Gamma-emitting Short-lived Nuclides Formed by Neutron Activation

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Rapid methods of neutron activation analysis make it possible to detect easily gamma-emitting, short-lived nuclides using multichannel gamma spectrometers. Because neutrons from reactors — which are widely used in neutron activation — exhibit an extremely broad energy range from zero to at least 15 MeV¹⁾, various types of neutron reactions are likely to occur simultaneously. For this reason, a particular reaction one selects to use is associated in most cases with interfering reactions that produce the desired activation product from elements other than the one sought. To analyze an element in a sample it is therefore necessary to consider all of these interfering reactions.

The table presented here shows original elements for these interfering reactions. The data have been collected from Table of Isotopes²⁾ and the Rohrmann Chart³⁾. The table is based on an original table of Short-Lived Nuclides Formed by Neutron Activation⁴⁾.

Radioactive nuclides that emit only β^- or α particles were not listed in the table because they cannot be detected with gamma spectrometers.

Type of reaction To indicate the type of reaction responsible for the activity, numbers are given in parenthesis following each ele-

ment. These numbers correspond to the following reactions:

1: n, γ	5: $n, 2n$	9: $n, {}^3\text{He}$
2: n, n'	6: $n, \alpha n$	10: $n, 2p$
3: n, p	7: n, pn	
4: n, α	8: n, t	

Energies and intensities Quantities enclosed in square brackets are calculated or inferred, not measured.

The intensities of radiations when expressed as percentages without other qualifications refer to percentages of the total decay events. A number following the dagger ($\dagger$) symbol is the relative intensity for the particular mode of decay beside which the $\dagger$ appears.

References

- 1) D.J. Hughes: *Nucleonics*, 11 (1)30 (1953)
- 2) C.M. Lederer, J.M. Hollander, I. Perlman: "Table of Isotopes. Sixth Edition", John Wiley & Sons, Inc. (1967)
- 3) C.A. Rohrmann: "Chart of the Nuclides Emphasizing Nuclear Power By-product Elements and Isotopes for Large Scale Applications", Battelle-Northwest, Richland, Washington 99352, U.S.A., May (1969)
- 4) M. Okada: *Nucleonics*, 22,(8) 110 (1964)

