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N-64-8

U S ARMY NATICK LABORATORIES

TECHNICAL REPORT

FD-I

HANDBOOK OF PHOTONUCLEAR REACTIONS

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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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Scientific Director

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Brigadier General, USA
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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 photo-proton 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:

β^- negative beta particle emission

β^+ 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	Symbol	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	Mendelevium	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		
Tantalum	Ta	73	(Wolfram)	W	74
Technetium	Tc	43	Uranium	U	92
Tellurium	Te	52	Vanadium	V	23
Terbium	Tb	65	Xenon	Xe	54
Thallium	Tl	81	Ytterbium	Yb	70
Thorium	Th	90	Yttrium	Y	39
Thulium	Tm	69	Zinc	Zn	30
Tin	Sn	50	Zirconium	Zr	40

ACKNOWLEDGEMENT

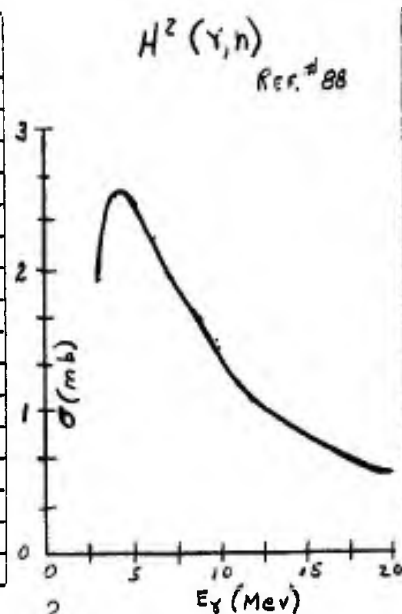
This report is made possible by the fine work of all the authors listed in the references.

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.

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

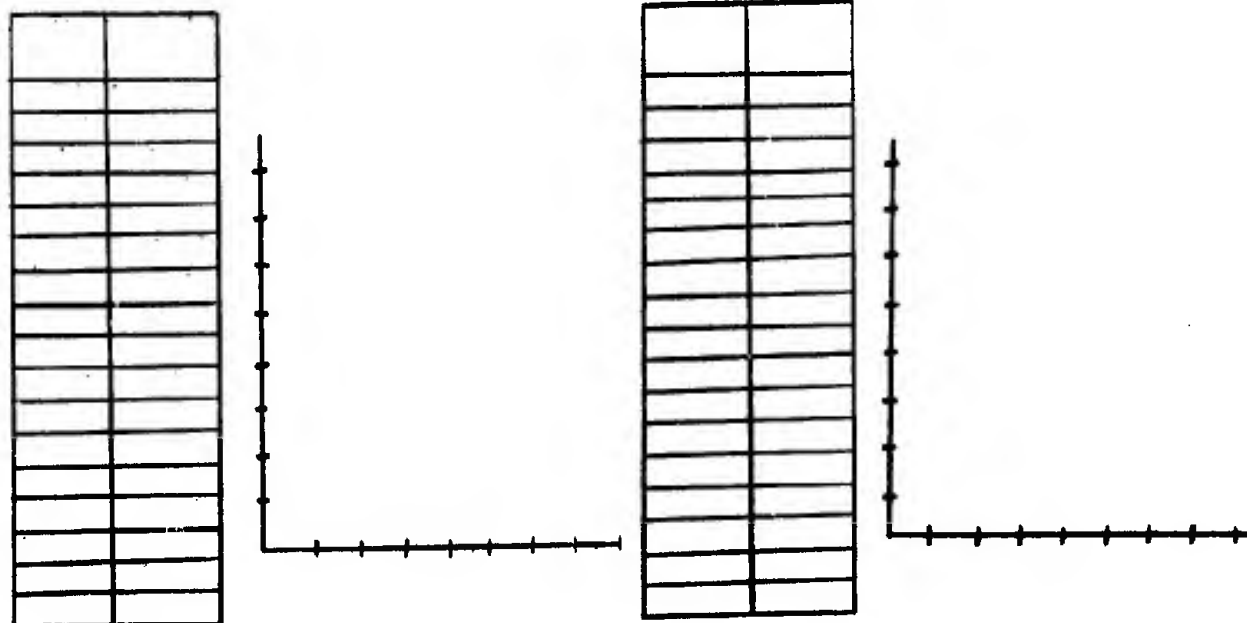
E MeV	σ mb
3	1.9
4	2.5
5	2.45
6	2.2
7	1.9
8	1.8
9	1.6
10	1.4
11	1.2
12	1.1
13	1.0
14	0.9
15	0.85
16	0.78
17	0.70

[illegible]

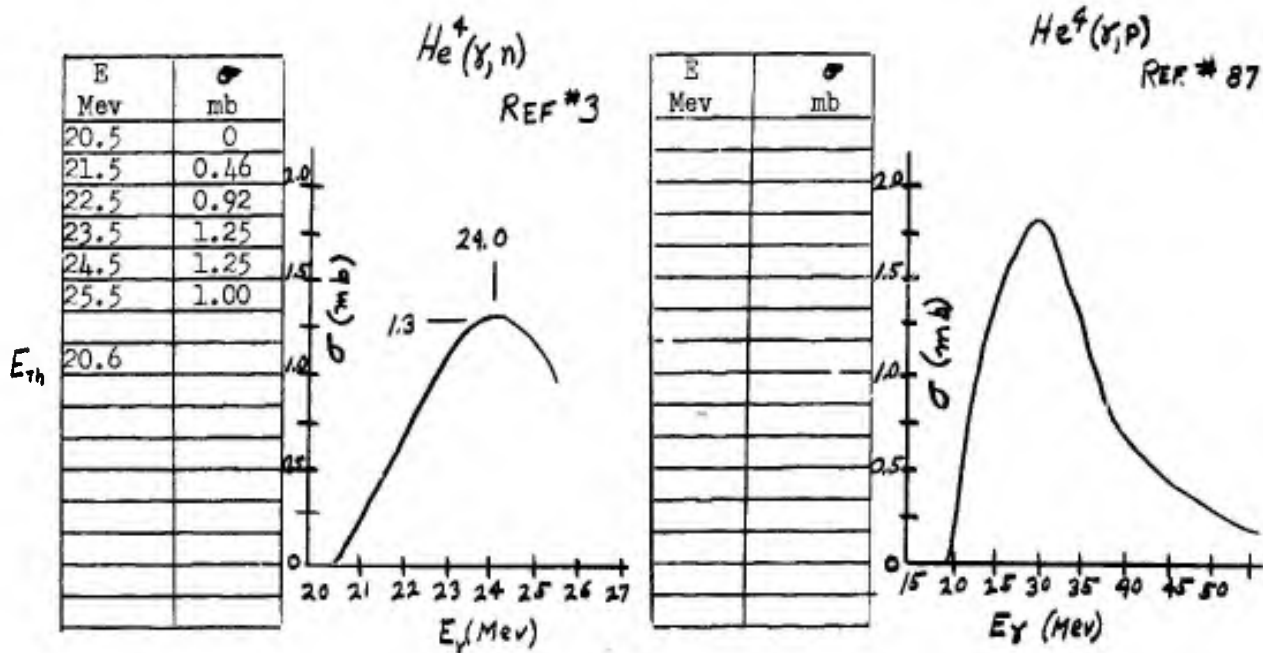
H² (δ, n)
 $E_{th} = 2.22471 \pm 0.00040$ Mev
 Ref. #6

1. H

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



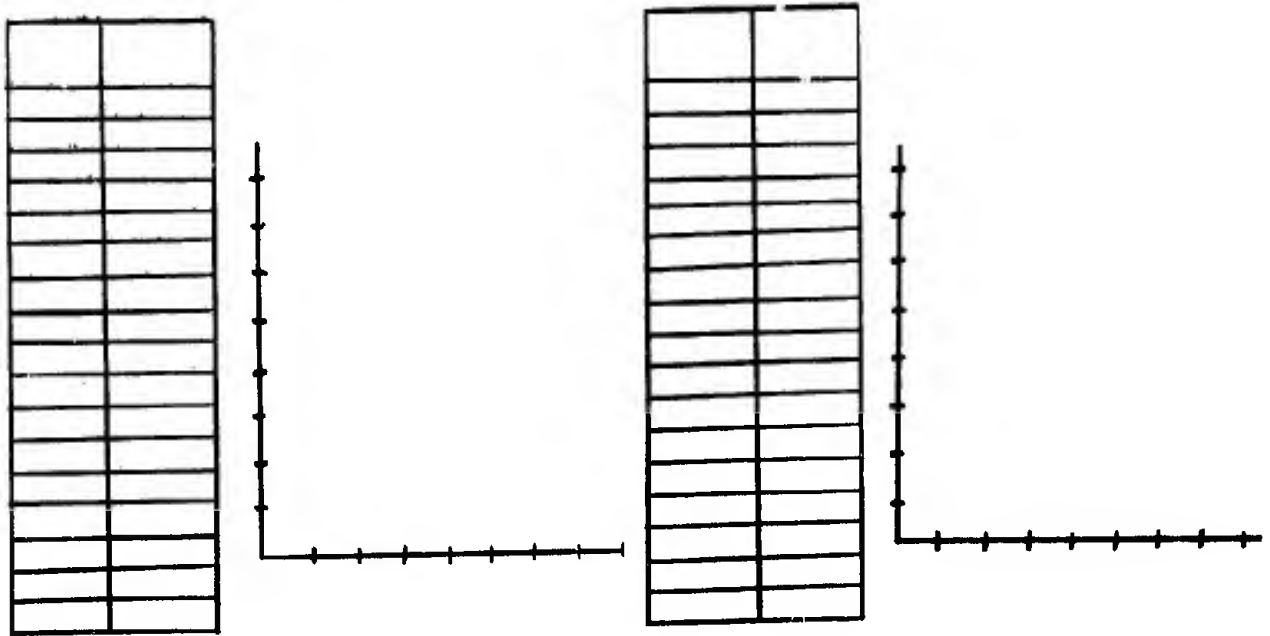
Z	CHEM. SYM.	A	ATOMIC MASS AMU	+	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF
2	Helium	- 3	3.016986	5	0.00013			2
	-	4	4.003873	2	~ 100			2
	-	5	5.013888	32		2×10^{-21} s	n, α	2, 5
	-	6	6.020831	31		0.82	B-3.50	2, 5



${}^2\text{He}$

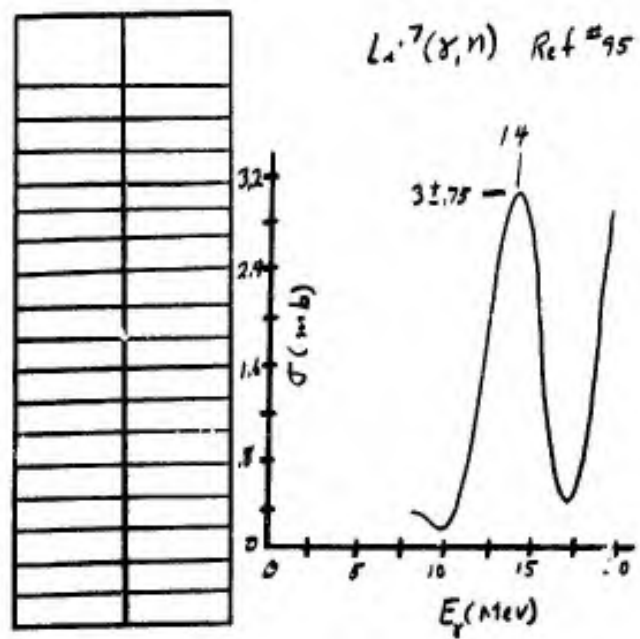
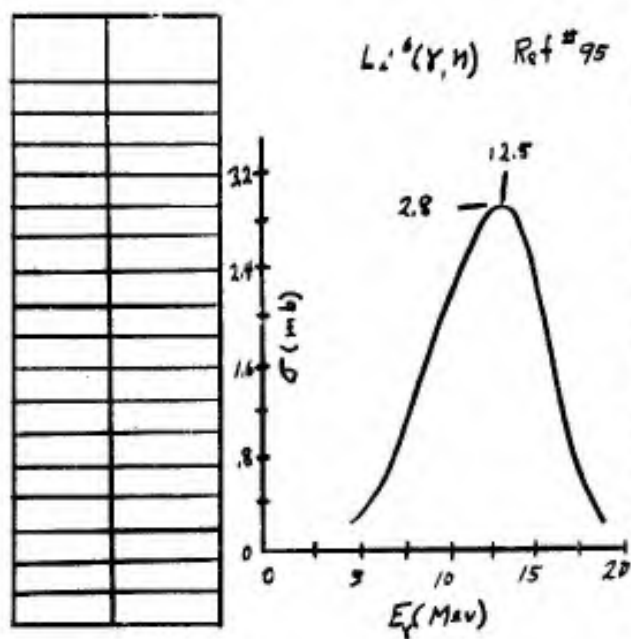
REMARKS

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



The graph plots the cross section σ in millibarns (mb) on the y-axis against the photon energy E_γ in MeV on the x-axis. The y-axis ranges from 0 to 1.0 with major ticks every 0.5 units. The x-axis ranges from 10 to 28 with major ticks every 2 units. The curve begins at $E_\gamma = 10$ MeV, $\sigma = 0$. It rises steeply, passing through a point labeled 1.46 at approximately $E_\gamma = 15.5$ MeV. It reaches a maximum value of 1.45 at $E_\gamma = 16.5$ MeV. After the peak, the cross section decreases, reaching approximately 0.4 mb at $E_\gamma = 28$ MeV.

REMARKS				
${}^3\text{Li}$				
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

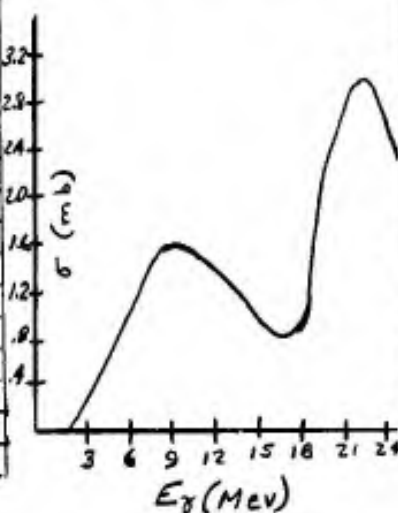


${}^4\text{Be}$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
4	Beryllium-7		7.019159	5	54 d	K; σ 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

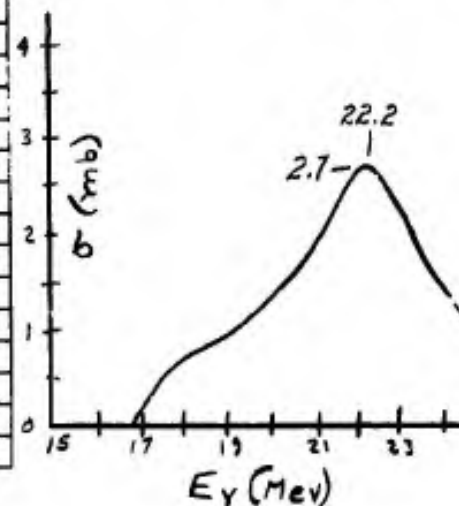
E_γ Mev	σ mb
1	0
2	0.05
3	0.24
4	0.48
5	0.70
6	1.00
7	1.30
8	1.50
9	1.58
10	1.57
11	1.51
12	1.43
13	1.32
14	1.20
15	1.08
16	0.92

$\text{Be}^9(\gamma, n)$ REF. #7



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

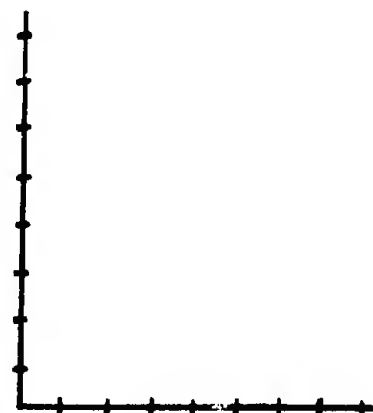
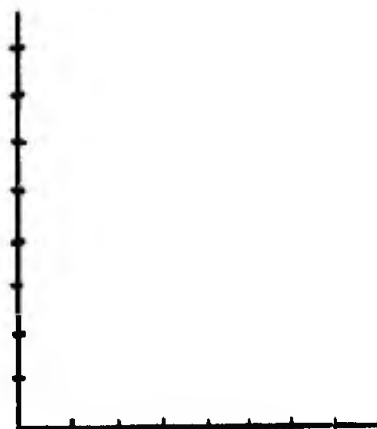
$\text{Be}^9(\gamma, p)$ REF. #79

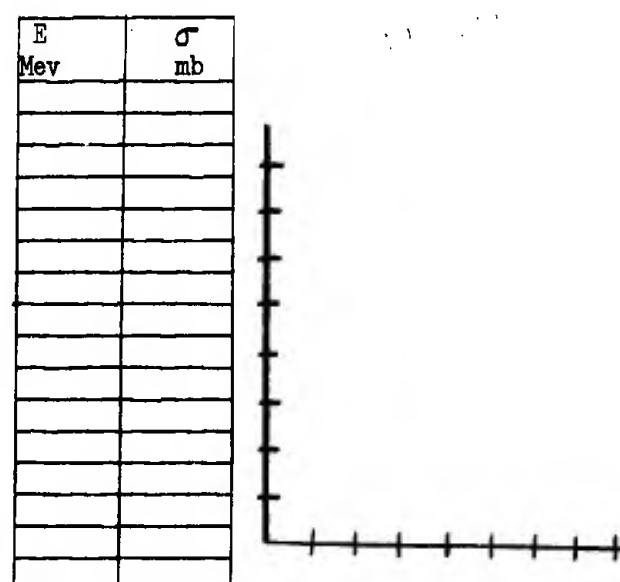
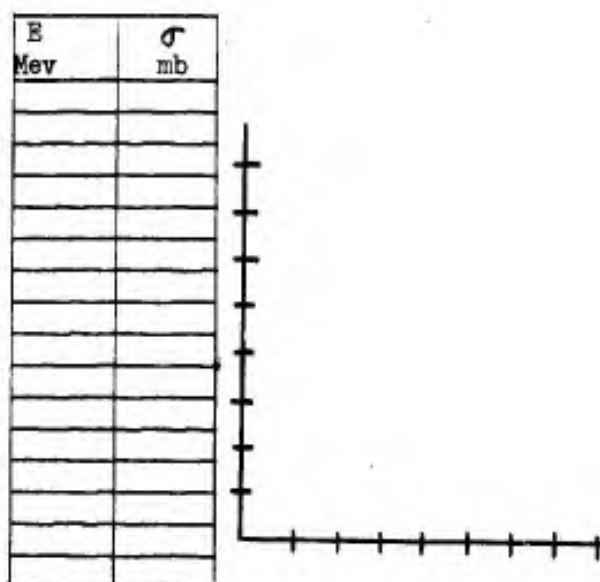


${}^4\text{Be}$

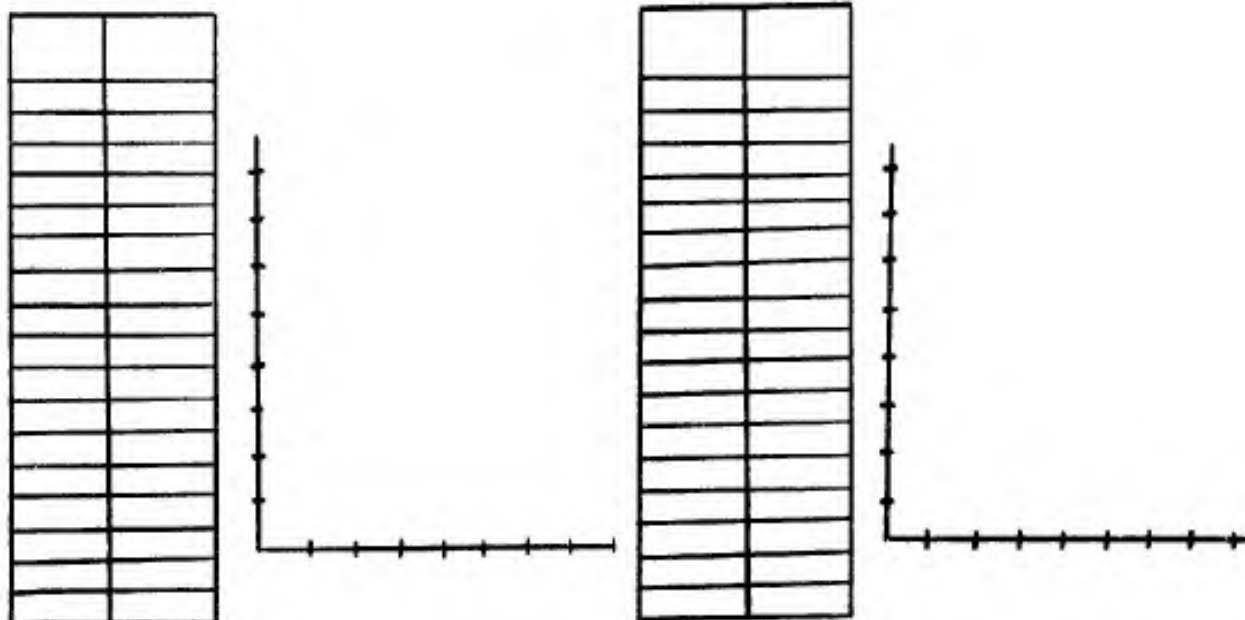
REMARKS

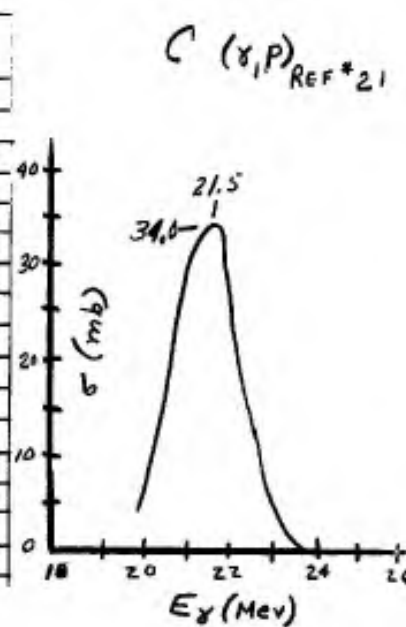
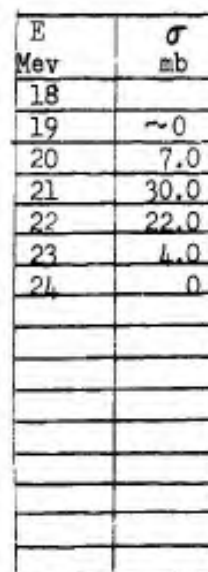
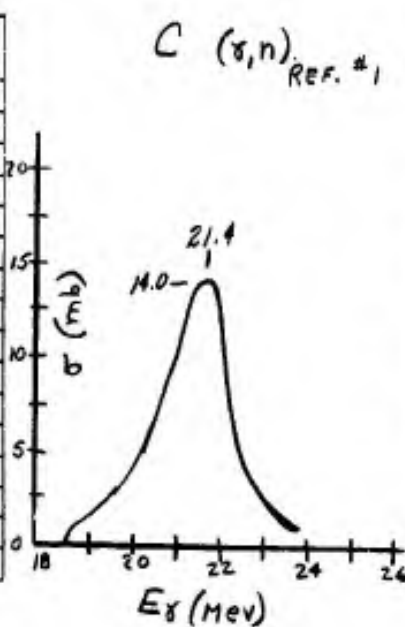
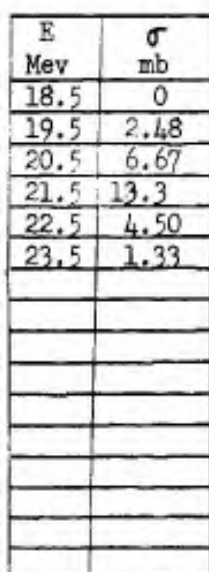
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Be^9	-1.665		6
(γ, p)	Be^9	-16.855		6
(γ, α)	Be^9	-2.528		6





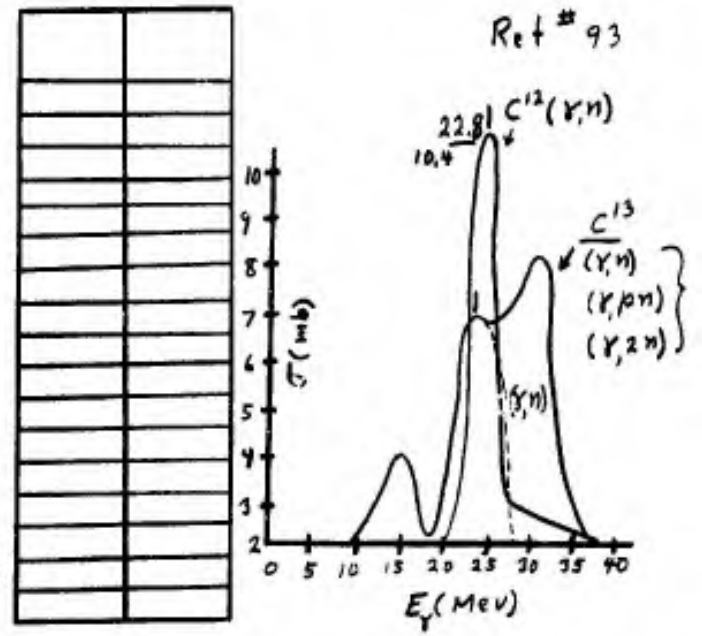
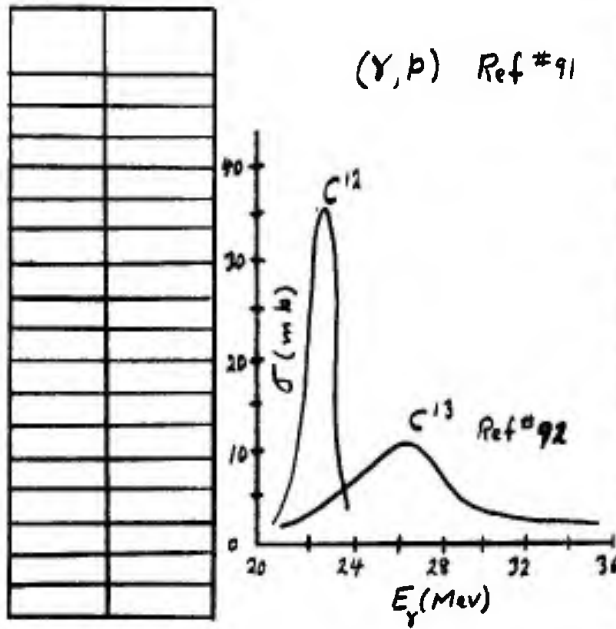
<u>REMARKS</u>				⁵ B
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	B ¹⁰	- 8.440		6
	B ¹¹	-11.456		6
(γ, p)	B ¹⁰	- 6.587		6
	B ¹¹	-11.229		6



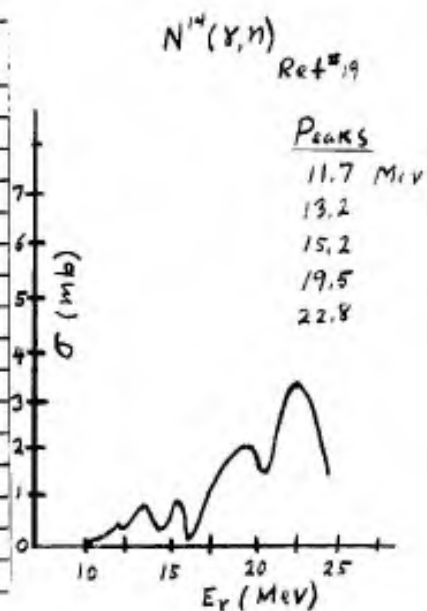


REMARKS

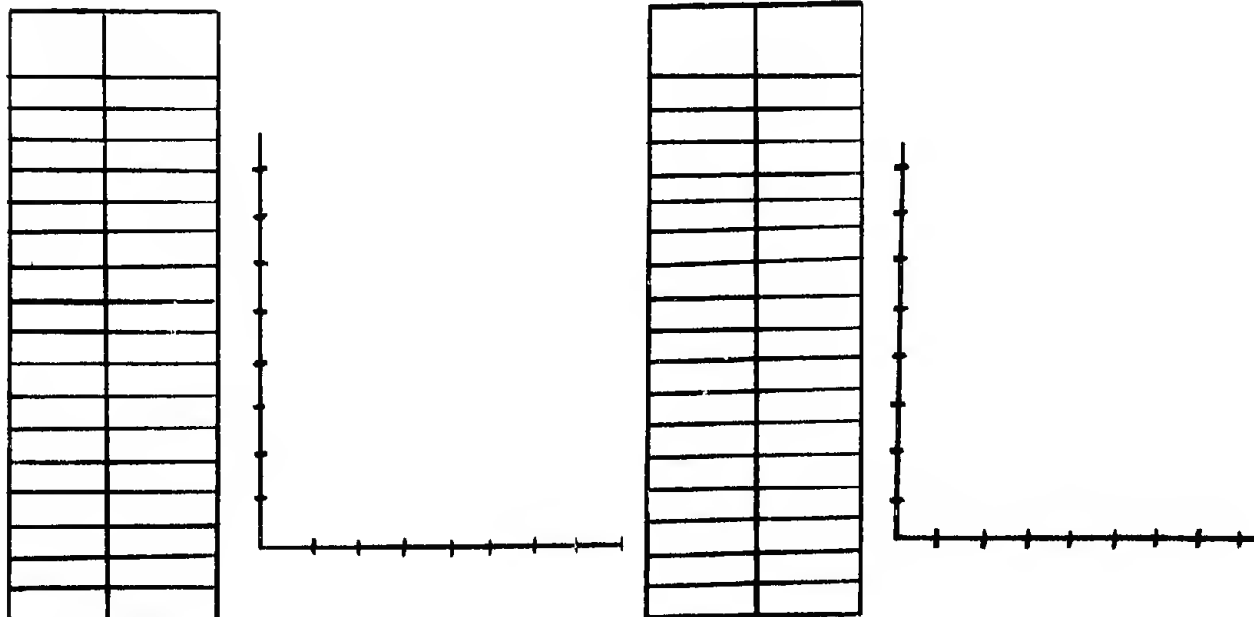
Thresholds	Isotope	Theoretical	Experimental	Reference
(Y,n)	C ¹²	-18.721		6
	C ¹³	- 4.947		6
(Y,p)	C ¹²	-15.956		6
	C ¹³	-17.533		6
(Y,α)	C ¹²	- 7.3695		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
7	Nitrogen-12	12.022776	110			0.013 s	B+17, 3 α ~ 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

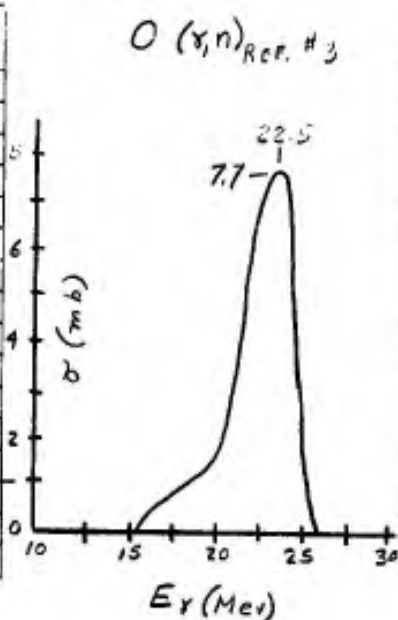


<u>Thresholds</u>	<u>Isotope</u>	<u>REMARKS</u>		⁷ N
		<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,n)	N ¹⁴	-10.553		6
	N ¹⁵	-10.834		6
(Y,p)	N ¹⁴	- 7.5494		6
	N ¹⁵	-10.2077		6

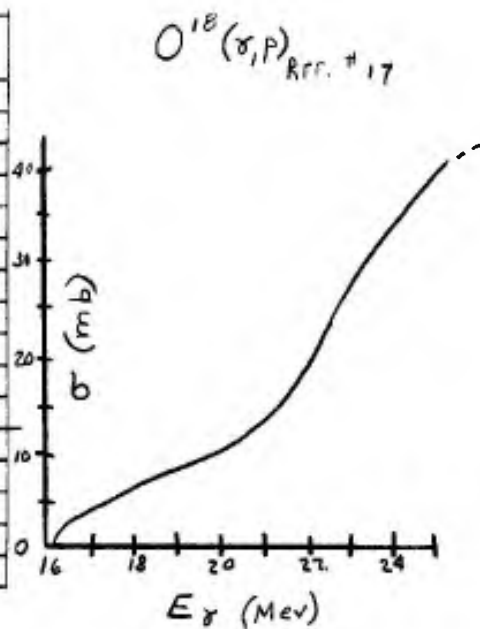


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
8	Oxygen	-14	14.013069	15		76 s	B+1.8; γ 2.3	2, 5
		-15	15.007767	6		2.1 m	B+1.66	2, 5
		-16	16.000000	0	99.76			2
		-17	17.004534	5	0.037			2
		-18	18.004855	8	0.20			2
		-19	19.009591	13		29 s	B-0.9, 4.5; γ 1.12, .200, 1.366	2, 5, 6

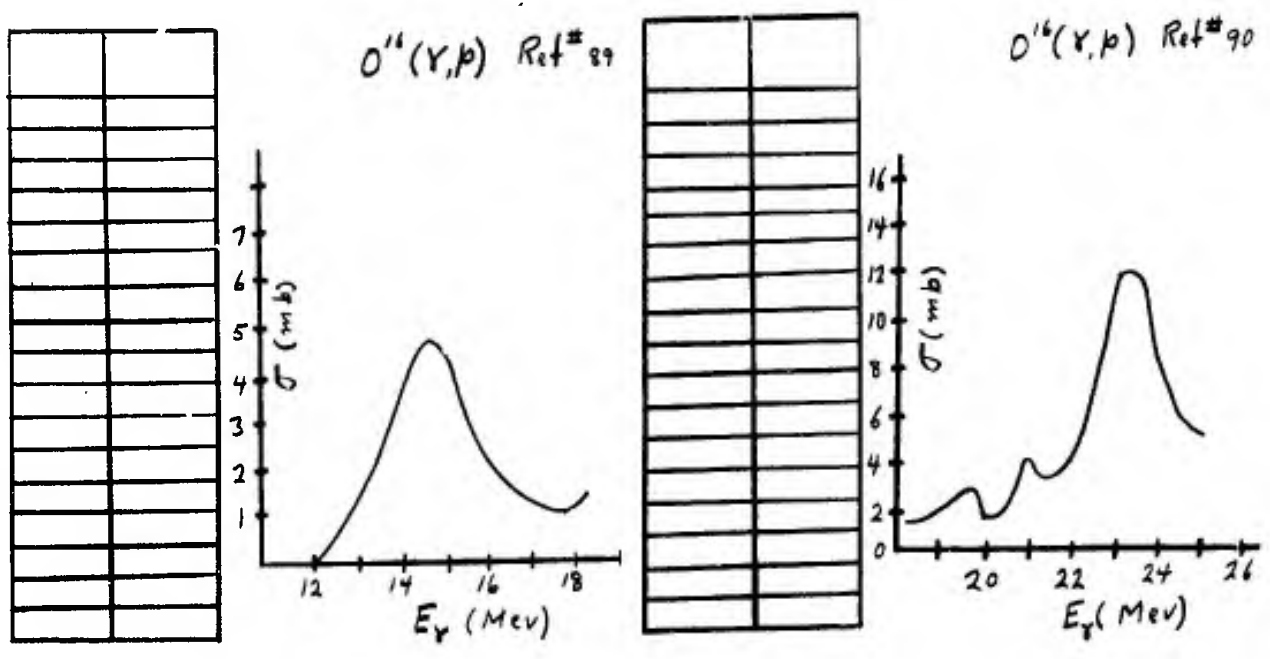
E Mev	σ mb
15.5	0
16.5	0.5
17.5	0.8
18.5	0.9
19.5	1.2
20.5	2.3
21.5	6.1
22.5	7.7
23.5	7.3
24.5	3.2
25.5	0.5



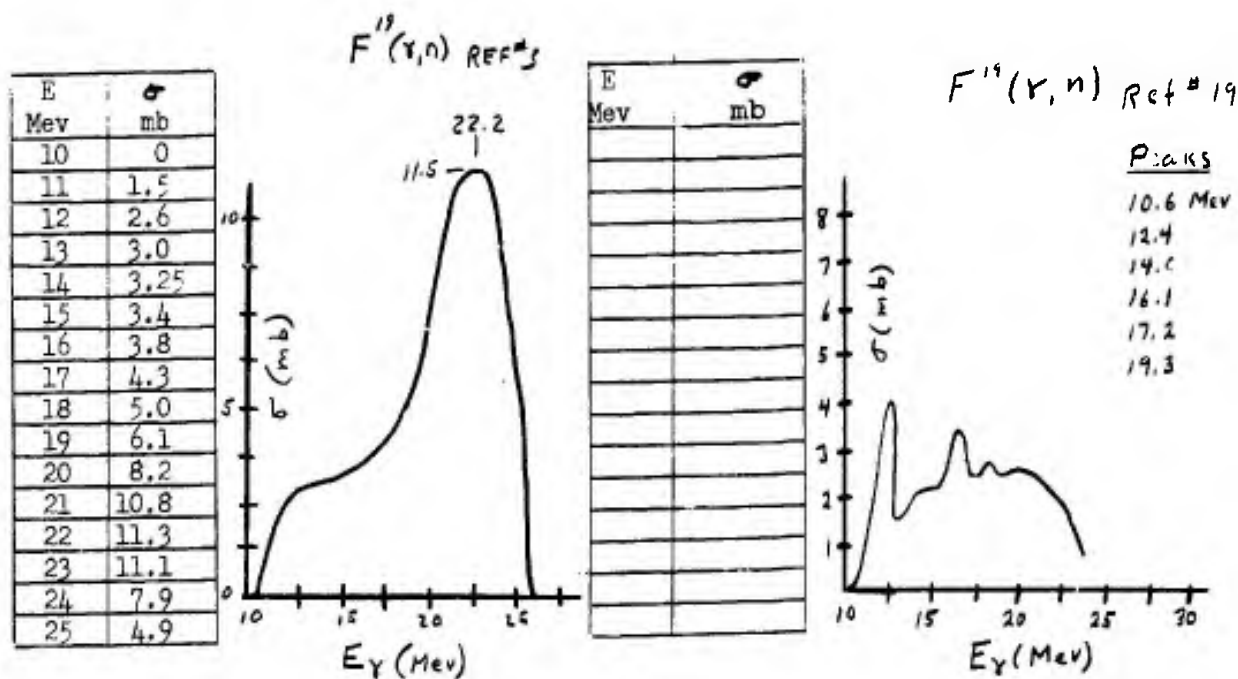
E Mev	σ mb
16	0.0
17	4.0
18	7.0
19	8.5
20	10.0
21	13.0
22	20.0
23	28.0
24	35.0
25	41.0



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



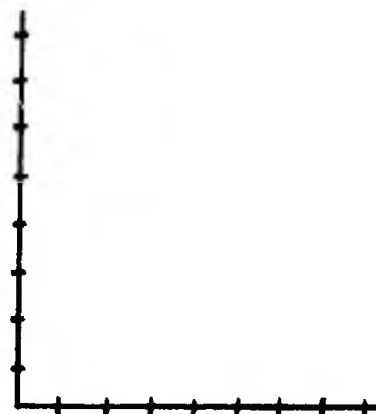
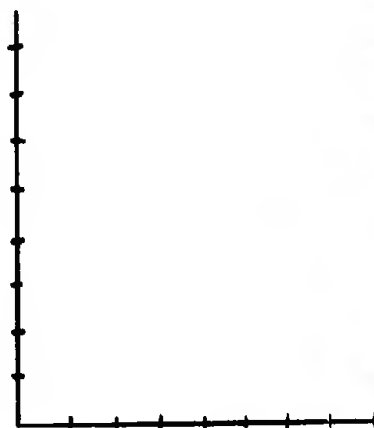
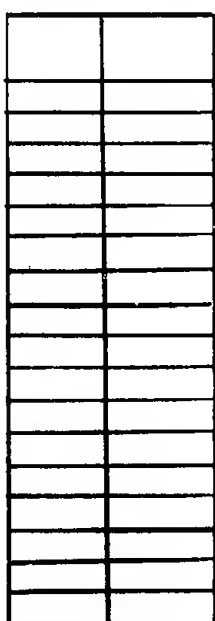
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
9	Fluorine	-17	17.007506	4		70 s	B+1.72	2, 5
		-18	18.006646	9		1.87 h	B+.65	2, 5
		-19	19.004448	7	100			2
		-20	20.006340	11		12 s	B-5.3, 6.7; γ 1.6	2, 5
		-21	21.					



