d	γ,d	2×10^{-14}
"	"	"	$Sn^{113}(\gamma)$	119d	γ,n	7×10^{-14}
"	"	"	$Sn^{113}(\gamma)$	119d	γ,2n	2×10^{-16}
"	"	"	$Sn^{113}(\gamma)$	119d	n,γ	3×10^{-14}
"	"	"	$Sn^{121m}(\bar{B})$	>400d	γ,n	2×10^{-13}
"	"	"	$Sn^{121m}(\bar{B})$	>400d	n,γ	3×10^{-16}
"	"	"	$Sn^{123}(\bar{B})$	136d	γ,n	6×10^{-13}
"	"	"	$Sn^{123}(\bar{B})$	136d	n,γ	1×10^{-15}
Iodine	53	3.5×10^{-6}	$I^{125}(x,\gamma)$	60.0d	γ,2n	2×10^{-12}
"	"	"	$I^{126}(\gamma)$	13.3d	γ,n	7×10^{-9}
Lead	82	1×10^{-6}	$Tl^{202}(\gamma)$	12.0d	γ,d	7×10^{-14}
"	"	"	$Tl^{204}(\bar{B})$	3.56y	γ,d	1×10^{-14}

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