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
Os(7)	^{183m}Re	1.0ms	0.194, 0.11—0.30
Ru(1, 5)	^{97m}Ru	1.8ms	0.227
Bi(5)	^{208m}Bi	2.7ms	0.92(*100), 0.51(*90)
Pb(1, 5)	^{205m}Pb	4ms	[0.703], [0.988], [1.04], ...
W(2), Os(6)	^{180m}W	5.2ms	0.10, 0.15—0.5
Mo(8)	^{90m2}Nb	0.010s	0.257
C(10)	^{12}Be	0.0114s	?
Y(5), Zr(8)	^{88m}Y	0.014s	0.23, 0.45
Pt(7)	^{189m}Ir	0.014s	0.072, 0.114, 0.187
As(2), Se(7, 8), Br(6)	^{75m}As	0.017s	0.304(95%), 0.280(<1%)
C(3), N(9, 10)	^{13}B	0.019s	3.68(7%)
Na(1), Mg(3, 7, 8), Al(4)	^{24m}Na	0.020s	0.472
Ge(1, 5), Se(4)	^{71m}Ge	0.020s	0.175
B(1), C(3, 7), N(4, 9)	^{12}B	0.0203s	4.43(1.3%)
Ga(1, 5), Ge(3, 8)	^{70m}Ga	0.021s	0.18
Ir(1), Pt(3, 7, 8), Au(4)	^{194m}Ir	0.032s	≤ 0.10
Ga(1), Ge(3, 7, 8), As(4)	^{72m}Ga	0.036s	≤ 0.099
In(5), Sn(3, 8)	$^{112m2}\text{In}$	0.042s	0.31
Yb(1, 5), Lu(3, 7), Hf(4, 6, 9, 10)	^{175}Yb	0.067s	0.513[63%]
Be(10)	^8He	0.122s	0.98(88%)
Be(3), B(9, 10)	^9Li	0.17s	?
Ti(3), V(10)	^{50m}Sc	0.35s	0.258 daughter radiations from ^{50}Sc
Ba(1, 2, 5), La(8), Ce(6, 9)	^{136m}Ba	0.37s	1.05(100%), 0.818(100%), Ba X-rays, 0.164(40%)
Ge(1, 2, 5), As(8), Se(4, 10)	^{73m}Ge	0.53s	Ge X-rays, 0.054(9%)
O(3), F(10)	^{18}N	0.63s	1.98(100%), 1.65(59%), 0.82(59%), 2.47(41%)
O(9, 10)	^{16}C	0.74s	?
Cl(1), Ar(3, 8), K(4, 9, 10)	^{38m}Cl	0.74s	0.66(100%) daughter radiations from ^{38}Cl
Pb(1, 2, 5), Bi(8)	^{207m}Pb	0.80s	0.570(98%), 1.064(83%)
Zr(2, 5), Mo(6, 9)	^{90m}Zr	0.81s	Zr X-rays, 2.32(86%), 2.18(14%), 0.133 (4%)
Li(1), Be(7), B(4, 9)	^8Li	0.84s	?
Ca(5)	^{39}Ca	0.87s	0.511(200%)
K(5), Ca(8)	^{38m}K	0.95s	0.511(200%)
Mg(3), Al(10)	^{26}Na	1.0s	1.82(100%)
Er(7)	^{163m}Ho	1.1s	0.305[$\approx 80\%$]
Cl(5), Ar(8)	^{34}Cl	1.56s	0.511(200%)
Ar(5)	^{35}Ar	1.83s	0.511(200%), 1.22(5%), 1.76(2%)
In(1), Sn(3, 7, 8)	$^{116m2}\text{In}$	2.16s	In X-rays, 0.164[$\approx 40\%$]
Er(1, 2, 5), Tm(8), Yb(4, 6, 10)	^{167m}Er	2.3s	Er X-rays, 0.208(43%)
N(3), O(4, 9, 10)	^{15}C	2.4s	5.299(68%)
In(1, 5), Sn(3, 7, 8)	$^{114m2}\text{In}$	2.5s	0.150
S(5)	^{31}S	2.7s	0.511(200%), 1.27(1.1%)
Sn(3, 8), Sb(4, 10)	^{120}In	3.2s	1.171(15%)

