5 Properties and activity yields of radionuclides produced through photonuclear reactions

5.1 General remarks

This chapter is intended to be used as an aid in the evaluation step during photon activation analysis. Data are presented which, with a few exceptions, concern all elements. The included reaction types, photon energies and yield data are based exclusively upon experimentally obtained results. Minor differences might be observed in comparison to other data compilations. For instance, some gamma-ray lines of an identified product nuclide might not be listed because they have not been observed in the spectra, be it by lack of counting efficiency of the spectrometer used or due to spectral interference or any other reason. It was not intended to simply copy a complete gamma-ray table but rather to include only those reactions and photon energies which are relevant for photon activation analysis. The tables are laid out in a way which enables the analyst to initially get a quick overview about the spectrum to be expected after bremsstrahlung exposure of an element; furthermore, to quickly help to find out optimal experimental conditions for a given task; finally, to obtain a complete qualitative evaluation of an "unknown" spectrum, and to get immediate information on possible interference. This is more important in photon activation than in thermal neutron activation, since many more reaction types are likely to occur during high energy photon exposure.

Taking a look at a typical gamma-ray spectrum of a photon-irradiated multicomponent sample, there is an obvious difference compared with spectra from neutron-irradiated material. Since predominantly β^+-emitters are produced through photon activation - at least in the lower Z region of the Chart of Nuclides - the most prominent gamma-ray line is almost always the 511 keV annihilation radiation. Another difference is the very intense characteristic X-ray spectrum, primarily due to nuclides which decay by electron capture. These are preferentially produced by photon activation of heavier elements. Therefore, low energy photon spectroscopy can be used very efficiently in photon activation analysis. Consequently, tables of the low energy photon spectra are included in this compilation.

5.2 Experimental conditions

5.2.1 Selection of the elements

In the data tables, there are some elements which are not considered for different reasons, namely:

- Some elements do not undergo an analytically suitable photonuclear reaction. These are: lithium, boron, sulphur, thorium.

- Elements which do not occur in the nature in considerable amounts. These are: technetium, promethium, and the elements beyond bismuth except uranium; these elements can be well determined by their intrinsic radioactivity.

- Hydrogen; as explained in chapters 1 and 2, this element can be determined with help of photodisintegration of ^{2}H, but in this data collection, only elements are included which can be detected by photon spectroscopy.

- The Noble Gases; they are generally of little analytical interest. The very few cases in which their analysis might be required[138,685-687] do not justify the considerable experimental difficulties of their handling during an activation analysis procedure.

5.2.2 Irradiation conditions

Depending on the expected product nuclei activities, between 50 milligrams and 5 grams of each element were irradiated as pure elements or as stoichiometrically well defined compounds, preferrably oxides. The halogens were irradiated as lithium salts to avoid interference by the cation. Glass test tubes served as irradiation vessels. A rotating irradiation facility was available which allowed simultaneous irradiation of 13 samples. The electron energy was set to 30 MeV; all other machine parameters are given in chapter 2. Since, as already noted, not all parameters relevant for photonuclear activation could either be explicitely determined or kept constant, an energy- and flux monitor was irradiated simultaneously with each set of samples. This was to obtain relative activity yield values which do not depend upon machine- or irradiation parameters other than the electron energy.

Nickel as Ni(II,III)oxide was selected as a monitor for different reasons, namely:

- assuming an electron energy of not greater than 45 MeV, there is no competing reaction of nickel which might falsify the activity yield of ^{57}Ni produced by the monitoring reaction[54]:

$$^{58}Ni(\gamma, n)^{57}Ni$$

- ^{57}Ni emits a very conveniently measurable gamma energy, namely 1379 keV.

Using two nuclear reactions with very differen threshold energies an assessment of the irradiation energy becomes possible. Since the yield curves of both reactions have largely different dependencies upon the activating radiation energy the ratio of the yielded specific activities sensitively depends upon the incident energy. The second monitoring reaction is:

$$^{58}Ni(\gamma, 2n)^{56}Ni$$

The calculation of the relative reaction yields of the elements with help of the nickel monitor activity will be explained further ahead of the data tables in 5.3.1. Generally, the elements were irradiated and measured several times to detect all expected product nuclides (see table 5-1 in 5.2.3).

5.2.3 Measurement conditions and spectra processing

If product nuclides were expected with half lives less than or equal to one hour, high energy (E>90 keV) gamma spectra were taken only. Otherwise, batches of 20 milligrams were taken from each irradiated sample, mixed with 380 milligrams of cellulose powder and pressed to a pellet of 20 millimeter diameter and ca. 1 millimeter thickness, which was used for low energy photon spectrometry. A similar pellet was prepared for gamma-ray spectrometry. The samples were measured at different distances from the detector (see Fig.4.32), depending upon the integral photon emission rates.

Low energy (E<90 keV) photon spectra were taken with a planar intrinsic germanium diode, gamma energies greater than or equal to 90 keV were measured with a conventional coaxial lithium-drifted germanium detector. The resulting photon spectra were stored in 2048 channels of a multichannel pulse-height analyser. The properties of the spectrometers are described in detail in chapter 4. In order to obtain comparable sensitivity data for the different spectrometry systems, the measurement geometry was kept as similar as possible at both detectors. Thereby, sensitivity comparisons could be obtained between gamma and low energy photon spectrometry (see tab. 5-3 and 5-4). All spectra were dumped on magnetic tape and processed with help of a computer program which allowed interactive peak integration plus linear background subtraction. No attempt was made to apply any automatic peak search programs; it was intended to ascertain, by visual inspection, complete and error-free spectra processing in any case.

Table 5-1 shows all exposure, cooling and counting periods which were used. Irradiation, decay and counting periods were selected according to the half-lives of the expected product nuclides.

Table 5-1: irradiation, decay and counting periods

$T_{1/2}$	T_i	T_D	T_c	Remarks
<1 m	15 s	30 s	1 m	no LEP-spectra
1 m - 1 h	5 m	5-60 m	5-120 m	no LEP-spectra
>1 h	5-60 m	60 m - 120 d	60 m - 48 h	

5.3 Data tables

There are, for practical reasons, certain limitations concerning the nuclear data of the activation products included in the data section. Only those reaction types are considered which are specified in chapter 2, although, in some cases, also other reactions were detected, e.g.

$$^{30}Si(\gamma, 2p)^{28}Mg$$

or

$$^{30}Si(\gamma, {}^{4}He\,np)^{24}Na$$

These reactions are, due to their small effective cross sections, of little analytical relevance; under the established irradiation conditions they are detectable only in gram amounts of pure element target irradiated. Nuclides are included whose half-lives lie between 10 seconds and 150 years; all others are barely measurable and thus of little analytical interest.

The included photon emission energies range from 4.5 to 3000 keV. Using the described spectrometry devices energies outside these limits are not measurable with satisfactory efficiency to meet analytical requirements.

Within these limits, 608 nuclear reactions have been detected after bremsstrahlung activation of 69 elements, giving an average of about 9 reactions per element (the actual number ranges from 1 to 24). About 3000 photon energies in total have been assigned which gives a mean of about 5 lines per product nuclide (the numbers vary from 1 to more than 100) or a total mean of about 45 emission lines per irradiated element. These numbers are listed to give an idea of a photon spectrum to be expected after about one hour bremsstrahlung exposure of some tens of milligrams of an element.

5.3.1 The photonuclear reactions of the elements

In table 5-2, all photonuclear reactions of each individual element are listed in the order of the atomic number of the target as far as they have been detected after 30 MeV bremsstrahlung exposure. The criterion which was followed to ascertain the detection of a reaction was the detectability of at least one

photon energy line with a height exceeding the background noise of the concerned spectrum region by a factor of at least 4. This seems to be a somewhat arbitrary value, but it meets the practical spectroscopy requirements satisfactorily. No attempts have been made to detect other reactions utilising special sample handling, e.g. radiochemical separation procedures after irradiation; since it is intended to present data in accordance with the requirements of a purely instrumental analysis, only reactions were included which could be observed in the unprocessed sample after bremsstrahlung exposure.

Since, as noted in chapter 3, a high energy bremsstrahlung source is also a powerful neutron source, photoneutrons frequently induce reactions of various types, e.g. (n,γ), $(n,2n)$, (n,p), (n,α) etc.. Although not being photon-induced reactions, they are included in the data collection, again following practical analytical considerations. These reactions can well be used for analysis or, depending upon the individual case, they have to be taken into account as sources of interference. Simply summarised, they are listed, because they occur.

In the case of fissile material as a target element, photofission reactions are excluded; they are of little analytical use and their product activity yields are subject to additional experimental parameters which are not taken into account in this compilation. However, analysing material which contains considerable amounts of fissile material one has to be aware of interference caused by photofission products during analysis (Segebade et al.[688]).

In table 5-2, the reactions which are most suitable for analysis (these are not always those with the highest reaction yields!) are underlined.

In the first column, ordered by the atomic number of the target element and by the relative isotopic mass of the target nuclide, respectively, all observed reactions of the above specified elements are presented. The half-lives in the next column are taken from the Chart of Nuclides (Seelmann-Eggebert et al.[689]).

In the next column relative quantitative activity yields are given. Following the authors' philosophy, it is of little use to present absolute yields which are, caused by many variable parameters, scarcely reproducible, as already mentioned. Therefore, the activities of the individual nuclides produced during activation were normalised to the reference reaction of the nickel monitor simultaneously irradiated (see 5.2.2).

For practical reasons, a common exposure period of one hour was assumed. The relative yield is defined as follows:

$$N = \frac{a_{0,el}(T)}{a_{0,Ni}(T)} \tag{5.1}$$

$a_0$el(T) = specific activity of the reaction product under consideration immediately after one hour bremsstrahlung irradiation

a_0Ni(T) = specific activity of ^{57}Ni in the nickel monitor immediately after one hour bremsstrahlung irradiation

T = standard exposure period (=1h)

Specific activities were calculated based upon eq. 1.17 in 1.3:

$$a(T_i, T_D) = \frac{L \cdot h}{A_r} \cdot \varphi \cdot \sigma_{eff} \cdot (1 - e^{-\lambda \cdot T_I}) \cdot e^{-\lambda \cdot T_D} \tag{1.17}$$

The specific activity has to be determined by evaluation of the measured gamma-ray spectra. Thus, two additional parameters have to be introduced, namely the gamma-ray emission probability of the product nuclide and the counting efficiency of the spectrometer. The determined pulse rate in the gamma-ray line is:

$$P = A \cdot \Theta \cdot \eta \tag{5.2}$$

P = measured pulse rate in the photopeak (pulses per second)

θ = absolute emission probability of the gamma-ray line (emitted photons per disintegration)

η = absolute photopeak counting efficiency of the spectrometer at the gamma energy (registered pulses per photon emitted)

Insertion of eq.1.17 into the above equation yields:

$$P(T_i, T_D) = \frac{m \cdot L \cdot h}{A_r} \cdot \varphi \cdot \sigma_{eff} \cdot \Theta \cdot \eta \cdot (1 - e^{-\lambda \cdot T_i}) \tag{5.3}$$

or, since

$$A(T_i) = \frac{m \cdot L \cdot h}{A_r} \cdot \varphi \cdot \sigma_{eff} \cdot (1 - e^{-\lambda \cdot T_i}) \qquad (5.4)$$

the pulse rate after a waiting period of T_D is:

$$P(T_i, T_D) = A(T_i) \cdot e^{-\lambda \cdot T_D} \cdot \Theta \cdot \eta \qquad (5.5)$$

By spectroscopy measurement, it is more useful to determine the integral number of pulses of a photon line within a counting period of T_c rather than a pulse rate. This number is expressed as:

$$I = \int_{T_D}^{T_D + T_C} P(t)\,dt \qquad (5.6)$$

I = number of counts in the photopeak after a cooling time of T_D and a measuring period of T_c

From eq's.5.5 and 5.6 follows:

$$\frac{I}{m} = a(T_i) \cdot \Theta \cdot \eta \cdot \frac{e^{-\lambda \cdot T_D}}{\lambda} \cdot (1 - e^{-\lambda \cdot T_C}) \qquad (5.7)$$

This expression has to be formed for both the element reaction under consideration and the monitoring reaction

$$^{58}Ni(\gamma, n)^{57}Ni$$

to provide an expression which can be used for calculation of the desired N-value (see eq.5.1).

Since, as already mentioned, yield values are normalised for a common exposure period of one hour, the following expression is required, which converts the individual activities yielded using other irradiation times to those after standard exposure period T:

$$N(T) = \frac{a_{0,el}(T_i)}{a_{0,Ni}(T_i)} \cdot \frac{1 - e^{-\lambda_{el} \cdot T}}{1 - e^{-\lambda_{el} \cdot T_i}} \cdot \frac{1 - e^{-\lambda_{Ni} \cdot T_i}}{1 - e^{-\lambda_{Ni} \cdot T}} \qquad (5.8)$$

el = product nuclide under consideration
Ni = monitoring nuclide (^{57}Ni)
T_i = actual exposure period
T = normalised exposure period (=1h)

Insertion of eq's. 5.7 and 5.8 into eq. 5.1 yields the final expression for the calculation of the N-value:

$$N = \frac{a_{0,el}(T)}{a_{0,Ni}(T)} = \frac{I_{el}}{I_{Ni}} \cdot \frac{m_{Ni}}{m_{el}} \cdot \frac{\Theta_{\gamma,Ni}}{\Theta_{\gamma,el}} \cdot \frac{\eta_{\gamma,Ni}}{\eta_{\gamma,el}} \cdot \frac{\lambda_{el}}{\lambda_{Ni}} \cdot \frac{1 - e^{-\lambda_{el} \cdot T}}{1 - e^{-\lambda_{el} \cdot T_i}} \cdot \frac{1 - e^{-\lambda_{Ni} \cdot T_i}}{1 - e^{-\lambda_{Ni} \cdot T}} \cdot \frac{1 - e^{-\lambda_{Ni} \cdot T_{C,Ni}}}{1 - e^{-\lambda_{el} \cdot T_{C,el}}} \cdot \frac{e^{-\lambda_{Ni} \cdot T_{D,Ni}}}{e^{-\lambda_{el} \cdot T_{D,el}}} \qquad (5.9)$$

$a_0$el(T) = specific activity of the reaction product under consideration immediately after one hour bremsstrahlung irradiation
a_0Ni(T) = specific activity of ^{57}Ni in the nickel monitor irradiated simultaneously with the element under consideration, immediately after exposure
I = Photopeak pulse number
m_{el} = mass of the element under consideration
m_{Ni} = mass of the nickel monitor
Θ_γ = absolute emission probability of the gamma-ray line
η_γ = absolute photopeak counting efficiency of the spectrometer at the energy under consideration
T = normalised irradiation period (=1 hour)
T_i = actual exposure period
T_c = counting period
T_D = decay period

N-values of neutron reactions have to be taken as estimates since their yields are subject to other parameters than those which are relevant for photon reactions (see chapter 3).

N-values of reactions detectable only close to the detection limit are indicated as weak ("w").

The selection of the gamma-ray energies in the last column is somewhat arbitrary. First, no low energies ($E \lesssim 90$ keV) are included. This is done because the first approach to the qualitative analysis usually is made with help of gamma-ray spectroscopy rather than low energy photon measurement. Second, only some of the strongest lines, i.e. those with the greatest emission probabilities, are presented. In order to keep the table as short as convenient not more than five lines are given for any individual product nuclide; all other ones can be found in tables 5-4 and 5-5. Third, also escape lines, i.e. pair peaks from high energy gamma-rays, and sum energies are given both in this table and in Tab.5-5, although they are due to certain detector properties (see Ch.4) and not emitted by the measured radionuclide. Again following the "practical" idea, they are included since they are present in the spectra and hence have to be identified and accounted for. Of course, no emission probabilities can be given for these lines; their intensities are primarily governed by the counting geometry. Only those lines are included which are quoted and confirmed by the Table of Isotopes, 7^{th} ed. (Lederer et al.[690]) ; no attempt was made to detect new lines. The emission probabilities, given in emissions per hundred disintegrations, are presented in integer numbers, if they are ≥ 1. Otherwise, one significant digit is given. This is done because of the large discrepancies of the literature data. They were taken from Erdtmann and Soyka[691], Meixner[692], the Table of Isotopes, 7^{th} ed. (Lederer et al.[690]) and other sources.

Reaction	T	N	E keV (I%)
		$_4$Be	
Be-9(γ,2n)Be-7	53.4 d	1.7 E-3	478(10)
		$_6$C	
C-12(γ,αn)Be-7	53.4 d	1.6 E-5	478(10)
		$_{11}$Na	
Na-23(γ,n)Na-22	2.6 a	3.0 E-3	1275(100)
Na-23(n,γ)Na-24	15.03 h	9.6 E-3	1369(100), 2754(100)
		$_{12}$Mg	
Mg-24(γ,n)Mg-23	12.0 s	1.2 E+1	440(9)
Mg-24(γ,np)Na-22	2.6 a	1.3 E-5	1275(100)
Mg-25(γ,p)Na-24	15.03 h	2.5 E-1	1369(100), 2754(100)
Mg-26(γ,p)Na-25	59.6 s	3.6	390(13), 585(13), 975(15)
		$_{13}$Al	
Al-27(γ,αn)Na-22	2.6 a	9.5 E-7	1275(100)
Al-27(n,γ)Al-28	2.246 m	9.2 E-2	1779(100)
Al-27(n,p)Mg-27	9.46 m	2.4 E-1	844(72), 1015(30)
Al-27(n,α)Na-24	15.03 h	2.3 E-3	1369(100), 2754(100)
		$_{14}$Si	
Si-29(γ,p)Al-28	2.246 m	3.6	1779(100)
Si-30(γ,p)Al-29	6.6 m	1.5	1274(91), 2028(3), 2426(6)
Si-30(n,α)Mg-27	9.46 m	2.2 E-2	844(72), 1015(30)
		$_{15}$P	
P-31(n,α)Al-28	2.246 m	1.9 E-1	1779(100)

Reaction	T	N	E keV (I%)
		$_{17}$Cl	
Cl-35(γ,n)Cl-34m	32 m	9.4	147(45), 1178(12), 2129(38)
Cl-37(n,γ)Cl-38	37.18 m	9.4 E-2	1642(33), 2168(44)
		$_{19}$K	
K-39(γ,n)K-38	7.7 m	1.6 E+1	2168(100)
K-39(γ,αn)Cl-34m	32 m	6.7 E-3	147(45), 2129(38)
K-41(n,γ)K-42	12.36 h	3.7 E-4	1525(18)
K-41(n,p)Ar-41	1.83 h	w	1294(99)
		$_{20}$Ca	
Ca-40(γ,np)K-38	7.7 m	1.7 E-1	2168(100)
Ca-43(γ,p)K-42	12.36 h	5.8 E-3	1525(18)
Ca-44(γ,p)K-43	22.2 h	4.0 E-2	373(100), 593(16), 617(87)
Ca-46(γ,np)K-44	22.2 m	w	1157(58)
Ca-46(γ,p)K-45	16.3 m	4.3 E-5	174(82)
Ca-48(γ,n)Ca-47	4.54 d	3.7 E-3	489(7), 808(7), 1297(75)
Ca-48(γ,np)K-46	115 s	5.4 E-3	1347(90)
Ca-48(γ,p)K-47	17.5 s	4.2 E-2	586(85)
Ca-47 Sc-47	(3.42 d)	---	159(70)
		$_{21}$Sc	
Sc-45(γ,n)Sc-44	3.92 h	2.5 E+1	1157(94), 1500(1), 2657(.2)
Sc-45(γ,n)Sc-44m	2.44 d	1.6 E-1	271(86), 1126(1), 1157(1)
Sc-45(n,γ)Sc-46	84 d	8.0 E-4	889(100), 1121(100)
		$_{22}$Ti	
Ti-46(γ,n)Ti-45	3.08 h	2.9	720(.2), 1408(.1)
Ti-46(γ,np)Sc-44	3.92 h	5.3 E-3	1157(94), 1500(1), 2657(.2)
Ti-46(γ,np)Sc-44m	2.44 d	3.3 E-5	271(86), 1126(1), 1157(1)
Ti-47(γ,p)Sc-46	84 d	2.1 E-3	889(100), 1121(100)
Ti-48(γ,p)Sc-47	3.42 d	9.5 E-1	159(70)
Ti-49(γ,p)Sc-48	43.67 h	3.1 E-2	984(100), 1312(100)

Reaction	T	N	E keV (I%)
		($_{22}$Ti)	
Ti-50(γ,p)Sc-49	57.2 m	9.4 E-2	1762(.1)
Ti-50(n,p)Sc-50	1.7 m	w	524(91)
		$_{23}$V	
V-50(γ,2n)V-48	15.97 d	3.8 E-5	944(9), 983(100), 1312(99)
V-50(γ,α)Sc-46 V-51(γ,αn)Sc-46	84 d	8.3 E-6	889(100), 1121(100)
V-51(γ,α)Sc-47	3.42 d	4.5 E-2	159(70)
V-51(n,γ)V-52	3.75 m	9.2 E-1	1434(100)
V-51(n,p)Ti-51	5.8 m	w	320(95)
		$_{24}$Cr	
Cr-50(γ,n)Cr-49	42 m	1.9	91(26), 153(12)
Cr-50(γ,np)V-48	15.97 d	3.2 E-4	983(100), 1312(99)
Cr-50(γ,2n)Cr-48	23 h	4.0 E-4	308(99)
Cr-50(γ,αn)Ti-45	3.08 h	1.5 E-1	720(.2)
Cr-52(γ,n)Cr-51	27.7 d	3.9 E-1	320(10)
Cr-53(γ,p)V-52	3.75 m	2.3	1434(100)
Cr-54(γ,p)V-53	1.6 m	3.6 E-1	1006(89), 1289(11)
Cr-54(n,p)V-54	43 s	w	835(100), 986(82)
Cr-54(n,α)Ti-51	5.8 m	w	320(95)
		$_{25}$Mn	
Mn-55(γ,n)Mn-54	312.2 d	2.0 E-2	835(100)
Mn-55(n,γ)Mn-56	2.58 h	3.7 E-1	847(99), 1811(29), 2113(16)
		$_{26}$Fe	
Fe-54(γ,2n)Fe-52	8.2 h	?	169(99)
Fe-54(γ,n)Fe-53	8.51 m	2.6	377(32)
Fe-54(γ,n)Fe-53m	2.5 m	?	701(99), 1012(86), 1328(87)
Fe-54(γ,np)Mn-52	5.7 d	1.7 E-4	744(85), 936(84), 1434(100)
Fe-54(γ,np)Mn-52m	21 m	?	1434(98)

Reaction	T	N	E keV (I%)
		($_{26}$Fe)	
Fe-54(γ,αn)Cr-49	42 m	1.9 E-3	153(12)
Fe-56(γ,np)Mn-54	312.2 d	1.5 E-3	835(100)
Fe-56(γ,αn)Cr-51	27.7 d	7.0 E-5	320(10)
Fe-57(γ,p)Mn-56	2.58 h	1.9 E-1	847(99),1811(29),2113(16)
Fe-58(γ,p)Mn-57	1.7 m	7.1 E-2	122(10)
Fe-52 Mn-52m	(21 m)	---	1434(98)
		$_{27}$Co	
Co-59(γ,n)Co-58	70.78 d	1.4 E-1	811(100), 864(1), 1675(.5)
Co-59(γ,n)Co-58m	8.94 h	2.7 E+1	---
Co-59(γ,2n)Co-57	270 d	3.6 E-3	122(85), 136(11)
Co-59(γ,αn)Mn-54	312.2 d	5.3 E-5	835(100)
Co-59(n,γ)Co-60	5.272 a	1.0 E-4	1173(100), 1333(100)
		$_{28}$Ni	
Ni-58(γ,n)Ni-57	36 h	1.000	127(15), 1378(79), 1920(15)
Ni-58(γ,2n)Ni-56	6.1 d	2.1 E-3	158(100), 750(48), 812(75)
Ni-58(γ,np)Co-56	77.3 d	1.3 E-3	847(99), 1038(14)
Ni-58(γ,p)Co-57	270 d	6.1 E-2	122(85), 136(11)
Ni-58(γ,αn)Fe-53	8.51 m	8.9 E-3	377(32)
Ni-58(γ,αn)Fe-53m	2.5 m	5.5 E-4	701(99), 1012(86), 1328(87)
Ni-60(γ,np)Co-58	70.78 d	7.3 E-4	811(100), 864(1)
Ni-60(γ,np)Co-58m	8.94 h	?	---
Ni-61(γ,p)Co-60	5.272 a	1.4 E-4	1173(100), 1333(100)
Ni-64(γ,np)Co-62	14 m	4.5 E-3	1164(71), 1173(100)
Ni-64(n,γ)Ni-65	2.52 h	6.1 E-2	1481(27)
		$_{29}$Cu	
Cu-63(γ,n)Cu-62	9.76 m	7.9 E+2	876(.2), 1173(.4)
Cu-63(γ,2n)Cu-61	3.3 h	1.2	283(13), 656(10), 1185(4)
Cu-63(γ,αn)Co-58	70.78 d	6.4 E-5	811(100), 864(1)
Cu-65(γ,n)Cu-64	12.7 h	7.7	1346(.6)
Cu-65(γ,αn)Co-60	5.272 a	1.2 E-6	1173(100), 1333(100)

