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MEASUREMENTS AND EVALUATION OF NUCLEAR AND ATOMIC DATA OF THE APPLIED RADIONUCLIDES

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Abstract: XK-rays intensities of radionuclides ^{119m}Sn, ^{125m}Te, ^{238}Pu, ^{239}Pu, K-shell fluorescence yield (ω_K) of Mn, the intensities of γ-rays ^{75}Se, ^{119m}Sn, ^{170}Tm and the half-life ^{125m}Te are measured:

ΣI_{xK} + I_γ (^{119m}Sn) = 42.7(10) % (P=0.99; P - confidence level);

ΣI_{xK}(^{125m}Te) = 112.2(10) % (P=0.99);

ΣI_{xL}(^{238}Pu) = 10.63(32) % (P=0.99);

ΣI_{xL}(^{239}Pu) = 4.50(17) % (P=0.99);

ω_K(Mn) = 0.340(17) (P=0.68);

I_γ(^{119m}Sn) = 15.9(3) % (P=0.68);

$I_{\gamma\,84}$(^{170}Tm) = 2.56(7) % (P=0.95);

$T_{1/2}$(^{125m}Te) = 57.8(4) d (P=0.68).

In addition compilation, analysis and evaluation of the experimental nuclear data and atomic data, published up to 1987, were performed for 12 radionuclides put into practice (^{54}Mn, ^{55}Fe, ^{57}Co, ^{60}Co, ^{75}Se, ^{109}Cd, ^{119m}Sn, ^{125m}Te, ^{170}Tm, ^{238}Pu, ^{239}Pu, ^{241}Am).

(XK-rays intensities, radionuclide, evaluation)

Introduction

In this report the results of measurements and evaluations of nuclear and atomic data for ^{54}Mn, ^{55}Fe, ^{57}Co, ^{60}Co, ^{75}Se, ^{109}Cd, ^{119m}Sn, ^{125m}Te, ^{170}Tm, ^{238}Pu, ^{239}Pu, ^{241}Am are presented. This radionuclides are often used for the production of standard radioactive sources and solutions. Nuclear and atomic data of this radionuclides are important for energy and efficiency calibration of the different detectors and spectrometers.

The work was made by the Khlopin Radium Institute specialists on the basis of combined investigations with Czecho-Slovak physicists (UVVVR, Prague) performed in last years/1/. The measurements accomplished using modern precise insttruments: the $4\pi\alpha$ (β)- (X)-coincidence systems, $4\pi\gamma$-, $4\pi\beta$-; Ge(HP), Ge(Li), Si(Li) detectors.

The evaluation of decay data of the 12 radionuclides was performed taking into account the results of our measure ments on the basis of analysis and examination of data totality published to 1988. The main features of evaluation technique are descibed in /2,3,5/.

The results of decay data measurements

^{55}Fe The K-shell fluorescence yield ω_K(Mn)=0.340±0.017 (at confidence level P=0.68) and the internal bremsstrahlung emission probability (E_γ>60 keV) $I_{IB}=3.10^{-3}$ photons per 100 decays were measured.

^{75}Se Relative intensities were measured for the 66, 97, 121, 136, 199, 265, 280, 304, 401-keV γ-rays.

^{109}Cd The relative intensities of Ag characteristic XK-ray components $I_{K\beta}/I_{K\alpha}$ =20.7±0.4, $I_{K\beta'2}/I_{K\beta'1}$ =0.181±0.004 (P=0.95) and the summary absolute intensity of Ag XK-rays ΣI_{xK}=102.5±3.0 γ/100 decays (P=0.95) were measured.

^{119m}Sn The emission probability of the 23.87 keV γ-rays $I_{\gamma 24}$=15.9±0.3 γ/100 decays (P=0.68), those of Sn XK-ray commponents $I_{K\alpha}$=22.0±0.5, $I_{K\beta'1}$= =3.9±0.2, $I_{K\beta'2}$=0.83±0.06 /100 decays (P=0.68) and summary (XK+γ)-intensity $\Sigma I_{xK+\gamma}$=42.7±1.0 γ/100 decays (P=0.99) were measured.