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
Si(3), P(10)	^{30}Al	3.3s	2.23(61%), [1.27(46%)], 3.51(39%)
Sn(3)	^{124}In	$\approx 3.6\text{s}$	1.13($\dagger$ 10), 3.21($\dagger$ 3), 0.99($\dagger$ 3)
Ne(3), Na(10)	^{22}F	4.0s	1.28(100%), 2.06(67%)
O(3,7), F(9)	^{17}N	4.16s	0.87(3%), 2.19(0.5%)
Si(5)	^{27}Si	4.2s	0.511(200%)
Hf(1,2,5), Ta(8), W(6,9)	$^{178\text{m}}\text{Hf}$	4.3s	Hf X-rays, 0.427(97%), 0.326(94%), 0.214(75%), 0.089(54%), 0.093(14%)
Ne(3,7), Na(9)	^{21}F	4.4s	0.350($\dagger$ 100), 1.38($\dagger$ 13)
Cd(3,8), In(10)	^{114}Ag	4.5s	0.57
Br(2), Kr(7)	$^{79\text{m}}\text{Br}$	4.8s	[Br X-rays], 0.21
Ir(2), Pt(7)	$^{191\text{m}}\text{Ir}$	4.9s	Ir X-rays, 0.129(25%)
Ru(3,8), Rh(10)	^{102}Tc	5s	?
Pd(3)	^{110}Rh	5s	0.374[$\approx 14\%$]
Sn(3,7,8), Sb(4)	^{118}In	5.1s	1.230(15%)
W(1,2,5), Re(8), Os(4,6,10)	$^{183\text{m}}\text{W}$	5.3s	W X-rays, 0.108(19%), 0.053(11%), 0.099(9%), 0.046(8%), 0.160(6%), ...
Pb(5)	$^{203\text{m}}\text{Pb}$	6.1s	Pb X-rays, 0.825(70%)
Os(3), Ir(10)	^{192}Re	6.2s	0.20, 0.29, 0.37, 0.48, 0.57
Al(5), Si(8)	$^{26\text{m}}\text{Al}$	6.4s	0.511(200%)
Yb(1), Hf(4,9,10)	$^{177\text{m}}\text{Yb}$	6.5s	Yb X-rays, 0.104(65%), 0.228(13%)
N(1), O(3,7,8), F(4)	^{16}N	7.2s	6.13(69%), 7.11(5%), 2.75(1%)
Au(2), Hg(7,8)	$^{197\text{m}}\text{Au}$	7.2s	Au X-rays, 0.279(75%), 0.130(8%)
Sn(3,8), Sb(10)	^{122}In	7.5s	0.99, 1.14
As(5), Se(3,8)	$^{74\text{m}}\text{As}$	8.0s	0.283
Mo(7)	^{99}Nb	10s	?
Sn(7)	^{123}In	10s	1.1
Tb(5), Dy(3,8)	$^{158\text{m}}\text{Tb}$	11s	Tb X-rays, 0.110(0.5%)
F(1), Ne(3,7,8), Na(4)	^{20}F	11.4s	1.63(100%)
Yb(2), Lu(3), Hf(4,6,9,10)	$^{176\text{m}}\text{Yb}$	12s	Yb X-rays, 0.19, 0.29, 0.39
Mg(5)	^{23}Mg	12.1s	0.511(200%), 0.44(9%)
S(3,8), Cl(4,10)	^{34}P	12.4s	2.13(25%), 4.0(0.2%)
Kr(1,5), Sr(4)	$^{81\text{m}}\text{Kr}$	13s	Kr X-rays, 0.190(65%)
B(3), C(9,10)	^{11}Be	13.6s	2.12(32%), 6.79(4.4%), 5.85(2.4%), 4.67 (2.1%), 7.99(1.7%)
Ne(9,10)	^{20}O	14s	1.06(100%)
In(1), Sn(3,7,8)	^{116}In	14s	1.293(1.2%), 0.434(0.12%), 0.95(0.1%)
Pt(1), Hg(4,9,10)	$^{199\text{m}}\text{Pt}$	14.1s	Pt X-rays, 0.393(90%)
Se(3,8), Br(10)	^{80}As	15.3s	0.666(42%), 1.64(4%), 1.22(4%), 1.77 (1.7%), 0.8(1.4%, complex)
Y(2), Zr(7,8), Nb(6)	$^{89\text{m}}\text{Y}$	16s	0.91(99%)
Ru(3,7,8), Rh(4)	^{100}Tc	17s	0.540(strong), 0.60(strong), 0.71, 0.81, 0.89, 1.01, 1.31, 1.49, 1.8
Pd(3,8), Ag(10)	^{108}Rh	17s	0.434(43%), 0.62(22%), 0.51(10%, complex)
Ne(5)	^{19}Ne	17.5s	0.511(200%)
Ca(7)	^{47}K	17.5s	2.0(84%), 2.6(15%)
Se(1,5), Br(8), Kr(4,10)	$^{77\text{m}}\text{Se}$	17.5s	Se X-rays, 0.161(50%)
Hf(1,2,5), Ta(7,8), W(4,6,10)	$^{179\text{m}}\text{Hf}$	18.6s	Hf X-rays, 0.217(94%), ...
Sc(1), Ti(3,7,8), V(6)	$^{46\text{m}}\text{Sc}$	20s	[Sc X-rays], 0.142

