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JENDL GAS-PRODUCTION CROSS SECTION FILE

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JENDL Gas-production Cross Section File

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The JENDL gas-production cross section file was compiled by taking cross-section data from JENDL-3 and by using the ENDF-5 format. The data were given to 23 nuclei or elements in light nuclei and structural materials. Graphs of the cross sections and brief description on their evaluation methods are given in this report.

Keywords: JENDL, Gas-production Cross Section, Graph, ENDF-5 Format

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ＪＥＮＤＬガス生成断面積ファイル

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（1992年4月21日受理）

ＪＥＮＤＬガス生成断面積ファイルをＥＮＤＦ-5フォーマットを用い、ＪＥＮＤＬ-3のデータから編集した。データは軽核や構造材核種のうちの23核種（または元素）に対して与えた。本報告では、断面積のグラフと評価手法に関する簡単な情報をまとめた。

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1. Introduction

The JENDL-3 general purpose file[1] was released in 1989 with the data for 171 nuclides, and the JENDL-3 fission product nuclear data file[2] was completed as a part of the JENDL-3 general purpose file in 1990. JENDL-3 contains the data for 324 nuclides which consist of cross sections, angular distributions and energy distributions of neutrons emitted from reactions, in the neutron energy region from 10^{-5} eV to 20 MeV. The data for γ-ray production were also evaluated for 53 nuclides, and given in the JENDL-3 general purpose file.

On the other hand, files with only data needed for a certain purpose are called as special purpose files. A plan of the JENDL special purpose files was proposed by Iijima et al.[3], and they are in progress[4]. The JENDL gas-production cross section file was compiled as one of the JENDL special purpose files. This file contains cross sections of gas-production reactions of light and structural material nuclei, which are of importance for material damage study.

In the next chapter, the compilation of the file will be described and figures of the cross sections are given. In Chapter 3, descriptive information given in the JENDL gas-production cross section file is listed to show the evaluation methods of the data.

The present file which was completed in July 1991 is the first version of the JENDL gas-production cross section file. In the future, it will be updated by adding new materials and/or improving the present data.

2. Compilation of the File

The data were given for 23 materials listed in Table 1. The ENDF-5 format[5] was used to compile the data. The file contains the following data.

MF

1 Descriptive information (listed in Chapter 3)

2 Resonance parameters (only scattering radius is given)

3 Gas-production cross sections for the MT numbers described below

In the MF=3, the cross-section data are given for the following gas-production reactions.

MT

203 H production

204 D production

205 ^{3}H production

206 ^{3}He production

207 ^{4}He production

The data were adopted from JENDL-3, and summed up to the above gas-production cross sections. The summation equation for each reaction is given in the descriptive data in the file (MF=1, MT=451), and listed in Chapter 3 in this report. Curves of the cross sections are shown in Figs. 1 to 23.

3. Descriptive Information for Each Nuclide or Material

All the descriptive information given in MF=1 of the JENDL gas-production cross section file is given here.

3.1 Li-6

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  3-LI-  6 JAERI       EVAL-MAR85 S.CHIBA AND K.SHIBATA
JAERI-M 88-164         DIST-JUL91
HISTORY
83-12  NEWLY EVALUATED BY K.SHIBATA
85-03  MODIFIED BY S. CHIBA
       DATA OF MF=3 (MT=59,63) AND MF=4 (MT=59,63) WERE ADDED.
       PSEUDO-LEVEL REPRESENTATION WAS ADOPTED FOR THE
       (N,N')ALPHA-D CONTINUUM (MT=51,52,54-56,58,60-62,64-86).
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
          BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = SUM OF INELASTIC SCATTERING CROSS SECTIONS
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT105
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT204 + MT205

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3  CROSS SECTIONS

  MT=53     SIG-IN    2.185 MEV
        BASED ON THE EXPERIMENTAL DATA /1,2,3,4,5/.
  MT=57     SIG-IN    3.562 MEV
        BASED ON THE EXPERIMENTAL DATA /6,7/.
  MT=59     SIG-IN    4.31 MEV
        BASED ON A COUPLED-CHANNEL CALCULATION. THE SYMMETRIC
        ROTATIONAL MODEL WAS ASSUMED. THE COUPLING SCHEME WAS
        1+(G.S.) - 3+(2.185MEV) - 2+(4.31MEV) - 1+(5.7MEV).
        THE POTENTIAL PARAMETERS WERE;
        V  = 45.0766 MEV,          R = 1.1875 FM,  A  = 0.57335 FM
        WS = 0.4432*EL-1.1631 MEV, RI= 1.6113 FM,  AI = 0.26735 FM
        VSO= 5.5 MEV,              RSO=1.15 FM,    ASO= 0.5 FM
        BETA(2)=1.1395,
        WHERE EL MEANS THE INCIDENT NEUTRON ENERGY IN THE LAB.
        SYSTEM (MEV).
  MT=63     SIG-IN    5.7 MEV
        BASED ON THE CC CALCULATION NORMALIZED TO THE EXPERIMENTAL
        DATA /12/.
  MT=51,52,54-56,58,60-62,64-86 (N,N')ALPHA-D CONTINUUM
        REPRESENTED BY PSEUDO-LEVELS, BINNED IN 0.5 MEV INTERVALS.
        THE (N,N')ALPHA-D CROSS SECTION WAS BASED ON THE
        MEASUREMENT OF ROSEN AND STEWART /8/.  THE
        CONTRIBUTION FROM MT=53, 59 AND 63 WAS SUBTRACTED SO
        THAT SIG-T MIGHT BE EQUAL TO THE SUM OF PARTIAL CROSS
        SECTIONS. THE CROSS SECTION FOR EACH LEVEL WAS CALCULATED
        BY THE 3-BODY PHASE-SPACE DISTRIBUTION WITH A CORRECTION
        OF THE COULOMB INTERACTION IN THE FINAL STATE, ASSUMING
        ISOTROPIC CENTER-OF-MASS DISTRIBUTIONS.
  MT=103    (N,P)
```

BASED ON THE EXPERIMENTAL DATA /6,9/.

MT=105 (N,T)ALPHA

BELOW 1 MEV, R-MATRIX CALCULATION.

ABOVE 1 MEV, BASED ON THE EXPERIMENTAL DATA /10,11/.

REFERENCES

1) GUENTHER P. ET AL.: ANL/NDM-52 (1980).
2) HOGUE H.H. ET AL.: NUCL. SCI. ENG. 69 (1979) 22.
3) LISOWSKI P.W. ET AL.: LA-8342 (1980).
4) FOERTSCH H. ET AL.: ZFK-443 (1981), P.13.
5) DRAKE D.D.: DOE/NDC-24/U (1981), P.72.
6) PRESSER G. ET AL.: NUCL. PHYS. A131 (1969) 679.
7) BESOTOSNYJ ET AL.: YK-19 (1975), P.77.
8) ROSEN L. AND STEWART L.: PHYS. REV. 126 (1962) 1150.
9) MERCHEZ F. ET AL.: NUCL. PHYS. A182 (1972) 428.
10) BARTLE C.M.: NUCL. PHYS. A330 (1979) 1.
11) BARTLE C.M. ET AL.: NUCL. PHYS. A397 (1983) 21.

3.2 Li-7

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  3-LI-  7 JAERI       EVAL-DEC84 S.CHIBA AND K.SHIBATA
 JAERI-M 88-164        DIST-JUL91
HISTORY
83-12  NEWLY EVALUATED BY K.SHIBATA
84-12  MODIFIED BY S. CHIBA
87-02  LI7(N,NT) CROSS SECTION WAS MODIFIED.
88-02  LI7(N,N2) CROSS SECTION AND ANG. DIST. WERE MODIFIED.
       LI7(N,N0) WAS ALSO MODIFIED SO AS TO GIVE THE TOTAL CROSS
       SECTION WHICH IS EQUAL TO JENDL-3PR1.  THE LI7(N,N1) ANG.
       DIST. WAS ALSO MODIFIED.  LI7(N,NT) CROSS SECTION WAS
       FIXED TO 87-02 VERSION BY MODIFYING THE PSEUDO-LEVEL
       CROSS SECTIONS. COMMENT WAS ALSO MODIFIED.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT205 GIVEN IN JENDL-3
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT205

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  ********************

MF=3  CROSS SECTIONS

  MT=104    (N,D)
        THE (N,D) CROSS SECTION WAS CALCULATED WITH DWBA.
        NORMALIZATION WAS TAKEN SO THAT THE CALCULATED CROSS
        SECTION MIGHT BE CONSISTENT WITH THE ACTIVATION DATA /1/.
  MT=205    (N,N')ALPHA-T
        BASED ON THE EXPERIMENTAL DATA /2,3,4,5,6,7/.
```


REFERENCES
1) BATTAT M.E. AND RIBE F.L.: PHYS. REV. 89 (1953) 80.
2) SMITH D.L. ET AL.: NUCL. SCI. ENG. 78 (1981) 359.
3) LISKIEN H. ET AL.: PROC. INT. CONF. NUCLEAR DATA FOR SCIENCE AND TECHNOLOGY, ANTWERP 1982, (1983) P.349.
4) SMITH D.L. ET AL.: ANL/NDM-87 (1984).
5) TAKAHASHI A. ET AL.: PROC. 13TH SYMP. FUSION TECH., VARESE, ITALY (1984).
6) GOLDBERG E. ET AL.: NUCL. SCI. ENG. 91, 173 (1985).
7) MAEKAWA H. ET AL.: JAERI-M 86-125, P.130 (1986).

3.3 Be-9

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  4-BE-  9 JAERI       EVAL-AUG84 K.SHIBATA
 JAERI-M 84-226        DIST-JUL91
HISTORY
84-08  REEVALUATED FOR JENDL-3 BY K.SHIBATA.
       DETAILS OF THE EVALUATION ARE GIVEN IN REF/1/.
89-01  MODIFIED BY CONSIDERING NEUTRON EMISSION SPECTRA
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
  MT=451   DESCRIPTIVE DATA

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
         =  MT103.
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
         =  MT104.
 MT=205  TRITIUM PRODUCTION CROSS SECTION
         =  MT105.
 MT=207  HE-4 PRODUCTION CROSS SECTION
         =  MT024 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

        THE STATISTICAL MODEL CALCULATION WAS MADE FOR THE CHARGED
        PARTICLE EMISSION REACTIONS BY USING THE COMPUTER CODE
        ELIESE-3/2/.  OPTICAL MODEL PARAMETERS FOR NEUTRON WERE
        TAKEN FROM AGEE AND ROSEN /3/.
           V = 49.3 - 0.33E, WS = 5.75    , VSO = 5.5     (MEV)
           R = 1.25         , RS = 1.25    , RSO = 1.25    (FM)
           A = 0.65         , B  = 0.70    , ASO = 0.65    (FM)
  MT=24    (N,2N ALPHA)
        THIS IS THE CROSS SECTION FOR THE (N,A1) REACTION.  THE
        1ST EXCITED LEVEL OF HE-6 DECAYS BY EMITTING 2 NEUTRONS.
        THE (N,A1) CROSS SECTION WAS CALCULATED WITH THE
        STATISTICAL MODEL.
        ALPHA POTENTIAL PARAMETERS ARE THE FOLLOWING /4/:
           V = 125.0  , WS = 15.0  , VSO = 0.0        (MEV)
           R = 1.56   , RS = 1.56  , RC  = 1.22       (FM)
           A = 0.50   , B  = 0.11                     (FM)
        THE CROSS SECTION WAS NORMALIZED TO THE DATA OF
        PERROUD AND SELLEM /5/ AT 14 MEV.
  MT=103   (N,P)
        CALCULATED WITH THE STATISTICAL MODEL.
        PROTON POTENTIAL PARAMETERS ARE THE FOLLOWING /6/:
           V = 59.5 - 0.36E, WS = 12.0 + 0.07E, VSO = 4.9   (MEV)
           R = 1.24         , RS = 1.36        , RSO = 1.2   (FM)
           RC= 1.3                                           (FM)
           A = 0.63         , B  = 0.35        , ASO = 0.31  (FM)
        THE CROSS SECTION WAS NORMALIZED TO THE EXPERIMENTAL DATA
        OF AUGUSTSON AND MENLOVE /7/, WHO MEASURED DELAYED
        NEUTROS, BY TAKING ACCOUNT OF THE BRANCHING RATIO
        OF 49.5% FOR LI-9 => BE-9* => 2A + N.
  MT=104   (N,D)
        BASED ON THE EXPERIMENTAL DATA OF SCOBEL /8/.
  MT=105   (N,T)
        SUM OF MT=740 AND 741.
```

MT=107 (N,A0)
BASED ON THE EXPERIMENTAL DATA /4,5,9,10,11,12/.
MT=740, 741 (N,T0) AND (N,T1)
CALCULATED WITH THE STATISTICAL MODEL.
TRITON POTENTIAL PARAMETERS ARE THE FOLLOWING /13/:
V = 140.0 , WS = 7.5 , VSO = 6.0 (MEV)
R = 1.20 , RS = 2.69 , RSO = 1.20 , RC = 1.30 (FM)
A = 0.45 , B = 0.36 , ASO = 0.7 (FM)
NORMALIZATION WAS TAKEN SO THAT THE TOTAL (N,T) CROSS SECTION MIGHT BE CONSISTENT WITH THE EXPERIMENTAL DATA OF BOEDY ET AL./14/

REFERENCES

1) SHIBATA, K.: JAERI-M 84-226 (1984).
2) IGARASI, S.: JAERI 1224 (1972).
3) AGEE, F.P. AND ROSEN, L.: LA-3538-MS (1966).
4) SHIBATA, K. AND SHIRATO, S.: J. PHYS. SOC. JPN. 52 (1983) 3748
5) PERROUD, J.P. AND SELLEM, CH.: NUCL. PHYS. A227 (1974) 330.
6) VOTAVA, H.J. ET AL.: NUCL. PHYS. A204 (1973) 529.
7) AUGUSTSON, R.H. AND MENLOVE, H.O.: NUCL. SCI. ENG. 54(1974)190
8) SCOBEL, W.: Z. NATURFORSCH. A24 (1969) 289.
9) BATTAT, M.E. AND RIBE, F.L.: NUCL. PHYS. 89 (1953) 80.
10) STELSON, P.H. AND CAMPBELL, E.C.: NUCL. PHYS. 106 (1957) 1252.
11) BASS, R. ET AL.: NUCL. PHYS. 23 (1961) 122.
12) PAIC, G. ET AL.: NUCL. PHYS. A96 (1967) 476.
13) LUEDECKE, H. ET AL.: NUCL. PHYS. A109 (1968) 676.
14) BOEDY, Z.T. ET AL.: PROC. INT. CONF. NUCLEAR DATA FOR SCIENCE AND TECHNOLOGY, ANTWERP 1982, (1983), P.368.

3.1 B-10

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  5-B - 10 JAERI        EVAL-MAR87 S.CHIBA
                        DIST-JUL91
HISTORY
87-03  NEWLY EVALUATED BY S.CHIBA (JAERI) FOR JENDL-3.
88-11  DATA FOR MF=3(MT=1,2,3,4,51,103,107,113,780,781) WERE
       MODIFIED.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT016 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104 + (SUM OF MT'S FROM 60 TO 89).
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT113
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT016*2 + MT107 + MT113*2 + 2*(SUM OF MT'S FROM 60 TO
            89)

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

        THE 2200M/S AND 14 MEV CROSS SECTIONS ARE IN TABLE 1.

MF=3  NEUTRON CROSS SECTIONS
  MT=16     (N,2N)
        BASED ON THE EXPERIMENTAL DATA /1/. CROSS SECTION WAS
         EXTRAPOLATED AS 0.0120*SQRT(E-ETH), WHERE E IS INCIDENT
         NEUTRON ENERGY AND ETH THRESHOLD ENERGY IN MEV. NOTE
         THAT THIS REACTION PRODUCES 1 PROTON AND 2 ALPHA
         PARTICLES, I.E. (N,2NP)2ALPHA.
  MT=51-59, 61, 62, 64-66. INELASTIC SCATTERING TO REAL LEVELS
         CROSS SECTIONS WERE CALCULATED BY THE COLLECTIVE MODEL
         DWBA AND NORMALIZED TO THE EXPERIMENTAL DATA/2/ AT 14
         MEV. CALCULATED LEVELS AND ASSUMED ORBITAL ANGULAR
         MOMENTUM TRANSFERS (L) ARE SUMMARIZED IN TABLE 3.  DATA
         FOR MT=51 WAS NORMALIZED TO THE EXPERIMENTAL DATA/3/
         BELOW 6MEV.  ABOVE 6MEV, THE DEFORMATION PARAMETER
         DEDUCED FROM (P,P') REACTION/4/ WAS USED.
  MT=60,63,67-89 (N,N'D)2ALPHA CONTINUUM.
        REPRESENTED BY PSEUDO-LEVELS, BINNED IN 0.5 MEV INTERVALS.
         THE (N,N'D)2ALPHA CROSS SECTION WAS BASED ON THE
         MEASUREMENT OF FRYE+ /5/. THE CROSS SECTION FOR EACH
         LEVEL WAS CALCULATED BY THE 3-BODY PHASE SPACE
         DISTRIBUTION, ASSUMING ISOTROPIC CENTER-OF-MASS
         ANGULAR DISTRIBUTIONS.
  MT=103    (N,P)
        SUM OF MT = 700 TO 705.
  MT=104    (N,D)
        SUM OF MT = 720 AND 721.
  MT=107    (N,ALPHA)
        SUM OF MT = 780 AND 781. THE THERMAL CROSS SECTION OF
        3837 BARNS WAS ADOPTED/6/.
  MT=113    (N,T)2ALPHA
```

BASED ON THE EXPERIMENTAL DATA /5,7,8,9,10,11,
12,13,14/.

MT=700 (N,P) TO THE GROUND STATE OF BE-10.

BELOW 100 KEV, ASSUMED TO BE 1/V. THE THERMAL CROSS SECTION WAS ASSUMED TO BE 3MB/15/.

FROM 100 KEV TO 500 KEV, ASSUMED TO BE CONSTANT.

FROM 500 KEV TO 1 MEV, LINEARLY INTERPOLATED.

ABOVE 1 MEV, THE STATISTICAL MODEL CALCULATION WAS NORMALIZED BY A FACTOR OF 0.704. THE OPTICAL POTENTIAL, LEVEL SCHEMES AND LEVEL DENSITY PARAMETERS USED IN THE CALCULATION ARE SUMMARIZED IN TABLES 2, 3 AND 4.

MT=701-705 (N,P) TO THE LOW LYING EXCITED STATES OF BE-10.

THE STATISTICAL MODEL CALCULATION WAS NORMALIZED TO THE EXPERIMENTAL DATA/11/ AT 14 MEV.

MT=720 (N,D0)

BELOW 7.6 MEV, THE INVERSE REACTION CROSS SECTIONS/16,17/ WERE CONVERTED BY THE PRINCIPLE OF DETAILED BALANCE.

FROM 7.6 TO 14 MEV, INTERPOLATED LINEARLY.

ABOVE 14 MEV, DWBA CALCULATION WITH THE PROTON PICKUP MECHANISM WAS NORMALIZED TO THE EXPERIMENTAL DATA /18, 19/ AT 14 MEV. THE D + BE-9 AND BOUND PROTON POTENTIALS OF VALKOVIC+/19/ WERE USED. DEPTH OF THE PROTON POTENTIAL WAS SEARCHED BY THE SEPARATION ENERGY METHOD. THE POTENTIAL PARAMETERS ARE LISTED IN TABLE 2.

MT=721 (N,D2)

DWBA CALCULATION WITH THE PROTON PICKUP MECHANISM WAS NORMALIZED TO THE EXPERIMENTAL DATA/11,18,19/ AT 14 MEV. THIS IS REALLY THE (N,D) REACTION TO THE SECOND LEVEL OF BE-9.

MT=780, (N,ALPHA0)

BELOW 10 KEV, R-MATRIX CALCULATION.

FROM 10 KEV TO 800 KEV, BASED ON THE EXPERIMENTAL DATA /20,21/.

FROM 800 KEV TO 7.5 MEV, THE EXPERIMENTAL DATA/22/ WERE NORMALIZED BY A FACTOR OF 1.38 AND FITTED BY THE SPLINE FUNCTION.

ABOVE 7 MEV, THE EXPERIMENTAL DATA/11/ WERE ADOPTED.

MT=781 (N,ALPHA1)

BELOW 10 KEV, THE R-MATRIX CALCULATION.

FROM 10 KEV TO 100 KEV, BASED ON THE EXPERIMENTAL DATA /21, 23/. FROM 100 KEV TO 2 MEV, RECOMMENDATION BY LISKIEN AND WATTECAMPS/24/ WAS ADOPTED.

FROM 2 TO 7.5 MEV, THE EXPERIMENTAL DATA/22,23,24,25/ WERE NORMALIZED BY A FACTOR OF 1.38 AND FITTED BY THE SPLINE FUNCTION.

ABOVE 7 MEV, THE EXPERIMENTAL DATA/25/ WAS ADOPTED.

TABLE 1 THE 2200-M/S AND 14 MEV CROSS SECTIONS

	2200-M/S (B)	14 MEV (B)
ELASTIC	2.144	0.943
(N,N')	-----	0.269
(N,P)	0.003	0.038
(N,D)	-----	0.047
(N,T)	0.012	0.095
(N,ALPHA)	3837.0	0.049
(N,2N)	-----	0.027
CAPTURE	0.50	0.000
TOTAL	3839.7	1.467

TABLE 2 OPTICAL POTENTIAL PARAMETERS

B-10 + N /26/

V= 47.91 - 0.346EN, WS= 0.657 + 0.810EN, VSO=5.5 (MEV)
R= 1.387 , RS= 1.336 , RSO=1.15 (FM)
A= 0.464 , AS= 0.278 , ASO=0.5 (FM)

BE-10 + P /27/

V = 60.0 + 27.0(N-Z)/A -0.3ECM (MEV)
WS = 0.64ECM + 10.0(N-Z)/A ,(ECM < 13.8 MEV) (MEV)
= 9.60-0.06ECM + 10.0(N-Z)/A ,(ECM > 13.8 MEV) (MEV)
VSO= 5.5 (MEV)
R = RS = RSO = 1.15 (FM)
A = ASO = 0.57, AS= 0.5 (FM)

BE-9 + D /19/

V= 80.0 , WV= 30.0 , VSO=6.0 (MEV)
R= 1.0 , RV= 1.0 , RSO=1.0 ,RC= 1.3 (FM)
A= 1.0 , AV= 0.8 , ASO=1.0 (FM)

TABLE 3 LEVEL SCHEMES USED IN THE DWBA OR STATISTICAL MODEL CALCULATION

B-10				BE-10		
MT	ENERGY (MEV)	JP	L	MT	ENERGY (MEV)	JP
2	0.0	3+		700	0.0	0+
51	0.7183	1+	2	701	3.368	2+
52	1.7402	0+	4	702	5.958	2+
53	2.154	1+	2	703	5.960	1-
54	3.587	2+	2	704	6.179	0+
55	4.774	3+	2	705	6.263	2-
56	5.110	2-	3			
57	5.163	2+	2			
58	5.18	1+	2			
59	5.920	2+	2			
61	6.025	4+	2			
62	6.127	3-	3			
64	6.561	3+	2			
65	6.881	1-	3			
66	7.00	1+	2			
	7.430	1-				
	7.470	1+				
	7.477	2-				
	7.560	0+				
	7.670	1+				
	7.840	1-				
	8.070	2-				
	8.650	1+				
	8.890	3-				
	8.894	2+				

TABLE 4 LEVEL DENSITY PARAMETERS USED IN THE STATISTICAL MODEL CALCULATION

A(1/MEV)	T(MEV)	C(1/MEV)	PAIR.(MEV)	EX(MEV)

B-10	1.196	5.581	0.066	0.0	16.17
BE-10	1.088	5.866	0.021	5.13	19.63

REFERENCES

1) MATHER,D.S.: AWRE-O-47/69(1969).
2) VAUCHER,B. ET AL.: HELV. PHYS. ACTA 43, 237(1970).
3) PORTER D.: AWRE-O-45/70(1970)
4) SWINIARSKI, R.D. ET AL.: HELV. PHYS. ACTA 49, 227(1976).
5) FRYE,G.M. ET AL.: PHYS.REV. 103, 328(1956).
6) MUGHABGHAB,S.F. ET AL.: 'NEUTRON CROSS SECTIONS', VOL.1 PART A (ACADEMIC PRESS 1981, NEW YORK)
7) WYMAN,M.E. ET AL.: PHYS.REV. 112, 1264(1958).
8) KLEIN,P.D. ET AL.: EXFOR 12654,002(1966).
9) ANTOLKOVIC,B. ET AL.: NUCL.PHYS. A139, 10(1969).
10) VALKOVIC,V. ET AL: NUCL.PHYS. A98, 305(1967).
11) SELLEM,C. ET AL.: NUCL.INSTRUM.METH. 128, 495(1975).
12) CSERPAK,F. ET AL.: EXFOR 30474,003(1978).
13) SUHAIMI,A. ET AL.: RADIOCHIMICA ACTA 40, 113(1986).
14) QAIM,S.M. ET AL.: PROC. INT. CONF. NUCL. DATA FOR SCI. AND TECHNOL., MITO, MAY 30 - JUNE 3, 1988.
15) EGGLER,ET AL. : IN CINDA-A (1935-1976) VOL.1 (1979)
16) BARDES,R. ET AL.: PHYS.REV. 120, 1369(1960).
17) SIEMSSEN,R.H. ET AL.: NUCL.PHYS. 69, 209(1965).
18) RIBE,F.L. ET AL.: PHYS.REV. 94, 934(1954).
19) VALKOVIC,V. ET AL.: PHYS.REV. 139, B331(1965).
20) OLSON,M.D. ET AL.: PHYS.REV. C30, 1375(1984).
21) SEALOCK,R.M. ET AL.: PHYS.REV. C13, 2149(1976).
22) DAVIS,E.A. ET AL.: NUCL.PHYS. 27, 448(1961).
23) SCHRACK,R.A. ET AL.: NUCL.SCI.EENG. 68, 189(1978).
24) LISKIEN,H. AND WATTECAMPS, E.: NUCL.SCI.ENG. 68, 132(1978).
25) VIESTI,G. ET AL.: ANNALS NUCL. ENERG. 6, 13(1979).
26) DAVE,J.H. ET AL.: PHYS.REV. C28,2112(1983).
27) WATSON,B.A. ET AL: PHYS. REV. 182, 977(1969)

3.5 B-11

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  5-B - 11 JAERI       EVAL-MAY88 T.FUKAHORI
JAERI-M 89-046         DIST-JUL91
HISTORY
87-03  NEWLY EVALUATED BY T.FUKAHORI (JAERI)
88-05  REVISED BY T.FUKAHORI (JAERI)
       (N,D),(N,ND),(N,T),(N,NT) AND (N,N2A) ADDED.
       DETAILS OF EVALUATION ARE GIVEN IN REF./1/.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT032 + MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT029 + MT033 + MT105
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT029*2 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3          CROSS SECTIONS
  MT=22     (N,N'ALPHA)LI-7 CROSS SECTION
        CALCULATED WITH GNASH/2/. THE OPTICAL POTENTIAL
        PARAMETERS, THE LEVEL DENSITY PARAMETERS AND THE LEVEL
        SCHEME ARE SHOWN IN TABLES 1-3, RESPECTIVELY.
  MT=28     (N,N'P)BE-10 CROSS SECTION
        BASED ON THE GNASH CALCULATION. THE PARAMETERS USED ARE
        LISTED IN TABLES 1-3.
  MT=29     (N,N'2ALPHA)T CROSS SECTION
        BASED ON (N,N'T) CROSS SECTION OF THE GNASH CALCULATION
        AND NORMALIZED TO HE PRODUCTION CROSS SECTION OF KNEFF
        ET AL. /3/.
  MT=32     (N,N'D)BE-9 CROSS SECTION
        BASED ON THE GNASH CALCULATION. THE PARAMETERS USED ARE
        LISTED IN TABLES 1-3.
  MT=33     (N,N'T)BE-8 CROSS SECTION
        BASED ON THE GNASH CALCULATION. THE PARAMETERS USED ARE
        LISTED IN TABLES 1-3.
  MT=103    (N,P)BE-11 CROSS SECTION
        BASED ON THE GNASH CALCULATION WITH BEING NORMALIZED TO
        THE EXPERIMENTAL DATA OF STEPANCIC ET AL. /4/. THE
        PARAMETERS USED ARE SHOWN IN TABLES I-3, RESPECTIVELY.
  MT=104    (N,D)BE-10 CROSS SECTION
        BASED ON THE GNASH CALCULATION.
  MT=105    (N,T)BE-9 CROSS SECTION
        BASED ON THE GNASH CALCULATION.
  MT=107    (N,ALPHA)LI-8 CROSS SECTION
        THE GNASH CALCULATION WAS PERFORMED, AND NORMALIZED TO THE
        EXPERIMENTAL DATA OF ANTOLKOVIC ET AL. /5/ AND SCOBEL ET
        AL. /6/. THE PARAMETERS USED ARE SHOWN IN TABLES 1-3,
        RESPECTIVELY.
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TABLE 1 THE OPTICAL POTENTIAL PARAMETERS

NEUTRON	V = 41.8-0.005E	MEV*	R0= 1.40	FM	A0= 0.35	FM	REF./7/
	WS= 1.01E	MEV*	RI= 1.15	FM*	AI= 0.50	FM	
PROTON	V = 66.1-0.273E	MEV	R0= 1.15	FM	A0= 0.57	FM	REF./8/
	WS= 1.50+0.581E	MEV	RI= 1.15	FM	AI= 0.5	FM	
	VSYM = 5.5	MEV	R0= 1.15	FM	A0= 0.57	FM	
DEUTERON	V = 80.0	MEV*	R0= 1.0	FM*	A0= 1.0	FM*	REF./9/
	WV= 30.0	MEV	RI= 1.0	FM*	AI= 0.8	FM*	
	VSYM = 6.0	MEV*	R0= 1.0	FM*	A0= 1.0	FM*	
TRITON	V = 103.0+20.0E	MEV*	R0= 0.85	FM	A0= 0.70	FM	REF./10/
	WV= 1.49E	MEV*	RI= 2.06	FM	AI= 0.72	FM	
	VSYM = 8.55	MEV*	R0= 0.85	FM	A0= 0.70	FM	
ALPHA	V = 285.2-2.40E	MEV*	R0= 1.61	FM*	A0= 0.55	FM*	REF./11/
	WS= 16.16-0.70E	MEV*	RI= 1.81	FM	AI= 0.65	FM	

NOTE : E IS INCIDENT NEUTRON ENERGY IN LAB. SYSTEM.
* MEANS THAT PARAMETER IS MODIFIED FROM ORIGINAL ONE.