Reaction	T	N	E keV (I%)
		($_{29}$Cu)	
Cu-65(n,γ)Cu-66	5.1 m	1.5	1039(9)
		$_{30}$Zn	
Zn-64(γ,n)Zn-63	38.4 m	1.0 E+2	670(9), 962(7), 1412(1)
Zn-64(γ,2n)Zn-62	9.13 h	7.9 E-2	243(2), 548(14), 597(24)
Zn-64(γ,np)Cu-62	9.76 m	5.9	876(.2), 1173(.4)
Zn-66(γ,n)Zn-65	244 d	1.4 E-2	1116(51)
Zn-66(γ,np)Cu-64	12.7 h	3.6 E-2	1346(.6)
Zn-67(γ,p)Cu-66	5.1 m	1.2	1039(9)
Zn-68(γ,p)Cu-67	61.9 h	2.2 E-2	93(17), 185(47)
Zn-70(γ,n)Zn-69m	13.9 h	1.7 E-2	439(100)
Zn-70(γ,np)Cu-68	30 s	3.1 E-2	1078(100)
Zn-70(γ,np)Cu-68m	3.8 m	?	110(25), 526(100), 636(17)
Zn-70(γ,p)Cu-69	3 m	3.3 E-2	834(6), 1007(10)
Zn-70(γ,αn)Ni-65	2.52 h	1.4 E-2	1481(27)
		$_{31}$Ga	
Ga-69(γ,n)Ga-68	68.3 m	9.0 E+1	806(.09), 1078(3), 1261(.9)
Ga-69(γ,2n)Ga-67	78.3 h	1.9 E-1	93(38), 185(24), 300(21)
Ga-69(γ,αn)Cu-64	12.7 h	2.2 E-2	1346(.6)
Ga-71(γ,n)Ga-70	21.1 m	5.6	175(.2), 1039(.5)
Ga-71(γ,np)Zn-69m	13.9 h	1.5 E-2	439(100)
Ga-71(γ,αn)Cu-66	5.1 m	w	1039(9)
Ga-71(γ,α)Cu-67	61.9 h	2.4 E-1	185(47)
Ga-71(n,γ)Ga-72	14.1 h	9.7 E-2	630(25), 834(96), 2202(26)
		$_{32}$Ge	
Ge-70(γ,n)Ge-69	39 h	1.2	574(13), 1107(28), 1335(3)
Ge-70(γ,np)Ga-68	68.3 m	2.5 E-1	1078(3)
Ge-70(γ,αn)Zn-65	244 d	5.1 E-5	1116(51)
Ge-72(γ,np)Ga-70	21.1 m	2.1	175(.2), 1039(.5)
Ge-73(γ,p)Ga-72	14.1 h	1.3 E-1	630(25), 834(96), 2202(26)
Ge-73(γ,α)Zn-69m Ge-74(γ,αn)Zn-69m	13.9 h	3.3 E-1	439(100)

Reaction	T	N	E keV (I%)
		($_{32}$Ge)	
Ge-74(γ,p)Ga-73	4.8 h	8.6 E-1	297(94), 326(14), 739(6)
Ge-76(γ,n)Ge-75	83 m	1.9 E+1	199(1), 265(11)
Ge-76(γ,n)Ge-75m	48 s	9.9 E+5	140(34)
Ge-76(γ,np)Ga-74	8.3 m	4.7 E-3	596(99), 608(16), 2354(49)
Ge-76(γ,p)Ga-75	2.1 m	?	253(100)
Ge-76(γ,αn)Zn-71	2.4 m	1.8 E-1	390(4)
Ge-76(γ,αn)Zn-71m	3.9 h	1.3 E-2	386(92), 487(62), 620(57)
Ge-76(γ,α)Zn-72	46.5 h	2.6 E-3	145(83)
Ge-76(n,γ)Ge-77m	54 s	7.4 E-2	160(10), 216(22)
		$_{33}$As	
As-75(γ,n)As-74	17.77 d	6.8 E-1	596(60), 608(.6), 635(15)
As-75(γ,αn)Ga-70	21.1 m	3.2 E-2	1039(.5)
As-75(n,γ)As-76	26.4 h	1.3 E-1	559(44), 657(6), 1216(3)
As-75(γ,2n)As-73	80.3 d	?	---
		$_{34}$Se	
Se-74(γ,n)Se-73	7.1 h	1.5 E-1	361(100), 865(.6), 1111(.2)
Se-74(γ,n)Se-73m	39 m	3.2	254(3), 393(5), 402(4)
Se-74(γ,np)As-72	26 h	1.0 E-3	630(10), 786(.5), 834(100)
Se-74(γ,p)As-73	80.3 d	?	---
Se-74(γ,αn)Ge-69	39 h	8.6 E-5	574(13), 873(9), 1107(28)
Se-76(γ,n)Se-75	120 d	1.3 E-2	136(55), 265(59),280(25)
Se-76(γ,np)As-74	17.77 d	8.0 E-5	596(60), 608(.6), 635(15)
Se-77(γ,p)As-76	26.4 h	4.4 E-2	559(44), 657(6), 1216(3)
Se-78(γ,n)Se-77m	17.5 s	1.1 E-1	162(52)
Se-78(γ,p)As-77	38.8 h	8.6 E-2	239(2), 250(.4), 521(.4)
Se-80(γ,n)Se-79m	3.9 m	5.9	96(10)
Se-80(γ,np)As-78	1.5 h	2.2 E-2	614(54), 695(18), 1309(13)
Se-80(γ,p)As-79	8.2 m	1.3	96(9), 432(2), 879(2)
Se-80(γ,αn)Ge-75	83 m	2.8 E-1	265(11)
Se-80(γ,αn)Ge-75m	48 s	3.2 E-2	140(34)
Se-82(γ,n)Se-81	18 m	5.4 E-1	276(.9), 290(.8), 828(.3)
Se-82(γ,n)Se-81m	57.3 m	2.5 E-1	103(8), 260(.01),

Reaction	T	N	E keV (I%)
		$_{35}$Br	
Br-79(γ,n)Br-78	6.46 m	5.2 E+4	614(14), 695(.1), 1020(.1)
Br-79(γ,2n)Br-77	56 h	2.2 E-1	239(22), 297(4), 520(24)
Br-79(γ,αn)As-74	17.77 d	2.8 E-5	596(60), 635(15)
Br-81(γ,n)Br-80	17.6 m	6.9 E+4	617(7), 640(.2), 666(1)
Br-81(γ,n)Br-80m	4.42 h	5.9	s. Br-80
Br-81(γ,αn)As-76	26.4 h	5.1 E-2	559(44), 657(6)
Br-81(γ,α)As-77	38.8 h	1.3	239(1), 250(.4), 521(.4)
Br-81(n,γ)Br-82	35.34 h	4.9 E-3	554(70), 619(44), 777(83)
Br-81(n,γ)Br-82m	6.1 m	5.4 E+4	698(.02), 777(.2)
		$_{37}$Rb	
Rb-85(γ,n)Rb-84	34.5 d	2.7 E-1	882(74), 1016(.5), 1897(.8)
Rb-85(γ,n)Rb-84m	21 m	4.7 E+2	215(37), 248(65), 464(32)
Rb-85(γ,2n)Rb-83	86.2 d	6.4 E-3	521(46), 529(31), 553(16)
Rb-85(γ,αn)Br-80	17.6 m	3.4	617(6), 666(1)
Rb-85(γ,αn)Br-80m	4.42 h	2.5 E+1	s. Br-80
Rb-87(γ,n)Rb-86	18.7 d	2.1 E-1	1077(9)
Rb-87(γ,n)Rb-86m	1.02 m	1.1 E+1	556(98)
Rb-87(γ,np)Kr-85m	4.48 h	8.9 E-2	151(74), 304(14)
Rb-87(γ,αn)Br-82	35.34 h	4.0 E-3	554(70), 777(83)
Rb-87(γ,αn)Br-82m	6.1 m	?	698(.02)
Rb-87(γ,α)Br-83	2.4 h	2.3 E-1	530(1)
		$_{38}$Sr	
Sr-84(γ,n)Sr-83	33 h	2.8 E-2	381(24), 418(7), 763(30)
Sr-84(γ,np)Rb-82	1.3 m	3.8 E-2	777(14)
Sr-84(γ,np)Rb-82m	6.3 h	6.1 E-3	554(61), 777(83), 1044(40)
Sr-84(γ,p)Rb-83	86.2 d	3.7 E-4	521(46), 529(31), 553(16)
Sr-84(γ,αn)Kr-79	34.9 h	w	261(13), 606(8)
Sr-84(γ,αn)Kr-79m	50 s	w	130(27)
Sr-86(γ,n)Sr-85	64.9 d	1.0 E-2	878(.02)
Sr-86(γ,n)Sr-85m	67.7 m	1.1 E+1	151(12), 232(85), 239(.3)
Sr-86(γ,np)Rb-84	34.5 d	8.2 E-6	882(74)
Sr-86(γ,np)Rb-84m	21 m	1.2 E-1	215(37), 248(65), 464(32)

Reaction	T	N	E keV (I%)
		($_{38}$Sr)	
Sr-87(γ,p)Rb-86	18.7 d	2.3 E-3	1077(9)
Sr-87(γ,p)Rb-86m	1.02 m	7.1 E-1	556(98)
Sr-88(γ,n)Sr-87m	2.81 h	4.3 E+1	388(79)
		$_{39}$Y	
Y-89(γ,n)Y-88	108 d	1.1 E-1	898(91), 1836(99), 2734(.6)
Y-89(γ,2n)Y-87	80.3 h	6.6 E-2	485(91)
Y-89(γ,2n)Y-87m	13 h	1.3 E-1	381(77)
Y-89(γ,np)Sr-87m	2.81 h	9.8 E-2	388(79)
Y-89(γ,αn)Rb-84m	21m	9.9 E-4	215(37), 248(65), 464(32)
Y-89(γ,γ´)Y-89m	16 s	3.3	909(99)
		$_{40}$Zr	
Zr-90(γ,n)Zr-89	78.4 h	1.6	909(99), 1713(.8), 1745(.1)
Zr-90(γ,n)Zr-89m	4.16 m	2.0 E+2	588(87), 1508(6)
Zr-90(γ,2n)Zr-88	83.4 d	1.5 E-3	394(97)
Zr-90(γ,np)Y-88	108 d	7.7 E-5	898(91), 1836(99)
Zr-90(γ,p)Y-89m	16 s	5.1	909(99)
Zr-91(γ,p)Y-90	64.1 h	3.4	1761(.003)
Zr-91(γ,p)Y-90m	3.19 h	1.2 E-1	202(97), 480(91)
Zr-91(γ,α)Sr-87m	2.81 h	1.5 E-2	388(79)
Zr-92(γ,p)Y-91	58.5 d	4.5 E-2	1208(.3)
Zr-92(γ,p)Y-91m	49.7 m	5.2 E-1	556(96)
Zr-94(γ,np)Y-92	3.54 h	1.0 E-2	935(14), 1405(5)
Zr-94(γ,p)Y-93	10.1 h	1.1 E-1	267(6), 947(2), 1914(2)
Zr-96(γ,n)Zr-95	64 d	5.0 E-2	724(44), 757(55)
Zr-96(γ,np)Y-94	19 m	3.0 E-1	919(56)
Zr-96(γ,p)Y-95	10.3 m	4.1	954(19), 2176(8)
Zr-96(γ,αn)Sr-91	9.5 h	w	556(60), 1024(36)
Zr-96(γ,α)Sr-92	2.71 h	7.0 E-3	1384(90)
Zr-95 Nb-95	(35.15 d)	---	766(100)
Zr-95 Nb-95m	(86.6 h)	---	235(?)

Reaction	T	N	E keV (I%)
		$_{41}$Nb	
Nb-93(γ,n)Nb-92m	10.15 d	5.4 E-1	912(2), 935(99), 1847(.8)
Nb-93(γ,2n)Nb-91m	62 d	3.2 E-3	105(2), 1205(3)
Nb-93(n,γ)Nb-94m	6.26 m	2.3	871(.2)
		$_{42}$Mo	
Mo-92(γ,n)Mo-91	15.5 m	2.7 E-1	1582(.2), 1637(.3)
Mo-92(γ,n)Mo-91m	65 s	1.4 E+1	653(48), 1208(19), 1508(25)
Mo-92(γ,2n)Mo-90	5.7 h	1.5 E-2	122(64), 203(6), 257(78)
Mo-92(γ,np)Nb-90	14.6 h	3.8 E-2	141(67), 1129(93), 2319(82)
Mo-92(γ,np)Nb-90m	19 s	1.5 E-1	122(64)
Mo-92(γ,p)Nb-91m	62 d	2.1 E-1	105(2), 1205(3)
Mo-94(γ,n)Mo-93m	6.9 h	3.2 E-1	263(57), 685(100)
Mo-94(γ,np)Nb-92m	10.15 d	2.6 E-4	912(2), 935(99)
Mo-95(γ,p)Nb-94m	6.26 m	7.9	871(.2)
Mo-96(γ,p)Nb-95	35.15 d	2.6 E-3	766(100)
Mo-96(γ,p)Nb-95m	86.6 h	8.5 E-3	235(?)
Mo-97(γ,p)Nb-96	23.4 h	7.7 E-2	569(56), 778(97), 1091(49)
Mo-98(γ,p)Nb-97	74 m	1.9	658(98), 1025(1), 1269(.2)
Mo-98(γ,p)Nb-97m	53 s	1.1	743(98)
Mo-100(γ,n)Mo-99	66 h	3.1 E-1	181(6), 739(13), 778(4)
Mo-100(γ,np)Nb-98	51 m	5.4 E-3	722(77), 787(3), 1169(18)
Mo-100(γ,p)Nb-99	2.6 m	1.9 E-1	98(23), 254(14), 2642(13)
Mo-100(n,γ)Mo-101	14.6 m	5.7 E-2	192(20), 591(17), 1013(13)
Mo-99 Tc-99m	(6 h)	---	141(89)
Mo-101 Tc-101	(14 m)	---	307(89)
		$_{44}$Ru	
Ru-96(γ,n)Ru-95	1.65 h	1.7 E+1	336(70), 627(18), 1097(22)
Ru-96(γ,2n)Ru-94	51.8 m	?	367(79), 892(21)
Ru-96(γ,np)Tc-94	4.9 h	5.0 E-2	703(100), 850(98), 871(100)
Ru-96(γ,np)Tc-94m	53 m	7.5 E-3	871(94), 1522(5), 1869(6)
Ru-96(γ,p)Tc-95	20 h	8.0 E-1	766(93), 948(2), 1074(4)
Ru-96(γ,p)Tc-95m	60 d	1.6 E-3	204(66), 582(35), 835(30)
Ru-98(γ,n)Ru-97	2.9 d	3.7 E-1	216(91), 325(11), 570(.8)

Reaction	T	N	E keV (I%)
		($_{44}$Ru)	
Ru-98(γ,np)Tc-96	4.3 d	2.6 E-4	778(100), 813(82), 850(97)
Ru-98(γ,np)Tc-96m	52 m	1.3 E-4	778(2)
Ru-100(γ,p)Tc-99m	6 h	4.7 E-1	141(90)
Ru-101(γ,p)Tc-100	15.8 s	4.3	540(7), 591(5)
Ru-102(γ,p)Tc-101	14 m	1.6 E-1	127(2), 307(89), 545(6)
Ru-104(γ,n)Ru-103	39.35 d	1.7 E-1	497(86), 557(.8), 610(5)
Ru-104(γ,np)Tc-102m	4.3 m	w	475(85), 630(29)
Ru-104(γ,p)Tc-103	50 s	?	136(100)
Ru-104(n,γ)Ru-105	4.44 h	2.0 E-2	469(18), 724(48)
Ru-105 Rh-105m	(45 s)	---	129(20)
		$_{45}$Rh	
Rh-103(γ,n)Rh-102	206 d	4.7 E-2	469(3), 475(46), 628(5)
Rh-103(γ,n)Rh-102m	2.9 a	8.5 E-4	475(95), 631(56), 697(44)
Rh-103(γ,2n)Rh-101	3 a	8.3 E-5	127(70), 198(70), 326(11)
Rh-103(γ,2n)Rh-101m	4.4 d	3.0 E-1	127(.6), 307(87), 545(4)
Rh-103(n,γ)Rh-104	42 s	1.3 E+2	556(2), 1237(.1)
Rh-103(n,γ)Rh-104m	4.4 m	9.1	97(3), 556(.2)
		$_{46}$Pd	
Pd-102(γ,n)Pd-101	8.47 h	8.4 E+1	296(18), 566(3), 590(12)
Pd-102(γ,2n)Pd-100	3.7 d	9.9 E-3	126(11), 159(2)
Pd-102(γ,np)Rh-100	20 h	2.6 E-2	540(78), 1553(22), 2376(32)
Pd-102(γ,p)Rh-101	3 a	5.9 E-6	127(90), 198(70)
Pd-102(γ,p)Rh-101m	4.4 d	8.8 E-1	127(.6), 307(87), 545(4)
Pd-104(γ,n)Pd-103	17 d	3.0	357(.02)
Pd-104(γ,np)Rh-102	206 d	9.2 E-5	475(46)
Pd-104(γ,np)Rh-102m	2.9 a	1.2 E-6	475(95), 631(56)
Pd-105(γ,p)Rh-104	42 s	2.1	556(2), 1237(.1)
Pd-105(γ,p)Rh-104m	4.4 m	1.5 E-1	97(3), 556(.2)
Pd-106(γ,p)Rh-105	35.5 h	8.5 E-2	280(.2), 306(5), 319(19)
Pd-106(γ,p)Rh-105m	45 s	4.1 E-1	130(20)
Pd-108(γ,n)Pd-107m	21.3 s	2.4	214(68)
Pd-108(γ,np)Rh-106	30 s	1.3 E-2	622(10)

Reaction	T	N	E keV (I%)
		($_{46}$Pd)	
Pd-108(γ,np)Rh-106m	2.2 h	6.5 E-1	616(20), 717(29), 1047(31)
Pd-108(γ,p)Rh-107	22 m	5.5 E-1	303(66), 312(5), 392(9)
Pd-110(γ,n)Pd-109	13.46 h	4.1 E+2	311(.03), 647(.03)
Pd-110(γ,n)Pd-109m	4.69 m	2.1	189(58)
Pd-110(γ,np)Rh-108	16.8 s	w	619(14)
Pd-110(γ,np)Rh-108m	5.9 m	w	434(91)
Pd-110(γ,p)Rh-109	80 s	2.1 E-1	178(12), 215(2), 327(62)
Pd-110(γ,p)Rh-109m	50 s	?	291(?)
Pd-109 Ag-109m	(39.6 s)	---	---
		$_{47}$Ag	
Ag-107(γ,n)Ag-106	24 m	1.1 E+3	623(.3), 873(.2), 1050(.2)
Ag-107(γ,n)Ag-106m	8.3 d	4.2 E-2	451(28), 717(29), 1046(30)
Ag-107(γ,2n)Ag-105	41.2 d	2.6 E-2	280(32), 345(42), 443(12)
Ag-109(γ,n)Ag-108	2.41 m	4.9 E+2	434(.5), 619(.3), 633(2)
Ag-109(γ,n)Ag-108m	127 a	1.5 E-5	434(92)
Ag-109(γ,2n)Ag-107m	44.3 s	2.9 E-1	93(5)
Ag-109(γ,γ')Ag-109m	39.6 s	1.9 E+1	---
Ag-109(γ,np)Pd-107m	21.3 s	1.4 E-1	214(75)
Ag-109(n,γ)Ag-110	24.6 s	1.4 E+1	658(5)
Ag-109(n,γ)Ag-110m	250.4 d	4.1 E-5	658(94), 885(73), 1384(25)
		$_{48}$Cd	
Cd-106(γ,n)Cd-105	55 m	5.5 E-2	607(4), 962(5), 1302(4)
Cd-106(γ,2n)Cd-104	57.7 m	w	709(20)
Cd-106(γ,np)Ag-104	69.2 h	9.2 E-4	556(92), 767(66), 942(25)
Cd-106(γ,np)Ag-104m	33.5 m	1.3 E-2	556(60); 1239(3), 2730(1)
Cd-106(γ,p)Ag-105	41.2 d	5.4 E-3	280(31), 345(42), 645(12)
Cd-108(γ,n)Cd-107	6.5 h	1.0 E-1	93(5), 829(.2), 898(.06)
Cd-108(γ,np)Ag-106	24 m	2.1	623(.3)
Cd-108(γ,np)Ag-106m	8.3 d	w	451(31)
Cd-108(γ,p)Ag-107m	44.3 s	6.8 E-1	93(5)
Cd-110(γ,np)Ag-108	2.41 m	2.7	434(.4), 619(.2), 633(2)
Cd-110(γ,p)Ag-109m	39.6 s	6.0 E-1	---

Reaction	T	N	E keV (I%)
		($_{48}$Cd)	
Cd-111(γ,p)Ag-110	24.6 s	7.6 E-1	658(5)
Cd-111(γ,p)Ag-110m	250.4 d	1.2 E-6	658(94), 885(72), 1384(26)
Cd-112(γ,n)Cd-111m	49 m	3.9 E-1	150(30), 246(94)
Cd-112(γ,p)Ag-111	7.5 d	6.0 E-2	342(5)
Cd-112(γ,p)Ag-111m	1.2 m	?	245(?)
Cd-113(γ,p)Ag-112	3.12 h	1.6 E-2	617(42), 694(4), 1388(5)
Cd-114(γ,p)Ag-113	5.37 h	5.2 E-2	259(2), 298(9), 672(1)
Cd-114(γ,p)Ag-113m	1.1 m	1.8 E-3	298(48), 316(100), 392(60)
Cd-116(γ,n)Cd-115	53.38 h	6.2 E-1	261(3), 492(15), 528(50)
Cd-116(γ,n)Cd-115m	44.8 d	2.4 E-4	934(2), 1290(.8)
Cd-116(γ,p)Ag-115	20 m	1.7 E-1	230(32)
Cd-115 In-115m	(4.5 h)	---	336(46)
		$_{49}$In	
In-113(γ,n)In-112	14.4 m	5.0	607(2), 617(6), 1253(.3)
In-113(γ,n)In-112m	20.8 m	3.8	155(13)
In-113(γ,2n)In-111	2.83 d	3.7 E-2	171(89), 245(94)
In-113(γ,2n)In-111m	7.6 m	4.8 E-2	537(87)
In-115(γ,n)In-114	71.9 s	7.6 E+3	1300(.1)
In-115(γ,n)In-114m	49.5 d	2.3 E-1	190(17), 558(3), 725(3)
In-115(γ,2n)In-113m	99.48 m	2.0	393(64)
In-115(γ,γ´)In-115m	4.5 h	3.8 E-4	336(46)
In-115(n,γ)In-116m1	54 m	9.1	417(32), 1097(56), 1294(85)
		$_{50}$Sn	
Sn-112(γ,n)Sn-111	35.3 m	1.4	761(.7), 1152(1), 1915(1)
Sn-112(γ,2n)Sn-110	4 h	3.0 E-1	283(98)
Sn-112(γ,np)In-110	69.1 m	1.0 E-1	658(98)
Sn-112(γ,np)In-110m	4.9 h	1.1 E-2	658(99), 885(95), 937(70)
Sn-112(γ,p)In-111	2.83 d	5.2 E-1	171(89), 245(94)
Sn-112(γ,p)In-111m	7.6 m	3.8 E-3	537(87)
Sn-114(γ,n)Sn-113	115.1 d	1.5 E-3	255(2), 392(64)
Sn-114(γ,np)In-112	14.4 m	w	617(6)