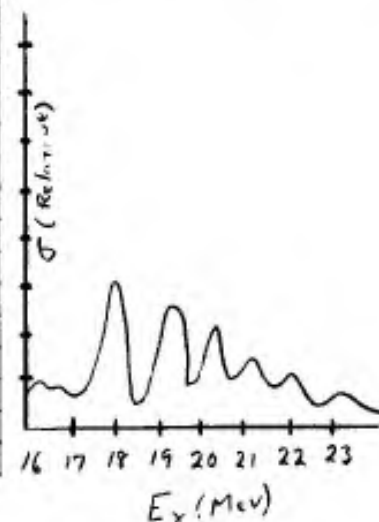
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REMARKS

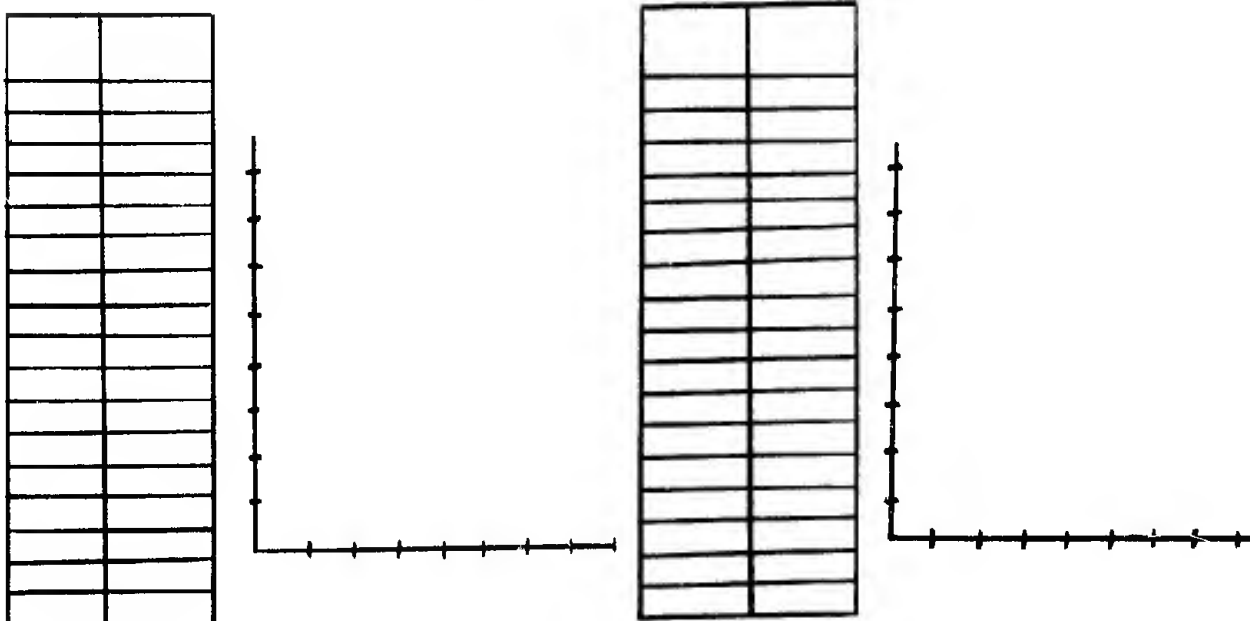
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	F^{19}	-10.442		6
(γ, p)	F^{19}	-7.992		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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 8 0.439, 1.65	2, 5, 6
		-24				3.4 m	B-1.95, 0.472, 0.878	2, 8, 6



<u>Thresholds</u>	<u>Isotope</u>	<u>REMARKS</u>		¹⁰ Ne
		<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Ne ²⁰	-16.875		6
	Ne ²²	-10.367		6
(γ, p)	Ne ²⁰	-12.844		6
	Ne ²²	-15.288		6



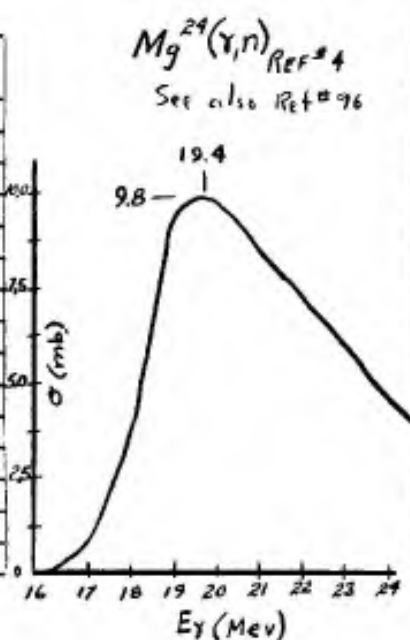
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
11	Sodium	- 20	20.015236	220		0.23 s	B ⁺ ; α 72	2, 5
	- 21		21.004281	35		23 s	B ⁺ 2.50	2, 5
	- 22		22.001404	14		2.6 y	B ⁺ 54, $\sim$ 1.8; γ 1.28	2, 5
	- 23		22.997053	11	100			2, 5
	- 24		23.998565	14		15.0 h	B ⁻ 1.39, 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; γ 0.39, γ 0.46, 0.58, 0.98, γ 1.61, 1.96	2, 5, 6

[illegible]

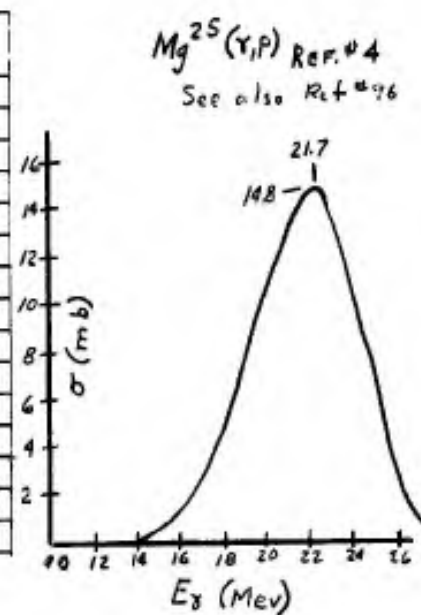
$_{12}Mg$

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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; 8 0.84, 0.180, 1.01	2,5,6
	-28		27.992714	32		21.3 h	B-0.45; 8 0.032, r 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



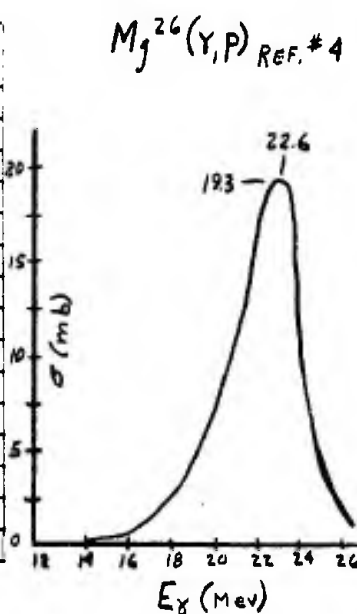
E Mev	σ mb
13	0
14	0.2
15	0.7
16	1.9
17	3.9
18	6.5
19	9.1
20	11.8
21	14.1
22	14.5
23	12.2
24	9.4
25	6.6
26	3.6



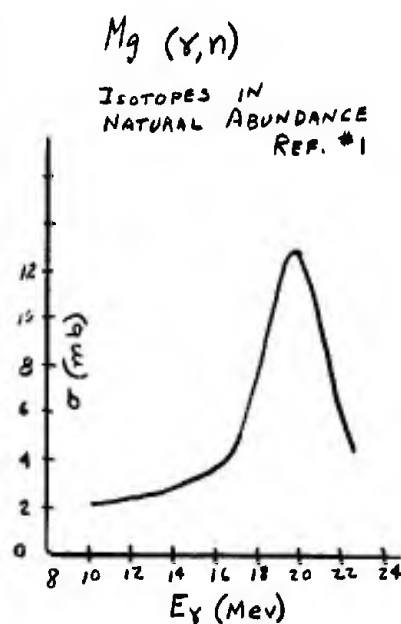
^{12}Mg

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

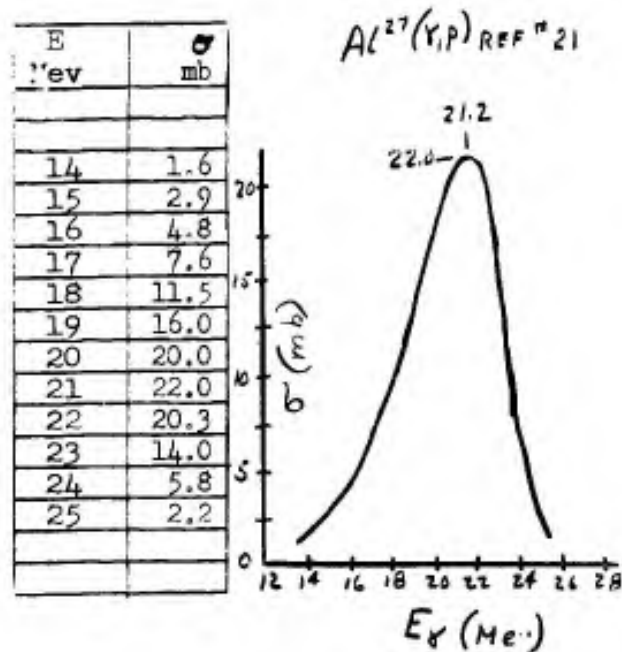
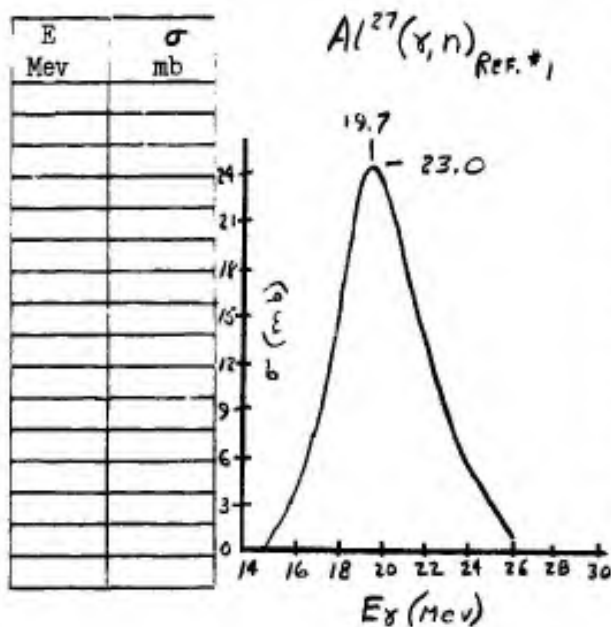


E Mev	σ mb
9	
10	2.1
11	2.3
12	2.5
13	2.7
14	3.0
15	3.3
16	4.0
17	5.0
18	9.0
19	12.2
20	10.2
21	7.8
22	5.0



¹³Al

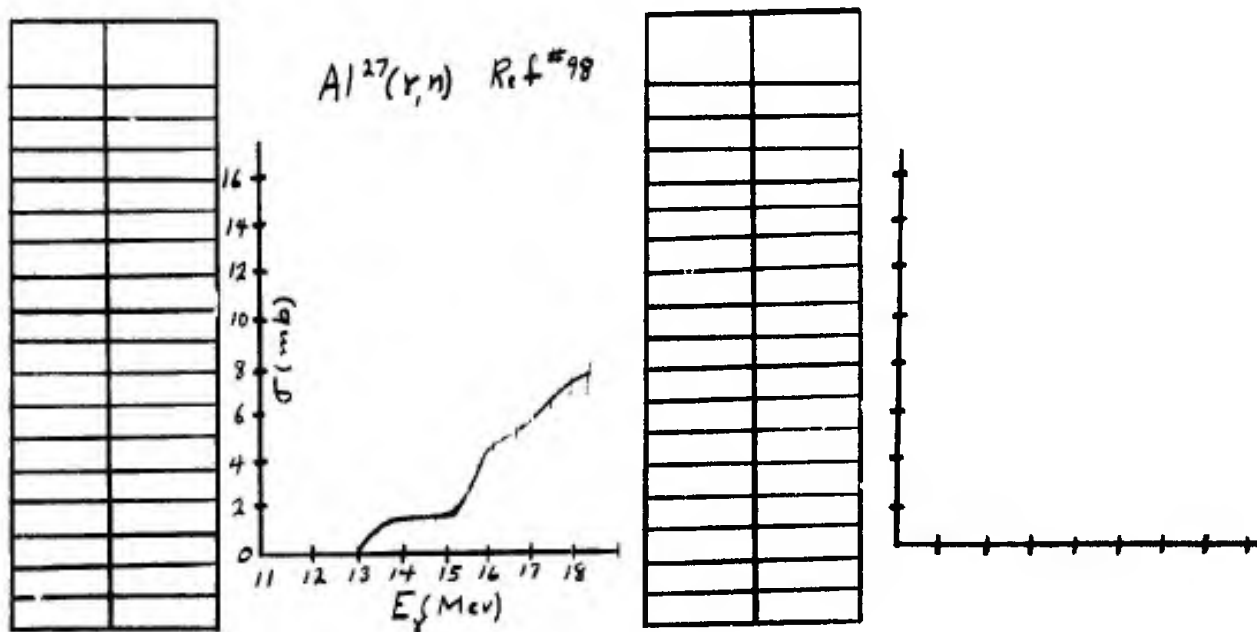
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
13	Aluminum-24		24.007691	320		2.3 s	B ⁺ ; γ 1.385, 2.72, 4.20, 5.40, 5.70, 7.05; α	2, 5, 6
		-25	24.998312	60		7.3 s	B ⁺ ; γ 1.58	2, 5, 6
		-26	25.995120	23		6.5 s	B ⁺ 3	2, 5
		-27	26.990081	16	100			2, 5
		-28	27.990771	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



^{13}Al

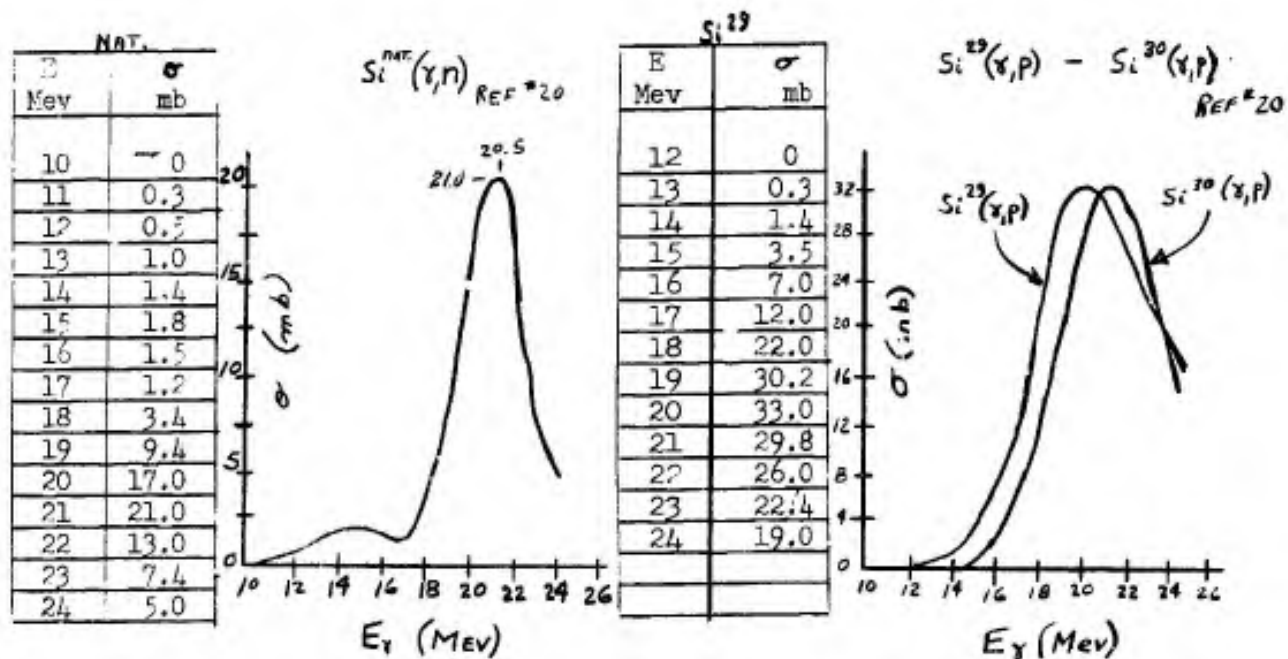
REMARKS

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



¹⁴Si

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

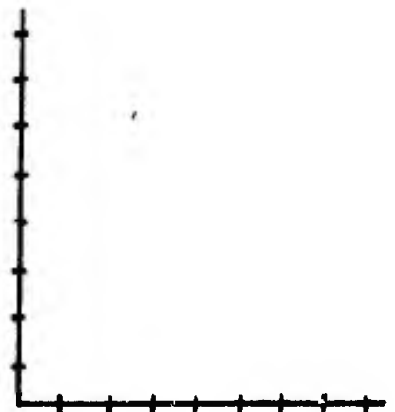
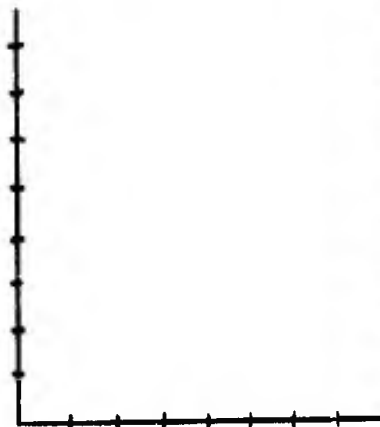
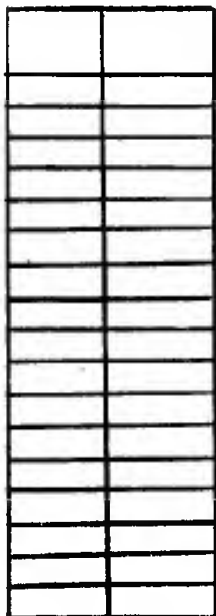


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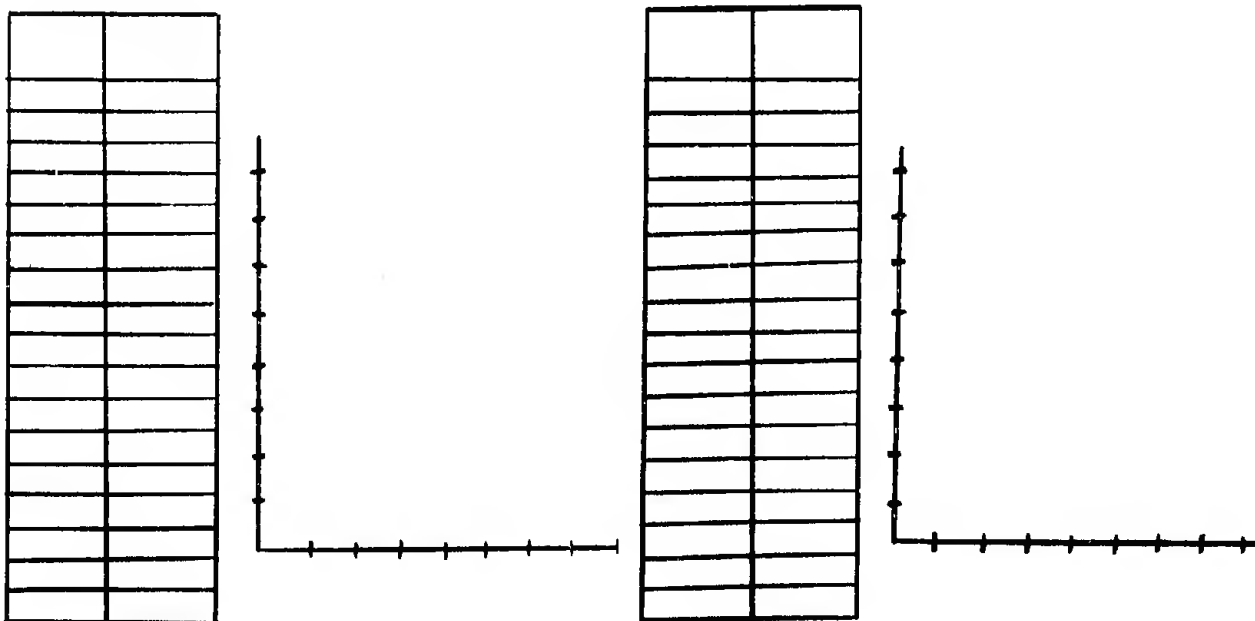
¹⁵P

REMARKS

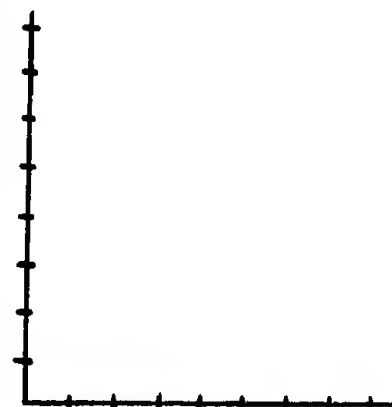
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	ρ^{31}	-12.316	-12.33, -12.39	6, 39, 48
(γ, p)	ρ^{31}	-7.286		6



		<u>REMARKS</u>		¹⁶ S
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ,n)	S ³²	-15.081		6
	S ³⁴	-11.421		6
(γ,p)	S ³²	- 8.8626		6
	S ³⁴	-10.8872		6



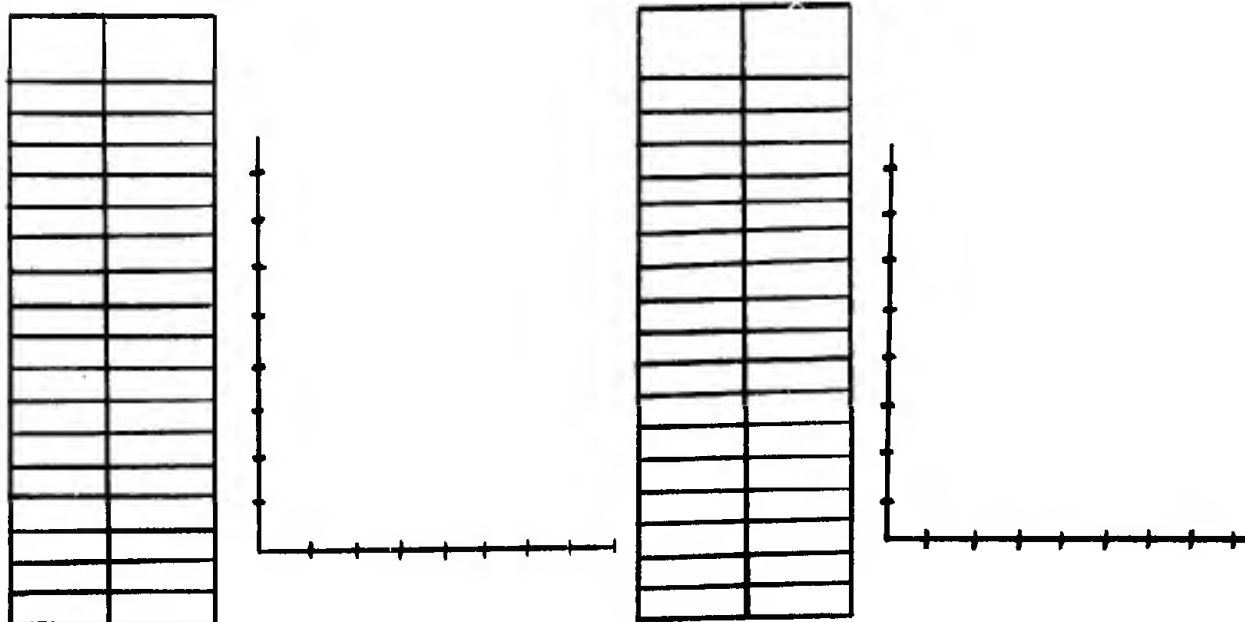
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
17	Chlorine	-32	31.996186	430		0.32 s	B+9.5; γ 2.23, 3.79 γ 4.30, 4.80	2,9,6
		-33	32.987744	140		1.8 s	B+4.2; γ 2.9	2,9
		-34	33.984570	60		1.5 s	B+4.45;	2,9
		-35	34.979905	35	75.53			2,9
		-36	35.979688	40		3.1×10^5 y	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

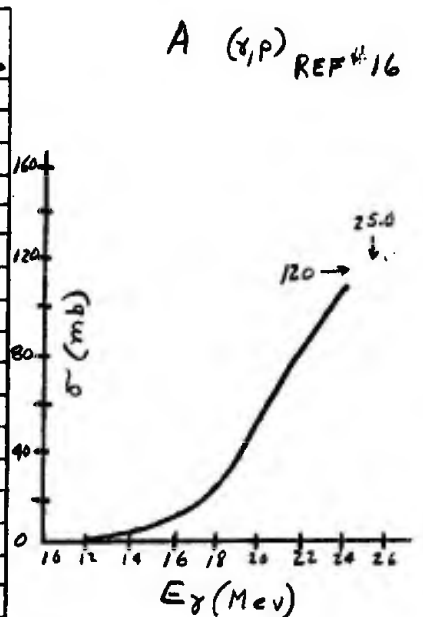


^{17}Cl

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ,n)	Cl^{35}	- 12.569		6
	Cl^{37}	- 10.322	- 10.307	6, 48
(γ,p)	Cl^{35}	- 6.3666		6
	Cl^{37}	- 8.4014		6

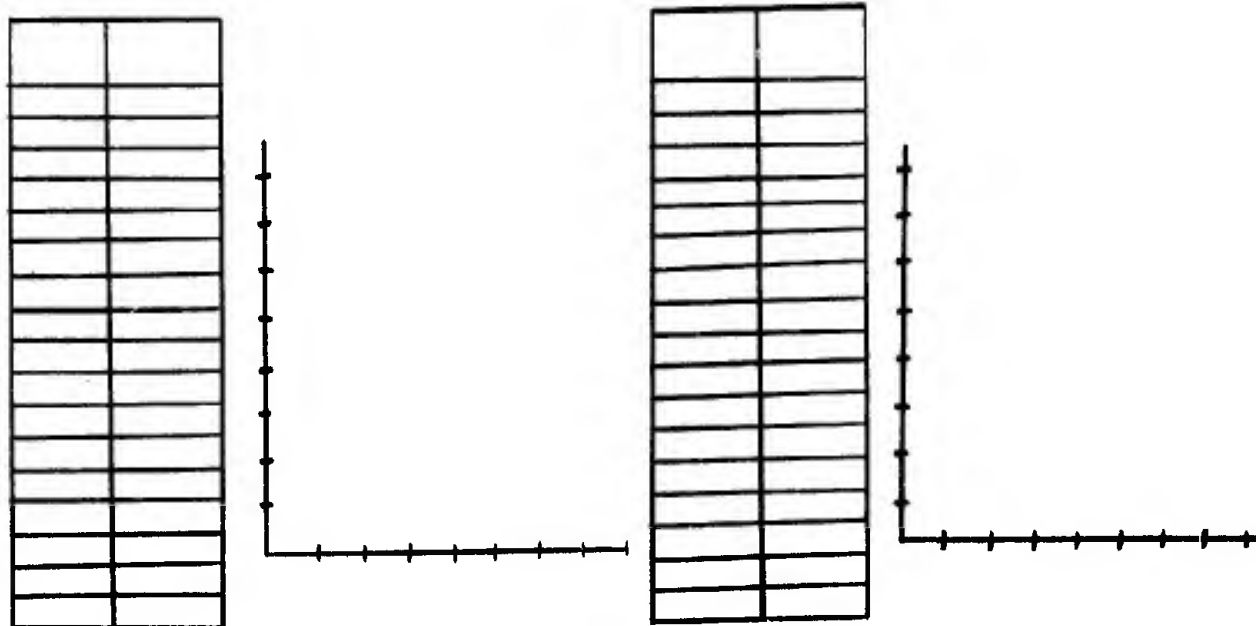




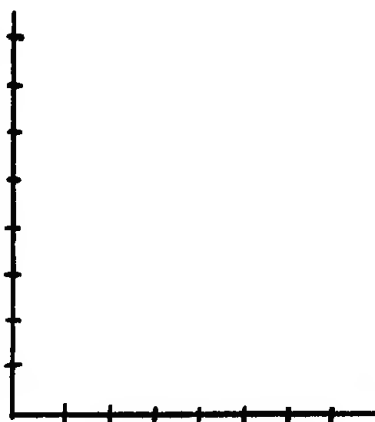
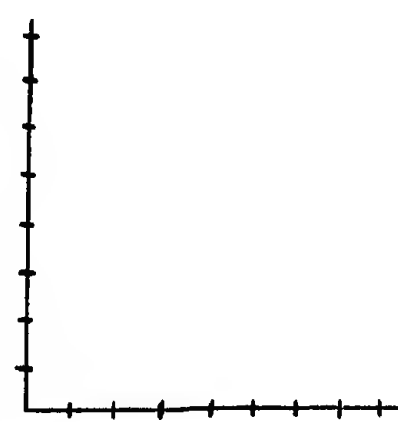
18

REMARKS

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

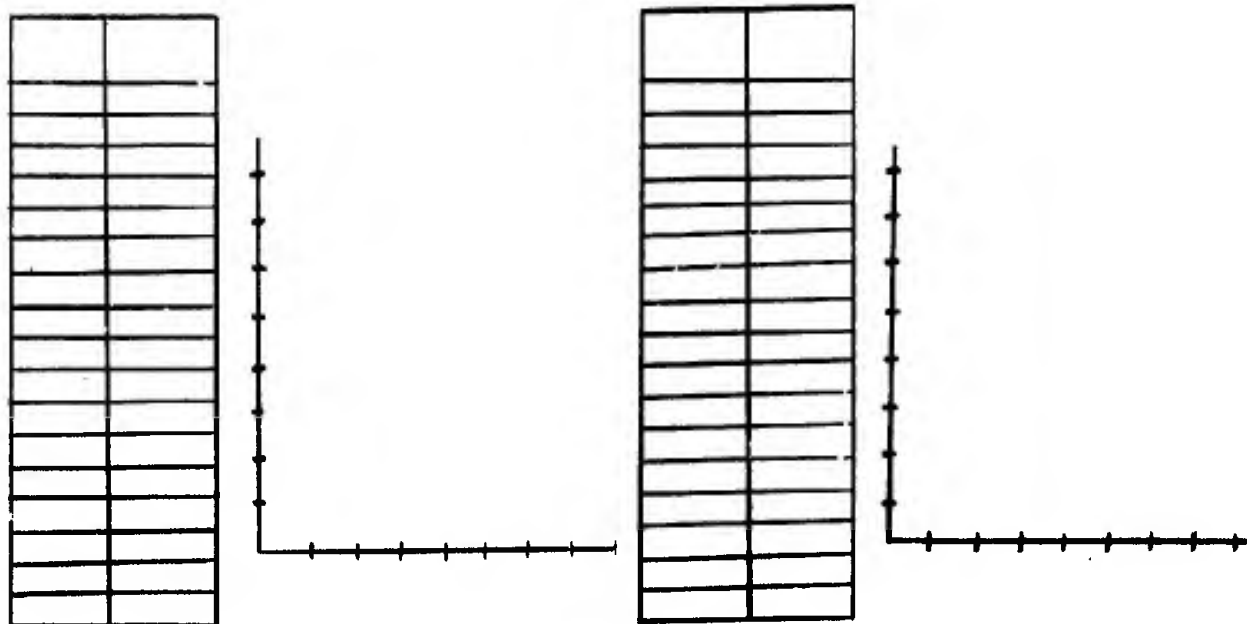


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
19	Potassium-37		36.985000	300		1.2 s	B+5.1	2,9
	-38		37.981100	60		7.7 m	B+2.68; γ 2.2	2,9
	-39		38.976037	70	93.08			2,9
	-40		39.976653	60	0.0118	1.39×10^9 y	B-1.3; γ 1.5	2,9
	-41		40.974760	60	6.91			2,9
	-42		41.975830	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, 0.146; 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

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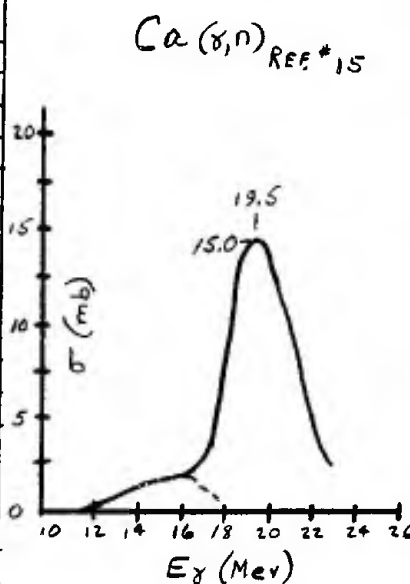
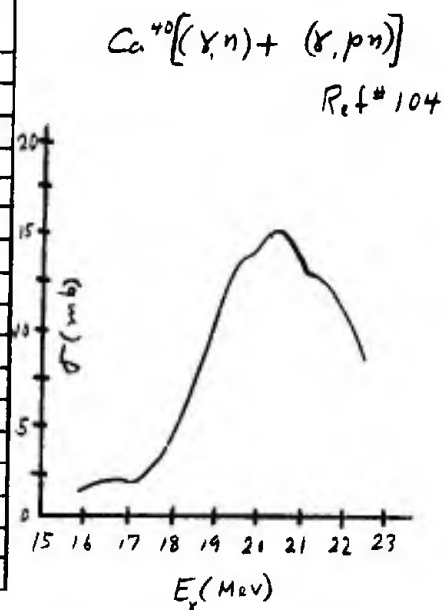
19 K

<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
20	Calcium	-38				0.66 s	B+ , 83.5	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

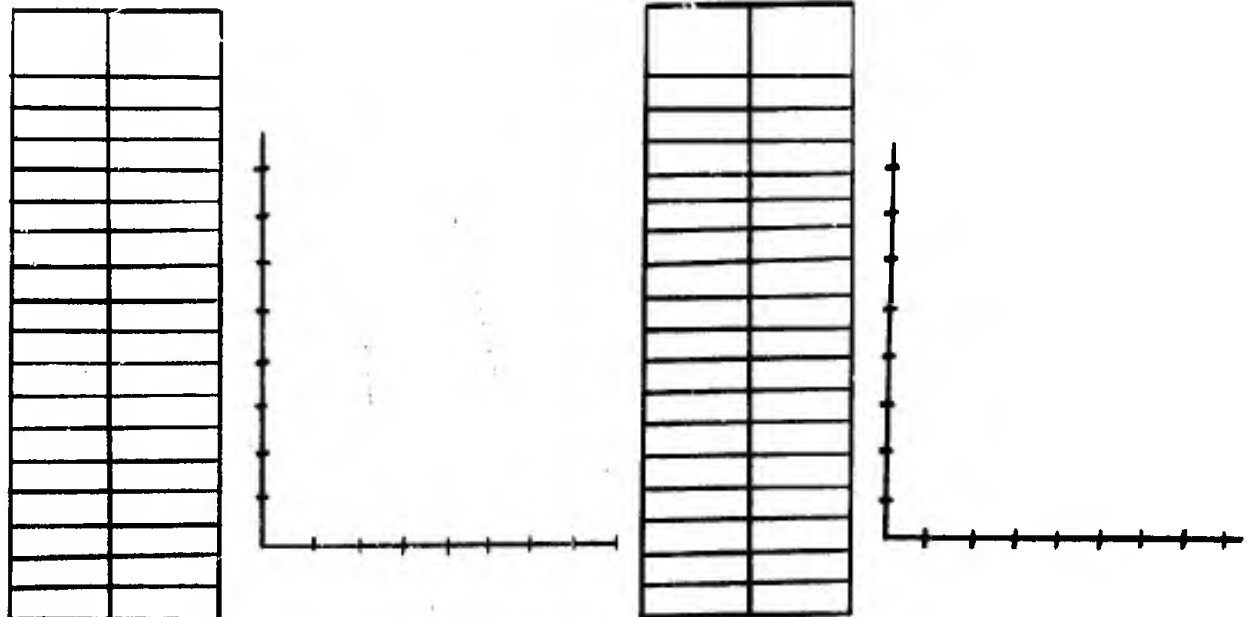
E Mev	σ_{mb}
11	~ 0
12	+
13	0.8
14	1.2
15	1.2
16	1.6
17	3.0
18	7.0
19	14.0
20	13.0
21	9.8
22	5.0
23	2.0

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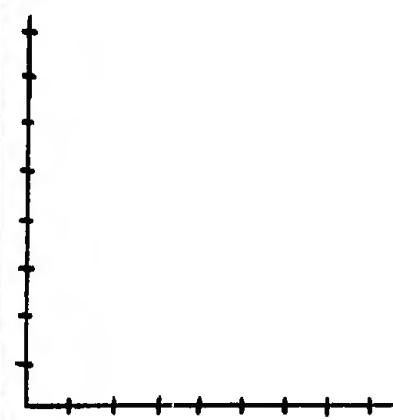
^{20}Ca

REMARKS

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

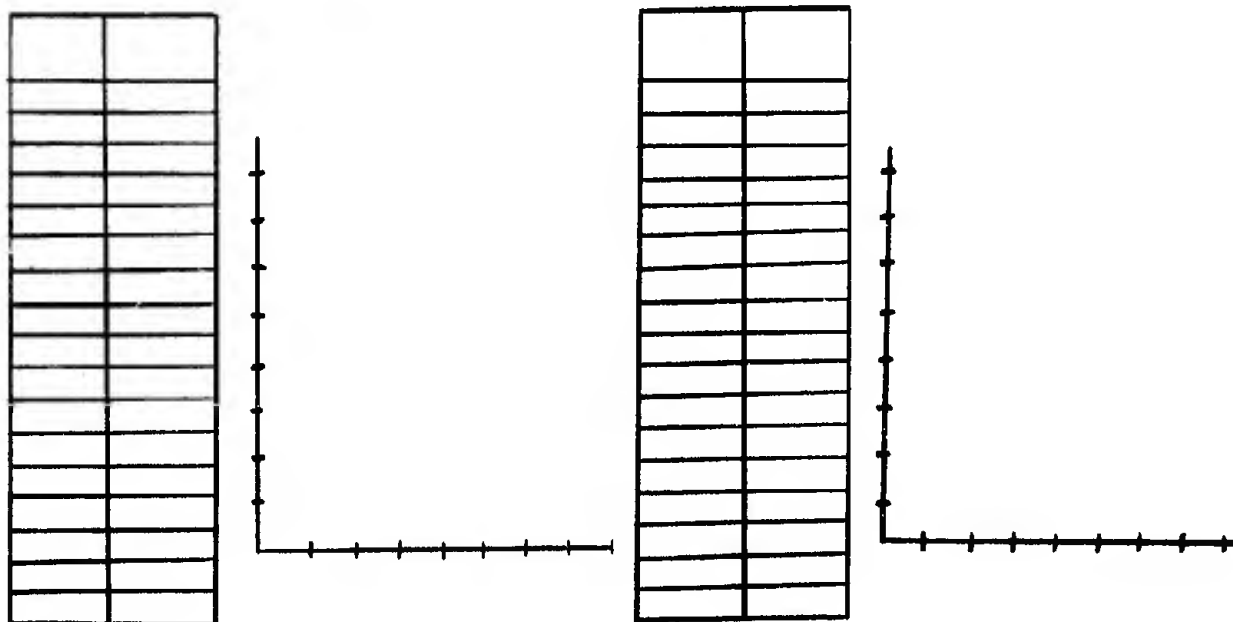


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
21	Scandium	-40	39.990250	500		0.22 s	B ⁺ 9.0; γ 3.75, 3.348	2, 9, 6
		-41	40.981630	70		0.87 s	B ⁺ 4.94	2, 9
		-42				0.68 s	B ⁺ 4.8	9
		-43	42.974730	80		3.9 h	B ⁺ 1.2, 0.8, 0.4; γ 0.25 γ 0.371, 0.627, 0.8, 1.2	2, 6, 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 ⁺ 3.6, 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	50		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

[illegible][illegible]

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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

		<u>REMARKS</u>		²⁴ Cr
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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

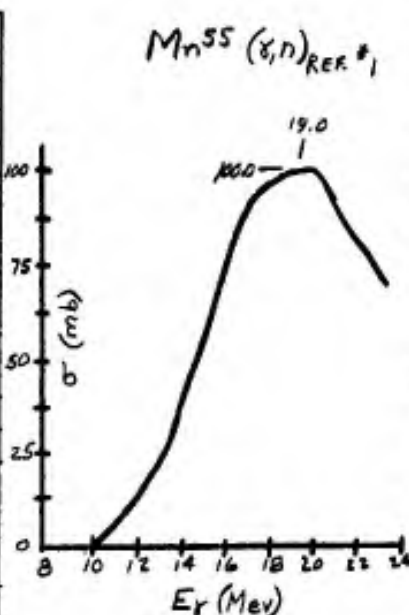
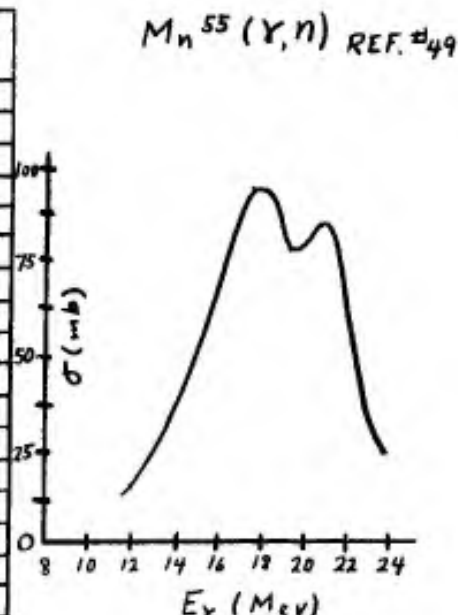


${}_{25}\text{Mn}$

25 Mr.

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
25	Manganese	49				0.4 s	F	9
		-50	49.970000	500		0.3 s	B+76.3	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		2×10^6 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

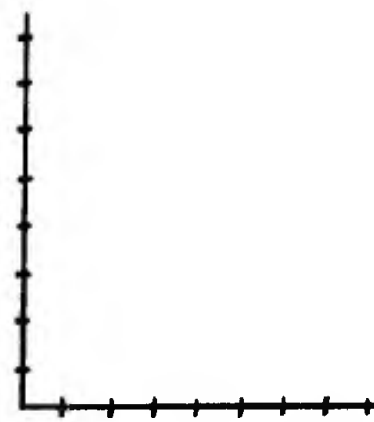
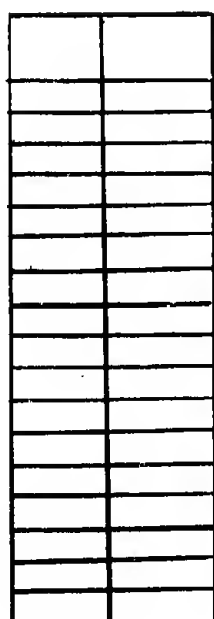
E Mev	σ_{mb}
10	1.0
11	6.0
12	13.0
13	22.0
14	39.0
15	62.0
16	84.0
17	90.0
18	95.0
19	100.0
20	98.0
21	90.0
22	88.0
23	77.0
24	66.0

[illegible]

^{25}Mn

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Mn^{55}	- 10.120		6
(γ, p)	Mn^{55}	- 8.058		6

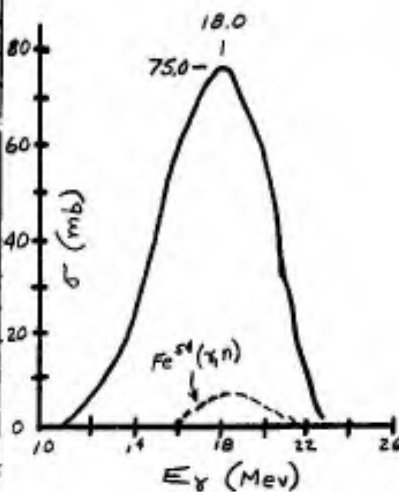


26Fc

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
26	Iron	-52	51.964210	150		8.3 h	B+0.8; τ 0.163	2, 9
		-53	52.962250	200		8.9 m	B+2.5; τ 0.370	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; τ 0.191, 0.337, 1.102, 1.290	2, 9
		-60				$\sim 3 \times 10^5$ y	B ⁻	9
		-61				5.5 m	B ⁻ ; τ 0.29	9

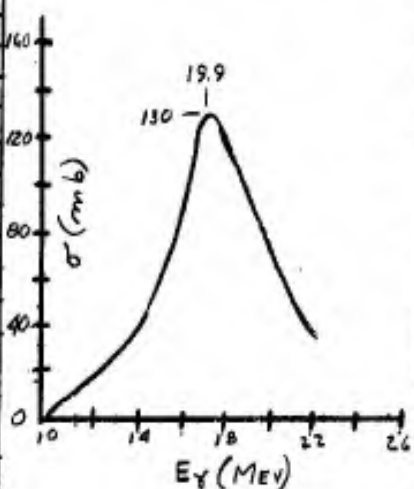
E Mev	σ_{mb}
11	0
12	5.0
13	13.0
14	25.0
15	39.0
16	57.0
17	68.0
18	75.0
19	68.0
20	57.0
21	35.0
22	13.0
23	~3.0
24	~0

Fe (r,n) NAT. ABUN.
REF. 21

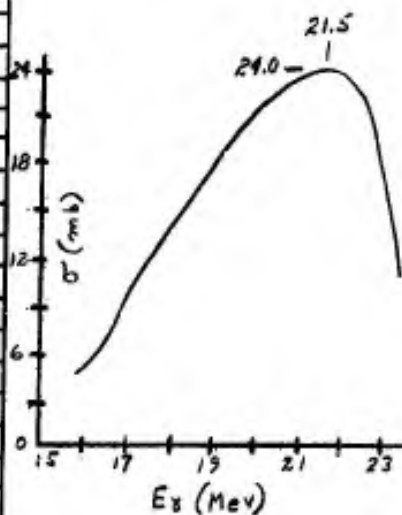
[illegible]

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 ⁺ ; 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

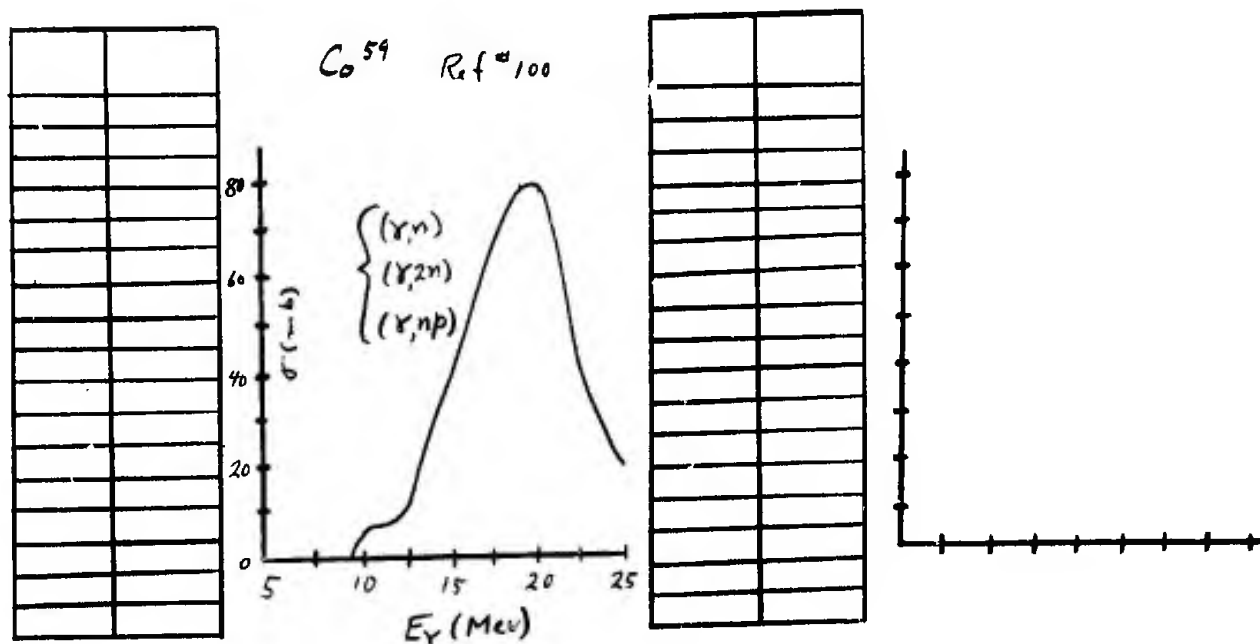
E Mev	σ_{mb}
15	
16	5.5
17	9.0
18	13.0
19	17.0
20	21.0
21	23.0
22	24.0
23	20.0