TABLE 2 THE LEVEL DENSITY PARAMETERS

	A(1/MEV)	T(MEV)	PAIR (MEV)
B-10	1.196	7.990	0.0
B-11	1.431	6.112	2.67
B-12	1.491	6.201	0.0
BE-8	1.115	9.187	5.13
BE-9	1.125	8.248	2.46
BE-10	1.088	10.029	5.13
BE-11	1.419	7.277	2.46
LI-7	1.138	7.197	2.67
LI-8	1.115	8.170	0.0

TABLE 3 THE LEVEL SCHEME (ENERGY(MEV), SPIN AND PARITY) /12,13/

	B-10		B-11		BE-10		BE-11		LI-7		LI-8	
GS	0.0	3+	0.0	3/2-	0.0	0+	0.0	1/2+	0.0	3/2-	0.0	2+
1	0.718	1+	2.125	1/2-	3.368	2+	0.320	1/2-	0.478	1/2-	0.981	1+
2	1.740	0+	4.445	5/2-	5.958	2+			4.630	7/2-		
3	2.154	1+	5.020	3/2-	5.960	1-			6.680	5/2-		
4	3.587	2+	6.743	7/2-	6.179	0+			7.460	5/2-		
5	4.774	3+	6.792	1/2+	6.263	2-			9.670	7/2-		
6	5.110	2-	9.120	7/2+	7.371	3-			9.850	3/2-		
7	5.164	2+	10.60	7/2+	7.452	2+			11.240	3/2-		
8	5.180	1+			9.270	4-						
9	5.926	2+			9.400	2+						
10	6.025	4+										
11	6.127	3-										
12	6.561	4-										
13	6.873	1-										
14	7.002	2+										
15	7.430	2-										
16	7.467	1+										
17	7.479	2+										
18	7.561	0+										

19	7.670	1+
20	7.819	1-
21	8.070	2+
22	8.700	2+
23	8.889	3-
24	8.895	2+

REFERENCES

1) FUKAHORI T.: JAERI-M 89-046 (1989).
2) YOUNG P.G. ET AL.: GNASH, A PREEQUILIBRIUM,STATISTICAL NUCLEAR-MODEL CODE FOR CALCULATION OF CROSS SECTION AND EMISSION SPECTRA, LA-6947 (1977).
3) KNEFF D.W. ET AL.: NUCL. SCI. ENG. 92 (1986) 491
4) STEPANCIC B.Z. ET AL.: BULL. INST. BORIS KIDRIC 17 (1966) 237
5) ANTOLKOVIC B. ET AL.: NUCL. PHYS. A325 (1979) 189
6) SCOBEL W. ET AL.: ZEITSCHRIFT F. NATURFORSCHUNG, SECTION A 25 (1970) 1406
7) GLENDINNING S.G. ET AL.: NUCL. SCI. ENG. 80 (1982) 256
8) WATSON B.A. ET AL.: PHYS. REV. 182 (1969) 977
9) MILJANIC D. ET AL.: NUCL. PHYS. A176 (1971) 110
10) HERLING G.H. ET AL.: PHYS. REV. 178 (1969) 178
11) MATSUKI S. ET AL.: J. PHYS. SOC. JAPAN 26 (1969) 1344
12) AJZENBERG-SELOVE F. : NUCL. PHYS. A413 (1984) 1
13) AJZENBERG-SELOVE F. : IBID. A433 (1985) 1

3.6 C-12

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  6-C - 12 JAERI       EVAL-AUG83 K.SHIBATA
 JAERI-M 83-221        DIST-JUL91
HISTORY
83-08  NEWLY EVALUATED BY K.SHIBATA
       DETAILS OF THE EVALUATION ARE GIVEN IN REF./1/.
85-02  DATA OF MT=2, 3, 4, 53 OF MF=3 WERE REVISED ABOVE 10.45
       MEV.  ANGULAR DISTRIBUTIONS FOR MT=52, 53 WERE ALSO
       REVISED.
88-07  DATA OF MT=1, 3, 4, 52 OF MF=3 WERE REVISED ABOVE 8.3 MEV.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = (MT052 + MT053 + MT091)*3 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3  CROSS SECTIONS
  MT=52    SIG-IN  7.65 MEV LEVEL
        THE CROSS SECTION WAS ESTIMATED SO THAT THE ELASTIC SCAT-
        TERING CROSS SECTION GIVEN AS THE DIFFERENCE BETWEEN THE
        TOTAL AND REACTION CROSS SECTIONS MIGHT BE CONSISTENT WITH
        EXPERIMENTAL DATA.  TAKING ACCOUNT OF THE MEASUREMENT /2/,
        THE CROSS SECTION WAS MODIFIED BY MULTIPLYING A FACTOR OF
        0.5.
  MT=53    SIG-IN  9.63 MEV LEVEL
        BASED ON THE EXPERIMENTAL DATA OF ANTOLKOVIC ET AL./3/.
        TAKING ACCOUNT OF THE MEASUREMENT OF ONO ET AL./4/, THE
        CROSS SECTION WAS MODIFIED BY A FACTOR OF 0.8.
  MT=91    (N,N')3A
        BASED ON THE EXPERIMENTAL DATA OF ANTOLKOVIC ET AL./3/.
        TOTAL (N,N')3A CROSS SECTION IS THE SUM OF MT=52, 53
        AND 91.
  MT=103   (N,P)
        BASED ON THE MEASUREMENT OF RIMMER AND FISHER /5/.
  MT=104   (N,D)
        CALCULATED WITH DWBA.
  MT=107   (N,A)
        BASED ON THE EXPERIMENTAL DATA /6,7,8,9,10,11,12,13,14/.
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REFERENCES

1) SHIBATA, K.: JAERI-M 83-221 (1983).
2) TAKAHASHI A. ET AL.: PROC. THE 1987 SEMINAR ON NUCLEAR DATA, JAERI-M 88-065, P.279, (19883).
3) ANTOLKOVIC, B. ET AL.: NUCL. PHYS. A394 (1983) 87.
4) ONO M. ET AL.: FALL MTG. OF THE ATOMIC ENERGY SOCIETY OF JAPAN, 1984
5) RIMMER, E.M. AND FISHER, P.S.: NUCL. PHYS. A108 (1968) 567.
6) CHATTERJEE, M.L. AND SEN, B.: NUCL. PHYS. 51 (1964) 583.

7) HUCK, A. ET AL.: J. DE PHYSIQ : C1 (1966) 86.
8) BRENDEL, M. ET AL.: Z. NATURFORSCH. 23A (1968) 1279.
9) KITAZAWA, H. AND YAMAMURO, N.: J. PHYS. SOC. JPN. 26(1969)600.
10) KARDONSKY, S. ET AL.: PHYS. REV. C4 (1971) 840.
11) STEVENS, A.P.: INIS-MF-3596 (1976).
12) REIZ-SCHMIDT, I. ET AL.: BULL. AM. PHYS. SOC. 5 (1960) 110.
13) VERBINSKI, V.V. ET AL.: PHYS. REV. 170 (1968) 916.
14) OBST, A.W. ET AL.: PHYS. REV. C5 (1972) 738.

3.7 Natural N

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  7-N -  0 JNDC+       EVAL-JUN89 Y.KANDA(KYU),T.FUKAHORI(JAERI)+
                       DIST-JUL91
HISTORY
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 DATA WERE CALCULATED FROM THOSE OF N-14 AND N-15.
          N-14 = 99.634 %
          N-15 =  0.366 %
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT032 + MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT033 + MT105
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107 + MT108*2

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

  7-N - 14 JNDC       EVAL-JUN89 Y.KANDA(KYU) T.MURATA(NAIG)+
                      DIST-SEP89
HISTORY
89-06  NEW EVALUATION FOR JENDL-3
        SUB-WORKING GROUP ON EVALUATION OF N-14,
        WORKING GROUP ON NUCLEAR DATA FOR FUSION,
        JAPANESE NUCLEAR DATA COMMITTEE
       IN CHARGE
        SIG-T       K.SHIBATA (JAERI)
        SIG-EL      T.ASAMI (JAERI), T.MURATA (NAIG)
        SIG-IN      T.ASAMI, T.MURATA
        (N,2N),(N,P),(N,T),(N,A)
                    Y.KANDA(KYU)
        (N,NA),(N,NP),(N,ND),(N,D)
                    T.ASAMI
        CAPTURE     T.ASAMI
        PHOTON PRODUCTION
                    T.ASAMI
       COMPILATION
        EVALUATED DATA WERE COMPILED BY T.FUKAHORI.

MF=3  CROSS SECTIONS
  MT=22    (N,N ALPHA)
         CALCULATED WITH THE GNASH CODE/1/.
  MT=28    (N,NP)
         CALCULATED WITH THE GNASH CODE, AND NORMALIZED TO THE
         EXPERIMENTAL DATA/2/.
  MT=32    (N,ND)
         CALCULATED WITH THE GNASH CODE.
  MT=103   (N,P)
         BELOW 7 MEV, BASED ON EXPERIMENTAL DATA /3,4,5,6,7,8/.
         ABOVE 7 MEV, BASED ON THE CALCULATIONS WITH GNASH.
  MT=104   (N,D)
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BELOW 8.5 MEV, BASED ON THE EXPERIMENTAL DATA/9/.
ABOVE 8.5 MEV, CALCULATED WITH GNASH.

MT=105 (N,T)
BELOW 9 MEV, BASED ON THE EXPERIMENTAL DATA/10/.
ABOVE 9 MEV, CALCULATED WITH GNASH AND NORMALIZED AT 9 MEV.

MT=107 (N,ALPHA)
BASED ON THE EXPERIMENTAL DATA/7,10/.

MT=108 (N,2ALPHA)
CALCULATED WITH GNASH AND NORMALIZED AT 14.1 MEV TO AN AVERAGE VALUE AMONG THE EXPERIMENTAL DATA/11,12/.

7-N - 15 EVAL-DEC88 T.FUKAHORI
JAERI-M 89-047 DIST-SEP89
HISTORY
88-12 NEWLY EVALUATED BY T.FUKAHORI (JAERI)

MF=3 CROSS SECTIONS
MT=16,22,28,32,33,103,104,105,107
CALCULATED WITH GNASH /1/. THE OPTICAL POTENTIAL POTENTIAL PARAMETERS, THE LEVEL DENSITY PARAMETERS AND THE LEVEL SCHEME ARE SHOWN IN TABLES 1-3, RESPECTIVELY.

TABLE 1 THE OPTICAL POTENTIAL PARAMETERS

NEUTRON	V = 50.08-0.012E	MEV	R0 = 1.22 FM	A0 = 0.66 FM
	WS = 8.91+0.618E	MEV	R1 = 1.45 FM	A1 = 0.13 FM
	VSYM= 5.50	MEV	R0 = 1.15 FM	A0 = 0.50 FM
PROTON	V = 51.30-0.220E	MEV	R0 = 1.21 FM	A0 = 0.61 FM
	WS = 6.40-0.050E	MEV	R1 = 1.03 FM	A1 = 0.53 FM
	VSYM= 6.00	MEV	R0 = 1.06 FM	A0 = 0.53 FM
DEUTERON	PEREY-PEREY'S POTENTIAL/13/			
TRITON	BECCHETTI-GREENLEES'S POTENTIAL/14/			
ALPHA	V = 43.9	MEV	R0 = 1.91 FM	A0 = 0.45 FM
	WV = 3.85	MEV	R1 = 1.91 FM	A1 = 0.45 FM

TABLE 2 THE LEVEL DENSITY PARAMETERS

	A(1/MEV)	T(MEV)	PAIR.(MEV)	EX(MEV)
B-11	1.431	6.149	2.67	25.58
B-12	1.491	6.201	0.0	26.78
C-12	1.700	5.971	5.60	37.41
C-13	1.846	5.382	2.80	30.57
C-14	1.988	4.887	5.00	28.94
C-15	1.988	4.600	0.0	19.78
N-14	1.600	5.000	0.0	10.03
N-15	2.130	3.758	2.20	10.07
N-16	2.130	4.547	0.0	22.11

TABLE 3 LEVEL SCHEME (ENERGY(MEV), SPIN AND PARITY) /15,16,17

N-14	N-15	N-16	C-15	C-14	C-13

GS	0.0	1+	0.0	1/2-	0.0	2-	0.0	1/2+	0.0	0+	0.0	1/2-
1	2.313	0+	5.270	5/2+	0.120	0-	0.740	5/2+	6.094	1-	3.089	1/2+
2	3.948	1+	5.299	1/2+					6.589	0+	3.685	3/2-
3	4.915	0-	6.324	3/2-					6.728	3-	3.854	5/2+
4	5.106	2-	7.155	5/2+					6.903	0-		
5	5.691	1-	7.301	3/2+					7.012	2+		
6	5.834	3-	7.567	7/2+					7.341	2-		
7	6.204	1+	8.313	1/2+								
8	6.446	3+	8.571	3/2+								
9	7.029	2+	9.050	1/2+								
10			9.152	3/2-								
11			9.155	5/2+								
12			9.225	1/2-								
13			9.758	5/2-								
14			9.829	7/2-								
15			9.928	3/2-								
16			10.070	3/2+								

C-12			B-11			B-12		
GS	0.0	0+	0.0	3/2-	0.0	1+		
1			2.125	1/2-	0.953	2+		
2			4.445	5/2-	1.674	2-		
3			5.020	3/2-	2.620	1-		
4			6.743	7/2-	2.720	0+		
5			6.793	1/2+				
6			7.286	5/2+				

REFERENCES

1) YOUNG P.G. AND ARTHUR E.D.: LA-6947 (1977).
2) CSIKAI J. AND NACY S.: NUCL. PHYS., A91, 222 (1967).
3) BATCHELOR R.: AERE-N/R-370 (1949).
4) COON J.H. ET AL.: PHYS. REV., 75, 1358 (1949).
5) CURE P. ET AL.: J. PHYS. RADIUM., 12, 6 (1951).
6) HANNA G.C. ET AL.: CAN. J. PHYS., 39, 1784 (1961).
7) MORGAN G.L. ET AL.: NUCL. SCI. ENG., 70, 163 (1979).
8) FELBER H. ET AL.:Z. PHYS., A276, 75 (1976).
9) CHASE, JR L.F. ET AL.: AFSWC-TR-61-15 (1961).
10) GABBARD F. ET AL.: NUCL. PHYS., 14, 277 (1959).
11) LILLIE A.B.: PHYS. REV., 87, 726 (1952).
12) SCHMIDT G. ET AL.: NUCL. PHYS., A103, 238 (1967).
13) PEREY F.G.: PHYS. REV. 131 (1963) 745
14) BECCHETTI JR. F.D. AND GREENLEES G.W.: 'POLARIZATION PHENOMENA IN NUCLEAR REACTIONS', THE UNIVERSITY OF WISCONSIN PRESS (1971)
15) AJZENBERG-SELOVE F.: NUCL. PHYS. A460 (1986) 1
16) AJZENBERG-SELOVE F.: NUCL. PHYS. A449 (1986) 1
17) AJZENBERG-SELOVE F.: NUCL. PHYS. A433 (1985) 1

3.8 F-19

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  9-F - 19 JAERI       EVAL-JUL89 T.SUGI
                       DIST-JUL91
HISTORY
83-11 EVALUATION FOR JENDL-2 WAS PERFORMED BY SUGI AND NISHIMURA
      (JAERI)/1/.
89-07 RESONANCE PARAMETERS AND TOTAL CROSS SECTION WERE
      RE-EVALUATED FOR JENDL-3.
91-07 GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
        BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT105
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

 MF=3  NEUTRON CROSS SECTIONS
   MT=22   (N,N' ALPHA) AND (N,ALPHA N') CROSS SECTIONS
       CALCULATED WITH A STATISTICAL MODEL BY USING PEARLSTEIN'S
       EMPIRICAL FORMULA/2/.
   MT=28   (N,N' P) AND (N,P N') CROSS SECTIONS
       CALCULATED WITH A STATISTICAL MODEL BY USING PEARLSTEIN'S
       EMPIRICAL FORMULA.
   MT=103  (N,P) CROSS SECTION
       UP TO 9MEV : BASED ON THE EXPERIMENTAL DATA OF BASS ET AL.
          /3/.
       9MEV - 20MEV : CALCULATED WITH THE STATISTICAL MODEL BY
          USING PEARLSTEIN' EMPIRICAL FORMULA.
   MT=104  (N,D) CROSS SECTION
       CALCULATED WITH THE PEARLSTEIN'S EMPIRICAL FORMULA.  THE
       CROSS SECTION WAS NORMALIZED TO 39.5 MILLI-BARNS AT 14.4
       MEV.
   MT=105  (N,T) CROSS SECTION
       CALCULATED WITH THE PEARLSTEIN'S EMPIRICAL FORMULA.  THE
       CROSS SECTION WAS NORMALIZED TO 15.0 MILLI-BARNS AT 14.4
       MEV.
   MT=107  (N,ALPHA) CROSS SECTION
       BELOW 9 MEV, BASED ON THE FOLLOWING EXPERIMENTAL DATA:
           UP TO 4MEV      DAVIS ET AL. /4/,
           4MEV - 5.5MEV   SMITH ET AL. /5/,
           5.5MEV - 9MEV   BASS ET AL. /3/.
       ABOVE 9 MEV, CALCULATED WITH THE PEARLSTEIN'S FORMULA.
```

REFERENCES

1) SUGI T. AND NISHIMURA K.: JAERI-M 7253 (1977), ENGLISH TRANSLATION : ORNL-TR-4605.
2) PEARLSTEIN S.: J. NUCL. ENERGY 27, 81 (1973).
3) BASS R. ET AL.: EANDC(E) 66-64.
4) DAVIS E.A. ET AL.: NUCL. PHYS. 27, 448 (1961).
5) SMITH D.M. ET AL.: PHYS. REV. 117, 514 (1960).

3.9 Al-27

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 13-AL- 27 TIT,JAERI  EVAL-MAR88 Y.HARIMA,H.KITAZAWA,T.FUKAHORI
                      DIST-JUL91
HISTORY
88-03  NEW EVALUATION WAS PERFORMED FOR JENDL-3 BY HARIMA,
       KITAZAWA (TOKYO INSTITUTE OF TECH.) AND FUKAHORI (JAERI).
       DETAILS ARE GIVEN IN REF./1/.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
         = MT028 + MT103 + MT111*2
 MT=207  HE-4 PRODUCTION CROSS SECTION
         = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3  NEUTRON CROSS  SECTIONS
 MT=22   (N,NA) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL, USING THE GNASH CODE./1,2/
   OPTICAL POTENTIAL FOR ALPHA-PARTICLES WAS DETERMINED, USING
   THE DISPERSION THEORY./3/
 MT=28   (N,NP) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL, USING THE GNASH CODE./1,2/
 MT=103  (N,P) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL, USING THE GNASH CODE./1,2/
 MT=107  (N,A) CROSS SECTIONS
   OBTAINED BY AN EYE-GUIDE TO FOLLOW OBSERVED VALUES /4/.
 MT=111  (N,2P) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL, USING THE GNASH CODE./1,2/
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REFERENCES
1) KITAZAWA H. ET AL.: PROC. INT. CONF. NUCLEAR DATA FOR SCIENCE AND TECHNOLOGY, MITO, 1988, P.473, (1988).
2) YOUNG P.G. AND ARTHUR E.D.: LA-6947 (1977).
3) KITAZAWA H. ET AL.: UNPUBLISHED.
4) VONACH H.: NUCLEAR DATA STANDARDS FOR NUCLEAR MEASUREMENTS, IAEA TECHNICAL REPORTS SERIES NO. 227 (1983).

3.10 Natural Si

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 14-SI-  0 TIT,JAERI  EVAL-MAR88 H.KITAZAWA,Y.HARIMA,T.FUKAHORI
                      DIST-JUL91
HISTORY
88-03  NEW EVALUATION WAS PERFORMED FOR JENDL-3 BY KITAZAWA,
       HARIMA (TOKYO INSTITUTE OF TECH.) AND FUKAHORI (JAERI).
       DETAILS ARE GIVEN IN REF./1/.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
         = MT028 + MT103 + MT111*2
 MT=207  HE-4 PRODUCTION CROSS SECTION
         = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3  NEUTRON CROSS  SECTIONS
 MT=22   (N,NA) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL USING THE GNASH CODE./1,2/
   OPTICAL POTENTIAL FOR ALPHA-PARTICLES WAS DETERMINED, USING
   THE DISPERSION THEORY./3/
 MT=28   (N,NP) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL USING THE GNASH CODE./1,2/
 MT=103  (N,P) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL USING THE GNASH CODE./1,2/
   THE IMAGINARY POTENTIAL STRENGTH OF THE PROTON SPHERICAL
   OPTICAL MODEL WAS MODIFIED FROM THAT IN REF./1/ TO BE
   W = 11.0 MEV BETWEEN 11 AND 20 MEV AND W = 8.8 + 0.2*E (MEV)
   BELOW 11 MEV.
 MT=107  (N,A) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL USING THE GNASH CODE./1,2/
   OPTICAL POTENTIAL FOR ALPHA-PARTICLES WAS DETERMINED, USING
   THE DISPERSION THEORY./3/
 MT=111  (N,2P) CROSS SECTIONS
   CALCULATED BY THE STATISTICAL MODEL USING THE GNASH CODE./1,2/
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REFERENCES
1) KITAZAWA H. ET AL.: PROC. INT. CONF. NUCLEAR DATA FOR
   SCIENCE AND TECHNOLOGY, MITO, 1988, P.473, (1988).
2) YOUNG P.G. AND ARTHUR E.D.: LA-6947 (1977).
3) KITAZAWA H. ET AL.: UNPUBLISHED.

3.11 Natural Ti

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 22-TI-  0 KUR          EVAL-SEP88 K.KOBAYASHI(KUR),H.HASHIKURA(TOK)
                        DIST-JUL91
HISTORY
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
        BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
         = MT028 + MT103
 MT=207  HE-4 PRODUCTION CROSS SECTION
         = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3  NEUTRON CROSS SECTIONS
 MT=22       (N,NA)
    CALCULATED WITH THE GNASH CODE/1/ FOR ALL THE ISOTOPES.
 MT=28       (N,NP)
    CALCULATED WITH THE GNASH CODE FOR TI-46, 48 AND 50, AND
    EVALUATED ON THE BASIS OF EXPRIMENTAL DATA FOR TI-47 AND 49.
 MT=103      (N,P)
    COMPOSED FROM THE ISOTOPIC DATA EVALUATED FROM EXPERIMENTAL
    DATA.
 MT=107      (N,A)
    CALCULATED WITH THE GNASH CODE FOR TI-48, AND EVALUATED ON THE
    BASIS OF EXPRIMENTAL DATA FOR TI-46, 47, 49 AND 50.

REFERENCES
 1) YOUNG, P.G. AND ARTHUR, E.D. : LA-6947 (1977).
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3.12 V-51

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 23-V - 51 KHI          EVAL-AUG88 T.WATANABE
                        DIST-JUL91
HISTORY
82-10  EVALUATION WAS MADE BY S.TANAKA(JAERI) FOR JENDL-2. DETAILS
       ARE GIVEN IN REF./1/
88-08  RE-EVALUATION WAS MADE BY T.WATANABE(KAWASAKI HEAVY
       INDUSTRIES LTD.) FOR JENDL-3.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA.

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT105
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  DESCRIPTIVE DATA FOR JENDL-3  ******************************

MF=3    NEUTRON CROSS SECTIONS
        DATA FOR MT'S=22, 28, 104 AND 105 WERE ADOPTED FROM THE
        JENDL-2 EVALUATION/1/.

  MT=22  (N,N'ALPHA)
      BASED ON THE DATA BY HILLMAN /2/
  MT=28  (N,N'P)
      GIVEN BY SUBTRACTING THE (N,P) CROSS SECTION (MT=103, FOR
      JENDL-2) FROM THE (N,XP) CROSS SECTION CALCULATED BY
      KITAZAWA AND ISOGAI /3/.
  MT=103 (N,P)
      BASED ON THE EXPERIMENTAL DATA /4,5/.
  MT=104 (N,D)
      CALCULATION BY GUENTHER ET AL. /6/
  MT=107 (N,ALPHA)
      BASED ON THE EXPERIMENTAL DATA /1,7,8,9/.
```

REFERENCES

1) TANAKA S.: JAERI-M 82-151 (1982).
2) HILLMAN, M.: PYS. REV. 129, 2227 (1963).
3) KITAZAWA, H. AND ISOGAI, Y.: PRIVATE COMMUNICATYION.
4) IKEDA Y. ET AL.: JAERI 1312 (1988).
5) SMITH, D.L. ET AL.: ANL/NDM-85 (1984).
6) GUENTHER, P. ET AL.: ANL/NDM-24 (1977).
7) KANNO, I. ET AL.: ANNALS NUCL. ENERGY 11, 623 (1984).
8) LU HAN-LIN, ET AL.: PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS 3, 88 (1979).
9) ZUPRANSKA, E ET AL.: ACTA PHYSICA POLONICA SECTION B 11, 853 (1980).