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
Pd(1, 5), Ag(3, 8), Cd(4, 6, 10)	^{107m}Pd	22s	Pd X-rays, 0.21
Mo(8)	^{90m}Nb	24s	Nb X-rays, 0.122(71%)
Ag(1), Cd(3, 7, 8), In(4)	^{110}Ag	24.4s	0.658(4.5%)
Hg(3, 8), Tl(4, 10)	^{202}Au	$\approx 25\text{s}$	γ ?
O(1), F(3), Ne(4, 9, 10)	^{19}O	29s	0.197(97%), 1.37(59%), 1.44[2.5%]
Xe(10)	^{135}Te	29s	?
Zn(3, 8), Ga(4, 10)	^{68}Cu	30s	1.078(95%), 0.80(17%), 1.88(5%), 1.24(3%)
Pd(3, 8), Ag(4, 10)	^{106}Rh	30s	0.512(21%), 0.622(11%, doublet), 1.05(1.5%, doublet), 1.13(0.5%, doublet), 1.55(0.2%)
Pd(7)	^{109}Rh	30s	0.49, 0.31
Sn(7), Sb(9)	^{121}In	30s	0.94
Gd(4, 10)	^{157}Sm	$\approx 30\text{s}$	0.57
Hg(7)	^{195m}Au	31s	Au X-rays, 0.261(77%)
Ge(3)	^{76}Ga	32s	0.563, 0.96, 1.12
Sn(7)	^{123}In	36s	?
Ne(1), Na(3), Mg(4, 9, 10)	^{23}Ne	37.6s	0.439(33%), 1.64(0.9%), 2.07(0.1%), 2.99(0.03%), ...
Kr(10)	^{85}Se	39s	?
Ag(2), Cd(7, 8), In(6)	^{109m}Ag	40s	Ag X-rays, 0.088(5%)
Sm(8)	^{142}Pm	40s	0.511(190%), Nd X-rays
Rh(1), Pd(3, 7, 8), Ag(4)	^{104}Rh	43s	Ru X-rays, 0.56(2.0%), 1.24(0.13%), ...
Nd(9)	^{148}Ce	$\approx 43\text{s}$	?
Er(3)	^{170}Ho	44s	0.43
Ag(2), Cd(7)	^{107m}Ag	44.3s	Ag X-rays, 0.094(5%)
Pd(3, 7), Ag(6, 9)	^{105m}Rh	45s	Rh X-rays, 0.129
Cd(10)	^{115}Pd	45s	?
Sn(3, 8), Sb(4, 10)	^{120}In	46s	1.171(15%), 1.02(9%), 0.86(5%), 1.28(2%), ...
Yb(1, 5)	^{169m}Yb	46s	Yb L X-rays
Zr(10)	^{95}Sr	$\approx 48\text{s}$	?
Ge(1, 5), As(3), Se(4, 9, 10)	^{75m}Ge	49s	Ge X-rays, 0.139(34%)
Zn(4, 10)	^{67}Ni	50s	0.90(51%, doublet), 1.26(15%)
Ru(7)	^{103}Tc	50s	0.135($\dagger$ 17), 0.21($\dagger$ 10), 0.35
Pd(7)	^{109m}Rh	50s	0.11
Pt(3)	^{198}Ir	50s	0.78
Ge(1), Se(4, 10)	^{77m}Ge	54s	Ge X-rays, 0.215(21%), 0.159(12%)
Kr(3), Rb(10)	^{86}Br	54s	1.56($\dagger$ 100), 1.36($\dagger$ 39), 2.75($\dagger$ 36), 2.34($\dagger$ 20), 1.97($\dagger$ 20), 1.29($\dagger$ 12)
Cr(3), Mn(10)	^{54}V	55s	0.99(100%), 0.84(100%), 2.21[100%]
Kr(1, 5)	^{79m}Kr	55s	Kr X-rays, 0.127
Xe(1, 5)	^{125m}Xe	55s	Xe X-rays, 0.075, 0.111
Ce(1, 5), Pr(8), Nd(4, 6)	^{139m}Ce	55s	Ce X-rays, 0.746(93%)
Hg(7), Tl(9)	^{203}Au	55s	0.69
Mg(3, 7), Al(9)	^{25}Na	60s	0.98(15%), 0.58(14%), 0.39(14%), 1.61(6%)
Mo(3, 7)	^{97m}Nb	$\approx 60\text{s}$	0.747(98%)
Rb(1, 5), Sr(3, 7, 8), Y(4)	^{86m}Rb	62s	Rb X-rays, 0.56
Nd(5), Sm(4)	^{141m}Nd	63s	0.755[90~100%]