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

$^{27}_{27}\text{Co}$

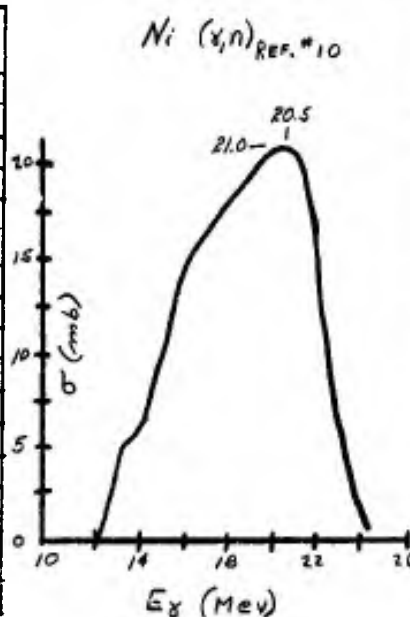
REMARKS

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

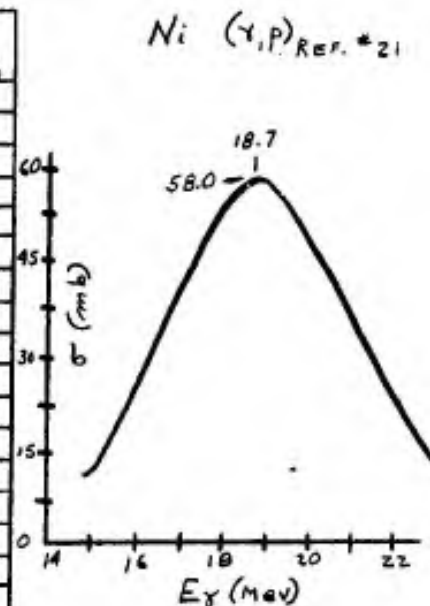


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
28	Nickel	-56				6.4 d	EC ; γ 0.16, 0.28, 0.48, 0.79, 0.96, 1.33, 1.58, 1.75	9, 6
		-57	56.957460	330		31.1 h #10 36 h #9	B $\pm$ 0.8, 0.7, 0.4; γ 0.125, 1.38, 1.90	2, 9, 10
		-58	57.953770	250	67.76			2, 9
		-59	58.953093	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	B $\pm$ 0.067	2, 9
		-64	63.948130	200	1.16			2, 9
		-65	64.950650	200		2.6 h	B $\pm$ 2.1, 1.0, 0.6; γ 0.37, 1.12, 1.49	2, 9

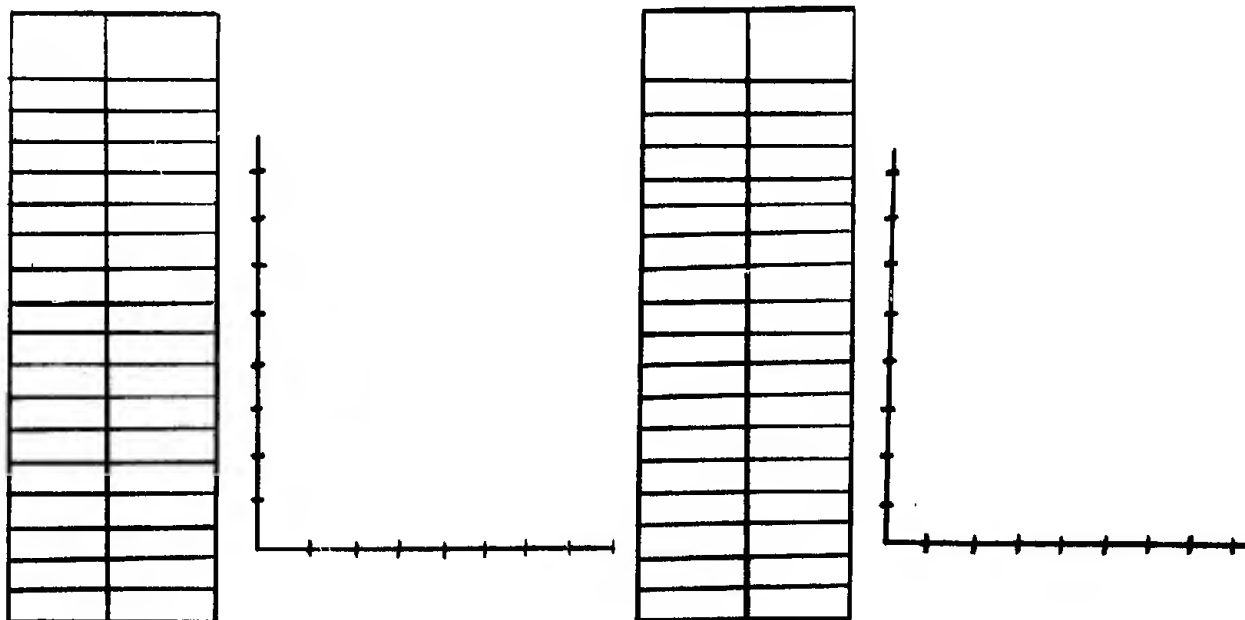
E Mev	σ_{mb}
12	0
13	5.0
14	7.0
15	10.5
16	14.0
17	16.0
18	17.8
19	20.0
20	20.4
21	20.4
22	13.0
23	7.0
24	2.0



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



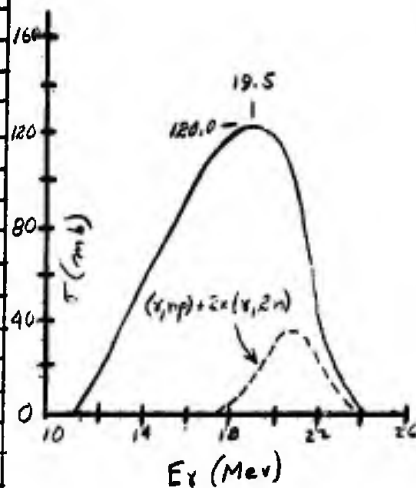
		<u>REMARKS</u>		²⁸ Ni
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ,n)	Ni ⁵⁸	-11.924		6
	Ni ⁶⁰	-11.389		6
	Ni ⁶²	-10.590		6
(γ,p)	Ni ⁵⁸	- 7.907		6
	Ni ⁶⁰	- 9.530		6
	Ni ⁶²	-11.097		6



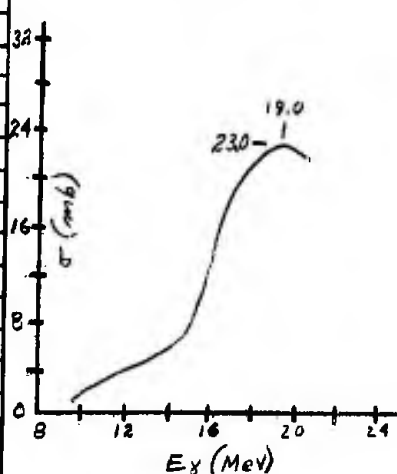
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
29	Copper	-57				0.18s		9
		-58	57.964000	900		3.0 s	B+ 77.5	9
						9.5 m	B+	2, 9
		-59				81 s	B+3.7; γ 0.34, 0.42, 0.463, 0.872, 1.30, 1.69, 2.07	9, 6
		-60	59.956580	250		23.4 m	B+2.0, 3.0, 4.0; γ 0.85, 1.33, 1.76, 2.13, 2.64, 3.13, 3.52, 4.0	9, 6
		-61	60.952084	250		3.3 h	B+1.2, 0.9, 0.6; γ 0.072, 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; γ 0.67, 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; γ 1.35	9, 6
		-65	64.948100	200	30.9			9
		-66	65.949760	200		5.1 m	B-2.6, 1.5; γ 0.83, 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	1.6, 0
23	18.0
24	1.0

Cu (γ, 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

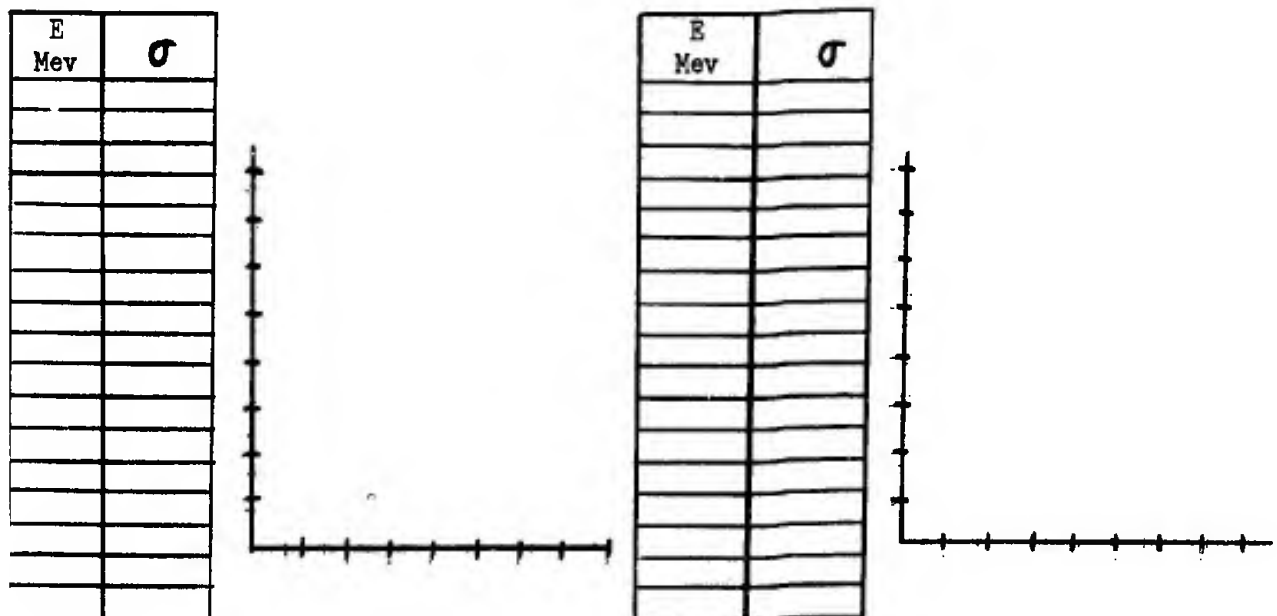
Cu (γ, p) REF. #50

^{29}Cu

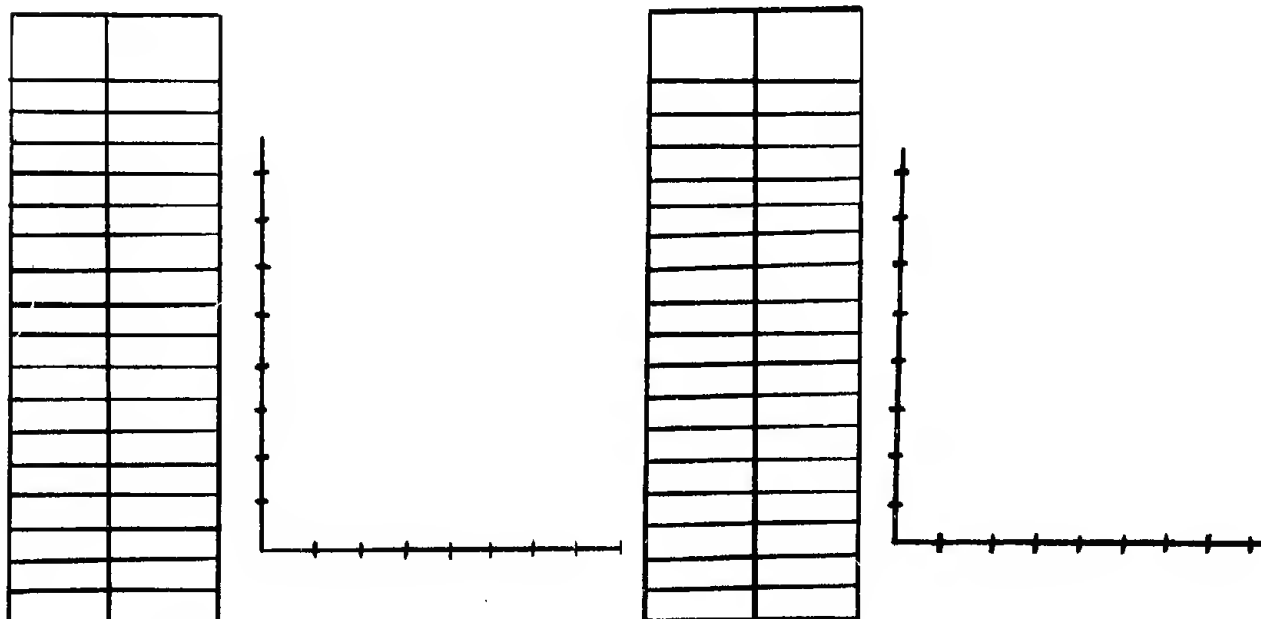
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
29	Copper	-68				32 s	B ⁻ ~3.0; γ	9

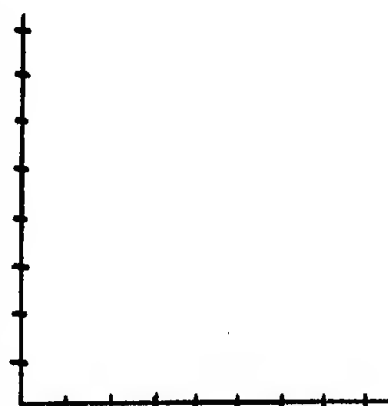
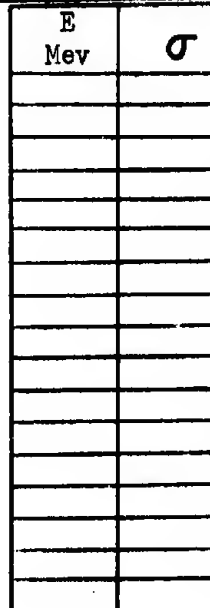
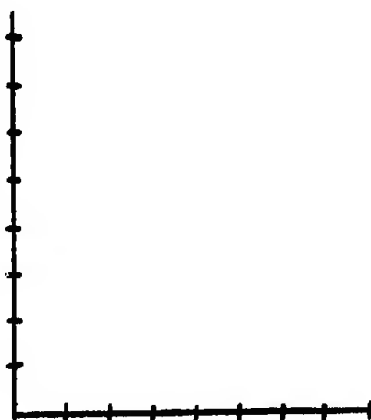
REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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



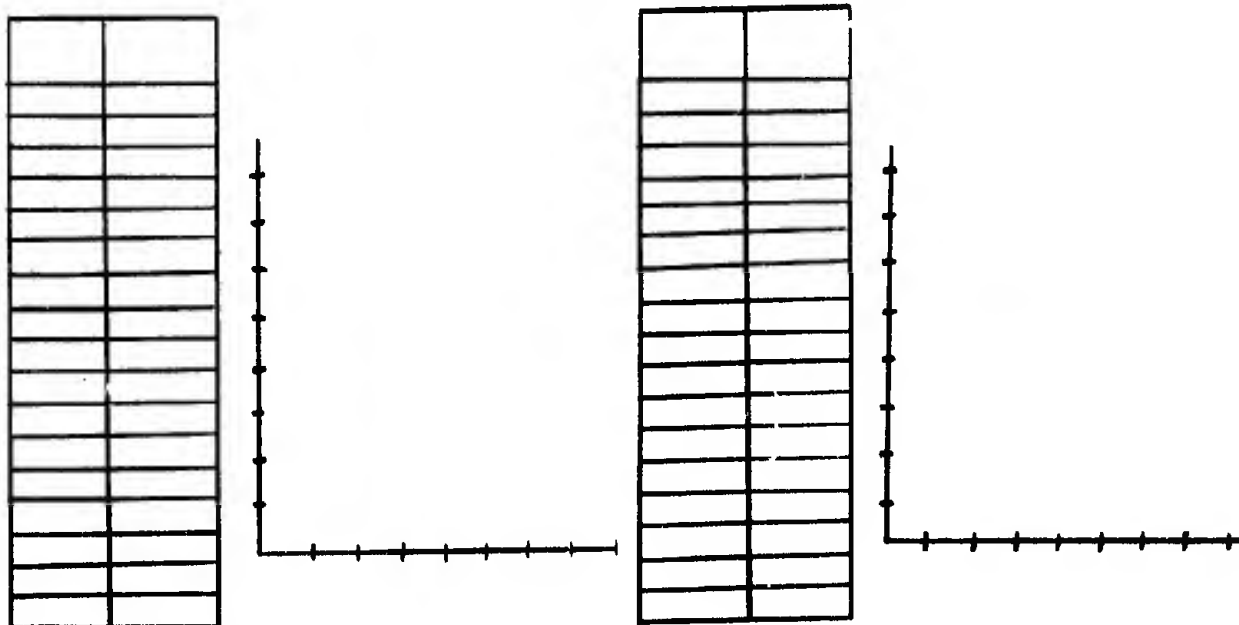
		<u>REMARKS</u>		³⁰ Zn
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ,n)	Zn ⁶⁴	-11.856		6
	Zn ⁶⁶	-11.039		6
	Zn ⁶⁸	-10.199		6
(γ,p)	Zn ⁶⁴	- 7.7067		6
	Zn ⁶⁶	- 8.708		6
	Zn ⁶⁸	- 9.988		6



^{31}Ga [illegible]

^{31}Ga

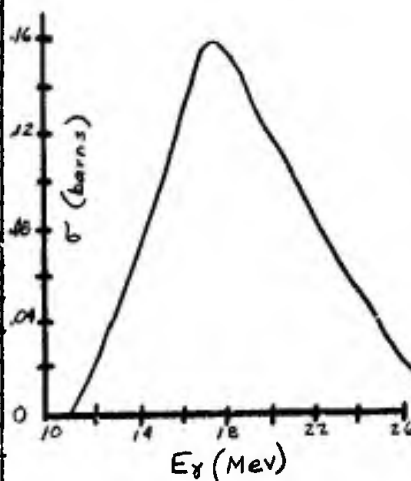
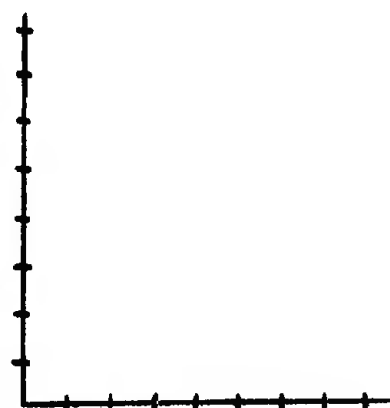
<u>Thresholds</u>	<u>Isotope</u>	<u>REMARKS</u>		<u>Reference</u>
		<u>Theoretical</u>	<u>Experimental</u>	
(Y,n)	Ga^{69}	-10.128		6
	Ga^{71}	-9.195		6
(Y,p)	Ga^{69}	-6.528		6
	Ga^{71}	-7.760		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
32	Germanium-66					150 m	β^+ ; 0.045, 0.070 0.114, 0.186	2, 9
	-67	66.954330	400			21 m	β^+ 2.9; 0.170, 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; 1.61, 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
	Ge ^{75m} Ref 6&9 -75	74.946620	100			82 m	β^- 1.14, 0.6; 0.066 0.199, 0.2645, 0.918 0.427, 0.477, 0.572 0.628	2, 9, 6
	-76	75.945330	150	7.67				2, 9
	-77	76.948020	140			11.3 h	β^- 2.2, 1.4, 0.7; 0.042, 0.073, 0.213 0.264, 0.368, 0.418 0.564, 1.105, 1.75	2, 9, 5
	Ge ^{77m} Ref 2							
	-78					86 m	$\beta^- \sim 0.9$	9

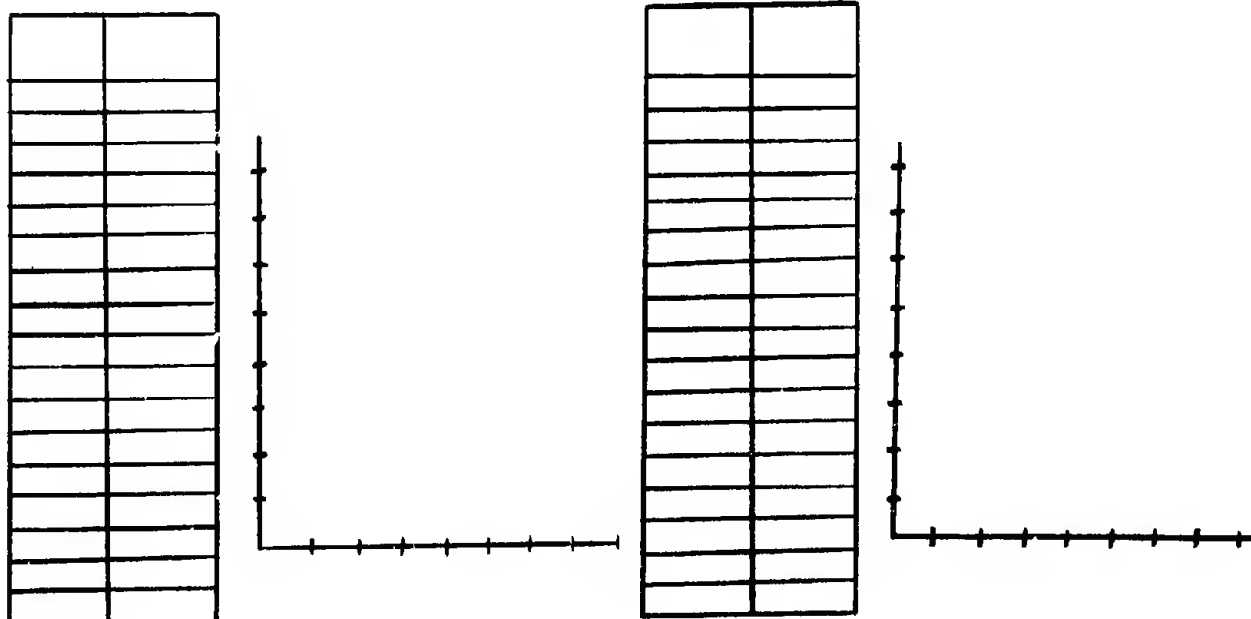
[illegible]

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

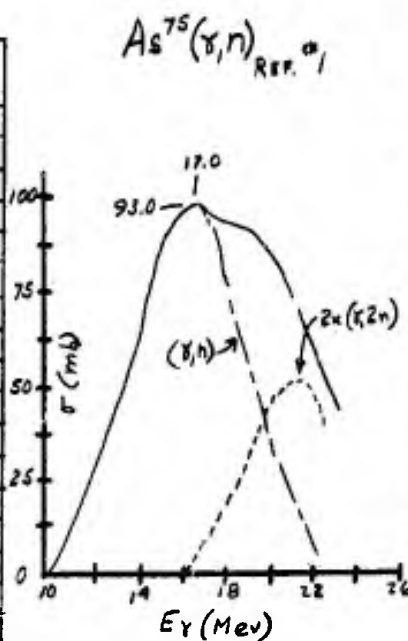
[illegible]

32Ge

<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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			



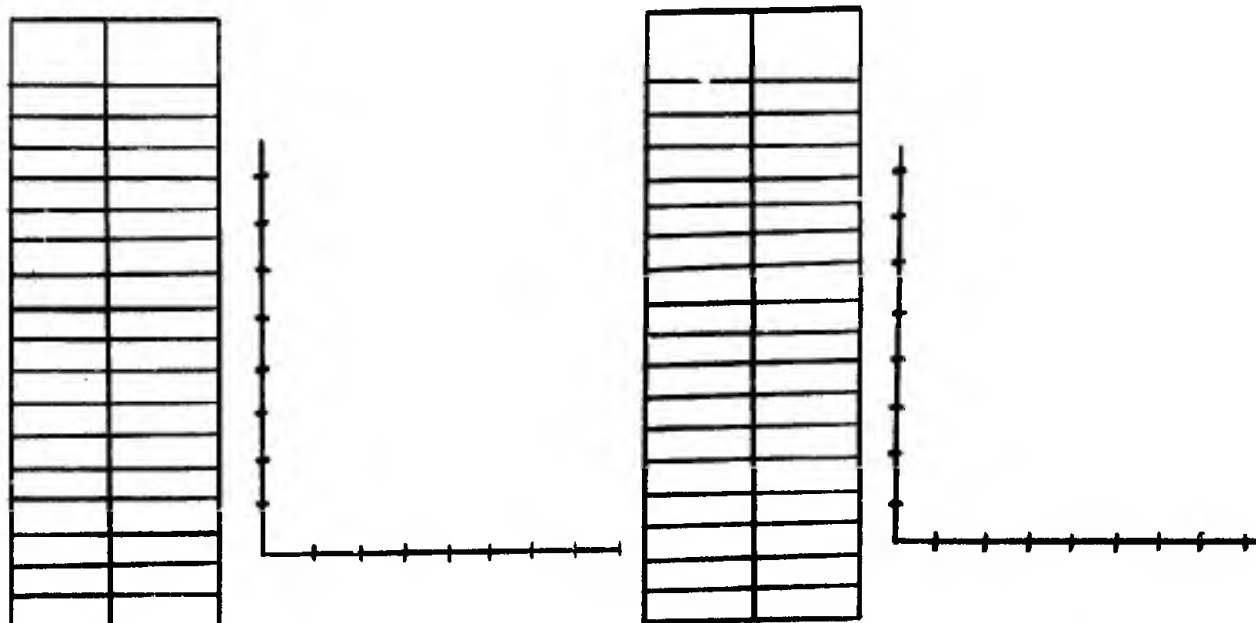
E Mev	σ_{mb}
10	0
11	12.0
12	29.0
13	45.0
14	68.0
15	88.0
16	92.0
17	93.0
18	88.0
19	86.0
20	81.0
21	69.0
22	52.0
23	39.0

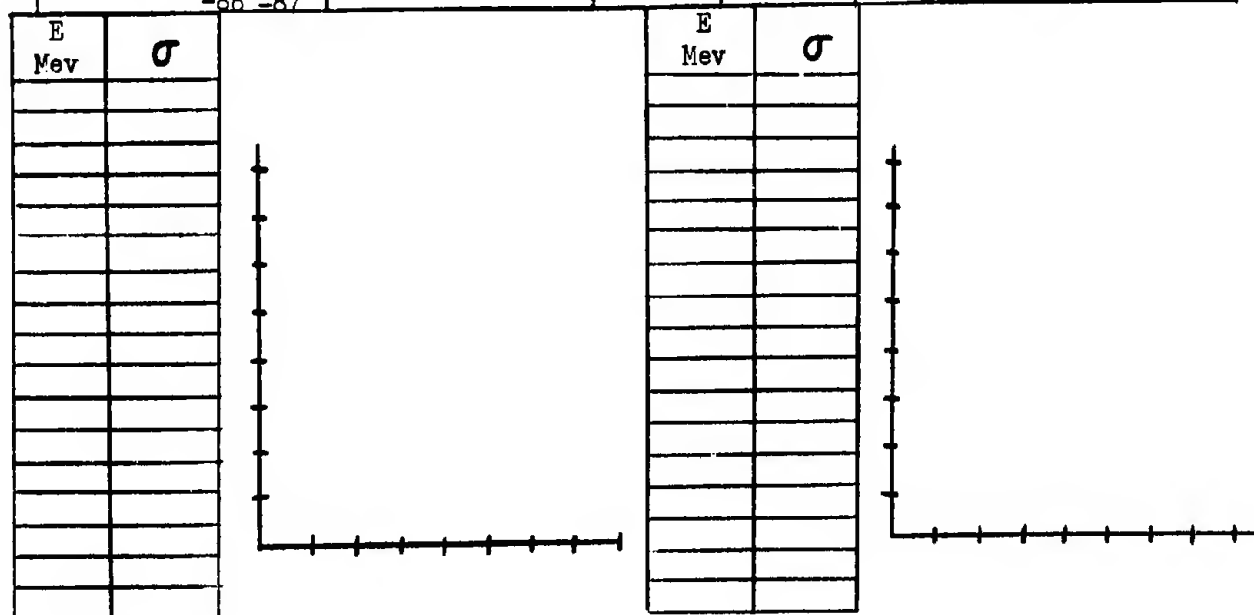
[illegible]

$^{33}_{As}$

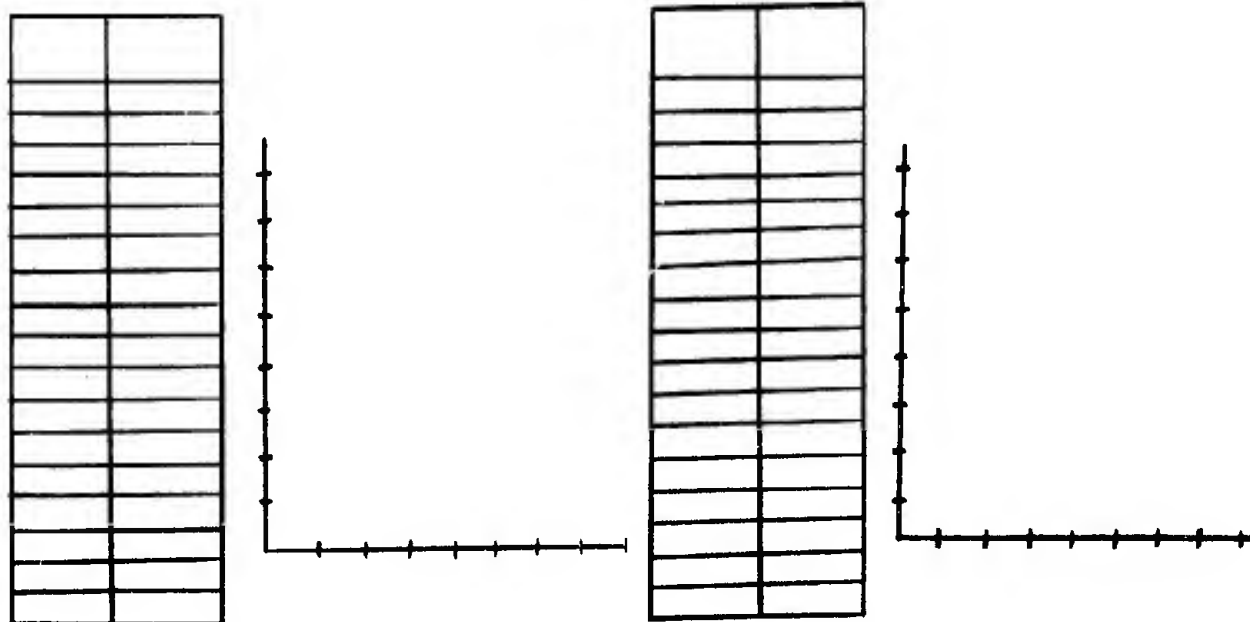
REMARKS

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



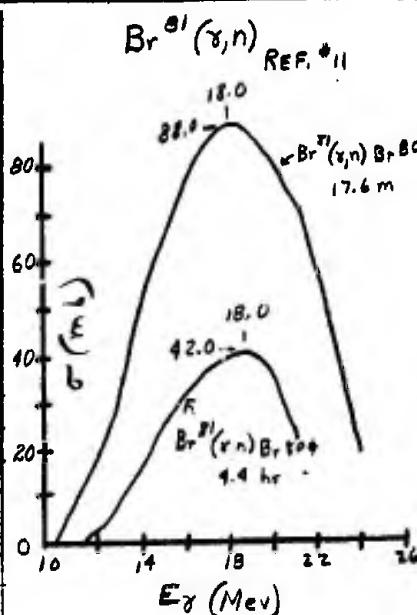


		<u>REMARKS</u>		³⁴ Se
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Se ⁷⁶	-11.126		6
	Se ⁷⁷	- 7.415		6
	Se ⁷⁸	-10.480		6
	Se ⁸⁰	- 9.942		6
	Se ⁸²	- 9.190		6
(γ, p)	Se ⁷⁶	- 9.477		6
	Se ⁷⁷	- 9.602		6
	Se ⁷⁸	-10.381		6
	Se ⁸⁰	-11.460		6
	Se ⁸²			

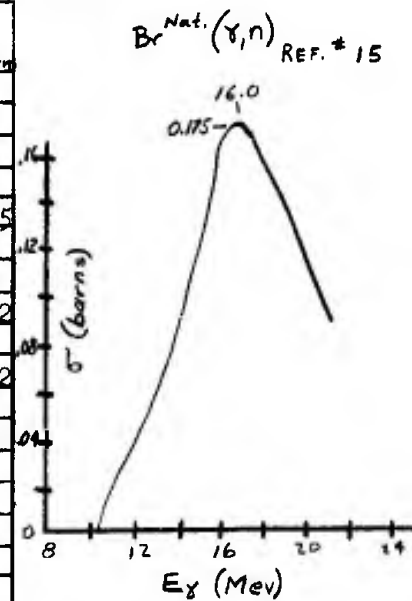


Z	CHEM. SYM.	A	ATOMIC MASS AMU	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
35	Bromine	-74			36 m	B ⁺ ; 0.64	9
		-75	74.949260	100	1.6 h	B ⁺ 1.7, 0.8, 0.6, 0.3; 0.29	2, 9
		-76	75.948270	130	17.2 h	B ⁺ 3.57, 1.7, 1.1, 0.8, 0.6; 0.25, 0.33, 0.37, 0.42, 0.56, 0.67, 0.75, 0.96, 1.20	2, 9, 6
		-77	76.945818	100	57 h	EC; B ⁺ 0.34; 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; 0.62	2, 9
		-81	80.942080	200	49.48		2, 9
		-82	81.942680	210	36 h	B ⁺ 0.44; 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; 0.048	2, 9, 6
		-84	83.943085	200	31.8 m	B ⁺ 4.68, 3.56, 2.53, 1.72; 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; 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



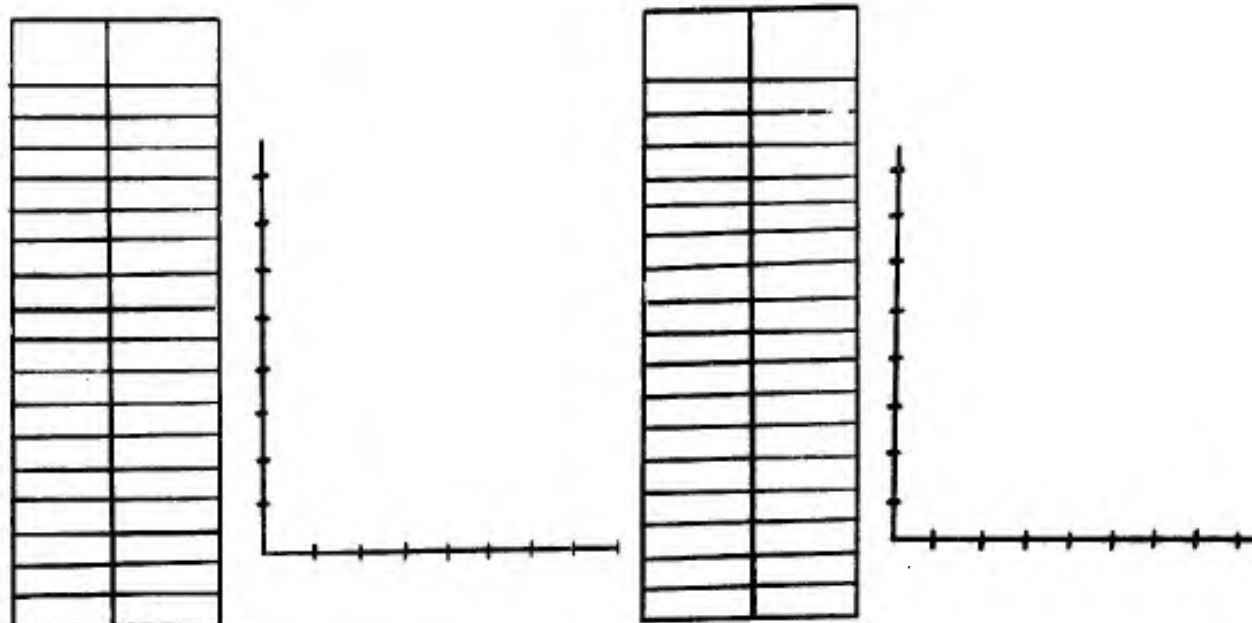
E Mev	σ_{barn}
10	0
11	0.02
12	0.04
13	0.06
14	0.095
15	0.13
16	0.17
17	0.162
18	0.15
19	0.132
20	0.11
21	0.09

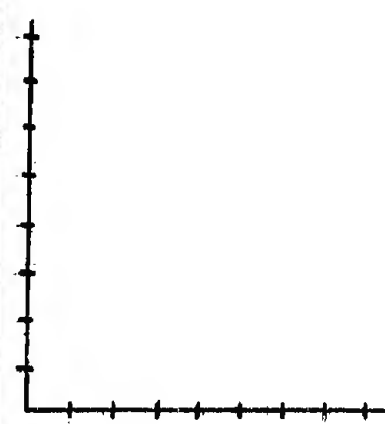


^{35}Br

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Br^{79}	- 10.600		6
	Br^{81}	- 10.117		6
(γ, p)	Br^{79}	- 6.357		6
	Br^{81}	- 7.445		6



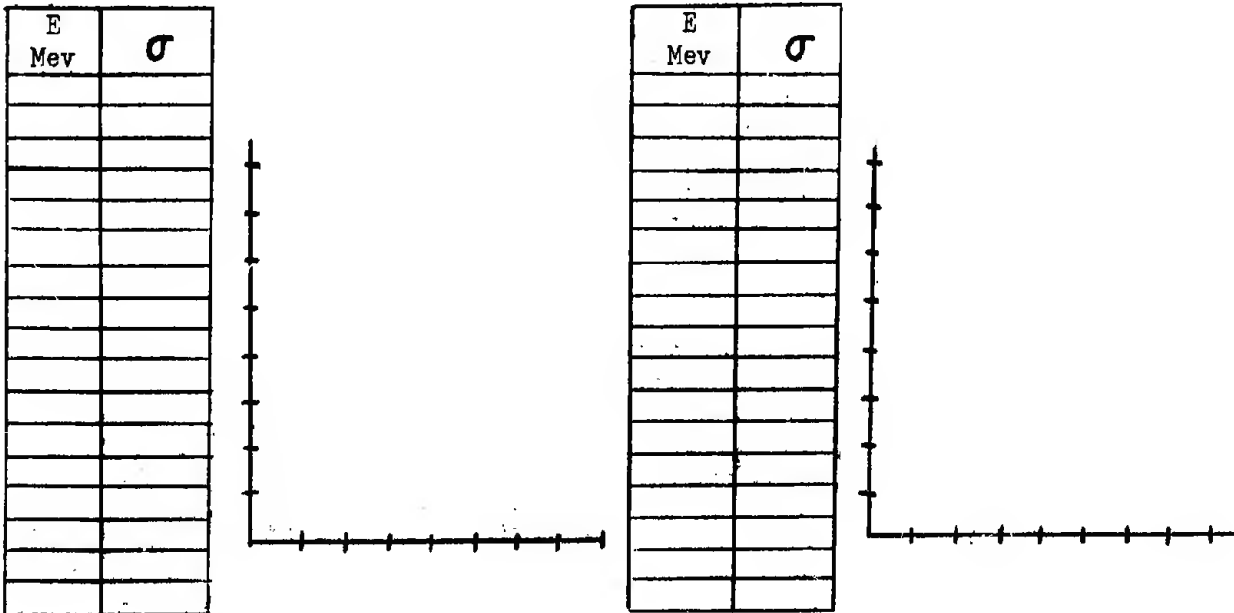
[illegible][illegible]

36

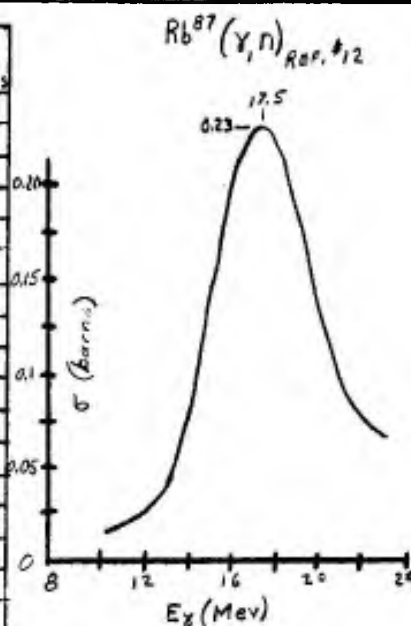
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (u)	REF.
36	Krypton	-95				Short	B-	9
		-97				~1 s	B-	9

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,n)	Kr ⁸⁴	- 10.518		6
	Kr ⁸⁶	- 9.760		6
(Y,p)	Kr ⁸⁴	- 10.735		6
	Kr ⁸⁶	- 11.780		6
(Y,α)	Kr ⁸⁴	- 7.090		6



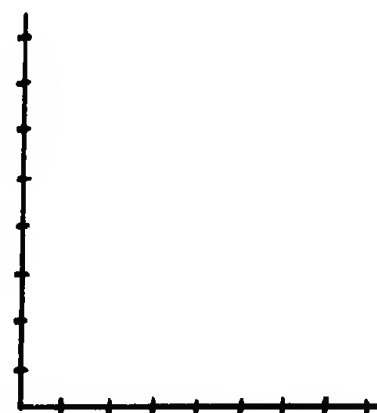
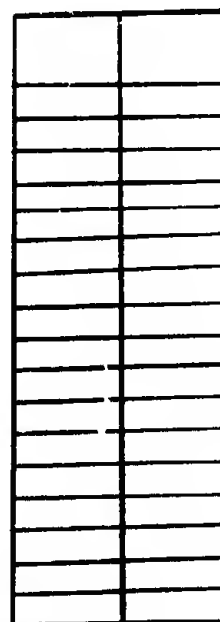
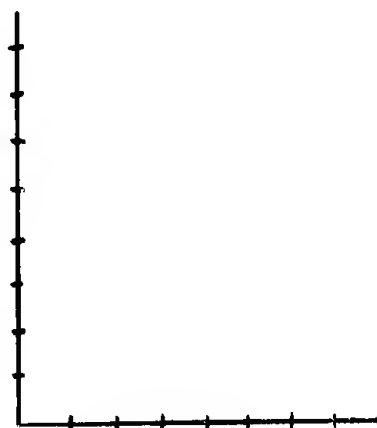
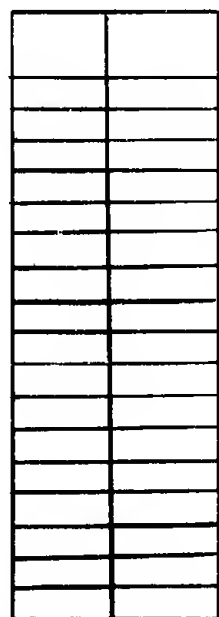
E Mev	σ_{burns}
10	
11	0.02
12	0.025
13	0.04
14	0.07
15	0.125
16	0.13
17	0.225
18	0.225
19	0.19
20	0.14
21	0.10
22	0.08
23	0.07

[illegible]