3.13 Natural Cr

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 24-CR-  0 MEDAC      EVAL-MAR87 T.ASAMI
                      DIST-JUL91
HISTORY
87-03  NEW EVALUATION WAS MADE BY T.ASAMI.
88-12  MF/MT=3/107 WAS MODIFIED.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  DESCRIPTIVE DATA FOR JENDL-3  ******************************

MF=3  NEUTRON CROSS SECTIONS
   ALL THE CROSS-SECTION DATA WERE DEDUCED FROM THE EVALUATED ONES
   FOR FOUR STABLE ISOTOPES OF CR CONSIDERING THEIR ABUNDANCES IN
   THE CR ELEMENT/1/.

 MT=22       (N,NA)
   FOR ALL ISOTOPES : CALCULATED WITH THE GNASH CODE/2/

 MT=28       (N,NP)
   FOR ALL ISOTOPES : CALCULATED WITH THE GNASH CODE/2/

 MT=103      (N,P)
   CR-50: CALCULATED WITH THE GNASH CODE/2/
   CR-52: CALCULATED WITH THE GNASH CODE, AND NORMALIZED TO THE
      RECOMMENDED VALUE OF FORREST /3/ AT 14.8 MEV.
   CR-53:  BELOW 9 MEV, EVALUATION WAS MADE ON THE BASIS OF THE
      EXPERIMENTAL DATA OF SMITH /4/.  ABOVE 9 MEV, CALCULATION
      WITH THE GNASH CODE WAS NORMALIZED SO AS TO CONNECTED WITH
      SMITH'S DATA /4/.
   CR-54: CALCULATED WITH THE GNASH CODE AND NORMALIZED AT 14.7
      MEV TO THE AVERAGE VALUE OF THE EXPERIMENTAL DATA /5,6,7/.

 MT=107      (N,A)
      THE DATA FOR ALL THE ISOTOPES NEAR THE THRESHOLD ENERGIES
      WERE MODIFIED ON THE BASIS OF THE EXPERIMENTAL DATA FOR
      CR-NAT(N,ALPHA) /8/.

   CR-50:  CALCULATED WITH THE GNASH CODE, AND NORMALIZED AT 14.8
      MEV IN REFERRING TO GRIMES' DATA /9/.
   CR-52:  CALCULATED WITH THE GNASH CODE, AND NORMALIZED TO THE
      AVERAGE VALUE OF EXPERIMENTAL DATA /9, 10/ AT 14.8 MEV.
   CR-53:  CALCULATED WITH THE GNASH CODE, AND NORMALIZED TO THE
      EXPERIMENTAL DATA /10/ AT 14.7 MEV.
   CR-54:  CALCULATED WITH THE GNASH CODE, AND NORMALIZED TO THE
      AVERAGE VALUE OF EXPERIMENTAL DATA /6,7,11/ AT 14.8 MEV.

REFERENCES
 1) HOLDEN N.E., MARTIN R.L. AND BARNES I.L. : PURE & APPL.
```

CHEM. 56, 675 (1984).
2) YOUNG P.G. AND ARTHUR E.D. : LA-6947 (1977).
3) FORREST R.A.: AERE-R-12419 (1986).
4) SMITH D.L. ET AL.: NUCL. SCI. ENG., 78, 420 (1981).
5) VALKONEN M.: TAKEN FROM EXFOR (1976).
6) HUSAIN L. ET AL.: J. INORG. NUCL. CHEM., 29, 2665 (1967).
7) QAIM S.M. ET AL.: NUCL. PHYS., A283, 269 (1977).
8) PAULSEN A. : NUCL. SCI. ENG. 78, 377 (1981).
9) GRIMES S.M. ET AL.: PHYS. REV. C19, 2127 (1979).
10) DOLJA G.D. ET AL.: 1973 KIEV CONF., VOL.3, 131 (1973).
11) SAILER K. ET AL.: 1977 KIEV CONF., VOL.1, 246 (1977).

3.1.1 Mn-55

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 25-MN- 55 JAERI,MAPI EVAL-MAR87 K.SHIBATA,T.HOJUYAMA
                      DIST-JUL91
HISTORY
87-03  RESONANCE PARAMETERS WERE EVALUATED BY T.HOJUYAMA (MAPI).
       MULTISTEP HAUSER-FESHBACH CALCULATIONS WERE PERFORMED
       BY K.SHIBATA (JAERI).
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT105
 MT=206  HE-3 PRODUCTION CROSS SECTION
          = MT106
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3          NEUTRON CROSS SECTIONS
        STATISTICAL-MODEL CALCULATIONS WERE PERFORMED USING THE
        TNG CODE /1/.  THE PRECOMPOUND PROCESS WAS CONSIDERED
        ABOVE 5 MEV.  THE OPTICAL POTENTIAL PARAMETERS USED ARE AS
        FOLLOWS/2/ (IN THE UNITS OF MEV AND FM):
   V  = 49.747 - 0.4295*E - 0.0003*E**2  R0 = 1.287  A0  = 0.56
   WS = 11.2 - 0.09*E                    RS = 1.345  AS  = 0.47
   VSO= 6.2                              RSO= 1.120  ASO = 0.47
        THE LEVEL SCHEME WAS TAKEN FROM REF./3/.
          NO.    ENERGY(MEV) SPIN-PARITY
          G.S.      0.0        5/2 -
           1.       0.126      7/2 -
           2.       0.984      9/2 -
           3.       1.290      1/2 -
           4.       1.292     11/2 -
           5.       1.293      1/2 -
           6.       1.528      3/2 -
           7.       1.884      7/2 -
           8.       2.015      7/2 -
           9.       2.198      7/2 -
          10.       2.215      5/2 -
          11.       2.252      3/2 -
          12.       2.267      5/2 -
          13.       2.312     13/2 -
          14.       2.366      5/2 -
          15.       2.398      9/2 +
          16.       2.427      1/2 +
          17.       2.563      3/2 -
          18.       2.727      7/2 -
          19.       2.753      5/2 -
          20.       2.822      9/2 -
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21.	2.824	5/2 -
22.	2.873	1/2 -
23.	2.954	3/2 -
24.	2.976	3/2 -
25.	2.992	7/2 -
26.	3.006	3/2 -
27.	3.036	11/2 -
28.	3.038	1/2 -
29.	3.040	3/2 +

LEVELS ABOVE 3.046 MEV WERE ASSUMED TO BE OVERLAPPING.

MT=22,28,103,107 (N,N'A),(N,N'P),(N,P) AND (N,A) CROSS SECTIONS
CALCULATED WITH TNG. GLOBAL OPTICAL-POTENTIAL PARAMETERS WERE EMPLOYED FOR PROTONS AND ALPHA-PARTICLES /4,5/.

MT=104 (N,D) CROSS SECTION
THE EXCITATION FUNCTION OF THE (N,P) CROSS SECTION CALCULATED WITH TNG WAS USED FOR THE (N,D) REACTION BY SHIFTING THE THRESHOLD ENERGY. THE CROSS SECTIONS WERE NORMALIZED TO THE EXPERIMENTAL DATUM AT 14.1 MEV /6/.

MT=105 (N,T) CROSS SECTION
THE EXCITATION FUNCTION OF THE (N,P) CROSS SECTION CALCULATED WITH TNG WAS USED FOR THE (N,T) REACTION BY SHIFTING THE THRESHOLD ENERGY. THE CROSS SECTIONS WERE NORMALIZED TO THE EXPERIMENTAL DATUM AT 14.7 MEV /7/.

MT=106 (N,HE-3) CROSS SECTION
BASED ON THE EXPERIMENTAL DATA /8,9/.

REFERENCES

1) FU, C.Y.: "A CONSISTENT NUCLEAR MODEL FOR COMPOUND AND PRECOMPOUND REACTIONS WITH CONSERVATION OF ANGULAR MOMENTUM", ORNL/TM-7042 (1980).
2) FU, C.Y.: PRIVATE COMMUNICATION (1985).
3) ZHOU ENCHEN, HUO JUNDE, ZHOU CHUNMEI, LU XIANE AND WANG LIZHENG: NUCL. DATA SHEETS, 44, 463 (1985).
4) PEREY, F.G.: PHYS. REV., 131, 745 (1963).
5) HUIZENGA, J.R. AND IGO, G.J.: NUCL. PHYS., 29, 462 (1962).
6) COLLI, L., IORI, I., MICHELETTI, S. AND PIGNANELLI, M.: NUOVO. CIM., 21, 966 (1962).
7) SUDAR, S. AND CSIKAI, J.: NUCL. PHYS., A319, 157 (1979).
8) DIKSIC, M., STROHAL, P. AND SLAUS, I.: J. INORG. NUCL. CHEM., 36, 477 (1974).
9) WU, C.H., WOELFLE, R. AND QAIM, S.M.: NUCL. PHYS., A329, 63 (1979).

3.15 Natural Fe

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 26-FE-  0 JNDC        EVAL-MAR87 S.IIJIMA,H.YAMAKOSHI
                       DIST-JUL91
HISTORY
87-03  EVALUATION WAS PERFORMED FOR JENDL-3.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

NATURAL IRON DATA CONSTRUCTED FROM FE-ISOTOPES.

MF=3  NEUTRON CROSS SECTIONS

  MT=22,28
      CALCULATED WITH GNASH /1/.

  MT=103
      CALCULATED WITH GNASH /1/ EXCEPT FOR FE-54 AND 56.
   FE-54
      BELOW 2.5 MEV, BASED ON THE DATA OF PAULSEN AND WIDERA/2/
      BETWEEN 2.5 AND 10 MEV, BASED ON THE DATA OF SMITH AND
      MEADOWS/3/.  ABOVE 10 MEV, CALCULATED WITH GNASH.
   FE-56
      BELOW 7 MEV, BASED ON THE DATA OF SMITH AND MEADOWS/3/.
       7 - 13 MEV, TAKEN FROM JENDL-2.
      13 - 16 MEV, BASED ON THE DATA OF IKEDA ET AL./4/
      16 - 20 MEV, TAKEN FROM JENDL-2.

  MT=107      (N,ALPHA)
      FOR FE-56, THE EVALUATION WAS MADE ON THE BASIS OF
      EXPERIMENTAL DATA.  FOR FE-54,57,58, THE GNASH CALCULATION
      WAS ADOPTED.
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REFERENCES
1) YOUNG P.G. AND ARTHUR E.D.: LA-6947 (1977).
2) PAULSEN A. AND WIDERA R.: PROC. CONF. CHEMICAL NUCLEAR DATA, MEASUREMENTS AND APPLICATION, CANTERBURY, 1971.
3) SMITH D.L. AND MEADOWS J.W.: NUCL. SCI. ENG., 58, 314 (1975).
4) IKEDA Y. ET AL.: JAERI 1312 (1988).

3.16 Co-59

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 27-CO- 59 KHI          EVAL-AUG88 T.WATANABE
                        DIST-JUL91
HISTORY
88-08  NEWLY EVALUATED BY T.WATANABE
                            (KAWASAKI HEAVY INDUSTRIES, LTD.)
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3    NEUTRON CROSS SECTIONS
  MT=22, 28 (N,N'ALPHA), (N,N'P)
      YAMAMURO'S CALCULATION WITH THE MODIFIED GNASH /1/ WAS
      ADOPTED.
  MT=103 (N,P)
      BASED ON THE EXPERIMENTAL DATA /2,3,4,5/.
  MT=104 (N,D)
      YAMAMURO'S CALCULATION WITH THE MODIFIED GNASH /1/ WAS
      ADOPTED.
  MT=107 (N,ALPHA)
      JENDL-2 DATA WHICH WERE EVALUATED FROM THE EXPERIMENTAL
      DATA OF SANTRY AND BUTLER /6/ WERE ADOPTED WITH SLIGHT
      MODIFICATION BASED ON EVAIN'S EVALUATION /7/ AND
      EXPERIMENTAL DATA /4,8/.
```

REFERENCES

1) YAMAMURO N.: JAERI-M 88-140 (1988).
2) SMITH D.L. ET AL.: NUCL. SCI. ENG. 58, 314 (1975).
3) WILLIAMS J.R. AND ALFORD, W.L.: PROC. INT. CONF. NUCLEAR DATA FOR BASIC AND APPLIED SCIENCE, SANTA FE, 1985, P.215 (1986).
4) IKEDA Y. ET AL.: JAERI 1312 (1988).
5) HASAN S.J. ET AL.: J. PHYS. G12, 397 (1986).
6) SANTRY D.C. AND BUTLER J.P: CAN. J. PHYS., 42, 1030 (1964).
7) EVAIN B.P. ET AL.: ANL/NDM-89 (1985).
8) MEADOWS J.W. ET AL.: ANN. NUCL. ENERGY 14, 603 (1987).

3.17 Natural Ni

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 28-NI-  0 TOSHIBA     EVAL-MAR87 S.IIJIMA
                       DIST-JUL91
HISTORY
87-03  EVALUATION WAS PERFORMED FOR JENDL-3.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103 + MT111*2
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT105
 MT=206  HE-3 PRODUCTION CROSS SECTION
          = MT106
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  DESCRIPTIVE DATA FOR JENDL-3  ******************************

   EVALUATION WAS REPORTED AT MITO CONFERENCE./1/

 MF=3  NEUTRON CROSS SECTIONS

   MT=22,28,103,104,105,106,107,111:
       (N,N'A),(N,N'P),(N,P),(N,D),(N,T),(N,HE-3),(N,A),(N,2P)
      CROSS SECTIONS WERE CONSTRUCTED FROM THE DATA FOR EACH
      ISOTOPE.

   NI-58
      MT=28,103   (N,N'P),(N,P)
          BASED ON EXPERIMENTAL DATA.
      MT=22,104,105,106,107,111  (N,N'A),(N,D),(N,T),(N,HE-3),
            (N,A),(N,2P)
          THE CROSS SECTIONS WERE CALCULATED USING THE PEGASUS
          CODE /2/ AND NORMALIZED TO EXPERIMENTAL DATA.

   NI-60
      MT=22,28,104,105,106,107,111: (N,N'A),(N,N'P),(N,D),
           (N,T),(N,HE-3),(N,A),(N,2P)
          THE CROSS SECTIONS WERE CALCULATED WITH PEGASUS /2/
          AND NORMALIZED TO EXPERIMENTAL DATA.
      MT=103     (N,P)
          MOST OF DATA WERE TAKEN FROM JENDL-2.

   NI-61
      MT=22,28,103,104,105,106,107,111  (N,N'A),(N,N'P),(N,P),
            (N,D),(N,T),(N,HE-3),(N,A),(N,2P)
          CALCULATED WITH PEGASUS /2/.

   NI-62 AND NI-64
      MT=22,28,103,104,105,106,111  (N,N'A),(N,N'P),(N,P),(N,D),
            (N,T),(N,HE-3),(N,2P)
```

CALCULATED WITH PEGASUS /2/.
MT=107 (N,A)
BASED ON EXPERIMENTAL DATA.

REFERENCES

1) IIJIMA S. ET AL.: 1988 MITO, 627 (1988).
2) IIJIMA S. ET AL.: JAERI-M 87-025, P.337 (1987).

3.18 Natural Cu

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 29-CU-  0 NAIG,MAPI  EVAL-MAR87 N.YAMAMURO,T.KAWAKITA
                      DIST-JUL91
HISTORY
87-03  EVALUATION WAS PERFORMED FOR JENDL-3.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT032 + MT104
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 +  MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3          NEUTRON CROSS SECTIONS
  MT=22,28,32,103,104 (N,N'A),(N,N'P),(N,N'D),(N,P) (N,D) CROSS
     SECTIONS
        CALCULATED WITH GNASH /1/.  OPTICAL POTENTIAL PARAMETERS
        WERE AS FOLLOWS (IN THE UNITS OF MEV AND FM):
     NEUTRON /2/
          V  = 51.725 - 0.447*E   R0 = 1.221    A0  = 0.683
          WS = 8.44 + 0.055*E     RS = 1.223    AS  = 0.507
          VSO= 8.0                RSO= 1.221    ASO = 0.683
     PROTON /3/
        V  = 59.11 - 0.55*E    R0 = 1.25    A0 = 0.65
        WS = 10.4              RS = 1.25    AS = 0.47
        VSO= 7.5               RSO= 1.25    ASO= 0.47

     ALPHA-PARTICLE /4/
        V  = 164.7             R0 = 1.442   A0 = 0.52
        WV = 22.4              RV = 1.442   AV = 0.52
                               RC = 1.30

     DEUTERON /5/
        V  = 106.69            R0 = 1.05    A0 = 0.86
        WS = 13.92             RS = 1.43    AS = 0.704
        VSO= 7.0               RSO= 0.75    ASO= 0.5
                               RC = 1.3
  MT=107    (N,A) CROSS SECTION
        CALCULATED CROSS SECTIONS OF CU-63 WERE NORMALIZED TO
        THE EXPERIMENTAL DATA /6/ AT 10 MEV.  ABOVE 12 MEV, THE
        EXCITATION FUNCTION FOLLOWS THE DATA OF PAULSEN /7/.
        FOR CU-65, THE GNASH CALCULATION WAS EMPLOYED.


REFERENCES
 1) YOUNG, P.G. AND ARTHUR, E.D.: "GNASH, A PREEQUILIBRIUM,
    STATISTICAL NUCLEAR-MODEL CODE FOR CALCULATION OF CROSS
    SECTIONS AND EMISSION SPECTRA", LA-6974 (1977).
 2) HETRICK, D.M., FU, C.Y. AND LARSON, D.C.: "CALCULATED
    NEUTRON-INDUCED CROSS SECTIONS FOR CU-63,65 FROM 1 TO 20 MEV
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AND COMPARISONS WITH EXPERIMENTS", ORNL/TM-9083 (1984).
3) PEREY, F.G.: PHYS. REV. 131, 745 (1963).
4) MCFADDEN, L. AND SATCHLER, G.R.: NUCL. PHYS. 84, 177 (1966).
5) LOHR, J.M. AND HAEBERLI, W.: NUCL. PHYS. A232, 381 (1974).
6) WINKLER, G., SMITH, D.L. AND MEADOWS, J.W.: NUCL. SCI. ENG. 76, 30 (1980).
7) PAULSEN, A.: NUCLEONIK, 10, 91 (1967)

3.19 As-75

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 33-As- 75  NDC        EVAL-Aug89 JNDC FP Nuclear Data W.G.
                       DIST-jul91
History
89-08  NEW EVALUATION FOR JENDL-3 WAS COMPLETED BY JNDC FPND
       W.G./1/
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT032 + MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT033 + MT105
 MT=206  HE-3 PRODUCTION CROSS SECTION
          = MT106
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  DESCRIPTIVE DATA for JENDL-3 FP ****************************

MF = 3  Neutron cross sections
  The threshold reaction cross sections were calculated with
  PEGASUS/2/ standing on a preequilibrium and multi-step
  evaporation model.  The OMP's for neutron given in Table 1 were
  determined to reproduce a systematic trend of the total cross
  section, changed from radii of Iijima and Kawai/3/.  The OMP's
  for charged particles are as follows:
     Proton   = Perey/4/
     Alpha    = Huizenga and Igo/5/
     Deuteron = Lohr and Haeberli/6/
     Helium-3 and triton = Becchetti and Greenlees/7/
  Parameters for the composite level density formula of Gilbert
  and Cameron/8/ were evaluated by Iijima et al./9/.  More
  extensive determination and modification were made in the
  present work.  Table 2 shows the level density parameters used
  in the present calculation.  Energy dependence of spin cut-off
  parameter in the energy range below E-joint is due to Gruppelaar
  /10/.

  MT = 22  (n,n'a) Cross Section
  MT = 28  (n,n'p) Cross Section
  MT = 32  (n,n'd) Cross Section
  MT = 33  (n,n't) Cross Section
  MT =103  (n,p) Cross Section
  MT =104  (n,d) Cross Section
  MT =105  (n,t) Cross Section
  MT =106  (n,He3) Cross Section
  MT =107  (n,alpha) Cross Section
    These reaction cross sections were calculated with the
    preequilibrium and multi-step evaporation model code
    PEGASUS/2/.
```

The Kalbach's constant K (= 83.0) was estimated by the formula derived from Kikuchi-Kawai's formalism/11/ and level density parameters.

Finally, the (n,p) and (n,alpha) cross sections were normalized to the following values at 14.5 MeV:

(n,p)	32.00	mb (recommended by Forrest/12/)
(n,alpha)	11.00	mb (recommended by Forrest/12/)

Table 1 Neutron Optical Potential Parameters

Depth (MeV)	Radius(fm)	Diffuseness(fm)
V = 46.0-0.25E	R0 = 5.7	a0 = 0.62
Ws = 7.0	Rs = 6.2	as = 0.35
Wso= 7.0	Rso= 5.7	aso= 0.62

Table 2 Level Density Parameters

Nuclide	SYST	a(1/MeV)	T(MeV)	C(1/MeV)	EX(MeV)	Pairing
31-Ga- 71	*	1.332E+01	9.155E-01	1.399E+01	9.613E+00	1.430E+00
31-Ga- 72	*	1.390E+01	9.028E-01	9.003E+01	8.399E+00	0.0
31-Ga- 73		1.269E+01	8.264E-01	1.933E+00	7.808E+00	1.880E+00
31-Ga- 74	*	1.350E+01	8.784E-01	5.236E+01	7.551E+00	0.0
32-Ge- 72	*	1.350E+01	9.028E-01	3.062E+00	1.086E+01	2.790E+00
32-Ge- 73	*	1.409E+01	8.904E-01	1.973E+01	9.644E+00	1.360E+00
32-Ge- 74	*	1.384E+01	8.784E-01	1.667E+00	1.106E+01	3.240E+00
32-Ge- 75	*	1.368E+01	8.667E-01	1.100E+01	8.816E+00	1.360E+00
33-As- 73	*	1.369E+01	8.904E-01	1.364E+01	9.389E+00	1.430E+00
33-As- 74		1.132E+01	9.475E-01	1.967E+01	7.033E+00	0.0
33-As- 75		1.250E+01	9.510E-01	6.830E+00	1.008E+01	1.880E+00
33-As- 76		1.330E+01	7.860E-01	1.900E+01	5.611E+00	0.0

SYST: * = LDP's were determined from systematics.

Spin cutoff params were calculated as 0.146*SQRT(a)*A**(2/3). In the CASTHY calculation, spin cutoff factors at 0 MeV were assumed to be 3.5 for As- 75 and 5.0 for As- 76.

References

1) Kawai, M. et al.: Proc. Int. Conf. on Nuclear Data for Science and Technology, Mito, p. 569 (1988).
2) Iijima, S. et al.: JAERI-M 87-025, p. 337 (1987).
3) Iijima, S. and Kawai, M.: J. Nucl. Sci. Technol., 20, 77 (1983).
4) Perey, F.G: Phys. Rev. 131, 745 (1963).
5) Huizenga, J.R. and Igo, G.: Nucl. Phys. 29, 462 (1962).
6) Lohr, J.M. and Haeberli, W.: Nucl. Phys. A232, 381 (1974).
7) Becchetti, F.D., Jr. and Greenlees, G.W.: Polarization Phenomena in Nuclear Reactions ((eds) H.H. Barshall and W. Haeberli), p. 682, The university of Wisconsin Press. (1971).
8) Gilbert, A. and Cameron, A.G.W.: Can. J. Phys., 43, 1446 (1965).
9) Iijima, S., et al.: J. Nucl. Sci. Technol. 21, 10 (1984).
10) Gruppelaar, H.: ECN-13 (1977).
11) Kikuchi, K. and Kawai, M.: "Nuclear Matter and Nuclear Reactions", North Holland (1968).
12) Forrest, R.A.: AERE-R 12419 (1986).

3.20 Natural Se

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 34-Se-  0 JNDC        EVAL-Aug89 JNDC FP Nuclear Data W.G.
                       DIST-Jul91
History
89-08  NEW EVALUATION FOR each isotope  WAS COMPLETED BY JNDC FPND
       W.G./1/
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
         = MT028 + MT103 + mt111*2
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
         = MT032 + MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
         = MT105
 MT=206  HE-3 PRODUCTION CROSS SECTION
         = MT106
 MT=207  HE-4 PRODUCTION CROSS SECTION
         = MT022 + MT107

****  DESCRIPTIVE DATA for JENDL-3 FP ****************************

MF = 3  Neutron cross sections
  The threshold reaction cross sections were calculated with
  PEGASUS/2/ standing on a preequilibrium and multi-step
  evaporation model.  The OMP's for neutron given in Table 1 were
  determined to reproduce a systematic trend of the total cross
  section, changed from radii of Iijima and Kawai/3/.  The OMP's
  for charged particles are as follows:
     Proton   = Perey/4/
     Alpha    = Huizenga and Igo/5/
     Deuteron = Lohr and Haeberli/6/
     Helium-3 and triton = Becchetti and Greenlees/7/
  Parameters for the composite level density formula of Gilbert
  and Cameron/8/ were evaluated by Iijima et al./9/.  More
  extensive determination and modification were made in the
  present work.  Table 2 shows the level density parameters used
  in the present calculation.  Energy dependence of spin cut-off
  parameter in the energy range below E-joint is due to Gruppelaar
  /10/.

  MT = 22  (n,n'a) Cross Section
  MT = 28  (n,n'p) Cross Section
  MT = 32  (n,n'd) Cross Section
  MT =103  (n,p) Cross Section
  MT =104  (n,d) Cross Section
  MT =105  (n,t) Cross Section
  MT =106  (n,He3) Cross Section
  MT =107  (n,alpha) Cross Section
    These reaction cross sections were calculated with the
    preequilibrium and multi-step evaporation model code
    PEGASUS/2/.