Reaction	T	N	E keV (I%)
		($_{50}$Sn)	
Sn-114(γ,np)In-112m	20.8 m	w	155(13)
Sn-114(γ,p)In-113m	99.48 m	4.1 E-2	393(64)
Sn-115(γ,p)In-114	71.9 s	9.0 E-1	1300(.1)
Sn-115(γ,p)In-114m	49.5 d	9.5 E-5	190(17)
Sn-116(γ,p)In-115m	4.5 h	1.8 E-1	336(46)
Sn-117(γ,p)In-116m1	54 m	3.6 E-2	417(32), 1097(56), 1293(85)
Sn-118(γ,n)Sn-117m	14 d	6.0 E-1	159(84)
Sn-118(γ,p)In-117	38 m	1.1 E-1	553(100)
Sn-118(γ,p)In-117m	1.95 h	4.7 E-2	315(17)
Sn-119(γ,p)In-118m	4.4 m	4.6 E-3	446(6), 683(55), 1051(82)
Sn-120(γ,p)In-119	2.3 m	1.1 E-3	763(100)
Sn-124(γ,n)Sn-123	129.2 d	2.3 E-3	1089(.6)
Sn-124(γ,n)Sn-123m	40.1 m	6.0	160(86), 382(.04)
		$_{51}$Sb	
Sb-121(γ,n)Sb-120	15.9 m	7.6 E+2	703(.3), 989(.1), 1172(2)
Sb-121(γ,n)Sb-120m	5.76 d	7.5 E-2	1023(100), 1172(100)
Sb-123(γ,n)Sb-122	2.7 d	2.6	564(70), 693(4), 1257(.8)
Sb-123(n,γ)Sb-124	60.3 d	3.4 E-4	603(98), 723(11), 1691(48),
		$_{52}$Te	
Te-120(γ,n)Te-119	16 h	5.1 E-3	644(84), 700(10), 1750(4)
Te-120(γ,n)Te-119m	4.7 d	3.9 E-4	153(66), 271(27), 1213(66)
Te-122(γ,n)Te-121	16.8 d	2.1 E-2	470(1), 508(18), 573(80)
Te-122(γ,n)Te-121m	154 d	7.3 E-4	212(83), 910(.07), 1102(2)
Te-122(γ,np)Sb-120m	5.76 d	w	1023(100), 1172(100)
Te-123(γ,p)Sb-122	2.7 d	5.9 E-4	564(66), 693(3), 1141(.7)
Te-124(γ,n)Te-123m	119.7 d	2.2 E-3	159(84)
Te-125(γ,p)Sb-124	60.3 d	3.6 E-4	603(98), 723(11), 1691(48)
Te-125(γ,p)Sb-124m	1.6 m	w	498(20)
Te-126(γ,n)Te-125m	58 d	8.7 E-3	109(.3)
Te-126(γ,p)Sb-125	2.77 a	7.9 E-5	428(30), 601(18), 636(12)
Te-128(γ,n)Te-127	9.35 h	1.1 E+1	203(.06), 360(.1), 418(1)
Te-128(γ,n)Te-127m	109 d	1.4 E-1	659(.01)

Reaction	T	N	E keV (I%)
		($_{52}$Te)	
Te-128(γ,np)Sb-126	12.4 d	8.5 E-6	415(88), 666(100), 695(100)
Te-128(γ,p)Sb-127	3.85 d	1.5 E-2	473(25), 686(36), 784(15)
Te-130(γ,n)Te-129	69.6 m	1.9 E+1	278(.6), 460(7), 487(1)
Te-130(γ,n)Te-129m	33.6 d	7.0 E-2	696(3), 730(.7)
Te-130(γ,p)Sb-129	4.32 h	3.3 E-2	544(19), 813(46), 915(21)
Te-130(n,γ)Te-131	25 m	6.2 E-4	150(68)
		$_{53}$I	
I-127(γ,n)I-126	13 d	1.1	389(35), 666(34), 754(4)
I-127(γ,2n)I-125	60.14 d	4.1 E-2	---
I-127(n,γ)I-128	25 m	3.7	443(16), 527(2)
		$_{55}$Cs	
Cs-133(γ,n)Cs-132	6.47 d	2.4	465(2), 630(1), 668(100)
Cs-133(n,γ)Cs-134	2.06 a	7.2 E-4	605(98)
Cs-133(n,γ)Cs-134m	2.9 h	2.2 E+1	127(13)
		$_{56}$Ba	
Ba-130(γ,n)Ba-129m	2.13 h	2.1 E-2	182(100), 221(53), 1459(56)
Ba-130(γ,2n)Ba-128	2.43 d	?	---
Ba-130(γ,p)Cs-129	32.06 h	1.3 E-2	372(32), 411(23), 549(4)
Ba-132(γ,n)Ba-131	11.5 d	1.5 E-3	216(22), 373(13), 496(42)
Ba-132(γ,n)Ba-131m	14.5 m	1.3 E-1	108(56)
Ba-134(γ,n)Ba-133	10.5 a	1.1 E-4	303(18), 356(62)
Ba-134(γ,n)Ba-133m	38.9 h	7.4 E-2	276(18)
Ba-135(γ,p)Cs-134m	2.9 h	7.8 E-4	127(13)
Ba-136(γ,n)Ba-135m	28.7 h	2.6 E-1	268(16)
Ba-136(γ,p)Cs-135m	53 m	7.7 E-4	787(100), 840(96)
Ba-137(γ,p)Cs-136	13 d	1.1 E-3	818(100), 1048(80)
Ba-138(γ,n)Ba-137m	2.55 m	6.8 E+1	662(90)
Ba-138(n,γ)Ba-139	82.7 m	1.1 E-2	166(22)
Ba-128 Cs-128	(3.8 m)	---	443(26)

Reaction	T	N	E keV (I%)
		$_{57}$La	
La-138(γ,2n)La-136	9.9 m	2.3 E-1	760(.3), 819(3)
La-138(γ,p)Ba-137m	2.55 m	1.5 E-1	662(90)
La-139(n,γ)La-140	40.2 h	1.2 E-2	487(45), 816(23), 1596(96)
		$_{58}$Ce	
Ce-136(γ,n)Ce-135	17 h	1.5 E-1	266(42), 300(24), 606(22)
Ce-136(γ,2n)Ce-134	72 h	?	---
Ce-136(γ,p)La-135	19.4 h	3.6 E-2	481(2)
Ce-138(γ,n)Ce-137	9 h	6.4 E-2	436(.3), 447(2), 916(.07)
Ce-138(γ,n)Ce-137m	34.4 h	4.5 E-3	169(.4), 254(11), 825(.4)
Ce-140(γ,n)Ce-139	137.5 d	1.4 E-1	166(80)
Ce-140(γ,n)Ce-139m	56.5 s	6.8 E+2	754(93)
Ce-142(γ,n)Ce-141	32.51 d	5.6 E-2	145(49)
Ce-142(γ,p)La-141	3.94 h	3.6 E-4	1354(3)
Ce-142(n,γ)Ce-143	33 h	2.1 E-4	293(42)
Ce-134 La-134	(6.8 m)	---	605(5)
La-135 Ba-135m	(28.7 h)	---	268(16)
		$_{59}$Pr	
Pr-141(γ,n)Pr-140	3.4 m	1.9 E+2	307(.2), 1596(.5)
Pr-141(γ,2n)Pr-139	4.5 h	1.0 E+2	255(.2), 1347(.4), 1631(.3)
Pr-141(γ,3n)Pr-138	144 m	w	789(2)
Pr-141(γ,3n)Pr-138m	2.02 h	w	789(99), 1038(100)
Pr-141(n,γ)Pr-142	19.2 h	4.8 E-2	1576(4)
		$_{60}$Nd	
Nd-142(γ,n)Nd-141	2.5 h	1.6 E+1	1127(.7), 1293(.4)
Nd-142(γ,n)Nd-141m	62 s	5.5	757(91)
Nd-142(γ,2n)Nd-140	3.38 d	?	---
Nd-142(γ,3n)Nd-139m	5.5 h	2.3 E-4	708(26), 738(35), 982(26)
Nd-143(γ,p)Pr-142	19.2 h	2.5 E-2	1576(4)
Nd-145(γ,p)Pr-144	17.3 m	1.3 E-1	696(1), 1489(.3), 2186(.7)
Nd-146(γ,p)Pr-145	5.98 h	1.1 E-1	676(.4)

Reaction	T	N	E keV (I%)
		($_{60}$Nd)	
Nd-148(γ,n)Nd-147	10.98 d	5.4 E-2	91(27), 319(2), 531(12)
Nd-148(γ,p)Pr-147	12 m	?	315(22)
Nd-150(γ,n)Nd-149	1.73 h	2.6	114(21), 211(31), 279(19)
Nd-140 Pr-140	(3.4 m)	---	307(.2)
Nd-139m Nd-139	(29.7 m)	---	405(6)
Nd-139 Nd-139m Pr-139	(4.5 h)	---	255(.2)
Nd-149 Pm-149	(53.1 h)	---	286(3)
		$_{62}$Sm	
Sm-144(γ,n)Sm-143	8.83 m	1.9 E+1	1057(2), 1173(.5), 1515(.7)
Sm-144(γ,n)Sm-143m	65 s	1.3	754(90)
Sm-144(γ,2n)Sm-142	72.4 m	?	---
Sm-144(γ,3n)Sm-141	11.3 m	?	---
Sm-144(γ,3n)Sm-141m	22.6 m	w	197(74), 432(40)
Sm-144(γ,p)Pm-143	265 d	1.7 E-3	742(39)
Sm-147(γ,2n)Sm-145	340 d	?	492(.003)
Sm-147(γ,p)Pm-146	5.53 a	2.2 E-5	454(63)
Sm-149(γ,p)Pm-148	5.37 d	2.2 E-3	550(23), 914(13), 1465(22)
Sm-149(γ,p)Pm-148m	41.3 d	2.0 E-4	550(93), 630(89), 726(32)
Sm-150(γ,p)Pm-149	53.1 h	8.1 E-2	286(3), 859(.1)
Sm-152(γ,n)Sm-151	93 a	2.5 E-4	---
Sm-152(γ,p)Pm-151	28 h	2.0 E-2	168(8), 275(6), 340(22)
Sm-154(γ,n)Sm-153	46.75 h	4.4	103(28), 173(.08), 531(.08)
Sm-154(n,γ)Sm-155	22.4 m	3.9 E-1	104(70), 246(4)
Sm-142 Pm-142	(40.5 s)	---	1576(3)
Sm-141 Sm-141m Pm-141	(20.9 m)	---	194(1), 1223(4)
Pm-141 Nd-141	(2.5 h)	---	1127(.7)
		$_{63}$Eu	
Eu-151(γ,n)Eu-150	36 a	1.4 E-4	334(94), 439(79), 584(52)
Eu-151(γ,n)Eu-150m	12.6 h	5.9	334(4), 407(3), 832(.2)
Eu-151(γ,2n)Eu-149	93.1 d	1.4 E-2	255(.6), 277(3), 328(4)

Reaction	T	N	E keV (I%)
		($_{63}$Eu)	
Eu-151(γ,3n)Eu-148	54 d	4.3 E-4	414(19), 551(116), 611(19)
Eu-153(γ,n)Eu-152	12.4 a	8.3 E-4	122(31), 344(37), 1408(21)
Eu-153(γ,n)Eu-152m1	96 m	3.8	90(72)
Eu-153(γ,n)Eu-152m2	9.3 h	7.5 E-1	122(6), 842(13), 963(12)
Eu-153(n,γ)Eu-154	8.5 a	1.9 E-4	123(40), 723(19), 1275(35)
		$_{64}$Gd	
Gd-152(γ,n)Gd-151	120 d	3.4 E-4	154(7), 175(4), 243(7)
Gd-152(γ,3n)Gd-149	9.5 d	2.7 E-5	150(53), 299(31), 347(25)
Gd-154(γ,n)Gd-153	241.6 d	3.5 E-3	97(27), 103(19)
Gd-155(γ,p)Eu-154	8.5 a	1.6 E-4	123(40), 723(19), 1275(35)
Gd-156(γ,p)Eu-155	4.96 a	w	105(23)
Gd-157(γ,p)Eu-156	15.2 d	9.4 E-4	812(10), 1154(12), 1231(8)
Gd-158(γ,p)Eu-157	15.15 h	1.2 E-2	373(11), 413(17), 619(4)
Gd-160(γ,n)Gd-159	18.56 h	4.4	363(10), 560(.02), 581(.06)
Gd-160(γ,p)Eu-159	18.7 m	4.1 E-1	96(7), 146(3), 805(3)
Gd-160(n,γ)Gd-161	3.6 m	1.0 E-1	283(6), 315(23), 361(61)
Gd-149 Eu-149	(93.1 d)	---	277(3), 328(4)
		$_{65}$Tb	
Tb-159(γ,n)Tb-158	150 a	2.2 E-4	780(9), 944(43), 962(20)
Tb-159(γ,3n)Tb-156	5.35 d	1.2 E-2	199(42), 534(66), 1222(32)
Tb-159(γ,3n)Tb-156m	5.4 h	?	---
Tb-159(n,γ)Tb-160	72.1 d	4.3 E-3	299(27), 879(30), 966(25)
		$_{66}$Dy	
Dy-156(γ,n)Dy-155	9.59 h	1.5 E-2	185(4), 227(68), 1000(3)
Dy-156(γ,p)Tb-155	5.32 d	2.1 E-3	105(23), 163(7), 180(7)
Dy-158(γ,n)Dy-157	8.1 h	3.6 E-2	182(2), 326(94), 598(.08)
Dy-160(γ,n)Dy-159	144.4 d	3.8 E-2	139(?)
Dy-161(γ,p)Tb-160	72.1 d	1.7 E-4	299(27), 879(30), 966(25)
Dy-162(γ,p)Tb-161	6.9 d	9.8 E-3	103(.2)
Dy-163(γ,p)Tb-162	7.6 m	3.4 E-1	260(80), 807(43), 888(39)

Reaction	T	N	E keV (I%)
		($_{66}$Dy)	
Dy-164(γ,p)Tb-163	19.5 m	3.6 E-1	351(26), 390(24), 495(23)
Dy-164(n,γ)Dy-165	2.35 h	9.5 E-1	95(4), 633(.6), 715(.5)
Dy-164(n,γ)Dy-165m	1.3 m	1.1	108(3), 154(.2), 362(.5)
		$_{67}$Ho	
Ho-165(γ,n)Ho-164	29 m	3.4 E+1	91(3)
Ho-165(γ,n)Ho-164m	37 m	4.1 E+1	---
Ho-165(γ,3n)Ho-162m	68 m	3.6 E-1	185(29), 937(11), 1220(23)
Ho-165(n,γ)Ho-166	26.7 h	4.4 E-1	1379(.9), 1582(.2)
		$_{68}$Er	
Er-162(γ,n)Er-161	3.1 h	2.1 E-1	211(12), 593(3), 827(61)
Er-162(γ,2n)Er-160	28.6 h	?	---
Er-162(γ,3n)Er-159	36 m	w	206(9), 624(37), 649(28)
Er-162(γ,p)Ho-161	2.5 h	3.7 E-2	103(3), 157(.5), 176(.4)
Er-164(γ,n)Er-163	75 m	5.3	436(.03), 440(.03)
Er-167(γ,p)Ho-166	26.7 h	1.1 E-2	1379(.9), 1582(.2)
Er-168(γ,p)Ho-167	3.1 h	1.2 E-1	238(5), 321(24), 347(57)
Er-170(γ,p)Ho-169	4.6 m	1.4	778(11), 788(23), 853(12)
Er-170(n,γ)Er-171	7.5 h	2.4 E-2	112(20), 296(29), 308(64)
Er-160 Ho-160m	(5 h)	---	728(30), 879(20), 962(18)
Ho-160m Ho-160	(26 m)	---	see Ho-160m
Er-159 Ho-159	(33 m)	---	121(34), 132(23), 310(14)
Er-159 Ho-159m	(8.3 s)	---	206(40)
Er-163 Ho-163m	(1.1 s)	---	299(78)
		$_{69}$Tm	
Tm-169(γ,n)Tm-168	93.1 d	1.7 E-1	198(50), 447(22), 816(46)
Tm-169(γ,2n)Tm-167	9.25 d	3.5 E-1	208(41), 532(1)
Tm-169(γ,3n)Tm-166	7.7 h	3.5 E-3	184(16), 779(20), 2053(20)
Tm-169(n,γ)Tm-170	128.6 d	1.5 E-1	---
Tm-167 Er-167m	(2.3 s)	---	208(43)

Reaction	T	N	E keV (I%)
		$_{70}$Yb	
Yb-168(γ,n)Yb-167	17.7 m	9.1 E-1	106(22), 113(54), 176(23)
Yb-168(γ,2n)Yb-166	56.7 h	2.1 E-3	---
Yb-168(γ,3n)Yb-165	10.5 m	1.2 E-1	1090(3)
Yb-168(γ,p)Tm-167	9.25 d	2.8 E-3	208(41), 532(1)
Yb-170(γ,n)Yb-169	30.7 d	2.8 E-2	110(18), 177(22), 198(35)
Yb-171(γ,p)Tm-170	128.6 d	4.8 E-2	---
Yb-173(γ,p)Tm-172	63.6 h	5.5 E-3	1094(6), 1387(5), 1530(5)
Yb-174(γ,p)Tm-173	8.2 h	4.4 E-1	399(88), 465(8)
Yb-176(γ,n)Yb-175	4.2 d	1.1	114(2), 283(3), 396(6)
Yb-176(γ,p)Tm-175	15.2 m	3.0 E-1	364(13), 941(14), 982(11)
Yb-176(n,γ)Yb-177	1.9 h	1.9 E-2	150(20), 1080(5), 1241(3)
Yb-166 Tm-166	(7.7 h)	---	184(16), 779(20), 2053(20)
		$_{71}$Lu	
Lu-175(γ,n)Lu-174	3.31 a	6.3 E-3	1242(6), 1318(.08)
Lu-175(γ,n)Lu-174m	142 d	8.6 E-3	273(.7), 992(.7)
Lu-175(γ,2n)Lu-173	1.37 a	6.7 E-3	101(3), 171(2), 272(13)
Lu-175(γ,3n)Lu-172	6.7 d	9.7 E-3	181(20), 901(28), 1094(63)
Lu-175(n,γ) Lu-176m	3.68 h	3.9	---
Lu-176(γ,γ´)			
Lu-176(γ,p)Yb-175	4.2 d	3.9 E-3	114(2), 283(3), 396(6)
Lu-176(n,γ)Lu-177m	161 d	3.1 E-4	208(61), 228(37), 379(28)
		$_{72}$Hf	
Hf-174(γ,n)Hf-173	23.6 h	1.9 E-2	124(83), 297(34), 311(11)
Hf-174(γ,p)Lu-173	1.37 a	w	272(13)
Hf-176(γ,n)Hf-175	70 d	3.2 E-2	230(.8), 343(87), 433(1)
Hf-177(γ,p)Lu-176m	3.68 h	1.7 E-2	---
Hf-178(γ,p)Lu-177	6.71 d	7.1 E-3	113(7), 208(11), 250(.2)
Hf-178(γ,p)Lu-177m	161 d	6.7 E-4	208(61), 228(37), 379(28)
Hf-179(γ,p)Lu-178	28.4 m	w	1341(5)
Hf-179(γ,p)Lu-178m	22.7 m	3.4 E-2	213(82), 325(94), 426(94)
Hf-179(γ,n)Hf-178n	31 a	w	326(94), 426(97), 574(84)
Hf-180(γ,n)Hf-179m	18.7 s	1.0 E+2	214(95)

Reaction	T	N	E keV (I%)
		($_{72}$Hf)	
Hf-180(γ,n)Hf-179n	25 d	?	453(65)
Hf-180(γ,p)Lu-179	4.6 h	?	214(12)
Hf-180(γ,γ')Hf-180m	5.5 h	3.4 E-3	215(82), 332(94), 443(85)
Hf-180(n,γ)Hf-181	42.4 d	3.6 E-4	133(40), 346(13), 482(81)
		$_{73}$Ta	
Ta-180(γ,2n)Ta-178	9.25 m	4.4	93(6), 1341(1), 1351(1)
Ta-180(γ,2n)Ta-178m	2.2 h	2.3 E-1	214(80), 326(94), 426(100)
Ta-180(γ,3n)Ta-177	56.6 h	1.7 E-3	113(7), 208(.8)
Ta-180(γ,p)Hf-179m	18.7 s	2.3 E-2	214(95)
Ta-181(γ,n)Ta-180m	8.1 h	4.5 E+1	93(4), 102(.6)
Ta-181(γ,p)Hf-180m	5.5 h	2.7 E-2	215(82), 332(94), 443(85)
Ta-181(n,γ)Ta-182	115 d	2.3 E-3	1121(35), 1221(27)
Ta-178 Hf-178m	(4.3 s)	---	326(94), 426(80)
		$_{74}$W	
W-180(γ,n)W-179	38 m	3.9 E-1	134(.1)
W-180(γ,n)W-179m	6.7 m	3.4 E-2	222(9), 239(.2), 282(.2)
W-182(γ,n)W-181	121.2 d	9.2	136(.1), 152(.2)
W-183(γ,p)Ta-182	115 d	2.4 E-3	1121(35), 1221(27)
W-183(γ,p)Ta-182m	16 m	1.0 E-3	147(36), 172(47), 185(23)
W-184(γ,p)Ta-183	5 d	5.7 E-3	108(13), 246(36), 354(11)
W-186(γ,n)W-185	75.1 d	1.5 E-1	126(.02)
W-186(γ,n)W-185m	1.68 m	3.6 E-1	132(4), 174(3), 188(.8)
W-186(γ,p)Ta-185	49 m	?	178(26)
W-186(n,γ)W-187	23.8 h	1.1 E-1	134(9), 479(21), 686(26)
		$_{75}$Re	
Re-185(γ,n)Re-184	38 d	2.0 E-1	111(17), 792(38), 903(38)
Re-185(γ,n)Re-184m	165 d	?	216(10)
Re-185(γ,2n)Re-183	71 d	2.9 E-2	162(24), 209(3), 292(3)
Re-185(γ,3n)Re-182	64 h	2.0 E-3	100(15), 229(27), 1121(21)
Re-185(γ,3n)Re-182m	13 h	w	1121(32)

Reaction	T	N	E keV (I%)
		($_{75}$Re)	
Re-187(γ,n)Re-186	90.64 h	2.8	123(.7), 137(9)
Re-187(n,γ)Re-188	16.98 h	5.9 E-1	155(15), 478(1), 633(1)
Re-187(n,γ)Re-188m	18.6 m	1.6 E-1	106(11)
		$_{76}$Os	
Os-184(γ,n)Os-183	14 h	2.7 E-3	168(8), 382(86), 851(4)
Os-184(γ,n)Os-183m	10 h	1.0 E-2	1035(7), 1102(55), 1108(25)
Os-184(γ,2n)Os-182	22.1 h	1.3 E-4	131(3), 180(33)
Os-184(γ,3n)Os-181	1.8 h	?	239(46)
Os-184(γ,p)Re-183	71 d	4.9 E-3	162(24)
Os-186(γ,n)Os-185	94 d	3.6 E-3	646(82), 875(7), 880(5)
Os-187(γ,p)Re-186	90.64 h	1.3	137(9)
Os-189(γ,p)Re-188	16.98 h	8.2 E-3	155(15), 633(1)
Os-189(γ,p)Re-188m	18.6 m	2.0 E-4	106(11)
Os-190(γ,p)Re-189	24.3 h	2.3 E-2	186(2), 219(10), 245(3)
Os-192(γ,n)Os-191	15.4 d	7.7 E-4	130(26)
Os-192(γ,n)Os-191m	13.03 h	?	---
Os-192(γ,2n)Os-190m	9.9 m	1.8 E-2	187(79), 361(99), 616(99)
Os-192(n,γ)Os-193	30 h	9.8 E-3	139(4), 387(1), 461(4)
		$_{77}$Ir	
Ir-191(γ,n)Ir-190	12.1 d	7.1 E-1	187(52), 518(34), 605(39)
Ir-191(γ,n)Ir-190m	3.1 h	2.8	361(91), 503(94), 617(94)
Ir-191(γ,p)Os-190m	9.9 m	2.9	361(99), 503(94), 616(99)
Ir-191(γ,2n)Ir-189	13.3 d	4.8 E-2	245(6)
Ir-191(γ,3n)Ir-188	41.5 h	7.7 E-4	155(30), 633(23), 2215(19)
Ir-193(γ,n)Ir-192	74 d	1.3 E-1	308(30), 316(83), 468(48)
Ir-193(n,γ)Ir-194	19.4 h	9.3 E-2	294(2), 328(13), 645(1)
Ir-193(n,γ)Ir-194m	171 d	5.4 E-3	329(93), 483(97)
		$_{78}$Pt	
Pt-190(γ,n)Pt-189	11 h	9.8 E-2	94(5), 608(5), 721(6)
Pt-190(γ,2n)Pt-188	10.2 d	3.8 E-3	188(19), 195(18), 382(7)

