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TABLES OF NEUTRON CROSS SECTIONS

by

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12

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TABLE OF CONTENTS

Explanatory Remarks	1
Purpose and Acknowledgements	
Criteria for Omitting Measurements	
Material of Tables	
Abbreviations and Values of Neutron Energies	
Adopted for Various Neutron Sources	7
Tables of Neutron Cross Sections for All	
Elements from Hydrogen through Bismuth	10
References Cited in Tables	189
References to Transport, Inelastic and Differential	
Scattering Cross Sections	211
Errata and Supplement	215

22

TABLES OF NEUTRON CROSS SECTIONS

Compiled by K. Way and G. Haines

PURPOSE AND ACKNOWLEDGEMENTS: The following tables of neutron cross sections are intended to constitute a summary of neutron cross section data available on September 1, 1947 for elements from hydrogen through bismuth.

The compilers have made great use of three earlier tabulations. The one to which they owe the most is that of Hilda Castle Uchiyamada. Mrs. Uchiyamada's lists were never put in report form but consisted of notebooks in which were entered all project and non-project cross section values as these were reported from the spring of 1943 to the spring of 1945. Earlier project work and non-project work was also added. These notebooks were available to all project workers in Chicago and were much used and depended upon. After Mrs. Uchiyamada left the project in 1945, her notebooks were kept up to date in turn by Mr. Harold Schweinler, Mrs. Nancy Dismuke, and by the present compilers. The present tables contain essentially the data of these notebooks checked and somewhat rearranged.

A cross section compilation earlier than Mrs. Uchiyamada's was that of G. R. Carlson, J. H. Coon, M. Iona, Jr., L. S. Skaggs, and R. G. Wilkinson which was issued as Chicago report A-31, probably in 1942. This report gives a comprehensive survey of the data available on thermal neutrons cross sections at that time. Its bibliography seems to be fairly inclusive. If the cross section

values given in all of its references were combined with those of the present tables, the resulting list would probably be a nearly complete one of all neutron cross-sections measurements ever made. It was not thought practical, however, to include all the results referred to by Carlson and his co-workers in the present tables. It seemed important to keep them from being too cumbersome and, therefore, to omit data which are no longer useful. The criteria used in deciding when to leave something out are described below.

Still a third compilation of neutron cross section data is contained in the graphs of H. H. Goldsmith and H. C. Ibser, MUC-HHG-#7, which were first issued in August, 1945. This compilation is known to most as the wallpaper book and is referred to in the tables as WFB. It is understood that a revised edition, prepared by H. H. Goldsmith and B. T. Feld, will appear shortly in the REVIEWS OF MODERN PHYSICS. The present tables are meant to be used in conjunction with the old or new curves. The tables list all the papers which give data for curves and include in addition measured values of average cross sections which cannot be plotted. They can thus be used to check a given curve to see if it includes all pertinent data and for comparison of experimental averages with integrals over parts of the curve.

The present compilers received assistance not only from the three earlier collections but also from other members of the laboratory. Mrs. Nancy Dismuke did some of the work of checking and tabulating and Mrs. I. L. Pogue did all of the work of arranging the material on the pages and typing the manuscript. Their help has been very much appreciated. Many others have generously given time for discussion of certain experiments and have supplied references which had been missed.

42

CRITERIA FOR OMITTING MEASUREMENTS: As already mentioned not all known data has been included in these tables. On the one hand the compilers did not want to intrude unduly their judgment in selecting data and on the other they did not want to make the tables unnecessarily large and unwieldy. As a compromise the following principles were used as guides:

1. An experimenter's data was left out if poor agreement was found between some of his results and values which now seem fairly well established, and if in addition apparently more accurate work was available for all the elements or isotopes whose cross sections he measured. For instance, all the data of Sinma and Yamasaki (Phys. Rev. 59, 402 (1941)) were omitted. Their activation cross section measurements for thermal neutrons show in general very poor agreement with values now considered to be reliable. (For instance they found 6 b for Mn as opposed to the accepted 13 b and 130 b for Au against the current 95 b.) In addition the activation cross sections of all the isotopes studied by Sinma and Yamasaki have been remeasured by L. Seren and many of them by other experimenters who are in fair agreement with Seren.

The early transmission results of J. R. Dunning, G. B. Pegram, G. A. Fink, D. P. Mitchell (Phys. Rev. 48, 265 (1935)) have, however, been included. Although these data have been superseded in many cases by work in which better geometry, etc. was used, nevertheless in many other cases they are one of only two or three measurements about all of which there is still a good deal of doubt.

2. In the case of single measurements, early results were left out only in cases where there seemed to be overwhelming evidence that they must have been in error. For example, the early values of the hydrogen cross section at indium resonance were omitted. This quantity was originally thought to be ~ 13 b but now a value of ~ 21 b is generally adopted.

SN

3. In the cases of Al and Pb careful German measurements of thermal absorption cross sections were found to be a good deal higher than American values. It was assumed in both cases that the German material tested must have consisted of commercial samples containing impurities and the results were therefore omitted.

4. In cases where an experimenter's later work seemed to provide more accurate values by methods similar to those employed earlier, his earlier results were omitted. Project monthly reports often contain preliminary results which are later superseded by a final value. Similar preliminary data often appears in letters and abstracts in the open literature.

MATERIAL OF TABLES: The neutron cross sections of the various elements and their isotopes are arranged on SLOW and FAST sheets for each element. "SLOW" neutrons are taken to include all those with energies up to and including the energy for which iodine shows a marked resonance (~ 37 ev) and "FAST" neutrons are all those with energy greater than this, say greater than 40 ev. In the upper left hand corner of the SLOW page the stable isotopes of the element in question are listed together with the radioactive isotopes which can be made from these by neutron bombardment (by $n, 2n$ or n, γ reactions). The relative abundances of the stable isotopes are given in per cent just under their atomic numbers and the half lives, radiations, and radiation energies are given under the atomic numbers of the radioactive ones. Where they could be found, decay schemes for the radioactive nuclei are drawn in. Every effort was made to give the most up to date isotopic data possible. Values were taken from the recent table of G. T. Seaborg and I. Perlman, BC-59, May 1947 and from the monthly lists of the Clinton Laboratory Isotope Information Committee. No references are given for these data since they

62

are included chiefly for orientation purposes. References are given, however, for the decay schemes which might be otherwise a little difficult to locate.

Cross sections are divided into total, scattering, and absorption cross sections. Total cross sections, the sum of absorption plus all scattering cross sections, which are measured by transmission methods are given first. They are followed by scattering cross sections which are always for solid angles of 4π . Where the scattering has been measured at some particular angle and this value assumed to hold for other angles, this fact is noted in the reference sheets. Following the regular reference list is an additional one for material on differential, inelastic and transport cross sections which could not be systematized in time for inclusion in the main tables. Under absorption are given first the cross section values for the entire element and below those for individual isotopes when these are known. Activation cross sections for $n\gamma$ reactions are marked with the half-life of the activity produced. The cross sections for np and $n\alpha$ reactions follow symbols such as S^{32}_{np} , etc.

All cross sections are given per atom of element unless otherwise indicated by a symbol for a molecule or isotope in the extreme left hand column. Such symbols apply to all cross sections given before the next symbol.

The column headed "Source" describes the neutron source by means of symbols which are explained on the abbreviation page.

The symbols or figures in the column headed "Neutron Energy" are supposed to give the average or effective energy of the neutrons detected in the experiment. The symbols and other conventions used are again explained on the abbreviation page.

712

Under " σ Measured" is given the experimenter's result. In case any corrections or changes have been made by the compilers because of changes in "standard" values or for other reasons, this fact is noted either in the main table or under the appropriate reference.

At first it was intended to include the experimenter's limits of error. As the work of compilation progressed, however, it became evident that usually these limits of error applied only to reproducibility of the result of the particular method used and did not give a measure of the error in the absolute value of the cross section. It was then decided to omit almost all measures of error but a number had already been included so that the result is that no consistent policy in this matter has been followed on all the sheets.

The SLOW page contains a special column for the value of " σ at .025 ev." (This neutron energy is taken to correspond to a neutron velocity of 2200 m/s.) Often the experimenter calculated from his data the cross section to be expected for monochromatic neutrons of this energy assuming the cross section in question to vary as $1/v$. In some cases in which the experimenter did not do this, the compilers have made an estimate of the .025 ev cross section by finding the factor by which one of the experimenter's values must be multiplied to give an .025 ev. cross section that is fairly well established and then multiplying all the other results of this particular experimenter by this same factor. Factors used and the cross sections on which they are based are given in a note after the appropriate reference.

At the top of the FAST page are given values for absorption resonance energies, the cross sections at these energies and the whole widths of the line where this is known. The recent data on scattering resonances was not included. Here again this material is intended just for purposes of orientation and no references have been given.

b2

ABBREVIATIONS

b	barns
C	neutrons are those that have been slowed down in paraffin or water and for which Cd differences were taken.
c.e.	Crystal effect.
CS	Crystal spectrometer.
E_0	Resonance energy in ev.
Γ	Whole width of resonance line at half maximum in ev.
mb	Millibarns.
MC	Modulated cyclotron.
MVS	Mechanical velocity selector.
Osc.	Oscillator.
P	Pile.
Ra-Be-H ₂ O	A Ra-Be source surrounded by water.
Ra-Be-Par	" " " " " paraffin.
Res	Resonance.
σ_0	Cross section at E_0 .
T	This symbol is used in two ways: (1) to indicate the energy of thermal column neutrons and (2) to designate neutrons for which the experimenter gave no other information except that they were "thermal."
TC	Thermal column.
WPB	Wallpaper book, cross section curves prepared by H. H. Goldsmith and H. W. Ibser, MUC-HHG #7, 1945.

ENERGIES OF PHOTO NEUTRONS: The energies of neutrons coming from photo sources have been assigned 'standard' values irrespective of the energies

92

attributed to them by different experimenters. Pertinent data on γ ray and neutron energies were collected in a memorandum by Nancy Dismuke and K. Way (CLM-KW-5) and used to assign 'best values' to the energies which photo neutrons would have if there were no moderation in the source. The values used in the tables are these values reduced by 20% to allow for degradation. This figure of 20% was chosen somewhat arbitrarily. Most experimenters do not make any estimate of the energy degradation. Different amounts will certainly occur in differently constructed sources so the actual values of the energies of the different photo neutrons used may be 10% higher or lower than the value given in the tables even if the 'best' thin source value was a correct choice.

<u>Source</u>	<u>Neutron Energy if No Moderation in Source*</u>	<u>Neutron Energy if 20% Moderation in Source*</u>
Sb-Be	0.029	0.023
Ra-Be**	0.12 0.51	0.09 0.4
La-D ₂ O	0.16	0.13
Th-D ₂ O	0.22	0.18
Y-Be	0.22	0.18
Na-D ₂ O	0.29	0.23
La-Be	0.77	0.62
Th-Be	0.88	0.70
Na-Be	1.00	0.80

* From CLM-KW-5.

** A γ ray with 2.42 mev energy is given by Latyshev, Rev. Mod. Phys. 19, 132 (1947). The relative intensities of the photo neutron group is not known.

102

OTHER NEUTRON ENERGIES: The energy of a Ra- α -Be source has been given rather arbitrarily in the tables as ~ 4 mev. A recent paper by D. L. Hill (CP-3800) indicates, however, that the Ra- α -Be spectrum has a maximum at ~ 5 mev with an average energy of 4.4 mev. Demers (MP-204) found a maximum at ~ 5 mev also but an average of 5.3 mev. In general for other sources, the experimenter's estimate of the mean or effective neutron energy has been used.

112

1 Hydrogen (H)

1	2	3
99.9844	0.0156	

~12y
 $\sigma^- .011$
 No γ

Compound Used*	Neutron Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL Paraffin	Rn-Be-Par	at liq. air temp.	53		Frisch et al, F-2, '38.
"	Ra-Be-Par	" " " "	55		Powers et al, P-4, '38.
H ₂ O	Rn-Be-Par	" " " "	56		Brickwedde et al, B-2, '38.
Paraffin	Rn-Be-Par	C	38		Fink, F-4, '36.
"	Ra-Be-Par	C	47.5		Goldhaber and Briggs, G-1, '37.
"	"	C	42.5		Powers et al, P-4, '38.
"	Rn-Be-Par	C	48		Frisch et al, F-2, '38.
"	"	C	49.8		Carroll, C-3, '41.
"	Be-p-Par	C	49		Hanstein, H-4, '41.
"	TC	T	55		Anderson et al, A-6, '43.
Paraffin	Rn-Be-Par	RhRes 1.3	20 $\pm$ 2		Cohen et al, C-10, '39.
"	Be-p-Par	InRes 1.44	21 $\pm$ 1		Hanstein, H-4, '41.
H ₂ O	P	" "	20.2		Marshall, M-3, '46.
	Theoretical extrapolation 20.8				Bohm and Richman, B-31, '47.
Paraffin	MC	.005-10	graph WPB	57	Rainwater and Havens, R-4, '45 and R-20, '44.
H ₂ gas	Rn-Be-Par		22		Libby and Long, L-26, '39.
" "	"	C	31.8		Carroll, C-3, '41.
" "	CS	.0030-.1415	34-25		Fermi et al, F-5, '46. Values for gas at room and liq. air temperatures given.
H ₂ liq.	Rn-Be-Par	C	25		Brickwedde, B-2, '38.
H ₂ O	Rn-Be-Par	C	44.6		Carroll, C-3, '41.
"	"	"	43.6		Brickwedde, B-2, '38.

All cross sections on this page are for the hydrogen atom. Values of $\sigma_t(C)$ used ranged only from 4.6 to 4.9 and for $\sigma_t(0)$ from 4.0 to 4.1 so no corrections were made.

122

SLOW (continued)

Hydrogen

(H)

Compound Used*	Neutron Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
H ₂ O	MC	.007-20	graph for HO _{1/2}	47	Bacher et al, B-32, '42.

Values of σ_t for ortho- and para-hydrogen at room and liquid air temperatures are given by Brickwedde et al, B-2 (liquid) and by Libby and Long, I-26, (gas). Los Alamos work will be published soon.

For cross sections of H in other hydrogenous compounds, see Carroll, C-3; Libby and Long, I-26; and Carlson, C-2.

ABSORPTION	Rn-Be-Par D-D	C T	.25	.33 .33	Vols, V-1, '43. Manley et al, M-22, '42.
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ABSORPTION RATIOS from integrated neutron densities in different solutions.

Elements	Ratio	σ of standard at .025 ev	σ at .025 ev	
Li/H	242.4	63	.26	Frisch et al, F-2, '38.
B/H	1940	730	.38	Frisch et al, F-2, '38.
	1954	"	.37	Schulz and Goldhaber, S-42, '45.
	2160	"	.34	Fenning et al, F-16, '43.
	2380	"	.31	Kubitschek, K-5, '44.
	2270	"	.32	Frisch and Walker, F-17, '45.
	2270	"	.32	Whitehouse and Graham, W-15.
Mn/H	44.2	13.0	.29	Kubitschek, K-5, '44.
Cd/H	1.0x10 ⁴	2900	.29	Spees et al, S-6, '38.

For diffusion length experiments see S. K. Allison et al, Report C-82 and V. C. Wilson, CP-2906. Gamertsfelder and Goldhaber, Phys. Rev. 62, 556 (1942).
L = 3 cm $\pm$ 10%

* All cross sections on this page are for the hydrogen atom.

132

Hydrogen

	Source	Neutron Energy	Measured	Reference
TOTAL	C-D	0.18	3.3	Amaldi et al, A-1, '39.
	Th-D	0.18	5.0	Goloborodko and Leipunski, G-3, '39.
	Th-Be	0.7	3.7	Good and Scharff-Goldhaber, G-2, '41.
	D-D	2.4	2.11	Ladenburg and Kanner, L-3, '37.
	D-D	2.38-2.5	2.28	Aoki and Kikuchi, A-2, '39.
	D-D	2.88	2.36	Zinn et al, Z-1, '39.
	Rn-Be	~4	1.68	Dunning et al, D-1, '35.
	Be-D	4.1	1.73	Agno et al, A-11, '47. WPB
	B-D	12.5	0.69	Agno et al, A-11, '47. WPB
	Li-D	13.5	0.694	" " " " " "
	Li-D	14	0.70	Salant & Ramsey, S-35, '40. WPB
	Li-D	15	0.66	" " " " " "
	Li-D	25.4	0.39	Sherr, S-29, '45. WPB
	Li-p	.03-0.5	graph WPB	Frisch, F-12, '46.
	D-D	.22-4	" "	Bretscher and Murrell, B-25.
	p-Li, D-D or C	.35-6.0	" "	Bailey et al, B-14, '46.
	D-Li or Be	6-22	" "	Sleator, S-30, '47.

742

FAST (continued)

Hydrogen

(H)

	Source	Neutron Energy	σ Measured	Reference
SCATTERING				
	Possible slight asymmetry in scattering in center of gravity system found for 12 mev neutrons. J. S. Laughlin and P. G. Kruger, Phys. Rev. <u>71</u> , 736 (1947). This letter gives references to other work on this point.			
	Curve for transport cross section calculated by P. Olum and V. F. Weisskopf, MDDC-241.			
ABSORPTION				
$\int \sigma dE/E$			0	Langsdorf, L-4, '45. $\sigma_s \xi_p = 17$. H ₂ O and paraffin used.

152

1 Deuterium (D) (H²)

1	2	3
99.44	0.0156	

~12y
 β^- .011
 No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
D ₂ O	Ra-Be-Par	C	16		Beyer and Whitaker, B-6, '40.
"	p-Be-Par	C	15.4		Hanstein, H-4, '41.
"	TC			14.53	Anderson, A-8.
"	Ra-Be-Par	C	11.4		Demers, D-2, '46.
D ₂ O	p-Be-Par	InRes 1.44	10.6		Hanstein, H-4, '41.
"	P	" "	10.3		Marshall, M-3, '46.
"	Ra-Be-Par	AuRes 4.8	7.6		Demers, D-2, '46.
	MC	.005-40	graph WPB	14.6	Rainwater & Havens, R-18, and
	"	"	$\sigma = 10 + 0.72/E^{\frac{1}{2}}$		R-4, '45. " " " " " " "
SCATTERING					
D ₂ O	Ra-Be-Par	T	15.3		Raether, R-19, '46.
		C	18.2		Goldhaber and Briggs, G-1, '37.
TRANSPORT					
	TC	T	12.2		Wattenberg et al, W-16, '45. From extrapolation of n density at boundary.
			12.6		Auger et al, A-13, '44. Above method.
ABSORPTION					
	Ra-Be-H ₂ O	T		1.0 mb	Balban and Kowarski, H-10, From n density in solution.
D ₂ O	Ra- γ -Be			0.63 "	Fenning and Knowles, F-18, '44. Above method.
"	P			1.6	Anderson et al, A-12, '43. Danger method. H possibly present.
D ~12y	P			0.65	Langsdorf, L-27, '43. Found.
	P				$\sigma_a(Li)/\sigma_a(D) = 10^5 \pm 22\%$.
	P	L (meas.)	$\lambda_{tr} (meas.)$	Calc. σ_a at .025	
D ₂ O	1.1	171 ± 20	2.4	0.92 mb	Sargent et al, S-43, '47.
"	"	178	2.5	0.90 "	Wattenberg et al, W-16, '45.

162

FAST

Deuterium

(D)

	Source	Neutron Energy	σ Measured	Reference
TOTAL	D-D	2.38-2.5	1.98	Kikuchi and Aoki, A-2, '39.
	D-D	2.88 ± 0.04	2.2	Zinn et al, Z-1, '39. WPB.
	Rn-Be	~4	1.71	Dunning et al, D-1, '35. WPB
	Be-D	4.1	1.79	Agono et al, A-11, '47.
	B-D	12.5	0.78	Agono et al, A-11, '47.
	Li-D	13.5	0.864	" " " "
	D-D	2.1-2.8	graph WPB	Aoki, A-4, '39.
	p-Li, D-D or D-C	0.35-6.0	" "	Williams et al, W-10, '43.

SCATTERING

Curve for transport cross section calculated
by P. Olum and V. F. Weisskopf, MDDC-241.

Differential σ shows max. for back scattering for 2.5 mev neutrons.
J. H. Coon and H. H. Barschall, P.R. 70, 592 (1946).

ABSORPTION

D₂O

 $\int \sigma dE/E$

0.19

Langsdorf, L-4, '46. $\sigma_s \xi_p = 4.75$.

12/24/44

SLOW

16

AECD - 2274

2 Helium (He)

3 4 5 6
~10⁻⁴ ~100

atmos.

 $2.5 \times 10^{-14} \text{ s}$

0.89s

 $\beta^{-3.7}$
No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	1.51		Carroll, C-3, '41.
SCATTERING					
ABSORPTION					

182

FAST
Helium

AECD - 2274

17 (He)

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING	D-D	2.5	3.2	Barschall and Kanner, B-15, '40.
	Li-p	0.6-1.6	graph	Koontz and Hall, K-9. Measured angular distributions and total scattering at different energies. Staub and Tatel, S-44, '40. Elastic back scattering only.
	D-D	0.5-1.8	"	
	D-D	0.5-4.3	graph	Staub and Stephens, S-45, '39. Elastic back scattering only.
He/H	Curve for transport cross section calculated by P. Olum and V. F. Weisskopf, MDDC-241.			
ABSORPTION				

1972

SLOW

18

AECD - 2274

3 Lithium (Li)

6 7 8

7.5 92.5

0.89s

 β^{-12}
No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Ra-Be-Par	C		63	Frisch et al, F-2, '38. Li comp. used not given.
LiF	Rn-Be-Par	C	72		Fink, F-4, '36.
"	Ra-Be-Par	C	48		Dunning et al, D-1, '36.
"	P	.025 InRes 1.44	70 13.75	70	Fermi and Marshall, F-11, '44. " " " " "
"	MC	.015-100ev	$\sigma = 4.2 + 11.5/E^2$		Rainwater et al, R-4, '45 and H-26, '46.
"	"	"	graph WPB	77	" " " " " "
SCATTERING					
Li			$4\pi a^2 = 3.4$		Fermi and Marshall, F-3, '47.
LiF		.025 1.44	5.1 5.2		From Fermi & Marshall $\sigma_t - \sigma_a$ From Fermi & Marshall $\sigma_t - \sigma_a$ at In res.
ABSORPTION					
	P Rn-Be-H ₂ O	C .025 ev	75 58	75 77 64.9	Wattenberg, W-2. Volz, V-1, '43. Fermi and Marshall, F-11, '44.
			$\sigma_B/\sigma_{Li} = 10.53 \pm .15$		Fenning et al, F-15, '44.
Li ⁷ .89s		C		<4 mb 1 " 33 "	Rumbaugh et al, R-14, '38. Poole and Paul, P-3, '46. Hughes and Goldfarb, H-29, '45 and H-27, '47.

202

FAST

(Li)

Lithium

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	.09, .4	0.9, 1.0	Goloborodko, G-13, '47.
	"	" "	1.0	Fedorov and Perfilieva, F-1, '37.
	Th-D	.18	2.2	Goloborodko, G-13, '47.
	"	"	2.2	Goloborodko and Leipunski, G-3, '39.
	C-D	"	2.0	Amaldi, A-1, '39.
	Th-Be	.7	2.3	Goloborodko, G-13, '47.
	D-D	2.38-2.50	2.01	Kikuchi and Aoki, A-2, '39.
	Ra-Be	~4	1.84	Dunning et al, D-1, '35.
SCATTERING				
ABSORPTION				
Li n α		.04-.80	graph	Bailey et al, B-22, '46. Supersedes curve of LA-150 WPB.
$\int \sigma dE/E$			28.4	Langsdorf, L-4, '46.

2/12

4. Beryllium (Be) For BeO see following page.

10^{-12}
 10^{-17} s
 $\alpha .062$

$\geq 5.1 \times 10^6$ y
 $\beta^- .58$
 No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C		5.3	Dunning et al, D-1, '35.
	D-D-Par	C		4.5	Carlson et al, C-2.
		InRes 1.44		6.1	Marshall, M-3, '43.
	MVS & CS	.004-10	graph	c.e.	Fermi et al, F-14, '47. Microcryst.
	MC	.004-5	graph WPB	c.e.	Rainwater et al, R-4, '45. Cryst.
	MVS	.003-.2	graph	c.e.	Lichtenberger, L-13, '44.
SCATTERING	Ra-Be-Par	C	6.9		Goldhaber and Briggs, G-1, '37.
			$4\pi a^2 =$	8.1	Fermi and Marshall, F-3, '46.
	Filtered n's		Residual $\sigma_s =$	.47	Fermi and Marshall, F-7, '46.
TRANSPORT			5.32		Goldberger, G-16, '47. Microcryst.
			3.52		Calc. from F-14. Averaged over max. dist. $kT = .025$ ev. Graves and Manley, G-4, '44.
ABSORPTION	P			.0085	Wattenberg, W-2. Danger method.
	ρ	meas. L	meas. σ_{tr}	calc. σ_a at .025	
	1.735	26.0 $\pm$ 0.2	3.52	.012	Graves and Manley, G-4, '44.

222

FAST

AEC - 2274

21
(Be)

Beryllium

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	.09, .4	2.9	Goloborodko and Leipunski, G-3, '39.
	Th-D	.18	2.8	Fedorov and Perfilieva, F-1, '37.
	C-D	.18	2.6	Amaldi et al, A-1, '39.
	Th-Be	.7	2.82	Good and Scharff-Goldhaber, G-2, '41. WPB.
	Ra-Be Li-D	~ 4 14	1.65 .65	Dunning et al, D-1, '35. WPB. Amaldi et al, A-3, '46.
	Photo n's.		graph WPB	Wattenberg, W-8, '47.

SCATTERING

For references to transport and inelastic cross sections, see reference sheet.

ABSORPTION

$\int \sigma dE/E$			1.22	Langsdorf, L-4, '45. $\sigma_s \bar{S}_p = 1.13$.
$\text{Be}^9 n \alpha$	Fission n's	~ 1	10 mb	Goldstein et al, G-5, '46.
$\text{Be}^9 n, 2n$			55 mb	Montgomery et al, M-5, '43.

237

4 Beryllium Oxide (BeO)

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Ra-Be-Par	C		6.7	Demers, D-2, '46.
	Ra-Be-Par P	InRes 1.44 " "		10.0 10.1	Demers, D-2, '46. Marshall, M-3, '46.
	Ra-Be-Par	AuRes 4.8		14.8	Demers, D-2, '46.
	MVS & CS	.004-.2		graph c.e.	Fermi et al, F-14, '47. Micro-cryst. Earlier graphs incorrect.

SCATTERING

TRANSPORT

			~ 10.3		Sachs, S-38, '46. Calc. from F-14. Averaged over a max. dist. $KT = .025$ ev.
			> 6.8 8.7		Spatz et al, S-37, '46 and S-38. Egger and Goldstein, E-5, '47.