    Finally, the (n,p) and (n,alpha) cross sections were
```

normalized to the following values at 14.5 MeV:

Isotope	(n,p)/11/	(n,alpha)/11/
Se- 74	135 mb	34.8 mb
Se- 76	79 mb	15.6 mb
Se- 77	35 mb	10.1 mb
Se- 78	18 mb	5.5 mb
Se- 80	16 mb	17 mb
Se- 82	2.4 mb	-

Table 1 Neutron Optical Potential Parameters

Depth (MeV)	Radius(fm)	Diffuseness(fm)
V = 46.0-0.25E	R0 = 5.7	a0 = 0.62
Ws = 7.0	Rs = 6.2	as = 0.35
Wso= 7.0	Rso= 5.7	aso= 0.62

Table 2 Level Density Parameters

Nuclide	SYST	a(1/MeV)	T(MeV)	C(1/MeV)	EX(MeV)	Pairing
32-Ge- 70	*	1.236E+01	9.286E-01	1.710E+00	1.048E+01	2.860E+00
32-Ge- 71	*	1.293E+01	9.155E-01	1.132E+01	9.208E+00	1.360E+00
32-Ge- 72	*	1.350E+01	9.028E-01	3.062E+00	1.086E+01	2.790E+00
32-Ge- 73	*	1.409E+01	8.904E-01	1.973E+01	9.644E+00	1.360E+00
32-Ge- 74	*	1.384E+01	8.784E-01	1.667E+00	1.106E+01	3.240E+00
32-Ge- 75	*	1.368E+01	8.667E-01	1.100E+01	8.810E+00	1.360E+00
32-Ge- 76	*	1.352E+01	8.553E-01	1.533E+00	9.919E+00	2.830E+00
32-Ge- 77	*	1.334E+01	8.442E-01	6.660E+00	8.098E+00	1.360E+00
32-Ge- 78		1.234E+01	8.699E-01	7.304E-01	9.395E+00	2.930E+00
32-Ge- 79		1.362E+01	7.523E-01	2.737E+00	6.567E+00	1.360E+00
32-Ge- 80	*	1.277E+01	8.125E-01	5.273E-01	8.551E+00	2.820E+00
32-Ge- 81	*	1.255E+01	8.025E-01	2.496E+00	6.770E+00	1.360E+00
33-As- 71	*	1.254E+01	9.155E-01	7.299E+00	9.012E+00	1.500E+00
33-As- 72	*	1.311E+01	9.028E-01	5.047E+01	7.739E+00	0.0
33-As- 73	*	1.369E+01	8.904E-01	1.364E+01	9.389E+00	1.430E+00
33-As- 74		1.132E+01	9.475E-01	1.967E+01	7.033E+00	0.0
33-As- 75		1.250E+01	9.510E-01	6.830E+00	1.008E+01	1.880E+00
33-As- 76		1.330E+01	7.860E-01	1.900E+01	5.611E+00	0.0
33-As- 77		1.300E+01	8.440E-01	4.637E+00	7.951E+00	1.470E+00
33-As- 78		1.150E+01	7.500E-01	5.001E+00	3.894E+00	0.0
33-As- 79		1.290E+01	8.230E-01	3.020E+00	7.585E+00	1.570E+00
33-As- 80		1.150E+01	7.250E-01	4.181E+00	3.535E+00	0.0
33-As- 81	*	1.293E+01	8.025E-01	2.772E+00	7.120E+00	1.460E+00
33-As- 82	*	1.271E+01	7.927E-01	1.371E+01	5.344E+00	0.0
34-Se- 72	*	1.272E+01	9.028E-01	1.477E+00	1.034E+01	2.930E+00
34-Se- 73		1.404E+01	8.250E-01	7.927E+00	8.288E+00	1.430E+00
34-Se- 74		1.290E+01	8.620E-01	1.070E+00	9.612E+00	2.860E+00
34-Se- 75		1.391E+01	8.500E-01	9.741E+00	8.707E+00	1.430E+00
34-Se- 76		1.315E+01	8.900E-01	1.097E+00	1.082E+01	3.310E+00
34-Se- 77		1.438E+01	8.000E-01	7.140E+00	8.015E+00	1.430E+00
34-Se- 78		1.287E+01	8.750E-01	1.163E+00	9.882E+00	2.900E+00
34-Se- 79		1.412E+01	8.000E-01	5.994E+00	7.842E+00	1.430E+00
34-Se- 80		1.334E+01	8.130E-01	6.129E-01	9.136E+00	3.000E+00

34-Se- 81	1.368E+01	7.490E-01	2.463E+00	6.614E+00	1.430E+00
34-Se- 82	1.259E+01	7.980E-01	3.563E-01	8.246E+00	2.890E+00
34-Se- 83	1.381E+01	7.500E-01	2.666E+00	6.708E+00	1.430E+00

SYST: * = LDP's were determined from systematics.

Spin cutoff params were calculated as 0.146*SQRT(a)*A**(2/3).

References

1) Kawai, M. et al.: Proc. Int. Conf. on Nuclear Data for Science and Technology, Mito, p. 569 (1988).
2) Iijima, S. et al.: JAERI-M 87-025, p. 337 (1987).
3) Iijima, S. and Kawai, M.: J. Nucl. Sci. Technol., 20, 77 (1983).
4) Perey, F.G: Phys. Rev. 131, 745 (1963).
5) Huizenga, J.R. and Igo, G.: Nucl. Phys. 29, 462 (1962).
6) Lohr, J.M. and Haeberli, W.: Nucl. Phys. A232, 381 (1974).
7) Becchetti, F.D., Jr. and Greenlees, G.W.: Polarization Phenomena in Nuclear Reactions ((eds) H.H. Barshall and W. Haeberli), p. 682, The university of Wisconsin Press. (1971).
8) Gilbert, A. and Cameron, A.G.W.: Can. J. Phys., 43, 1446 (1965).
9) Iijima, S., et al.: J. Nucl. Sci. Technol. 21, 10 (1984).
10) Gruppelaar, H.: ECN-13 (1977).
11) Forrest, R.A.: AERE-R 12419 (1986).

3.21 Natural Zr

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 40-Zr-  0 JNDC        EVAL-Aug89 JNDC FP Nuclear Data W.G.
                       DIST-Jul91
History
89-08  NEW EVALUATION FOR each isotope  WAS COMPLETED BY JNDC FPND
       W.G./1/
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103 + MT111*2
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT032 + MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT033 + MT105
 MT=206  HE-3 PRODUCTION CROSS SECTION
          = MT106
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  DESCRIPTIVE DATA for JENDL-3 FP ****************************

MF = 3  Neutron cross sections
  The threshold reaction cross sections were calculated with
  PEGASUS/2/ standing on a preequilibrium and multi-step
  evaporation model.  The OMP's for neutron given in Table 1 were
  determined/3/ to reproduce a systematic trend of the total
  cross section.  The OMP's for charged particles are as follows:
     Proton   = Perey/4/
     Alpha    = Huizenga and Igo/5/
     Deuteron = Lohr and Haeberli/6/
     Helium-3 and triton = Becchetti and Greenlees/7/
  Parameters for the composite level density formula of Gilbert
  and Cameron/8/ were evaluated by Iijima et al./9/.  More
  extensive determination and modification were made in the
  present work.  Table 2 shows the level density parameters used
  in the present calculation.  Energy dependence of spin cut-off
  parameter in the energy range below E-joint is due to Gruppelaar
  /10/.

  MT = 22  (n,n'a) Cross Section
  MT = 28  (n,n'p) Cross Section
  MT = 32  (n,n'd) Cross Section
  MT = 33  (n,n't) Cross Section
  MT =103  (n,p) Cross Section
  MT =104  (n,d) Cross Section
  MT =105  (n,t) Cross Section
  MT =106  (n,He3) Cross Section
  MT =107  (n,alpha) Cross Section
  MT =111  (n,2p) Cross Section
    These reaction cross sections were calculated with the
    preequilibrium and multi-step evaporation model code
    PEGASUS/2/.
```

The (n,p) and (n,alpha) cross sections were normalized to the following values at 14.5 MeV:

Isotope	(n,p)/11/	(n,alpha)/11/
Zr- 90	40 mb/11/	10.0 mb/11/
Zr- 91	29 mb/11/	8.51 mb/11/
Zr- 92	22 mb/12/	10.1 mb/13,14/
Zr- 94	10 mb/11/	4.8 mb/12/
Zr- 96	3.79 mb/11/	3.0 mb/11/

Table 1 Neutron Optical Potential Parameters

Depth (MeV)	Radius(fm)	Diffuseness(fm)
V = 46.0-0.25E	R0 = 5.893	a0 = 0.62
Ws = 7.0	Rs = 6.393	as = 0.35
Wso= 7.0	Rso= 5.893	aso= 0.62

Table 2 Level Density Parameters

Nuclide	SYST	a(1/MeV)	T(MeV)	C(1/MeV)	EX(MeV)	Pairing
38-Sr- 86		1.120E+01	8.900E-01	5.328E-01	8.599E+00	2.700E+00
38-Sr- 87		1.030E+01	8.610E-01	1.186E+00	5.938E+00	1.240E+00
38-Sr- 88		9.160E+00	7.510E-01	8.288E-02	4.550E+00	2.170E+00
38-Sr- 89		9.380E+00	8.200E-01	5.043E-01	4.642E+00	1.240E+00
38-Sr- 90		9.940E+00	8.530E-01	3.795E-01	6.252E+00	1.960E+00
38-Sr- 91		1.090E+01	8.100E-01	1.103E+00	5.625E+00	1.240E+00
38-Sr- 92	*	1.288E+01	7.065E-01	2.515E-01	6.391E+00	2.360E+00
38-Sr- 93	*	1.386E+01	6.989E-01	1.878E+00	5.664E+00	1.240E+00
38-Sr- 94	*	1.485E+01	6.915E-01	4.495E-01	7.333E+00	2.530E+00
38-Sr- 95	*	1.586E+01	6.842E-01	4.531E+00	6.411E+00	1.240E+00
39-Y - 87	*	1.388E+01	7.471E-01	2.541E+00	6.730E+00	1.460E+00
39-Y - 88		1.109E+01	7.450E-01	3.738E+00	3.570E+00	0.0
39-Y - 89		7.900E+00	8.500E-01	3.983E-01	3.440E+00	9.300E-01
39-Y - 90		1.027E+01	6.770E-01	1.716E+00	2.209E+00	0.0
39-Y - 91		1.050E+01	7.140E-01	8.362E-01	3.521E+00	7.200E-01
39-Y - 92		1.012E+01	7.629E-01	2.480E+00	3.191E+00	0.0
39-Y - 93		1.150E+01	8.053E-01	1.740E+00	5.854E+00	1.120E+00
39-Y - 94		9.149E+00	7.385E-01	1.378E+00	2.222E+00	0.0
39-Y - 95		1.070E+01	8.306E-01	1.082E+00	5.839E+00	1.290E+00
39-Y - 96	*	1.603E+01	6.771E-01	2.794E+01	5.117E+00	0.0
40-Zr- 88	*	1.404E+01	7.386E-01	4.932E-01	7.870E+00	2.660E+00
40-Zr- 89		1.095E+01	8.260E-01	1.379E+00	5.864E+00	1.200E+00
40-Zr- 90		9.152E+00	8.222E-01	1.526E-01	5.383E+00	2.130E+00
40-Zr- 91		1.036E+01	8.000E-01	7.822E-01	5.057E+00	1.200E+00
40-Zr- 92		1.088E+01	8.192E-01	5.122E-01	6.429E+00	1.920E+00
40-Zr- 93		1.298E+01	7.000E-01	1.273E+00	5.183E+00	1.200E+00
40-Zr- 94		1.275E+01	7.530E-01	4.411E-01	7.019E+00	2.320E+00
40-Zr- 95		1.331E+01	6.070E-01	5.453E-01	3.985E+00	1.200E+00
40-Zr- 96		1.320E+01	7.000E-01	2.235E-01	6.589E+00	2.490E+00
40-Zr- 97		1.259E+01	5.590E-01	2.497E-01	3.084E+00	1.200E+00

SYST: * = LDP's were determined from systematics.

Spin cutoff params were calculated as 0.146*SQRT(a)*A**(2/3).

References

1) Kawai, M. et al.: Proc. Int. Conf. on Nuclear Data for Science and Technology, Mito, p. 569 (1988).
2) Iijima, S. et al.: JAERI-M 87-025, p. 337 (1987).
3) Iijima, S. and Kawai, M.: J. Nucl. Sci. Technol., 20, 77 (1983).
4) Perey, F.G: Phys. Rev. 131, 745 (1963).
5) Huizenga, J.R. and Igo, G.: Nucl. Phys. 29, 462 (1962).
6) Lohr, J.M. and Haeberli, W.: Nucl. Phys. A232, 381 (1974).
7) Becchetti, F.D., Jr. and Greenlees, G.W.: Polarization Phenomena in Nuclear Reactions ((eds) H.H. Barshall and W. Haeberli), p. 682, The university of Wisconsin Press. (1971).
8) Gilbert, A. and Cameron, A.G.W.: Can. J. Phys., 43, 1446 (1965).
9) Iijima, S., et al.: J. Nucl. Sci. Technol. 21, 10 (1984).
10) Gruppelaar, H.: ECN-13 (1977).
11) Forrest, R.A.: AERE-R 12419 (1986).
12) Ikeda, Y. et al.: JAERI 1312 (1988).
13) Qaim, S. M., et al.: Euratom Report 5182E, 939 (1974).
14) Bayhurst, B. P., et al.:J. Inorg. Nucl. Chem., 23, 173 (1961).

3.22 Nb-93

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 41-NB- 93 TOSHIBA     EVAL-NOV88 M.KAWAI, N.YAMAMURO
                       DIST-JUL91
HISTORY
88-10  EVALUATION WAS PERFORMED.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=2  RESONANCE PARAMETERS
 MT=151   SCATTERING RADIUS ONLY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT104
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF=3          NEUTRON CROSS SECTIONS
  MT=4,51-91 INELASTIC SCATTERING
        THE INELASTIC SCATTERING CROSS SECTIONS TO DISCRETE LEVELS
        WERE CALCULATED WITH THE STATISTICAL-MODEL CODE CASTHY/1/,
        CONSIDERING LEVEL FLUCTUATION, USING MODIFIED WALTER-GUSS
        POTENTIAL PARAMETERS FOR NEUTRONS.  THE COMPONENTS OF THE
        DIRECT PROCESS WERE ADDED TO THE LEVELS OF MT=53,54,56,57,
        58,60 BY USING THE DWUCK CODE /2/.  THE CROSS SECTION TO
        CONTINUUM WAS CALCULATE WITH THE THE GNASH CODE /3/
        CONSIDERING PRE-EQUILIBRIUM.

        THE LEVEL SCHEME IS GIVEN AS FOLLOWS:
          NO.    ENERGY(MEV) SPIN-PARITY
           G.S   0.0          9/2 +
           1.    0.0304       1/2 -
           2.    0.6860       3/2 -
           3.    0.7440       7/2 +
           4.    0.8087       5/2 +
           5.    0.8101       3/2 -
           6.    0.9499      13/2 +
           7.    0.9791      11/2 +
           8.    1.0826       9/2 +
           9.    1.2900       3/2 -
          10.    1.2974       9/2 +
          11.    1.3156       5/2 +
          12.    1.3351      17/2 +
        LEVELS ABOVE 1.34 MEV WERE ASSUMED TO BE OVERLAPPING.

        OPTICAL-MODEL PARAMETERS ARE AS FOLLOWS:
          V=52.56-0.30*EN,  WS=3.233+0.271*EN,  VSO=6.004-0.015*EN
          VSYM=-16.5      ,  WI=-0.963+0.153*EN, WSO=0.291-0.018*EN
          R0=1.229        ,  RS=1.282   , RI=1.42,  RSO=1.103
          A0=0.688        ,  B=0.512    , AI=0.509, ASO=0.56