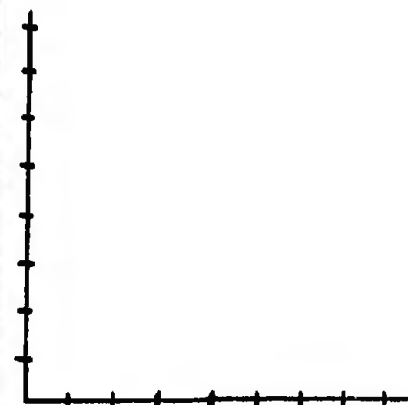
37Rb

REMARKS

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

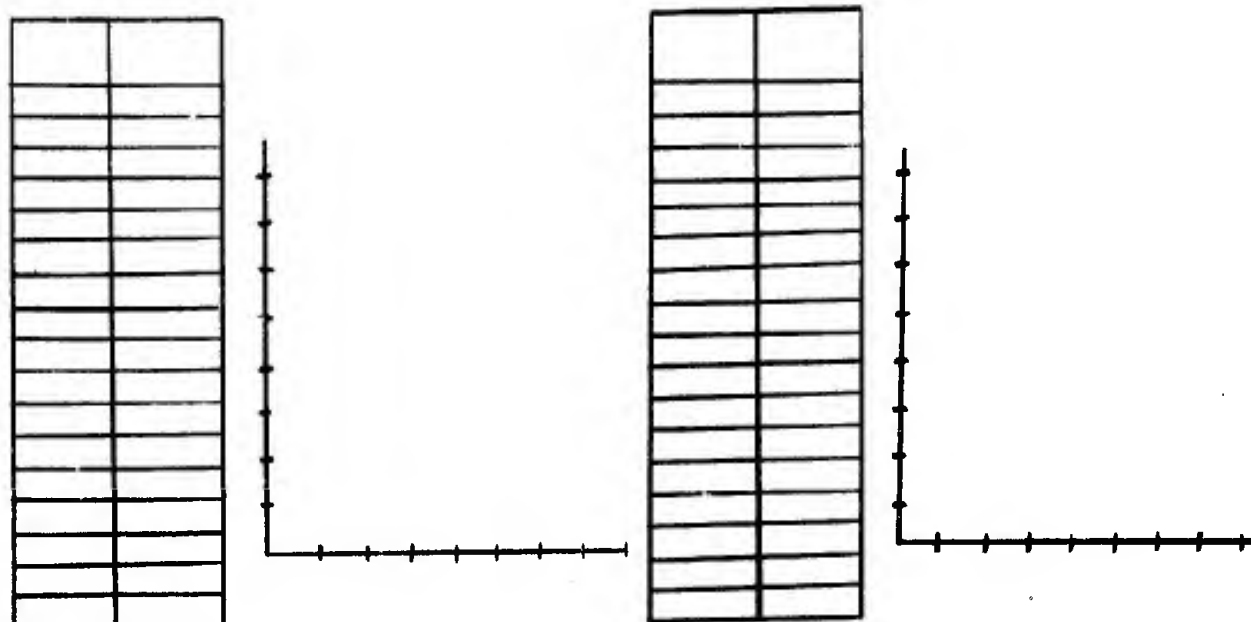


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
38	Strontium-81					29 m	EC; B ⁺	9
	-82					25.5 d	EC; 0.95, .4, .15	9
	-83					33 h	EC; B ⁺ 1.15; 0.040, 0.074, 0.101, 0.151, 0.165	9, 6
	-84	83.939860	250	0.56				2, 9
85 ^m Ref. #9	-85	84.940000	500			64.0 d	EC; 0.5133	2, 9, 6
	-86	85.936620	200	9.86				2, 9
87 ^m Ref. 90, 39	-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; 0.551, 0.645, 0.748, 0.93, 1.025, 1.913	2, 9, 6
	-92	91.939650	240			2.6 h	B ⁻ 0.55; 0.23, 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

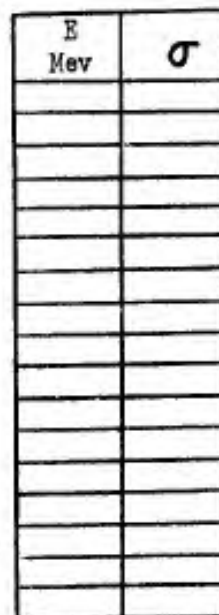
[illegible][illegible]

<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,n)	Sr ⁸⁶	-11.460	-11.5	6, 39
	Sr ⁸⁷	- 8.418		6
	Sr ⁸⁸	-11.124		6
(Y,p)	Sr ⁸⁶	- 9.570		6
	Sr ⁸⁷	- 9.408		6
	Sr ⁸⁸	-10.614		6

³⁸Sr

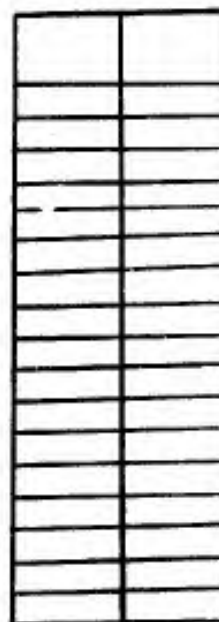
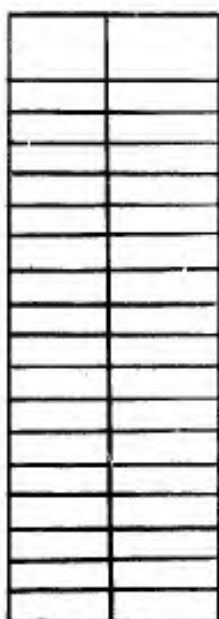


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
39	Yttrium	-82				70 m		9
		-83				3.5 h		9
		-84				3.7 h	B ⁺ 2.0	9
		-85				5 h		9
		-86	85.941130	230		14.6 h	B ⁺ 1.8, 1.19; α 0.18 0.635, 1.08, 1.93	2, 9, 6
87 ^m Ref. 960.384		-87	86.938390	270		80 h	EC; B ⁺ 0.7; α 0.388, 0.484	2, 9, 6
		-88	87.937770	200		104 d	EC; B ⁺ 0.58; α 0.9082, 1.87, 2.76	2, 9
89 ^m Ref. 960.914		-89	88.934080	200	100			2, 9
		-90	89.935200	200		64.2 h	B ⁺ 2.26; α 1.739	2, 9
91 ^m Ref. 960.551		-91	90.935805	200		57.5 d	B ⁺ 1.537; α 1.21	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; α 0.7	2, 9
		-94	93.941600	480		16.5 m	B ⁺ 5.4; α 1.4	9
		-95				10.5 m	B ⁻	
		-97				Short	B ⁻	9



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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
89 ^m Ref. 9	-89	88.937131	200			79.3 h	IT; EC; B ⁺ ; γ	2, 9
0.588, 1.53								
90 ^m Ref. 9	-90	89.932840	200	51.46				2, 9
	-91	90.934140	200	11.23				2, 9
	-92	91.833820	210	17.31				2, 9
	-93	92.935327	240			1.1x10 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

<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,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
(Y,p)	Zr ⁹⁰	- 8.324		6
	Zr ⁹¹	- 8.680		6
	Zr ⁹²	- 9.450		6
	Zr ⁹⁴	-10.130		6

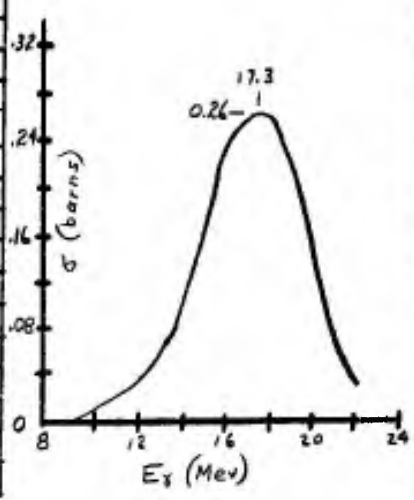


41 Nb

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+; 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; 0.90, 0.931, 1.835	2, 9, 6
		-93	92.935260	240	100			2, 9
		-94	93.936520	250		1.8x10 ⁴ y	B-0.50; 0.71, 0.89, 1.61	2, 9, 6
		-95	94.936700	400		35 d	B-0.158; 0.768	2, 9
		-96	95.938261	430		23.35 h	B-0.750, 0.37; 0.453, 0.55, 0.76, 1.06	2, 9, 6
		-97	96.938550	500		72.1 m	B-1.27; 0.665, 1.02	2, 9, 6
		-98				26.0 m	B-	9
		-99				3.8 m	B-3.2	9

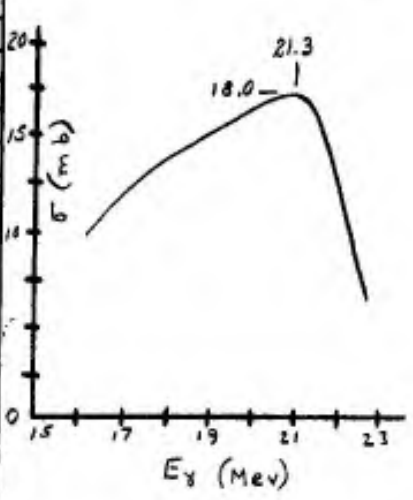
E Mev	σ_{barns}
8	0
9	0+
10	0.01
11	0.03
12	0.04
13	0.07
14	0.12
15	0.17
16	0.24
17	0.255
18	0.25
19	0.22
20	0.15
21	0.08
22	0.03

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



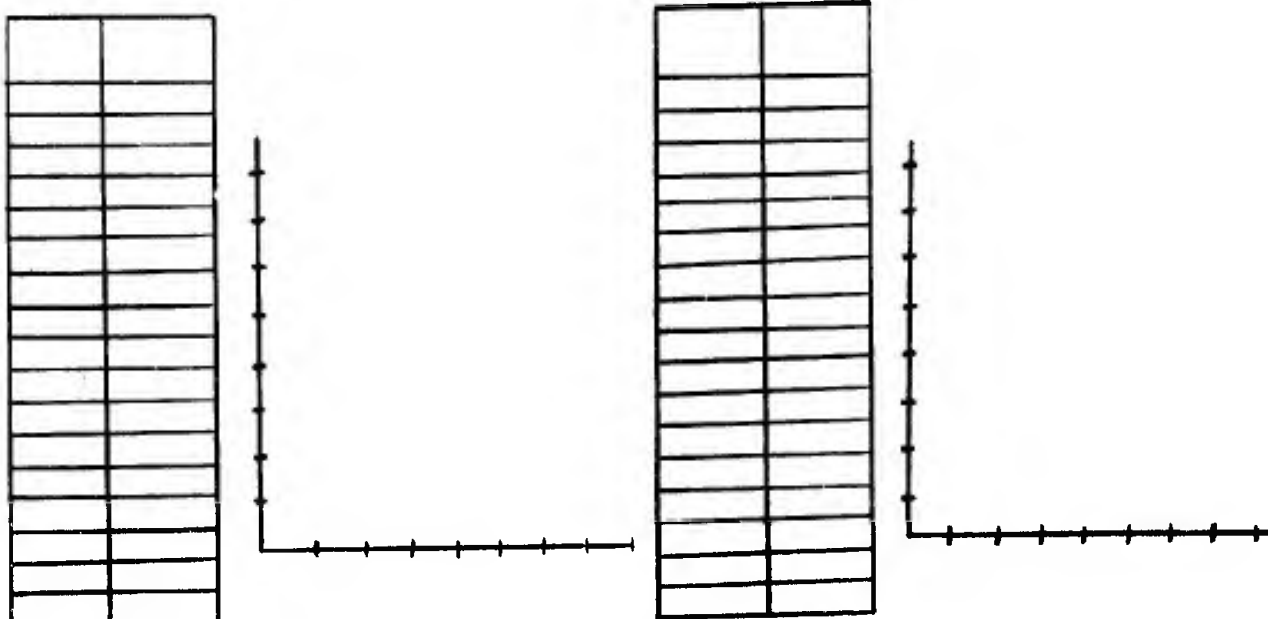
E Mev	σ_{mb}
14	
15	
16	9.5
17	12.0
18	13.5
19	15.0
20	17.0
21	18.0
22	13.0

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



⁴¹Nb

<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Nb ⁹³	- 8.818	- 8.86	6, 22
(γ, p)	Nb ⁹³	- 5.962		6

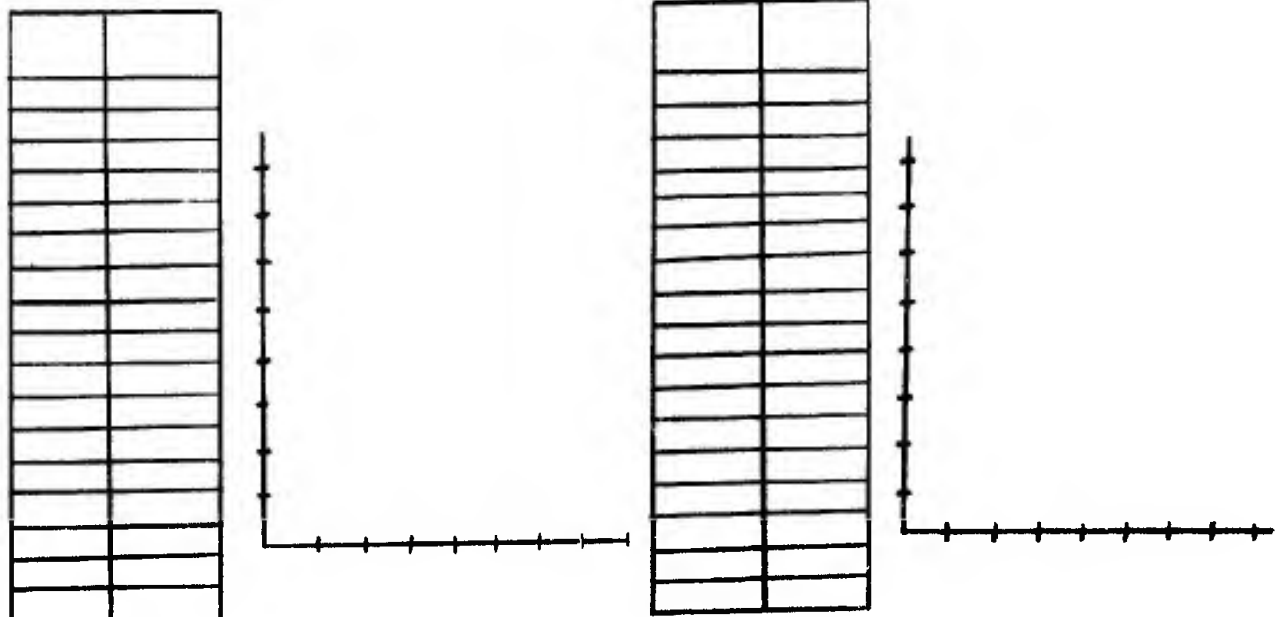


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
42	Molybdenum	-90	89.940600	280		5.7 h	B+1.2; EC; γ 0.12, 0.25	2,9,6
		-91	90.939490	340		15.5 m	B+3.44	2,9
		-92	91.935210	290	15.86			2,9
		-93	92.935730	290		> 2 y	EC;	2,9
		-94	93.934330	270	9.12			2,9
		-95	94.935700	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; γ 0.140, 0.181, 0.739	2,9,6
		-100	99.938280	500	9.62			2,9
		-101				14.6 m	B-2.23; γ 0.191, 0.960	9,6
		-102				11.5 m	B-	9
		-103				< 2 m	B-	9

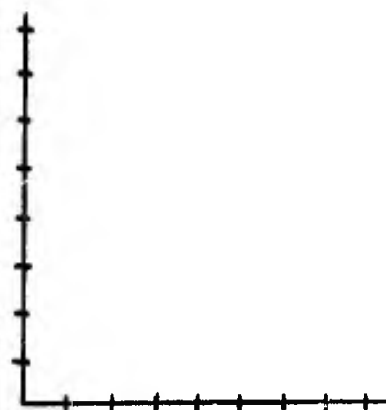
[illegible]

42^{Mo}

<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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
	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
	Mo ⁹⁸	- 9.440		6



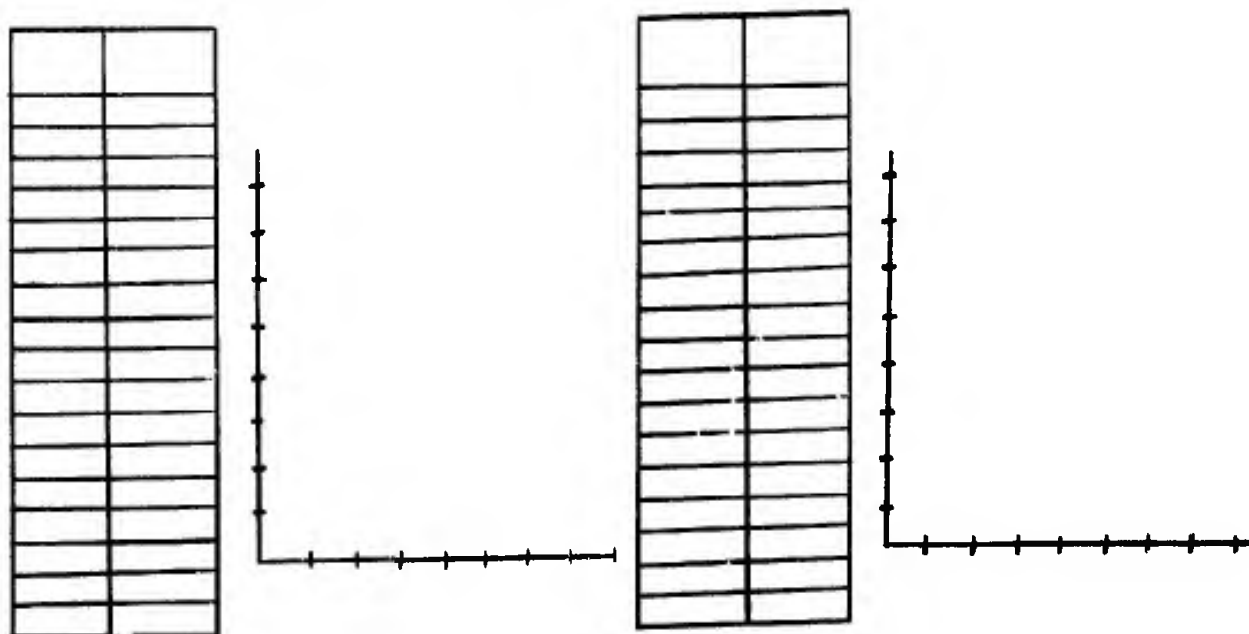
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
43	Technetium	-92	91.942080	750		4.3 m	B+4.1; γ 1.3	2, 9
		-93	92.939100	290		2.75 h	B+0.8; γ 1.35, 1.5, 2.0	2, 9
		-94	93.938980	400		53 m	B+2.41; γ	2, 9
		-95	94.937451	400		20.0 h	B+0.762, 0.932, 1.071	2, 9
		-96	95.938230	60		4.20 d	B+0.312, 0.770, 0.809, 0.841, 1.118, 1.65, 1.89, 2.39	2, 9, 6
		-97				2.6x10 ⁶ y		2, 9
		-98				1.5x10 ⁶ y	B-0.30; γ 0.655, 0.745	2, 9, 6
		-99	98.938515	900		2.12x10 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				4.5 m	B-	2, 9

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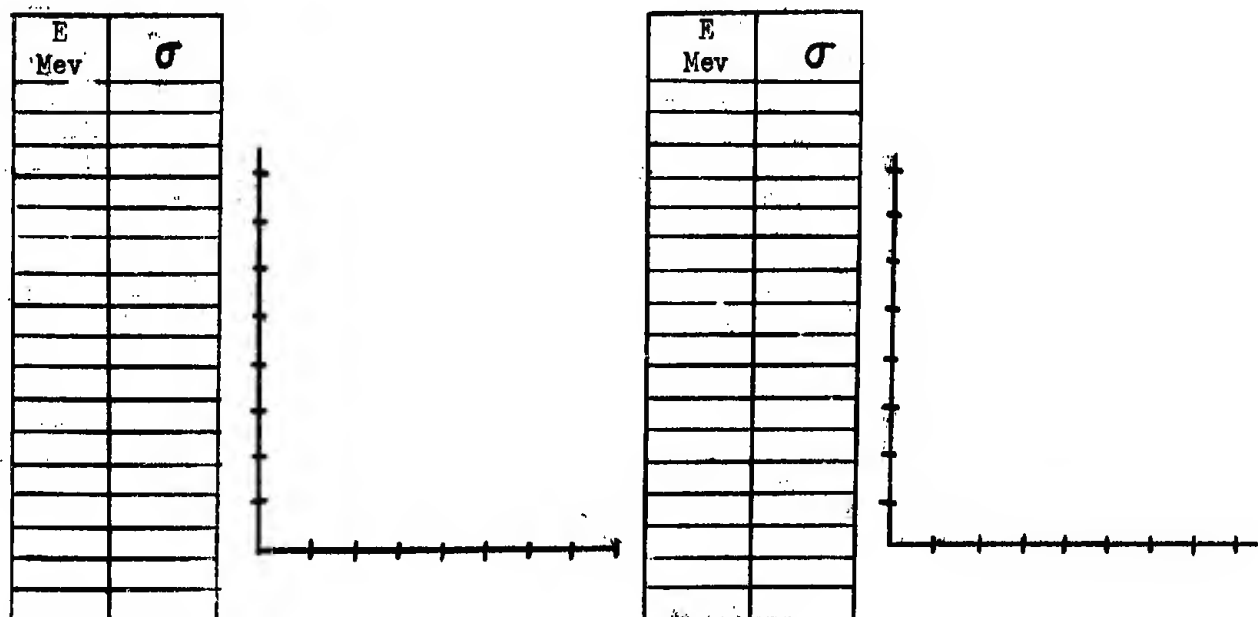
$^{93}_{43}\text{Tc}$

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y, n)	Tc^{98}			
	Tc^{99}	- 8.900		6
(Y, p)	Tc^{98}	- 5.800		6
	Tc^{99}	- 6.500		6



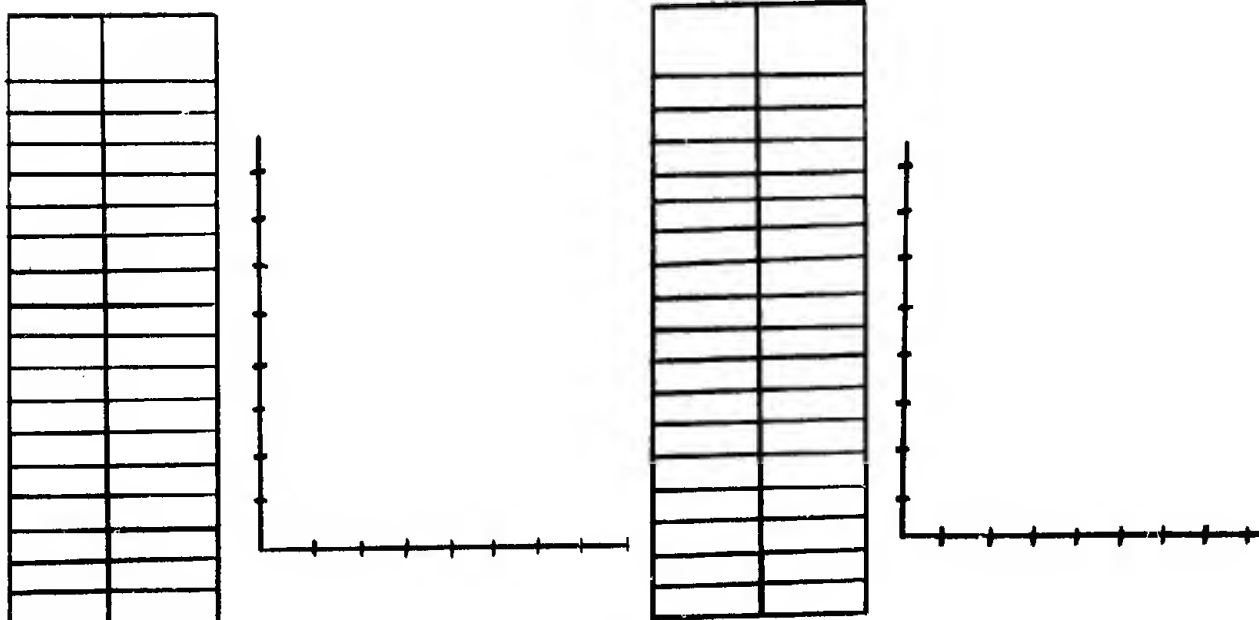
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
44	Ruthenium-93							
	-94					~57 m	EC	2
	-95	94.939700	450			1.65 h	EC; B+1.1; γ 0.145, 0.340, 0.640, 1.053	2, 6
	-96	95.937920	500		5.57			2, 9
	-97					2.8 d	EC; γ 0.1091, 0.2180, 0.325, 0.567	2, 6
	-98	97.937130	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							



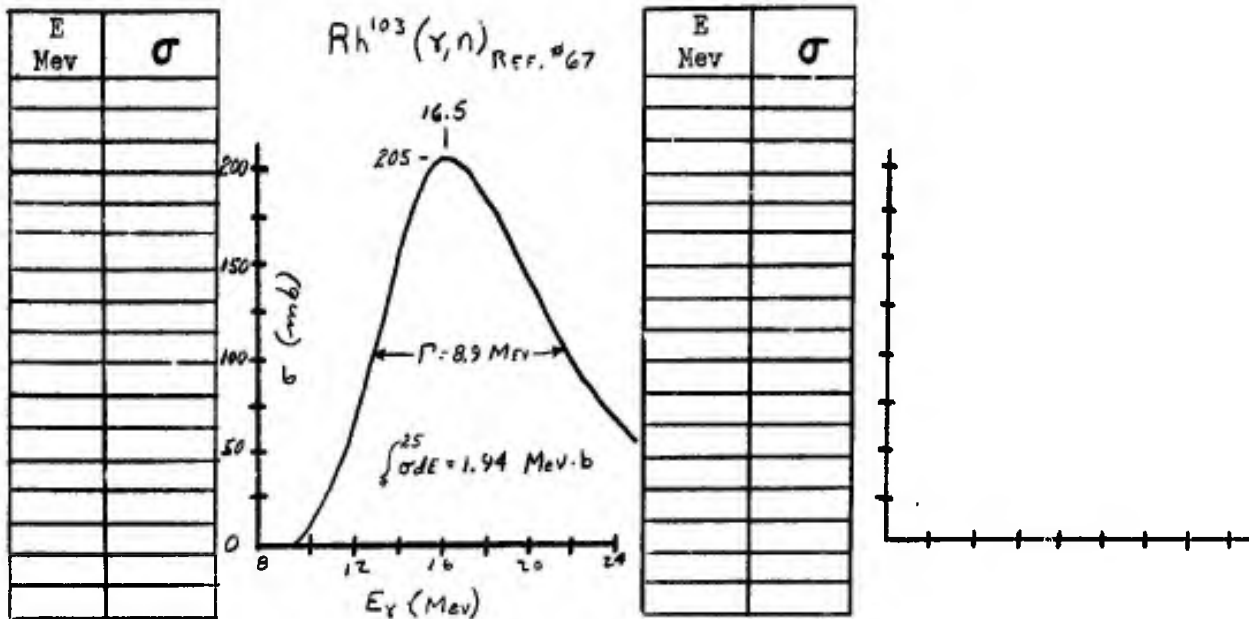
44 R_U

REMARKS

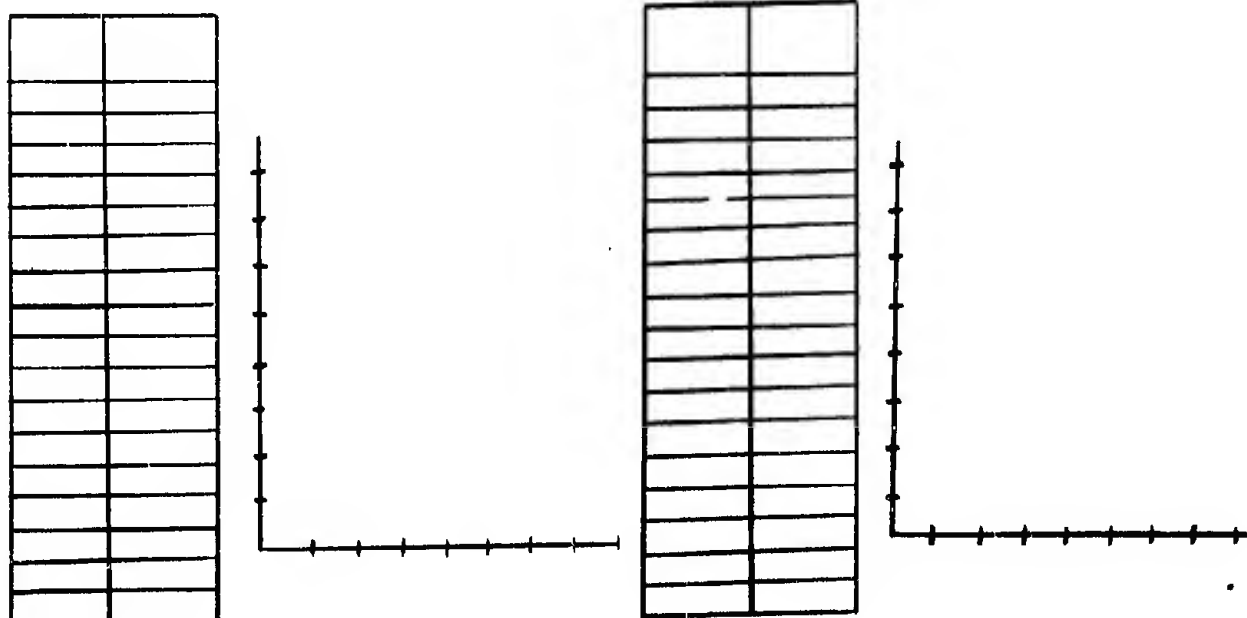
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ , n)	Ru^{96}	- 10,200		6
	Ru^{104}	- 8,150		6
(γ , p)	Ru^{96}	- 7,200		6



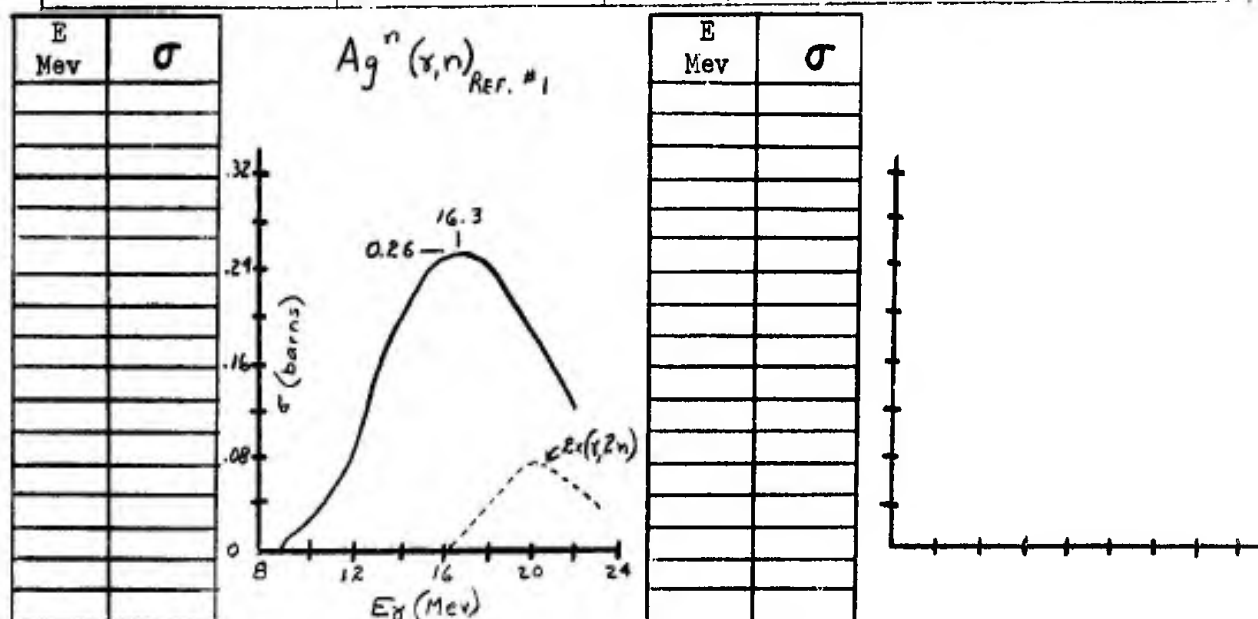
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF- LIFE	DECAY Type & Energy (Q)	REF.
45	Rhodium	-97						
		-98					β^- ; 80.650	2, 6
		-99				4.5 h	β^+ 0.74; EC; 80.286 0.34, 0.62, 0.89, 1.26, 1.41	2, 6
		-100				9.4 h	EC; β^+ 3.0; 81.2	2, 6
		-101				4.3 d	EC; 80.146; 0.30	2, 6
		-102	101.938750	500		210 d	β^- 1.0; β^+ 1.1; γ	2
		-103	102.937900	500	100			
		-104	103.939600	700		44 s	β^- 2.6; 80.555, 1.18	
		-105	104.938692	500		36.5 h	β^- 0.570, 0.25; 80.08 0.16, 0.22, 0.31, 0.316, 0.415, 0.550	2, 6
		-106	105.940190	500		30 s	β^- 3.53, 3.1, 2.44, 2.0; 80.513, 0.624	2
		-107	106.940240	410		26 m	β^- 1.2; 80.305, 0.388	6
		-108					β^- ; 80.43	6
		-109				41 h	β^-	



REMARKS				
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; 0.549, 0.764	9, 6
		-104	103.910870	510		1.2 h 27 m	B+ B+2.7; 0.1184, 0.5562	2, 9 2, 9, 6
		-105	104.940500	750		40 d	EC; 0.0625, 0.280, 0.343, 0.440	2, 9, 6
		-106	105.939590	500		8.2 d 24.0 m	EC; 0.220, 0.409, 0.511, 0.620, 0.717, 0.815 B+1.95; B-0.36; 0.512	9 2, 9, 6
		-107	106.938910	400	51.35			2, 9
		-108	107.910090	400		2.3 m	B-1.77; EC; 0.42, 0.62	2, 9, 6
		-109	108.939340	400	48.65			2, 9
		-110	109.941390	400		253 d	B-; 0.66, 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; 0.245, 0.337	2, 9, 6
		-112	111.942450	510		3.2 h	B-4.1, 3.5, 2.7, 1.0; 0.618, 1.39	2, 9, 6
		-113	112.942280	510		5.3 h	B-2.0; 0.57	2, 9
		-114				5 s 2 m	B-4.6; B-	2, 9, 6 9

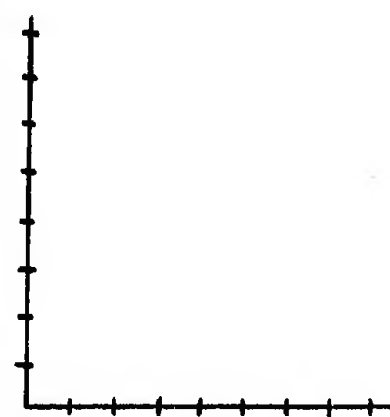
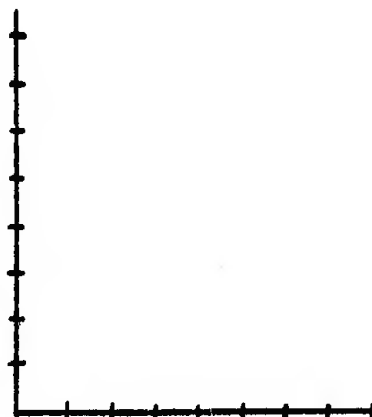


47 Ag

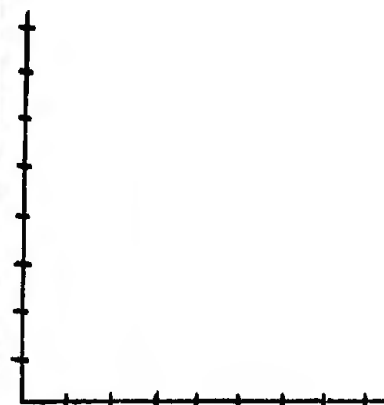
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
47	Silver	-115	114.915280	50		21.1 m	B ⁻ 2.9; 80.138, 0.227	2, 9, 6
	(Cont'd)	-116				2.5 m	B ⁻ 5.0; 70.70, 0.52	9
		-117				1.1 m	B ⁻	9

REMARKS

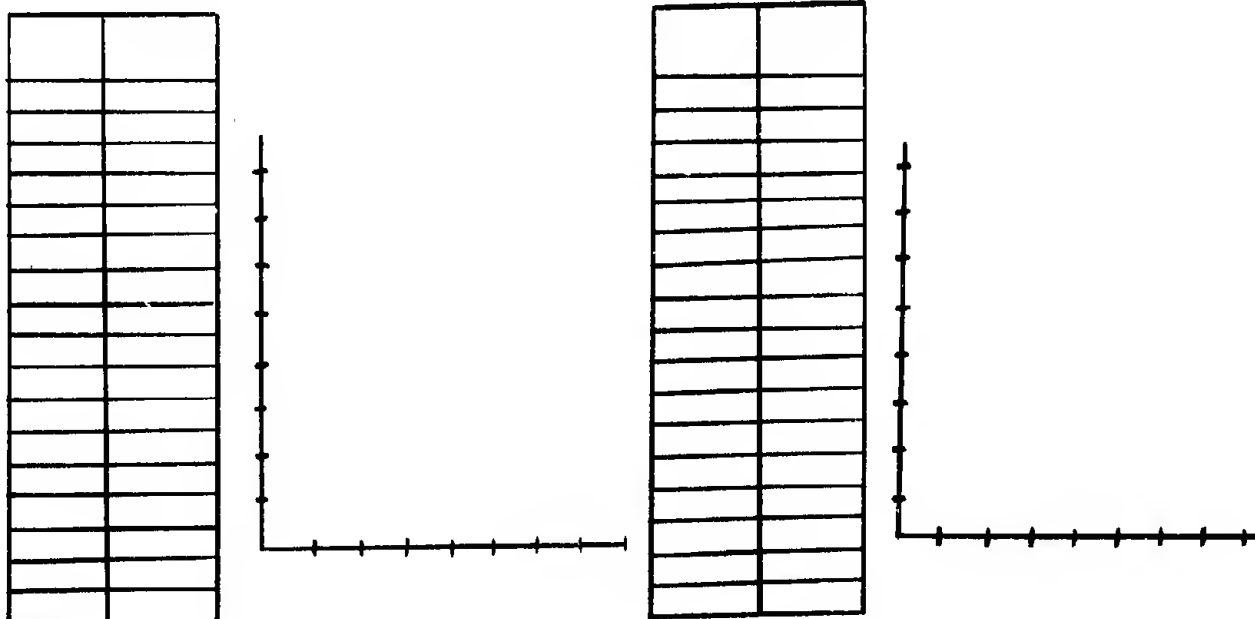
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Ag^{107}	- 9.391	- 9.353	6, 48
	Ag^{109}	- 9.180	- 9.196	6, 48
(γ, p)	Ag^{107}	- 5.638		6
	Ag^{109}	- 6.560		6



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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

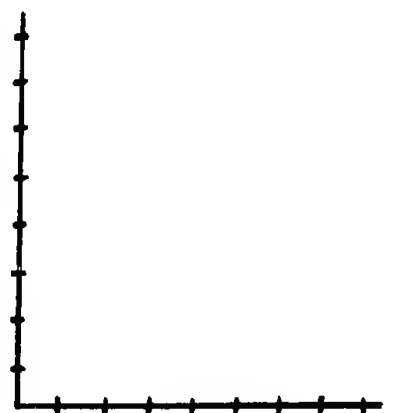
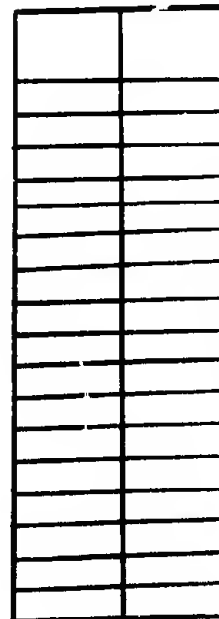
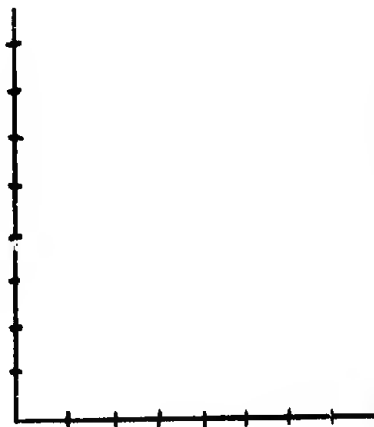
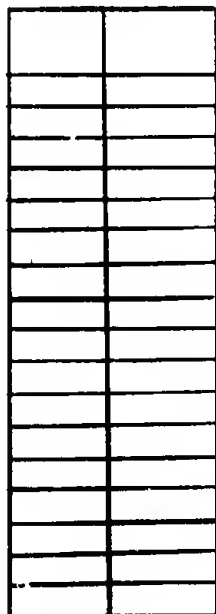


		<u>REMARKS</u>		⁴⁸ Cd
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ,n)	Cd ¹¹⁰	-9.847		6
	Cd ¹¹¹	-6.970		6
	Cd ¹¹²	-9.300		6
	Cd ¹¹³	-6.420		6
	Cd ¹¹⁴	-9.046		6
(γ,p)	Cd ¹¹⁰	-8.907		6
	Cd ¹¹¹	-9.060		6
	Cd ¹¹²	-9.560		6
	Cd ¹¹³	-9.670		6
	Cd ¹¹⁴	-10.263		6

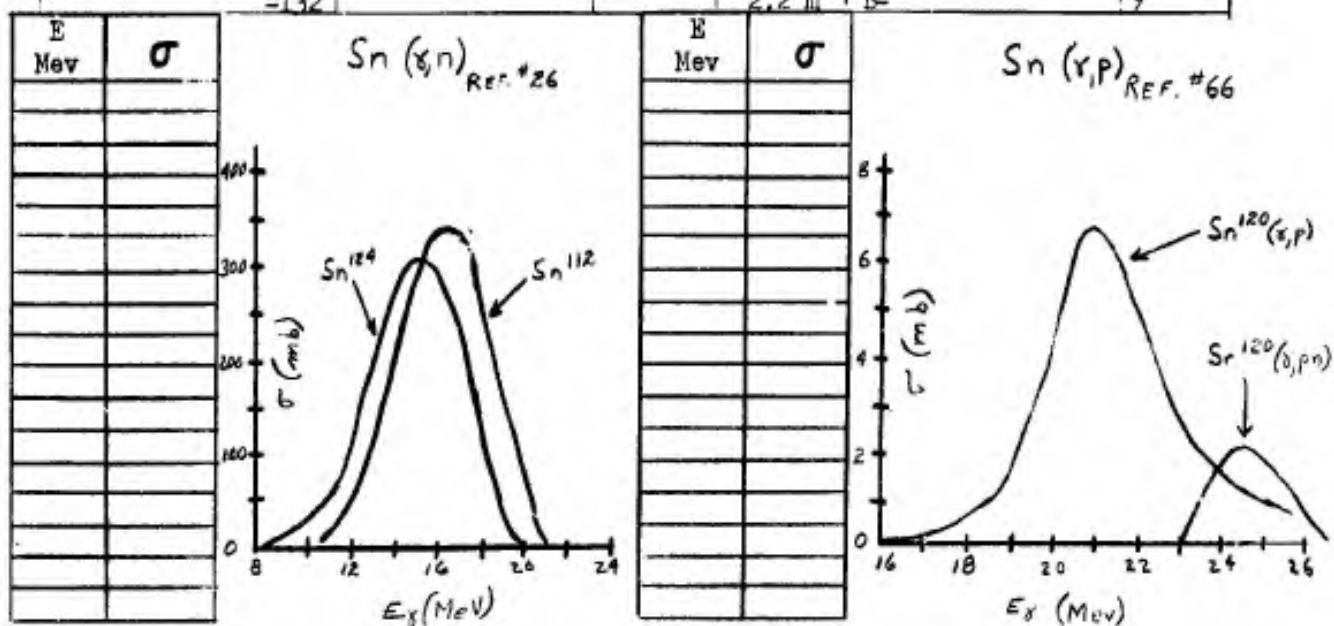


^{43}In

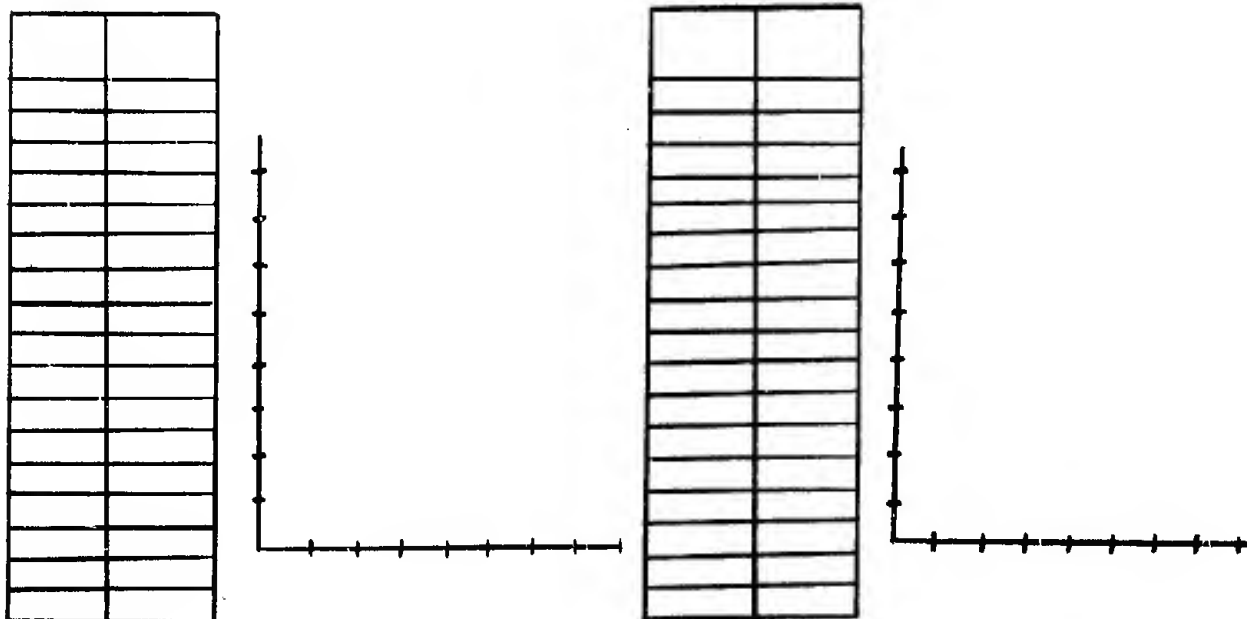
<u>Thresholds</u>	<u>Isotope</u>	<u>REMARKS</u>		<u>Reference</u>
		<u>Theoretical</u>	<u>Experimental</u>	
(γ, n)	In^{113}	- 9.340		6
	In^{115}	- 9.025		6
(γ, p)	In^{113}	- 5.940		6
	In^{115}	- 6.822		6