Reaction	T	N	E keV (I%)
		($_{78}$Pt)	
Pt-190(γ,p)Ir-189	13.3 d	2.7 E-4	245(6)
Pt-192(γ,n)Pt-191	2.8 d	5.3 E-2	360(6), 409(8), 539(14)
Pt-194(γ,n)Pt-193m	4.33 d	9.3 E-1	136(.1)
Pt-195(γ,p)Ir-194	19.4 h	3.0 E-2	294(2), 328(13), 645(1)
Pt-195(γ,p)Ir-194m	171 d	w	329(93)
Pt-196(γ,n)Pt-195m	4.02 d	5.9 E-1	130(3), 240(.06)
Pt-196(γ,p)Ir-195	2.5 h	3.8 E-2	99(9), 130(.1), 211(?)
Pt-196(γ,p)Ir-195m	3.8 h	1.5 E-2	320(13), 365(13), 685(13)
Pt-198(γ,n)Pt-197	20 h	2.2	191(4), 269(.3)
Pt-198(γ,n)Pt-197m	81 m	2.7	279(2), 346(11)
Pt-198(n,γ)Pt-199	30.8 m	w	543(15)
Pt-188 Ir-188	(41.5 h)	---	155(30)
Pt-197m Au-197m	(7.8 s)	---	130(3), 279(73)
		$_{79}$Au	
Au-197(γ,n)Au-196	6.2 d	2.6	333(23), 356(88), 426(7)
Au-197(γ,n)Au-196m	9.7 h	1.2 E+1	148(43), 168(8), 188(38)
Au-197(γ,2n)Au-195	183 d	7.2 E-3	99(11), 130(.8)
Au-197(γ,3n)Au-194	39.5 h	7.6 E-2	294(11), 329(61), 1469(6)
Au-197(n,γ)Au-198	2.695 d	8.8 E-2	412(96), 676(1), 1088(.2)
Au-195 Pt-195m	(4.02 d)	---	99(11), 130(3), 240(.06)
		$_{80}$Hg	
Hg-196(γ,n)Hg-195	9.5 h	7.7 E-2	262(2), 585(2), 780(8)
Hg-196(γ,n)Hg-195m	40 h	2.3 E-3	262(38), 388(3), 560(9)
Hg-196(γ,3n)Hg-193m	11.1 h	w	258(60)
Hg-196(γ,p)Au-195	183 d	1.0 E-3	99(11)
Hg-198(γ,n)Hg-197	64.1 h	1.4 E-1	191(.5), 269(.04)
Hg-198(γ,n)Hg-197m	23.8 h	1.7 E-1	134(34), 165(.3), 279(5)
Hg-199(γ,p)Au-198	2.695 d	5.1 E-3	412(96)
Hg-200(γ,n)Hg-199m	42.6 m	5.3	158(52), 374(12)
Hg-200(γ,p)Au-199	3.13 d	5.9 E-3	158(39), 208(8)
Hg-201(γ,p)Au-200	48.4 m	3.2 E-2	368(21), 1226(15), 1263(4)
Hg-201(γ,p)Au-200m	18.7 h	5.2 E-6	368(83), 498(82), 579(80)

Reaction	T	N	E keV (I%)
		($_{80}$Hg)	
Hg-202(γ,p)Au-201	26.4 m	7.2 E-1	527(.7)
Hg-204(γ,n)Hg-203	46.6 d	3.7 E-2	279(82)
Hg-193m Au-193m	(3.9 s)	---	257(?)
Hg-197m Au-197m	(7.8 s)	---	130(3), 279(73)
		$_{81}$Tl	
Tl-203(γ,n)Tl-202	12.2 d	4.3 E-1	439(91), 520(.1), 960(.1)
Tl-203(γ,2n)Tl-201	73.5 h	3.0 E-1	135(2), 167(9)
Tl-203(γ,3n)Tl-200	26.1 h	8.4 E-5	368(88), 1206(30)
		$_{82}$Pb	
Pb-204(γ,n)Pb-203	52.1 h	1.4 E-1	279(81), 401(4), 681(.7)
Pb-204(γ,2n)Pb-202m	3.62 h	2.7 E-4	422(86), 658(33), 961(92)
Pb-204(γ,3n)Pb-201	9.4 h	w	331(78)
Pb-206(γ,2n)Pb-204m	66.9 m	3.8 E-2	374(90), 899(99), 912(96)
Pb-201 Tl-201	(73.5 h)	---	167(9)
		$_{83}$Bi	
Bi-209(γ,2n)Bi-207	38 a	2.7 E-4	570(98), 1064(74), 1770(7)
Bi-209(γ,3n)Bi-206	6.24 d	2.9 E-3	516(41), 803(99), 881(67)
		$_{92}$U	
U-238(γ,n)U-237	6.75 d	1.6	165(2), 208(23), 332(1)

5.3.2 Low energy photon spectra

In table 5-3, ordered by the atomic number of the target element, low energy ($E \leq 90$ keV; characteristic X-ray and low energy gamma-ray) photons emitted after bremsstrahlung irradiation are listed. In the first column the photon energy is given as accurately as available from the Table of Isotopes[690]. In brackets behind, the percent emission probabilities are presented. The data in the second column indicate the origin of the energy (kX or LX-ray series or low energy gamma). In the third column the nuclides are given, by which the radiations are emitted, and in the last column the half-lives of these nuclides are listed.

E keV (I%)	Origin	Nuclide	T
	$_{23}$V		
4.51 (?)	kα1 Ti	V-49	330 d
4.9 (?)	kβ Ti	V-49	330 d
	$_{24}$Cr		
4.95 (?)	kα1 V	Cr-51	27.7 d
5.4 (?)	kβ V	Cr-51	27.7 d
	$_{25}$Mn		
5.41 (15)	kα1 Cr	Mn-54	312.2 d
6.0 (3)	kβ Cr	Mn-54	312.2 d
	$_{26}$Fe		
5.90 (w)	kα1 Mn	Fe-55	2.7 a
6.5 (w)	kβ Mn	Fe-55	2.7 a
	$_{27}$Co		
6.40 (20)	kα1 Fe	Co-58	70.78 d
		Co-57	270 d
6.93 (22)	kα1 Co	Co-58m	8.94 h
7.1 (2)	kβ Fe	s. kα1 Fe	
7.7 (2)	kβ Co	s. kα1 Co	
14.4 (10)	γ	Co-57	270 d
24.9 (0.03)	γ	Co-58m	8.94 h
	$_{28}$Ni		
6.40 (20)	kα1 Fe	Co-57	270 d
		Co-58	70.78 d
6.93 (10)	kα1 Co	Ni-57	36 h
		Co-58m	8.94 h
7.1 (2)	kβ Fe	s. kα1 Fe	
7.7 (2)	kβ Co	s. kα1 Co	
14.4 (10)	γ	Co-57	270 d
	$_{29}$Cu		
7.48 (14)	kα1 Ni	Cu-64	12.7 h
		Cu-61	3.3 h
8.3 (2)	kβ Ni	s. kα1 Ni	
	$_{30}$Zn		
8.05 (35)	kα1 Cu	Zn-62	9.13 h
		Zn-65	244 d
8.64 (w)	kα1 Zn	Zn-69m	13.9 h
8.9 (6)	kβ Cu	s. kα1 Cu	
9.6 (w)	kβ Zn	s. kα1 Zn	

E keV (I%)	Origin	Nuclide	T
	($_{30}$Zn)		
40.9 (25)	γ	Zn-62	9.13 h
	$_{31}$Ga		
8.64 (2)	kα1 Zn	Ga-67	78.3 h
		Ga-68	68.3 m
9.6 (1)	kβ Zn	s. kα1 Zn	
	$_{32}$Ge		
9.25 (30)	kα1 Ga	Ge-69	39 h
		Ge-71	11.2 d
		Ge-68	287 d
10.2 (6)	kβ Ga	s. kα1 Ga	
53.5 (10)	γ	Ga-73	4.8 h
68.7 (0.2)	γ	Ga-73	4.8 h
	$_{33}$As		
9.89 (16)	kα1 Ge	As-74	17.77 d
		As-73	80.3 d
11.0 (3)	kβ Ge	s. kβ1 Ge	
53.4 (10)	γ	As-73	80.3 d

E keV (I%)	Origin	Nuclide	T
	$_{34}$Se		
9.89 (16)	kα1 Ge	As-73	80.3 d
10.54 (15)	kα1 As	Se-73	7.1 h
		Se-75	120 d
		Se-72	8.5 d
11.0 (3)	kβ1 Ge	s. kα1 Ge	
11.7 (3)	kβ1 As	s. kα1 As	
46.0 (57)	γ	Se-72	8.5 d
53.4 (10)	γ	As-73	80.3 d
88.0 (0.3)	γ	As-77	38.8 d
	$_{35}$Br		
11.22 (50)	kα1 Se	Br-77	56 h
11.92 (100)	kα1 Br	Br-80m	4.42 h
12.5 (10)	kβ1 Se	s. kα1 Se	
13.3 (21)	kβ1 Br	s. kα1 Br	
37.1 (39)	γ	Br-80m	4.42 h
48.9 (0.5)	γ	Br-80m	4.42 h
87.6 (1.1)	γ	Br-77	56 h
	$_{37}$Rb		
9.4 (6)	γ	Rb-83	86.2 d
9.4 (5)	γ	Kr-83m	(1.83 h)

E keV (I%)	Origin	Nuclide	T
	($_{37}$Rb)		
12.65 (35)	kα1 Kr	Rb-84	34.5 d
		Rb-83	86.2 d
14.1 (7)	kβ1 Kr	s. kα1 Kr	
	$_{38}$Sr		
9.4 (6)	γ	Rb-83	86.2 d
12.65 (35)	kα1 Kr	Rb-83	86.2 d
13.40 (50)	kα1 Rb	Sr-83	33 h
		Sr-85	64.9 d
14.1 (7)	kβ1 Kr	s. kα1 Kr	
14.17 (99)	kα1 Sr	Sr-87m	2.81 h
15.2 (11)	kβ1 Rb	s. kα1 Rb	
15.8 (22)	kβ1 Sr	s. kα1 Sr	
42.3 (2)	γ	Sr-83	33 h
	$_{39}$Y		
14.17 (53)	kα1 Sr	Y-88	108 d
		Y-87	80.3 h
		Sr-87m	2.81 h
14.96 (10)	kα1 Y	Y-87m	13 h
15.8 (12)	kβ1 Sr	s. kα1 Sr	
16.7 (2)	kβ1 Y	s. kα1 Y	

E keV (I%)	Origin	Nuclide	T
	$_{40}$Zr		
14.96 (40)	kα1 Y	Zr-89	78.4 h
		Zr-88	83.4 d
16.7 (9)	kβ1 Y	s. kα1 Y	
	$_{41}$Nb		
15.78 (50)	kα1 Zr	Nb-92m	10.15 d
16.62 (40)	kα1 Nb	Nb-91m	62 d
17.7 (12)	kβ1 Zr	s. kα1 Zr	
18.6 (9)	kβ1 Nb	s. kα1 Nb	
	$_{42}$Mo		
16.62 (40)	kα1 Nb	Nb-91m	62 d
		Mo-90	5.7 h
		Nb-95m	86.6 h
18.37 (10)	kα1 Tc	Tc-99m	(6 h)
18.6 (9)	kβ1 Nb	s. kα1 Nb	
20.6 (2)	kβ1 Tc	s. kα1 Tc	
	$_{44}$Ru		
17.48 (50)	kα1 Mo	Tc-95	20 h
		Tc-95m	60 d

E keV (I%)	Origin	Nuclide	T
		($_{44}$Ru)	
18.37 (40)	kα1 Tc	Ru-95	1.65 h
		Tc-99m	6 h
		Ru-97	2.9 d
		Tc-97m	91 d
19.6 (12)	kβ1 Mo	s. kα1 Mo	
20.22 (64)	kα1 Rh	Rh-103m	(56.1 m)
20.6 (10)	kβ1 Tc	s. kα1 Tc	
22.7 (16)	kα1 Rh	s. kβ1 Rh	
		$_{45}$Rh	
19.28 (58)	kα1 Ru	Rh-101m	4.4 d
		Rh-102	206 d
		Rh-102m	2.9 a
		Rh-101	3 a
20.22 (5)	kα1 Rh	Rh-101m	4.4 d
21.7 (14)	kβ1 Ru	s. kα1 Ru	
22.7 (1)	kα1 Rh	s. kβ1 Rh	
		$_{46}$Pd	
19.28 (58)	kα1 Ru	Rh-101m	4.4 d
		Rh-100	20 h
		Rh-101	3 a

E keV (I%)	Origin	Nuclide	T
		($_{46}$Pd)	
20.22 (60)	kα1 Rh	Pd-101	8.47 h
		Pd-103	17 d
21.7 (14)	kβ1 Ru	s. kα1 Ru	
22.16 (27)	kα1 Ag	Ag-109m	(39.6 s)
22.7 (15)	kβ1 Rh	s. kα1 Rh	
24.4 (4)	γ	Pd-101	8.47 h
25.0 (7)	kβ1 Ag	s. kα1 Ag	
39.7 (0.07)	γ	Pd-103	17 d
88.0 (4)	γ	Ag-109m	(39.6 s)
		$_{47}$Ag	
21.18 (60)	kα1 Pd	Ag-106m	8.3 d
		Ag-105	41.2 d
23.8 (15)	kβ1 Pd	s. kα1 Pd	
64.3 (11)	γ	Ag-105	41.2 d
		$_{48}$Cd	
21.18 (65)	kα1 Pd	Ag-105	41.2 d
22.16 (60)	kα1 Ag	Cd-107	6.5 h
		Cd-105	55 m
		Cd-104	57.7 m
		Cd-109	453 d

E keV (I%)	Origin	Nuclide	T
		($_{48}$Cd)	
23.17 (34)	kα1 Cd	Cd-111m	49 m
23.8 (16)	kβ1 Pd	s. kα1 Pd	
24.21 (20)	kα1 In	In-115m	(4.5 h)
24.9 (15)	kβ1 Ag	s. kα1 Ag	
26.1 (9)	kβ1 Cd	s. kα1 Cd	
27.3 (5)	kβ1 In	s. kα1 In	
27.9 (1)	kβ2 In	s. kα1 In	
35.5 (0.4)	γ	Cd-115	53.38 h
		$_{49}$In	
23.17 (68)	kα1 Cd	In-111	2.83 d
24.21	kα1 In	In-113m	99.48 m
		In-114m	49.5 d
		In-115m	4.5 h
26.1 (18)	kβ1 Cd	s. kα1 Cd	
27.3 (3)	kβ1 In	s. kα1 In	
27.9 (1)	kβ2 In	s. kα1 In	
		$_{50}$Sn	
23.17 (68)	kα1 Cd	In-111	2.83 d
24.21 (42)	kα1 In	Sn-110	4 h
		Sn-113	115.1 d

E keV (I%)	Origin	Nuclide	T
		($_{50}$Sn)	
25.27 (33)	kα1 Sn	Sn-117m	14 d
		Sn-119m	245 d
26.1 (18)	kβ1 Cd	s. kα1 Cd	
27.3 (11)	kβ1 In	s. kα1 In	
27.9 (2)	kβ2 In	s. kα1 In	
28.5 (9)	kβ1 Sn	s. kα1 Sn	
29.1 (2)	kβ2 Sn	s. kα1 Sn	
		$_{51}$Sb	
23.8 (16)	γ	Sb-119	38.5 h
25.27 (61)	kα1 Sn	Sb-122	2.7 d
		Sb-120m	5.76 d
		Sb-119	38.5 h
28.5 (16)	kβ1 Sn	s. kα1 Sn	
29.1 (3)	kβ2 Sn	s. kα1 Sn	
		$_{52}$Te	
23.8 (16)	γ	Sb-119	38.5 h
25.27 (41)	kα1 Sn	Sb-119	38.5 h
26.36 (64)	kα1 Sb	Te-121	16.8 d
		Te-119	16 h
		Te-121m	154 d

E keV (I%)	Origin	Nuclide	T
		($_{52}$Te)	
26.36 (64)	kα1 Sb	Te-119m	4.7 d
27.47 (30)	kα1 Te	Te-127m	109 d
		Te-129m	33.6 d
		Te-125m	58 d
		Te-123m	119.7 d
28.5 (11)	kβ1 Sn	s. kα1 Sn	
29.1 (3)	kβ2 Sn	s. kα1 Sn	
29.7 (17)	kβ1 Sb	s. kα1 Sb	
30.4 (3)	kβ2 Sb	s. kα1 Sb	
31.0 (8)	kβ1 Te	s. kα1 Te	
31.7 (2)	kβ2 Te	s. kα1 Te	
35.5 (7)	γ	Te-125m	58 d
57.6 (0.03)	γ	Te-127	9.35 h
	γ	Te-127m	109 d
61.0 (1)	γ	Sb-127	3.85 d
		$_{53}$I	
27.47 (23)	kα1 Te	I-126	13 d
		I-125	60.14 d
31.0 (6)	kβ1 Te	s. kα1 Te	
31.7 (1)	kβ2 Te	s. kα1 Te	
35.5 (7)	γ	I-125	60.14 d

E keV (I%)	Origin	Nuclide	T
		$_{55}$Cs	
29.78 (40)	kα1 Xe	Cs-132	6.47 d
		Cs-131	9.7 d
33.6 (11)	kβ1 Xe	s. kα1 Xe	
34.4 (2)	kβ2 Xe	s. kα1 Xe	
		$_{56}$Ba	
29.78 (66)	kα1 Xe	Cs-129	32.06 h
		Cs-131	9.7 d
30.97 (60)	kα1 Cs	Ba-129m	2.13 h
		Ba-131	11.5 d
		Ba-133	10.5 a
32.19 (38)	kα1 Ba	Ba-135m	28.7 h
		Ba-133m	38.9 h
33.6 (18)	kβ1 Xe	s. kα1 Xe	
34.4 (4)	kβ2 Xe	s. kα1 Xe	
35.0 (17)	kβ1 Cs	s. kα1 Cs	
35.8 (4)	kβ2 Cs	s. kα1 Cs	
36.4 (11)	kβ1 Ba	s. kα1 Ba	
37.3 (2)	kβ2 Ba	s. kα1 Ba	
39.6 (3)	γ	Cs-129	32.06 h
66.9 (13)	γ	Cs-136	13 d

E keV (I%)	Origin	Nuclide	T
		$_{57}$La	
34.28 (0.42)	kα2 Ce	La-140	40.2 h
34.72 (0.81)	kα1 Ce	s. kα2 Ce	
39.2 (0.23)	kβ1 Ce	s. kα2 Ce	
40.2 (0.05)	kβ2 Ce	s. Kα2 Ce	
68.9 (0.06)	γ	La-140	40.2 h
		$_{58}$Ce	
32.19 (42)	kα1 Ba	La-135	19.4 h
33.03 (5)	kα2 La	Ce-139	137.5 d
		Ce-137	9 h
		Ce-135	17 h
33.44 (9)	kα1 La	s. kα2 La	
34.28 (21)	kα2 Ce	Ce-137m	34.4 h
34.49 (2.4)		Ce-135	17 h
34.72 (40)	kα1 Ce	s. kα2 Ce	
35.55 (4.6)	kα2 Pr	Ce-141	32.51 d
		Ce-143	33 h
36.03 (8.9)	kα1 Pr	s. kα2 Pr	
36.4 (12)	kβ1 Ba	s. kα1 Ba	
37.3 (2.5)	kβ2 Ba	s. kα1 Ba	
37.8 (3)	kβ1 La	s. kα2 La	
38.7 (1)	kβ2 La	s. kα2 La	
40.7 (2.6)	kβ1 Pr	s. kα2 Pr	

E keV (I%)	Origin	Nuclide	T
		($_{58}$Ce)	
41.8 (0.5)	kβ2 Pr	s. kα2 Pr	
		$_{59}$Pr	
33.03 (4.8)	kα2 La	Ce-139	137.5 d
33.44 (9)	kα1 La	s. kα2 La	
34.28 (26)	kα2 Ce	Pr-139	4.5 h
		Pr-138m	2.02 h
34.72 (50)	kα1 Ce	s. kα2 Ce	
37.8 (2.6)	kβ1 La	s. kα2 La	
38.7 (0.6)	kβ2 La	s. kα2 La	
39.2 (w)	kβ1 Ce	s. kα2 Ce	
40.2 (w)	kβ2 Ce	s. kα2 Ce	
		$_{60}$Nd	
34.28 (w)	kα2 Ce	Pr-140	(3.4 m)
34.72 (w)	kα1 Ce	s. kα2 Ce	
35.55 (31)	kα2 Pr	Nd-141	2.5 h
		Nd-140	3.38 d
36.03 (60)	kα1 Pr	s. kα2 Pr	
38.17 (6)	kα2 Pm	Nd-149	1.73 h
38.72 (20)	kα1 Pm	s. kα2 Pm	
39.2 (w)	kβ1 Ce	s. kα2 Ce	

E keV (I%)	Origin	Nuclide	T
	($_{60}$Nd)		
40.2 (w)	kβ2 Ce	s. kα2 Ce	
40.7 (17)	kβ1 Pr	s. kα2 Pr	
41.8 (4)	kβ2 Pr	s. kα2 Pr	
43.8 (4)	kβ1 Pm	s. kα2 Pm	
44.9 (0.7)	kβ2 Pm	s. kα2 Pm	
58.9 (2)	γ	Nd-149	1.73 h
	$_{62}$Sm		
21.6 (0.03)	γ	Sm-151	93 a
36.85 (w)	kα2 Nd	Pm-143	265 d
		Pm-146	5.53 a
37.36 (w)	kα1 Nd	s. kα2 Nd	
38.17 (10)	kα2 Pm	Sm-142	72.4 m
		Sm-145	340 d
38.72 (20)	kα1 Pm	s. kα2 Pm	
40.90 (16)	kα2 Eu	Sm-153	46.75 h
41.54 (30)	kα1 Eu	s. kα2 Eu	
42.2 (w)	kβ1 Nd	s. kα2 Nd	
43.3 (w)	kβ2 Nd	s. kα2 Nd	
43.8 (6)	kβ1 Pm	s. kα2 Pm	
44.9 (1)	kβ2 Pm	s. kα2 Pm	
47.0 (9)	kβ1 Eu	s. kα2 Eu	
48.3 (2)	kβ2 Eu	s. kα2 Eu	

E keV (I%)	Origin	Nuclide	T
	($_{62}$Sm)		
61.3 (12)	γ	Sm-145	340 d
69.7 (5)	γ	Sm-153	46.75 h
	$_{63}$Eu		
5.6 (1)	Lα1 Sm	Eu-150m	12.6 h
		Eu-152m2	9.3 h
		Eu-149	93.1 d
		Eu-152	12.4 a
		Eu-148	54 d
		Eu-150	35 a
39.52 (2.3)	kα2 Sm	s. Lα1 Sm	
40.12 (4.4)	kα1 Sm	s. Lα1 Sm	
40.90 (6.1)	kα2 Eu	Eu-152m1	96 m
41.54 (12)	kα1 Eu	s. kα2 Eu	
42.31 (5.5)	kα2 Gd	Eu-154	8.5 a
43.00 (10)	kα1 Gd	s. kα2 Gd	
45.4 (1.3)	kβ1 Sm	s. Lα1 Sm	
46.6 (0.3)	kβ2 Sm	s. Lα1 Sm	
47.0 (3.5)	kβ1 Eu	s. kα2 Eu	
48.2 (0.8)	kβ2 Eu	s. kα2 Eu	
48.7 (3.1)	kβ1 Gd	s. kα2 Gd	
50.0 (0.7)	kβ2 Gd	s. kα2 Gd	

E keV (I%)	Origin	Nuclide	T
		$_{64}$Gd	
5.84 (1)	Lα1 Eu	Gd-153	241.6 d
		Gd-151	120 d
6.27 (1)	Lα1 Tb	Gd-159	18.56 h
6.46 (0.5)	Lβ1 Eu	s. Lα1 Eu	
6.98 (0.5)	Lβ1 Tb	s. Lα1 Tb	
40.90 (32)	kα2 Eu	s. Lα1 Eu	
41.54 (60)	kα1 Eu	s. Lα1 Eu	
43.74 (3.3)	kα2 Tb	s. Lα1 Tb	
44.48 (6.3)	kα1 Tb	s. Lα1 Tb	
47.0 (18)	kβ1 Eu	s. Lα1 Eu	
48.3 (4)	kβ2 Eu	s. Lα1 Eu	
50.4 (1.9)	kβ1 Tb	s. Lα1 Tb	
51.7 (0.4)	kβ2 Tb	s. Lα1 Tb	
58.0 (2)	γ	Gd-159	18.56 h
64.0 (20)	γ	Eu-157	15.15 h
69.7 (2)	γ	Gd-153	241.6 d
79.5 (0.04)	γ	Gd-159	18.56 h
89.0 (9)	γ	Eu-156	15.2 d
		$_{65}$Tb	
6.06 (1)	Lα1 Gd	Tb-156	5.35 d
		Tb-158	150 a
6.71 (0.5)	Lβ1 Gd	s. Lα1 Gd	
		($_{65}$Tb)	
42.31 (29)	kα2 Gd	s. Lα1 Gd	
43.00 (55)	kα1 Gd	s. Lα1 Gd	
43.74 (w)	kα2 Tb	Tb-156m2	5.4 h
44.48 (w)	kα1 Tb	s. kα2 Tb	
45.21 (8.5)	kα2 Dy	Tb-160	72.1 d
46.00 (16)	kα1 Dy	s. kα2 Dy	
48.7 (17)	kβ1 Gd	s. Lα1 Gd	
50.0 (4)	kβ2 Gd	s. Lα1 Gd	
50.4 (w)	kβ1 Tb	s. kα2 Tb	
51.7 (w)	kβ2 Tb	s. kα2 Tb	
52.1 (4.8)	kβ1 Dy	s. kα2 Dy	
53.5 (1.1)	kβ2 Dy	s. kα2 Dy	
79.6 (11)	γ	Tb-158	150 a
86.8 (13)	γ	Tb-160	72.1 d
89.2 (18)	γ	Tb-156	5.35 d
		$_{66}$Dy	
6.27 (1)	Lα1 Tb	Dy-159	144.4 d
		Dy-157	8.1 h
		Dy-155	9.59 d
6.72 (1)	Lα1 Ho	Dy-165	2.35 h
6.98 (0.5)	Lβ1 Tb	s. Lα1 Tb	
7.52 (0.5)	Lβ1 Ho	s. Lα1 Ho	