ABSORPTION

	ρ	Meas. L	Assumed σ_{tr}	Calc. σ_a at .025 ev	
	2.69	$29.4 \pm 7\%$	10.3	.0101	Hinton and King, H-33, '44.

242

Boron (B)

11 12
18.83 81.17
.022s
B-12

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	MVS	.025	702	702	Fermi et al, F-13, '44.
	P	InRes 1.44	96	712	Marshall, N-3, '43. Used HF_3 , $\sigma(F) = 3.7$.
	MC	$\sigma = 4 + (111.3 \pm 2.5)/E^2$		708	Bacher et al, B-19, '42.
	MC	$\sigma = (118 \pm 4)/E^2$		745	Rainwater and Havens, R-11, '46.
	MC	$\sigma = 4.2 + (115.8 \pm 1.4)/E^2$		737	Sutton et al, S-32, '47.
SCATTERING	TC		2.8		Lichtenberger, L-5, '44.
	P	Epi-Cd	3.7		Anderson and Fermi, A-8, '44.
	"	" "	3.9		Dancoff et al, D-11, '46.
B ¹⁰	P	Epi-Cd	2.6		Dancoff et al, D-11, '46. From enriched samples.
B ¹¹	P	Epi-Cd	4.0		Dancoff et al, D-11, '46. From enriched samples.
ABSORPTION		P		716	Wattenberg, W-2.
B ¹⁰ n,p			<0.2		Bretscher, B-28, '46.
B/H ratios. See H.					
B ¹¹ .02s			<0.05		Beeman and Muehlhause, B-27, '46.

25/2

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	.09, .4	4.7, 6.5	Goloborodko, G-13, '47.
	"	"	3.8	Fedorov and Perfilieva, F-1, '37.
	C-D	.18	2.1	Amaldi et al, A-1, '39.
	"	"	4.2	Goloborodko, G-13, '47.
	Th-Be	.7	2.9	Goloborodko, G-13, '47.
	D-D	2.38-2.50	1.65	Kikuchi and Aoki, A-2, '39.
	D-D	2.88	2.0	Zinn et al, Z-1, '39.
	Ra-Be	~4	1.60	Dunning et al, D-1, '35. WPB.
	Li-D	14	1.16	Amaldi et al, A-3, '46.
	Photo n's	.023-.8	graph WPB	Wattenberg et al, W-8, '47.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.
	Li-p	0.2	$\sigma_t(B)$ 3.7	Barschall et al, B-23, '46. Reported values corrected by 7% for geom. assuming spher. sym. scatt.
		0.6	2.6	
		0.8	2.0	
		1.0	1.7	
		1.2	2.2	
		1.5	2.0	
		3.0	1.7	
	D-D		$\sigma_t(B^{10})$ 1.7	
			$\sigma_t(B^{11})$ 3.6	

SCATTERING

For references on inelastic and transport cross sections, see reference sheet.

ABSORPTION

B n α		.03-3.0	graph	Bailey et al, B-22, '46. Supersedes LA-46 and LA-150.
	Y-Be	.18	.57	Fischer et al, F-8, '45.
B^{11} n α	Fission n's	~1	0.085 mb	Goldstein et al, G-5, '46.

262

SLOW

AECD - 2274

25

6 Carbon (C)

11	12	13	14
	98.9	1.1	

20.5m
3+.955,100 y
3-.154
No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	4.1		Dunning, D-1, '35.
	Ra-Be-Par	C	4.83		Goldhaber and Briggs, G-1, '37.
	Rn-Be-Par	C	4.87		Beyer and Whitaker, B-6, '40.
	p-Be-Par	C	4.9		Hanstein, H-4, '41.
	Ra-Be-Par	C	4.5		Whitaker and Bright, W-1, '41.
	D-D-Par	C	4.2		Carlson et al, C-2.
	p-Be-Par	InRes 1.44	4.9		Hanstein, H-4, '41. WPB.
	P	" "	4.84		Marshall, M-3, '43. WPB.
CF ₄	MC	.002-4	graph WPB		Rainwater et al, R-4, '45.
	CS	.004-.2	graphs		Sturm, S-14, '46. Graphs for
					irrad. and unirrad. samples.
	CS	.002-.005	"		Weber and Arnold, W-12, '47.
					Graphs for extruded sample.
		Theoretical	graphs		Sachs and Goldberger, S-34, '47.
CO ₂					
	Filtered n's	.003	24.8		Fermi and Marshall, F-5, '47.
					$\lambda = 5.2 \text{ \AA}^\circ$.

272

SLOW (Continued)

⁶ Carbon (C)

	Neutron Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
SCATTERING					
TRANSPORT			4.5		Anderson, A-14, '42.

	Ra-Be-H ₂ O	T		4.8 mb ~4.5	Halban and Kowarski, H-10. From diffusion length measurements.
¹³ C	P		~0.1 b		Langsdorf and Purbrick, L-28, '45.
¹⁴ C	P		<200 b		Eggler and Wallace, E-4, '46.

292

Carbon (C)

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	2.1	Amaldi et al, A-1, '39.
	Th-D	.18	4.8	Goloborodko and Leipunski, G-3, '39.
	Th-Be	.7	2.7	Good and Scharff-Goldhaber, G-2, '41.
	D-D	2.38-2.5	1.5	Kikuchi and Aoki, A-2, '39.
	D-D	2.4	1.57	Ladenburg and Kanner, L-3, '37.
	D-D	2.46	1.37	Zinn et al, Z-1, '39.
	D-D	2.88	1.97	" " " "
	Rn-Be	~4	1.65	Dunning, D-1, '35.
	Be-D	4.1	1.99	Agno et al, A-11, '47.
	B-D	12.5	1.40	Agno et al, A-11, '47.
	Li-D	13.5	1.23	" " " "
	Li-D	14	1.23	Amaldi et al, A-3, '46.
	Li-D	14	1.27	Salant and Ramsey, S-35, '40.
	"	15	1.36	" " " "
	Li-D	25.4	1.29	Sherr, S-29, '45.
	Photo n's	.023-.8	graph WPB	Wattenberg, W-8, '47.
	p-Li	.035-.49	" "	Frisch, F-12, '46.
	D-D	.22-4	" "	Bretscher, B-25.
	p-Li, D-D or D-C	.35-6.0	graph WPB	Bailey et al, B-14, '46.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.
	D-D	2.34-2.8	" "	MacPhail, M-4, '40.
	D-Li or Be	6-22	graph	Sleator, S-30, '47.

29 N

28
FAST

AECD - 2274

(c)

Carbon (continued)

Source	Neutron Energy	σ Measured	Reference
For references on inelastic and transport cross sections, see reference sheets.			
ABSORPTION			
$\int \sigma dE/E$		$\sim .02$	Langsdorf, L-4, '46. $\sigma_S^E p = .69$.

3072

7 Nitrogen (N)

13	14	15	16
	99.62	0.38	

100m
3+1.24
Annih. γ
.515

7.4s
 β -3.5
10
 γ 6.5

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	12.7(liq)		Brickwedde, B-2, '38. ~ 300°K.
	Rn-Be-Par	C	12.2(gas)		Carroll, C-3, '41.
NaN ₃	D-D-Par	C	36.8		Carlson et al, C-2.
"	Rn-BepPar	C	38.1		Dunning et al, D-1, '35.
"	MC	.02-65	$\sigma = 33.3 + 1.8/E^{1/2}$		Rainwater et al, R-4 & R-13, '45.
"	"	"	graph WPB	44.7	" " " " " "
N ₂	BeO filtered	~.003	47.4		Fermi and Marshall, F-5, '46.
N ₂ O	" "	~.003	57.8		$\lambda = 5.2A^\circ$.
DNO ₃	TC			31.35	Anderson, A-8, '44.

SCATTERING	Ra-Be-Par	C	28.2		Goldhaber and Briggs, G-1, '37.
NaN ₃					

ABSORPTION	Ra- γ -Be-Par	T		1.3	Fenning and Seligman, F-6, '42.
	Ra-Be-Par	C		1.6	Based on $\sigma_a(H) = .33$.
	Ra-Be-H ₂ O	C	1.2	1.5	Frisch et al, F-2, '37. Based
	Rn-Be-H ₂ O	C	1.05	1.4	on $\sigma_a(H) = .33$.
	P			1.75	Lapointe and Rasetti, L-1, '40.
					Volz, V-1, '43.
					Wattenberg et al, W-2, '43.
N ¹⁵ 7.4s	D-D-Par	C	$< .03$ mb		Levinger and Stempel, L-19, '44.
	P		$< 5 \times 10^{-5}$ mb		Hughes et al, H-29, '45.

312

Nitrogen

Resonance

2.7 ev Possible

	Source	Neutron Energy	Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim .4$	1.6	Fedorov and Perfilieva, F-1, '37.
	C-D	.18	2.1	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	1.5	Aoki and Kikuchi, A-2, '39.
	D-D	2.4	1.27	Ladenberg & Kanner, L-3, '37.
	D-D	2.46	1.40	Zinn et al, Z-1, '39. WPB.
	D-D	2.88	1.38	" " " " "
	Rn-Be	~ 4	1.76	Dunning et al, D-1, '35. WPB.
	D-D	2.1-2.8	graph WPB	Aoki, A-4, '39.
	D-D	2.38-2.85	" "	MacPhail, M-4, '40.
SCATTERING	D-D	2.6	0.97	Huber et al, H-20, '40. WPB.
ABSORPTION				
N^{14}_{np}	D-D	2.8	.04	Baldinger and Huber, B-29, '39. WPB.
	Li-p	0.2-1.7	graph WPB	Barschall and Battat, B-13, '46.
$N^{14}_{n\alpha}$	D-D	2.8	.16	Baldinger and Huber, B-29, '39. WPB.
	Li-p	1.3-1.7	graph WPB	Barschall and Battat, B-13, '46.

322

8-Oxygen (0)

15	16	17	18	19
	99.757	.039	.204	

8-1.7

29.4s

 β^- 4.1 γ 1.6

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	4.05 (14)		Brickwedde, B-2, '38. 300°K.
	Rn-Be-Par	T ?	4.1 (gas)		Carroll and Dunning, C-3, '38.
O ₂	P BeO filtered	InRes 1.44 ~ .003	4.0 16.2		Marshall, M-3, From $\sigma_t(\text{BeO})$ 10.1. Fermi and Marshall, F-5, '46. $\lambda = 5.2\text{\AA}^\circ$.
	Measured σ for O compounds See also SiO ₂ .				Beyer and Whitaker, B-6, '40.
SCATTERING	Ra-Be-Par	C	4.2		Goldhaber and Briggs, G-1, '37. Used Al ₂ O ₃ , $\sigma(\text{Al})=1.6$.

ABSORPTION	Ra-Be-H ₂ O	T	< 5.6 mb		Halban and Kowarski, H-10.
	P	T		1.6 mb	Lichtenberger and Fowler, L-10, '43.
	Ra-Be-H ₂ O	C		10 "	Frisch et al, F-2, '37.
O ¹⁸ _{31s}	P			0.22 " ± 20%	Marshall's value of .00035 (M-7, '43) corrected by Seren for energy, S-8, '44.
	P ?		0.28 mb		Jesse, J-1, '43.
	P			0.20 mb	Hughes et al, H-29, '45.
O ¹⁷ _{nα}		T	< 0.4 b		Eggler and Huddleston, E-1, '46.
		T	0.48 "		Hincks, H-9, '46. Corrected for $\sigma(\text{N}^{14}) = 1.75$.

33N

Oxygen

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra-Be	$\sim .09, \sim .4$	1.8	Fedorov and Perfilieva, F-1, '37.
	RdTh-D	0.18	3.0	Goloborodko & Leipunski, G-3, '39.
	C-D	0.18	2.1	Amaldi et al, A-1, '39.
		0.36	4.3	BIRG-33. From PbO ₂ measurement
		0.39	4.7	which gave for σ_t (PbO ₂) 14.1,
		0.60	4.4	15.8, 15.3, and 7.4
		2.35	0.7	respectively for the energies listed.
	D-D	2.38-2.5	1.41	Aoki and Kikuchi, A-2, '39.
	"	2.46	1.05	Zinn et al, Z-1, '39.
	"	2.88	1.25	" " " "
	D-D	2.4	0.75	Ladenburg and Kanner, L-3, '37.
	D-Li	25.4	1.60	Sherr, S-29, '45.
	Photo n's	.023-0.87	graph WPB	Wattenberg, W-8, '47.
		0.26-.66	" "	BLRG - 32 CP, '44.
	p-Li, D-D or C	0.35-6.0	" "	Williams, W-10, '43.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

ABSORPTION

^{16}O np	Fission n's	~ 1	.014 mb	Goldstein et al, G-5, '46.
$\int \sigma_{\text{AE/E}}$	P		<0.40	Langsdorf, L-4, '46. Osc. $\sigma_s \sigma_p = .45$.

342

SLOW

AECD - 2274

33

9 Fluorine (F)

18	19	20
	100	

12s
 β^- 5
 γ 2.2

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	P	1.44 mms	3.7 ± 0.2		Bragdon and Marshall, M-3, '43. WPB.
	MC	.02-37	graph WPB	4.0	Havens et al, H-13 and R-4, '45. Used fluoro carbon oil, F19C, $\sigma(C) = 4.5$. " " " " " " " " " " " "
CF ₄		.00318-.0106 (see carbon)			Fermi and Marshall, F-5, '46.
See Na page for NaF values.					

SCATTERING	Ra-Be-Par	C	4.1		Goldhaber and Briggs, G-1, '37. Used CaF ₂ . Took $\sigma_a(Ca) = 9.5$.
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ABSORPTION	Rn-Be-H ₂ O	C T	.05 .008	.07	Volz, V-1, '43. Wilkinson and Levinger, W-5, '42.
F ¹⁹ 12s	D-D-Par Ra-Be-Par P	C C	.01 <.05	<.07 .0094 $\pm$ 20%	Manley et al, M-2, '41. O'Neal and Goldhaber, O-1, '41. Seren et al, S-2, '44.

25N

34
FAST

Fluorine

AECD - 2274

(F)

TOTAL	Source	Neutron Energy	σ Measured	Reference
	D-D	2.38-2.5	2.30	Aoki and Kikuchi, A-2, '39.
	C-D	0.18	2.7	Amaldi et al, A-1, '39.
	RdTh-D	0.18	6.4	Goloborodko and Leipunski, G-3, '39.
	Ra-Be	~0.09-0.4	6.3	Fedorov and Perfilieva, F-1, '37.
	Photo n's	.023-0.67	graph WPB	Wattenberg, W-8, '47.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

ABSORPTION

F^{19}_{np}	Fission n's	~1	0.5 mb	Goldstein et al, G-5, '46.
$F^{19}_{n\alpha}$	Fission n's	~1	4.5 mb	Goldstein et al, G-5, '46.
$\int \sigma dE/E$	P		0.59	Langsdorf, L-4, '46. $\sigma_s \int p = .37$ Osc.

362

SLOW

AEC D - 2274

35

Neon (Ne)				
20	21	22	23	
90.00	0.27	9.73		
20.3s $\beta^+ 2.2$			40s $\beta^- 4.1$	

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Bs-Par	C	2.79±0.14		Carroll, C-3, '41.

SCATTERING

ABSORPTION

372

36
FAST
Neon

AECD - 2274

(Ne)

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

28 W

11. Sodium (Na)
22 23 24
100

3.
 β^+ 56
1.3
 $\beta/\gamma = 1$

14.8h
 β^- 1.39
 γ 1.38
2.76

Siegbahn, S-12, '46.

	Source	Neutron Energy	σ Measured	σ at .025 ev	References
TOTAL	Rn-Be-Par	C	3.0		Dunning et al, D-1, '35.*
	D-D-Par	C	3.6		Carlson et al, C-2.*
SCATTERING	Ra-Be-Par	C	4.0 $4\pi a^2 = 3.7$		Goldhaber and Briggs, G-1, '37.* Fermi and Marshall, F-3, '47.
ABSORPTION	Ra-Be-H ₂ O	C	<0.5	<0.6	Lapointe and Rasetti, L-1, '40.
	Rn-Be-H ₂ O	C	0.38	0.50	Volz, V-1, '43.
	Ra-Be-Par	C	0.47	0.57	Coltman and Goldhaber, C-1, '45.
	P		0.41		Wattenberg et al, W-2, '44.
Na ²³ 14.8h	Ra-Be-Par	C	0.35	0.47	Rasetti, R-2, '40.
	Ra-Be-Par	C	0.40	0.54	O'Neal and Goldhaber, O-1, '41.
	P			0.63 $\pm$ 20%	Seren et al, S-2, '44. May be high due to conversion electrons.

Used NaF. Based on $\sigma_t(F) = \sigma_s(F) = 3.7$.

392

38
FAST
Sodium

AECD - 2274

(Na)

Resonances

E_0
1710

	Source	Neutron Energy	σ Measured	References
TOTAL	C-D	0.18	3.4	Amaldi et al, A-1, '39.
	RdTh-D	0.18	3.2	Goloborodko and Leipunski, G-3, '39.
	Ra- γ -Be	~0.09-0.4	3.5	Fedorov and Perfilieva, F-1, '37.
	D-D	2.38-2.5	3.33	Aoki and Kikuchi, A-2, '39.
		2.3-2.8	graph WPB	MacPhail, M-4, '40.
		2.1-2.8	" "	Aoki, A-4, '39.
		2.5-2.9	" "	Zinn et al, Z-1, '39.
		.023-0.88	" "	Wattenberg, W-8, '47.

SCATTERING

ABSORPTION

Na ²³ 14.8 h	Y-Be	0.18	<0.29	LA-140
	Na-D ₂ O	0.23	.001	Wattenberg, W-6, '44. Based on
	Na-Be	0.80	<.0005	gold cross sections of .41 and .13 for .23 mev and .80 mev respectively.
$\int \sigma dE/E$	Fission n's	~1	.00029	Hughes et al, H-2, '46.
			~0.27 0.27	Langsdorf et al, L-4, '47. Obs. $\sigma_{sp} = .27$ Lichtenberger et al, L-8, '47. B abs. .051 due to resonance.
σ_{np}	Fission n's	~1	0.7 mb	Goldstein et al, G-5, '46.
$\sigma_{n\alpha}$	" "	~1	0.4 mb	" " " " " "
$\sigma_{n,2n}$	" "	~1	0.006 mb	Hughes et al, H-8, '46.

402

12 Magnesium (Mg)

23	24	25	26	27
	78.41	10.18	11.41	

1.00s
 $\beta^+ 2.8$

9.6m
 $\beta^- 1.8$
 $\gamma 0.64$
 0.84
 1.05

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	Rn-Be-Par	C	3.5		Dunning et al, D-1, '35.
MgO	Ra- γ -Be-Par	C	7.1		Demers, D-2, '46.
Mg	MC	.02-65	graph WPB	3.0	Meaker et al, M-6 and R-4, '45.

SCATTERING	Ra-Be-Par	C Epi-Cd	3.0	$4\pi a^2 = 3.7$	Mitchell et al, M-1, '36. Goldhaber and Briggs, G-1, '37. Langsdorf, L-14, '44. Based on $\sigma_s(C) = 4.6$ Fermi and Marshall, F-3, '46.
	Ra-Be-Par		4.2		
	P		3.6		

ABSORPTION	D-Be-Par	C	0.22	0.20	Ramm, R-1, '42. Volz, V-1, '43. Coltman and Goldhaber, C-1, '45. Fenning and Seligman, F-6, '42. Based on $\sigma_H = 0.33$ O'Neal and Goldhaber, O-1, '41. Seren et al, S-2, '44.
	Rn-Be-H ₂ O	C	0.31	0.41	
	Ra-Be-Par	C	0.27	0.33	
	Ra- γ -Be-Par	T	0.19	0.19	
	Ra- α -Be P	C	.03	.04 .048 $\pm 20\%$	

Mg²⁶ 10.2m

412

40
FAST

AEC - 2274

(Mg)

Magnesium

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim .4$	8.4	Fedorov and Perfilieva, F-1, '37.
	"	"	6.5, 8.3	Goloborodko, G-13, '47.
	C-D	0.18	3.3	Amaldi et al, A-1, '39.
	Th-D	"	3.9	Goloborodko and Leipunski, G-3, '39.
	"	"	3.9	Goloborodko, G-13, '47.
	Th-Be	0.7	3.6	" " "
				See ref. sheet for discussion.
	D-D	2.88 ± 0.04	2.25	Zinn et al, Z-1, '39. WPB
	D-D	2.38-2.5	1.89	Aoki, A-2, '38.
	D-Li	14	$1.83 \pm .09$	Amaldi et al, A-3, '46.
SCATTERING		2.1-2.8	graph WPB	Aoki, A-4, '39.
		.023-.88	" "	Wattenberg et al, W-8, '47.
	D-D	2.34-2.8	" "	MacPhail, M-4, '40.
σ_0	D-D	2.5	~ 1.6	Little et al, L-9, '44.
	$\sigma_1 (\Delta E \sim 1.4)$	2.5	~ 0.6	" Presumably due to Mg^{24} . See Na^{24} decay scheme.
ABSORPTION				
$Mg^{26}_{9.6m}$	Fission n's	~ 1	0.60 mb	Hughes et al, H-2, '46.
$Mg^{24}_{n,p}$	Fission n's	~ 1	1.0 mb	Goldstein et al, G-5, '46.
"	Ra-Be	~ 4	7.5 mb	Dementi and Timoshuk, D-7, '40.
$Mg^{25}_{n,p}$	Fission n's	~ 1	2.5 mb	Goldstein et al, G-5, '46.
$Mg^{25}_{n,p}$	D(7 Mev)-Be		0.66	Riezler, R-10, '44.
$Mg^{24}_{n,p}$			0.9	Langedorf, L-4, '45. Osc.
$\int \sigma dE/E$				

SLOW

AECD - 2274

41

¹³Aluminum (Al) Bleuler and Zünti,
B-7, '47.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	1.5		Dunning, D-1, '35.
	Ra-Be-Par	C	1.6 ± 0.1	1.6 ± 0.1	Frisch, F-2, '38.
	D-D-Par	C	1.6		Carlson et al, C-2.
	Ra- γ -Be-Par	C	1.35		Demers, D-2, '46.
	p-Be-Par	InRes 1.44	1.5		Hanstein, H-4, '41.
	P	InRes 1.44	1.46		Marshall, M-3, '43.
	Ra- γ -Be-Rar	" "	1.4		Demers, D-2, '46.
	MC	$\sigma_t = \text{const} \approx 1.5$			Havens et al, R-4 & H-23, '45.
	"	.025-70 ev graph WPB		1.7	" " " " "

SCATTERING	TC	T	1.37		LA-140A
		T	$1.33 \pm .02$		Bragdon et al, B-9, '44. Based on $\sigma_s(C) = 4.8$.
	TC	T	~ 1.5		Lichtenberger, L-5, '44.
	Ra-Be-Par		1.0		Mitchell and Murphy, M-1, '36.
	Ra-Be-Par	C	1.6		Goldhaber and Briggs, G-1, '37.
		residual $\sigma_s = 0.26$			Fermi and Marshall, F-7, '46.
	Epi-Cd	$\sigma_s 1.7$			Langsdorf, L-14, '44. Based on $\sigma_s(C) = 4.6$.

ABSORPTION	Ra-Be-Par	C	0.19	0.23	Coltman and Goldhaber, C-1.
	Ra γ Be-Par	C	0.18		Demers, D-2, '46.
			0.24		
A-27 2.75m	Ra-Be-Par	C	0.21	0.29	Rasetti, R-2, '40.
	"	C	0.2	0.28	O'Neal and Goldhaber, O-1, '41.
	TC	T		0.21	Seren, S-2, '44.

432

Resonances E_0
9,100

	Source	Neutron Energy	Measured	Reference
TOTAL	Ra- γ -Be	~.09, ~.4	4.0	Fedorov and Perfilieva, F-1, '39.
	C-D	.18	3.7	Amaldi et al, A-1, '39.
	RdTh-D	.18	3.8	Goloborodko & Leipunski, G-3, '39.
	RdTh-Be	.70	3.39	Good and Scharff-Goldhaber, G-2, '41, WPB.
	D-D	2.4	2.16	Ladenburg and Kanner, L-3, '37.
	D-D	2.38-25	3.15	Aoki, A-2, '39.
	D-D	2.46	2.99	Zinn et al, Z-1, '39.
	D-D	2.88	2.34	" " " "
	Ra-Be	~4	2.4	Dunning et al, D-1, '35, WPB.
	Li-D	14	1.92 $\pm$.08	Amaldi et al, A-3, '46.
	Li-D	25.4	1.85	Sherr, S-29, '45.
	Photo n's	.023-.87	graph WPB	Wattenberg, W-8, '47.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.
	D-D	2.34-2.65	" "	MacPhail, M-4, '40.

SCATTERING

For references on differential, transport and inelastic cross sections see reference sheets.

442

FAST

Aluminum (continued)

(A1)

ABSORPTION	Source	Neutron Energy	σ Measured	Reference
	Sb-Be	.023	8 mb	Redman, R-9, '46. Sphere technique.
Al^{27} 2.75 m	Th-D	0.18	5 mb	Halban and Kowarski, H-18, '38.
	Y-Be	0.18	<0.8 "	Ia-140A.
	Fission n's	~1	0.4 "	Hughes et al, H-2, '46.
	D-C	see ref.	<0.3 "	Levinger, L-22, '44.
	RdTh-D ₂ O	$\sigma_c(0.18)$	$= 0.6 \pm 0.45$	Demers and Halban, D-4, '46.
	RdTh-Be	$\sigma_c(0.70)$		
np	Fission n's	~1	2.8 mb	Goldstein et al, G-5, '46.
	Ra-Be	~4	15 "	Dementi and Timoshuk, D-7, '40.
	"	"	19 "	Levinger, L-7, '44.
	D-C	see ref.	18 "	" " "
n γ	Fission n's	~1	0.6 mb	Goldstein et al, G-5, '46.
	Ra-Be	~4	3.9 "	Dementi and Timoshuk, D-7, '40.
	"	"	6.0 "	Levinger, L-7, '44.
	D-C	see ref.	1.1 "	" " "
$\int \sigma dE/E$			0.47 b 0.14 "	Langsdorf, L-4, '45. Lichtenberger, L-8, '47. 0.0195 due to res.