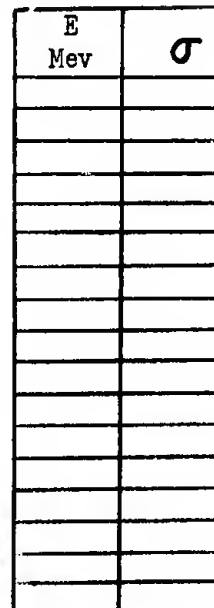


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
50	Tin	-108				9 m	EC	9
		-109				18.1 m	EC; B-1.6; γ 0.335	9, 6
		-110				4.0 h	EC; γ 0.283	9
		-111	110.94311	750		35 m	EC; B-1.51	2, 9
		-112	111.940256	510	0.95			2, 9
		-113				119 d	EC; γ 0.256, 0.392, 0.605	9, 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; γ 0.153	2, 9
		-124	123.944540	500	5.98			2, 9
		-125	124.947420	500		9.5 m	B-2.04, 1.17, 0.51; γ 0.326	2, 9
		-126				$\sim$ 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

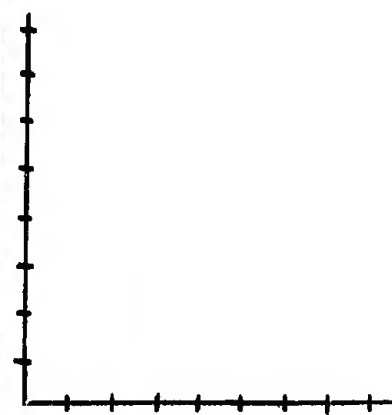
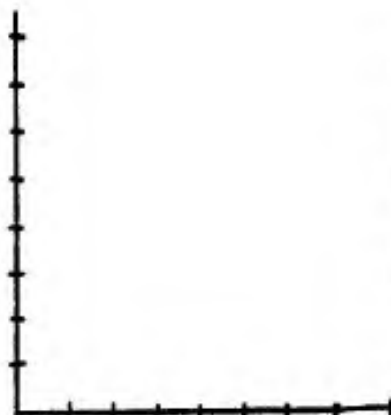


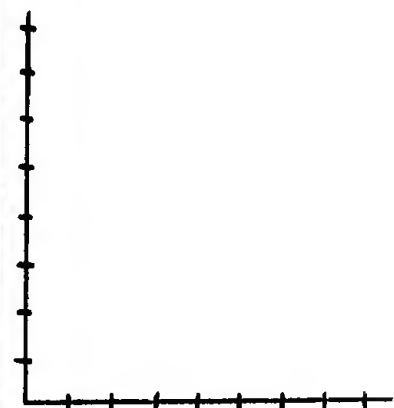
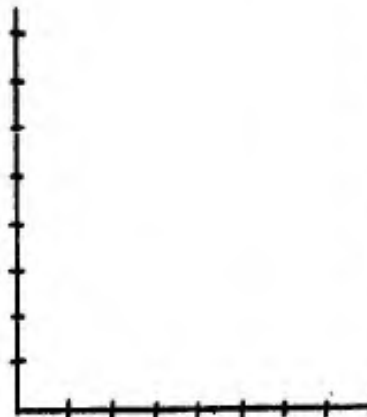
<u>Thresholds</u> (γ, n)	<u>Isotope</u>	<u>REMARKS</u>		⁵⁰ Sn
		<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
	Sn ¹¹⁶	-9.390		6
	Sn ¹¹⁷	-7.190		6
	Sn ¹¹⁸	-9.250		6
	Sn ¹¹⁹	-6.590		6
	Sn ¹²⁰	-9.240		6
(γ, p)	Sn ¹¹⁶	-9.110		6
	Sn ¹¹⁷	-9.690		6
	Sn ¹¹⁸	-9.940		6
	Sn ¹¹⁹			
	Sn ¹²⁰			





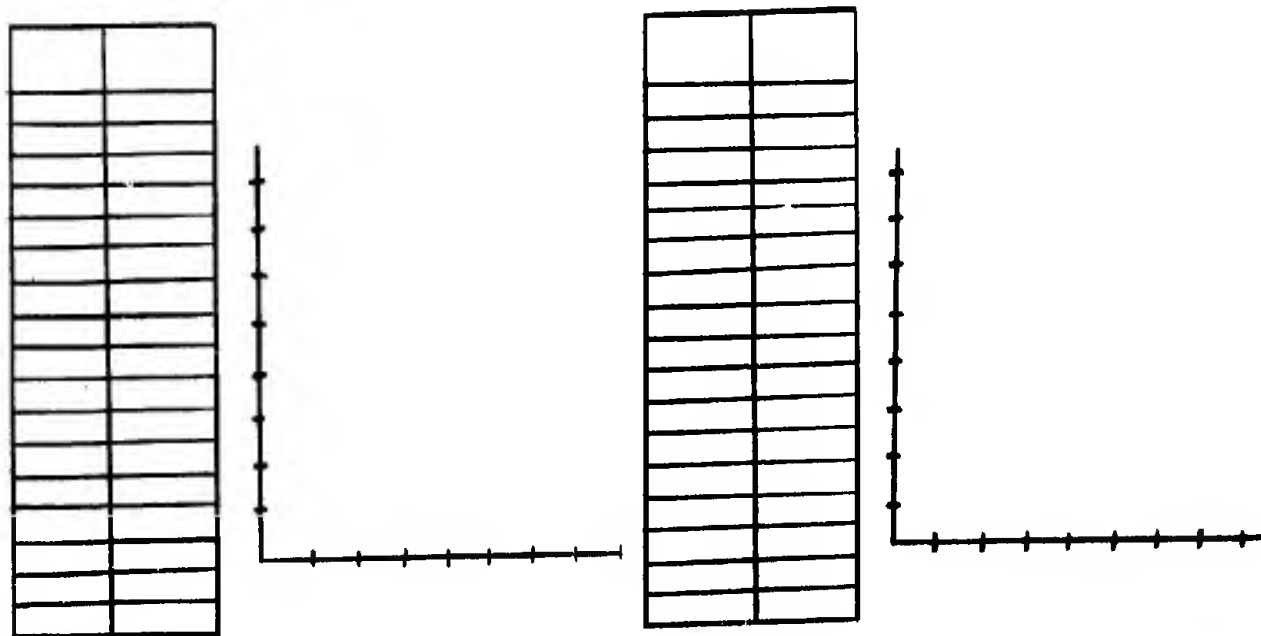
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ,n)	Sb ¹²¹	-9.284		6
	Sb ¹²³	-8.976		6
(γ,p)	Sb ¹²¹	-5.779		6
	Sb ¹²³	-6.600		6



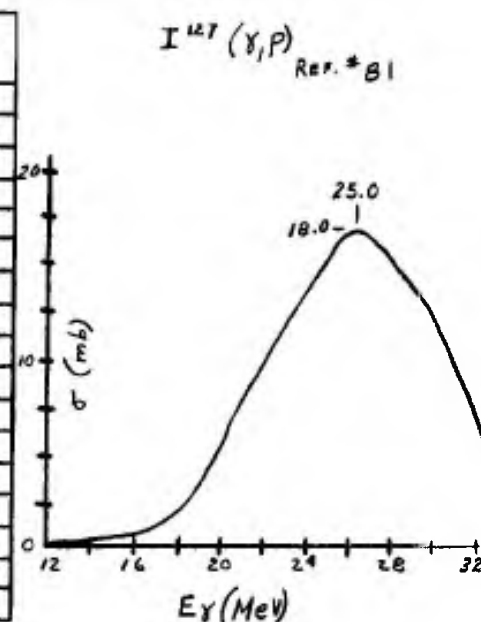
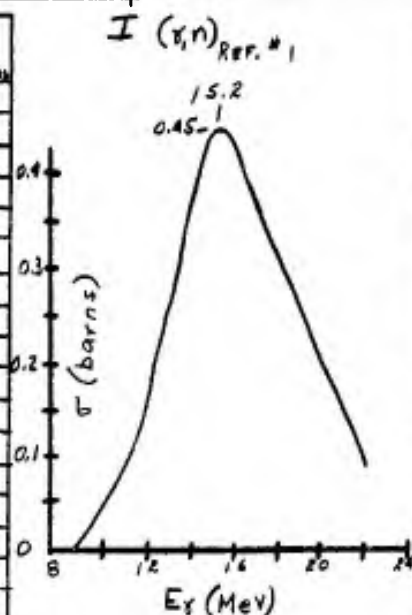


^{52}Te

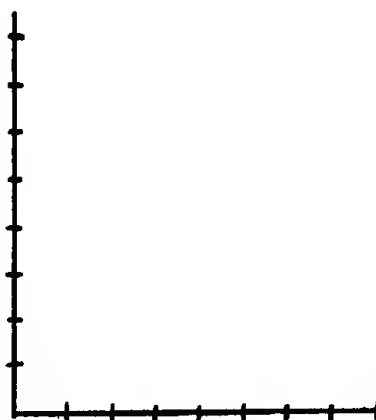
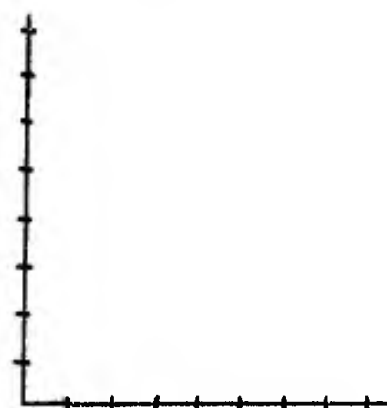
<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Te^{126}	- 9.170	- 8.84	6, 48
	Te^{128}	- 8.430	- 8.41	6, 48
	Te^{130}	- 7.760		6
(γ, p)	Te^{126}	- 9.140		6
	Te^{128}	- 7.140		6
	Te^{130}			



E MeV	σ_{bare}
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



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

[illegible][illegible]

Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
54	Xenon	-121				40 m	B+; 60.096	9
		-122				19.5 h	EC; 60.182, 0.235	9
		-123				2.1 h	EC; B+1.7; 60.148	9
		-124	123.945390	500	0.096			2, 9
		-125				18.0 h	EC; 60.055, 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; 60.565, 0.1450 0.1700, 0.202, 0.367	2, 9,
		-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; 60.0809	2, 9
		-134	133.947620	500	10.44			2, 9
		-135				9.13 h	B-0.91; 60.249, 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; 60.42, 0.51	6
		-139				41 s	B-	9

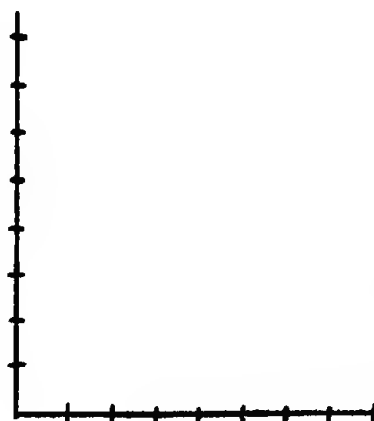
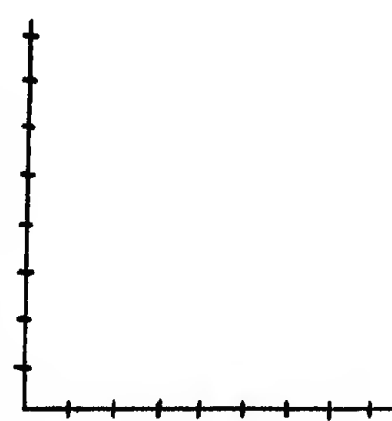
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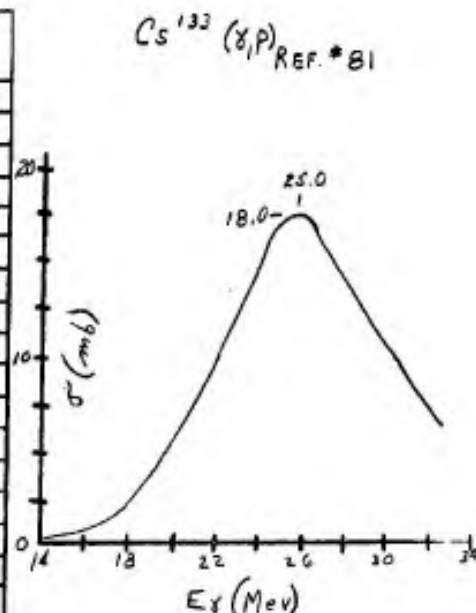
${}_{54}^{136}\text{Xe}$

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

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,n)	Xe ¹²⁹	- 6.910		6
	Xe ¹³¹	- 6.603		6
	Xe ¹³²	- 8.932		6
(Y,p)	Xe ¹²⁹	- 8.251		6
	Xe ¹³¹	- 8.777		6
	Xe ¹³²	- 9.120		6
(Y,α)	Xe ¹³²	- 2.940		6

[illegible][illegible]

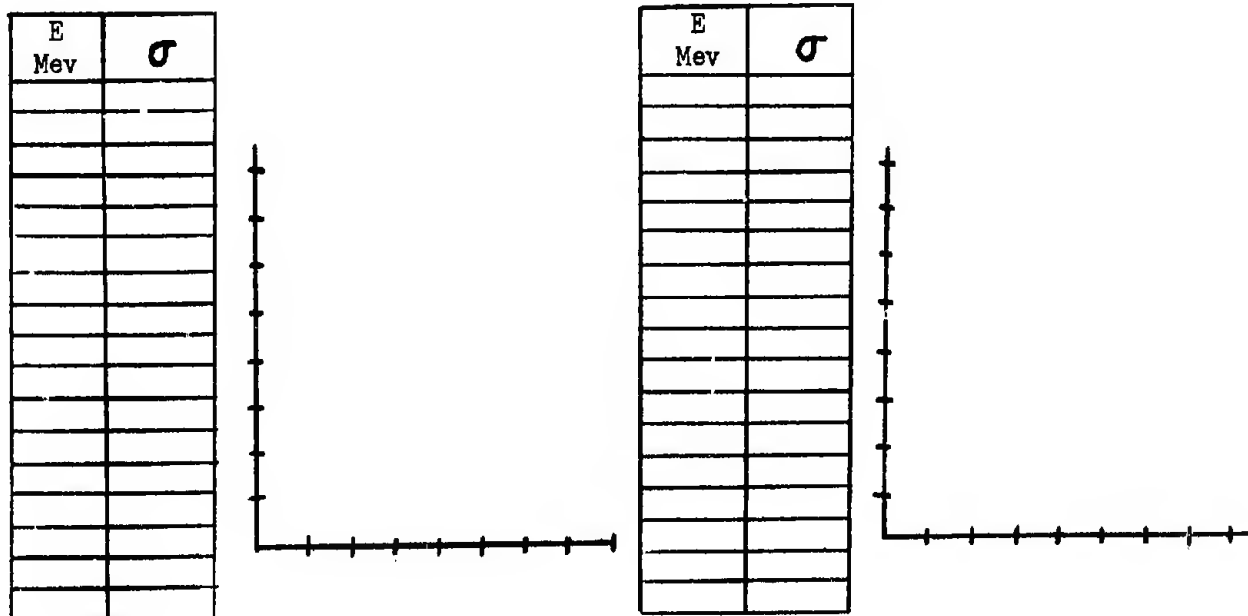
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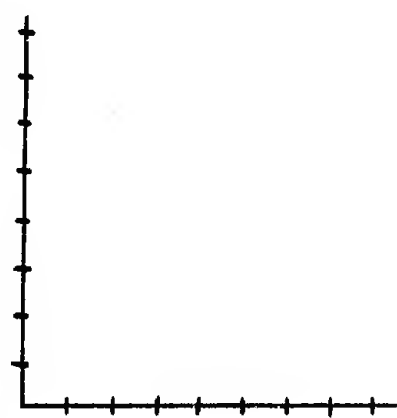
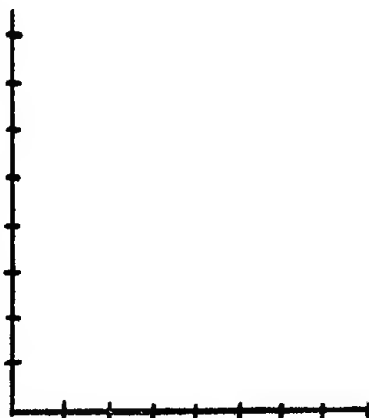
55 65

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

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Cs ¹³³	- 9.026	- 8.988	6, 48
(γ, p)	Cs ¹³³	- 6.430		6

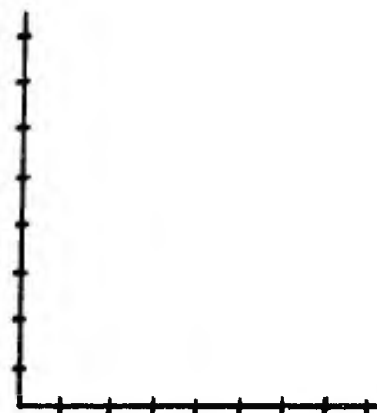
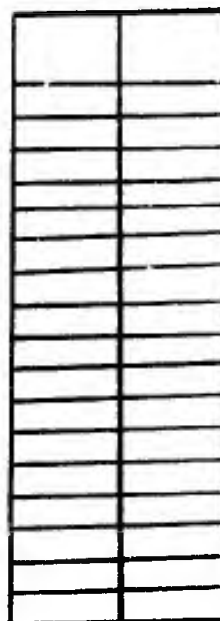
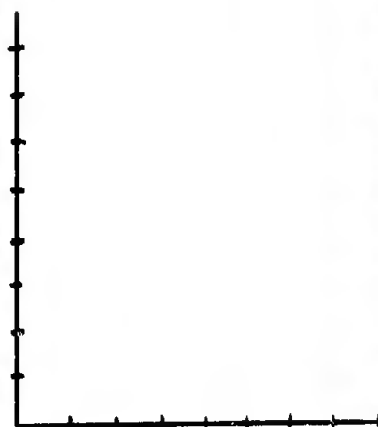




^{56}Ba

REMARKS

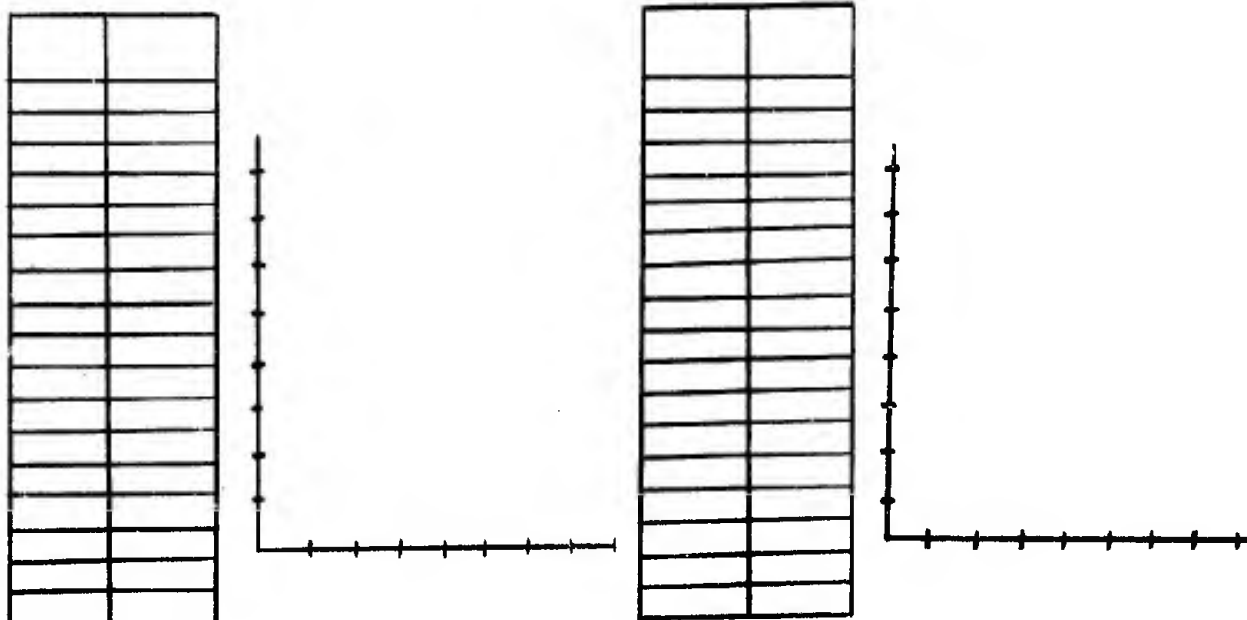
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Ba^{137}	-6.450	-6.949	6, 48
	Ba^{138}	-8.580		6
(γ, p)	Ba^{137}	-8.747		6
	Ba^{138}	-8.970		6



^{56}Ba

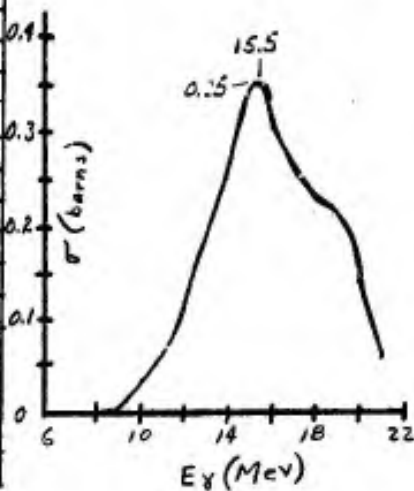
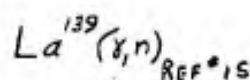
REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Ba^{137}	-6.950	-6.949	6, 48
	Ba^{138}	-8.580		6
(γ, p)	Ba^{137}	-8.741		6
	Ba^{138}	-8.970		6



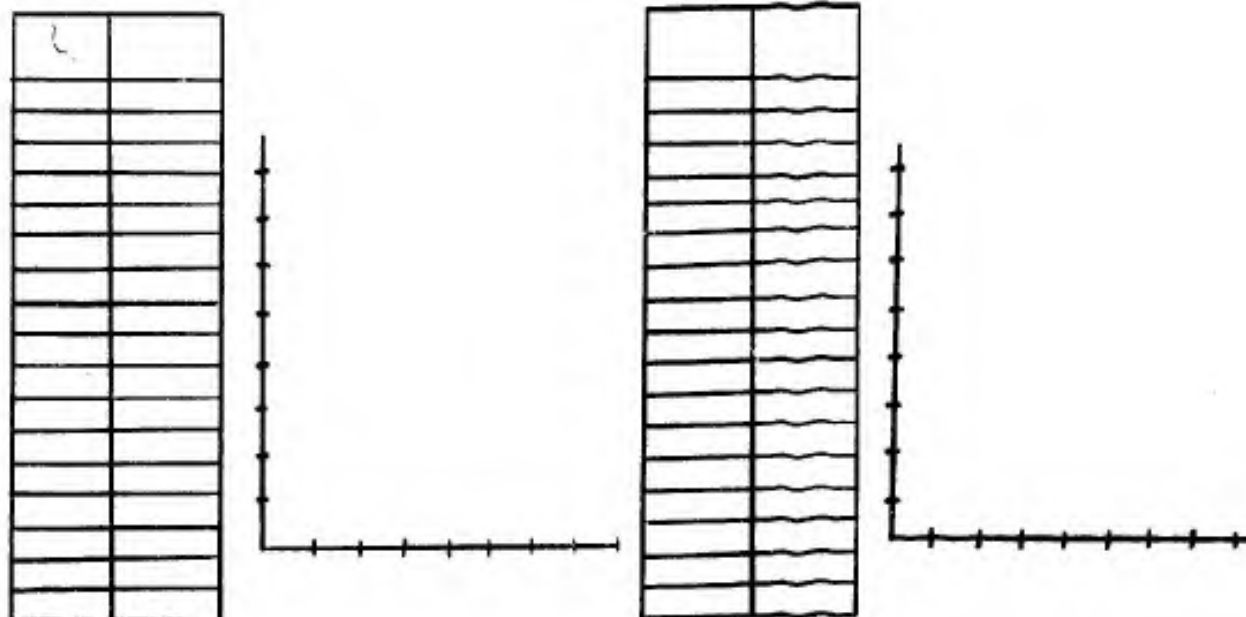
Z	CHEM. SYM.	A	ATOMIC MASS AMU	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
57	Lanthanum	-131			58 m	B+1.6	9
		-132			4.5 h	B+3.8; γ 1.0	9
		-133			4.0 h	EC; B+~1.2; γ 0.8	9
		-134	133.950730 820		6.5 m	B+2.7	2, 9
		-135			19.5 h	EC; γ 0.104, 0.218, 0.265, 0.295, 0.367, 0.483, 0.588, 0.65, 0.86	9, 6
		-136			9.5 m	EC; B+2.1	9
		-137			6x10 ⁴ y	EC;	9
		-138	137.950100 1020	0.089	1011y	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 [±] 1, 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- γ 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

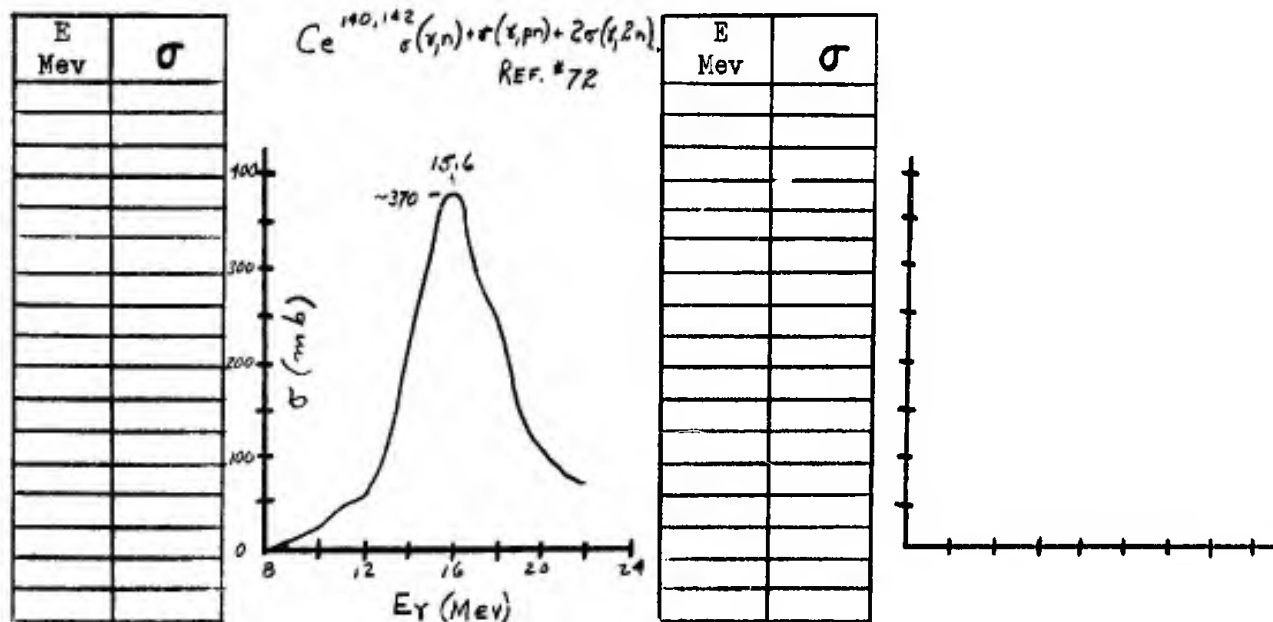


57La

<u>Thresholds</u>	<u>Isotope</u>	<u>REMARKS</u>		<u>Reference</u>
		<u>Theoretical</u>	<u>Experimental</u>	
(γ, n)	La^{139}	- 8,777	- 8,81	6, 22
(γ, p)	La^{139}	- 6,318		6



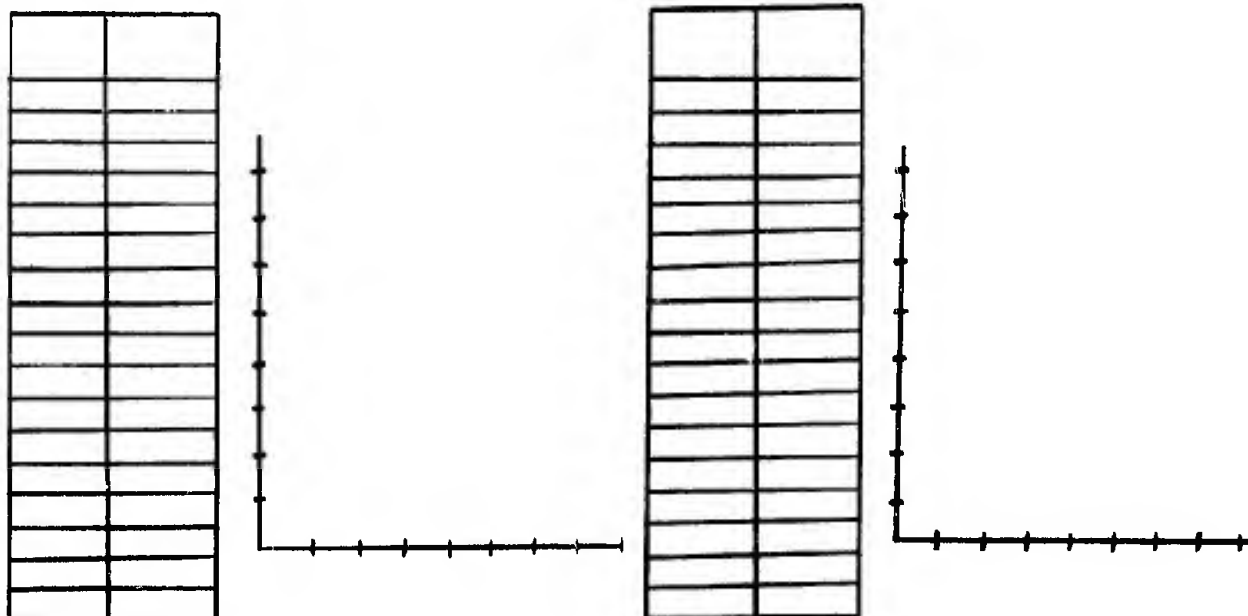
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
58	Cerium	-131				30 m	B+4.2	9
		-132				4.2 h	B+	9
		-133				6.3 h	B+1.3; 1.8	9
		-134				72.0 h	EC	9
		-135				22 h	EC; B+0.81	9
		-136			0.193			9
		-137				8.7 h	EC; 0.443	9
		-138	137.949030	1040	0.250			2, 9
		-139	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; 0.144	2, 9
		-142	141.953020	1000	11.07	5x10 ¹⁵ y	~ 1.5	2, 9
		-143	142.956538	1000		33 h	B- ; 0.035, 0.126, 0.160, 0.289, 0.356, 0.660, 0.720	2, 9,
		-144	143.958445	1000		285 d	B- ; 0.0337, 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; 0.11, 0.142 0.22, 0.27, 0.32	



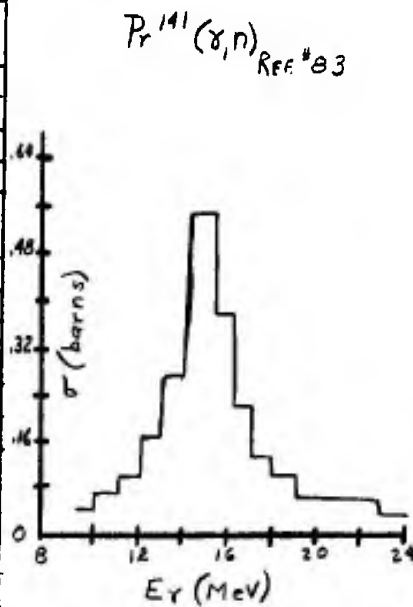
${}_{58}\text{Ce}$

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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

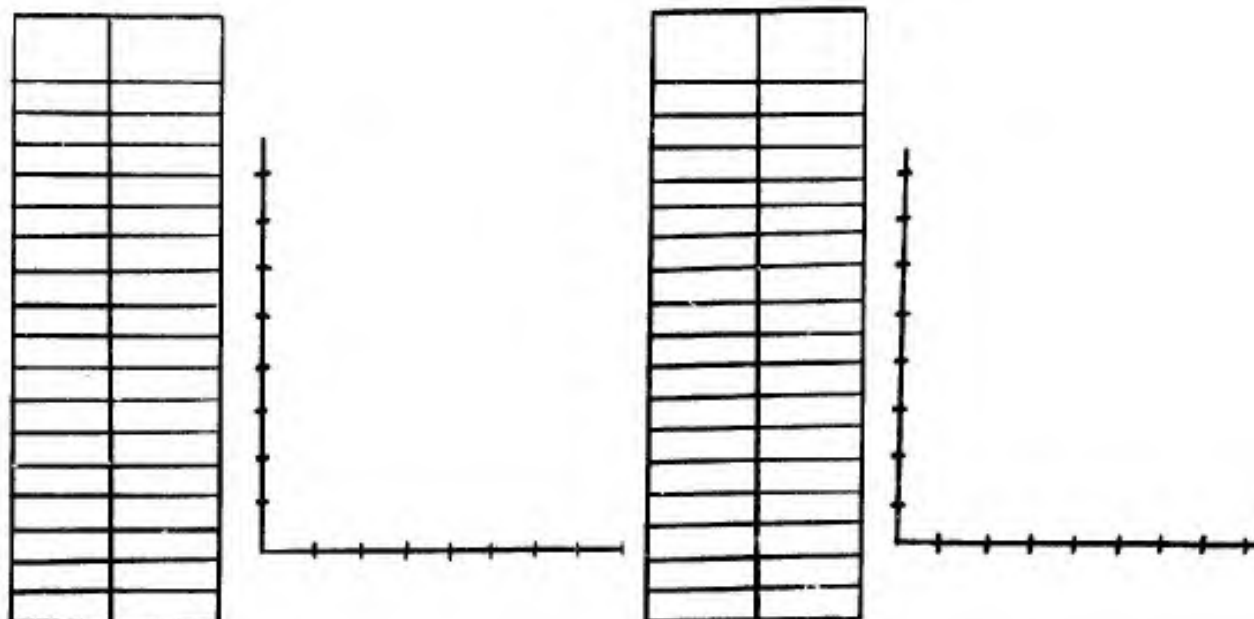


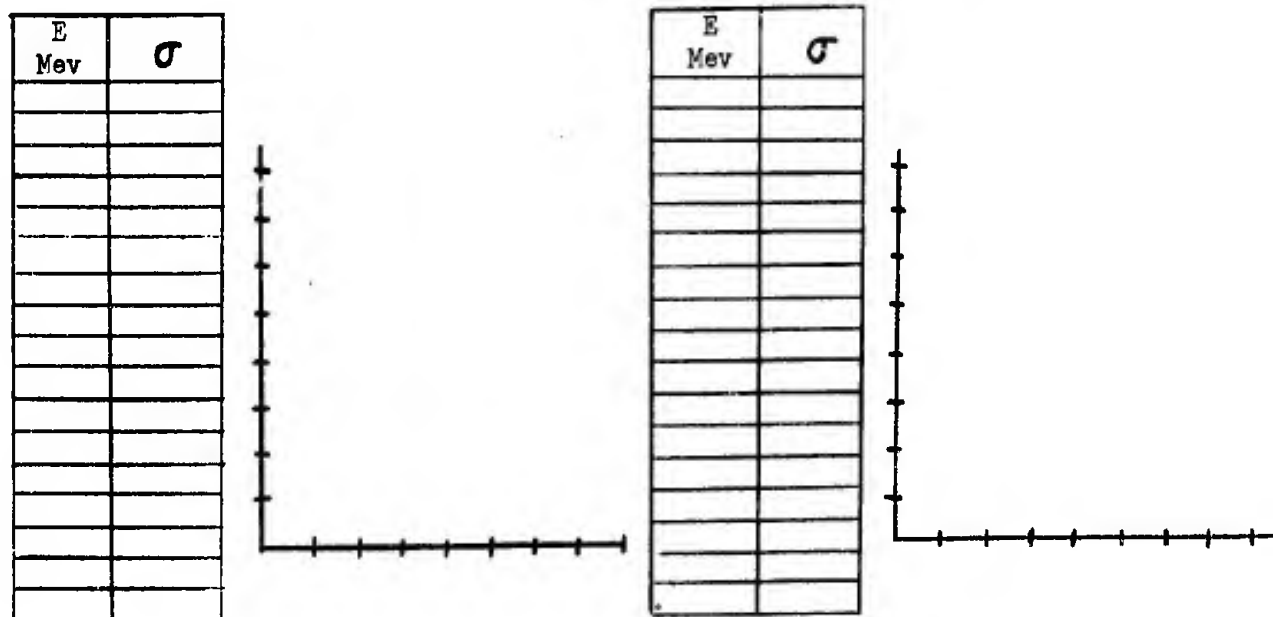
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
59	Praseodymium	135				22 m	B+2.5; ϵ 0.08, 0.22, 0.3	9
	-136					70 m	B+2.0; ϵ 0.17, 0.8, 1.1	9, 6
	-137					1.4 h	EC; B+1.8	9
	-138	137.952790	1060			2.0 h	EC; B+1.4; ϵ 0.30, 0.80, 1.05, 1.4, 1.7	2, 9, 6
	-139					4.5 h	EC; B+1.0; ϵ 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; ϵ 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; ϵ 0.455, 0.59, 0.75, 1.49	2, 9, 6



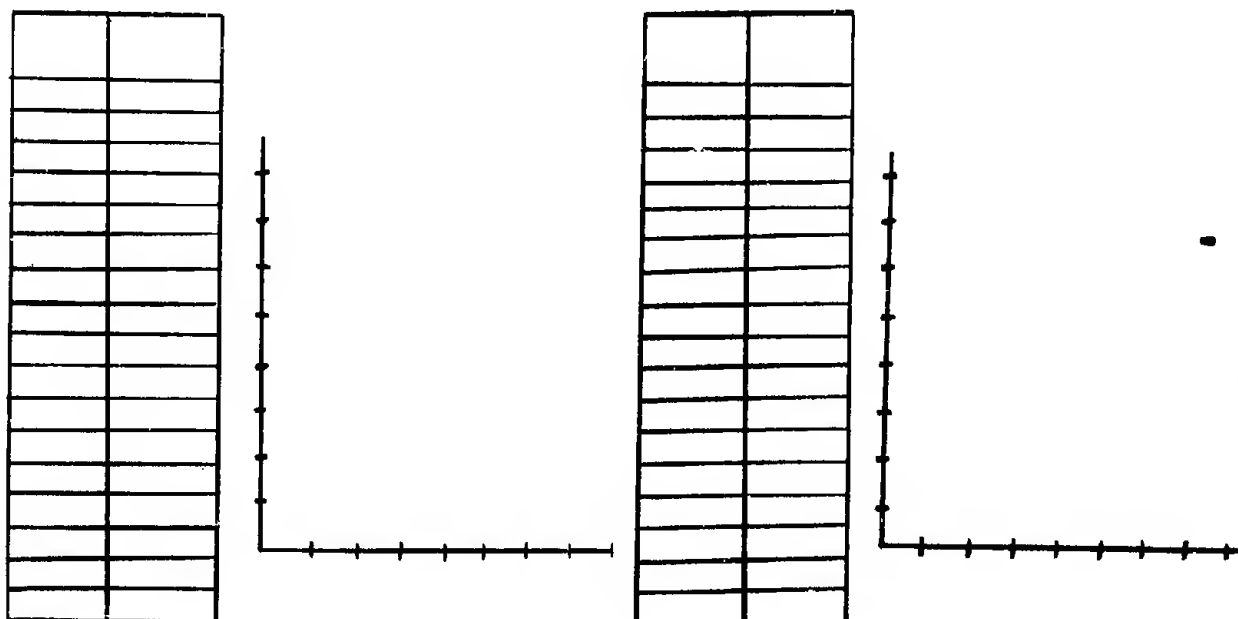
⁵⁹Pr

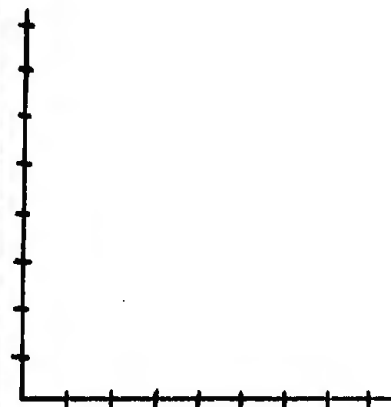
<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Pr ¹⁴¹	- 9,368		6
(γ, p)	Pr ¹⁴¹	- 5,326		6





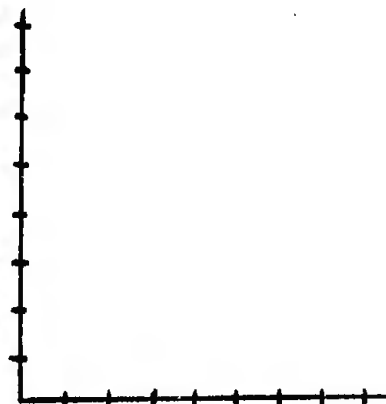
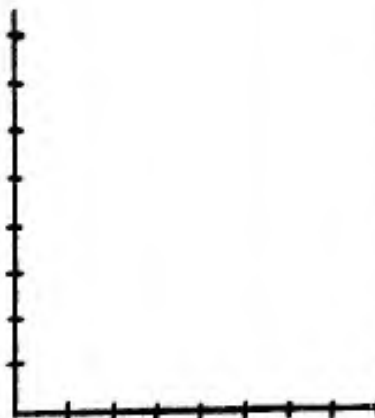
<u>Thresholds</u>	<u>Isotope</u>	<u>REMARKS</u>		⁶⁰ Nd
		<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Nd ¹⁴²	-9.789		6
	Nd ¹⁴³	-6.070		6
	Nd ¹⁴⁴	-7.814		6
	Nd ¹⁴⁵	-5.970	-6.38	6
	Nd ¹⁴⁶	-7.580		6
(γ, p)	Nd ¹⁴²	-7.206		6
	Nd ¹⁴³	-7.440		6
	Nd ¹⁴⁴	-7.965		6
	Nd ¹⁴⁵	-8.160		6
	Nd ¹⁴⁶	-8.602		6