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
Sm(5)	^{143m}Sm	64s	0.748
Nd(4, 10)	^{147}Ce	65s	?
Fe(3), Co(10)	^{58}Mn	$\approx 66\text{s}$	0.36, 0.41, 0.52, 0.57, 0.82, 1.0, 1.25, 1.4, 1.6, 2.2, 2.8
Mo(5)	^{91m}Mo	66s	0.511[76%], Mo X-rays, 0.658(54%), Nb X-rays, 1.21(22%), 1.53(15%)
Se(1), Kr(4, 10)	^{83m}Se	70s	1.01($\dagger$ 100, complex), 2.02($\dagger$ 40), 0.65($\dagger$ 20), 0.35($\dagger$ 16) daughter radiations from ^{83}Br , ^{83m}Kr
U(3, 7)	^{234m}Pa	70.3s	U LX-rays, 1.001(0.60%), 0.765(0.30%), ...
Cd(3, 7), In(9)	^{113}Ag	$\approx 72\text{s}$	0.14, 0.30, 0.39, 0.56, 0.70
In(1, 5), Sn(3, 7, 8)	^{114}In	72s	Cd X-rays, 1.299(0.17%)
Cd(3, 7, 8), In(6, 9)	^{111m}Ag	74s	[Ag X-rays], 0.065
Sr(8)	^{82}Rb	75s	Kr X-rays, 0.511(192%), 0.777(9%), ...
Xe(1, 5), Ba(4)	^{127m}Xe	75s	Xe X-rays, 0.125, 0.175
Dy(1), Ho(3), Er(4, 9, 10)	^{165m}Dy	75.4s	Dy X-rays, 0.108(3%), 0.514(1.8%), 0.362(0.6%), 0.152(0.3%) daughter radiations from ^{165}Dy
Zr(9)	^{94}Sr	$\approx 78\text{s}$	1.42(100%)
Xe(3)	^{136}I	83s	1.32(95%, complex), 2.3(19%, complex), 0.39(19%), 0.27(18%), 0.20(12%), 2.63(10%), 2.8(8%), 3.2(5%)
Ar(3), K(10)	^{40}Cl	1.4m	2.83($\dagger$ 100), 1.46($\dagger$ 100), 5.8, 3.10
Cd(4, 10)	^{113}Pd	1.4m	no γ daughter radiations from 5.3h ^{113}Ag and 1.2m ^{113}Ag
Ir(1, 5), Pt(3, 8)	^{192m}Ir	1.4m	Ir L X-rays, 0.317(0.008%), 0.058(0.005%), 0.612(0.003%)
Sb(1), Te(3, 7, 8), I(4)	^{124m}Sb	1.55m	Sb L X-rays, 0.644(20%), 0.603(20%), 0.505(20%)
Ni(3, 8), Cu(4, 10)	^{62}Co	1.6m	γ rays observed
W(1, 5), Re(3, 8), Os(4, 6, 9, 10)	^{185m}W	1.6m	W X-rays, 0.17($\dagger$ 100), 0.13($\dagger$ 70), 0.100($\dagger$ 16), 0.075($\dagger$ 8)
Fe(3, 7), Co(9)	^{57}Mn	1.7m	[Fe X-rays, 0.014], 0.122(strong), 0.136(strong), 0.22, 0.353, 0.692
Ti(3), V(10)	^{50}Sc	1.72m	1.55(100%), 1.12(100%), 0.520(100%)
Cr(3, 7), Mn(9)	^{53}V	2.0m	1.00[100%]
Ge(7)	^{75}Ga	2m	0.58(3%), 0.36?(1%) [daughter radiations from ^{75}Ge]
Nd(3, 8)	^{148}Pr	2.0m	0.30
O(5)	^{15}O	2.06m	0.511(200%)
Sn(3, 7), Sb(6, 9)	^{119}In	2.1m	0.82(95%), ...
Zr(3)	^{96}Y	2.3m	0.7, 1.0, 1.5(complex)
Nd(7)	^{149}Pr	2.3m	0.08, 0.155, 0.325, 0.36, 0.745
Al(1), Si(3, 7, 8), P(4)	^{28}Al	2.31m	1.780(100%)
Zn(1), Ga(3), Ge(4, 9, 10)	^{71}Zn	2.4m	0.510(13%), 0.92(3%), 1.12(1.3%), 0.39(1.3%), 0.120(0.9%)