452

SLOW

AECD - 2274

14 Silicon (Si)

27	28	29	30	31
	92.17	4.70	3.13

$B+3.5$

170m
 $\delta-1.8$
 No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	2.5		Dunning et al, D-1, '35. Used Si.
	D-D-Par	C	2.7		Carlson et al, C-2. Powdered Si.
	MC	.02-100	$\sigma = \text{const} = 2.25 \pm 0.10$		Rainwater et al, R-4, '45. " "
SiO ₂	MC	0.025		~1.0	Rainwater and Havens, R-5, '44.
	MC	1.0	9.5		Large quartz crystal.
	Rn-Be-Par	C	4.3		Beyer and Whitaker, B-6, '40.
"	Rn-Be-Par	C	8.8	}	Single crystal.
	Rn-Be-Par	C	8.0		Beyer and Whitaker, B-6, '40. Sand.
	p-Be-Par	InRes 1.44	7.5 $\pm$ 0.5		" " " " Fused.
"	"	" "	8.8 $\pm$ 0.8	}	Hanstein, H-4, '41. Single crystal.
	"	" "			" " " Sand.
	Rn-Be-Par	C	9.1		Dunning et al, D-1, '35.
"	D-D-Par	C	8.9		Carlson et al, C-2.
SCATTERING	Ra-Be-Par	C	1.7		Goldhaber and Briggs, G-1, '37.
ABSORPTION	P		0.24		Wattenberg, W-2, '44.
Si ³⁰ 170m	Rn-Be-H ₂ O	C	< .06	< .08	Volz, V-1, '43.
	D-D-C	T	0.169		Coon, C-4, '42.
	Ra- α -Be	C	< 0.5		O'Neal and Goldhaber, O-1, '41.
	P			0.116 $\pm$ 20%	Seren et al, S-2, '44.

462

FAST

Silicon

AECD - 2274

45

(Si)

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim 0.4$	1.4	Fedorov and Perfilieva, F-1, '37.
	C-D	0.18	3.2	Amaldi et al, A-1, '39.
	RdTh-D	0.18	7.2	Goloborodko & Leipunski, G-3, '39.
	RdTh-Be	0.7	4.2	Goloborodko, G-6, '41. Also gives several values for Ra- γ -Be source.
	D-D	2.38-2.5	2.95	Aoki, A-2, '39.
	D-D	$2.88 \pm .04$	2.75	Zinn et al, Z-1, '39.

SCATTERING

ABSORPTION

Si ³⁰ _{170m}	Fission n's	~ 1	1.1 mb	Hughes et al, H-2, '46.
Si ²⁸ _{np}	Fission n's	~ 1	3.0 mb	Goldstein et al, G-5, '46.
	Ra-Be	~ 4	34 "	Dementi and Timoshuk, D-7, '40.
Si ²⁹ _{np}	Fission n's	~ 1	2.7 mb	Goldstein et al, G-5, '46.
$\int \sigma dE/E$			0.51 b	Langsdorf, L-4, '46. Osc.

477

SLOW

AECD - 2274

15 Phosphorus (P)

30 31 32

100

3.35

m

14.7 d

1.7

No γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	14.7		Dunning et al, D-1, '35.
	Ra-Be-Par	C	13.6		Goldhaber and Briggs, G-1, '37.
	D-D-Par	C	10.1		Carlson et al, C-2, Red compressed sample.
	NC	.02-65	graph WPB	4.3	Rainwater et al, W-7 and R-4, '45. Powdered sample. Rainwater et al. " "
$\sigma_t = (3.3 \pm 0.2) + (0.158 \pm .007)/E^2$					
SCATTERING	Ra-Be-Par	C	10.4		Goldhaber and Briggs, G-1, '37.
ABSORPTION	P		0.24		Wattenberg, W-2, '44.
	Rn-Be-H ₂ O	C	0.23	0.30	Volz, V-1, '43.
	Ra-Be-H ₂ O	C	1.0	1.2	Lapointe and Rasetti, L-1, '40.
	Ra-Be-Par	C	~0.2	~0.3	Rasetti, R-2, '40.
	Ra- α -Be	C	0.3	0.4	O'Neal and Goldhaber, O-1, '41.
	P			0.23 $\pm$ 20%	Seren et al, S-2, '44.

P³¹ 14.7d

482

FAST

AECD - 2274

47 (P)

Phosphorus

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	0.18	4.4	Amaldi et al, A-1, '39.
	RdTh-D	0.18	2.4	Goloborodko and Leipunski, G-3, '39.
	D-D	2.38-2.5	3.24	Aoki and Kikuchi, A-2, '39.
	Photo n's D-D	.023-0.87 2.1-2.8	graph WPB " "	Wattenberg et al, W-8, '47. Aoki, A-4, '39.

SCATTERING

ABSORPTION

P^{31} mp		1.4-4	graph WPB	Taschak and Bretscher, T-1, '45.
	Ra-Be	~4	47 mb	Dementi and Timoshuk, D-7, '40.
P^{31} n, α	Ra-Be	~4	9 mb	Dementi and Timoshuk, D-7, '40.

492

SLOW

AEC - 2274

16 Sulfur (S)

31	32	33	34	35	36	37
	95.1	.74	4.2		.016	

 $\beta^+ 3.85$ 87 d
 $\beta^- 1.7$ 5.0 m
 $\beta^- 1.4, 4$
 $\gamma 2.75$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	1.4		Dunning et al, D-1, '35.
	Rn-Be-Par	C	2.0		Beyer and Whitaker, B-6, '40.
	Ra-Be-Par	C	2.2		Whitaker and Bright, W-1, '42.
					From CS ₂ value of 9.0.
	MC	.025-65	graph WPB	1.64	Rainwater et al, H-11 and R-4, '45. Powdered.
$\sigma_t = (1.0 \pm 0.1) + (.098 \pm .005)/E^2$					
SCATTERING	Ra-Be-Par	C	1.1		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par		0.9		Mitchell et al, M-1, '36.
	Ra-Be-Par	C	1.9		Whitaker and Bright, W-1, '42.
					From CS ₂ value of 8.5.
	Rn-Be-Par	C	1.1		Kimura, K-2, '40.
	Rn-Be-Par	InRes 1.44	1.05		" " "
	TC	T	1.66		Anderson et al, A-6, '43. Crystal
	TC	T	3.52		" " " " Amorphous.
	Graphite filtered		2.89		" " " " Crystal.
	" "		7.06		" " " " Amorphous.
$4\pi a^2 = 0.95$					
Fermi and Marshall, F-3, '47.					
ABSORPTION	Ra-Be-Par	C	0.35	0.43	Coltman and Goldhaber, C-1.
	Rn-Be-H ₂ O	C	0.62	0.82	Volz, V-1, '43.
	Ra- γ -Be-Par	T	0.39	0.39	Fenning and Seligman, F-6, '42.
	P		0.42		Based on $\sigma(H) = .33$.
					Wattenberg and Thomas, W-2.
S ³⁴ 87 d S ³⁶ 5 m	P			0.26 $\pm$ 20%	Seren et al, S-2, '44.
				0.14	Hughes et al, H-21, '46.

50

FAST
Sulfur

(S)

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim .4$	1.0	Fedorov and Perfilieva, F-1, '37.
	"	"	1.1, 1.0	Goloborodko, G-13, '47.
	C-D	0.18	2.6	Amaldi, A-1, '39.
	Th-D	"	2.3	Goloborodko and Leipunski, G-3, '39.
	"	"	2.4	Goloborodko, G-13, '47.
	Th-Be	0.7	2.3	" " "
				See ref. sheet for discussion.
	D-D	2.38-2.5	2.38	Aoki and Kikuchi, A-2, '39.
	"	2.46	2.77	Zinn et al, Z-1, '39. WFB
	"	2.88	3.13	" " " " "
	Rn-Be	~ 4	2.6	Dunning et al, D-1, '35. WFB.
	D-Li	14	$1.58 \pm .09$	Amaldi et al, A-3, '46.
	D-D	2.1-2.8	graph WFB	Aoki, A-4, '39.
	Photo n's	.023-.88	" "	Wattenberg et al, W-8, '47.

SCATTERING

ABSORPTION

S^{32} n, α		2.9	.065	P. Huber, H-12, '41. WFB.
S^{32} n, p	P	Fast	0.23	Seren et al. S-11, '44.
" "	Fission n's	~ 1	~ 0.012	Goldstein et al, G-5, '46.
" "	Ra-Be	~ 4	0.14	Dementi and Timoshuk, D-7, '40.
" "	D-D	1.6-5.7	graph	Hanson et al, H-19, '45.
$\int \sigma dE/E$			0.65	Langsdorf et al, L-4, '46. Osc.

512

17 Chlorine (Cl)

34	35	36	37	38
75.4		24.6		
β^+ 2.4-20%		$2 \times 10^6 y$	$37 m$	
5.1-80%		β^+	$\beta^- 1.19$	
		$\beta^- .6$	2.8	
		K	5.0	
$\gamma 3.4$			$\gamma 1.60$	
			2.15

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par Ra-Be-Par	C C	39	51	Dunning et al, D-1, '35. Used NaCl. Frisch et al, F-2, '37.
			$\sigma = (15 \pm 1.5) + (6.0 \pm 0.5)/E^2$.023-70 graph WPB	55	Rainwater et al, R-6 and R-4, '45. " " " " " "
SCATTERING	Ra-Be	C	<10		Goldhaber and Briggs, G-1, '37. Used NaCl, $\sigma_s(K) = 1.5$.
ABSORPTION	Ra-Be-H ₂ O Ra-Be-Par Rn-Be-H ₂ O P Ra-Be-Par Ra-Be-Par	C C C C C C	27 29 24 28.6 37 ± 5 36 ± 4 36	33 35 32 34 40 41	Lapointe and Rasetti, L-1, '40. Coltman and Goldhaber, C-1, '45. Volz, V-1, '43. Wattenberg, W-2, '44. Kikuchi et al, K-6, '37. Spees et al, S-6, '38. Horvath and Salant, H-6, '41.
Cl ³⁷ 37 m Cl ³⁷ 37 m	Ra- α -Be TC	C T	0.3	0.4 0.56 $\pm 20\%$	O'Neal and Goldhaber, O-1, '41. Seren et al, S-2, '44.
Cl ³⁵ np " " " "	TC	T T T T	0.46 ± 0.06 0.32 0.44	0.169 $\pm 20\%$	Seren et al, S-2 and S-11, '44. D. Hughes, H-7, '45. A. Langsdorf, L-6, '44. Gibert et al, G-17, '44.

522

FAST

Chlorine

AECD - 2274

51 (C1)

Resonances E_0

9.9

4.4

} possible levels

 $Cl^{37} \text{ --- } 1800$

TOTAL	Source	Neutron Energy	σ Measured	Reference
	Ra- γ -Be	$\sim .09, \sim 0.4$	3.5	Fedorov and Perfilieva, F-1, '37.
	C-D	0.18	2.7	Amaldi et al, A-1, '39.
	RdTh-D	0.18	3.8	Goloborodko and Leipunski, G-3, '39.
	D-D	2.38-2.5	2.78	Aoki, A-2, '39.
	D-D	$2.88 \pm .04$	3.4	Zinn et al, Z-1, '39.
	D-Li	25.4	1.88	Sherr, S-29, '45.

SCATTERINGABSORPTION

$Cl^{37} 37m$	Fission n's Y-Be	~ 1 0.18	0.80 mb <50 "	Hughes et al, H-2, '46. LA-140.
$Cl^{35} n \alpha$	Fission n's Ra-Be P	~ 1 ~ 4	6 mb 220 " 72 "	Goldstein et al, G-5, '46. Dementi and Timoshuk, D-7, '40. Seren et al, S-11, '44.
$Cl \int \sigma dE/E$	P		14 b	Langsdorf, L-4, '46. Osc.
$Cl^{37} \int \sigma dE/E$			0.087 b	Lichtenberger et al, L-8, '47. B abs. .0064 due to resonance.

53 N

SLOW

AECD - 2274

18 Argon (A)

35 36 37 38 39 40 41

35 36 37 38 39 40 41

1.33s
B⁺4.4

.307

34.1d
K
no γ

.061

99.632

110m
 β^- 1.18
2.55
 γ 1.3A⁴¹

0.7%

99.3%

Bleuler et al,
B-4, '46. β^- 1.18 β^- 2.55 γ 1.3K⁴¹

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	2.53		H. Carroll, C-3, '41.
SCATTERING		T	2.53		LA-140A
ABSORPTION	P			0.62	Wattenberg et al, W-2, '43.
A ⁴⁰ 110m	D-Be-Par	T	1.24 $\pm$.03		Kern, K-3, '43.

542

FAST

Argon

AECD - 2274

53 (A)

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

552

SLOW

AECD - 2274

19 Potassium (K)

38	39	40	41	42
93.38		.012	6.61	

 $\beta^+ 2.3$ $2.4 \times 10^8 y$ $\beta^- 1.3$ $\gamma 1.54$

K

12.4h

 $\beta^- 3.58$ $\gamma 2.07$ $\gamma 1.51$ i=4 K⁴⁰

K

 $\gamma 1.54$ A⁴⁰Ca⁴⁰K⁴⁰ $\beta^- 1.4$ $\beta^- 3.58$ $\gamma 2.07$ $\gamma 1.51$

Hirzel and Wäffler,

H-15, '46.

K⁴²

K

 $\beta^- 3.58$

75%

 $\beta^- 2.07$

25%

 $\gamma 1.51$ Ca⁴²

Siegbahn, S-17, '46.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	8.2		Dunning et al, D-1, '35.
SCATTERING					
KF	Ra-Be-Par	C	5.6		Goldhaber and Briggs, G-1, '37.
ABSORPTION					
	Ra-Be-H ₂ O	C	3.2	3.9	Lapointe and Rasetti, L-1, '40.
	Rn-Be-H ₂ O	C	2.0	2.6	Volz, V-1, '43.
	P		1.8		Wattenberg, W-2, '44.
K ⁴¹ 12.4h	Ra-Be-Par	C	~1.4	~1.9	Rasetti, R-2, '40.
	Ra- α -Be	C	~1.5	~2.0	O'Neal and Goldhaber, O-1, '41.
	P			1.0 $\pm$ 20%	Seren et al, S-2, '44.
K ⁴⁰ np		T	<1		Hill, H-14, '46.

562

FAST

Potassium

	Source	Neutron Energy	Measured σ	Reference
TOTAL	C-D	0.18	3.8	Amaldi et al, A-1, '39.
	RdTh-D	0.18	7.4	Golcboedko and Leipunski, G-3, '39.
	D-D	2.38-2.5	4.15	Aoki, A-2, '39.
	D-D	2.46	3.44	Zinn et al, Z-1, '39. WPB
	D-D	2.88	3.13	" " " " "
		.023-0.88	graph WPB	Wattenberg et al, W-8, '47.
		2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

ABSORPTION

K^{41} 12.4h	Fission n's ~1	.0029	Hughes et al, H-2, '46.
$\int \sigma dE/E$	P	1.12	Langsdorf et al, L-4, '46. Osc. $\sigma_p = .07$.

572

56
SLOW

AECD - 2274

20 Calcium (Ca)

39	40	41	42	43	44	45	46	47	48	49
4.5m β^+	1.06s	96.92	10d K X-rays	0.64	0.132	2.13	180d β^- .21 no γ	.0032	0.179	2.5h β^- 2.3 γ 0.8 30m β^-

Unassigned activity

5.8d
 β 1.1
 γ 1.3

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
Ca CaO	Ra-Be-Par Rn-Be-Par	C C	4.4 ± 0.2 14.3		Rasetti, R-7, '40. Dunning et al, D-1, '35.

SCATTERING	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
Ca	Ra-Be-Par	C	9.5 $4\pi r_a^2 = 7.5$		Goldhaber and Briggs, G-1, '37. Fermi and Marshall, F-3, '46.

ABSORPTION	P	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Ra-Be-Par	C	0.33		Wattenberg et al, W-2, '44.
	Ra- γ -Be-Par	T	0.37	0.45	Coltman and Goldhaber, C-1, '45.
	Rn-Be-H ₂ O	C	0.55	0.55	Fenning and Seligman, F-6, '42.
			0.28	0.37	Volz, V-1, '43.
Ca ⁴⁰ 10d	P			.125 $\pm$ 40% mb	Seren et al, S-2, '44.
	P		.27mb		Cohn et al, C-7, '46.
Ca ⁴⁴ 180d	P			0.63 $\pm$ 20%	Seren et al, S-2, '44.
Ca ⁴⁸ 2.5h				0.205 $\pm$ 20%	Seren et al, S-2, '44.
Ca ⁴⁸ 30m	P			0.55 $\pm$ 20%	Seren et al, S-2, '44.

582

FAST
Calcium

AECD - 2274

57 (Ca)

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	4.9	Amaldi et al, A-1, '39.
	RdTh-D	.18	4.1	Goloborodko and Leipunski, G-3, '39.
	D-D	2.38-2.5	3.85	Aoki and Kikuchi, A-2, '39.

SCATTERING				
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ABSORPTION				
$\int \sigma dE/E$			2.1	Langsdorf, L-4, '46. Osc.

59 n

58
SLOW

21 Scandium (Sc)

44 45 46
100

2.44h 3.92h
I.T. β^- 1.33
e⁻ K
 γ 2.28 γ 1.33

85d
 β^- 0.36
K?
 γ 1.12
0.9

AECD - 2274

Miller and
Deutsch,
M-9, '47.

See also
Neitner,
M-20, '45.
and Peacock,
P-5, '47.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
SCATTERING					
ABSORPTION					
Sc ⁴⁵ 85d				22 $\pm$ 20%	Seren et al, S-2, '44.

602

FAST

AECD - 2274

59 (Sc)

Scandium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Se ⁴⁵ _{np}	P		~ 1 mb	Cohn et al, G-5, '45.

61 ~

SLOW

AECD - 2274

22 Titanium (Ti)

45	46	47	48	49	50	51
7.95	7.75	73.45	5.51	5.34		
8h	21d				6m	72d
$\beta^+ 1.2$					$\beta^- 1.6$	$\beta^- 0.36$
					γ	$\gamma 1.0$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
TiO ₂	Rn-Be-Par	C	18.5		Dunning et al, D-1, '35.
TiO ₂	Ra-Be-Par	C	27.9		Demers, D-2, '46.
		AuRes 4.8	9.5		" " "

SCATTERING					
TiO ₂	Ra-Be-Par	C	14.2		Goldhaber and Briggs, G-1, '37.

ABSORPTION	P		4.8		Wattenberg et al, W-2, '44.
	Ra-Be-Par	C	5.2 $\pm$ 0.3	6.3 $\pm$ 0.3	Coltman and Goldhaber, C-1, '45.
	Rn-Be-H ₂ O	C	3.8	5.0	Volz, V-1, '43.
Ti ⁵⁰ 6m	P			0.141 $\pm$ 20%	Seren et al, S-2, '44.
Ti ⁵⁰ 72d	P			.039 $\pm$ 20%	Seren et al, S-2, '44.

622

FAST

AEC - 2274

61 (Ti)

Titanium

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	4.4	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	1.73	Aoki and Kikuchi, A-2, '39.

SCATTERING				
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ABSORPTION				
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632

62
SLOW

AECD - 2274

23 Vanadium (V)

50 51 52
100

3.7m
 β^+

3.9m
 β^- 2.05
 γ 1.45
 $\beta/\gamma=1$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
V_2O_5	Rn-Be-Par	C	37		Dunning et al, D-1, '35.
	Ra-Be-Par	C	40.2		Demers, D-2, '46.
		AuRes 4.8	41.6		" " "
SCATTERING					
V	Ra-Be-Par	C	<4		Goldhaber and Briggs, G-1, '37.
ABSORPTION					
V^{51} 3.9m	Ra-Be-H ₂ O	C	6.8	8.3	Lapointe and Rasetti, L-1, '40.
	P		3.7		Wattenberg et al, W-2, '44.
	TC	T		4.50 $\pm$ 20%	Seren et al, S-2, '44.
	Ra-Be-Par	C	5.2	7.0	Rasetti, R-2, '40.

642

FAST

Vanadium

AECD - 2274

63 (v)

Resonances E_0

3370

TOTAL	Source	Neutron Energy	σ Measured	Reference

SCATTERING

ABSORPTION

 $\nu^{51}_{3.9m}$ Ra- γ -Be

0.09

.013

Griffiths, G-9, '39.

Th-D₂O

0.18

.016

Halban and Kowarski, H-18, '38.

Y-Be

0.18

<.005

LA-140.

Fission n's ~1

.0022

Hughes et al, H-2, '46.

D-D

2.7

.0013

Mescheryakov, M-14, '45.

 $\int \sigma dE/E$

3.04

Lichtenberger et al, L-8, '47.
0.36 due to resonance.

652

64
SLOW

AECD - 2274

24 Chromium (Cr)

49	50	51	52	53	54	55
	4.31		83.75	9.55	2.38	
4.5h		26.5d				1.3h
β^+ 1.45		K				
γ 0.18		γ .32				
1.55		e ⁻				

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	4.9		Dunning et al, D-1, '35.
		.01 to 100	$\sigma_t = (3.8 \pm 0.4) + (0.55 \pm 0.3)/E^2$	7.25	Rainwater et al, R-4, '45. Value of .7 given in report does not agree with graph. .55 does agree.
SCATTERING	Ra-Be-Par		1.4		Mitchell et al, M-1, '36.
	Ra-Be-Par	C	3.6		Goldhaber and Briggs, G-1, '37.
ABSORPTION	Ra-Be-Par	C	2.5	3.0 2.4	Coltman and Goldhaber, C-1, '45. Wattenberg et al, W-2, '44.
Cr ⁵⁰ 26.5d	P			11 $\pm$ 40%	Seren et al, S-2, '44.
Cr ⁵⁴ 1.3h	P			$\sim .0061 \pm 40\%$	Seren et al, S-2, '44.

662

FAST
Chromium

AECD - 2274

65 (Cr)

Resonances

E_0

100 weak
10000 strong

TOTAL	Source	Neutron Energy	σ Measured	Reference
	C-D	.18	3.5	Amaldi et al, A-1, '39. Goloborodko, G-14, '44. " " " See reference sheets for discussion.
	Ra- γ -Be	~.09, ~.4	2.5, 3.3	
	Th-D	0.18	5.9	
	Th-Be	0.7	4.0	
	D-D	2.38-2.5	3.38	Aoki and Kikuchi, A-2, '39.

SCATTERING

ABSORPTION

62 2

Elliot and Deutsch, E-2, 143.
See also K. Sieghbahn, S-40, 146.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	14.3		Dunning et al, D-1, '35.
	Ra-Be-Par	C	15.1		Whitaker and Bright, W-1, '41.
	Rn-Be-Par	C	13.1 $\pm$ 0.6		Beyer and Whitaker, B-6, '40.
					Metallic grains. Also give values for compounds of Mn.
	MC	.01-.5 .015-5000	graph "	14.3 16.2	Manley, M-10, '42. Rainwater et al, R-8, '46.
			$\sigma_t = (2.2 \pm 0.4) + (2.24 \pm 0.12)/E^2$ $\sigma_t = 2.8 + 1.9$		Rainwater et al, R-4 and R-8, '45 and '46. Manley, M-10, '42.
SCATTERING	Ra-Be-Par		2.2		Mitchell and Murphy, M-1, '36.
	Ra-Be-Par	C	2.1		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	2.1		Whitaker and Bright, W-1, '41.
		C	2.43		La-140A
ABSORPTION	Ra-Be-H ₂ O	C	9.4	11.5	Lapointe and Rasetti, L-1, '40
	Rn-Be-H ₂ O	C	11.2	14.8	Volz, V-1, '43.
	Ra-Be-Par	C	10.7	13.0	Coltman and Goldhaber, C-1, '45.
	Ra-Be-Par	C	11.2		Horvath and Salant, H-6, '41.
	P		10.6		Wattenberg et al, W-2, '44.
	Ra-Be-H ₂ O	C		13.6 $\pm$ 1.0	Kubitschek and Anderson, K-5, '44.
					From Mn/H=42.4 $\pm$ 3.2. $\sigma_H=0.32$.
	Ra- α -Be-H ₂ O	C		12.5 $\pm$ 0.6	Graham et al, G-7, '45. From $\sigma_{Mn}/\sigma_H=39 \pm 2$, $\sigma_H=0.32$.
Mn ⁵⁵ 2.59h	TC			10.7 $\pm$ 20%	Seren et al, S-2, '44.
				10.2	Anderson, A-5, '42.
	TC			13.0	Deutsch and Linenberger, D-3, '44.
I Mn ⁵⁵ 2.59h	Ra-Be	C		1.69	Grummitt et al, G-8, '44.
	"	C		4.55	" " " "

692

FAST

AEC - 2274

67 (Mn)

Manganese

Resonances

$$\frac{E_0}{300 \pm 40} \approx \frac{\sigma_0}{5,000}$$

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim .4$	5.2, 5.8	Goloborodko, G-14, '44.
	Th-D	0.18	7.0	" " "
	C-D	0.18	4.9	Amaldi et al, A-1, '39.
	Th-Be	0.7	2.9	Goloborodko, G-14, '44. See ref. sheet for discussion.
	D-D	2.38-2.5	3.02	Aoki and Kikuchi, A-2, '39.
	D-D	$2.88 \pm .04$	3.8	Zinn et al, Z-1, '39.

SCATTERINGABSORPTIONMn⁵⁵2.59h

		.040	.022	LAMS-111
		0.170	.011	LAMS-95
		0.180	.0076	
		0.560	.0039	
		0.750	.0042	
		1.320	.0026	
	Ra-Be	.09	.022	Griffiths, G-9, '39.
	Y-Be	0.18	.0148	LAMS-93, LA-140.
	Th-D ₂ O	.18	.0157	Halban and Korwarski, H-18, '38.
	RdTh-D ₂ O	$\frac{\sigma_0(0.18)}{\sigma_0(0.70)} = 1.5 \pm 0.2$		Demers and Halban, D-4, '46.
	RdTh-Be			
	Fission n's	~ 1	.0035	Hughes et al, H-2, '46.
	D-D	2.7	.0026	Mescheryakov, M-14, '45.
	Ra-Be	~ 4	.0056	Dementi and Timoshuk, D-7, '40.
			15.7	Kubitschek and Anderson, K-5, '44.
			14.	Langsdorf, L-4, '46.
			14.31	Lichtenberger et al, L-8, '47. ⁶⁹ W
				B abs. 8.16 due to resonance.

 $\int \sigma dE/E$

SLOW

AECID - 2274

26 Iron (Fe)

53	54	55	56	57	58	59
	5.81		91.66	2.20	0.33	

~4y
K
e⁻
γ .07

46.3d
β⁻ .26
.46
γ 1.10
1.30

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	12.0		Dunning et al, D-1, '35. See also P-4.
	Ra-Be-Par	C	13.6		Goldhaber and Briggs, G-1, '37.
	D-D-Par	C	10.2		Bradbury et al, B-5, '37.
	Ra-Be-Par	C		12	Frisch et al, F-2, '38.
	D-D-Par	C	12.3		Carlson et al, C-2.
	Rn-Be-Par	C	12.0 ± 0.2		Beyer and Whitaker, B-6, '40.
	Ra-Be-Par	C	12.8		Whitaker and Bright, W-1, '41.
	p-Be-Par	InRes L44	11.1		Hanstein, H-4, '41.
	NC	$\sigma_t = 11.5 + 0.46/E^{1/2}$			Havens et al, H-16 and R-4, '45.
	NC	.024-65	graph WPB	13.3	" " " " " "
	CS	.005-0.5	graph c.e.	12.2	Sturm and Arnold, S-31, '47.