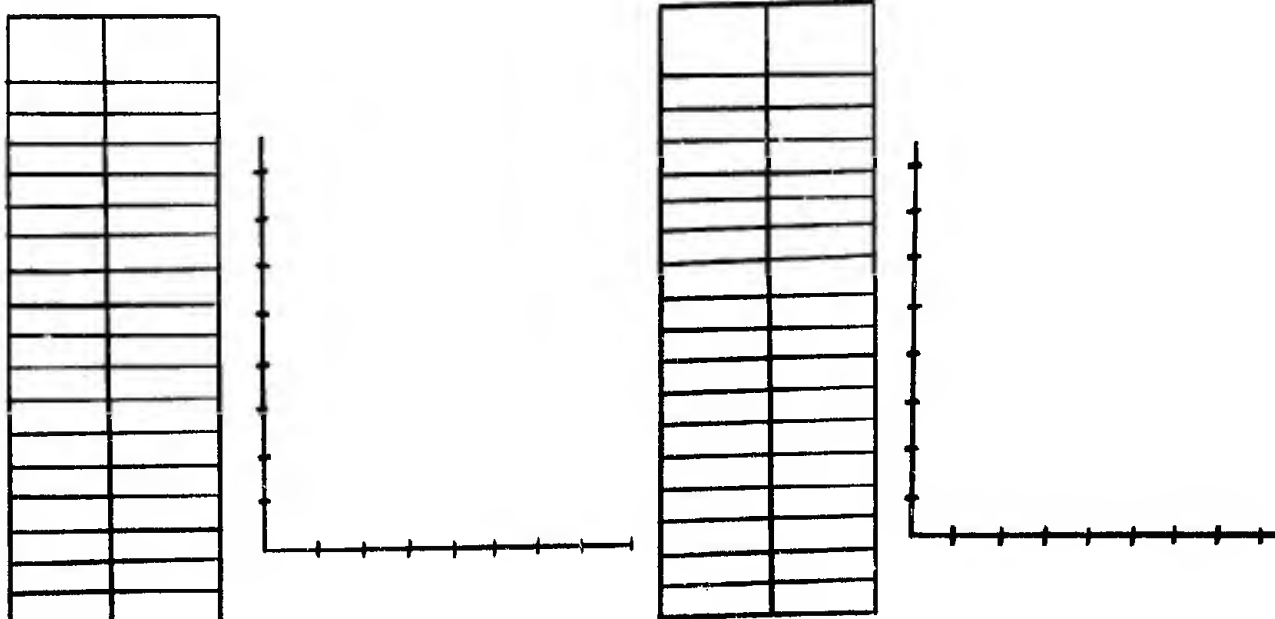


${}^{62}\text{Sm}$

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		5×10^7 y	α 2.55	2, 9
		-147	146.960310	1000	15.07	1.3×10^{11} 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



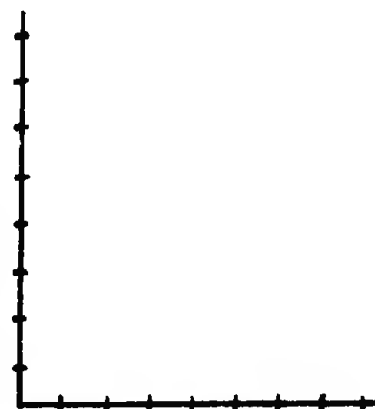
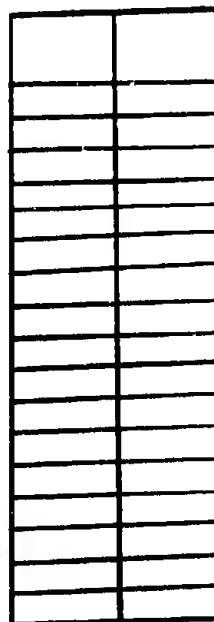
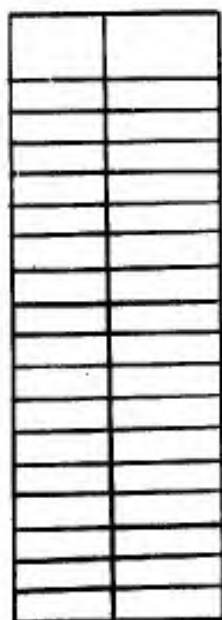
		<u>REMARKS</u>			⁶² Sm
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>	
(γ, n)	Sm ¹⁴⁷	-6.470			6
	Sm ¹⁴⁸	-8.130			6
	Sm ¹⁴⁹	-5.860			6
	Sm ¹⁵²	-8.410			6
	Sm ¹⁵⁴				
(γ, p)	Sm ¹⁴⁷	-6.440			6
	Sm ¹⁴⁸	-7.570			6
	Sm ¹⁴⁹				
	Sm ¹⁵²	-9.430			6
	Sm ¹⁵⁴				



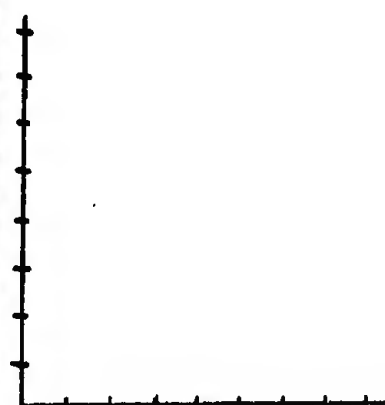
2, 9, 6

${}^{63}\text{Eu}$

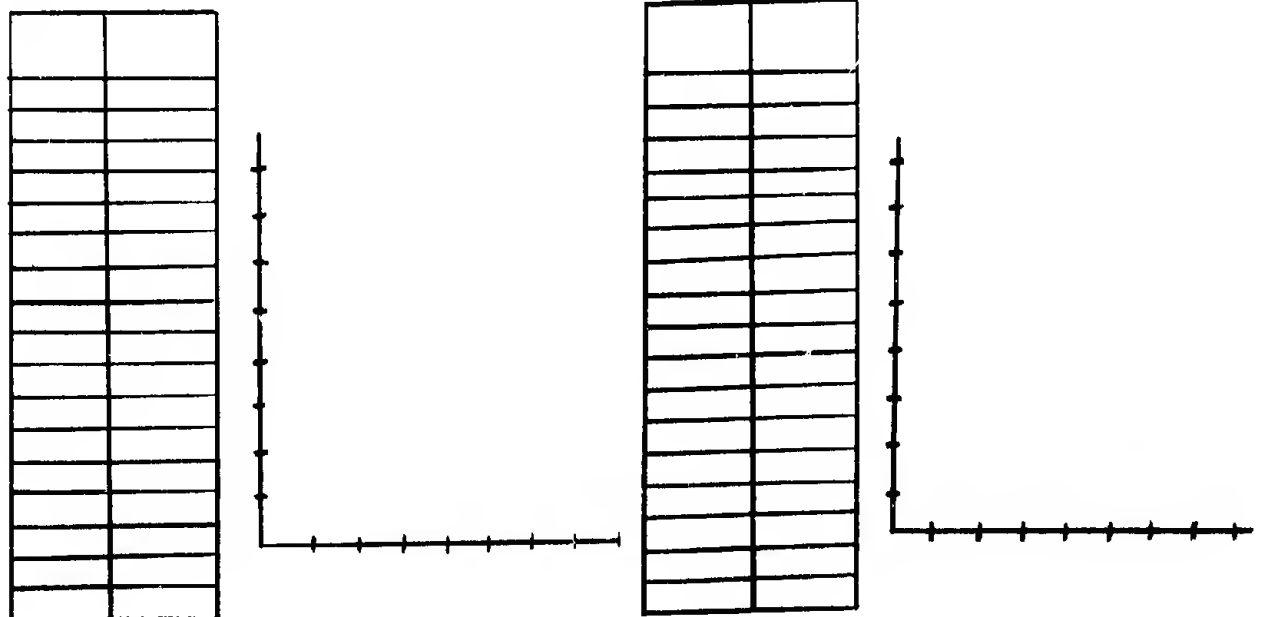
<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,n)	Eu^{151}	-8.050	-8.04	6, 48
	Eu^{153}	-8.650	-8.65	6, 48
(Y,p)	Eu^{151}	-4.850		6
	Eu^{153}	-6.010		6



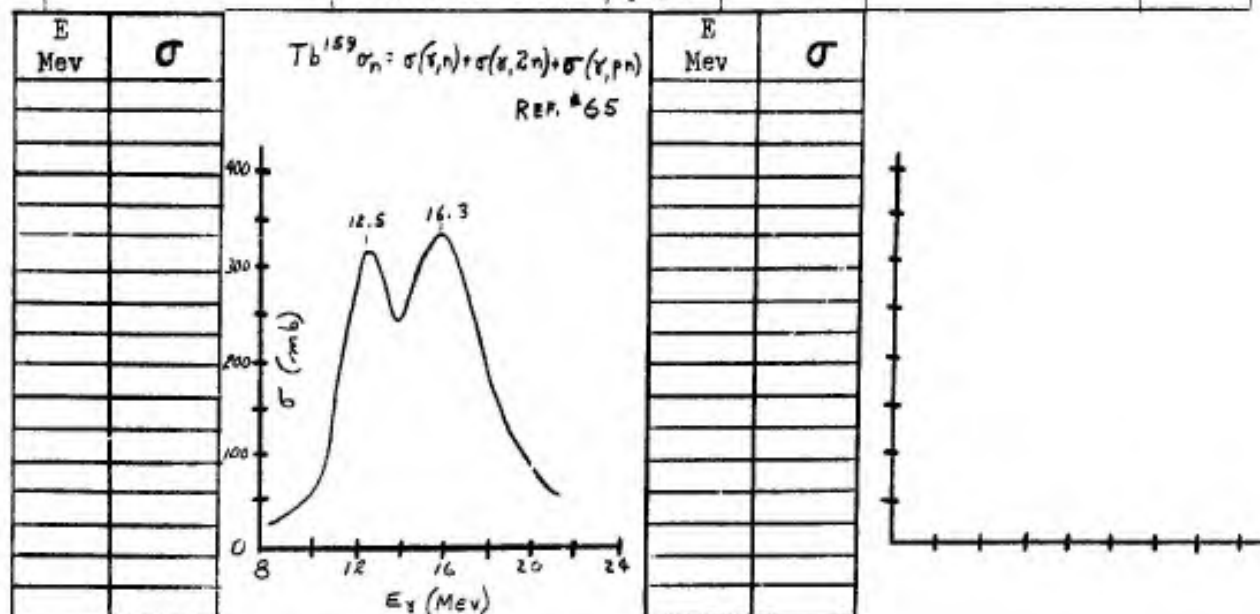
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
64	Gadolinium-147					29.0 h	EC; γ	9
	-148	147.963370	1600			~130 y	α 3.2	2, 9
	-149					9.3 d	EC; 3.0;	9
	-150	149.965050	1000			>10 ⁵ y	α 2.7	2, 9
	-151					150 d	EC; γ 0.0215, 0.1531 0.1753, 0.242, 0.305	9, 6
	-152			0.20				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



<u>REMARKS</u>				⁶⁴ Gd
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(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; < 3.95; < 0.17, 0.23, 0.36, 0.50, 0.64	9, 6
		-151				19 h	EC; < 3.4; < 0.108, 0.180, 0.192, 0.252, 0.271, 0.287, 0.344, 0.432, 0.615	9, 6
		-153				62 h	EC; < 0.6, 1.5, 0.0517, 0.0681, 0.0875, 0.102, 0.110, 0.174, 0.195, 0.212, 0.250	9, 6
		-154				8 h	EC; < 0.6	9
		-155				17.2 h	EC; B+2.75; < 0.6	9
		-156				5.6 d	EC; < 1.4	9
		-157				5.6 d	EC; B+0.2, 0.6; < 1.3	9
		-158				11.0 s	IT; < 0.111	9
		-159			100	72.3 d	B-; < 0.970, 0.886, 0.300, 0.200, 0.085	2, 9, 6
		-160	159.977755	2000		6.88 d	B-; < 0.0256, 0.0489, 0.078	9, 6
		-161				14 m		9
		-162				6.5 h		9
		-163	Continued on next page.					

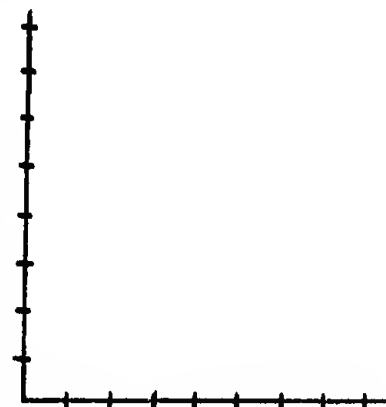
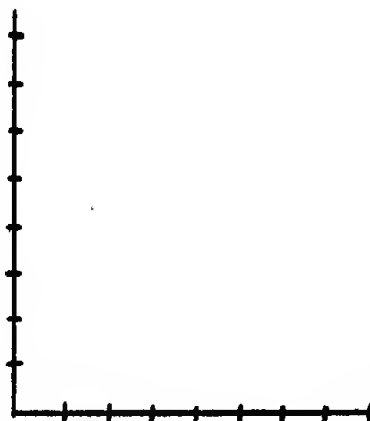


65 Tb

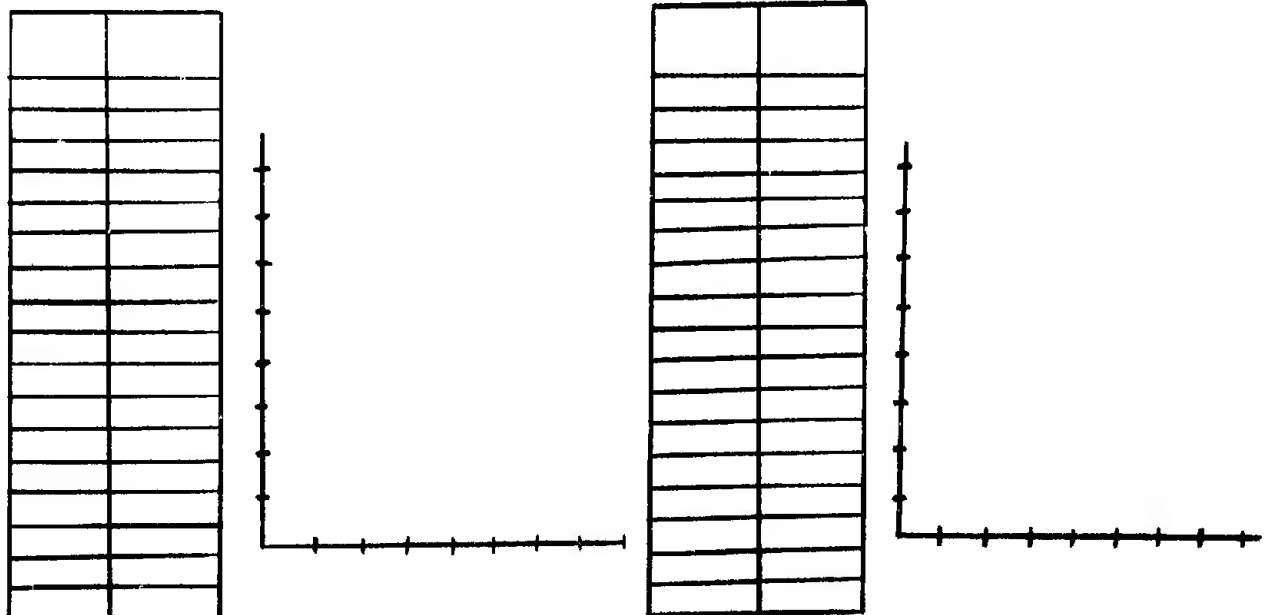
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
65	Terbium	-164				23 h		9
	Tb?					217 h	B+3.1	9

REMARKS

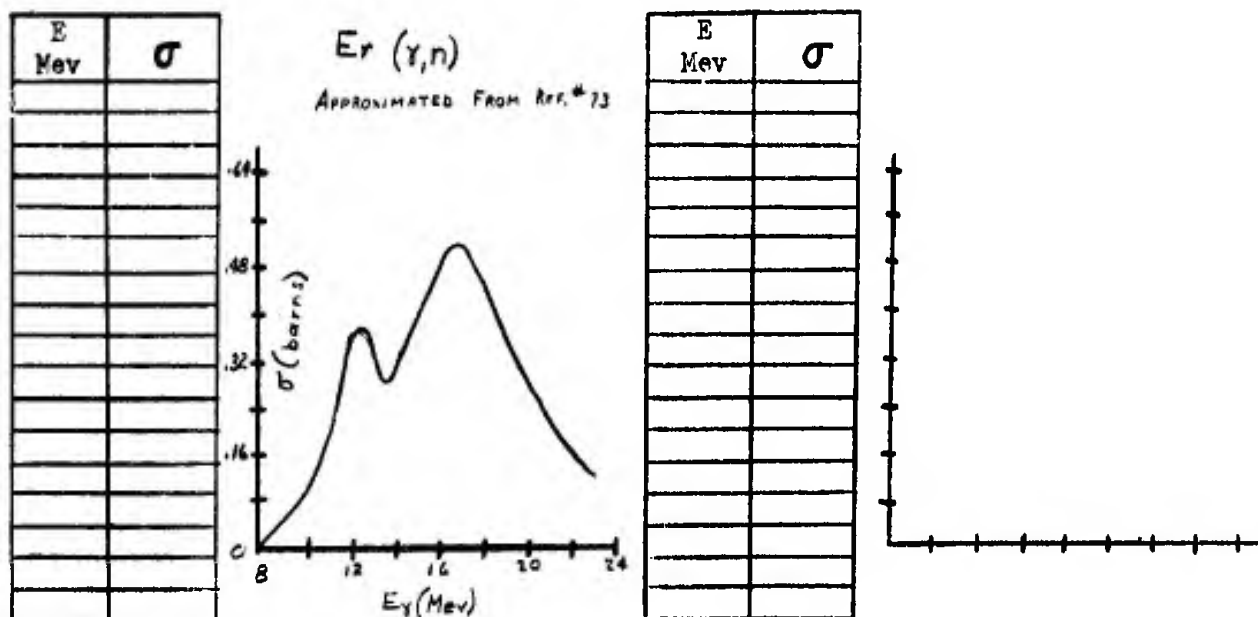
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Tb^{159}	- 8,148		6
(γ, p)	Tb^{159}	- 7,200		6



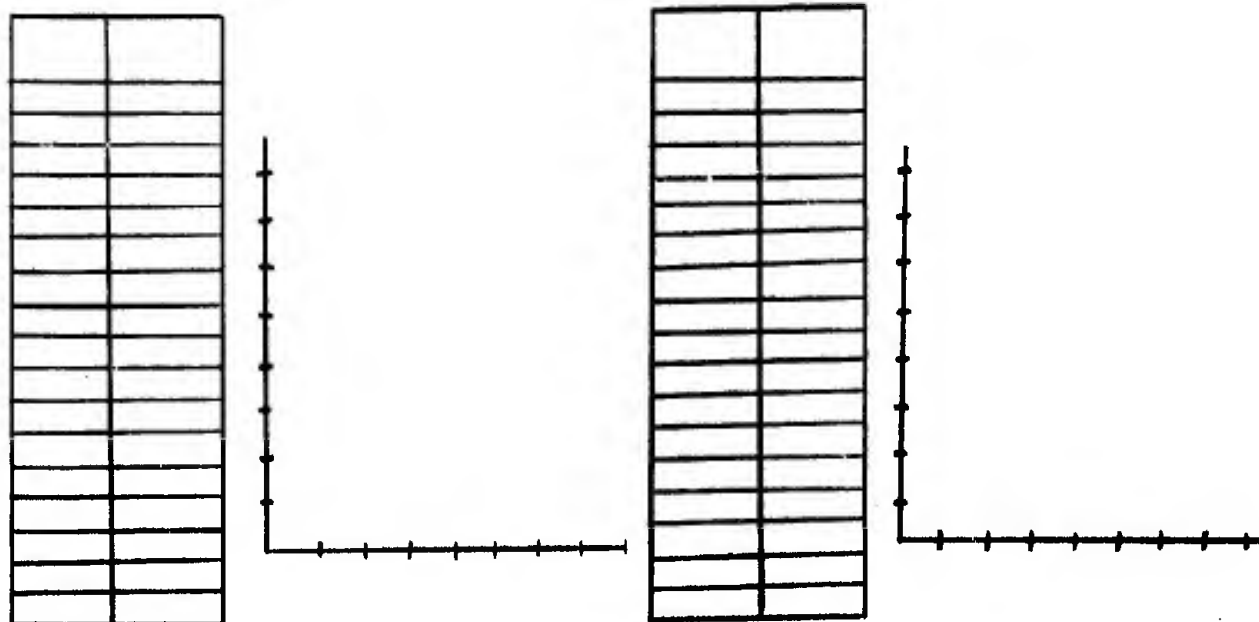
<u>REMARKS</u>				
^{66}Dy				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Dy ¹⁶¹	-6.410		6
	Dy ¹⁶²	-8.170		6
	Dy ¹⁶³	-6.300	-6.32	6, 48
	Dy ¹⁶⁴	-7.620		6
(γ, p)	Dy ¹⁶¹	-7.450		6
	Dy ¹⁶²	-7.970		6
	Dy ¹⁶³			
	Dy ¹⁶⁴			

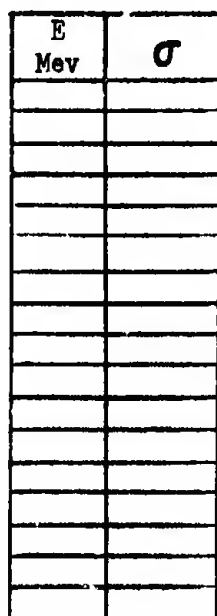


Z	CHEM. SYM.	A	ATOMIC MASS AMU	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
68	Erbium	-160			29 h	EC	9
		-161			3.1 h	EC; B ⁺ 1.2; γ	9
		-162		0.136			9
		-163			75 m	EC; γ 0.43, 1.10	9
		-164	163.981720 1000	1.56			2, 9
		-165			10.0 h	EC; γ 1.1	9
		-166		33.41			9
		-167		22.94			9
		-168	167.983920 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, 0.175 0.295, 0.308, 0.420	9, 6
		-172			50 h	B ⁻	9

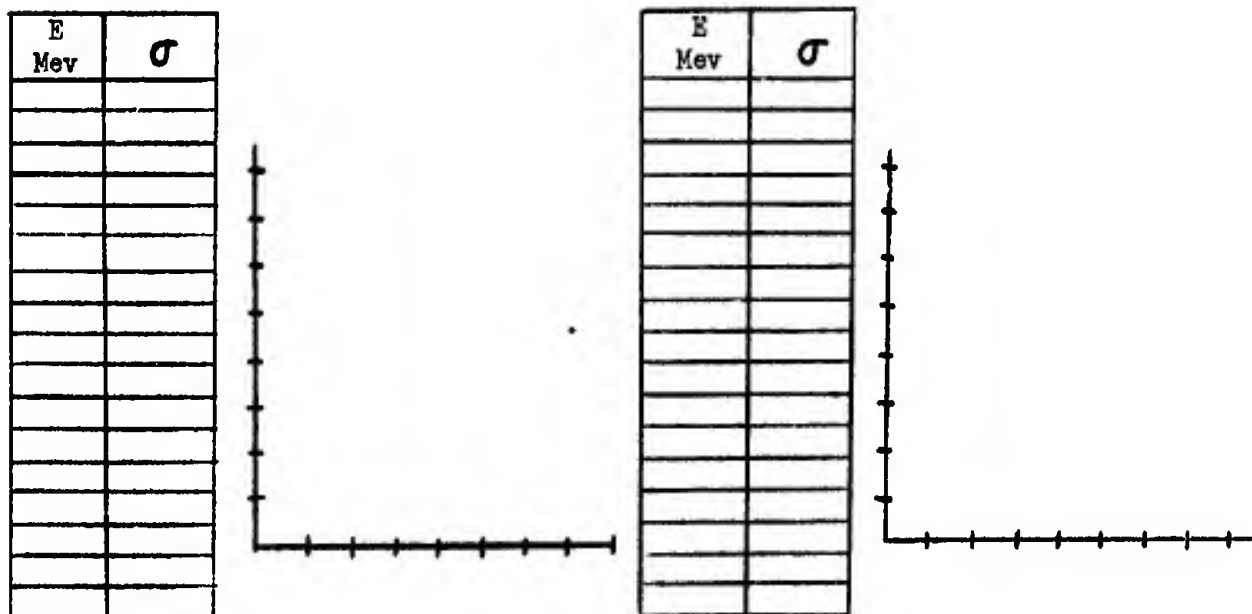


		<u>REMARKS</u>		^{Er} ₆₈
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Er ¹⁶⁶			
	Er ¹⁶⁷	-6.540	-6.64	6, 48
	Er ¹⁶⁸	-7.780		6
(γ, p)	Er ¹⁶⁶	-7.430		6
	Er ¹⁶⁷	-7.600		6
	Er ¹⁶⁸	-8.000		6



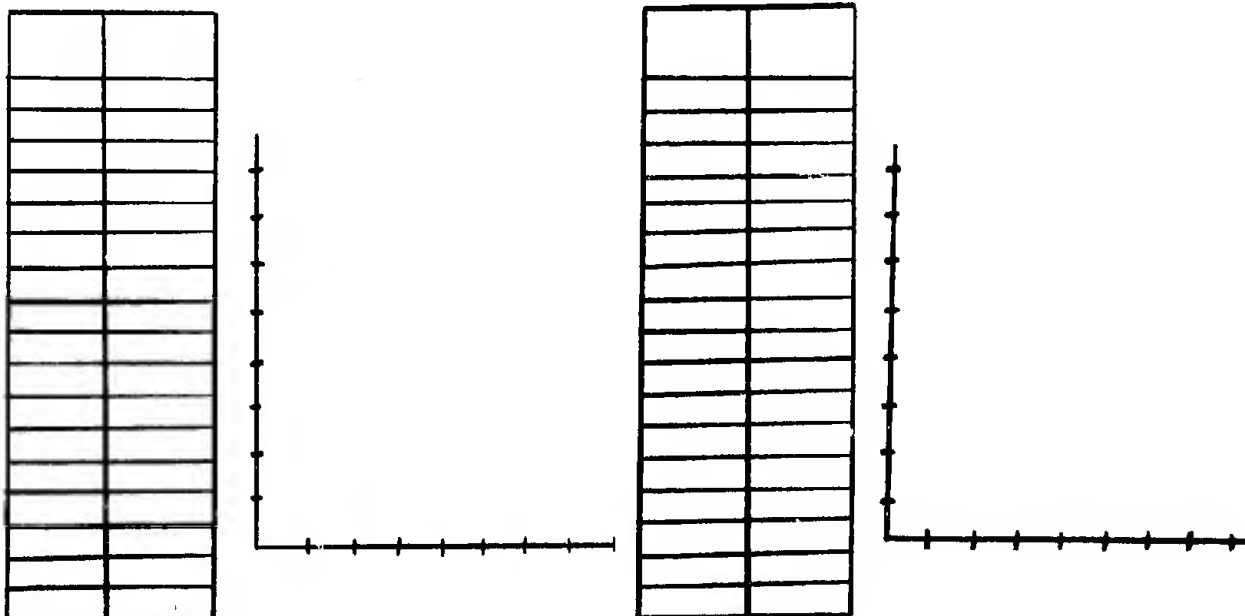


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
70	Ytterbium	-166				54 h	EC; γ 0.112, 0.140	9
		-167				74 m	B ⁺ 2.4	
					0.140	19 m	EC; γ 0.118, 0.18, 0.33	9, 6
		-168						9
		-169				31.8 d	EC; γ 0.064, 0.110, 0.133, 0.178, 0.198	9, 6
		-170			3.03			9
		-171			14.31			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; $\sim$ 0.025	9
	Yb ^m					0.15 s		9



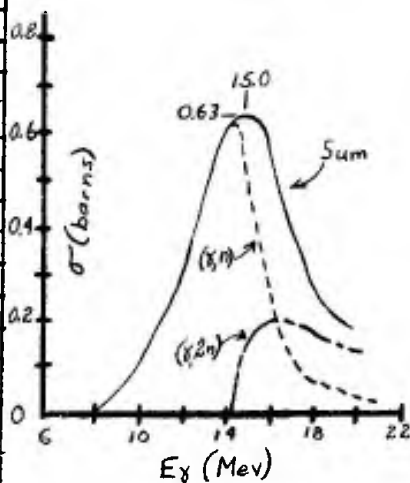
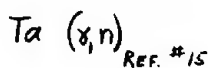
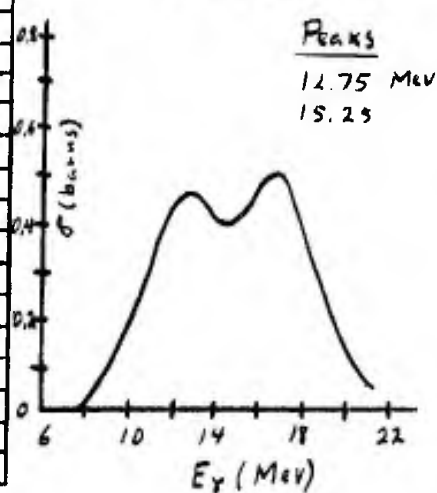
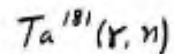
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
72	Hafnium	-170				112 m	B+2.4	9
		-171				16.0 h	EC; γ 0.18, 1.4	9, 6
		-172				5 y	EC; γ 0.28, 0.8	9
		-173				23.6 h	EC; γ 0.123, 0.2985	9, 6
		-174			0.163			9
		-175				70 d	EC; γ 0.089, 0.3434, 0.433	9, 6
		-176	175.996300	2005	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

		REMARKS		
		72 ^{Hf}		
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference.</u>
(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			



53	Tantalum-170				8.0 h	EC; δ 0.0883, 0.202	9, 6
	-177				53 h	EC; δ 0.113, 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; δ 0.332, 1.4	9, 6
	-178				9.35 m	EC; B ⁺ 1.06; δ 0.093, 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 ⁻ ; δ 0.068, 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; δ 0.24	9, 6
	-184				8.7 h	B ⁻ 1.26, 0.15; δ 0.110, 0.24, 0.30, 0.41, 0.89, 1.18	9, 6
	-185				50 m	B ⁻ 1.7, δ 0.15; δ 0.125, 0.175, 0.235	9, 6
	-186				10.5 m	B ⁻ 2.2; δ 0.125, 0.20, 0.30, 0.41, 0.51, 0.61, 0.73, 0.94	9, 6

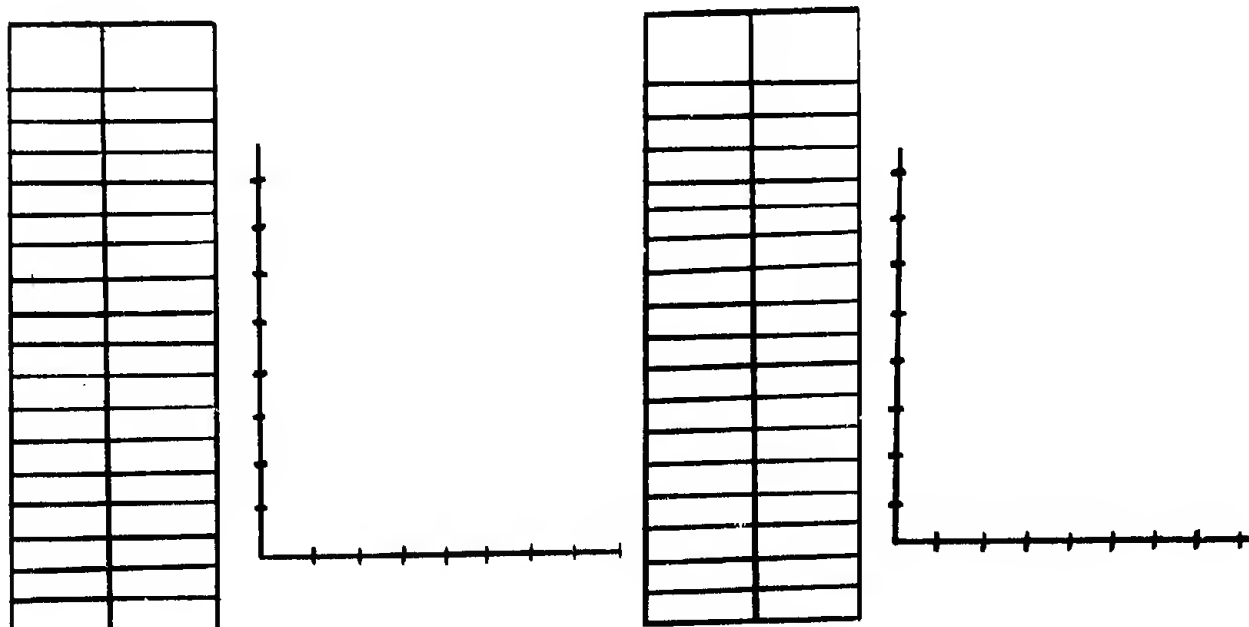
E Mev	σ barns
8	0
9	0.04
10	0.10
11	0.18
12	0.30
13	0.44
14	0.60
15	0.63
16	0.53
17	0.36
18	0.26
19	0.21
20	0.18

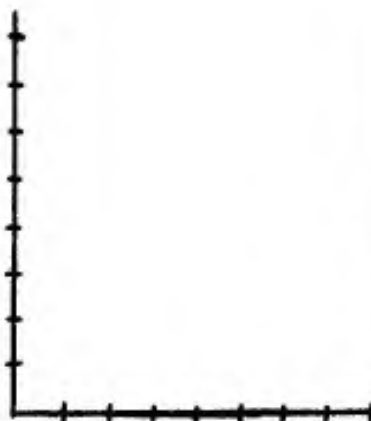
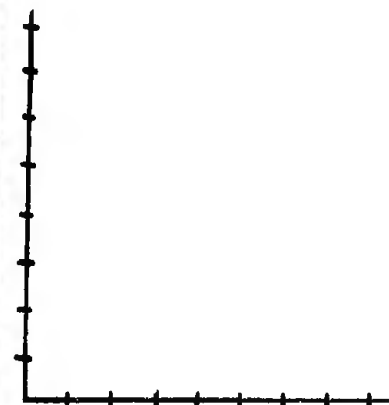
[illegible]

^{73}Ta

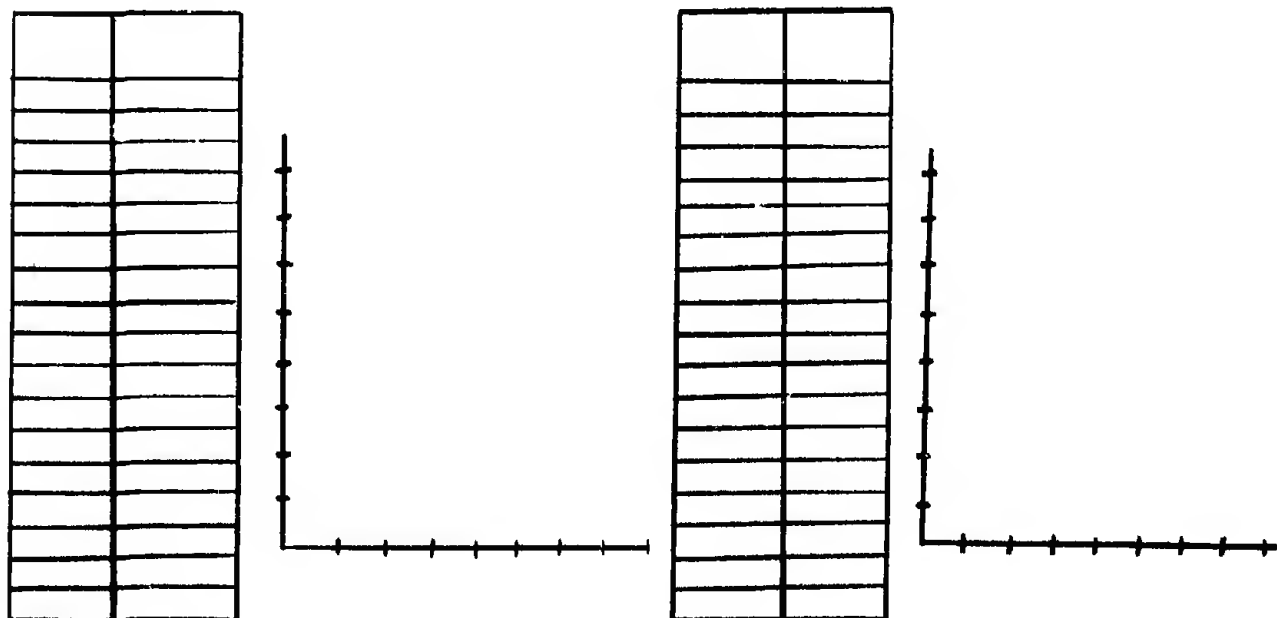
REMARKS

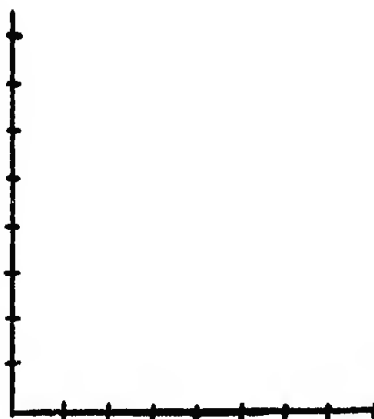
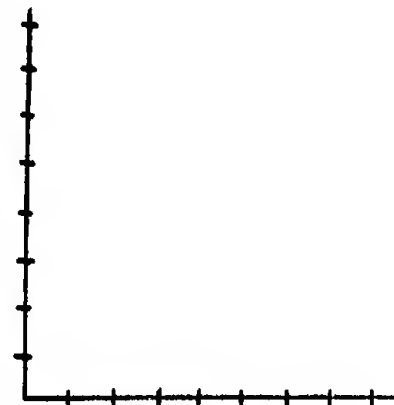
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Ta^{181}	-7.645		6
(γ, p)	Ta^{181}	-6.300		6



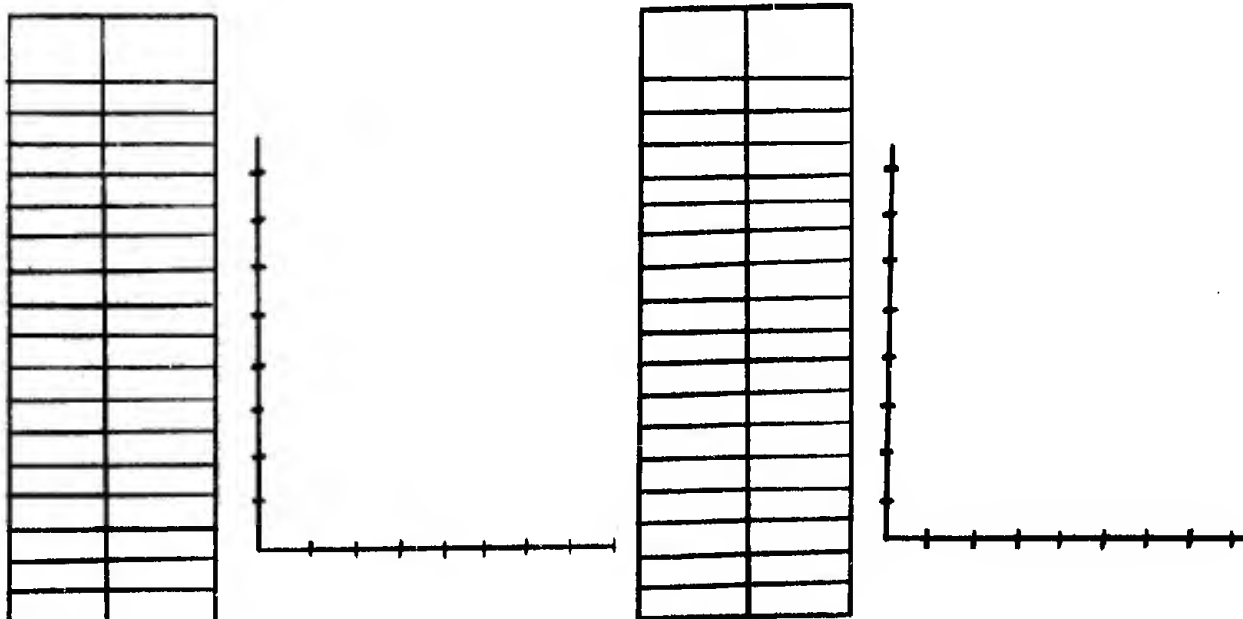
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		<u>REMARKS</u>		^W ₇₄
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	^W 182	-8.000		6
	^W 183	-6.185	-6.29	6, 48
	^W 184	-7.460		6
	^W 186	-7.280	-7.28	6, 48
(γ, p)	^W 182	-7.021		6
	^W 183	-7.135		6
	^W 184	-7.740		6
	^W 186	-8.200		6

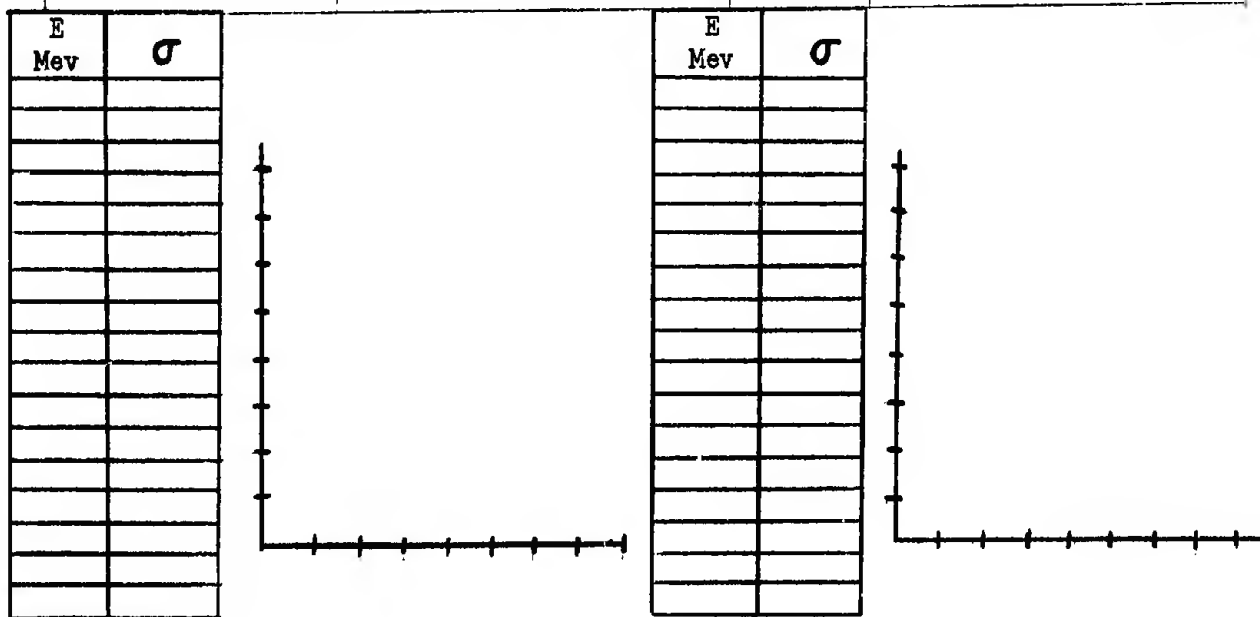


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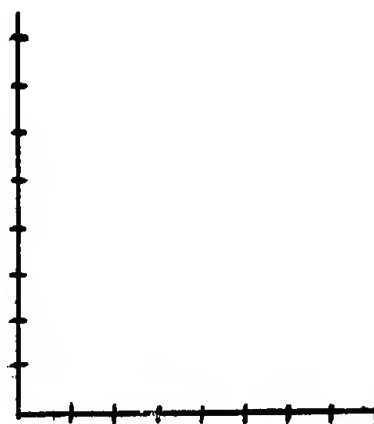
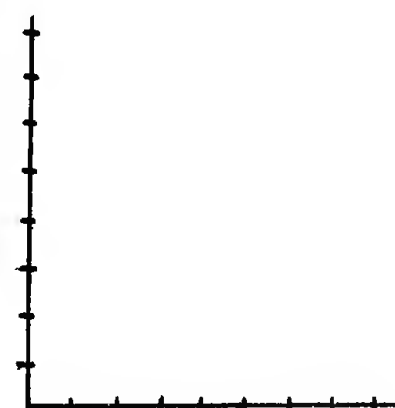
REMARKS				
Thresholds	Isotope	Theoretical	Experimental	Reference
(γ, n)	¹⁸⁸ Os	-8.060		6
	¹⁸⁹ Os	-5.990		6
	¹⁹⁰ Os	-7.880		6
	¹⁹² Os	-7.810		6
(γ, p)	¹⁸⁸ Os	-7.280		6
	¹⁸⁹ Os	-7.320		6
	¹⁹⁰ Os			
	¹⁹² Os			