^{125m}Te The half-life $T_{1/2}$=57.8± ±0.4 days (P=0.68) and the summary Te XK-ray intensity ΣI_{xK}=112.2±1.0 γ/100 decays (P=0.99) were measured.

^{170}Tm The 84.255 keV γ-ray emission probability $I_{\gamma 84}$=2.56±0.07 γ/100 decays (P=0.95) were measured/1/. Our result is different from before accepted value/2/ more then 25 % and it coincides with value $I_{\gamma 84}$=2.54±0.06 γ/100 decay (P=0.68) that have obtained in /4/ as passing quantity.

^{238}Pu, ^{239}Pu The prominent γ-ray intensities and the intensities of uranium XL-rays were measured. The information about 34 components of both spectra is obtained.

The summary uranium XL-rays intensities ΣI_{xL}(^{238}Pu)=10.63±0.32

γ/100 decays, $\Sigma I_{xL}(^{239}Pu)=4.50\pm0.17$ γ/100 decays (P=0.99) were measured.

The results of decay data evaluation

The evaluated values of some decay characteristics are presented in Tables 1,2. The uncertainties at confidence level P=0.68 (1σ) are given in brackets being expressed as the last significant digit units. The evaluated values of ^{109}Cd decay characteristics are presented in Table 3.

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Table 1. Evaluated values of half-life of 12 radionuclides

Radionuclide	Half-life
^{54}Mn	312.16(9) d
^{55}Fe	991(15) d
^{57}Co	271.81(4) d
^{60}Co	5.2714(5) y
^{75}Se	119.77(5) d
^{109}Cd	462.3(4) d
^{119m}Sn	293.1(7) d
^{125m}Te	57.8(4) d
^{170}Tm	128.6(3) d
^{238}Pu	87.74(3) y
^{239}Pu	$2.410(2).10^4$ y
^{241}Am	432.4(7) y

Table 2. Evaluated values of energy and emission probability of most prominent photons of 12 radionuclides

Radionuclide	$E_{x,\gamma}$, keV	$I_{x,\gamma}$, %
^{54}Mn	834.848(3)	99.9755(4)
^{55}Fe	($K\alpha_1$) 5.898(1)	16.2(2)
^{57}Co	122.06135(12)	85.70(9)
^{60}Co	1173.237(5)	99.89(2)
	1332.502(5)	99.9818(3)
^{75}Se	136.000(3)	58.6(6)
	264.656(4)	58.6(5)
^{109}Cd	($K\alpha_1$)22.163(1)	54.6(14)
^{119m}Sn	23.87(1)	15.9(3)
	($K\alpha_1$)25.271(1)	14.3(3)
^{125m}Te	($K\alpha_1$)27.472(1)	60.4(12)
^{170}Tm	84.2552(2)	2.56(4)
^{238}Pu	($L\alpha$) 13.56(2)	4.10(6)
^{239}Pu	($L\alpha_1$)13.58(2)	1.50(5)
^{241}Am	59.537(1)	35.8(2)

Table 3. Evaluated values of ^{109}Cd decay characteristics

Types of radiations: γ, X, CE, e_A

$T_{1/2}$ 462.3(4) d

E_γ, keV	I_γ, %
88.0341(11)	3.65(2)

XKi(Ag)	E_{XKi}, kev	I'_{XKi}	I_{XKi}, %
$K\alpha_2$	21.990	52.9(12)	28.9(7)
$K\alpha_1$	22.163	100	54.6(14)
$K\beta'_1$	24.934	26.8(3)	14.6(3)
$K\beta'_2$	25.603	4.83(5)	2.64(6)

ΣI_{XK} 100.7(15)%

ei	Eei, keV	Iei, %
L1	84.228(2)	2.3(5)
L2	84.510(2)	20.0(6)
L3	84.683(2)	22.3(7)
M	87.316-87.667	8.7(3)
NO	87.94-88.03	1.45(9)

e_{AK}	E_{eAK}, keV	I_{eAK}, %
KLL	17.7-18.7	13.4(14)
KLX	21.0-22.2	5.6(6)
KXY	24.1-25.2	0.8(1)

ΣI_{eAK} 19.8(6) %