        THE LEVEL DENSITY PARAMETERS FOR GNASH AND CASTHY
        CALCULATIONS ARE AS FOLLOWS:
                 A        EX       T       DS    GAMMA-G
```

	(1/MEV)	(MEV)	(MEV)	(EV)	(EV)
NB-94	14.4	4.059	0.719	30.0	0.052
NB-93	13.0	5.884	0.834	-	0.170
NB-92	11.5	3.254	0.790	-	0.170
NB-91	11.0	5.461	0.895	-	0.170
ZR-93	13.7	5.923	0.781	-	0.140
ZR-92	11.9	6.284	0.858	-	0.140
Y-90	11.1	1.441	0.721	1210.	0.130
Y-89	10.7	2.946	0.762	-	0.130

MT=22,28,103,104,107 (N,N'A),(N,N'P),(N,P) (N,D) AND (N,A) CROSS SECTIONS

CALCULATED WITH GNASH/3/. OPTICAL POTENTIAL PARAMETERS FOR PROTON, ALPHA-PARTICLE AND DEUTERON WERE TAKEN FROM THE WORKS OF PEREY/4/, LEMOS/5/, AND LOHR AND HAEVERLI /6/, RESPECTIVELY.

REFERENCES

1) IGARASI, S.: J. NUCL. SCI. TECHNOL., 12, 67 (1975).
2) KUNZ, P.D.: UNIV. COLORADO (1974).
3) YOUNG, P.G. AND ARTHUR, E.D.: LA-6947 (1977).
4) PEREY, F.G.: PHYS. REV. 131, 745 (1963).
5) LEMOS, O.F.: "DIFFUSION ELASTIQUE DE PARTICULES ALPHA DE 21 A 29.6 MEV SUR DES NOYAUX DE LA REGION TI-ZN", ORSAY REPORT, SERIES A., NO. 136, (1972).
6) LOHR, J.N. AND HAEBERLI, W.: NUCL. PHYS. A232, 381 (1974).

3.23 Natural Mo

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 42-MO-  0 JNDC        EVAL-MAR89 JNDC FPND W.G.
                       DIST-JUL91
HISTORY
89-03  DATA WERE COMPILED FROM ISOTOPE DATA EVALUATED BY JNDC FPND
       W.G.
91-07  GAS-PRODUCTION DATA FILE WAS CREATED FROM JENDL-3
         BY T.NARITA AND T.NAKAGAWA

MF=1  GENERAL INFORMATION
 MT=451   DESCRIPTIVE DATA AND DICTIONARY

MF=3  NEUTRON CROSS  SECTIONS
 MT=203  HYDROGEN PRODUCTION CROSS SECTION
          = MT028 + MT103 + MT111*2
 MT=204  DEUTERIUM PRODUCTION CROSS SECTION
          = MT032 + MT104
 MT=205  TRITIUM PRODUCTION CROSS SECTION
          = MT105
 MT=206  HE-3 PRODUCTION CROSS SECTION
          = MT106
 MT=207  HE-4 PRODUCTION CROSS SECTION
          = MT022 + MT107

****  ORIGINAL DESCRIPTIVE DATA IN JENDL-3  **********************

MF = 3  NEUTRON CROSS SECTIONS
  THE THRESHOLD REACTION CROSS SECTIONS WERE CALCULATED WITH
  PEGASUS/1/ STANDING ON A PREEQUILIBRIUM AND MULTI-STEP
  EVAPORATION MODEL.  THE OMP'S FOR NEUTRON GIVEN IN TABLE 1 WERE
  DETERMINED BY IIJIMA ET AL./2/ TO REPRODUCE A SYSTEMATIC TREND
  OF THE TOTAL CROSS SECTION.  THE OMP'S FOR CHARGED PARTICLES ARE
  AS FOLLOWS:
     PROTON   = PEREY/3/
     ALPHA    = HUIZENGA AND IGO/4/
     DEUTERON = LOHR AND HAEBERLI/5/
     HELIUM-3 AND TRITON = BECCHETTI AND GREENLEES/6/
  PARAMETERS FOR THE COMPOSITE LEVEL DENSITY FORMULA OF GILBERT
  AND CAMERON/7/ WERE EVALUATED BY IIJIMA ET AL./8/.  MORE
  EXTENSIVE DETERMINATION AND MODIFICATION WERE MADE IN THE
  PRESENT WORK.  TABLE 2 SHOWS THE LEVEL DENSITY PARAMETERS USED
  IN THE PRESENT CALCULATION.  THE ENERGY DEPENDENCE OF SPIN
  CUT-OFF PARAMETER IN THE ENERGY RANGE BELOW E-JOINT (EX) IS DUE
  TO GRUPPELAAR/9/.

  MT = 22,28,32,103,104,105,106,107,111
       (N,N'A), (N,N'P), (N,N'D), (N,P), (N,D), (N,T), (N,HE3),
       (N,ALPHA) AND (N,2P) CROSS SECTIONS
    THESE REACTION CROSS SECTIONS WERE CALCULATED WITH PEGASUS
    /1/.  THE KALBACH'S CONSTANTS WERE  ESTIMATED BY THE FORMULA
    DERIVED FROM KIKUCHI-KAWAI'S FORMALISM/10/ AND LEVEL DENSITY
    PARAMETERS.  THE (N,P) AND (N,ALPHA) CROSS SECTIONS WERE
    NORMALIZED TO THE EXPERIMENTAL DATA OR SYSTEMATICS AT 14.5 MEV
    AS FOLLOWS.
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ISOTOPE	(N,P)	(N,ALPHA)
MO- 92	116 MB/11/	24 MB/12/
MO- 93	55.1 MB/11/	17.5 MB/11/