E keV (I%)	Origin	Nuclide	T
		($_{66}$Dy)	
42.31 (29)	kα2 Gd	Tb-155	5.32 d
43.00 (54)	kα1 Gd	s. kα2 Gd	
43.74 (27)	kα2 Tb	s. Lα1 Tb	
44.48 (51)	kα1 Tb	s. Lα1 Tb	
45.21 (4.8)	kα2 Dy	Tb-161	6.9 d
46.00 (9)	kα1 Dy	s. kα2 Dy	
46.70 (2.7)	kα2 Ho	s. Lα1 Ho	
47.55 (5.1)	kα1 Ho	s. Lα1 Ho	
48.7 (16)	kβ1 Gd	s. kα2 Gd	
50.0 (3.8)	kβ1 Gd	s. kα2 Gd	
50.4 (16)	kβ1 Tb	s. Lα1 Tb	
51.7 (3.6)	kβ2 Tb	s. Lα1 Tb	
52.1 (2.8)	kβ1 Dy	s. kα2 Dy	
53.5 (0.6)	kβ2 Dy	s. kα2 Dy	
53.8 (1.5)	kβ1 Ho	s. Lα1 Ho	
55.3 (0.35)	kβ2 Ho	s. Lα1 Ho	
57.2 (2)	γ	Tb-161	6.9 d
58.0 (4)	γ	Dy-159	144.4 d
60.0 (1)	γ	Tb-155	5.32 d
60.8 (0.5)	γ	Dy-157	8.1 h
65.5 (2)	γ	Dy-155	9.59 h
74.6 (10)	γ	Tb-161	6.9 d
83.0 (0.6)	γ	Dy-157	8.1 h
86.5 (29)	γ	Tb-155	5.32 d
86.8 (13)	γ	Tb-160	72.1 d
		($_{66}$Dy)	
		$_{67}$Ho	
6.95 (1)	Lα1 Er	Ho-166	26.7 h
7.81 (0.5)	Lβ1 Er	s. Lα1 Er	
8.19 (0.2)	Lβ2 Er	s. Lα1 Er	
9.09 (0.05)	Lγ1 Er	s. Lα1 Er	
45.21 (14)	kα2 Dy	Ho-162m	68 m
46.00 (25)	kα1 Dy	s. kα2 Dy	
46.70 (w)	kα2 Ho	s. kα2 Dy	
47.55 (w)	kα1 Ho	s. kα2 Dy	
48.22 (2.5)	kα2 Er	s. Lα1 Er	
49.13 (4.7)	kα1 Er	s. Lα1 Er	
52.1 (8)	kβ1 Dy	s. kα2 Dy	
53.5 (1.8)	kβ2 Dy	s. kα2 Dy	
53.8 (w)	kβ1 Ho	s. kα2 Dy	
55.3 (w)	kβ2 Ho	s. kα2 Dy	
55.6 (1.5)	kβ1 Er	s. Lα1 Er	
57.2 (0.3)	kβ2 Er	s. Lα1 Er	
80.6 (6)	γ	Ho-166	26.7 h
80.7 (9)	γ	Ho-162m	68 m

E keV (I%)	Origin	Nuclide	T
		$_{68}$Er	
6.72 (1)	Lα1 Ho	Er-165	10.3 h
		Er-163	75 m
		Er-161	3.1 h
7.52 (0.5)	Lβ1 Ho	s. Lα1 Ho	
7.91 (0.2)	Lβ2 Ho	s. Lα1 Ho	
8.4 (0.3)	γ	Er-169	9.3 d
8.75 (0.05)	Lγ1 Ho	s. Lα1 Ho	
25.7 (29)	γ	Ho-161	2.5 h
45.21 (w)	kα2 Dy	Ho-161	2.5 h
46.00 (w)	kα1 Dy	s. kα2 Dy	
46.70 (32)	kα2 Ho	s. Lα1 Ho	
47.55 (60)	kα1 Ho	s. Lα1 Ho	
48.22 (2.5)	kα2 Er	Ho-166	26.7 h
49.13 (4.7)	kα1 Er	s. kα2 Er	
49.76 (14)	kα2 Tm	Er-171	7.5 h
50.74 (26)	kα1 Tm	s. kα2 Tm	
52.1 (w)	kβ1 Dy	s. kα2 Dy	
53.5 (w)	kβ2 Dy	s. kα2 Dy	
53.8 (19)	kβ1 Ho	s. Lα1 Ho	
55.3 (4)	kβ2 Ho	s. Lα1 Ho	
55.6 (1.5)	kβ1 Er	s. kα2 Er	
57.2 (0.3)	kβ2 Er	s. kα2 Er	
57.5 (8.3)	kβ1 Tm	s. kα2 Tm	
59.0 (1.8)	kβ2 Tm	s. kα2 Tm	

E keV (I%)	Origin	Nuclide	T
		($_{68}$Er)	
73.8 (0.5)	γ	Ho-167	3.1 h
76.2 (0.5)	γ	Er-161	3.1 h
77.5 (3)	γ	Ho-161	2.5 h
79.3 (2)	γ	Ho-167	3.1 h
80.6 (6)	γ	Ho-166	26.7 h
83.5 (2)	γ	Ho-167	3.1 h
87.5 (0.4)	γ	Er-161	3.1 h
		$_{69}$Tm	
6.95 (1)	Lα1 Er	Tm-167	9.25 d
		Tm-168	93.1 d
		Tm-166	7.7 h
		Er-167m	(2.3 s)
7.81 (0.5)	Lβ1 Er	s. Lα1 Er	
8.19 (0.2)	Lβ2 Er	s. Lα1 Er	
9.09 (0.05)	Lγ1 Er	s. Lα1 Er	
48.22 (28)	kα2 Er	s. Lα1 Er	
49.13 (53)	kα1 Er	s. Lα1 Er	
55.6 (17)	kβ1 Er	s. Lα1 Er	
57.1 (49	γ	Tm-167	9.25 d
57.2 (4)	kβ2 Er	s. Lα1 Er	
79.8 (11)	γ	Tm-168	93.1 d
80.6 (11)	γ	Tm-166	7.7 h

E keV (I%)	Origin	Nuclide	T
		($_{69}$Tm)	
84.3 (3)	γ	Tm-170	128.6 d
		$_{70}$Yb	
7.18 (1)	Lα1 Tm	Yb-169	30.7 d
		Yb-166	56.7 h
8.10 (0.5)	Lβ1 Tm	s. Lα1 Tm	
8.47 (0.2)	Lβ2 Tm	s. Lα1 Tm	
9.42 (0.05)	Lγ1 Tm	s. Lα1 Tm	
19.77 (38)	kα2 Tm	s. Lα1 Tm	
50.74 (70)	kα1 Tm	s. Lα1 Tm	
52.97 (1)	kα2 Lu	Yb-175	4.2 d
54.07 (1.9)	kα1 Lu	s. kα2 Lu	
57.5 (23)	kβ1 Tm	s. Lα1 Tm	
59.0 (5)	kβ1 Tm	s. Lα1 Tm	
61.3 (0.6)	kβ1 Lu	s. kα2 Lu	
62.9 (0.14)	kβ2 Lu	s. Kα2 Lu	
63.1 (44)	γ	Yb-169	30.7 d
82.3 (15)	γ	Yb-166	56.7 h
		$_{71}$Lu	
7.41 (1)	Lα1 Yb	Lu-172	6.7 d
		Lu-173	1.37 a

E keV (I%)	Origin	Nuclide	T
		($_{71}$Lu)	
7.41 (1)	Lα1 Yb	Lu-174	3.31 a
8.40 (0.5)	Lβ1 Yb	s. Lα1 Yb	
8.76 (0.2)	Lβ2 Yb	s. Lα1 Yb	
9.78 (0.05)	Lγ1 Yb	s. Lα1 Yb	
51.35 (?)	kα2 Yb	s. Lα1 Yb	
52.39 (?)	kα1 Yb	s. Lα1 Yb	
52.97 (?)	kα2 Lu	Lu-174m	142 d
54.07 (?)	kα1 Lu	s. kα2 Lu	
54.61 (?)	kα2 Hf	Lu-177	6.71 d
		Lu-177m	161 d
		Hf-177m1	(51 m)
55.79 (?)	kα1 Hf	s. kα2 Hf	
59.3 (?)	kβ1 Yb	s. Lα1 Yb	
61.0 (?)	kβ2 Yb	s. Lα1 Yb	
61.3 (?)	kβ1 Lu	s. kα2 Lu	
62.9 (?)	kβ2 Lu	s. Kα2 Lu	
63.2 (?)	kβ1 Hf	s. kα2 Hf	
65.0 (?)	kβ2 Hf	s. kα2 Hf	
67.1 (7)	γ	Lu-174m	142 d
76.5 (5)	γ	Lu-174	3.31 a
78.7 (11)	γ	Lu-172	6.7 d
78.7 (8)	γ	Lu-173	1.37 a
88.3 (9)	γ	Lu-176m	3.68 h

E keV (I%)	Origin	Nuclide	T
		$_{72}$Hf	
7.65 (1)	Lα1 Lu	Hf-175	70 d
		Hf-173	23.6 h
8.71 (0.5)	Lβ1 Lu	s. Lα1 Lu	
9.05 (0.2)	Lβ2 Lu	s. Lα1 Lu	
10.14 (0.05)	Lγ1 Lu	s. Lα1 Lu	
52.97 (19)	kα2 Lu	s. Lα1 Lu	
54.07 (35)	kα1 Lu	s. Lα1 Lu	
54.61 (8.6)	kα2 Hf	Hf-180m	5.5 h
		Hf-179n	25 d
		Hf-178m	31 a
55.79 (16)	kα1 Hf	s. kα2 Hf	
56.28 (3.3)	kα2 Ta	Hf-181	42.4 d
57.5 (48)		Hf-180m	5.5 h
57.54 (6.3)	kα1 Ta	s. kα2 Ta	
61.3 (11)	kβ1 Lu	s. Lα1 Lu	
62.9 (2.8)	kβ2 Lu	s. Lα1 Lu	
63.2 (5.3)	kβ1 Hf	s. kα2 Hf	
65.0 (1.3)	kβ2 Hf	s. kα2 Hf	
65.2 (2.0)	kβ1 Ta	s. kα2 Ta	
67.0 (0.5)	kβ2 Ta	s. kα2 Ta	
88.3 (9)	γ	Lu-176m	3.68 h
89.4 (2)	γ	Hf-175	70 d

E keV (I%)	Origin	Nuclide	T
		$_{73}$Ta	
7.90 (1)	Lα1 Hf	Ta-180m	8.1 h
		Ta-178	2.2 h
		Ta-179	600 d
9.02 (0.5)	Lβ1 Hf	s. Lα1 Hf	
9.35 (0.2)	Lβ2 Hf	s. Lα1 Hf	
10.51 (0.1)	Lγ1 Hf	s. Lα1 Hf	
54.61 (21)	kα2 Hf	s. Lα1 Hf	
55.79 (39)	kα1 Hf	s. Lα1 Hf	
63.2 (13)	kβ1 Hf	s. Lα1 Hf	
65.0 (3)	kβ2 Hf	s. Lα1 Hf	
67.7 (41)	γ	Ta-182	115 d
		$_{74}$W	
6.2 (1)	γ	W-181	121.2 d
8.15 (1)	Lα1 Ta	W-181	121.2 d
		W-178	22 d
8.65 (1)	Lα1 Re	W-187	23.8 h
9.34 (0.5)	Lβ1 Ta	s. Lα1 Ta	
9.65 (0.2)	Lβ2 Ta	s. Lα1 Ta	
10.01 (0.5)	Lβ1 Re	s. Lα1 Re	
10.27 (0.2)	Lβ2 Re	s. Lα1 Re	
10.89 (0.1)	Lγ1 Ta	s. Lα1 Ta	
11.68 (0.1)	Lγ1 Re	s. Lα1 Re	

E keV (I%)	Origin	Nuclide	T
	($_{74}$W)		
46.5 (6)	γ	Ta-183	5 d
52.6 (6)	γ	Ta-183	5 d
56.28 (22)	kα2 Ta	s. Lα1 Ta	
57.54 (40)	kα1 Ta	s. Lα1 Ta	
57.98 (23)	kα2 W	Ta-183	5 d
59.32 (44)	kα1 W	s. kα2 W	
59.72 (6.9)	kα2 Re	s. Lα1 Re	
61.14 (13)	kα1 Re	s. Lα1 Re	
65.2 (13)	kβ1 Ta	s. Lα1 Ta	
67.0 (3)	kβ2 Ta	s. Lα1 Ta	
67.2 (15)	kβ1 W	s. kα2 W	
69.1 (3.5)	kβ2 W	s. Kα2 W	
69.2 (4.3)	kβ1 Re	s. Lα1 Re	
71.2 (1)	kβ2 Re	s. Lα1 Re	
72.5 (11)	γ	W-187	23.8 h
	$_{75}$Re		
8.40 (1)	Lα1 W	Re-184	38 d
		Re-183	71 d
		Re-182	64 h
8.91 (1)	Lα1 Os	Re-186	90.64 h
		Re-188	16.98 h
9.67 (0.5)	Lβ1 W	s. Lα1 W	

E keV (I%)	Origin	Nuclide	T
	($_{75}$Re)		
9.96 (0.2)	Lβ2 W	s. Lα1 W	
10.35 (0.5)	Lβ1 Os	s. Lα1 Os	
11.28 (0.1)	Lγ1 W	s. Lα1 W	
12.09 (0.1)	Lγ1 Os	s. Lα1 Os	
39.1 (9)	γ	Re-182	64 h
57.98 (3)	kα2 W	s. Lα1 W	
59.32 (5.5)	kα1 W	s. Lα1 W	
59.72 (9)	kα2 Re	Re-184m	165 d
61.14 (16)	kα1 Re	s. kα2 Re	
61.49 (1)	kα2 Os	s. Lα1 Os	
63.00 (1.8)	kα1 Os	s. Lα1 Os	
65.7 (1)	γ	Re-182	64 h
67.2 (1.8)	kβ1 W	s. Lα1 W	
67.8 (13)	γ	Re-182	64 h
69.1 (0.4)	kβ2 W	s. Lα1 W	
69.2 (6)	kβ1 Re	s. kα2 Re	
71.2 (1.3)	kβ2 Re	s. kα2 Re	
71.3 (0.6)	kβ1 Os	s. Lα1 Os	
73.4 (0.1)	kβ2 Os	s. Lα1 Os	
84.7 (0.9)	γ	Re-183	71 d
	$_{76}$Os		
8.65 (1)	Lα1 Re	Os-183m	10 h

E keV (I%)	Origin	Nuclide	T
		($_{76}$Os)	
8.65 (1)	Lα1 Re	Os-185	94 d
		Os-183	14 h
		Os-181	108 m
10.01 (0.5)	Lβ1 Re	s. Lα1 Re	
11.68 (0.1)	Lγ1 Re	s. Lα1 Re	
57.98 (43)	kα2 W	Re-183	71 d
59.32 (80)	kα1 W	s. Kα2 W	
59.72 (12)	kα2 Re	s. Lα1 Re	
61.14 (23)	kα1 Re	s. Lα1 Re	
61.49 (25)	kα2 Os	Os-191m	13.03 h
		Os-189m	6 h
63.00 (47)	kα1 Os	s. kα2 Os	
63.29 (18)	kα2 Ir	Os-191	15.4 d
		Os-193	30 h
64.90 (33)	kα1 Ir	s. Kα2 Ir	
67.2 (26)	kβ1 W	s. kα2 W	
69.1 (6.5)	kβ2 W	s. kα2 W	
69.2 (7.5)	kβ1 Re	s. Lα1 Re	
71.2 (1.8)	kβ2 Re	s. Lα1 Re	
71.3 (16)	kβ1 Os	s. kα2 Os	
73.4 (4.2)	kβ2 Os	s. kα2 Os	
73.5 (11)	kβ1 Ir	s. kα2 Ir	
74.4 (0.07)	γ	Os-191m	13.03 h
75.6 (3)	kβ2 Ir	s. kα2 Ir	

E keV (I%)	Origin	Nuclide	T
		($_{76}$Os)	
82.5 (0.03)	γ	Os-191	15.4 d
		$_{77}$Ir	
8.91 (1)	Lα1 Os	Ir-190m	3.1 h
		Ir-190	12.1 d
		Ir-189	13.3 d
		Ir-188	41.5 h
10.35 (0.5)	Lβ1 Os	s. Lα1 Os	
12.09 (0.1)	Lγ1 Os	s. Lα1 Os	
61.49 (26)	kα2 Os	s. Lα1 Os	
63.00 (48)	kα1 Os	s. Lα1 Os	
63.29 (w)	kα2 Ir	Ir-190n	1.2 h
		Ir-193m	11.9 d
64.90 (w)	kα1 Ir	s. kα2 Ir	
65.12 (3)	kα2 Pt	Ir-192	74 d
		Ir-194	19.4 h
66.83 (5)	kα1 Pt	s. kα2 Pt	
71.3 (16)	kβ1 Os	s. Lα1 Os	
73.4 (4.5)	kβ2 Os	s. Lα1 Os	
73.5 (w)	kβ1 Ir	s. kα2 Ir	
75.6 (w)	kβ2 Ir	s. kα2 Ir	
75.7 (1.7)	kβ1 Pt	s. kα2 Pt	
77.8 (0.5)	kβ2 Pt	s. kα2 Pt	

E keV (I%)	Origin	Nuclide	T
		$_{78}$Pt	
9.17 (1)	Lα1 Ir	Pt-189	11 h
		Pt-191	2.8 d
		Pt-188	10.2 d
		Ir-193m	11.9 d
9.44 (1)	Lα1 Pt	Pt-197m	81 m
		Pt-193m	4.33 d
		Pt-195m	4.02 d
10.71 (0.5)	Lβ1 Ir	s. Lα1 Ir	
11.07 (0.5)	Lβ1 Pt	s. Lα1 Pt	
12.51 (0.1)	Lγ1 Ir	s. Lα1 Ir	
12.94 (0.1)	Lγ1 Pt	s. Lα1 Pt	
30.8 (3)	γ	Ir-195m	3.8 h
61.49 (24)	kα2 Os	Ir-189	13.3 d
63.00 (44)	kα1 Os	s. kα2 Os	
63.29 (35)	kα2 Ir	s. Lα1 Ir	
64.90 (65)	kα1 Ir	s. Lα1 Ir	
65.12 (11)	kα2 Pt	s. Lα1 Pt	
66.83 (21)	kα1 Pt	s. Lα1 Pt	
66.99 (1)	kα2 Au	Pt-197	20 h
68.81 (1.9)	kα1 Au	s. kα2 Au	
71.3 (15)	kβ1 Os	s. kα2 Os	
73.4 (4)	kβ2 Os	s. kα2 Os	
73.5 (229	kβ1 Ir	s. Lα1 Ir	
75.6 (5.5)	kβ2 Ir	s. Lα1 Ir	

E keV (I%)	Origin	Nuclide	T
		($_{78}$Pt)	
75.7 (7)	kβ1 Pt	s. Lα1 Pt	
77.4 (17)	γ	Pt-197	20 h
77.8 (1.9)	kβ2 Pt	s. Lα1 Pt	
77.9 (0.7)	kβ1 Au	s. kα2 Au	
80.1 (0.2)	kβ2 Au	s. kα2 Au	
82.2 (2)	γ	Pt-189	11 h
		$_{79}$Au	
9.44 (1)	Lα1 Pt	Au-196	6.2 d
		Au-194	39.5 h
		Au-195	183 d
11.07 (0.5)	Lβ1 Pt	s. Lα1 Pt	
12.94 (0.1)	Lγ1 Pt	s. Lα1 Pt	
65.12 (24)	kα2 Pt	s. Lα1 Pt	
66.83 (44)	kα1 Pt	s. Lα1 Pt	
66.99 (22)	kα2 Au	Au-196m	9.7 h
68.81 (40)	kα1 Au	s. kα2 Au	
75.7 (15)	kβ1 Pt	s. Lα1 Pt	
77.8 (4)	kβ2 Pt	s. Lα1 Pt	
77.9 (14)	kβ1 Au	s. kα2 Au	
80.1 (3.6)	kβ2 Au	s. kα2 Au	

E keV (I%)	Origin	Nuclide	T
		$_{80}$Hg	
9.71 (1)	Lα1 Au	Hg-197	64.1 h
		Hg-195	9.5 h
		Hg-195m	40 h
11.44 (0.5)	Lβ1 Au	s. Lα1 Au	
13.38 (0.1)	Lγ1 Au	s. Lα1 Au	
61.5 (7)	γ	Hg-199	9.5 h
66.99 (20)	kα2 Au	s. Lα1 Au	
68.81 (36)	kα1 Au	s. Lα1 Au	
68.89 (8)	kα2 Hg	Hg-197m	23.8 h
		Hg-195m	40 h
70.82 (15)	kα1 Hg	s. kα2 Hg	
70.83 (3.5)	kα2 Tl	Hg-203	46.6 d
72.87 (6.4)	kα1 Tl	s. kα2 Tl	
77.4 (19)	γ	Hg-197	64.1 h
77.9 (13)	kβ1 Au	s. Lα1 Au	
80.1 (3.3)	kβ2 Au	s. Lα1 Au	
80.2 (5.1)	kβ1 Hg	s. kα2 Hg	
82.5 (1.5)	kβ2 Hg	s. kα2 Hg	
82.5 (2.2)	kβ1 Tl	s. kα2 Tl	
84.9 (0.64)	kβ2 Tl	s. kα2 Tl	
		$_{81}$Tl	
9.99 (1)	Lα1 Hg	Tl-202	12.2 d

E keV (I%)	Origin	Nuclide	T
		($_{81}$Tl)	
9.99 (1)	Lα1 Hg	Tl-201	73.5 h
		Tl-200	26.1 h
11.82 (0.5)	Lβ1 Hg	s. Lα1 Hg	
13.83 (0.1)	Lγ1 Hg	s. Lα1 Hg	
68.89 (23)	kα2 Hg	s. Lα1 Hg	
70.82 (42)	kα1 Hg	s. Lα1 Hg	
80.2 (15)	kβ1 Hg	s. Lα1 Hg	
82.5 (4)	kβ2 Hg	s. Lα1 Hg	
		$_{82}$Pb	
10.26 (1)	Lα1 Tl	Pb-203	52.1 h
		Pb-202m	3.62 h
		Pb-201	9.4 h
12.21 (0.5)	Lβ1 Tl	s. Lα1 Tl	
14.29 (0.1)	Lγ1 Tl	s. Lα1 Tl	
70.83 (26)	kα2 Tl	s. Lα1 Tl	
72.80 (2.7)	kα2 Pb	Pb-204m	66.9 m
		Pb-202m	3.62 h
72.87 (47)	kα1 Tl	s. Lα1 Tl	
74.97 (5)	kα1 Pb	s. kα2 Pb	
82.5 (17)	kβ1 Tl	s. Lα1 Tl	
84.8 (1.8)	kβ1 Pb	s. kα2 Pb	
84.9 (4.7)	kβ2 Tl	s. Lα1 Tl	

E keV (I%)	Origin	Nuclide	T
	($_{82}$Pb)		
87.3 (0.5)	kβ2 Pb	s. kα2 Pb	
	$_{83}$Bi		
10.55 (1)	Lα1 Pb	Bi-206	6.24 d
		Bi-207	38 a
12.61 (0.5)	Lβ1 Pb	s. Lα1 Pb	
14.76 (0.1)	Lγ1 Pb	s. Lα1 Pb	
72.80 (36)	kα2 Pb	s. Lα1 Pb	
74.97 (65)	kα1 Pb	s. Lα1 Pb	
84.8 (23)	kβ1 Pb	s. Lα1 Pb	
87.3 (6.5)	kβ2 Pb	s. Lα1 Pb	
	$_{92}$U		
13.94 (1)	Lα1 Np	U-237	6.75 d
17.75 (0.5)	Lβ1 Np	s. Lα1 Np	
20.78 (0.1)	Lγ1 Np	s. Lα1 Np	
26.3 (2)	γ	s. L 1 Np	
51.0 (0.2)	γ	s. L 1 Np	
59.5 (36)	γ	s. L 1 Np	
64.8 (1)	γ	s. L 1 Np	
97.07 (18)	kα2 Np	s. Lα1 Np	
101.07 (27)	kα1 Np	s. Lα1 Np	

E keV (I%)	Origin	Nuclide	T
	($_{92}$U)		
113.7 (9.6)	kβ1 Np	s. Lα1 Np	
117.6 (3.7)	kβ2 Np	s. Lα1 Np	

5.3.3 Low energy (energy less than 90 keV) gamma-rays

In table 5-4 the low energy gamma-rays are listed which have been detected after bremsstrahlung activation. No characteristic X-rays are included, since those are presented in the preceding table and the most prominent ones also in table 5-7.