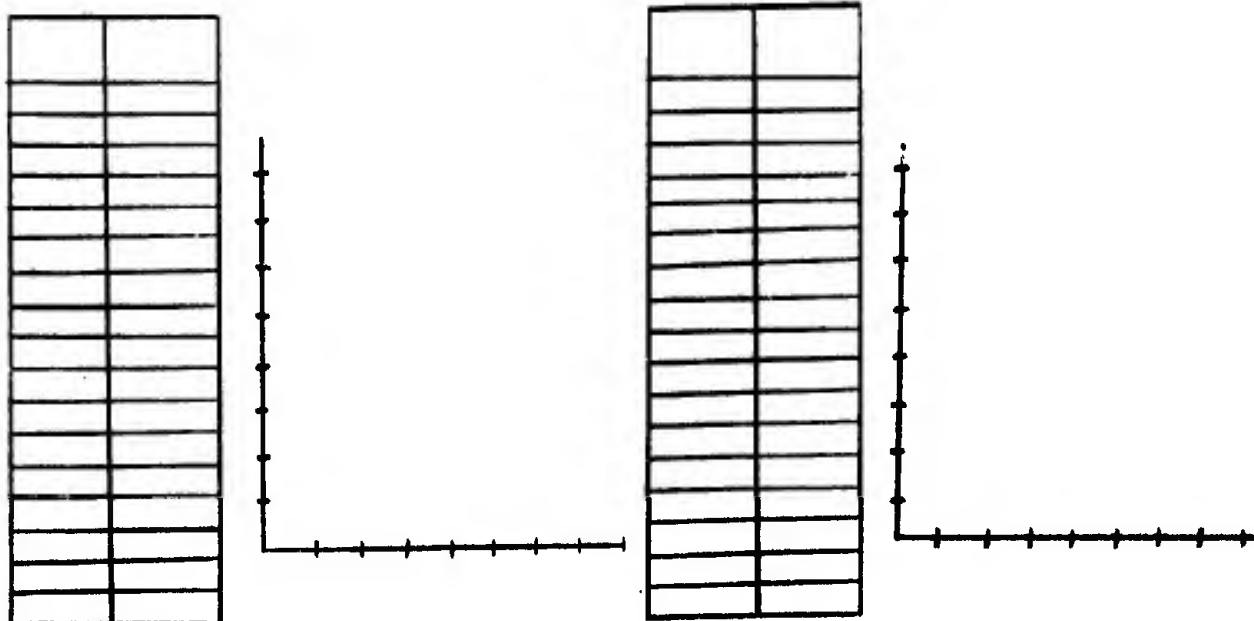
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
77	Iridium-185					15 h	EC; γ 0.0374, 0.0599, 0.0973, 0.1008, 0.1044, 0.2544	9, 6
	-186					15 h	EC; B ⁺ ; γ 0.138, 0.298, 0.436	9, 6
	-187					13 h	EC; γ 10 ⁴ s	9, 6
	-188					41.5 h	EC; B ⁺ ; 2.0, 10 ⁴ s	9, 6
	-189					11 d	EC; γ 10 ⁴ 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	9, 6
Continued on next page							~1	

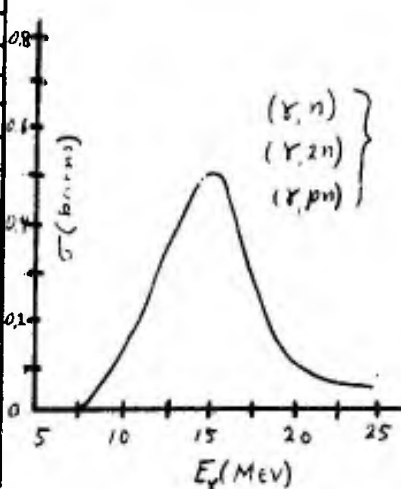
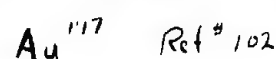


Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
78	Platinum-186					2.5 h	EC	9
	-188					10.0 d	EC; 0.20, 0.28, 0.40	9, 6
	-189					11.0 h	EC; 0.14, 0.55, 0.70	9, 6
	-190				0.0127	5.9×10^{11} y	α 3.30	9
	-191					3.00 d	EC; 0.083, 0.096, 0.173	9, 6
	-192	192.023100	2050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

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78 ^{Pt}				
<u>REMARKS</u>				
<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(Y,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
(Y,p)	Pt ¹⁹⁴	-7.200		6
	Pt ¹⁹⁵	-7.631		6
	Pt ¹⁹⁶			
	Pt ¹⁹⁸			



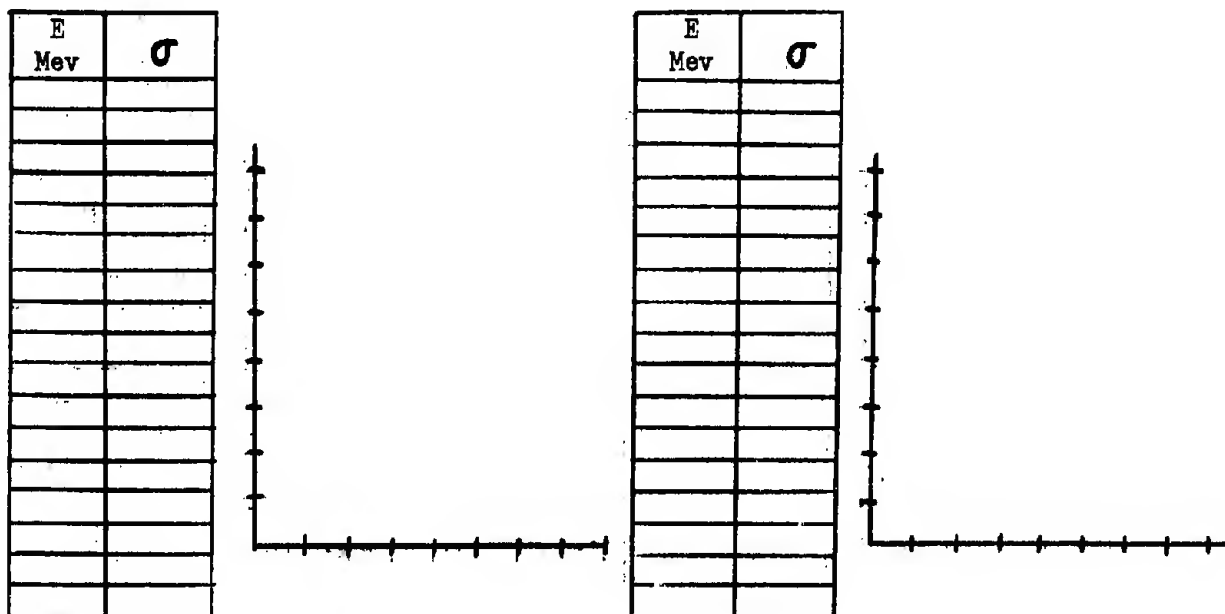
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$$Au^{197}(\gamma, n)_{REF. *1}$$


79 Au

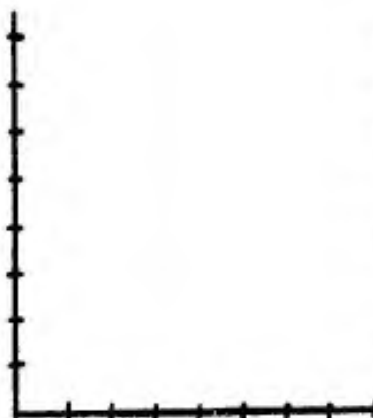
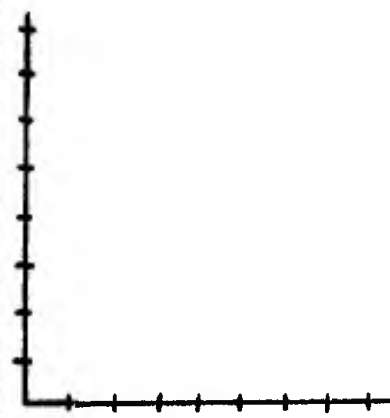
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
79	Gold	-200	200.034380	3030		48 m	B-2.18, 0.6; γ 0.39, 1.13, 1.23	2, 9, 6
		-201	201.035600	3010		26 m	B-1.5; γ 0.55	2, 9
	202	-204				~25 s	B- or IT	9
		-203				55 s	B-1.9; γ 0.69	9

REMARKS

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



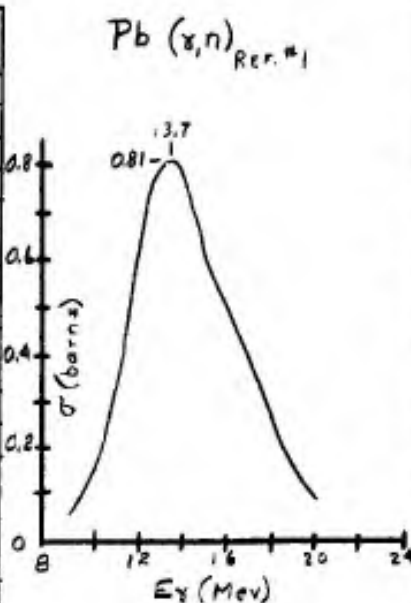
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
80	Mercury	-189				23 m	EC; γ 0.0286	9
		-191				90 m		9
						3 h		9
		-191				0.7 m	α 5.60	9
		-191				57 m	EC; γ 0.2526, 0.2741	9, 6
		-192				5.7 h	EC; β 1.18; γ 1.4	9
		-193				$\sim$ 6 h	EC; γ 0.0379, 0.1865, 0.570, 0.860	9
		-194				0.4 s	γ	
						$\sim$ 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	β 0.208; γ 0.280	2, 9
		-204	204.037323	230	6.85			2, 9
		-205	205.040359	160		5.5 m	β 1.8; γ 0.203	2, 9
		-206					β^-	9

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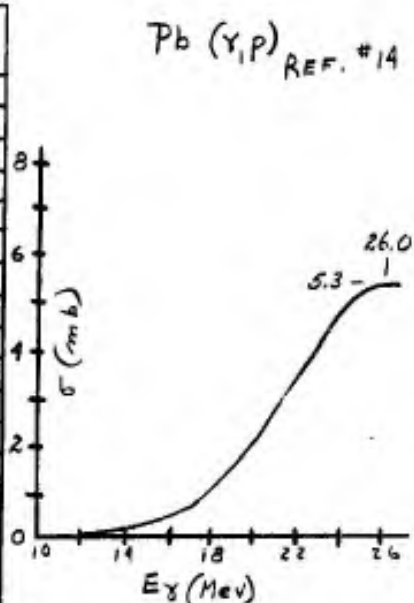
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
82	Lead	-195				17 m	EC; γ	9
		-196				37 m	EC; γ 0.191, 0.24, 0.25	9, 6
		-197				42 m	EC; IT; γ	9
		-198				25 m	EC	
						2.4 h	EC; γ 0.117, 0.173, 0.259, 0.290, 0.365, 0.382	9, 6
		-199				90 m	EC; B+2.8; γ 0.267, 0.353, 0.367, 0.721, 1.132	9, 6
		-200				21.5 h	EC; γ 0.0328, 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 > 10 ⁸ eV	9
		-202	202.036501	460		$\sim 3 \times 10^5$ y	EC; γ	2, 9
		-203	203.037347	530		52.1 h	EC; γ 0.2795, 0.401	2, 9, 6
		-204	204.036859	130	1.40			2, 9
		-205	205.038539	50		5×10^7 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



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

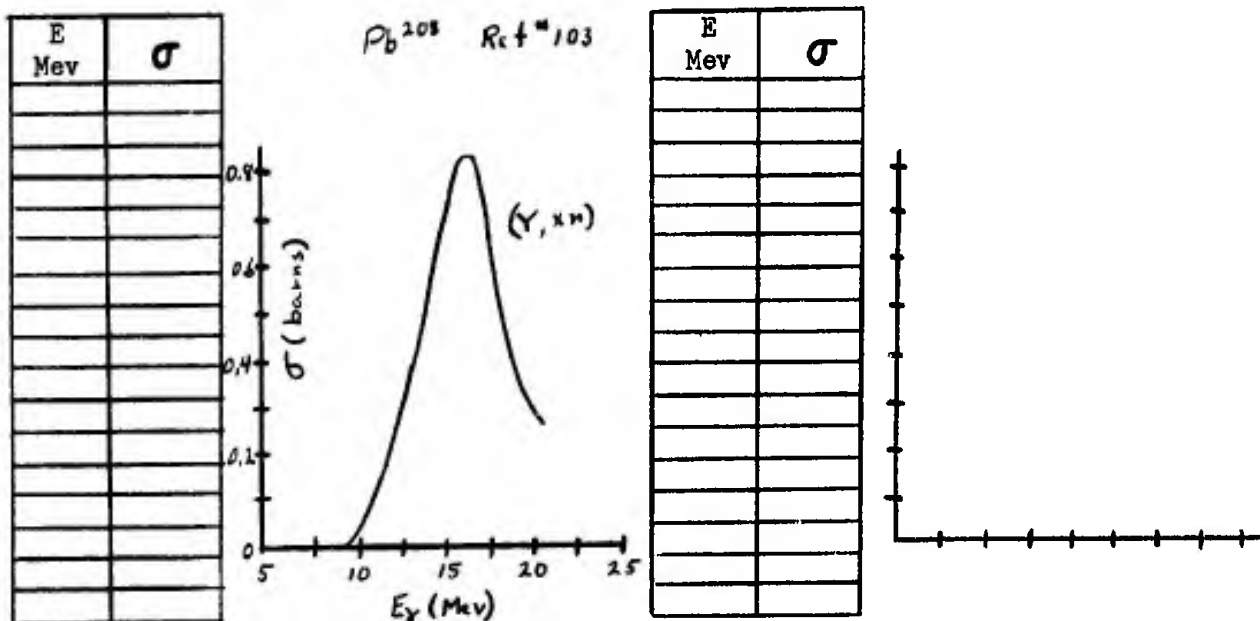


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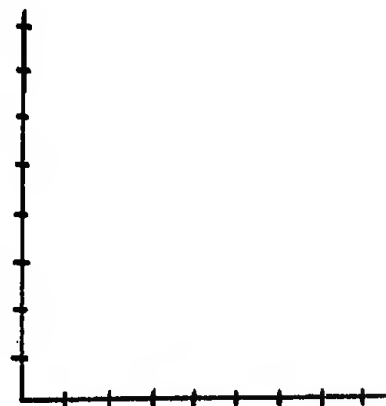
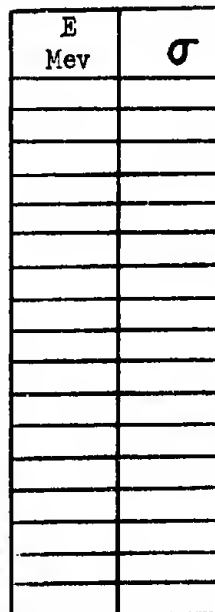
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
82	Lead	-210	210.049830	20		19.4 y	B-0.017; γ 0.0465	2, 9, 6
		-211	211.054754	100		36.1 m	B-1.3 α , ~0.5; γ 0.065, 0.083, 0.404	2, 9, 6
		-212	212.058170	30		10.64 h	B-0.355, 0.589; γ 0.238, 0.300	2, 9, 6
		-213	213.063028	390				2
		-214	214.066581	80		26.8 m	B- ; γ 0.242, 0.295, 0.352	2, 9, 6

REMARKS

<u>Thresholds</u>	<u>Isotope</u>	<u>Theoretical</u>	<u>Experimental</u>	<u>Reference</u>
(γ, n)	Pb ²⁰⁶		-8.09	48
	Pb ²⁰⁷		-6.790	48
	Pb ²⁰⁸		-7.404	48

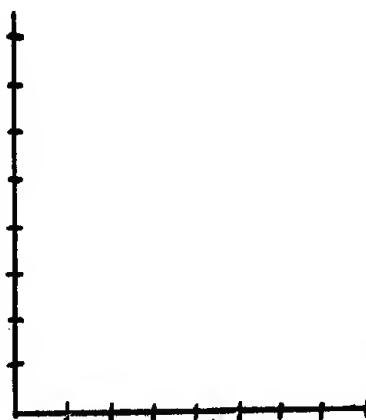
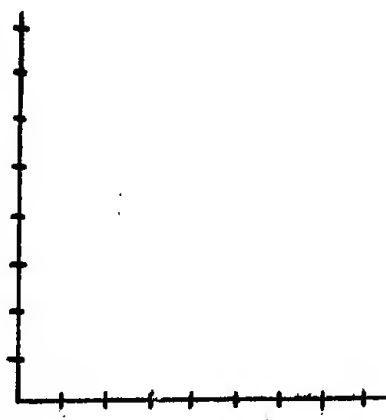


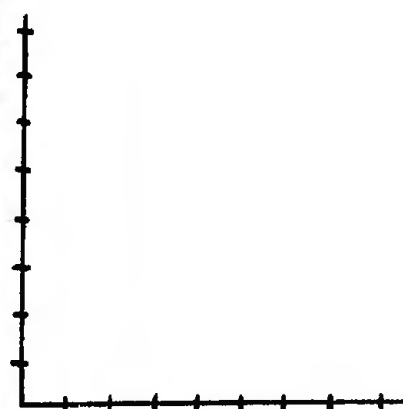
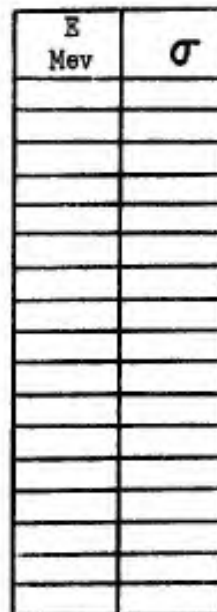
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$$Bi^{209}(\gamma, n)_{REF. \# 1}$$


83 B

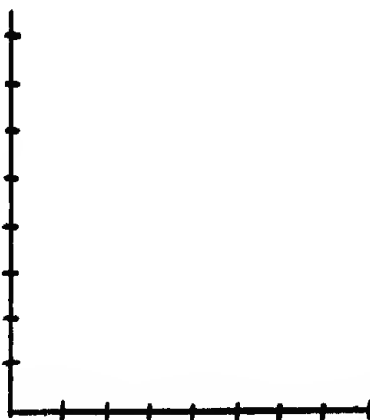
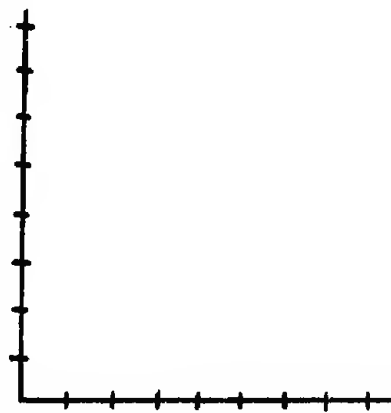
Z	CHEM. SYM.	A	ATOMIC MASS AMU	±	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
83	Bismuth	-213	213.060966	60		47 m	B-1.39, 0.96; α 5.86; γ 0.44	2, 9, 6
		-214	214.065518	40		19.7 m	B- ; α ; 108's	2, 9
		-215	215.068911	250		8 m	B-	2, 9
		-216	216.073802	350				2

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Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
85	Astatine	202				43 s	6.50	9
		203				1.7 m	6.35	9
		203				7 m	6.10	9
		204				~25 m	EC	9
		205				25 m	5.90	9
		206				2.9 h	EC	9
		207				1.8 h	EC; 5.75	9
		208				6.3 h	EC;	9
						1.6 h	EC; 5.65; 0.120,	9, 6
							0.175, 0.250, 0.660	
		209				5.5 h	EC; 5.642; 0.195,	9, 6
							0.547, 0.782	
		210	210.052611	230		8.3 h	EC; 5.519, 5.437,	2, 9
							5.355, 710's	
		211	211.053543	50		7.20 h	5.862; EC;	2, 9
							0.67, 710's	
		212	212.056934	550		0.22 s	5	2, 9
		213	213.059746	130			9.2	2, 9
		214	214.063251	60		~2x10 ⁻⁶ s	8.78	2, 9
		215	215.065892	60		~10 ⁻⁴ s	8.00	2, 9
		216	216.069950	50		~3x10 ⁻⁴ s	7.79	2, 9
		217	217.072512	80		0.018 s	7.05	2, 9
		218	218.076645	240		1.5-2.0s	6.63	2, 9
		219	219.079651	260		0.9 m	6.27; B ⁻	2, 9
		220	220.084124	290				2

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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 ; 5.10×10^8 s	9, 6
		-212				23 m	α 6.264	9
		-213	213.057062	120				2
		-214	214.062370	330				2
		-215	215.065891	120		$\sim 10^{-6}$ s	α 8.6	2, 9
		-216	216.067770	40		$\sim 10^{-4}$ s	α 8.01	2, 9
		-217	217.071824	80		$\sim 10^{-3}$ 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	β^- ; 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

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${}_{86}Rn$

REMARKS

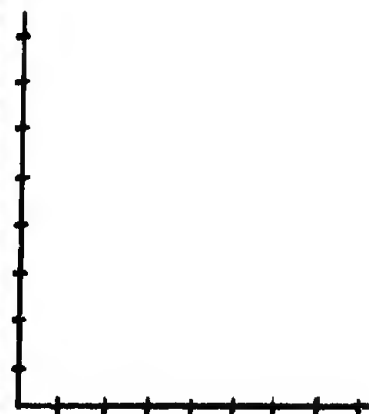
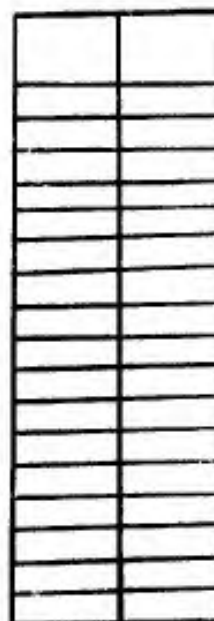
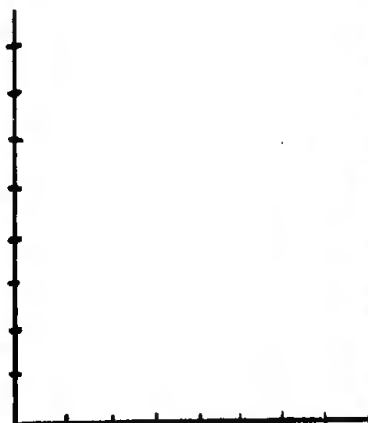
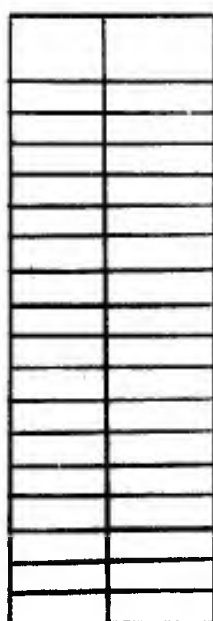
Thresholds

Isotope

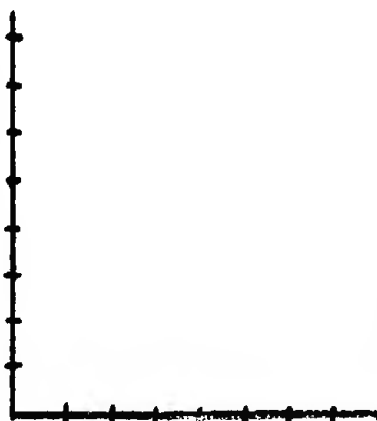
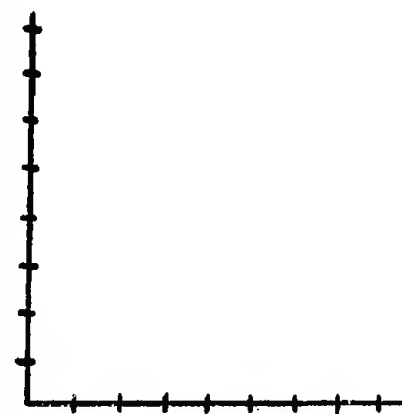
Theoretical

Experimental

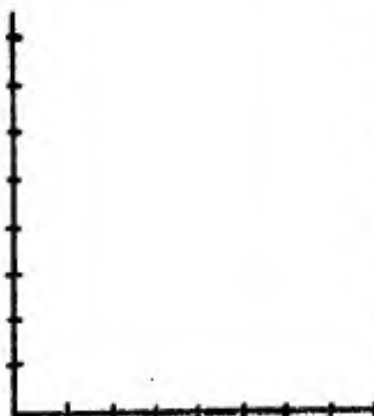
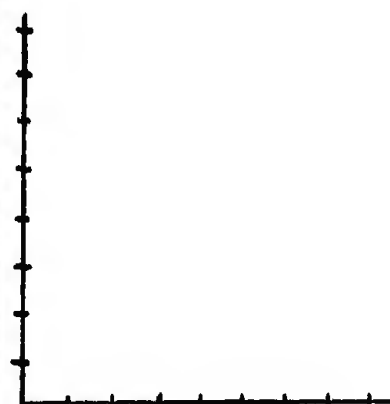
Reference



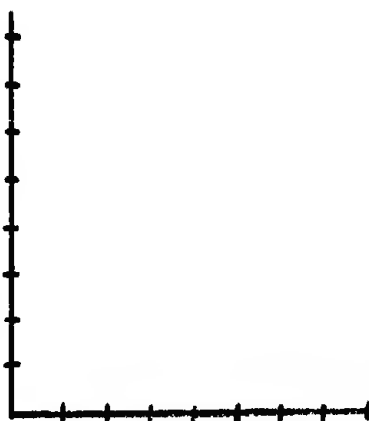
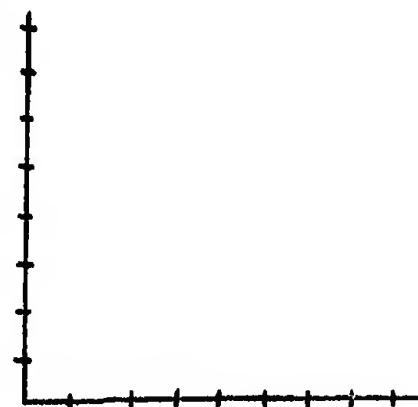
Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
87	Francium	-212				19.3 m	EC; α 6.342	9
		-217	217.072709	170			α 8.3	2, 9
		-218	218.075720	100		5×10^{-3} s	α 7.85	2, 9
		-219	219.077760	80		0.02 s	α 7.30	2, 9
		-220	220.081142	60		27.5 s	α 6.69	2, 9
		-221	221.083240	90		4.8 m	α ; γ 0.218	2, 9, 6
		-222	222.087074	290		14.8 m	β^-	2, 9
		-223	223.089597	130		22 m	β^- 1.15, 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

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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
		-218	218.075506	370				2
		-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		11.68 d	α ; γ 0.144, 0.155, 0.180, 0.270, 0.340	2, 9, 6
		-224	224.090300	40		3.64 d	α ; γ 0.241	2, 9, 6
		-225	225.093885	100		14.8 d	B-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	B-1.31; δ 0.0275, 0.295, 0.499	2, 9, 6
		-228	228.102555	90		6.7 y	B-0.012; δ 0.03	2, 9, 6
		-229	229.106415	210		Short	B-	2, 9
		-230	230.109141	260		1 h	B-1.2	2, 9
		-231	231.113457	350				2

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Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
89	Actinium	-221	221.084899	230			α 7.6	2, 9
		-222	222.087213	120		5.5 s	α 6.46	2, 9
		-223	223.088898	90		2.2 m	α 6.64	2, 9
		-224	224.091764	90		2.9 h	EC, α 6.17; γ 0.133, 0.217	2, 9, 6
		-225	225.093498	90		10.0 d	α ; γ 0.0366, 0.0384, 0.0628, 0.0873, 0.0944, 0.150, 0.187	2, 9, 6
		-226	226.096891	340		29 h	B $\sim$ 1.2; γ 0.158, 0.185, 0.230, 0.253	2, 9, 6
		-227	227.988780	130		21.6 y	B $\sim$ 0.046; α 4.492; γ 0.037	2, 9, 6
		-228	228.102512	60		6.13 h	B $\sim$ 2.18, 1.85, 1.72, 1.15, 0.66, 0.46; γ 0.058, 0.129, 0.184, 0.338, 0.462, 0.914, 0.969	2, 9
		-229	229.104482	270		66 m	B $\sim$	2, 9
		-230	230.108179	490		>1 m	B $\sim$ 2.2	2, 9
		-231	231.110826	350				2
		-232	232.114859	420				2

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Ac

REMARKS

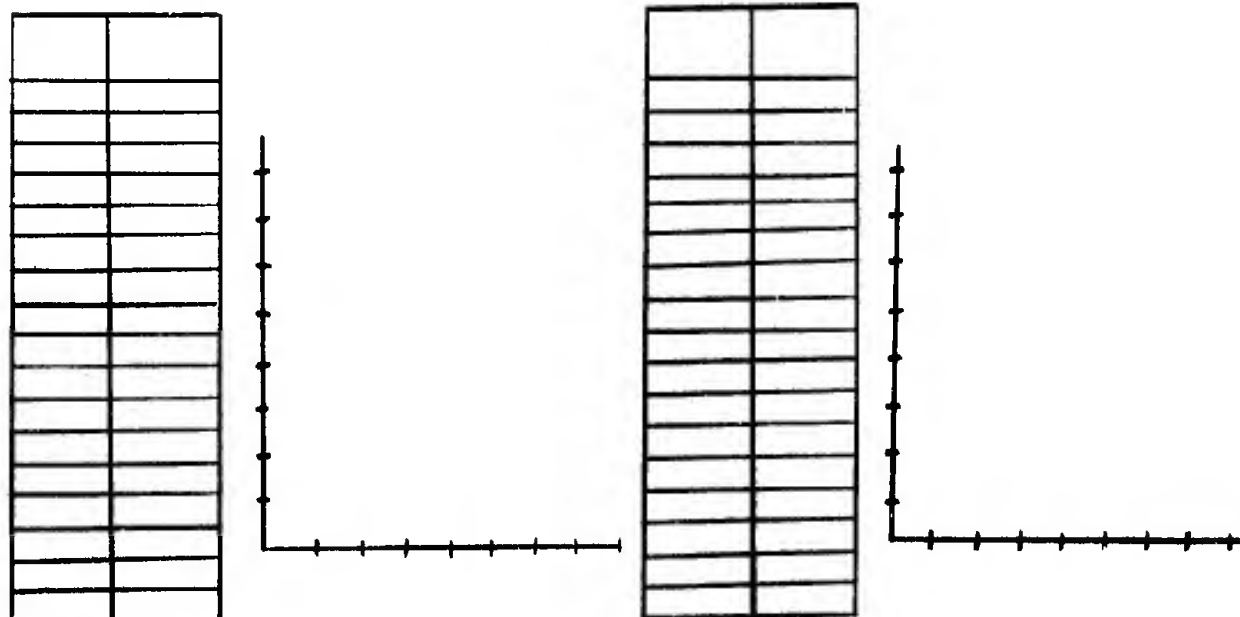
Thresholds

Isotope

Theoretical

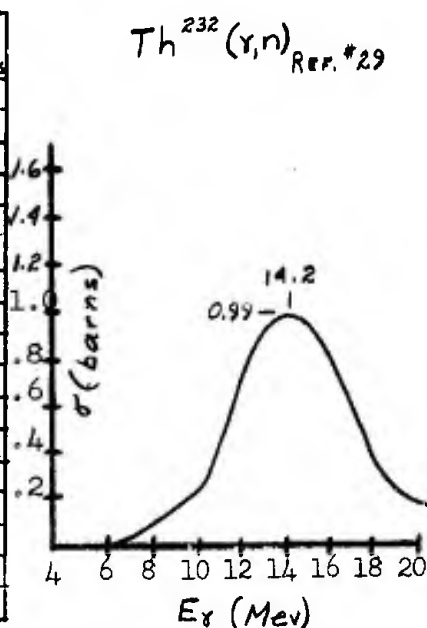
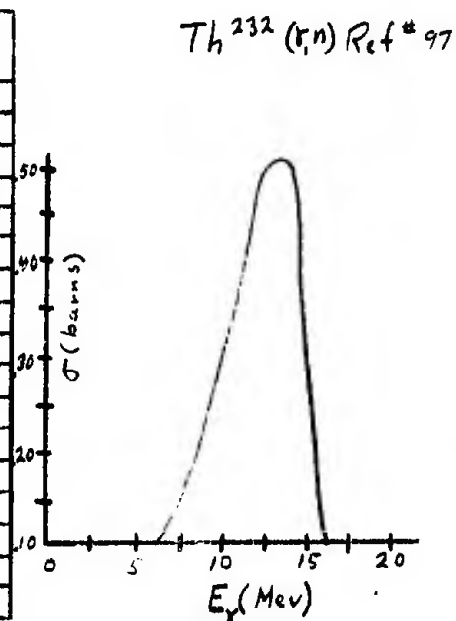
Experimental

Reference



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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	1.39×10^9 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_{barms}
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

[illegible]

${}_{90}\text{Th}$

REMARKS

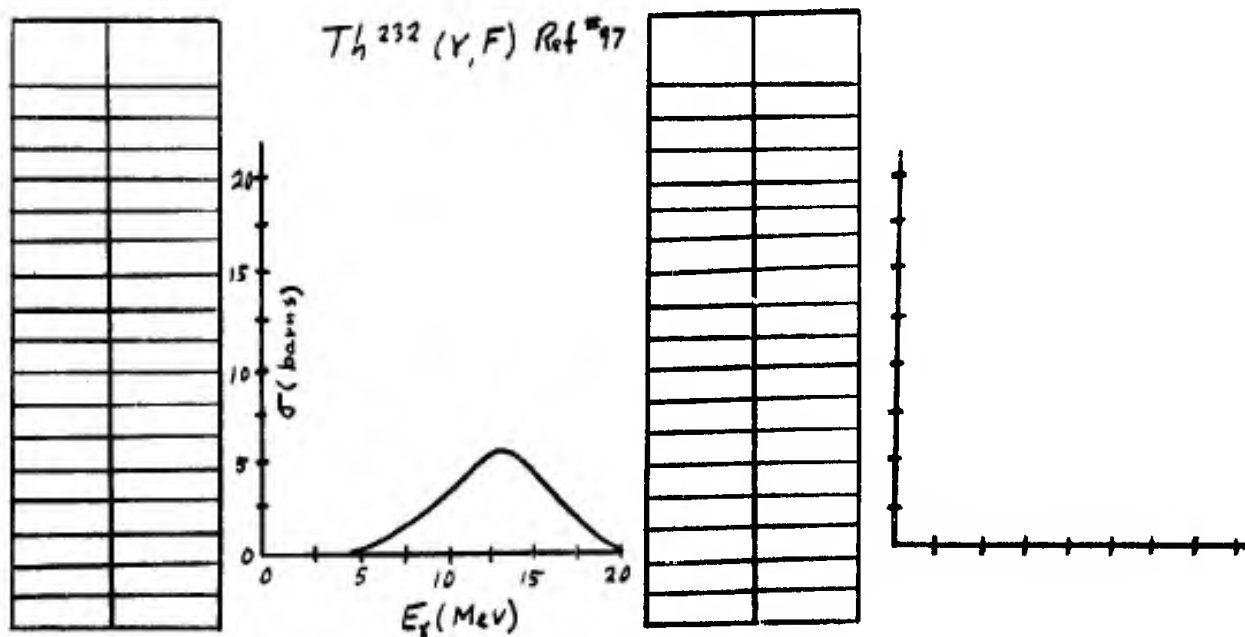
Thresholds

Isotope

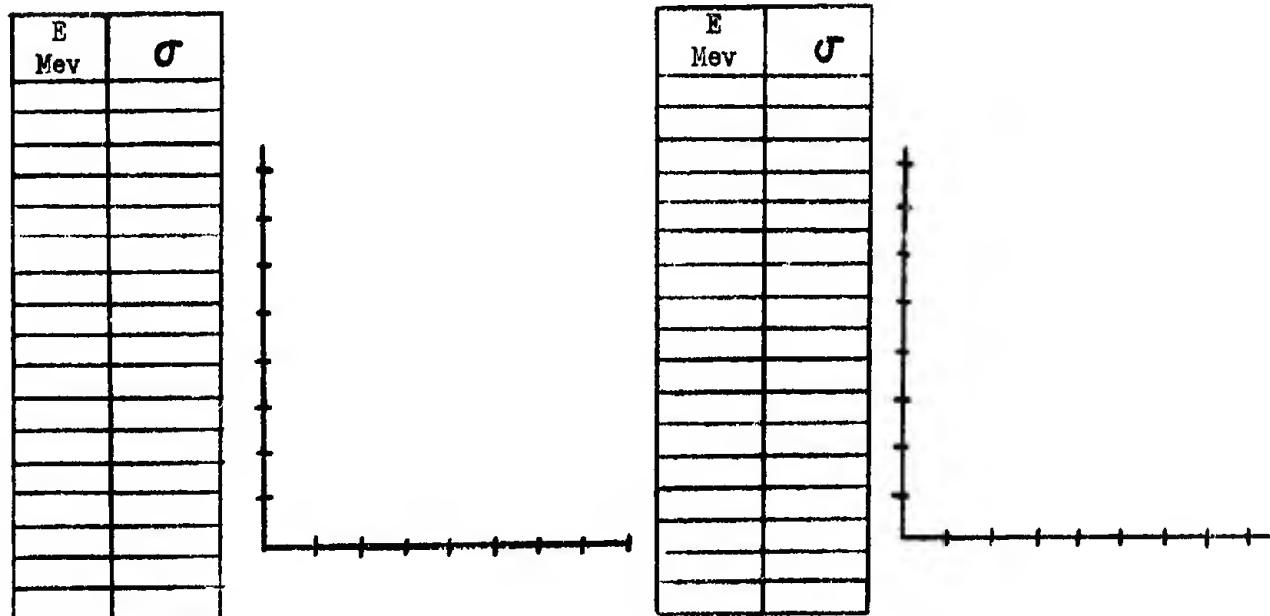
Theoretical

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 ; $\delta > 10^8$'s	2, 9, 6
		-229	229.103594	110		1.5 d	EC; α 5.69	2, 9
		-230	230.106622	390		17.7 d	EC; β 0.41; δ 0.94	2, 9
		-231	231.108266	130		3.4×10^4 y	α ; $\delta > 10^8$'s	2, 9
		-232	232.111180	60		1.31 d	β^- ; $\delta > 10^8$'s	2, 9
		-233	233.113000	130		27.0 d	β^- ; $\delta > 10^8$'s	2, 9
		-234	234.116567	370		6.66 h	β^- ; $\delta > 10^8$'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



$91 Pa$

REMARKS

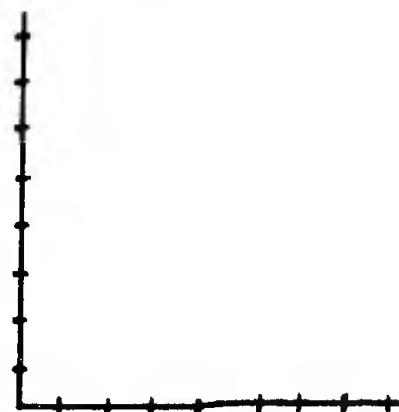
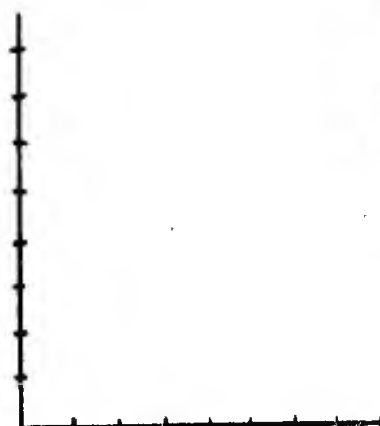
Thresholds

Isotope

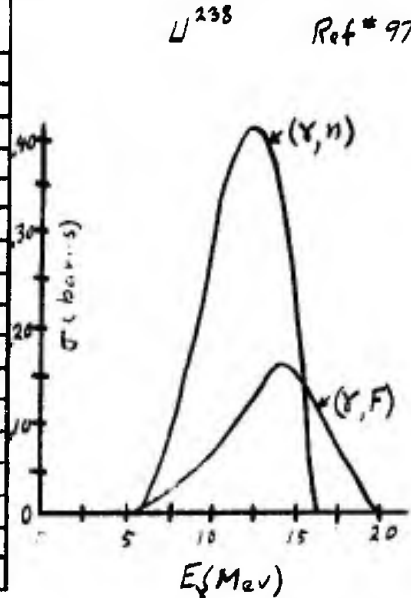
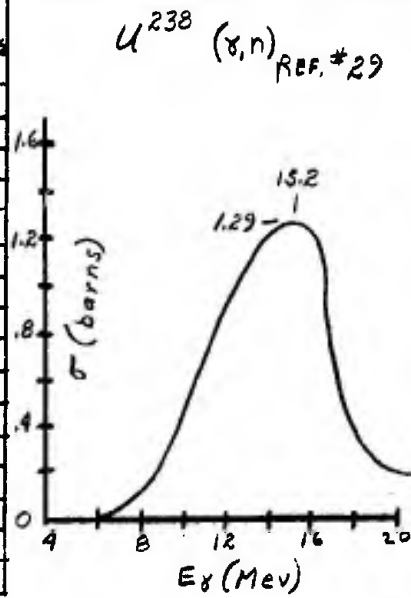
Theoretical

Experimental

Reference



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	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	B ⁻ ; γ 108'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	B ⁻ 1.21; γ	2, 9, 6
		-240	240.131807	110		14.1 h	B ⁻ 0.36	2, 9
		-241	241.135466	550				2
		-242	242.138444	710				2
		-243	243.142876	970				2
		-244	244.146650	1070				2



92 L

REMARKS

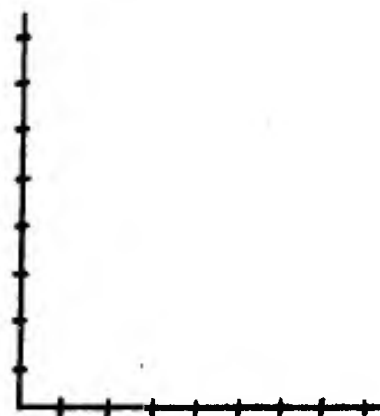
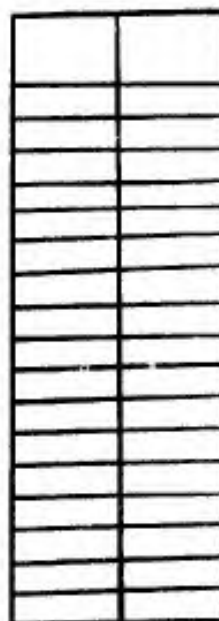
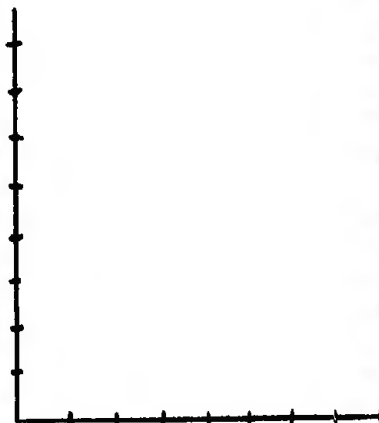
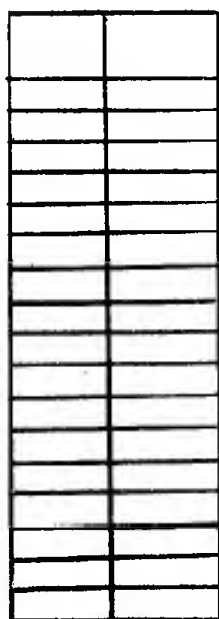
Thresholds

Isotope

Theoretical

Experimental

Reference



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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; β^- 0.8; γ 10 ⁶ '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; β^- 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	β^- ; γ 10 ⁶ 's	2, 9, 6
		-239	239.127769	150		2.346 d	β^- ; γ 10 ⁶ 's	2, 9, 6
		-240	240.131421	100		7.3 m	β^- ; γ	2, 9
						60 m	β^- 0.89; γ 10 ⁶ '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