MO- 94	38 MB/11/	13.5 MB/11/

MO- 95	23 MB/12/	10 MB/11/
MO- 97	17 MB/12/	7.5 MB/11/
MO- 98	5.8 MB/12/	5.7 MB/12/
MO-100	2.5 MB/11/	2.8 MB/12/

TABLE 1 NEUTRON OPTICAL POTENTIAL PARAMETERS

DEPTH (MEV)	RADIUS(FM)	DIFFUSENESS(FM)
V = 46.0-0.25E	R0 = 5.893	A0 = 0.62
WS = 7.0	RS = 6.393	AS = 0.35
WSO= 7.0	RSO= 5.893	ASO= 0.62

TABLE 2 LEVEL DENSITY PARAMETERS

NUCL.	SYST	A(/MEV)	T(MEV)	C(/MEV)	FX(MEV)	PAIRING
40-ZR- 88	*	1.404E+01	7.386E-01	4.932E-01	7.870E+00	2.660E+00
40-ZR- 89		1.095E+01	8.260E-01	1.379E+00	5.864E+00	1.200E+00
40-ZR- 90		9.152E+00	8.222E-01	1.526E-01	5.383E+00	2.130E+00
40-ZR- 91		1.036E+01	8.000E-01	7.822E-01	5.057E+00	1.200E+00
40-ZR- 92		1.088E+01	8.192E-01	5.122E-01	6.429E+00	1.920E+00
40-ZR- 93		1.298E+01	7.000E-01	1.273E+00	5.183E+00	1.200E+00
40-ZR- 94		1.275E+01	7.530E-01	4.411E-01	7.019E+00	2.320E+00
40-ZR- 95		1.331E+01	6.070E-01	5.453E-01	3.985E+00	1.200E+00
40-ZR- 96		1.320E+01	7.000E-01	2.235E-01	6.589E+00	2.490E+00
40-ZR- 97		1.259E+01	5.590E-01	2.497E-01	3.084E+00	1.200E+00
40-ZR- 98	*	1.725E+01	6.633E-01	1.790E+00	7.555E+00	2.140E+00
40-ZR- 99	*	1.831E+01	6.566E-01	1.170E+01	6.957E+00	1.200E+00
41-NB- 89	*	1.420E+01	7.303E-01	2.467E+00	6.611E+00	1.460E+00
41-NB- 90	*	1.395E+01	7.222E-01	1.458E+01	4.869E+00	0.0
41-NB- 91	*	9.464E+00	7.143E-01	3.924E-01	3.082E+00	9.300E-01
41-NB- 92		1.040E+01	8.410E-01	4.607E+00	4.477E+00	0.0
41-NB- 93		1.250E+01	7.120E-01	2.205E+00	4.629E+00	7.200E-01
41-NB- 94		1.281E+01	7.230E-01	7.763E+00	4.250E+00	0.0
41-NB- 95		1.277E+01	7.500E-01	2.121E+00	5.782E+00	1.120E+00
41-NB- 96		1.331E+01	5.880E-01	3.406E+00	2.530E+00	0.0
41-NB- 97		1.337E+01	6.710E-01	9.771E-01	5.026E+00	1.290E+00
41-NB- 98		1.380E+01	5.110E-01	2.350E+00	1.731E+00	0.0
41-NB- 99	*	1.742E+01	6.566E-01	1.085E+01	6.300E+00	9.400E-01
41-NB-100	*	1.850E+01	6.500E-01	7.329E+01	5.699E+00	0.0
42-MO- 90	*	1.436E+01	7.222E-01	4.129E-01	7.834E+00	2.740E+00
42-MO- 91		1.168E+01	7.820E-01	1.284E+00	5.770E+00	1.280E+00
42-MO- 92		1.064E+01	7.770E-01	2.062E-01	5.938E+00	2.210E+00
42-MO- 93		1.125E+01	7.800E-01	9.792E-01	5.457E+00	1.280E+00
42-MO- 94		1.301E+01	6.850E-01	3.417E-01	5.770E+00	2.000E+00
42-MO- 95		1.360E+01	7.150E-01	1.847E+00	5.835E+00	1.280E+00
42-MO- 96		1.403E+01	7.410E-01	6.991E-01	7.645E+00	2.400E+00
42-MO- 97		1.517E+01	6.800E-01	2.769E+00	6.036E+00	1.280E+00
42-MO- 98		1.594E+01	6.900E-01	7.358E-01	7.888E+00	2.570E+00
42-MO- 99		1.774E+01	6.200E-01	4.294E+00	6.058E+00	1.280E+00
42-MO-100		1.780E+01	6.000E-01	6.702E-01	6.645E+00	2.220E+00
42-MO-101		2.085E+01	5.650E-01	7.153E+00	6.092E+00	1.280E+00

SYST: * = LDP'S WERE DETERMINED FROM SYSTEMATICS.
SPIN CUT-OFF PARAMS WERE CALCULATED AS 0.146*SQRT(A)*A**(2/3).

REFERENCES

1) IIJIMA, S. ET AL.: JAERI-M 87-025, P. 337 (1987).
2) IIJIMA, S. AND KAWAI, M.: J. NUCL. SCI. TECHNOL. 20, 77(1983).
3) PEREY, F.G: PHYS. REV. 131, 745 (1963).
4) HUIZENGA, J.R. AND IGO, G.: NUCL. PHYS. 29, 462 (1962).
5) LOHR, J.M. AND HAEBERLI, W.: NUCL. PHYS. A232, 381 (1974).
6) BECCHETTI, F.D., JR. AND GREENLEES, G.W.: POLARIZATION PHENOMENA IN NUCLEAR REACTIONS, P. 682, THE UNIVERSITY OF WISCONSIN PRESS. (1971).
7) GILBERT, A. AND CAMERON, A.G.W.: CAN. J. PHYS., 43,1446(1965).
8) IIJIMA, S., ET AL.: J. NUCL. SCI. TECHNOL. 21, 10 (1984).
9) GRUPPELAAR, H.: ECN-13 (1977).
10) KIKUCHI, K. AND KAWAI, M.: "NUCLEAR MATTER AND NUCLEAR REACTIONS", NORTH HOLLAND (1968).
11) FORREST, R.A.: AERE-R 12419 (1986).
12) IKEDA, Y. ET AL.: JAERI 1312 (1987).

References