702

SLOW

AEC - 2274

69 (Fe)

26 Iron (Fe) (continued)

SCATTERING	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	TC	T	10.9 ± 0.2		Bragdon, B-9, '44.
	Ra-Be-Par	C	10.3		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	9.8		Mitchell and Varney, M-13, '37.
	Rn-Be-Par	C	9.7		Kimura, K-2, '40.
	Ra-Be-Par	C	9.5		Whitaker and Bright, W-1, '41.
	Ra-Be-Par	RhRes 1.3	10.0		
	Rn-Be-Par	InRes 1.44	8.5		Mitchell and Varney, M-13, '37.
					Kimura, K-2, '40.
	Ra-Be-Par	AgRes 5.1	11.6		Mitchell and Varney, M-13, '37.
	Ra-Be-Par	I Res 37	10.8		Mitchell and Varney, M-13, '37.
	P	Epi-Cd	9.8		Langsdorf, L-14, '44.
			$4\pi a^2 = 8.1$		Fermi and Marshall, F-3, '47.

ABSORPTION					
	P		2.5	2.5	Monk and Montgomery, M-11, '43.
	P		2.0		Wattenberg et al, W-2, '44.
	P			2.5	Pomerance & Hoover, P-2, '47.0sc.
	D-Be-Par	C	3.1	2.8	Ramm, R-1, '42.
	Rn-Be-H ₂ O	C	1.6	2.6	Volz, V-1, '43.
	Ra-Be-Par	C	2.05	2.5	Coltman and Goldhaber, C-1, '45.
	Ra- γ -Be-H ₂ O	C	2.14		Demers, D-2, '46.
Fe ⁵⁴ _{4y}	P			0.7	Overman, O-2, '47.
Fe ⁵⁸ _{45.5d}	P			$0.36 \pm .07$	Seren et al, S-2, '44.
	P			~ 0.9	Swartout, S-20, '46.
	P			0.79	Overman, O-2, '47.
Fe ⁵⁷ _{n, α}		T	≥ 1.5 mb		Hughes et al, H-17, '44.

712

70
FAST

Iron

AECD - 2274

(Fe)

TOTAL	Source	Neutron Energy	σ Measured	Reference
		.09	3.5	Leipunski, L-18, '40.
		.18	3.6	" " " "
	C-D	.18	3.7	Amaldi et al, A-1, '39.
		.70	3.1	Leipunski, L-18, '40.
	D-D	2.38-2.5	3.20	Aoki and Kikuchi, A-2, '39.
	D-D	2.88 $\pm$.04	3.15	Zinn et al, Z-1, '39. WPB.
	Rn-Be	~4	3	Dunning et al, D-1, '35. WPB.
	Li-D	14	2.75	Amaldi et al, A-3, '46.
	Photo n's	.023-0.88	graph WPB	Wattenberg et al, W-8.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

For references to differential scattering, inelastic scattering, and transport cross sections see reference sheet.

ABSORPTION

	Sb-Be	.023	$\approx$.033	Redman et al, R-9, '46.
Fe ⁵⁶ n,p.	Ra-Be	~4	.0047	Dementi and Timoshuk, D-7, '40.

722

SLOW

AECD - 2274

71

27 Cobalt (Co)

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	35		Dunning et al, D-1, '35.
	D-D-Par	C	26 ± 2.6		Bradbury et al, B-5, '37.
	MC		$\sigma_t = (6.7 \pm 0.3) + (6.4 \pm 1.5)/E^{1/2}$		Wu et al, W-3, '46. From .15 to 5 ev.
	MC		.15-10,000 graphs		" " " "

SCATTERING	Ra-Be-Par	C	~ 5		Goldhaber and Briggs, G-1, '37.
	D-D-Par	C	5.6 ± 1.8		Bradbury et al, B-5, '37.
	D-D-Par	Rh res 1.3	3.7 ± 1.8		" " " "

ABSORPTION	Ra-Be-H ₂ O	C	33	40	Lapointe and Rasetti, L-1, '40.
	Rn-Be-H ₂ O	C	24.0	32	Volz, V-1, '43.
	P		30		Wattenberg, W-2, '44.
	P			35.9	Pomerance and Hoover, P-2, '47.
	Ra-Be-Par	C	31	36	Horvath and Salant, H-6, '41.
Co ⁵⁹ 10.7m	TC	T		$0.66 \pm 20\%$	Seren et al, S-2, '44.
Co ⁵⁹ 5.3y	P			$21.7 \pm 20\%$	Seren et al, S-2, '44.

732

72
FAST

AECD - 2274

(Co)

Cobalt

Resonances

$$\frac{E_0}{115 \pm 5} \quad \frac{\sigma_0 r^2}{\approx 200,000}$$

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	5.2	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	2.59	Aoki and Kikuchi, A-2, '39.

SCATTERING

For inelastic scattering and transport cross sections see reference sheets.

ABSORPTION	Li p, n	.20	.04	LA-140A, 12.
	Y-Be	.18	.03	Fischer et al, F-8, '45.
Co ⁵⁹ 5y ?	Fission n's	~1	92 mb	Hughes et al, H-2, '46.
Co ⁵⁹ mp	P		~.04 mb	Irvine, I-2, '46.

742

28 Nickel (Ni)

57	58	59	60	61	62	63	64	65
	67.76		26.16	1.25	3.66		1.16	

36.9
 $\beta^+ 0.67$

12y
 $\beta^- .05$

2.6h
 $\beta^- 1.9$
 $\gamma 0.28$
0.65
0.93

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par	C	15.4		Dunning et al, D-1, '35.
	Ra-Be-Par	C	19.7		Goldhaber and Briggs, G-1, '37.
	Rn-Be-Par	C	19.8		Beyer and Whitaker, B-6, '40.
	Ra-Be-Par	C	21.2		Whitaker and Bright, W-1, '41.
	p-Be-Par	InRes 1.44	16.1		Hanstein, H-4, '41. Rolled Ni sample.
	MO	$\sigma \approx \text{const} \approx 18$.01 to 75	graph WFB	18.5	Rainwater et al, R-4, '45. " " " "

752

74
SLOW

AECD - 2274

(Ni)

28 Nickel (Ni) (continued)

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
SCATTERING	TC	T	15.9		Bragdon et al, B-9, '44.
	TC	T	13.4		Lichtenbarger, L-5, '44.
	Ra-Be-Par	C	12.4		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	19.2		Mitchell and Varney, M-13, '37.
	Rn-Be-Par	C	20		Kimura, K-2, '40.
	Ra-Be-Par	C	13.9		Whitaker and Bright, W-1, '41.
	Ra-Be-Par	RhRes 1.3	11.9		Mitchell and Varney, M-13, '37.
	Rn-Be-Par	InRes 1.44	19		Kimura, K-2, '40.
	Ra-Be-Par	AgRes 5.1	13.5		Mitchell and Varney, M-13, '37.
	Ra-Be-Par	I Res 37	12		Mitchell and Varney, M-13, '37.
		$4\pi a^2 = 14$			Fermi and Marshall, F-3, '47.

ABSORPTION	P		3.5		Wattenberg, W-2, '44.
	P			4.75	Pomerance & Hoover, P-2, '47.
	Ra-Be-Par	C	6.7		Kikuchi, K-6, '37.
	Ra-Be-Par	C	5.6 ± 0.5	6.8	Coltman and Goldhaber, C-1.
	Rn-Be-H ₂ O	C	3.6	4.8	Vols, V-1, '43.
	Ni ⁵⁸ 12y	P		$\sim 0.5 \pm 50\%$	Camac and Brown, C-8, '44.
	Ni ⁶⁴ 2.6h	TC	T	$1.4 \pm 20\%$	Seren et al, S-2, '44.
		T		2.6	Hughes et al, H-3, '46.
	Ra-Be-Par	C	2.6	3.6	O'Neal and Goldhaber, O-1, '41.

762

Nickel

	Source	Neutron Energy	Measured	Reference
TOTAL	Ra-γ -Be	~.09, ~.4	5.7, 6.3	Goloborodko, G-13, '47.
	C-D	0.18	6.6	Amaldi et al, A-1, '39.
	Th-D	"	6.6	Goloborodko, G-13, '47.
	Th-Be	0.7	3.6	" " " "
				See notes for discussion
	D-D	2.38-2.5	2.56	Aoki and Kikuchi, A-2, '39.
	D-Li	14	2.62	Amaldi et al, A-3, '46.
		2.1-2.8 .023-0.88	graph WPB " "	Aoki, A-4, '39. Wattenberg et al, W-8.
SCATTERING				
For inelastic scattering and transport cross section see reference sheets.				
ABSORPTION				
Ni ⁶⁴ 2.6h	Th-D	0.18	<16 mb	Halban and Kowarski, H-18, '38.
	Fission n's ~1		6.7 mb	Hughes et al, H-2, '46.
Ni ⁵⁸ np	P		~0.7 mb	Brosi, B-30, '46.

772

76
SLOW

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	7.5		Dunning et al, D-1, '35.
	Ra-Be-Par	C	11.9		Goldhaber and Briggs, G-1, '37.
	Rn-Be-Par	C	10.5 $\pm$ 0.4		Beyer and Whitaker, B-6, '40.
					Rolled plate. Also measured cross sections of some Cu compounds.
	Ra-Be-Par	C	10.3		Whitaker and Bright, W-1, '41.
	D-D-Par	C	9.5		Carlson et al, C-2.
	Ra- γ -Be-Par	C	8.3 $\pm$ 0.4		Demers, D-2, '46.
	p-Be-Par	InRes 1.44	8.3 $\pm$ 0.3		Hanstein, H-4, '41. Rolled Cu.
	Ra- γ -Be-Par	AuRes 4.8	9.4 $\pm$ 0.6		Demers, D-2, '46.
	MC	.015-100	graph WPB	10.6	Rainwater et al, R-4, '45.

782

SCATTERING	Source	Neutron Energy	Measured	at .025 ev	Reference
	TC	T	6.9		Bragdon et al, B-9, '44.
	TC	T	7.2		Lichtenberger, L-5, '44.
	Ra-Be-Par		8.3		Mitchell et al, M-1, '36.
	Ra-Be-Par	C	8.6		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	5.5		Whitaker and Bright, W-1, '41.
			7.16		LA-140A
	P	Epi-Cd	7.9		Langedorf, L-14, '44.
		$4\pi a^2 = 8.0$			Fermi and Marshall, F-3, '47.
Evidence for scattering resonance					Harris, H-30, '47.

ABSORPTION	P		3.05		Wattenberg et al, W-2, '44.
	D-Be-Par	C	3.6	3.2	Ramm, R-1, '42.
	Rn-Be-H ₂ O	C	2.2	2.9	Volz, V-1, '43.
	Ra-Be-Par	C	3.4	4.1	Coltman and Goldhaber, C-1.
Cu ⁶³ 12.8h	TC	T		2.82 ± 20%	Seren et al, S-2, '44.
	Ra-Be-Par	C	1.8		Rasetti, R-2, '40.
	Ra-Be-Par	C	1.4	1.9	Houtermans, H-1, '41.
	P		2.6		Swartout, S-41, '46.
Cu ⁶⁵ 5m	TC	T		1.82 ± 20%	Seren et al, S-2, '44.
	Ra-Be-Par	C	1.2	1.7	Rasetti, R-2, '40.
	Ra- α -Be	C	2.4	3.3	O'Heal and Goldhaber, O-1, '41.
	Ra-Be-Par	C	1.6	2.2	Houtermans, H-1, '41.
	P		0.6		Swartout, S-41, '46.

792

78
FAST

AECD - 2274

Resonances $\frac{E_0}{\text{eV}}$
0.36 eV } possible
0.65 }Cu⁶⁵

570

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	3.6	Amaldi et al, A-1, '39.
	RdTh-Be	.7	2.8	Good & Scharff-Goldhaber, G-2, '41. WPB.
	D-D	2.38-2.5	2.6	Aoki and Kikuchi, A-2, '39.
	D-D	2.88 $\pm$.04	2.8	Zinn et al, Z-1, '39. WPB.
	Rn-Be	~4	3.2	Dunning et al, D-1, '35. WPB.
	D-Li	14	2.86	Amaldi et al, A-3, '46.
	D-Li	25.4	2.50	Sherr, S-29, '45.
	D-D Photo n's	2.1-2.8 .023-0.88	graph WPB " "	Aoki, A-4, '39. Wattenberg et al, W-8.

SCATTERING

802

Copper (Continued)

ABSORPTION	Source	Neutron Energy	Measured	Reference
Cu^{63} 12.8h	Ra- γ -Be Y-Be "	0.09	.0175	Griffiths, G-9, '39. Fischer et al, F-8, '45. LA-140.
		0.18	.05	
		0.18	.036	
		0.17	.021	LANS-95
		0.18	.028	
		0.24	.025	
		0.56	.009	
		0.75	.012	
		1.32	<.0065	
	D-D	2.7	.0017	Mescheryakov, M-14, '45.
	Fission n's ~1		.0089	Hughes et al, H-2.
Cu^{63} np	Ra-Be	~4	.0014	Dementi and Timoshuk, D-7, '40.
Cu^{65} 5h	Ra- γ -Be Th-D Y-Be	0.09	.013	Griffiths, G-9, '39. Halban and Kowarski, H-18, '38. LA-140.
		0.18	~.016	
		0.18	.036	
	Fission n's ~1		.006	Hughes et al, H-2.
	D-D	2.7	.0026	Mescheryakov, M-14, '45.
	Ra-Be	~4	.004	Dementi and Timoshuk, D-7, '40.
	Th-D Th-Be	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 1.5 \pm 0.65$	0.621	Demers and Halban, D-4, '46.
			~.04 mb	Lichtenberger et al, L-8, '46. .299 due to resonance.
				Swartout, S-39, '46. Also S-41.

4612

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	4.7		Dunning et al, D-1, '35.
	Rn-Be-Par	C	4.5 $\pm$ 0.5		Beyer and Whitaker, B-6, '40. Also measured cross sections for compounds.
	D-D-Par	C	8.6		Carlson et al, C-2.
	p-Be-Par	InRes 1.44	4.2		Hanstein, H-4, '41.
	MC	.015 - 30	graphs		Rainwater et al, R-4, '45.
	"	$\sigma \approx \text{const}$	4.2		" " " "
SCATTERING	Ra-Be-Par	C	5.2		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	3.7		Mitchell et al, M-1, '36.
		T	3.63		LA-140A
	TC	T	3.8		Bragdon and Wilson, B-9, '44.
	Rn-Be-Par	C	5.6		Kimura, K-2, '40.
	Rn-Be-Par	InRes 1.44	5.1		" " "
		$4\pi a^2 = 4.1$			Fermi and Marshall, F-3, '47.
ABSORPTION	Rn-Be-H ₂ O	C	1.2	1.6	Volz, V-1, '43.
			0.92	1.02	Coltman and Goldhaber, C-1.
	P		0.9		Wattenberg et al, W-2, '44.
	Zn ⁶⁴ 250d	P		0.51 $\pm$ 20%	Seren et al, S-2, '44.
		P		0.30	Overman, O-2, '47.
	Zn ⁶⁸ 57m	TC		1.09 $\pm$ 20%	Seren et al, S-2, '44.
		TC		0.89	Hughes et al, H-3, '46.
	Zn ⁶⁸ 13.8h	P		0.31 $\pm$ 20%	Seren et al, S-2, '44.
		TC		.086	Hughes et al, H-3, '46.
	Zn ⁷⁰ 2.2m	T		.086	Hughes et al, H-22, '46.

82N

Zinc

	Source	Neutron Energy	Measured	Reference
TOTAL	Ra-Y-Ba	~.09, ~.4	5.1, 6.0	Goloborodko, G-13, '47.
	C-D	0.18	3.6	Amaldi et al, A-1, '39.
	Th-D	0.18	4.0	Goloborodko, G-13, '47.
	Th-Ba	0.7	2.8	" " "
				See ref. sheet for discussion.
	D-D	2.38-2.5	2.7	Aoki and Kikuchi, A-2, '39.
	D-D	2.88±0.04	3.3	Zinn et al, Z-1, '39. WPB.
	Rn-Ba	4	3.3	Dunning, D-1, '35. WPB.
	D-Li	14	3.03	Amaldi et al, A-3, '46.
	D-D Photo n's	2.1-2.8 .024-0.87	graph WPB " "	Aoki, A-4, '39. Wattenberg et al, W-8.

SCATTERING

ABSORPTION

Zn^{66} n,p	Ra-Ba	~4	3.7 mb	Dementi and Timoshuk, D-7, '40.
Zn^{68} 57m	Fission n's D-D	~1 2.7	7 mb <.05 mb	Hughes et al, H-2, '46. Mescheryakov, M-14, '45.
Zn^{68} 13.8h	Fission n's D-D	~1 2.7	13 mb <.05 mb	Hughes et al, H-2, '46. Mescheryakov, M-14, '45.

932

82
SLOW

AECD - 2274

37 Lithium (Ga)

68	69	70	71	72
61.2			38.8	
68m $\beta^+ 1.9$		20.5m $\beta^- 1.62$ γ		14.3h $\beta^- 3.23$ 2.5 γ 0.64 0.84 1.86 2.25 2.65

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	D-D-Par.	C	18.5 $\pm$ 7.6		Lauterjung, L-2, '42. Used Ga.

SCATTERING	Ra-Be-Par	C	<4		Goldhaber and Briggs, G-1, '37.
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ABSORPTION					
Ga ⁶⁹ 20.5m	TC Ra- α -Be	T C	1	1.40 $\pm$ 20% 1.4	Seren et al, S-2, '44. O'Neal and Goldhaber, O-1, '41. K capture not considered in either case.
Ga ⁷¹ 14.3h	P Ra- α -Be	C	2.6	3.36 $\pm$ 20% 3.6	Seren et al, S-2, '44. O'Neal and Goldhaber, O-1, '41.

842

FAST

AECD - 2274

83 (Ga)

Gallium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

8572

84
SLOW

AECD - 2274

Germanium (Ge)

68	70	71	72	73	74	75	76	77
	21.2		27.3	7.9	37.1		6.5	
	11d K $\beta^- .6$ $\gamma .5$	40h $\beta^+ 1.2$			89m $\beta^- 1.1$ γ		12h $\beta^- 1.8$ γ	59s $\beta^- 2.8$

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par	C	~ 75		Dunning et al, D-1, '35.
	D-D-Par	C	24.3 ± 7.3		Lauterjung, L-2, '42.
	MC	.01-40 .015-5000	graph WPB graphs	15 6	Rainwater et al, R-4, '45. Wu et al, W-3, '46.

SCATTERING

ABSORPTION

Ge ⁷⁰ 11d	P			$0.45 \pm 40\%$	Seren et al, S-2, '44.
Ge ⁷⁰ 40h	P			$0.018 \pm 20\%$	Seren et al, S-2, '44. Correcting for 40h As. See A-7.
Ge ⁷⁴ 89m	P			$0.38 \pm 20\%$	Seren et al, S-2, '44.
Ge ⁷⁶ 12h	P			$0.085 \pm 20\%$	Seren et al, S-2, '44.
Ge ⁷⁶ 9s				0.095	Arnold and Sugarman, A-7, '47.

862

FAST

Germanium

AECD - 2274

85 (Ge)

Resonances

$$\frac{E_0}{95 \text{ ev}} \approx \frac{\sigma_0 \Gamma^2}{800}$$

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

872

86
SLOW

3 Arsenic (As)
74 75 76
100

16d
 $\beta^- 1.3$
 $\beta^+ 0.9$
 $\gamma .582$

26.8h
K, γ ?
 $\beta^+ 2.6$
See β^-
decay
scheme

AECD - 2274

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	Rn-Be-Par Ra-Be-Par	C C	8.6	8.8	Dunning et al, D-1, '35. Frisch et al, F-2, '37.
SCATTERING	Ra-Be-Par	C	7.1		Goldhaber and Briggs, G-3, '37.
ABSORPTION	P Ra-Be-H ₂ O D-Be-Par Rn-Be-H ₂ O	C C C C	4.4 6.5 5.2 3.5	7.9 4.6 4.6	Wattenberg et al, W-2, '44. Lapointe and Rasetti, L-1, '40. Ramm, R-1, '42. Volz, V-1, '43.
As ⁷⁵ 26.8h	TC Ra-Be-Par	T C	3.1	4.2 $\pm$ 20% 4.2	Seren et al, S-2, '44. Rasetti, R-2, '40.

882

FAST
Arsenic

AECD - 2274
Resonance

(As)

E_c

~ 30

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim .4$	8.2, 7.0	Goloborodko, G-13, '47.
	C-D	0.18	4.7	Amaldi et al, A-1, '39.
	Th-D	0.18	6.3	Goloborodko, G-13, '47.
	Th-Be	0.7	5.8	Goloborodko, G-13, '47. See reference sheets for discussion.
	D-D	2.38-2.5	3.39	Aoki and Kikuchi, A-2, '39.

SCATTERING

ABSORPTION

As⁷⁵ 26.8h

Ra- γ -Be	0.09	0.16	Griffiths, G-9, '39.
Th-D	0.18	0.15	Halban and Kowarski, H-18, '38.
Y-Be	0.18	0.29	LA-140.
Th-D Th-Be	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 4.4 \pm 0.45$		Demers and Halban, D-4, '46.
D-D	2.7	0.014	Mescheryakov, M-14, '45.

89 2

88
SLOW

AECD - 2274

Selenium (Se)

74	75	76	77	78	79	80	81	82	83
0.87	115d K, e ⁻ γ 0.335 0.18	9.02	7.58	23.52	long?	49.82	57m 19m I.T. β ⁻ 1.5 γ .099 no γ e ⁻	9.19 25m 67s β ⁻ 1.5 β ⁻ 3.4 γ 0.17 0.37 1.1	

Unassigned Activity

17.5s
γ ~.15

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par Ra-Be-Par	C C	19 20.4		Dunning et al, D-1, '35. Goldhaber and Briggs, G-1, '37.

SCATTERING	Ra-Be-Par	C	12.7		Goldhaber and Briggs, G-1, '37.
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ABSORPTION	Ra-Be-H ₂ O Rn-Be-H ₂ O	C C	11.5 12.0	14.0 16.0	Lapointe and Rasetti, L-1, '40. Volz, V-1, '43.
Se ⁷⁴ 115d	P			22 ± 40%	Seren et al, S-2, '44.
Se ⁸⁰ 19m	P TC	T		.46 ± 20%	Glendenin and Gest, G-11, '46. Seren et al, S-2, '44.
Se ⁸⁰ 57m	P			.034 ± 20%	Seren et al, S-2, '44.
Se ⁸² 25m	P			~.005	Arnold and Sugarman, A-7, '47. Based on Seren's value for prod. of Br ⁸³ .
Se ⁸² 67s	P			~.054	
Se ¹⁷⁶ 17s	P			(atomic ~0.6)	Arnold and Sugarman, A-7, '47.

902

FAST

AECD - 2274

89 (Se)

Selenium

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim 0.09, \sim 0.4$	6.9, 8.3	Goloborodko, G-14, '44.
	C-D	0.18	4.5	Amaldi et al, A-1, '39.
	Th-D	0.18	5.6	Goloborodko, G-14, '44.
	Th-Be	0.7	4.9	Goloborodko, G-14, '44. See reference sheets for discussion.
	D-D	2.88 ± 0.04	4.0	Zinn et al, Z-1, '39.
	D-Li	14	3.35	Amaldi et al, A-3, '46.

SCATTERING

ABSORPTION

912

90
SLOW

AECD - 2274

Bromine (Br)				
79	80	81	82	
50.53	4.4h	18m	49.47	34h
6.4m	I.T.	β^- 2.0		β^- .465
β^+ 2.3	e^-	γ < 0.5		γ .547
γ .046	γ .049			γ .787
e^- .108	.037			1.35

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
	Rn-Be-Par	C	11.8		Dunning et al, D-1, '35. Used KBr. Took $\sigma_t(K) = 8.2$.

SCATTERING	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
	Ra-Be-Par	C	7		Goldhaber and Briggs, G-1, '37. Used KBr. Took $\sigma_t(K) = 1.5$. Fermi and Marshall, F-3, '47.
		$4\pi a^2$	= 3.9		

ABSORPTION	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
	Rn-Be-H ₂ O	C	3.2	4.2	Volz, V-1, '43.
	Ra-Be-H ₂ O	C	7	8.5	Lapointe and Rasetti, L-1, '40.
Br ⁷⁹ 18m	TC	T		8.1 ± 20%	Seren et al, S-2, '44.
	Ra-Be-Par	C	7	9.5	Rasetti, R-2, '40.
Br ⁷⁹ 4.4h	TC	C	4.1	5.7	Houtermans, H-1, '41.
	Ra-Be-Par	T		2.76 ± 20%	Seren et al, S-2, '44.
		C	6	8	Rasetti, R-2, '40.
Br ⁸¹ 34h	P			2.25 ± 20%	Seren et al, S-2, '44.

920

Bromine

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	0.18	6.6	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	2.69	Aoki and Kikuchi, A-2, '39.
SCATTERING				
ABSORPTION				
Br ⁷⁹ 18m	Ra- γ -Be	0.09	0.24	Griffiths, G-9, '39.
	Y-Be	0.18	0.49	LA-120
	Fission n's ~1		0.040	Hughes et al, H-2, '46.
	D-D	2.7	0.035	Mescheryakov, M-14, '45.
	Ra-Be	~4	0.030	Dementi and Timoshuk, D-7, '40.
	$\frac{\text{RdTh-D}_2\text{O}}{\text{RdTh-Be}}$	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 4.4 \pm 1.1$		Demers and Halban, D-4, '46.
Br ⁷⁹ 4.4h	Ra- γ -Be	0.09	0.13	Griffiths, G-9, '39.
	Y-Be	0.18	0.07	LA-120
	Fission n's ~1		0.022	Hughes et al, H-2, '46.
	D-D	2.7	0.017	Mescheryakov, M-14, '45.
	Ra-Be	~4	0.024	Dementi and Timoshuk, D-7, '40.
	$\frac{\text{RdTh-D}_2\text{O}}{\text{RdTh-Be}}$	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 4.4$		Demers and Halban, D-4, '46.
Br ⁸¹ 34h	Fission n's ~1		0.020	Hughes et al, H-2, '46.
	$\frac{\text{RdTh-D}_2\text{O}}{\text{RdTh-Be}}$	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 3.75$		Demers and Halban, D-4, '46.

Q32

92
SLOW

AECD - 2274

Krypton (Kr)

78	79	80	81	82	83	84	85	86	87
0.35		2.01		11.53	11.53	57.11		17.47	
34h β^+ 0.9, 30% 0.6, 70% γ 0.2				113m I.T. e^- .029 .046		4.6h~10y β^- 1.0 γ 0.17 0.37	4.6h~10y β^- 0.74 no γ	75m β^- 4	

Unassigned Activities

55s 13s
I.T., e^- I.T., e^-
no β^+
 γ 0.127 γ 0.187

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par D-D-Par	C C	27.3 23.5±14		Carroll, C-3, '41. Reizler, R-16, '42.