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
Mo(7)	^{99}Nb	2.4m	0.260($\dagger$ 1), 0.100($\dagger$ 1)
Ag(1,5), Cd(3,8)	^{108}Ag	2.42m	Pd X-rays, 0.632(1.7%), 0.511(0.56%), 0.434(0.45%), 0.615(0.18%)
P(5), S(8)	^{30}P	2.50m	0.511(200%), 2.23(0.5%)
Cd(3)	^{116}Ag	2.5m	0.52, 0.70
Sm(3)	^{154}Pm	2.5m	?
Hg(4,10)	^{201}Pt	2.5m	0.15, 0.23, 1.76 daughter radiation from ^{201}Au
Ba(1,2,5), La(7,8), Ce(4,10)	$^{137\text{m}}\text{Ba}$	2.55m	Ba X-rays, 0.662(89%)
Sn(4,10)	^{119}Cd	2.7m	daughter radiations from $^{119\text{m}}\text{In}$, ^{119}In
Os(3,8), Ir(4,10)	^{190}Re	2.8m	Os X-rays, 0.57($\dagger$ 10), 0.392($\dagger$ 10), 0.191($\dagger$ 10), 0.83($\dagger$ 3)
Kr(7), Rb(9)	^{85}Br	3.0m	no γ daughter radiations from $^{85\text{m}}\text{Kr}$
Mo(3)	^{100}Nb	3.0m	0.53($\dagger$ 100, complex), 0.36($\dagger$ 55), 0.45($\dagger$ 40), 0.140($\dagger$ 10), 0.65, 2.2, 2.3, 2.65, 2.85
Nd(4,10)	^{145}Ce	3.0m	0.72, 0.44, ...
Sn(7), Sb(9)	^{121}In	3.1m	?
Pb(3), Bi(10)	^{208}Tl	3.10m	2.614(100%), 0.583(86%), 0.511(23%), 0.860(12%)
Kr(9)	^{84}Se	3.3m	?
Er(3,8), Tm(10)	^{168}Ho	3.3m	0.85
Mg(9,10)	^{24}Ne	3.38m	0.472(100%, with $^{24\text{m}}\text{Na}$), 0.88(8%) daughter radiations from ^{24}Na
Pr(5), Nd(8)	^{140}Pr	3.39m	0.511(100%), Ce X-rays, 1.596(0.3%)
Te(8)	^{118}Sb	3.5m	0.511(150%), Sn X-rays, 1.230(3%, doublet), 0.83(0.4%)
Xe(8)	^{122}I	3.5m	0.511[130%], Te X-rays, 0.564, 0.69, 0.78
Gd(1), Dy(4,9,10)	^{161}Gd	3.7m	Tb X-rays, 0.361(66%), 0.315(25%), 0.102(11%), 0.284(8%)
V(1), Cr(3,7,8), Mn(4)	^{52}V	3.76m	1.434(100%)
Ba(8)	^{128}Cs	3.8m	0.511(110%), Xe X-rays, 0.441(27%), 1.12(1%), 0.97(1%), 0.528, 0.576
Se(1,5), Br(3,8), Kr(4,6,10)	$^{79\text{m}}\text{Se}$	3.9m	Se X-rays, 0.096(9%)
Xe(1), Ba(10)	^{137}Xe	3.9m	0.455(33%)
Te(4,10)	^{127}Sn	4m	0.49(100%)
Zr(5), Mo(4)	$^{89\text{m}}\text{Zr}$	4.18m	Zr, Y X-rays, 0.588(87%), 1.51(6%)
Kr(7)	$^{77\text{m}}\text{Br}$	4.2m	[Br X-rays], 0.108
Pd(4,10)	^{107}Ru	4.2m	0.195(14%), 0.86(7%), 1.29(4%), 1.03 (4%), 0.93(4%), ... daughter radiations from ^{107}Rh
Sb(1,5), Te(3,7,8)	$^{122\text{m}}\text{Sb}$	4.2m	Sb X-rays, 0.061(50%), 0.075(17%)
Sn(3,7,8), Sb(4)	^{118}In	4.4m	1.230(97%), 1.05(80%), 0.69(41%), 2.04 (3%)
Er(4,10)	^{167}Dy	4.4m	0.19, 0.26, 0.31, 0.51, 0.57
Rh(1), Pd(3,7,8), Ag(4)	$^{104\text{m}}\text{Rh}$	4.41m	Rh X-rays, 0.051(47%), 0.097(2.6%), 0.078(2.5%), 0.77(0.24%doublet), 0.56 (0.18%)