1) Shibata K., Nakagawa T., Asami T., Fukahori T., Narita T., Chiba S., Mizumoto M., Hasegawa A., Kikuchi Y., Nakajima Y., and Igarasi S.: "Japanese Evaluated Nuclear Data Library, Version-3, -- JENDL-3 --", JAERI 1319 (1990).

2) Kawai M., Iijima S., Nakagawa T., Nakajima Y., Sugi T., Watanabe T., Matsunobu H., Sasaki M., and Zukeran A.: J. Nucl. Sci. Technol., **29**, 195 (1992).

3) Iijima S., Nakazawa M., Kawai M., Katakura J., Asami T., and Nakagawa T.: private communication (1986).

4) Nakagawa T.: Proc. of the 1990 Symposium on Nuclear Data, JAERI-M 91-032, p. 32 (1991).

5) Revised by Kinsey R.: "ENDF-102, Data Formats and Procedures for the Evaluated Nuclear Data File, ENDF", BNL-NCS-50496 (ENDF-102), 2 nd edition (1979).

Table 1 Data in the JENDL-gas-production cross section file

Material	MAT number	reactions
Li- 6	341	p, d, t, ^{4}He production
Li- 7	342	d, t, ^{4}He production
Be- 9	441	p, d, t, ^{4}He production
B - 10	541	p, d, t, ^{4}He production
B - 11	542	p, d, t, ^{4}He production
C - 12	641	p, d, ^{4}He production
N -nat	740	p, d, t, ^{4}He production
F - 19	941	p, d, t, ^{4}He production
Al- 27	1341	p, ^{4}He production
Si-nat	1440	p, ^{4}He production
Ti-nat	2240	p, ^{4}He production
V - 51	2341	p, d, t, ^{4}He production
Cr-nat	2440	p, ^{4}He production
Mn- 55	2541	p, d, t, ^{3}He, ^{4}He production
Fe-nat	2640	p, ^{4}He production
Co- 59	2741	p, d, ^{4}He production
Ni-nat	2840	p, d, t, 3He, ^{4}He production
Cu-nat	2940	p, d, ^{4}He production
As-75	3341	p, d, t, ^{3}He, ^{4}He production
Se-nat	3440	p, d, t, ^{3}He, ^{4}He production
Zr-nat	4040	p, d, t, ^{3}He, ^{4}He production
Nb- 93	4141	p, d, ^{4}He production
Mo-nat	4240	p, d, t, ^{3}He, ^{4}He production

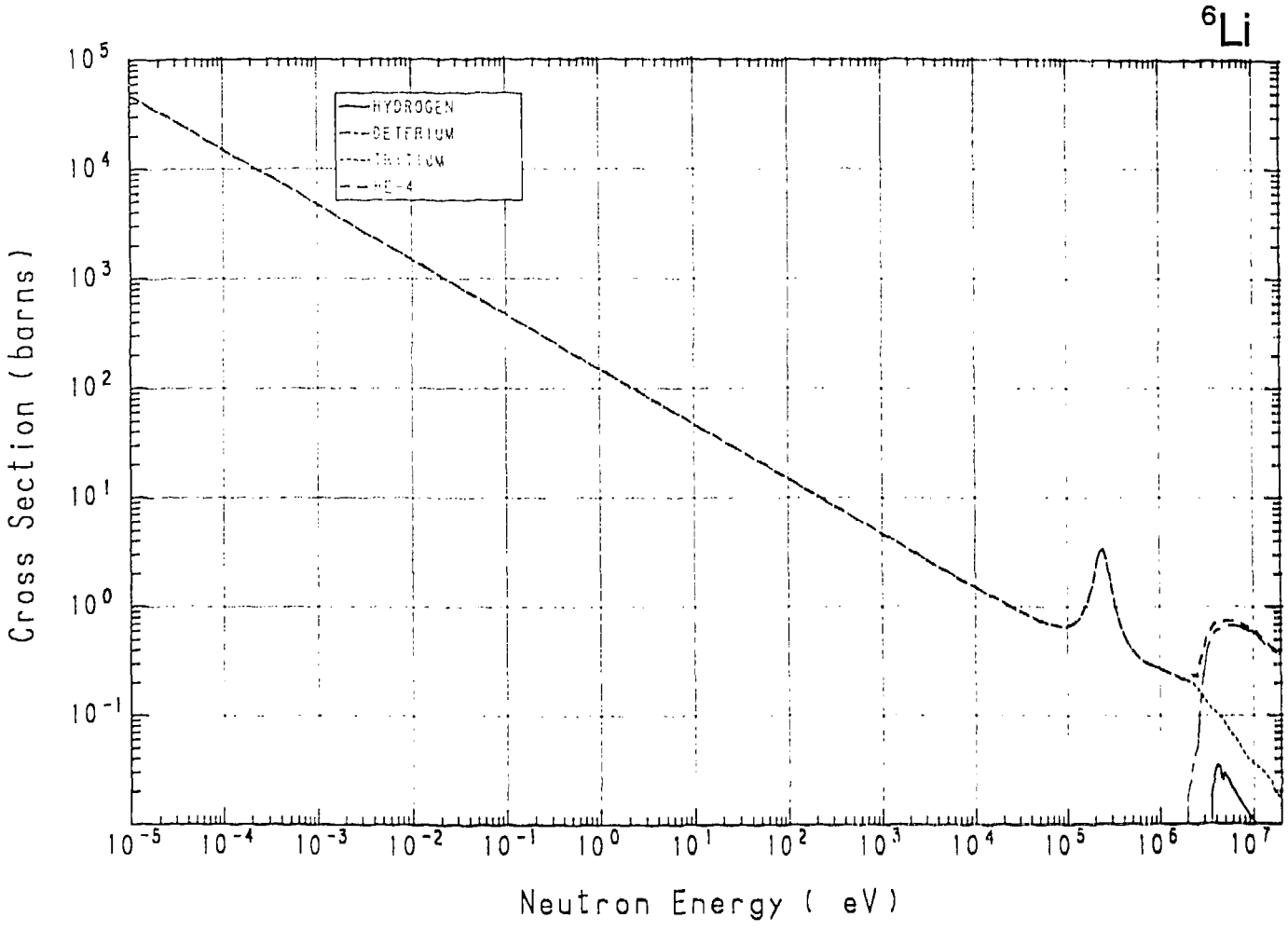

Fig. 1(a) Gas-production cross sections of ^6Li
The ^4He production cross section is equal to the ^3H production cross section below 1.75 MeV.

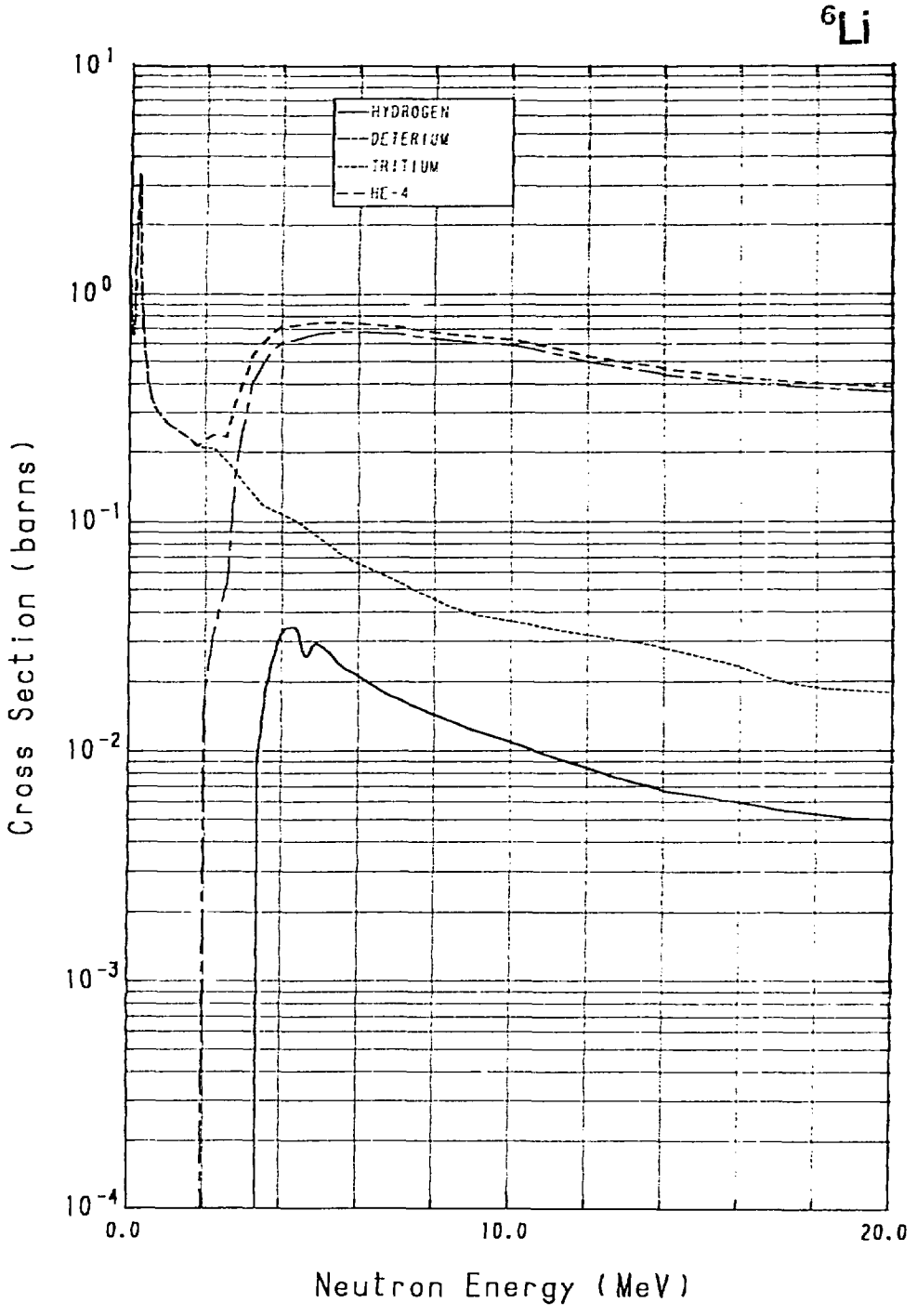

Fig. 1(b) Gas-production cross sections of ^{6}Li

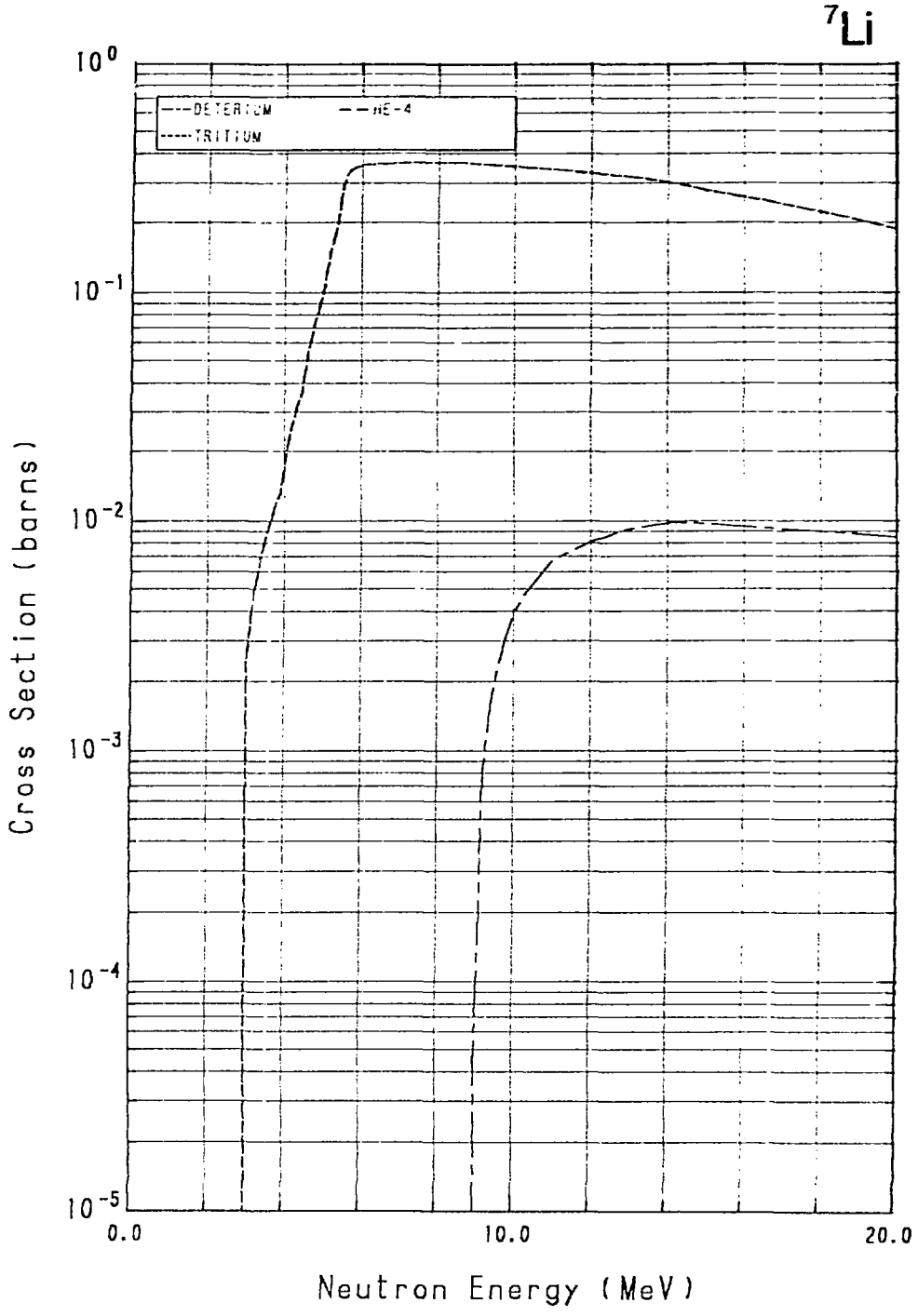

Fig. 2 Gas-production cross sections of ^{6}Li
The ^{4}He production cross section is equal to the ^{3}H production cross section.

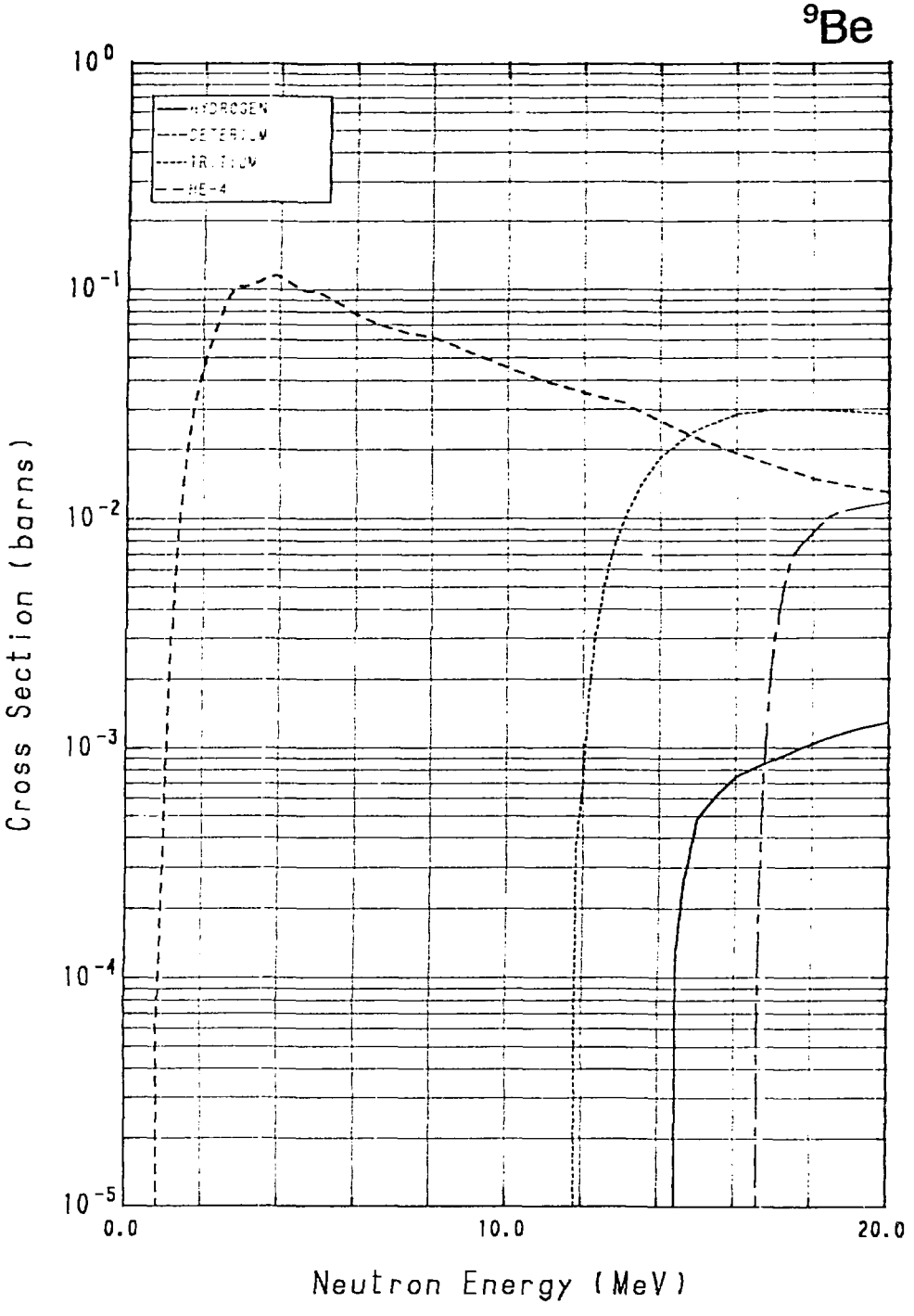

Fig. 3 Gas-production cross sections of ^{9}Be

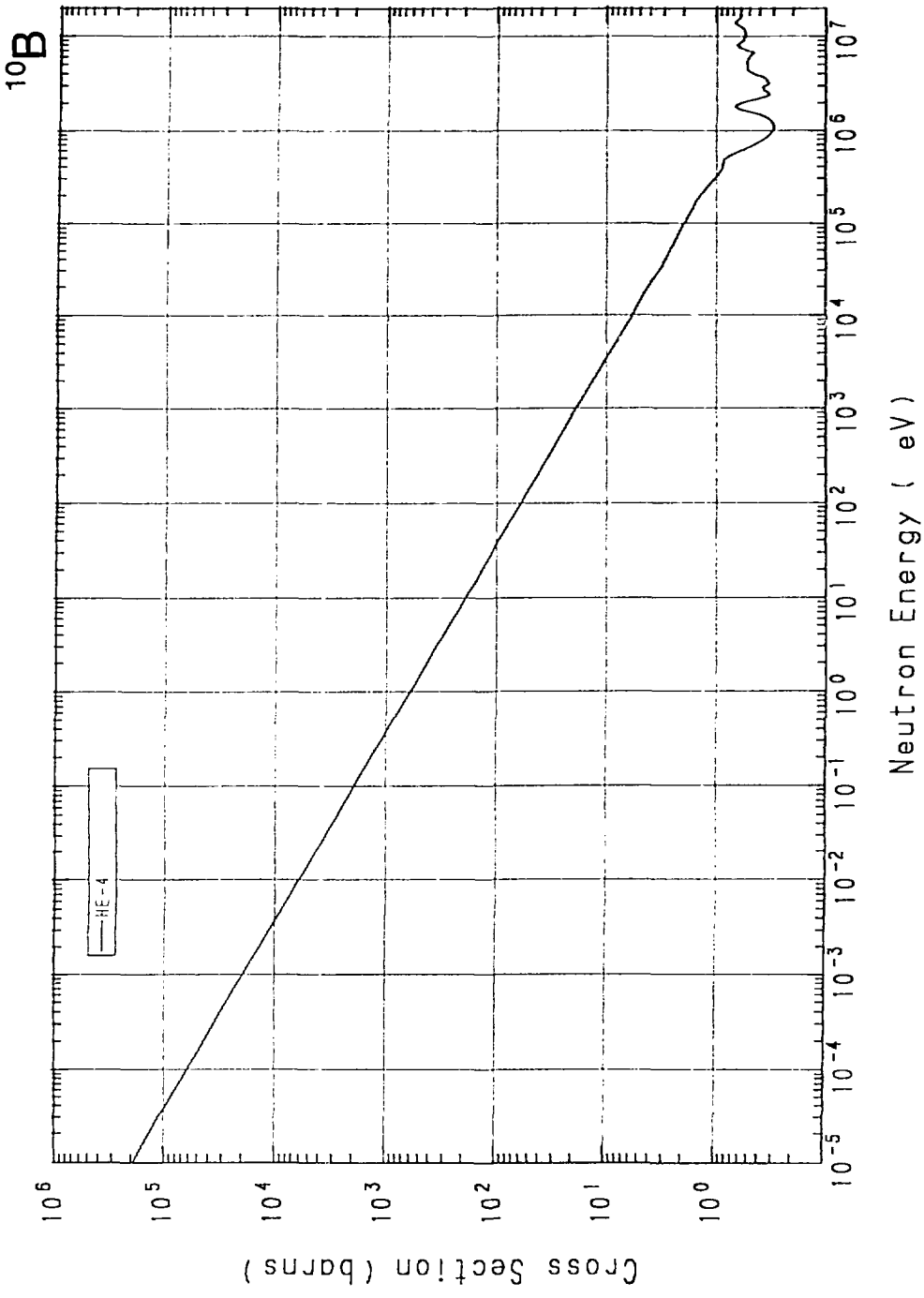

Fig. 4(a) ^{4}He-production cross sections of ^{10}B

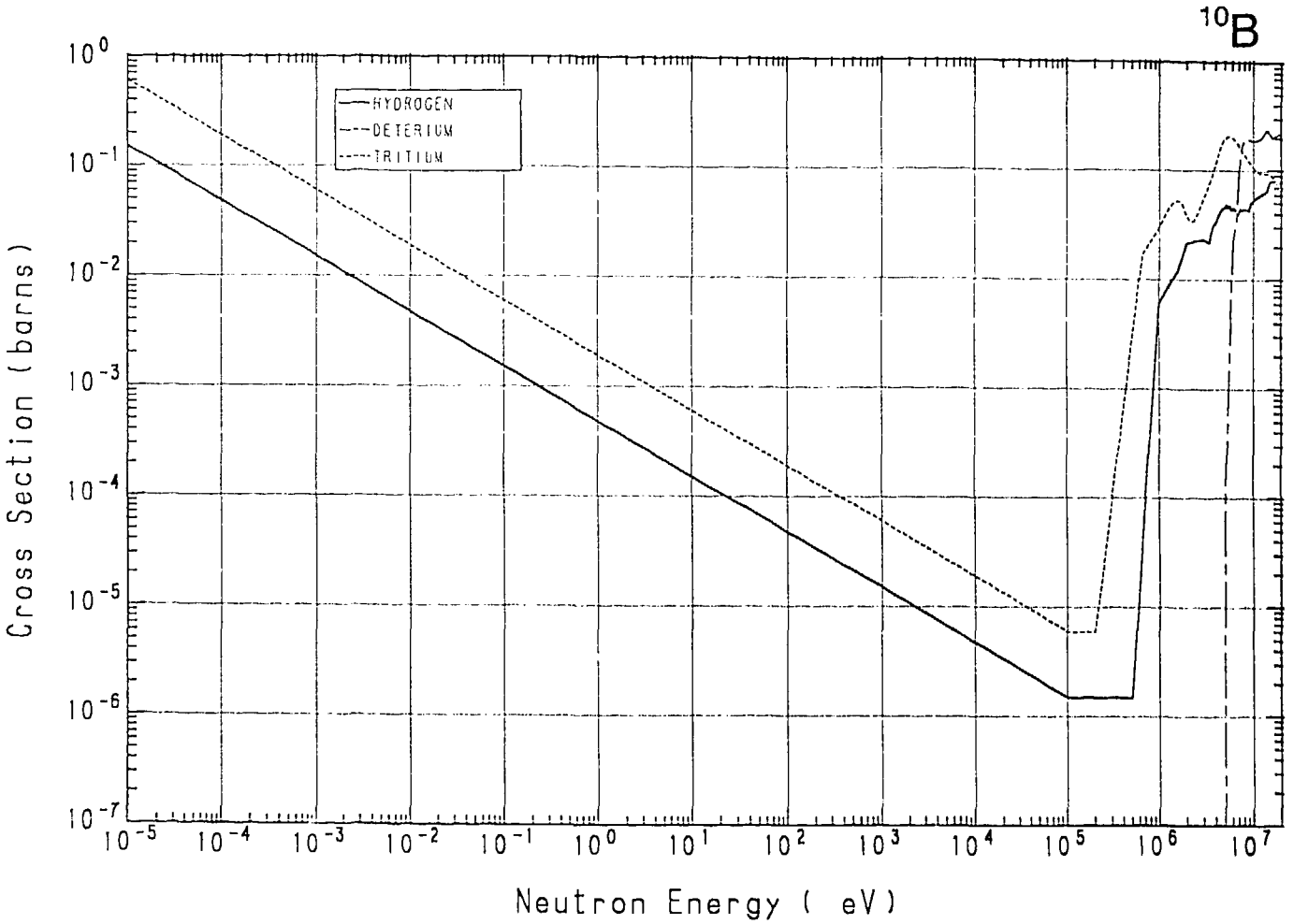

Fig. 4(b) Gas-production cross sections of ^{10}B

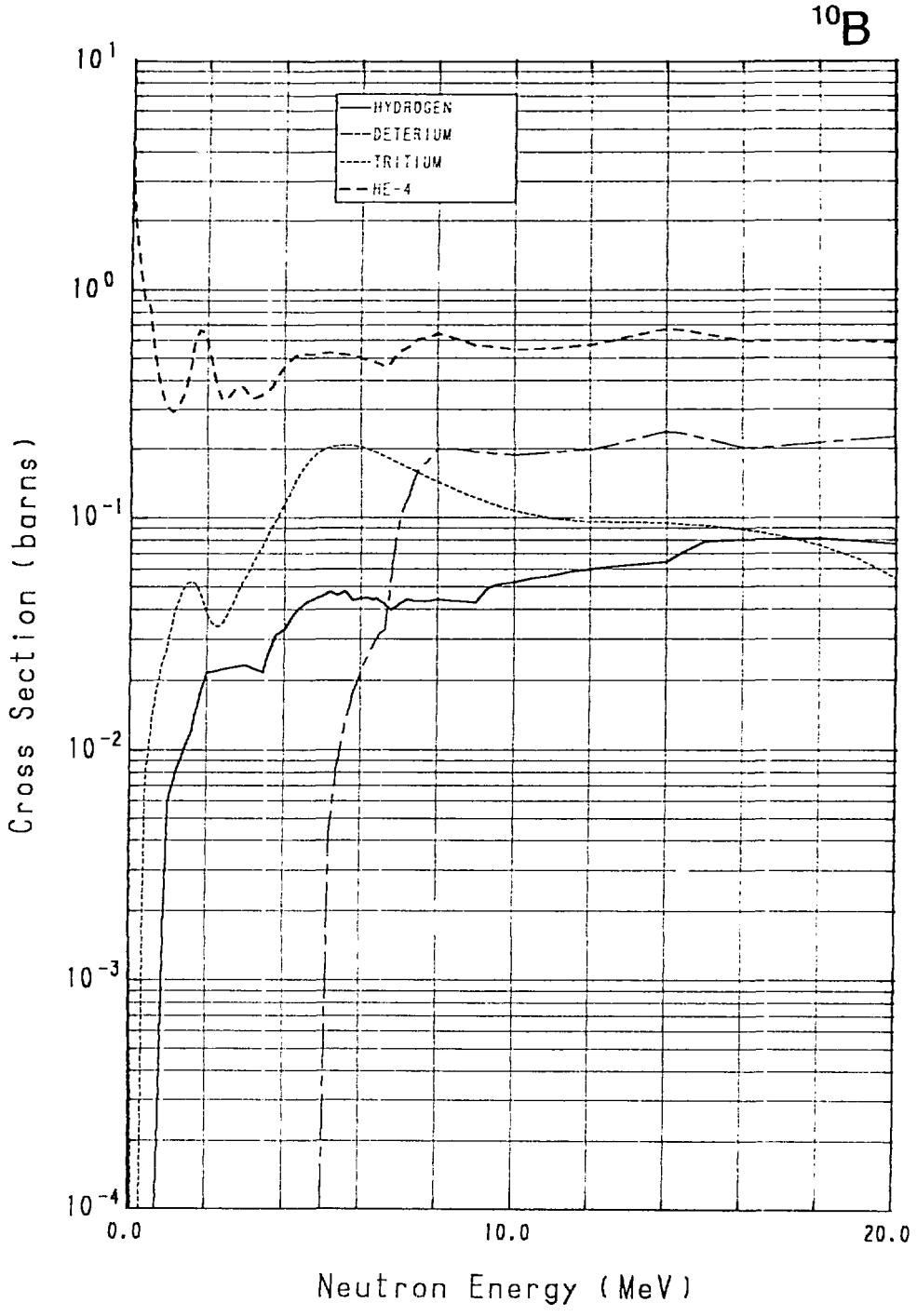

Fig. 4(c) Gas-production cross sections of ^{10}B

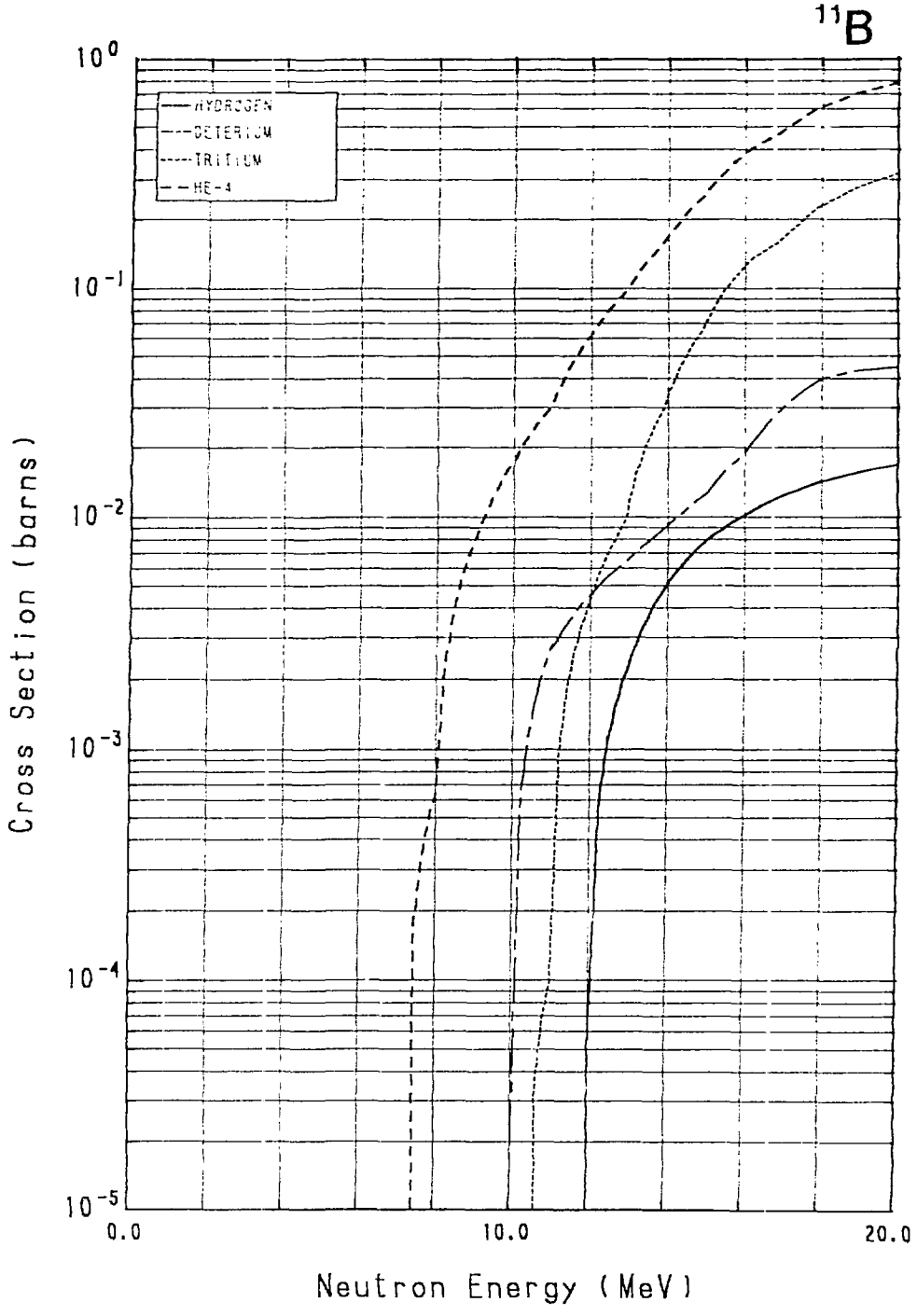

Fig. 5 Gas-production cross sections of ^{11}B

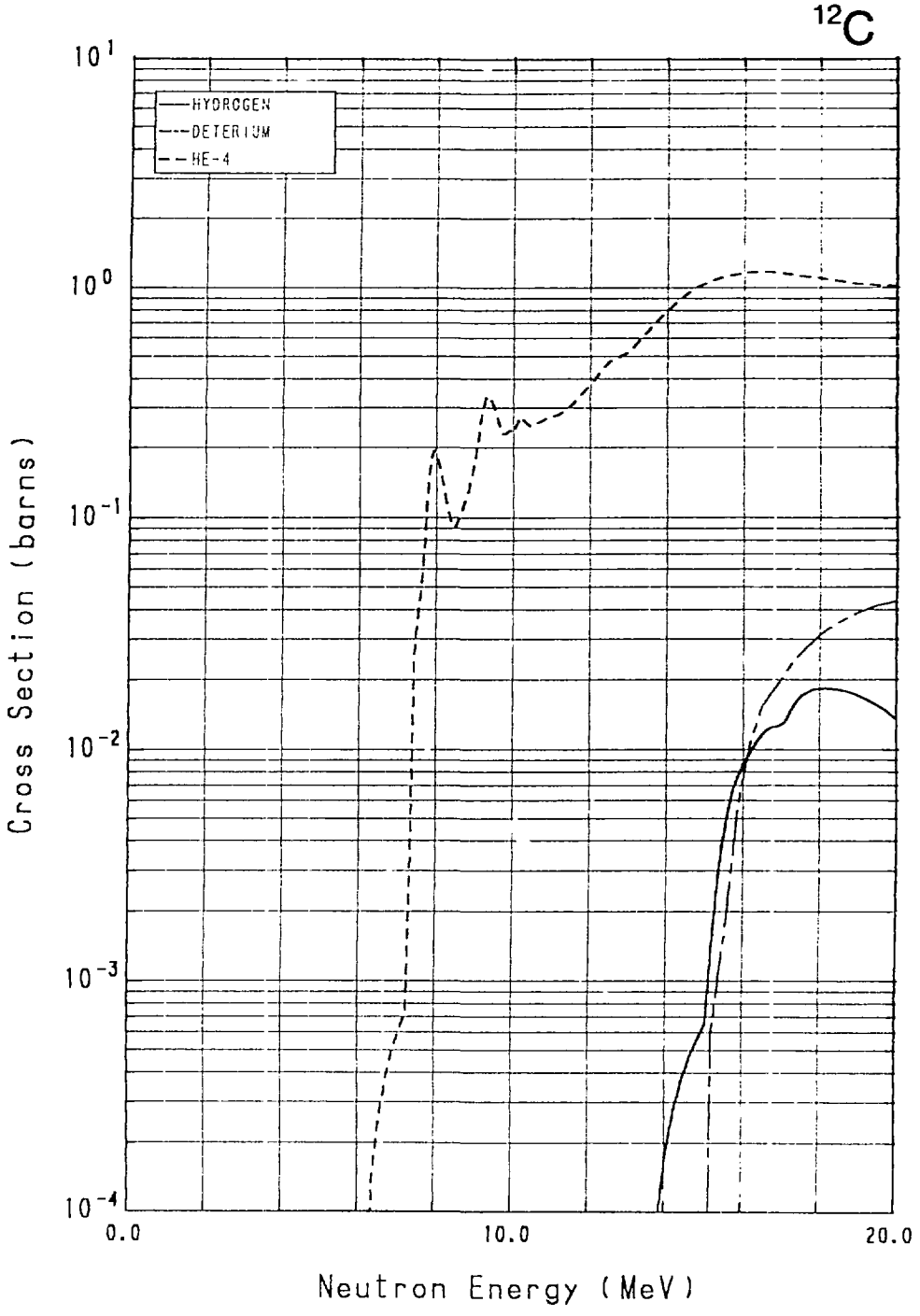

Fig. 6 Gas-production cross sections of ^{12}C

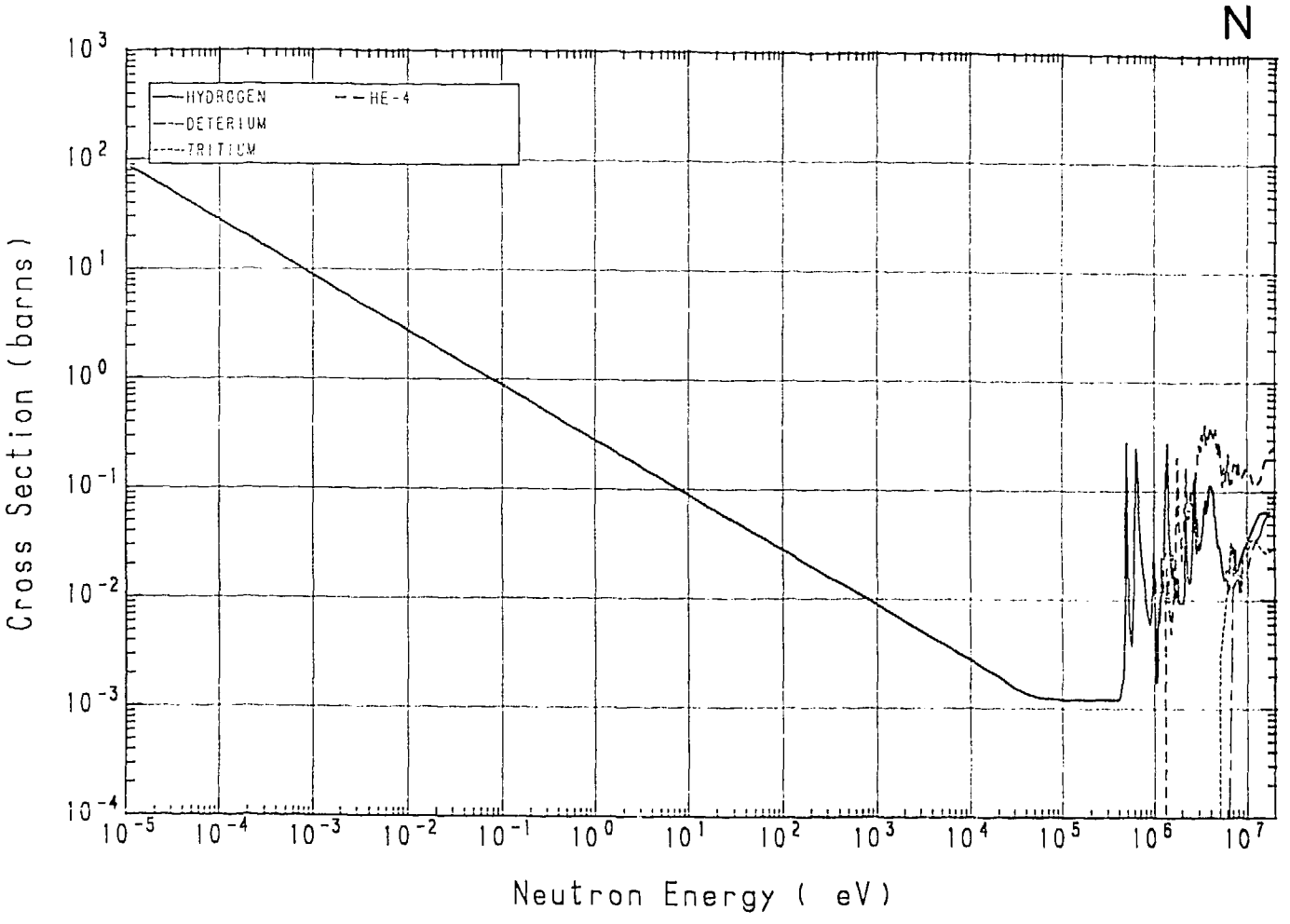

Fig. 7(a) Gas-production cross sections of N

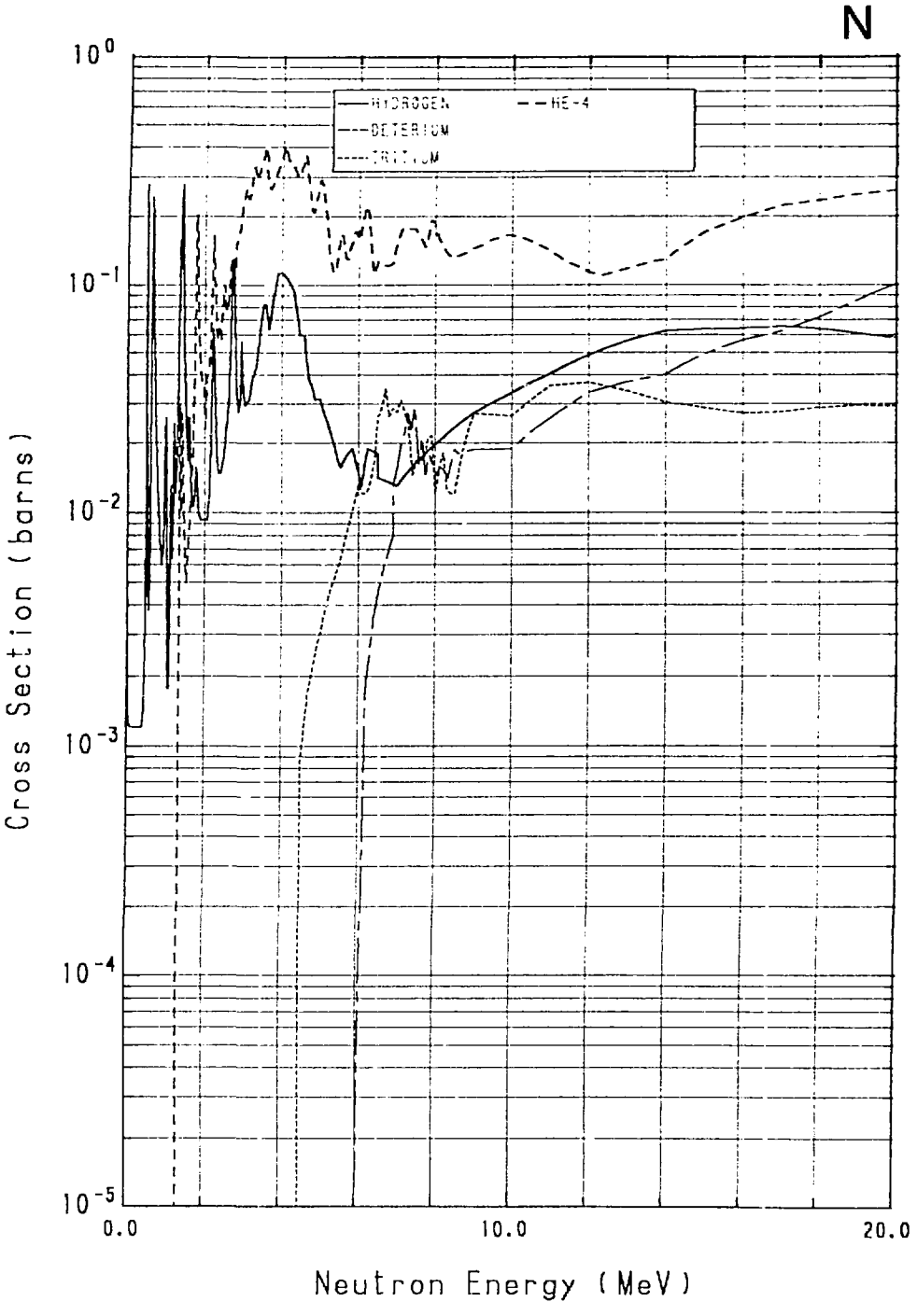

Fig. 7(b) Gas-production cross sections of N

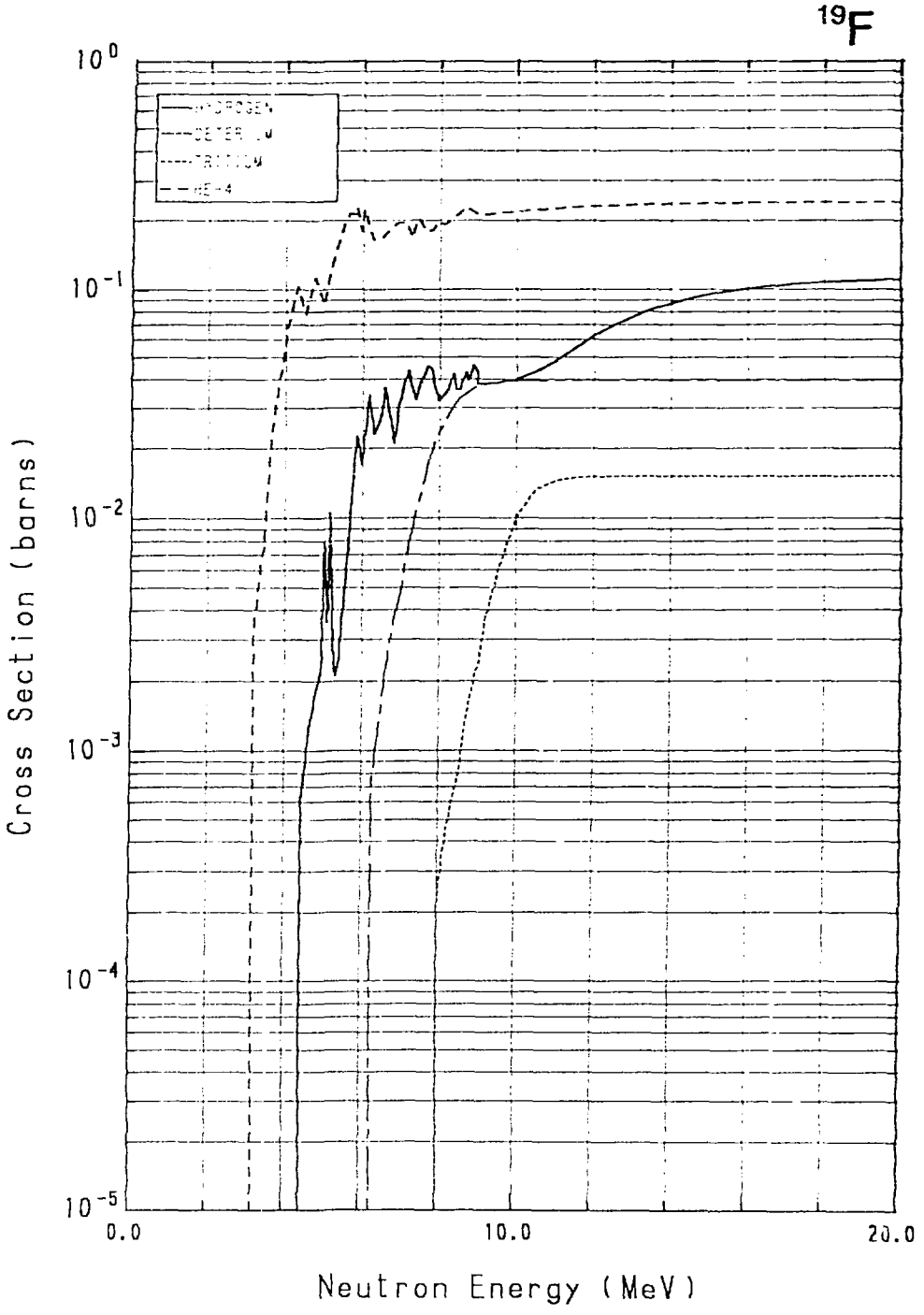

Fig. 8 Gas-production cross sections of ^{19}F

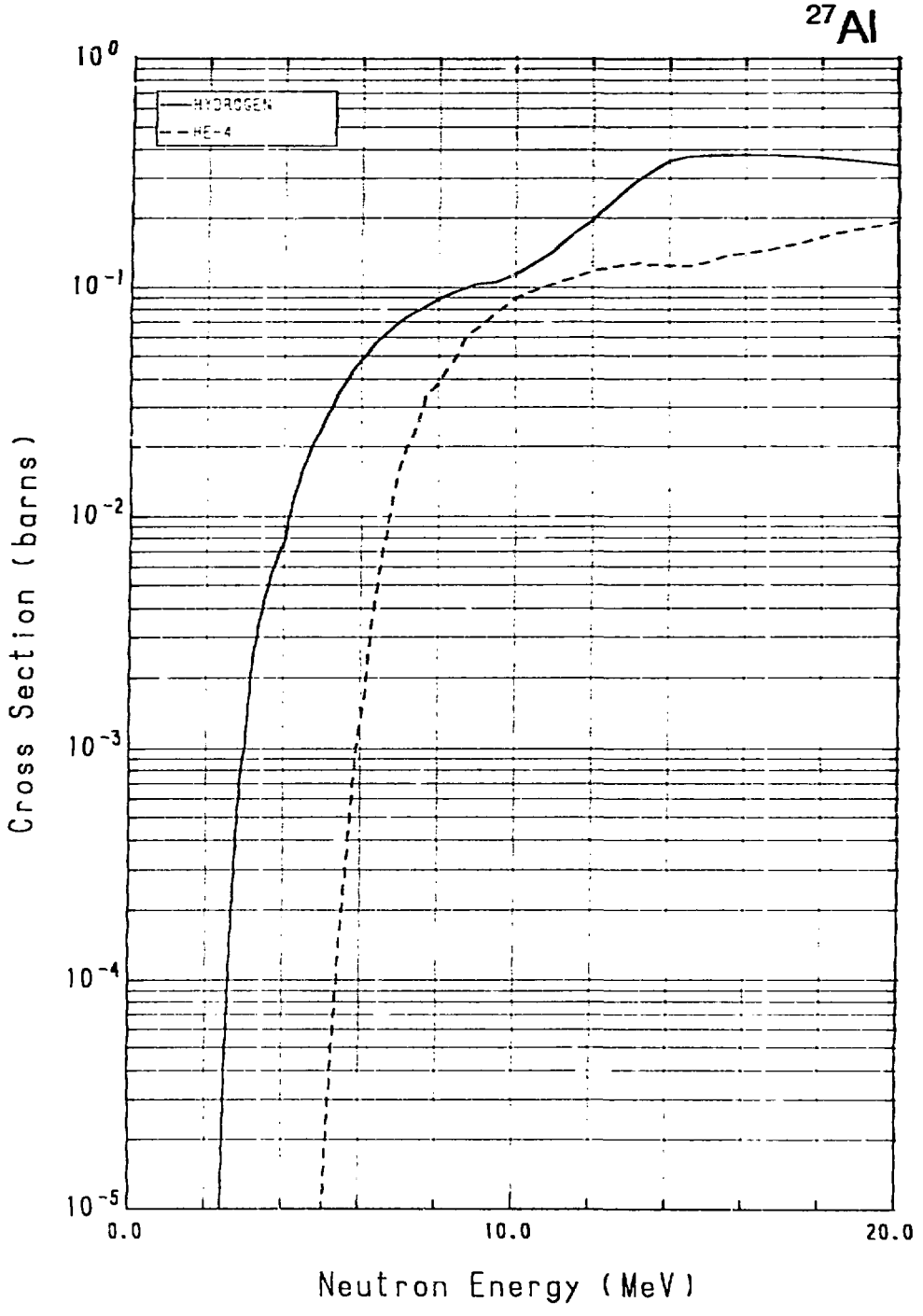

Fig. 9 Gas-production cross sections of ^{27}Al

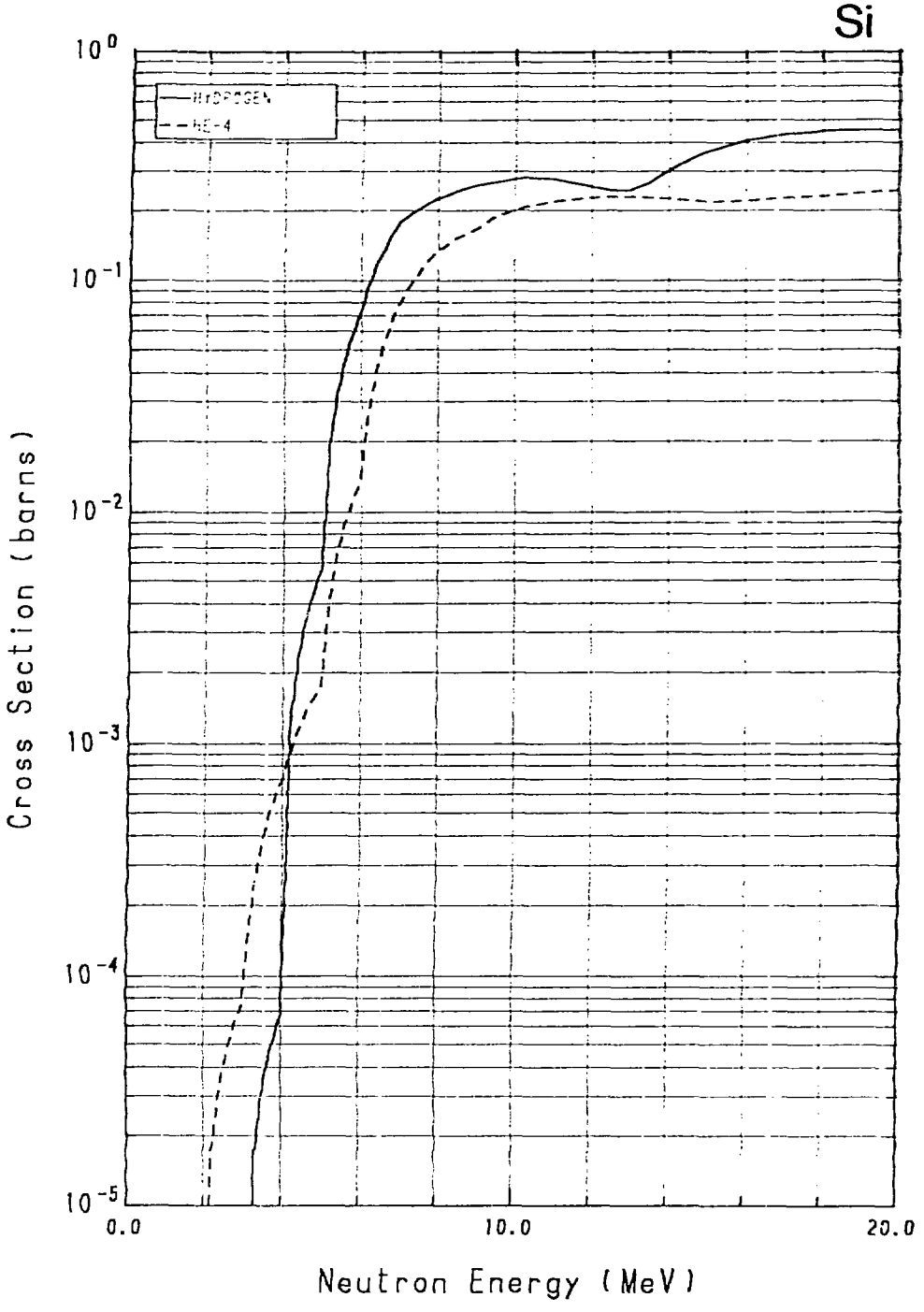

Fig. 10 Gas-production cross sections of Si

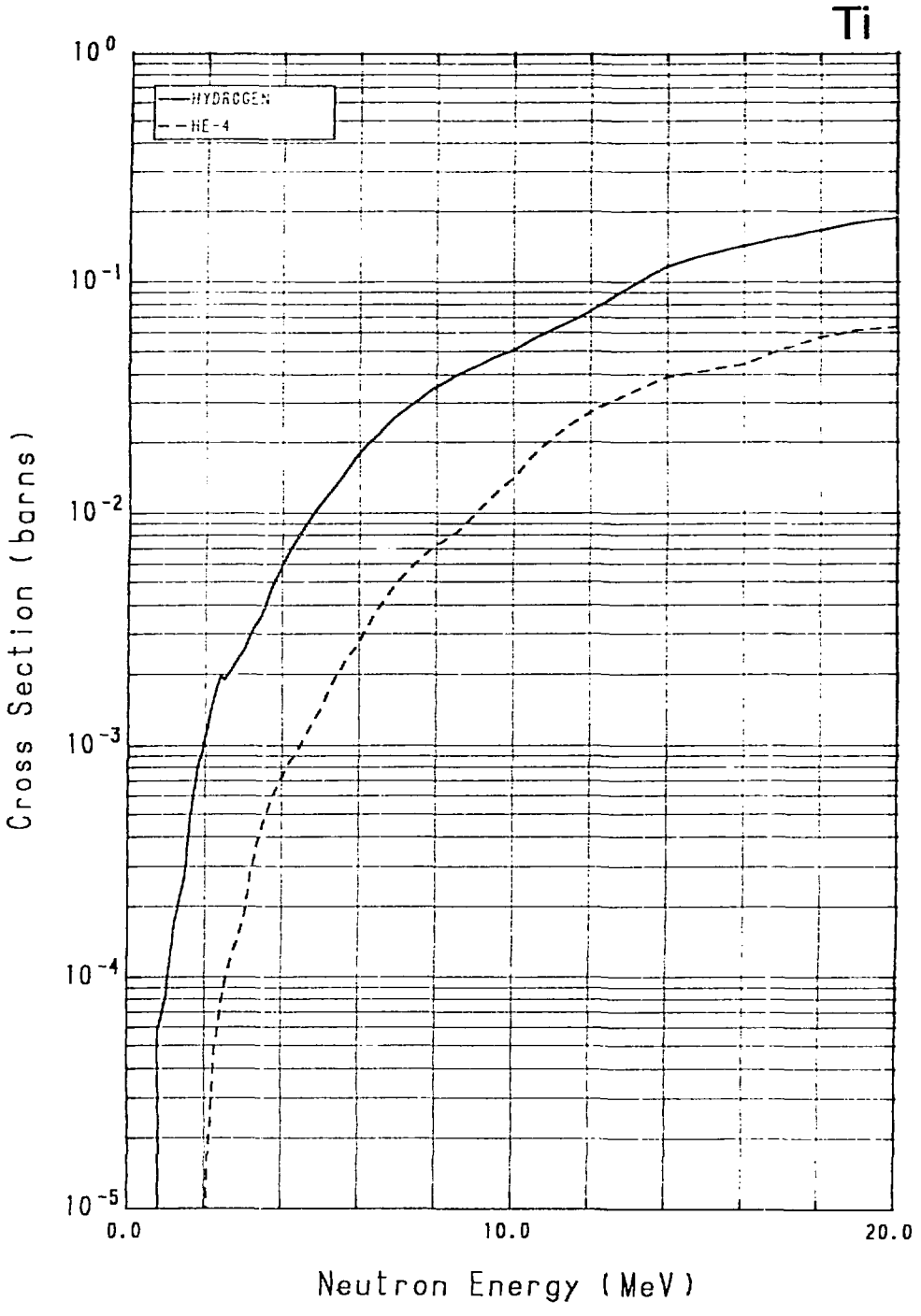

Fig. 11 Gas-production cross sections of Ti

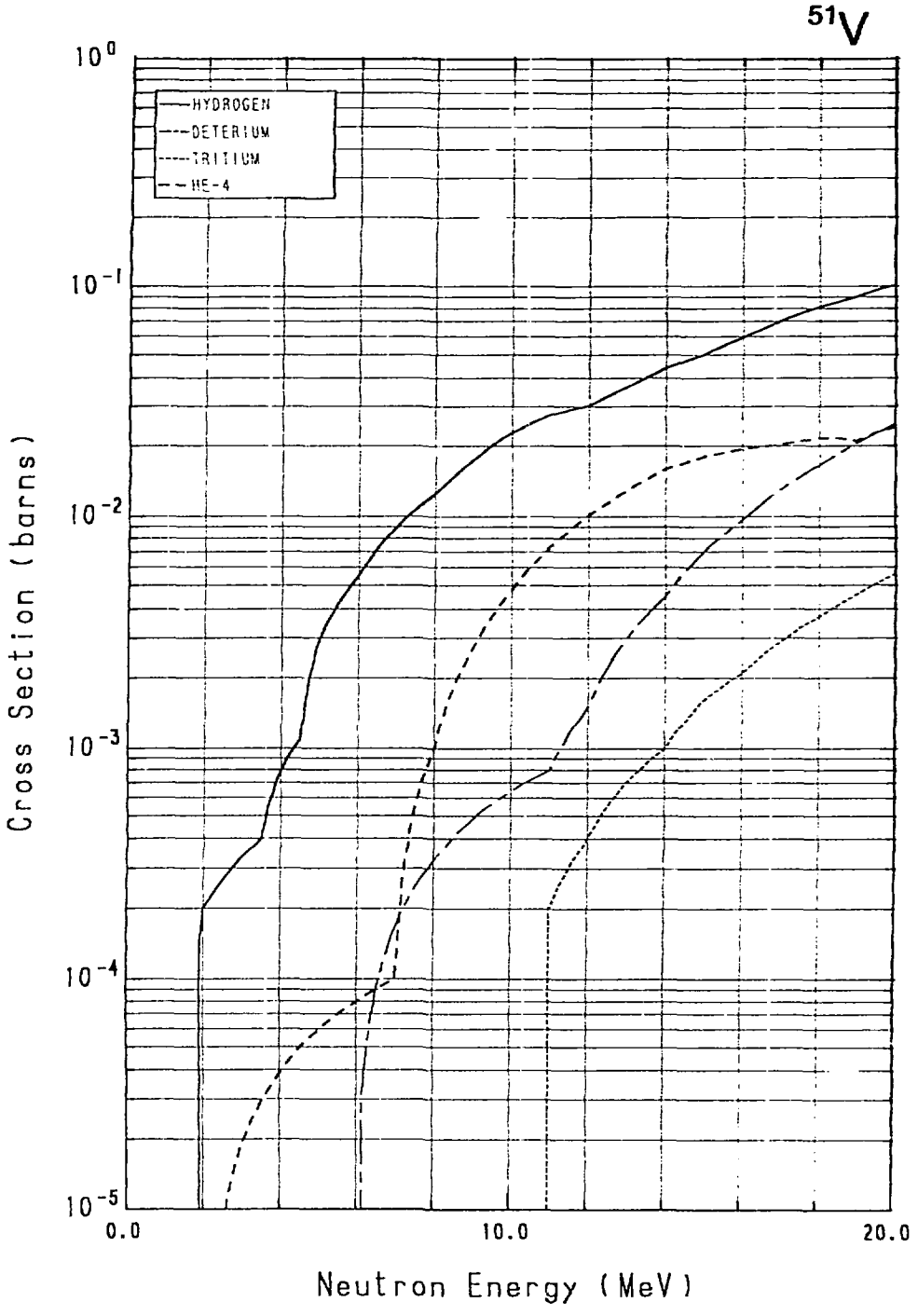

Fig. 12 Gas-production cross sections of ^{51}V

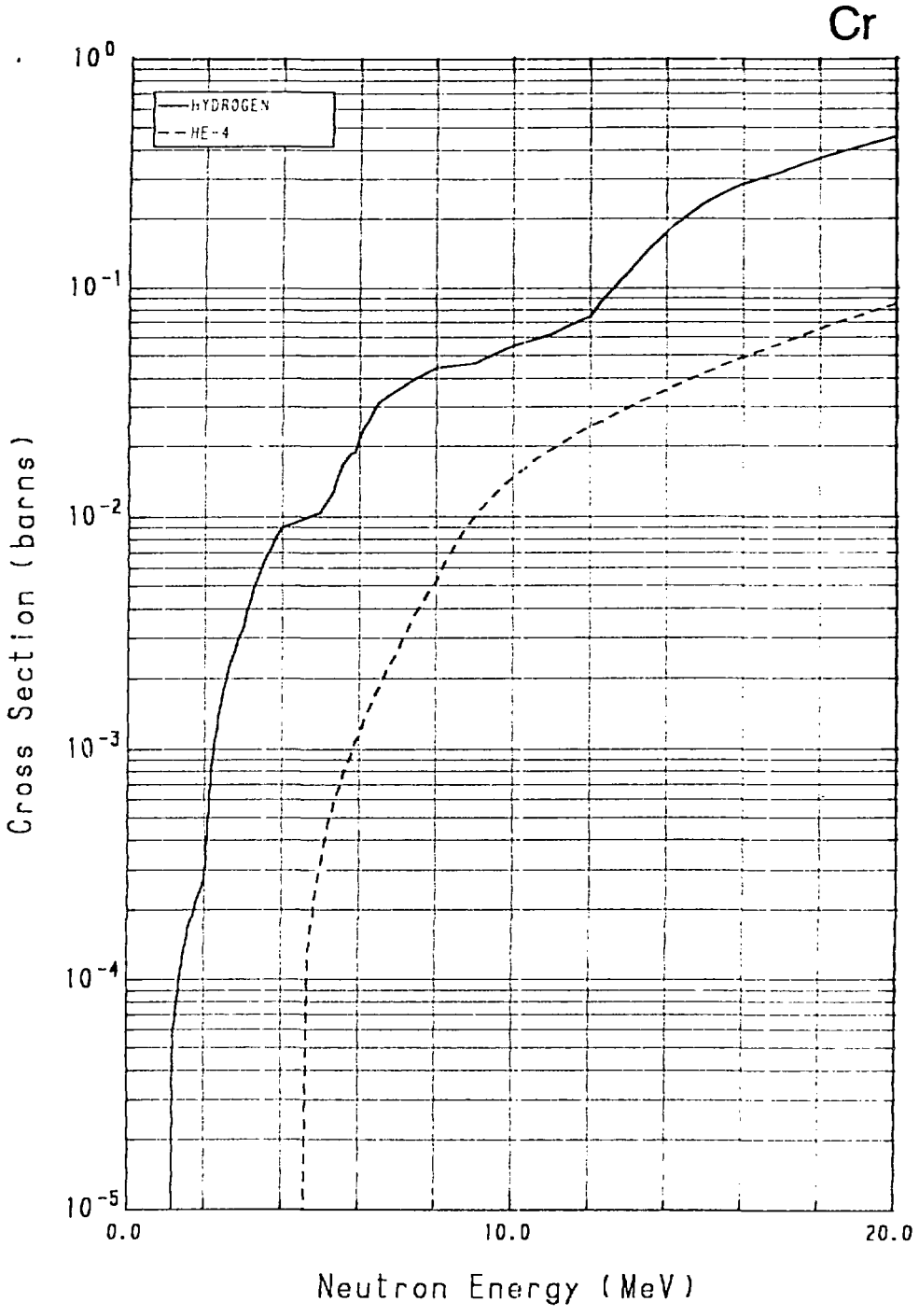

Fig. 13 Gas-production cross sections of Cr

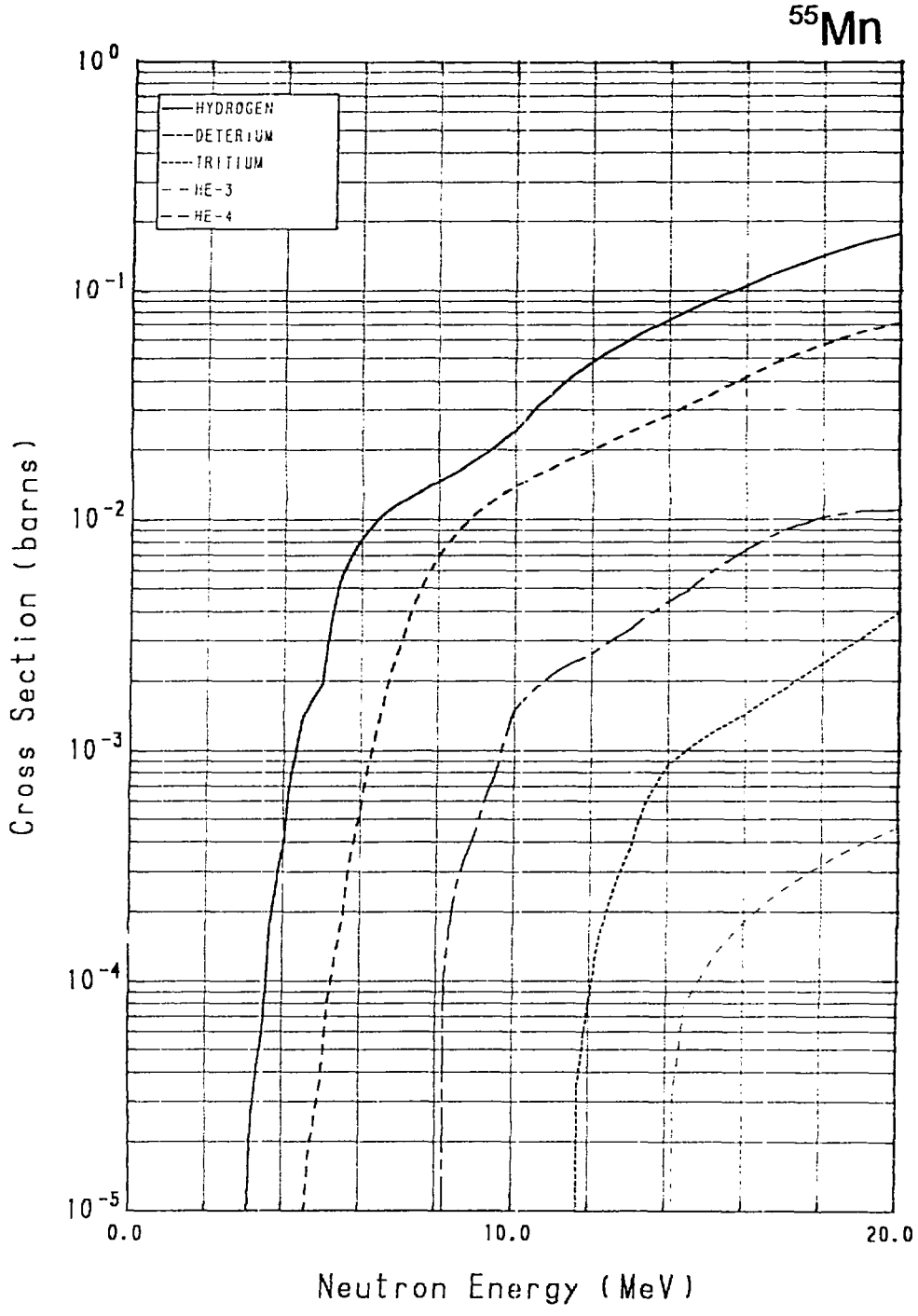