SCATTERING

ABSORPTION

	P		σ		
Kr 78 34h	P		.045		Wattenberg et al, W-2, '43. Purity of sample doubtful.
Kr 84 4.6h	P		0.26		Hoagland and Sugarman, H-24, '45.
Kr 84 4.6h~10y	P		.096		" " " " "
Kr 84 4.6h~10y	P		.063		" " " " "
Kr 86 75m	P		0.061		" " " " "
γ	P		<450		Sugarman, S-22, '45.

942

FAST

AECD - 2274

93 (Kr)

Krypton

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

95.2

94
SLOW

AECD - 2274

84 85 86 87 88
Ibodium (Rb)
72.8 27.2

6.5h

19.5d 5.8x10¹⁰y 17.5m
β⁻ 1.6 β⁻ .13 β⁻ 4.6
γ .034
.053
.082
.102
.129

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	D-D-Par	C	11.8 ± 1.9		Lauterjung, L-2, '42. Used RbI. σ(I) = 9.4.

SCATTERING

ABSORPTION

Rb ⁸⁵ 19.5d	P			0.72 ± 20%	Seren et al, S-2, '44.
Rb ⁸⁷ 17.5m	TC	T		0.122 ± 20%	Seren et al, S-2, '44.
Rb ⁸⁸	P		< 200		Sugarman and Katcoff, K-1, '45.

962

Rubidium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Rb ⁸⁷ 17.5m	Fission n's	~ 1	.045	Hughes et al, H-2.

972

96
SLOW

AECD - 2274

Strontium (Sr)				
85	86	87	88	89
0.55	9.75	6.96	82.74	
65d K γ .8	70m I.T. e ⁻ γ .170	2.7h I.T. e ⁻ .386		55d β ⁻ 1.5 no γ

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Measured
TOTAL	Rn-Be-Par	C	~5		Dunning et al, D-1, '35. From σ(SrCrO ₄) = 27.1, σ(O) = 4, σ(Cr) = 6.6.
SCATTERING	Ra-Be-Par	C	9.5		Goldhaber and Briggs, G-1, '37. Used SrS, σ _s (S) = 1.1.
ABSORPTION	P Rn-Be-H ₂ O Ra-Be-Par	C C C	1.2 1.5 1.3	2.0 1.6	Wattenberg et al, W-2, '44. Volz, V-1, '43. Coltman and Goldhaber, C-1
Sr ⁸⁶ 2.7h	P			1.29 ± 20%	Seren et al, S-2, '44. Assuming int. conv. = 15%
Sr ⁸⁸ 55d	P			.005 ± 20%	Seren et al, S-2, '44.

Q82

FAST

AECD - 2274

97

(Sr)

Strontium

TOTAL	Source	Neutron Energy	σ Measured	Reference
	C-D	0.18	5.8	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	4.14	Aoki and Kikuchi, A-2, '39.

SCATTERING

ABSORPTION

992

98
SLOW

AECD - 2274

Yttrium (Y)		
88	89	90
2.0h	105d	62h
$\beta^+ 1.2$	K	$\beta^- 2.1$
	$\gamma .908$	no γ
	1.89	

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	800		Dunning et al. D-1, '35.
	RdTh-Be-Par	C	~ 4		Bomke and Reddemann, B-1, '42.

SCATTERING	Ra-Be-Par	C	< 14		Goldhaber and Briggs, G-1, '37. Used Y_2O_3 .
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ABSORPTION					
Y^{89}_{62h}	P			$1.24 \pm 20\%$	Seren et al, S-2, '44.

1800

FAST

AECD - 2274

99 (Y)

Yttrium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
$Y^{89}_{62}h$	Ra- γ -Be	.09	.093	Griffiths, G-9, '39.

1012

100
SLOW

AECD - 2274

Zirconium (Zr)

89	90	91	92	93	94	95	96	97
78h	4.5m	51.51	11.27	17.14	17.30	65d	2.78	
$\beta^+ 1.07$ no γ	$e^- \gamma$ I.T. or K			> 40y		See decay scheme	17h $\beta^- 2.2$ $\gamma \sim 0.8$	

Unassigned Activity

Sugarman, S-26, '45.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par		15.3		Dunning et al, D-1, '35. Used ZrO ₂ .
	MC	.01-.4	$\sigma_t = (6.8 + 0.74)/E^{1/2}$		Havens et al, H-25, '47. " "
	MC	.024-65	graph WPB	11	Wu et al, W-11 and R-4, '45. " "
	MC	.01-1000	graph	11	Havens et al, H-25, '47. " "
SCATTERING	Rn-Be-H ₂ O	C	<16		Goldhaber and Briggs, G-1, '37.
		C	8.15		LA-140A
ABSORPTION	Rn-Be-H ₂ O	C	<0.35	<0.4	Volz, V-1, '43.
	P		2.8		Wattenberg et al, W-2, '44.
	P			2.0	Langsdorf et al, L-17, '47. Osc.
	P			1.1	Pomerance and Hoover, P-2, '47. "
Zr ⁹⁴ 65d	P			0.43 $\pm$ 40%	Seren, S-2, '44.
Zr ⁹⁶ 17h	P			0.60 $\pm$ 20%	" " "
6m	TC			atomic .016 $\pm$ 40%	" " "

1022

FAST

AECD - 2274

101

(Zr)

Zirconium

Resonances

E_0	σ_0
$1.09 \pm .03$	~ 5
$2.3 \pm .07$	~ 8
5.7 ± 0.5	7?
7.6 ± 0.4	

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1032

102
SLOW

AECD - 2274

Columbium (Cb)

92	93	94
11d	21.6h	100
σ 1.38	σ 1.2	42d
0.59	0.6	I.T.
γ 1.0		e^- .036
		σ 1.3 (.01%)
		γ 1

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par	C	~ 12		Dunning et al, D-1, '35. Used Cb_2O_5 .
	MC	.05-1	$\sigma_t = 6.4 + 0.1/E^2$		Wu et al, W-3, '46.
	MC	.008-1000	graph e.e.	6.4	Wu et al, W-3, '46.

SCATTERING	Ra-Be-Par	C	5		Goldhaber and Briggs, G-1, '37.
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ABSORPTION	P P D-Be-Par	C	1.4 ~ 1.45 1.5	1.3	Sturm et al, S-24, '44. Moak and Strong, M-15, '46.0sc. Ramm, R-1, '42.
$Cb^{93} 6.6m$				~ 1	Goldhaber et al, G-10, '46. Seren's value recalculated for present decay scheme.

1042

TOTAL	Source	Neutron Energy	σ Measured	Reference

SCATTERING				

ABSORPTION				
$Cb^{93} 6.6m$	Fission n's	~ 1	.052	Hughes et al. H-2
$\int \sigma dE/E$			8.5 4.55	<p>Lichtenberger et al. L-4, '45. Osc.</p> <p>Lichtenberger et al. L-8, '47. B</p> <p>also 1.85 due to resonance at uncertain energy.</p>

10572

Molybdenum (Mo)										
93	94	95	96	97	98	99	100	101		
15.84	9.04	15.72	16.5	9.46	23.78	9.63				
6.7h	17m					67h		14.6m		
$\beta^+ 0.3$	$\beta^+ 2.65$					$\beta^- 1.5$		$\beta^- 1.0$		
0.7						$\gamma .24$		2.2		
$\gamma 1.6$						.75		$\gamma 0.3$		
								0.9		

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	7.1		Dunning et al, D-1, '35.
MoO ₃	Ra- γ -Be-Par	C	18.5		Demers, D-2, '46.
MoO ₃	Ra- γ -Be-Par	AuRes 4.8	16.1		Demers, D-2, '46.

SCATTERING	Ra-Be-Par	C	6.7		Goldhaber and Briggs, G-1, '37.
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ABSORPTION	Ra-Be-Par	C	2.3	2.8	Coltman and Goldhaber, C-1.
	P		2.37	2.37	Wattenberg et al, W-2, '43.
	Rn-Be-H ₂ O	C	5.8	7.7	Volz, V-1, '43.
	P			2.80	Pomerance and Hoover, P-2, '47. Osc.
Mo ⁹² 6.7h	P			.0063 $\pm$ 40%	Seren et al, S-2, '44. Did not consider possible K capture.
Mo ⁹⁸ 67h	P			0.415 $\pm$ 20%	Seren et al, S-2, '44.
Mo ¹⁰⁰ 14.6m	P			0.475 $\pm$ 20%	Seren et al, S-2, '44.

106 N

FAST

Molybdenum

AECD - 2274

105

(Mo)

TOTAL	Source	Neutron Energy	σ Measured	Reference
	D-D	2.88 ± 0.04	4.1	Zinn et al, Z-1, '39.

SCATTERING				
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ABSORPTION				
Mo ⁹⁸ 67h	Fission n's	~ 1	.032	Hughes et al, H-2.
Mo ¹⁰⁰ 14.6m	Fission n's	~ 1	.015	Hughes et al, H-2.

1072

Technetium (Tc)

96	97	98	99	100	101
4.2d	93d	2.7d	2×10^6 y	6.0h	?
K	K	K?	$\beta^- 0.32$	I.T., e ⁻	14.0m
e ⁻	e ⁻	$\beta^- .75$	no γ	$\gamma .14$	$\beta^- 1.3$
$\gamma .92$	$\gamma .097$	$\gamma 1.0$			$\gamma 0.30$

2.7d

?

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
SCATTERING					
ABSORPTION					

10872

FAST
Technetium

AECD - 2274

107 (Tc)

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

109N

108
SLOW

AECD - 2274

Ruthenium (Ru)									
96	97	98	99	100	101	102	103	104	105
5.68		2.22	12.81	12.70	16.98	31.34		18.27	
20m	2.8d						42d		4.5h
	K						β^- 0.2		β^- 1.4
	e^- 0.2						95%		γ 0.76
	γ 0.22						0.8		
	X-ray .0183						5%		
							γ 0.56		

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	12.5		Dunning et al, D-1, '35.
SCATTERING	Ra-Be-Par	C	5.6		Goldhaber and Briggs, G-1, '37.
ABSORPTION					
Ru ⁹⁶ 90d Tc ⁹⁷	P			>0.5 mb	Glendenin and Gest, G-11, '46.
Ru ¹⁰² 41d	P			10 mb	Boyd and Motta, B-24, '46.
Ru ¹⁰⁴ 4.5h	P			1.18 ± 20%	Seren et al, S-2, '44.
				0.668 ± 20%	Seren et al, S-2, '44.

1102

FAST

AEC - 2274

109

(Ru)

Ruthenium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Ru ⁹⁸ np Tc(2.7d)			.04 mb	Glendenin and Gest, G-11, '46.

112

110
SLOW

AECD - 2274

Rhodium		103		104	
210d	100	57m	44s	4.7m	
$\beta^- 1.0$		I.T.		I.T.	
$\beta^+ 1.1$		$e^- .03$	$\beta^- 2.3$	e^-	
$\gamma 0.46$		X-ray	$\gamma 0.18$	$\gamma 0.05$	
			0.95		
			0.04		

Tentative Decay Scheme

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	115		Dunning et al, D-1, '35.
	Rn-Be-Par	C	130		Fink, F-4, '36.
	TC	.025		155	Fermi and Marshall, F-9, '44.
	CS	.04-65	graph		Sturm and Turkel, S-27, '47.
	CS	.018-1.3	"	145	Borst, private com. '46.

SCATTERING

ABSORPTION	Rn-Be-H ₂ O	C	149	197	Volz, V-1, '43.
Rh ¹⁰³ 44s	Ra-Be-Par	C	137	189	Houtermans, H-1, '41.
	TC			137 $\pm$ 10%	Seren, S-2, '44.
Rh ¹⁰³ 4.7m	TC			11.6 $\pm$ 10%	Seren, S-2, '44.

1122

FAST

AECD - 2274

111

(Rh)

Rhodium

Resonances

E_0 Γ σ_0
 1.29 < 0.13 > 1550

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Rh ¹⁰³ 44s	Y-Be	0.18	0.48	LA-140.
	Th-D ₂ O	$\sigma_c(0.18)$	$= 5.4 \pm 2.6$	Demers, D-4, '46.
	Th-Be	$\sigma_c(0.70)$		
	Fission n's	~1	0.103	Hughes et al, H-2, '46.
	D-D	2.7	.0266	Mescheryakov, M-14, '45.
	Ra-Be	~4	.043	Dementi and Timoshuk, D-7, '40.
Rh ¹⁰³ 4.72	Y-Be	0.18	0.14	LA-140.
	Th-D ₂ O	$\sigma_c(0.18)$	$= 1.4 \pm 0.7$	Demers, D-4, '46.
	Th-Be	$\sigma_c(0.70)$		
	Fission n's	~1	.016	Hughes et al, H-2, '46.
	D-D	2.7	.0069	Mescheryakov, M-14, '45.

1132

112
SLOW

AECD - 2274

Palladium (Pd)									
102	103	104	105	106	107	108	109	110	111
0.8		9.3	22.6	27.2		26.8		13.5	
	17d K						13h $\beta^-1.0$ no γ		26m $\beta^-3.5$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	10		Dunning et al, D-1, '35.

SCATTERING	Ra-Be-Par	C T	3 4.51		Goldhaber and Briggs, G-1, '37. LA-140A
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ABSORPTION	P		~6		Pardue, P-1, '45. Osc.
Pd ¹⁰⁸ 13h	TC Ra-Be-Par	T C	23	11.6 ± 20% 32	Seren et al, S-2, '44. Houtermans, H-1, '41.
Pd ¹¹⁰ 26m	TC	T		0.39 ± 20%	Seren et al, S-2, '44.

1142

Palladium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Pd^{108}_{13h}	$\frac{\text{RdTh-D}_2\text{O}}{\text{RdTh-Be}}$	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 2.3 \pm 0.3$		Demers and Halban, D-4, '46.
	$\frac{\text{RdTh-D}_2\text{O}}{\text{RdTh-Be}}$	0.18	0.42	Halban and Kowarski, H-18, '38.
Pd^{110}_{26m}	$\frac{\text{RdTh-D}_2\text{O}}{\text{RdTh-Be}}$	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 0.85 \pm 0.65$		Demers and Halban, D-4, '46.
	P		$\sim .01$	Elliot et al, E-3, '46.
Pd^{105}_{np}				

1157

Silver (Ag)

106	107	108	109	110
8.2d K _α ⁺ γ 1.63 1.06 0.7	24.5m β ⁺ 2.04 No γ	51.35 44.38 I.T., s- γ .094	2.3m β ⁻ 2.8 48.65 40.48 I.T., s- γ .088	22s β ⁻ 2.8 225d β ⁻ 1.3 ? 0.6 γ 1.40 0.90 0.66

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	TC			64.2	Fermi and Marshall, F-9, '44.
	Rn-Be-Par	C	55		Dunning, D-1, '35.
	Rn-Be-Par	C	56 ± 2		Fink, F-4, '36.
	Ra-Be-Par	C		60 ± 4	Frisch et al, F-2, '37.
	Ra-Be-Par	C	63		Goldhaber and Briggs, G-1, '37.
	MC	.015-.5	σ = 6.6 + 9.05/E ^{1/2}		Havens and Rainwater, H-26, '46.
	MC	.015-200	graph	65	" " " " " "
	MC	3-1,000	graphs		Rainwater et al, R-8, '47.
	MC	.5-50	graph		Bacher et al, B-19, '42.

SCATTERING	TC	T	5.5		Lichtenberger, L-5, '44.
	TC	T	3.9		σ _s (C) = 4.8
					Bragdon, B-9, '44.
	Ra-Be-Par		6.3		
	Rn-Be-Par	C	5.5		Mitchell et al, M-1, '36.
					Kimura, K-2, '40.
	Rn-Be-Par	InRes 1.44	5.0		" " "
	P	Epi-Cd	7.7		Langsdorf, L-14, '44.
	Scattering as well as abs. res. at 5.1 ev.				Langsdorf and Arnold, L-11, '46.

ABSORPTION	P		55		Wattenberg, W-2.
	P			57.3	Pomerance & Hoover, P-2, '47.086.
	D-Be-Par	C	64	57 ⁺	Ramm, R-1, '42. *See references.
	Rn-Be-E ₂ O	C	58	77	Volz, V-1, '43.
Ag ¹⁰⁷ 2.3m	TC	T		44.3 ± 20%	Seren et al, S-2, '44.
	Ra-Be-Par	C	32	44.1	Houtermans, H-1, '41.
Ag ¹⁰⁹ 22s	TC	T		97.0 ± 20%	Seren, S-2, '44.
	Ra-Be-Par	C	87	120	Houtermans, H-1, '41.
225d	P			2.3 ± 20%	Seren, S-2, '41.

1162

FAST
Silver

AECD - 2274

115 (Ag)

Resonances

E_0 $\sigma_0 \Gamma^2$
5.1 (Ag¹⁰⁹) 300 ± 50
16 ± 1 ~ 24
45 ± 4 ~ 700

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	5.5	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	4.30	Aoki, A-2, '39.
	Li-D	14	3.82	Amaldi et al, A-3, '46.
	"	25.4	3.70	Sherr, S-29, '45.
	Photo n's	.023-.80	graph WPB	Wattenberg, W-8, '47.
	D-D	2.1-2.8	"	Aoki, A-4, '39.

SCATTERING

ABSORPTION

Source	Neutron Energy	σ Ag ¹⁰⁷ 2.3n	σ Ag ¹⁰⁹ 225d	
Th-D	$\sigma_0(0.18)$	$= 1.5 \pm 0.45$	1.25 ± 1.05	Demers and Halban, D-4, '46.
Th-Be	$\sigma_0(0.70)$			
Li-p	~.003	2.04	3.61	Linenberger and Miskel, L-15, '46.
	.016	1.04	1.06	
	.033	.703	.856	
	.067	.556	.511	
	.098	.635	.635	
	.195	.246	.273	
	.390	.130	.170	
Ra-Be	.09	.462		Griffiths, G-9, '39.
Y-Be	.18	.49		LAHS-93, '44.
Th-D	.18	.52	.80	Halban & Kowarski, H-18, '38.
Fission n's	~1	.127	.228	Hughes et al, H-2.
D-D	2.7	.052	.074	Mescheryakov, M-14, '45.
Ra-Be	~4	.060		Dementi and Timoshuk, D-7, '40.
Ag ¹⁰⁹ np	P		~.01	Elliot et al, E-3, '46.

1172

Cadmium (Cd)

106	107	108	109	110	111	112	113	114	115	116	117
1.4		1.0		12.8	13.0	24.2	12.3	28.0		7.3	
	6.7h K~100% β+.32, 3% γ .8, 4%		330d K			48m I.T. e ⁻ 0.195			2.33d β 0.55 1.25 γ ~0.5	43d β 1.85 β 1.3	2.83h

Unassigned Activities

33m 2m ?

β⁺

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	3300		Dunning et al, D-1, '35.
	Rn-Be-Par	C	2900±100		Rink, F-4, '36.
	Ra-Be-Par	C		3100±150	Frisch et al, F-2, '37.
	RdTh-Be-Par	C	2640		Bomke and Reddemann, B-1, '42.
	TC	T		2970	Fermi and Marshall, F-9, '44.
	TC	.0026	5200		" " " F-10, '44.
		.006-0.4	graph WPB	2500	Early data
	CS	0-0.5	graph	2600	Wollan et al, W-9, '45.
	MVS	.005-.23	"	2500	Lichtenberger et al, L-13, '45.
	CS	.015-10	"	2500	Zinn and Sturm, Z-3, '47.
	MC	.01-.28	graphs	2400	Rainwater et al, R-8, '46.
	MC	.015-.25	graph	2300	" " R-4 and R-11, '45.

SCATTERING	Ra-Be-Par		1.2		Mitchell et al, M-1, '36.
	TC	T	6±1		Hughes and Bragdon, B-9, '44.
	TC	T	7.5		Lichtenberger, L-5, '44.
		.01-2	Constant term = 5.3		Rainwater et al, R-8, '46.
		.01-10	" " 6.0		Zinn and Sturm, Z-3, '47.

ABSORPTION	Ra-Be-H ₂ O	C	2900		Lapointe and Rasetti, L-1, '40.
	Rn-Be-H ₂ O	C	2950		Volz, V-1, '43.
Cd ¹⁰⁶ 6.7h	P		~1		Goldhaber et al, G-12, '46.
Cd ¹¹⁰ 48m	TC ?			~0.2	Goldhaber and Muehlhause, G-15, '47.
Cd ¹¹⁴ 2.33d	P			1.1±20%	Seren et al, S-9, '47.
Cd ¹¹⁴ 43d	P			0.14±20%	" " " " " "
Cd ¹¹⁶ 2.83h	P			1.4±20%	" " " " " Used T _{1/2} = 3.75 h.
Cd 2m	P			atomic 0.05±20%	" " " " " "

Cd¹¹³ is large absorber. Other main isotopes have $\sigma < 1/40 \sigma(\text{Cd}^{113})$. Dempster, D-6, '47.

FAST
Cadmium

AECD - 2274

117 (Cd)

Resonances

E_0 σ_0 Γ
Cd¹¹³ 0.176 7,200 0.115

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	0.18	4.9	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	4.07	Aoki and Kikuchi, A-2, '39.
	D-Li	14	4.25	Amaldi et al, A-3, '46.
	Photo n's D-D	.023-0.8 2.1-2.8	graph WPB " "	Wattenberg et al, W-8. Aoki, A-4, '39.

SCATTERING

ABSORPTION

1192

118
SLOW

AECD - 2274

Indium (In)

113	114	115	116
4.23	48d 72s	95.77	13s 54.3m
105m	I.T. β^- 1.98	4.5h	β^- 2.8 β^- .85
I.T., e ⁻	e ⁻ .19	I.T., e ⁻	No γ 2.32
γ .39		γ .34	1.31
			1.12
			0.43

Lawson and Cork, L-16, '40.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	D-D-Par TC	C	199 $\pm$ 11	194	Lauterjung, L-2, '42. Fermi and Marshall, F-9, '44.
	MC	.017-50		191	McDaniel, M-21, '42.
	CS	.018-55	graph WPB	190	Borst et al, B-3, '45.
	MC	.05 to 10ev	" "		Havens et al, H-26, '46 and R-4, R-12.
	MC	0.8 to 1000 ev	graphs		Havens et al, H-25, '47.
SCATTERING	TC	T	2.2		Bragdon et al, B-9, '44.
	P	Epi-Cd	10		Langsdorf, L-14, '44.
Scattering as well as abs. res. at 1.44 ev. Langsdorf & Arnold, L-11, '46.					

ABSORPTION	P	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-H ₂ O	C	147	165	Wattenberg et al, W-2, '43.
	P			194	Volz, V-1, '43.
				194	Pomerance and Hoover, P-2, '47.
In ¹¹³ 48d	TC	T		56 $\pm$ 10%	Seren et al, S-2, '44.
In ¹¹³ 72s	TC	T		2	Goldhaber and Meuhlhaue, G-15, '47.
In ¹¹⁵ 13s	TC	T		52 $\pm$ 10%	Seren et al, S-2, '44.
In ¹¹⁵ 54m	TC	T		145 $\pm$ 10%	Seren et al, S-2, '44.
	Ra-Be-Par	C	127	176	Houtermans, H-1, '41.

1200

FAST

Indium

AECD - 2274
Resonances

(In)

119

In^{115}	E_0	$\sigma_0 \sqrt{E}$
	1.44	~ 210
	3.8	~ 120
	8.6	~ 300

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
In^{115}_{13s}	Fission n's	~ 1	0.063	Hughes et al, H-2, '46.
In^{115}_{54m}	Li-p	$\sim .003$	1.95	Linenberger and Miskel, L-15, '46.
	"	0.016	0.757	" " " "
	"	0.033	0.695	" " " "
	"	0.067	0.428	" " " "
	"	0.098	0.406	" " " "
	"	0.195	0.308	" " " "
	"	0.390	0.214	" " " "
	"	5.900	0.0237	" " " "
	Ra- γ -Be	.09	0.231	Griffiths, G-9, '39.
	Fission n's	~ 1	0.18	Hughes et al, H-2, '46.
	Y-Be	0.18	0.37	LA-140.
		0.04	0.73	LAMS-111
		0.17	0.27	LAMS-95
		0.18	0.25	" "
		0.56	0.27	" "
		0.75	0.30	" "
		1.32	0.31	" "
	Na-D ₂ O	0.23	0.25	Wattenberg, W-6, '45.
	Na-Be	0.80	0.34	" " " "
	Th-D	$\sigma_c(0.18)$		
	Th-Be	$\sigma_c(0.70)$	0.95	Demers and Halban, D-4, '46.
$\text{In}^{115} \int \sigma dE/E$			2790	Lichtenberger et al, L-8, '47.

1212

120
SLOW

AECD - 2274

50 ¹¹⁰Sn (Sn)

	113	114	115	116	117	118	119	120	121	122	123	124	125
	0.61	0.35	14.07	7.54	23.98	8.62	33.03		4.78	?	6.11		

110d
K, e⁻
γ .085

62h
β⁻ 0.8
no γ

10d
β⁻ 2.6
γ

10m
β⁻ 2.2
γ ~ 0.74

Unassigned activities
40m 26h 400d 130d
β⁻ β⁻ β⁻ β⁻
no γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	p-Be-Par	C	5.7		Hanstein, H-4, '41.
	D-D-Par	C	4.9		Carlson et al, C-2.
	Rn-Be-Par	C	4.0		Dunning et al, D-1, '35.
	MC	.01-50	graph	4.5 c.e.	Rainwater et al, R-4, '45.

SCATTERING	Ra-Be-Par		4.9		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par		4.1		Mitchell and Murphy, M-1, '36.
	TC		6.6		Bragdon and Wilson, B-9, '44.
	TC		4.2		Lichtenberger, L-5, '44.
	P	Epi-Cd	5.0		Langsdorf, L-14, '44. Based on
		T	4.25		σ _p (C) = 4.6 LA-140A

ABSORPTION	Rn-Be-H ₂ O	C	0.4	0.5	Volz, V-1, '43.
	P			0.54	Wattenberg, W-2, '43.
	Ra-Be-Par	C	0.53	0.64	Coltman and Goldhaber, C-1, '45.
Sn ¹¹² 110d	P			1.2 ± 40%	Seren, S-2, '44.
Sn ¹²⁴ 10m	P			0.574 ± 20%	" " "
Sn 40m	P			atomic	" " "
				.0142 ± 20%	" " "
Sn ¹¹⁰ h	P			atomic	" " "
				.072 ± 20%	" " "
Sn 10d	P			atomic	" " "
				.009 ± 20%	" " "
Sn 400d	P			atomic	" " "
				.018 ± 20%	" " "

1222

FAST

Tin

AECD - 2274

121 (Sn)

ResonancesE₀

1.5 ?

0.36 ?