The energies in the first column are given as precisely as convenient and necessary for low energy photon spectroscopy.

Half-life values in brackets listed in the second column indicate that the radiation is or may be due to a secondary decay product and hence the actual half-life may be different from the given value.

In the third column the radionuclides are presented and in the fourth one the target nuclides which the photon radiation is due to. In case of more than one possible target element these are listed in the order of the integral specific activity yield of the reaction producing the given radionuclide. For example, ^{105}Ag can be produced both by $(\gamma,2n)$ reaction of ^{107}Ag and (γ,p) reaction of ^{106}Cd. In the table, ^{107}Ag is given first, because the reaction of ^{107}Ag yields greater activity of ^{105}Ag than the cadmium reaction, assuming equal masses of target element.

The relative line intensities in the last column are calculated by multiplying the relative reaction yield (N; see table 5-2) with the emission probability of the line (I being the number of emissions per 100 disintegrations). In case of more than one possible reaction the one with the greatest specific activity yield is taken as relevant. These values may help to estimate the quantitative distribution of the components within a complex gamma-ray line in the case of interference by overlapping gamma energies. As an example: A gamma-ray line be detected at the energy of approximately 57.1 keV. This line may be emitted by ^{167}Tm (E=57.10 keV) or by ^{161}Tb (E=57.20 keV) or by both of them. The actual energies of the quoted components can not be resolved by normal photon spectroscopy. The N·I-values indicate that in the case of equal masses of target elements (Tm and Dy) possibly present in the irradiated sample the 57.10 keV line emitted by ^{167}Tm would be more intense than the 57.20 keV line of ^{161}Tb by a factor of 56.

At the end of T_i this is simply the ratio:

$$\frac{(N \cdot I)^{167}Tm}{(N \cdot I)^{167}Tb} = 56$$

In the case of more than one possible target nuclide, the other N·I-values can be, if required, easily calculated using the N-values given in table 5-2.

Tab. 5-4

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
6.2	(1)	121.2 d	W-181	W-182	9.2 E-2
8.4	(0.3)	9.3 d	Er-169	Er-170	9.4 E-4
9.4	(6)	86.2 d	Rb-83	Rb-85, Sr-84	?
9.4	(5)	1.83 h	Kr-83m	Rb-85, Sr-88	?
13.8	(?)	6.75 d	U-237	U-238	?
14.4	(10)	270 d	Co-57	Ni-58, Co-59	6.1 E-3
21.0	(0.2)	5.32 d	Tb-155	Dy-156	4.2 E-6
21.6	(0.03)	93 a	Sm-151	Sm-152	7.5 E-8
23.8	(16)	38.5 h	Sb-119	Te-120	2.8 E-5
24.4	(4)	8.47 h	Pd-101	Pd-102	3.4
24.9	(0.03)	8.94 h	Co-58m	Co-59	8.0 E-3
25.7	(29)	2.5 h	Ho-161	Er-162	1.1 E-2
26.3	(2)	6.75 d	U-237	U-238	?
30.8	(3)	3.8 h	Ir-195m	Pt-196	4.5 E-4
33.2	(?)	6.75 d	U-237	U-238	?
34.5	(2)	17 h	Ce-135	Ce-136	7.4 E-4
35.5	(7)	58 d	Te-125m	Te-126	6.1 E-4
35.5	(7)	60.14 d	I-125	I-127	2.8 E-3
35.5	(0.4)	53.38 h	Cd-115	Cd-116	2.5 E-3
37.1	(39)	4.42 h	Br-80m	Br-81	2.3
39.1	(9)	64 h	Re-182	Re-185, Os-184	1.8 E-4
39.6	(3)	32.06 h	Cs-129	Ba-130	3.9 E-4
39.7	(0.07)	17 d	Pd-103	Pd-104	2.1 E-3
40.9	(25)	9.13 h	Zn-62	Zn-64	2.0 E-2
42.3	(2)	33 h	Sr-83	Sr-84	?
45.3	(1)	5.32 d	Tb-155	Dy-156	2.1 E-5
46.0	(57)	8.5 d	Se-72	Se-74	3.7 E-5
46.5	(6)	5 d	Ta-183	W-184	3.4 E-4
48.9	(0.5)	4.42 h	Br-80m	Br-81	2.4 E-2
51.0	(0.2)	6.75 d	U-237	U-238	?
52.6	(6)	5 d	Ta-183	W-184	3.4 E-4
53.5	(10)	4.8 h	Ga-73	Ge-74	8.6 E-2
53.4	(10)	80.3 d	As-73	Se-74, As75	?
57.1	(4)	9.25 d	Tm-167	Tm-169, Yb-168	1.4 E-2
57.2	(2)	6.9 d	Tb-161	Dy-162	2.0 E-4
57.5	(48)	5.5 h	Hf-180m	Ta-181, Hf-180	?
57.6	(0.03)	9.35 h	Te-127	Te-128	3.3 E-3

Tab. 5-4, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
57.6	(0.5)	109 d	Te-127m	Te-128	7.0 E-4
58.0	(2)	18.56 h	Gd-159	Gd-160	8.8 E-2
58.0	(4)	144.4 d	Dy-159	Dy-160	1.5 E-3
58.9	(2)	1.73 h	Nd-149	Nd-150	5.3 E-2
59.5	(36)	6.75 d	U-237	U-238	2.1
60.0	(0.5)	5.32 d	Tb-155	Dy-156	1.7 E-5
60.8	(0.5)	8.1 h	Dy-157	Dy-158	1.8 E-4
61.0	(1)	3.85 d	Sb-127	Te-128	1.5 E-4
61.3	(12)	340 d	Sm-145	Sm-147	?
61.5	(7)	9.5 h	Hg-195	Hg-196	5.4 E-3
63.1	(44)	30.7 d	Yb-169	Yb-170	1.3 E-2
64.0	(20)	15.15 h	Eu-157	Gd-158	2.4 E-3
64.0	(11)	41.2 d	Ag-105	Ag-107, Cd-106	2.9 E-3
64.8	(1)	6.75 d	U-237	U-238	?
65.5	(2)	9.59 h	Dy-155	Dy-156	3.0 E-4
65.7	(1)	64 h	Re-182	Re-185, Os-184	2.0 E-5
66.9	(13)	13 d	Cs-136	Ba-137	1.4 E-4
67.0	(72)	7.1 h	Se-73	Se-74	1.1 E-1
67.1	(7)	142 d	Lu-174m	Lu-175	6.0 E-4
67.7	(41)	115 d	Ta182	W-183, Ta-181	1.0 E-3
67.8	(13)	64 h	Re-182	Re-185, Os-184	2.6 E-4
68.7	(0.2)	4.8 h	Ga-73	Ge-74	1.7 E-3
68.9	(0.06)	40.2 h	La-140	La-139	7.2 E-6
69.7	(2)	241.6 d	Gd-153	Gd-154	7.0 E-5
69.7	(5)	46.75 h	Sm-153	Sm-154	2.2 E-1
72.5	(11)	23.8 h	W-187	W-186	1.2 E-2
73.8	(0.5)	3.1 h	Ho-167	Er-168	6.0 E-4
74.4	(0.07)	13.03 h	Os-191m	Os-192	?
74.6	(10)	6.9 d	Tb-161	Dy-162	1.0 E-3
76.2	(0.5)	3.1 h	Er-161	Er-162	1.1 E-3
76.5	(5)	3.31 a	Lu-174	Lu-175	3.1 E-4
77.4	(17)	20 h	Pt-197	Pt-198	3.7 E-1
77.4	(19)	64.1 h	Hg-197	Hg-198	2.6 E-2
77.5	(3)	2.5 h	Ho-161	Er-162	1.1 E-3
78.6	(8)	1.37 a	Lu-173	Lu-175	5.3 E-4
78.7	(11)	6.7 d	Lu-173	Lu-175	1.1 E-3
79.3	(2)	3.1 h	Ho-167	Er-168	2.4 E-3

Tab. 5-4, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
79.5	(0.04)	18.56 h	Gd-159	Gd-160	1.8 E-3
79.6	(11)	150 a	Tb-158	Tb-159	2.4 E-5
79.8	(11)	93.1 d	Tm-168	Tm-169	1.8 E-2
80.6	(6)	26.7 h	ho-166	Ho-165, Er-167	2.7 E-2
80.6	(11)	7.7 h	Tm-166	Tm-169, Yb-168	3.9 E-4
80.7	(9)	68 m	Ho-162m	Ho-165	?
82.2	(2)	11 h	Pt-189	Pt-190	2.0 E-3
82.3	(15)	56.7 h	Yb-166	Yb-168	3.2 E-4
82.5	(0.03)	15.4 d	Os-191	Os-192	2.3 E-7
83.0	(0.6)	8.1 h	Dy-157	Dy-158	2.1 E-4
83.5	(2)	3.1 h	Ho-167	Er-168	2.0 E-3
84.3	(3)	128.6 d	Tm-170	Tm-169, Yb-171	4.5 E-3
84.7	(0.9)	71 d	Re-183	Re-185, Os-184	2.6 E-4
86.5	(29)	5.32 d	Tb-155	Dy-156	6.1 E-4
86.8	(13)	72.1 d	Tb-160	Tb-159, Dy-161	5.6 E-4
87.5	(0.4)	3.1 h	Er-161	Er-162	8.4 E-4
87.6	(1)	56 h	Br-77	Br-79	2.2 E-3
88.0	(0.3)	38.8 h	As-77	Se-78	2.5 E-4
88.0	(4)	(39.6 s)	Ag-109m	Pd-110	?
88.3	(9)	3.68 h	Lu-176m1	Lu-175, Hf-177	3.5 E-1
89.0	(9)	15.2 d	Eu-156	Gd-157	8.7 E-5
89.2	(18)	5.35 d	Tb-156	Tb-159	2.1 E-4
89.4	(2)	70 d	Hf-175	Hf-176	6.5 E-4

5.3.4 High energy (energy greater than 90 keV) gamma-rays

In table 5-5, all gamma-ray energies from 90 to 3000 keV which have been detected after bremsstrahlung irradiation, are listed following the same format as in the preceding table. Because of poorer energy resolution capability of a coaxial large volume Ge-detector compared with a planar low energy photon diode, the energy values are given in integer keV-units in this table.

Tab. 5-5

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
90	(85)	5.76 d	Sb-120m	Sb-121, Te-122	6.4 E-2
90	(72)	96 m	Eu-152m1	Eu-153	2.7
90	(1.0)	9.56 h	Dy-155	Dy-156	1.5 E-4
91	(26)	42 m	Cr-49	Cr-50, Fe-54	4.8 E-1
91	(27)	10.98 d	Nd-147	Nd-148	1.4 E-2
91	(3)	29 m	Ho-164	Ho-165	1.0
92	(0.8)	11.5 d	Ba-131	Ba-132	1.2 E-5
93	(17)	61.9 h	Cu-67	Zn-68, Ga-71	3.0 E-2
93	(38)	78.3 h	Ga-67	Ga-69	7.2 E-2
93	(5)	44.3 s	Ag-107m	Ag-109, Cd-108	1.5
93	(5)	6.5 h	Cd-107	Cd-108	5 E-3
93	(0.1)	19.5 m	Tb-163	Dy-164	3.6 E-4
93	(7)	28.4 m	Lu-178	Hf-179	2.3 E-3
93	(19)	22.7 m	Lu-178m	Hf-179	w
93	(7)	5.5 h	Hf-180m	Ta-181, Hf-180	4.6 E-3
93	(6)	9.25 m	Ta-178	Ta-180	1.4 E-2
93	(17)	2.2 h	Ta-178m	Ta-180	7.5 E-1
93	(4)	8.1 h	Ta-180m	Ta-181	1.8
94	(0.5)	33 h	Sr-83	Sr-84	1.4 E-4
94	(2)	30.7 d	Yb-169	Yb-170	5.6 E-4
94	(5)	11 h	Pt-189	Pt-190	4.9 E-3
95	(4)	2.35 h	Dy-165	Dy-164	3.8 E-2
96	(10)	3.9 m	Se-79m	Se-80	5.9 E-1
96	(7)	18.7 m	Eu-159	Gd-160	2.9 E-2
96	(9)	8.2 m	As-79	Se-80	1.2 E-1
97	(3)	120 d	Se-75	Se-76	3.9 E-4
97	(2)	1.73 h	Nd-149	Nd-150	5.1 E-2
97	(0.7)	46.75 h	Sm-153	Sm-154	3.1 E-2
97	(3)	2.8 d	Pt-191	Pt-192	1.6 E-3
97	(18)	6.75 d	U-237	U-238	?
97	(27)	241.6 d	Gd-153	Gd-154	9.0 E-4
97	(3)	4.4 m	Rh-104m	Rh-103, Pd-105	2.8 E-1
98	(23)	2.6 m	Nb-99	Mo-100	4.4 E-2
99	(5)	150 a	Tb-158	Tb-159	1.1 E-5
99	(4)	93.1 d	Tm-168	Tm-169	6.8 E-3
99	(3)	71 d	Re-183	Re-185, Os-184	8.7 E-4
99	(9)	2.5 h	Ir-195	Pt-196	3.4 E-3

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
99	(11)	183 d	Au-195	Au-197, Hg-196	7.9 E-4
100	(14)	115 d	Ta-182	W-183, Ta-181	3.4 E-4
100	(15)	64 h	Re-182	Re-185, Os-184	3.0 E-4
100	(14)	13 h	Re-182m	Re-185	w
100	(?)	12.1 d	Ir-190	Ir-191	?
101	(3)	1.37 a	Lu-173	Lu-175, Hf-174	2.0 E-4
101	(27)	6.75 d	U-237	U-238	?
102	(0.6)	8.1 h	Ta-180m	Ta-181	2.7 E-1
103	(8)	57.3 m	Se-81m	Se-82	2.0 E-2
103	(28)	46.75 h	Sm-153	Sm-154	1.2
103	(19)	241.6 d	Gd-153	Gd-154	6.7 E-4
103	(0.1)	6.9 d	Tb-161	Dy-162	9.7 E-6
103	(3)	2.5 h	Ho-161	Er-162	1.1 E-3
104	(70)	22.4 m	Sm-155	Sm-154	2.7 E-1
105	(2)	62 d	Nb-91m	Mo-92, Nb-93	4.4 E-3
105	(23)	4.96 a	Eu-155	Gd-156	w
105	(23)	5.32 d	Tb-155	Dy-156	4.8 E-4
105	(12)	161 d	Lu-177m	Hf-178, Lu-176	8.0 E-5
106	(0.09)	120 d	Gd-151	Gd-152	3.1 E-7
106	(22)	17.7 m	Yb-167	Yb-168	2.0 E-1
106	(11)	18.6 m	Re-188m	Re-187, Os-189	1.8 E-2
108	(56)	14.5 m	Ba-131m	Ba-132	7.3 E-2
108	(3)	1.3 m	Dy-165m	Dy-164	3.3 E-2
108	(13)	5 d	Ta-183	W-184	7.4 E-4
109	(0.3)	58 d	Te-125m	Te-126	2.6 E-5
109	(0.2)	40.2 h	La-140	La-139	2.4 E-5
110	(0.9)	10.5 s	Tb-158m	Tb-159	?
110	(18)	30.7 d	Yb-169	Yb-170	5.0 E-3
111	(17)	38 d	Re-184	Re-185	3.4 E-2
112	(20)	7.5 h	Er-171	Er-170	4.8 E-3
113	(7)	6.71 d	Lu-177	Lu-176, Hf-178	6.7 E-4
113	(21)	161 d	Lu-177m	Hf-178, Lu-176	1.4 E-4
113	(54)	17.7 m	Yb-167	Yb-168	4.9 E-1
113	(1)	6.7 d	Lu-172	Lu-175	1.0 E-4
113	(7)	56.6 h	Ta-177	Ta-180	1.2 E-4
114	(2)	4.2 d	Yb-175	Yb-176, Lu-176	2.2
114	(21)	1.73 h	Nd-149	Nd-150	5.4 E-1

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
114	(0.3)	70 d	Hf-175	Hf-176	9.6 E-5
114	(2)	115 d	Ta-182	W-183, Ta-181	4.8 E-5
114	(2)	11 h	Pt-189	Pt-190	2 E-3
114	(10)	6.75 d	U-237	U-238	?
115	(20)	14 h	Os-183	Os-184	5.4 E-4
116	(95)	23 h	Cr-48	Cr-50	3.8 E-4
116	(0.5)	22 m	Rh-107	Pd-108	2.8 E-3
117	(25)	12.4 m	Nd-151	Nd-150	?
117	(2)	7.5 h	Er-171	Er-170	8.5 E-4
117	(2)	30.7 d	Yb-169	Yb-170	5.6 E-4
118	(4)	6.75 d	U-237	U-238	?
121	(16)	120 d	Se-75	Se-76	2.0 E-3
121	(0.4)	10.98 d	Nd-147	Nd-148	2.2 E-4
121	(34)	(33 m)	Ho-159	Er-162	?
122	(10)	1.7 m	Mn-57	Fe-58	7.1 E-3
122	(85)	270 d	Co-57	Ni-58, Co-59	5.2 E-2
122	(64)	19 s	Nd-90m	Mo-92	9.6 E-2
122	(64)	5.7 h	Mo-90	Mo-92	9.6 E-3
122	(31)	12.4 a	Eu-152	Eu-153	2.6 E-4
122	(6)	9.3 h	Eu-152m2	Eu-153	4.5 E-2
123	(0.2)	1.73 h	Nd-149	Nd-150	5.2 E-3
123	(40)	8.5	Eu-154	Eu-153, Gd-155	7.6 E-5
123	(0.7)	90.64 h	Re-186	Re-187, Os-187	2.0 E-2
124	(28)	11.5 d	Ba-131	Ba-132	4.2 E-4
124	(9)	7.5 h	Er-171	Er-170	2.1 E-3
124	(83)	23.6 h	Hf-173	Hf-174	1.5 E-2
125	(0.02)	75.1 d	W-185	W-186	3.1 E-5
125	(0.4)	94 d	Os-185	Os-186	1.4 E-5
126	(11)	3.7 d	Pd-100	Pd-102	1.1 E-3
126	(0.2)	10 h	Os-183m	Os-184	2.0 E-5
127	(15)	36 h	Ni-57	Ni-58	1.5 E-1
127	(2)	14 m	Tc-101	Ru-102, Mo-100	3.2 E-3
127	(70)	3.a	Rh-101	Rh-103, Pd-102	5.8 E-4
127	(0.6)	4.4 d	Rh-101m	Pd-102, Rh-103	5.3 E-3
127	(13)	2.9 h	Cs-134m	Cs-133, Ba-135	2.9
129	(51)	2.13 h	Ba-129m	Ba-130	1.1 E-2
129	(15)	161 d	Lu-177m	Hf-178, Lu-176	1.0 E-4

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
129	(3)	2.8 d	Pt-191	Pt-192	1.5 E-3
129	(20)	45 s	Rh-105m	Pd-106, Ru-104	8.0 E-2
130	(27)	50 s	Kr-79m	Sr-84	w
130	(26)	15.4 d	Os-191	Os-192	2.0 E-4
130	(0.1)	2.5 h	Ir-195	Pt-196	3.8 E-5
130	(0.1)	3.8 h	Ir-195m	Pt-196	1 E-5
130	(3)	4.02 d	Pt-195m	Pt-196	1.8 E-2
130	(0.8)	183 d	Au-195	Au-197, Hg-196	5.7 E-5
130	(3)	7.8 s	Au-197m	Au-197, Hg-198, Pt-198	?
130	(0.2)	23.8 h	Hg-197m	Hg-198	3.4 E-4
131	(0.5)	40.2 h	La-140	La-139	6.0 E-5
131	(0.6)	3.1 h	Er-161	Er-162	1.2 E-3
131	(11)	30.7 d	Yb-169	Yb-170	3.1 E-3
131	(3)	22.1 h	Os-182	Os-184	3.9 E-6
132	(4)	1.68 m	W-185m	W-186	1.4 E-2
132	(23)	(33 m)	Ho-159	Er-162	?
132	(3)	17.7 m	Yb-167	Yb-168	2.6 E-2
133	(0.02)	8.47 h	Pd-101	Pd-102	1.7
133	(4)	14.6 h	Nb-90	Mo-92	1.5 E-3
133	(2)	11.5 d	Ba-131	Ba-132	3.0 E-5
133	(40)	42.4 d	Hf-181	Hf-180	1.5 E-4
134	(0.04)	6.7 d	Lu-172	Lu-175	3.9 E-6
134	(0.1)	38 m	W-179	W-180	3.9 E-4
134	(9)	23.8 h	W-187	W-186	1.0 E-2
134	(34)	23.8 h	Hg-197m	Hg-198	5.7 E-2
135	(5)	23.6 h	Hf-173	Hf-174	9.0 E-4
135	(2)	73.5 h	Tl-201	Tl-203	6.0 E-3
136	(11)	270 d	Co-57	Ni-58, Co-59	6.7 E-3
136	(55)	120 d	Se-75	Se-76	7.1 E-3
136	(100)	50 s	Tc-103	Ru-104	?
136	(8)	2.13 h	Ba-129m	Ba-130	1.7 E-3
136	(8)	42.4 d	Hf-181	Hf-180	2.9 E-5
136	(0.1)	121.2 d	W-181	W-182	9.1 E-3
136	(0.1)	4.32 d	Pt-193m	Pt-194	9.3 E-4
137	(0.09)	4.2 d	Yb-175	Yb-176, Lu-176	1.0 E-3
137	(9)	90.64 h	Re-186	Re-187, Os-187	2.6 E-1
138	(3)	54 m	In-116m1	In-115, Sn-117	2.7 E-1

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
138	(2)	12.1 d	Ir-190	Ir-191	1.4 E-2
138	(1)	9.7 h	Au-196m	Au-197	1.2 E-1
139	(?)	144.4 d	Dy-159	Dy-160	?
139	(0.1)	56 h	Br-77	Br-79	2.2 E-4
139	(0.5)	1.73 h	Nd-149	Nd-150	1.3 E-2
139	(0.5)	28 h	Pm-151	Sm-152	1.0 E-4
139	(4)	30 h	Os-193	Os-192	3.9 E-4
139	(0.2)	39 m	Se-73m	Se-74	6.4 E-3
140	(34)	48 s	Ge-75m	Ge-76, Se-80	3.4 E+5
140	(13)	23.6 h	Hf-173	Hf-174	2.5 E-3
141	(89)	6 h	Tc-99m	Ru-100, Mo-100	4.2 E-1
141	(67)	14.6 h	Nb-90	Mo-92	2.5 E-2
141	(3)	11 h	Pt-189	Pt-190	2.9 E-3
143	(2)	17.7 m	Yb-167	Yb-168	1.8 E-2
144	(0.08)	8.1 h	Dy-157	Dy-158	2.9 E-5
144	(3)	5 d	Ta-183	W-184	1.7 E-4
145	(83)	46.5 h	Zn-72	Ge-76	2.1 E-3
145	(49)	32.51 d	Ce-141	Ce-142	2.7 E-2
145	(0.2)	2.5 h	Nd-141	Nd-142	3.2 E-2
145	(0.3)	4.2 d	Yb-175	Yb-176, Lu-176	3.3 E-3
146	(3)	18.7 m	Eu-159	Gd-160	1.2 E-2
147	(45)	32 m	Cl-34m	Cl-35, K-39	4.3
147	(0.2)	19.5 m	Tb-163	Dy-164	7.2 E-4
147	(36)	16 m	Ta-182m	W-183, Ta-181	3.6 E-4
147	(2)	24.3 h	Re-189	Os-190	4.6 E-4
147	(0.5)	10 h	Os-183	Os-184	5.0 E-5
148	(0.03)	3.1 h	Er-161	Er-162	6.2 E-4
148	(43)	9.7 h	Au-196m	Au-197	5.1
149	(2)	5.32 d	Tb-155	Dy-156	4.2 E-5
149	(?)	64 h	Re-182	Re-185, Os-184	?
150	(53)	9.5 d	Gd-149	Gd-152	1.4 E-5
150	(68)	25 m	Te-131	Te-130	4.2 E-4
150	(0.04)	17.7 m	Tb-167	Tb-168	3.6 E-4
150	(20)	1.9 h	Yb-177	Yb-176	3.8 E-3
150	(30)	49 m	Cd-111m	Cd-112	1.2 E-1
151	(74)	4.48 h	Kr-85m	Rb-87	6.6 E-2
151	(12)	67.7 m	Sr-85m	Sr-86	1.3