Fig. 14 Gas-production cross sections of ^{55}Mn

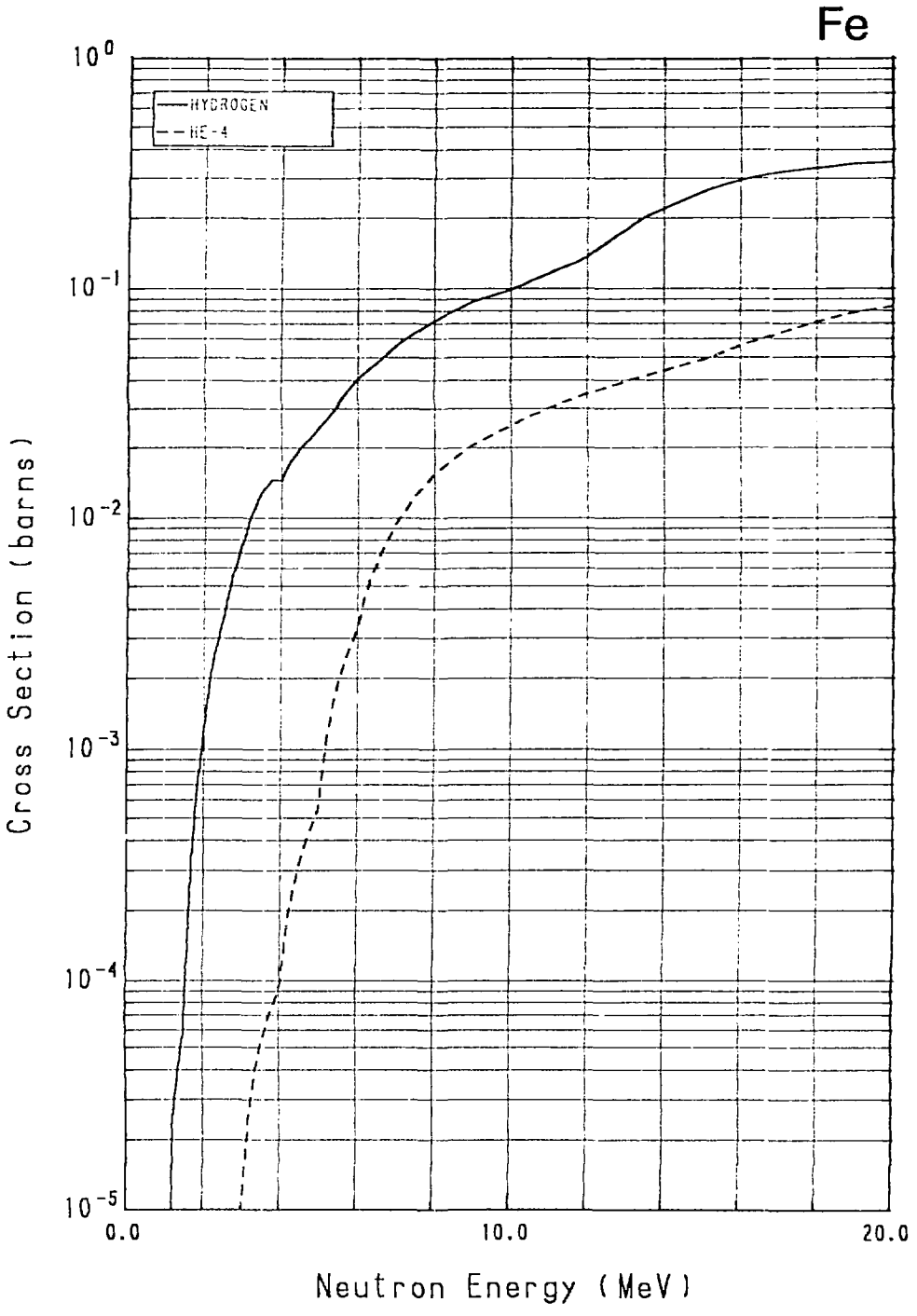

Fig. 15 Gas-production cross sections of Fe

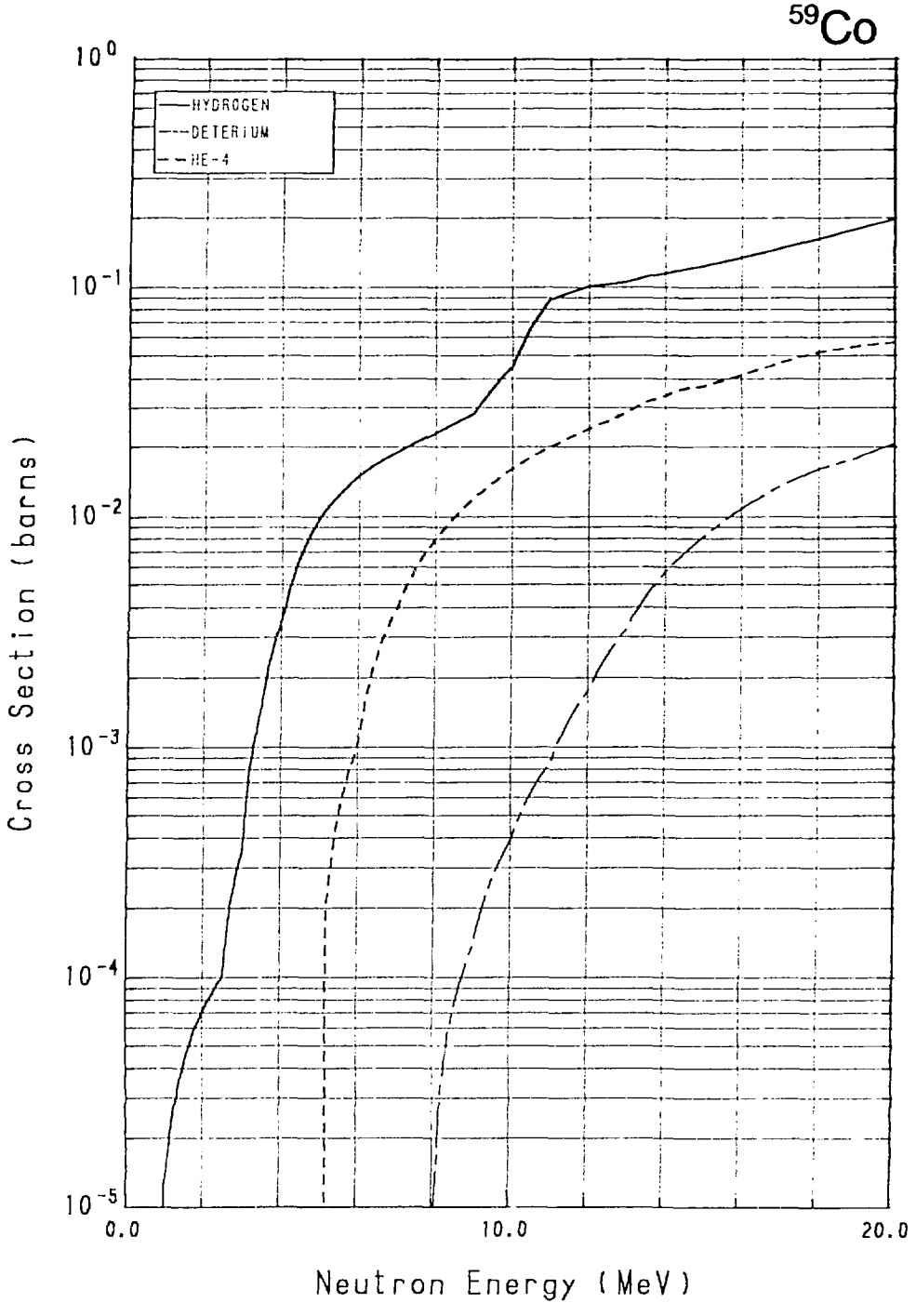

Fig. 16 Gas-production cross sections of ^{59}Co

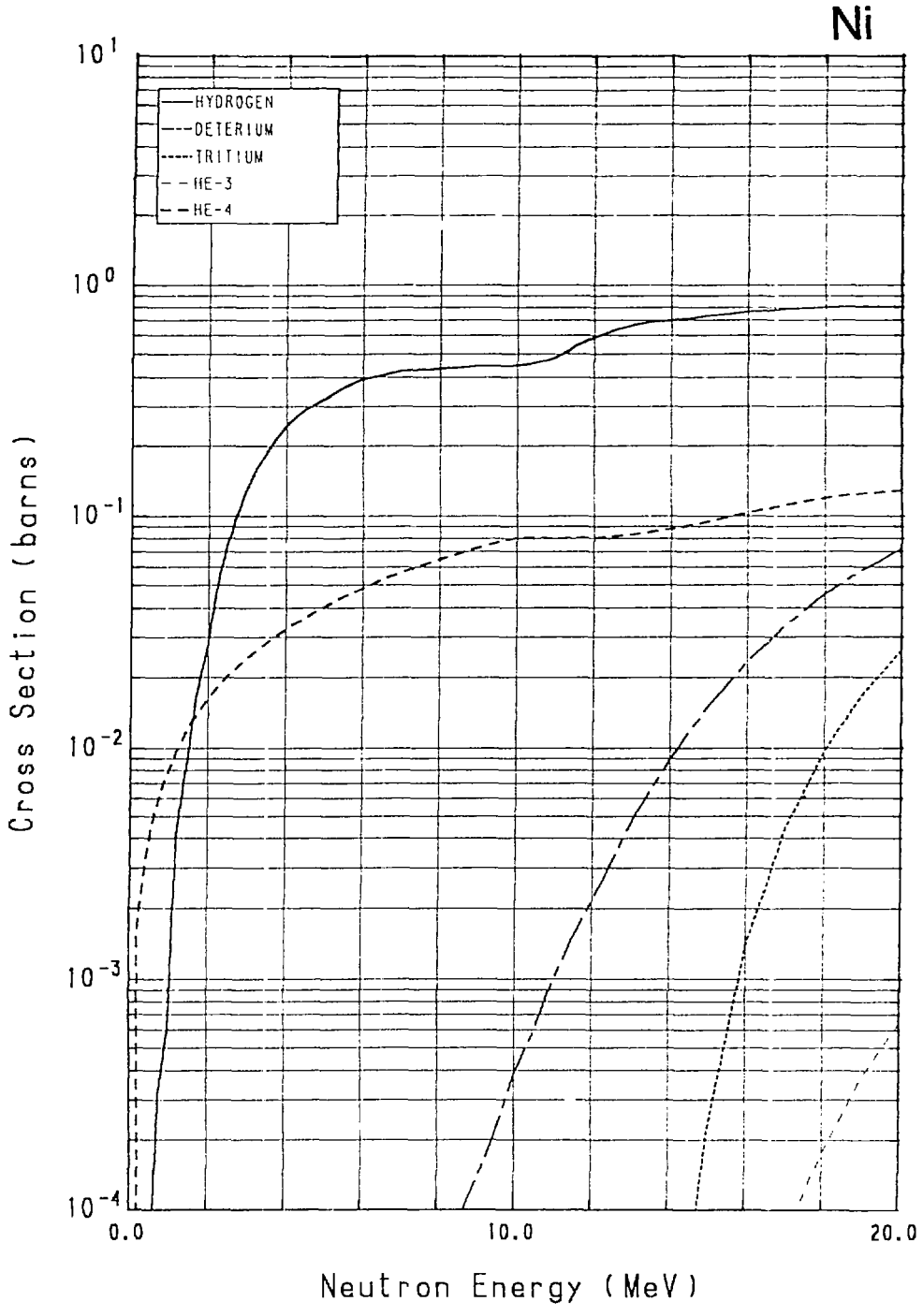

Fig. 17 Gas-production cross sections of Ni

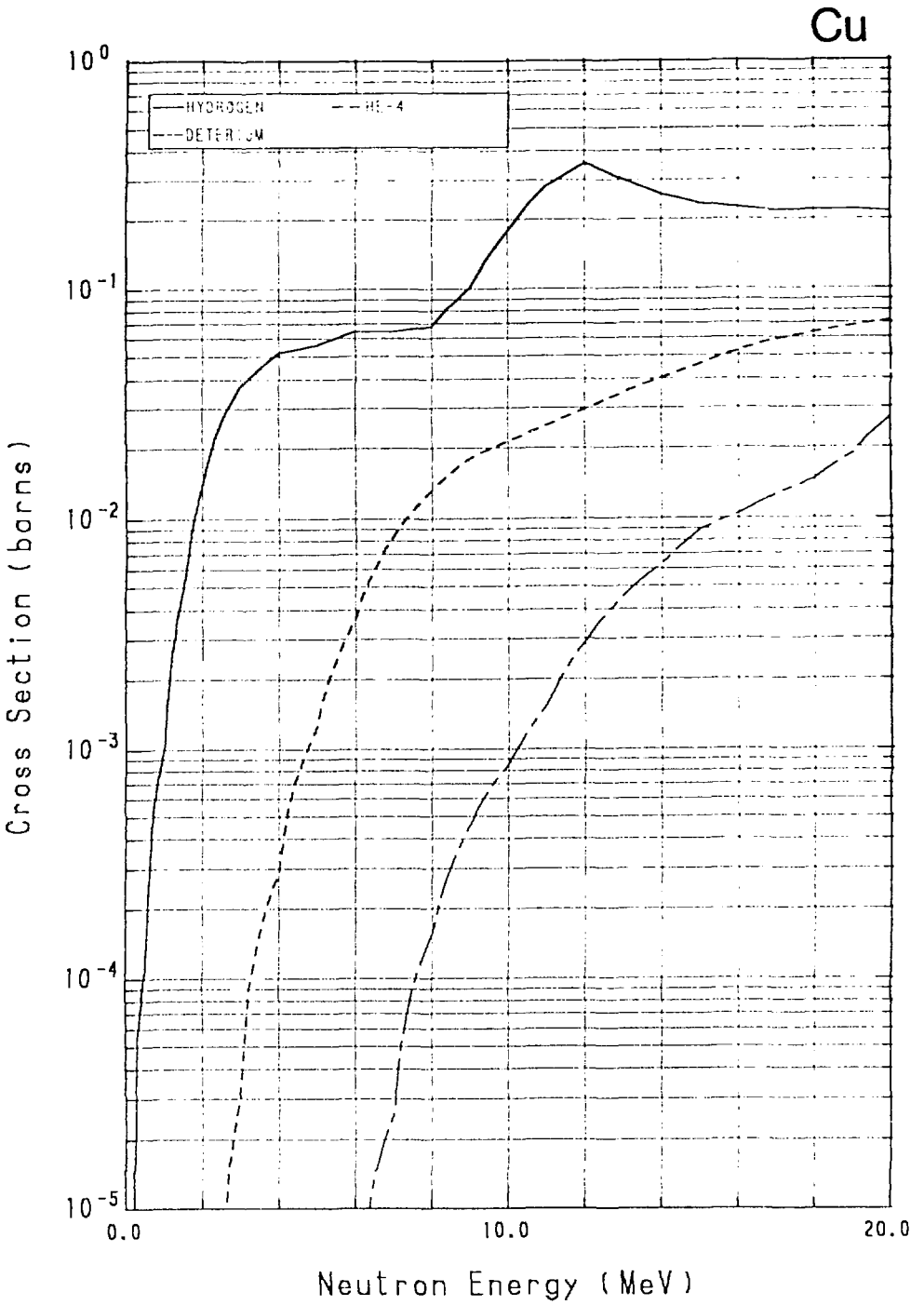

Fig. 18 Gas-production cross sections of Cu

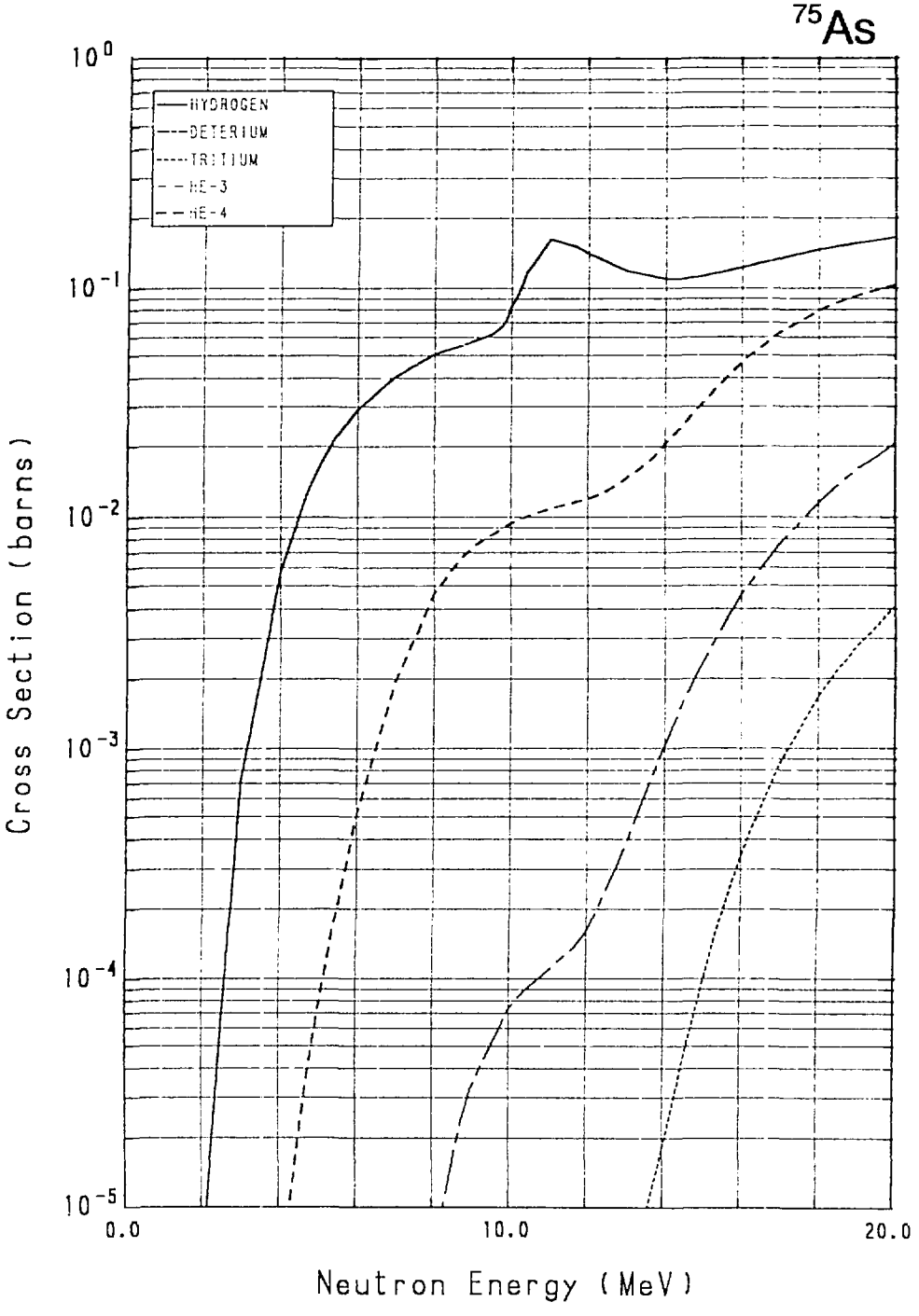

Fig. 19 Gas-production cross sections of ^{75}As

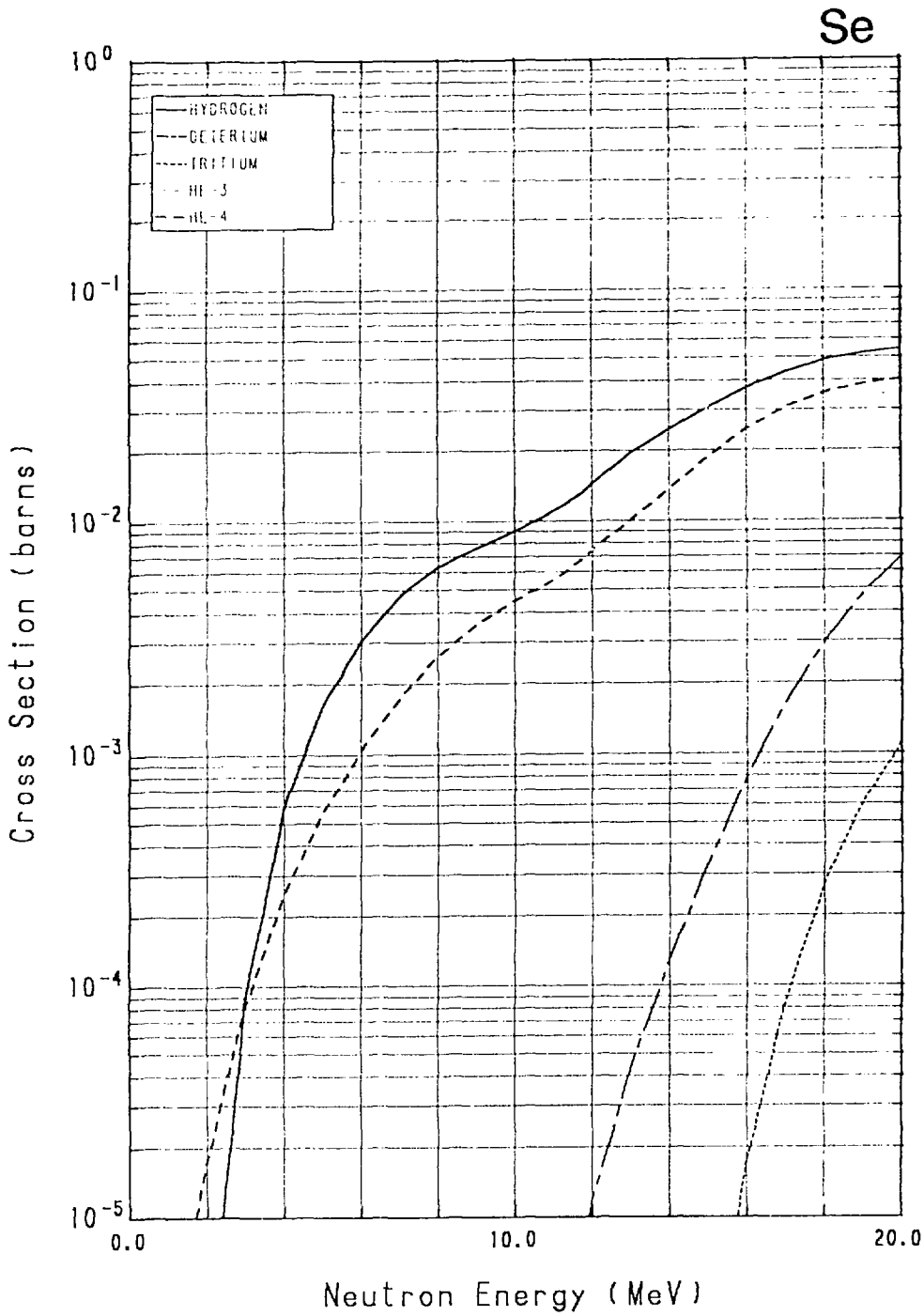

Fig. 20 Gas-production cross sections of Se

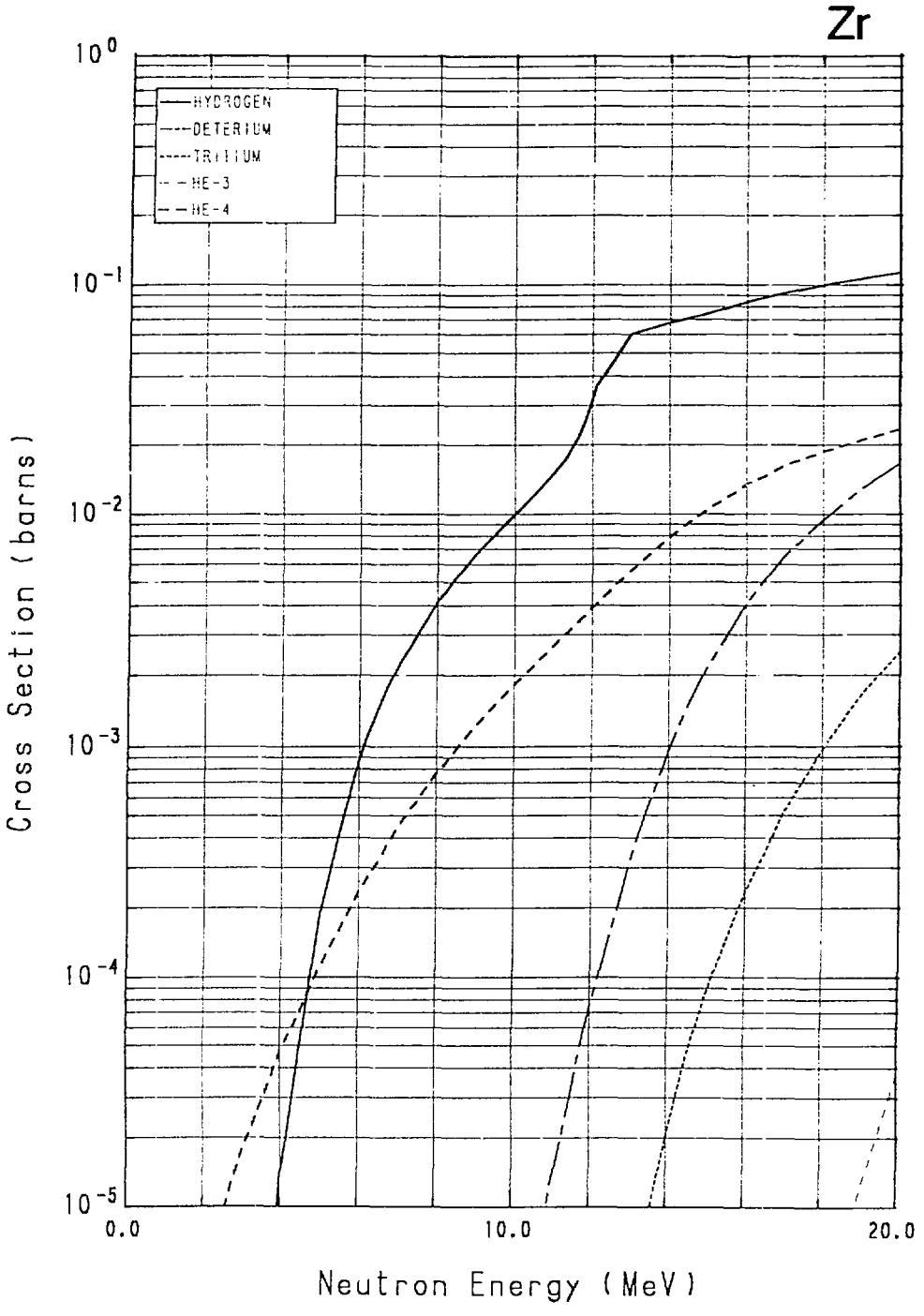

Fig. 21 Gas-production cross sections of Zr

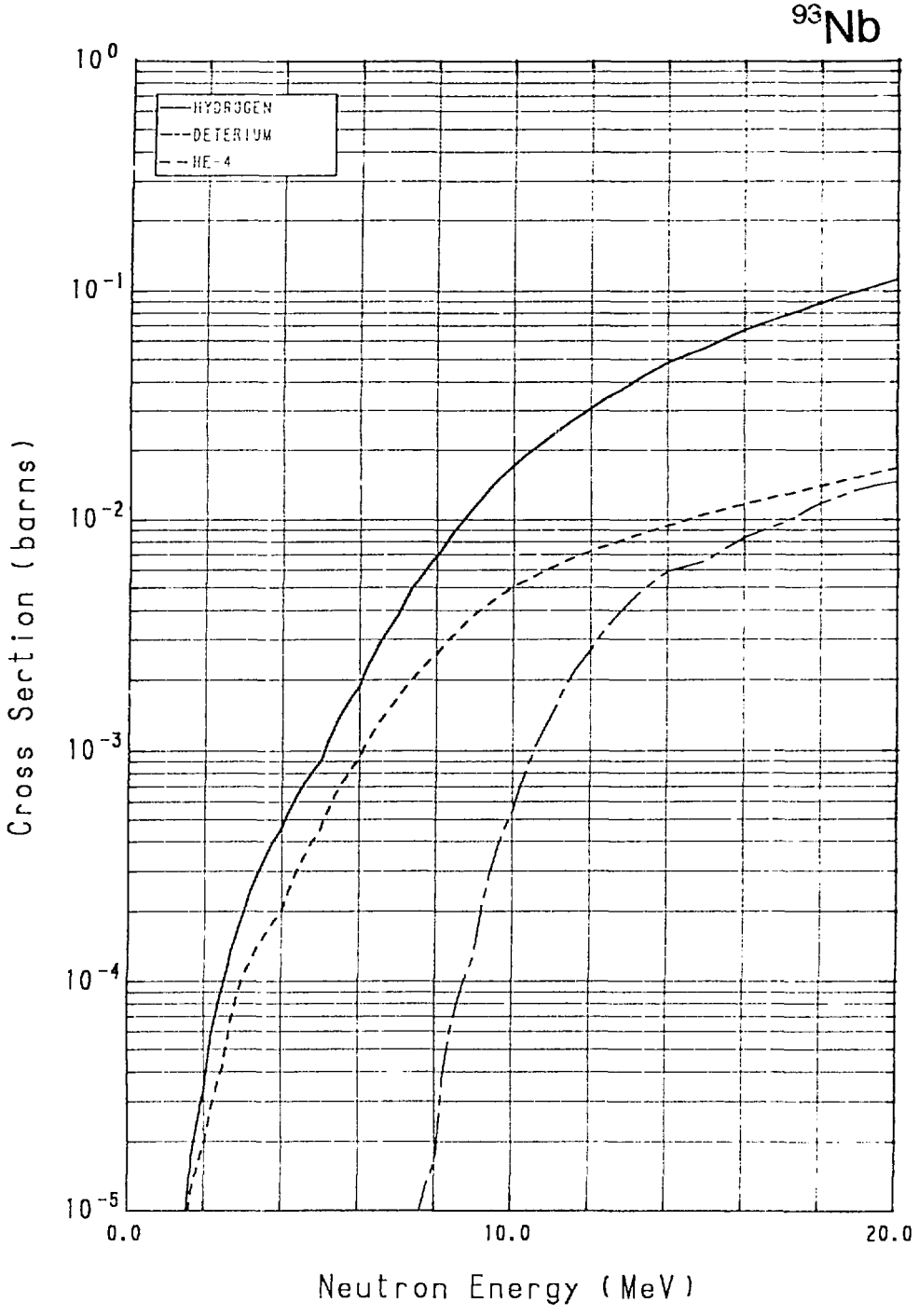

Fig. 22 Gas-production cross sections of ^{93}Nb

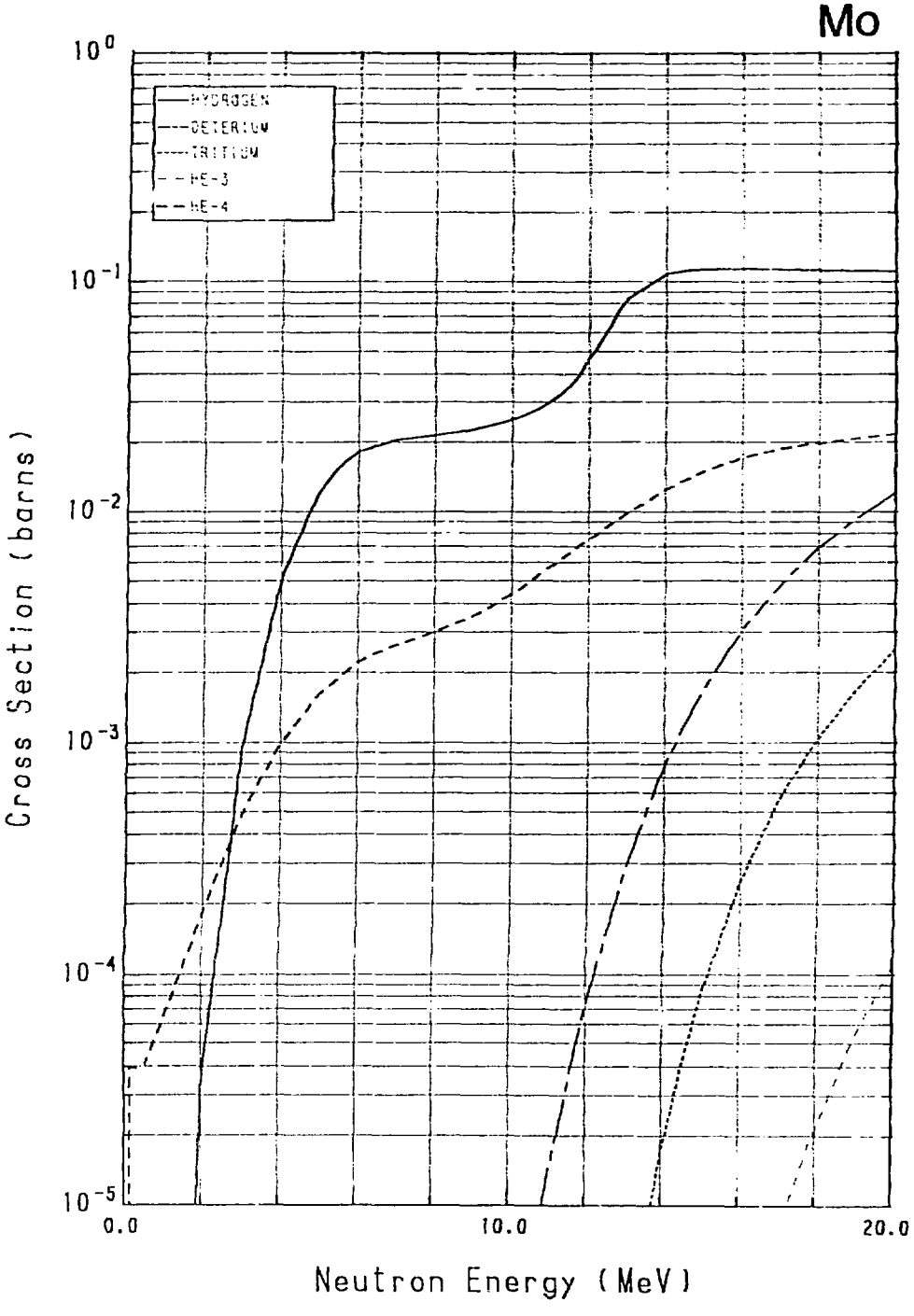

Fig. 23 Gas-production cross sections of Mo

国際単位系 (SI) と換算表

表1 SI基本単位

[illegible]	
[illegible]	[illegible]
[illegible]	m
[illegible]	kg
[illegible]	s
[illegible]	A
[illegible]	K
[illegible]	mol
[illegible]	cd
[illegible]	rad
[illegible]	sr

表2 SI [illegible]

[illegible]	
[illegible]	[illegible]
[illegible]	min, h, d
[illegible]	[illegible]
[illegible]	L, l
[illegible]	t
[illegible]	eV
[illegible]	u

1 eV = 1.602 × 10⁻¹⁹ J
1 u = 1.660 × 10⁻²⁷ kg

表3 [illegible] SI [illegible]

[illegible]			[illegible] SI中 [illegible]
[illegible]	[illegible]	Hz	[illegible]
[illegible]	[illegible]	N	m·kg/s²
[illegible]	[illegible]	Pa	N/m²
[illegible]	[illegible]	J	N·m
[illegible]	[illegible]	W	J/s
[illegible]	[illegible]	C	A·s
[illegible]	[illegible]	V	W/A
[illegible]	[illegible]	F	C/V
[illegible]	[illegible]	Ω	V/A
[illegible]	[illegible]	S	A/V
[illegible]	[illegible]	Wb	V·s
[illegible]	[illegible]	T	Wb/m²
[illegible]	[illegible]	H	Wb/A
[illegible]	[illegible]	°C	
[illegible]	[illegible]	lm	cd·sr
[illegible]	[illegible]	lx	lm/m²
[illegible]	[illegible]	Bq	s⁻¹
[illegible]	[illegible]	Gy	J/kg
[illegible]	[illegible]	Sv	J/kg

表4 SI [illegible]

[illegible]	
[illegible]	Å
[illegible]	b
[illegible]	bar
[illegible]	Gal
[illegible]	Ci
[illegible]	R
[illegible]	rad
[illegible]	rem

1 Å = 0.1 nm = 10⁻¹⁰ m
1 b = 100 fm² = 10⁻²⁸ m²
1 bar = 0.1 MPa = 10⁵ Pa
1 Gal = 1 cm/s² = 10⁻² m/s²
1 Ci = 3.7 × 10¹⁰ Bq
1 R = 258 × 10⁻⁴ C/kg
1 rad = 1 cGy = 10⁻² Gy
1 rem = 1 cSv = 10⁻² Sv

表5 SI [illegible]

[illegible]	
[illegible]	E
[illegible]	P
[illegible]	T
[illegible]	G
[illegible]	M
[illegible]	k
[illegible]	h
[illegible]	da
[illegible]	d
[illegible]	c
[illegible]	m
[illegible]	μ
[illegible]	n
[illegible]	p
[illegible]	f
[illegible]	a

[illegible] 表1 [illegible] SI [illegible] CODATA [illegible] 1 [illegible] 1 bar = 0.1 MPa [illegible] JIS [illegible] 5.5 [illegible]

1 [illegible] bar, barn [illegible] nmHg [illegible]

換算表

1 N	dyn	kgf	lbf
1	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	1	[illegible]

1 Pa·s = N·s/m² = 10 P; 1 cP = [illegible] mPa·s
1 m²/s = 10⁴ St; 1 St = [illegible] cm²/s

1 MPa	bar	kgf/cm²	atm	mmHg, Torr	lbf/in², psi
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1

1 J	erg	kgf·m	kW·h	cal	Btu	ft·lbf	eV
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1

1 cal = [illegible] J (国際蒸気表)
[illegible] PS [illegible]
[illegible] W

[illegible]	Bq	Ci
[illegible]	1	[illegible]
[illegible]	[illegible]	1

[illegible]	Gy	rad
[illegible]	1	[illegible]
[illegible]	[illegible]	1

[illegible]	C/kg	R
[illegible]	1	[illegible]
[illegible]	[illegible]	1

[illegible]	Sv	rem
[illegible]	1	[illegible]
[illegible]	[illegible]	1

[illegible]