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	0.18	5.2	Amaldi et al, A-1, '39.
	D-D	2.38-2.50	3.82 $\pm$ 0.19	Aoki and Kikuchi, A-2, '39.
	D-D	2.88	4.4	Zinn et al, Z-1, '39. WPB.
	Li-D	~14	4.5	Amaldi et al, A-3, '46.
	Rn- α -Be	~4	4.3	Dunning et al, D-1, '35. WPB.
	Photo n's	.023-0.8	graph WPB	Wattenberg et al, W-8.
	D-D	2.2-2.9	" "	Aoki, A-4, '39.

SCATTERING

For references to differential scattering cross section
see reference sheet.

ABSORPTION

1232

122
SLOW

AEC - 2274

Antimony (Sb)				
	121	122	123	124
	57.25		42.75	
^{17m} $\beta^+ 1.53$		2.8d $\beta^- 1.36$ 1.94 $\gamma 0.57$		60d See decay scheme

Meyerhof and Scharff-Goldhaber, E-16,
'47 and priv. comm.

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	Rn-Be-Par	C	8.1		Dunning et al, D-1, '35.
	D-D-Par	C	7.6		Carlson et al, C-2.
	MC	.014-76	graph WPB	8.2	Rainwater and Havens, R-12.
	MC	.015-1000	graphs	8.3	Rainwater et al, R-4, '45 and R-8, '46.
		.015-1	$\sigma_t = 4.2 \pm 0.64/E^{1/2}$		" " " " " "

SCATTERING	Ra-Be-Par		6.5 4.31		Goldhaber and Briggs, G-1, '37. LA-140A
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ABSORPTION	Ra-Be-Par	C	4.8	5.8	Coltman and Goldhaber, C-1.
	P			5.4	Wattenberg et al, W-2, '43.
	Rn-Be-H ₂ O	C	4.4	5.8	Volz, V-1, '43.
Sb^{121} 2.8d	Ra-Be-Par	C	3.3	4.6	Rasetti, R-2, '40.
	Ra- α -Be	C	3.6	5	O'Neal and Goldhaber, O-1, '41.
	P			$6.8 \pm 20\%$	Seren et al, S-2, '44.
Sb^{123} 60d	Ra- α -Be	C	2.3	3.2	O'Neal and Goldhaber, O-1, '41.
	P			$2.5 \pm 20\%$	Seren et al, S-2, '44.

1242

Antimony

Resonances

E_0	$\sigma_0 \Gamma$
5.8	~ 12
15	~ 35
21	~ 35

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	0.18	5.4	Amaldi et al, A-1, '39.
	D-D	2.38-2.50	4.88	Aoki, A-2, '39.
	Li-D	~ 14	4.35	Amaldi et al, A-3, '47.
	Photo n's D-D	.023-0.8 2.2-2.9	graph WPB " "	Wattenberg et al, W-8. Aoki, A-4, '39.

SCATTERING

ABSORPTION

Sb ¹²¹ 2.8d	Ra- γ -Be	.09	0.31	Griffiths, G-9, '39.
	Th-D	0.18	0.192	Halban and Kowarski, H-18, '38.
	Y-Be	0.18	0.36	LA-140.
	D-D	2.7	0.034	Mescheryakov, M-14, '45.
	Th-D ₂ O Th-Be	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)}$	2.25 ± 0.55	Demers and Halban, D-4, '46.
	Fission	~ 1	.090	Hughes et al, H-2.
Sb ¹²¹ 17m, n, 2n	Ra-Be	~ 4	.041	Dementi and Timoshuk, D-7, '40.
	Ra-Be	~ 4	.013	Dementi and Timoshuk, D-7, '40.

125N

124
SLOW

ABCD - 2274

52 Tellurium (Te)

119	120	121	122	123	124	125	126	127	128	129	130	131
0.091			2.49	0.89	4.63	7.01	18.72		31.72		34.46	
	143d	17d						90d	9.3h	32d	72m	30h 25m
	I.T., e ⁻ K							I.T. 0.76		I.T. 1.8		I.T. 0.3
	γ.05	γ.61.						e ⁻	No γ	e ⁻ γ0.3		e ⁻
	.225							γ.086		γ0.102 0.8		γ0.177

	Source	Neutron Energy	Measured	at .025 ev	Reference
TOTAL	Rn-Be-Par	C	8.2		Dunning et al, D-1, '35.
SCATTERING	Ra-Be-Par	C	5.3		Goldhaber and Briggs, G-1, '37.
ABSORPTION	Rn-Be-H ₂ O P	C	2.9 4.1	3.8	Volz, V-1, '43. Wattenberg, W-2, '44.
Te ¹²⁶ _{9.3h}				0.80 ± 20%	Seren et al, S-2, '44.
Te ¹²⁶ _{90d}				0.075 ± 20%	Seren et al, S-2, '44.
Te ¹²⁸ _{72m}				0.138 ± 20%	Seren et al, S-2, '44.
Te ¹²⁸ _{32d}				0.0159 ± 20%	Seren et al, S-2, '44.
Te ¹²⁸ _{25m}				0.212 ± 20%	Seren et al, S-2, '44.
Te ¹³⁰ _{30h}				<0.009 ± 40%	Seren et al, S-2, '44.

1262

FAST
Tellurium

AECD - 2274

125

(Te)

Duffield et al, D-9, '46.

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Te ¹²⁶ 9.3h ?	Fission	~ 1	.0105	Hughes et al, H-2.
Te ¹²⁸ 72m ?	Fission	~ 1	>.0067	Hughes et al, H-2.
Te ¹³⁰ 25m	Fission	~ 1	7.0076	Hughes et al, H-2.

1272

126
SLOW

AECD - 2274

Iodine (I)			
126	127	128	129
100			
13d	25m		$>10^8$ y
$\beta^- 1.1$	$\beta^- 2.02$		
$\gamma 0.5$	$\gamma 1.59$		
	$\gamma 0.43$

Siegbahn and Hole, S-25, '46.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Ra-Be-Par	C	9.4		Dunning et al, D-1, '35.
	Rd-Be-Par	C	14		Fink, F-4, '36.
	TC	T		9.4	Sturm and Tabin, S-4, '45.
	MC	.025-30	graph WPB	10	Rainwater et al, R-4, '45.
	MC	.01-1	$\sigma = 3.8 + 1.2/E^2$		Wu et al, W-3, '47.
	MC	.01-1000	graph	11	" " " "

SCATTERING	Rn-Be-Par	C	2.5		Kimura, K-2, '40.
	"	InRes 1.44	2.7		" " "

ABSORPTION	Ra-Be-H ₂ O	C	6.8	8.2	Lapointe and Rasetti, L-1, '40.
	Ra-Be-Par	C	7.1	9.8	Houtermans, H-1, '41.
	Ra-Be-H ₂ O	C	5.0	6.6	Volz, V-1, '43.
I^{127}_{25m}	Ra-Be-Par	C	6.5	8.8	Rasetti, R-2, '40.
	TC	T		$6.25 \pm 20\%$	Seren, S-2, '44.
σ_{Mn}/σ_I	Ra-Be	C	1.69		Grummitt et al, G-8, '44.
σ_{Th}/σ_I	"	C	0.975		" " " "
σ_I/σ_{28}	"	C	2.71		" " " "
	P		≈ 8		Katcoff, K-7, '46.

1282
3

Iodine

Resonances

E_0	$\sigma_0 \Gamma^2$
20.6 ± 0.4	~ 4
32 ± 2	~ 135
42 ± 2	~ 135

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	0.18	6.6	Amaldi et al, A-1, '39.
	D-D	2.38-2.5	5.40 ± 0.25	Aoki, A-2, '39.
	Ra-Be	~ 4	4.6	Dunning et al, D-1, WPB.
	Photo n's	.023-0.87	graph WPB	Wattenberg et al, W-8, '47.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

ABSORPTION 127 25m	Y-Be	0.18	0.32	LAMS-93, [redacted]
	Th-D	$\sigma_c(0.18)$	2.3 ± 0.2	Demers and Halban, [redacted], '46.
"	Th-Be	$\sigma_c(0.70)$		Griffiths, G-9, '39.
	Ra- γ -Be	.09	0.34	Halban and Kowarski, H-18, '38.
	Th-D	.18	0.30	Wattenberg, W-6, '45.
	Na-Be	0.80	0.18	Mescheryakov, M-14, '45.
	D-D	2.7	.026	
"	Li-p	.003	3.07	Linenbarzer and Miskel, L-15, '46.
		.016	1.37	
		.033	1.05	
		.067	.727	
		.098	.593	
		.195	.529	
		.390	.288	
	Ra-Be	5.90	.0289	Dementi and Timoshuk, D-7, '40.
		~ 4	.0657	

1292

128
SLOW

AECD - 2274

5 non	124	125	126	127	128	129	130	131	132	133	134	135	136	137
0.094		0.088			1.90	26.23	4.07	21.17	26.96		10.54		8.95	
			75s I.T.? e ⁻ γ 0.175 0.125	34d e ⁻ γ 0.9						5.3d β ⁻ 0.34 e ⁻ γ .085	9.2h β ⁻ 0.95 e ⁻ γ 0.25	15.6m I.T., e ⁻ γ ~0.5	3.4m β ⁻ ~4	

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	D-D-Par	0	37		Riezler, R-16, '42.

SCATTERING					
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ABSORPTION					
Xe ¹³² 5.3d	P		0.2		Kern and Snell, K-8, '43.
Xe ¹³⁴ 9.2h	P		0.2		Turkevich et al, T-2, '44.
Xe ¹³⁷ 33y C.e	P		0.15		Turkevich et al, T-3, '44.

1202

FAST

AECD - 2274

129
(Xe)

Xenon

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

12/2

130
SLOW

AECD - 2274

55 Cesium (Cs)

	133	134	135
100			
7.1d	3.15h	2.3y	>2.5x10 ⁴ y
K, e ⁻	β 2.4	See decay	β 8
γ .62	γ 0.7	See decay	γ 8

Siegbahn and
Deutsch,
S-28, '47.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	D-D-Par	C	50.5 ± 3.8		Lauterjung, L-2, '42. Used CsCl. σ(Cl) = 39.
SCATTERING					
ABSORPTION					
Cs-133 3h 2.3y	P P			.016 ± 20% 26 ± 20%	Seren et al, S-2, '44. " " " "

1322

FAST

AECD - 2274

(Cs)

Cesium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

133 W

132
SLOW

AECD - 2274

57 Barium (Ba)

	131	132	133	134	135	136	137	138	139
		.097		2.42	6.59	7.81	11.32	71.66	
12d			38.8h						85m
K			I.T.						$\beta^- 2.3$
$\gamma .22$			e^-						$\gamma 0.6$
.50			$\gamma .276$						
1.7									

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Ba-Par	C	140		Dunning et al, D-1, '35. Used BaO.
	Rn-Ba-Par	C	<10		Griffiths and Szilard, G-4, '37.

SCATTERING	Ra-Ba-Par	C	8.2 $4\pi a^2 = 7.7$		Goldhaber and Briggs, G-1, '37. Fermi and Marshall, F-3, '47.
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ABSORPTION	P	C	1.02		Wattenberg et al, W-2, '43.
	Ra-Ba-H ₂ O	C	<1	<1.2	Lapointe and Rasetti, L-1, '40.
	Ra-Ba-Par	C	1.3	1.6	Coltman and Goldhaber, C-1, '37.
	Rn-Ba-H ₂ O	C	0.95	1.3	Volz, V-1, '43.
Ba ¹³⁸ 85m	TC	T		0.51±20%	Seren, S-2, '44.

1342

FAST

AECD - 2274

133 (Ba)

Barium

	Source	Neutron Energy	σ Measured	Reference
TOTAL	D-D	2.4	6.19	Aoki, A-2, '39.
SCATTERING				
ABSORPTION				
Ba ¹³⁸ 85m	Th-D	0.18	30 mb	Halban and Kowarski, H-18, '38.
	Fission n's	~1	2.7 mb	Hughes et al, H-2.
	D-D	2.7	<0.1 "	Mescheryakov, M-14, '45.
	This cross section has same order for magnitude for Na-Be and Na-D neutrons.			Spatz et al, S-3, '47.

138/2

134
SLOW

AECD - 2274

Lanthanum (La)
139 140
? 100
2.2h
40.0h
β-90 γ-33
1.4 .49
2.12 .83
1.63
2.3

	Source	Neutron Energy	Measured	at .025 ev	Reference
TOTAL	Rn-Be-Par	C	80		Dunning et al, D-1, '35. Used La ₂ O ₃ .
	D-D-Par	C	26.32		Riezler, R-3, '42. Used La ₂ O ₃ .
	RdTh-Be-Par	C	10		Bonke and Reddemann, B-1, '42. Used La ₂ O ₃ .

SCATTERING					
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ABSORPTION	P		7.5 ± 2		
	Rn-Be-H ₂ O		9.1	12.0	Wattenberg, W-2, '45. Volz, V-1, '43.
La ¹³⁹ _{40h}	P			8.4 ± 20%	Seren et al, S-2, '44.

1362

FAST
Lanthanum

AECDR-2274

135 (La)

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
La ¹³⁹ _{40h}	Ra- γ -Be	0.09	.026	Griffiths, G-9, '39.
	D-D	2.7	.004	Mescheryakov, M-14, '45.

137 ~

136
SLOW

AECD - 2274

Cerium (Ce)				
	140	141	142	143
	89		11	
140d	2.1m	30d		33h
I.T.	β^+	$\beta^- .65$		$\beta^- 1.36$
$\gamma .21$		$\gamma .2$		$\gamma .5$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	~ 25		Dunning et al, D-1, '35. Used CeO_2 .
	D-D-Par	C	3 ± 4		Riezler, R-3, '42.
	RdTh-Be-Par	C	~ 15		Bomke and Reddemann, B-1, '42. Used Ce_2O_3 .
	• TC	T		28.9	Sturm and Tabin, S-4, '45.

SCATTERING

ABSORPTION

	P		
			6 ± 3 11 ± 2 20 ± 1
Ce ¹⁴² 33h		T(?)	~ 0.1

Wattenberg
et al,
W-2, '45.

Katcoff, K-1, '45.

1382

FAST

AECD - 2274

137 (Co)

Cerium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1392

SLOW

AECD - 2274

59 Praseodymium (Pr)

141	142
100	

3.5m
32.519.3h
β⁻ 2.14
γ 1.9

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par D-D-Par	C C	25 3.5 ± 8		Dunning et al, D-1, '35. Used Pr ₂ O ₃ . Riezler, R-3, '42. Used Pr ₄ O ₇ .

SCATTERING

ABSORPTION

Pr ¹⁴¹ 19.3h	TC	T		10 ± 20%	Seren et al, S-2, '44.
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1402

FAST

AEC - 2274

139 (Pr)

Praseodymium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Pr ¹⁴¹ 19h	Ra- γ -Be D-D	.09 2.7	.052 .0090	Griffiths, G-9, '39. Mescheryakov, M-14, '45.

141 n

SLOW

AEC - 2274

Neodymium (Nd)									
142	143	144	145	146	147	148	149	150	151
25.95	13.0	22.6	9.2	16.5		6.8		5.95	
2.5h					11d		1.8h		Short
$\beta^+ .78$					$\beta^- .4$ 40%		$\beta^- 1.5$		
					$\gamma .9$ 60%				
					$\delta .58$				

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	220		Dunning et al, D-1, '35. Used Nd_2O_3 .
	D-D-Par	C	65 ± 14		Riezler, R-3, '42. Used Nd_2O_3 .
	RdTh-Be-Par	C	72		Bonke and Reddemann, B-1, '42. " "
	CS	.04-.4	$\sigma_t = 15 + 14.5/E^{1/2}$		Sturm and Arnold, S-5, '46. " "
	CS	.04-10	graph	108 (extrap.)	" " " " " "

SCATTERING					
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ABSORPTION					
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1422

FAST

AECD - 2274

141

(Nd)

Neodymium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1432

AECD - 2274

63 Mllinium (II)

147 148 149

~4y 5a 55h
 β^- .22 β^- 2.5 β^- 1.2
 no γ γ .25

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL					
SCATTERING					
ABSORPTION					
$^{147}_{54}\text{P}$	P		60		Dempster et al, D-10, '46.

1442

FAST

AECD - 2274

143

142

(11)

Illinium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

145-2

144
SLOW

AECD - 2274

Samarium (Sm)									
145	146	147	148	149	150	151	152	153	154
		17	14	15	5		26		20
						long lived ~20y	46h $\beta^- .78$ $\gamma .6$.1		21m $\beta^- 1.8$ $\gamma .3$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	4400 $\pm$ 100		Fink, F-4, '36.
	Rn-Be-Par	C	4700		Dunning et al, D-1, '35.
	D-D-Par	C	6290		Riezler, R-3, '42.
	RdTh-Be-Par	C	7040		Bomke and Reddemann, B-1, '42.
	Maxwell distribution KT = .025		8800 = $\bar{\sigma}$		Numerical integration of curve of Sturm & Turkel, S-13, '45.
	CS	.04-0.27	graph		Sturm and Turkel, S-13, '45.
	CS	.06-0.2	" WPB		Borst et al, B-3, '46.
	CS	.04-60	"		Sturm, S-27, '46.

SCATTERING					

ABSORPTION					
Sm ¹⁵² 46h	TC	T		135	Seren et al, S-2, '44.
Sm ¹⁵⁴ 21m	TC	T		5.5	" " " "
Large absorption found mass spectrographically at mass 149					Lapp et al, L-25, '47.

1462

FAST

AEC D - 2274

145 (Sm)

Samarium

Resonances

E_0	σ_0	Γ
.096	15,500	.074
10	2,800	
35?		

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1472

146
SLOW

AECD - 2274

6 Europium (Eu)

	150	151	152	153	154	155
		49.1		50.9		
27h β^+			9.2h long-lived β^- 1.88 γ .123 .163 .725 e^- K	5-8y β^- 0.34 0.82 K γ 1.1		2-3y β^- .23 γ .084

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	<1000		Dunning et al, D-1, '35.
	D-D-Par	C	3810		Riezler, R-3, '42.
	D-D-Par		4120		" " "
	RdTh-Be-Par	C	~2700		Bonke and Reddemann, B-1, '42.
	CS	0.12-0.84	graph WPB		Sturm and Turkel, S-15, '45.
	CS	.02-65	"		Sturm, S-27, '46.
	MVS	.008-1	"	4800	" " "

SCATTERING

ABSORPTION

Eu ¹⁵¹ 9.2h	TC	T		1380 ± 20%	Søren et al, S-2, '44.
Eu ¹⁵³ 5-8y	P			768 ± 20%	" " " "
Eu ¹⁵⁵			14,000		Dempster et al, D-10, '47.

1482

FAST

AECD - 2274

147 (Eu)

Europium

Resonances

	E_0	σ_0	Γ
(Eu-151)*	-.011	5570	.08
(Eu-153)	.465	5670	.2
	3.5		
	9.2		
	22		
	> 30?		

*See Borst et al, B-3, '46.

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Eu / 9L	Ra- γ -Be	.09	0.47	Griffiths, G-9, '39.

1492

148
SLOW

AECD - 2274

6/ Holmium (Gd)

153	154	155	156	157	158	159	160
0.2	1.5	18.4	19.9	18.9	20.9		20.2

Unassigned
Activities
20h 8.6d

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	22000		Fink, F-4, '36.
	Rn-Be-Par	C	30000		Dunning et al, D-1, '35.
	D-D-Par	C	29200		Riezler, R-3, '42.
	D-D-Par	C	35700		" " "
	RdTh-Be-Par	C	22500		Bomke and Reddemann, B-1, '42.
	NVS	.002-.2	graph WPB	48,000	Lichtenberger et al, L-13, '45.
	CS	.005-.2	graph	42,000	Sturm et al, S-27, '44.

SCATTERING

ABSORPTION

Gd 8.6d	P				
Gd 20h	P			Atomic { 0.6 0.9	Seren et al, S-2, '44. " " " "

Large absorption found mass spectrographically at mass numbers 155 and 157.

Lapp et al, L-25, '47.
 $\sigma_a(157) \cong 3.5 \sigma_a(155)$.

1502

FAST

AEC - 2274

149 (Gd)

Gadolinium

Resonances		
E_0	σ_0	Γ
0.044	32,000	.10 CS
0.028	45,000	.236 MVS

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1572

150
SLOW

AECD - 2274

6 Terbium (Tb)

100 160

3.9h 73.5d
 β^- β^- .75
 γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	<1,000		Dunning et al, D-1, '35.
SCATTERING					
ABSORPTION					
Tb ¹⁵⁹ 3.9h	TC	T		10.7 $\pm$ 20%	Seren et al, S-2, '44.
Tb ¹⁵⁹ 72d	Be-D	T		~100	Bothe, B-12, '43.

1522

FAST

AECD - 2274

151

(Tb)

Terbium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Tb ¹⁵⁹ 3.9h 72d	Ra- γ -Be "	.09 "	.013 .89	Griffiths, G-9, '39. " " "

1532

152
SLOW

AECD - 2274

66 Dysprosium (Dy)

159	160	161	162	163	164	165
~0.1	0.1	21.1	26.6	24.8	27.3	
1.4m β^+ ?				1.25m e $\sim$.13		145m β^- 0.42 0.88 1.25 γ 0.125 0.914 0.73

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	700		Dunning et al, D-1, '35.
	D-D-Par	C	863		Riezler, R-3, '42.
	Ra-Be-Par	C	870		L. Meitner, M-8, '40.
	RdTh-Be-Par	C	780		Bomke and Reddemann, B-1, '42.
	MVS	.007-0.2	graph WPB		Lichtenberger et al, L-13, '45.
	CS	.052-0.92	graph WPB		Sturm and Turkel, S-19, '45.
	"	0.1-20	graph		Sturm, S-5, '47.
	"	.02-0.3	graph		Sturm, S-27, '47.

SCATTERING

ABSORPTION	Rn-Be-H ₂ O	C	745	980	Volz, V-1, '43.
Dy ¹⁶⁴ 140m	Ra-Be-Par	C	970	1350	Houtermans, H-1, '41.
" "	TC	T		2620 $\pm$ 10%	Seren et al, S-2, '44.
Dy ¹⁵⁸ 1.4m	TC	T		(atomic 37 $\pm$ 40%)	" " " "

1542

FAST

AEC - 2274

153

(Dy)

Dysprosium

Resonances

E_0	σ_0	Γ
-1.01	79,000	.20
1.74	334	
5.5	270	

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Dy-164, 140m	Th-D D-D	0.18 2.7	<.12 .0184	Halban and Kowarski, H-19, '38. Mescheryakov, M-14, '45.

15572

154
SLOW

AECD - 2274

67 ¹⁶⁵Er (Ho)
165 166
100

47m β^- 27h β^- 1.9

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	~400		Dunning et al, D-1, '35. Used Ho-Al.
	D-D-Par	C	47		Riezler, R-3, '42. Used Ho ₂ O ₃ .
	RdTh-Be-Par	C	52		Bomke and Reddemann, B-1, '42. Ho.

SCATTERING

ABSORPTION

Ho ¹⁶⁵ 27h	TC	T	59.6 ± 20%	Seren et al, S-2, '44.
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156 h

FAST

AECD - 2274

155

(Ho)

Holmium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

157 R

156
SLOW

AECD - 2274

68 ¹⁵⁶Er (Er)

162	164	165	166	167	168	169	170	171
0.1	1.5	?	32.9	24.4	26.9		14.2	

1.1m
 β^+

Unassigned Activities
7m 6-12h* 20h* 10d
 $\beta^-1.6$ β^-6 Soft β^-
 γ no γ

*Could also be Tm¹⁷¹.

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	120		Dunning et al, D-1, '35, Used Er ₂ O ₃ .
	D-D-Par	C	233		Riezler, R-3, '42.
	RdTh-Be-Par	C	185		Bomke and Reddemann, B-1, '42.

SCATTERING

ABSORPTION

1582

Erbium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1592

158
SLOW

AECD - 2274

⁶⁹Tm (Tm)
170

100

125d
B ~ 1.1
no γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	~500		Dunning et al, D-1, '35. Used Tm-Al.
	D-D-Par	C	69		Riezler, R-3, '42. Used Tm ₂ O ₃ .
	RdTh-Be-Par	C	114		Bomke and Reddemann, B-1, '42. " "

SCATTERING

ABSORPTION

Tm¹⁶⁹_{125d}

TC

T

126 ± 20%

Seren et al, S-2, '44.

160 R

FAST

AECD - 2274

159 (Tm)

Thulium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1612

160
SLOW

AECD - 2274

76 Ytterbium (Yb)

168	169	170	171	172	173	174	175	176	177
0.06	?	4.21	14.26	21.49	17.02	29.58		13.38	
	33d β^- ? K ? $\gamma \sim .3$						99h $\beta^- .13$.50 $\gamma .35$		2.4h $\beta^- 1.3$

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	90		Dunning et al, D-1, '35. Used Yb ₂ O ₃
	D-D-Par	C	46		Riezler, R-3, '42. Used Yb ₂ O ₃
	RdTh-Be-Par	C	50		Bomke and Reddemann, B-1, '42. " "

SCATTERING

ABSORPTION

1622

SLOW

AECD - 2274

(Yb)

Ytterbium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

163 n

162
SLOW

AECD - 2274

71 Lutetium (Lu)

175	176	177
97.5	2.5	
	$7.3 \times 10^{10} \text{ y}$	6.6d
	$\beta^- .22$	$\beta^- .44$
	$\gamma .26$	$\gamma .2$
	K ?	

Unassigned Activity

3.4h
 $\beta^- 1.15$
no γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	~400		Dunning et al, D-1, '35. Used Lu-Al.
	D-D-Par	C	99		Riezler, R-3, '42. Used Lu_2O_3 .
	RdTh-Be-Par	C	165		Bomke and Reddemann, B-1, '42. " "

SCATTERING

ABSORPTION

Lu ¹⁷⁶ 6.6d	TC	T		$3640 \pm 20\%$	Seren et al, S-2, '44.
Lu 3.4h	TC	T		(atomic $15.9 \pm 20\%$)	" " " "

1642

FAST

AEC - 2274

163 (1u)

Lutecium

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Lu ¹⁷⁵ 3.5h	Ra- γ -Be	.09	0.84	Griffiths, G-9, '39.

1652

164
SLOW

AECD - 2274

72 ¹⁸⁰Hf (Hf)

174	175	176	177	178	179	180	181
0.18		5.30	18.47	27.13	13.85	35.14	

Unassigned Activities

19 $\pm$.5s
e⁻ ~ .19

46d
 β^- < .45
 γ .52
.30
.07

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	D-D-Par	C	175.4 $\pm$ 29.0		Lauterjung, L-2, '42.

SCATTERING					
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ABSORPTION					
Hf-180 46d	P			10.0 $\pm$ 20%	Seren et al, S-2, '44.