${}_{93}\text{Np}$

REMARKS

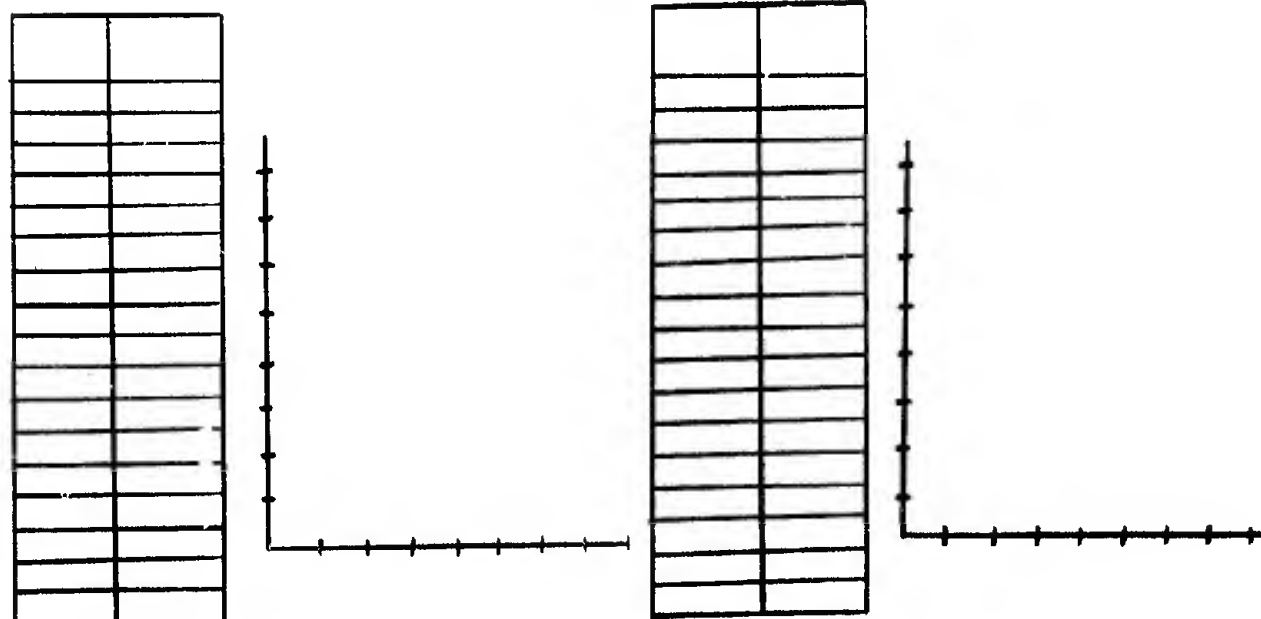
Thresholds

Isotope

Theoretical

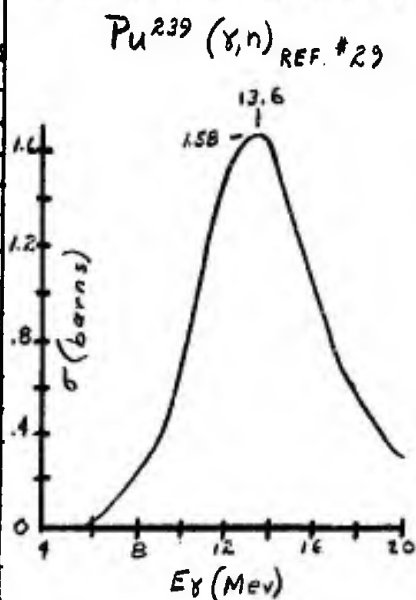
Experimental

Reference

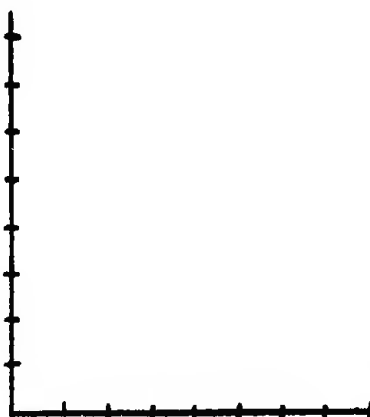
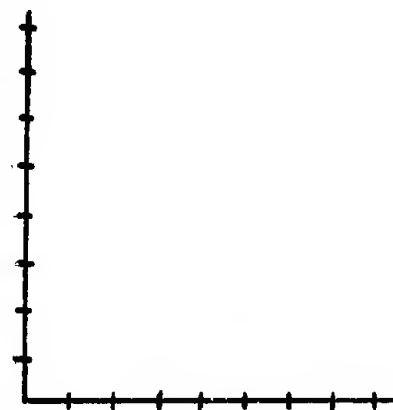


Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
94	Plutonium-230	230.111571	640					2
	-231	231.113416	330					2
	-232	232.113696	110			36 m	α 6.58; EC	2, 9
	-233	233.115849	170			20 m	EC; α 6.30	2, 9
	-234	234.116595	100			9.0 h	EC; α 6.19	2, 9
	-235	235.118898	160			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	B ⁻ ; α ; γ 0.100, 0.145	2, 9, 6
	-242	242.134449	120			3.79x10 ⁵ y	α ; γ	2, 9
	-243	243.138087	160			4.98 h	B ⁻ ; γ > 10 ⁵ s	2, 9, 6
	-244	244.140647	270			~7.6x10 ⁷ y		2, 9
	-245	245.144123	500			10.1 h	B ⁻	2, 9
	-246	246.147123	560			10.85 d	B ⁻ ; α	2, 9
	-247	247.151587	860					2
	-248	248.155414	980					2
	-249	249.159847	1040					2
	-250	250.163501	1270					2

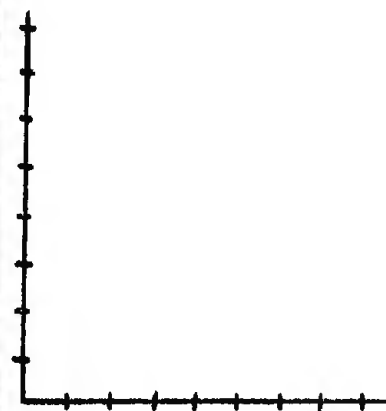
E Mev	σ_{Aarn}
6	0
7	.10
8	.20
9	.40
10	.60
11	1.00
12	1.35
13	1.55
14	1.55
15	1.30
16	1.00
17	.70
18	.55
19	.38
20	.25
21	.21

[illegible]

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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; 6.01	2, 9
		238	238.126642	450		1.9 h	EC; 80.58, 0.98	2
		239	239.127835	160		12 h	EC; 5.75; 80.3	2
		240	240.130556	160		51 h	EC; 80.92, 1.02, 1.40	2, 6
		241	241.132126	150		458 y	α ; 5.10 MeV	2, 6
		242	242.135187	110		~100 y	B-0.59	2
		243	243.137479	150		7.95x10 ³ y	α ; 80.0748	2, 6
		244	244.140925	170		26 m	B-1.5	2
		245	245.142834	190		1.98 h	B-0.91; 80.036, 0.06, 0.78, 0.140, 0.153, 0.23, 0.25	2, 6
		246	246.146800	310		25 m	B-; 80.035, 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

[illegible][illegible]

Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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; 6.50	2, 9
		-239	239.129756	200		2.9 h	EC; 80.188	2
		-240	240.130664	110		26.8 d	6.25	2
		-241	241.133074	210		35 d	EC; 5.95; 80.47, ~0.60	2, 6
		-242	242.134506	110		162.5 d	6.1; 80.044, 0.101, 0.157	2, 6
		-243	243.137483	150		35 y	6.1; 80.210, 0.228, 0.277	2, 6
		-244	244.139314	110		17.9 y	6.1; 80.043, 0.100, 0.150	2, 6
		-245	245.142093	290		8x10 ³ y	6.1; 80.13, 0.173	2, 6
		-246	246.144126	140		6600 y	6.5.37	2
		-247	247.147495	340		6x10 ⁷ y	6	2
		-248	248.150088	450		4.7x10 ³ y	6.5.05	2
		-249	249.153586	690		64 m	B-0.9	2
		-250	250.156639	310		Sp. Fission	Sp. Fission	2
		-251	251.160910	710				2
		-252	252.164522	880				2
		-253	253.168740	960				2
		-254	254.172179	1190				2
		-255	255.177320	1250				2

[illegible][illegible]

76 Cm

REMARKS

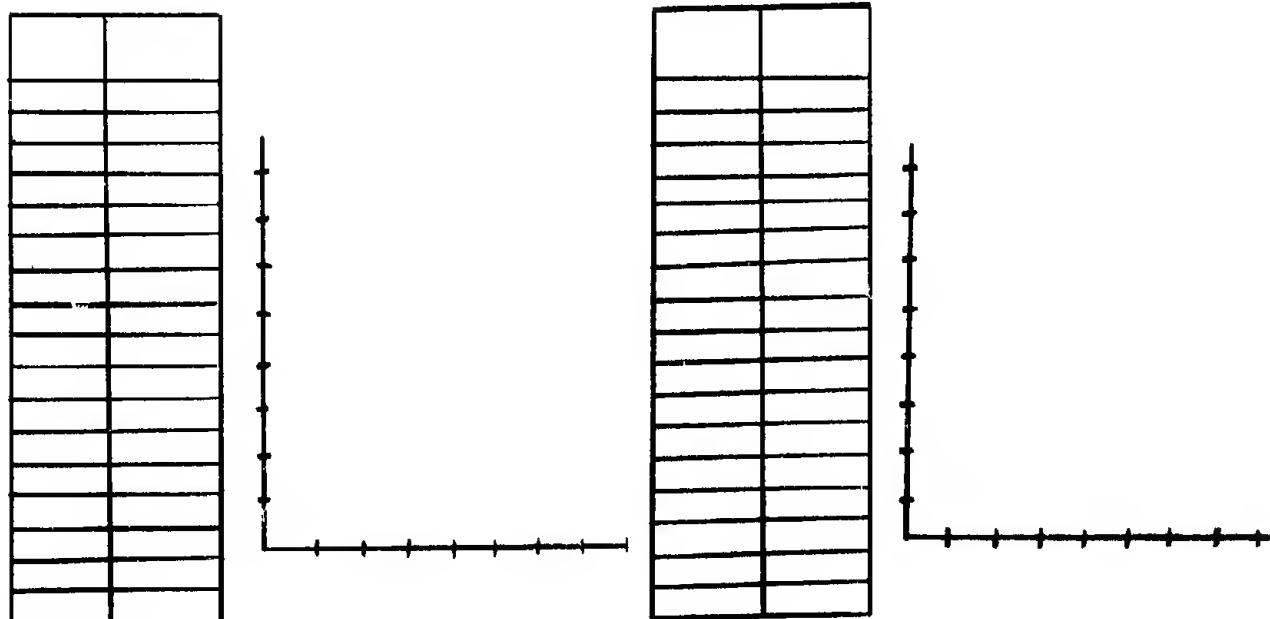
Thresholds

Isotope

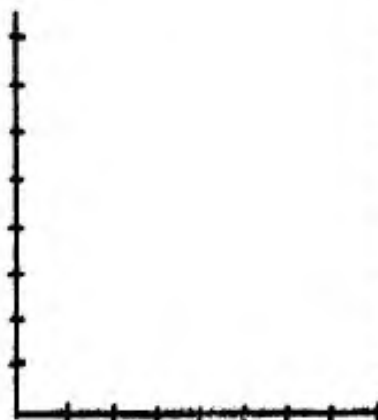
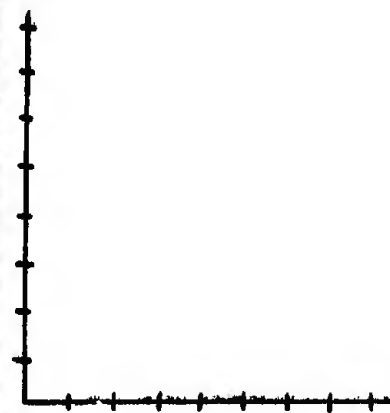
Theoretical

Experimental

Reference



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% 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	B- 0.65	2
		-249	249.152608	190		314 d	B- 0.11; α ; γ 0.32	2, 6
		-250	250.156639	190		3.13 h	B- ; 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

[illegible][illegible]

97 Вк

REMARKS

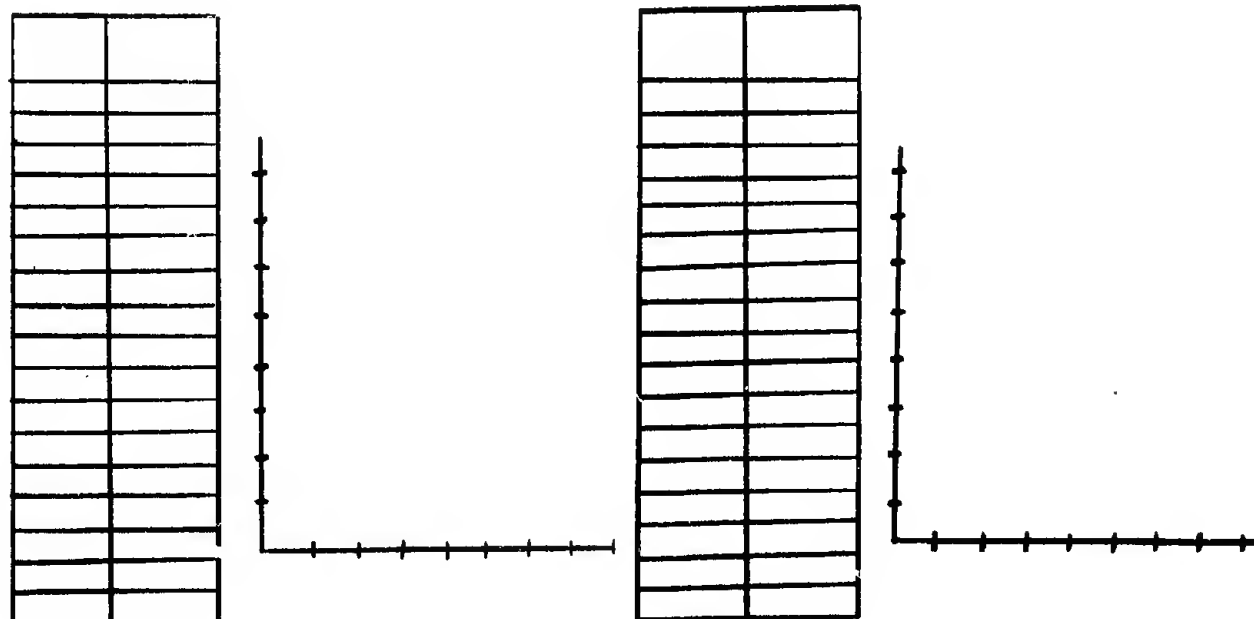
Thresholds

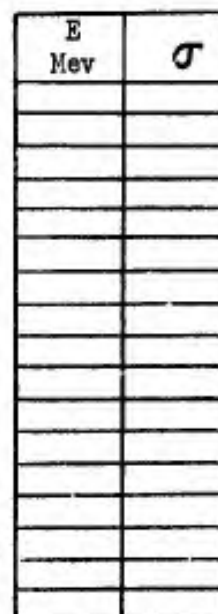
Isotope

Theoretical

Experimental

Reference





98 Cf

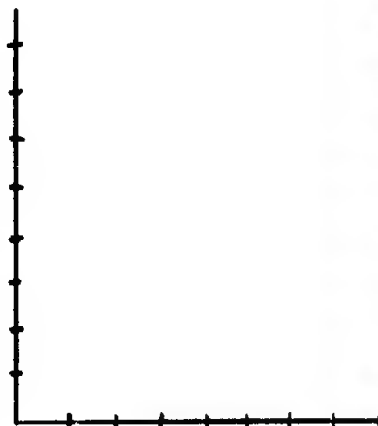
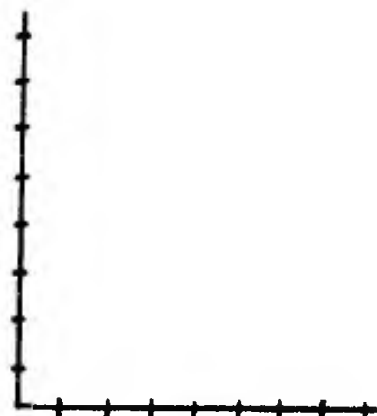
REMARKS

Thresholds

IsotopeTheoretical

Experimental

Reference

[illegible][illegible]

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 ; 60.0419; 0.051, 0.398, 0.422	2,9,6
		-254	254.167508	210		480 d	α 6.42; 80.062	9
		-255	255.169835	660		37 h	B ⁻ 1.04; 80.66	9
		-256	256.174200	730		Short	B ⁻	9
		-257	257.176323	960				
		-258	258.180600	810				
		-259	259.183690	1080				
		-260	260.188355	1000				

99E

REMARKS

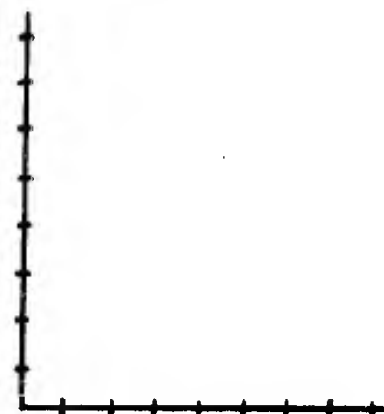
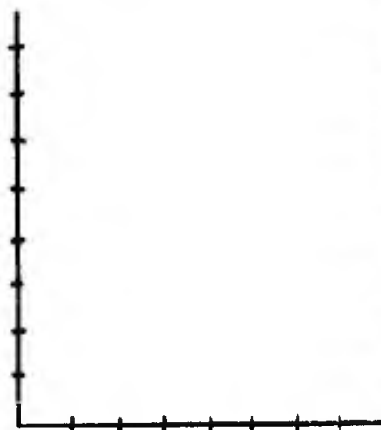
Thresholds

Isotope

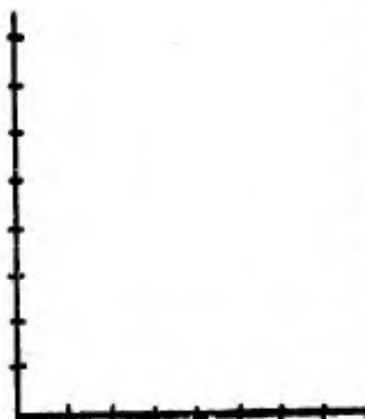
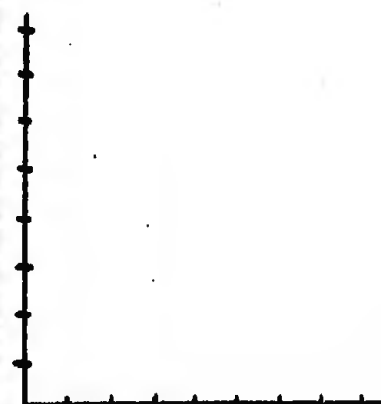
Theoretical

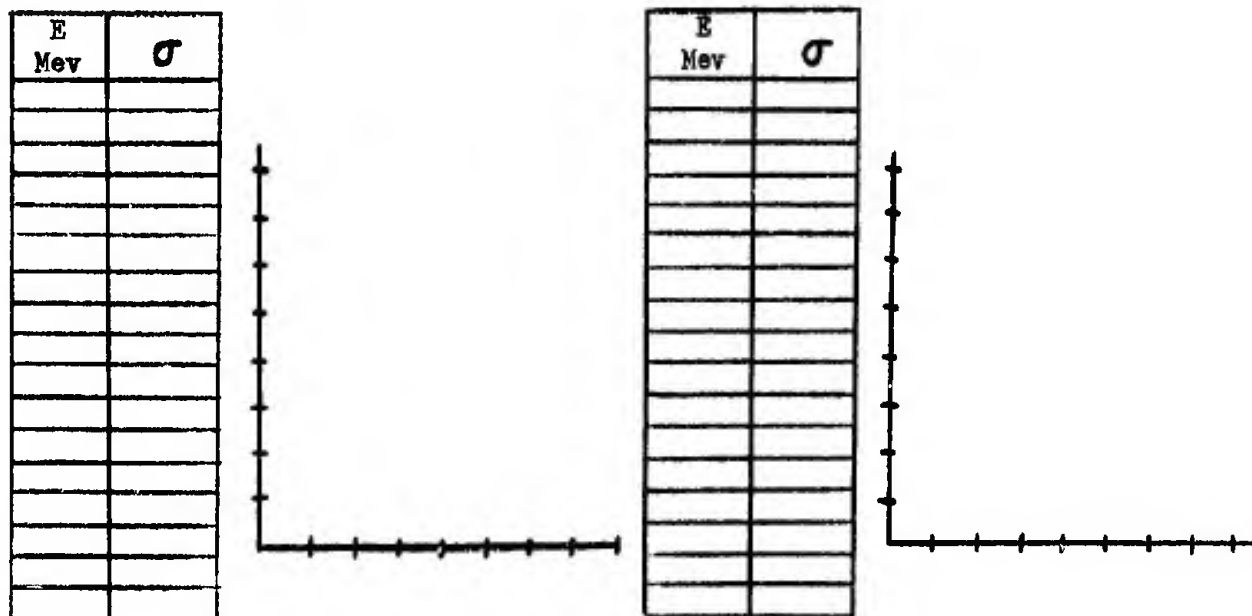
Experimental

Reference



Z	CHEM. SYM.	A	ATOMIC MASS AMU	$\pm$	% ABUN.	HALF LIFE	DECAY Type & Energy (Q)	REF.
100	Fermium	-246	246.152586	540				2
		-247	247.151373	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		$^{54}\sim 3.4$ 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

[illegible][illegible]



101 M_v

REMARKS

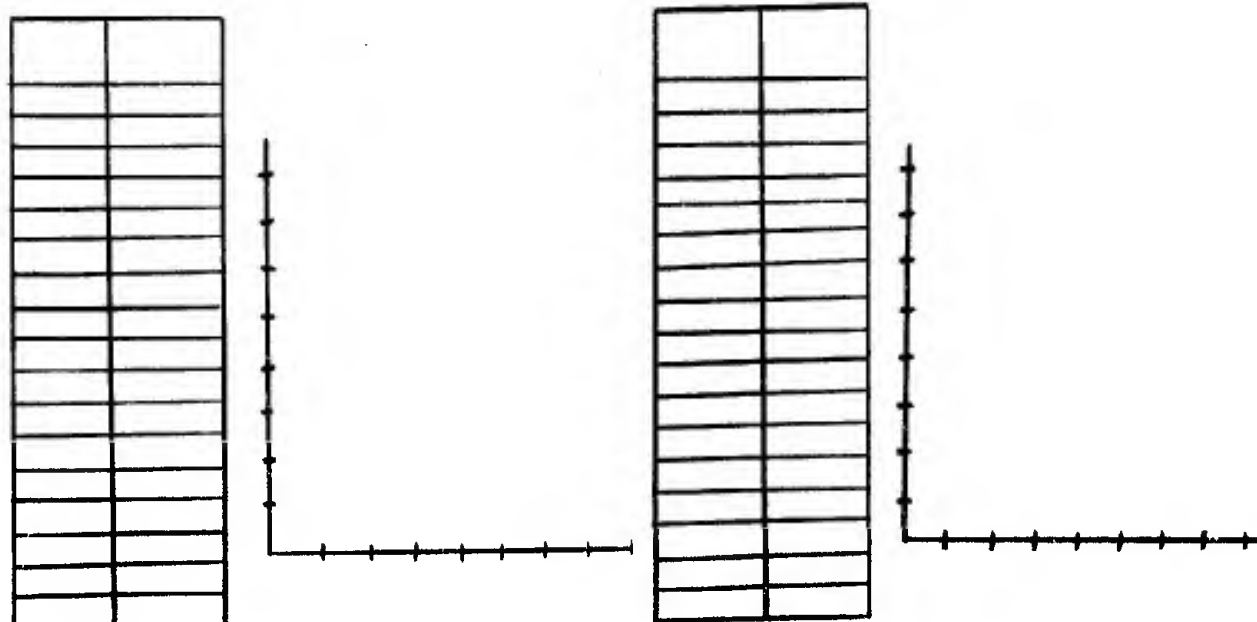
Thresholds

Isotope

Theoretical

Experimental

Reference



REMARKS

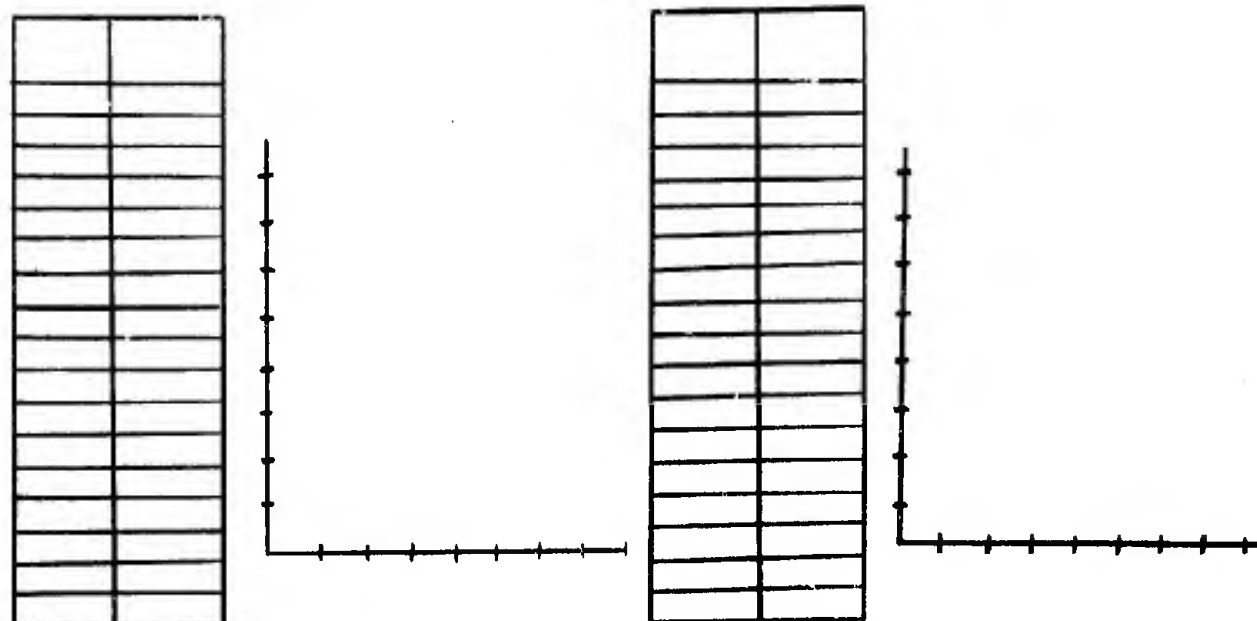
Thresholds

Isotope

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:

$$Y(E) = N_s \int_0^\infty B(E_0, E) \sigma(E) dE$$

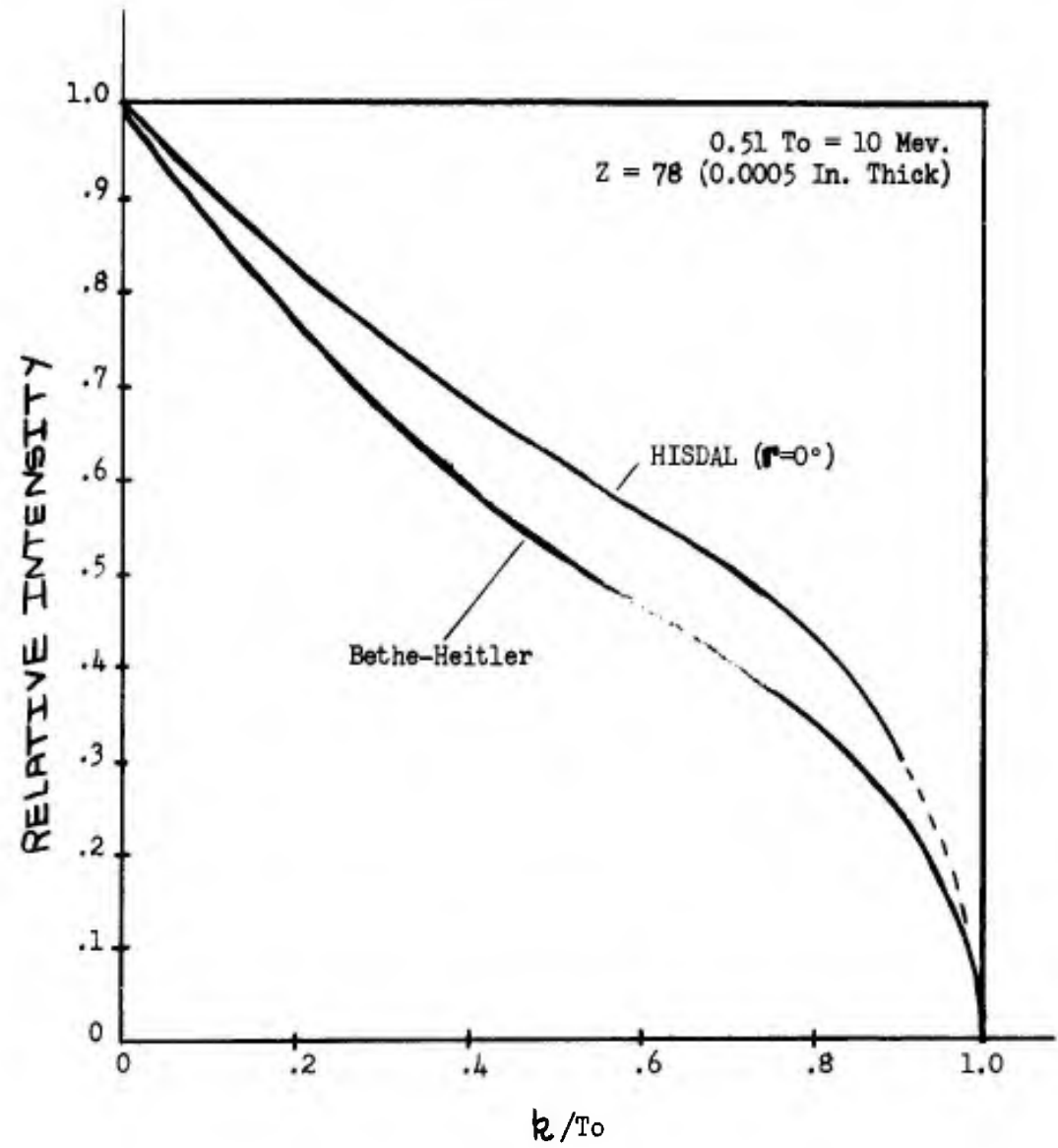
where N_s is the number of nuclei of the appropriate type per cm^2 , $\sigma(E)$ is the photo cross section and $B(E_0, E)$ is the number of photons of energy between E and $E + dE$ due to bremsstrahlung of maximum energy E_0 . Therefore to calculate the amount of activity produced under particular conditions, 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,

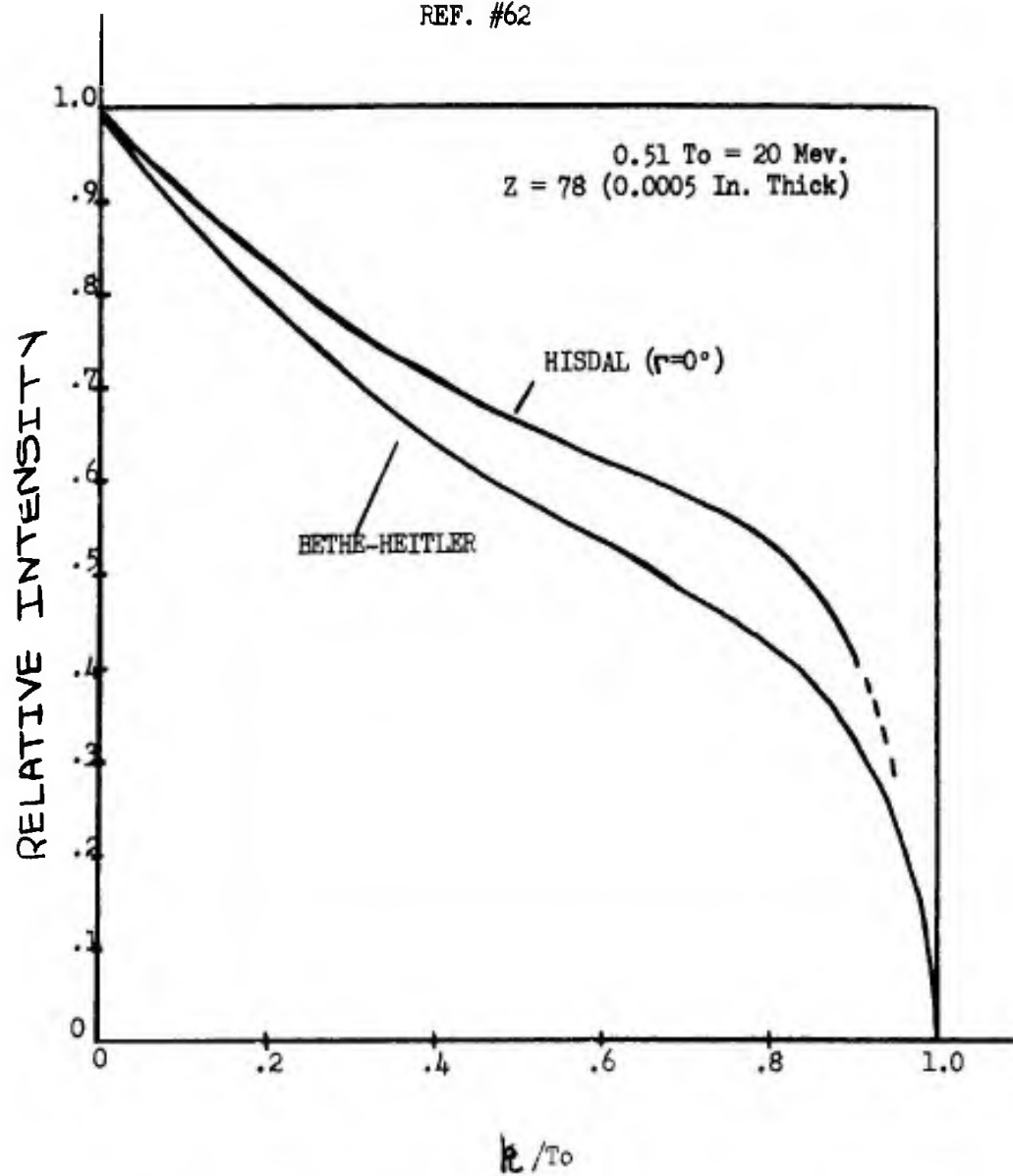
so only the Bethe-Heitler curves are shown. Also included is a tabulation showing the relative number of photons at each energy for bremsstrahlung spectra due to electrons with energy between 9 and 30 Mev. This should simplify the numerical integration of the equation for the yield given above.

REF. #62



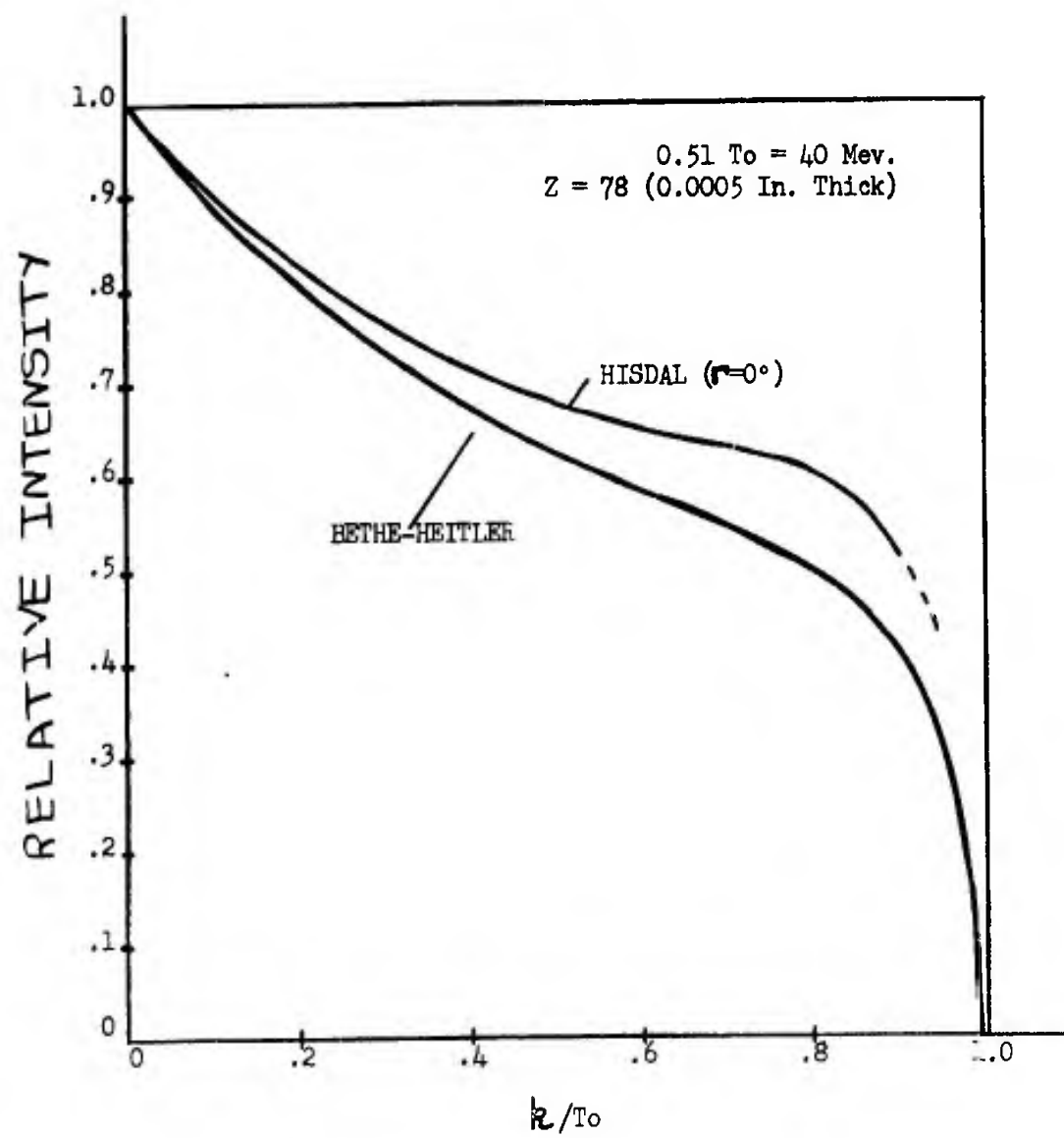
10 MEV BREMSSTRAHLUNG SPECTRA

REF. #62



20 MEV. BREMSSTRAHLUNG SPECTRA

REF. #62



40 MEV. BREMSSTRAHLUNG SPECTRA

RELATIVE NUMBERS OF PHOTONS OF VARIOUS ENERGIES

ELECTRON ENERGY, E_0 , 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

X-Ray Photon Energy (K)		(Continued)										
		In Mev	20.51	21.51	22.51	23.51	24.51	25.51	26.51	27.51	28.51	29.51
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 (μ curies/g/5 Mrads)
Hydrogen	1	9.3	None			
Boron	5	6×10^{-6}	None			
Carbon	6	18	None			
Nitrogen	7	1.5	None			
Oxygen	8	70	None			
Sodium	11	6.6×10^{-2}	$\text{Na}^{22}(\gamma)$	2.58y	γ, n	2×10^{-7}
Magnesium	12	3.2×10^{-2}	$\text{Na}^{22}(\gamma)$	2.58y	γ, d	2×10^{-10}
Aluminum	13	1×10^{-6}	None			
Silicon	14	6×10^{-6}	None			
Phosphorus	15	0.198	$\text{P}^{32}(\bar{\nu})$	14.2d	n, γ	6×10^{-8}
Sulfur	16	0.221	$\text{P}^{32}(\bar{\nu})$	14.2d	γ, p	1×10^{-7}
"	"	"	$\text{P}^{32}(\bar{\nu})$	14.2d	γ, d	6×10^{-9}
"	"	"	$\text{P}^{33}(\bar{\nu})$	24.4d	γ, p	6×10^{-7}
"	"	"	$\text{S}^{35}(\bar{\nu})$	87d	γ, n	9×10^{-10}
"	"	"	$\text{S}^{35}(\bar{\nu})$	87d	n, γ	5×10^{-10}
Chlorine	17	5.6×10^{-2}	$\text{S}^{35}(\bar{\nu})$	87d	γ, d	2×10^{-9}
Potassium	19	0.382	$\text{A}^{37}(x)$	35.0d	γ, d	1×10^{-7}
Calcium	20	1.4×10^{-2}	$\text{Ca}^{45}(\bar{\nu})$	164d	γ, n	7×10^{-12}
"	"	"	$\text{Ca}^{45}(\bar{\nu})$	164d	n, γ	1×10^{-11}
Chromium	24	3×10^{-7}	$\text{V}^{48}(\gamma)$	16.0d	γ, d	1×10^{-12}
"	"	"	$\text{Cr}^{51}(\gamma)$	27d	γ, n	3×10^{-11}
"	"	"	$\text{Cr}^{51}(\gamma)$	27d	$\gamma, 2n$	2×10^{-14}
"	"	"	$\text{Cr}^{51}(\gamma)$	27d	n, γ	3×10^{-17}

Appendix B (Continued)

Element	Atomic Number	% in Food	Isotope	Half Life	Photonuclear Reaction	Estimated Radioactivity (microcuries/g/5Mrads)
Manganese	25	2×10^{-5}	Mn ⁵⁴ (γ)	291d	γ, n	2×10^{-10}
Iron	26	4.2×10^{-3}	Mn ⁵⁴ (γ)	291d	γ, d	2×10^{-10}
"	"	"	Fe ⁵⁵ (x)	2.9y	γ, n	1×10^{-8}
"	"	"	Fe ⁵⁵ (x)	2.9y	$\gamma, 2n$	1×10^{-12}
"	"	"	Fe ⁵⁵ (x)	2.9y	n, γ	2×10^{-12}
"	"	"	Fe ⁵⁹ (γ)	45.1d	n, γ	2×10^{-12}
Cobalt	27	2×10^{-7}	Co ⁵⁷ (γ)	270d	$\gamma, 2n$	1×10^{-14}
"	"	"	Co ⁵⁸ (γ)	71d	γ, n	1×10^{-11}
"	"	"	Co ⁶⁰ (γ)	5.24y	n, γ	9×10^{-16}
Nickel	28	3×10^{-7}	Co ⁵⁶ (γ)	77.3d	γ, d	4×10^{-14}
"	"	"	Co ⁵⁷ (γ)	270d	γ, p	1×10^{-12}
"	"	"	Co ⁵⁸ (γ)	71d	γ, d	2×10^{-13}
Copper	29	5×10^{-5}	None			
Zinc	30	1.5×10^{-3}	Zn ⁶⁵ (γ)	245d	γ, n	4×10^{-9}
"	"	"	Zn ⁶⁵ (γ)	245d	$\gamma, 2n$	5×10^{-14}
"	"	"	Zn ⁶⁵ (γ)	245d	n, γ	3×10^{-13}
Molybdenum	42	1.5×10^{-6}	Nb ⁹¹ (γ)	64d	γ, p	1×10^{-11}
"	"	"	Nb ⁹² (γ)	10.1d	γ, d	4×10^{-13}
"	"	"	Nb ⁹⁵ (γ)	35d	γ, p	2×10^{-11}
"	"	"	Nb ⁹⁵ (γ)	35d	γ, d	1×10^{-13}
"	"	"	Mo ⁹³ (x)	72y	γ, n	1×10^{-12}
"	"	"	Mo ⁹³ (x)	72y	$\gamma, 2n$	9×10^{-15}
Silver	47	1.4×10^{-6}	Ag ¹⁰⁵ (γ)	40d	$\gamma, 2n$	5×10^{-13}
"	"	"	Ag ^{110m} (γ)	253d	n, γ	4×10^{-14}

Appendix B (Continued)

Element	Atomic Number	% in Food	Isotope	Half Life	Photonuclear Reaction	Estimated Radioactivity (μ curies/g/5Mrads)
Tin	50	2×10^{-7}	$\text{In}^{114\text{m}}(\gamma)$	50.0d	γ, p	4×10^{-14}
"	"	"	$\text{In}^{114\text{m}}(\gamma)$	50.0d	γ, d	2×10^{-14}
"	"	"	$\text{Sn}^{113}(\gamma)$	119d	γ, n	7×10^{-14}
"	"	"	$\text{Sn}^{113}(\gamma)$	119d	$\gamma, 2n$	2×10^{-16}
"	"	"	$\text{Sn}^{113}(\gamma)$	119d	n, γ	3×10^{-14}
"	"	"	$\text{Sn}^{121\text{m}}(\beta)$	7400d	γ, n	2×10^{-13}
"	"	"	$\text{Sn}^{121\text{m}}(\beta)$	7400d	n, γ	3×10^{-16}
"	"	"	$\text{Sn}^{123}(\beta)$	136d	γ, n	6×10^{-13}
"	"	"	$\text{Sn}^{123}(\beta)$	136d	n, γ	1×10^{-15}
Iodine	53	3.5×10^{-6}	$\text{I}^{125}(x, \gamma)$	60.0d	$\gamma, 2n$	2×10^{-12}
"	"	"	$\text{I}^{126}(\gamma)$	13.3d	γ, n	7×10^{-9}
Lead	82	1×10^{-6}	$\text{Tl}^{202}(\gamma)$	12.0d	γ, d	7×10^{-14}
"	"	"	$\text{Tl}^{204}(\beta)$	3.56y	γ, d	1×10^{-14}

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