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
151	(0.01)	46.75 h	Sm-153	Sm-154	4.4 E-4
152	(8)	4.6 m	Ho-169	Er-170	1.1 E-1
152	(7)	115 d	Ta-182	W-183, Ta-181	1.7 E-4
152	(0.2)	121.1 d	W-181	W-182	1.8 E-2
153	(12)	42 m	Cr-49	Cr-50, Fe-54	2.3 E-1
153	(66)	4.7 d	Te-119m	Te-120	2.6 E-4
153	(8)	13 d	Cs-136	Ba-137	8.8 E-5
153	(18)	161 d	Lu-177m	Hf-178, Lu-176	1.2 E-4
154	(0.2)	1.3 m	Dy-165m	Dy-164	2.2 E-3
154	(0.1)	3.85 d	Sb-127	Te-128	1.5 E-5
154	(7)	120 d	Gd-151	Gd-152	2.4 E-5
154	(0.3)	19.5 m	Tb-163	Dy-164	1.1 E-3
155	(13)	20.8 m	In-112m	In-113	5.0 E-1
155	(15)	16.98 h	Re-188	Re-187, Os-189	8.6 E-2
155	(30)	41.5 h	Ir-188	Ir-191	2.3 E-4
155	(0.5)	41.2 d	Ag-105	Ag-107, Cd-106	1.3 E-4
156	(7)	1.73 h	Nd-149	Nd-150	1.8 E-1
156	(3)	115 d	Ta-182	W-183, Ta-181	6.1 E-5
157	(0.2)	4.4 d	Rh-101m	Pd-102, Rh-103	1.7 E-3
157	(0.5)	2.5 h	Ho-161	Er-162	1.9 E-4
158	(100)	6.1 d	Ni-56	Ni-58	2.1 E-3
158	(0.03)	8.47 h	Pd-101	Pd-102	2.5 E-2
158	(39)	3.13 d	Au-199	Hg-200	2.3 E-3
158	(52)	42.6 m	Hg-199m	Hg-200	2.8
159	(84)	14 d	Sn-117m	Sn-118	5.0 E-1
159	(70)	3.42 d	Sc-47	Ti-48, Ca-48	6.7 E-2
159	(2)	3.7 d	Pd-100	Pd-102	2.0 E-4
159	(14)	1.95 h	In-117m	Sn-118	6.6 E-3
159	(86)	40.1 m	Sn-123m	Sn-124	5.1
159	(84)	119.7 d	Te-123m	Te-124	1.8 E-3
160	(10)	54 s	Ge-77m	Ge-76	7.1 E-3
160	(1)	18.7 m	Eu-159	Gd-160	4.1 E-3
160	(1)	4.6 m	Ho-169	Er-170	1.4 E-2
161	(0.03)	17.7 m	Yb-167	Yb-168	2.8 E-4
161	(10)	5 d	Ta-183	W-184	5.7 E-4
162	(0.02)	36 h	Ni-57	Ni-58	2.0 E-4
162	(52)	17.5 s	Se-77m	Se-78	5.7 E-2

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
162	(52)	17.5 s	Se-77m	Se-78	5.7 E-2
162	(0.1)	38.8 h	As-77	Se-78, Br-81	8.5 E-5
162	(1)	56 h	Br-77	Br-79	2.2 E-3
162	(1)	9.59 h	Dy-155	Dy-156	1.5 E-4
162	(7)	23.6 h	Hf-173	Hf-174	1.3 E-3
162	(24)	71 d	Re-183	Re-185, Os-184	7.0 E-3
163	(6)	5.7 h	Mo-90	Mo-92	9.0 E-4
163	(2)	28 h	Pm-151	Sm-152	4.0 E-4
163	(7)	5.32 d	Tb-155	Dy-156	1.4 E-4
163	(0.1)	10 h	Os-183m	Os-184	1.0 E-4
163	(0.7)	94 d	Os-185	Os-186	2.5 E-5
164	(5)	13 d	Cs-136	Ba-137	5.5 E-5
164	(0.6)	1.68 m	W-185m	W-186	2.2 E-3
165	(0.3)	23.8 h	Hg-197m	Hg-198	5.1 E-4
165	(2)	6.75 d	U-237	U-238	?
166	(22)	82.7 m	Ba-139	Ba-138	2.4 E-3
166	(80)	137.5 d	Ce-139	Ce-140	1.1 E-1
167	(0.6)	19.5 m	Tb-163	Dy-164	2.2 E-3
167	(9)	73.5 h	Tl-201	Tl-203	2.7 E-2
168	(8)	28 d	Pm-151	Sm-152	1.6 E-3
168	(8)	14 h	Os-183	Os-184	2.2 E-4
168	(8)	9.7 h	Au-196m	Au-197	9.6 E-1
169	(0.4)	34.4 h	Ce-137	Ce-138	1.8 E-5
169	(99)	8.2 h	Fe-52	Fe-54	?
169	(0.16)	17.7 m	Yb-167	Yb-168	1.5 E-3
171	(89)	2.83 d	In-111	Sn-112, In-113	4.6 E-1
171	(0.39)	10 h	Os-183m	Os-184	3.9 E-5
171	(2)	1.37 a	Lu-173	Lu-175, Hf-174	1.3 E-4
172	(47)	16 m	Ta-182m	W-183, Ta-181	4.7 E-4
172	(3)	2.8 d	Pt-191	Pt-192	1.6 E-3
173	(0.08)	46.75 h	Sm-153	Sm-154	3.5 E-3
173	(7)	3.8 h	Ir-195m	Pt-196	1.1 E-3
174	(0.1)	40.2 h	La-140	La-139	1.2 E-5
174	(12)	161 d	Lu-177m	Hf-178, Lu-176	8.0 E-5
174	(22)	49 m	Ta-184m	W-186	?
174	(3)	1.68 m	W-185m	W-186	1.1 E-2
174	(82)	16.3 m	K-45	Ca-46	3.5 E-5

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
168	(8)	28 d	Pm-151	Sm-152	1.6 E-3
168	(8)	14 h	Os-183	Os-184	2.2 E-4
168	(8)	9.7 h	Au-196m	Au-197	9.6 E-1
169	(0.4)	34.4 h	Ce-137	Ce-138	1.8 E-5
169	(99)	8.2 h	Fe-52	Fe-54	?
169	(0.16)	17.7 m	Yb-167	Yb-168	1.5 E-3
171	(89)	2.83 d	In-111	Sn-112, In-113	4.6 E-1
171	(0.39)	10 h	Os-183m	Os-184	3.9 E-5
171	(2)	1.37 a	Lu-173	Lu-175, Hf-174	1.3 E-4
172	(47)	16 m	Ta-182m	W-183, Ta-181	4.7 E-4
172	(3)	2.8 d	Pt-191	Pt-192	1.6 E-3
173	(0.08)	46.75 h	Sm-153	Sm-154	3.5 E-3
173	(7)	3.8 h	Ir-195m	Pt-196	1.1 E-3
174	(0.1)	40.2 h	La-140	La-139	1.2 E-5
174	(12)	161 d	Lu-177m	Hf-178, Lu-176	8.0 E-5
174	(22)	49 m	Ta-184m	W-186	?
174	(3)	1.68 m	W-185m	W-186	1.1 E-2
174	(82)	16.3 m	K-45	Ca-46	3.5 E-5
175	(6)	43.67 h	Sc-48	Ti-49	1.9 E-3
175	(0.2)	21.1 m	Ga-70	Ga-71, Ge-72, As-75	1.1 E-2
175	(4)	120 d	Gd-151	Gd-152	1.3 E-5
176	(0.4)	2.5 h	Ho-161	Er-162	2.2 E-4
176	(23)	17.7 m	Yb-167	Yb-168	2.1 E-1
177	(12)	2.13 h	Ba-129m	Ba-130	2.5 E-3
177	(0.3)	32.06 h	Cs-129	Ba-130	3.9 E-5
177	(14)	13 d	Cs-136	Ba-137	1.6 E-4
177	(4)	28 h	Pm-151	Sm-152	8.0 E-4
177	(1)	18.7 m	Eu-159	Gd-160	4.1 E-3
177	(0.7)	19.5 m	Tb-163	Dy-164	2.5 E-3
177	(22)	30.7 d	Yb-169	Yb-170	6.2 E-3
177	(3)	161 d	Lu-177m	Hf-178, Lu-176	2.0 E-5
178	(26)	49 m	Ta-185	W-186	?
178	(12)	80 s	Rh-109	Pd-110	2.5 E-2
178	(6)	(33 m)	Ho-159	Er-162	?
179	(6)	64 h	Re-182	Re-185, Os-184	1.2 E-4
179	(0.8)	1.37 a	Lu-173	Lu-175, Hf-174	5.5 E-5
179	(1)	2.8 d	Pt-191	Pt-192	5.3 E-4

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
179	(3)	115 d	Ta-182	W-183, Ta-181	7.2 E-5
180	(0.5)	4.4 d	Rh-101m	Pd-102, Rh-103	4.4 E-3
180	(7)	5.32 d	Tb-155	Dy-156	1.5 E-4
180	(33)	22.1 h	Os-182	Os-184	4.3 E-5
180	(0.4)	30 h	Os-193	Os-192	3.9 E-5
180	(2)	9.5 h	Hg-195	Hg-196	1.5 E-3
181	(0.3)	56 h	Br-77	Br-79	6.6 E-4
181	(6)	66 h	Mo-99	Mo-100	1.9 E-2
181	(0.8)	3.6 m	Gd-161	Gd-160	8.0 E-4
181	(20)	6.7 d	Lu-172	Lu-175	1.9 E-3
181	(62)	18.7 h	Au-200m	Hg-201	3.2 E-6
181	(1)	39 m	Se-73m	Se-74	3.2 E-2
182	(100)	2.13 h	Ba-129m	Ba-130	2.1 E-2
182	(9)	150 a	Tb-158	Tb-159	1.9 E-5
182	(2)	8.1 h	Dy-157	Dy-158	7.2 E-4
182	(3)	63.6 h	Tm-172	Yb-173	1.7 E-4
183	(0.4)	41.2 d	Ag-105	Ag-107, Cd-106	1.0 E-4
184	(1)	14 m	Tc-101	Ru-102, Mo-100	1.6 E-3
184	(0.1)	4.4 d	Rh-101m	Pd-102, Rh-103	8.7 E-4
184	(16)	7.7 h	Tm-166	Tm-169	5.6 E-4
184	(17)	93.1 d	Tm-168	Tm-169	2.9 E-2
184	(16)	6.24 d	Bi-206	Bi-209	4.7 E-4
185	(4)	9.59 h	Dy-155	Dy-156	6.1 E-4
185	(47)	61.9 h	Cu-67	Zn-68, Ga-71	8.0 E-2
185	(24)	78.3 h	Ga-67	Ga-69	4.6 E-2
185	(17)	7.6 m	Tb-162	Dy-163	5.8 E-2
185	(29)	68 m	Ho-162m	Ho-165	1.1 E-1
185	(23)	16 m	Ta-182m	W-183, Ta-181	2.3 E-4
186	(2)	24.3 h	Re-189	Os-190	4.6 E-4
187	(0.06)	56 h	Br-77	Br-79	1.3 E-4
187	(79)	9.9 m	Os-190m	Ir-191, Os-192	2.3
187	(52)	12.1 d	Ir-190	Ir-191	3.7 E-1
187	(68)	3.1 h	Ir-190m	Ir-191	2.0
187	(1)	11 h	Pt-189	Pt-190	1.0 E-3
188	(0.8)	1.68 m	W-185m	W-186	2.9 E-3
188	(19)	10.2 d	Pt-188	Pt-190	7.3 E-4
188	(0.4)	2.8 d	Pt-191	Pt-192	2.1 E-4

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
187	(52)	12.1 d	Ir-190	Ir-191	3.7 E-1
187	(68)	3.1 h	Ir-190m	Ir-191	2.0
187	(1)	11 h	Pt-189	Pt-190	1.0 E-3
188	(0.8)	1.68 m	W-185m	W-186	2.9 E-3
188	(19)	10.2 d	Pt-188	Pt-190	7.3 E-4
188	(0.4)	2.8 d	Pt-191	Pt-192	2.1 E-4
188	(38)	9.7 h	Au-196m	Au-197	4.5
189	(58)	4.69 m	Pd-109m	Pd-110	1.2
189	(2)	1.73 h	Nd-149	Nd-150	5.2 E-2
190	(17)	49.5 d	In-114m	In-115, Sn-115	3.9 E-2
190	(1)	41.3 d	Pm-148m	Sm-149	2.0 E-6
190	(0.1)	12.1 d	Ir-190	Ir-191	7.2 E-4
191	(4)	20 h	Pt-197	Pt-198	9.1 E-2
191	(0.5)	64.1 h	Hg-197	Hg-198	7.0 E-4
192	(20)	14.6 m	Mo-101	Mo-100	1.1 E-2
192	(0.7)	1.73 h	Nd-149	Nd-150	1.8 E-2
194	(1)	(20.9 m)	Pm-141	Sm-144	?
195	(0.6)	2.2 h	Rh-106m	Pd-108	4.0 E-3
195	(0.3)	8.3 d	Ag-106m	Ag-107	1.3 E-4
195	(18)	10.2 d	Pt-188	Pt-190	6.9 E-4
197	(100)	5.76 d	Sb-120m	Sb-121	7.5 E-2
197	(0.2)	10.98 d	Nd-147	Nd-148	1.1 E-4
197	(74)	22.6 m	Sm-141m	Sm-144	w
197	(5)	72.1 d	Tb-160	Tb-159, Dy-161	2.2 E-4
197	(14)	(5 h)	Ho-160n	Er-162	?
197	(6)	12.1 d	Ir-190	Ir-191	4.3 E-2
198	(70)	3 a	Rh-101	Rh-103, Pd-102	5.8 E-4
198	(50)	93.1 d	Tm-168	Tm-169	8.5 E-2
198	(36)	30.7 d	Yb-169	Yb-170	9.9 E-3
198	(1)	115 d	Ta-182	W-183, Ta-181	2.4 E-5
199	(1)	120 d	Se-75	Se-76	1.3 E-4
199	(1)	83 m	Ge-75	Ge-76, Se-80	1.9 E-1
199	(1.0)	1.73 h	Nd-149	Nd-150	2.6 E-2
199	(0.8)	15.2 d	Eu-156	Gd-157	7.5 E-6
199	(42)	5.35 d	Tb-156	Tb-159	5.0 E-4
200	(1)	56 h	Br-77	Br-79	2.2 E-3
200	(0.04)	9.5 h	Hg-195	Hg-196	3.1 E-5

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
200	(1)	40 h	Hg-195m	Hg-196	2.4 E-5
201	(1)	3.2 h	Er161	Er-162	2.1 E-3
202	(39)	2.13 h	Ba-129m	Ba-130	8.2 E-3
202	(0.07)	23.8 h	Hg-197m	Hg-198	1.2 E-4
202	(0.04)	6.24 d	Bi-206	Bi-209	1.2 E-6
202	(97)	3.19 h	Y-90m	Zr-91	1.2 E-1
203	(6)	5.7 h	Mo-90	Mo-92	9.1 E-4
203	(0.06)	9.35 h	Te-127	Te-128	6.6 E-3
203	(5)	6.7 d	Lu-172	Lu-175	4.8 E-4
204	(66)	60 d	Tc-95m	Ru-96	1.1 E-3
204	(14)	161 d	Lu-177m	Hf-178, Lu-176	9.4 E-5
206	(8)	17 h	Ce-135	Ce-136	2.9 E-3
206	(0.4)	9.59 h	Dy-155	Dy-156	6.0 E-5
206	(9)	36 m	Er-159	Er-162	w
206	(40)	(8.3 s)	Ho-159m	Er-162	?
206	(0.1)	23.8 h	W-187	W-186	1.1 E-4
206	(3)	74 d	Ir-192	Ir-193	3.9 E-3
207	(2)	9.5 h	Hg-195	Hg-196	1.6 E-3
207	(0.5)	40 h	Hg-195m	Hg-196	1.2 E-5
208	(3)	1.73 h	Nd-149	Nd-150	7.8 E-2
208	(5)	3.1 h	Ho-167	Er-168	6.2 E-3
208	(41)	(2.3 s)	Er-167m	Tm-169	?
208	(41)	9.25 h	Tm-167	Tm-169, Yb-168	1.5 E-1
208	(11)	6.71 d	Lu-177	Lu-176, Hf-178	1.1 E-3
208	(61)	161 d	Lu-177m	Hf-178, Lu-176	4.2 E-4
208	(0.8)	56.6 h	Ta-177	Ta-180	1.4 E-5
208	(2)	12.1 d	Ir-190	Ir-191	1.4 E-2
208	(8)	3.13 d	Au-199	Hg-200	4.7 E-4
208	(23)	6.75 d	U-237	U-238	?
209	(2)	78.3 h	Ga-67	Ga-69	3.8 E-3
209	(2)	4.4 m	In-118m	Sn-119	9.4 E-5
209	(0.2)	69.6 m	Te-129	Te-130	3.8 E-2
209	(2)	28 h	Pm-151	Sm-152	4.0 E-4
209	(3)	71 d	Re-183	Re-185, Os-184	8.7 E-4
209	(0.1)	2.8 d	Pt-191	Pt-192	5.3 E-5
210	(5)	5 d	Ta-183	W-184	2.9 E-4
211	(29)	11.3 h	Ge-77	Se-82	7.0 E-5

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
211	(31)	1.73 h	Nd-149	Nd-150	8.0 E-1
211	(0.2)	2.5 h	Ho-161	Er-162	7.4 E-5
211	(12)	3.1 h	Er-161	Er-162	2.6 E-2
211	(0.6)	7.5 h	Er-171	Er-170	1.4 E-4
211	(?)	2.5 h	Ir-195	Pt-196	?
211	(?)	3.8 h	Ir-195m	Pt-196	?
212	(83)	154 d	Te-121m	Te-122	6.0 E-4
212	(0.7)	19.5 m	Tb-163	Dy-164	2.5 E-3
213	(82)	22.7 m	Lu-178m	Hf-179	2.8 E-2
213	(0.1)	9.25 m	Ta-178	Ta-180, W-180	4.4 E-3
214	(68)	21.3 s	Pd-107m	Pd-108, Ag-109	1.6
214	(12)	4.6 h	Lu-179	Hf-180	?
214	(87)	2.13 h	Ba-129m	Ba-130	1.8 E-2
214	(0.5)	1.73 h	Nd-149	Nd-150	1.3 E-2
214	(80)	2.2 h	Ta-178m	Ta-180, W-180	1.8 E-1
214	(95)	18.7 s	Hf-179m	Hf-180, Ta-180	9.5 E+1
215	(37)	21 m	Rb-84m	Rb-85, Sr-86, Y-89	1.7 E+2
215	(2)	80 s	Rh-109	Pd-110	4.2 E-3
215	(82)	5.5 h	Hf-180m	Ta-181, Hf-180	2.2 E-2
216	(91)	2.9 d	Ru-97	Ru-98	3.4 E-1
216	(4)	72.1 d	Tb-160	Tb-159, Dy-161	1.7 E-4
216	(26)	11.3 h	Ge-77	Se-82	6.2 E-5
216	(22)	54 s	Ge-77m	Se-82, Ge-76	2.1 E-2
216	(22)	11.5 d	Ba-131	Ba-132	3.4 E-4
216	(5)	7.7 h	Tm-166	Tm-169	1.8 E-4
216	(10)	165 d	Re-184m	Re-185	?
218	(0.9)	150 a	Tb-158	Tb-159	2.0 E-6
219	(4)	23.4 h	Nb-96	Mo-97	3.1 E-3
219	(10)	24.3 h	Re-189	Os-190	2.3 E-3
219	(0.3)	30 h	Os-193	Os-192	2.9 E-5
220	(0.8)	2.8 d	Pt-191	Pt-192	4.2 E-4
221	(2)	35.34 h	Br-82	Br-81, Rb-87	9.6 E-5
221	(53)	2.13 h	Ba-129m	Ba-130	1.1 E-2
221	(0.6)	5.32 d	Tb-155	Dy-156	1.3 E-4
221	(6)	22.2 h	K-43	Ca-44	2.4 E-3
222	(7)	8.3 d	Ag-106m	Ag-107	2.9 E-3
222	(8)	115 d	Ta-182	W-183, Ta-181	1.9 E-4

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
222	(9)	6.7 m	W-179m	W-180	3.0 E-3
223	(0.09)	1.37 a	Lu-173	Lu-175, Hf-174	6.1 E-6
224	(4)	12.1 d	Ir-190	Ir-191	2.8 E-2
226	(0.2)	18.56 h	Gd-159	Gd-160	8.8 E-3
227	(0.2)	1.73 h	Nd-149	Nd-150	5.2 E-3
227	(68)	9.59 h	Dy-155	Dy-156	1.0 E-2
228	(2)	18.7 m	Eu-159	Gd-160	7.9 E-3
228	(37)	161 d	Lu-177m	Hf-178, Lu-176	2.5 E-4
229	(2)	8.3 d	Ag-106m	Ag-107	8.4 E-4
229	(0.3)	6.7 d	Lu-172	Lu-175	2.9 E-5
229	(4)	115 d	Ta-182	W-183, Ta-181	9.6 E-5
229	(27)	64 h	Re-182	Re-185, Os-184	5.4 E-4
230	(32)	20 m	Ag-115	Cd-116	5.4 E-3
230	(0.6)	1.73 h	Nd-140	Nd-150	1.6 E-2
230	(0.8)	70 d	Hf-175	Hf-176	2.5 E-4
230	(0.8)	10 h	Os-183m	Os-184	8.0 E-5
231	(0.2)	55 m	Cd-105	Cd-106	1.1 E-4
231	(1)	53.38 h	Cd-115	Cd-116	6.1 E-3
231	(0.08)	72.1 d	Tb-160	Tb-159, Dy-161	3.4 E-6
232	(85)	67.7 m	Sr-85m	Sr-86	9.4
232	(0.2)	22 m	Rh-107	Pd-108	1.1 E-3
232	(1)	28 h	Pm-151	Sm-152	2.0 E-4
233	(0.3)	6.7 d	Lu-172	Lu-175	2.9 E-5
233	(0.3)	1.37 a	Lu-173	Lu-175, Hf-174	2.0 E-5
234	(0.3)	39 h	Ge-69	Ge-70, Se-74	3.6 E-3
234	(3)	14 m	Tc-101	Ru-102, Mo-100	4.8 E-3
234	(0.2)	4.4 d	Rh-101m	Pd-102, Rh-103	1.8 E-3
234	(0.4)	94 d	Os-185	Os-186	1.5 E-5
234	(0.3)	6.24 d	Bi-206	Bi-209	8.7 E-6
235	(25)	86.6 h	Nb-95m	Mo-96	2.1 E-3
235	(0.4)	12.1 d	Ir-190	Ir-191	2.8 E-3
236	(0.5)	3.1 h	Er-161	Er-162	1.0 E-3
236	(3)	14 h	Os-183	Os-184	8.1 E-5
237	(0.3)	7.5 h	Er-171	Er-170	7.2 E-5
238	(3)	14 m	Tc-101	Ru-102, Mo-100	4.8 E-3
238	(0.2)	4.4 d	Rh-101m	Pd-102, Rh-103	1.7 E-3
238	(0.01)	72.1 d	Tb-160	Tb-159, Dy-161	4.3 E-7

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
238	(5)	3.1 h	Ho-167	Er-168	6.0 E-3
239	(2)	38.8 h	As-77	Se-78, Br-81	1.7 E-3
239	(22)	56 h	Br-77	Br-79	4.8 E-2
239	(0.3)	67.7 m	Sr-85m	Sr-86	3.1 E-2
239	(0.2)	120 d	Gd-151	Gd-152	6.8 E-7
239	(0.2)	5.32 d	Tb-155	Dy-156	4.2 E-6
239	(0.2)	2.7 m	W-179m	W-180	6.8 E-5
239	(46)	1.8 h	Os-181	Os-184	?
240	(0.06)	4.02 d	Pt-195m	Pt-196	3.5 E-4
240	(3)	11.5 d	Ba-131	Ba-132	4.5 E-5
240	(5)	1.73 h	Nd-149	Nd-150	1.3 E-1
240	(3)	28 h	Pm-151	Sm-152	6.0 E-4
241	(4)	23.4 h	Nb-96	Mo-97	3.1 E-3
242	(0.4)	40.2 h	La-140	La-139	4.8 E-5
242	(0.08)	9.5 h	Hg-195	Hg-196	6.2 E-5
243	(2)	9.13 h	Zn-62	Zn-64	1.6 E-3
243	(7)	120 d	Gd-151	Gd-152	2.4 E-5
244	(4)	11 h	Pt-189	Pt-190	3.9 E-3
245	(8)	12.4 a	Eu-152	Eu-153	6.7 E-5
245	(94)	2.83 d	In-111	Sn-112, In-113	4.9 E-1
245	(3)	24.3 h	Re-189	Os-190	6.9 E-4
245	(6)	3.3 d	Ir-189	Ir-191, Pt-190	2.9 E-3
246	(0.9)	7.5 d	Ag-111	Cd-112	?
246	(?)	1.2 m	Ag-111m	Cd-112	?
246	(94)	49 m	Cd-111m	Cd-112	3.7 E-1
246	(1)	1.73 h	Nd-149	Nd-150	2.6 E-2
246	(36)	22.4 m	Sm-155	Sm-154	1.6 E-2
246	(36)	5 d	Ta-183	W-184	2.1 E-3
246	(2)	71 d	Re-183	Re-185, Os-184	5.8 E-4
246	(0.1)	23.8 h	W-187	W-186	1.1 E-4
246	(0.3)	10 h	Os-183m	Os-184	3.0 E-5
247	(0.4)	6.7 d	Lu-172	Lu-175	3.9 E-5
248	(65)	21 m	Rb-84m	Rb-85, Sr-86, Y-89	3.1 E+2
249	(4)	11.5 d	Ba-131	Ba-132	5.9 E-5
250	(0.4)	38.8 h	As-77	Se-78, Br-81	3.5 E-4
250	(3)	56 h	Br-77	Br-79	6.6 E-3
250	(?)	50 s	Rh-109m	Pd-110	?