166 R

FAST

Hafnium

AECD 2274

(Hf)

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

1672

Tantalum (Ta)			
180	181	182	
14-21m 8.2h	100	117d 16.2m	
β^- ?	2×10^{-5} s	$\beta^- 0.53$ $\beta^- 0.2$	
γ , K	$\gamma 0.18$	$\gamma 1.22$ 57% γ ?	
$e^- < 0.5$?	e^-	1.13 37%	
		0.22 4%	
		0.15 2%	

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par TC	C	27	24.5	Dunning et al, D-1, '35. Sturm and Tabin, S-4, '44.
	MC	.025-5000	graph	26	Havens et al, H-25, '46 and R-4, '45.
		.025-1	$\sigma_t = 7.2 + 3/E^{1/2}$		Havens et al, H-25, '46 and R-4, '45.

SCATTERING	Ra-Be-Par	C	~ 10		
	TC		4.83		Goldhaber and Briggs, G-1, '37.
	TC		4.9		LA-140A
	TC		4.9		Bragdon and Wilson, B-9, '44.
					Lichtenberger, L-5, '44.

ABSORPTION	P				
	D-Be-Par	C	28		Wattenberg, W-14, '44.
	Rn-Be-H ₂ O	C	20	18	Ramm, R-1, '42.
	P		11.5	15.2	Volz, V-1, '43.
$\sigma_c(Ta)/\sigma_c(Au)$ T			0.242	19.6	Pomerance and Hoover, P-2, '47.
					LA-140 and LA-140A
Ta ¹⁸¹ 117d	TC			21 $\pm$ 20%	Seren et al, S-2, '44 and S-36, '47.
	Ra-Be-Par	C	5	6.9	Houtermans, H-1, '41.
Ta ¹⁸¹ 16.2m	TC			0.034 $\pm$ 20%	Seren et al, S-2, '44 and S-36, '47.

1682

FAST

AECD - 2274

167

(Ta)

Tantalum

Resonances

E_0	$\sigma_0 \Gamma^2$
4.1	~ 44
10.0	~ 25
13.0	~ 3
22	~ 18
37	~ 400

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
For references to differential and inelastic cross sections see reference sheet.				
ABSORPTION				
	Y-Be	0.18	0.43	Fischer et al, F-8, '45.
	La-Be	0.62	0.19	" " " " " "
Ta ¹⁸¹	Y-Be	0.18	no act.	LA-140.

1692

168
SLOW

AECD - 2274

74 Tungsten (W)

181 182 183 184 185 186 187
0.12 25.77 14.24 30.68 29.17
21m 3.9h

74d
β⁻ 0.6
No γ
24.1h
β⁻ 1.35 ~25%
0.6
6 γ's
between
.18 and .77

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par	C	23	21.0	Dunning et al, D-1, '35. L. Marshall, F-10, '44.
	MC	.014-5000	graphs WPB 23		
	MC	.014-1	$\sigma_t = 5.7 + 2.72/E^2$		Havens et al, H-25, '46, and R-4, '45. " " " " " " "

SCATTERING	Ra-Be-Par	C	7.8 4.87		Goldhaber and Briggs, G-1, '37. LA-140A
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ABSORPTION	Rn-Be-H ₂ O	C	20.4	27 20 18	Volz, V-1, '43. Wattenberg et al, W-2. Pomerance and Hoover, P-2, '47.0sc.
	P P				
W18474d	P			2.1±20%	Seren et al, S-2, '44.
W18624.1h	TC Ra-Be-Par	T C	41	34±20% 57	Seren et al, S-2, '44. Houtermans, H-1, '41.

1202

Tungsten

Resonances

E_0	$\sigma_0 \sqrt{^2}$
4.0	~ 13
7.4	~ 5
18	~ 3000
45	~ 400
180	$\sim 10,000$
1100(?)	

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra-Be	.09, 0.4	7.2, 10.4	Goloborodko, G-14, '44.
	Th-D	0.18	9.2	" " "
	Th-B	0.70	6.5	" " " See ref.
	D-D	2.38-2.50	6.21	sheets for discussion
	Rn-Be	~ 4	5.3	Kikuchi and Aoki, A-2, '39.
				Dunning et al, D-1, '35.
	photo n's	.023-0.80	graph WFB	Wattenberg et al, W-8.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.
SCATTERING				
For references to differential and inelastic cross sections see reference sheet.				

ABSORPTION				
W186 ₂₄ , 1h	Y-Be	0.18	0.17	Fischer et al, F-8, '45.
	La-Be	0.62	0.10	" " " "
	Y-Be	0.18	no act.	LA-140.
	RaTh-D	$\sigma_0(0.18)$	1.25 $\pm$ 0.5	Demers and Halban, D-4, '46.
	RaTh-Be	$\sigma_0(0.70)$		
	Th-D	0.18	.045	Halban and Kowarski, H-18, '38.
	Fission n's	~ 1	.067	Hughes et al, H-2.
	Ra-Be	~ 4	.02	Dementie and Timochuk, D-7, '40.
	D-D	2.7	.02	Mescheryakov, M-14, '45.

1712

170
SLOW

AECD - 2274

Radium (Ra)				
184	185	186	187	188
	38.2		61.8	
50d		92.8h		18.9h
β^- 0.22 to 0.26		β^- 1.07		β^- 2.05
		No γ	γ 0.135	γ 0.16
K				0.48
γ 0.17				0.64
1.05				0.94
				1.43

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Ra-Be-Par	C	89		Dunning et al, D-1, '35.
	C.S.	.015-6.5	graph	98	Sturm et al, S-16, '46.

SCATTERING					
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ABSORPTION	Ra-Be-H ₂ O	C	104		Vols, V-1, '43.
Re ¹⁸⁵ 92.8h	TC	T		101 ± 20%	Seren et al, S-2, '44.
Re ¹⁸⁷ 18.9h	TC	T		75.3 ± 20%	Seren et al, S-2, '44.

1722

FAST

AEC - 2274

171 (Re)

Rhenium

Resonances E_0
2.30

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Re ¹⁸⁵ _{92.8h}	Y-Be	0.18	0.78	LA-140.
Re ¹⁸⁷ _{18.9h}	Y-Be	0.18	0.88	LA-140.

173 W

172
SLOW

AECD - 22

7^{1/2}mium (Os)

185	186	187	188	189	190	191	192	193
0.018	1.59	1.64	13.3	16.1	26.4	41.0		

95d
I.T.
γ

31.9h
β⁻.95
γ 1.17

17d
β⁻.35
γ

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	27		Dunning et al, D-L, '35.
	MC	0.1-0.5	$\sigma_t = 15 + 2.7/E^{1/2}$		Wu et al, W-3, '46.
	"	.012-10	graph c.e.	29.3	" " " "
	"	4-5000	"		" " " "

SCATTERING	Ra-Be-Par	C	10.8		Goldhaber and Briggs, G-1, '37.
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Os ¹⁹⁰ _{32h}	P			2.50 ± 20%	Seren et al, S-2, '44.
Os ¹⁹² _{17d}	P			5.34 ± 20%	Seren et al, S-2, '44.

1742

FAST

AEC - 2274

173

(Os)

Osmium

Resonances.

E_0	$\sigma_c / \sqrt{2}$
$6.5 \pm .3$	~ 10
$8.8 \pm .3$	~ 35
20 ± 1	~ 25
$28 \pm 1.5(?)$	~ 8
42 ± 2	~ 10
86 ± 6	

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				

175 ~

174
SLOW

AECD - 2274

77 Iridium (Ir)

190	191	192	193	194
	38.5		61.5	
10.7d β^- or e^- .091 K (?) γ 0.25	70d β^- 0.59 12 γ 's .2 to .62	1.5m γ .06 e^-	19h β^- 2.1 γ 1.65 0.38	

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par Ra-Be-Par	C	285 324		Dunning et al, D-1, '35. Powers et al, P-4, '38.
	CS	.055-15	graph WPB		
	MC	.022-1000	" "	430	Sturm and Turkel, S-19, '45 and S-27, '47. Rainwater et al, R-8, '46 and R-4, '45.
	CS	.022-0.1 .05-1.6	$\sigma_t = 14 + 64/E^{1/2}$ graph		" " " " " " " Wollan et al, W-9, '47.

SCATTERING

ABSORPTION

Ir ¹⁹¹ 70d +	TC		1010 ± 20%	Seren et al, S-2, '44.
Ir ¹⁹¹ 1.5m			~260	Goldhaber et al, G-10, '46.
Ir ¹⁹³ 19h	TC		130 ± 20%	Seren et al, S-2, '44.

176 n

FAST

AECD - 2274

175

(Ir)

Iridium

Resonances

E_0	$\sigma_0 \Gamma^2$
0.64	5-20
1.27	5-20
5.2	~ 55
8.7	~ 50

25

	Source	Neutron Energy	σ Measured	Reference
TOTAL				
SCATTERING				
ABSORPTION				
Ir- ¹⁹³ Ir ¹⁹¹	Ra- γ -Be Y-Be	.09 0.18	0.64 0.75	Griffiths, G-9, '39. LA-140.

1772

176
SLOW

AECD - 2274

⁷²Platinum (Pt)

	193	194	195	196	197	198	199
0.8		30.2	35.3	26.6	18h β-0.65	7.2	31m β-1.5
					3.3d β- γ		

Unassigned Activity

80m
I.T.
e- ?

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	Rn-Be-Par	C	25		Dunning et al, D-1, '35.
	Ra-Be-Par	C	21.5		Goldhaber and Briggs, G-1, '37.
	MC	.022-80 .004-5000 .04-0.8	graph WPB graphs $\sigma_t = 12 + 1.03/E^2$	17 16.6 c.e.	Wu et al, W-13, '45. Havens et al, H-25, '46. " " " "

SCATTERING			8.3 10.74		Goldhaber and Briggs, G-1, '37. LA-140A.
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ABSORPTION	P			15	Wattenberg et al, W-2, '43.
Pt ¹⁹⁶ 18h	P			1.1 ± 20%	Seren et al, S-2, '44.
Pt ¹⁹⁶ 3.3d	P			4.5 ± 20%	Seren et al, S-2, '44. Possible Au impurity.
Pt ¹⁹⁸ 31m	TC	T		3.92 ± 20%	Seren et al, S-2, '44.

1782

FAST

AECD - 2274

177 (Pt)

Platinum

Resonances

E_0	$\sigma_0 \Gamma^2$
11.5	~ 55
18.2	~ 30
100 ?	broad dip

	Source	Neutron Energy	σ Measured	Reference
TOTAL				

SCATTERING

For references to differential cross sections
see reference sheets.

ABSORPTION

Pt ¹⁹⁶	Fission n's ~ 1	> 60 mb	Hughes et al, H-2, '46. Activity studied not given.
Pt ¹⁹⁸ _{31m}	Fission n's ~ 1	60 mb	Hughes et al, H-2, '46.

1792

P. W. Levy, Priv.
Communication
August 11, 1947.
See also Mon P-368.

TOTAL	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
	NVS	.025		101	Fermi and Marshall, F-9, '44.
	CS	.073	68.9		Branch, B-16, '46.
	NC	$\sigma = 10 + 14.9/E^{1/2}$			E.E. Anderson et al, A-9, '44.
	"	.015-.3	graph	104	" " " "
	NVS	$\sigma = 1.5 + 15.4/E^{1/2}$			Lichtenberger, L-13, '47.
	"	.01-.13	graph WPB	100	" " "
	CS	.03-10	" WPB	99.3	Sturm, S-27, '47. Also S-19.
	NC	4-9	"		Havens et al, H-25, '47.

TC	T	6.48		LA-140A
P	T Epi-Cd	11.5	6.5	Bragdon, B-9, '44. Langsdorf, L-14, '44.
Scattering as well as abs. res. at 4.8 ev.				Langsdorf & Arnold, L-11, '46.

ABSORPTION	Ra-Be-H ₂ O P	C	72	78	Vols, V-1, '43. Wattenberg et al, W-2, '43.
An ¹⁹⁷ 2.7d	TC Ra-Be-Par TC	T C T	89 ± 9	96.4 ± 10% 123 101	Seren et al, S-2, '44. Houtermans, H-1, '41. Deutsch and Linenberger, D-3, '44.
0- (Au)				.242	LA-140 and LA-140A.

7802

FAST

ABCD - 2274

179

(Au)

Gold

Resonances

$$\frac{E_0}{4.8}$$

$$\frac{\sigma_0}{600}$$

TOTAL	Source	Neutron Energy	σ Measured	Reference
	Li-D	14	4.68	Amaldi et al, A-3, '46.

SCATTERING

For references to inelastic and differential cross sections see reference sheet.

ABSORPTION

Au¹⁹⁷ 2.7d

Y-Be	0.18	0.48	Winkler et al, L-20, '43.
"	"	0.41	"
Th-D	$\sigma_c(0.18)$		Fischer et al, F-8, '45.
Th-Be	$\frac{\sigma_c(0.18)}{\sigma_c(0.70)} = 1.7 \pm 0.1$		Demers and Halban, D-4, '46.
La-Be	0.62	0.20	Fischer et al, F-8, '45.*
Fission n's ~1		.121	Hughes et al, H-2, '45.
Ra-Be	~4	.057	Dementi and Timoshuk, D-7
	.03-3	graph	Blair et al, B-17, '44.

Activation meas. for n's passing thru > 4 gm/cm² B consistent with $\sigma = k/v$ and n dist. = dE/E.

Lichtenberger and Dancoff, L-23, '44.

* Absorption not activation measurements. See reference sheet.

Mercury (Hg)										
196	197	198	199	200	201	202	203	204	205	
0.15		10.1	17.0	23.3	13.2	29.6		6.7		
23h K _a e ⁻ γ 0.161 0.130	64h K _a e ⁻ γ 0.075	2μs								

5.5m
β 1.62

Unassigned Activities

43m 51.5d
I.T. β < 0.3
e⁻ 0.53 γ 0.28
γ

	Source	Neutron Energy	σ Measured	σ at .025 ev.	Reference
TOTAL	Rn-Be-Par	C	380		Dunning et al, D-1, '35.
	Rn-Be-Par	C	445		Fink, F-4, '36. Used HgO.
	MC	T	540		Manley, M-10, '42.
	CS	.03-.25	σ = 67/E ^{1/2}		Borst et al, B-18, '45.
	CS	.01-.25	graph WPB	400	" " " " " "
	MC	.01-.75	" "	400	Rainwater et al, R-12 and R-4, '44 and '45.
			Const. term = 15		" " " " " " " "
SCATTERING	Ra-Be-Par		4.7		Mitchell and Murphy, M-1, '36.
ABSORPTION	Rn-Be-H ₂ O	C	325	430	Vols, V-1, '43.
Hg 196	P		3100		Inghram et al, I-1, '47. Mass spect.
Hg 199	P		2500		" " " " " "
Hg 200	P		< 60		" " " " " "
Hg 201	P		< 60		" " " " " "
Hg 202	P		< 60		" " " " " "
Hg 204 5.5m	TC	T		0.34 ± 20%	Soren et al, S-2, '44.
Hg 51.5d	P			Atomic } 0.725 ± 20%	" " " " " "

1892

FAST

AECD - 2274

181 (Hg)

Mercury

Resonances

$$\frac{E_0}{-2.0} \quad \frac{\sigma_0 \sqrt{2/4E_0}^{3/2}}{64}$$

	Source	Neutron Energy	σ Measured	Reference
TOTAL	C-D	.18	6.8	Amaldi et al, A-1, '39.
	C-D	0.46	6.3	Bretscher and Murrell, B-21.
	D-D	2.70	6.2	" " " "
	Rn-Bc	~4	5.8	Dunning et al, D-1, '35.
	Li-D	14	5.64	Amaldi, et al, A-3, '46.
	Li-D	25.4	5.25	Sherr, S-29, '45.
SCATTERING				
	Li-D	14	($\sigma_a + \sigma_{in} = 2.47$)	Amaldi et al, A-3, '46.
ABSORPTION				
Hg ²⁰⁴ 5.5m	Fission	~1	.088	Hughes et al, H-2.

1832

182
SLCH

AECD - 2274

Thallium (Tl)				
	203	204	205	206
	29.46		71.54	
13d		3.5y		4.23m
K ?		$\beta^- 0.80$		$\beta^- 1.65$
e ⁻		No γ		No γ
γ 0.40				

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Ra-Be-Par	C	11		Dunning et al, D-1, '35.
	MC		$\sigma_t = 9.7 + 0.6/E^{1/2}$		Wu et al, W-3, '46.
	MC	.015 - 10,000	graphs	11.6	" " " "
SCATTERING	Ra-Be-Par	C	14.2		Goldhaber and Briggs, G-1, '37.
ABSORPTION	D-Be-Par	C	3.2	2.9	Ramm, R-1, '42.
	Rn-Be-H ₂ O	C	2.2	2.9	Volz, V-1, '43.
Tl ²⁰³ 3.5y	P			7.5	Seren et al, S-2, '44. K cap. not considered.
	P		≈ 10		Hagemann, H-31, '46. K cap. not considered.
Tl ²⁰⁵ 4.23m	TC	T		0.111	Seren et al, S-2, '44.
	D-D-Par	C	0.069		Manley et al, M-2, '41.

1842

FAST

AECD - 2274

183 (T1)

Thallium

Resonances

E_0	$\sigma_0 \Gamma^2$
270	20000
1100	

	Source	Neutron Energy	Measured	Reference
TOTAL	Ra- γ -Be	~.09, ~.4	11.3, 10.0	Goloborodko, G-13, '47.
	Th-D	0.18	6.5	" " "
	C-D	0.46	6.4	Bretscher and Murrell, B-21.
	Th-Be	0.7	6.8	Goloborodko, G-13, '47. See ref. sheet for discussion.
	D-D	3.00	5.2	Bretscher and Murrell, B-21.

SCATTERING

ABSORPTION

Tl ²⁰⁵	Ra-Be	0.09	.03	Griffiths, G-9, '39. Assuming 4.2 m act. measured.
	Th-D	0.18	~.02	Halban and Kowarski, H-18, '38. "

185-2

184
SLOW

AECD - 2274

Lead (Pb)

	204	205	206	207	208	209
	1.37	25.15	21.11	52.38		
52h	68m	852y				
K, e ⁻	I, T, e ⁻	long lived				
0.27	0.90					
0.47						

3.32h

$\beta^- 0.7$

No γ

No e⁻

	Source	Neutron Energy	σ Measured	σ at .025 ev	Reference
TOTAL	Rn-Be-Par	C	8.6		Dunning et al, D-1, '35.
	D-D-Par	C	9.4		Carlson et al, C-2.
	Ra-Be-Par	C	12.5		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	9.3		Rasetti, R-7, '40. Liquid.
	"	"	9.5		" " " Microcrystalline.
	"	"	7.15		" " " Single crystal.
	Ra-Be-Par	C	10		Whitaker and Bright, W-1, '41.
	p-Be-Par	InRes 1.44	9.6		Hanstein, H-4, '41.
	P	" " "	11.39		Marshall, M-3, '43.
	MC	.014-.76	graph WPB	c.e.	Rainwater et al, R-4, '45.
	"	.5-.76	$\sigma \approx 13$		" " " "
	MVS	.002-.02	graph	c.e.	Sturm and Arnold, S-31, '47.

1862

82 Lead (Pb)

SCATTERING	Source	Neutron Energy	σ Measured	σ at .025ev	Reference
	TC	T	10.8		Hughes and Bragdon, B-9, '44.
	Ra-Be-Par	C	6.2		Mitchell and Varney, M-13, '37.
	"	C	12.9		Goldhaber and Briggs, G-1, '37.
	Rn-Be-Par	C	12.0		Kimura, K-2, '40.
	Ra-Be-Par	C	9.0		Whitaker and Bright, W-1, '41.
	Ra-Be-Par	RhRes 1.29	6.6		Mitchell and Varney, M-13, '37.
	Rn-Be-Par	InRes 1.44	10.5		Kimura, K-2, '40.
	Ra-Be-Par	AgRes 5.1	12.3		Mitchell and Varney, M-13, '37.
	P	Epi Cd	11.0		Langsdorf, L-14, '44.
	Ra-Be-Par	I Res ~37	13		Mitchell and Varney, M-13, '37.
			$4\pi a^2 = 2.9$ Residual $\sigma_s = 0.85$		Fermi and Marshall, F-3, '47. " " " F-7, '47.

ABSORPTION	Source	Neutron Energy	σ Measured	σ at .025ev	Reference
	D-Be-Par	C	0.80	0.70	Ramm, R-1, '42.
	Rn-Be-H ₂ O	C	0.3	0.4	Volz, V-1, '43.
	Ra-Be-Par	C	0.23	0.28	Coltman & Goldhaber, C-1.
	Ra- γ -Be-Par	T		0.25	Fenning and Seligman, F-6, '42.
	P			0.14	Wattenberg, W-2, '43.
Pb^{208} 3.32h	D-Be-Par	C	.00045		Levinger, L-21, '43.
	D-Be-Par	C	~ .001		Maurer and Ramm, M-17, '42.

1972

Lead

Resonances

 E_0

0.36 Possible

	Source	Neutron Energy	σ Measured	Reference
TOTAL	Ra- γ -Be	$\sim .09, \sim 0.4$	8.8, 9.0	Goloborodko, G-14, '44.
	C-D	0.18	7.2	Amaldi et al, A-1, '39.
	Th-D	0.18	6.4	Goloborodko, G-14, '44.
	C-D	0.46	5.8	Bretscher and Murrell, B-21.
	Th-Be	0.70	6.8	Good and Scharff-Goldhaber, G-2, '41. WPB.
	"	"	4.9	Goloborodko, G-14, '44. See ref. sheet for discussion.
	D-D	2.38-2.5	5.25	Aoki and Kikuchi, A-2, '39.
	D-D	2.5	6.0	Barghall and Ladenburg, B-26, '42.
	D-D	2.7	6.4	Bretscher and Murrell, B-21.
	D-D	2.88 ± 0.04	6.7	Zinn et al, Z-1, '39. WPB
	Li-D	14	5.05	Amaldi et al, A-3, '46.
	Photo n's	0.023-0.87	graph WPB	Wattenberg et al, W-8.
		0.26-0.66	" "	BLRG-32, '44.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

For inelastic, differential and transport cross sections, see reference sheet.

ABSORPTION

	Sb-Be	0.023	$\sim .034$	Redman et al, R-9, '46.
^{208}Pb 3.32h "	C-D fission n's	See ref. ~ 1	$.003 \pm 50\%$.0018	Levinger, L-22, '44. Hughes et al, H-2, '45.

1882

82 Bismuth (Bi)

209 210
100

long

K ?

 γ 1.1e⁻

5d

 σ 1.17 α 4.8No γ

	Source	Neutron Energy	σ Measured	σ at .025 eV	Reference
TOTAL	Rn-Be-Par	C	8.2		Dunning et al, D-1, '35.
	Ra-Be-Par	C	8.9		Goldhaber and Briggs, G-1, '37.
	Ra-Be-Par	C	8.3		Rasetti, R-7, '40. Liquid Bi.
	"	"	6.6		" " " Single crystal.
	D-D-Par	C	9.2		Carlson et al, C-2.
	p-Be-Par	InRes 1.44	8.7		Hanstein, H-4, '41.
	MC	.024-.65	graph WPB	c.e.	Rainwater et al, R-15 & R-4, '45.
	"	.5-.64	$\sigma \approx 9$		" " " " "
	CS	.001-.15	graph	c.e.	Sturm and Arnold, S-31, '47.
SCATTERING	Ra-Be-Par		10.2		Mitchell et al, M-1, '36.
	Ra-Be-Par	C	8.9		Goldhaber and Briggs, G-1, '37.
	Rn-Be-Par	C	7.5		Kimura, K-2, '40.
	P		10.8		Langsdorf and Arnold, L-24, '45.
			8.91		LA-140-A
	Rn-Be-Par	InRes 1.44	8.3		Kimura, K-2, '40.
	Filtered neutrons	Residual	$\sigma_s = 0.85$		Fermi and Marshall, F-7, '46.
ABSORPTION	D-Be-Par	C	0.45	0.40	Ramm, R-1, '42.
	Rn-Be-H ₂ O	C	0.33	0.44	Volz, V-1, '43.
	P			0.015 $\pm$ 20%	Seren et al, S-2, '44.
	Ra- α -Be	C	<0.1		O'Neal and Goldhaber, O-1, '41.
	Ra-Be-Par	C	0.02	0.03	Routermans and Bortz, H-34, '42.
	Ra-Be-Par	C	0.016	0.019	Coltman and Goldhaber, C-1.
	D-Be-Par	C	0.012		Maurer, M-19, '44.
	P			0.055	Langsdorf and Arnold, L-24, '45.
					Purity doubtful.

Bi²⁰⁹_{5d}

1892

Bismuth

	Source	Neutron Energy	Measured	Reference
TOTAL		0.09	8.1	Leipunski, L-18, '40.
	C-D	0.18	7.7	Amaldi et al, A-1, '39.
		0.18	8.4	Munn and Pontecorvo, M-18.
	C-D	0.46	6.7	Bretscher and Murrell, B-21.
		0.70	5.4	Leipunski, L-18, '40.
	D-D	2.38-2.5	6.30	Aoki and Kikuchi, A-2, '39.
	D-D	2.7	6.5	Bretscher and Murrell, B-21.
	Li-D	14	5.17	Amaldi et al, A-3, '46.
	photo n's	.023-0.87	graph WPB	Wattenberg et al, W-8.
	D-D	2.1-2.8	" "	Aoki, A-4, '39.

SCATTERING

For references to differential and inelastic cross section see reference sheet.

ABSORPTION

Bi²⁰⁹_{5d}

"

"

 $\int dE/E$

D-C

fission n's

D-D

P

See ref.

~1

2.7

.0046 $\pm$ 50%

.0038

<.00005

0.59

Levinger, L-22, '44.

Hughes et al, H-2, '45.

Mescheryakov, M-14, '45.

Langsdorf et al, L-4, '46.

1902

REFERENCES FOR CROSS SECTION MEASUREMENTS[†]

- A-1 E. Amaldi, D. Bocciarelli, F. Rasetti, G. C. Trabacchi, Phys. Rev. 56, 881 (1939). Measured total cross sections of 39 elements by transmission method using C-D neutrons of estimated effective energy 0.18 mev. Took $Q = -0.28$ mev. Made 5% correction for imperfect geometry.
- A-2 S. Kikuchi and H. Aoki, Phys. Math. Soc. Japan, Proc. 21, 75 (1939). Measured total cross sections by transmission method of 38 elements using D-D neutrons whose energy lay between 2.32 and 2.50 mev. Took $Q = 3.18$ mev. Use of $Q = 3.32$ mev would increase energy values by 0.14 mev. This latter is the value used in plotting the results of Aoki, Zinn, and MacPhail in the wall paper book (MUC-NHG-7). Value from masses in the project handbook is 3.25 mev.
- Cross sections for Li-D neutrons were also measured but these were not included in the tables because of the wide energy spread of the neutrons.
- A-3 E. Amaldi, D. Bocciarelli, B. N. Cacciapuoti, G. C. Trabacchi, N. Cimento 3, 203 (1946). Used $\text{Cu}^{63}\text{n}, 2\text{n}$ reaction which has threshold at 11 mev to detect neutrons produced by Li-D reaction having maximum energy of 14.5 mev. Average neutron energy estimated as in 14 mev.
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- A-6 H. L. Anderson, E. Fermi, and L. Woods, CP-781, 1943, and CP-718 (1943).
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[†] Journal title abbreviations of Physics Abstracts used.