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
Ru(3, 8), Rh(10)	^{102}Tc	4. 5m	0. 47, ...
Pd(9)	^{108}Ru	4. 5m	0. 165(28%) daughter radiations from ^{108}Rh
Pd(1, 5), Ag(3), Cd(4, 6, 9, 10)	$^{109\text{m}}\text{Pd}$	4. 7m	Pd X-rays, 0. 188(58%)
Pb(3, 7), Bi(9)	^{207}Tl	4. 78m	0. 897(0. 16%)
Er(7)	^{169}Ho	4. 8m	0. 76(†30), 0. 84(†15), 0. 15(†12), 0. 68(†10), 0. 92(†5), ...
Hf(3, 7, 8), Ta(4, 9)	^{178}Lu	5m	0. 090, 0. 22, 0. 33, 0. 43
S(1), Cl(3), Ar(4, 10)	^{37}S	5. 06m	3. 09(90%)
Cu(1), Zn(3, 7, 8), Ga(4)	^{66}Cu	5. 1m	1. 039(9%), ...
W(5)	$^{179\text{m}}\text{W}$	5. 2m	W X-rays, 0. 222
Sm(7)	^{153}Pm	5. 5m	0. 090 ?, 0. 12, 0. 18
Hg(1), Tl(3), Pb(4, 9, 10)	^{205}Hg	5. 5m	0. 205
Ti(1), V(3), Cr(4, 9, 10)	^{51}Ti	5. 80m	0. 320(95%), 0. 928(5%), 0. 605(1. 5%)
Fe(9, 10)	^{56}Cr	5. 9m	[Mn X-rays], 0. 026, 0. 083 daughter radiations from ^{56}Mn
Ni(4, 10)	^{61}Fe	6. 0m	1. 20(†100), 1. 03(†98), 0. 30(†48), 0. 13(†11), ... daughter radiations from ^{61}Co
Kr(3, 8), Rb(4, 10)	^{84}Br	6. 0m	1. 46(75%), 0. 88(75%), 0. 44(68%), 1. 89(16%)
Br(1), Kr(3, 7, 8), Rb(4)	$^{82\text{m}}\text{Br}$	6. 1m	Br X-rays, 0. 046(0. 3%), 0. 777(0. 15%), 1. 475(0. 009%)
Nb(1), Mo(3, 7, 8)	$^{94\text{m}}\text{Nb}$	6. 3m	Nb X-rays, 0. 871(0. 2%), ...
Br(5), Kr(3, 8)	^{78}Br	6. 5m	0. 511(184%), Se X-rays, 0. 614(14%)
Sm(3, 8), Eu(10)	^{152}Pm	6. 5m	[Sm X-rays], 0. 122, 0. 245
Pt(4, 10)	^{195}Os	6. 5m	?
Si(3, 7), P(9)	^{29}Al	6. 6m	1. 28(94%), 2. 43(6%)
Ce(8)	^{134}La	6. 7m	0. 511(124%), Ba X-rays, 0. 605(6%), ...
Te(3)	^{130}Sb	7m	0. 20, 0. 82(complex), 1. 03, 1. 16
Pt(7)	^{197}Ir	7m	0. 50
Dy(3, 7, 8), Ho(4)	^{162}Tb	7. 5m	Dy X-rays, 0. 258(†100), 0. 89(†54), 0. 81 (†44), 0. 180(†26), 0. 040(†17), 0. 081(†8), 0. 140(†6)
K(5), Ca(8)	^{38}K	7. 71m	0. 511(200%), 2. 170(100%), ...
Ge(3, 8), As(10)	^{74}Ga	7. 9m	0. 60(100%, doublet), 2. 35(45%), 0. 50(11 %, complex ?), 0. 87 (9%, doublet), 1. 46(8%, doublet), 1. 20(8%, doublet), 1. 76(7%, doublet), 1. 33(5%), 1. 11(5%)
Zr(4, 10)	^{93}Sr	8m	0. 60(†100), 0. 8(†75), 1. 2(†18), 1. 7(†10), 0. 3(†8), ... daughter radiations from ^{93}Y
Pb(9, 10)	^{206}Hg	8m	0. 31 daughter radiations from ^{206}Tl
Fe(5)	^{53}Fe	8. 5m	0. 511(196%), 0. 38(32%)
Ca(1), Ti(10)	^{49}Ca	8. 8m	3. 10(89%), 4. 1(10%) daughter radiations from ^{49}Sc
Sm(5)	^{143}Sm	8. 9m	0. 511(100%), Pm X-rays
Se(7), Br(9)	^{79}As	9. 0m	0. 43(2%), 0. 36(2%), 0. 89(1%), 0. 73(0. 5