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
250	(0.2)	6.71 d	Lu-177	Lu-176, Hf-178	1.9 E-5
251	(0.4)	69.6 m	Te-129	Te-130	7.6 E-4
251	(7)	19.5 m	Tb-163	Dy-164	2.6 E-2
251	(0.08)	4.2 d	Yb-175	Yb-176, Lu-176	8.7 E-4
252	(0.4)	10 h	Os-183m	Os-184	4.0 E-5
252	(8)	3.85 d	Sb-127	Te-128	1.1 E-3
253	(0.7)	60 d	Tc-95m	Ru-96	1.1 E-5
253	(100)	2.1 m	Ga-75	Ge-76	?
253	(14)	(33 m)	Ho-159	Er-162	?
253	(0.5)	3.1 h	Er-161	Er-162	1.1 E-3
253	(3)	38 d	Re-184	Re-185	6.0 E-3
253	(0.1)	55 m	Cd-105	Cd-106	5.7 E-5
254	(3)	39 m	Se-73m	Se-74	9.7 E-2
254	(14)	2.6 m	Nb-99	Mo-100	2.6 E-2
254	(11)	34.4 h	Ce-137m	Ce-138	5.0 E-4
255	(2)	115.1 d	Sn-113	Sn-114	3.0 E-5
255	(0.2)	4.5 h	Pr-139	Pr-141	2.0 E-1
255	(0.6)	93.1 d	Eu-149	Eu-151	8.4 E-5
256	(17)	12.4 m	Nd-151	Nd-150	?
256	(10)	64 h	Re-182	Re-185, Os-184	1.8 E-4
256	(80)	18.7 h	Au-200m	Hg-201	4.1 E-6
257	(78)	5.7 h	Mo-90	Mo-92	1.2 E-2
257	(?)	(3.9 s)	Au-193m	Hg-196	?
258	(60)	11.1 h	Hg-193m	Hg-196	w
258	(0.4)	1.73 h	Nd-140	Nd-150	1.0 E-2
258	(0.5)	28 h	Pm-151	Sm-152	1.0 E-4
259	(2)	5.37 h	Ag-113	Cd-114	1.0 E-3
260	(1)	9.13 h	Zn-62	Zn-64	8.2 E-4
260	(0.05)	18 m	Se-81	Se-82	2.7 E-4
260	(0.01)	57.3 m	Se-81m	Se-82	2.6 E-5
260	(80)	7.6 m	Tb-162	Dy-163	2.7 E-1
260	(0.6)	19.5 m	Tb-163	Dy-164	2.1 E-3
261	(13)	34.9 h	Kr-79	Sr-84	w
261	(3)	53.38 h	Cd-115	Cd-116	1.8 E-3
262	(5)	5.32 d	Tb-155	Dy-156	1.0 E-4
262	(2)	9.5 h	Hg-195	Hg-196	1.5 E-3
262	(38)	40 h	Hg-195m	Hg-196	8.8 E-4

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
263	(0.4)	39 m	Se-73m	Se-74	1.2 E-2
263	(57)	6.9 h	Mo-93m	Mo-94	1.9 E-1
263	(0.2)	55 m	Cd-105	Cd-106	1.1 E-4
263	(3)	6.24 d	Bi-206	Bi-209	8.7 E-5
264	(0.02)	14.6 a	Cd-113m	Cd-114	w
264	(4)	115 d	Ta-182	W-183, Ta-181	9.6 E-5
265	(50)	11.3 h	Ge-77	Se-82	1.2 E-4
265	(11)	83 m	Ge-75	Ge-76, Se-80	2.1
265	(59)	120 d	Se-75	Se-76	7.6 E-3
265	(0.6)	6.7 d	Lu-172	Lu-175	5.8 E-5
266	(42)	17 h	Ce-135	Ce-136	1.6 E-2
266	(0.3)	22 m	Rh-107	Pd-108	1.6 E-3
267	(6)	10.1 h	Y-93	Zr-94	6.6 E-3
267	(0.3)	32.06 h	Cs-129	Ba-130	3.9 E-5
267	(0.5)	40.2 h	La-140	La-139	6.0 E-5
268	(16)	28.7 h	Ba-135m	Ba-136	4.2 E-2
268	(2)	2.8 d	Pt-191	Pt-192	1.1 E-3
269	(0.3)	20 h	Pt-197	Pt-198	6.6 E-3
269	(0.04)	64.1 h	Hg-197	Hg-198	5.6 E-5
270	(34)	6.1 d	Ni-56	Ni-58	7.1 E-4
270	(7)	8.47 h	Pd-101	Pd-102	5.8
270	(19)	1.73 h	Nd-140	Nd-150	5.0 E-1
270	(2)	6.7 d	Lu-172	Lu-175	1.9 E-4
271	(86)	2.44 d	Sc-44m	Sc-45, Ti-46	1.4 E-1
271	(0.3)	56 h	Br-77	Br-79	6.6 E-4
271	(0.1)	16 h	Te-119	Te-120	5.1 E-5
271	(27)	4.7 d	Te-119m	Te-120	1.1 E-4
271	(1)	9.59 h	Dy-155	Dy-156	1.5 E-4
272	(13)	1.37 a	Lu-173	Lu-175, Hf-174	8.9 E-4
272	(0.3)	8.83 m	Sm-143	Sm-144	5.7 E-2
273	(0.7)	142 d	Lu-174m	Lu-175	6.0 E-5
274	(13)	13 d	Cs-136	Ba-137	1.5 E-4
274	(0.005)	18.56 h	Gd-159	Gd-160	2.2 E-4
275	(0.8)	10.98 d	Nd-147	Nd-148	4.3 E-4
275	(0.7)	1.73 h	Nd-149	Nd-150	1.8 E-2
275	(6)	28 h	Pm-151	Sm-152	1.2 E-3
276	(0.9)	18 m	Se-81	Se-82	4.9 E-3

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
276	(0.7)	57.3 m	Se-81m	Se-82	1.8 E-3
276	(8)	38.9 h	Ba-133m	Ba-134	1.0 E-2
276	(0.09)	3.1 h	Er-161	Er-162	1.9 E-4
276	(9)	64 h	Re-182	Re-185, Os-184	1.8 E-4
277	(3)	93.1 d	Eu-149	Eu-151	4.2 E-4
277	(0.6)	7.5 h	Er-171	Er-170	1.5 E-4
277	(96)	88 m	Ge-78	Se-82	2.9 E-3
278	(2)	22 m	Rh-107	Pd-108	1.1 E-2
278	(0.6)	69.6 m	Te-129	Te-130	1.2 E-2
279	(2)	32.06 h	Cs-129	Ba-130	2.6 E-4
279	(2)	81 m	Pt-197m	Pt-198	4.5 E-2
279	(73)	(7.8 s)	Au-197m	Pt-198	?
279	(0.2)	40 h	Hg-195m	Hg-196	4.7 E-6
279	(5)	23.8 h	Hg-197m	Hg-198	8.5 E-3
279	(82)	46.6 d	Hg-203	Hg-204	3.0 E-2
279	(81)	52.1 h	Pb-203	Pb-204	1.1 E-1
280	(0.5)	2.35 h	Dy-165	Dy-164	4.8 E-3
280	(1)	6.7 d	Lu-172	Lu-175	1.0 E-4
280	(25)	120 d	Se-75	Se-76	3.3 E-3
280	(32)	41.2 d	Ag-105	Ag-107, Cd-106	8.3 E-3
280	(1)	6.7 d	Lu-172	Lu-175	1.0 E-4
280	(0.2)	35.5 h	Rh-105	Pd-106	1.7 E-4
281	(0.6)	3.85 d	Sb-127	Te-128	9.0 E-5
281	(0.2)	5.32 d	Tb-155	Dy-156	4.2 E-6
281	(1)	30 h	Os-193	Os-192	9.7 E-5
282	(0.06)	38.8 h	As-77	Se-78, Br-81	5.2 E-5
282	(2)	56 h	Br-77	Br-79	4.4 E-3
283	(13)	3.3 h	Cu-61	Cu-63	1.6 E-1
283	(98)	4 h	Sn-110	Sn-112	3.0 E-1
283	(0.7)	1.73 h	Nd-149	Nd-150	1.8 E-2
283	(6)	3.6 m	Gd-161	Gd-160	6.0 E-3
283	(11)	68 m	Ho-162m	Ho-165	3.9 E-2
283	(3)	4.2 d	Yb-175	Yb-176, Lu-176	3.3 E-2
283	(0.2)	6.7 m	W-179m	W-180	7.8 E-4
283	(0.5)	12.1 d	Ir-190	Ir-191	3.6 E-3
283	(0.3)	74 d	Ir-192	Ir-193	3.9 E-4
285	(0.4)	1.37 a	Lu-173	Lu-175, Hf-174	2.7 E-5

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
286	(3)	53.1 h	Pm-149	Sm-150	2.4 E-3
287	(0.2)	5.37 d	Tb-155	Dy-156	4.7 E-6
288	(0.7)	22 m	Rh-107	Pd-108	3.8 E-3
288	(0.8)	1.73 h	Nd-149	Nd-150	2.0 E-2
288	(12)	41.3 d	Pm-148m	Sm-149	2.4 E-5
288	(2)	12.1 d	Ir-190	Ir-191	1.4 E-2
290	(0.8)	18 m	Se-81	Se-82	4.4 E-3
290	(0.6)	33 h	Sr-83	Sr-84	1.7 E-4
290	(0.03)	18.56 h	Gd-159	Gd-160	1.3 E-3
291	(4)	1.65 h	Ru-95	Ru-96	6.8 E-1
291	(?)	50 s	Rh-109m	Pd-110	?
291	(2)	3.85 d	Sb-127	Te-128	3.1 E-4
291	(0.8)	28 h	Pm-151	Sm-152	1.6 E-4
292	(0.2)	55 m	Cd-105	Cd-106	1.1 E-4
292	(4)	5 d	Ta-183	W-184	2.3 E-4
292	(3)	71 d	Re-183	Re-185, Os-184	8.7 E-4
293	(42)	33 h	Ce-143	Ce-142	8.9 E-5
294	(0.4)	3.1 h	Er-161	Er-162	8.4 E-4
294	(3)	19.4 h	Ir-194	Ir-193, Pt-195	2.8 E-3
294	(11)	39.5 h	Au-194	Au-197	8.4 E-3
295	(0.2)	39.35 d	Ru-103	Ru-104	3.4 E-4
295	(0.02)	17 d	Pd-103	Pd-104	6.0 E-4
295	(0.7)	1.73 h	Nd-149	Nd-150	1.9 E-2
295	(6)	12.1 d	Ir-190	Ir-191	4.2 E-2
295	(0.07)	9.59 h	Dy-155	Dy-156	1.1 E-5
296	(18)	8.47 h	Pd-101	Pd-102	1.5 E+1
296	(29)	7.5 h	Er-171	Er-170	6.9 E-3
296	(?)	115 d	Ta-182	W-183, Ta-181	?
296	(29)	74 d	Ir-192	Ir-193	3.8 E-2
297	(94)	4.8 h	Ga-73	Ge-74	8.2 E-1
297	(4)	56 h	Br-77	Br-79	8.8 E-3
297	(34)	23.6 h	Hf-173	Hf-174	6.5 E-3
298	(48)	1.1 m	Ag-113m	Cd-114	8.6 E-4
298	(0.6)	36 a	Eu-150	Eu-151	8.4 E-7
298	(0.01)	75 m	Er-163	Er-164	5.3 É-4
298	(9)	5.37 h	Ag-113	Cd-114	4.6 E-3
299	(27)	72.1 d	Tb-160	Tb-159, Dy-161	1.2 E-3

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
299	(31)	9.5 d	Gd-149	Gd-152	8.3 E-6
299	(78)	(1.1 s)	Ho-163m	Er-164	?
300	(21)	78.3 h	Ga-67	Ga-69	4.1 E-2
300	(24)	17 h	Ce-135	Ce-136	8.9 E-3
301	(2)	1.65 h	Ru-95	Ru-96	3.4 E-1
301	(0.4)	1.73 h	Nd-149	Nd-150	1.0 E-2
301	(2)	11 h	Pt-189	Pt-190	1.9 E-3
303	(18)	10.5 a	Ba-133	Ba-134	2.0 E-5
303	(6)	22 m	Rh-107	Pd-108	3.6 E-1
304	(1)	120 d	Se-75	Se-76	1.3 E-4
304	(1)	56 h	Br-77	Br-79	2.2 E-3
304	(14)	4.48 h	Kr-85m	Rb-87	1.2 E-2
305	(?)	8.47 h	Pd-101	Pd-102	?
306	(0.9)	41.2 d	Ag-105	Ag-107, Cd-106	2.3 E-4
306	(5)	35.5 h	Rh-105	Pd-106	4.2 E-3
306	(0.06)	18.56 h	Gd-159	Gd-160	3.6 E-3
307	(6)	23.6 h	Hf-173	Hf-174	1.1 E-3
307	(89)	14 m	Tc-101	Ru-102, Mo-100	1.5 E-1
307	(87)	4.4 d	Rh-101m	Pd-102, Rh-103	7.7 E-1
307	(0.2)	3.4 m	Pr-140	Pr-141	3.8 E-1
307	(0.2)	28 h	Pm-151	Sm-152	4.0 E-5
308	(99)	23 h	Cr-48	Cr-50	4.0 E-4
308	(0.8)	55 m	Cd-105	Cd-106	4.5 E-4
308	(1)	120 d	Gd-151	Gd-152	3.4 E-6
308	(64)	7.5 h	Er-171	Er-170	1.5 E-2
308	(10)	30.7 d	Yb-169	Yb-170	2.8 E-2
308	(30)	74.2 d	Ir-192	Ir-193	3.9 E-2
309	(0.5)	39 m	Se-73m	Se-74	1.6 E-2
309	(0.9)	72.1 d	Tb-160	Tb-159, Dy-161	3.8 E-5
310	(0.3)	3.85 d	Sb-127	Te-128	4.5 E-5
310	(14)	(33 m)	Ho-159	Er-162	?
311	(0.03)	13.46 h	Pd-109	Pd-110	1.2 E-1
311	(0.6)	1.73 h	Nd-149	Nd-150	1.5 E-2
311	(11)	23.6 h	Hf-173	Hf-174	2.1 E-3
312	(5)	22 m	Rh-107	Pd-108	2.7 E-2
312	(4)	41.3 d	Pm-148m	Sm-149	7.9 E-6
313	(7)	5 d	Ta-183	W-184	4.0 E-4

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
315	(17)	1.95 h	In-117m	Sn-118	8.0 E-3
315	(22)	12 m	Pr-147	Nd-148	?
315	(23)	3.6 m	Gd-161	Gd-160	3.0 E-2
315	(2)	3.1 h	Er-161	Er-162	4.2 E-3
316	(1)	5.37 h	Ag-113	Cd-114	5.2 E-4
316	(100)	1.1 m	Ag-113m	Cd-114	1.8 E-3
316	(8)	19.5 m	Tb-163	Dy-164	2.9 E-2
316	(83)	74 d	Ir-192	Ir-193	1.1 E-1
317	(1)	4.3 d	Tc-96	Ru-98	2.6 E-6
318	(0.2)	9.59 h	Dy-155	Dy-156	3.0 E-5
318	(3)	32.06 h	Cs-129	Ba-130	4.0 E-4
318	(6)	165 d	Re-184m	Re-185	?
318	(2)	11 h	Pt-189	Pt-190	1.9 E-3
319	(1)	39 h	Ge-69	Ge-70, Se-74	1.2 E-2
319	(5)	41.2 d	Ag-105	Ag-107, Cd-106	1.3 E-3
319	(2)	10.98 d	Nd-147	Nd-148	1.1 E-3
319	(0.2)	6.7 d	Lu-172	Lu-175	1.9 E-5
319	(0.2)	70 d	Hf-175	Hf-176	6.4 E-5
319	(19)	35.5 h	Rh-105	Pd-106	1.6 E-2
320	(95)	5.8 m	Ti-51	V-51	w
320	(10)	27.7 d	Cr-51	Cr-52, Fe-56	3.8 E-2
320	(3)	39 m	Se-73m	Se-74	9.6 E-2
320	(13)	3.8 h	Ir-195m	Pt-196	2.0 E-3
321	(0.6)	8.47 h	Pd-101	Pd-102	5.0 E-1
321	(3)	15.15 h	Eu-157	Gd-158	3.6 E-4
321	(24)	3.1 h	Ho-167	Er-168	2.8 E-2
321	(0.2)	6.71 d	Lu-177	Lu-176, Hf-178	1.9 E-5
322	(2)	22 m	Rh-107	Pd-108	1.1 E-2
322	(1)	30 h	Os-193	Os-192	9.8 E-5
324	(1)	28 h	Pm-151	Sm-152	2.0 E-4
324	(1)	6.7 d	Lu-172	Lu-175	9.7 E-5
325	(11)	2.9 d	Ru-97	Ru-98	4.1 E-2
325	(11)	3 a	Rh-101	Rh-103, Pd-102	9.3 E-5
325	(94)	22.7 m	Lu-178m	Hf-179	3.3 E-2
326	(94)	2.2 h	Ta-178m	Ta-180, W-180	2.2 E-1
326	(14)	4.8 h	Ga-73	Ge-74	1.2 E-1
326	(94)	8.1 h	Dy-157	Dy-158	3.4 E-2

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
326	(94)	(4.3 s)	Hf-178m	Hf-179, Ta-180	?
326	(94)	31 a	Hf-178n	Hf-179	w
326	(0.05)	6.2 d	Au-196	Au-197	1.3 E-3
327	(62)	80 s	Rh-109	Pd-110	1.3 E-1
327	(5)	1.73 h	Nd-149	Nd-150	1.3 E-1
328	(4)	93.1 d	Eu-149	Eu-151	5.6 E-4
328	(1)	8.3 d	Ag-106m	Ag-107	4.2 E-4
328	(13)	19.4 h	Ir-194	Ir-193, Pt-195	1.2 E-2
329	(19)	40.2 h	La-140	La-139	2.3 E-2
329	(93)	171 d	Ir-194m	Ir-193, Pt-195	5.0 E-3
329	(61)	39.5 h	Au-194	Au-197	4.6 E-2
330	(0.6)	6.7 d	Lu-172	Lu-175	5.8 E-5
331	(78)	9.4 h	Pb-201	Pb-204	w
332	(5)	41.2 d	Ag-105	Ag-107, Cd-106	1.3 E-3
332	(12)	22.7 m	Lu-178m	Hf-179	4.1 E-3
332	(94)	5.5 h	Hf-180m	Ta-181, Hf-180	2.5 E-2
332	(32)	2.2 h	Ta-178m	Ta-180, W-180	1.4
333	(0.03)	4.4 d	Rh-101m	Pd-102, Rh-103	2.7 E-4
333	(23)	6.2 d	Au-196	Au-197	5.9 E-1
334	(94)	36 a	Eu-150	Eu-151	1.3 E-4
334	(4)	12.6 h	Eu-150m	Eu-151	2.4 E-1
336	(70)	1.65 h	Ru-95	Ru-96	1.2 E+1
336	(46)	4.5 h	In-115m	Sn-116, In-115	8.3 E-2
336	(0.8)	15.15 h	Eu-157	Gd-158	9.6 E-5
337	(0.4)	72.1 d	Tb-160	Tb-159, Dy-161	1.7 E-5
339	(5)	19.5 m	Tb-163	Dy-164	1.8 E-2
339	(55)	171 d	Ir-194m	Ir-193, Pt-195	3.0 E-3
340	(0.004)	270 d	Co-57	Ni-58, Co-59	2.4 E-6
340	(22)	28 h	Pm-151	Sm-152	4.4 E-3
341	(47)	13 d	Cs-136	Ba-137	5.2 E-4
341	(1)	5.32 d	Tb-155	Dy-156	2.1 E-5
342	(5)	7.5 d	Ag-111	Cd-112	3.0 E-3
343	(0.04)	69.6 m	Te-129	Te-130	7.6 E-3
343	(0.03)	17.7 m	Yb-167	Yb-168	2.7 E-4
343	(87)	70 d	Hf-175	Hf-176	2.8 E-2
344	(27)	12.4 a	Eu-152	Eu-153	2.2 E-4
344	(2)	9.3 h	Eu-152m	Eu-153	1.5 E-2

Tab. 5-5, continued

E,keV	(I%)	T	Nuclide	Target Nuclide	N · I
344	(24)	6.24 d	Bi-206	Bi-209	7.0 E-4
345	(42)	41.2 d	Ag-105	Ag-107, Cd-106	1.1 E-2
346	(13)	42.4 d	Hf-181	Hf-180	4.7 E-5
346	(11)	81 m	Pt-197m	Pt-198	3.0 E-1
347	(25)	9.5 d	Gd-149	Gd-152	6.8 E-6
347	(4)	55 m	Cd-105	Cd-106	2.2 E-3
347	(57)	3.1 h	Ho-167	Er-168	6.9 E-2
348	(2)	22 m	Rh-107	Pd-108	1.1 E-2
348	(0.2)	18.56 h	Gd-159	Gd-160	8.8 E-3
348	(6)	19.5 m	Tb-163	Dy-164	2.2 E-2
348	(0.3)	93.1 d	Tm-168	Tm-169	5.1 E-4
349	(2)	1.73 h	Nd-149	Nd-150	5.2 E-2
350	(1)	23.4 h	Nb-96	Mo-97	7.7 E-4
350	(0.3)	93.1 d	Eu-149	Eu-151	4.2 E-5
350	(0.02)	72.1 d	Tb-160	Tb-159, Dy-161	8.6 E-7
351	(26)	19.5 m	Tb-163	Dy-164	9.4 E-2
351	(0.2)	1.37 a	Lu-173	Lu-175, Hf-175	1.3 E-5
351	(3)	2.8 d	Pt-191	Pt-192	1.5 E-3
352	(0.003)	270 d	Co-57	Ni-58, Co-59	6.5 E-2
352	(10)	2.6 m	Nb-99	Mo-100	1.9 E-2
352	(0.2)	6.7 d	Lu-172	Lu-175	1.9 E-5
353	(0.02)	83 m	Ge-75	Ge-76, Se-80	3.8 E-3
354	(0.2)	70 d	Hf-175	Hf-176	6.4 E-5
354	(11)	5 d	Ta-183	W-184	6.3 E-4
355	(0.3)	8.47 h	Pd-101	Pd-102	2.5 E-1
355	(0.6)	14 h	Os-183	Os-184	1.6 E-5
355	(0.9)	54 m	In-116m1	In-115, Sn-117	8.2 E-2
356	(?)	36 h	Ni-57	Ni-58	?
356	(62)	10.5 a	Ba-133	Ba-134	6.8 E-5
356	(13)	5.35 d	Tb-156	Tb-159	1.5 E-4
356	(88)	6.18 d	Au-196	Au-197	2.3
357	(0.02)	17 d	Pd-103	Pd-104	6.0 E-4
358	(0.4)	22 m	Rh-107	Pd-108	2.3 E-3
358	(0.1)	6.7 d	Lu-172	Lu-175	1.0 E-5
359	(3)	4.32 h	Sb-129	Te-130	1.0 E-3
359	(6)	3.8 h	Ir-195	Pt-196	9.0 E-4
360	(?)	2.1 m	Ga-75	Ge-76	?