1912

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B-2 F. G. Brickwedde, J. R. Dunning, H. J. Hoge and J. H. Manley, Phys. Rev. 54, 266 (1938). Measured transmission of liquid H, N, O and H_2O for neutrons from Rn-Be source slowed in paraffin kept at room temperature and at liquid air temperature.

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B-4 E. Bleuler, W. Boltmann and W. Zunti, Helv. Phys. Acta 19, 419 (1946).

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1922

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1962
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1982

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203N

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- R-5 L. J. Rainwater and W. W. Havens, CP-2424 (1944).
- R-6 L. J. Rainwater, W. W. Havens, and C. S. Wu, M-2223 (1945).
- R-7 F. Rasetti, Phys. Rev. 58, 321 (1940).
- R-8 L. J. Rainwater, W. W. Havens, Jr., C. S. Wu and J. R. Dunning, Phys. Rev. 71, 65 (1947) and A-3852 (1946).
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- R-13 L. J. Rainwater, W. W. Havens and C. S. Wu, M-2259 (1945).
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- S-4 W. Sturm and J. Tabin, CP-2301 (1944).
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210 N

- W-2 A. Wattenberg, H. Lichtenberger, H. Fowler, G. Thomas, W. Moyer and E. Rylander, CP-781, CP-871, CP-964, CP-2081, CP-2749, and private communication to H. R. Goldsmith. Measured absorption cross sections by noting change in critical position of control rod of CP-2 produced by samples (danger coefficient method). Measurements were standardized by means of Cd wires whose cross sections were determined from their geometrical areas. Cross sections in CP-964, CP-2081 and CP-2749 are apparently for pile neutrons. It is implied in CP-781 and CP-871 that values given there have been corrected so that they apply to neutrons of .025 ev energy and they have been CP-1141. Remarks: These are given in the table.
- W-3 C. S. Wu, L. J. Rainwater and W. W. Havens, Jr., A-3854 (1946) and Phys. Rev. 71, 174 (1947).
- W-5 R. C. Wilkinson and J. S. Levinger, CP-341 (1942). No details are given in this report.
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- W-7 C. S. Wu, W. W. Havens and L. J. Rainwater, M-2264 (1945).
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- W-10 J. H. Williams, CP-507 (1943). Also R. G. Nuckolls, C. L. Bailey, W. E. Bennett, T. Bergstrahl, H. T. Richards, and J. H. Williams, Phys. Rev. 72, 805 (1946). There are slight discrepancies between values in the wall paper book (MUC-WMZ #7) and those in the Phys. Rev.
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- 2112

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W-14 A. Wattenberg, CP-1965 (1944). Miscellaneous cross section measurements presumably by the danger coefficient method for pile neutrons.

W-15 W. J. Whitehouse and G. A. R. Graham, CP-172.

W-16 A. Wattenberg, CP-3364. Corrected for H content using $\sigma_a(H) = 0.27$ for Maxwell distribution of their experiment.

Z-1 W. Zinn, S. Seely and V. W. Cohen, Phys. Rev. 56, 260 (1939). Used ionization chamber filled with He. Amplifier set so that only recoils which had received a considerable portion of the energy were counted. Used $Q = 3.29$ mev. Value of Q used in plotting results in wall paper book was 3.32 mev. See A-2.

Z-2 W. Zinn, CP-718 (1943).

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2122

REFERENCES FOR MEASUREMENTS OF TRANSPORT,
INELASTIC, AND DIFFERENTIAL SCATTERING CROSS SECTIONS

It was originally hoped to include data on inelastic, transport and differential scattering cross sections in the tables. It appeared, however, that the job of systematizing the results would involve some correspondence and would unduly hold up the issuing of the main part of the tables. The collection of this particular kind of data has therefore been temporarily postponed. A list of references with a few notes is given below.

W. D. Allen and C. Hurst, Phys. Soc., Proc. 52, 501 (1940). Determined inelastic plus absorption cross sections for a number of elements for neutrons of 3.25 mev. energy. Measured values are not a smooth function of atomic number.

E. Amaldi, D. Bocciarelli, B. N. Cacciapuoti, G. C. Trabacchi, N. Cim. 3, 302 (1946). Gives values of absorption plus inelastic scattering cross section for 14 mev. neutrons for Al, Fe, Hg, and Pb.

H. Aoki, Phys. Math. Soc. Japan, Proc. 19, 367 (1937). Found relative yields of instantaneous γ rays produced in a number of elements on bombardment with 2.4 mev. D-D neutrons. The γ rays are apparently due to inelastic scattering.

H. H. Barschall, M. E. Battat, W. C. Bright, E. R. Graves, T. Jorgensen, J. H. Manley, MDDC-452; and H. H. Barschall, J. H. Manley, V. F. Weisskopf MDDC-451. Data on poor geometry and back scattering from which values for inelastic, transport, and differential cross sections can be calculated. Elements investigated were Be, BeO, B, C, Al, Fe, Ni, Co, Cu, Ta, W, Au, Pb.

H. H. Barschall and R. Ladenburg, Phys. Rev. 61, 129 (1942). Measured differential cross sections for elastic scattering at scattering angles of 45° and 100° for C, Al, Fe, Cu, Zn, Pb using D-D neutrons of 2.5 mev. energy.

2132

H. F. Dunlap and R. N. Little, Phys. Rev. 60, 693 (1941). Found σ_{in} (Pb) = 1.31 ± 0.53 b for neutrons with energies between 2.2 and 2.9 mev. Energy peak of inelastically scattered neutrons at ~ 1.7 mev.

D. H. Frisch and J. L. McKibben, CF-625 (1943). Differential back scattering cross sections measured for Pb, Ta, W, Pt, Au, and Bi for 1.6 mev neutrons. Ring geometry. Summary of work reported in CF-304, CF-348, CF-392 and CF-420.

214 ~

S. Kikuchi, H. Aoki, T. Wakatuki, PPMS Jap. 21, 410 (1939). Differential scattering cross sections for scattering angles of 23° to 55° for neutrons of 3.1 mev. energy for C, Al, Fe, Cu, Sn, Pb, Bi.

J. H. Manley, H. M. Agnew, H. H. Barschall, W. C. Bright, J. H. Coon, E. R. Graves, T. Jorgensen, B. Waldman, Phys. Rev. 70, 602 (1946). Back scattering cross sections for 3.1 mev neutrons for C, BeO, Al, SiC, Fe, Al_2O_3 , Pt, Au, Pb.

P. Olum, MDDC-353, no date. Calculations of transport, inelastic, and differential cross sections presumably from data of MDDC-452 for Be, BeO, B, C, Al, Fe, W, Au, Pb.

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L. Szilard, S. Bernstein, B. Feld, and J. Ashkin, Mon P-375 (1947). Work done in 1943. Gives values for inelastic scattering cross sections of Pb, Bi, and Fe for $\text{Ra}\alpha\text{Be}$ and $\text{Ra}\alpha\text{B}$ neutrons to below the fission threshold of U^{238} . Results are dependent on assumptions about elastic cross sections. See also B. Feld, CP-964, 24 (1943).

T. Wakatuki, PPMS Jap. 22, 430 (1940). Differential scattering cross sections for scattering angles of 14° to 31° for neutrons of 3.1 mev. energy for Al, Fe, Sn, Pb, C. Values also given for Li-D neutrons.

AECD-2274 ERRATA AND SUPPLEMENT

This supplement contains cross sections reported in the Physical Review Vol. 72 # 5-12 (1947) and Vol. 73 # 1-5 (1948), Argonne reports, ANL-4010 (1947), ANL-4076 (1947), ANL-4097 (1947) and ANL-4112 (1947), and Clinton reports, Mon P-437 and Mon N-432 (1947), as well as some that were unintentionally left out of AECD-2274.

Any abbreviations or notations not explained in this report are explained in the earlier report.

References given in AECD-2274 are not repeated in this supplement.

No attempt has been made to bring the abundances, half-lives and radiation energies up to date since these were included primarily for purposes of orientation. Changes in mass assignments have been noted since these affect values of isotopic cross sections.

All cross sections are given in barns unless otherwise stated. A half life following the symbol for an isotope indicates that the cross section given is an activation cross section for that particular activity.

New open literature or declassified references for data already listed in AECD-2274 are given in the reference section.

2172

ERRATA FOR MON-205

Page	Element and Section	Does Read	Should Read	Reference
25	C slow σ_a	CO	CO ₂	Fermi and Marshall, F-5, '47.
29				Langsdorf & Pennington, L-28, '46.
31				Langsdorf, L-28, '46.
32	N ¹⁵ slow σ_a	$< 5 \times 10^{-5}$ mb	$< 5 \times 10^{-5}$ mb (atomic) or < 0.013 mb (isotopic).	Hughes et al, H-29, '45.
75	Co fast σ_a	92 mb	9.2 mb	Hughes et al, H-2, '46.
174	Ir ¹⁹¹ slow σ_a	Ir ¹⁹¹ 70 d	Ir ¹⁹¹ 70 d+1.5 m	Seren et al, S-2, '44.
	Bi σ_t at 0.18 mev	Munn & Pontecorvo, M-18.	Leipunski, L-18, '40.	Munn & Pontecorvo, M-18.
200	Reference I-1	Phys. Rev. 71, 567 (1947).	Phys. Rev. 71, 561 (1947).	Inghram et al.

Complete items left out appear on the supplement pages.

2182

SUPPLEMENT TO MON-2

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
H	MC	2.5-15 ev	$\sigma_t = 19.96 \pm 0.2$	Melkonian, M-30, '48.
	MC	above 1 ev at 0.005 ev below 0.05	$\sigma_t = 20.6$ $\sigma_t = \sim 76$ Agreement with Bethe's theoretical curve.	Havens, H-43, '48. Used paraffin.
	Be-D	90 mev	$\sigma_t = 0.083$	Cook et al, C-11, '47.
		0.025 ev	$\sigma_a = 0.31$	Ballini et al, B-33, '47. From $\sigma(\text{Mn})/\sigma(\text{H}) = 42$ and $\sigma(\text{Mn}) = 13.$
H ₂ gas	Ra-Be-Par	C	$\sigma_t = 31.6$ per H atom	Gilbert and Rossel, G-19, '46. Gas at 290° K.
D	Be-D	90 mev	$\sigma_t = 0.111$	Cook et al, C-11, '47.
D ₂ O	MC	0.005-1 ev	$\sigma_t = 10 + 0.72/E^{1/2}$	Havens, H-43, '48.
Li		T	$\sigma_a = 59$	Hereward et al, H-35, '47. Measured diffusion length of D ₂ O containing Li ₂ CO ₃ . Used σ_{tr} of D ₂ O = 2.31.
	Be-D	90 mev	$\sigma_t = 0.312$	Cook et al, C-11, '47.
Be	P	0.025 ev	$\sigma_a = 0.010$	Hughes et al, H-37, '47. Danger method.
	P	"	$\sigma_a = 0.009$	Nobles and Wallace, N-1, '47. Danger method.

21912

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Be	Ra-Be-Par "	C AuRes 4.8 ev	$\sigma_t = 6.2$ $\sigma_t = 6.7$	Demers et al, D-2, '46. " " " "
	MVS	.00075-.005 ev	σ_t graph	Arnold & Baer, A-20, '47.
		0.025 ev.	$\sigma = 0.010$	Nobles and Wallace, N-1.
	Be-D	90 mev.	$\sigma_t = 0.432$	Cook et al, C-11, '47.
	Pile n's+B filters	1 ev-~500 ev	$\sigma_s = 6.0$	Thomas, T-4, '47.
Be ⁹ n, He ⁶	D-D and C-D " " "	0.5-4 mev. " " "	σ_t graph "	Allen et al, A-17, '47. " " " "
BeO	MVS	0.001-0.0037 ev	σ_t graph	Arnold and Baer, A-20, '47.
	MVS	0.003-0.1 ev	σ_t graph	Eggler and Goldstein, E-5, '47.
	CS	0.1-5.0 ev	σ_t graph	Myers and Weber, M-24, '47.
B ¹⁰ n,p	Fission n's	~1 mev	$\sigma = 3$ mb	Eggler and Huddleston, E-7, '47.
C	Pile n's+B filters	1 ev-~500 ev	$\sigma_s = 4.7$	Thomas, T-4, '47.
	MVS	0.0008- 0.0027 ev	σ_t graph	Arnold and Baer, A-20, '47.
	MVS	0.002-0.007 ev	σ_t graph	Arnold and Myers, A-15, '47.
	Ra-Be-Par "	C AuRes 4.8 ev	$\sigma_t = 5.9$ $\sigma_t = 5.3$	Demers, D-2, '46. " " " "

2202

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
C	Be-D	90 mev	$\sigma_t = 0.556$	Cook et al, C-11, '47.
C ¹² n,2n	Be-D	90 mev	$\sigma = 0.022$	McMillan and York, M-29, '48.
N	Be-D	90 mev	$\sigma_t = 0.650$	Cook et al, C-11, '47.
	MC	T	$\sigma_t = 9.60 + 0.48/E^2$	Melkonian, M-30, '48.
N ¹⁴ n,p	P	0.025 ev	$\sigma = 1.55-1.7$	Rasmussen, R-21, '47.
N ¹⁴	Be-D	90 mev $\sigma(N^{14} n, p3n C^{11})/\sigma(C^{12} n, 2n C^{11}) = 0.40$		Knox, K-10, '47.*
	Be-D	90 mev $\sigma(N^{14} n, 2n N^{13})/\sigma(C^{12} n, 2n C^{11}) = 0.32$		Knox, K-10, '47.*
N ¹⁵ 7.4 s	P		$\sigma_a = 0.024$ mb	Eggler et al, E-6, '46.
O	MC	T	$\sigma_a = 3.68$	Melkonian, M-30, '48.
	Be-D	90 mev	$\sigma_t = 0.765$	Cook et al, C-11, '47.
O ¹⁶	Be-D	90 mev $\sigma(O^{16} n, 2p4n C^{11})/\sigma(C^{12} n, 2n C^{11}) = 0.31$		Knox, K-10, '47.*
	Be-D	90 mev $\sigma(O^{16} n, p3n N^{13})/\sigma(C^{12} n, 2n C^{11}) = 0.12$		Knox, K-10, '47.*
	Be-D	90 mev $\sigma(O^{16} n, 2n O^{15})/\sigma(C^{12} n, 2n C^{11}) = 0.90$		Knox, K-10, '47.*
F ¹⁹	Be-D	90 mev $\sigma(F^{19} n, 2n F^{18})/\sigma(C^{12} n, 2n C^{11}) = 1.7$		Knox, K-10, '47.*
Na	P	0.025 ev	$\sigma_a = 0.45$	Hoover et al, H-36, '47.

* Compilers have assumed reactions took place in most abundant isotopes of bombarded elements and have listed the product particles necessary for such a reaction but do not imply that the reaction products are known.

2212

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Mg	Be-D	90 mev	$\sigma_t = 1.03$	Cook et al, C-11, '47.
Al	MVS	0.003-0.1 ev	σ_t graph	Arnold & Weber, A-16, '47.
	"	0.002-0.05 ev	" "	Soft Al.
	"	0.003-0.05 ev	" "	" " " " " Pressed powder.
	"			" " " " " Cold drawn half hard Al.
	Li-p n's	0.010-1.00 mev	σ_t graph	Seagondollar and Barschall, S-46, '47.
	D-D and C-D	0.5-4.0 mev	σ_t graph	Allen et al, A-17, '47.
	Be-D	90 mev	$\sigma_t = 1.12$	Cook et al, C-11, '47.
SiO ₂	MC	above 0.57 ev	$\sigma_t = 9.0$	Havens et al, H-43, '48.
		below 0.01 ev	$\sigma_t = 1.25$	" " " " "
		at 0.1 ev	$\sigma_t = 5$	" " " " "
Cl	Be-D	90 mev	$\sigma_t = 1.40$	Cook et al, C-11, '47.
Cl ³⁵ n, α	D-D	2.98 mev	$\sigma = 0.017$	Metzger et al, M-23, '47. Based on $\sigma(N^{14}n, \alpha)$ = 16 mb.
A	MC	T	$\sigma_t = 0.64 + 0.123/E^{1/2}$	Melkonian, M-30, '48.
Ca		T	$4\pi a^2 = 2.5$	Meneghetti et al, M-28, '47. Based on $\sigma(0) = 4.1$.
CaCO ₃	MVS and CS	0.0006-1.0 ev	σ_t graph	Arnold et al, A-19, '47. Single crystal used.
	MC	above 0.57 ev	$\sigma_t = 19.8$	Havens et al, H-43, '47.
	"	below 0.009 ev	$\sigma_t = 3.5$	" " " " "
	"	at .08 ev	$\sigma_t = 11$	" " " " "

2222

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Se	Be-D-Par	T	$\sigma_a = >13$	Bothe, B-34, '46. Based on $\sigma_{ac}(\text{Ho } 27h)$ $= \sigma_a(\text{Ho}) = 49.$
V	May have scattering resonance at > 1000 ev.			Harris, H-44, '48.
Mn	P	0.025 ev	$\sigma_a = 12.3$ $\sigma_a = 13.3$	Hoover et al, H-36, '47. Osc.
		$\sigma_a(\text{Mn})/\sigma_a(\text{H}) = 42$		Ballini et al, B-33, '47.
Fe	No scattering resonance effects observed.			Harris, H-44, '47.
	MC	below 300 ev	$\sigma_t = 11.0 + 0.35/E^{1/2}$	Rainwater et al, R-22, '48.
	Li-p	0.01-0.50 mev	σ_t graph	Barschall et al, B-35, '47.
	P	0.025 ev	$\sigma_a = 2.44$	Hoover et al, H-36, '47. Osc.
Fe ⁵⁴	P	0.025 ev	$\sigma_a = 2.1$	Hoover et al, H-40, '46. Osc.
Fe ⁵⁶	P	0.025 ev	$\sigma_a = 3.1$	" " " "
Fe ⁵⁷	P	0.025 ev	$\sigma_a = 0.5$	" " " "
Co	Scattering resonance at 115 ev.			Harris et al, H-39, '47.
Ni	No scattering resonance effects observed.			Harris, H-44, '47.
	MC	below 60 ev Resonance near 100 ev.	$\sigma_t = 17.0 + 0.77/E^{1/2}$	Rainwater et al, R-22, '47. " " " "
	Pile n's+B filters	1 ev-~500 ev	$\sigma_s = 17.5$	Thomas, T-4, '47.
	Li-p	0.01-0.50 mev	σ_t graph	Barschall et al, B-35, '47.

223

2232

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Ni	P	0.025 ev	$\sigma_a = 4.2$	Hoover et al, H-36, '47. Osc.
Ni Ni ⁵⁸ Ni ⁶⁰		0.025 ev " "	$\sigma_a = 4.9$ $\sigma_a = 4.7$ $\sigma_a = 2.1$	Hoover et al, H-40, '47. " " " " " " " "
Cu	Be-D	90 mev	$\sigma_t = 2.0$	Cook et al, C-11, '47.
	MC	below 20 ev	$\sigma_t = 7.8 + 0.54/E^{1/2}$	Rainwater et al, R-22, '47.
Zn	Be-D	90 mev	$\sigma_t = 2.21$	Cook et al, C-11, '47.
Ga	Strong scattering resonance between 100 and 300 ev. $\geq$ thermal		$\sigma_s \approx 14$	Harris, H-44, '47. " " "
Ga ⁶⁹ 20.5 m	Fission n's	1 mev	$\sigma_a = 34$ mb	Hughes et al, H-2, '46.
As	May have scattering resonance > 1000 ev.			Harris, H-44, '47.
Sr ⁸⁹	P		$\sigma_a = < 100$	Katcoff, K-13, '45.
Y	Be-D-Par	T	$\sigma_a = 1$	Bothe, B-34, '46.
Zr	P	0.025 ev	$\sigma_a = 0.4$	Pomerance, Private comm. '48.
Cb	No resonance characteristics.			Harris, H-44, '47.
Mo ⁹⁵ Mo ⁹⁶ Mo ⁹⁷ Mo ⁹⁸ Mo ¹⁰⁰	P " " " "	0.025 ev " " " "	$\sigma_a = 2.4$ $\sigma_a = 13.4$ $\sigma_a = 1 \pm 70\%$ $\sigma_a = 2.3 \pm 30\%$ $\sigma_a = 0.34 \pm 100\%$ $\sigma_a = 0.22 \pm 40\%$	Hoover et al, H-36, '47. " " " " " " " " " " " " " " " "

2242

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Ag	Ra-Be-Par	4.8 ev AuRes	$\sigma_t = 440$	Demers, D-2, '47.
Ag ¹⁰⁷	P	0.025 ev	$\sigma_a = 29.9$	Hoover et al, H-36, '47.
Ag ¹⁰⁹	"	"	$\sigma_a = 83.7$	" " " "
Ag	"	"	$\sigma_a = 59.8$	" " " "
Sn	Be-D	90 mev	$\sigma_t = 3.29$	Cook et al, C-11, '47.
Sb	Scattering as well as absorption resonance at 5.8 ev.			Harris et al, H-44, '47.
I	MC	0.0026-0.3 ev 0.0026-1000 ev at 0.025 ev	$\sigma = 3.6 + 1.06/E^{1/2}$ σ_t graph $\sigma_t = 10.3$	Jones, J-2, '47. " " " " " "
	Fission n's	~1 mev	$\sigma_a = 0.110$	Hughes et al, H-2, '46.
Cs ¹³³ 3 h	P	0.025 ev	$\sigma_a = \sim 3$	Muehlhause, M-25, '47.
Ba ¹³² > 20 y	P	T	$\sigma_a = 6$	Katcoff, K-11, '47.
Ba ¹³⁹	P	T	$\sigma_a = 3.8$	Katcoff, K-14, '45.
La ¹³⁹ 40 h	Be-D-Par	T	$\sigma_a = > 7$	Bothe, B-34, '46.
Ce ¹⁴⁰ 30 d Ce ¹⁴² 33 h	Be-D-Par "	T T	$\sigma_a = > 0.4$ $\sigma_a = 1.1$	Bothe, B-34, '46. " " "
Pr ¹⁴¹ 19.3 h	Be-D-Par	T	$\sigma_a = 13$	Bothe, B-34, '46.
Nd ¹⁴⁶ 11 d Nd ¹⁴⁸ 1.8 h Nd ¹⁴⁸ 47h 61	Be-D-Par " "	T T T	$\sigma_a = 1.5$ $\sigma_a = 2.4$ $\sigma_a = 3.1$	Bothe, B-34, '46. " " " " " "
Sm ¹⁵² 46 h	Be-D-Par	T	$\sigma_a = 280$	Bothe, B-34, '46.
Eu ¹⁵¹ 9.2 h Eu ^{151,153} ~7y	Be-D-Par "	T T	$\sigma_a = 1530$ $\sigma_a = 2500$ (atomic)	Bothe, B-34, '46. " " "

2252

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Gd 160 d	P		$\sigma_a = < 0.25$ (atomic)	Seren et al, S-2, '44.
Tb ¹⁵⁹ 72 d	Be-D-Par	T	$\sigma_a = < 22$	Bothe, B-34, '46.
Dy ¹⁶⁵	1.3 m activity assigned here as isomeric state. Seren's atomic cross section of 37 b for this activity based on assumption of β decay is therefore probably erroneous.			Inghram et al, I-3, '47, Seren et al, S-2, '47.
Dy ¹⁶⁴ 140 m	Be-D-Par	T	$\sigma_a = 2200$	Bothe, B-34, '46.
Dy ¹⁶⁴ 1.3 m	P	0.025 ev	$\sigma_a = 2860$	Goldhaber and Muehlhause, G-18, '47.
Er ¹⁶⁹ Er ¹⁷¹	9.4 d activity assigned here. 7.5 h activity assigned here.			Boyd and Ketelle, B-38, '47. Give decay scheme for Er ¹⁷¹ .
Er ¹⁷⁰ 6-7 h Er 20 h	Be-D-Par	T "	$\sigma_a = > 7$ $\sigma_a = > 0.4$ (atomic)	Bothe, B-34, '46. " " "
Tm ¹⁶⁹ 125 d	Be-D-Par	T	$\sigma_a = 95$	Bothe, B-34, '46.
Yb 33 d	Be-D-Par	T	$\sigma_a = 11$ (atomic)	Bothe, B-34, '46.
Yb 45 d	Be-D-Par	T	$\sigma_a = 23$ (atomic)	Atterling, A-18, '45. Based on σ_a (Dy ¹⁶⁴ 140 m) = 2600 b. " " " " " "
Yb ¹⁷⁴ 99 h	Be-D-Par	T	$\sigma_a = 74$	Bothe, B-34, '46. " " "
" " " Yb ¹⁷⁶ 2.4 h	Be-D-Par	T T	$\sigma_a = 6.7$	
Yb ¹⁷⁶ 1.9 h	Be-D-Par	T	$\sigma_a = 4.8$	Atterling, A-18, '45. Based on σ_a (Dy ¹⁶⁴ 140 m) = 2600 b.

2262

Cross Section for	Neutron Source	Neutron Energy	Cross Section	Reference
Lu ¹⁷⁵ 3.4 h	TC	0.025 ev	$\sigma_a = 16.3$	Seren et al, S-2, '44. Replaces atomic σ in Mon P-405.
	Be-D-Par	T	$\sigma_a = 48$	Atterling et al, A-18, '45. Based on $\sigma_a(\text{Dy}^{164} \text{ } 140 \text{ m})$ = 2600 b.
	Be-D-Par	T	$\sigma_a = 27$	Bothe, B-34, '46.
Lu ¹⁷⁶ 6.6 d	Be-D-Par	T	$\sigma_a = 4640$	Atterling et al, A-18, '45. Based on $\sigma_a(\text{Dy}^{164} \text{ } 140 \text{ m})$ = 2600 b.
	Be-D-Par	T	$\sigma_a = 3160$	Bothe, B-34, '46.
Hf	P	0.025 ev	$\sigma_a = 105$	Hoover et al, H-36, '47. Osc.
Os	P	Relative capture cross sections of Os ¹⁸⁴ , Os ¹⁹⁰ and Os ¹⁹² 80:3.5:1		Katzin and Pobereskin, K-15, '47.
Hg			σ_t graph	Arnold and Baer, A-20, '47.
Pb	MVS	.0005-.0029 ev	σ_t graph	Arnold and Baer, A-20, '47.
	MC	0.003-10 ev	σ_t graph	Havens et al, H-38, '47.
	Be-D	90 mev	$\sigma_t = 4.57$	Cook et al, C-11, '47.
	Pile n's + B filters	1 ev-500 ev	$\sigma_s = 11.2$	Thomas, T-4, '47.
Bi	Li-p	0.01-0.50 mev	σ_t graph	Barschall et al, B-35, '47.

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AECD - 2274

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2312