Element and type of reaction	Nuclide formed	Half life	Energies (MeV) and intensities of γ -, X- and annihilation radiations
			%, 0.54(0.5%) daughter radiations from ^{79m}Se
Te(10)	^{129}Sn	9m	1.15, ...
Xe(3, 7, 8), Cs(4)	^{130m}I	9.2m	γ
W(8)	^{178}Ta	9.4m	Hf X-rays, 0.093($\dagger$ 100), 1.35($\dagger$ 46), 1.10($\dagger$ 11), 0.511($\dagger$ 10), 1.45($\dagger$ 9, complex), 1.18($\dagger$ 4, complex)
Mg(1), Al(3), Si(4, 9, 10)	^{27}Mg	9.5m	0.84(70%), 1.013(30%), 0.18(0.7%)
Ce(3, 8)	^{136}La	9.5m	Ba X-rays, 0.511(66%), 0.818(2.5%)
Sn(1), Te(4, 10)	^{125m}Sn	9.7m	0.325(97%), 1.39(0.8%), ...
Cu(5), Zn(8)	^{62}Cu	9.8m	0.511(195%), 1.17(0.5%, complex), ...
Os(7), Ir(9)	^{191}Re	9.8m	?
Os(1, 2), Ir(7), Pt(6, 9)	^{190m}Os	9.9m	Os X-rays, 0.616(99%), 0.502(98%), 0.361(94%), 0.187(70%)
N(5)	^{13}N	10.0m	0.511(200%)
Sn(7)	^{111m}In	$\approx 10\text{m}$	0.53
Sn(4, 10)	^{119}Cd	10m	daughter radiations from ^{119m}In , ^{119}In
W(3), Re(10)	^{186}Ta	10m	W X-rays, 0.20(74%), 0.73(48%), 0.61 (33%), 0.51(33%), 0.30(18%), 0.123 (18%), 0.41(15%), 0.94(11%)